5.5 GEOLOGY AND SOILS

This section of the Draft Environmental Impact Report (DEIR) evaluates the potential for implementation of the General Plan Update to impact geological and soil resources in the Town of Yucca Valley. The analysis in this section is based in part on the following technical report:

- *Chapter 1, Seismic Hazards, and Chapter 2, Geologic Hazards. In Technical Background Report to the Safety Element Update, Town of Yucca Valley, California. Earth Consultants International, September 2012.*

A complete copy of this study is included as Appendix F to this Draft EIR.

5.5.1 Environmental Setting

5.5.1.1 Regulatory Setting

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act (California Public Resources Code Sections 2621 et seq.) was signed into law in 1972 to mitigate the hazard of fault rupture by prohibiting structures for human occupancy across the trace of an active fault. This state law was passed in direct response to the 1971 San Fernando earthquake, which caused extensive surface fault ruptures that damaged numerous homes, commercial buildings and other structures.

The act requires the State Geologist to delineate "Earthquake Fault Zones" along faults that are "sufficiently active" and "well defined," that is they show evidence of surface displacement within the last 11,500 years (Holocene Epoch) along one or more or their segments (sufficiently active) and are clearly detectable by a trained geologist as a physical feature at or just below the ground surface (well defined). The boundary of an Earthquake Fault Zone is generally about 500 feet from major active faults, and 200 to 300 feet from well-defined minor faults. The act dictates that cities and counties withhold development permits for sites within an Earthquake Fault Zone until geologic investigations demonstrate that the sites are not threatened by surface displacements from future faulting. There are several Alquist-Priolo Earthquake Fault Zones mapped through the Town of Yucca Valley; faults and Earthquake Fault Zones in the Town are discussed further below.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act (SHMA; California Public Resources Code Section 2695), passed in 1990, addresses earthquake hazards other than surface fault rupture, including strong ground shaking, liquefaction, and earthquake-induced landslides. The California Geological Survey (CGS) is directed by the SHMA to provide local governments with seismic hazard zone maps that identify areas susceptible to liquefaction, earthquake-induced landslides, and other ground failures. The goal is to minimize loss of life and property by identifying and mitigating seismic hazards. The seismic hazard zones delineated by the CGS are referred to as “zones of required investigation.” Site-specific geological hazard investigations are required by the SHMA for construction projects in these areas.

The CGS has released seismic hazards maps of the large metropolitan areas of Los Angeles, Orange, and Ventura counties; funding for this program limits the geographic scope of these studies in southern California to these three counties. Thus, there are currently no state-issued seismic hazard zone maps for the Town of Yucca Valley. Nevertheless, the methodology that the CGS uses to prepare these maps is well documented and can be duplicated in areas that the CGS has yet to map. Areas in Yucca Valley susceptible to liquefaction or earthquake-induced slope instability were mapped during preparation of the technical background report; these hazards are discussed in more detail below.

California Building Code

Every local agency, such as cities and counties, enforcing building regulations must adopt the provisions of the California Building Code (CBC) within 180 days of its publication, although each jurisdiction can require more stringent regulations, issued as amendments to the CBC. The CBC is known as Title 24 of the California Code of Regulations. The CBCs are published on a triennial basis. The California Building Standards Commission issued the 2010 edition of the CBC based on the 2009 International Building Code published by the International Code Council. The 2010 CBC became effective on January 1, 2011, and remains in effect through 2013. The 2013 CBC is scheduled to go into effect January 2014. Similarly, the 2013 edition of the CBC is based on the 2012 IBC.

The CBC provides requirements for structural design that apply to the construction, alteration, replacement, and demolition of every building or structure and any appurtenances connected or attached to such buildings or structures throughout the state of California. The code is meant to safeguard the public's health, safety, and general welfare through structural strength, general stability, and means of egress by regulating and controlling the design, construction, quality of materials, use and occupancy, location, and maintenance of all buildings and structures within its jurisdiction. Note that building codes provide minimum standards. With respect to seismic shaking, for example, building code provisions are designed to prevent the catastrophic collapse of structures during a strong earthquake; however, structural damage to buildings is expected.

Requirements for Geotechnical Investigations

Requirements for geotechnical investigations are included in CBC; additional requirements for subdivisions requiring tentative and final maps and for other specified types of structures are contained in California Health and Safety Code Sections 17953 to 17955 and in the CBC. Testing of samples from subsurface investigations is required, such as from borings or test pits. Studies must be done as needed to evaluate slope stability, soil strength, position and adequacy of load-bearing soils, the effect of moisture variation on load-bearing capacity, compressibility, liquefaction, differential settlement, and expansiveness.

California Plumbing Code

The California Plumbing Code, California Code of Regulations Title 24 Part 5, contains requirements for septic tanks.

Unreinforced Masonry Law

Enacted in 1986, the Unreinforced Masonry Law (Senate Bill 547, codified in Section 8875 et seq. of the California Government Code) required all cities and counties in what was then referred to as Seismic Zone 4 (zones near historically active faults) to identify potentially hazardous unreinforced masonry (URM) buildings in their jurisdictions, establish a URM loss-reduction program, and report their progress to the state by 1990. The owners of such buildings were to be notified of the potential earthquake hazard these buildings pose. Then, starting in 1997, California required all jurisdictions to enforce the 1997 Uniform Code for Building Conservation (UCBC) Appendix, Chapter 1, as the model building code, although local governments could adopt amendments to that code under certain circumstances. The UCBC standards were meant to significantly reduce but not necessarily eliminate the risk to life from collapse of the structure. The CBC includes building standards for historical buildings (California Historical Building Code, Part 8 of Title 24) and for existing buildings (California Existing Building Code, Part 10 of Title 24) based on the International Existing Building Code.

Although the Town of Yucca Valley is in Seismic Zone 4, there is no record that the Town has reported to the Seismic Safety Commission whether or not it has unreinforced masonry buildings in its jurisdiction. The Town of Yucca Valley is not included in either the 2003 or 2006 reports by the Seismic Safety Commission.

Unreinforced masonry and other potentially hazardous building types are discussed further under *Geologic Hazards,* below.

Real Estate Disclosure Requirements

Since June 1, 1998, the Natural Hazards Disclosure Act has required that sellers of real property and their agents provide prospective buyers with a "Natural Hazard Disclosure Statement" when the property being sold is located within one or more state-mapped hazard areas. For example, if a property lies in a Seismic Hazard Zone as shown on a map issued by the state Geologist, the seller or the seller's agent must disclose this fact to potential buyers. The law specifies two ways in which this disclosure can be made: (1) Using the Natural Hazards Disclosure Statement as provided in Section 1102.6c of the California Civil Code, or (2) using the Local Option Real Estate Disclosure Statement as provided in Section 1102.6a of the California Civil Code.

California state law also states that when houses built before 1960 are sold, the seller must give the buyer a completed earthquake hazards disclosure report and a copy of the booklet entitled "The Homeowner's Guide to Earthquake Safety" written by the California Seismic Safety Commission. The booklet describes structural weaknesses common in homes that can cause significant damage to the structure and provides detailed information on strengthening homes.

The Alquist-Priolo Earthquake Fault Zoning Act and the Seismic Hazards Mapping Act also require that real estate agents, or sellers of real estate acting without an agent, disclose to prospective buyers that the property is in an Earthquake Fault or Seismic Hazard Zone. This mandate, therefore, applies to all properties within the official Alquist-Priolo maps for Yucca Valley, and within any other fault hazard management zones if defined in the Safety Element. In addition, those regions in the study area that have the potential of being impacted by other natural hazards, such as seismically induced liquefaction or slope instability, as identified in the technical background report (Appendix F), should be disclosed to prospective buyers following the provisions of the Natural Hazards Disclosure Act.

California Environmental Quality Act (CEQA)

Environmental impact reports prepared pursuant to CEQA are required to identify geologic and seismic hazards and to recommend potential mitigation measures, thus giving the local agency the authority to regulate private development projects in the early stages of planning.

Mojave Desert Air Quality Management District Rules 403 and 403.2 (Fugitive Dust Control)

Mojave Desert Air Quality Management District (MDAQMD) Rules 403 and 403.2 set forth requirements limiting dust that may be emitted from construction, grading, excavation, and clearing of land, and that crosses a property line. Rule 403 requirements include that every reasonable precaution be taken to minimize fugitive dust emissions from wrecking, excavation, grading, clearing of land. Rule 403 applies to all of the MDAQMD spanning Imperial County, most of San Bernardino County, and parts of Riverside, Los Angeles, and Kern Counties. Rule 403.2 sets forth specific requirements for dust control including construction area watering; minimizing tracking of soil onto paved surfaces; covering loaded haul vehicles while operating on paved public roads; stabilizing graded surfaces that will be left exposed 30 days or more; and reducing non-essential earth-moving activity during high winds. Rule 403.2 applies in the Mojave Desert Planning Area of San Bernardino County which includes the Mojave River Valley (Victor Valley and Barstow areas), Morongo Basin, and Lucerne Valley.

5.5.1.2 Existing Setting

Landforms

The Town of Yucca Valley encompasses highly variable terrain that includes a broad central valley, gently sloping alluvial fans, and rugged mountains. Within the Town limits, the central east-west trending valley slopes very gently to the east, from an elevation of about 3,400 feet above sea level (asl) at its western edge to about 3,100 feet asl at its eastern edge. North of the valley, the Sawtooth Mountains form rounded hills with picturesque boulder outcrops. In

addition to the Sawtooths, the valley is framed by the San Bernardino Mountains to the west, the Bartlett Mountains to the east, and the Little San Bernardino Mountains to the south. Peaks within the Town have elevations of between 3,800 and 4,500 feet asl, with the highest peak within the Town's southern boundary reaching up to an elevation of about 4,600 feet asl. South of Yucca Valley, the Little San Bernardino Mountains rise to more than 5,000 feet asl. Compared to the Sawtooths, the Town's sparsely vegetated hillsides to the south are moderately steep, jagged, and have considerably fewer outcrops—a reflection of the variation in the underlying rock types within Yucca Valley.

The most extensively developed area of Yucca Valley lies along State Highway 62 (SR-62), which generally coincides with the axis of the central valley. Development near the highway is predominantly commercial with a few multifamily residential units. Single family homes comprise most of the remaining development away from SR-62, with the highest concentration of homes spreading across the valley floor and up the gently sloping alluvial fans. Scattered rural and semirural residential development has spread out into hilly areas to the north and south. More than half of the Town's area is still undeveloped, however, including many of the steeper hills and ridgelines. The mountains that border the Town on the south are dedicated to open space and recreation, as part of Joshua Tree National Park and Big Morongo Canyon Preserve.

Geologic Setting

Southern California is divided into distinct geomorphic provinces, that is, regions having their own unique physical characteristics formed by geologic, topographic, and climatic processes. Yucca Valley is at the boundary of two very distinct provinces. The northern part of the Town, generally north of SR-62, lies within the Mojave Desert Province, an arid region of alluvial fans, desert plains, dry lakebeds, and scattered mountain ranges. This province covers a large portion of southeastern California, stretching from the southern end of the Sierra Nevada Mountains to the Colorado River. Faults in the Mojave Desert Province have a predominant northwesterly trend; however, some faults have a trend more aligned with the Transverse Ranges, described below.

In contrast, the southern part of the Town reaches up the north flank of the Little San Bernardino Mountains, a moderately high range that is the southernmost extension of the Transverse Ranges Province. This province is a series of generally east-west trending mountain ranges and valleys including the San Gabriel and San Bernardino Mountains. These ranges are called "transverse" because they lie at an oblique angle to the prominent northwesterly structural grain of the southern California landscape, a trend that is generally aligned with the San Andreas Fault. The Transverse Ranges are being intensely compressed by active tectonic forces; therefore, they are some of the fastest rising (and fastest eroding) mountains in the world. In Yucca Valley, the boundary of these two provinces is defined by the Pinto Mountain fault, a wide zone of multiple fault strands.

Mountains and hills in and near Yucca Valley are composed of rocks that have been sheared and intensely fractured under the strain of tectonic movement. The down-dropped blocks form deep basins that are filled with overlapping alluvial fans. Yucca Valley overlies two such basins: the Warren Valley Groundwater Basin underlies the main valley and gently sloping terrain to the south; the southwestern edge of the Copper Mountain Groundwater Basin underlies the northern part of the Town, with the Sawtooth Mountains, the Pinto Mountain fault zone, and the Bartlett Mountains forming a barrier between the two basins (CDWR, 2004a; 2004b).

The physiographic and geologic histories of the Yucca Valley area are important because they control to a great extent the geologic hazards as well as the natural resources in the area. For example, erosion and flooding pose significant hazards in Yucca Valley due to the fractured condition of the rock in the local mountains, the sandy nature of the valley sediments, and the intense thunderstorms that occur in the high desert. On the other hand, deep, alluvium-filled basins that are bounded at depth by relatively impermeable rock and faults function as natural underground reservoirs (aquifers) for groundwater, the area's primary source of drinking water.

Geologic Units

Engineering properties of each geologic unit discussed below are described in Chapter 2, Geologic Hazards, of the Technical Background Report included as Appendix F; some properties are discussed below under "Geologic Hazards." Geologic units in Yucca Valley are mapped on Figure 5.5-1, *Geologic Map*.

Sedimentary Deposits

Surface Sediments

Surface geologic units overlie bedrock in the area. In Yucca Valley these units consist predominantly of unconsolidated or semiconsolidated sand, silt, and gravel. The youngest sediments are water-laid alluvium deposited in active or recently active gullies, washes, and floodplains. Gently sloping areas in the southern and northern parts of the Town consist of older, slightly elevated alluvial fan sediments that have been dissected by the active washes and gullies. Erosional remnants of very old fans are present in isolated areas, where they form deeply incised hills, such as Burnt Mountain.

Young Alluvium (Map Symbol: Qya)

Young alluvium includes sediments deposited by water in washes, on small fans emanating from canyons within the local hills and mountains, and on floodplains on the valley floor. These deposits predominantly consist of unconsolidated, coarse-grained sediments filling the major active drainage courses, including the Yucca Wash, Water Canyon, Covington Wash, West Burnt Mountain Creek, East Burnt Mountain Creek, and Pipes Wash, as well as silt, sand, and gravel in numerous unnamed washes and gullies that cross the older alluvial fans. The upper reaches of these drainages, especially near the mountains, may contain very large boulders deposited during flash floods. Finer-grained alluvium, including fine sand, silt, and clay, is generally present where past floodwaters have spread out on the valley floor. Young alluvium has no soil development on the surface and is typically reworked by floodwaters or buried by new sediment during storms. Young alluvium is Holocene in age and may be up to about 100 feet thick.

Older Alluvium (Map Symbol: Qoa)

Older alluvial fan deposits are Pleistocene age (ranging from about 11,000 to 1 million years old) and generally consist of massive to crudely stratified sand and pebble-cobble gravel eroded from bedrock exposed in the adjacent hills and mountains. Deposits closer to the mountains are typically coarse grained, transitioning to finer-grained sediments (silty sand) downslope, near the valley axis. Layers of clay, sandy clay and gravelly clay are present throughout the sedimentary sequence. The oldest deposits are commonly tilted, folded, and/or faulted near the major active fault zones.

Very Old Alluvium (Map Symbol: Qof)

This unit is classified as a fanglomerate, meaning it was deposited in an alluvial fan environment and is composed mostly of boulders and cobbles in a sand matrix. Where exposed at the surface, the fanglomerate is light gray in color, massive, and contains subrounded rock fragments transported from mountains to the south and northwest. At depth, this unit underlies the sequence of young and old alluvium filling the mid to upper part of the basin and is estimated to be at least 2,000 feet thick. The fanglomerate is estimated to be early Quaternary to possibly late Tertiary age (1 million to about 5 million years old).

Sedimentary Rock (Map Symbol: Ts)

Sedimentary rock consisting of buff-colored, fine- to medium-grained sandstone, locally with lenses of rounded pebble-cobble conglomerate and minor thin lenses of siltstone, is present in the northern part of the Town. Sediments in this unit were deposited on the quartz monzonite rock described below, then buried by the basaltic lava flows that cap the hills in this area. Consequently, exposure of this unit at the surface by erosion is very limited.

The sandstone is described as friable (grains are not well cemented together), and massive to very faintly bedded. Based on its position between the monzonite and the basalt, it is estimated to be Tertiary in age (between about 1.6 and 65 million years old).

Crystalline Rocks

The oldest geologic units in the Yucca Valley area consist of hard, crystalline rock that is exposed in the mountains and buried beneath the alluvium. Crystalline rock classifications are based primarily on origin, texture, and mineral composition. Based on origin alone, the rocks in this area can be classified into three main groups: 1) igneous rocks that crystallized from molten lava that flowed out on the surface (volcanic rocks); 2) igneous rocks that crystallized from the molten state deep within the Earth's crust (plutonic rocks); and 3) rocks of sedimentary origin that have recrystallized under extreme conditions of heat and pressure deep below the Earth's surface (metamorphic rocks).

Volcanic Igneous Rock: Basalt (Map Symbol: QTb)

Volcanic rocks are those that solidified on the ground surface. Because these rocks cooled very quickly, they are very fine grained. Classified as basalt, these rocks are black, hard, massive, and vesicular (meaning they have small voids caused by gas bubbles trapped in the flowing lava). This unit is resistant to erosion and tends to form relatively flat-topped hills and ridges.

Plutonic Rocks: Quartz Monzonite (Map Symbol: Mqm, Mqm-l, Mqm-p)

Commonly referred to as "granitic," these rocks generally have large grains that can easily be seen without magnification. They often have a spotted appearance and have somewhat variable mineral compositions. Most of these rocks crystallized from magmas that were emplaced over a period of time ranging between about 65 million and 225 million years ago, during the latter part of the Mesozoic Era. In the Yucca Valley area, the predominant mineral assemblage is a light-colored, massive, medium- to coarse-grained rock composed mainly of quartz and feldspars, termed quartz monzonite. These rocks form hills in the easternmost end of the Sawtooth Mountains and the western part of the Bartlett Mountains.

Metamorphic Rocks: Gneissic Rocks (Map Symbol: Pgn)

The oldest rocks in the Yucca Valley area are metamorphic rocks that are possibly as old as Precambrian (more than about 500 million years old). These rocks occur predominantly in the mountains south of the central valley, but are also present in isolated areas north of the Pinto Mountain fault zone. This group consists of gneissic rocks consisting mostly of quartz and feldspar. The minerals in gneissic rocks are separated into layers, commonly giving the rock a banded appearance. The bands may be relatively straight, undulating, or contorted.

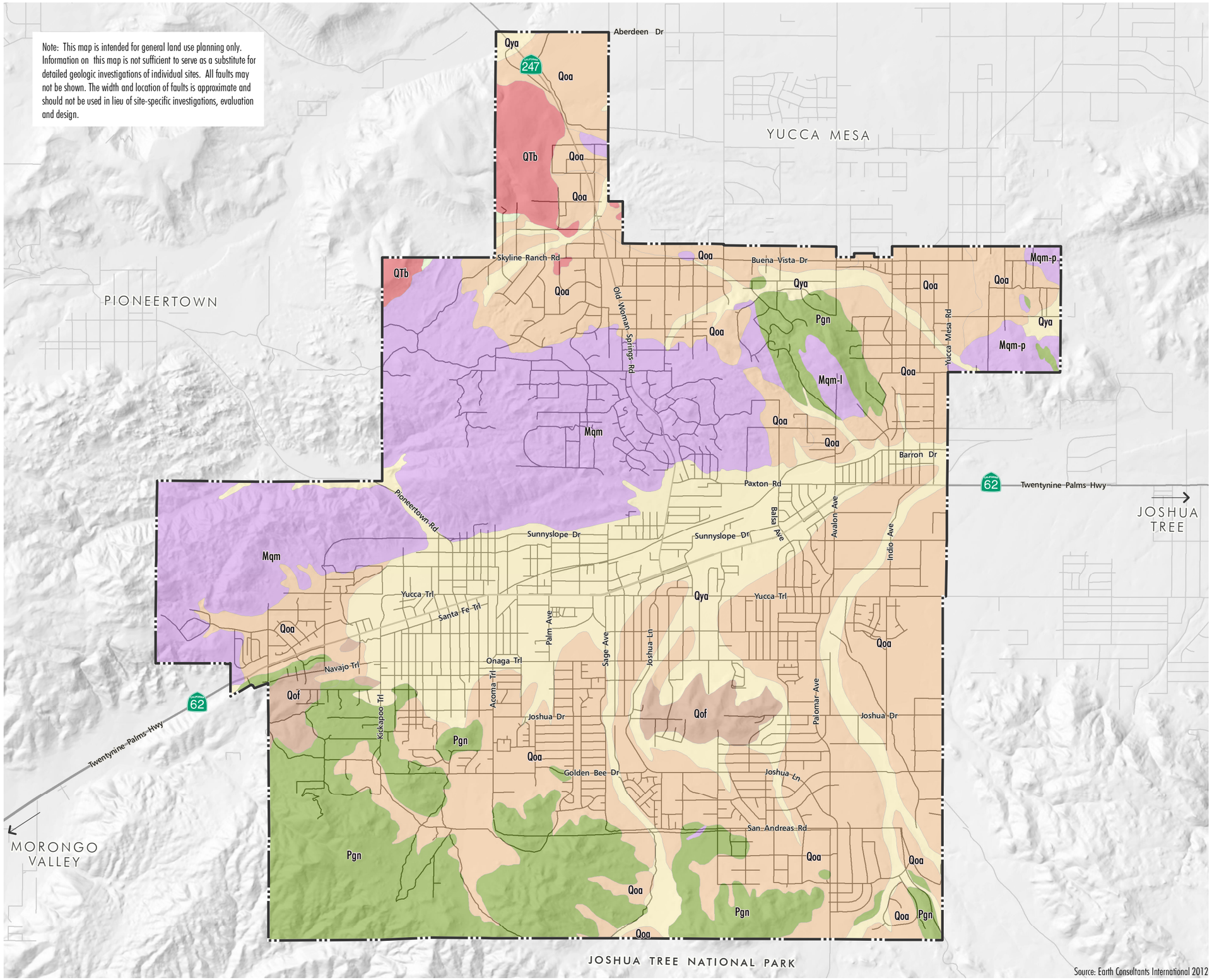
Geologic Hazards

Faulting and Seismicity

Strong ground shaking causes the vast majority of earthquake damage. When a fault breaks below ground, the seismic energy released by the earthquake radiates away from the break location in waves that are felt at the surface as shaking. In general, the bigger and closer the earthquake, the more damage it causes. However, other effects (discussed below) are also important. Earthquakes are typically classified by the amount of damage reported or by how strong and how far the shaking was felt. An early measure of earthquake size still used today is the seismic intensity scale, which is a qualitative assessment of an earthquake's effects at a given location. The most commonly used measure of seismic intensity is called the Modified Mercalli Intensity (MMI) scale, a 12-point scale in which an Intensity I earthquake is rarely felt by people and causes no damage to buildings and an Intensity XII earthquake causes total damage to structures and throws objects into the air.

5.5 - GEOLOGY AND SOILS

Figure 5.5-1
GEOLOGIC MAP



Surficial Sediments
- Qya - Young Alluvium
- Qoa - Older Alluvium
- Qof - Very Old Alluvium

Sedimentary Rock
- Ts - Sandstone

Igneous Rocks
- QTb - Basalt
- Mqm, Mqm-l, Mqm-p - Quartz Monzonite

Metamorphic Rocks
- Pgn - Gneissic Rocks

Town Limits

YUCCA VALLEY GENERAL PLAN
DRAFT EIR

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Seismologists now measure the size of an earthquake by the amount of energy released when a fault ruptures. This measure is called the seismic moment magnitude (abbreviated M_w or M), and most moderate to large earthquakes today are reported using moment magnitude. The seismic moment scale is logarithmic. Thus, each one-point increase in magnitude represents a tenfold increase in amplitude of the waves as measured at a specific location, and a 32-fold increase in energy. That is, a magnitude 7 earthquake produces 100 times (10 x 10) the ground motion amplitude of a magnitude 5 earthquake; and a moment magnitude 7 earthquake releases approximately 1,000 times more energy (32 x 32) than a moment magnitude 5 earthquake.

Faults in the Yucca Valley Region

The San Andreas fault, which passes 11 miles south of Yucca Valley near the City of Desert Hot Springs, is the principal separation between two tectonic plates of the earth's crust: the North American Plate, on which Yucca Valley and most of eastern California are located, and the Pacific Plate west of the fault. The two plates are moving past each other horizontally, with the North American plate moving southeast and the Pacific Plate moving northwest. About 30 percent of the plate motion occurs on other faults, including the San Jacinto, Whittier-Elsinore, Newport-Inglewood, Palos Verdes, and several faults offshore, in the Pacific Ocean. To the east of the San Andreas fault, movement is distributed among faults of the Eastern California Shear Zone, including those responsible for the 1992 M_W 7.3 Landers and 1999 M_W 7.1 Hector Mine earthquakes. Several of the faults in and near Yucca Valley described below are component faults of the Eastern California Shear Zone. Note also that several faults in and near Yucca Valley were discovered due to ground rupture in the 1992 Landers earthquake and its aftershocks. Faults in and near Yucca Valley are mapped on Figure 5.5-2, *Regional Fault Map,* and Figure 5.5-3, *Faults in and near Yucca Valley*.

Pinto Mountain Fault Zone

The Pinto Mountain fault is a prominent fault zone that bounds the north side of the Little San Bernardino Mountains and extends in a westerly direction through the heart of Yucca Valley and on to the Morongo Valley, where it is known as the Morongo Valley fault. The fault zone is at least 45 miles long and possibly as many as 56 miles long, ending at its west end against the San Andreas fault. Recent studies show that this fault has ruptured repeatedly in the last 14,000 years, with at least four surface-rupturing earthquakes within the past about-9,400 years. Rupture of the Pinto Mountain fault is considered the worst-case scenario for Yucca Valley.

Burnt Mountain Fault

The Burnt Mountain fault, as with several other faults in the region, was unknown prior to late June 1992, when a 3.7-mile length of this fault ruptured at the ground surface, probably during a large aftershock of the Landers earthquake, with about 2.4 inches of right-lateral offset. The Burnt Mountain fault was later mapped with a total length of about 13 miles. Based on their location, the Burnt Mountain and Eureka Peak faults are thought to be important structures that are accommodating the transfer of strain from the San Andreas fault system to the Eastern California Shear Zone.

Eureka Peak Fault

This 12-mile-long fault was "discovered" when it broke the ground surface during the 1992 Landers earthquake sequence, in part as a result of a large aftershock. Although the maximum surface offset measured on the 6.8-mile-long section of the fault that ruptured was only 8 inches, and therefore considerably less than the 6- to 9-foot offsets measured elsewhere, this small amount of offset allowed geologists to map the fault and discover the nearby Burnt Mountain fault. Creepmeters[1] installed along the fault following the Landers earthquake suggest that the fault slipped about 12 cm (4.7 inches) immediately following the main earthquake sequence and that it has since continued to slip.

[1] A creepmeter is an instrument that monitors the slow surface displacement of an active fault. Its function is not to measure fault slip during earthquakes, but to record the slow aseismic slip between earthquakes.

Landers (or Kickapoo) Fault

The Landers fault was the name given to the group of faults that ruptured during the 1992 Landers earthquake, including the Homestead Valley, Kickapoo, and Johnson Valley faults, and segments of the Burnt Mountain and Eureka Peak faults. The interval between major ruptures on these faults is uncertain, but is probably in the thousands of years, which is why these faults were unknown or poorly known prior to 1992. As a result of the 1992 earthquake, some of these faults experienced significant lateral displacements—the Kickapoo fault moved laterally nearly 9.5 feet. Individually, these faults could rupture in smaller earthquakes (similar to the 1979 Homestead Valley earthquake swarm that ruptured a portion of the southern Johnson Valley and Homestead Valley faults), but their combined lengths allowed for the magnitude 7.3 earthquake that shook southern California on the morning of June 28, 1992.

Emerson South – Copper Mountain Fault Zone

The Emerson South fault last ruptured during the Landers earthquake. This earthquake illustrated the transfer of strain from one fault segment to the next: rupture on the South Johnson Valley fault was transferred to the Emerson fault by the right-stepping Kickapoo (Landers) and Homestead Valley faults, and rupture on the Emerson fault was in turn transferred northward to the Camp Rock fault.

The Emerson South fault is about 34 miles long. The last surface-rupturing earthquake before 1992 on this fault is thought to have occurred about 9,000 years ago, so this fault seems to have long periods of dormancy.

North Frontal Fault Zone

This fault zone along the east flank of the San Bernardino Mountains consists of several fault splays that have a combined total length of approximately 40 miles. Several of the fault splays interact with other nearby faults; the most significant of these is the Helendale fault, which seems to right-laterally offset the North Frontal fault zone, dividing it into two main segments referred to as the East and West segments.

The North Frontal fault is thought to have moved in the past 10,000 years, making it an active fault. However, the fault has not been studied in detail. Furthermore, movement on this fault is thought to be responsible for uplift of the San Bernardino Mountains at an average rate of about 1 millimeter/year (40 inches/1,000 years).

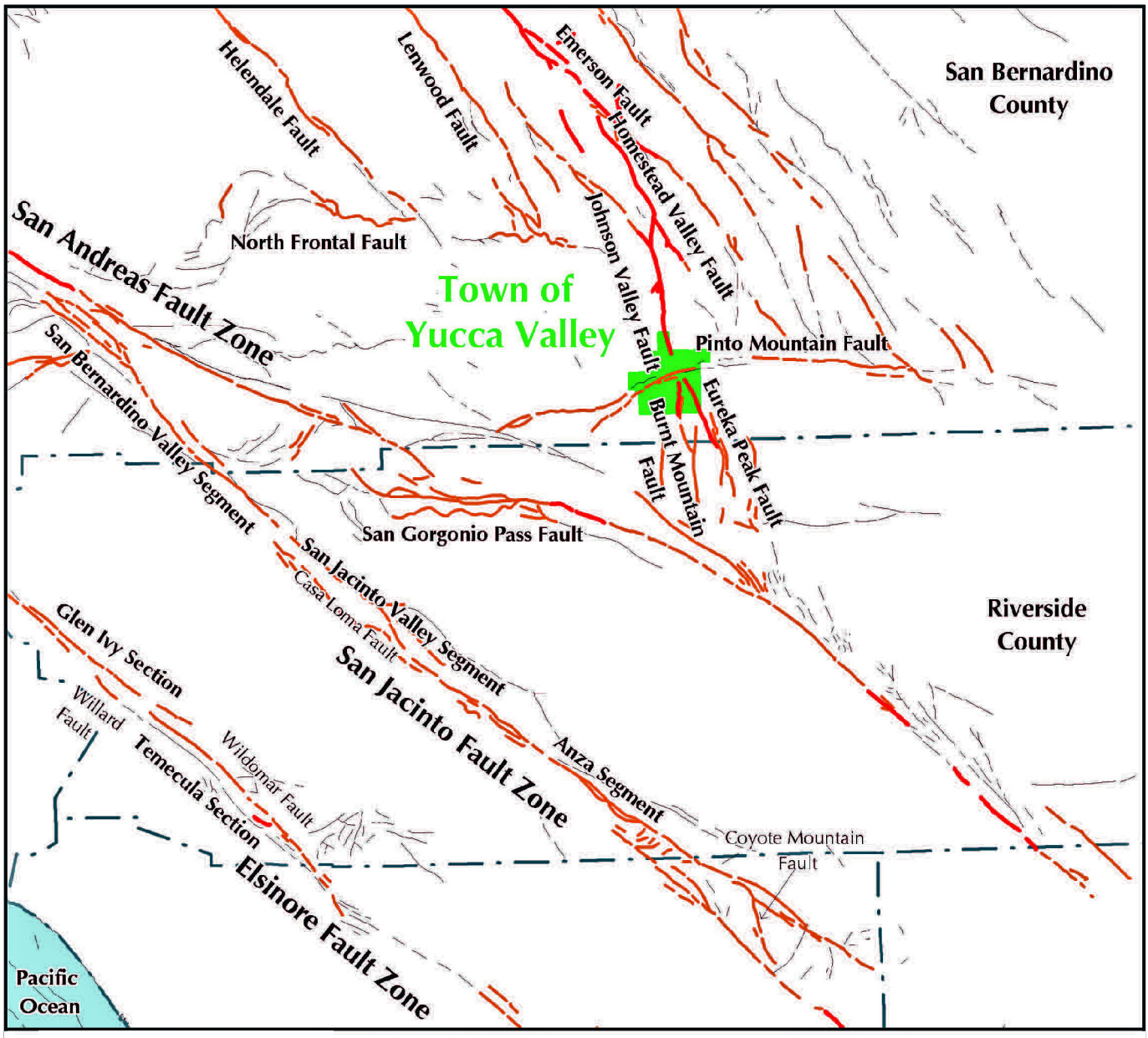
Johnson Valley Fault

The Southern Johnson Valley fault is one of the five faults that ruptured during the 1992 Landers earthquake, whereas its northern extension, the Northern Johnson Valley fault, did not. Trenching studies have shown that the Northern Johnson Valley fault last ruptured about 5,800 and 7,500 years ago in large earthquakes. A smaller earthquake may have ruptured the fault about 11,500 years ago. These data suggest that the northern segment of the fault is at or near the end of its cycle and is a likely candidate for an earthquake in the not-too-distant future.

San Andreas Fault Zone

The San Andreas fault is the principal boundary between the Pacific and North American plates. The fault extends nearly 800 miles from near Cape Mendocino in northern California to the Salton Sea region in southern California. This fault is considered the "Master Fault" in southern California because it has frequent, large earthquakes and controls the seismic hazards of the area. Many refer to an earthquake on the San Andreas fault as "The Big One," and for many parts of southern California, this is indeed true. However, as shown above, several other faults closer to Yucca Valley have the potential to cause stronger ground shaking, and therefore more local damage, than the San Andreas fault. Nevertheless, the San Andreas fault should be considered in all seismic hazard assessment studies in southern California given its high probability of causing an earthquake in the near future. In 2007–2008, a group of scientists calculated that the southern San Andreas had a 59 percent probability of causing an earthquake of at least magnitude 6.7 in the next 30 years. That probability increases with each passing year without an earthquake.

Figure 5.5-2
REGIONAL FAULT MAP



Modified from: Jennings, 1995

Explanation

- Fault Showing Evidence of Historic Rupture (Active).
- Fault Showing Evidence of Holocene Rupture (Active).
- Fault Showing Evidence of Quaternary and Late Quaternary Rupture (Potentially Active).

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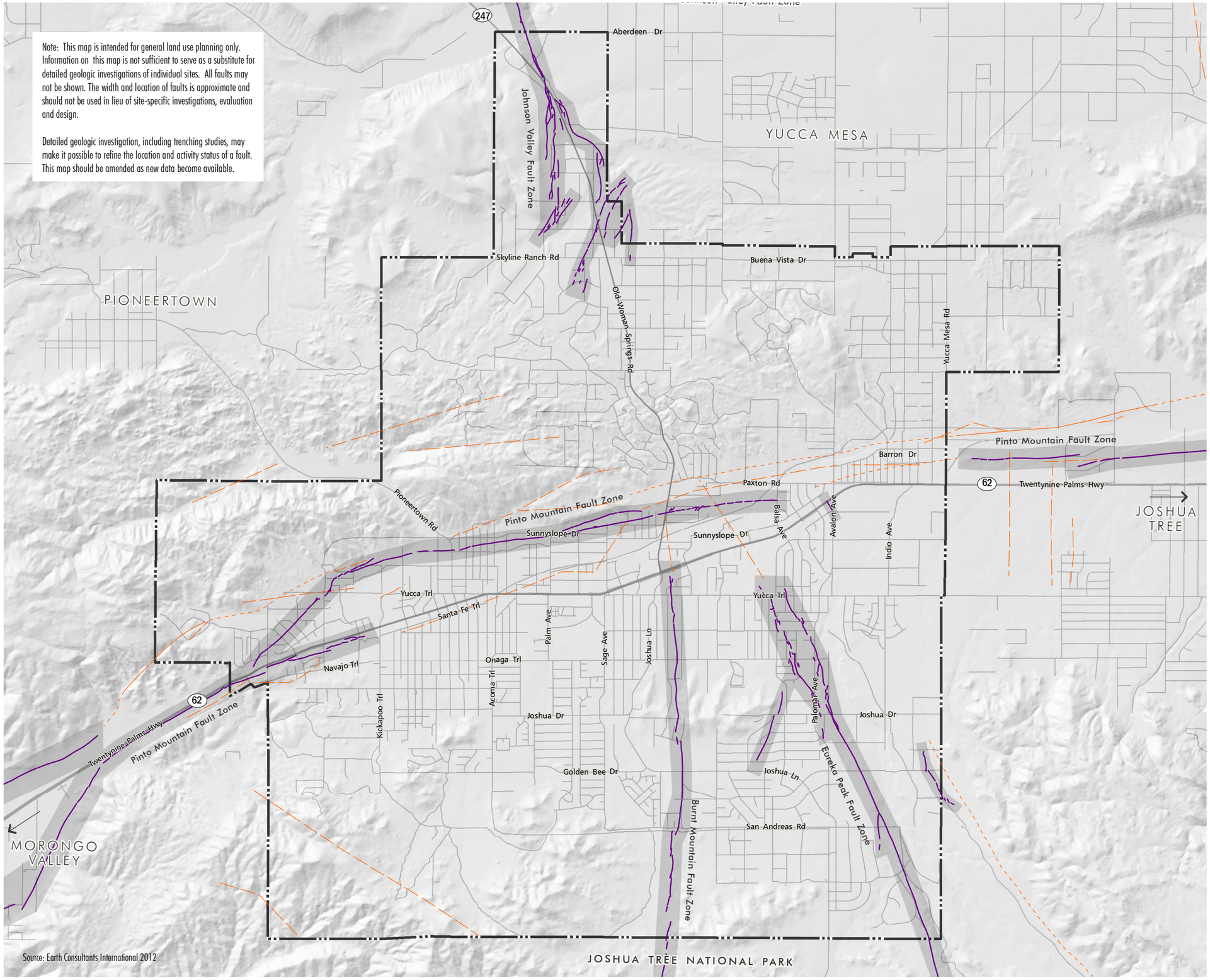
5.5 - GEOLOGY AND SOILS

Figure 5.5-3

FAULTS IN AND NEAR YUCCA VALLEY



Source: Earth Consultants International 2012

Alquist-Priolo Earthquake Fault
Fault; not zoned under the Alquist-Priolo Act
Alquist-Priolo Earthquake Fault Zone
Town Limits

YUCCA VALLEY GENERAL PLAN
DRAFT EIR

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Large faults, such as the San Andreas, are often divided into segments or sections in order to evaluate their future earthquake potential. The sections are typically based on physical characteristics along the fault, particularly changes in the angle and/or direction of the fault, and type of faulting (movement along a fault can be horizontal, vertical, or some combination thereof). Each fault section is assumed to have a characteristic slip rate, recurrence interval (time between moderate to large earthquakes), and displacement (amount of offset during an earthquake). Historical records and studies of prehistoric earthquakes show it is possible for more than one section to rupture during a large quake or for ruptures to overlap into adjacent sections. For example, the last major earthquake on a portion of the southern San Andreas fault (and the largest earthquake reported in California) was the 1857 Fort Tejon (magnitude 8) event. This earthquake ruptured the Cholame, Carrizo, Big Bend, and Mojave North and Mojave South sections of the fault, resulting in displacements of as much as 27 feet along the rupture zone. There are data that suggest that these sections and portions of sections, which are combined into a fault segment, tend to rupture together time and time again in what is referred to as a "characteristic earthquake."

The southern San Andreas fault is now divided into ten sections named, from north to south, Parkfield, Cholame, Carrizo, Big Bend, Mojave North, Mojave South, San Bernardino North, San Bernardino South, San Gorgonio-Garnet Hill, and Coachella. The southernmost sections are discussed further below because these are the sections closest to Yucca Valley. Specifically, the Yucca Valley area is, at a minimum, about 21.5 miles from the San Bernardino South section, 11 miles from the San Gorgonio-Garnet Hill segment, and 22 miles from the Coachella segment.

- **The San Bernardino (South and North) segments** combined are about 43 miles long from north of the city of Banning northwest to near Cajon Pass. These faults, like the Coachella section, appear to be nearly vertical; motion along the fault is mainly horizontal. Both segments appear to have last ruptured in the M_w7.5 (estimated) Wrightwood Earthquake of 1812. If both sections rupture together in the future, the resultant magnitude 7.5 earthquake could cause peak ground accelerations in the Town of Yucca Valley of between about 0.44g and 0.15g. If these fault sections rupture in conjunction with the Mojave and/or Coachella Valley segments, higher ground motions could be expected in the region.

- **The San Gorgonio-Garnet Hill section** is about 41 miles long and extends northwesterly and westerly from just north of the city of Indio through the San Gorgonio Pass to north of the City of Banning. From south to north, this section is composed of two main branches (the Banning fault on the south and the Mission Creek fault on the north) in addition to several other faults, including the Garnet Hill fault. At its western end, the Garnet Hill fault merges with the San Gorgonio Pass fault. Unlike the San Bernardino and Coachella sections to the north and south, respectively, this section is very complex; fault movement is both horizontal and vertical. Each of these faults that are part of the San Gorgonio-Garnet Hill section is discussed further in the paragraphs below.

- **The Banning fault** is an older structure dating back to latest Miocene time about 4 or 5 to 7.5 million years ago, when it is thought to have served as an ancestral strand of the San Andreas fault. Based on geologic and geomorphic characteristics, as well as the fault's tectonic history during the last two million years, the Banning fault is divided into three segments. The western segment, extending from the San Jacinto fault southeastward to the Calimesa area, is considered not active because it does not break Quaternary alluvium and has no surface expression (the location of the fault has been inferred from gravity data and other indirect evidence). The central segment for the most part also does not affect Quaternary deposits. There is, however, a two-mile-long section of the central Banning fault that offsets young alluvium. Therefore, the fault is active in that area. The easternmost portion of the ancestral Banning fault, from Cottonwood Canyon to its junction with the Coachella section of the fault near the Indio Hills, has been reactivated during Quaternary time and has many geomorphic characteristics of an active fault.

- **The Mission Creek fault**. Some researchers have suggested this fault is an older strand of the San Andreas that is either less active than other strands or no longer active. This is most likely true for the northern end of

the fault, but trenching near its southern end, at Thousand Palms Oasis, has shown that at this site, the fault has experienced four, and probably as many as five, surface-rupturing earthquakes in the past about 1,200 years. The most recent earthquake on this strand is most likely an A.D. 1680 event. Comparison of data obtained at the Thousand Palms Oasis site with data from the Indio site to the south and the Wrightwood site about 75 miles to the northwest, suggests that the southernmost 125 miles of the San Andreas fault have ruptured together and thus has the potential to rupture again together in large earthquakes.

- **The Garnet Hill fault** parallels the trend of the Banning fault, extending from a few miles west of Whitewater south to Thousand Palms, where the fault trace dies out.

- **The San Gorgonio Pass fault zone** begins west of Whitewater and extends westward to the Calimesa area. Faults within this east–west trending zone have thrust ancient crystalline rock southward over younger sedimentary rock and alluvial sediments. These faults formed during the Pleistocene in response to compression; activity of some of these faults continued into the Holocene, as indicated by many youthful scarps present in young alluvium.

- **The San Gorgonio-Garnet Hill section** is thought to have last ruptured in 1812, although additional studies need to be conducted to confirm this. Paleoseismic data also suggest that the Coachella, San Gorgonio-Garnet Hill, and San Bernardino sections ruptured simultaneously in earthquakes that occurred around A.D. 1500 and possibly A.D. 1680. Investigators suggest that some of the strain is also being transferred northward onto the faults in the Indio Hills and probably the Eastern California Shear Zone.

- ***The Coachella segment*** comprises the relatively straight fault extending from Bombay Beach in the Salton Sea northward to north of Indio, a distance of about 42 miles. This section is the only section of the southern San Andreas fault that has not produced a major earthquake in historic times. The last surface-rupturing earthquake on this section appears to have occurred more than 320 years ago, around A.D 1680 or 1690. In the A.D. 1680 earthquake, the Coachella section appears to have ruptured together with the San Gorgonio-Garnet Hill and San Bernardino segments; this also appears to have happened in an earthquake around A.D. 1450.

Calico-Hidalgo Fault Zone

The Calico fault, 34 miles long, slipped during the 1992 Landers earthquake and was the source of a magnitude 5.3 earthquake that shook the eastern California area on March 18, 1997. The 1997 earthquake is considered the last large aftershock of the Landers earthquake, and its epicenter was on the northern section of the fault, about 12 miles east-northeast of Barstow.

The Calico fault is the longest and possibly the fastest slipping of the faults in the Eastern California Shear Zone. The recurrence interval between earthquakes on this fault is estimated at about 1,500 years, although researchers have suggested that in this portion of the southern California fault system earthquakes recur in clusters, with long periods of inactivity between clusters.

Pisgah-Bullion Mountain-Mesquite Lake Fault Zone

The Pisgah fault, 21 miles long, experienced triggered slip in 1992 due to the Landers earthquake. The fault is thought to have last moved in the Holocene, but the interval between surface-rupturing earthquakes is unknown. The Pisgah fault alone could generate an earthquake of estimated magnitude between 6.0 and 7.0. However, the Pisgah fault may also rupture together with the 34-mile-long Bullion fault to the south and the 22-mile-long Mesquite Lake fault farther south. The Bullion fault last ruptured on October 16, 1991, during the M_w 7.1 Hector Mine earthquake. Prior to that, both the Bullion and Mesquite Lake faults appear to have ruptured during a large earthquake in the mid to late Holocene.

Relatively recent studies of the Mesquite Lake fault have shown that this fault has had three large surface-rupturing earthquakes in the past about 10,200 years, each creating an apparent vertical offset of between 3.3 to 3.9 feet,, suggesting similar-sized earthquakes.

Lenwood, Lockhart, Old Woman Springs Faults

Another of the Eastern California Shear Zone faults, the Lenwood fault is approximately 47 miles long. Trenching studies have shown that the fault has ruptured at least three times in the Holocene, roughly 200–400, 5,000–6,000, and 8,300 years ago, for a recurrence between major surface ruptures of 4,000 to 5,000 years.

The Lockhart fault, approximately 44 miles long, is north of the Lenwood fault. The North Lockhart fault—a segment that shows no evidence of Holocene activity—adds 6 miles to the length above. The interval between major surface-rupturing earthquakes on the Lockhart fault is estimated at between 3,000 and 5,000. The central portion of the fault ruptured during the Holocene, and segments both to the north and south are believed to have last ruptured in the Quaternary.

The Old Woman Springs fault segment, approximately 6 miles long, is the main trace of a complex system of faulting at the junction between the Eastern segment of the North Frontal Fault Zone and the Lenwood fault. The fault is thought to have last moved in the Holocene, and is therefore considered active.

Although the Lenwood and Lockhart faults form an essentially a continuous, 90-mile-long system, there is no evidence that these faults ruptured together in the past. Nevertheless, such an event might be possible, as evidenced by the rupture of five separate fault segments during the Landers earthquake.

Helendale-South Lockhart Fault

The Helendale fault is the westernmost fault of the Eastern California Shear Zone. The Helendale fault is 56 miles long, but it also seems to form a continuous fault with the South Lockhart fault to the north. Towards its southern end, the Helendale fault seems to offset the North Frontal fault, separating it into east and west segments.

The central and southern segments of the South Lockhart fault display evidence of Holocene rupture, including deformed Holocene sediments and well-defined scarps. The northern segment of the South Lockhart fault is poorly defined and does not show evidence of Holocene rupture, indicating that the whole fault may not rupture at the same time. Rupture of multiple segments of both the Helendale and the South Lockhart faults may result in a large-magnitude earthquake that would be greater than if the South Lockhart or the Helendale fault ruptured alone. Estimates of the recurrence interval for large surface-rupturing events on the Helendale fault range from 3,000 to 11,000 years.

Ground Shaking

Ground shaking and fault rupture are the geologic hazards that have the greatest potential to severely impact the Yucca Valley area, given that the town is intersected by and located near several significant faults that could cause moderate to large earthquakes. Epicenters of earthquakes detected by instruments between 1932 and December 2011 in and around the Town of Yucca Valley, and the approximate location of earlier earthquakes extending back to 1800, are shown in Figure 5.5-4, *Historical Seismicity Map*). The locations of earlier earthquakes are approximate because prior to 1932 there were no instruments to measure the location and magnitude of an earthquake. The map shows the locations most earthquakes in Yucca Valley occurred along the north–south trending faults extending through the Town that ruptured in 1992. In fact, a large percentage of the seismic events shown on Figure 5.5-4 are aftershocks of the 1992 Landers earthquake, with most of these occurring in the 1990s. Some aftershocks of the Landers sequence have continued into the new millennium. The east-trending Pinto Mountain fault has a relatively low number of earthquakes associated with it, possibly suggesting that the section of the fault that extends through the Yucca Valley area is locked. A locked fault is one that is not slipping because the frictional forces on the fault

exceed the shear forces across the fault. A locked fault stores strain that is eventually released, typically during an earthquake.

In order to provide a better understanding of the shaking hazard posed by these local faults and other, more distant seismic sources, a deterministic seismic hazard analysis for a central point in the town and several other randomly selected points within town limits was conducted using the software program EQFAULT. This analysis estimates the Peak Horizontal Ground Accelerations (PHGA) that could be expected at these locations due to earthquakes occurring on any of the known active or potentially active faults within 62 miles.

PHGA depends on the size of the earthquake (which is dependent on the rupturing fault's dimensions), the proximity of the rupturing fault to the study area, and local soil and rock conditions. The underlying geologic conditions, as described above under "Geologic Units," were considered in the study.

Ground Shaking in the Yucca Valley Area

Based on the ground shaking analyses described above, those faults that can cause peak horizontal ground accelerations of about 0.1g or greater (Modified Mercalli Intensities greater than VII) in the Yucca Valley area are listed in Table 5.5-1. Most of the faults in this table are mapped on Figures 5.5-2, *Regional Fault Map*, and 5.5-3, *Faults in and near Yucca Valley*. The deterministic analyses indicate that the Pinto Mountain, Burnt Mountain, and Eureka Peak faults have the potential to generate very strong ground shaking in Yucca Valley, with median PHGA values as high as 0.7g to 0.8g. Shaking at these levels can cause significant damage to older structures and moderate damage to even newer buildings constructed in accordance with the latest building codes.

Table 5.5-1
Estimated Horizontal Peak Ground Accelerations and Seismic Intensities in the Yucca Valley Area

Fault or Fault Segment	Approx. Distance to Yucca Valley (miles)	Magnitude of Mmax	PHGA (g)[1] from Mmax (median)	MMI from Mmax
Pinto Mountain	0 – 4.8	7.2	0.8 – 0.35	XII – IX
Burnt Mountain	0 – 5.4	6.5	0.75 – 0.21	XII - VIII
Eureka Peak	0 – 6.0	6.5	0.74 – 0.16	XII - VII
Landers (faults involved in the Landers 1992 earthquake)	0 – 6.8	7.3	0.65 – 0.23	XI - IX
Emerson – South Copper Mountain	6.8 – 16.5	7.0	0.37 – 0.10	X - VII
North Frontal (East segment)	7.7 – 15.5	6.7	0.36 – 0.15	X – VIII
Johnson Valley (Northern)	8.5 – 17.2	6.7	0.25 – 0.09	X - VII
San Andreas (entire southern)	11.3 – 31.1	8.0	0.38 – 0.19	X – VIII
San Andreas (San Bernardino + San Gorgonio-Garnet Hill + Coachella)	11.3 – 31.1	7.7	0.33 – 0.17	X – VIII
San Andreas (San Bernardino [South and North])	21.5 – 30.8	7.5	0.30 – 0.15	X - VIII
San Andreas (San Gorgonio-Garnet Hill Coachella)	22 – 31.1	7.2	0.26 – 0.12	IX – VIII
Calico – Hidalgo	14.2 – 23.1	7.3	0.26 – 0.10	IX - VII
Pisgah – Bullion Mountain.– Mesquite Lake	15.6 – 25.1	7.3	0.24 – 0.09	IX – VII
Lenwood – Lockhart – Old Woman Springs	15.8 – 24.5	7.5	0.23 – 0.11	IX - VII
North Frontal (West Segment)	22.9 – 30.6	7.2	0.18 – 0.08	IX – VII
Helendale – South Lockhart	27 – 35.1	7.3	0.13 – 0.07	IX – VI

Source: ECI 2012.
Abbreviations: PHGA: Peak Horizontal Ground Acceleration: g: gravity; Mmax: maximum magnitude earthquake; MMI: Modified Mercalli Intensity
[1] Median PHGA is listed as two numbers with the first number higher than the second; the two numbers correspond to the range of distance in miles shown in the second column from left.

The ground motions presented in Table 5.5-1 are based on the largest earthquake that each fault, or fault segment, is believed capable of generating, referred to as the maximum magnitude earthquake (Mmax). This deterministic approach is useful to study the effects of a particular earthquake on a building or community. However, since many faults pose a hazard to the region, it is also important to consider the overall likelihood of damage from a plausible

suite of earthquakes, including earthquakes of different sizes on the same fault. This approach is called probabilistic seismic hazard analysis (PSHA), and typically considers the likelihood of exceeding a certain level of damaging ground motion that could be produced by any or all faults within a given radius of the project site, or in this case, the Town of Yucca Valley. Most seismic hazard analyses consider a distance of 100 km (62 miles), but this is arbitrary. PSHA has been utilized by the U.S. Geological Survey (USGS) to produce national seismic hazard maps such as those used by the Uniform Building Code, the International Building Code, and the California Building Code.

Ground motions that have a 10 and 2 percent probability of being exceeded in 50 years in the vicinity of Town Hall were estimated using the interactive ground motion module from the CGS and the USGS. For Yucca Valley, the estimated level of ground motion that has a 10 percent probability of being exceeded in 50 years is approximately 0.5g. The level of ground motion with a 2 percent probability of being exceeded in 50 years is nearly 1.0g. The principal sources responsible for these levels of shaking are the Pinto Mountain and Burnt Mountain faults, with the Pinto Mountain fault contributing most to the seismic hazard. These levels of shaking are in the moderate to very high range for southern California and can be expected to cause significant damage, particularly to older and poorly constructed buildings.

Regardless of which fault causes a damaging earthquake, there will always be aftershocks. By definition, these are smaller earthquakes that happen close to the mainshock (the biggest earthquake of the sequence) in time and space. These smaller earthquakes occur as the Earth adjusts to the regional stress changes created by the mainshock. As the size of the mainshock increases, there typically is a corresponding increase in the number of aftershocks, the size of the aftershocks, and the size of the area in which they might occur.

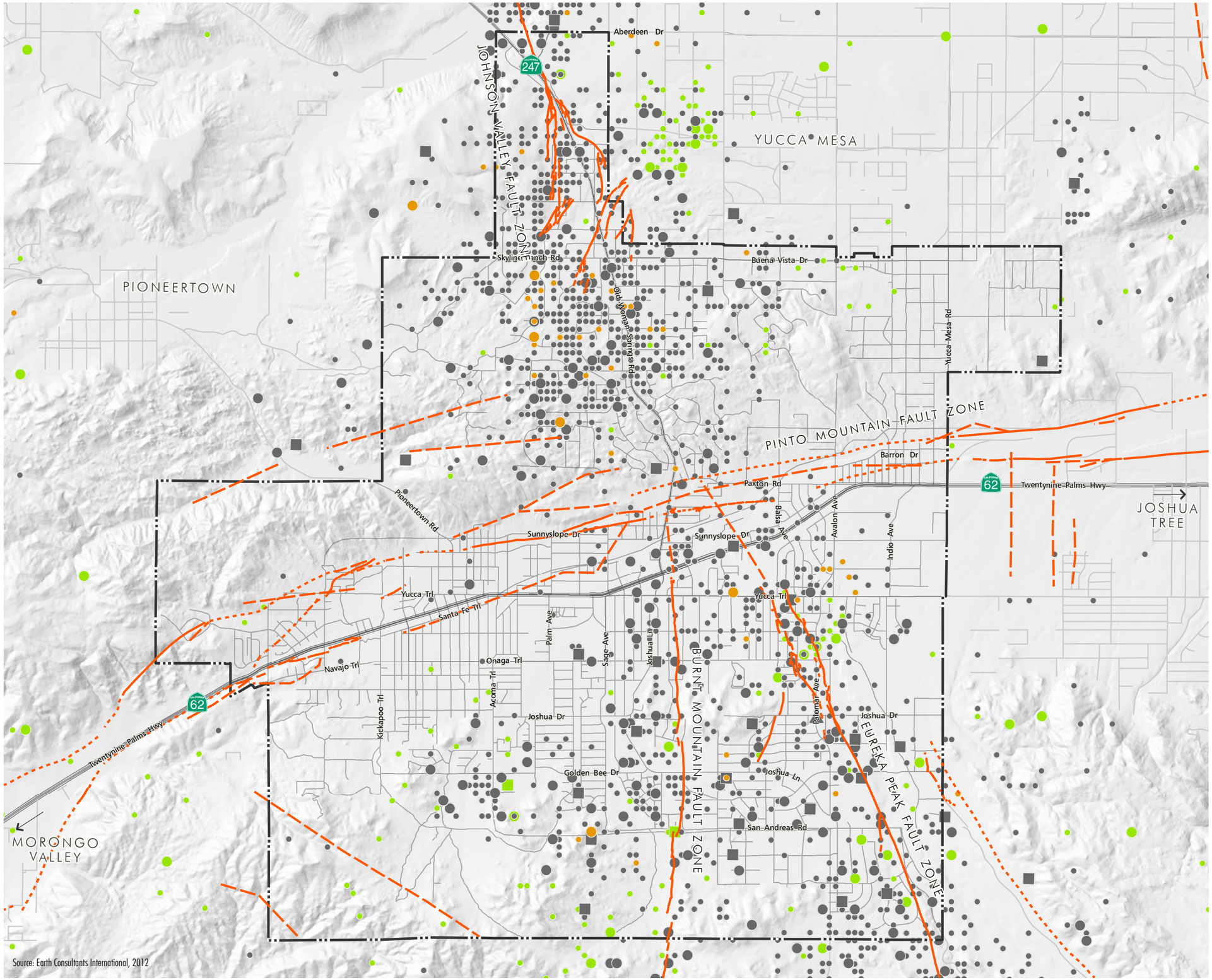
On average, the largest aftershock will be 1.2 magnitude units less than the mainshock. Thus, a M_w 6.9 earthquake will tend to produce aftershocks up to M_w 5.7 in size. This is an average, and there are many cases where the biggest aftershock is larger than the average predicts. The key point is that: any major earthquake will produce aftershocks large enough to cause additional damage, especially to already weakened structures. Consequently, postdisaster response planning must take damaging aftershocks into account.

ShakeMaps

Another way to communicate the seismic shaking hazard is with the use of ShakeMaps. A ShakeMap depicts various levels of ground shaking throughout the region where an earthquake occurs. ShakeMaps are compiled from the California Integrated Seismic Network—a network of seismic recording instruments located throughout the state—and are automatically generated following moderate to large earthquakes.

ShakeMaps can also be used for planning and emergency preparedness by creating hypothetical earthquake scenarios. These scenarios are not predictions—knowing when or how large an earthquake will be in advance is still not possible. However, using realistic assumptions about the size and location of a future earthquake, we can make predictions of its effects and use this information for loss estimations and emergency response planning. Figure 5.5-5, *ShakeMap, 1992 Landers Earthquake*, is based on actual reports of damage observed and shaking felt by residents throughout the region. Seismic ground shaking in the Town of Yucca Valley was perceived as severe to violent.

Figure 5.5-4
HISTORICAL SEISMICITY MAP



Earthquake Magnitude
- 2 to 3
- 3 to 4
- 4 to 5
- 5 to 6
- 6 to 7
- 7+

Pre - 1992 Earthquakes in green
1992 - 1999 Earthquakes in gray
2000 - 2011 Earthquakes in orange

Quaternary Fault
- Fault - Known Location
- Fault - Approximate Location
- Fault - Concealed or Inferred Location
- Town Limits

YUCCA VALLEY GENERAL PLAN
DRAFT EIR

TYV-01 04.30.13

0 1,500 3,000 6,000 Feet

THE PLANNING CENTER DC&E

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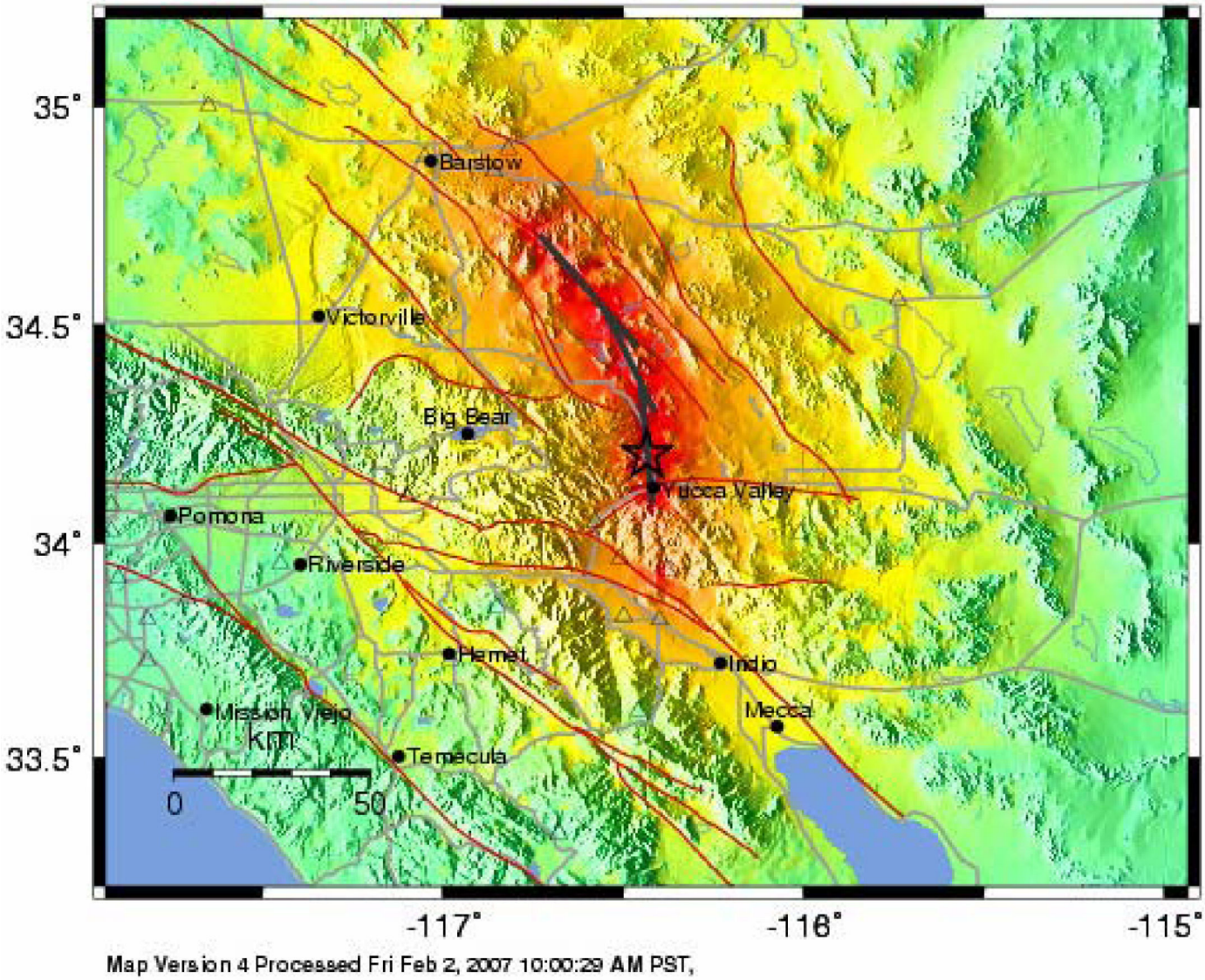
Figure 5.5-5

SHAKEMAP, 1992 LANDERS EARTHQUAKE



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Source: http://earthquake.usgs.gov/eqcenter/shakemap/sc/shake/9108645/

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Historic Earthquakes

Notable past earthquakes that have caused significant ground shaking in the southern California area, including Yucca Valley, are described in detail in the technical background report (see Appendix F) and summarized below in Table 5.5-2.

Table 5.5-2
Selected Historic Earthquakes

Earthquake	*Year*	*Fault*	*Magnitude*	*Notable Effects*
Wrightwood	1812	San Andreas, Mojave segment	7.5 (estimated)	San Juan Capistrano Mission church roof collapsed, killing 40. Walls damaged and statues destroyed at San Gabriel Mission.
San Jacinto	1899	San Jacinto	6.5 (estimated)	Extensive damage in San Jacinto and Hemet, with nearly all brick buildings either badly damaged or destroyed. Six people were killed in the Soboba Indian Reservation as a result of falling adobe walls.
San Jacinto	1918	San Jacinto	6.8	Extensive damage to the business districts of San Jacinto and Hemet; many masonry structures collapsed.
North San Jacinto Fault	1923	San Jacinto	6.3	Minor damage in San Bernardino and Redlands.
Long Beach	1933	Newport-Inglewood	6.4	115 fatalities; $40 to 50 million in property damage.
Desert Hot Springs	1948	San Andreas, south branch	6.5	Walls cracked, water mains broke across wide area of southern California.
Borrego Mountain	1968	Coyote Creek fault, a branch of the San Jacinto Fault Zone	6.5	
San Fernando	1971	San Fernando	6.6	65 deaths; over $500 million property damage.
Homestead Valley Earthquake Sequence	1979	Johnson Valley	5.2 (largest)	Surface cracks, surface displacements suggesting fault rupture, ground lurching, and minor structural damage.
North Palm Springs	1986		5.6	29 injuries; 51 homes destroyed or damaged in the Palm Springs-Morongo Valley area.
Joshua Tree	1992	Eureka Peak (?)	6.1	Slight to moderate damage in Joshua Tree, Yucca Valley, Twentynine Palms, Desert Hot Springs, and Palm Springs.
Landers	1992	5 faults	7.3	1 death; largest earthquake in southern California in 40 years.

Table 5.5-2
Selected Historic Earthquakes

Earthquake	Year	Fault	Magnitude	Notable Effects
Big Bear	1992	Unknown	6.4	Substantial damage in Big Bear Lake area.
Northridge	1994	Oak Ridge	6.7	57 deaths; 1,500 injuries; damaged 12,500 structures; most expensive earthquake (property damage) in US history.
Hector Mine	1999	several	7.1	
Baja California	2010	Borrego	7.2	

Source: ECI 2012.

Hazardous Buildings

The principal threat in an earthquake is not limited to ground shaking, fault rupture or liquefaction, but the damage that the earthquake causes to buildings that house people or an essential function. Continuing advances in engineering design and building code standards over the past decade have greatly reduced the potential for collapse in an earthquake of most of our new buildings. However, many buildings were built before some of the earthquake design standards were incorporated into the building code. Several building types are a particular concern in this regard.

- **Unreinforced Masonry Buildings:** In the late 1800s and early 1900s, unreinforced masonry was the most common type of construction for larger downtown commercial structures and for multistory apartment and hotel buildings. These were recognized as a collapse hazard following the San Francisco earthquake of 1906, the Santa Barbara earthquake of 1925, and again the aftermath of the Long Beach earthquake of 1933. These buildings are still recognized as the most hazardous buildings in an earthquake. Per Senate Bill 547, local jurisdictions are required to enact structural hazard reduction programs by inventorying pre-1943 unreinforced masonry buildings and developing mitigation programs to correct the structural hazards.

- **Precast Concrete Tilt-up Buildings:** This building type was introduced following World War II and gained popularity in light industrial buildings during the late 1950s and 1960s. Extensive damage to concrete tilt-up buildings in the 1971 San Fernando earthquake revealed the need for better anchoring of walls to the roof, floor, and foundation elements of the building and for stronger roof diaphragms.[2] In the typical damage to these buildings, the concrete wall panels would fall outward and the adjacent roof would collapse, creating a direct hazard.

- **Soft-Story Buildings:** Soft-story buildings are those in which at least one story, commonly the ground floor, has significantly less rigidity and/or strength than the rest of the structure. This can form a weak link in the structure unless special design features are incorporated to give the building adequate structural integrity. Typical examples of soft-story construction are buildings with glass curtain walls on the first floor only or buildings placed on stilts or columns, leaving the first story open for landscaping, street-friendly building entry, parking, or other purposes. In the early 1950s to early 1970s, soft story buildings were a popular construction style for low- and mid-rise concrete frame structures.

[2] A roof diaphragm is a structural roof deck that is capable of resisting shear that is produced by lateral forces, such as wind or seismic loads.

- **Nonductile Concrete Frame Buildings:** Nonductile concrete frame buildings have stiff reinforced concrete frames that do not bend when shaken or twisted, which increases the likelihood of structural failure during an earthquake. This type of construction was common in the very early days on reinforced concrete buildings, and they continued to be built until the codes were changed to require improved building performance in earthquakes in 1973. There were large numbers of these buildings built for commercial and light industrial use in California's older, densely populated cities. Although many of these buildings have four to eight stories, there are many in the lower height range. This category also includes one-story parking garages with heavy concrete roof systems supported by nonductile concrete columns.

Surface Fault Rupture

Surface fault rupture is fissuring and displacement of the ground surface and can occur along the fault that breaks in an earthquake or another fault. Faults are classified as active, potentially active, or inactive:

- Active: faults show evidence of ground displacement within the last 11,000 years, and are thus thought capable of producing earthquakes.

- Potentially Active: show evidence of movement within the past 1.6 million years, but no evidence shows movement within the last 11,000 years.

- Not Active: evidence shows the fault has not moved in the last 11,000 years.

However, some faults previously thought not active have ruptured in recent earthquakes—including the Landers earthquake—and evidence needed to determine whether a fault has moved in the last 11,000 years can be difficult to obtain. Surface fault rupture hazard on faults in Yucca Valley is described below:

- **Pinto Mountain fault:** Several traces are classified active. Several fault strands within the zone were interpreted as having ruptured repeatedly in the past 14,000 years, with four events occurring in the past 9,400 years, for an approximate recurrence interval of about 2,500 to 3,000 years. Although the fault has not ruptured historically, sections of it did experience minor slip associated with the Landers earthquake. Traces of this fault are zoned Alquist-Priolo Earthquake Fault Zones.

- **Burnt Mountain fault:** Discovered due to Landers earthquake. Landforms associated with fault indicate the fault has ruptured the ground surface in the Holocene or late Pleistocene. No data on past earthquakes or earthquake recurrence are available. This fault is designated an Alquist-Priolo Earthquake Fault Zone.

- **Eureka Peak fault**: Discovered due to Landers earthquake. Fault trenching showed evidence of past (pre-1992) surface rupturing events in the Holocene and late Pleistocene that indicate that this fault has been active in the past and has the potential to rupture again in the future. The fault is designated an Alquist-Priolo Earthquake Fault Zone.

- **Lower Covington Flat fault:** Activity unknown; should be investigated if development is proposed across it.

- **Southern Johnson Valley fault:** The maximum displacement in the Landers earthquake was 10.2 feet. The fault zone varies in width up to over 330 feet wide. Trenching data indicate that the Johnson Valley fault has ruptured five times in the last 25,000 years, for an average recurrence interval of 5,000 years.

Liquefaction and Related Ground Failure

Liquefaction causes various types of ground failure. It typically occurs within 50 feet of the surface, in saturated, loose, fine- to medium-grained sandy to silty soils in the presence of ground accelerations over 0.2g. Earthquake shaking suddenly increases pressure in the water that fills the pores between soil grains, causing the soil to behave like a liquid or semiviscous substance. This process can be observed at the beach standing on wet sand; when you tap the sand with your feet, water comes to the surface, the sand liquefies, and your feet sink.

Liquefaction can cause damage due to ground settlement, a loss of bearing capacity in the foundation soils, and the buoyant rise of buried structures. That is, when soils liquefy, the structures built on them can sink, tilt, and suffer significant damage. In addition to loss of bearing strength, liquefaction-related effects include ground oscillations, lateral spreading, and flow failures or slumping.

There are three general conditions that need to be met for liquefaction to occur. The first of these—strong ground shaking of relatively long duration—can be expected to occur in the Yucca Valley area as a result of an earthquake on any of the several active faults in the region. The second condition—geologically young, loose, unconsolidated sediments—occurs locally in some areas, typically along the active drainages, and on the young alluvial fans. The third condition—water-saturated sediments within about 15 meters (50 feet) of the surface—has not been reported historically in the Yucca Valley area, and as a result, the hazard of liquefaction occurring in the alluvial sediments underlying the valley portion of the study area is currently considered low to very low. Liquefaction susceptibility in Yucca Valley is mapped on Figure 5.5-6, *Seismic Hazard Zones.*

Unchecked groundwater recharge in the area could increase liquefaction susceptibility in the future. However, personnel from both the USGS and the Hi-Desert Water District (HDWD) are aware of this issue, and as reclaimed water is recharged into some of the subbasins in the area, they will reportedly monitor and maintain groundwater levels below the critical 50-foot depth to avoid developing susceptibility to liquefaction. The types of ground failure typically associated with liquefaction are explained below.

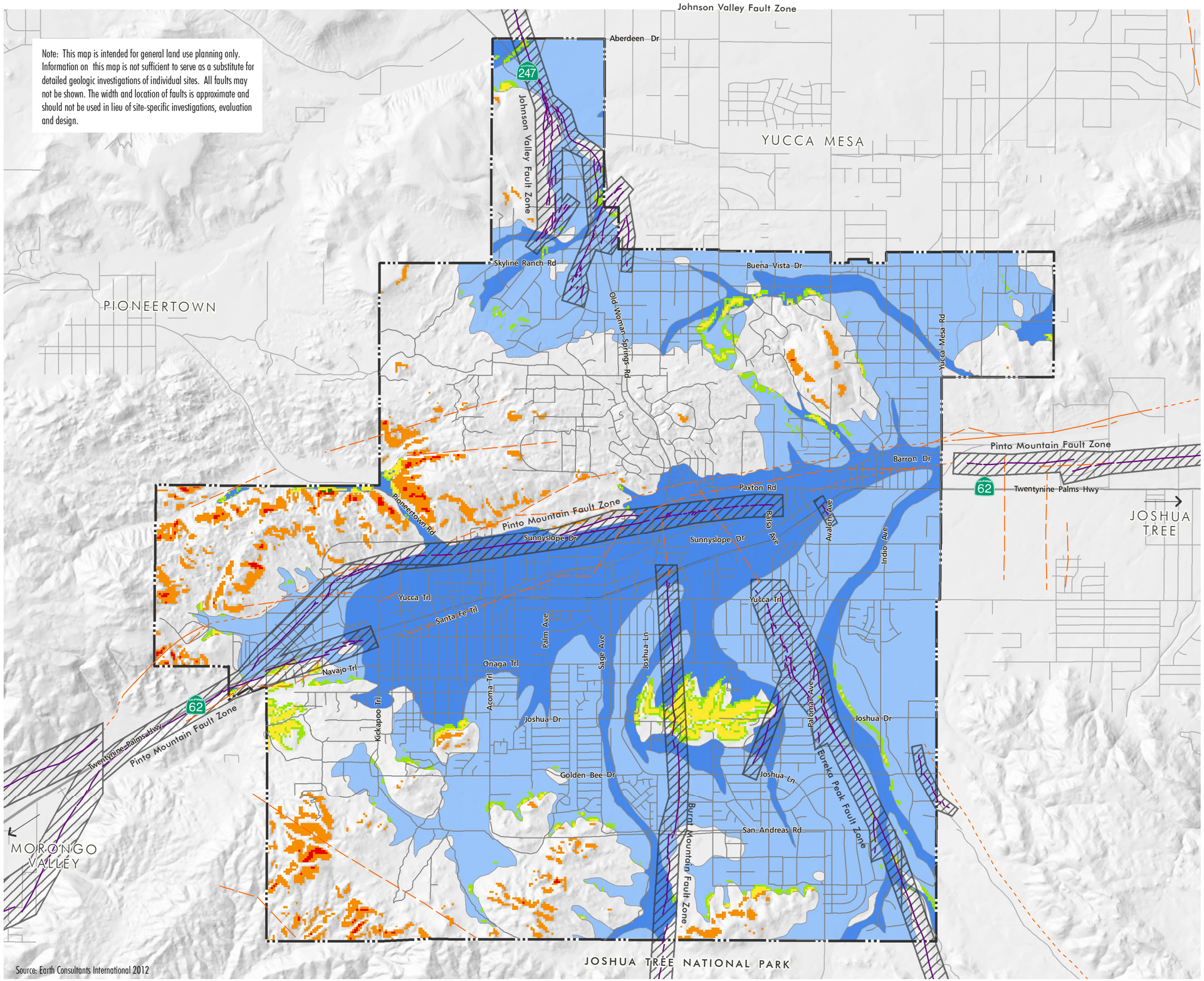
- **Lateral Spreading.** Lateral displacement of soil due to liquefaction in a subsurface layer is called lateral spreading. Even a very thin liquefied layer can act as a hazardous slip plane if it is continuous over a large enough area. Once liquefaction transforms the subsurface layer into a fluid-like mass, the mass may move down-slope toward a cut slope or free face (such as a river channel or a canal). Lateral spreading most commonly occurs on gentle slopes between 0.3 and 3 degrees, and it can displace the ground surface by several feet to tens of feet. Such movement damages pipelines, utilities, bridges, roads, and other structures.

- **Flow Failure.** The most catastrophic mode of ground failure caused by liquefaction is flow failure. Flow failure usually occurs on slopes greater than 3 degrees. Flows are principally liquefied soil or blocks of intact material riding on a liquefied subsurface. Displacements are often in the tens to hundreds of feet, but under certain conditions, soils can be displaced for tens of miles, at velocities of tens of miles per hour.

- **Ground Oscillation.** When liquefaction occurs at depth but the slope is too gentle to permit lateral displacement, the soil blocks that are not liquefied may separate from one another and oscillate on the liquefied zone. The resulting ground oscillation may be accompanied by the opening and closing of fissures (cracks) and sand boils, potentially damaging structures and underground utilities.

- **Loss of Bearing Strength.** When a soil liquefies, loss of bearing strength may occur beneath a structure, possibly causing the building to settle and tip. If the structure is buoyant, it may float upward.

Figure 5.5-6
SEISMIC HAZARD ZONES



Source: Earth Consultants International 2012

Alquist-Priolo Earthquake Fault
Fault; not zoned under the Alquist-Priolo Act
Alquist-Priolo Earthquake Fault Zone

Earthquake-Induced Slope Instability
- Rock Falls
- Rock Slides
- Soil Falls
- Soil Slides
- Soil Slumps

Liquefaction Susceptability
- Low - Areas underlain by course-grained Holocene age sediments, groundwater depth > 100' or unknown
- Very Low - Areas underlain by course-grained Pleistocene age sediments, groundwater depth > 100' or unknown
- Town Limits

YUCCA VALLEY GENERAL PLAN
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- **Ground Lurching.** Soft, saturated soils have been observed to move in a wavelike manner in response to intense ground shaking, forming ridges or cracks on the ground surface. At present, the potential for ground lurching at a given site can be predicted only generally. Areas underlain by a thick accumulation of colluvium and alluvium appear to be the most susceptible to ground lurching. Under strong ground motion, lurching can be expected in loose, cohesionless soils or in clay-rich soils with high moisture content. The deformation can persist after shaking stops.

Earthquake-Induced Slope Failure

Strong ground motions can worsen existing unstable slope conditions. Seismically induced landslides can overrun structures, harm people or damage property, sever utility lines, and block roads, thereby hindering rescue operations after an earthquake. Although numerous types of earthquake-induced landslides have been identified, the most widespread type generally consists of shallow failures involving surficial soils and the uppermost weathered bedrock in moderate to steep hillside terrain (these are also called disrupted soil slides). Rockfalls and rock slides on very steep slopes are also common.

A combination of geologic conditions leads to landslide vulnerability. These include high seismic potential; rapid uplift and erosion resulting in steep slopes and deeply incised canyons; highly fractured and folded rock; and rock with inherently weak components, such as silt or clay layers. The orientation of the slope with respect to the direction of the seismic waves (which can affect the shaking intensity) can also control the occurrence of landslides. Groundwater conditions at the time of the earthquake also play an important role in the development of seismically induced slope failures.

The specific types of earthquake-induced landslides that occur in rock and sedimentary deposits under dry conditions include rock falls, rock slides, rock avalanches, soil falls, and soil slides. With the exception of rock avalanches, the materials involved are mostly shallow, generally less than 10 feet deep. The geologic and slope conditions commonly necessary for these failures to occur were used to evaluate the earthquake-induced slope instability potential in the Yucca Valley area and develop the potential earthquake-induced landslide zones shown on Figure 5.5-6, *Seismic Hazard Zones*.

Rockfalls may happen suddenly and without warning, but are more likely to occur in response to earthquake-induced ground shaking, during periods of intense rainfall, or as a result of human activities, such as grading and blasting. Ground acceleration of at least 0.10g in steep terrain is necessary to induce earthquake-related rockfalls. Such ground acceleration is anticipated in the Sawtooth Mountains when the Pinto Mountain fault ruptures next.

Ridgetop Fissuring and Shattering

Ridgetop shattering—which leaves the surface looking as if it was plowed—by the 1994 Northridge earthquake occurred locally to structures at the tops of relatively high (greater than 100 feet), narrow (typically less than 300 feet wide) ridges flanked by slopes steeper than about 2.5:1 (horizontal:vertical). Ridgetop fissuring and shattering is considered a result of intense amplification or focusing of seismic energy due to local topographic effects.

Ridgetop shattering may occur locally in the mountains bordering the Yucca Valley area, including the Sawtooths and Little San Bernardinos. Particularly susceptible to this hazard would be the long, narrow ridgetop dominating the view to the north when entering the Town of Yucca Valley from the west, both to the west-southwest and northeast of Pioneertown Road. To the south, ridgetop shattering could also occur locally along the top of Burnt Mountain and at the top of the mountain flanking South Park.

Seismically Induced Settlement

Under certain conditions, strong ground shaking can cause the densification of soils, resulting in local or regional

settlement of the ground surface. During strong shaking, soil grains become more tightly packed due to the collapse of voids and pore spaces, resulting in a shrinkage of the soil column. This type of ground failure typically occurs in loose granular, cohesionless soils, and can occur in either wet or dry conditions. Unconsolidated young alluvial deposits are especially susceptible to this hazard. Artificial fills may also experience seismically induced settlement. Damage to structures typically occurs as a result of local differential settlements. Regional settlement can damage pipelines by changing the flow gradient on water and sewer lines, for example. As shown in Figure 5.5-1, certain areas of the Town of Yucca Valley are underlain by young, unconsolidated alluvial deposits and artificial fill. These sediments are susceptible to seismically induced settlement.

Slope Instability

Ground shaking is considered the most likely trigger of slope failure in the Yucca Valley area; earthquake-induced slope failures are discussed above under "Seismic Hazards." Therefore, slope instability other than earthquake-induced landslides is discussed very briefly here and is described in more detail in Chapter 2, Geologic Hazards, of the technical background report included as Appendix F of this DEIR.

Slope failures are grouped in two categories: gross or global failures involving deep-seated or relatively thick slide masses; and surface failures.

Gross or Global Failures

Landslides are movements of relatively large landmasses, either as nearly intact bedrock blocks or as jumbled mixes of bedrock blocks, fragments, debris, and soils. Landslides are considered the least likely type of slope failure to occur in Yucca Valley.

Surface Failures

Surface failures include the following:

- **Slope creep** in general involves deformation and movement of the outer soil or rock materials that cover a slope due to the forces of gravity overcoming the shear strength of the material. Movement is imperceptibly slow and relatively continuous on moderate to steep slopes. Creep occurs most often in soils that develop on fine-grained bedrock units. Rock creep is a similar process and involves permanent deformation of the outer few feet of the rock face resulting in folding and fracturing. Rock creep is most common in highly fractured, fine-grained rock units, such as siltstone, claystone, and shale.

- **Soil slip** is generated by strong storms and is widespread in steeper slope areas, particularly after winters with prolonged and/or heavy rainfall. Most slips occur on slopes having gradients between about 50 to 150 percent. Slopes within this range of gradients are present in the foothills and mountains within and surrounding Yucca Valley.

- **Debris flows or mudflows**, the most dangerous and destructive of all types of slope failure, are rapidly moving slurries of water, mud, rock, vegetation and debris generated by prolonged heavy rainfall. This type of failure is especially dangerous because it can move at speeds as fast as 40 feet per second (27 miles per hour), is capable of crushing buildings, and can strike with very little warning. Canyons in the Sawtooth and Bartlett Mountains and Little San Bernardino Mountains are susceptible to mudflows, and canyons on Burnt Mountain are susceptible to small mudflows.

- **Rockfalls** are free-falling to tumbling masses of bedrock that have broken off steep canyon walls or cliffs; repeated rockfalls form talus slopes at the bases of cliffs. The granitic bedrock that forms the Sawtooth and Bartlett Mountains commonly weathers into large boulders that perch precariously on slopes, posing a

rockfall hazard to areas adjacent to and below these slopes. Rockfalls can occur suddenly and without warning, but are more likely to occur in response to earthquakes, during periods of intense rainfall, or due to activities such as grading and blasting.

The natural hillsides in Yucca Valley are vulnerable to the types of slope instability mentioned above, mostly in the form of surficial failures and rockfalls. The susceptibility is outlined in Table 5.5-3.

Table 5.5-3
General Slope Stability Potential in Yucca Valley

Location	*Existing Geologic Conditions*	*Types of Potential Slope Stability*
Sawtooth and Bartlett Mountains	Moderate to steep natural slopes, many in excess of 26 degrees (50 percent slope gradient). Fractured and faulted bedrock; soils and loose debris at the toes of slopes and in drainage courses. Locally, small to large boulders perched on slopes.	Most Probable Rockfalls and rockslides, falling boulders, soil slips, slumping of oversteepened stream banks; small to large debris flows in canyons; sedimentation at the mouths of canyons and downstream. Least Probable: Large, deep-seated landslides.
Little San Bernardino Mountains	Moderate to steep natural slopes, many in excess of 26 degrees (50 percent slope gradient). Fractured and faulted bedrock; soils and loose debris at the toes of slopes and in drainage courses. Foliation dipping steeply to the northwest.	Most Probable: Rockfalls and rockslides, soil slips, slumping of oversteepened stream banks; small to large debris flows in canyons; sedimentation at the mouths of canyons and downstream. Least Probable: Large, deep-seated landslides.
Burnt Mountain	Moderate to steep slopes. Although the sediments forming these hills are generally granular with massive to crude bedding, there is a localized potential for slope failure if natural slopes are oversteepened by erosion or grading operations.	Most Probable: Slumps on oversteepened slopes; soil slips, small debris flows, sedimentation at the mouth of canyons. Least Probable: Large, deep-seated landslides.

Source: ECI 2012.

Compressible Soils

Compressible soils are typically geologically young, unconsolidated sediments of low density that may compress under the weight of proposed fill embankments and structures. The settlement potential and the rate of settlement in these sediments depends on the soil characteristics (texture and grain size), natural moisture and density, thickness of the compressible layer(s), the weight of the proposed load, the rate at which the load is applied, and drainage.

In Yucca Valley, compressible soils are most likely to occur where young Holocene-age deposits are present, including the modern and prehistoric floodplains of Yucca Wash and other major drainages. Compressible soils are also commonly found in hillside areas, typically in canyon bottoms, swales, and at the base of natural slopes. The upper few feet of older alluvium, which are commonly weathered and/or disturbed, are also typically compressible.

Collapsible Soils

Hydroconsolidation or soil collapse typically occurs in Holocene-age soils that were deposited in an arid or semiarid environment. Soils prone to collapse are commonly associated with wind-deposited sands and silts, and alluvial fan or debris flow sediments deposited during flash floods. These soils are typically dry and contain minute pores and voids. The soil particles may be partially supported by clay, silt, or carbonate bonds. When saturated, collapsible soils undergo a rearrangement of their grains and a loss of cementation, resulting in substantial and rapid settlement under relatively light loads. An increase in surface water infiltration, such as from irrigation, or a rise in the groundwater table, combined with the weight of a building or structure, can initiate rapid settlement and cause foundations and walls to crack. Typically, differential settlement of structures occurs when landscaping is heavily irrigated close to the structure's foundation.

The young alluvial sediments in the Yucca Valley area may be locally susceptible to this hazard due to their low density, granular nature, rapid deposition in the alluvial fan environment, and the generally dry condition of the near-surface soils.

Expansive Soils

Fine-grained soils, such as silts and clays, may contain variable amounts of expansive clay minerals. These minerals can shrink or swell as the moisture content decreases or increases; the shrinking or swelling can shift, crack, or break structures built on such soils.

The valley is underlain by alluvial sediments that are composed predominantly of granular materials (silty sand, sand, and gravel). Such units typically have a low expansion potential, although pockets of fine-grained expansive soils are present within these units. Silt and clay beds within the older alluvium, although not prevalent, are potentially expansive. Weathered clay soil in the older fan deposits probably falls in the moderately expansive range. The rock units in Yucca Valley are generally not expansive, except where they have been chemically altered (by natural processes), are very weathered, or contain clayey sheared zones. Engineered fills may be expansive and can damage improvements if such soils are incorporated into the fill near the finished surface.

Corrosive Soils

Corrosive soils can, over time, cause extensive damage to buried metallic objects, commonly impacting such things as buried pipelines (such as water mains), and even affecting steel elements within foundations. The electrochemical and bacteriological processes that take place between the soil and the buried structure are complex and depend on a number of factors involving the structure type and certain soil characteristics. For instance, the type, grade, length, and size of the piping, as well as the materials used in pipe connections, can determine which electrochemical reactions will take place in differing soils. The most common factor used in identifying corrosion potential of soils is electrical resistivity. Soils with low resistivity are especially susceptible to corrosion reactions. Other soil characteristics that increase the risk of corrosion to metals are low pH (acidic soils), wet soils, high chloride levels, low oxygen levels, and the presence of certain bacteria. Sulfate-reducing bacteria in soil can increase corrosion risk; soils with high concentrations of soluble sulfates will be corrosive to concrete.

Land Subsidence Due to Groundwater Withdrawal

Land subsidence is the gradual settling or sinking of the ground surface with little or no horizontal movement. Most ground subsidence is caused by human activities, chiefly extraction of groundwater.

Ground-surface effects related to regional subsidence can include earth fissures, sinkholes or depressions, and disruption of surface drainage. Damage is generally restricted to structures sensitive to slight changes in elevations, such as canals, levees, underground pipelines, and drainage courses; however, significant subsidence can result in

damage to wells, buildings, roads, railroads, and other improvements. Subsidence due to the overdraft of groundwater supplies can also result in the permanent loss of aquifer storage capacity.

In the Mojave region, groundwater occurs in sediment-filled basins that are floored by crystalline rock and bounded by faults or various types of impervious rock—all of which act as barriers to groundwater movement. For the most part, natural groundwater replenishment (recharge) in the aquifers occurs by infiltration of stormwater runoff that percolates through the alluvial sediments. During the early years of population growth in the high desert, the rate of groundwater extraction exceeded the natural replenishment, resulting in declining water levels and overdraft of the groundwater supply in more densely populated areas, including Yucca Valley. Since then, overdraft has been greatly reduced in many of the affected areas by careful management of local water supplies, including reducing pumping of local wells, importing water, and the use of artificial recharge.

Because surface water is scarce, Yucca Valley, like many other high desert communities, relied entirely on groundwater from the underlying aquifers for their domestic supply from the early 1900s to the mid-1990s. The main sources of Yucca Valley's water supply are wells in the northern part of the Warren Valley Groundwater Basin. This basin underlies the Town's alluvial area south of the Pinto Mountain fault zone. The Warren Valley Basin was in a state of overdraft for many years, with water levels in some areas dropping as much as 300 feet between 1940 and 1994. Since 1995, recharge sites (percolation ponds) in the Yucca Valley region receive water from the California Aqueduct via the Morongo Basin Pipeline, and water levels in the Warren Valley Basin have recovered significantly. Recharge is also supplied by irrigation and septic system return flows that percolate back into the ground.

To date, subsidence has not been reported in Yucca Valley. However, the thick alluvial deposits comprising these aquifers may be susceptible to compaction (with resulting subsidence at the surface) should rapid groundwater withdrawal occur beneath the area in response to the water needs of the Town's growing population.

Capability of Soils to Support Septic Tanks

All residents and businesses in the Town of Yucca Valley currently use septic systems and subsurface disposal systems to treat and dispose of wastewater. Soils in the Yucca Valley are mostly porous and permeable with high percolation rates. However, high levels of nitrate in groundwater under the Town have resulted from the large number of septic systems in and near the Town. The Colorado River Basin Regional Water Quality Control Board prohibited new septic systems in parts of Yucca Valley in 2011. The HDWD in 2009 adopted a revised Sewer Master Plan that includes a three-phase development of new sewer collection and treatment systems. The treated wastewater would then be used for groundwater recharge. The District plans to construct a water reclamation facility that will use a tertiary advanced treatment system to treat wastewater and generate effluent that would then be delivered to recharge basins where it would percolate into and recharge the Warren Valley groundwater basin. Water quality is discussed further in Section 5.8, *Hydrology and Water Quality*, of this DEIR.

5.5.2 Thresholds of Significance

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

5.5.3 Environmental Impacts

The following impact analysis addresses thresholds of significance for which the Initial Study disclosed potentially significant impacts. The applicable thresholds are identified in brackets after the impact statement.

IMPACT 5.5-1: BUILDOUT OF THE GENERAL PLAN UPDATE WOULD NOT EXPOSE PEOPLE AND STRUCTURES TO SUBSTANTIAL HAZARDS FROM STRONG GROUND SHAKING OR FROM SURFACE RUPTURE OF A FAULT. [THRESHOLDS G-1.I, G-1.II]

Impact Analysis: The following describes potential hazards from strong ground-shaking and fault rupture in Yucca Valley:

Strong Ground Shaking

Faults in the Yucca Valley region; the maximum magnitude earthquake that each fault is considered likely capable of generating; and the MMI intensity of ground shaking in Yucca Valley that would result respecting each fault, are described above in Section 5.5-1. Buildout of the proposed General Plan Update would increase the number of residents and workers, and total development intensity, in the Town. Thus, General Plan Update buildout would increase the numbers of people and structures in Yucca Valley that would be exposed to strong ground shaking.

Geologic investigations of project sites would be required under the Alquist-Priolo Earthquake Fault Zoning Act and the Seismic Hazards Mapping Act. Design and construction of structures built pursuant to the General Plan Update would be required to comply with the current CBC, which is updated on a three-year cycle. Projects developed pursuant to the General Plan Update would comply with legal and regulatory requirements regarding geologic investigations of project sites, building design, and building construction. No substantial hazards would occur.

Surface Rupture of a Fault

Four active faults are known in the Town of Yucca Valley, two of which were discovered by surface rupture resulting from the 1992 Landers earthquake. The activity of a fifth fault in Yucca Valley, the Lower Covington Flat Fault, is unknown; however, geologic investigation is required if development is proposed across it under the Alquist-Priolo Earthquake Fault Zoning Act. Geologists and/or engineers conducting such investigations would identify setbacks from identified active fault traces. Setbacks would be subject to approval by the Town Community Development

Department. No substantial hazard would occur.

IMPACT 5.5-2 ***BUILDOUT OF THE GENERAL PLAN UPDATE WOULD NOT EXPOSE PEOPLE AND STRUCTURES TO SUBSTANTIAL HAZARDS FROM LIQUEFACTION AND RELATED GROUND FAILURE. [THRESHOLD G-1.III]***

Impact Analysis: Liquefaction potential in the alluvial sediments underlying the valley portion of the Town is currently considered low to very low due to the lack of groundwater within 50 feet of the ground surface. The USGS and HDWD control groundwater recharge into the groundwater basins underlying the Town to prevent groundwater levels from rising to less than 50 feet below ground surface. No substantial hazard would occur.

IMPACT 5.5-3 ***ADHERENCE TO THE RECOMMENDATIONS IDENTIFIED IN THE GEOTECHNICAL STUDIES REQUIRED FOR NEW DEVELOPMENT ASSOCIATED WITH BUILDOUT OF THE PROPOSED GENERAL PLAN UPDATE WOULD ENSURE THAT RISKS FROM H EARTHQUAKE-RELATED HAZARDS WOULD BE MINIMIZED. [THRESHOLD G-1.IV]***

Impact Analysis: The following describes potential hazards from earthquake-related ground failure in Yucca Valley.

Earthquake-Related Slope Failures

Ground acceleration of at least 0.10g in steep terrain is necessary to induce earthquake-related rockfalls. Such ground acceleration is anticipated in the Sawtooth Mountains when the Pinto Mountain fault ruptures next. Ridgetop shattering may occur locally in the mountains bordering the Yucca Valley area, including the Sawtooths and Little San Bernardinos.

The hills and mountains in the Yucca Valley area have not been mapped within a State-delineated Seismic Hazard Zone for seismically induced landsliding. Nevertheless, mapping procedures similar to those used by the CGS were used to identify the potentially unstable slopes identified in Figure 5.5-6. Until an official map of seismic hazards is issued for this area by the CGS, this figure should be used as the official map. All development projects proposed within or near the potentially unstable slopes identified in Figure 5.5-6 should be evaluated to determine their potential for seismically induced landsliding.

For suspect slopes, appropriate geotechnical investigation and slope stability analyses should be performed for both static and dynamic (earthquake) conditions. Protection from rockfalls or surficial slides can often be achieved by protective devices such as barriers, retaining structures, catchment areas, or a combination of the above. The runout area of the slide at the base of the slope and the potential bouncing of rocks must also be considered. If it is not feasible to remedy the unstable slope conditions, building setbacks should be imposed. After required geotechnical investigations, and required implementation of recommendations in geotechnical investigation reports, developments pursuant to the General Plan Update would not create substantial hazards arising from earthquake-related slope failures.

Seismic Settlement

Certain areas of the Town of Yucca Valley (see Figure 5.5-1) are underlain by young, unconsolidated alluvial deposits and by artificial fill; these sediments are susceptible to seismically induced settlement.

Remedial measures to reduce hazards from seismically induced settlement are similar to those used for liquefaction. Recommendations are provided by the project's geologist and soil engineer following a detailed geotechnical investigation of the site. Overexcavation and recompaction is the most commonly used method to densify soft soils susceptible to settlement. Deeper overexcavation below final grades, especially at cut/fill, fill/natural, or alluvium/bedrock contacts may be recommended to provide a more uniform subgrade. Overexcavation should also

be performed so that large differences in fill thickness are not present across individual lots. In some cases, specially designed deep foundations, strengthened foundations, and/or fill compaction to a minimum standard that is higher than required by the CBC may be recommended.

Projects developed pursuant to the proposed General Plan Update would be required to have geotechnical investigations of the project sites conducted per state laws and regulations and General Plan policies. Compliance with recommendations in the geotechnical investigations reports would be required as conditions of issuance of building and grading permits by the Town. No substantial hazard would occur.

IMPACT 5.5-4 BUILDOUT OF THE PROPOSED GENERAL PLAN UPDATE WOULD NOT CAUSE SUBSTANTIAL EROSION. [THRESHOLD G-2]

Impact Analysis: Erosion is the movement of rock and soil, and is a natural process. Common agents of erosion in the Yucca Valley region are water and wind. However, ground-disturbing activities can greatly accelerate erosion if effective erosion control measures are not used. The Town of Yucca Valley gets very little rainfall; the average annual rainfall over the entire Lucerne Planning Area watershed is five inches (CRBRWQCB 2006). The CORPs has identified that there are currently no Waters of the U.S. within the Town because the most prominent water course in the Town, the Yucca Valley Creek, is classified as an intermittent desert stream.[3] Therefore, water courses in the Town discharge to desert basins (not water bodies). If a jurisdictional determination has been made that the project does not discharge to federal waters, then no enrollment under the General Construction Permit is necessary and no impacts are considered to occur. Furthermore, demolition, land clearing, grading, and construction activities of projects approved pursuant to the proposed General Plan Update would be required to comply with Mojave Desert Air Quality Management District (MDAQMD) Rules 403 and 403.2 regulating fugitive dust emissions, thus minimizing wind erosion from such ground-disturbing activities. Construction activities within the Town would not generate substantial erosion.

IMPACT 5.5-5: ADHERENCE TO THE RECOMMENDATIONS IDENTIFIED IN THE GEOTECHNICAL STUDIES REQUIRED FOR NEW DEVELOPMENT ASSOCIATED WITH BUILDOUT OF THE PROPOSED GENERAL PLAN UPDATE WOULD NOT EXPOSE PEOPLE AND STRUCTURES TO GEOLOGIC HAZARDS FROM COLLAPSIBLE SOILS, COMPRESSIBLE SOILS, CORROSIVE SOILS, OR GROUND SUBSIDENCE. [THRESHOLD G-3]

Impact Analysis: The following describes potential hazards from soil conditions in Yucca Valley.

Collapsible Soils

Young alluvial sediments in the Yucca Valley area may be locally susceptible to soil collapse due to their low density, granular nature, rapid deposition in the alluvial fan environment, and the generally dry condition of the near-surface soils.

The potential for soils to collapse should be evaluated on a site-specific basis as part of the geotechnical studies for development. If the soils are determined to be collapsible, the hazard can be reduced by several different measures or combination of measures, including excavation and recompaction, or presaturation and preloading of the susceptible soils in place to induce collapse prior to construction. After construction, infiltration of water into the subsurface soils should be minimized by proper surface drainage design, which directs excess runoff to catch basins and storm drains.

[3] Waters of the US include waters used, or potentially usable, in interstate or foreign commerce; interstate waters including interstate wetlands; waters—including intermittent waters—and wetlands, the destruction of which could affect interstate or foreign commerce; tributaries to waters identified above; and wetlands adjacent to waters identified above (Code of Federal Regulations, Title 33, Section 328.3). It should be noted that the Corps determination is reviewed every five years.

Compressible Soils

In Yucca Valley, compressible soils are most likely to occur where young Holocene-age deposits are present, including floodplains. Compressible soils are also commonly found in hillside areas, typically in canyon bottoms, swales, and at the base of natural slopes. The upper few feet of older alluvium, which are commonly weathered and/or disturbed, are also typically compressible.

When development is planned within areas that contain potentially compressible soils, a geotechnical soil analysis is required to identify this hazard. The analysis should consider soil types onsite; the load of any proposed fills and structures that are planned; the type of structure (i.e., a road, pipeline, or building); and local groundwater conditions. Removal and recompaction of near-surface soils is generally the minimum that is required. Deeper removals may be needed for heavier loads or for structures that are sensitive to minor settlement. Based on the soil analysis, partial removal and recompaction of the compressible soils is sometimes performed, followed by settlement monitoring for a number of months after additional fill has been placed but before structures are built. In cases where it is not feasible to remove the compressible soils, buildings can be supported on specially engineered foundations that may include caissons or piles.

Corrosive Soils

Corrosion testing is an important part of geotechnical investigations. Onsite soils, as well as any imported soils, are typically tested in the laboratory for resistivity, pH, chloride, and sulfates. For treatment of high sulfate content, special cement mixes and specified water contents are typically used for concrete that will be in contact with the soil. For corrosion of metals, there are a number of procedures used to protect the structure, including cathodic protection, coatings such as paint or tar, or wrapping with protective materials. Site-specific recommendations must be provided by an engineer who is a corrosion specialist.

Land Subsidence

To date, subsidence has not been reported in Yucca Valley; however, subsidence could occur in the event of rapid groundwater withdrawal.

Preventing land subsidence requires management of groundwater conservation and recharge to avoid overdraft of groundwater basins. Measures for minimizing subsidence include:

- Determining the safe yields of groundwater basins so that available supplies can be balanced with extraction.
- Increase natural recharge by developing spreading basins to capture and percolate stormwater runoff. In rural areas, individual property owners should be encouraged to collect stormwater in rain barrels or cisterns.
- Water recycling.
- Continued monitoring of the groundwater levels in both HDWD wells and available private wells.
- Monitoring ground elevations in areas where groundwater levels are decreasing.
- Minimizing adverse land use effects on the supply and quality of the local groundwater. For example, there is currently no community-wide sewage treatment and disposal system in Yucca Valley. Wastewater is discharged to individual septic tanks and leaching systems. This is thought to contribute to high

concentrations of nitrate locally in groundwater wells of the Warren Valley Basin. As a consequence, the California Regional Water Quality Control Board - Colorado River Basin Region (CRBRWQCB), has recommended a septic prohibition for parts of Yucca Valley (2010) and adopted the prohibition in the form of an amendment to the Basin Plan for the Colorado River Basin Region (2011). The HDWD has developed a plan for a centralized sewer collection and wastewater treatment facility. Treated water would be returned to the Warren Valley Basin aquifer.

The HDWD has already implemented several water saving programs, including discouraging the wasteful use of water and providing public information on water conservation, desert landscaping, and resource management.

The HDWD currently has water supply capabilities to meet daily demands as well as future demands into the year 2035, even for multiple dry years. This supply includes local groundwater, future imported water allotments, and imported groundwater currently banked in the Warren Valley Basin aquifer. Considering water supplies available in Yucca Valley and current and planned water management efforts, substantial hazards from land subsidence in Yucca Valley are unlikely.

IMPACT 5.5-6: ***NEW SEPTIC TANKS ARE PROHIBITED IN PARTS OF YUCCA VALLEY, AND NEW SEPTIC TANKS ALLOWED IN AREAS OUTSIDE THE WASTEWATER TREATMENT PLANT PHASING PLAN BOUNDARIES WOULD BE REQUIRED TO COMPLY WITH THE PLUMBING CODE TO ENSURE SOIL CONDITIONS WOULD ADEQUATELY SUPPORT SEPTIC TANKS. [THRESHOLD G-4]***

Impact Analysis: All residents and businesses in the Town of Yucca Valley currently use septic systems and subsurface disposal systems to treat and dispose of wastewater. Soils in the Yucca Valley are mostly porous and permeable with high percolation rates.

Nitrate Pollution

The large number of septic tanks used in Yucca Valley has resulted in nitrate pollution of groundwater. Increasing groundwater use caused the groundwater level to drop over 300 feet between the 1940s and 1995, when recharge of the basin with imported SWP water began. During that time, groundwater levels dropped faster than nitrates from septic systems moved downward. However, groundwater levels in HDWD Warren Valley Basin wells have risen an average of 151 feet between the 1992–93 and 2011–2012 water years. High levels of nitrates from septic systems were found in some wells after recharge with SWP water began. An estimated 880 acre-feet of septic discharge currently reaches the groundwater annually (HDWD 2012b).

Septic System Prohibition and Proposed Wastewater Treatment and Water Reclamation System

The CRBRWQCB in 2011 prohibited discharge from septic systems in areas of the Town of Yucca Valley shown on Figure 5.8-4, *Wastewater Treatment Project Phasing Map*. The prohibition will be phased, with areas of the Town prohibited from discharging beginning in 2016, 2019, and 2022. A wastewater treatment and water reclamation system that would collect, treat, and reclaim wastewater in the majority of Yucca Valley is currently being developed. The system, which is projected to begin operation in 2016, includes a sewer collection system, a wastewater treatment plant, and water reclamation recharge ponds. The prohibition of new septic tanks in parts of Yucca Valley is due to groundwater pollution and not due to physical characteristics of soils including percolation rates.

Requirements Governing Septic Systems Where Still Permitted

Septic systems that would be installed in parts of the Town where they would still be permitted—that is, outside of the phased prohibited areas shown on Figure 5.8-4—would be mandated to comply with requirements for septic tanks in the California Plumbing Code, California Code of Regulations, Title 24, Part 5.

5.5.4 Relevant General Plan Policies and Implementation Actions

Safety Element

Safety Element Policies

S 1-1 Collect and maintain data on soils and areas of steep slopes (30 percent or greater) or slopes prone to failure within the Town boundaries.

S 1-2 Limit grading associated with development to the minimum necessary to provide for planned improvements, while maintaining maximum natural and undisturbed vegetation to control soil disturbance and erosion.

S 1-3 Require development proposals with a slope of 30 percent or greater and/or subject to rockfalls, landslides or excessive erosion to be accompanied by a geotechnical analysis and associated technical reports.

S 1-4 Require development on slopes prone to failure or slopes 30 percent or greater to

S 2-1 Participate in local and regional emergency preparedness planning efforts with public and quasi-public agencies to assure the continued functionality of major utility services in the event of a major earthquake.

S2-2 Collect and distribute earthquake preparedness information and materials to Town residents and local businesses.

S 2-3 Encourage and promote the development of ground water recharge basins in areas where increased potential for liquefaction resulting from an earthquake will have a minimal effect on existing and planned development.

S 2-4 Encourage the location of heavily irrigated areas away from foundations and other structural supports to minimize the creation of a localized liquefaction hazards in areas of high seismicity.

S 2-5 Evaluate development in areas identified as being subject to a rockfall or landslide hazard to minimize the potential of those hazards impacting property.

S 2-6 Implement development restrictions and seismic study requirements around active faults pursuant to the Alquist-Priolo Act to ensure that potential impacts of seismic hazards are mitigated.

S 2-7 Maintain an inventory of unreinforced masonry structures in compliance with California's Unreinforced Masonry Law.

S 2-8 Coordinate with the U.S. Geological Survey to assure the provision of earthquake predictions which may impact the Town and surrounding area.

S 2-9 Coordinate and cooperate with public and quasi-public agencies to ensure that major utility systems and roadways have continued functionality in the event of a major earthquake.

Safety Element Implementation Actions

S 1 Disseminate information on areas of landslide susceptibility at Town Hall and on the Town's website by making available/ posting a link to the Slope Distribution Map.

S 2 Develop and adopt a detailed hillside grading ordinance with review standards to assess potential impacts from development on slopes 30 percent or greater.

S 3 Contract with a state-certified geologist and/or geological engineer to review and determine the adequacy of geotechnical studies for proposed projects.

S 4 Establish and maintain a reference collection of maps and other materials illustrating the location of seismic hazards occurring within the Town boundaries.

S 5 Disseminate information on fault locations at Town Hall and on the Town website by making available/ posting a link to the Seismic Hazards Map.

S 6 Update building, zoning and grading codes as needed to ensure adopted standards mitigate potential seismic hazards and comply with the Alquist-Priolo Act and Unreinforced Masonry Law.

S 7 Communicate with the Hi-Desert Water District to ensure the seismic safety of all existing and proposed water storage tanks and pipe connections.

S 8 Revise the Municipal Code to include requirements that protect the community from liquefaction.

S 9 Identify unreinforced masonry structures and maintain an inventory of their locations to inform local emergency response personnel and educate the public of the dangers associated with these structures during a catastrophic event.

5.5.5 Existing Regulations and Standard Conditions

State

- Alquist-Priolo Earthquake Fault Zoning Act (California Public Resources Code Sections 2621 et seq.)
- Seismic Hazards Mapping Act (California Public Resources Code Section 2695)
- California Building Code (CBC; Title 24, California Code of Regulations [CCR], Part 2)
- Unreinforced Masonry Law (California Government Code Sections 8875 et seq.)

- Natural Hazards Disclosure Act (California Civil Code Sections 1103 et seq.; California Public Resources Code Section 2694)
- General Permit for Discharges of Storm Water Associated with Construction Activity (Order 2009-0009-DWQ, State Water Resources Control Board)
- California Health and Safety Code Sections 17953 to 17955 and CBC Section 1802: Requirements for Geotechnical Investigation
- California Code of Regulations Title 24 Part 5: California Plumbing Code

Regional

Mojave Desert Air Quality Management District Rules 403 and 403.2: Fugitive Dust Control

Town of Yucca Valley

- The Town of Yucca Valley Building Code, Municipal Code Section 8.02.020.A, adopts the California Building Code including the Grading Code contained therein.

5.5.6 Level of Significance Before Mitigation

Upon implementation of regulatory requirements and standard conditions of approval, the following impacts would be less than significant: 5.5-1, 5.5-2, 5.5-3, 5.5-4, 5.5-5, and 5.5-6.

5.5.7 Mitigation Measures

No mitigation measures are required.

5.5.8 Level of Significance After Mitigation

Impacts would be less than significant after compliance with legal and regulatory requirements and General Plan policies; no mitigation is required.

5.5.9 References

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Mojave Desert Air Quality Management District. 2013, May 1. Rules 403 and 403.2. http://www.mdaqmd.ca.gov/Modules/ShowDocument.aspx?documentid=313.