Appendix G
Safety Analysis

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TECHNICAL BACKGROUND REPORT to the SAFETY ELEMENT of the GENERAL PLAN for the

CITY OF MENIFEE

OCTOBER 1, 2008

RIVERSIDE COUNTY, CALIFORNIA

SEISMIC HAZARDS
GEOLOGIC HAZARDS
FLOODING HAZARDS
FIRE HAZARDS
HAZARDOUS MATERIALS MANAGEMENT
WIND HAZARDS

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CHAPTER 1: SEISMIC HAZARDS

Earthquake-triggered geologic effects include ground shaking, surface fault rupture, landslides, liquefaction, subsidence, tsunamis and seiches. Some of these hazards can occur in the city of Menifee, as discussed in detail below. Earthquakes can also lead to reservoir failures, urban fires, and toxic chemical releases. These man-related hazards are also discussed in this document, in Chapters 3, 4 and 5, respectively.

In seismically active southern California, an earthquake has the potential to cause far-reaching loss of life or property, and economic damage. This is so because damaging earthquakes are relatively frequent, affect widespread areas, trigger many secondary effects, and can overwhelm the ability of local jurisdictions to respond. Although it is not possible to prevent earthquakes, their destructive effects can be minimized. Comprehensive hazard mitigation programs that include the identification and mapping of hazards, prudent planning, public education, emergency exercises, enforcement of building codes, and expedient retrofitting and rehabilitation of weak structures can significantly reduce the scope of an earthquake's effects and avoid disaster. The record shows that local government, emergency relief organizations, and residents can and must take action to develop and implement policies and programs to reduce the effects of earthquakes. Thus, this document not only discusses the potential hazards that can impact Menifee, but also provides action items and programs that can help the City become more self-sufficient in the event of an earthquake.

1.1 Seismic Context – Earthquake Basics

The outer 10 to 70 kilometers of the Earth consist of enormous blocks of moving rock called ***tectonic plates***. There are about a dozen major plates, which slowly collide, separate, and grind past each other. In the uppermost brittle portion of the plates, friction locks the plate edges together, while plastic movement continues at depth. Consequently, the near-surface rocks bend and deform near plate boundaries, storing strain energy. Eventually, the frictional forces are overcome and the locked portions of the plates move. The stored strain energy is then released in seismic waves that radiate out in all directions from the rupture surface causing the Earth to vibrate and shake as the waves travel through. This shaking is what we feel in an earthquake. Most earthquakes occur on or near plate boundaries. Southern California has many earthquakes because it straddles the boundary between the North American and Pacific plates, and fault rupture accommodates their motion.

By definition, the break or fracture between moving blocks of rock is called a ***fault***, and such differential movement produces a fault rupture. Few faults are simple, planar breaks in the Earth. They more often consist of smaller strands, with a similar orientation and sense of movement. A strand is mappable as a single, fairly continuous feature. Sometimes geologists group strands into segments, which are believed capable of rupturing together during a single earthquake. The more extensive the fault, the bigger the earthquake it can produce. Therefore, multi-strand fault ruptures produce larger earthquakes.

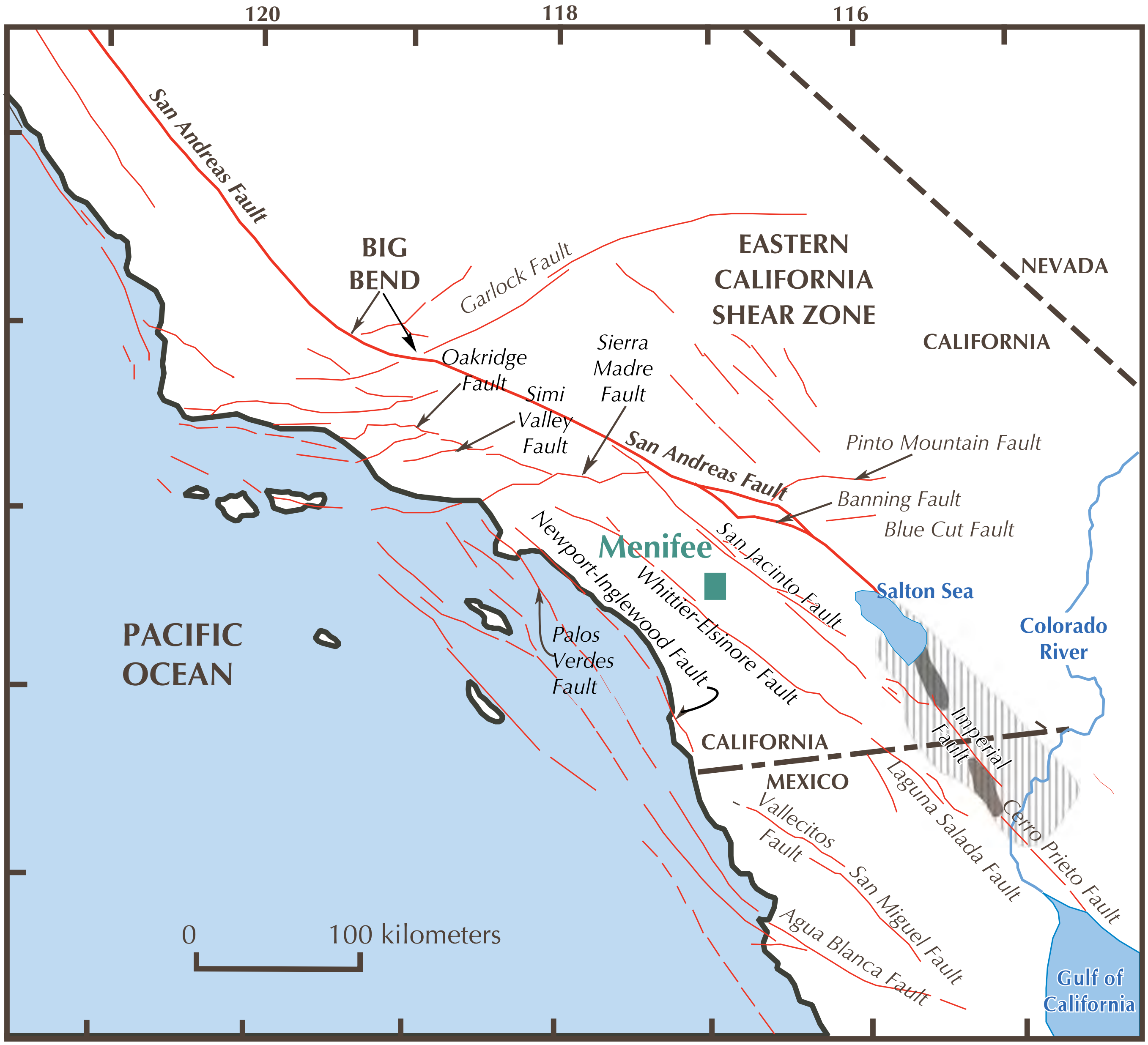
Total ***displacement*** is the length, measured in kilometers (km), of the total movement that has occurred along a fault over as long a time as the geologic record reveals. It is usually estimated by measuring distances between geologic features that have been split apart and separated (offset) by the cumulative movement of the fault over many earthquakes. ***Slip rate*** is a speed, expressed in millimeters per year (mm/yr). Slip rate is estimated by measuring an amount of offset accrued during a known amount of time, obtained by dating the ages of geologic features. Slip rate data also are used to estimate a fault's earthquake recurrence interval. Sometimes referred to as "repeat time" or "return interval," the ***recurrence interval*** represents the average amount of time that elapses between major earthquakes on a fault. The most specific way to derive the recurrence interval for a given fault is to excavate trenches across the fault to obtain ***paleoseismic*** evidence of earthquakes that have occurred during prehistoric time. Paleoseismic studies show that faults with high slip rates generally have shorter recurrence intervals between major earthquakes. This is so because a high slip rate indicates rocks that, at depth, are moving relatively quickly, and the stored energy trapped within the locked, surficial rocks needs to be released in frequent (geologically speaking), large earthquakes.

Menifee, and most of the western part of southern California, is riding on the Pacific Plate, which is moving northwesterly (relative to the North American Plate), at about 50 millimeters per year (mm/yr), or about 165 feet in 1,000 years. This is about the rate at which fingernails grow, and seems unimpressive. However, it is enough to accumulate enormous amounts of strain energy over tens to thousands of years. Despite being locked in place most of the time, in another 15 million years (a short time in the context of the Earth's history), due to plate movements, Los Angeles (which, like Menifee, is on the Pacific Plate) will be almost next to San Francisco (which is on the North American Plate).

Although the San Andreas fault marks the actual separation between the Pacific and North American plates, only about 60 to 70% of the plate motion actually occurs on this fault. The rest is distributed along other faults of the San Andreas system, including the San Jacinto, Whittier-Elsinore, Newport-Inglewood, Palos Verdes, and several offshore faults. To the east of the San Andreas fault, slip 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. (M_W stands for ***moment magnitude***, a measure of earthquake energy release, discussed further below.) Thus, the zone of plate-boundary earthquakes and ground deformation covers an area that stretches from Nevada to the Pacific Ocean (see Figure 1-1).

Because the Pacific and North American plates are sliding past each other, with relative motions to the northwest and southeast, respectively, all of the faults mentioned above trend northwest-southeast, and are strike-slip faults. On average, ***strike-slip faults*** are nearly vertical breaks in the rock, and when a strike-slip fault ruptures, the rocks on either side of the fault slide horizontally past each other. However, there is a kink in the San Andreas fault commonly referred to as the "Big Bend," located about 125 miles northwest of Menifee (Figure 1-1). Near the Big Bend, the two plates do not slide past each other. Instead, they collide, causing localized compression, which results in folding and thrust faulting. ***Thrusts*** are a type of dip-slip fault where rocks on opposite sides of the fault move up or down relative to each other. When a thrust fault ruptures, the top block of rock moves up and over the rock on the opposite side of the fault.

In southern California, ruptures along thrust faults have built the Transverse Ranges geologic province, a region with a unique east-west trend to its landforms and underlying geologic structures that is a direct consequence of the plates colliding at the Big Bend. Many of southern California's most recent damaging earthquakes have occurred on thrust faults that are uplifting the Transverse Ranges, including the 1971 M_W 6.7 San Fernando, the 1987 M_W 5.9 Whittier Narrows, the 1991 M_W 5.8 Sierra Madre, and the 1994 M_W 6.7 Northridge earthquakes. Thrust faults in



Source: Modified from Fuis and Mooney, 1990.

MAP EXPLANATION

Fault

Onshore Spreading Center

New Crust (late Cenozoic)

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Regional Fault Map

Figure 1-1

southern California have been particularly hazardous because many are "***blind***;" that is, they do not extend to the surface of the Earth, and have therefore been difficult to detect and study before they rupture. Some of the latest earthquakes in southern California, including the 1987 Whittier Narrows earthquake and the 1994 Northridge earthquake, occurred on previously unknown blind thrust faults. A great amount of research in the last decade has gone into learning to recognize subtle features in the landscape that suggest the presence of a buried thrust fault at depth, and developing techniques to confirm and study these structures. Some geologists have started to develop paleoseismic data for these buried thrust faults, including recurrence interval, estimates of the maximum magnitude earthquake these faults are capable of generating, and displacement per event.

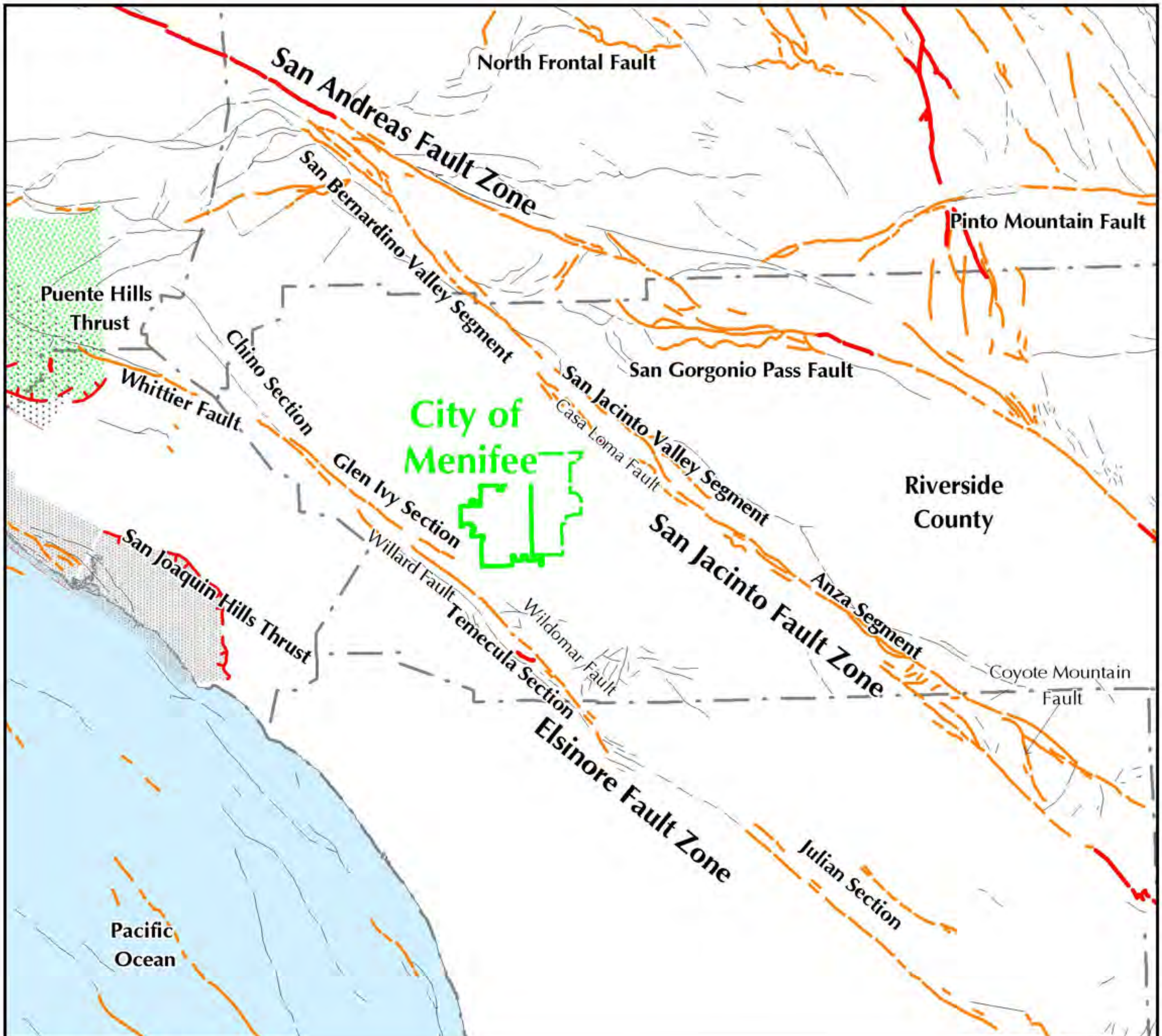
Menifee is located in the west-central part of the Perris block, in the Peninsular Ranges geomorphic province of southern California. The Perris block is a relatively stable, internally unfaulted mass of crustal rocks bounded on the west by the Elsinore fault zone, and on the east by the San Jacinto fault zone (Jahns, 1954; Morton, 1991; Morton and Cox, 1994). These two fault systems, and other seismic sources farther away, including the San Andreas, Pinto Mountain, North Frontal, San Joaquin Hills, and Puente Hills blind thrust fault have the potential to generate strong to moderate ground shaking in Menifee (see Figure 1-2). The Elsinore, San Jacinto and San Andreas faults, as mentioned above, are right-lateral strike-slip faults; the Pinto Mountain fault is a left-lateral strike-slip fault, and the North Frontal, San Joaquin Hills and Puente Hills faults are thrust faults. The Puente Hills is a blind thrust fault, as described above. Each of these faults is discussed in more detail in Section 1.4 below.

1.2 Regulatory Context

1.2.1 Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Special Studies Zones Act was signed into law in 1972 (in 1994 it was renamed the Alquist-Priolo Earthquake Fault Zoning Act). The primary purpose of the Act is to mitigate the hazard of fault rupture by prohibiting the location of structures for human occupancy across the trace of an active fault (Hart and Bryant, 1999; 2007). This State law was passed in direct response to the 1971 San Fernando earthquake, which was associated with extensive surface fault ruptures that damaged numerous homes, commercial buildings and other structures.

The Act requires the State Geologist (Chief of the California Geological Survey) to delineate "Earthquake Fault Zones" along faults that are "sufficiently active" and "well defined." These faults show evidence of Holocene (the time period between the present and about 10,000 years before present) surface displacement 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 (Hart and Bryant, 2007).



Modified from: Jennings, 1995

Explanation

N W E S

0 15 Miles

- 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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Local Active and Potentially Active Faults

Figure 1-2

Alquist-Priolo maps are distributed to all affected cities and counties for their use in planning and controlling new or renewed construction. Local agencies must regulate most development projects within these zones. Projects include all land divisions and most structures for human occupancy. State law exempts single-family wood-frame and steel-frame dwellings that are less than three stories and are not part of a development of four units or more. However, local agencies can be more restrictive. There are no Alquist-Priolo zoned faults in the Menifee area. The two closest zoned faults to the city are the San Jacinto fault to the east, and the Elsinore fault to the west (see Figure 1-2).

1.2.2 Seismic Hazards Mapping Act

The Alquist-Priolo Earthquake Fault Zoning Act only addresses the hazard of surface fault rupture and is not directed toward other earthquake hazards. Recognizing this, in 1990, the State passed the Seismic Hazards Mapping Act (SHMA), which addresses non-surface fault rupture earthquake hazards, including strong ground shaking, liquefaction and seismically induced landslides. The California Geological Survey (CGS) is the principal State agency charged with implementing the Act. Pursuant to the SHMA, the CGS is directed 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 when construction projects fall within these areas.

The CGS, pursuant to the 1990 SHMA, has been releasing seismic hazards maps since 1997, with emphasis on the large metropolitan areas of Los Angeles, Orange and Ventura counties (funding for this program limits the geographic scope of this studies to these three counties in southern California). As a result, at this time, there are no State-issued (and therefore official) seismic hazard zone maps for the city of Menifee. 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. To that end, and for the purposes of this study, we have followed a simplified version of the CGS methodology to identify areas in Menifee that are susceptible to liquefaction or earthquake-induced slope instability. These hazards are discussed in more detail in Section 1.6.

1.2.3 California Building Code

The International Conference of Building Officials (ICBO) was formed in 1922 to develop a uniform set of building regulations; this led to the publication of the first Uniform Building Code (UBC) in 1927. In keeping with the intent of providing a safe building environment, building codes were updated on a fairly regular basis, but adoption of these updates at the county- and city-level was not mandatory. As a result, the building codes used from one community to the next were often not the same. Then in 1980, recognizing that many building code provisions, like exiting from a building, are not affected by local conditions, and to facilitate the concept that industries working in California should have some uniformity in building code provisions throughout the State, the legislature amended the State's Health and Safety Code to require local jurisdictions to adopt, at a minimum, the latest edition of the Uniform Building Code (UBC). The law states that every local agency, such as individual 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 publication date of the CBC is established by the California Building Standards Commission and the code is known as Title 24 of the California Code of Regulations. Based on the publication cycle of the UBC, the CBC used to be updated and republished every three years.

Then, in 1994, to further the concept of uniformity in building design, the ICBO joined with the two other national building code publishers, the Building Officials and Code Administrators International, Inc. (BOCA) and the Southern Building Code Congress International, Inc. (SBCCI), to form a single organization, the International Code Council, (ICC). In the year 2000, the group published the first International Building Code (IBC) as well as an entire family of codes, (i.e. building, mechanical, plumbing and fire) that were coordinated with each other. As a result, the last (and final) version of the UBC was issued in 1997. After the formation of the ICC and the publication of the IBC, the California legislature did not address the matter of updating the CBC with a building code other than the UBC. In fact, the California Building Standards Commission, after careful review of the 2000 IBC, chose not to use the IBC, but instead continued to adopt the older 1997 UBC as the basis for the CBC. The 2001 CBC (based on the 1997 UBC) was used throughout the State from 2001 to 2007, often with local, more restrictive amendments based upon local geographic, topographic or climatic conditions.

In 2003, California considered adopting the National Fire Protection Association (NFPA) 5000 building code. Specifically, on July 29, 2003, the California Building Standards Commission recommended adoption of the NFPA 5000 code as the basis for California's next building code. However, state agencies that reviewed the proposed building code found it to be incomplete, requiring the adoption of substantial amendments, many transcribed directly from the CBC, to bring it to the level provided by the 2001 CBC. For this and other reasons, including the cost of developing the amendments and training state, county and city officials responsible for the enforcement of the code, on March 8, 2005, the Coordinating Council of the California Building Standards Commission recommended rescission of the 2003 decision to adopt the NFPA 5000 code, and instead recommended adoption of the latest International Building Code (IBC) as the basis for the next CBC. Thus, the California Building Standards Commission (BSC) reviewed the 2006 IBC, and using the IBC as a basis, prepared the 2007 edition of the CBC. The building code in use as of the writing of this document became available to the public on July 1, 2007, and became effective on January 1, 2008. However, the 2010 California Building Standards Code based on the 2009 International Building Code is expected to become effective on January 1, 2011. [For more recent information regarding this subject, refer to the California Building Standards Commission website at www.bsc.ca.gov/].

It is emphasized that building codes provide **minimum** requirements. With respect to seismic shaking, for example, the provisions of the building code are designed to prevent the catastrophic collapse of structures during a strong earthquake; however, structural damage to buildings, and potential loss of functionality, are expected. Specific provisions contained in the California Building Code that pertain to seismic, geologic, and fire hazards are discussed further in other sections of this document.

1.2.4 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 zones near historically active faults (Seismic Zone 4 per the Building Code at the time of the bill passage) to identify potentially hazardous unreinforced masonry (URM) buildings in their jurisdictions, establish an 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. Some jurisdictions implemented mandatory retrofit programs, while others established voluntary programs. A few cities only notified the building owners, but did not adopt any type of strengthening program. 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 (ICBO, 2001; CSSC, 2006). The UCBC standards are meant to significantly reduce but not necessarily eliminate the risk to life from collapse of the structure. Prior to 1997, local governments could adopt other building standards that preceded the UCBC, and in fact, in many jurisdictions, retrofits were conducted in accordance with local ordinances that only partially complied with the latest UCBC. The 2007 California Building Code (CBC) includes newly approved building standards for historical buildings (2007 California Historical Building Code, Part 8 of Title 24), and building standards for existing buildings (2007 California Existing Building Code, Part 10 of Title 24) based on the 2006 International Existing Building Code.

Given that Menifee was only recently incorporated, the California Seismic Safety Commission (CSSC, 2006) does not list URMs in Menifee, nor in any of the other communities that incorporated to become Menifee. Unincorporated Riverside County reported 4 URMs, but this figure seems low given the large number of URMs in communities surrounding Menifee. For example, Perris reported 17 URMs, San Jacinto reported 15 URMs, and Hemet reported 12 (CSSC, 2006). The HazUS database used for the analyses presented in Section 1.9 included 71 URMs in the census tracts that roughly cover the General Plan area. Research conducted by DiscoveryWorks (e-mail communication, April 5, 2010) for the General Plan indicate that the Menifee area is archaeologically rich, with as many as 200 recorded historical sites within city limits. If this is the case, the figure reported by Hazus of 71 URMs may be approximately correct. An accurate count of unreinforced masonry structures in the city should be conducted and provided to the Seismic Safety Commission.

1.2.5 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 lies within one or more State-mapped hazard areas. For example, if a property is located 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. The Local Option Real Estate Disclosure Statement (Option 2) can be substituted for the Natural Hazards Disclosure

Statement (Option 1) only if the Local Option Statement contains substantially the same information and substantially the same warnings as the Natural Hazards Disclosure Statement.

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." This publication was written and adopted by the California Seismic Safety Commission. The most recent edition of this booklet is available from the web at www.seismic.ca.gov/. The booklet includes a sample of a residential earthquake hazards report that buyers are required to fill in, and describes structural weaknesses common in homes that if they fail in an earthquake can result in significant damage to the structure. The booklet then provides detailed information on actions that homeowners can take to strengthen their homes.

Those regions in the study area that have the potential of being impacted by seismically induced liquefaction or slope instability (see Section 1.6), as identified in this report, should be disclosed to prospective buyers, following the provisions of the Natural Hazards Disclosure Act.

1.2.6 California Environmental Quality Act

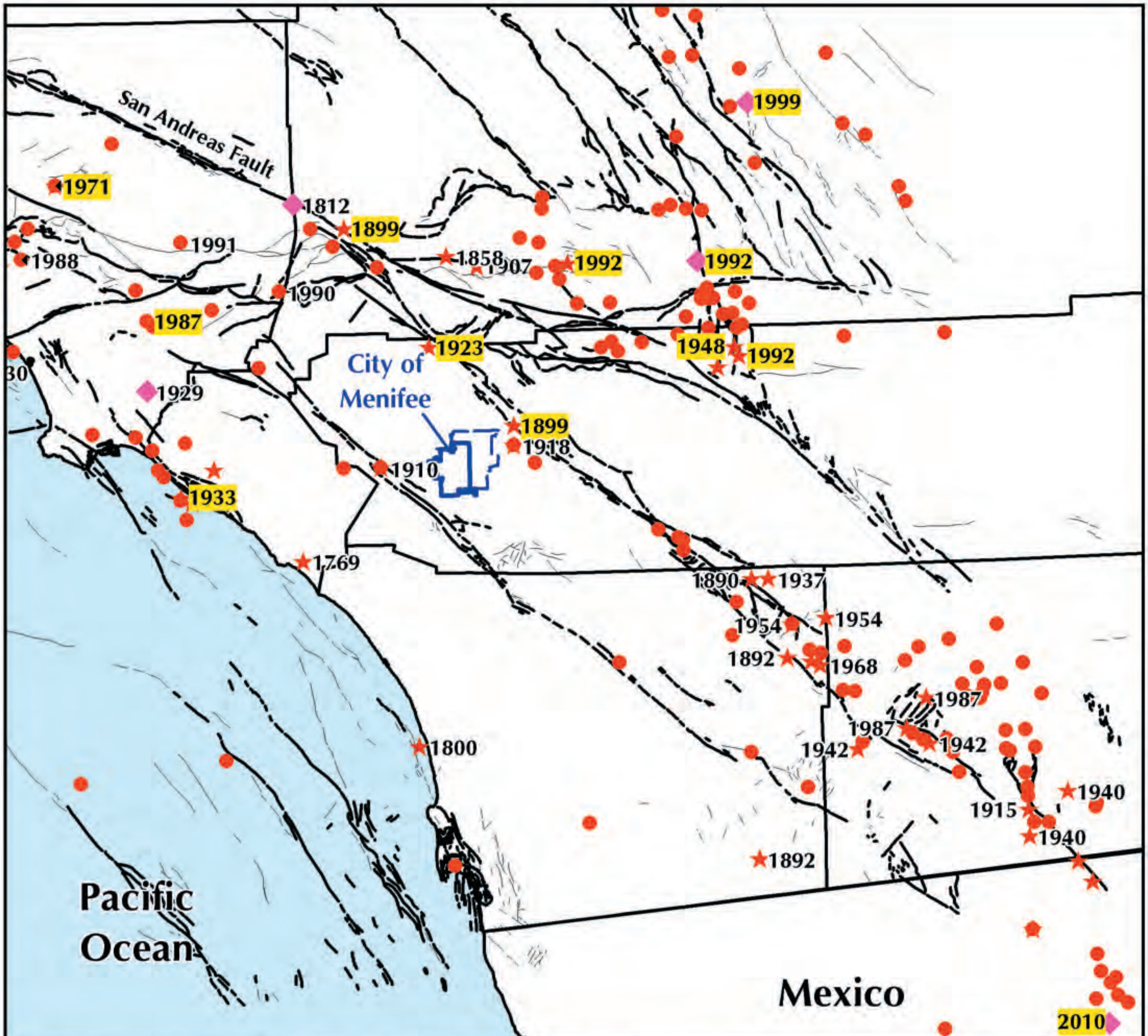
The California Environmental Quality Act (CEQA) was passed in 1970 to insure that local governmental agencies consider and review the environmental impacts of development projects within their jurisdictions. CEQA requires that an Environmental Impact Report (EIR) be prepared for projects that may have significant effects on the environment. EIRs 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. The law requires that these documents be issued in draft form and made available at local libraries and City Hall for individuals and organizations to review and comment on. The comments are addressed in the final report submitted for approval or refusal by the Planning Commission and/or City Council.

1.3 Notable Past Earthquakes

Figure 1-3 shows the approximate epicenters of some of the historical earthquakes that have resulted in significant ground shaking in the southern California area, including Menifee. The most significant of these events, either because they were felt strongly in the General Plan area, or because they led to the passage of important legislation, are described below.

1.3.1 Unnamed Earthquake of 1769

On July 28, 1769 the first recorded earthquake in southern California was noted by the Spanish explorers traveling north with Gaspar de Portola. At the time of the earthquake, the explorers were camped in the present-day city of Orange, on the east bank of the Santa Ana River. Father Juan Crespo, who kept a daily account of the expedition, reported a strong mainshock followed by five days of moderate aftershocks; an estimated magnitude of at least 6.0 has been assigned to the event based on the explorers' account (Teggart, 1911). Recent studies of coastal uplift attributed to the earthquake suggest that it may have



Source: Jennings, 1994; SCEC earthquake catalog; NEIC earthquake catalog

N W E S

0 20 Miles

Explanation

- Magnitude 7+
- Magnitude 6 - 7
- Magnitude 5 - 6
- Quaternary faults
- 1899 Earthquakes discussed further in the text

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Regional Seismicity Map

Figure 1-3

had a magnitude as high as 7.3 and that it occurred on a blind fault beneath the San Joaquin Hills (Grant and others, 2002), although this location is still being debated by the paleoseismology community. The San Jacinto, Elsinore and Newport-Inglewood faults are also considered possible sources for this earthquake.

1.3.2 Wrightwood Earthquake of December 8, 1812

This large earthquake occurred on December 8, 1812 and was felt throughout southern California. Based on accounts of damage recorded at missions in the earthquake-affected area, an estimated magnitude of 7.5 has been calculated for the event (Toppozada and others, 1981). Subsurface investigations and tree ring studies show that the earthquake likely ruptured the Mojave section of the San Andreas fault near Wrightwood, and may have been accompanied by a significant surface rupture between Cajon Pass and Tejon Pass (Jacoby, Sheppard and Sieh, 1988). The worst reported damage caused by the earthquake occurred significantly west of the San Andreas fault at San Juan Capistrano Mission, where the roof of the church collapsed, killing 40. The earthquake also damaged walls and destroyed statues at San Gabriel Mission, and is thought to have triggered an earthquake thirteen days later that damaged several missions in the Santa Barbara area (Deng and Sykes, 1996). Strong aftershocks that occurred for several days after the main earthquake collapsed many buildings that had been damaged by the main shock.

1.3.3 San Bernardino Area Earthquakes of December 1858

Two earthquakes considered aftershocks of the Great Fort Tejon earthquake (M7.9) of 1857 were felt near San Bernardino, at the southern end of the 1857 rupture, in December 1858 (Ellsworth, 1990; Meltzner and Wald, 1999). The first occurred on the night of December 15th, and the second in the early morning of December 16th. The December 16th event is thought to have had a magnitude of about 6.0, and was felt in San Bernardino with Modified Mercalli Intensity of VII. Very little data are available on these events.

1.3.4 San Jacinto Earthquake of 1899

This earthquake occurred at 4:25 in the morning on Christmas Day, 1899. The main shock is estimated to have had a magnitude of 6.5. Several smaller aftershocks followed the main shock, and in the city of San Jacinto, as many as thirty smaller tremors were felt throughout the day. The epicenter of this earthquake is not well located, but damage patterns suggest the location shown on Figure 1-3, near the city of San Jacinto, with the causative fault most likely being the San Jacinto fault. The cities of San Jacinto and Hemet both reported extensive damage, 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. In Riverside, chimneys toppled and walls cracked (Claypole, 1900). The main earthquake was felt over a broad area that includes San Diego to the southwest, Needles to the northeast, and Arizona to the east. No surface rupture was reported, but several large “sinks” or subsidence areas were reported about 10 miles to the southeast of San Jacinto. Seismic shaking in the Menifee region would have been perceived as very strong to severe, estimated at Modified Mercalli intensity VIII.

1.3.5 San Jacinto Earthquake of 1918

The magnitude 6.8 San Jacinto earthquake occurred on April 21, 1918 at 2:32 P.M. PST, near the town of San Jacinto. The earthquake caused extensive damage to the business districts of San Jacinto and Hemet, where many masonry structures collapsed, but because it occurred on a Sunday, when these businesses were closed, the number of fatalities and injuries was low. Several people were injured, but only one death was reported. Minor damage as a result of this earthquake was reported outside the San Jacinto area, and the earthquake was felt as far away as Taft (west of Bakersfield), Seligman (Arizona), and Baja California. Seismic shaking in the Menifee area as a result of this earthquake would have been perceived as violent, with an estimated Modified Mercalli intensity of IX, and peak horizontal ground acceleration of about 0.24g.

1.3.6 North San Jacinto Fault Earthquake of 1923

This earthquake occurred about 7 miles south of San Bernardino on July 22, 1923, at 11:28 P.M. Pacific Standard Time (PST). The M_L 6.3 earthquake on the San Jacinto fault caused minor damage primarily in the cities of San Bernardino and Redlands, where chimneys collapsed and windows broke. Two public buildings in San Bernardino, the San Bernardino County Hospital and the Hall of Records, were badly damaged, and extensive damage was sustained by the State Hospital building in Patton. However, most of the buildings that sustained damage were deemed of poor construction. Slight damage was reported in Los Angeles. Two people were critically injured, but no deaths were reported. The shaking was felt as far away as Needles and Santa Barbara. Seismic shaking in the Menifee area as a result of this earthquake is estimated at Modified Mercalli intensity VII.

1.3.7 Long Beach Earthquake of 1933

The M_w 6.4 Long Beach earthquake occurred on March 10, at 5:54 P.M. PST, following a strong foreshock the day before. The earthquake killed 115 people and caused $40 to 50 million in property damage (www.scecdc.scec.org/quakedex.html). The earthquake ruptured the Newport-Inglewood fault, and shaking was felt from the San Joaquin Valley to Northern Baja California (Mexico). The epicenter was located at the boundary between Huntington Beach and Newport Beach, although the earthquake was called "the Long Beach earthquake" because the worst damage was focused in the city of Long Beach. This earthquake would have been felt only slightly in the Menifee area (Modified Mercalli intensity of V), and is therefore discussed herein only because it led to code changes that apply to all of California. Specifically, the regional significance of this earthquake is that damage to school buildings was especially severe, which led to the passage of the Field and Riley Acts by the State legislature. The Field Act regulates school construction and the Riley Act regulates the construction of buildings larger than two-family dwellings.

1.3.8 Desert Hot Springs Earthquake of 1948

This magnitude 6.5 earthquake struck on December 4, 1948 at 3:43 P.M. PST. The fault involved is believed to be the South Branch of the San Andreas (or Banning fault, depending on nomenclature used). The shaking from this earthquake was felt over a large area (as far away as central Arizona, parts of Mexico, Santa Catalina Island, and Bakersfield), and caused damage in regions far from the epicenter. In the Los Angeles area, a 5,800-gallon water tank split open, water pipes broke at UCLA and in Pasadena, and plaster cracked and fell from many buildings. In San Diego, a water main broke. In Escondido and Corona, walls cracked. The administration building of Elsinore High School was permanently closed, due to the damage it sustained, as was a building at the Emory School in Palm City. Numerous other instances of minor structural damage were reported. Closer to the epicenter, landslides and ground cracks were reported, and a road leading to the Morongo Indian Reservation was badly damaged (Louderback, 1949). In

Palm Springs, the city hit hardest by the quake, merchandise was thrown from shelves with losses in the thousands of dollars. Part of a furniture store collapsed. Two people were injured when a crowd fled a movie theater in panic. Fortunately, despite the damage brought on by this earthquake, no lives were lost. Shaking in Menifee was light to moderate, estimated at about 0.05g, with Modified Mercalli intensities in the V range.

1.3.9 San Jacinto Fault Earthquake of 1954

This MW 6.4 earthquake occurred on March 19, 1954, at 1:54 A.M. PST, on the Clark fault segment of the San Jacinto fault, about 30 miles south of Indio. It caused minor damage throughout southern California including cracked plaster walls in San Diego and falling ceiling plaster at Los Angeles City Hall. In the Palm Springs area, a water pipe was damaged and the walls of several swimming pools were cracked. Parts of San Bernardino experienced temporary blackouts because the shaking caused power lines to snap. The earthquake was felt as far away as Ventura County, Baja California, and Las Vegas.

1.3.10 Borrego Mountain Earthquake of 1968

This Mw 6.5 earthquake occurred on the evening of April 8, 1968 at 6:29 P.M. PST. The epicenter was located about 40 miles south of Indio on the Coyote Creek fault, which is a branch of the San Jacinto fault. The earthquake was felt throughout southern California, and as far away as Las Vegas, Fresno and the Yosemite Valley. The earthquake produced minor surface rupture near Ocotillo Wells and triggered minor slip on the Superstition Hills, Imperial and Banning-Mission Creek faults (www.scecdc.scec.org/quakedex.html). Damage was reported throughout southern California, most notably in the Imperial Valley, where several buildings collapsed, and in Anza-Borrego Desert State Park where landslides damaged several vehicles. The earthquake also severed power lines in San Diego, knocked plaster from ceilings in Los Angeles, and the Queen Mary II, which was dry-docked at Long Beach, rocked back and forth on its keel blocks for five minutes. No injuries were reported.

1.3.11 San Fernando (Sylmar) Earthquake of 1971

This magnitude 6.6 earthquake occurred on the San Fernando fault, the westernmost segment of the Sierra Madre fault zone, on February 9, 1971, at 6:00 in the morning local time. The surface rupture caused by this earthquake was nearly 12 miles long, and occurred in the Sylmar-San Fernando area of Los Angeles. Maximum slip measured at the surface was nearly 6 feet (2 meters). The earthquake caused over $500 million in property damage and 65 deaths. Most of the deaths occurred when the Veteran's Administration Hospital collapsed. Several other hospitals, including the Olive View Community Hospital in Sylmar suffered severe damage. Newly constructed freeway overpasses also collapsed, in damage scenes similar to those that occurred 23 years later in the 1994 Northridge earthquake. Loss of life could have been much greater had the earthquake struck at a busier time of the day. As with the Long Beach earthquake, legislation was passed in response to the damage caused by the 1971 earthquake. In this case, the building codes were strengthened and the Alquist-Priolo Special Studies (now called the Earthquake Fault Zone) Act was passed in 1972.

1.3.12 Whittier Narrows Earthquake of 1987

The Whittier Narrows earthquake occurred on October 1, 1987, at 7:42 in the morning local time (Hauksson and Jones, 1989). This magnitude 5.9 earthquake occurred on a previously unknown, north-dipping concealed thrust fault (blind thrust) now called the Puente Hills fault (Shaw and Shearer, 1999). The earthquake caused eight fatalities, over 900 injured, and $358 million in property damage. Severe damage was confined mainly to communities east of Los Angeles and near the epicenter. Areas with high concentrations of URMs, such as the "uptown" district of Whittier, the old downtown section of Alhambra, and the "Old Town" section of Pasadena, were severely impacted. Several tilt-up buildings partially collapsed, including tilt-up buildings built after 1971 that were constructed to meet improved building standards, but were of irregular configuration, revealing seismic vulnerabilities not previously recognized. Residences that sustained damage usually were constructed of masonry, were not fully anchored to their foundations, or were houses built over garages with large openings. Many chimneys collapsed and in some cases, fell through roofs. Wood-frame residences, in contrast, sustained relatively little damage, and no severe structural damage to high-rise structures in downtown Los Angeles was reported.

1.3.13 Joshua Tree Earthquake of 1992

This magnitude 6.1 earthquake struck on April 22, 1992 at 9:50 P.M. Pacific Daylight Time (PDT), approximately 15 miles north of Palm Desert, and about 53 miles from downtown Menifee. This event resulted from right-lateral strike-slip faulting and was preceded by a magnitude 4.6 foreshock. The Joshua Tree earthquake raised some concern due to its proximity to the San Andreas fault. A San Andreas Hazard Level B was declared following this quake, meaning that the San Andreas fault was given a 5 to 25 percent chance of generating an even larger earthquake within 3 days. Although this did not happen, the concern caused by the Joshua Tree earthquake was at least partially warranted: about two months and 6,000 aftershocks later, the Landers earthquake broke the surface of the Mojave Desert in the largest quake to hit southern California in 40 years. The aftershocks of the Joshua Tree quake indicated that the fault that slipped is a north- to northwest-trending, right-lateral strike-slip fault at least 9 miles long (Jones and others, 1995). Based on these data, and the location of the shocks, researchers suggested that the Eureka Peak fault may have been the fault responsible for this earthquake.

Damage caused by the Joshua Tree earthquake was slight to moderate in the communities of Joshua Tree, Yucca Valley, Twentynine Palms, Desert Hot Springs, and Palm Springs. Thirty-two people had to be treated for minor injuries. Though somewhat forgotten in the wake of the Landers earthquake, the Joshua Tree event was a significant on its own, and was felt as far away as San Diego, Santa Barbara, Las Vegas, Nevada, and even Phoenix, Arizona (Person, 1992).

1.3.14 Landers Earthquake of 1992

On the morning of June 28, 1992, most people in southern California were awakened at 4:57 by the largest earthquake to strike California in 40 years. Centered near Landers, the earthquake had a magnitude of 7.3, and was associated with more than 50 miles of surface rupture on five separate but related faults: the Johnson Valley, Landers, Homestead Valley, Emerson, and Camp Rock faults (Sieh and others, 1993). Other nearby faults also experienced triggered slip and minor surface rupture. The average right-lateral strike-slip displacement on these faults was about 10 to 15 feet; the maximum was up to 18 feet. The Landers earthquake released about four times as much energy as the very destructive Loma Prieta earthquake of 1989, but because it occurred in a relatively unpopulated area about

120 miles from Los Angeles, the earthquake caused relatively little damage for its size (Brewer, 1992), and fortunately it did not claim many lives (one child died when a chimney collapsed). Seismic intensities of level VI to VII were reported in the Menifee area (http://pasadena.wr.usgs.gov/shake/ca/STORE/XLanders/ciim_display.html).

1.3.15 Big Bear Earthquake of 1992

This magnitude 6.4 earthquake struck little more than 3 hours after the Landers earthquake on June 28, 1992 at 8:05:30 A.M. PDT. This earthquake is technically considered an aftershock of the Landers earthquake (indeed, the largest aftershock), although the Big Bear earthquake occurred over 20 miles west of the Landers rupture, on a fault with a different orientation and sense of slip than those involved in the main shock. From its aftershocks, the causative fault was determined to be a northeast-trending left-lateral fault. This orientation and slip are considered "conjugate" to the faults that slipped in the Landers rupture. The Big Bear earthquake did not break the ground surface, and, in fact, no surface trace of a fault with the proper orientation has been found in the area. The Big Bear earthquake caused a substantial amount of damage in the Big Bear area, but fortunately, it claimed no lives. However, landslides triggered by the quake blocked roads in the mountainous areas, aggravating the clean-up and rebuilding process (SCEC-DC, 2001).

1.3.16 Northridge Earthquake of 1994

On the morning of January 17th, 1994, at 4:31 PST, a M_w 6.7 earthquake struck the San Fernando Valley. This moderate-sized tremor is to date the most expensive earthquake in United States history, due primarily to its proximity to the heavily populated northern Los Angeles area. The rupture occurred on the previously unidentified eastern continuation of the Oak Ridge fault, a blind thrust fault. The earthquake produced widespread ground accelerations of about 1g, some of the highest ever recorded for an earthquake of its size. The earthquake caused 57 deaths, 1,500 injuries and damaged 12,500 structures, knocking out of commission several major freeways for days to months. Most damage was focused in the northern Los Angeles area; Modified Mercalli intensities of only about level V (see Table 1-1) were recorded in the Menifee area (http://pasadena.wr.usgs.gov/ shake/ca/STORE/XNorthridge/ciim_stats_8).

1.3.17 Hector Mine Earthquake of 1999

This widely felt magnitude M_w 7.1 earthquake occurred on October 16, 1999, at 2:46 A.M. PDT, in the Mojave Desert, about 81 miles from Menifee, in a remote area. Although this earthquake occurred on northwest-trending strike-slip faults within the Eastern California Shear Zone similar to those that ruptured during the Landers earthquake, the Hector Mine event is not considered an aftershock of the Landers earthquake. With no towns or communities nearby, the earthquake was named after an open pit quarry, the Hector Mine, located about 14 miles (22 km) northwest of the epicenter. Geologists documented nearly 26 miles (48 km) of surface rupture on the Lavic Lake fault, the central section of the Bullion fault, and small sections of the Mesquite Lake and West Calico faults. Average displacements of 8.2 feet (2.5 meters) and a maximum of 18 feet (5.5 meters) of right-lateral offset were measured on the Lavic Lake fault. Modified Mercalli Intensities of V (http://earthquake.usgs.gov/eqcenter/dyfi/events/ci/hectormi/us/ index.html; see Table 1-1) were reported in the Menifee area (http://pasadena.wr.usgs.gov/shake/ca/).

1.3.18 Baja California Earthquake of 2010

A magnitude 7.2 earthquake that occurred just south of the U.S. / Mexico border on Easter Sunday, April 4, 2010, at 3:40:42 PM PDT, was felt throughout Mexico, southern California, Arizona, and Nevada. Researchers are still reviewing the data, but preliminary analysis suggests that there were two sub-events, with the first one rupturing an 18-km section of the Pescadores fault, followed, six to 12 seconds later by a second, larger event on the Borrego fault. Both of these faults are part of the Laguna Salada fault system, which is the southern extension of the Elsinore fault. Surface rupture continued northward to just past the border into California. The main earthquake caused triggered slip of up to a few centimeters on several faults in the Salton Sea area, and as far north as in the Mecca Hills. Secondary effects, including liquefaction, rockfalls and shattering were reported along a wide area in the El Centro and Brawley region, and westward toward San Diego. As of April 14th, 10 days after the main shock, more than 4,000 aftershocks had been recorded (http://www.scsn.org/2010sierraelmayor.html). A peak instrumental ground acceleration of 1.1g was recorded at the Salton Sea. Similar or stronger shaking may have occurred closer to the epicenter, but given the lack of instrumentation in that area, went unrecorded. Many of the aftershocks occurred along the Elsinore, San Jacinto, and the southern extension of the San Andreas fault through the Brawley area. Based on observations reported by many residents, shaking in Menifee as a result of this earthquake was light, in the Modified Mercalli intensity IV range (http://earthquake.usgs.gov/earthquakes/dyfi/events/ci/14607652/us/index.html).

1.4 Seismic Ground Shaking

Strong ground shaking causes the vast majority of earthquake damage. As mentioned previously, when a fault breaks in the subsurface, the seismic energy released by the earthquake radiates away from the hypocenter in waves that are felt at the surface as shaking. In general, the bigger and closer the earthquake, the more damage it may cause. 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, which has 12 damage levels (see Table 1-1). Although it has limited scientific application, intensity is intuitively clear and quick to determine. Keep in mind, however, that earthquake damage depends on the characteristics of human-made structures, and the complex interaction between the ground motions and the built environment. Governing factors include a building's height, construction, and stiffness, which determine the structure's resonant period; the underlying soil's strength and resonant period; and the periods of the incoming seismic waves. Other factors include architectural design, condition, and age of the structures.

Scientists used to measure the amplitude of ground motion, as recorded by an instrument a given distance from the epicenter, to report the size of an earthquake (such as the now outdated Richter magnitude). Seismologists now find that the most meaningful factor in determining the size of an earthquake is the amount of energy released when a fault ruptures. This measure is called the ***seismic moment*** (abbreviated M_w), and most moderate to large earthquakes today are reported using moment magnitude. Both traditional magnitude scales and seismic moment scales are logarithmic. Thus, each one-point increase in magnitude represents a ten-fold increase in amplitude of the waves as measured at a specific location, and a 32-fold increase in energy. That is, a Richter magnitude 7 earthquake produces 100 times (10 x 10) the ground motion amplitude of a magnitude 5 earthquake. Similarly, a moment magnitude 7 earthquake releases approximately 1,000 times more energy (32 x 32) than a moment magnitude 5 earthquake.

An important point to remember is that any given earthquake will have one moment and, in principle, one magnitude, although there are several methods of calculating magnitude, which give slightly different results. However, one earthquake will produce many levels of intensity because intensity effects vary with the location and the perceptions of the observer.

Fault dimensions and proximity are key parameters in any hazard assessment. In addition, it is important to know a fault's style of movement (i.e., is it dip-slip or strike-slip), total displacement, slip rate, and the age of its most recent activity. These values allow an estimation of how often a fault produces damaging earthquakes, and how big an earthquake should be expected the next time the fault ruptures. Horizontal ground acceleration is frequently responsible for widespread damage to structures, so it is commonly estimated as a percentage of ***g***, the ***acceleration of gravity***. Full characterization of shaking potential, though, requires estimates of peak (maximum) ground displacement and velocity, the duration of strong shaking, and the periods (lengths) of waves that will control each of these factors at a given location.

In general, the degree of shaking can depend upon:

- **Source effects**. These include earthquake size, location, and distance. In addition, the exact way that rocks move along the fault can influence shaking. For example, the 1995, M_W 6.9 Kobe, Japan earthquake was not much bigger than the 1994, M_W 6.7 Northridge, California earthquake, but the city of Kobe suffered much worse damage. This is in part because during the Kobe earthquake, the fault's orientation and movement directed seismic waves into the city, whereas during the Northridge earthquake, the fault's motion directed waves away from populous areas.

- **Path effects**. Seismic waves change direction as they travel through the Earth's contrasting layers, just as light bounces (reflects) and bends (refracts) as it moves from air to water. Sometimes seismic energy gets focused in one location and causes damage in unexpected areas. Focusing of the seismic waves during the 1989 M_W 7.1 Loma Prieta earthquake caused damage in San Francisco's Marina district, some 62 miles (100 km) distant from the rupturing fault.

- **Site effects**. Seismic waves slow down in the loose sediments and weathered rock at the Earth's surface. As they slow, their energy converts from speed to amplitude, which heightens shaking. This is similar to the behavior of ocean waves – as the waves slow down near shore, their crests grow higher. The Marina District of San Francisco also serves as an example of site effects. Earthquake motions were greatly amplified in the deep, sediment-filled basin underlying the District compared to the surrounding bedrock areas. Seismic waves can get trapped at the surface and reverberate (resonate). Whether resonance will occur depends on the period (the length) of the incoming waves. Waves, soils and buildings all have resonant periods. When these coincide, tremendous damage can occur.

Table 1-1: Abridged Modified Mercalli Intensity Scale

Intensity Value and Description		Average Peak Velocity (cm/sec)	Average Peak Acceleration (g = gravity)
I.	Not felt except by very few under especially favorable circumstances (I Rossi-Forel scale). Damage potential: None.	<0.1	<0.0017
II.	Felt only by a few persons at rest, especially on upper floors of high-rise buildings. Delicately suspended objects may swing. (I to II Rossi-Forel scale). Damage potential: None.	0.1 – 1.1	0.0017 – 0.014
III.	Felt quite noticeably indoors, especially on upper floors of buildings, but many people did not recognize it as an earthquake. Standing automobiles may have rocked slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel scale). Damage potential: None.		
IV.	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls made creaking sound. Sensation like a heavy truck striking building. Standing automobiles rocked noticeably. (IV to V Rossi-Forel scale). Damage potential: None. Perceived shaking: Light.	1.1 – 3.4	0.014 - 0.039
V.	Felt by nearly everyone; many awakened. Some dishes, windows, and so on broken; plaster cracked in a few places; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may have stopped. (V to VI Rossi-Forel scale). Damage potential: Very light. Perceived shaking: Moderate.	3.4 – 8.1	0.039-0.092
VI.	Felt by all; many frightened and ran outdoors. Some heavy furniture moved, few instances of fallen plaster and damaged chimneys. Damage slight. (VI to VII Rossi-Forel scale). Damage potential: Light. Perceived shaking: Strong.	8.1 - 16	0.092 -0.18
VII.	Everybody ran outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving cars. (VIII Rossi-Forel scale). Damage potential: Moderate. Perceived shaking: Very strong.	16 - 31	0.18 - 0.34
VIII.	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, and walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving cars disturbed. (VIII+ to IX Rossi-Forel scale). Damage potential: Moderate to heavy. Perceived shaking: Severe.	31 - 60	0.34 - 0.65
IX.	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel scale). Damage potential: Heavy. Perceived shaking: Violent.	60 - 116	0.65 – 1.24
X.	Some well-built wooden structures destroyed; most masonry and frame structures destroyed; ground badly cracked. Rails bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed, slopped over banks. (X Rossi-Forel scale). Damage potential: Very heavy. Perceived shaking: Extreme.	> 116	> 1.24
XI.	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.		
XII.	Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown into air.		

Modified from Bolt (1999); Wald and others (1999).

NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

Fault lines on the map are used solely to approximate the fault location. The width and location of the faults should not be used in lieu of site-specific investigations, evaluation, and design.

Detailed geologic investigations, including trenching studies, may make it possible to refine the location and activity status of a fault. All faults may not be shown. This map should be amended as new data become available and are validated.

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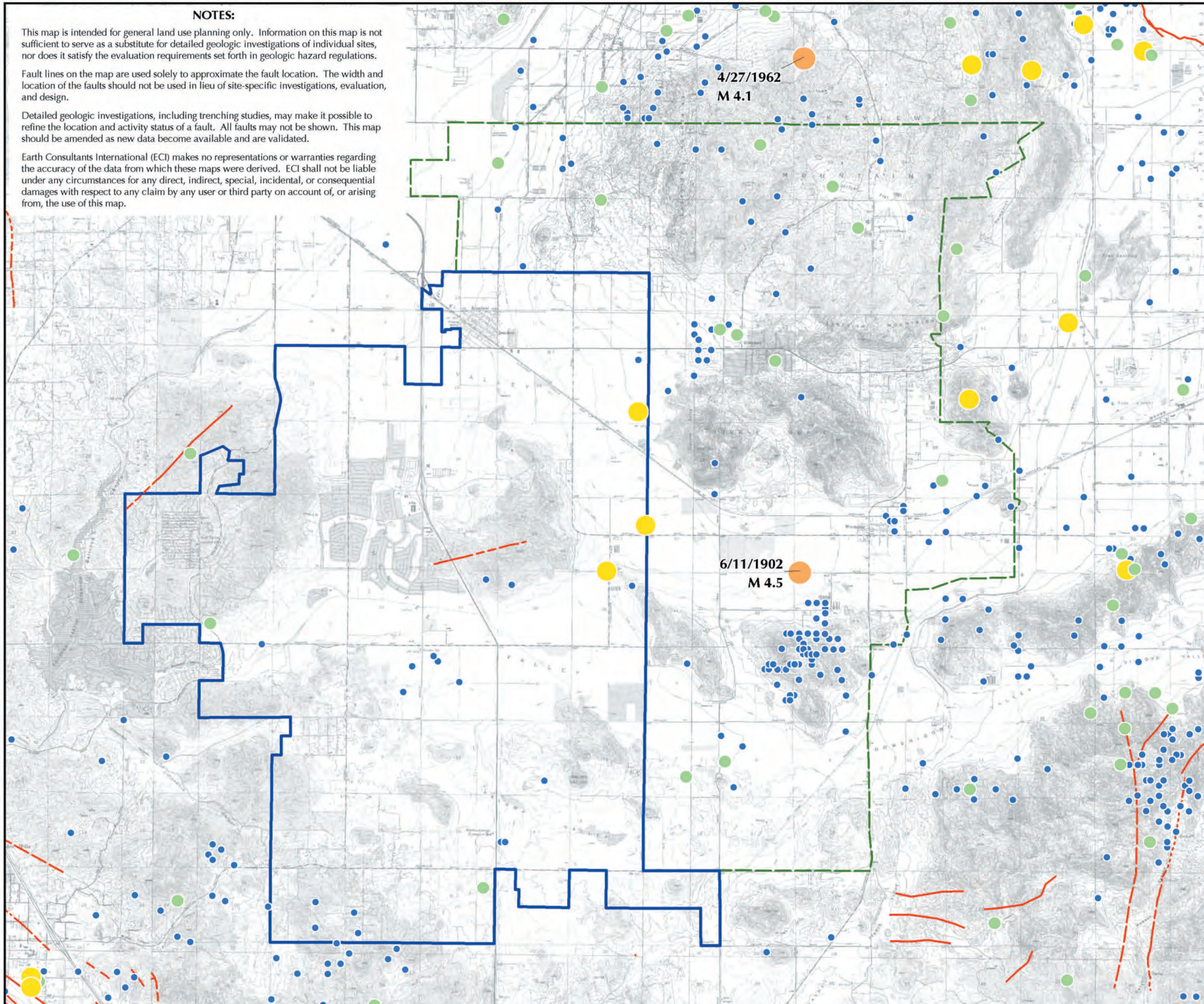

Historical Seismicity Map (1900-2010)

Menifee, California

Explanation

Earthquake Magnitude

- 5 to 6
- 4 to 5
- 3 to 4
- 2 to 3
- <2

Earthquakes of magnitude 4 and greater labeled with year and magnitude.

- Fault or lineament, solid where location known, dashed where approximate, dotted where inferred (for more information refer to Plate 1-2)
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N W E S

0 7000 14000 Feet

0 2000 4000 Meters

Scale: 1:84,000

Base Map: USGS Topographic Map from Sure!MAPS RASTER (1997).
Sources: Southern California Earthquake Center (January 1932 to March 2010); National Earthquake Information Center (1855 to 1931); Morton (2006).

Earth Consultants International

CITY OF MENIFEE

Project Number: 2917
Date: 2010

Plate 1-1

[Waves repeat their motions with varying frequencies. Slow-to-repeat waves are called long-period waves. Quick-to-repeat waves are called short-period waves. Long-period seismic waves, which are created by large earthquakes, are most likely to reverberate and cause damage in long-period structures, like bridges and high-rise buildings that respond to long-period waves. Shorter-period seismic waves, which tend to die out quickly, will most often cause damage in areas relatively close to the rupturing fault, and they will cause most damage to shorter-period structures such as one- to three-story buildings. Very short-period waves are most likely to cause near-fault, interior damage, such as to equipment.]

Seismic shaking has the potential to impact the Menifee area, given that the city is located in between two of the most significant seismic sources (faults) in the southern California area – the Elsinore fault to the west, and the San Jacinto fault to the east. These faults have the potential to generate moderate to large earthquakes that would be felt in the Menifee area. Plate 1-1 shows the epicentral locations of earthquakes and around the city instrumentally detected between 1932 and March 2010, and those estimated to have occurred in the area between 1900 and 1932. Earthquakes that occurred prior to 1932 are only approximately located because prior to that year there were no instruments available to measure the location and magnitude of an earthquake. The map shows that, although there are no active faults mapped through the General Plan area, there is substantial micro-seismicty in the region. The largest earthquake reported in the region is an estimated magnitude 4.5 event that occurred in June 1902.

In order to provide a better understanding of the shaking hazard posed by those faults near the General Plan area, we conducted a deterministic seismic hazard analysis for a central point in the city (City Hall) and several other randomly selected points in the General Plan area using the software program EQFAULT by Blake (2000). 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 about 62 miles (100 km). The fault database (including fault locations and earthquake magnitudes of the maximum magnitude earthquakes for each fault) used to conduct these seismic shaking analyses is that used by the California Geological Survey (CGS) and the U.S. Geological Survey (USGS) for the National Seismic Hazard Maps (Petersen and others, 1996; Cao and others, 2003). However, as described further in the text, recent paleoseismic studies suggest that some of these faults may actually generate even larger earthquakes than those used in the analysis. Where appropriate, this is discussed further below.

PGHA depends on the size of the earthquake, the proximity of the rupturing fault, and local soil conditions. Effects of soil conditions are estimated by use of an attenuation relationship derived empirically from an analysis of recordings of earthquake shaking in similar soils during earthquakes of various sizes and distances. Given that most of Menifee is underlain by semi-consolidated sediments and bedrock, and that bedrock occurs locally in the shallow subsurface, we used rock for most of the deterministic analyses conducted for this study, and the attenuation relationships of Bozorgnia, Campbell and Niazi (1999). 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 Menifee area are listed in Table 1-2. For maps showing most of these faults, refer to Figures 1-1 and 1-2. Those faults included in Table 1-2 that could have the greatest impact on the Menifee area, or that are thought to have a higher probability of causing an earthquake, are described in more detail in the following pages. The active faults near Menifee are shown on Figures 1-2 and Plate 1-2. The deterministic analyses indicate that both the San Jacinto and Elsinore faults have the potential to generate moderate to strong ground shaking in Menifee, with PGHA (median) of between 0.26g and 0.3g (stronger shaking could occur in those valley areas underlain by deeper sediments). Shaking at these levels can cause significant damage to older structures, and slight to moderate damage to newer buildings constructed in accordance with the latest building code provisions.

Table 1-2 shows:

- The approximate distance, in miles and kilometers, between the fault and various points in the Menifee area, given as a range. Since these measurements are based on specific, but randomly selected points in the study area; other points in the city could be closer or farther away from the faults than the distances provided herein;
- The maximum magnitude earthquake (M_{max}) each fault is estimated capable of generating;
- The range in peak ground horizontal accelerations (PGHA), or intensity of ground motion, expressed as a fraction of the acceleration of gravity (g), that could be experienced in different areas of Menifee if the M_{max} occurs on the faults listed; and
- The range in Modified Mercalli seismic Intensity (MMI) values estimated for the Menifee area.

The peak ground horizontal accelerations and intensities summarized in Table 1-2 are shown from largest to lowest for each fault; these should be considered as average values, since different areas of Menifee are expected to feel and respond to each earthquake differently in response to site-specific conditions. As mentioned before, peak ground accelerations and seismic intensity values decrease with increasing distance away from the causative fault. However, local site conditions, such as reflection off of the hard rock forming the mountains in the region, can amplify the seismic waves generated by an earthquake, resulting in localized higher accelerations than those listed here. Please note that the PHGA analyses conducted for this study provide a general indication of relative earthquake risk throughout the Menifee General Plan area. For individual projects however, site-specific analyses that consider the precise distance from a given site to the various faults in the region, as well as the local near-surface soil types, should be conducted.

The ground motions presented in Table 1-2 are based on the largest earthquake that each fault, or fault segment, is believed capable of generating, referred to as the ***maximum magnitude earthquake*** (M_{max}). This deterministic approach is useful to study the effects of a particular earthquake on a building or community. However, since many potential earthquake sources can shake the region, it is also important to consider the overall likelihood of damage from a plausible suite of earthquakes. 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 city. 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 to produce national seismic hazard maps such as those used by the Uniform Building Code (ICBO, 1997), the International Building Code (ICC, 2006) and the California Building Code (CBSC, 2007).

Table 1-2: Estimated Horizontal Peak Ground Accelerations and Seismic Intensities in the Menifee Area

Fault or Fault Segment	Distance to Menifee (mi)	Distance to Menifee (km)	Magnitude of M_{max}	PGHA (g) from M_{max}	MMI from M_{max}
Elsinore (Temecula)	6 – 15.9	9.7 – 25.6	6.8	0.3 – 0.11	IX - VII
San Jacinto (San Jacinto Valley)	6.8 – 16.8	10.9 – 27	6.9	0.28 – 0.16	IX - VIII
Elsinore (Glen Ivy)	6.8 – 16.8	11 – 27.1	6.8	0.27 – 0.10	IX - VII
San Jacinto (Anza)	10.1 – 19.2	16.3 – 30.9	7.2	0.24 – 0.12	IX - VIII
Elsinore (Julian)	18.5 – 26.5	29.7 – 42.6	7.1	0.12 – 0.08	VII
San Jacinto (San Bernardino)	20.1 – 27.8	32.4 – 44.8	6.7	0.09 – 0.06	VII - VI
San Andreas (entire Southern)	22.1 – 30.8	35.5 – 49.5	8	0.19 – 0.14	VIII
San Andreas (San Bernardino Segment)	22.1 – 30.8	35.5 – 49.5	7.5	0.14 – 0.09	VIII - VII
San Andreas (San Bernardino + Coachella Segment)	22.1 – 30.8	35.5 – 49.5	7.7	0.16 – 0.11	VIII – VII
Elsinore (Chino – Central Avenue)	22.2 – 31.1	36.8 – 50.1	6.7	0.11 – 0.07	VII
Elsinore (Whittier)	26.3 – 35.1	42.3 – 56.5	6.8	0.07 – 0.05	VI
San Joaquin Hills	26.8 – 36.7	43.2 – 59	6.6	0.09 – 0.06	VII - VI
Pinto Mountain	29.8 – 40	47.9 – 64.3	7.2	0.08 – 0.06	VII – VI
North Frontal (West Segment)	34 – 41.9	54.7 – 67.5	7.2	0.1 – 0.07	VII
San Andreas (1857 rupture)	43.9 – 51.1	70.6 – 82.2	7.8	0.09 – 0.07	VII – VI
Puente Hills Blind Thrust	40.3 – 49.3	64.9 – 79.3	7.2	0.09 – 0.06	VII - VI

Abbreviations used in Table 1-2:
mi – miles; **km** – kilometer; M_{max} – maximum magnitude earthquake; **PGHA** – peak ground horizontal acceleration as a percentage of **g**, the acceleration of gravity; **MMI** – Modified Mercalli Intensity.

We ran the interactive ground motion module from the California Geological Survey (http://www.consrv.ca.gov/CGS/rghm/pshamap/pshamap.asp) and that by the U.S. Geological Survey (http://earthquake.usgs.gov/research/hazmaps/design/) to estimate the ground motions that have a 10 and 2 percent probability, respectively, of being exceeded in 50 years in the vicinity of City Hall. [Seismic design parameters in the 2007 California Building Code are based on the maximum considered earthquake, with a ground motion that has a 2 percent probability of being exceeded in 50 years and a recurrence interval of about 2,500 years.] For Menifee, the estimated level of ground motion that has a 10 percent probability of being exceeded in 50 years is between about 0.37g and 0.43g, depending on whether the underlying material is bedrock or alluvium, respectively. Similarly, the level of ground motion with a 2 percent probability of being exceeded in 50 years is between about 0.6g and 0.7g, again depending on whether the site is underlain by bedrock or alluvium. The principal sources responsible for these levels of shaking are the Elsinore and San Jacinto faults, both of which have relatively high probabilities of rupturing in the next 30 years. These levels of shaking are in the moderate to high range for southern California, and can be expected to cause moderate to extensive damage, particularly to older and poorly constructed buildings.

NOTES:

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Fault lines on the map are used solely to approximate the fault location. The width and location of the faults should not be used in lieu of site-specific investigations, evaluation, and design.

Detailed geologic investigations, including trenching studies, may make it possible to refine the location and activity status of a fault. All faults may not be shown. This map should be amended as new data become available and are validated.

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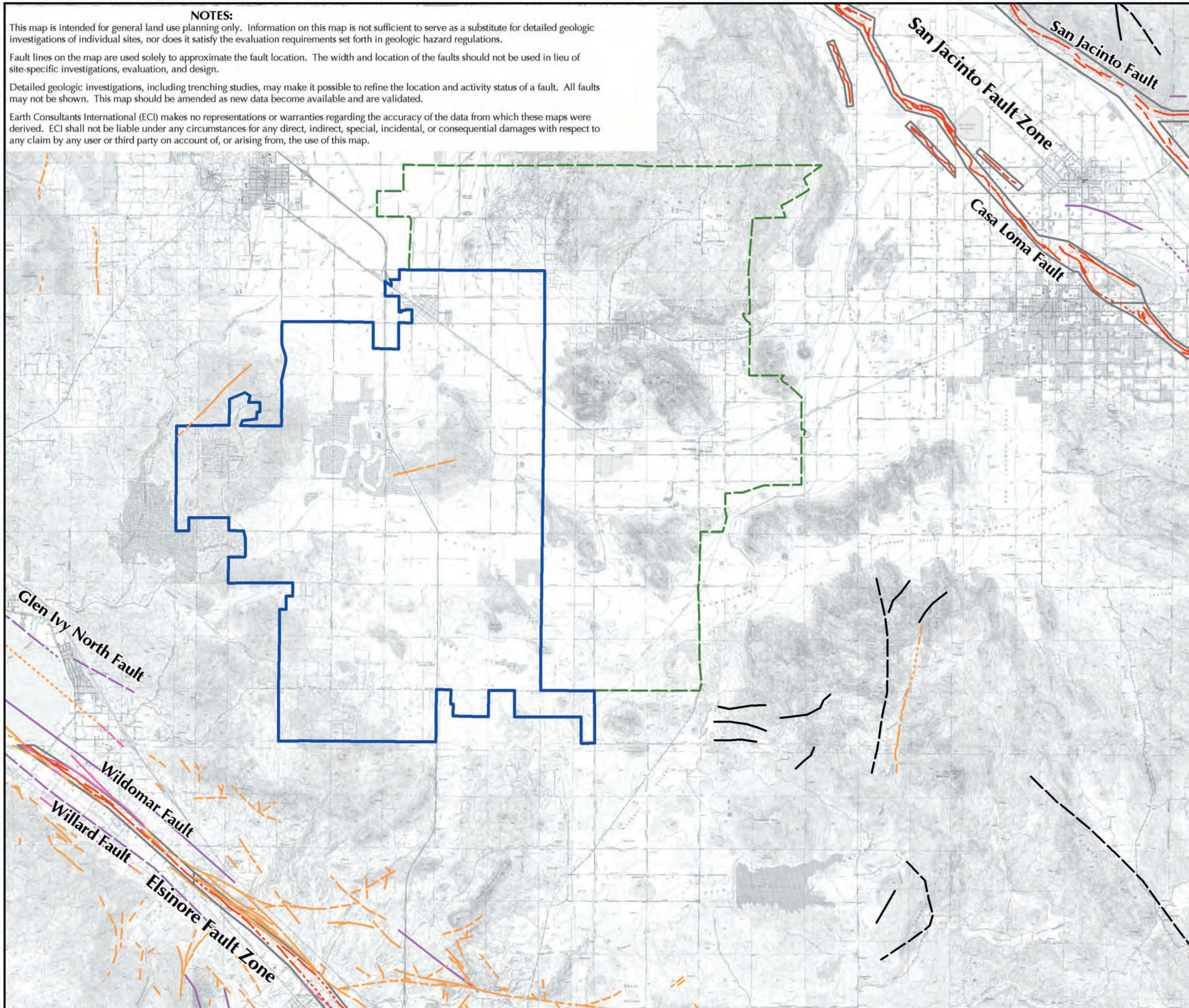


Fault Map

Menifee, California

Explanation

Faults; solid where location is known, dashed where approximate, dotted where inferred.

- Active fault zoned under the Alquist-Priolo Earthquake Fault Zone Act. From CGS (2002).
- Alquist-Priolo Earthquake Fault Zone. From CGS (2002).
- Fault that has moved in the Holocene or late Pleistocene. From Morton and Miller (2006).
- Fault that has not moved in the Holocene or late Pleistocene. From Morton and Miller (2006).
- Fault that has moved in the Quaternary. From Jennings (1994).
- Fault that predates the Quaternary. From Jennings (1994).
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N S W E

10000 0 10000
Feet

2 0 2 4
Kilometers

Scale: 1:120,000

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: Morton and Miller (2006), Alquist-Priolo Earthquake Fault Zones [Reproduced with permission CGS CD-ROM 2001-05 (2002)], and Jennings (1994) [reproduced with permission CDMG, CD-ROM 2000-06 (2000)].

Earth Consultants International

City of Menifee

Project Number: 2917
Date: 2010

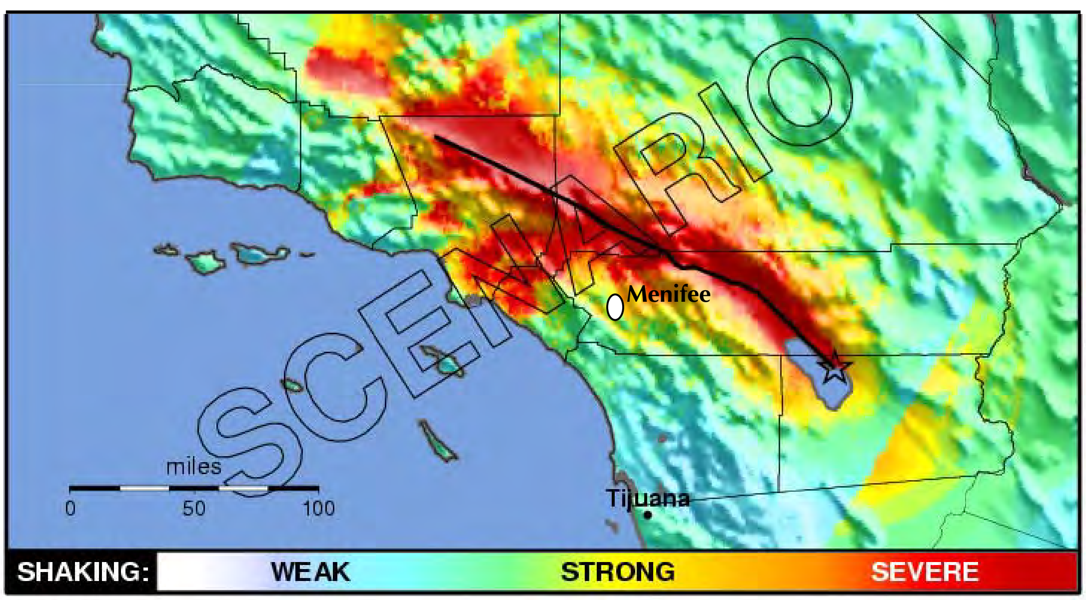
Plate 1-2

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 this: any major earthquake will produce aftershocks large enough to cause additional damage, especially to already-weakened structures. Consequently, post-disaster response planning must take damaging aftershocks into account.

Another way to communicate the seismic shaking hazard is with the use of ShakeMaps. A ShakeMap is a representation of the various levels of ground shaking throughout the region where an earthquake occurs. ShakeMaps are compiled from the California Integrated Seismic Network (CISN) – a network of seismic recording instruments placed throughout the state – and are automatically generated following moderate to large earthquakes. Preliminary real-time maps are posted within minutes on the Internet (http://earthquake.usgs.gov/eqcenter/shakemap/) giving disaster response personnel an immediate picture of where the most damage likely occurred. Although several shaking parameters can be illustrated on ShakeMaps, such as peak acceleration and peak velocity, most people can relate more easily to maps illustrating the *intensity* of ground shaking. Using actual instrumental ground motion recordings and comparing them to observed Modified Mercalli Intensities from recent California earthquakes, scientists can now estimate shaking intensities within a few minutes after an earthquake.

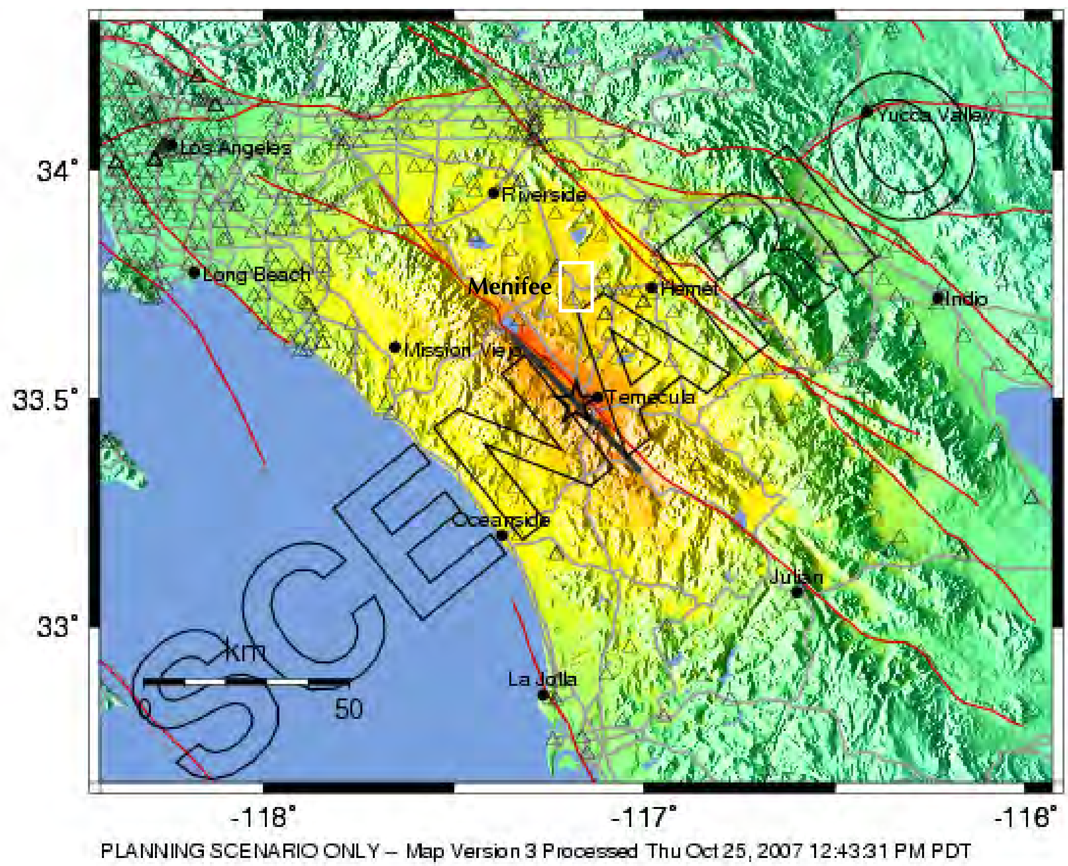
Figure 1-4: ShakeMap for a Magnitude 7.8 Earthquake Scenario on the Southern San Andreas Fault



Source: http://earthquake.usgs.gov/eqcenter/shakemap/sc/shake/ShakeOut2_full_se/#Decorated

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 1-4 is an Intensity ShakeMap for the hypothetical magnitude 7.8 "Shakeout" earthquake scenario that involves rupture of the entire southern San Andreas fault, from the Salton Sea northward to Lake Hughes, in northern Los Angeles County, and at its closest, approximately 22 miles to east-northeast of Menifee. The ShakeMap shows that the area in and around Menifee would experience moderate shaking. Figure 1-5 shows an intensity ShakeMap for a hypothetical magnitude 6.8 eathquake on the Temecula segment of the Elsinore fault. Notice the level of shaking anticipated in Menifee.

Figure 1-5: ShakeMap for a Magnitude 6.8 Earthquake Scenario on the Temecula Segment of the Elsinore Fault



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/earthquakes/shakemap/sc/shake/Elsinore6.8_se/download/intensity.jpg

The most significant faults in Table 1-2 are discussed in greater detail in the pages below.

1.4.1 San Andreas Fault Zone

The San Andreas fault is the principal boundary between the Pacific and North American plates. The fault extends over 1,200 km (750 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,” however, as discussed further below, at least two other faults closer to Menifee have the potential to cause stronger ground shaking, and therefore more 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. A group of scientists referred to as the 2007 Working Group on California Earthquake Probabilities (WGCEP, 2008) has calculated that the southern San Andreas fault has a 59 percent probability of causing an earthquake of at least magnitude 6.7 in the next 30 years.

Large faults, such as the San Andreas fault, are often divided into segments in order to evaluate their future earthquake potential. The segmentation is based on physical characteristics along the fault, particularly discontinuities that may affect the rupture length. The southern and central San Andreas fault is now divided into ten segments 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 (WGCEP, 2008).

Each segment is assumed to have a characteristic slip rate (rate of movement averaged over time), recurrence interval (time between moderate to large earthquakes), and displacement (amount of offset during an earthquake). While this methodology has some value in predicting earthquakes, historical records and studies of prehistoric earthquakes show it is possible for more than one segment to rupture during a large quake or for ruptures to overlap into adjacent segments. For example, the last major earthquake on the southern portion of the San Andreas fault (and the largest earthquake reported in California) was the 1857 Fort Tejon (M 8) event. The 1857 earthquake ruptured the Cholame, Carrizo, and Mojave segments of the fault, resulting in displacements of as much as 27 feet (9 meters) along the rupture zone. These fault segments are thought to have a recurrence interval of between 104 and 296 years. Peak ground accelerations in Menifee as a result of the 1857 earthquake are estimated at about 0.08g, a fairly low level of shaking. However, if a similar earthquake ruptured the entire southern San Andreas fault, including, from south to north, the Coachella, San Gorgonio-Garnet Hill, San Bernardino and Mojave segments, with its epicenter along that section of the San Andreas fault closest to Menifee, could generate moderate shaking in Menifee, with peak ground accelerations estimated at between 0.2g and 0.14g (see Table 1-2).

The **Coachella South and North segments** combined extend 114 km from approximately the Salton Sea to San Gorgonio Pass. These segments have not produced any large surface-rupturing earthquakes in historic times (Sieh and Williams, 1990). Paleoseismic studies suggest that the last surface-rupturing earthquake on the Coachella segments occurred around A.D 1680. The data also suggest that the Coachella and San Bernardino segments ruptured simultaneously in earthquakes that occurred around 1680 and A.D. 1450. Using a slip rate of 25 ± 5 mm/yr and a characteristic displacement of 4.0 +4,-2 meters, the 1995 WGCEP derived a recurrence interval of 220 ±13 years for the Coachella segments. More recently, the 2007 WGCEP assigned a slip rate of 20±6 mm/yr to this section of the San Andreas fault. Rupture of the Coachella fault segments in a magnitude 7.2 earthquake is estimated capable of generating peak ground accelerations in Menifee of about 0.06g. If the Coachella and San Bernardino segments rupture together in a magnitude 7.7 earthquake, Menifee would experience peak ground accelerations of between 0.16g and 0.11g.

The **San Bernardino segments** combined are about 49 miles (78 km) long and extend from the San Gorgonio Pass northward to approximately Cajon Pass. This is a structurally complex zone that is poorly understood, and for which there are scant data on fault behavior. Using a slip rate of 24±5 mm/yr and a characteristic displacement per event of 3.5 ± 1.0 m, the WGCEP (1995) derived a recurrence interval of 146 years. [The CGS (Cao et al., 2003) uses a slip rate of 24±6 mm/yr for this fault segment, whereas the 2007 WGCEP assigned a slip rate of 22±6 mm/yr to the northern section of the San Bernardino Mountains segment.] This section of the San Andreas fault is thought capable of producing a magnitude 7.5 earthquake, which could result in peak ground accelerations in Menifee of between 0.09g and 0.06g. If, as discussed above, the San Bernardino segments rupture in conjunction with the Mojave and/or Coachella segments, higher ground motions would be expected in the region.

The **Mojave segments** of the San Andreas fault combined extend from just northwest of Cajon Creek, at the southern limit of the 1857 rupture, northward to the San Andreas fault juncture with the Garlock fault (WGCEP, 2008). Using a slip rate of 30±8 mm/yr and a characteristic displacement of 4.5±1.5 meters, the WGCEP (1995) derived a recurrence interval for this section of 150 years. [Cao et al. (2003) assigned this section a slip rate of about 34±5 mm/yr, whereas more recently, the WGCEP (2008) assigned it a slip rate of 28±3.5 mm/yr]. The Mojave segments combined are thought capable of producing a magnitude 7.4 earthquake, which could result in peak ground accelerations in Menifee of between about 0.06g and 0.05g.

1.4.2 Elsinore Fault Zone

The Elsinore fault is a major right-lateral strike-slip fault that extends from northern Baja California to the Los Angeles Basin, a distance of approximately 306 km (190 miles) (Treiman, 1998). As part of the San Andreas fault system in southern California, the Elsinore fault accommodates about 10% of the motion between the Pacific and North American plates (WGCEP, 1995), with a slip of about 5 mm/yr (Bergmann et al., 1993; Millman and Rockwell, 1986; Vaughan and Rockwell, 1986). The fault is divided, from south to north into the Laguna Salada, Coyote Mountain, Julian, Temecula, Glen Ivy, Chino, and Whittier segments (Treiman, 1998). The section closest to Menifee is the Temecula segment, which at its closest approach is about 6 miles to the west. This segment includes two roughly parallel faults, the Wildomar and Willard strands. The next closest segment is the Glen Ivy, located 6.8 miles to the northwest of Menifee (Plate 1-2).

The **Glen Ivy** and **Temecula** segments bound the Elsinore Trough, a relatively shallow depression formed where the Temecula segment steps right to the Glen Ivy segment. Although historical earthquakes have been reported on only two segments (the Glen Ivy and Laguna Salada segments, as discussed further below), studies indicate that all segments of the Elsinore fault have moved in the last about 11,000 years, and are therefore active by California's Alquist-Priolo definition of fault activity. Trenching studies at Glen Ivy Marsh in the Temescal Valley suggest that surface-rupturing earthquakes on this segment occur on average about every 175 years (WGCEP, 2008, based on data provided by T. Rockwell), with the most recent earthquake on this segment having occurred in May 1910. This earthquake, of estimated magnitude 6 (Toppozada and Parke, 1982) reportedly displaced a cement flume about 35 cm laterally (Brake, 1987; Rockwell and Brake, 1987). Although no individual earthquakes have been directly dated on the Wildomar fault, paleoseismic studies on the Murrieta Creek fault, an oblique-slip fault secondary to the Temecula segment (Bergmann and Rockwell, 1989), suggest an average recurrence interval of 300 to 700 years for the Elsinore fault in the Murrieta area, just to the southwest of Menifee. Similarly, paleoseismic studies on the southeastern end of the Temecula segment, near Agua Tibia Mountain, indicate a recurrence interval of 400 to 600 years for this segment (Vaughan et al., 1999; WGCEP, 2008). Historical records suggest that there have been no surface-rupturing earthquakes on the Temecula segment since at least 1818, when the Serrano family first settled the valley (WGCEP, 1995), and trenching studies suggest the most recent event on this segment occurred around A.D. 1655 (WGCEP, 2008).

At about 35 miles (65 km) long, the **Julian** segment is the longest section of the Elsinore fault zone. Its north end is defined by a restraining bend, whereas at its south end, it steps across a 4- to 5-km wide area to the Coyote Mountain section. The most recent surface-rupturing earthquake on this section appears to have occurred about 1,500 years ago, and the penultimate event about 3,000 years ago. There are too few earthquakes resolved on this segment to calculate a recurrence interval.

As discussed above, the Elsinore fault zone broke in a ~M 6 earthquake on the Glen Ivy segment on May 15, 1910 (Toppozada and Parke, 1982; Rockwell et al., 1986). To the south, the Laguna Salada fault is thought to have produced a M>7.1 event in 1892 (Rockwell 1989; Mueller and Rockwell, 1995), and the Pescadores and Borrego faults ruptured during the Easter Sunday (April 4), 2010 earthquakes (see Section 1.3.18). The Chupamiertos fault, farther south, is thought to have produced a M 6.5 earthquake in 1934. These earthquakes indicate that the Elsinore fault zone is capable of producing destructive earthquakes in the future. The 2007 Working Group on California Earthquake Probabilities (WGCEP, 2008) assigned the Elsinore fault an 11% probability of rupturing in a M>6.7 earthquake in the next 30 years.

A M 6.8 earthquake on either the Temecula or Glen Ivy segments of the fault would generate strong shaking in Menifee, with horizontal peak ground accelerations between 0.3g and 0.1g, and Modified Mercalli intensities in the VII to IX range. If the Julian segment of the Elsinore fault ruptured in a M 7.1 earthquake, peak ground motions of between about 0.12g and 0.08g are anticipated in the Menifee area. Rupture of the Chino segment in a M 6.7 earthquake would generate peak ground motions between about 0.11g and 0.07g, whereas the Whittier segment, farther north, would generate shaking of at least 0.07g. This last estimate on the Whittier fault is based on a maximum magnitude 6.8

earthquake. However, some investigators suggest that the Whittier fault is capable of a larger earthquake, possibly of magnitude 7.1 or even larger (Dolan et al., 1995).

1.4.3 San Jacinto Fault Zone

The San Jacinto fault zone consists of a series of closely spaced faults that form the western margin of the San Jacinto Mountains. The zone is about 280 km (175 miles) in length and extends from its junction with the San Andreas fault in San Bernardino, southeasterly toward the Brawley area, where it continues south of the international border as the Imperial fault. The San Jacinto fault zone has been divided into seven segments. From north to south these include the San Bernardino Valley, San Jacinto Valley, Anza, Coyote Creek, Borrego Mountain, Superstition Hills and Superstition Mountain segments. Each segment, in turn, consists of a series of subparallel faults. Fault slip rates on the various segments of the San Jacinto fault are less well constrained than for the San Andreas fault, but the data available suggest right-lateral slip rates of 12±6 mm/yr for the northern segments of the fault and slip rates of 4±2 mm/yr for the southern segments (WGCEP, 1995). This amounts to between about 12% and 30% of the total slip on the San Andreas fault system. The Working Group on California Earthquake Probabilities (1995) gave the San Bernardino and San Jacinto Valley segments a 37% and 43% probability, respectively, of rupturing sometime between 1994 and 2024. These probabilities were reduced somewhat by the WGCEP (2008), to an average of 31% for all segments of the San Jacinto fault.

The **San Bernardino Valley** segment extends from the San Gabriel Mountains, at a point roughly coincident with the southern limit of the 1857 earthquake fault rupture on the adjacent San Andreas fault (WGCEP, 2008), to the northern end of the San Jacinto Valley. There is no earthquake event chronology for this section, but radiocarbon dating of faulted and unfaulted deposits trenched at Sycamore Flat, across the Glen Helen fault, suggest that this section last broke between 280(±70) and 490(±70) years before present (Jeff Johnston, 1994 personal communication, as reported in Burnett and Hart, 1994). The only historical earthquake sequence that could be attributed to this fault segment is a series of earthquakes reported by the Anza expedition in July and August 1769 (see section 1.3.1).

The segment of the San Jacinto fault closest to Menifee is the **San Jacinto Valley** segment – this segment includes several strands, including the San Jacinto, Claremont, Hot Springs, Casa Loma and Park Hill faults, and extends about 24 miles (45 km), to where the Claremont and Casa Loma faults come together forming the Clark fault (WGCEP, 1995; Treiman and Lundberg, 1999). This segment was defined based on microseismicity and the inferred extent of the April 21, 1918 earthquake (Section 1.3.5). The **Anza** segment to the south has been studied in detail at Hog Lake, where at least 16 past earthquakes have been resolved from the faulted stratigraphy (WGCEP, 2008 based on data provided by T. Rockwell). The data indicate an average recurrence interval of 238 years for this segment, with the most recent earthquake having occurred between about A.D. 1775 and A.D. 1805. The **Superstition Mountain** segment has a preferred recurrence interval of 325 years, and the most recent surface-rupturing earthquake on this section is though to have occurred between about A.D. 1640 and A.D. 1440 (Gurrola and Rockwell, 1996; WGCEP, 2008). Event chronology and recurrence interval for the other segments of the San Jacinto fault zone are not available.

The San Jacinto fault has historically produced more large earthquakes than any other fault in southern California, although none of these earthquakes has been as large as the 1857 and 1906 earthquakes on the San Andreas fault. The two most-recent surface-rupturing earthquakes on the San Jacinto fault were the April 9, 1968, M_w 6.5 on the Coyote Creek segment (Jennings, 1994), and the 1987 event on the Superstition Hills segment. Offset across the fault traces is predominantly right-lateral strike-slip, similar to the San Andreas fault, although Brown (1990) has suggested that vertical motion contributes up to 10% of the net slip.

A maximum credible earthquake of magnitude 6.7 on the San Bernardino Valley segment of the San Jacinto fault has the potential to generate ground motions with peak horizontal ground accelerations of between about 0.1g and 0.06g in the Menifee area. A 6.9 earthquake on the San Jacinto Valley segment would generate peak horizontal ground accelerations in Menifee of between about 0.3g and 0.16g, and a 7.2 earthquake on the Anza segment would generate peak horizontal ground accelerations in the city of between about 0.24g and 0.12g (see Table 1-2). The San Jacinto Valley section of the San Jacinto fault, and the Temecula segment of the Elsinore fault, both have the potential to generate the worst-case earthquake scenario for Menifee.

1.4.4 San Joaquin Hills Fault

Analysis of uplifted marine terraces between Huntington Beach and San Juan Capistrano, in Orange County, suggests the presence of a southwest-dipping blind thrust beneath the San Joaquin Hills, adjacent to the Newport-Inglewood fault zone (Grant et al., 1999). Based on structural modeling of dated marine terraces, Grant et al. (1999) calculated a slip rate of about 0.42-0.79 mm/yr and a minimum average recurrence interval of about 1,600 to 3,100 years for moderate size earthquakes on this fault. Uplift of late Holocene shorelines and marsh deposits above the active shoreline are attributed to a relatively recent earthquake larger than magnitude 7 on the San Joaquin Hills fault (Grant et al., 2002). Radiocarbon dating and pollen analyses suggest this earthquake occurred between A.D. 1635 and A.D. 1855. Rivero et al. (2000) consider this fault to be part of a larger structure that extends offshore to the south. An estimated magnitude 6.6 earthquake on this fault would generate peak horizontal ground accelerations in the Menifee area of between about 0.09g and 0.06g, and Modified Mercalli intensities in the VII to VI range. Note that some researchers (Grant et al., 1999) think this fault is capable of producing earthquakes of M>7, which would generate stronger ground shaking in Menifee than what is reported above.

1.4.5 Pinto Mountain Fault

The Pinto Mountain fault is a prominent left-lateral strike-slip fault that bounds the north side of the Little San Bernardino Mountains and extends in a westerly direction through the city of Twentynine Palms. The fault is at least 45 miles (73 km) long, and possibly as much as 56 miles (90 km). 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 (Cadena and others, 2004). Current estimates on its rate of slip suggest a rate of between 1.1 and 2.3 mm/yr. Additional studies should refine those estimates further. A magnitude 7.2 earthquake on this fault could generate peak horizontal ground acceleration in the Menifee area of about 0.08g to 0.06g. A potentially larger magnitude 7.5

earthquake on the Pinto Mountain fault would generate slightly stronger ground shaking in Menifee.

1.4.6 North Frontal Fault

This south-dipping, partially blind reverse fault zone along the east flank of the San Bernardino Mountains consists of several fault splays that have a combined total length of approximately 65 km (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; Meisling, 1984; Bryant, 1986b).

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, and its recurrence interval, slip rate and other fault parameters are not well understood, although a slip rate of about 0.5 mm/yr is attributed to it. Furthermore, movement on this fault is thought to be responsible for an average uplift rate of about 1 mm/yr of the San Bernardino Mountains. Based on its length, the West segment of the North Frontal fault zone is thought capable of generating a maximum magnitude 7.2 earthquake. An earthquake of that size on this fault would be felt in Menifee with peak ground accelerations of between about 0.1g and 0.07g, resulting in Modified Mercalli intensities as high as VII.

1.4.7 Puente Hills Blind Thrust Fault

In 1999, Shaw and others announced the discovery of a blind thrust fault that extends from northern Orange County to the Los Angeles metropolitan area. The fault does not extend upward to the surface, which is why it is called blind, although it is expressed at the surface by a series of low hills, including the Puente Hills on its eastern end. These hills have risen over the surrounding landscape in response to movement on the underlying fault; Dolan and others (2003) suggest that the hills rise 1 to 2 meters (3.2 to 6.6 feet) every time the Puente Hills thrust fault breaks in a large magnitude M_w 7.2 to 7.5 earthquake.

Studies by Dolan and others (2003) also suggest that the Puente Hills thrust fault has experienced four large earthquakes in the past about 11,000 years. More recent studies (Leon and others, 2007) indicate three uplift events in the past about 8,000 years, with estimated moment magnitudes of between 7.0 and 7.5. The most recent uplift-causing event on the Puente Hills thrust fault appears to have occurred between about 200 and 2,200 years ago, the penultimate event about 3,000 to 6,300 years ago, and the next older event occurred about 6,600 to 8,100 years ago. The fourth, older earthquake occurred between about 9,000 and 10,700 years ago (Dolan and others, 2003). Smaller earthquakes that rupture only a section of the fault are also possible, as evidenced by the Mw 6.0 Whittier Narrows earthquake of 1987, which is now attributed to rupture of a small, deep patch of the Santa Fe Springs segment of the Puente Hills thrust.

Thrust faults typically generate stronger ground shaking than strike-slip faults, as the ground above the plane of the fault is moved up and over the underlying plane. Ground shaking from earthquakes on these types of faults is also felt over a broader area, tends to last longer, and has more of the lower frequency seismic waves. A 2005 study on the impact that an earthquake on the Puente Hills fault would have on Los Angeles estimates between 3,000 and 18,000 fatalities, and more than $250 billion in total losses (Field and others, 2005), making this fault "The Big One" for the Los Angeles area. A M 7.2 earthquake on this fault would generate peak ground accelerations in the Menifee area of between about 0.09g and 0.06g, with Modified Mercalli intensities in the VII to VI range.

1.5 Surface Fault Rupture

1.5.1 Definitions

Primary fault rupture refers to fissuring and displacement of the ground surface along a fault that breaks in an earthquake. Primary fault rupture is rarely confined to a simple line along the fault trace. As the rupture reaches the brittle surface of the ground, it commonly spreads out into complex fault patterns of secondary faulting and ground deformation. In the 1992 Landers earthquake, the zone of deformation around the main trace was locally hundreds of feet wide (Lazarte and others, 1994). Surface displacement and distortion associated with secondary faulting and deformation can be relatively minor or can be large enough to cause significant damage to structures.

Primary ground rupture due to fault movement typically results in a relatively small percentage of the total damage in an earthquake, yet being too close to a rupturing fault can result in extensive damage. It is difficult and generally costly to safely reduce the effects of this hazard through building and foundation design. Therefore, the preferred, and traditional mitigation measure for this hazard is to avoid active faults by setting structures back from the fault zone. In California, application of this measure is subject to requirements of the Alquist-Priolo Earthquake Fault Zoning Act and guidelines prepared by the California Geological Survey – previously known as the California Division of Mines and Geology (CGS Note 42 by Hart and Bryant, 2007). The final approval of a fault setback lies with the local reviewing agency.

Secondary fault rupture refers to ground surface displacements along faults other than the main traces of active regional faults. Secondary ground deformation includes fracturing, shattering, warping, tilting, uplift and/or subsidence. Unlike the regional faults, most subsidiary faults are not deeply rooted in the Earth's crust and are not capable of producing damaging earthquakes on their own. Movement along these faults generally occurs in response to movement on a nearby regional fault. Yet, the zone of secondary faulting can be quite large, even in a moderate-sized earthquake. For instance, in the 1971 San Fernando quake, movement along subsidiary faults occurred as much as 2 km from the main trace (Ziony and Yerkes, 1985). Triggered slip as a result of a regionally large earthquake can also occur in faults many kilometers away from the causative fault. For example, as a result of the 1992 Landers earthquake, triggered surface slips were documented in the Coachella Valley area (Rymer, 2000). Similarly, following the 1999 Hector Mine earthquake, triggered surface slips were recorded in the Salton Trough (Rymer et al., 2002; Meltzner et al., 2006). More recently, as a result of the April 4, 2010 Sierra El Mayor earthquake in Baja California, triggered slip was reported on the San Andreas, Superstition Hills, Imperial and Brawley fault zones.

Faults have formed over millions of years, usually in response to regional stresses. Shifts in these stress regimes do occur over millennia. As a result, some faults change in character. For example, a thrust fault in a compressional environment may become a strike-slip fault in a transpressive (oblique compressional) environment. Other faults may be abandoned altogether, and previously not active faults may be reactivated. Consequently, the State of California, under the guidelines of the Alquist-Priolo Earthquake Fault Zoning Act of 1972 (Hart and Bryant, 1999, 2007), classifies faults according to the following criteria:

- ***Active***: faults showing proven displacement of the ground surface within about the past about 11,000 years (within the Holocene Epoch), that are thought capable of producing earthquakes;
- ***Potentially Active***: faults showing evidence of movement within the past 1.6 million years, but that have not been shown conclusively whether or not they have moved in the past 11,000 years; and
- ***Not active***: faults that have conclusively NOT moved in the past 11,000 years.

The Alquist-Priolo classification is used primarily for residential subdivisions. Different definitions of activity are used by other agencies or organizations depending on the type of facility being planned or developed. For example, longer periods of inactivity are generally required for dams or nuclear power plants. An important subset of active faults are those with historical earthquakes. In California, that means faults that have ruptured since 1769, when the Spanish first arrived and settled in the area. However, since many parts of the State were not settled until well into the middle of the 1800s, some historical earthquakes most likely went un-noticed and therefore unreported.

The underlying assumption in this classification system is that if a fault has not ruptured in the past about 11,000 years, it is not likely to be the source of a damaging earthquake in the future. In reality, however, most potentially active faults have been insufficiently studied to determine their hazard level. For example, some of the faults that ruptured in the 1992 Landers and 1999 Hector Mine earthquakes were previously thought to be not active, as they appeared to have not moved in at least 11,000 years. Also, although simple in theory, the evidence necessary to determine whether a fault has or has not moved during the past 11,000 years can be difficult to obtain.

In most cases, it is impractical to reduce the damage potential of surface fault rupture by engineering design, and most regulatory agencies, following the position of the California Geological Survey, currently do not allow engineering design for habitable structures (although this is being reconsidered for "minor" faults at this time). Therefore, the most often-used mitigation measure is to simply avoid placing structures on or near active fault traces. The Alquist-Priolo Earthquake Fault Zones Act requires that geologic investigations, which generally include fault trenching, be performed if conventional structures designed for human occupancy are proposed within a fault zone. These studies must evaluate whether or not an active segment of the fault extends across the area of proposed development, following the guidelines for evaluating the hazard of fault rupture presented in Note 49, published by the CGS, which is available on the world wide web at http://www.consrv.ca.gov/CGS/rghm/ap/index.htm.

Based on the results of these geologic studies, appropriate structural setbacks are recommended to prevent the siting of the proposed structures directly on top or within a certain distance from the fault. A common misperception regarding setbacks is that they are always 50 feet from the active fault trace. In actuality, as part of a geologic investigation, the project geologist is required to characterize the ground deformation associated with an active fault. Based on these studies, specific setbacks are recommended. If a fault trace is narrow, with little or no associated ground deformation, a setback distance less than 50 feet could be recommended. Conversely, if the fault zone is wide, with multiple splays, or is poorly defined, a setback distance greater than 50 feet may be warranted.

1.5.2 Faults in the Menifee Area

There are two main faults zoned by the State of California under the criteria of the Alquist-Priolo Act near but outside the Menifee General Plan area: the San Jacinto fault zone to the northeast, and the Elsinore fault to the southwest (see Plate 1-2). No active faults have been zoned in the Menifee General Plan area proper.

Morton and Miller (2006) show a relatively short bedrock fault just east of the Sun City portion of Menifee, and another fault extending from the northeast into the hills northwest of Quail Valley (see Plate 1-2). The faults are confined to bedrock and do not affect sediments deposited in the Holocene or late Pleistocene (Morton and Miller, 2006). Therefore, these faults are not active per the definition of fault activity provided by the Alquist-Priolo Earthquake Fault Zone Act, and structural setbacks from these faults are not warranted.

1.6 Ground Failure due to Earthquake Shaking

Various types of ground failure that are the result of earthquake shaking can cause substantial damage to the built environment. The most destructive of these failures include liquefaction and slope failure, but other tectonically induced forms of ground failure are also possible. These are described further below.

1.6.1 Liquefaction

Liquefaction is a geologic process that causes various types of ground failure. It typically occurs within the upper 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 (Borchardt and Kennedy, 1979; Tinsley and Fumal, 1985). Earthquake shaking suddenly increases pressure in the water that fills the pores between soil grains, causing the soil to have a total or substantial loss of shear strength, and behave like a liquid or semi-viscous substance. This process can be observed at the beach by standing on the wet sand near the surf zone. Standing still, the sand will support our weight. However, if we tap the sand with our feet, water comes to the surface, the sand liquefies, and our feet sink.

Liquefaction can cause structural distress or failure 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 structural damage. In addition to loss of bearing strength, liquefaction-related effects include ground oscillations, lateral spreading and flow failures or slumping. The excess water pressure is relieved by the ejection of material upward through fissures and cracks; water or water-soil slurries may bubble onto the ground surface, resulting in features called "sand boils," "sand blows," "sand volcanoes," or "mud spouts." Seepage of water through cracks may also be observed.

The types of ground failure typically associated with liquefaction are explained below.

Lateral Spreading. Lateral displacement of surficial blocks of soil as the result of 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, gravity plus inertial forces caused by the earthquake may move the mass down-slope towards a cut slope or free face (such as a river channel or a canal). Lateral spreading most commonly occurs on gentle slopes that range between 0.3 degrees and 3 degrees, and can displace the ground surface by several feet to tens of feet. Such movement damages pipelines, utilities, bridges, roads, and other structures. During the 1906 San Francisco earthquake, lateral spreads with displacements of only a few feet damaged every major pipeline in the area. Thus, liquefaction compromised San Francisco's ability to fight the fires that caused about 85% of the damage (Tinsley and others, 1985). Lateral spreading was also reported in and around the Port of Los Angeles during both the 1933 and 1994 earthquakes (Barrows, 1974; Stewart and others, 1994; Greenwood, 1998).

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 of meters, but under favorable circumstances, soils can be displaced for tens of miles, at velocities of tens of miles per hour. For example, the extensive damage to Seward and Valdez, Alaska, during the 1964 Great Alaskan earthquake was caused by submarine flow failures (Tinsley and others, 1985).

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 (Tinsley and others, 1985).

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. During the 1964 Niigata, Japan earthquake, buried septic tanks rose as much as 3 feet, and structures in the Kwangishicho apartment complex tilted as much as 60 degrees (Tinsley and others, 1985).

Ground Lurching. Soft, saturated soils have been observed to move in a wave-like manner in response to intense seismic ground shaking, forming ridges or cracks on the ground surface. At present, the potential for ground lurching to occur at a given site can be predicted only generally. Areas underlain by thick accumulation of colluvium and alluvium appear to be the most susceptible to ground lurching. Under strong ground motion conditions, lurching can be expected in loose, cohesionless soils, or in clay-rich soils with high moisture content. In some cases, the deformation remains after the shaking stops (Barrows and others, 1994).

As indicated above, there are three general conditions that need to be met for liquefaction to occur. The first of these –ground shaking of relatively long duration – can be expected to occur in the Menifee 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 the Menifee General Plan area, typically along the active drainages (note the distribution of very young wash, very young alluvial valley deposits, young alluvial fan, and young alluvial valley and channel deposits – Qw, Qv, Qyf and Qya deposits, respectively, on Plates 2-2a and 2-2b). The third condition – water-saturated sediments within about 50 feet of the surface, has been reported locally in some of the valleys in the area.

Shallow groundwater within 20 feet of the ground surface was reported throughout the Menifee and Paloma valleys in 1915 (Waring, 1919). In some parts of Menifee valley, Waring (1919) reported groundwater within 10 feet of the surface, whereas in some parts of Paloma valley, even shallower water was reported. The shallow aquifer reportedly rises after a wet winter, or in response to irrigation, suggesting that the groundwater perches on top of the clay-rich older alluvium or bedrock that underlies the younger alluvium. Given the irregular bedrock surface, depth to water varies throughout the region. This is supported by some of the geotechnical studies that have been conducted in the area that show significant variations in the depth to groundwater within the same project area (T&B Planning Consultants, 2005; T&B Planning Consultants, 1994). Shallow groundwater has also been reported to underlie approximately 60% of the leaking underground storage tank sites reported in the Menifee area between 1983 and 2006 (see Chapter 5).

The areas of Menifee where young unconsolidated sediments and historically shallow groundwater conditions co-exist are shown on Plate 1-3 as susceptible to liquefaction. Three main areas are identified: 1) the Salt Creek floodplain, 2) the Warm Springs Creek floodplain, and 3) portions of the Paloma Valley. Geotechnical studies to evaluate the potential for liquefaction-induced differential settlement are recommended in these areas prior to development. Given that the groundwater levels in this area seem to fluctuate, the geotechnical analyses should use the shallowest groundwater levels reported in the area to calculate the anticipated settlement due to liquefaction.

Absent an official map from the California Geological Survey, Plate 1-3 should be used as if it were the official map, and site-specific liquefaction susceptibility studies should be conducted in the mapped areas prior to any proposed development. In accordance with the Seismic Hazards Mapping Act (SHMA), all projects within a State-delineated Seismic Hazard Zone for liquefaction must be evaluated by a Certified Engineering Geologist and/or Registered Civil Engineer (this is typically a civil engineer with training and experience in soil engineering). Most often however, it is appropriate for both the engineer and geologist to be involved in the evaluation, and in the implementation of the mitigation measures. Likewise, project review by the local agency must be performed by geologists and engineers with the same credentials and experience.

NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

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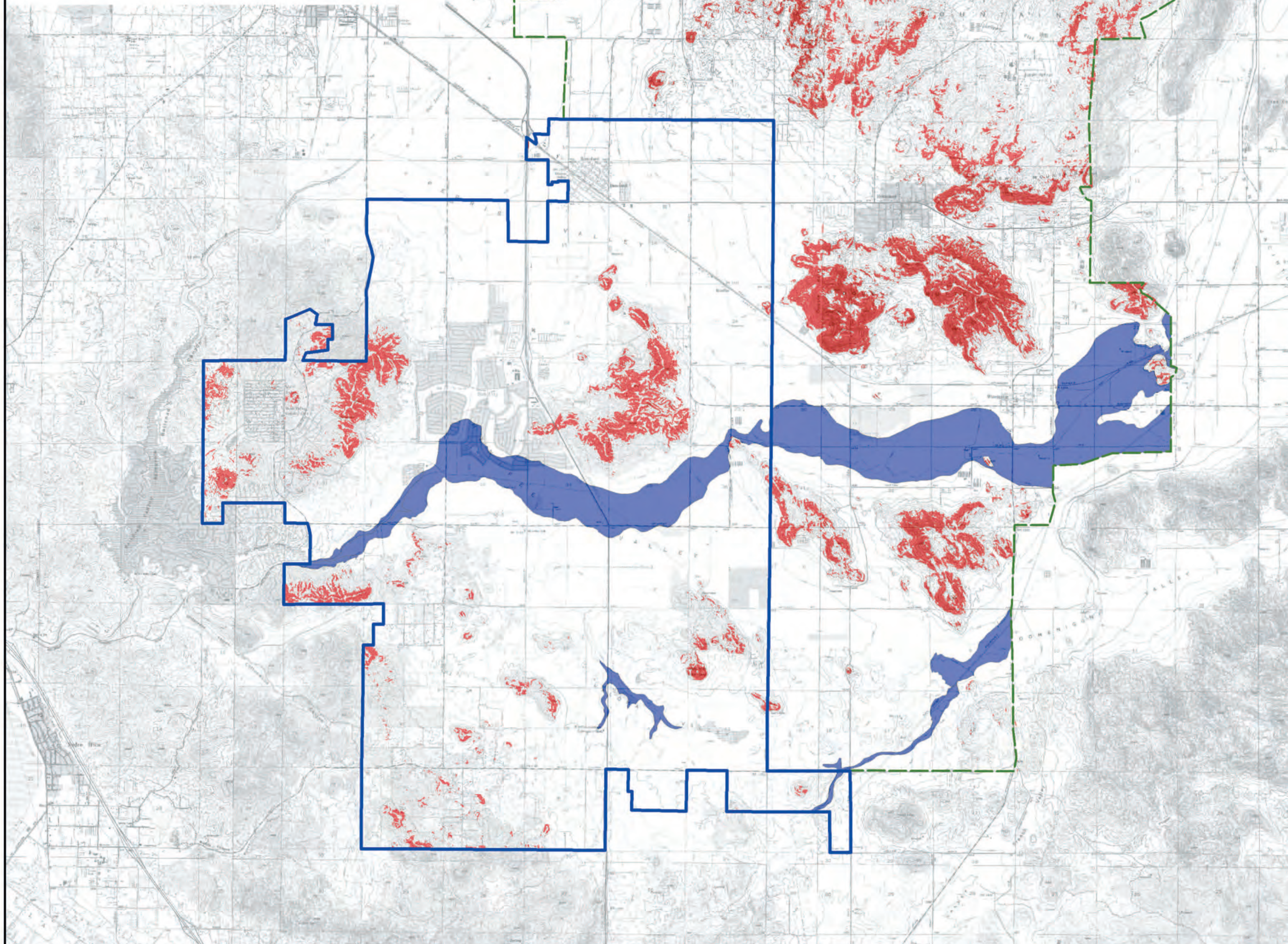


Seismic Hazard Zones

Menifee, California

Explanation

- Areas where local geological and groundwater conditions suggest a potential for liquefaction
- Areas where local topographic and geological conditions suggest the potential for earthquake-induced landslides
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N S W E

Scale: 1:84,000

7000 0 7000
Feet

2 0 2
Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Sources: Derived from Morton and Miller (2006), Waring (1919), and USGS 30m Digital Elevation Model

Earth Consultants International

CITY OF MENIFEE

Project Number: 2917
Date: 2010

Plate 1-3

In order to assist project consultants and reviewers in the implementation of the SHMA, the State has published specific guidelines for evaluating and mitigating liquefaction (CDMG, 1997; CGS, 2008). Furthermore, in 1999, a group sponsored by the Southern California Earthquake Center (SCEC, 1999) published recommended procedures for carrying out the California Geological Survey guidelines. More recently, a consensus report that describes new criteria for the definition and study of the liquefaction resistance of soils has been published by the Earthquake Engineering Research Center (Seed and others, 2003), and additional studies can be expected in this field. Consultants should review and apply the most recent, peer-reviewed guidelines for liquefaction study as applicable to the specific site being studied.

In general, a liquefaction study is designed to identify the depth, thickness, and lateral extent of any liquefiable layers that would affect the project site. An analysis is then performed to estimate the type and amount of ground deformation that might occur, given the seismic potential of the area. Mitigation measures generally fall in one of two categories: ground improvement or foundation design.

Ground improvement includes such measures as removal and recompaction of low-density soils, removal of excess ground water, in-situ ground densification, and other types of ground improvement (such as grouting or surcharging). Special foundations that may be recommended range from deep piles to reinforcement of shallow foundations (such as post-tensioned slabs). Mitigation for lateral spreading may also include modification of the site geometry or inclusion of retaining structures. The types (or combinations of types) of mitigation depend on the site conditions and on the nature of the proposed project (CDMG, 1997; CGS, 2008).

1.6.2 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. Over 11,000 landslides were mapped shortly after the 1994 Northridge earthquake, all within a 45-mile radius of the epicenter (Harp and Jibson, 1996). 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. The 1989 Loma Prieta and Northridge earthquakes showed that reactivation of existing deep-seated landslides can also occur (Spittler and others, 1990; Barrows and others, 1995).

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. For instance, the 1906 San Francisco earthquake occurred in April, after a winter of exceptionally heavy rainfall, and produced many large landslides and mudflows, some of which were responsible for several deaths. The 1987 Loma Prieta earthquake however, occurred in October, during the third year of a drought, and slope failures were limited primarily to rockfalls and reactivation of older landslides that was manifested as ground cracking in the scarp areas but with very little movement (Griggs and others, 1991).

Menifee has not been mapped as being located within a State-delineated Seismic Hazard Zone for seismically induced landsliding because this mapping program has not yet been funded for Riverside County. Topographically, the Menifee General Plan area encompasses numerous brush-covered, rugged and moderately steep hills and low mountains surrounded by a series of interconnected, broad, nearly flat-bottomed valleys. Although the hills and mountains in the General Plan area are for the most part still undeveloped, scattered houses and residential developments are present at the foot of these slopes. Two main types of hard crystalline bedrock form the hills and mountains in the area: granitic rocks, and metasedimentary rocks (see Chapter 2 for a more detailed discussion of these rock types in the Menifee area). Although large deep-seated landslides have not been mapped in the region, these bedrock areas are susceptible to shallow, surficial failures that could impact the areas directly downslope. The granitic bedrock in particular weathers into large boulders that perch precariously on slopes, posing a rockfall hazard to areas adjacent to and below these slopes. A rockfall may happen suddenly and without warning, but is more likely to occur in response to earthquake-induced ground shaking, during periods of intense rainfall, or as a result of man's activities, such as grading and blasting.

Plate 1-3 shows those areas in the General Plan area where the combined topographic and bedrock conditions suggest the potential for earthquake-induced slope instability. Areas directly downhill from the areas shaded in red on Plate 1-3 are most vulnerable to the effects of slope failure. Existing slopes that are to remain adjacent to or within proposed developments should be evaluated for the geologic conditions mentioned above. 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 mitigate the unstable slope conditions, building setbacks should be imposed.

In accordance with the SHMA, all development projects within a State-delineated Seismic Hazard Zone for seismically induced landsliding must be evaluated and reviewed by State-licensed engineering geologists and/or civil engineers (for landslide investigation and analysis, this typically requires both). In order to assist in the implementation of the SHMA, the State has published specific guidelines for evaluating and mitigating seismically induced landslides (CDMG, 1997; CGS, 2008). The Southern California Earthquake Center (SCEC, 2002) sponsored the publication of the "Recommended Procedures for Implementation of DMG Special Publication 117." The steep slope areas identified in Plates 1-3 and 2-4 should be evaluated following these procedures if development near these slopes is proposed.

1.6.3 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 reduction of the thickness 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 Plate 2-2a, certain areas of Menifee are underlain by young, unconsolidated alluvial deposits, and artificial fill. These sediments are susceptible to seismically induced settlement.

Mitigation measures for 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 that required by the UBC may be recommended.

1.6.4 Deformation of Sidehill Fills

Sidehill fills are artificial fill wedges typically constructed on natural slopes to create roadways or level building pads. Deformation of sidehill fills was noted in earlier earthquakes, but this phenomenon was particularly widespread during the 1994 Northridge earthquake. Older, poorly engineered road fills were most commonly affected, but in localized areas, building pads of all ages experienced deformation. The deformation was usually manifested as ground cracks at the cut/fill contacts, differential settlement in the fill wedge, and bulging of the slope face. The amount of displacement on the pads was generally about three inches or less, but this resulted in minor to severe property damage (Stewart and others, 1995). This phenomenon was most common in relatively thin fills (about 27 feet or less) placed near the tops or noses of narrow ridges (Barrows and others, 1995).

This hazard could occur locally in Menifee, in the hillsides and mountains, where roads and building pads have been cut onto the side of a hillside, and fills on the outside side of the cut were placed to create a wider road or building pad. Some sidehill failures may occur in the hillsides surrounding Quail Valley, where some development is present, but for the most part the losses associated with this type of failure are anticipated to be small, if any. Road failures could occur locally, again in the hillsides surrounding Quail Valley, and possibly in the Juniper Flats area.

Hillside grading designs are typically conducted during site-specific geotechnical investigations to determine if there is a potential for this hazard. There are currently no proven engineering standards for mitigating sidehill fill deformation, consequently current published research on this topic should be reviewed by project consultants at the time of their investigation. It is thought that the effects of this hazard on structures may be reduced by the use of post-tensioned foundations, deeper overexcavation below finish grades, deeper overexcavation on cut/fill transitions, and/or higher fill compaction criteria.

1.6.5 Ridgetop Fissuring and Shattering

Linear, fault-like fissures occurred on ridge crests in a relatively concentrated area of rugged terrain in the Santa Cruz Mountains during the 1989 Loma Prieta earthquake. Shattering of the surface soils on the crests of steep, narrow ridgelines occurred locally in the 1971 San Fernando earthquake, but was widespread in the 1994 Northridge earthquake. Ridgetop shattering (which leaves the surface looking as if it was plowed) by the Northridge earthquake was observed as far as 22 miles away from the epicenter. In the Sherman Oaks area, severe damage occurred locally to structures located 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). It is generally accepted that ridgetop fissuring and shattering is a result of intense amplification or focusing of seismic energy due to local topographic effects (Barrows and others, 1995).

Ridgetop shattering may occur locally in the hillsides and mountains within and bordering the Menifee area, including the Lakeview Mountains, Double Butte, and the hills between Quail Valley on the west and Sun City on the east. Given that there is none or very little development on these ridgelines, and that no future development is anticipated because of the steepness of the slopes, damage to structures as a result of this hazard in the Menifee area is anticipated to be low to none, with a couple of exceptions: At least two above-ground water storage tanks are located at the top of ridgelines in the General Plan area – these tanks could experience strong ground shaking if the seismic energy is amplified along the ridges.

Projects located or proposed in steep hillside areas should be evaluated for this hazard by a Certified Engineering Geologist. Given that it is difficult to predict exactly where this hazard may occur, avoidance of development along the tops of steep, narrow ridgelines is probably the best mitigation measure. For large developments, recontouring of the topography to reduce the conditions conducive to ridgetop amplification, along with overexcavation below finish grades to remove and recompact weak, fractured bedrock might reduce this hazard to an acceptable level.

1.7 Other Potential Seismic Hazards

1.7.1 Seiches

A seiche is defined as a standing wave oscillation in an enclosed or semi-enclosed, shallow to moderately shallow water body or basin. Seiches continue (in a pendulum fashion) after the cessation of the originating force, which can be tidal action, wind action, or a seismic event. Reservoirs, lakes, ponds, swimming pools and other enclosed bodies of water are subject to these potentially damaging oscillations (sloshing). Whether or not seismically induced seiches develop in a water body is dependent upon specific earthquake parameters (e.g., frequency of the seismic waves, distance and direction from the epicenter), as well as site-specific design of the enclosed bodies of water, and is thus difficult to predict. Whether an earthquake will create seiches depends upon a number of earthquake-specific parameters, including the earthquake location (a distant earthquake is more likely to generate a seiche than a local earthquake), the style of fault rupture (e.g., dip-slip or strike-slip), and on the configuration (length, width and depth) of the basin.

Amplitudes of seiche waves associated with earthquake ground motion are typically less than 0.5 m (1.6 feet high), although some have exceeded 2 m (6.6 ft). A seiche in Hebgen Reservoir, caused by an earthquake in 1959 near Yellowstone National Park, repeatedly overtopped the dam, causing considerable damage to the dam and its spillway (Stermitz, 1964). The 1964 Alaska earthquake produced seiche waves 0.3 m (1 ft) high in the Grand Coulee Dam reservoir, and seiches of similar magnitude were reported in fourteen bodies of water in the state of Washington (McGarr and Vorhis, 1968). Seiches in pools and ponds as a result of the 2010 Baja California earthquake were reported and often captured on video in southern California and Arizona, and the Chile earthquake of February 27, 2010 reportedly caused a 0.5-foot-high seiche 4,700 miles away in Lake Pontchartrain, New Orleans.

Given that there are several lakes, ponds, and reservoirs in and around Menifee, seiches as a result of ground shaking can be expected to occur in the study area. The amplitude and of these seiche waves cannot be predicted, given the several parameters that combine to form these waves. Water in swimming pools is known to slosh during earthquakes, but in most cases, the sloshing does not lead to significant damage. However, property owners down-gradient from ponds, lakes and pools that could seiche during an earthquake should be aware of the potential hazard to their property should any of these bodies of water lose substantial amounts of water during an earthquake.

Damage as a result of sloshing of water inside water reservoirs is discussed further in the Flood Hazards Chapter (Chapter 3). Site-specific design elements, such as baffles, to reduce the potential for seiches are warranted in tanks and in open reservoirs or ponds where overflow or failure of the structure may cause damage to nearby properties. Damage to water tanks in recent earthquakes, such as the 1992 Landers-Big Bear sequence and the 1994 Northridge, resulted from seiching. As a result of those earthquakes, the American Water Works Association (AWWA) developed Standards for Design of Steel Water Tanks (D-100) that provide revised criteria for seismic design (Lund, 1994).

1.7.2 Tsunami

A tsunami is a sea wave caused by any large-scale disturbance of the ocean floor that occurs in a short period of time and causes a sudden displacement of water. The most frequent causes of tsunamis are shallow underwater earthquakes and submarine landslides, but tsunamis can also be caused by underwater volcanic explosions, oceanic meteor impacts, and even underwater nuclear explosions. Tsunamis can travel across an entire ocean basin, or they can be local. Tsunamis are characterized by their length, speed, low period, and low observable amplitude: the waves can be up to 200 km (125 mi) long from one crest to the next, they travel in the deep ocean at speeds of up to 950 km/hr (600 mi/hr), and have periods of between 5 minutes and up to a few hours (with most tsunami periods ranging between 10 and 60 minutes). Their height in the open ocean is very small, a few meters at most, so they pass under ships and boats undetected (Garrison, 2002), but may pile up to heights of 30 m (100 ft) or more on entering shallow water along an exposed coast, where they can cause substantial damage. The highest elevation that the water reaches as it runs up on the land is referred to as wave runup, uprush, or inundation height (McCulloch, 1985; Synolakis et al., 2002). Inundation refers to the horizontal distance that a tsunami wave penetrates inland (Synolakis et al., 2002).

Earthquake-generated tsunamis have been studied more extensively than any other type. Researchers have found that there is a correlation between the depth and size of the earthquake and the size of the associated tsunami: the larger the earthquake and the shallower its epicenter, the larger the resulting tsunami (Imamura, 1949; Iida, 1963, as reported in McCulloch, 1985). The size of the tsunami is also related to the volume of displaced sea floor (Iida, 1963). Because of the substantial increase in population in the last century and extensive development along the world's coastlines, a large percentage of the Earth's inhabitants live near the ocean. As a result, the risk of loss of life and property damage due to tsunami has increased substantially. Between 1992 and 2002, tsunamis were responsible for over 4,000 human deaths worldwide (Synolakis et al., 2002). Then, on December 26, 2004, a magnitude 9.3 earthquake off the northwest coast of Sumatra, Indonesia caused tsunamis in the Indian Ocean that resulted in more than 184,000 confirmed fatalities in the region, with another nearly 170,000 missing, and presumed killed, in Indonesia alone. The earthquake and resulting tsunamis also displaced nearly 1.7 million people in ten countries in South Asia and East Africa, making it the most devastating natural event in recorded history, and increasing overnight the worldwide awareness of tsunamis as a potentially devastating natural hazard. Hundreds of tourists that did not know about evacuating to higher ground were killed by the tsunamis. More recently, the September 29, 2009 earthquake and tsunami sequence in Samoa killed 189 people, and the February 27, 2010 earthquake in Chile also generated several tsunami waves. The damage from the 2010 Chilean tsunami has not been tallied yet.

Given Menifee's inland location, the tsunami hazard in the city is nil.

1.8 Vulnerability of Structures to Earthquake Damage

Although it is not possible to prevent earthquakes from occurring, their destructive effects can be minimized, especially since most of the loss of life and injuries due to an earthquake are related to the collapse of hazardous buildings and structures. [FEMA (1985) defines a hazardous building as "any inadequately earthquake resistant building, located in a seismically active area, that presents a potential for life loss or serious injury when a damaging earthquake occurs."]

Therefore, the vulnerability of a community to earthquake damage can be reduced with a comprehensive hazard mitigation program that includes the identification and mapping of hazards, prudent planning and enforcement of building codes, and expedient retrofitting and rehabilitation of weak structures.

As discussed previously, building codes have generally been made more stringent following damaging earthquakes. To mitigate for seismic shaking in new construction, recent building codes use amplification factors to account for the impacts that soft sediments and proximity to earthquake sources have on ground motion. Three main effects are considered: (1) soft soils, (2) proximity to earthquake sources (referred to as near-source factors), and (3) the seismic characteristics of the nearby earthquake sources (seismic source type). Each of these effects is discussed further below.

Soft-Soil Effects. The soft soil amplification factors were developed from observations made after the 1985 Mexico City, 1989 Loma Prieta and other earthquakes that showed the amplifying impact that underlying soil materials have on ground shaking. The ground-shaking basis for code design includes six soil types based on the average soil properties for the top 100 feet of the soil profile (see Table 1-3).

Table 1-3: Site Class Definitions (Based on Soil Profile Types) (from CBC, 2007)

Site Class	Soil Profile Name/ Generic Description	Average Soil Properties for the Upper 100 Feet		
		Shear Wave Velocity (feet/second)	Standard Penetration Resistance (blows/foot)	Undrained Shear Strength (psf)
A	Hard Rock	>5,000	N/A	N/A
B	Rock	2,500 to 5,000	N/A	N/A
C	Very dense soil and soft rock	1,200 to 2,500	>50	>2,000
D	Stiff soil profile	600 to 1,200	15 to 50	1,000 to 2,000
E	Soft soil profile	<600	<15	<1,000
	Any profile with more than 10 feet of soil having the following characteristics: 1. Plasticity index PI > 20 2. Moisture Content w>= 40%, and 3. Undrained shear strength < 500 psf			
F	Any profile containing soil having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays, where the thickness of this section is more than 10 feet. 3. Very high plasticity clays (more than 25 feet of clay with plasticity index PI > 75). 4. Very thick soft/medium stiff clays (thickness of the soil > 120 feet).			

From Table 1613.5.2 of the 2007 California Building Code
Psf = pounds per square foot

Youthful, unconsolidated alluvial sediments that can be designated as a site class type E soil profile underlie portions of the valleys in the Menifee General Plan area, but the thickness of these units varies across the valleys. Denser soils more characteristic of the class type D profile are also present throughout the region, in areas underlain by older sedimentary deposits. Even denser soil profiles, described as rock or hard rock occur in the hillsides (see Plate 2-2a). Given the irregular bedrock surface underlying many of the valleys in this region, the average soil properties for the upper 100-feet, and therefore the site class most applicable to the design of a specific project, need to be determined with site-specific studies designed to characterize the shear wave velocity and undrained shear strength of the soil column.

Near- Source Factors. The Menifee area is subject to near-source design factors given that there are two active faults within 15 km of the city, the San Jacinto fault and the Elsinore fault (see Table 1-2). These parameters, which first appeared in the 1997 Uniform Building Code (UBC), address the proximity of potential earthquake sources (faults) to the site. These factors were present in earlier versions of the UBC for implementation into the design of seismically isolated structures, but are now included for all structures. The adoption into the 1997 code of all buildings in UBC seismic zone 4 is the result of observations of intense ground shaking at levels higher than expected near the fault ruptures at Northridge in 1994, and again one year later, in Kobe, Japan. The 1997 UBC also included a near-source factor that accounts for directivity of fault rupture. The direction of fault rupture was observed to play a significant role in distribution of ground shaking at Northridge and Kobe. For Northridge, much of the earthquake energy was released into the sparsely populated mountains north of the San Fernando Valley, while at Kobe, the rupture direction was aimed at the city and was a contributing factor in the extensive damage. However, the rupture direction of a given source cannot be predicted, and as a result, the UBC required a general increase in estimating ground shaking of about 20% to account for directivity.

Seismic Source Type. Near-source factors also include a classification of seismic sources based on slip rate and maximum magnitude potential. These parameters are used in the classification of three seismic source types (A, B and C) summarized on Table 1-4.

Table 1-4: Seismic Source Type

Seismic Source Type	Seismic Source Description	Seismic Source Definition	
		Maximum Moment Magnitude, M	Slip Rate, SR (mm/yr.)
A	Faults which are capable of producing large magnitude events and which have a high rate of seismicity.	$M \geq 7.0$ and	$SR \geq 5$
B	All faults other than Types A and C.		
C	Faults which are not capable of producing large magnitude earthquakes and which have a relatively low rate of seismic activity.	$M < 6.5$	$SR \leq 2$

Type A faults are highly active and capable of producing large magnitude events. Most segments of the San Andreas fault, for example, are classified as Type A. The Type A slip rate (>5 mm/yr) is common only to tectonic plate boundary faults. Type C seismic sources are considered not capable of producing large magnitude events such that their potential ground shaking effects can be ignored. Type B sources include most of the active faults in California and include all faults that are neither Type A nor C. The Type A faults closest to Menifee are the San Jacinto, Elsinore and San Andreas faults. Type B faults in the region include the Pinto Mountain, San Joaquin Hills, and Puente Hills faults (see Table 1-2) (Cao and others, 2003).

To establish near-source factors for any proposed project in the city of Menifee, one has to determine the shortest distance between the project and the known active faults in the region. The International Conference of Building Officials (ICBO) provided an Atlas of the location of known faults for California to accompany the 1997 UBC, although this map is now dated, and consultants should refer to more recent sources as well. The rules for measuring distance from a fault are provided by the 1997 UBC.

Building damage is commonly classified as either structural or non-structural. Structural damage impairs the building's support. This includes any vertical and lateral force-resisting systems, such as frames, walls, and columns. Non-structural damage does not affect the integrity of the structural support system, but includes such things as broken windows, collapsed or rotated chimneys, unbraced parapets that fall into the street, and fallen ceilings.

During an earthquake, buildings get thrown from side to side and up and down. Given the same acceleration, heavier buildings are subjected to higher forces than lightweight buildings. Damage occurs when structural members are overloaded, or when differential movements between different parts of the structure strain the structural components. Larger earthquakes and longer shaking duration tend to damage structures more. The level of damage can be predicted only in general terms, since no two buildings undergo the exact same motions, even in the same earthquake. Past earthquakes have shown, however, that some types of buildings are far more likely to fail than others. This section assesses the general earthquake vulnerability of structures and facilities common in the southern California area, including in Menifee. This analysis is based on past earthquake performance of similar types of buildings in the U.S. The effects of design earthquakes on particular structures within Menifee are beyond the scope of this study.

1.8.1 Unreinforced Masonry Buildings

Unreinforced masonry buildings (URMs) are prone to failure due to inadequate anchorage of the masonry walls to the roof and floor diaphragms, lack of steel reinforcing, the limited strength and ductility of the building materials, and sometimes, poor construction workmanship. Furthermore, as these buildings age, the bricks and mortar tend to deteriorate, making the buildings even weaker. As a result, the State Legislature passed Senate Bill 547, addressing the identification and seismic upgrade of URMs.

In response to the URM Law, all cities and counties in what the Building Code in effect at the time referred as Seismic Zone 4 were to conduct an inventory of their URMs, establish an URM loss-reduction program, and report their progress to the State by 1990. The Seismic Safety Commission has conducted updates to this inventory, more recently in 2003 and 2006.

Given that Menifee only recently became a city (in 2008), an inventory of URMs in the city does not exist. The Seismic Safety Commission’s database does not include any data for Menifee, or for any of the communities that together became part of the City of Menifee. Riverside County reported 4 URMs in its unincorporated area, but this figure seems to be significantly understated, especially since several of the cities surrounding Menifee have several URMs in their inventory. Specifically, Perris reported 17 URMs, San Jacinto reported 15 URMs, and Hemet reported 12 (CSSC, 2006). A review of historical data by DiscoveryWorks for the General Plan studies indicates that there are about 200 sites of archaeological significance in Menifee. This suggests that several of these could be URMs, consistent with the relatively high number of URMs (71) that the HazUS database reports for the eleven census tracts that cover most of the Menifee General Plan area (see Section 1.9).

1.8.2 Soft-Story Buildings

Of particular concern are soft-story buildings (buildings with a story, generally the first floor, lacking adequate strength or toughness due to too few shear walls). Residential units above glass-fronted stores, and buildings perched atop parking garages are common examples of soft-story buildings. Collapse of a soft story and "pancaking" of the remaining stories killed 16 people at the Northridge Meadows apartments during the 1994 Northridge earthquake (EERI, 1995). There are many other cases of soft-story collapses in past earthquakes. In response, the State encourages the identification and mitigation of seismic hazards associated with these types of potentially hazardous buildings, and others such as pre-1971 concrete tilt-ups, mobile homes, and pre-1940 homes. The City of Menifee should consider conducting an inventory of their soft-stories, and encouraging the structural retrofit of these structures so that they not collapse during an earthquake.

1.8.3 Wood-Frame Structures

The loss estimations conducted for this study (see Section 1.9) indicates that nearly 35% of wood-frame structures in Menifee are expected to experience slight to extensive damage as a result of ground shaking caused by an earthquake on the San Jacinto fault. Similar levels of damage can be expected if the Elsinore fault causes an earthquake near the city.

Structural damage to wood-frame structures often results from an inadequate connection between the superstructure and the foundation. These buildings may slide off their foundations, with consequent damage to plumbing and electrical connections. Unreinforced masonry chimneys may also collapse. These types of damage are generally not life threatening, although they may be costly to repair. Wood frame buildings with stud walls generally perform well during an earthquake, unless they have no foundation or have a weak foundation constructed of unreinforced masonry or poorly reinforced concrete. In these cases, damage is generally limited to cracking of the stucco, which dissipates much of the earthquake's induced energy. The collapse of wood frame structures, if it happens, generally does not generate heavy debris, but rather, the wood and plaster debris can be cut or broken into smaller pieces by hand-held equipment and removed by hand in order to reach victims (FEMA, 1985).

1.8.4 Pre-Cast Concrete Structures

Partial or total collapse of buildings where the floors, walls and roofs fail as large intact units, such as large pre-cast concrete panels, cause the greatest loss of life and difficulty in victim rescue and extrication (FEMA, 1985). These types of buildings are common not only in southern California, but abroad. Casualties as a result of collapse of these structures in past earthquakes, including Mexico (1985), Armenia (1988), Nicaragua (1972), El Salvador (1986 and 2001), the Philippines (1990), Turkey (1999) and China (2008) add to hundreds of thousands. In southern California, many of the parking structures that failed during the Northridge earthquake, such as the Cal-State Northridge and City of

Glendale Civic Center parking structures, consisted of pre-cast concrete components (EERI, 1995).

Collapse of this type of structure generates heavy debris, and removal of this debris requires the use of heavy mechanical equipment. Consequently, the location and extrication of victims trapped under the rubble is generally a slow and dangerous process. Extrication of trapped victims within the first 24 hours after the earthquake becomes critical for survival. In most instances, however, post-earthquake planning fails to quickly procure the equipment needed to move heavy debris. The establishment of Heavy Urban Search and Rescue teams, as recommended by FEMA (1985), has improved victim extrication and survivability. Buildings that are more likely to fail and generate heavy debris need to be identified, so that appropriate mitigation and planning procedures are defined prior to an earthquake.

1.8.5 Tilt-up Buildings

Tilt-up buildings have concrete wall panels, often cast on the ground, or fabricated off-site and trucked in, which are then tilted upward into their final position. Connections and anchors have pulled out of walls during earthquakes, causing the floors or roofs to collapse. A high rate of failure was observed for this type of construction in the 1971 San Fernando and 1987 Whittier Narrows earthquakes. Tilt-up buildings can also generate heavy debris.

1.8.6 Reinforced Concrete Frame Buildings

Reinforced concrete frame buildings, with or without reinforced infill walls, display low ductility. Earthquakes may cause shear failure (if there are large tie spacings in columns, or insufficient shear strength), column failure (due to inadequate rebar splices, inadequate reinforcing of beam-column joints, or insufficient tie anchorage), hinge deformation (due to lack of continuous beam reinforcement), and non-structural damage (due to the relatively low stiffness of the frame). A common type of failure observed following the Northridge earthquake was confined column collapse (EERI, 1995), where infilling between columns confined the length of the columns that could move laterally in the earthquake.

1.8.7 Multi-Story Steel Frame Buildings

Multi-story steel frame buildings generally have concrete floor slabs. However, these buildings are less likely to collapse than concrete structures. Common damage to these types of buildings is generally non-structural, including collapsed exterior curtain wall (cladding), and damage to interior partitions and equipment. Overall, modern steel frame buildings have been expected to perform well in earthquakes, but the 1994 Northridge earthquake broke many welds in these buildings, a previously unanticipated problem.

Older, pre-1945 steel frame structures may have unreinforced masonry such as bricks, clay tiles and terra cotta tiles as cladding or infilling. Cladding in newer buildings may be glass, infill panels or pre-cast panels that may fail and generate a band of debris around the building exterior (with considerable threat to pedestrians in the streets below). Structural damage may occur if the structural members are subject to plastic deformation, which can cause permanent displacements. If some walls fail while others remain intact, torsion or soft-story problems may result.

1.8.8 Mobile Homes

Mobile homes are prefabricated housing units that are placed on isolated piers, jackstands, or masonry block foundations (usually without any positive anchorage). Floors and roofs of mobile homes are usually plywood, and outside surfaces are covered with sheet metal. Mobile homes typically do not perform well in earthquakes. Severe damage occurs when they fall off their supports, severing utility lines and piercing the floor with jackstands. The results of the loss estimation analyses indicate that about 60% of the mobile homes in Menifee are likely to experience moderate to complete damage as a result of an earthquake on a local fault, and almost 81% will experience some damage, from slight to complete. This indicates that the seismic hazard in the area can be mitigated substantially if manufactured homes in the city are inspected and seismically retrofitted as needed.

1.8.9 Combination Types

Buildings are often a combination of steel, concrete, reinforced masonry and wood, with different structural systems on different floors or different sections of the building. Combination types that are potentially hazardous include: concrete frame buildings without special reinforcing, precast concrete and precast-composite buildings, steel frame or concrete frame buildings with unreinforced masonry walls, reinforced concrete wall buildings with no special detailing or reinforcement, large capacity buildings with long-span roof structures (such as theaters and auditoriums), large un-engineered wood-frame buildings, buildings with inadequately anchored exterior cladding and glazing, and buildings with poorly anchored parapets and appendages (FEMA, 1985). Additional types of potentially hazardous buildings may be recognized after future earthquakes.

In addition to building types, there are other factors associated with the design and construction of the buildings that also have an impact on the structures' vulnerability to strong ground shaking. Some of these conditions are discussed below:

Building Shape. A building's vertical and/or horizontal shape can also be important in determining its seismic vulnerability. Simple, symmetric buildings generally perform better than non-symmetric buildings. During an earthquake, non-symmetric buildings tend to twist, as well as shake. Wings on a building tend to act independently during an earthquake, resulting in differential movements and cracking. The geometry of the lateral load-resisting systems also matters. For example, buildings with one or two walls made mostly of glass, while the remaining walls are made of concrete or brick, are at risk. Asymmetry in the placement of bracing systems that provide a building with earthquake resistance can result in twisting or differential motions.

Pounding. Site-related seismic hazards may include the potential for neighboring buildings to "pound," or for one building to collapse onto a neighbor. Pounding occurs when there is little clearance between adjacent buildings, and the buildings "pound" against each other as they deflect during an earthquake. The effects of pounding can be especially damaging if the floors of the buildings are at different elevations, so that, for example, the floor of one building hits a supporting column of the other. Damage to a supporting column can result in partial or total building collapse.

1.9 Earthquake Scenarios and Loss Estimations

HazUS-MH™ is a standardized methodology for earthquake loss estimation based on a geographic information system (GIS). [HazUS-MH stands for Hazards United States – Multi-hazard.] A project of the National Institute of Building Sciences, funded by the Federal Emergency Management Agency (FEMA), HazUS is a powerful advance in mitigation strategies. The HazUS project developed guidelines and procedures to make standardized earthquake loss estimates at a regional scale. With standardization, estimates can be compared from region to region. HazUS is designed for use by state, regional and local governments in planning for earthquake loss mitigation, and emergency preparedness, response and recovery. HazUS addresses nearly all aspects of the built environment, and many different types of losses. The methodology has been tested against the experience of several past earthquakes, and against the judgment of experts. Subject to several limitations noted below, HazUS can produce results that are valid for the intended purposes.

Loss estimation is an invaluable tool, but it must be used with discretion. Loss estimation analyzes casualties, damage and economic loss in great detail. It produces seemingly precise numbers that can be easily misinterpreted. Loss estimation results, for example, may cite 454 left homeless by a scenario earthquake. This is best interpreted by its magnitude. That is, an event that leaves 400 people homeless is clearly more manageable than an event causing 4,000 homeless people; and an event that leaves 40,000 homeless will most likely overwhelm the region's resources. However, another loss estimation analysis that predicts 500 people homeless should be considered equivalent to the 454 result. Because HazUS results make use of a great number of parameters and data of varying accuracy and completeness, it is not possible to assign quantitative error bars. Although the numbers should not be taken at face value, they are not rounded or edited because detailed evaluation of individual components of the disaster can help mitigation agencies ensure that they have considered all the important variables.

The more community-specific the data that are input to HazUS, the more reliable the loss estimation. HazUS provides defaults for all required information. These are based on best-available scientific, engineering, census and economic knowledge. The loss estimations in this report have been tailored to the Menifee General Plan area by including the more recent Riverside County HazUS data obtained as part of a project that developed a more detailed inventory of structures and essential facilities for Riverside, San Bernardino and Orange counties (H. Seligson and MMI Engineering, 2008). The revised inventory includes structure-specific information, including structural type, age and thus seismic design level (e.g., high, moderate, low, or pre-code), height, occupancy, and building replacement cost, among other variables, as provided by the owners of the structures. The HazUS analyses presented here also considered the soil types that underlie the city, and modifications to the population count, as described further below.

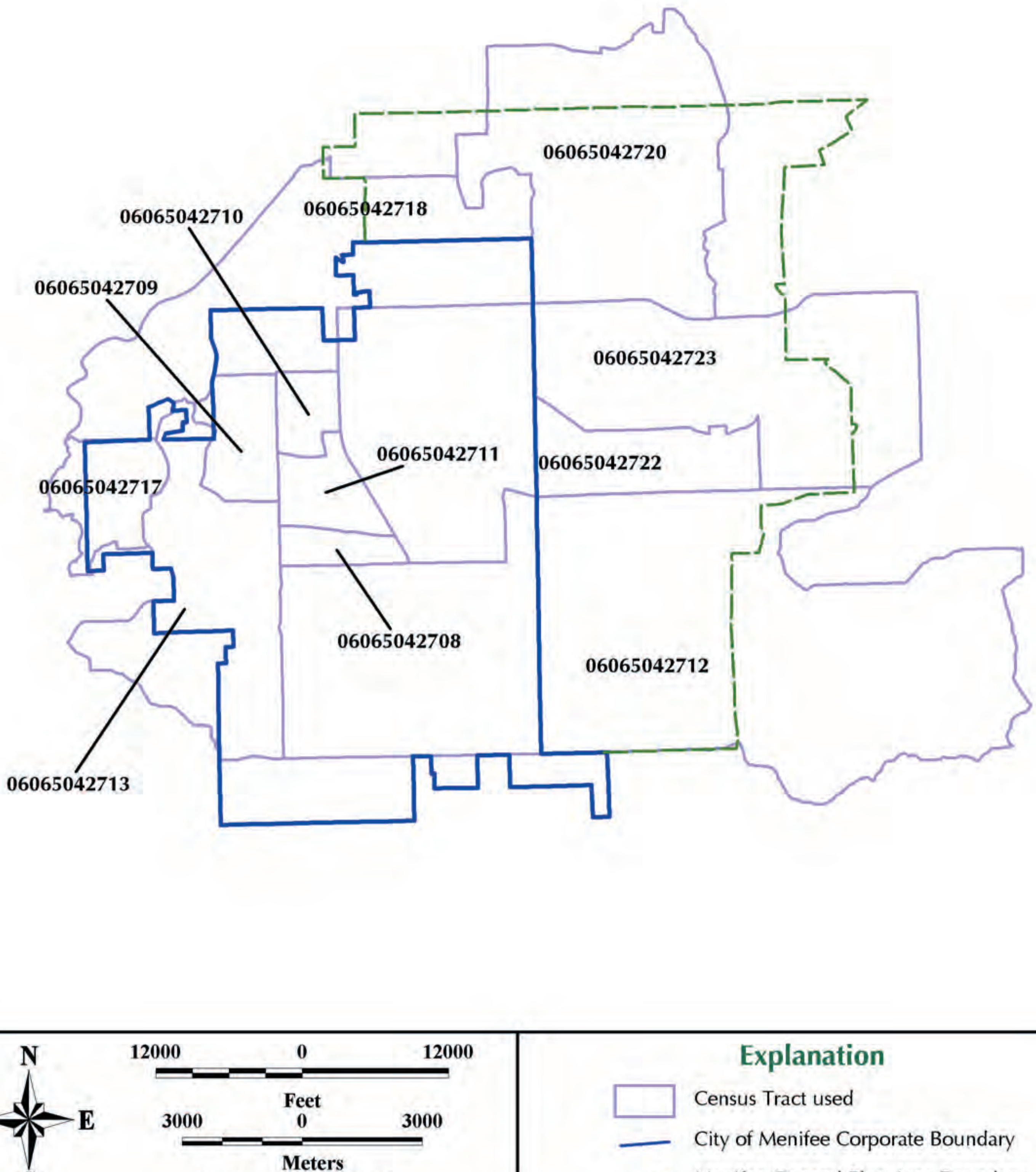
HazUS relies on census data, which are reported by geographical areas or tracts. Unfortunately, census tracts often do not correlate well with city boundaries, especially in areas with low population densities. This is certainly the case for Menifee, where eleven census tracts cover the General Plan area but extend farther beyond, for a total area of nearly 114 square miles (see Figure 1-6). Population counts were modified from those provided in the HazUS database (that date to the census of 2000) to acknowledge the significant growth that this area has experienced in recent years. Essentially, the HazUS census data available is about 7,700 people short of the 60,000 residents reported by the City (http://www.cityofmenifee.com/demographics.html). To resolve this difference, we distributed about 7,700 more people through the 11 census tracts considered in the analysis according to each tract's original percentage of the total population (thus, a tract with 10% of the total original population was assigned a new population number equal to the original count plus 10% of 7,700). Although not perfect, this method recognizes that growth has most likely not been uniform across the region.

As useful as HazUS can be, the loss estimation methodology has some inherent uncertainties. These arise, in part, from incomplete scientific knowledge concerning earthquakes and their effect upon buildings and facilities, and from the approximations and simplifications necessary for comprehensive analyses. Users should be aware of the following specific limitations:

- HazUS is driven by statistics, and thus is most accurate when applied to a region, or a class of buildings or facilities. It is least accurate when considering a particular site, building or facility.
- Losses estimated for lifelines may be less than losses estimated for the general building stock.
- Losses from smaller (less than M 6) earthquakes may be overestimated.
- Pilot and calibration studies have not yet provided an adequate test concerning the possible extent and effects of landsliding (although this is not a concern in most of the developed area of Menifee, and where there are slopes, rockfall is a more likely concern than landsliding).
- The indirect economic loss module is still experimental. While output from pilot studies has generally been credible, this module requires further testing.
- The databases that HazUS draws from to make its estimates are often incomplete or as mentioned above, either do not match the boundaries of the desired study area, or are no longer representative of current conditions. In the case of Menifee, we made adjustments to the population counts in the HazUS database to approximate the current population numbers.

Essential facilities and lifeline inventory are located by latitude and longitude. However, the HazUS inventory data for lifelines and utilities were developed at a national level and where specific data are lacking, statistical estimations are utilized. Specifics about the site-specific inventory data used in the models are discussed further in the paragraphs below. Other site-specific data used include soil types. The user then defines the earthquake scenario to be modeled, including the magnitude of the earthquake, and the location of the epicenter. Once all these data are input, the software calculates the loss estimates for each scenario (see Figure 1-7).

The loss estimates include physical damage to buildings of different construction and occupancy types, damage to essential facilities and lifelines, number of after-earthquake fires and damage due to fire. The model also estimates the direct economic and social losses, including casualties and fatalities for three different times of the day, the number of people left homeless and number of people that will require shelter, number of hospital beds available, and the economic losses due to damage to the places of businesses, loss of inventory, and (to some degree) loss of jobs.



Scale: 1:144,000

Explanation

Census Tract used

City of Menifee Corporate Boundary

Menifee General Plan Area Boundary

Earth Consultants International

Project Number: 2917
Date: 2010

Census Tract Boundaries

Used in HazUS Analyses

Figure 1-6

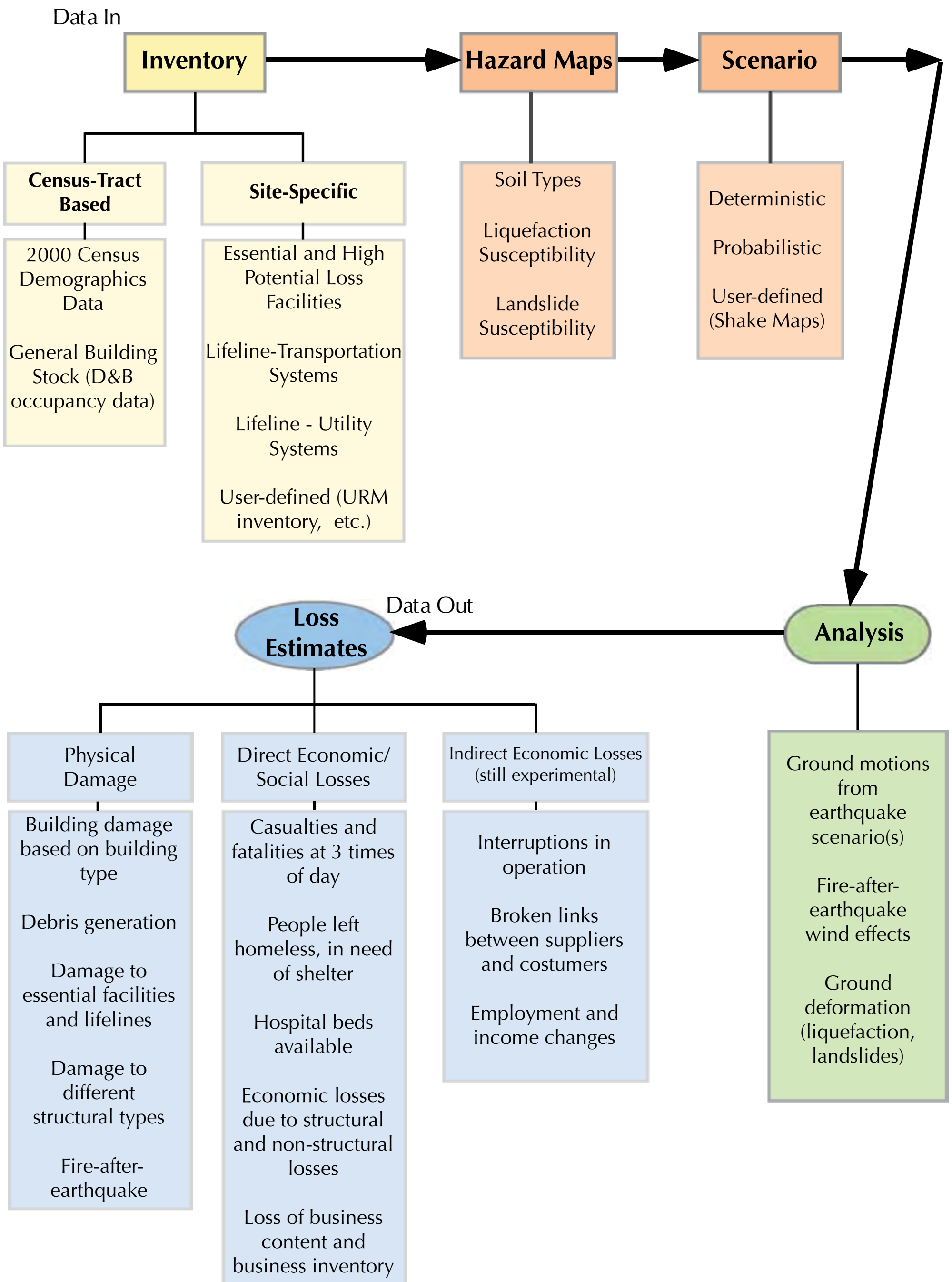
The indirect economic losses component is still experimental; the calculations in the software are checked against actual past earthquakes, such as the 1989 Loma Prieta and 1994 Northridge earthquakes, but indirect losses are hard to measure, and it typically takes years before these monetary losses can be quantified with any degree of accuracy.

Two specific earthquake scenarios were modeled: an earthquake on the southern San Andreas fault rupturing the Mojave, San Bernardino and Coachella Valley segments of the fault (the ShakeOut scenario prepared by the U.S. Geological Survey in the Fall of 2008 – see the ShakeMap for this scenario in Figure 1-4), and an earthquake on the San Jacinto Valley segment of the San Jacinto fault originating just northeast of Menifee. Specifics about each of these earthquake-producing faults were provided in Section 1.4 above, and in Table 1-5 below.

Table 1-5: HazUS Earthquake Scenarios for the City of Menifee

Fault Source	Magnitude	Description
Southern San Andreas	7.8	A large earthquake that ruptures the entire southern San Andreas fault using the USGS ShakeOut scenario. This earthquake was modeled because of its high probability of occurrence, and because it is considered the worst-case scenario for southern California, although, as the results included herein show, this earthquake is definitely not the worst-case scenario for the Menifee region.
San Jacinto Valley Segment of San Jacinto Fault	6.9	Lower probability but high-risk earthquake event. The HazUS results indicate that this earthquake scenario has the potential to cause significant damage in Menifee. A similar earthquake on the Elsinore fault to the west is anticipated to cause damage in Menifee at levels comparable to the earthquake on the San Jacinto fault.

Of the two earthquake scenarios modeled for the city, the results indicate that a M_w 6.9 earthquake on the San Jacinto fault has the potential to cause far more damage in Menifee than a larger, but more distant earthquake on the San Andreas fault. Specifics regarding the anticipated damage as a result of these two earthquake sources are summarized in the sub-sections below. An earthquake on the Elsinore fault, with its epicenter about 6 miles west of the city at its closest approach, is expected to yield losses similar to those caused by an earthquake on the San Jacinto fault.



Earth Consultants International

Project Number: 2917
Date: 2010

Generalized Flow Chart Summarizing the HazUS Methodology

Figure 1-7

1.9.1 Building Damage

HazUS provides damage data for buildings based on these structural types:

- Concrete
- Manufactured Housing (Trailers and Mobile Homes)
- Precast Concrete
- Reinforced Masonry Bearing Walls
- Steel
- Unreinforced Masonry Bearing Walls
- Wood Frame

and based on these occupancy (usage) classifications:

- Agricultural
- Commercial
- Education
- Government
- Industrial
- Other Residential
- Religion
- Single Family

Loss estimation for the general building stock is averaged for each census tract. Building damage classifications range from slight to complete. As an example, the building damage classification for light, wood frame buildings, the most numerous building type in the City, is provided below.

- <u>Slight Structural Damage</u>: Small cracks in the plaster or gypsum-board at corners of door and window openings and wall-ceiling intersections; small cracks in masonry chimneys and masonry veneer.
- <u>Moderate Structural Damage</u>: Large cracks in the plaster or gypsum-board at corners of door and window openings; small diagonal cracks across shear wall panels exhibited by small cracks in stucco and gypsum wall panels; large cracks in brick chimneys; toppling of tall masonry chimneys.
- <u>Extensive Structural Damage</u>: Large diagonal cracks across shear wall panels or large cracks at plywood joints; permanent lateral movement of floors and roof; toppling of most brick chimneys; cracks in foundations; splitting of wood sill plates and/or slippage of structure over foundations; partial collapse of "room-over-garage" or other "soft-story" configurations; small foundation cracks.
- <u>Complete Structural Damage</u>: Structure may have large permanent lateral displacement, may collapse, or be in imminent danger of collapse due to cripple wall failure or failure of the lateral load resisting system; some structures may slip

and fall off their foundations; or develop large foundation cracks.

The HazUS database includes more than 36,700 buildings in the region, with a total building replacement value (excluding contents) of $6,393 million. Approximately 95% of the buildings considered in the analysis (and 87% of the building value) are associated with residential housing. In terms of building construction types found in the region, wood-frame construction makes up approximately 67% of the building inventory, and manufactured housing comprises another 28%. The remaining about 4% is distributed between the other general building types.

Estimates of building damage are provided for "High," "Moderate" and "Low" seismic design criteria. Buildings of newer construction (e.g., post-1973) are best designated by "high." Buildings built after 1940, but before 1973, are best represented by "moderate" criteria. If built before about 1940 (i.e., before significant seismic codes were implemented), "low" is most appropriate. The building inventory for the eleven census tracts considered indicates that less than 1% of the housing units were built before 1940. About 19% of the building units were built between 1940 and 1969; and more than 69% of the units were built after 1980. The remaining about 22% of the units were built in the decade between 1970 and 1979. Therefore, most of the housing stock in Menifee can be described as in the “high” category for seismic design criteria.

The HazUS inventory of unreinforced masonry (URM) buildings in the study area includes 71 structures. Because there is no published survey of URMs available for Menifee, this number could not be corroborated. However, DiscoveryWorks (personal communication), in doing the archaeological survey for the General Plan, has indicated that there are nearly 200 structures of archaeological significance in Menifee. This suggests that the number of URMs in the General Plan area contained in the HazUS database is approximately correct. The City should conduct a survey of URMs in its jurisdiction and provide these data to the California Seismic Commission. The actual number of URMs in the area should be used in future HazUS analyses, possibly when this document is updated.

The HazUS models estimate that between 884 and 8,227 buildings will be at least moderately damaged in response to the earthquake scenarios presented herein, with the lower number representative of damage as a result of an earthquake on the San Andreas fault, and the higher number representing damage as a result of an earthquake on the San Jacinto fault. These figures represent about 2.4 and 22.4 percent, respectively, of the total number of buildings in the region considered in the analysis. Table 1-6 summarizes the expected damage to buildings by general occupancy type, whereas Table 1-7 summarizes the expected damage to buildings in the region, classified by construction type.

Although wood-frame buildings comprise the largest number of buildings in the area, and therefore one would expect that most of the buildings damaged would be wood-frame structures, the data show that the building type that will suffer the most damage is manufactured housing. An earthquake on the San Jacinto fault is anticipated to cause at least moderate damage to 1,611 wood-frame buildings, comprising about 6.5% of the total number of wood-frame buildings in the region, and to 6,199 manufactured homes, equal to more than 60% of the total number of manufactured homes in the study area. Similarly, an earthquake on the San Andreas fault is expected to cause at least moderate damage to less than 0.02% of the wood-frame buildings, but to more than 8% of the manufactured homes in the region. The other building types, by construction type, that are anticipated to suffer at least moderate damage as a result of an earthquake on the San Jacinto fault include steel (33.7%), unreinforced masonry (31%), precast (29%) and concrete (24%).

Table 1-6: Number of Buildings* Damaged, by Occupancy Type

Scenario	Occupancy Type	Slight	Moderate	Extensive	Complete	Total
San Andreas	Agriculture	21	9	3	0	33
	Commercial	28	6	1	0	35
	Education	8	1	0	0	9
	Government	0	0	0	0	0
	Industrial	13	5	1	0	19
	Other Residential	1,687	662	179	13	2,541
	Religion	2	1	0	0	3
	Single Family	413	3	0	0	416
	Total	**2,172**	**687**	**184**	**13**	**3,056**
San Jacinto	Agriculture	114	76	26	8	224
	Commercial	157	123	39	8	327
	Education	97	56	15	2	170
	Government	3	2	1	0	6
	Industrial	56	48	17	4	125
	Other Residential	2,188	3,365	2,188	657	8,399
	Religion	12	8	3	1	24
	Single Family	6,844	1,495	66	18	8,423
	Total	**9,471**	**5,174**	**2,354**	**699**	**17,698**

* Based on a total of 36,745 buildings in the region.

As a percentage of the building damage by occupancy type, the model estimates that more than 59% of the residential structures other than single-family homes (i.e., multi-family residential buildings, including duplexes, condominiums and apartments) will suffer at least moderate damage from an earthquake on the San Jacinto fault. More than 28% of the industrial structures, and 24% of the agricultural and commercial structures in the General Plan area will be at least moderately damaged by an earthquake on the San Jacinto fault. A large-magnitude earthquake on the San Andreas fault is expected to cause at least moderate damage to more than 8% of the residential structures other than single-family, and at least moderate damage to about 2.5%, 2.7% and 1% of the industrial, agricultural, and commercial structures, respectively, in the Hazus study area. The San Jacinto fault earthquake scenario is also anticipated to cause at least moderate damage to about 18% of the educational buildings in the region, whereas the San Andreas fault scenario is expected to cause at least moderate damage to less than 0.25% of the educational buildings.

Table 1-7: Number of Buildings* Damaged, by Construction Type

Scenario	Structure Type	Slight	Moderate	Extensive	Complete	Total
San Andreas	Wood	427	3	0	0	430
	Steel	27	16	4	0	47
	Concrete	10	2	0	0	12
	Precast	12	2	0	0	14
	Reinforced Masonry	8	1	0	0	9
	Unreinforced Masonry	5	1	0	0	6
	Manufactured Housing	1,683	662	180	13	2,538
	Total	**2,172**	**687**	**184**	**13**	**3,056**
San Jacinto	Wood	6,990	1,526	66	19	8,601
	Steel	89	92	35	12	228
	Concrete	62	42	16	4	124
	Precast	60	57	17	3	137
	Reinforced Masonry	109	89	26	2	226
	Unreinforced Masonry	18	15	5	2	40
	Manufactured Housing	2,142	3,354	2,188	657	8,341
	Total	**9,470**	**5,175**	**2,353**	**699**	**17,697**

* Based on a total of 36,745 buildings in the region.

1.9.2 Casualties

Casualties are estimated based on the observation that there is a strong correlation between building damage (both structural and non-structural) and the number and severity of casualties. In smaller earthquakes, non-structural damage, (such as toppled bookshelves and broken windows) is typically responsible for most of the casualties. In severe earthquakes where there is a large number of collapses and partial collapses, there is a proportionately larger number of fatalities. Data regarding earthquake-related injuries are, however, not of the best quality, nor are they available for all building types. Available data often have insufficient information about the type of structure in which the casualties occurred and the casualty-generating mechanism. HazUS casualty estimates are based on the injury classification scale described in Table 1-8.

In addition, HazUS produces casualty estimates for three times of day:

- Earthquake striking at 2:00 A.M. (population at home)
- Earthquake striking at 2:00 P.M. (population at work/school)
- Earthquake striking at 5:00 P.M. (commute time).

Table 1-8: Injury Classification Scale

Injury Severity Level	Injury Description
Severity 1	Injuries requiring basic medical aid without requiring hospitalization.
Severity 2	Injuries requiring a greater degree of medical care and hospitalization, but not expected to progress to a life-threatening status.
Severity 3	Injuries which pose an immediate life-threatening condition if not treated adequately and expeditiously. The majority of these injuries are the result of structural collapse and subsequent entrapment or impairment of the occupants.
Severity 4	Instantaneously killed or mortally injured.

Table 1-9 provides a summary of the casualties estimated for the earthquake scenarios considered. The analysis indicates that the worst time for an earthquake to occur in Menifee is during maximum residential occupancy loads, at 2 o'clock in the morning. Many Level 1 and Level 2 casualties are anticipated, most likely related to people running outside and in the process bumping into overturned furniture, walking barefoot on broken glass, and otherwise being hurt by non-structural elements, and by structural damage to residential structures and manufactured housing. Level 3 and Level 4 casualties are anticipated as a result of damage to residential structures other than single-family housing. An earthquake on the San Andreas fault during maximum residential occupancy loads is expected to cause a limited number of Level 1 injuries as a result of damage to residential structures other than single-family.

Casualty estimates as a result of an earthquake occurring either during peak commuting loads (at 5 o'clock in the afternoon) or peak educational, commercial and industrial loads (at 2 o'clock in the afternoon) are for all practical purposes identical. An earthquake on the San Jacinto fault during the day is anticipated to cause many Level 1 casualties due to damage to both commercial and residential structures. These numbers highlight the structural deficiencies anticipated in commercial and other-residential structures (over 24% of the commercial buildings, and nearly 60% of the other-residential structures, are expected to experience at least moderate damage during an earthquake on the San Jacinto fault). An earthquake on the San Andreas fault during the day is expected to cause only a small number of Level 1 casualties (see Table 1-9).

1.9.3 Damage to Critical and Essential Facilities

HazUS breaks critical facilities into two groups: (1) essential facilities, and (2) high potential loss (HPL) facilities. Essential facilities are those parts of a community's infrastructure that must remain operational after an earthquake. Buildings that house essential services include hospitals, emergency operation centers, fire and police stations, schools, and communication centers. HPL or high-risk facilities are those that if severely damaged, may result in a disaster far beyond the facilities themselves. Examples include power plants, dams and flood control structures, and industrial plants that use or store explosives, extremely hazardous materials or petroleum products in large quantities.

Table 1-9: Estimated Casualties*

Fault	Type and Time of Scenario		Level 1: Medical treatment without hospitalization	Level 2: Hospitalization but not life threatening	Level 3: Hospitalization and life threatening	Level 4: Fatalities due to scenario event
San Andreas Fault	2A.M. (max. residential occupancy)	Commercial	0	0	0	0
		Commuting	0	0	0	0
		Educational	0	0	0	0
		Hotels	0	0	0	0
		Industrial	0	0	0	0
		Other Residential	4	0	0	0
		Single-Family	0	0	0	0
		Total	**4**	**0**	**0**	**0**
	2 P.M. (max educational, industrial, and commercial)	Commercial	1	0	0	0
		Commuting	0	0	0	0
		Educational	0	0	0	0
		Hotels	0	0	0	0
		Industrial	0	0	0	0
		Other Residential	1	0	0	0
		Single-Family	0	0	0	0
		Total	**2**	**0**	**0**	**0**
	5 P.M. (peak commute time)	Commercial	1	0	0	0
		Commuting	0	0	0	0
		Educational	0	0	0	0
		Hotels	0	0	0	0
		Industrial	0	0	0	0
		Other Residential	1	0	0	0
		Single-Family	0	0	0	0
		Total	**2**	**0**	**0**	**0**
San Jacinto Fault	2A.M. (max. residential occupancy)	Commercial	0	0	0	0
		Commuting	0	0	0	0
		Educational	0	0	0	0
		Hotels	0	0	0	0
		Industrial	0	0	0	0
		Other Residential	78	16	1	1
		Single-Family	14	1	0	0
		Total	**92**	**17**	**1**	**1**
	2 P.M. (max educational, industrial, and commercial)	Commercial	16	4	0	1
		Commuting	0	0	0	0
		Educational	5	1	0	0
		Hotels	0	0	0	0
		Industrial	2	0	0	0
		Other Residential	23	5	1	1
		Single-Family	4	0	0	0
		Total	**49**	**10**	**1**	**2**
	5 P.M. (peak commute) time)	Commercial	15	3	0	1
		Commuting	0	0	1	0
		Educational	0	0	0	0
		Hotels	0	0	0	0
		Industrial	1	0	0	0
		Other Residential	28	6	0	0
		Single-Family	5	1	0	0
		Total	**49**	**10**	**1**	**1**

*Based on a population base of 59,986.

Other critical facilities not considered in the HazUS analysis but that should be considered in both emergency preparedness and emergency response operations given their potential impact on the community include: (1) High-occupancy facilities, such as high-rise buildings, large assembly facilities, and large multi-family residential complexes because of the potential for a large number of casualties or crowd-control problems; (2) dependent care facilities, such as preschools, schools, rehabilitation centers, prisons, group care homes, nursing homes, and other facilities that house populations with special evacuation considerations; and (3) economic facilities, such as banks, archiving and vital, record-keeping facilities, and large industrial or commercial centers, that should remain operational to avoid severe economic impacts.

In the census tracts used for the HazUS analysis, there is one hospital listed, the Menifee Valley Medical Center, located at 28400 McCall Boulevard, in Sun City. The Menifee Valley Medical Center is an acute care, full-service hospital with an 84-bed capacity that was founded in 1989. The other medical facility near, but outside the General Plan area, is the Hemet Valley Medical Center located at 1117 E. Devonshire Avenue, in Hemet. This 327-bed hospital was founded in 1943. Only the Menifee Valley Medical Center was considered in the Hazus analysis.

Other critical facilities in the HazUS database for Menifee include 404 school buildings, six fire stations (remember that the area used in the Hazus analysis extends beyond the General Plan area), zero police stations, and one emergency operations center (City Hall, at 29714 Haun Road). High potential loss facilities in the area include two dams, one hazardous materials site, zero military installations, and zero nuclear power plants. The Inland Empire gas turbine combined-cycle power plant located in Menifee started operation in 2008 and is not included in the HazUS database of high-loss potential facilities. One of the two dams (Eastside Reservoir) is classified as "high hazard." Critical facilities in the Menifee General Plan area are shown on Plate 1-4. Economic losses associated with those facilities in the HazUS database are computed as part of the analysis of the general building stock. The expected damage to the essential facilities is summarized in Table 1-10, below.

According to the earthquake scenario results, the San Andreas fault will not cause significant damage to any of the hospitals, school buildings, fire stations or the emergency operations center (EOC) in the area. All of these facilities are expected to be more than 50% functional one day after the earthquake.

The San Jacinto fault earthquake scenario is anticipated to impact some of the school buildings, with 3 buildings (out of a total of 404 in the area) experiencing more than 50% moderate damage. Furthermore, only 324 school buildings are expected to be more than 50% functional the day after the earthquake. This loss of functionality may be in great part related to non-structural damage, such as toppled bookshelves and computers, and loss of water and communications. All of the fire stations and the City's EOC are expected to be more than 50% functional on the day after the earthquake, but the local hospital will not be functioning at more than 50% capacity the day after. This is discussed further below.

NOTES:

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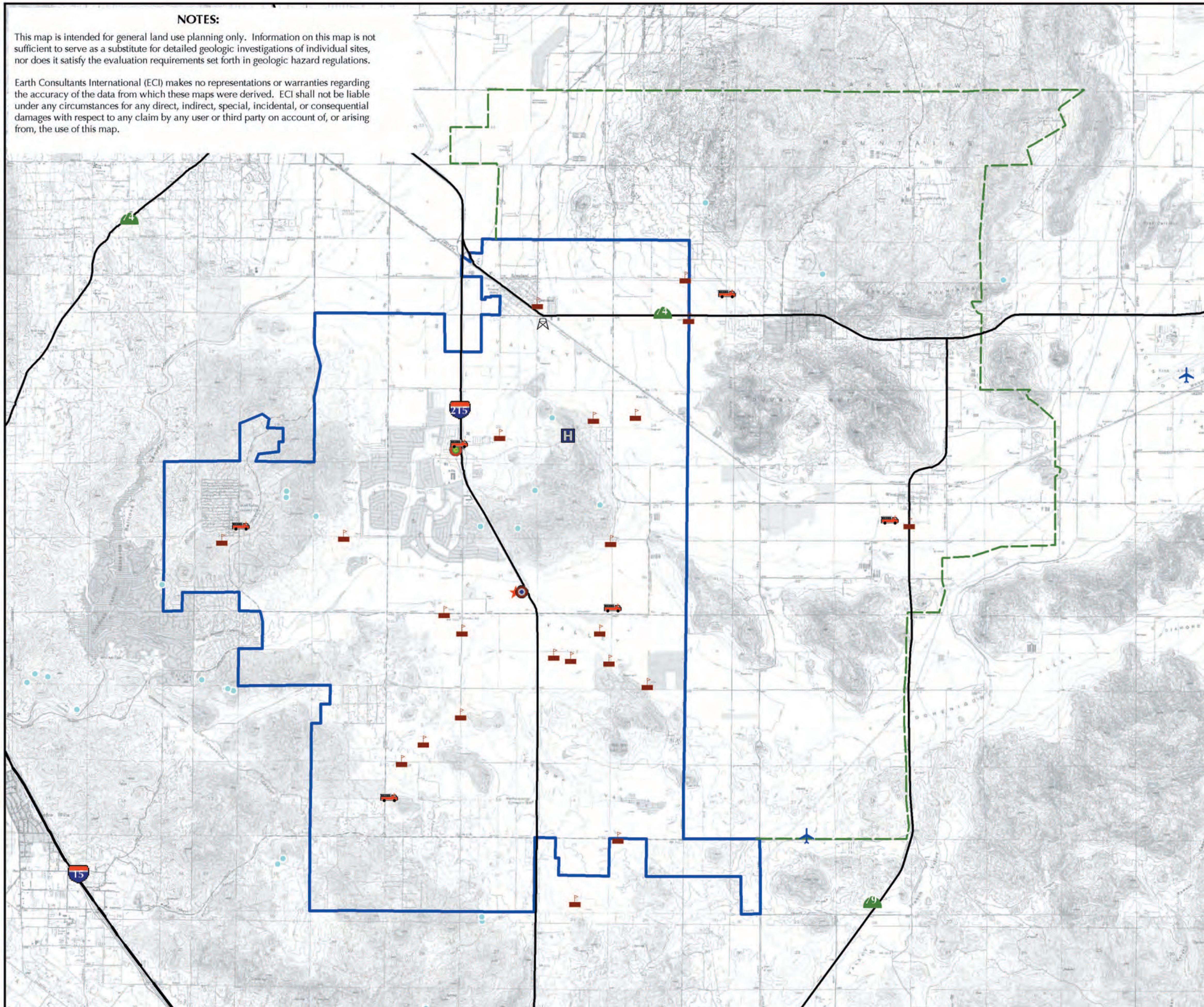

Critical Facilities Map

Menifee, California

Explanation

- City Hall
- Schools
- Fire Station
- Police Station
- Emergency Operations Center (City Hall)
- Emergency Operations Center (Alternate)
- Airport
- Reservoir
- Power Plant
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N S W E

0 7000 14000 Feet

0 2000 4000 Meters

Scale: 1:84,000

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: City of Menifee; Riverside County Fire Department; Menifee Union School District; Perris Union High School District; Hemet Unified School District

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Plate 1-4

Table 1-10: Expected Damage to Essential Facilities

Scenario	Classification	Total #	# Facilities		
			At Least Moderate Damage >50%	Complete Damage >50%	With Functionality >50% on Day 1
San Andreas Fault	Hospitals	1	0	0	1
	Schools	404	0	0	404
	EOCs	1	0	0	1
	Fire Stations	6	0	0	6
San Jacinto Fault	Hospitals	1	0	0	0
	Schools	404	3	0	324
	EOCs	1	0	0	1
	Fire Stations	6	0	0	6

The loss estimation model also calculates the total number (and percentage) of hospital beds in Menifee that will be available after each earthquake scenario. HazUS estimates how many hospital beds will be available for use by patients already in the hospital and those injured by the earthquake on the day of the earthquake, one week after the earthquake, and 30 days (1 month) after the earthquake. The results of this analysis are summarized below.

Table 1-11: Hospital Beds Available After the Earthquake Scenarios

Scenario	# of beds available on day of earthquake	# of beds available 1 week after earthquake	# of beds available 30 days after earthquake
San Andreas	73 (87%)	82 (98%)	84 (100%)
San Jacinto fault	27 (33%)	48 (58%)	79 (94%)

The Menifee Valley Medical Center is one of several regional hospitals. As discussed above, a much larger hospital is located in Hemet, and other hospitals are located in Perris, Moreno Valley, and Riverside. Given that about 60,000 people live in the Menifee area, the number of beds available (84 total) in the Menifee Valley Medical Center seems like too small a number to meet the medical demands of the community. Although the hospital is not expected to suffer at least moderate damage as a result of any of the two earthquake scenarios considered, it is expected to be less than 50% functional immediately after an earthquake on the San Jacinto fault, with only 33% (27) of its beds available the day after the earthquake. Estimates of the number of injured people in Menifee that will require hospitalization after an earthquake on the San Jacinto fault (about 17 maximum, if the earthquake occurs at night; see Table 1-9), suggest that the Menifee Valley Medical Center will be able to meet the demand for medical care if other nearby communities experience a similar, low number of casualties. However, some communities closer to the San Jacinto fault are likely to be impacted more severely, possibly as a result of older construction and stronger shaking, with a resultant higher number of damaged structures and casualties. Casualties from these communities may be evacuated to the Menifee Valley Medical Center and other nearby hospitals, straining the regional medical providers. Patients may have to be airlifted to other regional hospitals farther away from the epicenter. It is also important to mention that access to the hospital from communities on the east side of the San Jacinto fault could be difficult if the fault rupture damages the local roads, so that they become impassable to regular, low-clearance vehicles. The data indicate that there will not be any injuries requiring hospitalization as a result of an earthquake on the San Andreas fault. Thus the San Andreas earthquake scenario is not expected to place any additional demands on the local hospital.

1.9.4 Economic Losses

HazUS estimates structural and non-structural repair costs caused by building damage and the associated loss of building contents and business inventory. Building damage can cause additional losses by restricting the building's ability to function properly. Thus, business interruption and rental income losses are estimated. HazUS divides building losses into two categories: (1) direct building losses and (2) business interruption losses. Direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. Business interruption losses are associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

Earthquakes may produce indirect economic losses in sectors that do not sustain direct damage. All businesses are forward-linked (if they rely on regional customers to purchase their output) or backward-linked (if they rely on regional suppliers to provide their inputs) and are thus potentially vulnerable to interruptions in their operation. Note that indirect losses are not confined to immediate customers or suppliers of damaged enterprises. All of the successive rounds of customers of customers, and suppliers of suppliers are affected. In this way, even limited physical earthquake damage causes a chain reaction, or ripple effect, that is transmitted throughout the regional economy.

The model estimates that total economic losses in the Menifee area will range from about $18.7 million for an earthquake on the San Andreas fault, to more than $295 million for an earthquake on the San Jacinto fault. These figures include building-, transportation-, and lifeline-related losses based on the region's available inventory. Business-related losses include direct building losses (capital stock losses such as structural and non-structural damage, and damage to contents and inventory), and business interruption losses (loss of income from wages, rental properties, relocation expenses, and capital related). Building-related losses estimated for the two earthquake scenarios are summarized in Table 1-12 below. Transportation and utility lifeline losses are summarized in the following sections.

Direct building losses, excluding damage to contents and inventory, are estimated to account for 67 and 69 percent of the building-related economic losses in the Menifee region as a result of an earthquake on the San Andreas and San Jacinto faults, respectively. The loss analysis shows that residential occupancies would suffer the most, with a substantial amount of the property damage due to non-structural losses; that is, cosmetic damage to a structure that does not result in the collapse of the structure, and is repairable. This is essentially what building codes are designed to do. Business interruption losses account for about 11 to 13 percent of the losses in the region.

Table 1-12: Building-Related Economic Losses (in millions of $)
Estimated as a Result of Two Earthquake Scenarios

Scenario	Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
San Andreas	Income Losses	Wage	0.00	0.00	0.21	0.03	0.02	0.26
		Capital-Related	0.00	0.00	0.19	0.02	0.01	0.22
		Rental	0.02	0.13	0.07	0.01	0.00	0.24
		Relocation	0.01	1.06	0.08	0.04	0.08	1.27
		SubTotal	0.04	1.19	0.56	0.10	0.11	1.99
	Capital Stock Losses	Structural	0.43	1.11	0.11	0.12	0.33	2.11
		Non-Structural	4.93	3.29	0.88	0.42	0.96	10.47
		Content	2.32	0.55	0.54	0.25	0.33	3.99
		Inventory	0.00	0.00	0.01	0.06	0.03	0.11
		SubTotal	7.67	4.96	1.54	0.85	1.66	16.67
	Total		**7.71**	**6.15**	**2.10**	**0.95**	**1.76**	**18.66**
San Jacinto	Income Losses	Wage	0.00	0.42	3.25	0.21	0.54	4.43
		Capital-Related	0.00	0.18	2.95	0.13	0.22	3.48
		Rental	2.57	1.91	1.62	0.06	0.21	6.37
		Relocation	9.31	10.73	2.44	0.30	2.49	25.28
		SubTotal	11.88	13.24	10.26	0.69	3.47	39.55
	Capital Stock Losses	Structural	16.78	12.25	3.04	0.96	6.21	39.23
		Non-Structural	95.70	38.66	10.18	3.38	16.88	164.81
		Content	33.03	6.37	5.04	2.13	4.05	50.62
		Inventory	0.00	0.00	0.13	0.50	0.37	1.01
		SubTotal	145.50	57.29	18.39	6.97	27.51	255.66
	Total		**157.38**	**70.53**	**28.65**	**7.67**	**30.99**	**295.21**

1.9.5 Transportation Damage

Lifelines are those services that are critical to the health, safety and functioning of the community. They are particularly essential for emergency response and recovery after an earthquake. Furthermore, certain critical facilities designed to remain functional during and immediately after an earthquake may be able to provide only limited services if the lifelines they depend on are disrupted. Lifeline systems include transportation and utilities. Transportation systems are discussed in more detail in the following paragraphs, whereas utility lifelines are discussed further in the next section.

HazUS divides the transportation system into seven components: highways, railways, light rail, bus, ferry, ports, and airports. Only highways, railways, and airports are relevant to the area covered in the analysis for Menifee. The replacement value for the transportation system in the study area is estimated at nearly $588 million, with the highway segments ($525.5 million) and airport runways ($36.67 million) accounting for most of this value. The HazUS inventory for the study region includes over 91 kilometers (56.5 miles) of highways and 22 bridges. Major utilities and lifelines in the Menifee General Plan area are shown on Plate 1-5.

NOTES:

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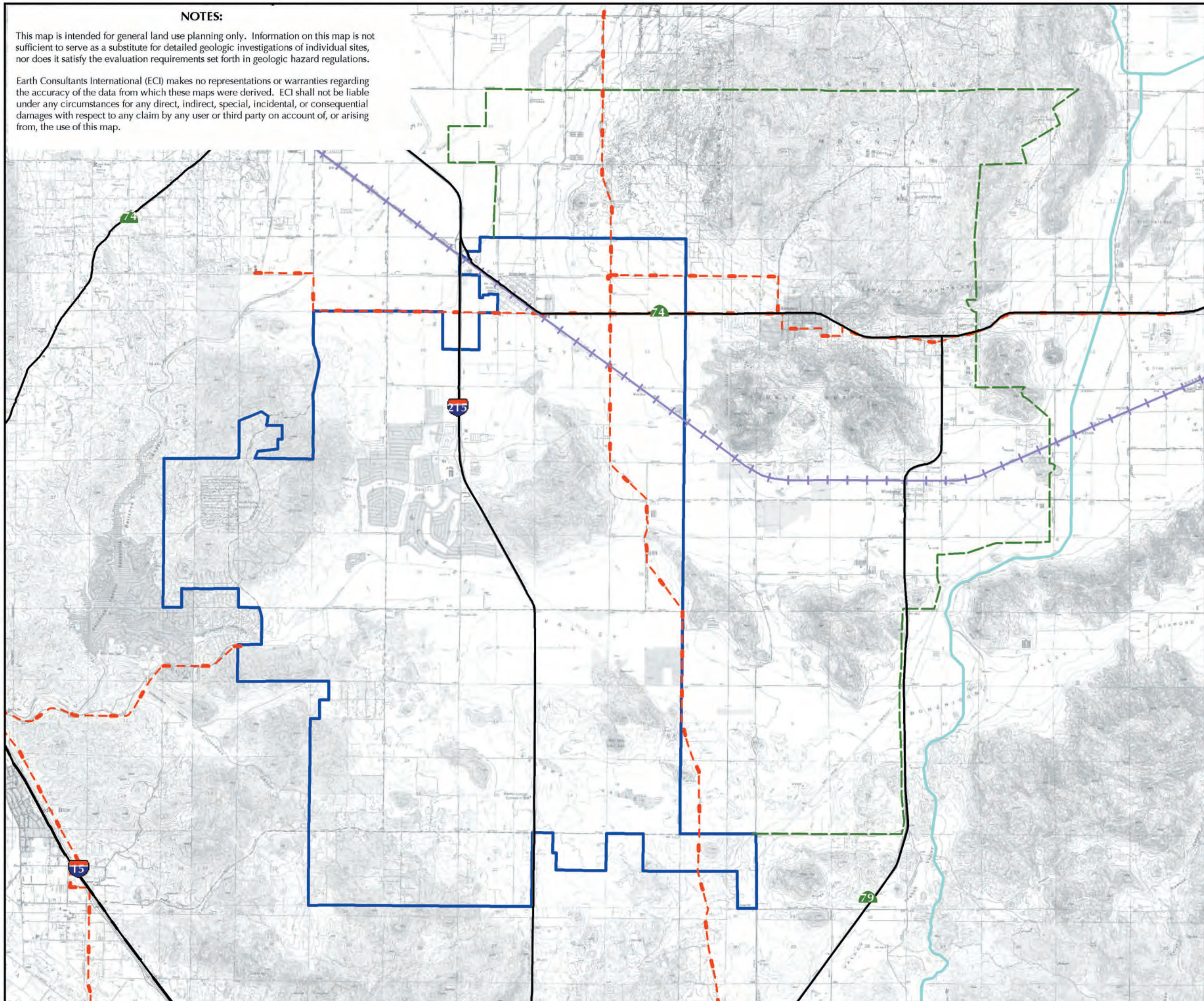

Major Utility and Lifelines Map

Menifee, California

Explanation

- Aqueduct
- Railroad
- Major Road
- Gas Transmission Pipeline
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N S W E

0 7000 14000 Feet

0 2000 4000 Meters

Scale: 1:84,000

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Data Source: Pipeline and Hazardous Materials Safety Administration, Topographic Map, and google.com

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Plate 1-5

Damage to the transportation system in Menifee is based on a generalized inventory of the region, which includes areas outside of the city, since the transportation network extends beyond corporate boundaries. Table 1-13 provides damage and loss estimates for specific components of the transportation system. The results of this analysis suggest that the transportation system in Menifee will not be impacted significantly by either of the earthquake scenarios considered. In fact, all of the components of the transportation system in Menifee are anticipated to be more than 50% functional on the day of either earthquake. Economic losses due to damage, albeit minor, to the transportation facilities would amount to between $0.46 and $2.2 million, with the lower figure associated with an earthquake on the San Andreas fault.

The model assumes that roadway segments and railroad tracks are damaged by ground failure only, but past earthquakes have shown that ground shaking can cause deformation to the ground surface, with resultant damage to the roadways. Therefore, the economic loss estimates for the highway system presented above may be low. It is also important to remember that these same transportation systems may be significantly impacted in areas outside of Menifee due to surface fault rupture, landsliding, liquefaction or other types of seismically induced ground deformation, which could directly and indirectly have an impact on Menifee's residents (especially those that commute) and businesses that rely on products shipped on these transportation systems.

Table 1-13: Transportation System – Expected Damage and Economic Losses

Scenario	System	Component	Locations/ Segments	With at Least Moderate Damage	With Complete Damage	Functionality >50%		Economic Loss (Millions $)
						After Day 1	*After Day 7*	
San Andreas	Highway	Segments	4	0	0	4	4	0.00
		Bridges	22	0	0	22	22	0.16
	Railways	Segments	3	0	0	3	3	0.00
	Airport	Facilities	1	0	0	1	1	0.26
		Runways	1	0	0	1	1	0.00
San Jacinto	Highway	Segments	4	0	0	4	4	0.00
		Bridges	22	0	0	22	22	0.80
	Railways	Segments	3	0	0	3	3	0.00
	Airport	Facilities	1	0	0	1	1	1.23
		Runways	1	0	0	1	1	0.00

1.9.6 Utility Systems Damage

Utility lifelines include potable water, wastewater, natural gas, crude and refined oil, electric power, and communications. The improved performance of lifelines in the 1994 Northridge earthquake relative to the 1971 San Fernando earthquake, shows that the seismic codes that were upgraded and implemented after 1971 have been effective. Nevertheless, the impact of the Northridge earthquake on lifeline systems was widespread and illustrated the continued need to study earthquake impacts, upgrade substandard elements in the systems, provide redundancies, improve emergency response plans, and provide adequate planning, budgeting and financing for seismic safety. Water supply facilities, such as dams, reservoirs, pumping stations, water treatment plants, and distribution lines are especially critical after an earthquake, not only for drinking water, but to fight fires. Possible failure of dams and above-ground water storage tanks as a result of an earthquake is discussed further in Chapter 3.

If site-specific lifeline utility data are not provided for these analyses, HazUS performs a statistical calculation based on the population served to develop an estimate of the total length of pipelines that comprise the potable water, natural gas, wastewater and oil systems. From this inventory, the model then calculates the expected number of leaks and breaks in these systems. The replacement value for the utility lifeline system in the Menifee study area is estimated at $118.3 million.

Table 1-14 summarizes the expected damage to the potable water, waste water, and natural gas systems in Menifee as a result of the earthquake scenarios on the San Andreas and San Jacinto faults. The models suggest that the potable water, waste water and natural gas systems in Menifee will experience slight and moderate damage as a result of an earthquake on the San Andreas and San Jacinto faults, respectively, with dozens of leaks and breaks anticipated in these systems, especially as a result of an earthquake on the San Jacinto fault. Where potable water lines extend across leach fields or occupy the same trench as sewer lines, breaks in these lines could result in contamination of the potable water supply.

Table 1-14: Expected Utility System Pipeline Damage

Scenario	System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks	Economic Loss ($Millions)
San Andreas	Potable Water	992	59	15	2.29
	Waste Water	595	47	12	0.21
	Natural Gas	397	50	13	0.23
San Jacinto	Potable Water	992	300	75	14.74
	Waste Water	595	237	59	1.07
	Natural Gas	397	254	63	1.14

Table 1-15 shows the expected performance of the potable water, and electric power systems using empirical relationships based on the number of households served in the area. According to the models, an earthquake on the San Andreas fault is not expected to have an impact on either the potable water or electric power services – all 20,800 households in the Menifee study area are expected to have both potable water and electric power following the San Andreas earthquake. The San Jacinto fault scenario has the potential to leave about 4,400 households in the Menifee area without potable water for at least one day, but by the third day, all households are expected to have water service. The electric power service is not expected to be disrupted by this earthquake, with all households anticipated to have service on the day after the earthquake. Given these results, Menifee residents should be strongly encouraged to store at least a three-day supply of drinking water for the entire household (including pets).

Table 1-15: Expected Performance of Potable Water and Electric Power Services

Scenario	Utility	Number of Households without Service*				
		Day 1	Day 3	Day 7	Day 30	Day 90
San Andreas	Potable Water	0	0	0	0	0
	Electric Power	0	0	0	0	0
San Jacinto	Potable Water	4,376	0	0	0	0
	Electric Power	0	0	0	0	0

*Based on Total Number of Households = 20,818

1.9.7 Shelter Needs

Earthquakes can cause loss of function or habitability of buildings that contain housing. Displaced households may need alternative short-term shelter, provided by family, friends, temporary rentals, or public shelters established by the City, County or by relief organizations such as the Red Cross. Long-term alternative housing may require import of mobile homes, occupancy of vacant units, net emigration from the impacted area, or, eventually, the repair or reconstruction of new public and private housing. The number of people seeking short-term public shelter is of most concern to emergency response organizations. The longer-term impacts on the housing stock are of great concern to local governments, such as cities and counties.

HazUS estimates that none of the households in Menifee will be displaced due to the San Andreas fault earthquake modeled for this study, and no one will seek temporary shelter in public shelters (see Table 1-16 below). An earthquake on the San Jacinto fault is anticipated to displace about 29 households, with approximately 23 people seeking temporary shelter in public shelters. The rest are expected to find alternate temporary housing with family or friends.

Table 1-16: Estimated Shelter Requirements

Scenario	Displaced Households	People Needing Short-Term Shelter
San Andreas fault	0	0
San Jacinto fault	23	29

1.10 Summary and Recommendations

Since it is not possible to prevent an earthquake from occurring, local governments, emergency relief organizations, and residents are advised to take action and develop and implement policies and programs aimed at reducing the effects of earthquakes. Individuals should also exercise prudent planning to provide for themselves and their families in the aftermath of an earthquake.

<u>Earthquake Sources:</u>

- There are no known earthquake sources within the Menifee General Plan area. However, the city is near (within 15 km or 9 miles) the San Jacinto and Elsinore faults. Both of these faults could generate an earthquake in the next 30 years. Therefore, proposed new developments in Menifee should incorporate near-source factors in the design of the structures.

- A number of historic earthquakes have caused moderate to strong ground shaking in Menifee. Strong ground shaking due to future earthquakes on nearby regional sources should be expected and designed for.

Design Earthquake Scenarios:

- Geologists, seismologists, engineers and urban planners typically use maximum magnitude and maximum probable earthquakes to evaluate the seismic hazard of a region, the assumption being that if we plan for the worst-case scenario, smaller earthquakes that are more likely to occur can be dealt with more effectively.

- The San Jacinto, Elsinore, and San Andreas faults have the potential to generate earthquakes that would be felt strongly in the Menifee region. Unfortunately, we cannot predict when a fault will break causing an earthquake, but we can anticipate the size of the resulting earthquake and estimate the level of damage that the earthquake would generate in the region. The segment of the San Jacinto fault closest to Menifee is though capable of generating a M 6.9 earthquake. Other segments of the fault could generate M 6.7 to M 7.2 earthquakes. Similarly, the sections of the Elsinore fault closest to Menifee are thought capable of generating earthquakes of M 6.8 to M 7.1. Depending on how many sections of the San Andreas fault rupture together, the region could experience a San Andreas fault earthquake of M 7.5 to M 8. Most other faults within 100 km (62 miles) of the city can generate earthquakes as large or larger than the M_w 6.7 Northridge earthquake, the single most-expensive earthquake yet to impact the United States.

- The loss estimation analyses conducted for this study indicate that the San Jacinto fault has the potential to be the worst-case scenario for Menifee, causing moderate to significant damage in the city. The Elsinore fault is considered to pose a similar hazard to Menifee. Although capable of generating a larger magnitude earthquake, the San Andreas fault is not expected to cause as much damage in the General Plan study area because it is farther away.

Fault Rupture and Secondary Earthquake Effects:

- No active faults have been mapped within the Menifee General Plan area.

- The California Geological Survey (CGS) has not conducted mapping in the Menifee area under the Seismic Hazards Mapping Act. This report presents a liquefaction susceptibility map that was prepared using a similar but simpler form of the method used by the California Geological Survey (geotechnical data providing density of the near-surface sediments were reviewed only locally). Studies in accordance with the guidelines prepared by the CGS should be conducted in those areas identified as susceptible to liquefaction, at least until sufficient studies have conclusively shown whether or not the sediments are indeed susceptible to liquefaction. Currently, shallow ground water levels (less than 30 feet from the ground surface) are known to occur in the Salt Creek and Warm Spring Creek floodplains, and along portions of the Paloma Valley. The shallow groundwater in the area seems to fluctuate in response to wet winters and irrigation. If in the future the Eastern Municipal Water District increases its dependence on imported water, and decreases pumping for ground water, this could result in an even higher groundwater table in the valleys. Development in the floodplains should be discouraged given the potential for storm-induced or dam-failure flooding, liquefaction, and other environmental concerns associated with the protection of riparian vegetation and fauna. However, in the event that infrastructure or other projects are proposed in these areas, liquefaction evaluation studies following the guidelines established by the CGS should be conducted and if liquefaction is found to be a hazard, mitigation measures should be implemented.

- Precariously perched rocks are common on the hillsides within and surrounding the Menifee General Plan area, especially in hillsides comprised of granitic rocks. Earthquake-induced ground shaking could dislodge some of the rocks, posing a rockfall hazard to areas adjacent to and below these slopes.

- Those areas of Menifee underlain by youthful unconsolidated alluvial sediments may be susceptible to seismically induced settlement. Geotechnical studies to evaluate this potential hazard should be conducted in areas underlain by Holocene sediments where developments are proposed. If the sediments are found to be susceptible to this hazard, mitigation measures designed to reduce settlement should be incorporated into the design.

Earthquake Hazard Reduction:

- Most of the loss of life and injuries that occur during an earthquake are related to the collapse of hazardous buildings and structures, or from non-structural components, including contents, in those buildings. The HazUS analyses conducted for this study indicate that more than 59% of the residential structures other than single-family homes (that is, multi-family residential buildings, including duplexes, condominiums and apartments) will suffer at least moderate damage as a result of an earthquake on the San Jacinto fault. More than 28% of the industrial structures, and 24% of the agricultural and commercial structures are also expected to be at least moderately damaged by a San Jacinto fault earthquake. Total economic losses in the Menifee area will range from about $18.7 million for a San Andreas fault earthquake, to more than $295 million for a San Jacinto fault earthquake.

- The HazUS results indicate that the worst time for an earthquake to occur on the San Jacinto fault is at night, when a large percentage of the population is at home. Most injuries will not require hospitalization, however.

- The regional hospital is expected to be able to meet the demand for medical care in the aftermath of an earthquake in the area.

- The inventory and retrofit of potentially hazardous structures, such as pre-1952 wood-frame buildings, concrete tilt-ups, pre 1971- reinforced masonry, soft-story buildings and especially mobile homes, are recommended.

- The best mitigation technique in earthquake hazard reduction is the constant improvement of building codes with the incorporation of the lessons learned from past earthquakes. This is especially true in areas not yet completely developed. In addition, current building codes should be adopted for re-development projects that involve more than 50% of the original cost of the structure. Current building codes incorporate two significant changes that impact the city of Menifee. First, there is recognition that soil types can have a significant impact on the amplification of seismic waves, and second, the proximity of earthquake sources will result in high ground motions and directivity effects. However, for those areas of Menifee already developed, and given that building codes are generally not retroactive, the adoption of the most recent building code is not going to improve the existing building stock, unless actions are taken to retrofit the existing structures. Retrofitting existing structures to the most current building code is in most cases cost-prohibitive and not practicable. However, specific retrofitting actions, even if not to the latest code, that are known to improve the seismic performance of structures should be attempted.

- While the earthquake hazard mitigation improvements associated with the latest building code address new construction, the retrofit and strengthening of existing structures requires the adoption of ordinances. The City of Menifee should consider the implementation of a mandatory ordinance aimed at retrofitting older wood-frame residential buildings that are not tied-down to their foundations, pre-cast concrete buildings, soft-story structures, and manufactured housing. Although retrofitted buildings may still incur severe damage during an earthquake, their mitigation results in a substantial reduction of casualties by preventing collapse.

- Adoption of new building codes does not mitigate local secondary earthquake hazards such as liquefaction and ground failure. Therefore, these issues are best mitigated at the local level. Avoiding areas susceptible to earthquake-induced liquefaction or settlement is generally not feasible. The best alternative for the City is to require “special studies” within these zones for new construction, as well as for significant redevelopment, and require implementation of the engineering recommendations for mitigation.

- Effective management of seismic hazards in Menifee includes technical review of consulting reports submitted to the City. For projects in areas susceptible to liquefaction, the City should consider following the State law that requires that the reviewer be a licensed engineering geologist and/or civil engineer having competence in the evaluation and mitigation of seismic hazards (CCR Title 14, Section 3724). Because of the interrelated nature of geology, seismology, and engineering, most projects will benefit from review by both the geologist and civil engineer. The California Geological Survey has published guidelines to assist reviewers in evaluating site-investigation reports (CDMG, 1997; CGS, 2008).

- The HazUS analyses suggest that the potable water, wastewater and electric systems in Menifee will be damaged by an earthquake on the San Jacinto fault, with hundreds of leaks and several dozens breaks anticipated. The City and its lifeline service providers should consider retrofitting the older pipelines in these systems, to reduce the number of potential breaks as a result of corrosion and age.

CHAPTER 2: GEOLOGIC HAZARDS

Geologic hazards are generally defined as surficial earth processes that have the potential to cause loss or harm to the community or the environment. The basic elements involved in the assessment of geologic hazards are: 1) underlying geology (including rock types; zones of weakness like faults, fractures, and bedding; groundwater, etc.), 2) overlying soils, 3) topography, 4) climate, and 5) land use. The geology and types of geologic hazards affecting the Menifee General Plan area are discussed in the following sections.

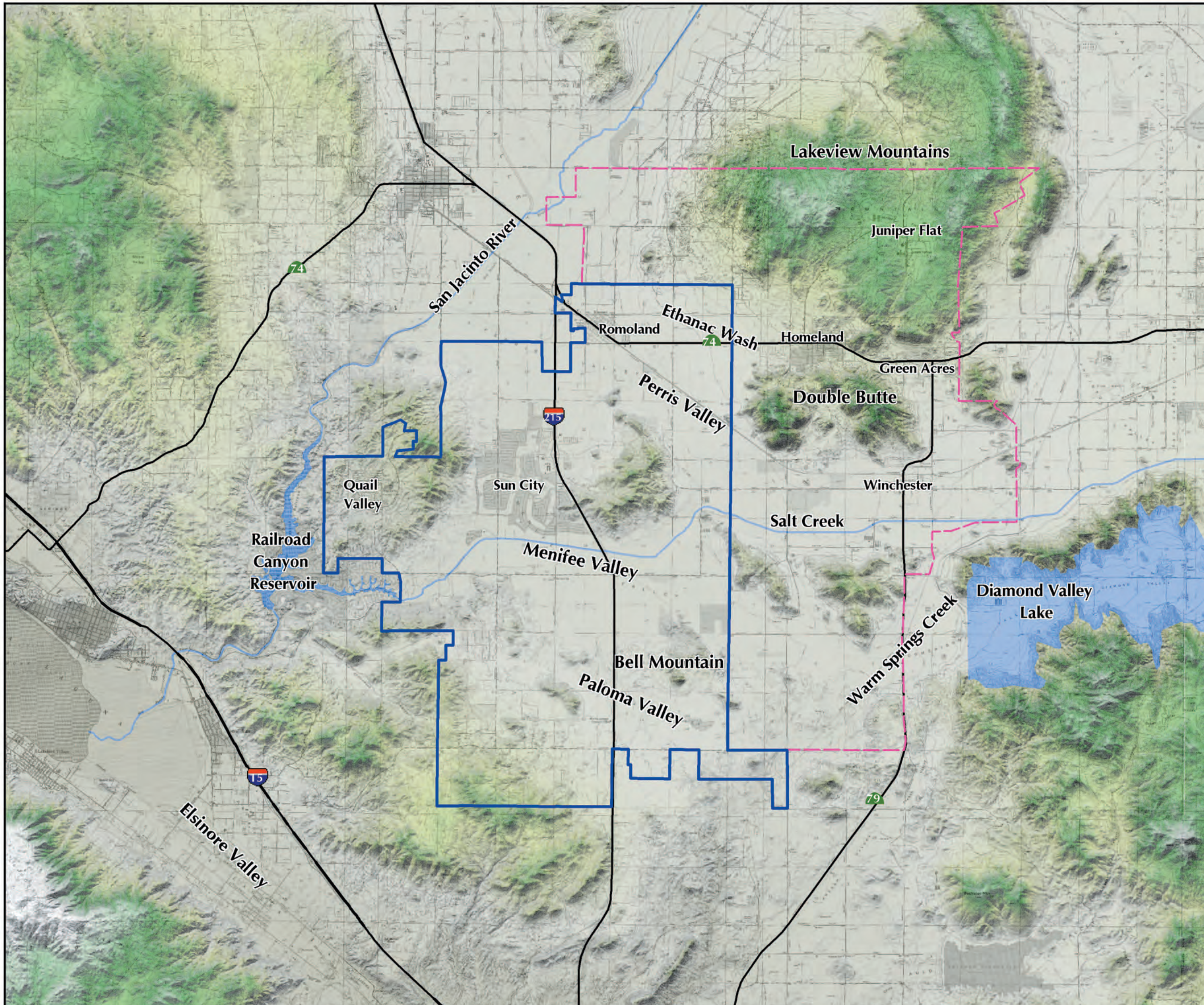
2.1 Physiographic Setting

Southern California is divided into distinct geomorphic provinces, that is, regions having their own unique physical characteristics formed by geologic, topographic, and climatic processes. Menifee lies in the northern part of the Peninsular Ranges, a province characterized by a northwest-trending geologic structural grain aligned with the San Andreas fault system. As a result, the Peninsular Ranges landscape is dominated by northwest-trending mountains and valleys stretching from Santa Monica south to the Baja Peninsula. The province is bounded by the San Andreas fault zone on the east, and extends offshore to the west. The northern, onshore part of the province is divided into three major fault-bounded blocks that are, from west to east, the Santa Ana Mountains block, the Perris block, and the San Jacinto Mountains block (Morton and Miller, 2006). The Perris block, where Menifee is located, is bounded by the Elsinore fault zone on the southwest and the San Jacinto fault zone on the northeast. In spite of being surrounded by active fault systems and growing mountain ranges, the Perris block is an area of lower relief that has remained relatively stable and undeformed for thousands of years.

Topographically, the General Plan area encompasses numerous brush-covered hills and low mountains surrounded by a series of interconnected, broad, nearly flat-bottomed valleys. The hills and mountains within the Menifee area are rugged and moderately steep, generally ranging in elevation from 1,500 feet to slightly more than 2,600 feet above mean sea level. The southwestern part of the city extends into a range of low mountains that border the Elsinore Valley and define the westerly edge of the Perris block. Plate 2-1 identifies some of the main physiographic features in the Menifee area.

Menifee is most densely populated in the central valleys. Rural and semi-rural residential development has spread out into valley and hillside areas in the northern, western, and southern areas of the city. Some of the prominent hills and ridgelines within and near the city are still largely undeveloped. Unpaved roads are common in the rural areas. Unincorporated areas within the General Plan include the communities of Juniper Flats, Green Acres, Homeland, and Winchester. These areas have a few densely populated neighborhoods, but for the most part are still largely rural or agricultural.

Menifee is also located within the Inland Empire, an area that has experienced rapid changes in the last few decades. In fact, this region, which includes San Bernardino and Riverside counties, has one of the fastest growing populations in California. Although much of the planned development in Menifee is concentrated on the valley floors, development in the hillsides is expected to grow as well. Future developments and the associated infrastructure will be increasingly impacted by natural hazards, unless coordinated mitigation measures are developed on both a regional and site-specific basis.



Physiographic Map of Menifee, California and Surrounding Areas

Explanation

Elevation Shading (feet)

1000 1500 2000 2500 3000

City of Menifee Corporate Boundary

Menifee General Plan Area Boundary

N S W E

Scale: 1:108,000

9000 0 9000
Feet

2 0 2 4
Kilometers

Base Map: USGS 30-meter Digital Elevation Model.
Source: CA Department of Water Resources and www.google.com

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Plate 2-1

Figure 2-1: Sun City Area of Menifee, Looking East, with Double Butte Mountain in the Background.

2.2 Geologic Setting

The physical features described above reflect geologic and climatic processes that have affected this region in the last few million years. The most striking feature is the contrast between the relatively low relief of the Perris block and the adjacent San Jacinto and Santa Ana Mountains – a direct result of movement along faults that have both elevated and down-dropped great blocks of the Earth's crust. In response, and aided by gravity, the uplifted mountains and hills are rapidly eroding (rapid in geologic time), shedding sand, silt and gravel, and forming multiple generations of overlapping alluvial fans that are filling the valleys. The alluvial fans of the Menifee area have a range of ages coincident with the rise of the nearby mountains (early Pleistocene to Holocene – approximately 1 million years to less than 11,000 years old). Deposition is still ongoing, with the youngest sediments filling the active drainage channels and floodplains. At depth, this sequence of alluvial sediments is underlain by crystalline rock similar to that exposed in the surrounding hills and mountains.

The physiography and geologic history of the Menifee area are important in that they control to a great extent the geologic hazards, as well as the natural resources, within the area. For example, the area receives great quantities of runoff from the nearby mountains during storms, leading to flooding problems within the developed areas. On the other hand, the deep, alluvium-filled basins, which are bounded by relatively impermeable rock, function as natural underground reservoirs (aquifers) for groundwater, an important component of Menifee's water supply.

2.3 Geologic Units and Their Engineering Properties

The general distribution of geologic units that are exposed at the surface is shown on the Geologic Map (Plates 2-2a and 2-2b). This map is a modified version of several geologic maps published for this area (Dibblee, 2003 a,b,c,d; Morton, 2004; Morton and Miller, 2006). In the sections that follow, the general physical and engineering characteristics of each unit, from youngest to oldest, are summarized using the descriptions derived from published maps and geotechnical consulting reports. The spatial distribution of geologic units with similar engineering characteristics is illustrated on Plates 2-3a and 2-3b.

2.3.1 Sedimentary Units in the Menifee General Plan Area

Sedimentary units in the Menifee area consist mainly of alluvial (water-transported) sand, silt, clay, and gravel derived from erosion of the adjacent hills and mountains. The youngest deposits also include reworked sediments eroded from older alluvium that is exposed at the surface. The various alluvial units and their estimated ages have been categorized by researchers primarily by noting the degree of soil development on the fan surface, stratigraphic position, degree of stream incision, relative uplift, and other physical characteristics. Most of these units do not have formal names, but they have been labeled with symbols that emphasize their age and mode of deposition. The younger sediments range in age from late Holocene to late Pleistocene (present day to approximately 15,000 years old). Older deposits, which for the most part have been buried by the younger deposits, range in age from late to early Pleistocene (approximately 15,000 to one million years old).

Young Surficial Deposits: Sediments Within Washes, Valleys, Fans, and Channels (Geologic Map Symbols: Qw, Qv, Qyf, and Qya).

Very young wash deposits **(Qw)** consist of unconsolidated sediments lining the active drainage courses. These deposits have been mapped only in the western part of the Salt Creek channel; however modern silt, sand, and gravel also occur in numerous small, unnamed channels, washes, and gullies that cut through the hills and fans in the area. These deposits have no pedogenic (soil) development on their surface, and may be reworked by floodwaters or buried by new sediment during storms. The upper reaches of the drainage channels, especially near the mountains, may contain large rocks deposited during flash floods.

Very young alluvial valley deposits **(Qv)** are represented in the Menifee area by fine-grained silt and clay deposited on the floodplain of the San Jacinto River. This unit is present in the northwestern corner of the General Plan area. The unit is so young that a soil has not formed on it, and its surface is subject to reworking and burial by new sediments when the river floods.

Young alluvial fan deposits **(Qyf)** are mapped locally on the south side of the Lakeview Mountains, in drainages near the head of older fans. These sediments are unconsolidated, lack pedogenic development, are undissected, and generally consist of poorly bedded silt, sand, and gravel.

Young alluvial valley and channel deposits **(Qya)** include unconsolidated sand and silt deposited in Salt Creek, the Paloma Valley drainages, and Warm Springs Creek.

NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

Fault lines on the map are used solely to approximate the fault location. The width and location of the faults should not be used in lieu of site-specific investigations, evaluation, and design.

Detailed geologic investigations, including trenching studies, may make it possible to refine the location and activity status of a fault. All faults may not be shown. This map should be amended as new data become available and are validated.

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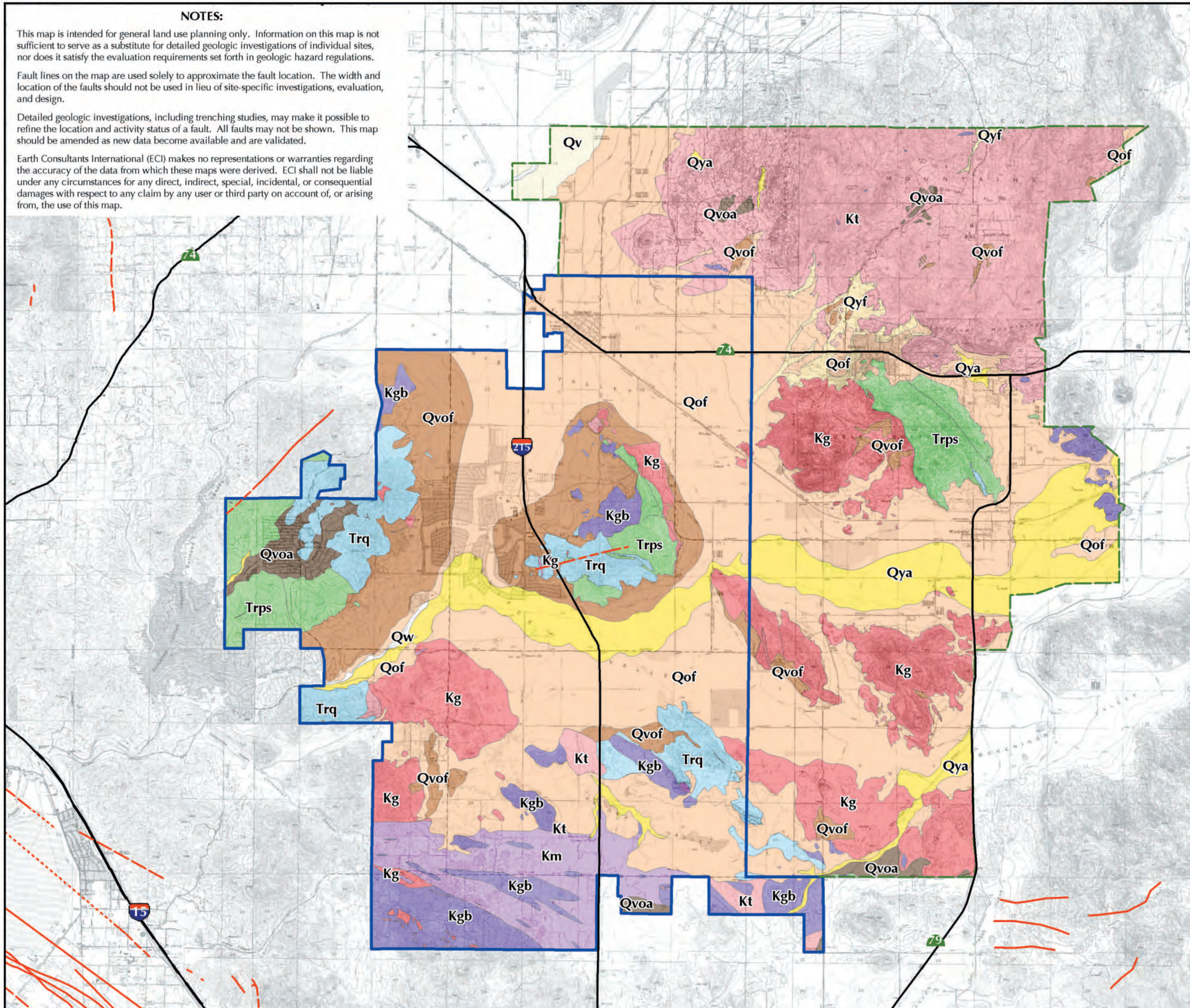

Geologic Map

Menifee, California

For Geologic Unit Descriptions
See Plate 2-2b

N
W E
S

Scale: 1:84,000

7000 0 7000
Feet

2 0 2
Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER (1997).
Sources: Modified from Morton and Miller (2006).

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Plate 2-2a

Geologic Unit Descriptions

SEDIMENTARY UNITS

Young Surficial Deposits

Qw Very Young Wash Deposits - Unconsolidated sand and gravel deposited in active washes, ephemeral river channels, and channels on active alluvial fans. Late Holocene.

Qv Very Young Alluvial Valley Deposits - Unconsolidated clay and silt in the San Jacinto River floodplain. Late Holocene.

Qyf Young Alluvial Fan Deposits - Unconsolidated silt, sand, and gravel on alluvial fans and the headward drainages of fans at the base of the Lakeview Mountains. Holocene to late Pleistocene.

Qya Young Alluvial Valley and Channel Deposits - Unconsolidated fluvial (stream deposited) sand and silt in Salt Creek, Paloma Valley, and Warm Springs Creek. Holocene to late Pleistocene.

Old Surficial Deposits

Qof Old Alluvial Fan Deposits - Moderately to well-consolidated silt and sand forming valley floors throughout the General Plan area. Late to middle Pleistocene.

Qvof Very Old Alluvial Fan Deposits - Moderately to well-consolidated silt, sand, and gravel. Erosional remnants of this unit are present throughout the General Plan area; largest deposits are present at the base of the hills to the east and west of Sun City. Middle to early Pleistocene.

Qvoa Very Old Channel Deposits - Predominantly well-consolidated to well-indurated fluvial sand deposited on canyon floors. Deposits in Quail Valley contain sand and rounded cobbles; isolated deposit in the hills south of Paloma Valley contains sand and clay. Middle to early Pleistocene.

CRYSTALLINE ROCK UNITS

Plutonic Rocks

Kt Tonalite - Gray biotite-hornblende tonalite with minor intermixed monzogranite, granodiorite, and gabbro; medium to coarse-grained; massive to foliated. Foliations commonly dip steeply to the north. Most abundant rock type in the Lakeview Mountains. Cretaceous.

Kg Granodiorite - Light gray hornblende biotite granodiorite grading to tonalite; relatively uniform; medium-grained; massive. Forms isolated hills in the central, eastern and western parts of the General Plan area including Bell Mountain and the western part of Double Butte. Locally contains fine-grained light to dark gray dikes consisting of massive to well foliated and lineated biotite, hornblende biotite, hornblende dacite, and quartz latite. The dikes are more resistant to weathering than the surrounding granodiorite and form conspicuous ribs and walls. Cretaceous.

Km Monzogranite - Pale gray biotite monzogranite with less abundant hornblende-biotite granodiorite; medium-grained; massive. Contains common to abundant, small to large blocks of gabbro. Cretaceous.

Kgb Gabbro - Mainly brown hornblende gabbro; medium to very coarse-grained. Very large hornblende crystals are common. Exposed primarily in the hills southwest of Paloma Valley; small isolated exposures are present in the hills north and south of Menifee Valley, and north of Quail Valley. Locally contains thin, discontinuous, arcuate dikes of light colored granitic pegmatite-aplite. Cretaceous.

Metasedimentary Rocks

Trq Quartz-rich Rocks - Quartzite and quartz-rich metasandstone, locally intermixed with metagraywacke; locally conglomeratic. Exposed intermittently in hills within the central, western, and southern part of the General Plan area. Triassic.

Trps Phyllite and Schist - Black fissile phyllite and dark gray biotite schist, locally intermixed or interlayered with metagraywacke or quartzite; fine-grained. Other metasedimentary rocks may be present in small amounts. Triassic.

Symbols

Fault; solid where location known, dashed where approximate, dotted where concealed. (for more information refer to Plate 1-2)

Geologic Contact

City of Menifee Corporate Boundary

Menifee General Plan Area Boundary

City of Menifee

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Explanation for Geologic Map

Plate 2-2b

Engineering Properties of Young Surficial Deposits: How and where the young and very young deposits were laid down have a significant bearing on the properties of these materials. Young alluvium often has organic debris, and is typically deposited rapidly. As a result, the engineering issues affecting these geologically young deposits are: 1) compressibility, which occurs when additional loads are applied, and 2) collapse (hydroconsolidation) upon introduction of irrigation water if the deposit is dry. Being unconsolidated, the young alluvium is also highly susceptible to erosion. Alluvium is suitable for use as fill, once the organic materials and oversized rocks are removed, however they typically require the addition of water to achieve compaction. Young alluvial deposits have moderate to high permeability, except where silt or clay layers may retard the downward percolation of water. The potential for expansive soils is generally low, except where deposits of silt and clay are within or just below the depth of the elements of a structural foundation.

Old Surficial Deposits: Alluvial Fan, Valley, and Channel Sediments (Geologic Map Symbols: Qof, Qvof, and Qvoa).
Older alluvial deposits **(Qof)** are late to middle Pleistocene in age (about 11,000 to 500,000 years old), and consist primarily of fan sediments, but also include some valley and channel sediments. This unit is widespread in the General Plan area, forming the numerous interconnected valleys, where it has been slightly dissected by modern streams. Near-surface soils of this unit are typically of low density and have various degrees of reddish-brown pedogenic development. Below the surface, this unit is moderately dense and consists of brown, yellowish brown, and olive brown silty sands, clayey sands, silty to sandy clays, and sandy to clayey silts with minor gravel.

Very old alluvial deposits **(Qvof** and **Qvoa)** are middle to early Pleistocene in age (about 500,000 to 1 million years old), and consist primarily of silt, gravel, and medium- to coarse-grained sand. These sediments are moderately consolidated to well indurated and have a deeply dissected surface. Crude bedding is characteristic. A mature pedogenic soil typically has developed on its surface, giving the upper part of the deposit a reddish color. These deposits occur in two large areas along the base of the hills east and west of Sun City, and as small isolated patches throughout the General Plan area. Very old channel deposits in Quail Valley contain rounded cobbles, whereas a small remnant patch of very old channel deposits containing primarily sand and clay occurs in the hills south of Paloma Valley.

Engineering Properties of Old Surficial Deposits: Older alluvium is more consolidated than young alluvium, and therefore generally provides better structural support, although, due to weathering or disturbance by man's past activities (such as from farming), the low density of the upper few feet is generally unacceptable for most buildings. Clayey pedogenic soils that have developed on the weathered fan surface, as well as clay-rich layers within the deposit, may be moderately expansive. Slope stability is generally good and may be a problem only where slopes have become severely oversteepened, typically by stream undercutting or by man-made cuts for roadways. Permeability of these units will be highly variable depending on the original sediment composition and the degree of weathering.

NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

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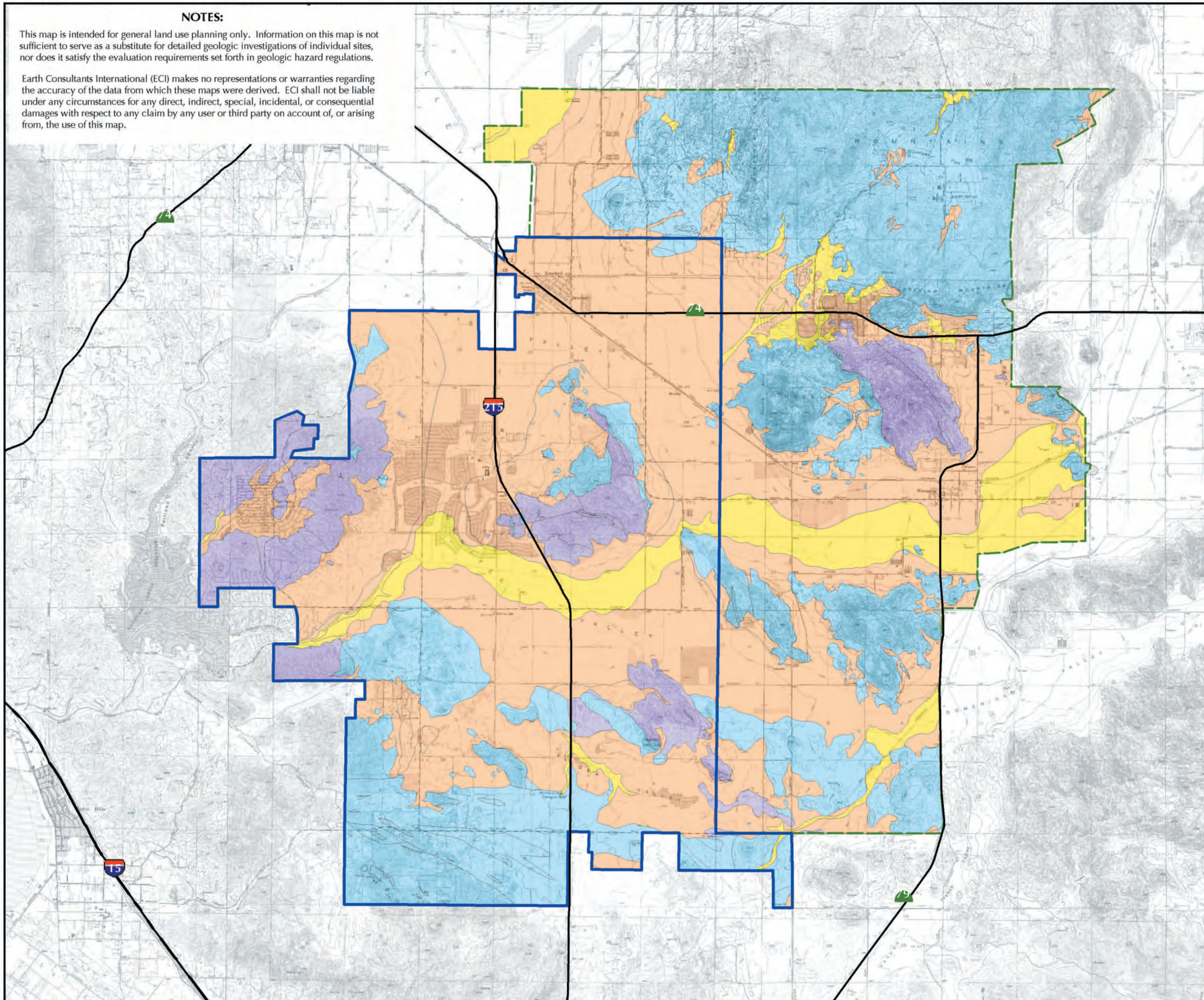

Engineering Materials Map

Menifee, California

Symbols

City of Menifee Corporate Boundary

Menifee General Plan Area Boundary

For Engineering Materials Descriptions See Plate 2-3b

N

W E

S

0 7000 14000 Feet

0 2000 4000 Meters

Scale: 1:84,000

Base Map: USGS Topographic Map from Sure!MAPS RASTER (1997).
Sources: Based on data from Morton and Miller (2006).

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Plate 2-3a

GENERAL ENGINEERING CHARACTERISTICS OF GEOLOGIC UNITS IN THE MENIFEE GENERAL PLAN AREA

SURFICIAL MATERIALS

Very Young to Young Alluvial Deposits (Qw, Qv, Qyf, and Qya)

COMPOSITION: Variable, but commonly contains locally derived silt, sand, and gravel; may also contain vegetation and debris. DENSITY: Generally low and compressible. EXPANSION POTENTIAL: Generally low; locally moderate, depending on fine-grained fraction. Silts and clays within the San Jacinto floodplain are in the moderate range. SLOPE STABILITY: Generally poor. EROSION/SEDIMENTATION POTENTIAL: Highly susceptible to erosion, especially where water flow is concentrated; locally subject to sedimentation carried by floodwaters and debris flows. PERMEABILITY: High. EASE OF EXCAVATION: Easy. SUITABILITY AS FILL: Generally good after organics, debris, and oversize rocks are removed. Clay-rich deposits should not be placed near finish grades.

Old Alluvial Deposits (Qof, Qvof, and Qvoa)

COMPOSITION: Variable mix of silt, sand, and gravel; weathered surface may be enriched with clay due to pedogenic soil development. DENSITY: Generally dense below the upper few feet. EXPANSION POTENTIAL: Low to high, depending on original composition and degree of pedogenic soil development. SLOPE STABILITY: Generally good. EROSION/SEDIMENTATION POTENTIAL: Moderate. PERMEABILITY: Highly variable. EASE OF EXCAVATION: Easy. SUITABILITY AS FILL: Generally good.

BEDROCK MATERIALS

Plutonic Rocks (Kt, Kg, Km, and Kgb)

COMPOSITION: Heterogeneous mix of medium- to coarse-grained granitic rocks. DENSITY: Very dense. EXPANSION POTENTIAL: Low. SLOPE STABILITY: Generally good in cut slopes that are not oversteepened. Natural slopes are typically covered with large boulders that pose a rockfall hazard. EROSION POTENTIAL: Very low. PERMEABILITY: Low. EASE OF EXCAVATION: Difficult to very difficult where unweathered. May require blasting. SUITABILITY AS FILL: Good for weathered, decomposed granitics. Relatively poor for unweathered rock, as excavation may produce significant oversize rock. Blasting may produce smaller rock sizes that can be used for rock fills, however these fills require greater amounts of applied water, and compaction is difficult to verify.

Metasedimentary Rocks (Trq and Trps)

COMPOSITION: Heterogeneous mix of metamorphosed sedimentary rocks, including quartzite, metasandstone, metagraywacke, phyllite, and schist. DENSITY: Very dense. EXPANSION POTENTIAL: Very low. SLOPE STABILITY: Good in natural slopes. Generally good in cut slopes. Due to steeply dipping foliation, cut slopes that are oversteepended (such as road cuts) may be unstable. EROSION POTENTIAL: Very low. PERMEABILITY: Low. EASE OF EXCAVATION: Difficult to very difficult where unweathered. May require blasting. SUITABILITY AS FILL: Moderate to poor, as excavation may produce significant oversize rock. Blasting may produce smaller rock sizes that can be used for rock fills, however these fills require greater amounts of applied water, and compaction is difficult to verify.

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Explanation for Engineering Materials Map

Plate 2-3b

2.3.2 Crystalline Rocks in the Menifee General Plan Area

The oldest geologic units in the Menifee area consist of very hard, crystalline rock that forms the hills and mountains, and is buried beneath the alluvium. Rock classifications are based primarily on genesis, texture, and mineral composition. Because the rocks are highly variable in texture and mineralogy, often grading from one type to another, the units are usually named by the dominant rock type. Many studies have discussed the mineralogy and character of the rocks in this area, along with their genesis (references are listed in Morton, 2006). Based on genesis alone, the rocks in this area can be classified into two main groups: 1) rocks that have crystallized from the molten state deep within the Earth's crust (**plutonic rocks**), and 2) rocks of sedimentary origin that have recrystallized under extreme conditions of heat and pressure deep below the Earth's surface (**metasedimentary rocks**).

Plutonic Rocks (Geologic Map Symbols: Kt, Kg, Km, and Kgb). 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 highly variable mineral assemblages. 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 Cretaceous age (symbolized on maps by the letter K). Hills formed of plutonic rocks are commonly covered by rounded, bouldery outcrops. Where very weathered, these rocks decompose producing sediments composed primarily of sand-sized grains.

In the Lakeview Mountains, the predominant mineral assemblage is a light gray, medium- to coarse-grained rock classified as tonalite **(Kt)**. This rock unit contains abundant light to dark colored "schlieren," essentially small to large streaks or bands that contain concentrations of light or dark colored minerals. Schlieren result from flow processes when the rock was in the magma state.

Isolated hills in the central, eastern, and southern part of the General Plan area are underlain predominantly by granodiorite **(Kg)**, a relatively uniform, gray, medium-grained rock. Locally, this unit has abundant fine-grained, light to dark colored bands of rock (dikes) that intruded a northwest trending joint system in the main body of rock.

Hills in the southern part of Menifee are underlain in part by pale gray medium-grained monzogranite **(Km)** with a lesser amount of granodiorite. This unit contains small to large blocks of gabbro, the dark, pre-existing rock into which it intruded.

Gabbro **(Kgb)**, is a dark colored, very coarse-grained rock that is present along the southern edge of the city, and as small isolated patches in the hills east of Green Acres, east of Sun City, and north of Quail Valley. This unit is very heterogeneous in both texture and mineral composition. In the southwestern corner of the city, it contains many arcuate-shaped dikes composed of pegmatite (a light colored, very coarse-grained rock). Scientists believe these formed when a volatile-rich magma infiltrated a dome-shaped set of fractures in the pre-existing body of rock.

Metasedimentary Rocks (Geologic Map Symbols: Trq and Trps). Rocks of Triassic age (symbolized on the map by the letters Tr) underlie portions of the hills throughout the General Plan area, where they tend to weather to rounded hilltops and generally lack the bold outcrops seen in the granitic hills and mountains. These rocks have been combined into two general categories: quartz-rich rocks **(Trq)** consisting mainly of quartzite and quartz-rich metasandstone or quartzite intermixed with metagraywacke; and a highly diverse group of fine-grained rocks consisting predominantly of black phyllite and gray schist **(Trps)**. Very fine-grained phyllite occurs in thick sections in the hills west of Quail Valley and in a portion of the hills east of Sun City, where it can be recognized by the sheen produced by layers of very fine-grained mica. The schist has slightly larger grains, but locally grades to a phyllite. It can also be found interlayed with quartzite and phyllite. Metasedimentary rocks typically exhibit foliation – a planar fabric in the rock structure. This is due to the compositional layering of minerals, as well as a preferred orientation of platy or tabular-shaped minerals in a planar fashion.

Engineering Properties of Crystalline Rock: These rock types have similar engineering properties. They are very hard where not highly weathered, and tend to form steep slopes and deep canyons. They are typically non-water bearing, except where extensively jointed and fractured. Accordingly, these materials have low to moderately low permeabilities, except where joints, shears and foliation surfaces provide avenues for water to move in and around the rock mass. Unweathered rock cannot be excavated easily; blasting is often required. Crystalline rocks provide strong foundation support and are generally non-expansive. Slope stability in rock units is generally good, and no large bedrock landslides have been mapped in the Menifee area. Nevertheless, these rocks contain fractures, cooling joints, and foliations that may locally serve as planes of weakness along which slope instability can occur. Very steep roadcuts are most vulnerable to this type of failure. Slopes covered by granitic boulders are subject to rockfall hazard.

Figure 2-2: Rock-Controlled Landforms.
Boulder-covered slopes indicate the hill on the left is underlain by granitic rock. The relatively smooth, rounded hills on the right are underlain by metasedimentary rocks.

2.4 Geologic Hazards in the Menifee Area

2.4.1 Landslides and Slope Instability

Developments that encroach upon the edge of natural slopes may be impacted by slope failures. Even if a slope failure does not reach the adjacent property, the visual impact will generally cause alarm to homeowners. Although slope failures tend to affect a relatively small area (as compared to an earthquake or major flood), and are generally a problem for only a short period of time, the dollar losses can be high. Homeowner's insurance policies typically do not cover land slippage, and this can add to the anguish of the affected property owners.

A significant portion of the General Plan area encompasses hillside terrain. At present, the hills and mountains have rural to semi-rural type development, and scattered development is present along the base of steep slopes. While the rock types in Menifee are generally resistant to slope failure, slope instability remains a potential hazard that should be geotechnically evaluated on a case-by-case basis in hillside areas.

2.4.1.1 *Types of Slope Failures*

Slope failures occur in a variety of forms, and there is usually a distinction made between **gross failures** (sometimes also referred to as "global" failures) and **surficial failures**. Gross failures include deep-seated or relatively thick slide masses, such as landslides, whereas surficial failures can range from minor soil slips to destructive mud or debris flows. Failures can occur on natural or man-made slopes. Most failures of man-made slopes occur on older slopes built at slope gradients steeper than those allowed by today's grading codes. Although infrequent, failures can also occur on newer, graded slopes, generally due to poor engineering or poor construction. Furthermore, slope failures often occur as elements of interrelated natural hazards in which one event triggers a secondary event, such earthquake-induced landsliding, fire-flood sequences, and storm-induced mudflows.

Gross 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. Landslide materials are commonly porous and very weathered in the upper portions and along the margins of the slide. They may also have open fractures and joints. The head of the slide may have a graben (pull-apart area) that has been filled with soil, bedrock blocks and fragments.

From an engineering perspective, landslides are generally unstable (may be subject to reactivation), and may be compressible, especially around the margins, which are typically highly disturbed and broken. The headscarp area above the landslide mass is also unstable, since it is may be oversteepened, cracked, and subject to additional failures. The type of movement is generally described as follows:

- Translational – slippage on a relatively planar, dipping layer.
- Rotational – circular-shaped failure plane.
- Wedge – movement of a wedge-shaped block from between intersecting planes of weakness, such as fractures, faults and bedding.

The potential for slope failure is dependent on many factors and their interrelationships. Some of the most important factors include slope height, slope steepness, shear strength and orientation of weak layers in the underlying geologic unit, as well as pore water pressures. Joints and shears, which weaken the rock fabric, allow water to infiltrate the rock mass. This in turn results in increased and deeper weathering of the rock, increased pore pressures, increased plasticity of weak clays that may be present in the rock, and increased weight of the landmass. Geotechnical engineers combine these factors in calculations to determine if a slope meets a minimum safety standard. The generally accepted standard is a factor of safety of 1.5 or greater (where 1.0 is equilibrium, and less than 1.0 is failure). Natural slopes, graded slopes, or graded/natural slope combinations must meet these minimum engineering standards where they have the potential to impact planned homes, subdivisions, or other types of developments. Slopes adjacent to areas where the risk of economic losses from landsliding is small, such as parks and roadways, are sometimes allowed a lesser factor of safety, at the discretion of the local reviewing agency.

The rock types in the Menifee General Plan area are generally resistant to large landslide failures, and no landslides have been mapped within the city. However, depending on their fracture pattern, foliation, and weathering, these rocks may become susceptible to slope failure if they are cut to very steep gradients, such as are commonly found in highway roadcuts.

Surficial Failures

Surficial failures are too small to map at the scale used in Plate 2-2a, however they may be present locally in hillside areas, typically occurring in drainage swales and in the accumulated sediments and deeply weathered bedrock near the base of steep slopes. Surficial failures generally occur throughout the mountainous areas during winters of particularly heavy and/or prolonged rainfall. The most common types of surficial instability are described below.

Slope creep generally involves the deformation and movement of the outer soil or rock materials in the face of 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 rock 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, but can also occur in igneous and metamorphic rocks, such as those that form the local mountains.

Creep also occurs in graded fill slopes. This is related to the alternate wetting and drying of slopes constructed with fine-grained, expansive soils. The repeated expansion and contraction of the soils at the slope face leads to loosening and fracturing of the soils, thereby leaving the soils susceptible to creep. While soil creep is not catastrophic, it can cause damage to structures and improvements located at the tops of slopes.

Soil creep and creep of graded fill slopes are not a widespread hazard in the General Plan area, since most soils in this area are granular and not highly expansive. Rock creep is not a common hazard in the rock types found in this area, however the presence or potential for creep to occur should be addressed for all new construction in hillside areas.

Soil slip failures are generated by strong winter storms, and are widespread in mountainous areas, particularly after winters with prolonged and/or heavy rainfall. Failures occur on canyon sideslopes, and in soils that have accumulated in swales, gullies and ravines. Slope steepness has a strong influence on the development of soil slips, with most slips occurring on slopes having gradients between about 27 and 56 degrees (Campbell, 1975).

Slopes within this range of gradients are present in the higher hills and mountains. Plate 2-4, the Slope Distribution Map, illustrates slope gradients in and around the General Plan area.

Debris flow is the most dangerous and destructive of all types of slope failure. A debris flow (also called mudflow, mudslide, and debris avalanche) is a rapidly moving slurry of water, mud, rock, vegetation and debris. Larger debris flows are capable of moving trees, large boulders, and even cars. This type of failure is especially dangerous as it can move at speeds as fast as 40 feet per second, is capable of crushing buildings, and can strike with very little warning. As with soil slips, the development of debris flows is strongly tied to exceptional storm periods of prolonged rainfall. Failure typically occurs during an intense rainfall event, following saturation of the soil by previous rains.

A debris flow most commonly originates as a soil slip in the rounded, soil-filled "hollow" at the head of a drainage swale or ravine. The rigid soil mass is deformed into a viscous fluid that moves down the drainage, incorporating into the flow additional soil and vegetation scoured from the channel. Debris flows also occur on canyon walls, often in soil-filled swales that do not have topographic expression. The velocity of the flow depends on the viscosity, slope gradient, height of the slope, roughness and gradient of the channel, and the baffling effects of vegetation. Even relatively small amounts of debris can cause damage from inundation and/or as a result of crashing into a structure (Ellen and Fleming, 1987; Reneau and Dietrich, 1987). Recognition of this hazard led FEMA to modify its National Flood Insurance Program to include inundation by "mudslides."

Watersheds that have been recently burned typically yield greater amounts of soil and debris than those that have not burned. Erosion rates during the first year after a fire are estimated to be 15 to 35 times greater than normal, and peak discharge rates range from 2 to 35 times higher. These rates drop abruptly in the second year, and return to normal after about 5 years (Tan, 1998). In addition, debris flows in burned areas can develop in response to small storms and do not require a long period of antecedent rainfall. These kinds of flows are common in small gullies and ravines during the first rains after a burn, and can become catastrophic when a severe burn is followed by an intense storm season (Wells, 1987). A recent example is the debris flows that impacted several communities at

NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

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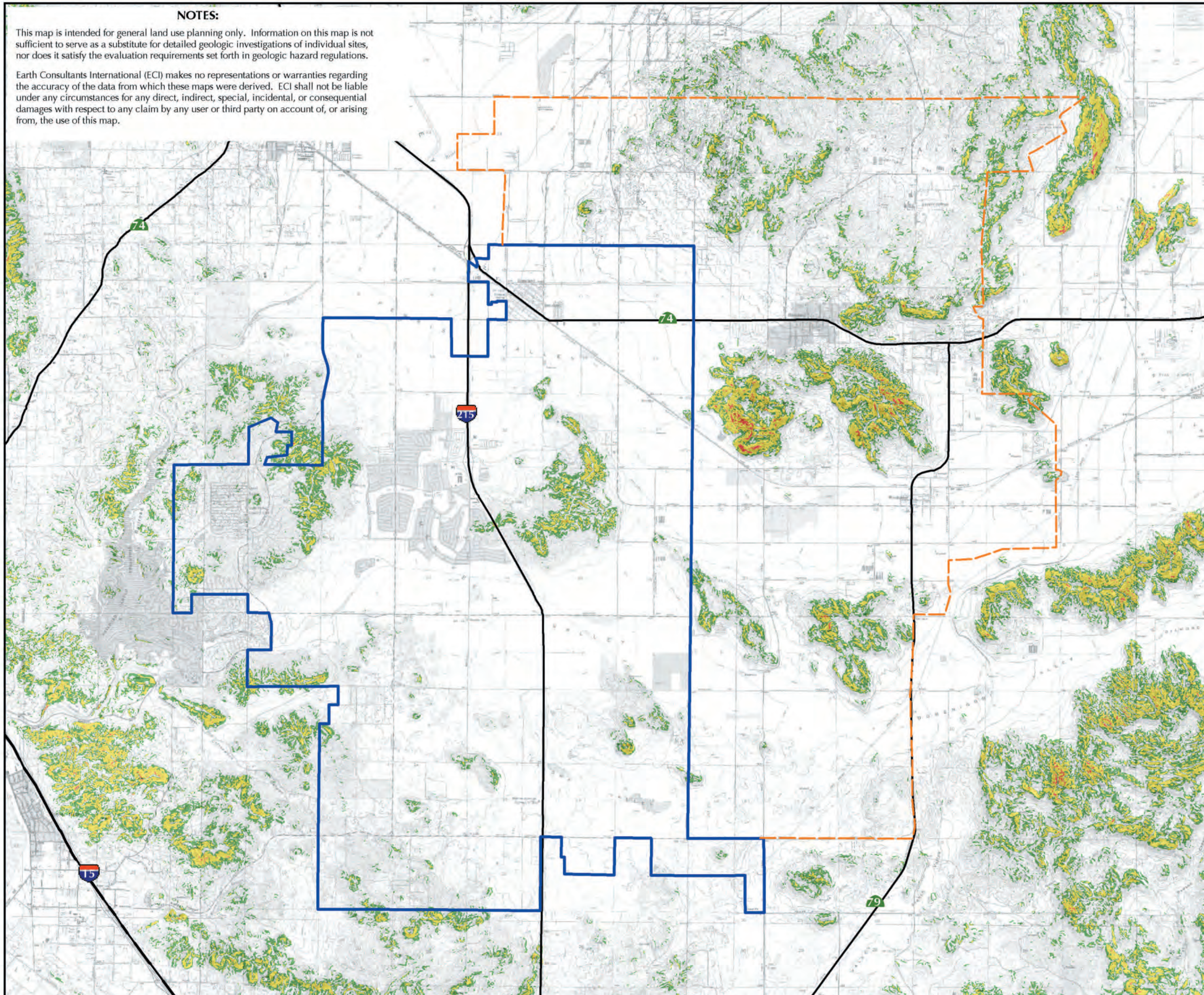

Slope Distribution Map

Menifee, California

Explanation

Slope (in degrees)

- 0 to 19
- 20 to 26
- 27 to 39
- 40 and greater

- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N / S / E / W

0 — 7000 — 14000 Feet

0 — 2000 — 4000 Meters

Scale: 1:84,000

Base Map: USGS Topographic Map from Sure!MAPS RASTER (1997).
Source: Derived from USGS 30m Digital Elevation Model.

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CITY OF MENIFEE

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Plate 2-4

the base of the portion of the Los Angeles National Forest that burned during the Station Fire of August and September 2009. The debris flows, which occurred in February 2010, following several intense rainstorms, severely destroyed more than 40 homes and many cars were swept by the mud- and debris-ladden water.

> *Within the General Plan area, locations that are most susceptible to debris flows are those properties at the base of moderate to steep slopes, or at the mouths of small to large drainage channels. Although surficial slope failures were not generally visible after the recent heavy winter rains, small surficial landslides, debris flows, and rock falls have been reported in the area in the past (T&B Planning Consultants, Inc., 1994 and 2005b).*

Rockfalls are free-falling to tumbling masses of bedrock that have broken off steep canyon walls or cliffs. The debris from repeated rockfalls typically collects at the base of extremely steep slopes in cone-shaped accumulations of angular rock fragments called talus. Rockfalls can happen wherever fractured rock slopes are oversteepened by stream erosion or man's activities.

The granitic bedrock common to the area's hillsides weathers into large boulders that perch precariously on slopes, posing a rockfall hazard to areas adjacent to and below these slopes. A rockfall may happen suddenly and without warning, but is more likely to occur in response to earthquake-induced ground shaking, during periods of intense rainfall, or as a result of man's activities, such as grading and blasting.

> *Rockfall hazard in the General Plan area is largely restricted to properties at or near the base of boulder-covered slopes.*

2.4.1.2 Mitigation of Slope Instability in Future Development

Careful land management in hillside areas can reduce the risk of economic and social losses from slope failures. This generally includes land use zoning to restrict development in unstable areas, grading codes for earthwork construction, geologic and soil engineering investigation and review, construction of drainage structures, and if warranted, placement of warning systems. Other important factors are risk assessments (including susceptibility maps), a concerned local government, and an educated public.

The City of Menifee has temporarily adopted Riverside County ordinances with respect to land use (Ordinance No. 348) and grading (Ordinance No. 457). As the City develops its own development codes, some suggested items for inclusion are:

- Develop standards and guidelines for design and construction in hillside areas based on slope steepness.
- Utilize steeper hillside areas for open space or rural, low-density development.
- Allow higher density development on the lower hillside slopes.

- Protect and preserve as much as possible existing landforms, drainage patterns, natural ridgelines and rock outcroppings, scenic vistas, and native vegetation.
- Discourage mass grading, terracing and unnatural contours.
- Encourage variety in design.
- Provide safe traffic circulation in hillside areas.
- Mitigate slope instability, erosion, and sedimentation by requiring soils reports, and where necessary, engineered drainage facilities.
- Set forth parameters for design that will retain the natural beauty of the area while protecting residents and property from slope failures and wildfires.

For the unincorporated areas of the Menifee General Plan, Riverside County Ordinances provide similar standards and guidelines for growth and development, in addition to providing a basis for county-wide planning and construction of public facilities such as drainage control. The ordinances address zoning, permitting, grading, and investigation requirements for areas subject to potential geologic problems, including slope instability.

Soils and geology reports for hillside areas, which are required by both the City and the County, should include a geotechnical evaluation of any slope that may impact the future use of the property, as well as any impact to adjacent properties. This includes existing slopes that are to remain natural, and any proposed graded slopes. This type of investigation typically includes borings and/or test pits to collect geologic data and soil samples, laboratory testing of the soil samples to determine soil strength parameters, and engineering calculations. Numerous soil-engineering methods are available for stabilizing slopes that pose a threat to development. These methods include designed buttresses (replacing the weak portion of the slope with engineered fill); reducing the height of the slope; designing the slope at a flatter gradient; and adding reinforcements to fill slopes such as soil cement or layers of geogrid (a tough polymeric net-like material that is placed between the horizontal layers of fill). Most slope stabilization methods include a subdrain system to prevent excessive ground water (typically landscape water) from building up within the slope area. If it is not feasible to mitigate the slope stability hazard, building setbacks are typically imposed.

For debris flows, assessment of this hazard for individual sites should focus on structures located or planned in vulnerable positions. This generally includes canyon areas; at the toes of steep, natural slopes; and at the mouth of small to large drainage channels. Mitigation of soil slips and debris flows is usually directed at containment (debris basins), or diversion (impact walls, deflection walls, diversion channels, and debris fences). A system of baffles may be added upstream to slow the velocity of a potential debris flow. Other methods may include avoidance by restricting habitable structures to areas outside of the potential debris flow path.

There are numerous methods for mitigating rockfalls. Choosing the best method depends on the geological conditions (i.e., slope height, steepness, fracture spacing, foliation orientation), safety, type and cost of construction repair, and aesthetics. A commonly used method is to regrade the slope. This ranges from locally trimming hazardous overhangs, to completely reconfiguring the slope to a more stable condition, possibly with the addition of benches to catch small rocks. Another group of methods focuses on holding the fractured rock in place by draping the slope with wire mesh, or by installing tensioned rock bolts, tie-back walls, or even retaining walls. A third type of mitigation includes catchment devices at the toe of the slope, such as ditches, walls, or combinations of both. Designing the width of the catchment structure requires analysis of how the rock will fall. For instance, the slope gradient and roughness of the slope determines if rocks will fall, bounce, or roll to the bottom (Wyllie and Norrish, 1996).

Temporary slope stability is also a concern, especially where earthwork construction is taking place next to existing improvements. Temporary slopes are those made for slope stabilization backcuts, fill keys, alluvial removals, retaining walls, and underground utility lines. The risk of slope failure is higher in temporary slopes because they are generally cut at a much steeper gradient. In general, temporary slopes should not be cut steeper than 1:1 (horizontal:vertical), and depending on actual field conditions, flatter gradients or shoring may be necessary. The potential for slope failure can also be reduced by cutting and filling large excavations in segments, and not leaving temporary excavations open for long periods of time. The stability of large temporary slopes should be geotechnically analyzed prior to construction, and mitigation measures provided as needed.

2.4.1.3 Mitigation of Slope Instability in Existing Development

There are a number of options for the management of potential slope instability where development has already taken place. Implementation of these options should reduce the hazard to an acceptable level, including reducing or eliminating the potential for loss of life or injury, and reducing economic loss to tolerable levels. Mitigation measures may include:

- Protecting existing development and population where appropriate by physical controls such as improved drainage, slope-geometry modification, protective barriers, and retaining structures;
- Posting warning signs in areas of potential slope instability;
- Encouraging homeowners to install landscaping consisting primarily of drought-resistant, preferably native vegetation that helps stabilize the hillsides;
- Incorporating recommendations for potential slope instability into geologic and soil engineering reports for building additions and new grading; and
- Providing public education on slope stability, including the importance of maintaining drainage devices and avoiding heavy irrigation. U.S. Geological Survey Fact Sheet FS-071-00 (May, 2000) and California Geological Survey Note 33 (March, 2004) provide public information on landslide and mudslide hazards. Both of these are available on the World Wide Web (see Appendix A).

2.4.2 Compressible Soils

Compressible soils are typically geologically young (Holocene age) 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 can vary greatly, depending 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 the Menifee General Plan area, compressible soils are most likely to occur where young Holocene-age deposits are present. This would generally include the modern and prehistoric floodplains of the major drainages, such as the San Jacinto River, Salt Creek, Warm Springs Creek, and Paloma Valley. Compressible soils are also commonly found in hillside areas, typically in canyon bottoms, swales, and at the base of natural slopes. Although older alluvium in the Menifee area is relatively dense, the upper few feet, which are commonly weathered and/or disturbed, are typically compressible. Deep fill embankments, generally those more than about 60 feet deep, will also compress under their own weight.

2.4.2.1 Mitigation of Compressible Soils

When development is planned within areas that contain potentially compressible soils, a geotechnical analysis is required to identify the presence of this hazard. The analysis should consider the characteristics of the soil column in that specific area, and also the load of any proposed fills and structures that are planned, the type of structure (i.e. a road, pipeline, or building), and the local groundwater conditions. Removal and recompaction of the 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 location-specific data and analyses, 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 buildings or infrastructure are constructed. Similar methods are used for deep fills. In cases where it is not feasible to remove the compressible soils, buildings can be supported on specially engineered foundations that may include deep caissons or piles.

2.4.3 Collapsible Soils

Hydroconsolidation or soil collapse typically occurs in recently deposited, Holocene-age soils that accumulated in an arid or semi-arid environment. Soils prone to collapse are commonly associated with alluvial fan and 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 in close proximity to the structure's foundation.

The young and very young alluvial sediments in the General Plan area may be locally susceptible to this hazard due to their low density, rapid deposition in the alluvial fan environment, and the generally dry condition of the upper soils.

2.4.3.1 Mitigation of Collapsible 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 mitigated by several different measures or combination of measures, including excavation and recompaction, or pre-saturation and pre-loading 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.

2.4.4 Expansive Soils

Fine-grained soils, such as silts and clays, may contain variable amounts of expansive clay minerals. These minerals can undergo significant volumetric changes as a result of changes in moisture content. The upward pressures induced by the swelling of expansive soils can have significant harmful effects upon structures and other surface improvements.

The valley and canyon areas of the General Plan area are underlain by alluvial sediments that are composed of interlayered granular materials (silty sand and sand) and fine-grained materials (silts and clays). Consequently, after site grading, the expansion characteristics of the soils at finish grade can be highly variable. The San Jacinto River floodplain contains very fine-grained silts and clays that are likely to be expansive. Pedogenic soil profiles that have developed on old alluvial fan deposits as a result of weathering are commonly clay-rich and probably fall in the moderately expansive range.

Igneous and metamorphic rocks underlying the hills and mountains generally have low expansion characteristics, however sheared zones within these rock units may contain clays with expansive minerals.

In some cases, engineered fills may be expansive and cause damage to improvements if such soils are incorporated into the fill near the finished surface.

2.4.4.1 Mitigation of Expansive Soils

The best defense against this hazard in new developments is to avoid placing expansive soils near the surface. If this is unavoidable, building areas with expansive soils are typically "presaturated" to a moisture content and depth specified by the soil engineer, thereby "pre-swelling" the soil prior to constructing the structural foundation or hardscape. This method is often used in conjunction with stronger foundations that can resist small ground movements without cracking. Good surface drainage control is essential for all types of improvements, both new and old. Property owners should be educated about the importance of maintaining relatively constant moisture levels in their landscaping. Excessive watering, or alternating wetting and drying, can result in distress to improvements and structures.

2.4.5 Corrosive Soils

Corrosive soils can, over time, cause extensive damage to buried metallic objects, commonly impacting such things as buried pipelines (think water main breaks), 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 what electrochemical reactions will take place in differing soils. For soils, the most common factor used in identifying the potential for corrosion 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.

Soils with high concentrations of soluble sulfates are not directly corrosive to metals, however the presence of sulfate-reducing bacteria in the soil may cause sulfates to convert to sulfides, which are compounds that do increase the risk for corrosion. If the concentration of soluble sulfates is high enough, the soil will be corrosive to concrete.

> *In general, the near-surface soils throughout the valley areas have low electrical resistivity, making them moderately to highly corrosive to metals. Soluble sulfates and chlorides are low, and pH is generally above the acidic range. There are exceptions though, and every site proposed for development should be tested for these parameters.*

2.4.5.1 Mitigation of 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. As mentioned above, the corrosion processes are complex; consequently, the site-specific recommendations must be provided by an engineer who is a corrosion specialist.

2.4.6 Ground Subsidence

Ground subsidence is the gradual settling or sinking of the ground surface with little or no horizontal movement. Most ground subsidence is man-induced. In the areas of California where ground subsidence has been reported (such as the San Joaquin Valley, Coachella Valley, and Wilmington), this phenomenon is most commonly associated with the extraction of fluids (water and/or petroleum) from sediments below the surface. Subsidence can also occur when dry collapsible soils become saturated. Less commonly, ground subsidence can also occur as a response to natural forces such as earthquake movements.

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. Subsidence has largely been brought under control in affected areas by careful management of local water supplies, including reducing pumping of local wells, importing water, and use of artificial recharge (Johnson, 1998; Stewart et al., 1998).

Although subsidence has not been reported in Menifee, this hazard has been documented nearby in the San Jacinto Valley, from Hemet to Moreno Valley, and in Temecula and Murrieta (Shlemon and Hakakian, 1992). In the San Jacinto Valley and Temecula, the subsidence and associated ground fissuring have been attributed to groundwater withdrawal. In Murrieta, the subsidence and fissuring were caused by a different mechanism: Rapid growth of the area led to large-scale application of landscape water to arid alluvial soils. This caused a rise in the water table and subsequent collapse of the soils, manifested at the surface by localized land subsidence and ground fissures, which cost millions of dollars in property damage to homes, schools, and infrastructure (Shlemon, 1995).

The Menifee General Plan area is located above the southwestern part of the San Jacinto Groundwater Basin. The basin's aquifers lie within the sediment-filled valleys, which are floored and surrounded by nearly water-tight rock. Within the basin, the water-bearing zones are compartmentalized by impermeable faults and irregularities in the buried bedrock topography. Natural replenishment to the basin is via percolation from the San Jacinto River and its tributaries; less recharge comes from rainfall on the valley floor. Natural recharge has been enhanced by man's activities since the early 1900s by spreading floodwaters over the adjacent sandy washes in the upper reaches of the river. Today artificial recharge also occurs by percolation of imported and reclaimed water through infiltration ponds in the upper reaches of the river, Lake Perris, and storage ponds distributed throughout the valleys. Artificial recharge often exceeds natural recharge, especially in dry years.

In 1915, groundwater levels in the greater part of the Menifee, Paloma and Winchester valleys were within 10 to 20 feet of the surface. Water was within 10 feet of the eastern part of Menifee Valley, and in one area of Paloma Valley a small marsh was formed by groundwater seepage at the base of the hills. In the Sun City and Perris Valley area, groundwater was deeper, ranging from about 40 to 100 feet deep. By this time many valleys in the area were already being irrigated for crops, and groundwater levels were in flux depending on precipitation and local pumping (Waring, 1919). Over the following decades, groundwater levels in various parts of the basin have declined and/or risen, largely as a result of pumping, artificial recharge, and recycling of water, as well as changes that occurred in usage as the Menifee area transitioned from agriculture to urbanization. More recently, well water levels in the General Plan area ranged from about 6 feet to 176 feet deep (EMWD, 2009).

Groundwater levels in the Menifee General Plan area have been increasing in recent years due to decreased extraction of water, which is high is dissolved salts. This has caused the saline water to migrate north into the Lakeview area, where the groundwater is of good quality (i.e., low in dissolved solids). Consequently, part of the groundwater management program in the Menifee area involves reducing the water levels by pumping groundwater and treating it to remove the salts (EMWD, 2005).

2.4.6.1 Mitigation of Ground Subsidence

Prevention of subsidence requires a regional approach to groundwater conservation and recharge. In the early years, groundwater in the San Jacinto Basin was distributed by various small water companies and irrigation districts. In 1951, the Eastern Municipal Water District (EMWD) was formed to supplement local wells with water imported by the Metropolitan Water District (MWD) from the Colorado River and eventually, from northern California. Since that time, the District's activities have expanded to include groundwater production, water distribution, and other services. Groundwater in the Menifee General Plan area is managed by the EMWD under the West San Jacinto Groundwater Basin Management Plan (adopted in 1995), a cooperative effort between private and public producers in the area. The primary goal of the EMWD is to insure a low-cost, sustainable supply of quality water for the future. To that end, the district has implemented programs with the following elements, all of which will result either directly or indirectly in the prevention of future ground subsidence:

- Understanding of the basin's geology, hydrology, hydraulic control, and water chemistry: This includes geophysical studies, groundwater level measurements, groundwater extraction metering, and water quality sampling. The EMWD compiles and archives collected data for future analysis, as needed.
- Imported water: The imported water supply is crucial to the area's survival, since residents have been using more water than is replaced naturally (about 65% of the area's water is imported). However the amount of water that is actually available each year is variable, depending on, for instance, if the State has a wet or dry year, or if there are multiple dry years. This variability is expected to increase as users compete for the available supply. To help alleviate this, programs continue to be developed to allow transfers of allotments between water contractors in order to maximize storage of State Water Project water supplies when they are available.
- Water reclamation: The EMWD has built five regional reclamation plants having a total capacity of more than 59 million gallons a day. Recycled water is distributed for agriculture, groundwater recharge, golf course and school grounds irrigation, and wildlife habitat.
- Desalination and filtration: Desalination plants treat groundwater high in total dissolved solids (TDS) through a reverse osmosis process to create drinking-quality water and to alleviate the problem of brackish groundwater migrating to areas with good water quality. The EMWD plans to expand its desalination program, including building a new plant. Further, production of the brackish water has the beneficial side effect of stabilizing the groundwater table in the area. Filtration

plants filter imported water to make it potable. Untreated imported water is percolated into the ground to replenish aquifers or is used for crop irrigation.

- Monitoring: The EMWD monitors groundwater levels, groundwater extraction, groundwater quality, and other basin conditions. This helps to determine the safe yields of groundwater basins so that available supplies can be balanced with extraction.
- Well capping program: The EMWD offers well-capping/sealing services free of charge to owners of inactive wells that might be a safety hazard or a potential source of groundwater contamination. The wells are not destroyed and may be used to collect data.
- Conservation: The EMWD's goal is to reduce long-term water demand with specific programs of water conservation and public education.

According to the EMWD's (2005) Urban Water Management Plan, they currently have water supply capabilities to meet daily demands as well as future demands into the year 2030 – provided the Metropolitan Water District (MWD) is able to meet the demands of its member agencies. In order to cope with long- or short-term water shortages, the EMWD has developed a four-stage contingency plan based on certain limitations in the water supply or delivery system. Currently, the EMWD's customers are under Stage 2 mandatory conservation requirements due to a 10% cutback in water allocations by the MWD. In the event of a catastrophic loss of supply, the EMWD has developed a Water Shortage Emergency Operations Plan. This situation could result from a natural disaster, such as an earthquake, or loss of power that prevents the EMWD or the MWD from supplying and distributing the water.

The EMWD does not have a program for periodic monitoring of land subsidence, however they have done baseline ground-level survey for future reference. In addition, they have an extensive network of wells, pump stations, and pipelines that would be sensitive to changes and ground elevations due to subsidence, and no problems have occurred to date, suggesting that subsidence has not occurred in the area. The broad network of wells, along with the water level monitoring program, allows them to balance extraction so that no areas are over-pumped. According to the EMWD, the potential for ground subsidence, as well as the geotechnical issues associated with groundwater production, are considered in their overall groundwater management programs (EMWD, 2010).

2.4.7 Erosion

Erosion, runoff, and sedimentation are influenced by several factors, including climate, topography, soil and rock types, and vegetation. The topographic relief between the valleys and the adjacent mountains makes erosion and sedimentation an important issue for communities built on alluvial fans and within hillside areas. The fractured condition of the bedrock forming the mountains, combined with rapid geologic uplift and infrequent but powerful winter storms leads to high erosion rates. Further, erosion can increase significantly when mountain slopes are denuded by wildfires. Winter storms that follow a season of mountain wildfires can transport great volumes of sediment onto the low-lying areas below.

In the General Plan area, the unconsolidated sediments are generally the most susceptible to erosion. Natural erosion processes, even in more consolidated deposits, are often accelerated through man's activities – whether they are agricultural or land development. Development often increases the potential for erosion and sedimentation by removing protective vegetation, altering natural drainage patterns, and constructing cut and fill slopes that may be more susceptible to erosion than the original, natural slope conditions. Developments also reduce the surface area available for infiltration, leading to increased flooding, erosion, and sedimentation downstream of the project.

2.4.7.1 Mitigation of Erosion

Because much of the runoff travels throughout the area in natural washes and gullies and by sheet flow, erosion remains a significant hazard for Menifee. In rural or semi-rural areas, new structures should not be placed where they obstruct natural flows, or direct flows to neighboring properties. Homes or structures on natural slopes should not be permitted at the head of steep drainage channels or gullies without protective measures against headward erosion of the gully. Structures placed near the base of slopes and/or near the mouths of small canyons, swales, washes, and gullies will need protection from sedimentation. Developments in the valley that are adjacent to natural drainage channels should be adequately set back from eroding channel banks, or modification of the channel to reduce erosion should be included in the project design. In similar fashion, mass-graded, moderate to high-density developments should not impair or divert natural drainage patterns in a way that causes damage within the project, or to downstream properties.

Mitigation of erosion and sedimentation typically includes structures to slow down stream velocity, such as check dams and drop structures, devices to collect and channel the flow, catchment basins, and elevating structures above the toes of the slopes. Diversion dikes, interceptor ditches, swales, and slope down-drains are commonly lined with asphalt or concrete, however ditches can also be lined with gravel, rock, decorative stone, or grass, to make them esthetically more pleasing. Larger basins can double as parks or recreation areas.

There are many options for protecting manufactured slopes from erosion, such as terracing slopes to minimize the velocity attained by runoff, the addition of berms and v-ditches, and installing adequate storm drainage structures. Other measures include establishing protective vegetation, and placing mulches, rock facings (either cemented or non-cemented), gabions (rock-filled galvanized wire cages), or building blocks with open spaces for plantings on the slope face. All slopes within developed areas should be protected from concentrated water flow over the tops of the slopes by the use of berms or walls. All hillside building pads should be engineered to prevent water from flowing over the tops of slopes.

Temporary erosion control measures must be provided during the construction phase of a development, as required by local building codes and ordinances, as well as State and Federal stormwater pollution regulations. In addition, permanent erosion control and clean water runoff measures are required for new developments. These measures might include desilting basins, percolation areas to cleanse runoff from the development, proper care of drainage control devices, appropriate irrigation practices, and rodent control. Erosion control devices should be field-checked following periods of heavy rainfall to assure they are performing as designed and have not become blocked by debris. Permanent erosion control devices should conform as much as possible to natural contours of the land and be designed to aesthetically fit in with the local environment.

Both the city of Menifee and the County of Riverside require plans be developed for both temporary and permanent erosion control in new projects. Construction must comply with the project's Storm Water Pollution Prevention Plan and Best Management Practices, which are part of the site's grading plans (see Chapter 5). The goal is to minimize or restrict the release of runoff and sediment from the site, as well as debris or potential pollutants.

2.5 Summary of Issues

The Menifee General Plan area is highly diverse geologically. This diversity is strongly related to the youthful (in geologic terms) seismic setting of the surrounding region, which includes the ongoing uplift of the San Jacinto Mountains to the northeast as a result of tectonic movement along the San Jacinto fault zone. This, along with the effects of climate, has resulted in a landscape that is complex in geologic processes and hazards. As Menifee's population grows in the next decades, new development will be needed to meet the demand for homes. When meeting this demand, it is imperative to manage land uses in a responsible way, as development disrupts natural processes, often leading to negative impacts on the environment as well as on the development and adjacent projects. The impacts of land development can be minimized, however, if both site-specific and regional planning elements are recognized and considered, the project incorporates knowledge gained from scientific research in developing and implementing a design appropriate to the area, and protective measures are constructed and maintained for the lifetime of the project.

Most of Menifee's existing more densely developed areas are situated in its broad valleys, with rural to semi-rural development in the surrounding hillsides. The San Jacinto Mountains not only form a dramatic backdrop to the area, but also greatly influence the area's climate, geology, and hydrology. These elements combine in various ways to create geologic hazards, as well as benefits to the community. Hazards that have the greatest impact on the Menifee General Plan area are summarized below.

Slope instability is a potential hazard where development has encroached onto the hills and washes. The rock types forming the local mountains are generally resistant to landsliding, so future slope failures are more likely to consist of surficial failures and erosion of sandy geologic materials. Such failures typically occur during exceptional and/or prolonged rainfall, and may manifest as mud or debris flows. Rockfall is a hazard near the base of the mountains, in areas where the bedrock forms bouldery outcrops. Rockfall is more likely to occur as a result of earthquake-induced ground shaking, posing a threat to structures and passing motorists.

Potentially compressible and/or collapsible soils underlie a significant part of Menifee's valleys and canyons, typically where geologically young sediments have been deposited, such as young alluvial fans, washes, and canyon bottoms. These are generally young sediments of low density with variable amounts of organic materials. Under the added weight of fill embankments or buildings, these sediments can settle, causing distress to improvements.

Although not prevalent, some of the geologic units in the Menifee area have fine-grained components that are likely to be moderately to highly expansive. These materials may be present at the surface or may be exposed by grading activities. Man-made fills can also be expansive, depending on the soils used to construct them.

Sediments in the valley areas are commonly corrosive to metallic objects, such as pipelines, that are in contact with the soil. All soils should be tested for corrosion potential, and mitigation developed by a corrosion engineer where needed.

Regional ground subsidence from groundwater withdrawal is a potential hazard that can proactively be prevented by aggressive water management, the use of recycled water, the continued development of new water sources, continuing public education, the widespread use of drought-tolerant plants in landscaping, and the implementation and enforcement of stringent water conservation measures, especially during droughts. The City should also consider requiring new subdivisions or commercial developments to install the infrastructure for water recycling, so that these sites can be connected to recycled water mains as they become available. With the expected increase in population, water shortage is one of the most serious challenges ahead. Overdraft of the aquifers underlying Menifee could result in ground subsidence, with resultant negative impact on the area's environmental quality.

Because of the topographic relief in and around Menifee, erosion and sedimentation are inherently significant elements of the natural setting. Land development can have adverse impacts on these elements by altering the natural processes, topography, and protective vegetation, in addition to reducing the area of natural infiltration. This in turn can lead to damage from increased flooding, erosion, and sedimentation in other areas, typically downstream. Erosion and sedimentation are also important considerations on a site-specific basis, with respect to developments adjacent to slopes and drainage channels. These issues are not only critical during the design of a project, but also during construction and during the long-term maintenance of the developed site.

Losses resulting from geologic hazards are generally not covered by insurance policies, causing additional hardship on property owners. The potential for damage can be greatly reduced by:

- Strict adherence to grading ordinances – many of which have been developed as a result of past disasters;
- Sound land planning and project design that avoids severely hazardous areas;
- Detailed, site-specific geotechnical investigations, followed by geotechnical oversight during grading and during construction of foundations and underground infrastructure;
- Effective geotechnical and design review of projects performed by qualified, California-registered engineering geologists, soil engineers, and design engineers; and
- Public education that focuses on reducing losses from geologic hazards, including the importance of proper irrigation and landscaping practices, in addition to the care and maintenance of slopes and drainage devices.

CHAPTER 3: FLOODING HAZARDS

Floods are natural and recurring events that only become hazardous when man encroaches onto floodplains, modifying the landscape and building structures in the areas meant to convey excess water during floods. Unfortunately, floodplains have been alluring to populations for millennia, since they provide level ground and fertile soils suitable for agriculture, as well as access to water supplies and transportation routes. Notwithstanding, these benefits come with a price – flooding is one of the most destructive natural hazards in the world, responsible for more deaths per year than any other geologic hazard. Furthermore, average annual flood losses (in dollars) have increased steadily over the last decades as development in floodplains has expanded.

The city of Menifee and surrounding areas are, like most of southern California, subject to unpredictable seasonal rainfall. Most years, the winter rains are barely sufficient to turn the hills green for a few weeks, but every few years the region is subjected to periods of intense and sustained precipitation that results in flooding. Historic flood events that occurred in southern California have resulted in an increased awareness of the potential for public and private losses as a result of this hazard, particularly in the highly urbanized parts of floodplains and alluvial fans. As the population grows, there is an increased pressure to build on flood-prone areas, and in areas upstream of previously developed land. With increased development also comes an increase in impervious surfaces, such as asphalt. Water that used to be absorbed into the ground becomes runoff to downstream areas. If drainage channels that convey storm waters are not designed or improved to carry these increased flows, areas that have not flooded in the past may be subject to flooding in the future. This is especially true for developments near the base of the mountains and downstream from canyons that have the potential to convey mudflows.

3.1 Storm Flooding

3.1.1 Hydrologic Setting

The Menifee General Plan area occupies an inland valley punctuated by rugged hills with rocky outcrops. This region is separated from the coastal watersheds by the Santa Ana Mountains, and shielded from the deserts by the San Bernardino and San Jacinto Mountain ranges. Menifee is situated in the lower part of the San Jacinto River Basin, a regional watershed that covers more than 700 square miles. The river's drainage basin encompasses the area from Moreno Valley to the hills south of Hemet, as well as the western flank of San Jacinto Mountains. The source of storm flooding in Menifee comes primarily from the San Jacinto River and its major tributary, Salt Creek, as well as several smaller drainages along the city's boundaries.

San Jacinto River. The San Jacinto River receives runoff from the San Jacinto Mountains, where steep slopes and high rates of precipitation result in a rapid concentration of runoff, causing flows with high velocities and large peaks. As peak flows reach the valley floor, large amounts of sediment and debris are deposited, thereby compounding the flood problems associated with the river. The portion of Menifee north of Sun City slopes very gradually towards the river, but the lack of topographic relief on the valley floor in this area allows floodwaters to spread out over a wide area, eventually reaching the northern boundary of the city. The expanse of flooding is further aggravated by the sudden constriction of flows at the entrance to the upper end of Railroad Canyon, located just northwest of Menifee. Winding through the narrow canyon, the river eventually discharges into the Railroad Canyon Reservoir. Below the Railroad Canyon Dam, the riverbed continues a sinuous course through the hills, terminating at Lake Elsinore.

Figure 3-1: The San Jacinto River Floodplain.
View is looking north from Menifee toward the Bernasconi Hills.

Salt Creek. The Salt Creek drainage occupies the southernmost part of the San Jacinto River Basin, reaching into the hills south of Hemet, and encompassing the southern part of Hemet, the communities of Green Acres and Winchester, and nearly all of the city of Menifee. Salt Creek bisects the Menifee area and has a large impact on zoning, development, and flood-hazard management. The lowlands around Salt Creek have experienced numerous floods over the past century, also due in part to the flatness of the valleys and the constricted entrance to the hills at the western edge of the city. The potential for Salt Creek to flood surrounding properties in the Menifee area has been reduced in recent years by the development of flood control measures that include channelization and land use restrictions, much of which have occurred concurrently with the progress of development. Nevertheless, because many of the road crossings are not designed to convey major storm flows, Salt Creek remains problematic. The Salt Creek channel discharges into the Railroad Canyon Reservoir, at the corporate boundary between the cities of Menifee and Canyon Lake.

Ethanac Wash. This watershed includes the southwestern flank of the rugged Lakewood Mountains, in addition to the communities of Romoland and Homeland. The drainage network begins in the Juniper Flats area within the highest part of the mountains, and includes numerous steep-sided channels that are generally dry except during storms or where springs are present. Upon reaching the alluvial fan surface, the drainage channels become increasingly less well defined, and the runoff eventually coalesces into sheet flow across the valley floor. Runoff that crosses the Romoland portion of Menifee eventually reaches the San Jacinto River, however the flow is impeded by the BN&SF railroad tracks and the 215 freeway, causing ponding of water upstream of these structures.

Quail Valley. The community of Quail Valley occupies a small drainage basin that is a tributary to Railroad Canyon. Flooding problems on the floor of Quail Valley are due in part to the original layout of the streets and homes in the 1950s, which consists of a grid pattern superimposed on the natural, irregular drainage network. This has led to localized problems due to blocked or diverted drainages, and is compounded by the lack of structures to control runoff.

Other Drainages. The southeastern corner of the General Plan area drains southward via numerous small tributaries to Warm Springs Creek. This creek passes through a small gap in the hills in the southeastern corner of the city. In the southwestern corner of the city, a drainage divide located just inside the city boundary separates the Salt Creek watershed from streams flowing toward the Elsinore Valley.

3.1.2 Weather and Climate

Southern California owes its agreeable climate of generally mild winters and warm, dry summers to a semi-permanent high-pressure area located over the eastern Pacific Ocean, which deflects storms to the north. During the winter months, this high breaks down, allowing the jet stream to move storms along a more southerly track.

In spite of southern California's reputation for a mild Mediterranean climate, there are varied and distinct climatic zones in close proximity that are controlled by terrain and altitude. As mentioned above, the San Bernardino and San Jacinto Mountains have a powerful effect on the climatic conditions in this region. Capturing precipitation from strong Pacific storms that pass through, the mountains separate the semi-arid environment to the west from the dry, desert regions to the east. Most precipitation occurs in the winter months, between November and April. However, high-intensity, short-duration tropical thunderstorms emanating from the south are common during the summer and fall. Often accompanied by strong winds, these powerful storms frequently result in localized damage to roadways, power poles, trees, and structures.

The San Jacinto Mountains receive significantly more precipitation than the adjacent valleys, consequently the San Jacinto River can carry increased discharge even if very little rain falls in the valleys. Average yearly precipitation in the Menifee area is nearly 12 inches (see Table 3-1), whereas more than 25 inches (average) of precipitation fall annually in the San Jacinto Mountains (Table 3-2).

Table 3-1: Average Annual Rainfall* by Month for Menifee Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Inches	1.8	1.8	2.8	1.2	0.3	0.0	0.0	0.6	0.4	0.3	0.9	1.7	**11.9**

Data based on 9 complete years between 1973 and 1995 for Sun City NCDC weather station (elevation: 1,417 feet above mean sea level).
Source: http://www.worldclimate.com/
*Average rainfall = Mean monthly precipitation, including rain, snow, hail, etc.

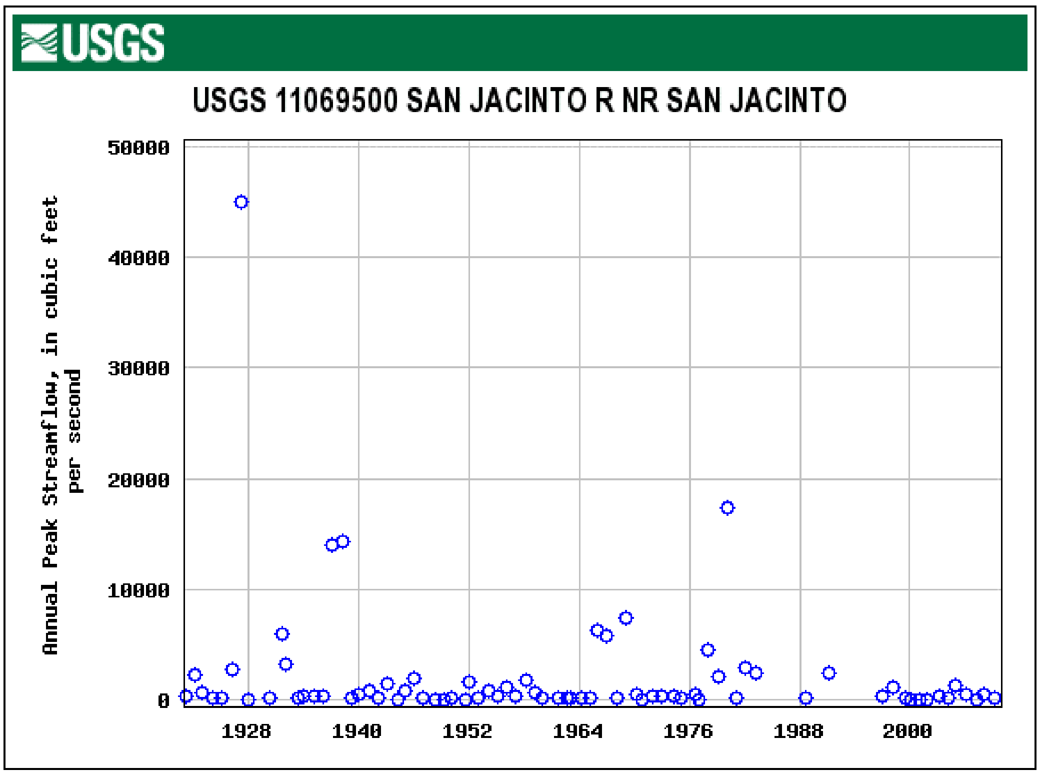
Table 3-2: Average Annual Rainfall* by Month for the San Jacinto Mountains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Inches	6.0	4.7	3.9	1.5	0.3	0.0	0.5	1.2	0.8	0.6	3.3	2.7	**25.3**

Data based on 8 complete years between 1965 and 1978 for Mount San Jacinto NCDC weather station (elevation: 8,425 feet above mean sea level).
Source: http://www.worldclimate.com/
*Average rainfall = Mean monthly precipitation, including rain, snow, hail, etc.

Not only does rainfall in southern California vary from one location to the next, often within short distances, it is also extremely variable from year to year, with periods of drought alternating with periods of flooding. For instance, annual rainfall totals are illustrated in the peak streamflow graph for a gage on the San Jacinto River (see Figure 3-2). This gage located near the City of San Jacinto illustrates the extreme fluctuations in stream discharge that can occur above Menifee. With peaks typically on the order of less than 1,000 cubic feet per second (cfs) for most years, peak flows reached more than 10,000 cfs in 1937, 1938 and 1980. The highest discharge for the San Jacinto River (recorded on February 16, 1927) was 45,000 cfs!

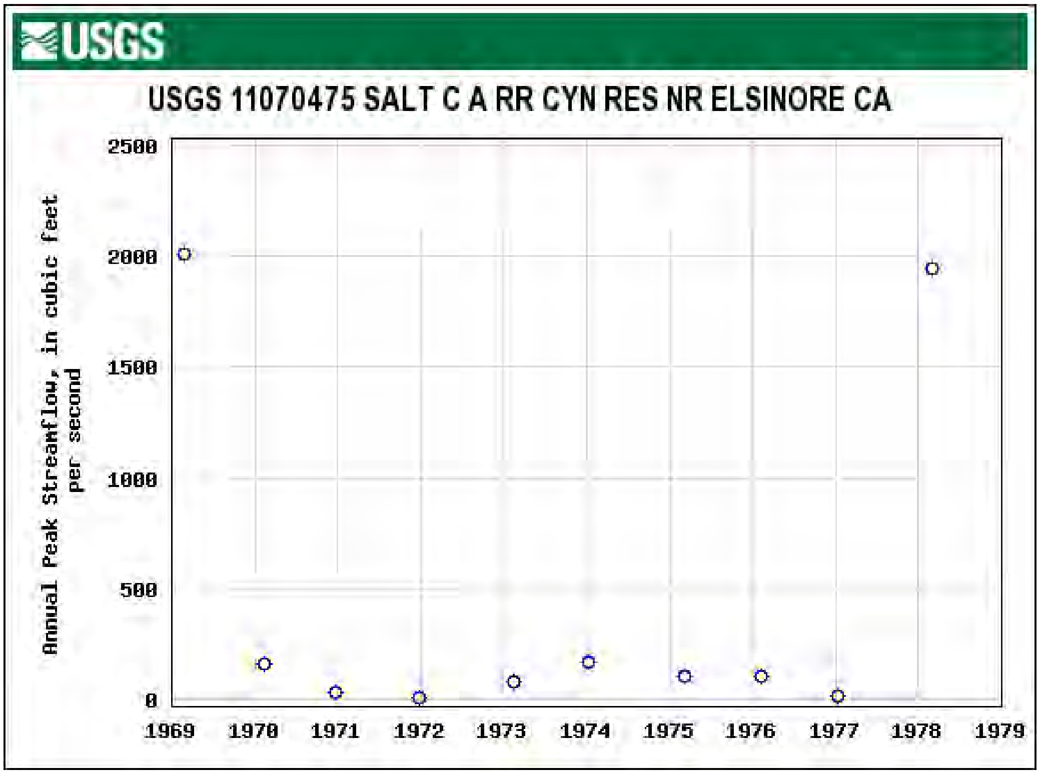
Figure 3-2: Peak Annual Streamflow Values for Gage Station 11069500 Located on the San Jacinto River near the City of San Jacinto



Source: http://nwis.waterdata.usgs.gov/ca/nwis/peak?site_no=11069500&agency_cd=USGS&format=html

For Salt Creek, within city of Menifee limits, peak streamflow has generally been less than about 200 cfs, however this swelled ten-fold during the 1969 and 1978 storms (based on measurements made on the now discontinued USGS stream gage 11070475 that was located at the western edge of Menifee). Although earlier stream gage data are limited, damaging floods are known to have occurred in the Salt Creek watershed during 1884, 1891, 1916, 1927, 1937, 1938, and 1952 (FEMA, 2008).

Figure 3-3: Peak Annual Streamflow Values for Discontinued Gage Station 11070475 Located on Salt Creek at the Western Edge of Menifee



Source: http://nwis.waterdata.usgs.gov.

Winter Storms. Winter storms are characterized by heavy and sometimes prolonged precipitation over a large area. These storms usually occur between November and April, and are responsible for most of the precipitation recorded in southern California. This is illustrated by the data presented above in Tables 3-1 and 3-2. The storms originate over the Pacific Ocean and move eastward (and inland). Mountain ranges, such as the San Bernardino and San Jacinto Mountains, form a rain shadow, slowing down or stopping the eastward movement of this moisture. A significant portion of the moisture is dropped on the mountains as snow. If large storms are coupled with snowmelt from the local mountains, large peak discharges can be expected in the main watersheds at the base of the mountains.

Some of the severe winter storm seasons that have historically impacted the southern California area have been related to El Niño events. El Niño is the name given to a phenomenon that originates every few years, typically in December or early January, in the southern Pacific, off the western coast of South America, but whose impacts are felt worldwide. Briefly, warmer than usual waters in the southern Pacific are statistically linked with increased rainfall in both the southeastern and southwestern United States, droughts in Australia, western Africa and Indonesia, reduced number of hurricanes in the Atlantic Ocean, and increased number of hurricanes in the Eastern Pacific. Two of the largest and most intense El Niño events on record occurred during the 1982-83 and 1997-98 water years. [A water year is the 12-month period from October 1 through September 30 of the second year. Often a water year is identified only by the calendar year in which it ends, rather than by giving the two years, as above.] These are also two of the worst storm seasons reported in southern California in recent decades.

More recently, the severe storms of December 2004 and January 2005 have been blamed on a different climatic condition, one where the sub-tropical jet stream carries moisture-laden air directly from the tropics to the west coast of California. Because it passes over the Hawaiian Islands, it is commonly referred to as the "Pineapple Express." In December 2004, as this condition was developing, the northern jet stream shifted towards the California coast allowing storms from the north to tap into the deep tropical moisture, dramatically increasing the rainfall in southern California (NOAA, 2005a). Powerful winter storms during February 2005, however, have been attributed to a weak but persistent El Niño condition, combined with an atmospheric condition that blocked or slowed the normal eastward movement of the storms (NOAA, 2005b). These events combined to give the region record-breaking rainfall in the 2005 water year, in addition to spawning numerous waterspouts and small tornadoes.

Monsoon Storms. Typically developing in late summer to fall, these storms are usually most prevalent in the higher mountains and the deserts, but can also move into nearby valleys. They develop when moist, unstable air moves into our area from Mexico through Arizona (Mexican monsoons), from the Sea of Cortez (Gulf Surge), or at times from tropical storms or hurricanes off of Baja California. Once the monsoonal moisture enters California and flows up steep mountain slopes, explosive thunderstorms can develop. Although these high-intensity, short-duration storms typically impact relatively small areas, they often release torrential rainfall that causes flash flooding and mudslides. Frequently packing lightning, hail, very strong wind gusts, and even small tornadoes, thunderstorms cause power outages and damage to people and property. Such storms have impacted Menifee and the surrounding area in the past.

3.1.3 Past Flooding

Because of the semi-arid climate and the generally dry local washes, residents might be surprised to learn that alluvial fans are the sites of infrequent but catastrophic flooding. Flood hazards to the Menifee area can be classified into two general categories: flash flooding down natural channels, including the San Jacinto River and Salt Creek, and sheet flooding across the valley floor.

Flash floods are short in duration, but have high peak volumes and high velocities. This type of flooding occurs in response to the local geology and geography, and the built environment (man-made structures). The local mountains are steep and consist of rock types that are fairly impervious to water. Consequently, little precipitation infiltrates the ground. When a major storm moves in, water collects rapidly and runs off quickly, making a steep, rapid descent from the mountains into natural or modified channels within developed valley areas. Because of the steep terrain and the constant shedding of debris from mountain slopes (primarily as dry ravel and rock falls), flood flows often carry large amounts of mud, sand, and rock fragments. Sheet flow occurs when the capacities of the existing channels (either natural or man-made) are exceeded or when channels become blocked by debris or structures, causing water to flow into the adjacent areas.

Some of the major historic floods that have had an impact on the Menifee area are mentioned below.

January 1862. Historical descriptions suggest the flood of 1862 was the largest rainfall event in southern California since the arrival of the Spanish mission fathers. Although very little scientific data on discharge or rainfall rates are available for that year, historical accounts reported that rain fell continuously from Christmas Day 1861 until January 18, 1862, followed by a downpour that lasted 24 hours. Many settlements were underwater, and lakes formed on the coastal plains of Los Angeles and Orange counties. One of the remarkable aspects of this flood was that it was statewide – devastating northern as well as southern California – leading to bankruptcy of the State when it was only 12 years old (Engstrom, 1996; Taylor and Taylor, 2007).

January 1916. This flood, which actually involved two intense storms in mid to late January, was most devastating in San Diego County but also caused significant damage to farmlands, bridges, roads, and railways in western Riverside County. Precipitation for the last half of the month was more than 10 inches for the San Jacinto area, and nearly 15 inches for Elsinore. Prior to the storms, discharge for the San Jacinto River was about 2 cfs near the town of Elsinore. On January 28, near the end of the second storm, peak discharge for the river reached 14,000 cfs at the same gaging station (Henry, 1916; McGlashan and Ebert, 1918).

February 1927. The San Jacinto River has flooded numerous times since 1900, but the largest flood on record for this river was in 1927. An estimated peak discharge of 45,000 cfs occurred on February 16. This is more than double the next highest discharge of 17,300 cfs on February 21, 1980, and more than three times the discharge recorded on March 2, 1938 (14,300 cfs) (FEMA, 2008). Agricultural lands, railways, and highways were extensively damaged.

February-March 1938. During the last century, one of the most disastrous southern California storm periods on record occurred during February 27 to March 4, 1938, when a series of strong storms centered over the San Gabriel and San Bernardino Mountains unleashed record-breaking rainfall in areas already saturated by previous storms. Almost every community in the area, including western Riverside County, was isolated as roads and bridges were destroyed, and hundreds of people were left homeless (San Bernardino County Flood Control District, 2005). Stream gages on rivers emanating from the mountains, including the San Jacinto River, logged record discharges, and losses were estimated at more than $78 million (1938 dollars) due to the extensive development that had taken place on the floodplains of major rivers (Troxell, 1942).

Prior to the 1938 flood, citizens in Riverside County had already developed an awareness of the need for flood control and water conservation. For instance, as early as 1908 residents of the San Jacinto Valley formed the San Jacinto Levee District with funding from

County, State and Federal governments. In addition, property owners taxed themselves to help build the levee system along the San Jacinto River. However the 1938 flood made it clear that growing cities in the region did not have adequate flood protection. This eventually led to the formation of the Riverside County Flood Control and Water Conservation District (RCFC&WCD) in 1945 (RCFC&WCD, 2009).

January-February 1969. In January and February of 1969, a series of closely spaced, intense storms released extremely heavy rainfall on saturated ground. More than 50 people died in southern California and storm flows damaged or destroyed miles of improved flood control channels, roads, bridges, and rail lines. Communities situated on alluvial fans at the base of the mountains suffered damages from sediment-laden floodwaters that overtopped channel banks and flowed through residential areas. In addition, damage to industrial buildings, public facilities and farmlands was severe (Waananen, 1969). Riverside County again suffered significant flood damage, including areas along the San Jacinto River and Salt Creek. As bad as this was, most flood control facilities constructed after 1938 performed well and prevented the extent of damage from being much worse. Nevertheless, the storms demonstrated the further need for new facilities throughout the area.

February 1980. The severe winter storms of 1980 again caused extensive damage in western Riverside County, in part due to the rapid growth the region was now experiencing. The February 1980 rainfall was record-breaking, with some valley areas of the County reporting February totals that were about 360 to 430% of normal, and 400 to 510% of normal in the mountains. On February 21, 1980 a section of the San Jacinto River levee collapsed (the fourth break since the winter storms began), sending an estimated flow of 25,000 cfs into portions of the city of San Jacinto. An estimated 5,000 people fled their homes, while others were trapped and rescued by helicopters, boats, and rafts (The Press Enterprise, 1980).

February 1998. In February1998, a series of powerful Pacific storms enhanced by warm El Niño conditions in the eastern Pacific Ocean pounded southern California with strong winds, thunderstorms, and intense rain. Widespread flooding and property damage occurred, including the loss of crops and livestock. Many roads, rail lines and bridges were damaged and temporarily closed, and swift-water rescues occurred throughout the area, including in Canyon Lake, Sun City, and San Jacinto. Estimated losses for the four southern California counties (Riverside, San Bernardino, Orange, and San Diego) as a result of the February storms exceeded $100 million (NCDC, 2009).

October 2004. Early winter storms brought record heavy rain to the region, causing widespread urban flooding, as well as rock and mudslides in the mountains. This series of strong storms resulted in October rainfall totals that were 1,000 to 2,000% above normal, the wettest October since record keeping began in 1850. In Sun City, seven people had to be rescued from their vehicles when they became trapped in a flooded intersection with water four feet deep (NCDC, 2009).

January-February 2010. Winter storms caused extensive flooding in Menifee. The Ethanac area upstream of the I-215 freeway flooded, and the floodwaters were within one foot of topping the freeway. The Salt Creek crossings at Bradley Road, Murrieta Road and

Newport Road had to be closed several times due to flooding (Don Allison, City of Menifee Public Works Department, written communication dated July 19, 2010).

3.1.4 National Flood Insurance Program (NFIP)

Because floods are the leading cause of natural disaster losses in the United States, the nation invests significant resources to reduce the risk of flooding. Because floods can be widespread and cause catastrophic losses, insurance companies generally consider flood hazards too costly to insure (National Research Council, 2009). In order to manage the increasing flood losses, the Federal Emergency Management Agency (FEMA) was mandated by the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 to evaluate flood hazards and provide affordable flood insurance to residents in communities that regulate future floodplain development. To that end, FEMA created **Flood Insurance Rate Maps (FIRMS)** for the purpose of setting flood insurance premiums and for regulating the elevations and flood proofing of structures in mapped flood zones.

The NFIP is required to offer federally subsidized flood insurance to property owners in those communities that adopt and enforce floodplain management ordinances that meet minimum criteria established by FEMA. Floodplain management may include such measures as requirements for zoning, subdivisions, and building construction, as well as special-purpose floodplain ordinances. The National Flood Insurance Reform Act of 1994 further strengthened the NFIP by providing a grant program for State and community flood mitigation projects. The act also established the **Community Rating System (CRS)**, a system for crediting communities that implement measures to protect the natural and beneficial functions of their floodplains, and managing their erosion hazard.

The County of Riverside has participated as a regular member in the NFIP since 1980 (Community ID No. 060245#). The most current effective FIRM maps were revised August 28, 2008. Because the County of Riverside is a participating member of the NFIP, flood insurance is available to any property owner in the unincorporated area of the Menifee General Plan. In fact, to secure financing to buy, build, or improve structures in a Special Flood Hazard Zone (SFHZ – see definition below), property owners are required to purchase flood insurance. Lending institutions that are federally regulated or federally insured must determine if the structure is located in a SFHZ and must provide written notice requiring flood insurance. Currently, the city of Menifee is not a member of the NFIP.

FEMA recommends that most property owners, whether residential or commercial, purchase and keep flood insurance, even if they are not located in a mapped flood hazard zone. Keep in mind that approximately 20 to 25 percent of all flood claims occur outside of mapped high flood risk areas, and typical homeowner or business insurance policies do not cover flooding. Residents or business owners that rent property can also purchase coverage for the contents of their homes or business inventories. In low to moderate risk areas, property owners should ask their agents if they are eligible for the FEMA Preferred Risk Policy, which provides inexpensive flood insurance protection. Insured property owners can be reimbursed for all covered losses, even if the flood is not officially declared a Federal disaster area. Residents should also be aware that localized flooding could be caused by a temporary situation, such as a storm drain inlet or culvert that becomes blocked by debris during a storm. Hillside areas are generally outside of mapped flood zones, however these areas can be vulnerable to mudslides, which are also covered under flood insurance.

FEMA also recommends that residents do not forgo purchasing insurance, assuming instead Federal disaster assistance will pay for flood damage. In order to receive assistance, a community must first be declared a Federal disaster area, and these declarations are issued in less than 50% of flood events. Remember also that Federal assistance is usually in the form of a loan, which must be repaid with interest. Furthermore, if uninsured property owners do receive Federal assistance, they must purchase flood insurance to remain eligible for future disaster relief.

3.1.5 FEMA Flood Zone Mapping

Flood risk information presented on FIRMs is based on historic, meteorological, hydrologic, and hydraulic data, as well as topographic surveys, open-space conditions, flood-control works, and existing development. Rainfall-runoff and hydraulic models are utilized by the FIRM program to analyze flood potential, adequacy of flood protective measures, surface-water and groundwater interchange characteristics, and the variable efficiency of mobile (sand bed) flood channels. For riverine flooding, the extent of potential flooding is predicted from statistical analyses and hydrologic models that rely heavily on data from U.S. Geological Survey stream gages and land surface topography.

Some FEMA flood map features that are relevant to the residents of the General Plan area are:

Flood Insurance Study (FIS). To prepare FIRMs that illustrate the extent of flood hazards in a flood-prone community, FEMA conducts engineering studies referred to as Flood Insurance Studies. The Menifee General Plan area is included in the FIS for Riverside County, currently updated in August 2008. This document includes community descriptions, flooding sources (including the San Jacinto River and Salt Creek), information of historical flooding, existing flood protection measures, hydrologic and hydraulic analyses, and definition of potential flood areas.

Special Flood Hazard Area (SFHA). Using information gathered in FIS studies, FEMA engineers and cartographers delineate Special Flood Hazard Areas on FIRMs. SFHAs are those areas subject to a high risk of inundation by a "base flood" which FEMA sets as a 100-year flood. As mentioned above, SFHAs are regulated zones, requiring the mandatory purchase of flood insurance. They are also subject to special standards and regulations that apply to new construction, and in some cases, existing buildings. Floodplain regulations required by the NFIP apply only to properties located in a SHFA. However, these are minimum requirements, and local jurisdictions may regulate areas outside of the SHFAs, based on knowledge specific to their area.

Base Flood. The base flood, also called the **100-year flood,** is defined by looking at the long-term average period between floods of a certain size, and identifying the size of flood that has a 1 percent chance of occurring during any given year. This base flood has a 26 percent chance of occurring during a 30-year period, the length of most home mortgages. However, a recurrence interval such as "100 years" represents only the long-term average period between floods of a specific magnitude; rare floods can in fact occur at much shorter intervals or even within the same year.

The base flood is a regulatory standard used by the National Flood Insurance Program (NFIP) as the basis for insurance requirements nationwide. The Flood Disaster Protection Act requires owners of all structures in identified SFHAs to purchase and maintain flood insurance as a condition of receiving Federal or federally related financial assistance, such as mortgage loans from federally insured lending institutions.

The base flood is also used by Federal agencies, as well as most County and State agencies to administer floodplain management programs. The goals of floodplain management are to reduce losses caused by floods, while preserving and restoring the natural and beneficial value of the floodplain.

Base flood elevation (BFE). This is the calculated elevation of the water surface during a base flood event. The BFE is important because it is the regulatory standard used for the elevation or flood proofing of structures. Further, the height of the first floor elevation above the BFE determines the amount of the flood insurance premium. BFEs are shown on FIRMs for those flooding sources that have been analyzed using detailed methods. BFEs on the maps have been rounded to whole-foot elevations and are intended for use in flood insurance rating purposes only. For construction or floodplain management, data in the FIS should be utilized as well.

Floodway. The basis of floodplain management is the concept of the "floodway." FEMA defines this as the channel of a river or other watercourse, and the adjacent land areas that must be kept free of encroachment in order to discharge the base flood without cumulatively increasing the water surface elevation more than a certain height. The intention is not to preclude development, but to assist communities in managing sound development in areas of potential flooding. The community is responsible for prohibiting encroachments into the floodway unless it is demonstrated by detailed hydrologic and hydraulic analyses that the proposed development will not increase the flood levels downstream.

Mapped flood areas outside of the 100-year flood zone. FIRMs in the Menifee area also show the estimated limits of areas with moderate to low risk of flooding. The flood having a 0.2% annual chance of occurring (also called the 500-year flood) is usually the basis for these categories, with moderate risk defined as the zone between the limits of the 100-year and 500-year floods, and low risk defined as the area outside of the 500-year flood limits. These zones may also include areas where the base flood is less than one foot deep, or where the drainage basin is small (less than one square mile), or areas that are protected from the base flood by levees. Flood insurance is available for properties in these zones, but is not mandated by the NFIP.

Letter of Map Revision (LOMR). A Letter of Map Revision is a modification to the FIRM or floodway boundaries, generally based on physical changes that affect the hydraulic or hydrologic characteristics of the flood source (usually as a result of development or new flood control facilities). The letter is typically accompanied by an annotated copy of the portion of the map that has been revised. Modifications to the FIRM maps are usually made in response to an agency supplying new hydraulic data that show that the flooding hazard in a specific area has changed or been abated. Several LOMRs have been issued for the Menifee area since the FIRMs were updated in 2008.

In addition to their original purpose of setting insurance rates and regulating flood hazards, FIRMs are now widely used by local and regional planners for other purposes, including land-use planning, emergency preparedness and response, natural resource management, and risk assessment. Therefore, it should be noted that there are many uncertainties inherent in the establishment of FEMA flood zones (Larsen, 2009). Given the importance of these maps, some of the limitations that communities should be aware of are discussed below:

- It is important to realize that FIRMs only identify potential flood areas based on the conditions at the time of the study, and do not consider the impacts of future changes in the area. Conditions that affect the maps and decisions made on their basis may include changes in corporate boundaries, changes in population, man-made and natural changes to the landscape, removal of vegetation, changes to hydrologic systems, construction of flood control facilities, and potential climate changes. These changes in the environment may increase or reduce the area susceptible to flooding.

- The level of detail studied and presented on the maps, as well as the boundaries of the area studied, depend on the type of flood hazard, the funding available, and the risk of flood damage at the time. For instance, areas studied by approximate methods do not provide BFEs on the map, and some study areas are limited in extent.

- The maps do not necessarily identify all areas of flooding. For instance, drainages of small size, areas of localized ponding during storms, or areas where drainages are restricted by temporary or permanent structures may not be shown.

- The analytical process relies on many assumptions and incomplete data. Data used to construct the maps may be too old, incomplete, interpolated, and/or inaccurate. For instance, in relatively flat floodplains (such as those in the Menifee area), small elevation errors in the topography can result in large errors in flood zone boundaries.

- One major drawback is the very short time period for which we have meteorological records. Research on some parts of southern California has shown slight climate fluctuations between wet and dry cycles have occurred since the late 1800s (Hereford and Longpre, 2009). Future global climate change is still intensely debated, but many scientists now believe even slight global warming could bring an increase in precipitation overall, although the specific effects on the Menifee region are not known.

- Long-term changes in the watershed or floodplain, primarily from man's encroachment, are even harder to predict. Even flood control structures, such as berms and levees, can increase the flood risk to other areas. The design of high-density developments often requires taking drainages that used to be spread over a wide area and constricting them into narrow channels, thereby increasing the velocity and erosive power of the flow, and perhaps leading to overtopping. Consequently, there are clearly limitations in using hydrologic calculations based on past, imperfect records to predict the future.

- Larsen (2009) also argues that the process of placing a line on a map (flood zone boundaries) conveys a sense of certainty about the risk to the public and policy makers that does not exist.

Flood Map Modernization Program. Because many flood maps and related products were outdated, FEMA started its Map Modernization Program in 2003 to reduce reliance on paper maps and transition to digital processes for distributing and reading flood maps. The program also includes collecting new flood data for unmapped areas. Based on funding limitations and feedback from stakeholders, FEMA changed its goals mid way through the program. Rather than try to create digitized flood maps for the entire nation, it was decided to improve the accuracy of the newly updated maps by establishing two criteria: 1) a floodway boundary standard that would insure flood maps match the topographic data used (although use of the standard itself does not validate the accuracy of the topographic data); and 2) guidelines for determining whether an existing flood study is adequate for current use or if an updated study is needed. The adjusted goal is to have 65% of the continental U.S. land area and 92% of the population covered by digital maps (National Research Council, 2009). FIRMs covering most of Menifee were updated in 2008.

Risk MAP Program. With the Risk Map Program approved in March 2009, FEMA is moving from simply portraying flood hazard zones on maps to more accurately communicating and assessing risk to the local community. Building on the digitized maps, FEMA has developed a 5-year plan to fill in data gaps, increase public awareness, increase their outreach on flood risks, support state and local agencies in risk-based mitigation planning, and provide an enhanced digital platform that improves communication and sharing of risk data.

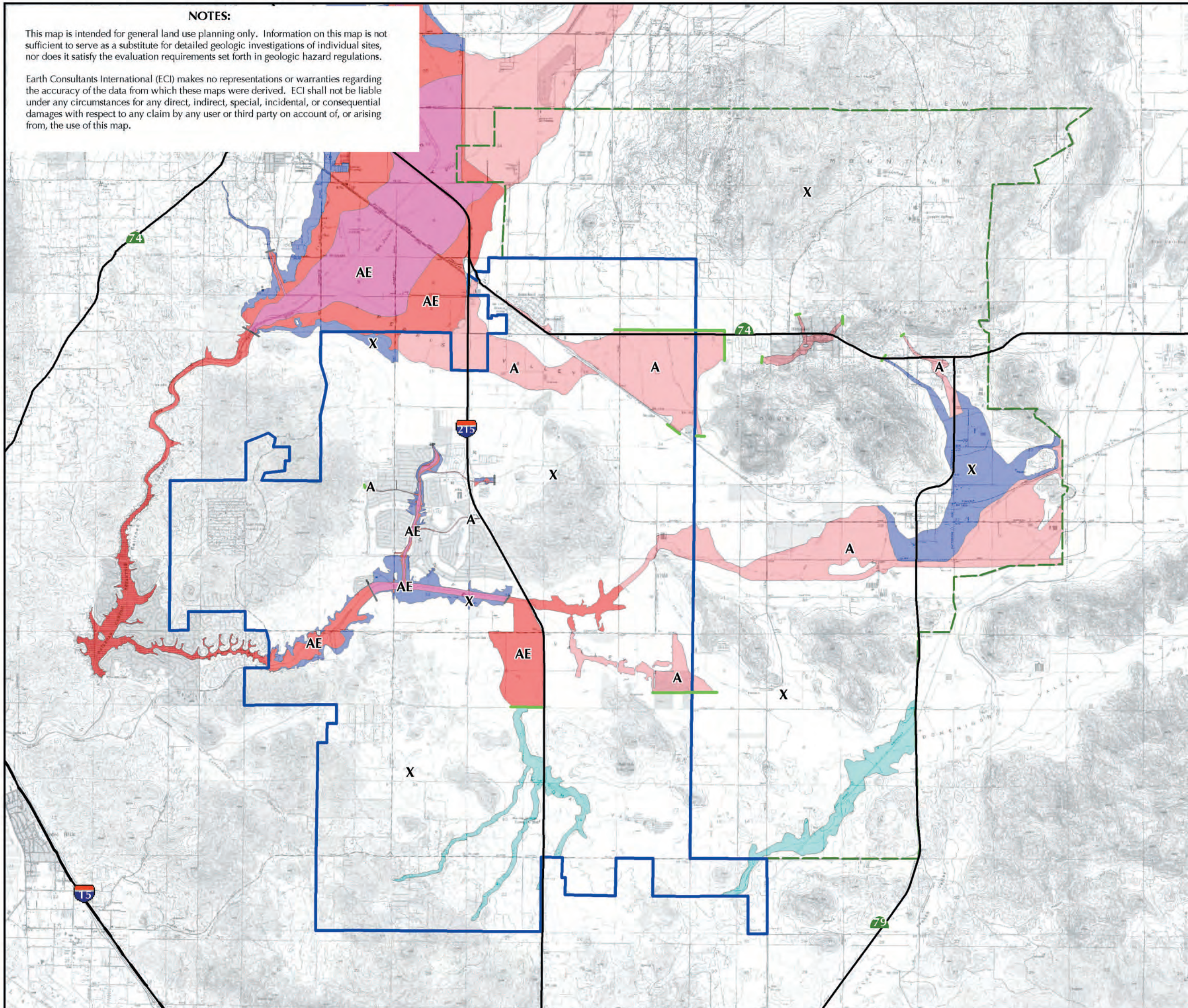
3.1.6 Flood Zone Mapping in Menifee

As part of the National Flood Insurance Program, the extent of flooding on portions of the Menifee General Plan area have been analyzed through the Flood Insurance Study for Riverside County (2008). The potential flood zones mapped by FEMA are published in Flood Insurance Rate Maps. Plate 3-1 shows the FIRM inundation limits for the 100-year and 500-year flood, however it should be noted that the study areas are limited and the flood zones are incomplete. Consequently, there are areas outside of the mapped flood zones that are likely to be subject to flood hazards. Riverside County has also published flood hazard zones, most of which coincide with the FEMA zones. Additional County flood zones that are outside of the FEMA mapping are shown on Plate 3-1. These areas include Paloma Wash and Warm Springs Creek.

NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

Earth Consultants International (ECI) makes no representations or warranties regarding the accuracy of the data from which these maps were derived. ECI shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages with respect to any claim by any user or third party on account of, or arising from, the use of this map.



Flood Hazard Map
Menifee, California

Explanation

FEMA Flood Insurance Rate Zones

High Risk Areas

- A — Zone that corresponds to the 100-year flood areas, as determined by approximate methods. Because detailed hydraulic analyses were not performed, no base flood elevations or depths have been determined. Mandatory flood insurance is required.
- AE — Zone that corresponds to the 100-year flood areas, as determined by detailed hydraulic analyses. In most cases, base flood elevations are shown at selected intervals.* Mandatory flood insurance is required.
- AE — Floodway zone*. Watercourse channel that generally must be kept free of encroachment. Development is subject to special regulations.

Moderate and Low Risk Areas

- X — Zone that corresponds to areas between the limits of the 100-year and 500-year floods. No base flood elevations or depths have been determined. Flood insurance is available but not required.
- X — Zone that corresponds to areas outside of the 500-year flood or areas protected from the 100-year flood by levees. Flood insurance is available but not required.
- Limit of FEMA Study
- Riverside County Flood Hazard Zone.
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

* See FEMA FLood Insurance Rate Maps and FEMA FLood Insurance Study for Riverside County for Base Flood Elevations.

N S W E

Scale: 1:84,000

7000 0 7000

Feet

2 0 2

Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: Federal Emergency Management Agency, Riverside County, Flood Insurance Rate Maps (Panel Numbers: 06065C1440G, 06065C1445G, 06065C2055G, 06065C2060G, 06065C2061G, 06065C2062G, 06065C2070G, 06065C2080G, 06065C2085G, 06065C2705G), Riverside County TMLA

Earth Consultants International

CITY OF MENIFEE

Project Number: 2917
Date: 2010

Plate 3-1

3.1.7 Local Flooding

Many storms smaller than the estimated 100-year event have caused localized flooding, particularly during and after intense precipitation fell on previously saturated ground. The General Plan area does not yet have a complete, interconnected storm drain system, nor does it have many adequate bridges and culverts where roads cross natural drainage channels. For instance, during heavy winter storms, access between the northern and southern parts of Menifee is severely restricted due to flood flows along Salt Creek, creating problems not only for citizens, but emergency vehicles as well. Major crossings such as Newport, Murrieta, and Bradley Roads become flooded and impassable, compounding traffic congestion in other parts of the city. Further, several other locations along Newport, Scott, and Garbani Roads remain persistent flood problems during storms. Flooded roadways also lead to temporary isolation of the Quail Valley community from the rest of the city, even during storms much less severe than the 100-year event.

Figure 3-4: Murrieta Road Crossing Salt Creek.
This major crossing is frequently flooded and impassable during storms.

Parts of Menifee's rural and semi-rural areas have unpaved roads in residential areas, and these, along with the natural channels, are vulnerable to local flooding and erosion. Most roads throughout these areas, either paved or unpaved, do not have curbs or channels to direct flow. In some cases, parts of these areas may be temporarily isolated due to eroded or flooded access roads. The older section of Quail Valley is especially vulnerable to problems during storms due to inadequate or blocked drainages and antiquated septic systems, which have overflowed in the past when the ground is saturated by intense or prolonged rainfall. Bringing a modern sewer system to this area is one of the City's top priorities.

3.1.8 Bridge Scour

Scour at bridges involves sediment-transport and erosion; processes that cause streambed material to be removed from the bridge vicinity. Nationwide, several catastrophic collapses of highway and railroad bridges have occurred due to scouring and a subsequent loss of support of foundations. This has led to a nationwide inventory and evaluation of bridges (Richardson et al., 1993).

Scour processes are generally classified into separate components, including pier scour, abutment scour, and contraction scour. ***Pier scour*** occurs when flow impinges against the upstream side of the pier, forcing the flow in a downward direction and causing scour of the streambed adjacent to the pier. ***Abutment scour*** happens when flow impinges against the abutment, causing the flow to change direction and mix with adjacent main-channel flow, resulting in scouring forces near the abutment toe. ***Contraction scour*** occurs when flood-plain flow is forced through a narrow opening at the bridge, resulting in an increase in the velocity of the surface water and scour of the streambed. ***Total scour*** for a particular site is the combined effects from all three components. Scour can occur within the main channel, on the flood plain, or both. While different materials scour at different rates, the ultimate scour attained for different materials is similar and depends mainly on the duration of peak stream flow acting on the material (Lagasse et al., 1991).

Because the streams in Menifee flow only occasionally, any scouring that occurs during the very sporadic but high-intensity storms may go undetected. Therefore, bridges should be inspected during and after a flood event to determine whether or not there is scour damage that could impact their foundations. Any damage observed near the bridge supports should be repaired as soon as possible, before the next storm event or storm season, as appropriate.

3.1.9 Existing Flood Protection Measures

Existing flood protection measures in the Menifee General Plan area consist of floodplain management carried out through land use zoning and building regulations, as well as various structures to detain, direct, or convey floodwaters.

General provisions for flood hazard reduction are provided in Riverside County Ordinance No. 458 and apply to all lands within FEMA SFHAs. The County regulations also apply to additional areas outside of SFHAs, within Paloma Wash and Warm Springs Creek (see Plate 3-1). The regulations apply at a minimum to those areas shown to be at risk on Plate 3-1; the City or County may include additional areas in the application of these provisions. Riverside County also has a subdivision ordinance that requires all new development in unincorporated areas to be protected from the 100-year flood (Ordinance No. 460.149). The Riverside County Flood Control and Water Control District (RCFC&WCD) reviews all proposed development plans and advises the County Planning Commission, which approves the plans for compliance with the flood protection provisions of these ordinances.

Within the city of Menifee, all land development maps, plans, and specifications are reviewed and processed by the City. However, because Menifee is a new city, they still rely heavily on Riverside County regulations, which they have adopted in the interim as they develop their own municipal codes and ordinances. With respect to flood control, all structures must be designed to County standards, and any project within a mapped flood zone must be subject to a Floodplain Management Review by the RCFC&WCD.

The County of Riverside has built numerous regional flood control structures both within and upstream from Menifee. The regional system is based on studies prepared by the RCFC&WCD that serve as "roadmaps" to developing economical drainage plans that will provide protection for existing and future development. Within the General Plan area, these studies, called Master Drainage Plans, have been prepared for Salt Creek, Romoland, Homeland, and Winchester. The plans presented in the study are conceptual in nature and intended to be used as guidelines, not only for regional planning by the RCFC&WCD, but for locating and sizing local facilities to be constructed by developers and others within the area. Storm drains larger than 36 inches, as well as open channels and other major structures, are maintained by the Riverside County Flood Control District. Regional and local structures affecting Menifee are briefly discussed below.

San Jacinto River. The meandering path of the San Jacinto River above Menifee has been straightened and channelized by levees through the Perris Valley, and in the Lakeview area up through the city of San Jacinto. There are also numerous detention and recharge basins in the upper reaches of the river to trap stormwater for beneficial uses. Revetted levees upstream on the river are designed to contain the 100-year flood, however the channel passing through Perris Valley does not contain the 100-year flood.

Figure 3-5: The San Jacinto River Channel at Goetz Road.
In this reach, located just north of Menifee, low-volume flows are confined to the straightened man-made channel. The channel is not designed to contain the 100-year flood during which floodwaters would spread out across the valley and into Menifee.

Salt Creek. Salt Creek, which bisects the city in an east-west direction, has been channelized throughout the General Plan area, and upstream, in the city of Hemet. The wide earthen channel with very gentle side slopes reflects a design move in recent years away from large concrete box channels to more natural-looking, dual-purpose channels that are compatible with recreation (such as the golf courses in Menifee), or wildlife habitats. Numerous smaller, open tributary channels, both earthen and concrete-lined, drain to Salt Creek in the central part of Menifee. Portions of Salt Creek and its tributary channels, such as those in Sun City, are designed to carry the 100-year flood. Salt Creek is nearly dry most of the year, receiving minor runoff primarily from irrigation between storms. During and after storms however, the wide channel becomes quickly flooded, causing problems primarily for traffic movement between the northern and southern parts of the city. The 2010 realignment of Newport Road through Audie Murphy Ranch bypassed the Newport Road crossing of Salt Creek. This change provides an all-weather, east-west arterial road connection between the I-15 Freeway in the City of Lake Elsinore and the I-215 Freeway in the City of Menifee.

Figure 3-6: Tributary Channel to Salt Creek within the Cherry Hills Golf Course.
This channel is part of the storm drainage system that mitigates flooding is Sun City.
The system is a good example of designing flood control for dual purpose uses
and to be more aesthetically pleasing.

Romoland/Homeland. Very few of the facilities recommended in the Master Drainage Plans for this area have been constructed, consequently flooding is still a significant problem. The Juniper Flats Basin at the base of the Lakeview Mountains collects water from streams draining the Juniper Flats area, and directs it via storm drains to the Briggs Road Detention Basin just south of Highway 74. The City is currently seeking funding to help build Storm Drain Line A, which will ultimately carry floodwater from Briggs Basin to the San Jacinto River. When the Line A system is completely built out, it will include numerous tributary lines that will greatly reduce the flooding problems in the northern part of the city.

Local Structures. Many smaller storm drains, culverts, and detention basins have been constructed throughout the General Plan area, mostly within the city of Menifee. These are generally designed and constructed in conjunction with new home subdivisions or commercial developments, and financed by the developer or landowner. Some detention basins are landscaped and serve as small pocket parks. Local drainage facilities in the city are maintained by Menifee's Public Works Department.

3.1.10 Future Flood Protection

The existing flood control structures have provided some measure of protection from flooding; nevertheless, additional protection is needed. Master Drainage Plans for the Menifee area recommend a combination of open channels (both lined and unlined), underground storm drain pipes, and detention basins. Unlined channels are typically used only for larger structures and only where erosion is not a concern. Detention basins store floodwaters temporarily during peak flows, thereby reducing flow rates downstream. The Salt Creek Master Drainage plans recommends upgrading the Lindenberger Road crossing to full 100-year storm flow capacity.

The City of Menifee is planning on replacing the two existing 30-inch culverts at the Bradley Road crossing of Salt Creek with multiple 2.5-feet high by 8-feet wide concrete box culverts. This change will improve the flow underneath Bradley Road and extend the frequency that this crossing will not be flooded. A Corps of Engineers 404 permit will be required prior to construction.

As new developments are considered, it is important that hydrologic studies be conducted to assess the impact that increased development may have on the existing development down gradient. These studies should quantify the effects of increased runoff and alterations to natural stream courses. Such constraints should be identified and analyzed in the earliest stages of planning. If any deficiencies are identified, the project proponent needs to prove that these can be mitigated to a satisfactory level prior to proceeding forward with the project, in accordance with California Environmental Quality Act (CEQA) guidelines. Mitigation measures typically include flood-control devices such as catch basins, storm drain pipelines, culverts, detention basins, desilting basins, velocity reducers, as well as debris basins for protection from mud and debris flows in hillside areas.

The methodology for analysis and design of flood-control structures is set forth by the RCFC&WCD. Developers of new projects are required to design flood control measures and submit them for review. Future responsibilities for operation of regional flood control facilities will be with the RCFC&WCD, while the local storm drains and other structures outside of the regional system are the responsibility of the City of Menifee. Therefore, both agencies must be involved in the planning and approval of mitigation measures, to assure compatibility. Public education is also an important element of flood protection in Menifee; citizens must also take responsibility for flood control, since they are the stewards of many of the natural drainage channels in rural or semi-rural areas.

Figure 3-7: Lindenberger Road Crossing at Salt Creek.
According to the Riverside County Flood Control District,
this structure does not have the capacity to contain the 100-year flood.

Across the United States, substantial changes in the philosophy, methodology and mitigation of flood hazards are currently in the works. For example:

- Some researchers have questioned whether or not the current methodology for evaluating average flood recurrence intervals is still valid, since we are presently experiencing a different, warmer and wetter climate. Even small changes in climate can cause large changes in flood magnitude (Gosnold et al., 2000).
- Flood control in undeveloped areas should not occur at the expense of environmental degradation. Certain aspects of flooding are beneficial and are an important component of the natural processes that affect regions far from the particular area of interest. For instance, lining major channels with concrete reduces the area of recharge to the underlying groundwater table. Thus there is a move to leave nature in charge of flood control. The advantages include lower cost, preservation of wildlife habitats and improved recreation potential.
- Floodway management design in land development projects can also include areas where stream courses are left natural or as developed open space, such as parks or golf courses. Where flood control structures are unavoidable, they are often designed with a softer appearance that blends in with the surrounding environment.
- Environmental legislation is increasingly coming in conflict with flood control programs. Under the authority of the Federal Clean Water Act and the Federal

Endangered Species Act, development and maintenance of flood control facilities has been complicated by the regulatory activities of several Federal agencies including the U.S. Army Corps of Engineers, the Environmental Protection Agency, and the U.S. Fish and Wildlife Service. For instance, FEMA requires that the County and its incorporated cities maintain the carrying capacity of all flood control facilities and floodways. However, this requirement can conflict with mandates from the U.S. Fish and Wildlife Service regarding maintaining the habitat of endangered or threatened species. Furthermore, the permitting process required by the Federal agencies is lengthy, and can last several months to years. Yet, if the floodways are not cleared of vegetation and other obstructing debris in a timely manner, future flooding of adjacent areas could develop.

As the population of Menifee grows, the consequences of flooding are likely to increase. In light of the uncertainties with respect to estimating floods, land use planning in the City and the General Plan area in general could benefit from additional mapping, a conservative approach to permitting, and a strong adherence to an area-wide, long-term vision for flood safety as individual projects are considered.

3.1.11 Flood Protection Measures for Property Owners

As discussed above, flooding remains a significant risk to structures and residents in Menifee. However, the City and property owners in susceptible areas can take measures to promote safety during future floods and reduce damages from flooding and from flood-related erosion. As a new city (incorporated in October 2008), Menifee is still in the process of developing its own municipal code; in the interim, Riverside County regulations have been adopted and are being implemented. Mitigation measures that can reduce the flood hazard in Menifee are discussed below.

At the City level:

- Continue the enforcement of the County's provisions for flood hazard reduction, tract drainage, and storm water management (Ordinance Nos. 458, 460, and 754). These ordinances include construction standards that address the major causes of flood damage – i.e., structures that are not adequately elevated, flood-proofed, or otherwise protected from flooding. The regulations apply to new construction or substantial improvements, and include provisions for anchoring, placement of utilities, elevating the lowest floors, flood resistant materials, and other methods to minimize damage.
- Join FEMA's National Flood Insurance Program (NFIP), so that City residents can purchase flood insurance (according to FEMA, Menifee residents that bought insurance when the area was unincorporated will not be able to renew their policies when it comes due for renewal if the City has not joined the NFIP).
- Once Menifee joins the NFIP, encourage residents to purchase flood insurance for areas outside of the 100-year flood zone.
- Develop methods to conduct real-time storm warnings and evacuations if necessary.
- Continue to educate the public on the risks of flooding, including the uncertainties inherent in flood hazard zoning.
- Establish easements for entrenched flow paths.
- Create flood overlays for zoning and land use maps.

- Create an atmosphere of working with nature and the natural processes inherent to the semi-arid environment characteristic of this area.
- Continue to seek funding for the Line A flood control system.
- Improve the crossing at Bradley Road and Salt Creek.

For Property Owners:

- Elevate new homes on pads, foundations, or piers in flood-prone areas.
- Orient new homes and pads to provide minimum obstruction to the direction of flow, and do not force flows onto adjacent properties.
- Try to accommodate natural flows rather than restricting them.
- Any grading to direct flow around a home or structure should include directing it back to its natural path downstream.
- Protect foundations or piers from erosion and scour.
- Numerous methods are available for flood protection – which methods are most appropriate for an individual lot should be based on the local conditions surrounding and upstream from the lot.
- Some lots may require special engineering studies to determine the extent of the hazard and to design appropriate mitigation.

FEMA has identified several flood protection measures that can be implemented by property owners to reduce flood damage. These include: installing waterproof veneers on the exterior walls of buildings; putting seals on all openings, including doors, to prevent the entry of water; raising electrical components above the anticipated water level; and installing backflow valves that prevent sewage from backing up into the house through the drainpipes. Obviously, these changes vary in complexity and cost, and some need to be carried out only by a professional licensed contractor. For additional information and ideas, refer to the FEMA web page at www.fema.gov. Structural modifications require a permit from the City or County Building Departments. Refer to them for advice regarding whether or not flood protection measures would be appropriate for your property.

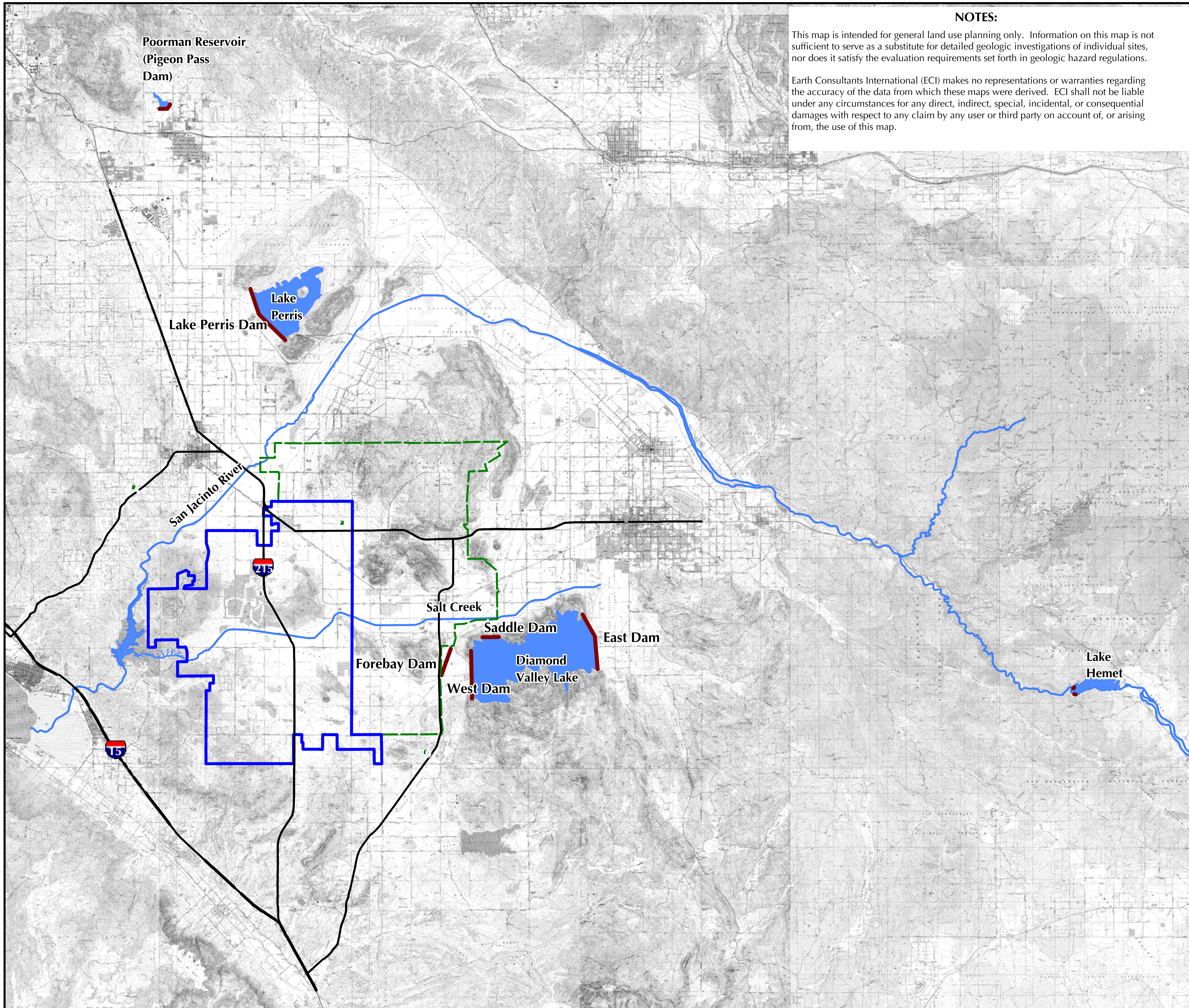
3.2 Seismically Induced Inundation

3.2.1 Dam Inundation

Seismically induced inundation refers to flooding that results when water retention structures, such as dams, fail due to an earthquake. Statutes governing dam safety are defined in Division 3 of the California State Water Code (California Department of Water Resources, 1986). These statutes empower the California Division of Dam Safety to monitor the structural safety of dams that are greater than 25 feet in height or have more than 50 acre-feet of storage capacity. Several structures upstream from Menifee meet these requirements: West Dam, East Dam, and Saddle Dam (Diamond Valley Lake), Forebay Dam, Lake Perris Dam, Lake Hemet Dam, and Pigeon Pass Dam (Poorman Reservoir). The characteristics of these dams are summarized in Table 3-3, and each dam is described in more detail in the pages that follow. For a map showing the location of each of these structures relative to Menifee refer to Plate 3-2a.

Dams with the Potential to Inundate the Menifee General Plan Area

Menifee, California



NOTES:

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Explanation

- Location of Dam and Lake discussed in the text.
- River
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N W E S

Scale: 1:180,000

15,000 0 15,000
Feet

4 0 4
Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: Governor's Office of Emergency Services; Google Earth

Earth Consultants International

Project Number: 2917
Date: 2010

Plate 3-2a

Table 3-3: Summary of Major Dams Impacting the Menifee General Plan Area

<table>
<tr><th>Name</th><th>Owner</th><th>Year Built</th><th>Height (feet)</th><th>Type</th><th>Capacity (Acre-feet)</th></tr>
<tr><td>East Dam</td><td>MWD</td><td>1999</td><td>185</td><td>Earth-core rockfill</td><td rowspan="3">800,000</td></tr>
<tr><td>West Dam</td><td>MWD</td><td>1999</td><td>284</td><td>Earth-core rockfill</td></tr>
<tr><td>Saddle Dam</td><td>MWD</td><td>1999</td><td>130</td><td>Earth-core rockfill</td></tr>
<tr><td>Forebay Dam</td><td>MWD</td><td>1999</td><td>22</td><td>Earthfill</td><td>500</td></tr>
<tr><td>Lake Perris Dam</td><td>DWR</td><td>1973</td><td>130</td><td>Earthfill</td><td>131,452</td></tr>
<tr><td>Lake Hemet Dam</td><td>LHMWD</td><td>1895</td><td>135</td><td>Gravity</td><td>14,000</td></tr>
<tr><td>Pigeon Pass Dam</td><td>RCFC&WCD</td><td>1958</td><td>36</td><td>Earthfill</td><td>900</td></tr>
</table>

Inundation maps must be prepared by dam owners showing the areas of potential flooding in the event of a dam failure that, as determined by the California Emergency Management Agency (EMA), would result in death or personal injury. Furthermore, inundation maps reviewed and approved by the EMA must be kept on file with the EMA, the DWR, and any city or county that is likely to be affected. The map requirement may be waived if, through site inspections and discussion with local jurisdictions, the EMA can delineate the hazardous area without an inundation map, and adequate evacuation procedures can be developed (California Code, Section 8589.5). Based on these inundation maps, cities and counties are encouraged to develop procedures for evacuation of populated areas below dams. In addition, California law (AB 1195, Chapter 65) requires real estate disclosure upon the transfer or sale of properties that are within a dam inundation area. EMA-approved inundation pathways are shown on Plates 3-2b through 3-2h for the dams mentioned above.

East, West, and Saddle Dams (Diamond Valley Lake). Three dams form Diamond Valley Lake, the largest reservoir in southern California. Receiving imported water from the Colorado River and northern California, the lake nearly doubled southern California's storage capacity when filling was completed in 2002. The reservoir's main purpose is to store water supplies for periods of drought, peak summer usage, and emergencies, such as earthquakes. The lake is also used for recreational fishing.

The three dams are similar in construction, consisting of earth-core rockfill embankments made with materials excavated from within the project area. The largest embankments – the East and West Dams – block the east and west ends of Diamond and Domenigoni Valleys respectively, and the Saddle Dam blocks a low point in the ridge on the northern side of the lake. The Menifee General Plan area that would be inundated if one of these dams breaks catastrophically, releasing the water contained in Diamond Valley Lake, is shown on Plate 3-2b for the East Dam, Plate 3-2c for the West Dam, and Plate 3-2d for the Saddle Dam. Given that failure or miss-operation of these dams would cause loss of human life, these dams are considered a high hazard potential by the National Inventory of Dams (2000).

Forebay Dam (Diamond Valley Lake Forebay). This dam is to the west of Diamond Valley Lake's West Dam. Water from the Colorado River Aqueduct is delivered to the Forebay reservoir through the San Diego Canal, and from there the water is pumped to Diamond Valley Lake. Twelve pumps, each with a 5,000 horse-power, are used to transfer the water from the forebay to the main lake. The forebay has a capacity of 500 acre-feet and a reservoir area of 31 acres. The Menifee General Plan area that would be inundated if this dam fails is shown on Plate 3-2e.

Figure 3-8: Diamond Valley Lake.
Failure of any of the three dams associated with this reservoir would inundate parts of Menifee.

Lake Perris Dam. Lake Perris is an artificial lake created to store water imported from northern California. The lake is the southernmost facility in the State Water Project system and is at the southern terminus of the East Branch of the California Aqueduct. Located adjacent to the cities of Moreno Valley and Perris, the lake is part of a broader State Recreation Area that also includes the surrounding low mountains and hills. Boating, fishing, and swimming are popular activities in the lake.

In 2005, the Department of Water Resources (DWR) determined there were potential seismic safety concerns with the dam's foundation if a magnitude 7.5 or larger earthquake struck the area. As a result, the DWR has lowered the lake level temporarily by about 25 feet, while the foundation is seismically strengthened. Completion of the dam remediation design is expected in late 2010, followed by construction starting in 2011, and completion of the repair work by 2014. Given that failure of this dam would probably cause loss of human life, this dam is also a high-hazard facility, per the National Inventory of Dams (2000) database. The Menifee General Plan area that would be impacted if this dam failed is shown on Plate 3-2f. The inundation area shown is representative of the original lake level, prior to it being lowered for repairs. If a new inundation map is issued by the DWR once the repairs to Lake Perris Dam are completed, Plate 3-2f should be replaced to reflect these changes.

NOTES:

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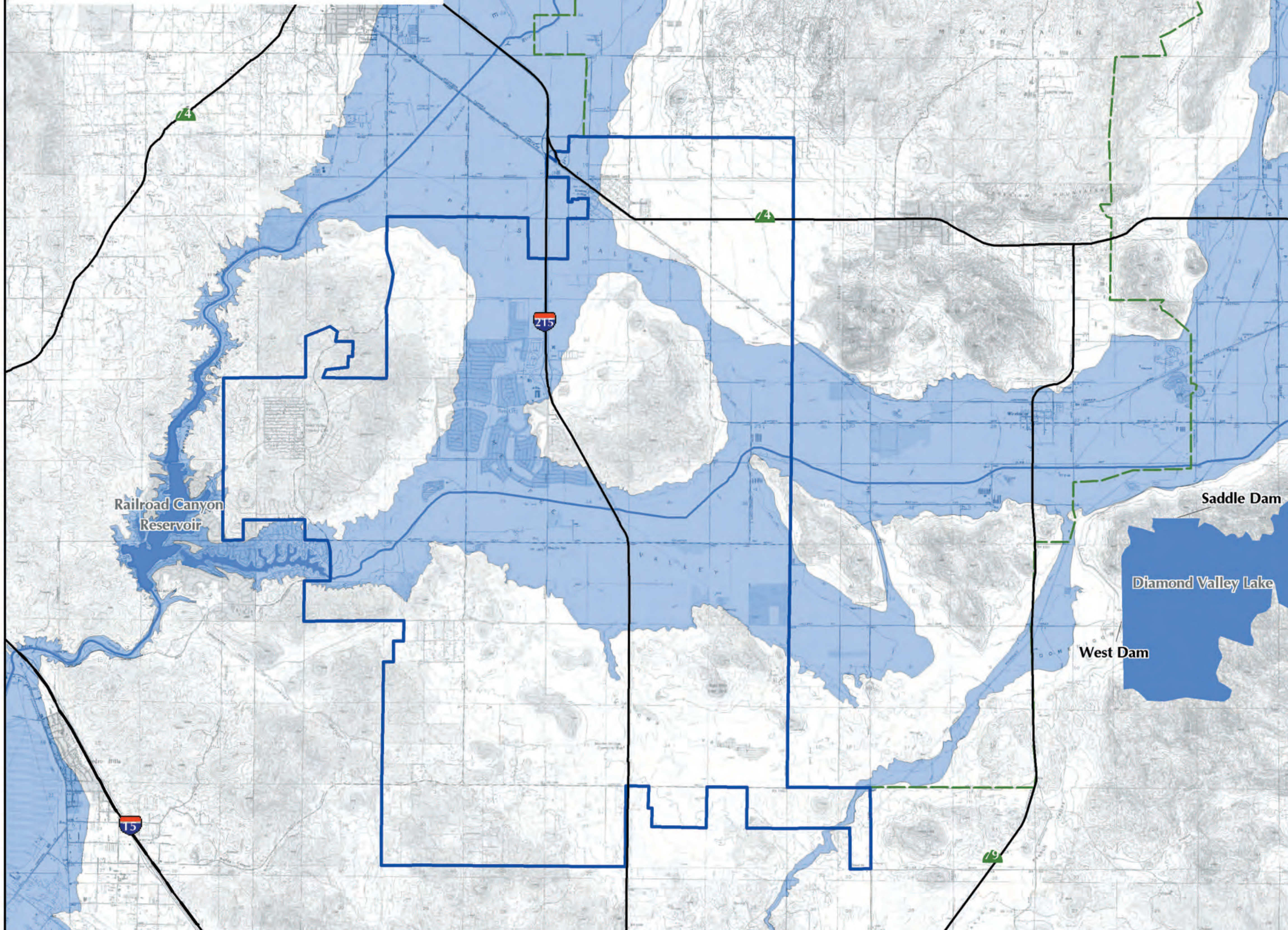

Dam Inundation

Menifee, California

Explanation

- East Dam Failure Inundation Pathway
- River
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N W E S

Scale: 1:84,000

7000 0 7000

Feet

2 0 2

Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: Governor's Office of Emergency Services, Riverside County, and MWD Inundation Map of Diamond Valley Lake East Dam

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CITY OF MENIFEE

Project Number: 2917
Date: 2010

Plate 3-2b

NOTES:

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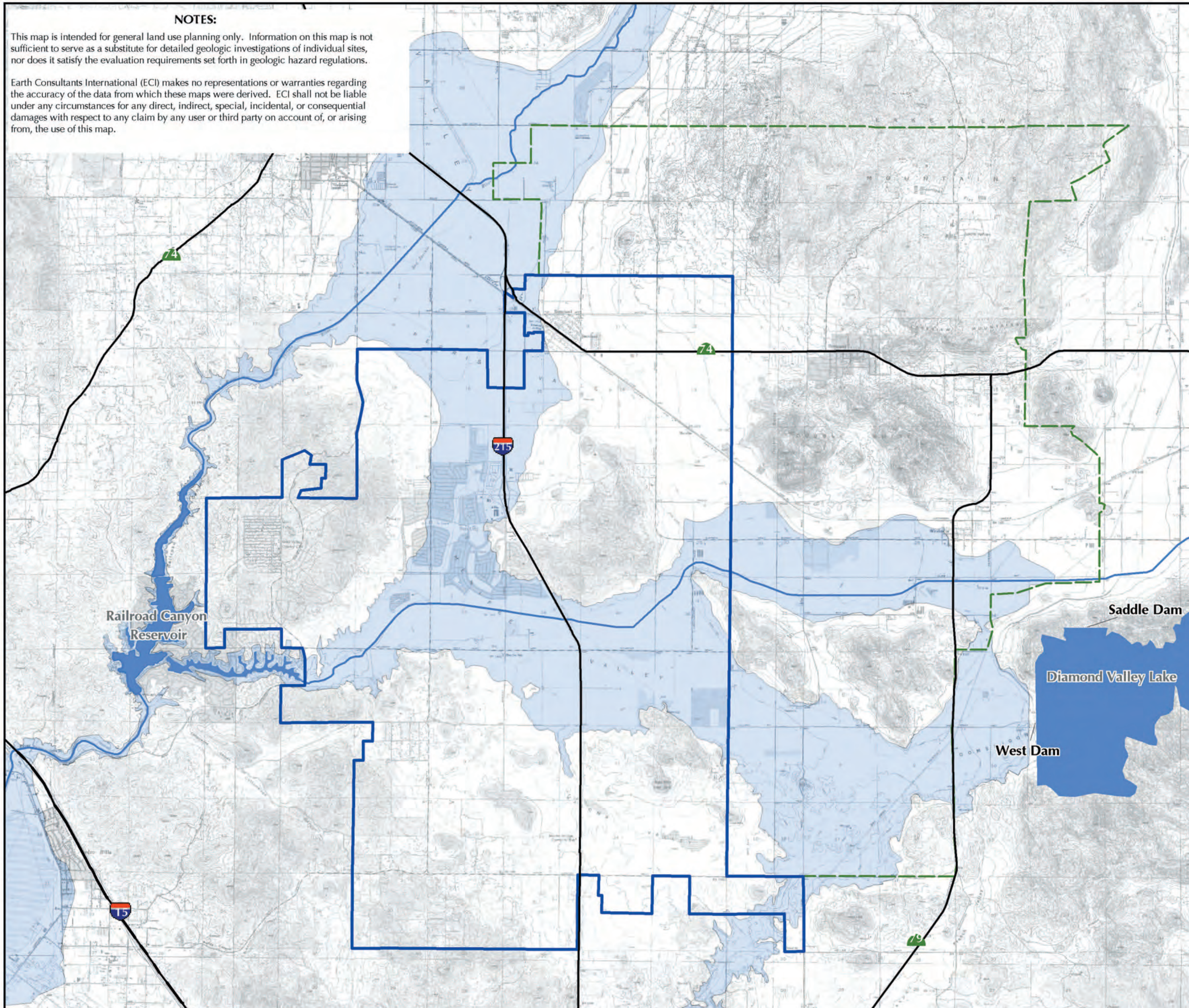

Dam Inundation

Menifee, California

Explanation

- West Dam Failure Inundation Pathway
- River
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N S W E

Scale: 1:84,000

7000 0 7000 Feet

2 0 2 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: Governor's Office of Emergency Services, Riverside County, and MWD Inundation Map of Diamond Valley Lake West Dam

Earth Consultants International

CITY OF MENIFEE

Project Number: 2917
Date: 2010

Plate 3-2c

NOTES:

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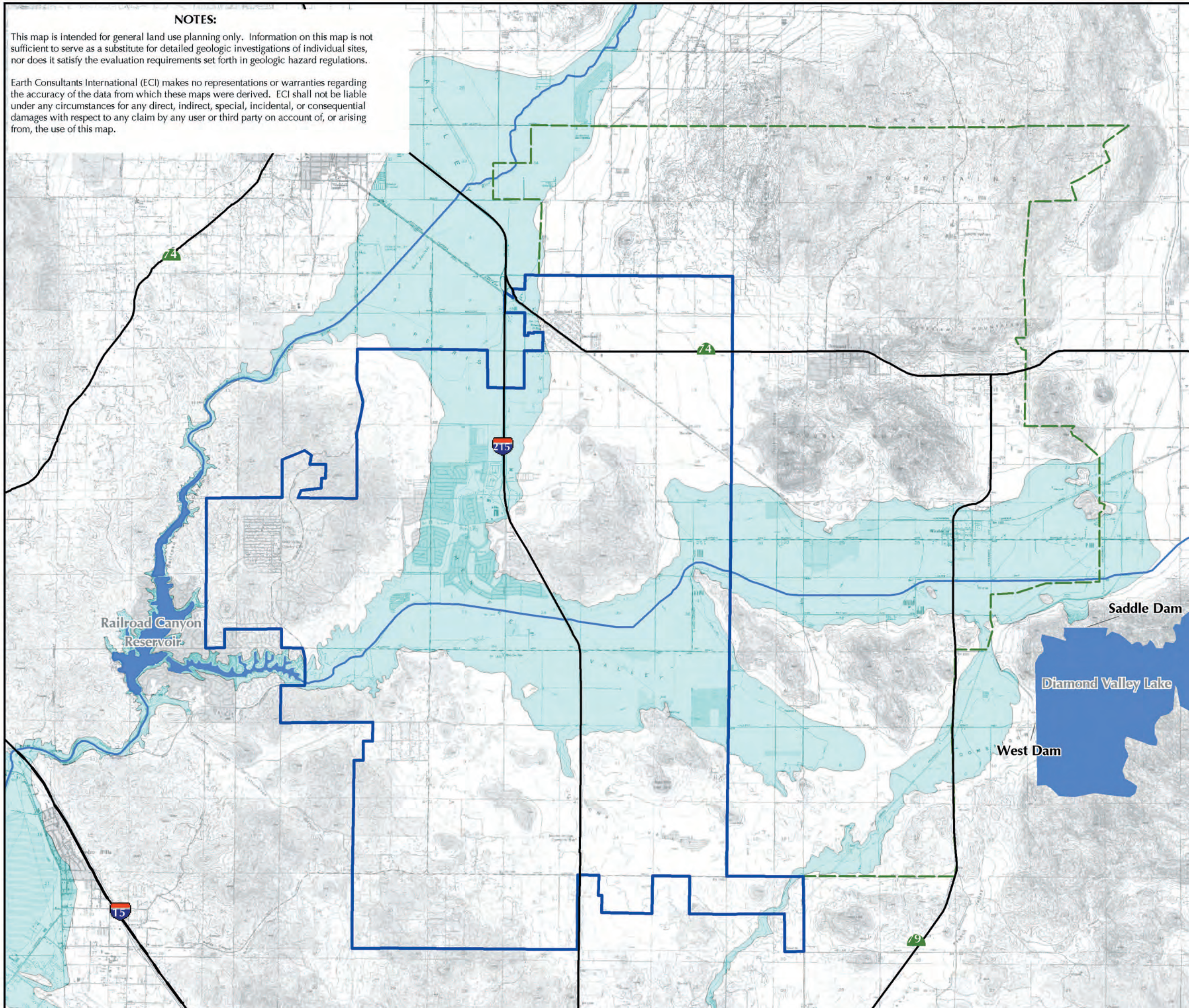

Dam Inundation

Menifee, California

Explanation

- Saddle Dam Failure Inundation Pathway
- River
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N S W E

Scale: 1:84,000

7000 0 7000 Feet

2 0 2 Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: Governor's Office of Emergency Services, Riverside County, and MWD Inundation Map of Diamond Valley Lake Saddle Dam

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CITY OF MENIFEE

Project Number: 2917
Date: 2010

Plate 3-2d

NOTES:

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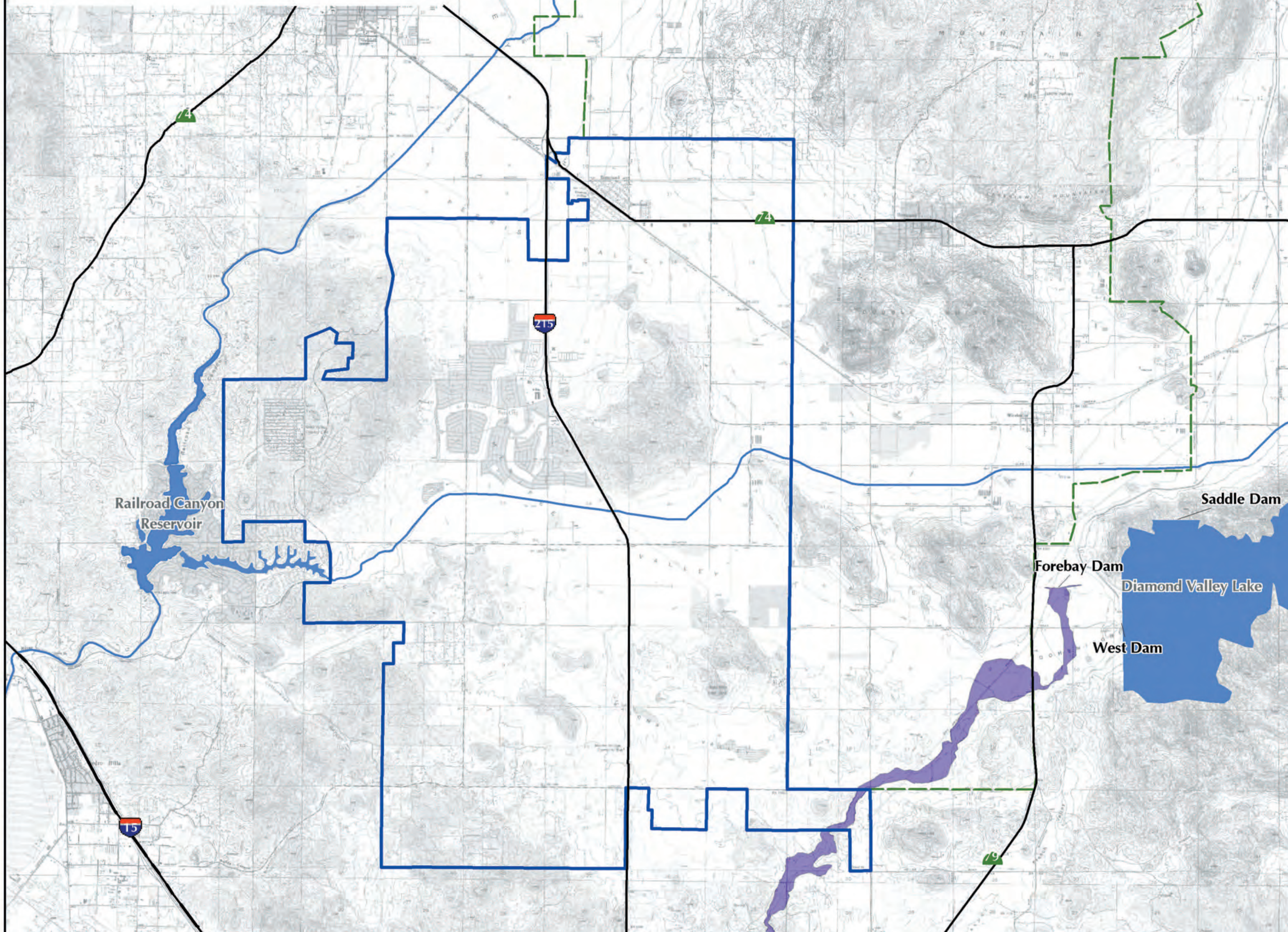

Dam Inundation

Menifee, California

Explanation

- Forebay Dam Failure Inundation Pathway
- River
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N S W E

Scale: 1:84,000

7000 0 7000

Feet

2 0 2

Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: Governor's Office of Emergency Services, Riverside County, and MWD Inundation Map of Diamond Valley Lake Forebay Dam

Earth Consultants International

City of Menifee

Project Number: 2917
Date: 2010

Plate 3-2e

Lake Hemet Dam. Lake Hemet is a water storage reservoir located in the San Jacinto Mountains. The dam is an arched masonry structure that was completed in 1895 by the Lake Hemet Water Company in order to impound water in the upper reach of the San Jacinto River for irrigation in the valleys below. In 1955, the lake and its water distribution system were purchased by the Lake Hemet Municipal Water District (LHMWD). Currently, the lake provides water to customers in the cities of San Jacinto and Hemet, as well as providing recreational activities such as fishing, boating, and camping. Failure of this reservoir would impact only the northwestern corner of the Menifee General Plan area, as shown on Plate 3-2g.

Pigeon Pass Dam (Poorman Reservoir). Pigeon Pass Dam, located in the northern part of the city of Moreno Valley, is an earthen structure designed to protect downstream properties from flooding by temporarily retaining runoff during storms. After cracks were discovered in the embankment in 1978, the dam was repaired and special drains were added to reduce the potential for cracking in the future. Although it is also known as Poorman Reservoir, it is dry most of the year, typically containing water only during and immediately after storms pass through the area. If this reservoir failed while full of water, the inundation area would extend southward to just north of Menifee. Only the northwesternmost portion of the General Plan area would be impacted, as shown on Plate 3-2h.

3.2.2 Inundation From Above-Ground Storage Tanks

Seismically induced inundation can also occur if strong ground shaking causes structural damage to aboveground water tanks. If a tank is not adequately braced and baffled, sloshing water can lift a water tank off its foundation, splitting the shell, damaging the roof, and bulging the bottom of the tank (causing what is referred to as "elephant's foot") (EERI, 1992). Movement can also shear off the pipes leading to the tank, releasing water through the broken connections. These types of damage were reported as a result of the 1992 Landers, 1992 Big Bear, 1994 Northridge, and 2010 Sierra El Mayor (Baja California) earthquakes. The Northridge earthquake alone rendered about 40 steel tanks non-functional (EERI, 1995), including a tank in the Santa Clarita area that failed and inundated several houses below. As a result of lessons learned from the 1992 and 1994 earthquakes, revised standards for design of steel water tanks were adopted in 1994 (Lund, 1994). The revised tank design includes flexible joints at the inlet/outlet connections to accommodate movement in any direction.

Older water tanks may not meet these revised construction requirements, lacking the flexible joints and other seismic upgrades that can help to limit the damage that a failed water tank could cause to areas downstream. If there is a potential for a water tank to fail catastrophically during an earthquake, its inundation path should be identified to evaluate whether or not habitable structures are located within the floodway. The evaluation should also address whether a water reservoir is self-contained. Specifically, in the event of a catastrophic breakage, will the water be contained within the site, or will it pose a hazard to properties downstream?

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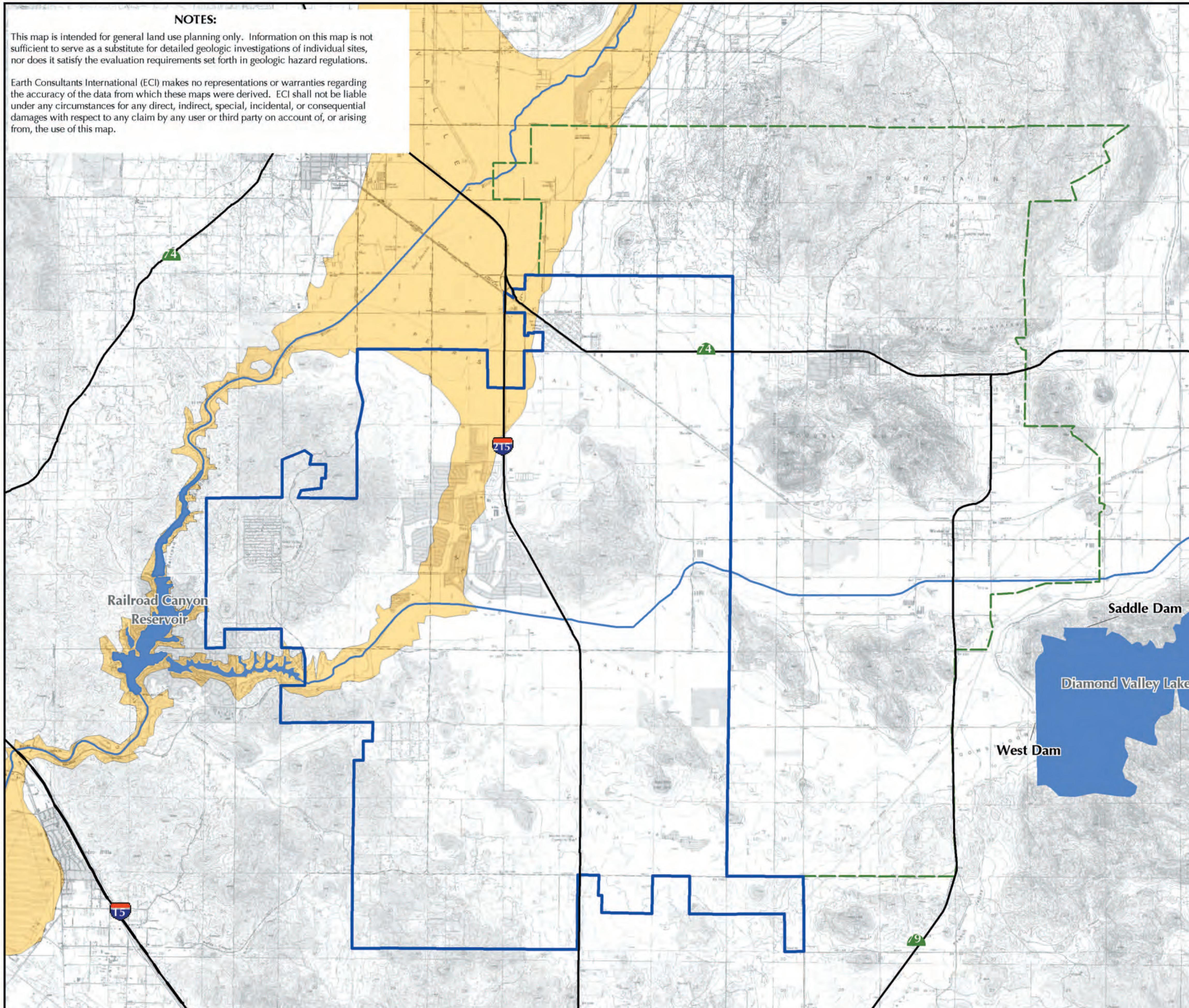

Dam Inundation

Menifee, California

Explanation

- Lake Perris Dam Failure Inundation Pathway
- River
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N W E S

Scale: 1:84,000

7000 0 7000
Feet

2 0 2
Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: Governor's Office of Emergency Services and Riverside County

Earth Consultants International

Project Number: 2917
Date: 2010

Plate 3-2f

NOTES:

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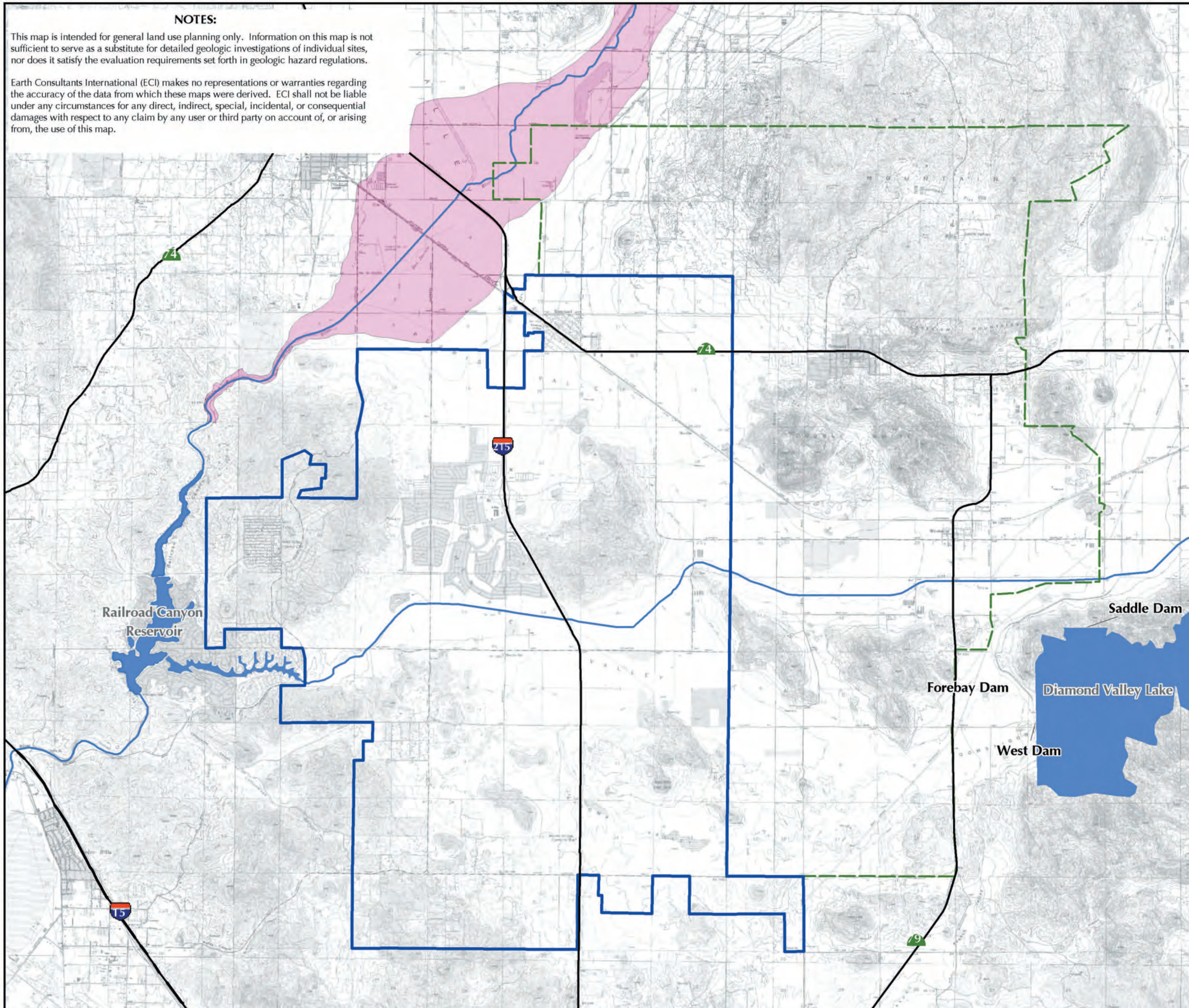

Dam Inundation

Menifee, California

Explanation

- Hemet Dam Failure Inundation Pathway
- River
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N S W E

Scale: 1:84,000

7000 0 7000
Feet

2 0 2
Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: Governor's Office of Emergency Services and Riverside County

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CITY OF MENIFEE

Project Number: 2917
Date: 2010

Plate 3-2g

NOTES:

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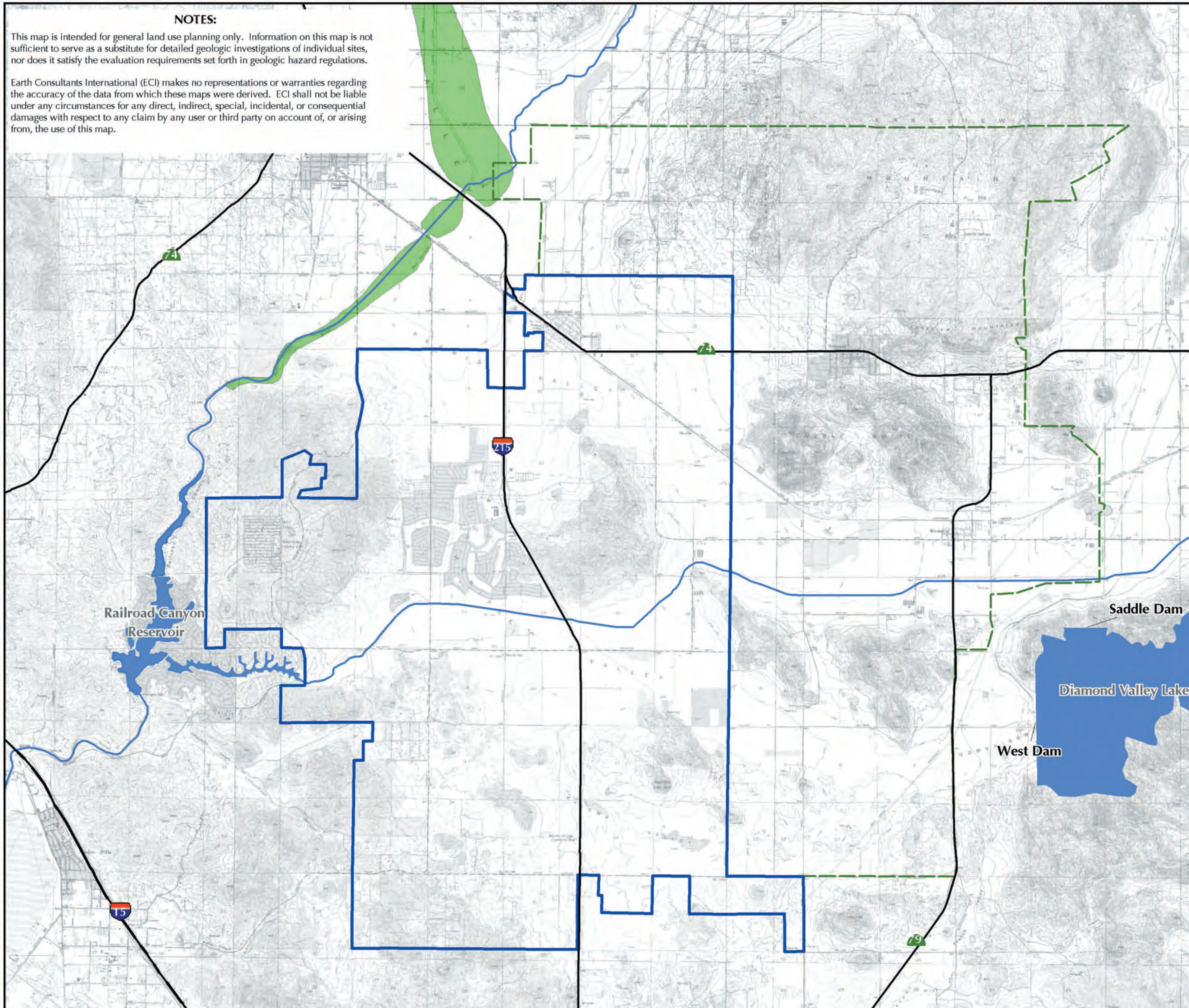

Dam Inundation

Menifee, California

Explanation

- Pigeon Pass Dam Failure Inundation Pathway
- River
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N S W E

Scale: 1:84,000

7000 0 7000

Feet

2 0 2

Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: Governor's Office of Emergency Services

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Project Number: 2917
Date: 2010

Plate 3-2h

The Eastern Municipal Water District (EMWD) provides water to the Menifee General Plan area through an extensive infrastructure of wells, pipelines, pump stations, desalinization plants, and reservoirs. Within the General Plan area, the district has 17 reservoirs, all of which are above-ground tanks, with a total capacity of about 29 million gallons (Homeland Reservoir is currently inactive and empty). Although some of the tanks are older, all have been fitted with flexible connections to prevent the inlet-outlet piping from breaking in case of an earthquake, and some are equipped with a seismic shut-off valve. Each tank also has an altitude valve tied to an alarm system to prevent the tank from overflowing.

Table 3-4: Above-ground Water Tanks in the Menifee General Plan Area

Tank	Capacity (millions of gallons)	Year Built	Control Valve Type
Antelope	1.0	1987	ALT, SE
Creag	3.2	2003	ALT
Daily	0.21	1974	ALT,SE
East Holland	0.0808	1997	ALT
Homeland	0.4	1959	Inactive and Empty
Juniper	0.21	1965	ALT
Keller	6.2	2003	S/A
Menifee Village	5.147	1988	ALT, SE
Quail Valley	0.4	1975	ALT, SE
Quail Valley II	2.18	2006	SA
Quality Farms	0.5	1993	ALT/SE
Ridgemoor	2.0	1968	ALT
Sky Mesa	0.2	1982	ALT, SE
Sun City	1.0	1962	ALT
Tally Rd	1.5	2009	ALT
Vista	1.0	1962	ALT
Chambers RW	4.0	1995	ALT

Source: Eastern Metropolitan Water District.
Abbreviations: ALT = Altitude valve; SE = Seismic shut-off valve; S/A = Combination altitude and seismic valve

Water lost from tanks during an earthquake can affect not only structures down slope from the tanks, but can significantly reduce the water resources available to suppress earthquake-induced fires. Damaged tanks and water mains can also limit the amount of water available to residents. The main aqueducts that deliver imported water to many parts of southern California are likely to suffer extensive damage if a major earthquake occurs on either the San Andreas fault or other nearby active faults. Repairs to these aqueducts could take two weeks or longer (Toppozada et al., 1993). Similar damage can be expected to the groundwater wells in the region, also limiting the water available to the community after an earthquake. Therefore, it is of paramount importance that the water storage tanks in the area retain their structural integrity during an earthquake, so water demands after an earthquake can be met. In addition to evaluating and retrofitting water reservoirs to meet current standards, this also requires that the tanks be kept at or near full capacity at all times. These tasks are the responsibility of the Eastern Municipal Water District.

3.3 Loss Estimation Analyses Using HazUS

HazUS is a regional multi-hazard loss estimation model developed by FEMA and the National Institute of Building Sciences. The primary purpose of HazUS is to provide a methodology and software application to develop multi-hazard losses at a regional scale. Local, state and regional officials can use these loss estimates to evaluate the area's vulnerability to multi-hazards and prepare for emergency response and recovery. Additional information regarding HazUS, including its uses and limitations, is provided in Chapter 1, Section 1.9. Unlike the earthquake analyses, where HazUS uses census tracts as the smallest areal unit of study, for flood analyses, HazUS uses census blocks. The geographical size of the region analyzed is 114 square miles (see Figure 1-6); this region contains 1,180 census blocks (and 11 census tracts).

We used HazUS to generate building stock and essential facility loss estimates for two different flood scenarios: 1) a 1% annual chance flood (100-year flood) in Salt Creek, and 2) a 1% annual chance flood event (100-year flood) in the San Jacinto River. The 100-year flood was chosen because it is the basis for FEMA's Flood Insurance Rate Maps, and is generally the flood hazard used by cities and counties for flood plain management and disaster preparedness. Although each drainage was evaluated separately, the results of these scenarios could occur simultaneously if a severe storm or series of closely spaced storms led to riverine flooding throughout the area, impacting both drainages. The results of the analyses are presented in the sections below.

The HazUS analyses conducted for Menifee use the enhanced building stock data and essential facilities compiled for Riverside County by MMI Engineering and ABSG Consulting Inc. for the Riverside County Essential Facilities Risk Assessment (RCEFRA) Project (MAP IX – Mainland, 2009). The enhanced data used include parcel data for single-family homes, apartment and condominiums, hotels/motels and agricultural properties that replace the basic, "out-of-the-box" default inventory provided with HazUS. Parcel data for mobile homes obtained for the RCEFRA project was used to supplement the HazUS default inventory. Essential facility data were provided by the facilities themselves. Use of these data is expected to yield more accurate results than the default data, however, the numbers generated should still be considered generalized and used with caution. The results do provide an estimate of the risk, and this information can be used to develop realistic disaster mitigation plans, hazard mitigation grant applications, and to design emergency response exercises (MAP IX – Mainland, 2009).

The flood analysis was conducted using a digital version of the Flood Insurance Rate Map presented on Plate 3-1 as a "user-supplied hazard" that was converted to a HazUS compatible format. The channel configurations and depth were obtained from the U.S. Geological Survey's 10-meter digital elevation model (DEM) for the area. The depth of the water along most of the reaches of Salt Creek through the General Plan area due to the 100-year flood ranges from 1 to 12 feet, but depths of as much as 28 feet are possible along some sections where the drainage is constricted by rock formations (forming narrow canyons), bridges, and intense development. These conditions occur preferentially both at the east and west ends of the General Plan area, and locally, in and around Homeland. Flooding along the San Jacinto River as a result of the 100-year flood is mostly in the 2 to 8 feet depth range, but where the drainage is constricted significantly by the surrounding hills at the north end of the Quail Valley area, much deeper water is possible.

3.3.1 Building-Related Losses

There is an estimated 21,000 households in this region, and 36,745 buildings with a total replacement value, excluding contents, of $6,393 million. Almost 95% of the buildings, and 87.3% of the building value, is associated with residential housing. The building exposure by occupancy type for the scenarios considered is summarized in Table 3-5, and the expected building damage, by both occupancy and building type is presented in Tables 3-6 and 3-7. The damage is measured as percent of the replacement cost. If a building suffers damage exceeding 50% of its replacement cost, it is considered substantially damaged. These buildings would be considered unsafe for continued occupancy and would be "red-tagged." Tables 3-6 and 3-7 show that the 100-year flood in Salt Creek would completely damage 5 buildings, all of them manufactured housing used for residential purposes. The 100-year flood on the San Jacinto River would completely damage 165 residential structures, the majority (162) being manufactured housing. Approximately 171 buildings in the study area are expected to suffer 20% or more damage as a result of a100-year flood event in Salt Creek, whereas 274 structures are expected to suffer 20% or more damage as a result of a 100-year flood event in the San Jacinto River.

Table 3-5: Building Exposure by Occupancy Type for Two Flood Scenarios

Scenario	Salt Creek (100-Year Flood)		San Jacinto River (100-Year Flood)	
Occupancy	**Exposure ($1,000)**	**Percent of Total**	**Exposure ($1,000)**	**Percent of Total**
Residential	1,576,477	89.7	2,133,869	86.9
Commercial	39,909	2.3	76,887	3.1
Industrial	7,646	0.4	20,515	0.8
Agricultural	31,152	1.8	47,155	1.9
Religion	6,533	0.4	8,343	0.3
Government	0	0.0	576	0.0
Education	95,096	5.4	167,275	6.8
Total	**1,756,813**	**100**	**2,454,620**	**100**

Table 3-6: Expected Building Damage by Occupancy Type for Two Flood Scenarios

Flood Scenario	Occupancy	1-10 Count	11-20 Count	21-30 Count	31-40 Count	41-50 Count	Substantially Count
100-Year Flood Salt Creek	Agriculture	22	3	0	0	0	0
	Commercial	1	0	0	0	0	0
	Education	4	0	0	0	0	0
	Government	0	0	0	0	0	0
	Industrial	0	0	0	0	0	0
	Religion	0	0	0	0	0	0
	Residential	4	52	158	0	8	5
	Total	31	55	158	0	8	5
100-Year Flood San Jacinto River	Agriculture	24	9	0	0	0	0
	Commercial	1	0	0	0	0	0
	Education	13	0	0	0	0	0
	Government	0	0	0	0	0	0
	Industrial	0	0	0	0	0	0
	Religion	0	0	0	0	0	0
	Residential	4	73	229	13	48	165
	Total	42	82	229	13	48	165

Table 3-7: Expected Building Damage by Building Type for Two Flood Scenarios

Scenario	Building Type	1-10 Count	11-20 Count	21-30 Count	31-40 Count	41-50 Count	Substantially Count
100-Year Flood Salt Creek	Concrete	3	0	0	0	0	0
	Manufactured Housing	0	0	0	0	8	5
	Masonry	3	0	0	0	0	0
	Steel	7	1	0	0	0	0
	Wood	12	53	158	0	0	0
100-Year Flood San Jacinto River	Concrete	5	1	0	0	0	0
	Manufactured Housing	0	0	0	0	19	162
	Masonry	6	1	0	0	0	0
	Steel	9	1	0	0	0	0
	Wood	14	75	229	13	29	3

Table 3-8: Building-Related Losses (in Millions of Dollars) as a Result of Flooding Due to Two Flood Scenarios

Flood Scenario	Category	Area	Residential	Commercial	Industrial	Others	Total
100-Year Flood Salt Creek	Building Loss	Building	12.34	0.74	0.16	1.04	14.28
		Content	7.41	2.33	0.29	2.95	12.97
		Inventory	0.00	0.03	0.05	0.45	0.53
		Subtotal	19.74	3.10	0.50	4.43	27.77
	Business Interruption	Income	0.00	0.04	0.00	0.05	0.09
		Relocation	0.10	0.00	0.00	0.00	0.10
		Rental Income	0.03	0.00	0.00	0.00	0.03
		Wage	0.01	0.03	0.00	0.14	0.17
		Subtotal	0.13	0.07	0.00	0.19	0.40
	Totals		**19.87**	**3.17**	**0.50**	**4.62**	**28.17**
100-Year Flood San Jacinto River	Building Loss	Building	30.94	1.19	0.90	6.69	39.72
		Content	18.34	3.72	2.15	10.32	34.53
		Inventory	0.00	0.05	0.53	0.80	1.37
		Subtotal	48.28	4.95	3.58	17.81	75.62
	Business Interruption	Income	0.00	0.05	0.00	0.09	0.14
		Relocation	0.16	0.01	0.00	0.00	0.17
		Rental Income	0.04	0.00	0.00	0.00	0.04
		Wage	0.01	0.05	0.00	0.22	0.27
		Subtotal	0.21	0.10	0.00	0.31	0.62
	Totals		**49.49**	**5.06**	**3.58**	**18.12**	**76.24**

Building-related losses are broken into two categories: direct building losses and business interruption losses. Direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. Business interruption losses are the losses associated with the inability to operate a business because of the damage sustained during the flood. This includes loss of income for business owners, and loss of wages for employees of facilities impacted by the flood. Business interruption losses also include temporary living expenses and relocation expenses for those people displaced from their homes because of the flood. The HazUS analysis estimates that the 100-year flood event in Salt Creek will generate $27.77 million in building related losses in the study area, with 1% of this figure related to business interruption. Residential occupancies make up 68.55% of the total loss. The 100-year flood event in the San Jacinto River is estimated to generate $75.62 million in building-related losses, with residential occupancies making up 63.82% of the total loss. Table 3-8 shows the estimated building-related losses that these flood events would generate in the study area.

3.3.2 Debris Generation

HazUS estimates the amount of debris that will be generated by a given flood. The model breaks debris into three general categories: 1) finishes (dry wall, insulation, etc.), 2) structural (wood, brick, etc.) and 3) foundation (concrete slab, concrete block, rebar, etc.). These distinctions are made because of the different types of equipment required to handle the debris. The HazUS estimates of debris that will be generated by the two flood scenarios considered for this study are presented in Table 3-9.

The model estimates that a 100-year flood event in Salt Creek will generate 2,969 tons of debris; 76% of that will be finishes, 8% will be comprised by structural components, and the remaining 16% will be foundation materials. It will require 119 truckloads (at 25 tons per truckload) to remove this debris from the study area. A 100-year flood event on the San Jacinto River will generate 9,724 tons of debris. Of that amount, 47% will be comprised of finishes, 19% will be structural components, and the remaining 34% will be foundation materials. It will require 389 truckloads to remove the debris generated by this flood event in the study area.

Table 3-9: Debris Generated by Flood Scenarios (in Tons)

Flood Scenario	Category of Debris Generated			Truckloads Required to Clean Debris
	Finishes	Structural	Foundation	
100-Year Salt Creek	2,256	238	475	119
100-Year San Jacinto River	4,570	1,848	3,306	389

3.3.3 Shelter Needs

HazUS estimates the number of households expected to be displaced from their homes due to the flood and the associated potential evacuation. HazUS also estimates those displaced people that will require accommodations in temporary public shelters. The results of the HazUS analyses for the two flood events analyzed for this study are presented in Table 3-10.

Table 3-10: Shelter Requirements Due to Flooding Scenarios

Flood Scenario	# Households Displaced	# of People that will Look for Shelter in Public Shelters
100-Year Salt Creek	645	1,579
100-Year San Jacinto River	970	2,291

3.3.4 Expected Damage to Essential Facilities

Essential facilities in these scenarios include hospitals, fire stations, police stations, emergency operation centers, hospitals, and schools. The essential facilities in the study area considered in the analysis include one hospital with a bed capacity of 84 beds, six fire stations, 404 school buildings, and one emergency operation center. The results presented in Table 3-11 show the number of facilities that will be impacted by the flooding scenario so that they experience at least moderate damage. The model shows that none of the essential facilities in the Menifee study area will be impacted by the 100-year flood event in Salt Creek. The 100-year flood event in the San Jacinto River will impact one of the fire stations and 6 school buildings. The flooded fire station will not be functional during the flood. The local hospital will not be impacted by either flood event.

Table 3-11: Estimated Damage to Essential Facilities as a Result of Two Flood Scenarios

Flood Scenario	Classification	Total	No. of Facilities: At Least Moderate Damage	No. of Facilities: At Least Substantial Damage	No. of Facilities: Loss of Use
100-Year Salt Creek	Fire Stations	6	0	0	0
	Hospitals	1	0	0	0
	School Buildings	404	0	0	0
100-Year San Jacinto River	Fire Stations	6	1	0	1
	Hospitals	1	0	0	0
	School Buildings	404	6	0	0

3.4 Summary of Issues, Planning Opportunities and Mitigation Measures

The Menifee General Plan area encompasses broad, nearly flat valleys surrounded by hills and low mountains. The most concentrated development occupies the valley floors, where flooding remains a serious problem. Although the existing flood control structures that have been installed by Riverside County and private developers have helped to alleviate flooding problems, numerous structures identified in the County's Master Drainage Plans remain to be funded and built. In Menifee's hillside areas, much of the older, rural to semi-rural development has been built with only minor alterations to the natural topography. As a result, facilities that can help reduce the flood hazard, such as underground pipelines, culverts and bridges are not common. This leads to localized flooding, road closures, erosion damage, and even temporary isolation during and following strong storms, particularly when the area is hit by high-intensity summer thunderstorms or winter storms that occur when the ground is already saturated.

Drainages within the General Plan that will be inundated by the 100-year flood, as identified by FEMA, include the San Jacinto River, Ethanac Wash, and Salt Creek. Riverside County has identified additional flood zones in Paloma Wash and Warm Springs Creek. It is important to note that the FEMA flood zones are based on limited studies and portions of the General Plan area have not been evaluated. Further, many storms smaller than the 100-year event have caused damage or flooded roadways in localized areas. Limited analysis of the impact of a 100-year flood event on two of these drainages, Salt Creek and the San Jacinto River, show that a more than $100 million in building-related losses could occur in the area. Most of the damage is anticipated to occur to residential structures, with manufactured housing comprising a significant percentage of the losses.

FEMA's National Flood Insurance Program makes federally subsidized flood insurance available in communities that agree to adopt and enforce floodplain management ordinances to reduce future flood damage. Owners of structures within the FEMA-mapped Special Flood Hazard Areas (100-year flood) are required to purchase and maintain flood insurance as a condition of receiving a federally related mortgage or home equity loan on that structure. Residents and business owners outside of the regulated zones should be encouraged to buy flood insurance as well, because between 20% and 25% of the National Flood Insurance Program claims come from structures located outside the designated 100-year flood zones, where insurance is not required. Riverside County is a member of the National Flood Insurance Program; consequently, flood Insurance is available to residents in the unincorporated areas adjacent to Menifee. The city of Menifee should consider joining the NFIP, so that flood insurance is available for residents within the city.

For those portions of Menifee where flooding is a persistent problem, the City should have evacuation plans in place. Critical facilities such as schools should also have evacuation plans that cover the possibility of flooding. Facilities using, storing, or otherwise involved with substantial quantities of onsite hazardous materials should not be permitted in the flood zones, unless all standards of elevation, anchoring, and flood proofing have been satisfied, and hazardous materials are stored in watertight containers that are not capable of floating.

The City should continue to require that future planning for new developments consider the impact on flooding potential, as well as the impact of flood control structures on the environment, both locally and regionally. Flood control should not be introduced in the undeveloped areas at the expense of environmental degradation. Land development planning should continue to consider leaving watercourses natural wherever possible, or continuing to develop them as parks, nature trails, golf courses or other types of recreation areas that can withstand inundation.

Because many of the natural drainages cross backyards, driveways, and other parts of private yards in rural areas, the citizens of Menifee should make an effort to be educated about their drainage and flooding issues, and not rely entirely on the local agencies. Drainage channels need to be kept free of debris and should not be altered in such a way that runoff is obstructed or significantly changed.

Menifee is downstream from several reservoirs, including Lake Perris, Lake Hemet, and Diamond Valley Lake, the largest water storage reservoir in southern California. The most likely cause for dam failure is a large earthquake occurring on one of the nearby major active faults, such as the

San Jacinto fault zone. Consequently, the City remains vulnerable to inundation and should have emergency plans in place in the event one of these dams should fail. Water tanks in the area are placed on hilltops or sideslopes, above the properties that they supply with domestic water. Emergency planning should include water tanks that could potentially fail and impact developed properties below.

CHAPTER 4: FIRE HAZARDS

4.1 Vegetation Fires

Wildfires are a significant hazard throughout the United States, and especially in the West, where they occur often. Large areas of southern California are particularly susceptible to wildfire due to the region's weather, topography and native vegetation. The typically mild, wet winters characteristic of our Mediterranean climate result in an annual growth of grasses and plants that dry out during the hot summer months. This dry vegetation provides fuel for wildfires in the autumn. Although wildfires are often considered highly disruptive and even dangerous, the fact is that wildland fires are a necessary part of the natural ecosystem of southern California, and have been part of the natural environment for millennia. Many of the native plants require periodic burning to germinate and recycle nutrients that enrich the soils. Native Americans took advantage of this, and used fire extensively to control their environment by enhancing feed for wildlife; killing insects and controlling diseases that impacted the plants that they used as foods; increasing the abundance and density of edible tubers, greens and other useful plants; and clearing underbrush to ease travel and provide increased visibility for hunting and gathering (Anderson, 2006).

Wildfires become a hazard when they extend out of control into developed areas, with a resultant loss of property, and sometimes, unfortunately, loss of life. The wildfire risk in the United States has increased in the last few decades with the increasing encroachment of residences and other structures into the wildland environment, and the increasing number of people living and playing in wildland areas. According to the National Interagency Fire Center, between 2001 and 2008, humans caused approximately 84% of the wildland fires (519,193 human-caused fires vs. 95,294 lightning fires) in the U.S.; however, fires caused by lightning strikes burned nearly 1.7 times more land (approximately 35.3 million acres burned by lightning vs. 20.5 million acres burned by man) (http://www.nifc.gov/). The most common (human) causes of wildfires are arson, sparks from brush-clearing equipment and vehicles, improperly maintained campfires, improperly disposed cigarettes, and children playing with matches.

As the 2003, 2006, 2007 and 2009 fires in southern California have shown, the containment of wildfires that consume hundreds of thousands of acres of vegetated property require the participation of a multi-jurisdictional emergency response effort, with hundreds to thousands of people at or near the fire lines combating the flames, clearing brush ahead of the fire to establish defensible zones, and assisting evacuees (Figures 4-1 and 4-2). Under the right wind conditions, multiple ignitions can develop as a result of the wind transport of burning cinders (called **brands**) over distances of a mile or more. Wildfires in those areas where the wildland approaches or interfaces with the urban environment (referred to as the **urban-wildland interface** area or **UWI** area) can be particularly dangerous and complex, posing a severe threat to public and firefighter safety, and potentially causing devastating losses of life and property. This is because when a wildland fire encroaches onto the built environment, ignited structures can then sustain and transmit the fire from one building to the next. It has become increasingly clear that continuous planning, preparedness, and education are required to reduce the fire hazard and limit the destruction caused by fires. These mitigation measures are discussed in this document.

Wildland fires usually last a few hours to days, but their effects can last much longer, especially in the case of intense fires that develop in areas where large amounts of dry, combustible vegetation have been allowed to accumulate. If wildland fires are followed by a period of intense rainfall, debris flows emanating from the recently burned hillsides can develop. Studies (Cannon, 2001) suggest that in addition to rainfall and slope steepness, other factors that contribute to the formation of post-fire debris flows include the underlying rock or sediment type, the shape of the drainage basin, and the presence or absence of water-repellant soils (during a fire, the organic material in the soil may be burned away or decompose into water-repellent substances that prevents water from percolating into the soil.) Flood control facilities may be severely taxed by the increased flow from the denuded hillsides and the resulting debris that washes down. If this debris overwhelms the flood control structures, widespread damage can ensue in areas down gradient from the failed structures. As an example, in San Bernardino County 16 people died as a result of debris flows during the 2004 storms that followed the 2003 fire season. During the storms of 2010, the Los Angeles County Public Works Department and several cities had crews around the clock cleaning out the debris basins between the mountains and the communities at the foot of the 250-square-mile area that burned during the Station Fire. These efforts helped significantly in reducing the hazard of mudflows, although unfortunately nearly 50 homes were still seriously damaged in the communities of La Crescenta, La Canada Flintridge, and Acton.

Other effects of wildfires are economical and social. Homeowners who lose their house to a wildfire may take years to recover financially and emotionally. Recreational areas that have been affected may be forced to close or operate at a reduced scale. In addition, buildings destroyed by fire are usually eligible for re-assessment, which reduces income to local governments from property taxes. The impact of wildland fire on plant communities is generally beneficial, although it often takes time for plant communities to re-establish themselves. If a grassland area has been burned, it will re-sprout the following spring. Chaparral plant communities will take three to five years. Oak woodland, if it has had most of the seedlings and saplings destroyed by fire, will require at least five to ten years for a new crop to start. Desert plants, like cacti, typically take more than a decade to recover after a fire.

Figure 4-1: View of the Cedar Fire of October 2003 Moving Down Oak Canyon, Toward the 52 Freeway, in San Diego County.

This fire burned more than 273,000 acres, destroyed 2,820 structures, damaged 63 others, and caused 15 fatalities. The fire was cased by a signal flare set off by a lost hunter. This is the largest fire by acreage burned in California since at least 1932, when reliable records were first kept.

Figure 4-2: View of a Backfire to the Station Fire Behind Homes in La Crescenta.
The Station Fire burned 160,557 acres, 209 structures and caused 2 deaths. It is considered the 10th largest California fire by acreage burned (http://cdfdata.fire.ca.gov/incidents/incidents_statsevents).
(Photograph by Jae C. Hong/AP Photo, taken on September 1, 2009).

4.1.1 Local Characteristics and History on Local Fires

The fire hazard of an area is typically based on the combined input of several parameters. These conditions include: 1) fuel loads – that is, the type of fuel or vegetation, and its density and continuity, 2) topography – elevation and slope, 3) weather, 4) wildfire history, 5) dwelling density, and 6) existing local mitigation measures that help reduce the area's fire hazard – such as fuel modification zones, fire-rated construction, fire hydrants, etc. These conditions as they pertain to Menifee and immediate surrounding areas are discussed further below.

- **Fuel Loads and Topography.** Menifee is located in the Valleys Section of the South Coast Bioregion. The Bioregion extends southward from the Transverse Ranges on the north to Mexico, and from the Pacific Ocean eastward to and including the San Jacinto and Santa Rosa Mountains. The region includes the highest peaks outside of the Sierra Nevada (the San Jacinto Mountains reach an elevation of more than 10,800 feet), although more than 50% of the area is at elevations below 1,600 feet. This range of elevations translates into a high diversity of vegetation types and fire regimes. The South Coast Bioregion comprises only about 8% of the land area of California, but houses 56% of the state's total human population. This "has placed immense pressure on natural resources and has created a fire management problem of extraordinary proportions" (Keeley, 2006).

  The predominant vegetation assemblage in the lower elevation areas of the South Coast Bioregion is semi-deciduous sage scrub. The sage scrub in the interior valleys is placed in the Riversidian Division. Oak woodlands and grasslands are also found locally in the lower valley areas. The southern California grasslands include small patches of native grassland (perennial bunchgrasses, purple needlegrass, pine bluegrass, and Junegrass), combined with larger, more-widespread patches of non-native annual grasslands. On north-facing slopes and in areas with deep soils, sage scrub is replaced by the taller evergreen chaparral, an assemblage of different floristic associations, including chamise and black sage. At higher elevations, the chaparral assemblage completely displaces the sage scrub (Keeley, 2006).

Figure 4-3: **Typical Fuel Loads in the Hillsides Surrounding Menifee**, consisting primarily of sage scrub and grasses.

This vegetation often provides fuel for wildfires in the autumn, when the plants have dried up, and when the area is intermittently impacted by Santa Ana winds, the hot, dry winds that blow across the region in the late fall (see Chapter 6). These winds often fan and help spread wildland fires. Furthermore, many of the native plants have a high oil content that makes them highly flammable, and many require periodic burning to germinate and recycle nutrients that enrich the soils.

Currently, in the developed, relatively flat areas of the city, vegetation fires are not considered a significant hazard, as the low topographic relief and lack of fuel loading due to carefully maintained and regularly watered landscaping combine to mitigate the potential for wildland fires. This is not to say that vegetation fires do not occur in developed areas, but these tend to be smaller and less intense in heat.

- **Weather.** As discussed in the Flooding Hazards section (Chapter 3), the Menifee area is semi-arid. Average annual precipitation in Menifee is almost 12 inches, with nearly 70% of that precipitation falling in the winter, between December and March inclusive. A small percentage of the precipitation in the region is attributed to summer thunderstorms that approach from the south (from Mexico through Arizona, or from the Sea of Cortez or Baja California).

Both winter and summer thunderstorms that pass through southern California often include lightning. In the interior ranges, lightning strikes are most common in August, and lightning strike density is substantially higher here than in the coastal areas, averaging 25 to 40 lightning strikes per 100 square kilometers per year (based on Bureau of Land Management detection data by van Wagtendonk and Cayan, 2008, as reported in Brooks and Minnich, 2006). As discussed in the opening paragraphs, lightning is responsible for a significant percentage of the acreage burned by wildfires in the United States, although human-caused fires are far more common.

Santa Ana winds have a significant impact on the fire weather conditions in the region, especially since these winds often occur in the fall, when the natural fuels are particularly dry. Fire spread is a serious concern during Santa Ana wind conditions; fire spreads of as much as 30,000 hectares in a single day have been reported (Phillips, 1971, as reported in Keeley, 2006). For additional information on wind-fanned fires, refer to Table 4-1 and Chapter 6.

- **Wildfire History.** According to data by the California Department of Forestry and Fire Protection (Cal Fire; http://frap.cdf.ca.gov/data/frapgismaps/download.asp), there have been several large fires in the Menifee General Plan area between 1970 and 2007. A few fires in the region are also reported for the period between 1910 and 1969 (see Plate 4-1). Table 4-1 summarizes several wildland fires reported in and near Menifee for the period between 1998 and 2009.

Table 4-1: Wildland Fires Reported In and Near the City of Menifee, 1998-2009

Date	Fire Description
August 31-Sept. 1, 1998	Strong thunderstorm with lightning strikes and strong winds caused a wildfire in the Juniper Flats area that burned 6,000 acres, destroyed 44 residences, 46 other structures, and 98 vehicles. The total loss from this wildfire was estimated at $4.45 million. Another fire that burned 9,000 acres was started by lightning in the Cleveland National Forest.
August 28-September 9, 1999	Fire started 3 miles west of Mountain Center and grew rapidly toward the southeast. Consumed 3,300 acres, injured four people, forced the evacuation of 100 residents and campers, and the closure of Highways 74 and 243. No property damage was reported, but fighting the fire cost an estimated $555,000.
July 29-August 10, 2000	Brush fire fanned by erratic winds consumed 11,734 acres, east and southeast of Temecula. The bulk of the fire was over the western half of the Agua Tibia Wilderness area so very few structures were destroyed or damaged. 41 firefighters were injured, 7 of them had to be hospitalized. $40K in property damage reported; the cost of fighting the fire was estimated at $15 million.
June 17-18, 2001	Arsonist-caused fire burned 200 acres 8 miles southeast of Hemet. Six firefighters sustained minor injuries.
June 24, 2001	Brush fire consumed 25 acres near Allen and Olson Avenues in Homeland.
July 1, 2001	Brush fire burned 12 acres in Quail Valley.
July 11, 2001	Brush fire burned 283 acres in the Good Hope area 3 miles west of Perris.
June 30-July,	High temperatures and dry brush led to a series of wildfires. One burned 300

Date	Fire Description
2003	acres in the hilly terrain northeast of Lake Skinner.
July 3, 2003	A fire broke out in a church under construction in the Lake Elsinore area. Gusty winds caused the flames to ignite nearby brush, quickly burning 850 acres of brush. Residents of the Sedco Hills subdivision were evacuated as a precaution. The main church and two sheds were destroyed causing $750K in property damage.
July 4-6, 2003	The Stage Fire consumed 1,602 acres of brush south and southwest of Hemet. Several homes and ranches were threatened, but no property damage was reported. 200 residents were evacuated.
July 5, 2003	Brush fire consumed 100 acres in Perris. One firefighter was overcome by heat exhaustion.
August 23-24, 2003	The Lake Mathews fire burned 200 acres about 5 to 6 miles west of Perris before being fully contained. About 100 homes were threatened, but no property was damaged.
October 26-November 2, 2003	The Mountain fire consumed 10,331 acres, destroyed 21 houses, 40 outbuildings, and damaged another 3 homes before being fully contained. The fire caused $6 million in property damage and 7 injuries. It began in Sage and extended toward Rancho California. Schools were closed in Hemet. The total cost of fighting the fire was estimated at $1.8 million.
May 2-7, 2004	Hot and dry conditions preceded several fires that broke out in the region. The Eagle fire started about 5 miles southeast of Temecula – it burned 8,900 acres, and destroyed 14 residences and 27 outbuildings east of Murrieta. The cost of fighting the fire was an estimated $4.9 million. The School fire broke out 13 miles east of Temecula. It burned 377 acres but no structures. The Gafford fire broke out 4 miles southeast of Lake Elsinore. It burned 375 acres and one structure. The Cerrito fire was started by sparks from a metal object drug across pavement. This fire burned 16,460 acres from north of Lake Elsinore to the Perris city limits. It destroyed 14 residences and 10 outbuildings. The cost of fighting this fire was $2.3 million. Overall, these fires caused $8.1 million in property damage and 18 injuries.
July 14, 2004	The Tulip fire consumed 151 acres in the Sedco Hills area of Lake Elsinore. Three firefighters suffered heat exhaustion.
July 17-20, 2004	The Melton fire consumed 3.667 acres, 14 vehicles, 4 mobile homes, 1 travel trailer, 1 motor home, and 14 outbuildings near Hemet, for a total in property damage of $163.5K. One injury was reported. The cost of fighting the fire was estimated at $1.14 million.
May 27-28, 2009	Two separate vegetation fires started by an arsonist spread over the next 24 hours, burning 503 acres near Lake Perris State Recreation Area. The fire led to the evacuation of the campground, and the closure of several roads in the area. No damage to structures or injuries were reported.
May 31, 2010	A fire that started east of I-215 near Scott Road spread quickly and threatened about a dozen homes in the area of Lindenberg Road at Camino de los Caballos, in Menifee. Two helicopters, 18 fire engines and 145 firefighters helped fight the 35-acre wildfire before it damaged any homes.
July 15, 2010	About a half-dozen brush fires sparked by lightning were reported in Riverside and San Diego counties. The Cactus blaze burned through more than 647 acres east of Murrieta. The Skinner blaze burned about 503 acres near the intersection of Crown Valley Road and De Portola Road in Temecula. The Saddle fire burned 80 acres near Oak Glen Road and Red Mountain Road south of Hemet, and the Don Juan fire near Lake Elsinore burned a travel trailer. Three firefighters were injured.

Source: NOAA, at http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms; Los Angeles Times, and The Californian

NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

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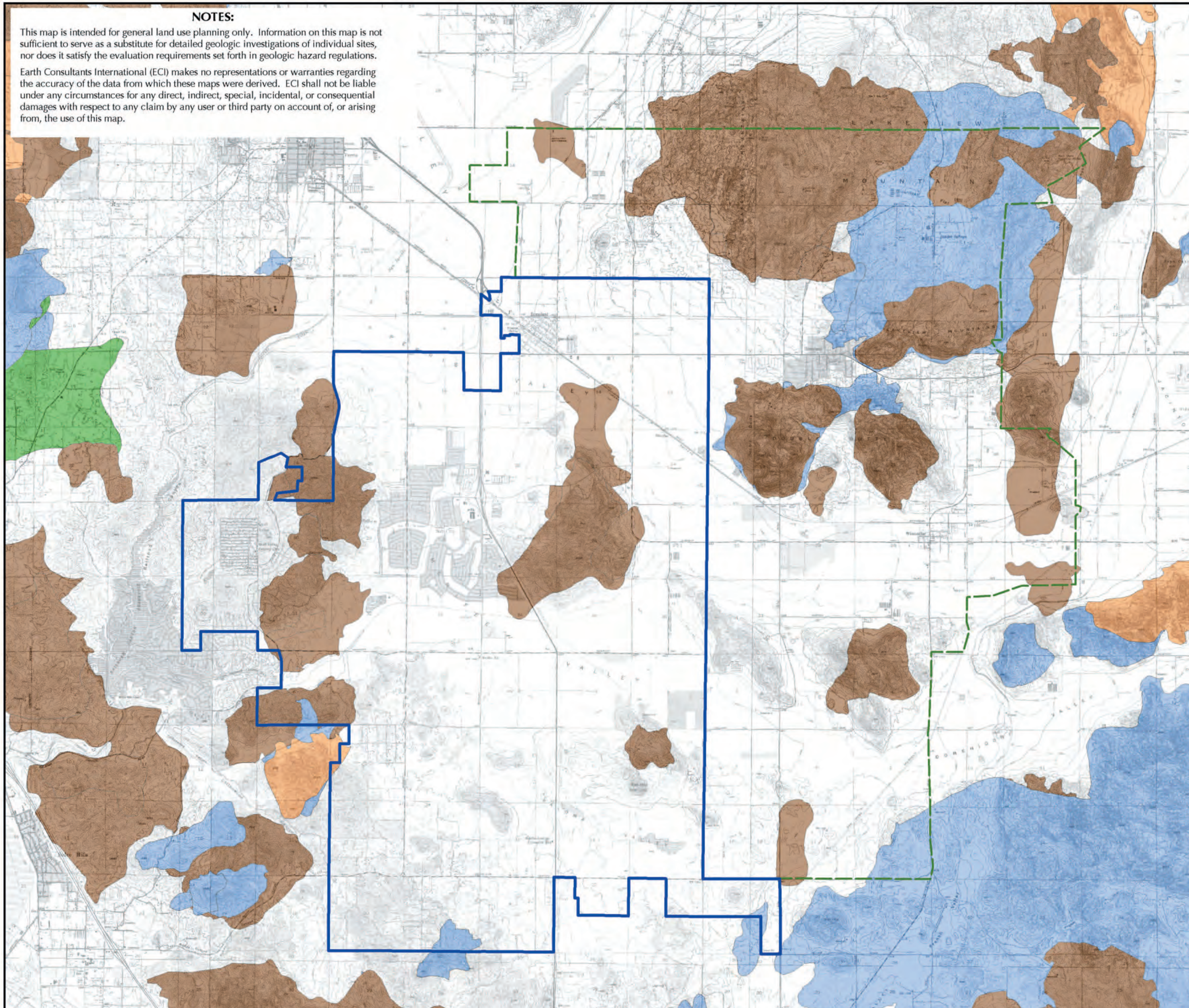

Historical Wildland Fires

in and Near Menifee, California

Explanation

Year of Last Burn

- 1990-2007
- 1970-1989
- 1950-1969
- 1910-1949

- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N, S, W, E

Scale: 1:84,000

7000 0 7000
Feet

2 0 2
Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997.
Source: California Fire and Resource Assessment Program (FRAP) @ http://frap.fire.ca.gov/data/frapgisdata/select.asp

Earth Consultants International

CITY OF MENIFEE

Project Number: 2917
Date: 2010

Plate 4-1

Comparing the data in Table 4-1 with maps showing wildland fires recorded by CalFire indicates that the NOAA table is incomplete. Furthermore, fires less than 10 acres in size are typically not recorded by CalFire. The Riverside County Fire Department reports that Battalion 13, the group of five fire stations that serve the Riverside County area where Menifee is located typically respond to between about 30 and 40 wildland fires per year. Specifically, in 2006, they responded to 36 wildland fire incidents, in 2007 to 29, in 2008 to 34, and in 2009 to 38 (based on Emergency Incident Statistics graciously provided by the Riverside County Fire Department Communications and Technology Division on 11/25/2009; see Table 4-2).

Figure 4-4: Evidence of Past Fires Along Juniper Flats Road.
Notice that the undersides of some of the tree trunks along the creek are black, scarred by fire.

4.1.2 Regulatory Context and Fire Risk Areas

Since the early 1970s, several fire hazard assessment and classification systems have been developed for the purpose of quantifying the severity of the fire hazard in a given area. Many of these are regulatory in that they were implemented as a result of legislation enacted either at the State or Federal level. Early systems characterized the fire hazard of an area based on a weighted factor that typically considered fuel, weather and topography. More recent systems rely on the use of Geographic Information System (GIS) technology to integrate the factors listed above to map the hazards, and to predict fire behavior and the impact on watersheds.

- **HUD Study System.** In April 1973, the California Department of Forestry (CDF – now the California Department of Forestry and Fire Protection, also known as CalFire) published a study funded by the Department of Housing and Urban Development (HUD) under an agreement with the Governor's Office of Planning and Research (Helm et al., 1973). As is the case with several other more recent programs, the study was conducted in response to a disaster: During September and October 1970, 773 wildfires burned more than 580,000 acres of California land. The HUD mapping process relied on information obtained from U.S. Geological Survey (USGS) 15- and 7.5-minute quadrangle maps on fuel loading (vegetation type and density) and slope, and combined it with fire weather information (now available in real-time at http://gacc.nifc.gov/oscc/predictive/fuels_fire-danger/index.htm) to determine the **Fire Hazard Severity** of an area. This system was the basis for several subsequent studies and programs that have been conducted as a result of more recent legislation, as described further below.

- **California Department of Forestry and Fire Protection – State Responsibility Areas System.** Legislative mandates passed in 1981 (Senate Bill 81, Ayala, 1981) and 1982 (Senate Bill 1916, Ayala, 1982) that became effective on July 1, 1986, required the California Department of Forestry and Fire Protection (CDF) to develop and implement a system to rank fire hazards in California. Areas were rated as moderate, high or very high based primarily on fuel types. Thirteen different fuel types were considered using the 7.5-minute quadrangle maps by the USGS as base maps (Phillips, 1983). Areas identified as having a fire hazard were referred to as **State Responsibility Areas** (SRAs) (Public Resources Code Section 4125). These are non-federal lands covered wholly or in part by timber, brush, undergrowth or grass, for which the State has the primary financial responsibility of preventing and suppressing fires. *There are several State Responsibility Areas in the Menifee General Plan area. These are shown in orange in Plate 4-2. There are also a few areas that are classified as* ***Federal Responsibility Areas (FRAs)*** *(CDF, 2007). These are shown in turquoise on Plate 4-2. Most of the low-lying areas of the city are located within Local Responsibility Areas (LRAs)*, as described further below.

- **Bates Bill Process.** The Bates Bill (Assembly Bill 337, September 29, 1992) was a direct result of the great loss of lives and homes in the Oakland Hills Tunnel Fire of 1991. Briefly, the CDF, in cooperation with local fire authorities was tasked to identify **Very High Fire Hazard Severity Zones (VHFHSZs)** in **Local Responsibility Areas (LRAs).** To accomplish this, the CDF formed a working group comprised of state and local representatives that devised a point system that considers subjective criteria for fuels, fire history, terrain influences, housing density, and occurrence of severe fire weather. To qualify as a VHFHSZ, an area had to score ten or more points in the grading scale. The original VHFHSZ maps that were prepared as a result of the Bates Bill are now more than ten years old and outdated. In the last few years, the CDF has been re-mapping both SRAs and LRAs using GIS technology and new data and science to better describe the potential fire behavior and fire probability for a give area. Areas are being mapped in the Moderate, High and Very High categories. *The CDF (2008) has recommended that the urban, low-lying areas in Menifee be classified as having a Moderate fire hazard (see Plate 4-2). The hillside areas are generally classified as having a Very High fire hazard, and the areas between the flatlands and the hillsides are classified in the High fire hazard.*

NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

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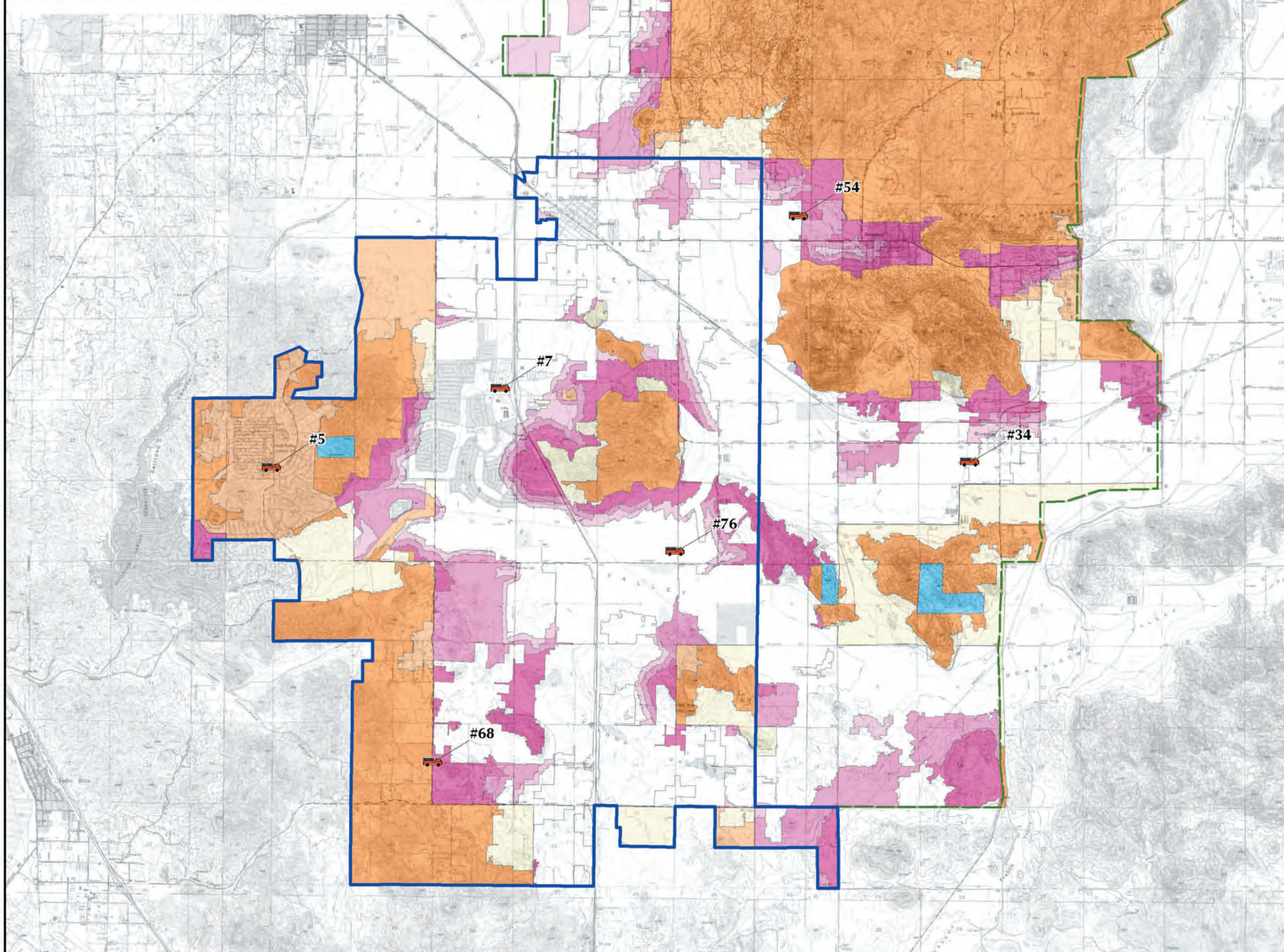

High Fire Hazard Areas

Menifee, California

Explanation

Local Responsibility Area

- Very High Fire Hazard Severity Zone
- High Fire Hazard Severity Zone
- Moderate Fire Hazard Severity Zone

State Responsibility Area

- Very High Fire Hazard Severity Zone
- High Fire Hazard Severity Zone
- Moderate Fire Hazard Severity Zone

Federal Responsibility Area

- Very High Fire Hazard Severity Zone

Fire Station

City of Menifee Corporate Boundary

Menifee General Plan Area Boundary

N S W E

Scale: 1:84,000

7000 0 7000
Feet

2 0 2
Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997.
Sources: Fire and Resource Assesment Program, California Department of Forestry and Fire Protection (2007); Riverside County Fire Deptment.

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Plate 4-2

- **California Fire Plan.** The 1996 California Fire Plan is a cooperative effort between the State Board of Forestry and Fire Protection and the CDF (California Board of Forestry, 1996). The main objective of the California Fire Plan is to reduce total costs and losses from wildland fire in the State by protecting assets at risk before a fire occurs. To do so, the plan identifies prefire management prescriptions that can be implemented to reduce the risk, and analyzes policy issues and develops recommendations for changes in public policy. For more information go to http://cdfdata.fire.ca.gov/fire_er/ fpp_planning_cafireplan. This system ranks the fire hazard of all wildland areas of the State using four main criteria: fuels, weather, assets at risk, and level of service (which is a measure of the Fire Department's success in initial-attack fire suppression). The California Fire Plan uses GIS-based data layers to conduct the initial evaluations, and local CDF Ranger Units are then tasked with field validation of the initial assessment. The final maps use a Fire Plan grid cell with an area of approximately 450 acres, which represents 1/81 of the area of a 7.5-minute quadrangle map (called Quad 81). The fire hazard of an individual cell is ranked as very high, high or moderate. The high and very high fire hazard zones are based on the availability of fuel (fuel load), terrain and assets at risk. In some cities in southern California, the high and very high fire threat areas include high-density residential subdivisions that are located at the urban-wildland interface. These are the areas where even though hardscape (concrete, asphalt and structures) and landscaping vegetation predominate, the high concentration of structures can allow fires to jump from one building to the next, and the loss due to fire would be greatest. These are therefore the areas where enhanced onsite protection for structures and people is necessary.

  Under the California Plan, and given the area's vegetation types and slope characteristics, Menifee is mapped as having a moderate fuel rank and potential fire behavior, with the hillside areas having a high to very high potential fire behavior (http://frap.cdf.ca.gov/data/frapgismaps/download.asp).

- **National Fire Plan**. During the 2000 fire season, wildfires burned millions of acres of land throughout the United States, prompting politicians, fire managers and government agencies to re-think their approach to fire management. Under Presidential Executive Order, the Secretaries of Agriculture and the Interior were tasked with preparing a report that outlined recommendations to minimize both the long- and short-term impacts of wildfires with a broader effort and closer cooperation between agencies and fire programs. The resultant report, entitled the "National Fire Plan," has as its main purposes to protect communities and restore ecological health on Federal lands (http://www.forestsandrangelands.gov/NFP/index.shtml). The Plan outlines five key points: 1) firefighting, 2) rehabilitation and restoration, 3) hazardous fuel reduction, 4) community assistance, and 5) accountability. The Plan, which was first funded in 2001, commits to funding for a continued level of "Hazardous Fuel Reduction" and new funding for a "Community Assistance/Community Protection Initiative." The intent of the Community Assistance initiative is to provide communities that interface with federal lands an opportunity to get technical assistance and funding to reduce their threat of wildfires.

  As part of the Community Assistance/Community Protection Initiative, the National Fire Plan funded a study to identify areas that are at high risk of damage from wildfire. Under this program, Federal fire managers authorized State foresters to determine which communities are at significant risk from wildland fire on Federal lands. In California, this task was undertaken by the California Fire Alliance (CFA), a cooperative group of State, Federal and local agencies, who in 2001 generated a list of communities at risk. Given California's extensive Urban-Wildland Interface (UWI), the list of communities extends beyond just those on Federal lands. In fact, the CFA identified 1,264 fire-threatened communities in California, and *the communities of Sun City, Quail Valley, Romoland, Homeland, and Juniper Flats are all considered* ***Communities at Risk****. Menifee as a community is not included in the list given the City's date of incorporation (2008) relative to the date of the list (2001). Sun City and Quail Valley are located adjacent to Federal lands with a high wildland fire hazard, and are federally regulated. Juniper Flats is not adjacent to Federal lands, but it is federally regulated, whereas Homeland and Romoland are not adjacent to Federal lands and are not federally regulated* (http://www.cafirealliance.org/communities_at_risk/). Communities can change their status on the Communities at Risk list, or they can request to be added to the list. Information on this program, including the Communities at Risk Application Form, is available from the worldwide web at http://www.cafirealliance.org/communities_at_risk/communities_at_risk_changestatus.

Under the auspices of the National Fire Plan, the CDF also produced a Wildland Fire Threat Map, released on October 20, 2005, that takes into account the combined effects of potential fire behavior (fuel rank) and expected fire frequency (fire rotation) from the past 50 years to create four threat classes for risk assessment. These threat classes are extreme, very high, high and moderate. Areas that do not support wildland fuels (such as open water, and agricultural lands) were not considered in the analysis. Most large urbanized areas receive a moderate fire threat classification to account for fires carried by ornamental vegetation and flammable structures. *The Fire Threat Map (available at http://www.frap.fire.ca.gov/data/frapgismaps/download.asp) shows that the developed areas of Menifee are included in either the non-fuel or moderate fire threat classification, whereas Quail Valley, Juniper Flats and the hillsides in the General Plan area have a very high to extreme fire threat.*

- **California Fire Alliance (CFA).** In addition to generating and updating the Communities at Risk list described above, the CFA funds a variety of projects designed to reduce the threat of wildfire before it happens. As part of this effort, the CFA encourages the development of Community Wildfire Protection Plans (CWPP), as defined by the Healthy Forest Restoration Act (HFRA) of 2003. CWPPs enable a community to plan how it will reduce its risk of wildfire by identifying strategic sites and methods for fuel reduction projects across the landscape and jurisdictional boundaries. Benefits of having a CWPP include National Fire Plan funding priority for projects identified in a CWPP. The USDA Forest Service and Bureau of Land Management can expedite the implementation of fuel treatments, identified in a CWPP, through alternative environmental compliance options offered under the HFRA. The CWPP must be agreed to by three entities: the local government, the local Fire Department, and the CDF. Communities developing CWPPs are encouraged to integrate their CWPP planning process into other planning processes, including the Safety Element of the General Plan (i.e., this document), Local Hazard Mitigation Plans, Flood Mitigation Plans, and other local hazard, evacuation and emergency plans. *Neither the City of Menifee, nor Riverside County, has a Community Wildfire Protection Plan on file with the California Department of Forestry and Fire Protection.*

- **Real-Estate Disclosure Requirements**. California state law [Assembly Bill 6; Civil Code Section 1103(c)(6)] requires that fire hazard areas be disclosed in real estate transactions; that is, real-estate sellers are required to inform prospective buyers whether or not a property is located within a wildland area that could contain substantial fire risks and hazards, such as a State Responsibility Area.

  Real-estate disclosure requirements are important because in California the average period of ownership for residences is only five years (Coleman, 1994). This turnover creates an information gap between the several generations of homeowners in fire hazard areas. Un-informed homeowners may attempt landscaping or modifications that could be a detriment to the fire-resistant qualities of their structure, with potentially negative consequences.

Although Federal, State and to some degree, local agencies have inventoried and classified the fire hazard of a given area, some users are in need of additional detail, or need to evaluate the fire conditions of an area at a specific time of the year, or under specific fuel loading and weather conditions. The tools below are not regulatory, but in that they are used by specific industry groups, or have applications that can be useful to an agency such as the local or County Department or the National Forest Service, they are described further.

- **FireLine System**. The Insurance Services Office (ISO) developed a program used by the insurance industry to identify those areas where the potential loss due to wildfire is greatest (ISO, 1997). ISO retained Pacific Meridian Resources of Emeryville, California to develop the FireLine software, which uses satellite-imagery interpretation to evaluate the factors of fuel types, slope and roads (access) to develop the risk rating. Most insurance companies that provide insurance services to homeowners in California now use this system. This software is only available through ISO. Updated versions of this system are being developed that include the factors of elevation, aspect, and relative slope position.

- **BEHAVE, FARSITE, FlamMap and Other Models**. These are computer programs, typically PC-based, that can be used by fire managers to calculate potential fire behavior in a given area using GIS data inputs for terrain and fuels. The purpose of these models is to predict fire behavior. Data inputs that can be used in the analyses include elevation, slope, aspect, surface fuel, canopy cover, stand height, crown base height and crown bulk density.

  The oldest of these models is the **BEHAVE** Fire Behavior Prediction and Fuel Modeling System (Burgan and Rothermel, 1984; Burgan, 1987; Andrews, 1986; Andrews and Chase, 1989; Andrews and Bradshaw, 1990) that has been used since 1984. A newer version of it is referred to as the BehavePlus Fire Modeling System (Andrews and Bevins, 1999). This software has been updated on a regular basis to make it more user-friendly and provide additional fire modeling capabilities. **FARSITE** (Fire Area Simulator; Finney, 1995, 1998) is a GIS-based software that "simulates the growth and behavior of a fire as it spreads through variable fuel and terrain under changing weather conditions" (http://fire.org/). This software can be used to project the growth of ongoing wildfires and prescribed fires in two dimensions (unlike BEHAVE, which is a one-dimensional model), and can be used as a planning tool for fire suppression and prevention, and fuel assessment. **FlamMap**, whose continued development is funded by the Bureau of Land Management, combines elements of the two older models, BEHAVE and FARSITE, but is not a replacement for either. The software computes potential fire behavior characteristics such as fire spread, flame length, fireline intensity, etc., over an entire FARSITE landscape using constant weather and fuel moisture conditions. Some other models also used by fire managers include EMBYR, DYNAFIRE, LANDFIRE, NEXUS, FireFamily Plus, and FOFEM (http://www.forestencyclopedia.net/p/p452).

- **Brian Barrette's Structural Vulnerability System**. This system starts with the State Responsibility Area fire hazard severity rating described above, but also includes structural elements as rating factors (Barrette, 1999). The structural elements considered include roofing, siding, vegetation clearance, roads and signage, chimneys, structural accessories, water supply, and the location of the structure in relation to the surrounding conditions. This system is intended for use in assessing individual parcels, and is therefore not likely to be used by agencies, as it is time- and personnel-intensive. However, the system is easy to use and can therefore be used by individual homeowners or insurance companies to determine whether or not a specific property has a high fire hazard and is thus a good candidate for specific fire hazard mitigation measures.

4.1.3 Fire Prevention and Suppression Programs and Regulations

There are several fire prevention and suppression programs that communities can implement to reduce their wildland fire hazard. Some of these programs aim to control the type, density and continuity of fuel (vegetation) available for a fire to burn; others are directed at the strengthening of structures to be more fire resistant. Given that the increase in catastrophic, human-caused wildland fires is associated with an increased number of people living and playing in wildland areas, limiting human-wildland interaction during periods of heightened fire risk can also help reduce the likelihood of human-caused fires in an area. Finally, the effective containment of a wildland fire before it impacts vulnerable structures is in great part the result of the suppression resources available to the agencies fighting the fire, and the fire department's accessibility to the impacted area. Some of these programs are described in more detail below.

- **Vegetation Management.** Experience and research have shown that vegetation management is an effective means of reducing the wildland fire hazard. Therefore, in those areas identified as susceptible to wildland fire, land development is governed by special State, county and local codes, and property owners are required to follow maintenance guidelines aimed at reducing the amount and continuity of the fuel (vegetation) available. Requirements for vegetation management at the urban-wildland interface (UWI) in California were revisited following the 1993 wildland fires that impacted large areas of Orange, Los Angeles and Ventura counties. The International Fire Code Institute formed a committee to develop a Wildland-Urban Interface Code under the direction of the California State Fire Marshal. The first draft of this code was published in October 1995. Then, in 2003, the International Fire Code Institute consolidated into the International Code Council. The most recent Wildland-Urban Interface Code was issued by the International Code Council in 2006. The code contains provisions addressing fire spread, accessibility, defensible space, and water supply for buildings constructed near wildland areas. California incorporated the

Wildland-Urban Interface Code into the California Building Standards Code, which incorporates the fire safety provisions of the California Fire Code and the California Building Code. The California Fire Code contains standards for building design, water supply and brush clearance.

Hazard reduction and **fuel modification** are the two methods that communities most often employ to reduce the risk of fire at the UWI. Both methodologies use the principle of reducing the amount of combustible fuel available, which reduces the amount of heat, associated flame lengths, and the intensity of the fire that would threaten adjacent structures. The purpose of these methods is to reduce the hazard of wildfire by establishing a **defensible space** around buildings or structures in the area. Defensible space is defined as an area, either natural or man-made, where plant materials and natural fuels have been treated, cleared, or modified to slow the rate and intensity of an advancing wildfire, and to create an area for firefighters to suppress the fire and save the structure. These standards require property owners in the UWI to conduct maintenance, modifying or removing non-fire-resistive vegetation around their structures to reduce the fire danger. This affects any person who owns, leases, controls, operates, or maintains a building or structure in, upon, or adjoining the UWI.

Effective January 1, 2005, properties in California within a wildland fire hazard area are required to maintain a defensible space clearance around buildings and structures of 100 feet (Public Resources Code 4291), or to their property line, whichever is less (Figure 4-5). This requirement applies to any person who owns, leases, controls, operates, or maintains a building or structure in, upon, or adjoining a mountainous area, forest-covered land, brush-covered land, grass-covered land, or any land that is covered with flammable material, and located within a State Responsibility Area. While individual property owners are not required to clear beyond the 100-foot distance, or beyond their property line, groups of property owners are encouraged to extend clearances beyond the 100 -foot requirement to create community-wide defensible spaces (State Board of Forestry and Fire Protection, 2006).

Figure 4-5: Road Sign Reminding Residents to Maintain a Defensible Space Around their Properties (on Juniper Flats Road, near its intersection with Pinacate Road)

Fuel or vegetation treatments often used include mechanical, chemical, biological and other forms of biomass removal (Greenlee and Sapsis, 1996) within a given distance from habitable structures. The intent of this hazard-reduction technique is to create a defensible space that slows the rate and intensity of the advancing fire, and provides an area at the urban-wildland interface where firefighters can set up to suppress the fire and save the threatened structures. **Hazard reduction** includes requirements for the maintenance of existing trees, shrubs, and ground cover within a setback zone, to reduce the amount of fuel on those sides of any structure that face the UWI. These requirements include: clearing all dead or dying foliage; planting fire-resistive vegetation; keeping clearances between tree stands, bushes and shrubs, and between trees and structures; irrigating ground covers, storing firewood and combustible materials away from habitable structures; using fire-resistant roofing and construction materials; cleaning vegetation debris from roofs and rain gutters; and using spark arresters on chimneys.

In some communities or developments adjacent to a wildland area, residents are required to comply with **fuel modification** requirements. A **fuel modification zone** is a ribbon of land surrounding a development within a fire hazardous area that is designed to diminish the intensity of a wildfire as it approaches the structures. Fuel modification includes both the thinning (reducing the amount) of combustible vegetation, and the removal and replacement of native vegetation with fire-resistive plant species. These modification zones may be owned by individual property owners or by homeowners' associations. Emphasis is placed on the space near structures that provides natural landscape compatibility with wildlife, water conservation and ecosystem health. Immediate benefits of this approach include improved aesthetics, increased health of large remaining trees and other valued plants, and enhanced wildlife habitat.

Before European settlers arrived, many areas of the United States experienced small but frequent wildfires that impacted primarily the grasses and low-lying bushes, without severely damaging the tree stands. Native Americans in California reportedly used fire to reduce fuel load; the increased visibility and access this provided helped them hunt and forage. It is thought that as much as 12% of the State was burned every year by various tribes (Coleman, 1994). European settlers, on the other hand, considered wildfires unacceptable, and in the early 20th century, as development started to encroach onto the foothills, the Fire Service began campaigns to prevent wildfires from occurring. Over time this has led to an increased volume of fuel per acre, that, combined with longer periods between fires, has resulted in an increase in fire risk as wildfires that impact areas with fuel buildup are more intense and significantly more damaging to the ecosystem than periodic, low-intensity fires. This makes it harder for firefighters to suppress fires, increases safety issues and reduces productivity for fire crews on perimeter lines, and increases taxpayer costs while increasing losses of life, property and resources.

Recognition of these problems has led to vegetation management programs such as those described above, and in some areas, **prescribed fires**. A prescribed fire is deliberately set under carefully controlled and monitored conditions. The purpose is to remove brush and other undergrowth that can fuel uncontrolled fires. Prescribed fire is used to alter, maintain or restore vegetative communities, achieve desired resource conditions, and to protect life and property that would be degraded by wildland fire.

Prescribed fire is only accomplished through managed ignition and should be supported by planning documents and appropriate environmental analyses.

Since 1981, prescribed fire has been the primary means of fuel management in Federal- and State-owned lands. Approximately 500,000 acres — an average of 30,000 acres a year — have been treated with prescribed fire under the vegetation management program throughout California alone. In the past, the typical vegetation management project targeted large wildland areas. Now, increasing development pressures (with increased populations) at the urban-wildland interface often preclude the use of large prescribed fires. Nevertheless, many still find the notion of "prescribed fire" difficult to accept given that it goes against nearly a century of common practice and beliefs. Prescribed fire does carry a risk, as relatively recent experiences in New Mexico, Arizona, and Orange County have shown. In 2000, in Los Alamos, New Mexico, the Cerro Grande fire began when a prescribed burn escaped, destroying several hundred homes and burning more than 50,000 acres. This fire triggered revisions in the guidelines for performing prescribed burns. In Orange County, the U.S. Forest Service lost control of a prescribed burn in the Santa Ana Mountains. The Sierra Fire burned for about 10 days in February 2006 causing road and highway closures and resident evacuations, but no damaged structures. In all, the Sierra Fire burned 10,584 acres of land and cost about $6.9 million. Furthermore, a recent program review by the CDF has identified needed changes, with focus on citizen and firefighter safety, and the creation of wildfire safety and protection zones.

- **Notification and Abatement**. Typically, city and county codes specify that property owners are required to mitigate the fire hazard in their properties by implementing vegetation management practices. *Riverside County Ordinance 695.4 addresses the issue of weeds and other vegetation as a potential fire hazard in properties void of structures*. Specifically, if dry weeds, grass, brush, plant material, dead trees, or other hazardous vegetation are present in an unimproved real property in Riverside County, the Fire Chief of the County or his designated representative has the authority to give the property owner of record a Notice of Violation and Order to Abate the hazard. If the owner does not abate the hazard during the time period specified in the notice, typically 30 days, the County may take further action to reduce the fire hazard. The costs of notification and abatement are charged to the property owner of record, and if not paid within 15 calendar days of its mailing, the County has the option of making the outstanding costs a Special Assessment against the property, or authorizing the recordation of a Nuisance Abatement Lien against the subject property. For additional information refer to Riverside County Ordinance 695.4 (http://rvcfire.org/opencms/quick_links/hazard_abatement.html). Furthermore, a citation may be issued for non-compliance. The City of Menifee may develop a City ordinance dealing with weed abatement and hazard reduction.

- **Building to Reduce the Fire Hazard**. Building construction standards for such items as roof coverings, fire doors, and fire resistant materials help protect structures from external fires and contain internal fires for longer periods. The portion of a structure most susceptible to ignition from a wildland fire is its roof, which is exposed to burning cinders (or brands) generally carried by winds far in advance of the actual fire. Roofs can also be ignited by direct contact with burning trees and large shrubs (Fisher, 1995). The danger of combustible wood roofs, such as wooden shingles and shakes, has been known to fire fighting professionals since 1923, when California's first major urban fire disaster occurred in Berkeley. It was not until 1988, however, that California was able to pass legislation calling for, at a minimum, Class C roofing in fire hazard areas (Class C roof coverings are effective against light fire exposures; under such exposures roof coverings of this class are not readily flammable, afford a measurable degree of fire protection to the roof deck, do not slip from position, and do not produce flying brands). Then, in the early 1990s, there were several other major fires, including the Paint fire of 1990 in Santa Barbara, the 1991 Tunnel fire in Oakland/Berkeley, and the 1993 Laguna Beach fire, whose severe losses were attributed in great measure to the large percentage of combustible roofs in the affected areas. In 1994-1996, new roofing materials standards were approved by California for Very High Fire Hazard Severity Zones.

To help consumers determine the fire resistance of the roofing materials they may be considering, roofing materials are rated as to their fire resistance into three categories that are based on the results of test fire conditions that these materials are subjected to under rigorous laboratory conditions, in accordance with test method ASTM-E-108 developed by the American Society of Testing Materials. The rating classification provides information regarding the capacity of the roofing material to resist a fire that develops outside the building on which the roofing material is installed (The Institute for Local Self Government, 1992). The ratings are as follows:

- **Class A**: Roof coverings that are effective against **severe** fire exposures. Under such exposures, roof coverings of this class are not readily flammable, afford a high degree of fire protection to the roof deck, do not slip from position; and do not produce flying brands.

- **Class B**: Roof coverings that are effective against moderate fire exposures. Under such exposures, roof coverings of this class are not readily flammable, afford a moderate degree of fire protection to the roof deck, do not slip from position, and do not produce flying brands.

- **Class C**: Roof coverings that are effective against light fire exposures. Under such exposures, roof coverings of this class: are not readily flammable, afford a measurable degree of fire protection to the roof deck, do not slip from position, and do not produce flying brands.

Roofing materials can also be:

- **Non-Combustible**: Roof made of non-combustible materials like metal. Although metal roofs don't burn, they are excellent heat conducts, and during an intense fire, heat can be conducted through the metal to the underlying, combustible materials.

- **Non-Rated**: Roof coverings have not been tested for protection against fire exposure. Under such exposures, non-rated roof coverings may be readily flammable; may offer little or no protection to the roof deck, allowing fire to penetrate into attic space and the entire building; and may pose a serious fire brand hazard, producing brands that could ignite other structures a considerable distance away.

For roof construction, the County of Riverside follows the requirements of the California Building Code. All buildings need to be constructed with fire-retardant roofing materials (minimum Class B), as described in Chapter 7A and Section 1505 of the California Building Code. The City of Menifee also has energy efficient roofing standards. For additional information contact the City's Building and Safety Department.

Attic ventilation openings are also a concern regarding the fire survivability of a structure. Attics require significant amounts of cross-ventilation to prevent the degradation of wood rafters and ceiling joists. This ventilation is typically provided by openings to the outside of the structure, but these opening can provide pathways for burning brands and flames to be deposited within the attic. To prevent this, it is important that all ventilation openings be properly screened. Additional prevention measures that can be taken to reduce the potential for ignition of attic spaces is to "use non-combustible exterior siding materials and to site trees and shrubs far enough away from the walls of the house to prevent flame travel into the attic even if a tree or shrub does torch" (Fisher, 1995).

The type of exterior wall construction used can also help a structure survive a fire. Ideally, exterior walls should be made of non-combustible materials such as stucco or masonry. During a wildfire, the dangerous active burning at a given location typically lasts about 5 to 10 minutes (Fisher, 1995), so if the exterior walls are made of non-combustible or fire-resistant materials, the structure has a better chance of surviving. For the same reason, the type of windows used in a structure can also help reduce the potential for fire to impact a structure. Single-pane, annealed glass windows are known for not performing well during fires; thermal radiation and direct contact with flames cause these windows to break because the glass under the window frame is protected and remains cooler than the glass in the center of the window. This differential thermal expansion of the glass causes the window to break. Larger windows are more susceptible to fracturing when exposed to high heat than smaller windows. Multiple-pane windows, and tempered glass windows perform much better than single-pane windows, although they do cost more. Fisher (1995) indicates that in Australia, researchers have noticed that the use of metal screens helps protect windows from thermal radiation.

The latest version of the California Building Code (2007) has specific construction requirements for new buildings located in any State Responsibility Areas, in Very High Fire Hazard Severity Zone in Local Responsibility Areas, and in any Wildland-Urban Interface Fire Area (Chapters 7A and 15 of Title 24, California Code of Regulations). The 2007 California Building Code also has specific fire-resistance-rated construction requirements for all types of construction, based on occupancy type and construction type. *The City of Menifee has adopted and enforces the use of the 2007 CBC for all new construction.* To help consumers, the Office of the State Fire Marshall (CalFire, Fire Engineering Division, 2010; see http://osfm.fire.ca.gov/strucfireengineer/pdf/bml/wuiproducts.pdf) has issued a list of construction products compliant with the CBC requirements that can be used in the Wildland-Urban Interface. The construction materials, or products, included in this handbook include exterior wall siding, exterior windows, under eave materials, decking, and ignition resistant materials.

- **Restricted Public Access.** In addition to the fire-susceptibility conditions described before, the wildfire susceptibility of an area changes throughout the year, and from year to year in response to local variations in precipitation, temperature, vegetation growth, and other conditions. To map these changes, the EROS Data Center (EDC) in Sioux Falls, South Dakota, has produced since the early 1990s weekly and biweekly maps for the 48 contiguous states and Alaska (available at http://edc.usgs.gov/). These maps, prepared under the Greenness Mapping Project, display plant growth and vigor, vegetation cover, and biomass production, using multi-spectral data from satellites of the National Oceanic and Atmospheric Administration (NOAA). The EDC also produces maps that relate vegetation conditions for the current two weeks to the average (normal) two-week conditions during the past seven years. EDC maps provide comprehensive growing season profiles for woodlands, rangelands, grasslands, and agricultural areas. With these maps, fire departments and land managers can assess the condition of all vegetation throughout the growing season, which improves planning for fire suppression, scheduling of prescribed burns, and study of long-term vegetation changes resulting from human or natural factors.

  Another valuable fire management tool developed jointly by the U.S. Geological Survey and the U.S. Forest Service is the Fire Potential Index (FPI). The FPI characterizes relative fire potential for woodlands, rangelands, and grasslands, both at the regional and local scale. The index combines multi-spectral satellite data from NOAA with geographic information system (GIS) technology to generate 1-km resolution fire potential maps. Input data include the total amount of burnable plant material (fuel load) derived from vegetation maps, the water content of the dead vegetation, and the fraction of the total fuel load that is live vegetation. The proportion of living plants is derived from the greenness maps described above. Water content of dead vegetation is calculated from temperature, relative humidity, cloud cover, and precipitation. The FPI is updated daily to reflect changing weather conditions.

  Local fire authorities can obtain data from either of the two sources above to better prepare for the fire season. When the fire danger is deemed to be of special concern, local authorities can rely on increased media coverage and public announcements to educate the local population about being fire safe. For example, to reduce the potential for wildfires during fire season, hazardous fire areas can be closed to public access during at least part of the year. Typically, the fire season in southern California begins in May and lasts until the first rains in November, but different counties or jurisdictions can opt to start the fire season earlier and end it later. With more site-specific data obtained from the FPI or Greenness Mapping Project, however, the fire hazard of an area can be assessed on a weekly or bi-weekly basis (for more information see http://edc.usgs.gov/greenness/index.html). These data can also be used to establish regional prevention priorities that can help reduce the risk of wildland fire ignition and spread, and help improve the allocation of suppression forces and resources, which can lead to faster control of fires in areas of high concern.

- **Fire Safety Education**. Individuals can make an enormous contribution to fire hazard reduction if provided with the information and tools to do so. In addition to the specific code requirements and guidelines mentioned in the sections above regarding defensible space and appropriate landscaping and construction materials, homeowners can implement several measures to reduce their fire risk. Some of these measures are listed below:

- Do not mow or use gas-powered landscaping tools during the hottest time of the day.
- Use care when refueling garden equipment and maintain it regularly.
- Dispose of cuttings and debris promptly, according to local regulations.
- Store firewood away from structures.
- If an irrigation system is used, keep it well maintained.
- Store and use flammable liquids properly.
- Dispose of smoking materials carefully.
- Do not light fireworks.
- Become familiar with local regulations regarding vegetation clearings, disposal of debris, and fire safety requirements for equipment.
- Follow manufacturers' instructions when using fertilizers and pesticides.
- When building, selecting or maintaining a home, consider the slope of the terrain. Be sure to build on the most level portion of the lot since fire spreads rapidly on slopes, even minor ones.
- Watch out for construction on ridges, cliffs, or drainage embankments. Keep a single-story structure at least 30 feet away from the edge of a cliff or ridge; increase this distance if the structure exceeds one story.
- Use construction materials that are fire-resistant or non-combustible whenever possible.
- Install an approved automatic fire sprinkler system. The California Building Code has fire sprinkler requirements for new buildings according to occupancy and construction type, but all types of structures can benefit from having a fire sprinkler system installed. This is particularly true of older construction.
- Driveways should provide easy access for fire engines. Driveways and access roads should be well maintained, clearly marked, and include ample turnaround space near houses.
- So that everyone has a way out, provide at least two ground level doors for safety exits and at least two means of escape (doors or windows) in each room.
- Keep gutters, eaves, and roofs clear of leaves and other debris.
- Occasionally inspect your home, looking for deterioration, such as breaks and spaces between roof tiles, warping wood, or cracks and crevices in the structure.
- If an all-wood fence is attached to your home, a masonry or metal protective barrier between the fence and house is recommended.
- Use non-flammable metal when constructing a trellis and cover it with high-moisture, non-flammable vegetation.
- Prevent combustible materials and debris from accumulating beneath patio decks or elevated porches. Screen, or box in, areas that lie below ground level with wire

mesh.

- Make sure an elevated wooden deck is not located at the top of a hill where it will be in the direct line of a fire moving up slope.
- Install automatic seismic shut-off valves for the main gas line to your house. Information for approved devices, as well as installation procedures, is available from the Southern California Gas Company.

4.2 Structure Fires

Menifee has a population of about 60,000, and there are about 36,000 buildings in the region. Residential development makes up nearly 95% of the building stock, and 70% of the residential buildings are detached, single-family homes. In the United States, deaths from fires and burns are the third leading cause of fatal injury, and four out of five fire deaths in 2008 occurred in homes (Karter, 2009, as reported by the Center for Disease Control and Prevention at http://www.cdc.gov/HomeandRecreationalSafety/Fire-Prevention/fires-factsheet.html). Smoking is the leading cause of fire-related deaths, and cooking is the primary cause of residential fires (Ahrens, 2009a, as reported by the Center for Disease Control and Prevention). Although the number of fatalities and injuries caused by residential fires has declined in the last decades, residential fire-related deaths and injuries still pose a significant public health issue. The good news is that residential fire-related deaths and injuries can be prevented.

When a fire develops in a newer, single-family residential structure consisting of fire-resistant construction materials and internal fire sprinklers, the fire can generally be contained to the room of origin, unless the building contents are highly flammable. In older residential areas where the building materials may not be fire-rated, and the structures are not fitted with fire sprinklers, there is a higher probability of a structural fire impacting adjacent rooms, and even adjacent structures, unless there is ample distance between structures, there are no strong winds, and the local fire department is able to respond in a timely manner. Fire losses, as a percentage of the total area of the building, are thus potentially higher in older buildings not built with fire-resistant materials (such as gypsum wallboard) that help slow down the spread of fire from the ignition source to other rooms in the structure. Older structures are also less likely to have the redundant exits and window-height requirements that allow occupants to more easily evacuate the building if needed.

In high-density residential areas, especially in older neighborhoods, fire can easily spread from one structure or unit to the next, and the narrow spaces between structures and property lines provide limited room for emergency access, hindering fire suppression and evacuation efforts. Emergency access and exits may also be compromised if obstructions, such as bay windows and roof awnings, project into the setback between structures, or if non-structural items, such as garbage cans or sheds are stored in those areas. Newer multiple-family units typically meet special fire protection requirements, including automatic fire sprinklers and smoke detectors, and fire-resistant construction materials, in conformance with the more recent California Building and Fire Codes. These improvements help retard the spread of fire between dwelling units.

Post-fire forensic data show that fire safety in structures is controlled to a great degree by the contents in the structure: upholstered furniture, bedding, curtains, mattresses and floor coverings (such as carpets and rugs) allow for quick fire spread and fire growth, and ignition of these materials is responsible for more deaths and injuries than the collapse of structures due to fire (Canadian Wood Council, 2000). Most injuries or deaths due to fire are in fact the result of smoke or toxic fumes inhalation, and not burns (Hall, 2001), so smoke detectors and/or fire alarm systems, combined with window and door openings that allow the occupants to evacuate safely, are very important in managing the impact of a structure fire. Approximately 40% of the home fire deaths occur in homes without smoke alarms (Ahrens, 2009b as reported by the Center for Disease Control and Prevention).

Data provided by the Riverside County Fire Department for the years 2006-2009 indicate that only about 2% to 3% of the incident calls received on a yearly basis by the Fire Department's Battalion 13 are for fires, with structure fires amounting to less than 1% of the incident responses. Response activity statistics for 2006-2009 are summarized further in Table 4-2 below.

Table 4-2: Response Activity Statistics for Riverside County Fire Department's Battalion No. 13, for the Years 2006 Through 2009

Response Activity	2006		2007		2008		2009	
	No. Events	%	No. Events	%	No. Events	%	No. Events	%
Commercial Fire	9	0.1	3	0.0	3	0.0	4	0.1
Residential Fire	55	0.8	50	0.7	40	0.5	18	0.3
Multi-Family Dwelling Fire			3	0.0	3	0.0		
Vehicle Fire	46	0.7	26	0.4	37	0.5	33	0.5
Wildland Fire	36	0.5	29	0.4	34	0.5	38	0.6
Other Fire	53	0.8	81	1.2	75	1.0	58	0.8
Hazardous Materials Incident	21	0.3	22	0.3	11	0.1	10	0.1
Traffic Collision	565	6.6	530	7.7	488	6.6	478	7.0
Rescue	1	0.0	2	0.0	2	0.0		
Public Service Assistance	454	6.6	434	6.3	526	7.1	490	7.2
Medical	5,227	75.6	5,272	76.4	5,803	78.3	5,287	77.3
Other Miscellaneous	34	0.5	18	0.3	18	0.2	8	0.1
Standby	108	1.6	109	1.6	79	1.1	77	1.1
False Alarm	302	4.4	322	4.7	294	4.0	335	4.9
Total	**6,911**	**100**	**6,901**	**100**	**7,413**	**100**	**6,836**	**100**

Although in relative terms, structure fires comprise only a small percentage of the calls that the Fire Department receives, Table 4-2 shows that several dozens of structure fires occur on a yearly basis in the region. The data available suggest that the number of fires is decreasing with time (64 fires were reported in 2006, whereas only 22 fires were reported in 2009), but a longer time interval of data would be required to confirm this trend. Consistent with statements made earlier, most of the structure fires are associated with residential occupancies, although between 3 and 9 commercial structure fires have been reported on a yearly basis also. Some of the commercial fires, and even some of the residential fires, could expose hazardous chemicals to heat, requiring the intervention of the fire department's hazardous materials response unit to safely contain any potential contamination. Issues associated with the storage, use and disposal of hazardous materials are discussed in more detail in Chapter 5, whereas a discussion of chemical fires is provided in Section 4.4 below. Finally, fires after earthquakes are a real concern in southern California, given the region's seismic potential. This is discussed further in Section 4.5.

4.2.1 Target Fire Hazards and Standards of Coverage

Fire departments quantify and classify structural fire risks to determine where a fire resulting in large losses of life or property is more likely to occur. The structures at risk are catalogued utilizing the following criteria:

- Their size, height, location and type of occupancy;
- The risk presented by the occupancy (probability of a fire and the consequence if one occurs);
- The unique hazards presented by the occupancy (such as the occupant load, the types of combustibles therein and any hazardous materials);
- Potential for loss of life;
- The presence of fire sprinklers and fire-resistant construction materials;
- Proximity to exposures;
- The estimated dollar value of the occupancy;
- The needed fire flow versus available fire flow; and
- The ability of the on-duty forces to control a fire therein.

These occupancies are called "Target Hazards." Target Hazards encompass all significant community structural fire risk inventories. Typically, fire departments identify the major target hazards and then perform intensive pre-fire planning, inspections and training to address the specific fire problems in that particular type of occupancy (for example, training to respond to fires in facilities that handle hazardous materials is significantly different than training to respond to a fire in a high-occupancy facility such as a mall or auditorium). As discussed above, the most common target hazard due to its life-loss potential, 24-hour occupancy, risk, and frequency of events, is the residential occupancy. However, the consequences of residential fires can range from high to low, depending on the age of the structure, location, size, and occupancy load, among other factors. Four classifications of risk are considered, as follows:

- **High Probability/High Consequences:** such as multi-family dwellings and residential buildings, facilities that house populations with mobility or evacuation concerns, hazardous materials occupancies, large shopping centers, and high-occupancy facilities like movie theaters, convention centers, and meeting halls.
- **Low Probability/High Consequences:** such as hospitals, schools, industrial occupancies, and large office complexes.
- **High Probability/Low Consequences:** such as older, detached single-family dwellings.
- **Low Probability/Low Consequences:** such as newer, detached single-family dwellings, and small office buildings.

Specific high-risk facilities identified by the Riverside County Fire Department as target hazards in the Menifee area are listed in Table 4-3 below.

Table 4-3: Target Hazards in the Menifee Area

Name	Type of Facility	Address
Verizon Wireless	Phone substation	29130 Bradley Road, Sun City
Sun City Gardens	Elderly care facility	28500 Bradley Road, Sun City
Cherry Hills Club	Elderly care facility	28333 Valley Boulevard, Sun City
Sun City Convalescent Center	Convalescent home	27600 Encanto Drive, Sun City
Menifee Valley Medical Center	Hospital	28400 McCall Boulevard, Sun City
Eastern Municipal Water District	Water treatment facility	29285 Valley Boulevard, Sun City
Ridgemoor Elementary School	School	25455 Ridgemoor Road, Menifee
Hans Christensen Middle School	School	27625 Sherman Road, Menifee
Boulder Ridge Elementary School	School	27327 Junipero Road
Heritage Lake Elementary School	School	27227 Heritage Lake Drive, Menifee
San Diego Gas & Electric (SDG&E) Power Station	Power substation	26125 Menifee Road, Menifee
Heritage High School	School	26001 Briggs Road, Romoland
Inland Empire Energy Center	Natural gas power generation station	26226 Antelope Road, Romoland
Quail Valley Elementary School	School	23757 Canyon Heights Drive, Quail Valley
Verizon Switching Station	Telecommunications	29655 Goetz Road, Sun City
Grace Evangelical Free Church	Church	29720 Goetz Road, Quail Valley
Quail Valley Bible Church	Church	28780 Quail Place, Quail Valley

Source: Riverside County Fire Department, 2010, written communication.

Some of the high probability/high consequence risks that fire departments worry the most are high-rise buildings due to the specialized fire-fighting equipment needed, the limited routes of access into and out of a building, and the potential for great loss of life. Fire departments typically define a high-rise as a building with floors for human occupancy located 75 feet or more above the lowest level of fire department access, as provided by their truck-mounted ladders. High-rise buildings are now required to have several redundant fire and life safety systems in place, including automatic fire sprinklers, fire alarms and smoke and carbon monoxide detectors.

The city of Menifee has a few multiple story and large commercial buildings that may require roof access by fire department personnel in the event of a fire. Fire Station No. 76 in the Menifee Lakes area has a 100-foot aerial ladder truck company staffed 24 hours a day, 7 days a week, with four firefighters. This truck company is dispatched to every fire in the city as part of the first alarm assignment.

4.2.2 Regulatory Context

Effective fire protection cannot be accomplished solely through the acquisition of equipment, personnel and training. The area's infrastructure also must be considered, including adequacy of nearby water supplies, transport routes and access for fire equipment, addresses, and street signs, as well as maintenance.

The Riverside County Fire Department and the City of Menifee have adopted the California Building Standards Code by reference. The codes presently in use include the 2007 California Fire Code and the 2007 California Building Code, both of which provide fire safety provisions. The California Fire Code outlines fire protection standards for the safety, health and welfare of the public, and contains standards for building design, water supply, and brush clearance. The Fire Code provisions also include sprinkler and fire hydrant requirements in new structures and remodels, road widths and configurations designed to accommodate the passage of fire trucks and engines, and requirements for minimum fire flow rates for water mains. The California Building Code prescribes performance characteristics and materials to be used to achieve acceptable levels of fire protection based on building use and occupancy. The construction requirements are a function of building size, purpose, type, materials, location, proximity to other structures, and the type of fire suppression systems installed. New 2010 California Fire and Building codes are expected to become effective in January 2011. The Riverside County Fire Department Chief is authorized and directed to enforce the provisions of the California Fire Code throughout the city of Menifee.

Some of the more significant Fire Code items that help reduce the hazard of structural fire include requirements regarding fire-extinguishing systems such as automatic fire sprinklers. Fire sprinklers can help contain a fire that starts inside a structure from spreading to other nearby structures, and also help prevent total destruction of a building. The most recent version of the California Fire Code requires fire sprinklers in all new residential structures beginning in 2011. Some jurisdictions are pushing that date forward.

Fire apparatus access to a burning structure is critical to the rapid containment of a fire. Given the size and weight configurations of fire engines, access roads need to comply with minimum width, maximum grade and surface requirements. Approved fire apparatus access roads need to be provided for every facility or building in the city. Fire apparatus roads need to extend to within 150 feet of all of the facility and all portions of the exterior walls of the first story of the building. In some areas, more than one road may be required if and when it is determined that access by a single road may be impaired by vehicle congestion, difficult terrain, weather conditions which could result in dangerous situations or other factors that could limit access. Furthermore, appropriate signage is important to identify the emergency access roads, and to identify the street number of a property, and the buildings therein. For specific information regarding these requirements as they pertain to the City of Menifee, consult the City's Building and Safety Department.

Fire Flow is the flow rate of water supply (measured in gallons per minute – gpm) available for fire fighting, measured at 20 pounds per square inch (psi; equal to 138 kPa) residual pressure. Available fire flow is the total water flow available at the fire hydrants, also measured in gallons per minute. All water mains and water hydrants are to be constructed in accordance with the appropriate sections of Riverside County Ordinance No. 460 and/or No. 787, subject to review and approval by the Riverside County Fire Department Planning and Engineering Division. The City of Menifee has adopted the 2007 California Fire Code that lists the minimum required fire-flow and flow duration for buildings of different floor areas and construction types (2007 California Fire Code, Appendix B – Fire Flow Requirements for Buildings). Fire flow requirements within commercial projects are based on square footage and type of construction of the structures. Minimum fire flow for any commercial structure is 1,500 gallons per minute (gpm) at a residual pressure of 20 psi, and can rise to 8,000 gpm, per Table A-III of the California Fire Code. For additional information regarding the required fire-flow for your building, contact the City's Building and Safety Department and the Riverside County Fire Department.

Emergency water storage is critical, especially when battling large structural fires or fires after earthquakes. During the 1993 Laguna Beach fire, water streams sprayed on burning houses sometimes fell to a trickle (Platte and Brazil, Los Angeles Times, 1993), primarily because of dwindling water pressure, inadequate pipeline connections and insufficient pumping capacity: most water reservoirs in Laguna Beach were located at lower elevations than the fire, and the water district could not supply water to the higher elevations as fast as the fire engines were using it. In contrast, many of the existing water tanks in the Menifee area are located at relatively higher surface elevations than most development in the city. This allows for a gravity-fed mechanism for water distribution that is not dependent on electric pumps to deliver water to the city residents and businesses.

Nevertheless, regional gravity-fed water distribution systems can still be compromised, especially as a result of an earthquake. While the majority of pipeline failures during earthquakes occur due to fault rupture and lateral spreading, about 40% of the failures are due to wave propagation effects, such as amplification in sedimentary basins (O'Rourke and Liu, 1999). Studies conducted by Eguchi (1991) [as referenced in O'Rourke and Liu (1999)] indicate that damage to X-grade welded steel pipes as a result of wave propagation is typically an order of magnitude less than that for ductile iron pipes, and nearly two orders of magnitude less than that for welded steel gas-welded joint, concrete or asbestos cement pipes. Thus, municipalities that have an older utilities system that includes some of these more vulnerable pipe types should consider upgrading their systems to prevent significant pipeline failures during an earthquake. In addition, a three- to seven-day emergency water storage supply is recommended for all communities.

4.3 Fire Suppression Services

Fire suppression services in the city of Menifee and the General Pan area are provided by the Riverside County Fire Department. The Fire Department provides all fire services including suppression, inspection, fire safety and emergency response. The Riverside County Fire Department also monitors the fire hazard in Menifee, and has ongoing programs for public education, and the investigation and mitigation of hazardous situations. Fire-fighting resources in Menifee and the immediate surrounding area include the five fire stations listed in Table 4-4 and shown on Plate 4-2. The general telephone number for the Riverside County Fire Department is **951-940-6900. For emergencies, dial 911.**

Table 4-4: Fire Stations In and Near Menifee

Station No.	Address	Equipment, Personnel
Station 76 – Menifee Lakes; Battalion Headquarters	29950 Menifee Road	1 Medic Engine; 1 Truck Company; Volunteer Squad; Water Tender; Swift Water Rescue Team; Urban Search and Rescue.
Station 5 – Quail Valley	28971 Goetz Road	1 Medic Engine; Volunteer Squad.
Station 7 – Sun City	27860 Bradley Road	1 Medic Engine; 1 Reserve Apparatus; Volunteer Squad.
Station 60 – Canyon Lake	28730 Vacation Drive	1 Medic Engine; 1 Reserve Apparatus; Volunteer Squad.
Station 68 – Menifee	26020 Wickerd Road	1 Medic Engine; Volunteer Squad.

The Riverside County Fire Department (RCFD) has been in business for over 50 years (the first county-owned fire stations and engines were provided in 1946), and includes city, county, state, and volunteer fire stations in its regional, integrated fire protection organization. The RCFD serves 16 of the 24 cities in the County of Riverside, in addition to one Community Services District. Funding for the RCFD is obtained from various sources, including the County's general fund, city general and benefit assessment funds, redevelopment money and other sources. RCFD's combined State, County, and contract cities budget is over $80 million. Volunteer firefighters, trained and available for emergencies, are paid for actual fire fighting services.

At the end of 2007, the RCFD converted each engine company to a Paramedic Assessment Engine. The staffing levels for the city of Menifee consist of a minimum 3-person crew, including paramedics operating a "Type-1" structural fire fighting apparatus. The Paramedic Engine Company is staffed full time, 24 hours / 7 days a week. All responding fire personnel are qualified as Emergency Medical Technicians (EMTs).

In addition, following the tragic Esperanza Fire that started on October 26, 2006 near Cabazon, the Riverside County Board of Supervisors created a Fire Hazard Reduction Task Force. This Task Force is tasked with reviewing and providing recommendations to reduce the fire hazards and clarify evacuation measures throughout the County. Recommendations made by the Task Force include adoption of the revised State Fire Codes, adoption of the Very High Fire Hazard Severity Zones (VHFHSZ) mapping into the County General Plan, and revision of Ordinance 787.

Figure 4-6: View of Fire Station No. 68 on Wickerd Road

4.3.1 Response Objectives and Statistics

The National Fire Protection Association (NFPA Standard 1710, 2010) recommends the following objectives for fire departments:

- An alarm answering time of not more than 15 seconds for at least 95% of the alarms received, and not more than 40 seconds for at least 99% of the alarms received;
- When the alarm is received at a public safety answering point (PSAP) and transferred to a secondary answering point (or communication center), the agency responsible for the PSAP should have an alarm transfer time of not more than 30 seconds for at least 95% of all alarms processed;
- The responding fire department should have an alarm processing time (the time interval from when the alarm is acknowledged at the communication center until response information begins to be transmitted via voice or electronic means to emergency response facilities and emergency response units) of not more than 60 seconds for at least 90% of the alarms, and not more than 90 seconds for at least 99% of the alarms;
- Turnout time for fire and special operations of 80 seconds, and turnout time for EMS response of 60 seconds;
- Travel time of 240 seconds or less for the arrival of the first arriving engine company at a fire suppression incident and 480 seconds or less travel time for the deployment of an initial full alarm assignment at a fire suppression incident;
- Travel time of 240 seconds or less for the arrival of a unit with first responder with automatic external defibrillator (AED) or higher level capability at an emergency medical incident;
- Travel time of 480 seconds or less for the arrival of an advanced life support unit at an emergency medical incident, where this service is provided by the fire department, provided that a first responder with AED or basic life support unit arrived in 240 seconds or less travel time.

These time recommendations for fire suppression incidents are based on the demands created by a structure fire: It is critical to attempt to arrive and intervene at a fire scene prior to the fire spreading beyond the room of origin, and this typically occurs within 8 to 10 minutes after ignition. In reality however, response times are going to vary depending on the distance between the responding fire stations and the incident location, the setting (urban, rural or outlying), traffic density and patterns, and conditions specific to the area that may hamper fire response times.

The NFPA Standard 1710 (2004) also states that in 90% of the time, fire departments should take 8 minutes or less for the deployment of a full first alarm assignment at a fire suppression incident, and 8 minutes or less for the arrival of an advanced life support unit at an emergency medical incident if this service is provided by the fire department. The 90% figure is stated as a goal to be achieved. Regular management audits by the Fire Chief are to be conducted to reveal if the goal is being met. In many communities, however, it is difficult to exceed the 90% figure in a cost-effective manner because of various factors that limit or hamper the Fire Department's response efforts.

In Menifee, rapid growth and development has created traffic challenges that can have an impact on emergency response by the Riverside County Fire Department, including extended response times and service delays. Some of these conditions are associated with recent land divisions and planning decisions that have resulted in roundabouts, narrow roadways, and single points of access. Railroad crossings are also a limiting factor. Finally, a significant issue in Menifee is traffic congestion –heavy traffic occurs along most major arterial road networks, the Interstate 215, the freeway on/off ramps, freeway ramp intersections, Mt. San Jacinto College, and near commercial/retail centers. Traffic is especially heavy on weekdays from 5:30 AM to 9:00 AM, and again from 3:30 PM to 6:30 PM.

Another potential issue that can impact emergency response is multiple emergency alarms. These do occur occasionally, and when this happens, and simultaneous or numerous calls are received, the Fire Department dispatches the next closest available resource to the new incident. If necessary, the Fire Department relies on its Automatic and Mutual Aid Agreements with neighboring communities, as discussed further in Section 4.3.2.

In addition to the response time, there is another component called "set up" time. This is the time it takes firefighters to get to the source of a fire and get ready to fight the fire. This may range from 2 minutes at a small house fire to 15 minutes or more at a large or multi-story occupancy, such as a large apartment complex. Structure fire response requires numerous critical tasks to be performed simultaneously, and the number of firefighters required to perform the tasks varies based upon the risk.

Obviously, the number of firefighters needed at a maximum high-risk occupancy, such as a shopping mall or large industrial occupancy would be significantly higher than for a fire in a lower-risk occupancy. Given the large number of firefighters that are required to respond to a high-risk, high-consequence fire, Fire Departments routinely rely on automatic and mutual aid agreements to address the fires suppression needs of their community. If additional resources are needed due to the intensity or size of the fire, a second alarm may be requested. The second alarm results in the response of at least another two engine companies, and a ladder truck. Beyond this response, additional fire units are requested via the automatic or mutual aid agreements. These agreements are discussed further in Section 4.3.2 below.

The Riverside County Fire Department has established specific objectives (or goals) for Land Use/Fire Suppression in their area of coverage that specify the Department's response times, fire ground operations and fire station locations. These objectives are summarized in Table 4-5.

Table 4-5: Riverside County Fire Department Land Use / Fire Suppression Objectives

Objectives	Heavy Urban	Urban	Rural	Outlying
Extinguishing agent applied to fires within listed minutes from dispatch	5 Response +3 Setup 8 Minutes	7 Response +3 Setup 10 Minutes	11 Response +3 Setup 14 Minutes	17 Response +3 Setup 20 Minutes
Full assignment in operation within listed minutes from dispatch	6 Response +4 Setup 10 Minutes	11 Response +4 Setup 15 Minutes	16 Response +4 Setup 20 Minutes	26 Response +4 Setup 30 Minutes
Suppression initiated within listed minutes of dispatch for 90% of all fires	Prior to flashover	8 Minutes	10 Minutes	15 Minutes
Fire station located within listed miles	1-1/2 miles	3 miles	5 miles	8 miles

Actual response times by the Riverside County Fire Department, Battalion 13 for the years 2006 through 2009 are presented in Table 4-6.

Table 4-6: Response Time Statistics for the Years 2006 Through 2009

Year	Minimum (minutes)	Maximum (minutes)	Average (minutes)	Incidents Responded to in Less than 5 Minutes
2006	1.0	209.0	4.0	78.0%
2007	1.0	47.0	4.1	76.8%
2008	1.0	46.0	4.3	76.2%
2009	1.0	63.0	4.2	75.9%

The Insurance Services Office (ISO) provides rating and statistical information for the insurance industry in the United States. To do so, ISO evaluates a community's fire protection needs and services, and assigns each community evaluated a Public Protection Classification (PPC) rating. The rating is developed as a cumulative point system, based on the community's fire-suppression delivery system, including fire dispatch (operators, alarm dispatch circuits, telephone lines available), fire department (equipment available, personnel, training, distribution of companies, etc.), and water supply (adequacy, condition, number and installation of fire hydrants). Insurance rates are based upon this rating. The worst rating is a Class 10. The best is a Class 1.

Menifee currently has a Class 4 ISO rating in the developed portions of the city, and a rating of 9 in its outlying areas. As urban sprawl continues to increase in the Menifee Valley, this land development will have a cumulative adverse impact on the Fire Department's ability to provide an acceptable level of service. The increase in population and development is also anticipated to result in an increased number of emergency and public service calls. The Menifee Valley Area Master Plan 2020 has identified one proposed fire station in the northwestern corner of the City of Menifee that may be needed to meet the anticipated service demands. Another proposed station has been identified in the southeastern portion of the Menifee General Plan area, off Scott Road, and west of Winchester Road.

4.3.2 Automatic and Mutual Aid Agreements

Although the Riverside County Fire Department is tasked with the responsibility of fire prevention and fire suppression in Menifee, in reality, fire-fighting agencies team up and work together during emergencies. These teaming arrangements are handled through automatic and mutual aid agreements, which obligate fire departments to help each other under pre-defined circumstances. **Automatic aid** agreements obligate the nearest fire company to respond to a fire regardless of the jurisdiction. **Mutual aid** agreements obligate fire department resources to respond outside of their district upon request for assistance.

The California Disaster and Civil Defense Master Mutual Aid Agreement (California Government Code Section 8555-8561) states: "Each party that is signatory to the agreement shall prepare operational plans to use within their jurisdiction, and outside their area." These plans include fire and non-fire emergencies related to natural, technological, and war contingencies. The State of California, all State agencies, all political subdivisions, and all fire districts signed this agreement in 1950.

Section 8568 of the California Emergency Services Act, (California Government Code, Chapter 7 of Division 1 of Part 2) states that "the State Emergency Plan shall be in effect in each political subdivision of the State, and the governing body of each political subdivision shall take such action as may be necessary to carry out the provisions thereof." The Act provides the basic authorities for conducting emergency operations following the proclamations of emergencies by the Governor or appropriate local authority, such as a City Manager. The provisions of the act are further reflected and expanded on by appropriate local emergency ordinances. The act further describes the function and operations of government at all levels during extraordinary emergencies, including war (www.scesa.org/cal_govcode.htm). Therefore, local emergency plans are considered extensions of the California Emergency Plan.

The Riverside County Fire Department has an Automatic Aid Agreement with the Fire Departments of the cities of Murrieta and Perris to provide response as needed in areas within the City of Menifee. There is also a Master Mutual Aid Agreement with surrounding fire departments, and the Riverside County Fire Department is the Operational Area Coordinator for the California Fire and Rescue Mutual Aid System for all fire service jurisdictions in the County.

Riverside County was one of the first counties in the State to endorse and support cooperative and integrated fire protection in support of greatest efficiency and economy. As early as 1906, the County authorized funds to augment the State's fire protection efforts. Since 1921 the County has appointed the California Department of Forestry Unit Chief as the County Fire Chief. It also has appropriated County funds to augment and improve the level of protection in 3,570,000 acres of local responsibility area, and to protect lives and structural property in the unincorporated areas of the County. The County also enhances the existing California Department of Forestry system that protects 1,070,000 acres of state responsibility area for year-round protection.

The County of Riverside contracts with the State of California for fire protection. Public Resources Cod 4142 affords legal authority for the California Department of Forestry and Fire Protection (CDF or CAL FIRE) to enter into agreements with local government entities to provide fire protection services with the approval of the Department of General Services.

By virtue of this authority, CAL FIRE administers the Riverside County Fire Department. CAL FIRE is primarily a wildland fire protection agency with the legal responsibility for protection of approximately 33 million acres of private and state lands in California. The Riverside Unit of CAL FIRE, with headquarters in Perris, provides direct protection for 1,070,000 acres of vegetation-covered wildlands designated by the State Board of Forestry as state responsibility areas (SRAs).

Numerous other agencies are available to assist the Riverside County Fire Department if needed. These include the Riverside County Police Department – Perris Station, and the California Highway Patrol, who, depending on the location of the incident, would provide support during evacuations and to discourage people from traveling to the incident area to observe Fire Department operations, as this can hinder fire suppression and emergency response efforts. Several State and Federal agencies have roles in fire hazard mitigation, response and recovery, depending on the type of incident and its location.

Other agencies that could provide assistance to the Riverside County Fire Department in the event of a significant fire include the Office of Emergency Services, Office of Aviation Services, National Weather Service, the Department of the Interior, and, in extreme cases, the Department of Defense. In forest and open areas, agencies that often assist with fire suppression include the National Park Service, US Forest Service, National Association of State Foresters, Fish and Wildlife Service, and the Department of Agriculture. Private companies and individuals may also be asked to provide assistance in some cases.

4.3.3 Standardized Emergency Management System (SEMS) and National Incident Management System (NIMS)

The SEMS law refers to the Standardized Emergency Management System described by the Petris Bill (Senate Bill 1841; California Government Code Section 8607, made effective January 1, 1993) that was introduced by Senator Petris following the 1991 Oakland fires. The intent of the SEMS law is to improve the coordination of State and local emergency response in California. It requires all jurisdictions within the State of California to participate in the establishment of a standardized statewide emergency management system.

When a major incident occurs, the first few moments are absolutely critical in terms of reducing loss of life and property. First responders must be sufficiently trained to understand the nature and the gravity of the event to minimize the confusion that inevitably follows catastrophic situations. The first responder must then put into motion relevant mitigation plans to further reduce the potential for loss of lives and property damage, and to communicate with the public. According to the State's Standardized Emergency Management System, local agencies have primary authority regarding rescue and treatment of casualties, and making decisions regarding protective actions for the community. This on-scene authority rests with the local emergency services organization and the incident commander.

Depending on the type of incident, several different agencies and disciplines may be called in to assist with emergency response. Agencies and disciplines that can be expected to be part of an emergency response team include medical, health, fire and rescue, police, public works, and coroner. The challenge is to accomplish the work at hand in the most effective manner, maintaining open lines of communication between the different responding agencies to share and disseminate information, and to coordinate efforts.

Emergency response in every jurisdiction in the State of California is handled in accordance with SEMS, with individual City agencies and personnel taking on their responsibilities as defined by the City's Emergency Plan. This document describes the different levels of emergencies, the local emergency management organization, and the specific responsibilities of each participating agency, government office, and City staff.

The framework of the SEMS system is the following:

- Incident Command System – a standard response system for all hazards that is based on a concept originally developed in the 1970s for response to wildland fires;
- Multi-Agency Coordination System – coordinated effort between various agencies and disciplines, allowing for effective decision-making, sharing of resources, and prioritizing of incidents;
- Master Mutual Aid Agreement and related systems – agreement between cities, counties and the State to provide services, personnel and facilities when local resources are inadequate to handle and emergency;
- Operational Area Concept – coordination of resources and information at the county level, including political subdivisions within the county; and
- Operational Area Satellite Information System – a satellite-based communications system with a high-frequency radio backup that permits the transfer of information between agencies using the system.

The SEMS law requires the following:

- Jurisdictions must attend training sessions for the emergency management system;
- All agencies must use the system to be eligible for funding for response costs under disaster assistance programs; and
- All agencies must complete after-action reports within 120 days of each declared disaster.

The September 11, 2001 terrorist attacks, and later, the 2004 and 2005 hurricane seasons demonstrated the need for improve the country's emergency management, incident response capabilities and coordination processes. On February 28, 2003, the President issued Homeland Security Presidential Directive 5 (HSPD-5), and in response, on March 1, 2004, the Department of Homeland Security unveiled the basic framework guiding the development and administration of the **National Incident Management System** (**NIMS**). NIMS provides a nationwide template that is meant to enable Federal, State, tribal, and local governments, in addition to non-governmental organizations and the private sector, to work together to "prevent, protect against, respond to, recover from, and mitigate the effects of incidents, regardless of cause, size, location, or complexity." NIMS is a core set of doctrines, concepts, principles, terminology and organizational processes that enable effective, efficient and collaborative incident management. NIMS works hand in hand with the National Response Framework (NRF), which provides the structure and mechanisms for national-level policy for incident management.

NIMS is the following:

- A comprehensive, nationwide systematic approach to incident management, including the Incident Command System, Multiagency Coordination Systems, and Public Information;
- A set of preparedness concepts and principles for all hazards;
- Essential principles for a common operating picture and interoperability of communications and information management;
- Standardized resource management procedures that enable coordination among different jurisdictions and organizations;
- Scalable, so that it may be used for all incidents (from day-to-day to large-scale); and
- A dynamic system that promotes ongoing management and maintenance.

NIMS components include:

- Preparedness;
- Communications and Information Management;
- Resource Management;
- Command and Management; and
- Ongoing Management and Maintenance.

HSPD-5 requires all Federal departments and agencies to adopt NIMS and use it in all their individual incident management and activities. *Furthermore, the directive requires Federal departments and agencies to make adoption of NIMS by State, tribal and local (i.e., cities) organizations a condition for receiving Federal preparedness assistance.* Given that the basic framework for NIMS was put together in short order, it was understood that it would be a work in progress. In the years since 2004, the NIMS process has been reviewed continuously to incorporate best practices and lessons learned from recent incidents. In 2005, all state, local and rribal jurisdictions were to adopt NIMS for all Departments/Agencies, and were to revise and update their emergency operations plans, standard operating procedures, and standard operating guidelines to incorporate NIMS and National Response Framework components, principles and policies. In 2008, local jurisdictions were to use existing resources, such as programs, personnel and training facilities to coordinate and deliver NIMS training requirements. These training requirements are based on a group of training courses at different levels have been developed and that all appropriate emergency response personnel at all levels of government are required to take to satisfy the NIMS objectives. The most recently published NIMS compliance metrics for Fiscal Year 2009 are available from http://www.oes.ca.gov/WebPage/oeswebsite.nsf/Content/E869AEBEE9DE3EF888257560007FDEA2?OpenDocument.

The Riverside County Fire Department adopted NIMS in 2007 by a Board of Supervisors Action.

Consistent with both SIMS and NIMS requirements, all employees of the Riverside County Fire Department are required to train daily. Each employee trains either individually and/or in groups, and participates in a formalized program of instruction (with a lesson plan, instructor, or instructional device) to acquire the skills and knowledge necessary to improve the employee's performance in his or her current position. In addition, the RCFD maintains an in-service training program that consists of monthly company drills, quarterly re-certification training, monthly emergency medical service skills labs, on-duty EMS skills proficiency verification, structured multi-company drills, on-line training delivery, spot drills, interagency drills, twelve hours of station-level training per month, quarterly truck/rescue drills, annual wildland preparedness drills, and company manipulative drills at both the Ben Clark (3423 Davis Avenue, Riverside) and Desert (31920 Robert Road, Thousand Palms) Training Centers.

4.4 Chemical Fires

Chemical substances are often unstable under high temperatures. Other chemicals are reactive to water or oxygen, and can self-ignite if exposed to water or air. For example, sulfuric acid, one of the most abundant and widely distributed chemicals produced in the U.S., is highly reactive when exposed in its concentrated form to water. Other substances if mixed together can also generate a fire. Therefore, when dealing with chemical fires it is important to know what type of chemicals are present in the area and where they are being stored or used. It is also important to note that when dealing with chemical fires, time is critical: the longer chemicals are exposed to extreme heat, the more likely that they will react violently, increasing the severity of the fire. Fire fighters can better respond to a situation with the appropriate equipment if they have the information needed to make these decisions immediately available to them. This is what the business plans and the Material Safety Data Sheets (MSDS) discussed in Chapter 5 – Hazardous Materials Management – are intended to provide.

Firefighters recognize four main different types of fires:

- **Class A** fires involve ordinary materials like paper, lumber, cardboard, and some types of plastics.
- **Class B** fires involve flammable or combustible liquids such as gasoline, kerosene, and common organic solvents.
- **Class C** fires involve energized electrical equipment, such as appliances, switches, panel boxes, power tools, and hot plates. Water is a particularly dangerous extinguishing medium for class C fires because of the risk of electrical shock.
- **Class D** fires involve combustible metals, such as magnesium, titanium, potassium and sodium, as well as pyrophoric organometallic reagents such as alkyllithiums, Grignards and diethylzinc. These materials burn at high temperatures and will react violently with water, air, and/or other chemicals.

It is not uncommon for fires to be a combination of the types discussed above. Therefore, it is typically recommended that fire extinguishers obtained for household and office use have an ABC rating, which means that they have the capacity to fight Class A, B and C fires.

Common types of extinguishers include:

- **Water extinguishers**, which are suitable for class A (paper, etc.) fires, but not for class B, C and D fires, because the water can make the flames spread.

- **Dry chemical extinguishers**, which are useful for class ABC fires and are the best all-around choice. They have an advantage over CO_2 extinguishers because they leave a blanket of non-flammable material on the extinguished material that reduces the likelihood of re-ignition. There are two kinds of dry chemical extinguishers:
  - Type BC fire extinguishers contain sodium or potassium bicarbonate, and
  - Type ABC fire extinguishers that contain ammonium phosphate.

- **CO_2 (carbon dioxide) extinguishers** are for class B and C fires. They do not work very well on class A fires because the material usually re-ignites. CO_2 extinguishers have an advantage over dry chemical extinguishers in that they leave behind no harmful residue – a good choice for an electrical fire on a computer or other delicate instrument. Note that CO_2 is a bad choice for flammable metal fires such as Grignard reagents, alkyllithiums and sodium metal because CO_2 reacts with these materials. CO_2 extinguishers are not approved for class D fires.

- **Metal/Sand Extinguishers** are for flammable metals (class D fires) and work by simply smothering the fire.

Not only is it imperative to control chemical fires as soon as possible, but two main "by-products" of these types of fires require special attention, including special handling and evacuation procedures. These by-products include the "smoke plume" and water run-off from the fire-extinguishing process. The smoke plume has the potential to pose a severe hazard to those exposed to it: chemicals in the vapor phase can be mildly to extremely toxic if inhaled, depending on the chemicals involved. Smoke inhalation is a hazard in itself, but when chemicals are part of the smoke, it can have severe negative impacts on the health of those nearby, including fire-fighting personnel and individuals not evacuated in time to prevent them from inhaling the smoke. Soot from some types of fires can also cause chemical burns on skin. Therefore, depending on the types of chemicals involved in the fire, an evacuation of the immediate area and especially of those areas down-wind should be conducted.

If water is used to fight a fire, the runoff could include chemicals or substances that pose a hazard to the environment. Therefore, the runoff should be contained to prevent it from flowing into storm drains or leach fields. Containing the water runoff from a fire is difficult but possible, especially if the special equipment to do so is available.

4.5 Fires Following Earthquakes

Although wildland fires can be devastating, history shows that earthquake-induced fires have the potential to be the worst-case fire-suppression scenarios for a community because an earthquake typically causes multiple ignitions distributed over a broad geographic area, with the potential to severely tax the local fire suppression agencies. Furthermore, if fire fighters are involved with search and rescue operations, they are less available to fight fires. Fire suppression efforts can also be limited by a water distribution system that has been impaired by the earthquake. Thus, many factors affect the severity of fires following an earthquake, including ignition sources, types and density of fuel, weather conditions, functionality of the water systems, and the ability of firefighters to suppress the fires. The principal causes of earthquake-related fires are open flames, electrical malfunctions, gas leaks, and chemical spills. Downed power lines may ignite fires if the lines do not automatically de-energize. Unanchored gas heaters and water heaters are common problems, as these readily tip over during strong ground shaking (State law now requires new and replaced gas-fired water heaters to be attached to a wall or other support).

The major urban conflagrations of yesteryear in major cities were often the result of closely built, congested areas of attached buildings with no fire sprinklers, no adequate fire separations, no Fire Code enforcement, and narrow streets. In the past, fire apparatus and water supplies were also inadequate in many large cities, and many fire departments were comprised of volunteers. Many of these conditions no longer apply to the cities of today. Nevertheless, major earthquakes can result in fires and the loss of water supply, as it occurred in San Francisco in 1906, and more recently in Kobe, Japan in 1995. A large portion of the structural damage caused by the great San Francisco earthquake of 1906 was the result of fires rather than ground shaking. The moderately sized, M6.7 Northridge earthquake of 1994 caused 15,021 natural gas leaks that resulted in three street fires, 51 structure fires (23 of these caused total ruin) and the destruction, by fire, of 172 mobile homes. In one incident, the earthquake severed a 22-inch gas transmission line and a motorist ignited the gas while attempting to restart his stalled vehicle. Response to this fire was impeded by the earthquake's rupture of a water main; as a result, five nearby homes were destroyed. Elsewhere, one mobile home fire started when a ruptured transmission line was ignited by a downed power line. In many of the destroyed mobile homes, fires erupted when inadequate bracing allowed the houses to slip off their foundations, severing gas lines and igniting fires.

As the examples above indicate, fires following earthquakes can cause severe losses. In some instances, these losses can outweigh the losses from direct damage, such as the collapse of buildings and disruption of lifelines. This potential hazard is particularly applicable to the southern California area given its high seismic potential. The two faults that could cause significant ground shaking in Menifee are the San Jacinto, and Elsinore faults. A strong earthquake on either of these faults could trigger multiple fires and disrupt lifelines services (such as the water supply) in Menifee. Specifics about the estimated losses to lifelines and other services in Menifee in the event of an earthquake are discussed further in Chapter 1.

The potential impact of fire following an earthquake in Menifee was evaluated using the loss-estimation software HazUS (refer to Section 1.9 for additional information regarding HazUS and the earthquake scenario results conducted for the City). This program uses a Monte Carlo simulation model to estimate the number of ignitions and the potential burn area resulting from a fire-after-earthquake scenario. Although a complete fire-following-earthquake model requires extensive input about the readiness of the local fire department and the types and availability (functionality) of the local water system, a simplified approach can be used to obtain a rough estimate of the potential losses associated with this hazard. The forecasting ability of the software is expected to improve as data garnered after future earthquakes provides a better understanding of the fire damage associated with different levels of ground shaking, differences in building construction type, and other factors.

Two earthquake scenarios were considered for Menifee. HazUS estimates that a magnitude 7.8 earthquake on the San Andreas fault would result in 3 ignitions in the Menifee General Plan area. Similarly, an earthquake on the San Jacinto fault is estimated to result in 4 ignitions in the area, displacing 181 people, and burning approximately $16 million in building value. If severe wind conditions are present at the time of either of these earthquakes, the area, building count, and population impacted by these fires can be expected to be significantly larger.

Table 4-7: Loss Estimates for Two Fire-Following-Earthquake Scenarios for Menifee

Earthquake Scenario	Number of Ignitions	Burn Area (in Acres)	# People Displaced	Value Exposed (in millions of $)
San Andreas M7.8 (Shakeout Scenario)	3	96	158	13
San Jacinto M6.9	4	109	181	16

Given the number of leaks (254) and breaks (63) that HazUS estimates will occur in the natural gas system in Menifee, the estimated number of fires after the San Jacinto fault earthquake may be underestimated. This is especially true if the natural gas system in the city includes several older pipe sections that have not been seismically retrofitted. In support of this argument consider the following example from the Los Angeles area: In 1988 the California Division of Mines and Geology (now the California Geological Survey; Toppozada and others, 1988) published a study that identified projected damages in the Los Angeles area as a result of an earthquake on the Newport-Inglewood fault. The Newport-Inglewood earthquake scenario estimated that thousands of gas leaks would result from damage to pipelines, valves and service connections. This study prompted the Southern California Gas Company to start replacing their distribution pipelines with flexible plastic polyethylene pipe, and to develop ways to isolate and shut off sections of supply lines when breaks are severe. Nevertheless, as a result of the 1994 Northridge earthquake, which occurred on a buried thrust fault that did not cause surface fault rupture, the Southern California Gas Company reported 35 breaks in its natural gas transmission lines and 717 breaks in its distribution lines. About 74% of the leaks were corrosion related. There were 51 structure fires, and approximately 172 mobile homes were destroyed by fire. The structure fires were caused by overturned water heaters (20), other overturned or damaged gas appliances (8), broken interior gas lines (8), broken gas meter set assemblies (2), street fires due to breaks in gas mains (7), and other unknown causes (8). The mobile home fires were primarily the result of failure of the supports leading to breakage of the gas risers, and breakage of the interior gas lines due to overturned water heaters and other appliances (Savage, 1995).

The Riverside County Fire Department has policies specific to earthquake planning. Specifically, in the event of an earthquake, the Fire Captain first ensures that the personnel are accounted for and are safe, then fire department personnel conduct a facility damage assessment inspection, move the fire apparatus outside the station, and start a local area damage reconnaissance. The assessment considers a review and identification of target hazards, potential rescue hazards, road closures, utility failures, hazardous materials releases, and other life-safety concerns. A number of fire engines in the County have the availability to draft water from alternate sources (such as swimming pools and ponds) to use for fire suppression.

4.6 Summary and Recommended Programs

The Riverside County Department manages the fire hazard in the city of Menifee by providing fire prevention, suppression and public education programs. The City and the County have also invested and continue to invest on infrastructure and equipment that help the Fire Department be as responsive as possible. However, the coverage area is large, and land development and traffic congestion at times hinder the Fire Department's response time to emergency calls. Menifee's ISO ratings of 4 for the city and 9 for the outlying areas reflect the Insurance Services Office's assessment that fire suppression capabilities in the outlying areas are still in need of improvement.

Several historical wildland fires have impacted the Menifee area and surrounding communities (Plate 4-1). Cal FIRE has delineated several different areas in the City and in the General Plan study area Federal, State or Local Responsibility Areas. The boundaries of these regions are shown on Plate 4-2. Residents of and near these high and very high fire hazard areas should be encouraged to practice fire-safe procedure, including maintaining a fire-safe landscape, and keeping combustibles (such as fire wood) a safe distance away from all structures. Similarly, the County and City should continue to enforce the weed abatement and notification program, to reduce the potential for vegetation fires to occur in vacant or poorly maintained lots.

Structure fires in the city of Menifee represent a very small percentage of the annual emergency calls that the Fire Department receives and responds to. However, structure fires can represent a large percent of the total annual fire losses. Therefore, programs that can be continued or implemented to reduce these losses should be encouraged.

Specifically the City and County:

- Should continue to regularly reevaluate specific fire hazard areas and adopt reasonable safety standards, covering such elements as adequacy of nearby water supplies, routes or throughways for fire equipment, clarity of addresses and street signs, and maintenance.
- Should encourage owners of non-sprinklered properties, especially high-occupancy structures, to retrofit their buildings and include internal fire sprinklers. The City may consider some form of financial assistance (such as low-interest or no-interest loans) to encourage property owners to do this as soon as possible.
- Should continue to conduct emergency response exercises, including mock earthquake-induced fire-scenario exercises to prepare for the multiple ignitions that an earthquake is expected to generate. Civilians should be encouraged to participate in these exercises as much as possible also, to empower neighborhoods to be self-reliant in the face of a natural or man-made disaster. These training sessions should use the adopted emergency management systems (SEMS and NIMS).
- Should continue to conduct regular assessments of the Fire Department's response objectives, to identify those areas that, because of increasing population, will require an increase in fire department presence. Specifically, as the city's population increases, additional fire stations may be required, their locations to be selected based on population demands. Funding for the construction of these new fire stations could be supported in part by the developers of the proposed large-scale master-planned communities.

Note: A significant portion of the data included in this Chapter specific to the Riverside County Fire Department and the City of Menifee was graciously compiled and provided to us by Captain Jason Neuman with the Strategic Planning Division of the Riverside County Fire Department. His assistance is immensely appreciated.

CHAPTER 5: HAZARDOUS MATERIALS MANAGEMENT

5.1 Setting and Definitions

A high standard of living has driven our increasing dependence on chemicals. Chemicals like hydrocarbon fuels, chlorine, pesticides and herbicides are used on a daily basis and in large quantities. Because of the high demand for these types of chemicals, their storage and transportation is necessary. Within the last decades, however, scientist have discovered that exposure to many of these chemical is hazardous to human health and to the environment. In response to these concerns, which began in the late 1960s, Federal, State, and local regulations have been implemented to dictate the use, storage, transportation, and handling of hazardous materials and wastes. These regulations help to minimize the risk of exposure to hazardous materials by the general public.

The United States Environmental Protection Agency (herein referred to as the EPA) has defined hazardous waste as substances: 1) that may cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness; 2) that pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of or otherwise managed; and 3) whose characteristics can be measured by a standardized test or reasonably detected by generators of solid waste through their knowledge of their waste. Hazardous waste is also ignitable, corrosive, or reactive (explosive) (EPA 40 CFR 260.10). A material may also be classified as hazardous if it contains defined amounts of toxic chemicals. The EPA has developed a list of specific hazardous wastes that are in the forms of solids, semi-solids, liquids, and gases. Producers of such wastes include private businesses, and Federal, State, and local agencies.

The State of California further defines hazardous materials as substances that are toxic, ignitable or flammable, reactive, and/or corrosive. The State also defines an extremely hazardous material as a substance that shows high acute or chronic toxicity, carcinogenity, bioaccumulative properties, is persistent in the environment, or is water reactive (California Code of Regulations, Title 22).

5.2 Regulatory Context and Lists of Sites

Various Federal and State programs regulate the use, storage, and transportation of hazardous materials. These will be discussed in this section as they pertain to the Menifee area and its management of hazardous materials. The goal of the discussions presented herein is to provide information that can be used to reduce or mitigate the danger that hazardous substances may pose to Menifee's residents and visitors, both in normal, day-to-day conditions, and as a result of a regional disaster, such as an earthquake.

Several of the existing Federal and State programs are summarized in the subsections below.

5.2.1 Federal Clean Water Act (33 U.S.C. §1251 et seq., 1972) and California Water Code

"Out of sight, out of mind" has been the traditional approach to dealing with trash, sediment, fertilizer-laden irrigation water, used motor oil, unused paint and thinner, and other hazardous substances that people dump onto the ground, or into the sewer and storm drains. What we often forget is that substances dumped into the storm drain system can make their way into drainages, lakes, rivers, and eventually the ocean. Contaminants in these waterways can endanger aquatic organisms and wildlife dependent on these water sources, and can impact human health and the environment. Some substances dumped onto the ground can eventually make their way into the groundwater, with the potential for contamination of our drinking water resources.

In part to deal with these issues, the Federal government enacted the Clean Water Act in 1972. This Act establishes the framework by which discharges of pollutants into the waters of the United States are regulated, including the establishment of quality standards for surface waters. One of the earliest programs established under the Act was the National Pollutant Discharge Elimination System (NPDES) to control wastewater discharges from various industries and wastewater treatment plants known as a "point sources." A point source is defined by the EPA as a discrete, easily discernible source of pollution, such as a smokestack or sewer. Then, in 1987, the Water Quality Act amended the NPDES permit system to include "non-point source" (NPS) pollution. NPS pollution refers to the introduction of bacteria, sediment, oil and grease, heavy metals, pesticides, fertilizers and other chemicals from less well defined sources into our rivers, lakes, bays and oceans. These pollutants are not released at one specific, identifiable point, but rather, from a number of points that are spread out and difficult to identify and control. The pollutants are washed away from roadways, parking lots, yards, farms and other areas by rain and dry-weather urban runoff into the storm drain system, from where they are ultimately conveyed to the area's water bodies and the ocean. NPS pollution is now thought to account for most water quality problems in the United States. Therefore, strict enforcement of this program at the local level, with everybody doing his or her part to reduce NPS pollution, can make a significant difference.

The NPDES program is handled at the State-level by the California State Water Resources Control Board (CSWRCB or "the Board"), with regional offices of the Board overseeing implementation and enforcement of the program at the local level. NPDES permits are required by all municipalities that own or operate a municipal separate storm sewer system (MS4) that: a) serves a population greater than 100,000 (medium) or 250,000 (large); b) contributes to a violation of a Water Quality Standard, c) is a significant contributor of pollutants to waters of the U.S., or d) is owned and/or operated by a small municipality that is interrelated to a medium or large municipality.

Urban runoff from Menifee discharges into watersheds within both the Santa Ana Regional Board and the San Diego Regional Board jurisdictions; therefore, the city is regulated by MS4 permits issued by both Regional Boards. The Region 8 – Santa Ana Board has its main office located at 3737 Main Street, Suite 500, Riverside, 92510-3339. Their general telephone number is (951) 782-4130. The Region 9 – San Diego Board offices are located at 9174 Sky Park Court, Suite 100, San Diego, 92123-4353. Their main phone number is (858) 467-2952. In accordance with the Clean Water Act, and the Porter-Cologne Water Quality Control Act (contained in Division 7 of the California Water Code), the CWRCB is responsible for the formulation and adoption of State policy for water quality control. This includes the development of water quality principles and guidelines for ground waters, surface waters and the use of reclaimed water; the formulation, adoption and periodic review and revision of water quality control plans; and the formulation and enforcement of waste discharge requirements (WDRs).

In 2002, the Santa Ana Regional Water Quality Control Board (Regional Board) issued a municipal storm water NPDES permit to the County of Riverside and the twelve incorporated cities of the County within the Santa Ana Region (Urban Runoff Management Program Order No. R8-2002-0011, NPDES Permit No. CAS618033). On April 27, 2007, the Riverside County Flood Control and Water Control District (RCFC&WCD), in cooperation with the County of Riverside and the incorporated cities of Beaumont, Calimesa, Canyon Lake, Corona, Hemet, Lake Elsinore, Moreno Valley, Murrieta, Norco, Perris, Riverside and San Jacinto jointly submitted NPDES Application No. CAS 618033, a Report of Waste Discharge (RoWD) and a revised Drainage Area Management Plan (DAMP) to renew the MS4 permit for the Santa Ana River watershed (the Permit Area) within Riverside County. Under this Order, the RCFC&WCD is the Principal Permittee, and the County and the incorporated cities are Co-Permittees. Since the application was submitted in 2007, the cities of Wildomar and Menifee have incorporated, and on May 6, 2009, the City of Menifee issued a Letter of Intent to be a Co-Permittee on this Order. The updated Order (No. R8-2010-0033) was adopted on January 29, 2010, and will expire on January 29, 2015. The current County of San Diego's Urban Runoff Management Program Order No. R9-2007-001, NPDES Permit No. CAS0108758, was adopted on January 24, 2007.

Co-permittees have certain responsibilities defined by the NPDES permit order. These responsibilities, which the City of Menifee needs to comply with, include:

1. Establish a Local Implementation Plan (LIP) in conformance with Section IV of the Order and using the approved LIP template;
2. Manage the Urban Runoff program within its jurisdiction, including: a) maintaining adequate legal authority to control the contribution of pollutants to the MS4 and enforce those authorities; b) conduct inspections of and maintain its MS4 facilities; c) implement management programs, monitoring and reporting programs, appropriate Best Management Practices (BMPs) and related plans and actions consistent with the Maximum Extent Practicable (MEP) standard; d) seek sufficient funding for the area-wide Urban Runoff management plan, local Urban Runoff program management, Urban Runoff enforcement, public outreach and education activities, and other Urban Runoff related program implementation; e) coordinate with other public agencies as appropriate to facilitate implementation of the Order; f) ensure that applicants for encroachment permits are notified of their obligations; g) maintain up-to-date MS4 facility maps; and h) prepare and submit to the Principal Permittee specific information and reports necessary to develop an Annual Report.
3. Participate in Management Steering Committee and Technical Committee meetings;
4. Together with the Principal Permittee, conduct and coordinate surveys and monitoring needed to identify pollutant sources and drainage area characteristics within its jurisdiction. Where an Illegal Discharge crosses jurisdictional boundaries, coordinate with neighboring jurisdictions to locate and end the Illegal Discharge;

5. Prepare and submit reports to the Principal Permittee to facilitate compilation of joint reports to the Regional Board;
6. Participate in the development and implementation of plans, strategies, management programs, monitoring and reporting programs proposed by the Principal Permittee, the Technical Committee, or the Management Steering Committee;
7. Participate in subcommittees formed to comply with the NPDES order;
8. Respond to or arrange for the appropriate entity or agency to respond to emergency situations such as accidental spills, leaks, etc., to reduce the discharge of pollutants to the local MS4 facilities and the receiving state waters; and
9. Pursue enforcement actions as necessary for violations of the Storm Water Ordinances and other elements of the Urban Runoff management program.

In addition to regulatory activities, Permittees and Co-permittees are required to implement public education programs, waste management, and operations and maintenance activities. As part of the educational program requirements, Riverside County and the Co-permittees pool together staff and resources to: 1) prepare informational materials that can be distributed to the public in general, and at schools and businesses; 2) conduct workshops and community events where information on the NPDES program is provided to attendees; and 3) sponsor free presentations to civic/rotary/group organizations to discuss the prevention of stormwater pollution. For additional information regarding this program, including scheduling of events, and downloadable materials, refer to http://www.floodcontrol.co.riverside.ca.us/stormwater/. Pamphlets with information regarding stormwater pollution, with emphasis on how to prevent it, and how to report an unauthorized release, are also available at Menifee's City Hall, at the front counter.

Specific programs that Co-permittees typically conduct in support of the NPDES program include:

- Regular maintenance of public rights of way, including street sweeping, litter collection, and storm drain facility maintenance;
- Implementation of spill response procedures;
- Periodic screening of water samples collected from the storm sewer system and local streams to test for specific contaminants;
- Adoption and enforcement of ordinances prohibiting the discharge of pollutants into the storm drain system;
- Plan review procedures to ensure that unauthorized connections to the storm sewer system are not made; and
- Public education efforts to inform residents about storm water quality. These efforts typically include publishing the City's annual water quality report describing the NPDES program and stormwater pollution prevention measures; stenciling of storm drains with warnings about the illegal discharge of substances; and organizing educational presentations at fairs and other public events, and for school programs.

The California Water Code states that anyone who is discharging or proposing to discharge wastewater onto land shall file a report with the Regional Board. After review, and following any necessary hearings, the Board may impose waste discharge requirements on that individual or facility. All dischargers, except from small, residential, on-site systems, are required to complete and submit to the Regional Board a Report of Waste Discharge. The appropriate forms, including descriptions and instructions for each, can be obtained online at http://www.waterboards.ca.gov/santaana/publications_forms/docs/form200.pdf.

The Regional Board also monitors development projects during the construction stage. Specifically, all dischargers whose projects will disturb one or more acres of soil, or whose projects are less than one acre in size but that are part of a larger development that in total will disturb one or more acres of land are required to obtain a General Permit for Discharges of Storm Water Associated with Construction Activity, under Construction General Permit Order 2009-0009-DWQ adopted on September 2, 2009. Construction activity includes clearing, grading and disturbances such as stockpiling or excavation. For additional information and copies of the appropriate forms for this program refer to http://www.waterboards.ca.gov/water_issues/programs/stormwater/construction.shtml.

5.2.2 Comprehensive Environmental Response, Compensation and Liability Act

The Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) is a regulatory or statute law developed to protect the water, air, and land resources from the risks created by past chemical disposal practices. This act is also referred to as the Superfund Act and contains the National Priority List (NPL) of sites, which are referred to as Superfund sites.

According to the EPA (http://cfpub.epa.gov/supercpad/cursites/srchrslt.cfm), there are no CERCLIS sites in the Menifee General Plan Area. The closest sites include a site in Perris, a site in Hemet, and March Air Force Base. The sites in Perris and Hemet are not on the NPL and are therefore not considered significantly hazardous. March Air Force Base is an NPL site; cleanup activities have been undertaken at this site since the 1980s and are still underway today.

5.2.3 Emergency Planning and Community Right-To-Know Act (EPCRA)

The primary purpose of the Federal Emergency Planning and Community Right-To-Know Act (EPCRA) of 1986 is to inform communities and citizens of chemical hazards in their areas. Sections 311 and 312 of EPCRA require businesses to report the locations and quantities of chemicals stored on-site to state and local agencies. These reports help communities prepare to respond to chemical spills and similar emergencies.

The EPA maintains and publishes a database that contains information on toxic chemical releases and other waste management activities that are reported annually by certain industry groups and federal facilities. The database is referred to as the Toxics Release Inventory (TRI), and it was first established under the EPCRA and expanded by the Pollution Prevention Act of 1990. EPCRA's power has allowed for the mandate that Toxic Release Inventory (TRI) reports be made public. TRI reports provide information about potentially hazardous chemicals and their uses in an attempt to give the community more power to hold companies accountable and to make informed decisions about how such chemicals should be managed.

Section 3131 of EPCRA requires manufacturers to report releases to the environment of more than 600 designated toxic chemicals. These reports are submitted to the EPA and State agencies. The EPA compiles these data into an on-line, publicly available national digital TRI. These data are readily available on the EPA website at http://www.epa.gov/tri/. The facilities are required to report on releases of toxic chemicals to the air, soil, and water. They are also required to report on off-site transfers of waste for treatment or disposal at separate facilities. Pollution prevention measures and activities and chemical recycling must also be reported. All reports must be submitted on or before July 1 of every year and must cover all activities that occurred at the facility during the previous year. Reporting by facilities is based on the following factors:

- If the facility has ten or more full-time employees;
- If the facility manufactures or processes over 25,000 pounds of approximately 600 designated chemicals, or 28 chemical categories specified in the regulations, or uses more than 10,000 pounds of any designated chemical or category; and
- If the facility engages in certain manufacturing operations in the industry groups specified in the U.S. Government Standard Industrial Classification Codes (SIC) 20 through 39; or
- If the facility is a Federal facility.

There are no TRI facilities in and near Menifee listed in the most recent TRI database last updated on September 17, 2009 with data for the year 2008. The RCRA database, however, lists one TRI facility in the Study Area: Matthews International Corporation, located at 28261 Highway 74, in Romoland 92585. In 2005, the year for the most recent data available, this facility appears to have released 5 pounds of copper and 1 pound of lead to the environment, via an air stack. The next closest TRI facility is Fibernetics Molded Products, located at 19940 Hansen Avenue, in Nuevo, approximately 3-1/4 miles north of the Study Area. In 2008, this site reported the on-site disposal or release of 7,430 pounds of styrene and 250 pounds of dimethyl phthalate. The EPA web site (http://www.epa.gov/tri/) should be reviewed periodically for updates to this information, including the potential future location of TRI sites in the Menifee area.

5.2.4 Resources Conservation and Recovery Act

The Resources Conservation and Recovery Act (RCRA) is the principal Federal law that regulates the generation, management and transportation of waste materials. Hazardous waste management includes the treatment, storage, or disposal of hazardous waste. Treatment is defined as any process that changes the physical, chemical, or biological character of the waste to make it less of an environmental threat. Treatment can include neutralizing the waste, recovering energy or material resources from the waste, rendering the waste less hazardous, or making the waste safer to transport, dispose of, or store. Storage is the holding of waste for a temporary period of time. The waste is treated, disposed of, or stored at a different facility at the end of the storage period. Disposal is the permanent placement of the waste into or on the land. Disposal facilities are usually designed to contain the waste permanently and to prevent the release of harmful pollutants to the environment.

Many different types of businesses can be producers of hazardous waste. Small businesses like dry cleaners, auto repair shops, medical facilities or hospitals, photo processing centers, and metal plating shops are usually generators of small quantities of hazardous waste. The EPA (Title 40 of the Code of Federal Regulations) defines a small quantity generator as a facility that produces between 100 and 1,000 kilograms (Kg) of hazardous waste per month (approximately equivalent to between 220 and 2,200 pounds, or between 27 and 275 gallons). A "conditionally exempt" small quantity generator is a business that generates 220 pounds (27 gallons) or less of hazardous waste per month.

Since many of these facilities are small, start-up businesses that come and go, the list of small-quantity generators in a particular area can change over time. Often, a facility remains, but the name of the business changes with new ownership. For this reason, please contact the Riverside County Fire Department, Hazardous Materials Division, or the EPA website for up-to-date information about generators of hazardous materials in the city of Menifee. As of March 2010, there were 23 locations in the Menifee Study area reported as small-quantity generators. These locations are included in Table 5-1, below, and their distribution in the area is depicted on Plate 5-1.

Larger businesses are sometimes generators of large quantities of hazardous waste. These include some gas stations, chemical manufacturers, large electroplating facilities, petroleum refineries, and military installations. The EPA defines a large-quantity generator as a facility that produces over 1,000 Kg (2,200 pounds or about 275 gallons) of hazardous waste per month. Large-quantity generators are fully regulated under RCRA. The EPA identifies five large-quantity generators in the Menifee area as of March 2010 (see Table 5-1 and Plate 5-1). Please note that these lists can change; therefore, to determine whether the list has been updated, and to obtain a more recent list, if available, contact the Riverside County Department of Environmental Health, Hazardous Materials Division, or refer to the EPA website.

Table 5-1: EPA-Registered Small- and Large-Quantity Generators of Hazardous Materials in the Menifee Study Area

Facility Name, Address	EPA ID	Type Facility
Mt. San Jacinto Community College District 28237 La Piedra, Menifee 92584	CAL000215453	Small Generator (conditionally exempt)
Newport Cleaners 26900 Newport Road, Menifee 92584	CAD983646597	Small Generator
Shell Service Station 30107 Antelope Road, Menifee 92584	CAR000125633	Small Generator
Amerimax 28921 E. Hwy. 74, Menifee 92585	CAR000079079	Small Generator
Block Graphics 28401 Matthews Drive, Romoland 92585	CAR000576968	Small Generator
Butler Scales Zepede 27736 Hwy. 74, Romoland 92585	CAD981621121	Small Generator
Calmat Co. Romoland	CAR000012500	Small Generator

Facility Name, Address	EPA ID	Type Facility
28023 Ethanac Road, Sun City 92585		
Datatronics Inc. 28151 Hwy. 74, Romoland 92585	CAD009532979	Small Generator
Lakeside Chevrolet 25351 Trumble Road, Romoland 92585	CAD981396070	Small Generator
Matthews International Corporation 28261 Hwy. 74, Romoland 92585	CAD981386956	Small Generator
Menifee Service Center 26100 Menifee Avenue, Romoland 92585	CAR000195925	Large Generator
Richardsons RV Center 26776 Encanto Drive, Sun City 92585	CAR000163907	Small Generator
Southern California Gas Company / Ramona Base 25200 Trumble Road, Romoland 92585	CAD981423122	Small Generator
United Parcel Service Hemet 25283 Sherman Road, Romoland 92585	CAD981634108	Small Generator
Valley Substation 26125 Menifee Road, Romoland 92585	CA0000562157	Small Generator
Carriage Cleaners 26904 Cherry Hills Blvd., Sun City 92586	CAD982034068	Small Generator
Chevron Station 92959 26980 McCall Blvd., Sun City 92586	CAR000118638	Large Generator
Exxon-Mobil Oil Corp. No. 11408 26820 McCall Blvd., Sun City 92586	CAL000055868	Large Generator
Intercommunity Radiology 28125 Bradley Rd. Ste. 230, Sun City 92586	CAD983635798	Small Generator
Reach 4 Sun City RWRF 29285 Valley Blvd., Sun City 92586	CAR000167643 CAC002597174	Small Generator & Large Generator
Shell Service Station 26730 McCall Blvd., Sun City 92586	CAR000125765	Large Generator
Sun City Desalter 29541 Murrieta Road, Sun City 92586	CAR000167783	Small Generator
Circle K Store #575 28968 Goetz Road, Quail Valley 92587	CAD981680689	Small Generator
Lakeside Chevrolet and Oldsmobile Co. Hwy. 395 (I-215?) and Hwy. 74, Sun City 92587	CAD981996739	Small Generator
Sun City Transmission 28300 Bradley Road, Sun City 92587	CAD981996911	Small Generator
La Ventana Dechlorination Facility 28264 La Ventana, Winchester 92596	CAR000188268	Small Generator
Golden State Auto Body 31198A Hwy. 74, Homeland 92548	CAD981569676	Small Generator

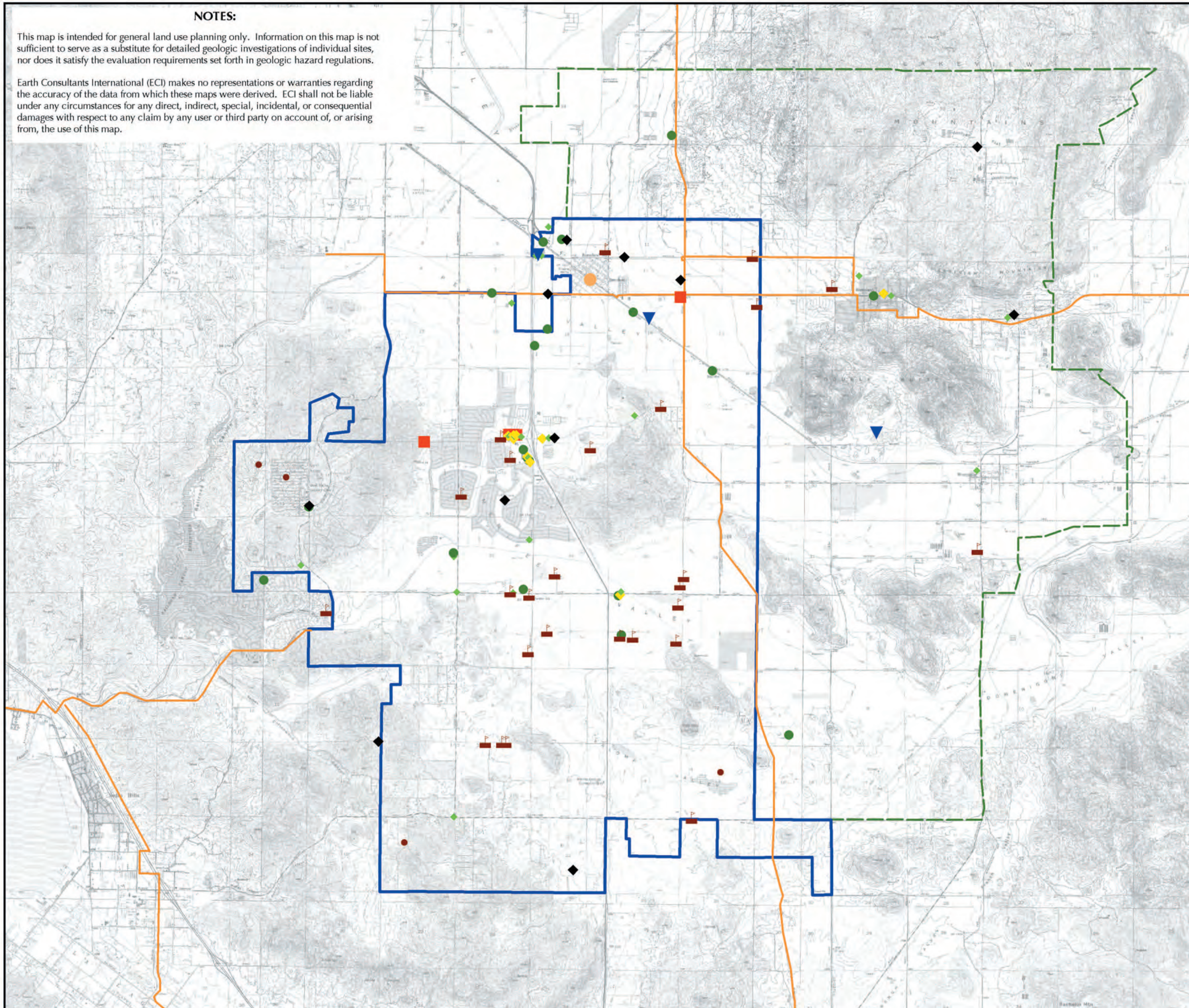
Source: http://iaspub.epa.gov/enviro/, based on data extracted February 18 and March 11, 2010.

There are also four registered transporters of hazardous waste in the Menifee area. These transporters are listed in Table 5-2. Hazardous waste is transported through the area by these companies and most likely by other transporters registered or based elsewhere. According to the National Hazardous Materials Route Registry maintained by the Federal

NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

Earth Consultants International (ECI) makes no representations or warranties regarding the accuracy of the data from which these maps were derived. ECI shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages with respect to any claim by any user or third party on account of, or arising from, the use of this map.



Hazardous Materials Site Map

Menifee, California

Explanation

- Land Disposal Site
- EPA-Registered Large Quantity Hazardous Waste Generator (LQG) Facility
- Leaking Underground Storage Tank (LUST) Site closed case shown in black
- Toxic Release Inventory (TRI) Facility
- EPA-Registered Small Quantity Hazardous Waste Generator (SQG) Facility
- Permitted Underground Storage Tank (UST) Site
- Hazardous Waste Transporter
- School
- Gas Transmission Line
- City of Menifee Corporate Boundary
- Menifee General Plan Area Boundary

N W E S

Scale: 1:84,000

7000 0 7000
Feet

2 0 2
Kilometers

Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: http://iaspub.epa.gov/enviro; http://cfpub.epa.gov/supercpad/cursites/srchrslt.cfm; http://www.epa.gov/tri; http://www.dtsc.ca.gov/database/Transporters/trans_cnty.cfm; http://iaspub.epa.gov/enviro; http://geotracker.swrcb.ca.gov; http://nhdgeo.usgs.gov/viewer.htm

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CITY OF MENIFEE

Project Number: 2917
Date: 2010

Plate 5-1

Motor Carrier Safety Administration, a division of the U.S. Department of Transportation, the only major route in the Menifee area prescribed or permitted to carry hazardous materials is the Interstate 215, from Interstate 15 to Interstate 10. All types of hazardous materials are permitted on this road, and it is recommended for the transport of Class 1 Explosives. The interstate was designated a Hazardous Materials Route on 1/1/1995. State Routes 74 and 79 are not on the registry.

Table 5-2: Registered Transporters of Hazardous Materials in the Menifee Area

Business Name	Address	State ID
Karrgo Transportation	33360 Wright Road, Menifee 92584	CAR000094565
Sollars Trucking	29530 Garland Lane, Menifee 92584	CAD980675037
Condos Trucking	28325 Hampshire Drive, Quail Valley 92587	CAD982470544
Visions West	28993 Avenida de las Flores, Quail Valley 92587	CAR000097857

Sources: http://www.dtsc.ca.gov/database/Transporters/trans_cnty.cfm;http://iaspub.epa.gov/enviro/

5.2.5 Hazardous Materials Disclosure Program

Both the Federal government (Code of Federal Regulations, EPA, SARA and Title III) and the State of California (California State Health and Safety Code, Division 20, Chapter 6.95, Sections 25500–25520; California Code of Regulations, Title 19, Chapter 2, Sub-Chapter 3, Article 4, Sections 2729-2734) require all businesses that handle more than a specified amount of hazardous materials or extremely hazardous materials, termed a reporting quantity, to submit a Hazardous Materials Business Plan to its local Certified Unified Program Agency (CUPA). The CUPA with responsibility for the City of Menifee is the Riverside County Department of Environmental Health, Hazardous Materials Division (RCDEH-HMD). The Business Plan includes the Business Owner/Operator Identification page, Hazardous Materials Inventory – Chemical Description page, and an Emergency Response Plan and Training Plan.

According to the RCDEH-HMD guidelines, the preparation, submittal and implementation of a Business Activity Form is required by all businesses that handle a hazardous material or a mixture containing a hazardous material in quantities equal to, or greater than, those outlined below:

- All hazardous waste generators, regardless of quantity generated.
- Any business that uses, generates, processes, produces, treats, stores, emits, or discharges a hazardous material in quantities at or exceeding:
  - 55 gallons or more of a liquid;
  - 500 pounds or more of a solid; or
  - 200 cubic feet (compressed) of gas at any one time in the course of a year.
- Any business that recycles more than 100 kg per month of excluded or exempted recyclable materials per Health and Safety Code (HSC) §25143.2.

- Any business that handles, stores, or uses Category (I) or (II) pesticides, as defined by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), regardless of amount.
- Any business that handles Department of Transportation (DOT) Hazard Class 1 (explosives, found in Title 49 of the Code of Federal Regulations).
- Any business that handles extremely hazardous substances in quantities exceeding the threshold planning quantity, as listed in Title 40 of the Federal Code of Regulations, Part 355, Appendix A or B.
- Any business subject to the EPCRA (also known as SARA Title III; see Section 5.2.2 above). EPCRA generally includes facilities that handle hazardous substances above threshold planning quantities.
- Any business that owns or operates an underground storage tank that contains hazardous substances as defined in the Health and Safety Code (HSC) §25316.
- Any business that handles radioactive materials in quantities for which an emergency plan is required pursuant to Parts 30, 40 or 70 of Chapter 10, Title 10, Code of Federal Regulations (CFR), or equal to or greater than the amounts specified above, whichever amount is less.

Within 30 days of any one of the following events, businesses are required to submit an amendment to their business plan to the CUPA:

- A 100-percent or more increase in the quantity of a previously disclosed hazardous material;
- Any handling of a previously undisclosed hazardous material subject to the inventory requirements of this chapter;
- Change of mailing address, phone number or location; change of emergency contact person;
- Change of ownership; or
- Change of business name.

Business plans must include an inventory of the hazardous materials at the facility. If no changes have been made to the facility's inventory, a written certification suffices for the update; however, if changes have been made, those changes must be submitted to the Riverside County Department of Environmental Health – Hazardous Materials Division (RCDEH-HMD). Businesses are required to update their business plan at least once every three years and the chemical inventory portion of their plan every year. They must certify in writing to the RCDEH-HMD that a review was conducted and all necessary changes were made. A copy of all changes must be submitted as part of the certification. Also, business plans are required to include emergency response plans and procedures to be used in the event of a significant or threatened significant release of a hazardous material. These plans need to identify the procedures to follow for immediate notification to all appropriate agencies and personnel of a release, identification of local emergency medical assistance appropriate for potential accident scenarios, contact information for all emergency coordinators of the business, a listing and location of emergency equipment at the business, an evacuation plan, and a training program for business personnel. Additional information regarding business plans and the CUPA forms required in the County of Riverside, including the City of Menifee, is available at http://www.rivcoeh.org/opencms/rivcoeh/Forms_Guidelines/#CUPA. They can also be contacted by phone at (888) 722-4234 (888-RC-CHA-EH).

Business plans are designed to be used by responding agencies, such as the Riverside County Fire Department, during a release or spill to allow for a quick and accurate evaluation of each situation for appropriate response. Businesses that handle hazardous materials are required by law to provide an immediate verbal report of any release or threatened release of hazardous materials if there is a reasonable belief that the release or threatened release poses a significant present or potential hazard to human health and safety, or to property or the environment. Fines of up to $25,000 per day and one year in prison may be awarded to an individual or business if a release or threatened release is not reported. If a release involves a hazardous substance listed in Title 40 of the Code of Federal Regulations in an amount equal to or exceeding the reportable quantity for that material, a notice must be filed with the California Office of Emergency Services within 15 days of the incident.

The Riverside County Department of Environmental Health, Hazardous Materials Division is charged with the responsibility of conducting compliance inspections of regulated facilities in Riverside County. Specialists are assigned countywide to address the wide variety of complex issues associated with hazardous substances. For example, all new installations of underground storage tanks require an inspection, along with the removal, under strict chain-of-custody protocol, of the old tanks (see Section 5.3 below).

5.2.6 Hazardous Materials Incident Response

There are thousands of different chemicals available today, each with its own unique physical characteristics; what might be an acceptable mitigation practice for one chemical could be totally inadequate for another. Therefore it is essential that agencies responding to a hazardous material release have as much available information as possible regarding the type of chemical released, the amount released, and its physical properties to effectively and quickly evaluate and contain the release. The EPA-required business plans are an excellent resource for this type of information. Other sources of information are knowledgeable facility agents or employees present onsite.

In 1986, Congress passed the Superfund Amendments and Reauthorization Act (SARA). Title III of this legislation requires that each community establish a Local Emergency Planning Committee (LEPC) that is responsible for developing an emergency plan to prepare for and respond to chemical emergencies in their community.

This emergency plan must include the following:

- An identification of local facilities and transportation routes where hazardous materials are present;

- The procedures for immediate response in case of an accident (this must include a community-wide evacuation plan);
- A plan for notifying the community that an incident has occurred;
- The names of response coordinators at local facilities; and
- A plan for conducting exercises to test the plan.

The plan is reviewed by the State Emergency Response Commission (SERC) and publicized throughout the community. The LEPC is required to review, test, and update the plan each year.

The Riverside County Office of Emergency Services (OES), the Riverside County Department of Environmental Health – Hazardous Materials Division, the Riverside County Fire Department, and the City of Menifee's Emergency Services Coordinator are responsible for coordinating hazardous material and disaster preparedness planning and appropriate response efforts with City departments, as well as local and State agencies. The goal is to improve public and private sector readiness, and to mitigate local impacts resulting from natural or man-made emergencies. The OES is a branch of the Riverside County Fire Department that deals with the planning for and response to the natural and technological disasters in the County, whereas the Riverside County Department of Environmental Health – Hazardous Materials Division deals with the coordination and inspection of hazardous materials facilities in the County and in the city of Menifee. The Riverside County Fire Department has developed and teaches a Community Emergency Response Team (CERT) training program to help county residents prepare for potential disasters. The CERT course, which is taught as a series of modules that combined add to about 20 hours of instruction over three consecutive days, is certified by the Federal Emergency Management Agency (FEMA) and the State OES. For more information on the CERT program, contact the County's CERT Program at (951) 955-4700 or visit http://www.rvcfire.org/opencms/functions/oes/CommunityServicePrograms/Riverside_County_CERT_Program.html. Information on CERT training held locally in Menifee is also available at Menifee's City Hall.

The Riverside County Fire Department has two Hazardous Materials Response Teams, one in the west end of the county, and one at the east end. The response team closest to Menifee is Haz Mat Team #34, located at Fire Station #34, in Winchester (32655 Haddock Street, Winchester, California 92596).

5.2.7 Hazardous Material Spill/Release Notification Guidance

All significant spills, releases, or threatened releases of hazardous materials must be immediately reported. **To report all significant releases or threatened releases of hazardous materials, first call 911** (or the local emergency response agency), and then call the Governor's OES Warning Center at 1-800-852-7550.

This guidance summarizes pertinent emergency notification requirements and applies to all significant releases of hazardous materials. Requirements for immediate notification of all significant spills or threatened releases cover: Owners, Operators, Persons in Charge, and

Employers. Notification is required regarding significant releases from facilities, vehicles, vessels, pipelines and railroads.

State notification requirements for a spill or threatened release include (at a minimum):

- Identity of caller,
- Location, date and time of spill, release, or threatened release,
- Substance and quantity involved,
- Chemical name (if known; also report whether or not chemical is extremely hazardous), and
- Description of what happened.

Federal notification requires additional information for spills (CERCLA chemicals) that exceed Federal-reporting requirements. This information includes:

- Medium or media impacted by the release,
- Time and duration of the release,
- Proper precautions to take,
- Known or anticipated health risks, and
- Name and phone number for more information.

Many State statutes require emergency notification of a hazardous chemical release. These statutes include:

- Health and Safety Codes §25270.7, 25270.8, and 25507,
- Vehicle Code §23112.5,
- Public Utilities Code §7673, (PUC General Orders #22-B, 161),
- Government Code §51018, 8670.25.5 (a),
- Water Codes §13271, 13272, and
- California Labor Code §6409.1 (b)10.

In addition, all releases that result in injuries, or workers harmfully exposed, must be immediately reported to Cal/OSHA (CA Labor Code §6409.1 (b)). For additional reporting requirements, also refer to the Safe Drinking Water and Toxic Enforcement Act of 1986, better known as Proposition 65, and §9030 of the California Labor Code.

The California Accidental Release Prevention Program (CalARP) became effective on January 1, 1997 in response to Senate Bill 1889. The CalARP replaced the California Risk Management and Prevention Program (RMPP). Under the CalARP, the Governor's Office of Emergency Services must adopt implementing regulations and seek delegation of the program from the EPA. The CalARP aims to be proactive and therefore requires businesses to prepare Risk Management Plans (RMPs), which are detailed engineering analyses of:

- The potential accident factors present at a business, and
- The mitigation measures that can be implemented to reduce this accident potential.

In most cases, local governments have the lead role in working directly with businesses in this program. The County of Riverside Department of Environmental Health – Hazardous Materials Division is designated as the Administering Agency for hazardous materials in the city of Menifee.

5.3 Leaking Underground Storage Tanks

Leaking underground storage tanks (LUSTs) have been recognized since the early 1980s as the primary cause of groundwater contamination by gasoline compounds and solvents. In California, regulations aimed at protecting against underground storage tank (UST) leaks have been in place since 1983, one year before the Federal Resource Conservation and Recovery Act (RCRA) was amended to add Subtitle I requiring UST systems to be installed in accordance with standards that address the prevention of future leaks. The Federal regulations are found in the Code of Federal Regulations (CFR), parts 280-281. The State law and regulations are found in the California Health and Safety Code, Division 20, Chapter 6.7, and in the California Code of Regulations Title 23, Division 3, Chapter 16, commonly referred to as the "Underground Tank Regulations." Federal and State programs include leak reporting and investigation regulations, and standards for clean up and remediation. UST cleanup programs are available to fund the remediation of contaminated soil and ground water caused by leaking tanks. California's program is more stringent than the Federal program, requiring that all tanks be double walled, and prohibiting gasoline delivery to non-compliant tanks. The State Water Resources Control Board (SWRCB) has been designated the lead regulatory agency in the development of UST regulations and policy.

Most older tanks were typically single-walled steel tanks. Many of these leaked as a result of corrosion and detached fittings. As a result, the state of California required the replacement of older tanks with new double-walled, fiberglass tanks with flexible connections and monitoring systems. UST owners were given a ten-year period to comply with the new requirements, and the deadline came due on December 22, 1998. However, many UST owners did not act by the deadline, so the State granted an extension for the Replacement of Underground Storage Tanks (RUST) program to January 1, 2002. Nevertheless, in that RUST grant funds are still available in 2010 indicates that there are still UST owners, typically small, independent operators that have yet to comply with the RUST requirements. RUST grants, ranging from $3,000 to $50,000 (maximum per person or entity), can be used to finance up to 100% of the costs to upgrade USTs by installing containment sumps, double-walled piping, dispensers, under-dispenser containment boxes or pans, electronic monitoring systems, and enhanced vapor recovery systems. The funds can also be used to conduct enhanced leak detection tests. For additional information on this program, refer to http://www.swrcb.ca.gov/water_issues/programs/ustcf/rust.shtml.

The California legislature established the Barry Keene Underground Storage Tank Cleanup Fund Act of 1989 to provide a means for petroleum UST owners and operators to meet the Federal and state requirements, and to assist small businesses and individuals by providing reimbursement for unexpected and catastrophic expenses associated with the cleanup of leaking petroleum USTs. The fund also provides money to the Regional Water Quality Control Boards to cleanup abandoned sites or abate emergency situations that pose a threat to human health, safety and the environment as a result of a petroleum release from an UST (http://www.swrcb.ca.gov/ water_issues/programs/ustcf/). Revenues for the Fund are generated by a storage fee for every gallon of petroleum product placed into a UST. The State Board of Equalization collects these fees on a quarterly basis from owners of active USTs. In the last few years, the fund has experienced a cash shortage. As a result, in May 2009, the State Water Resources Control Board passed Resolution No. 2009-0042 that defines specific actions that the Regional Boards are to take to improve administration of the UST Cleanup Fund and the UST Cleanup Program. The most significant decision in this resolution is that the Regional Boards are to review the open UST cleanup cases and identify those where continued investigation, remediation or monitoring poses little to no environmental benefit. Those sites open for more than five years that are found to not pose a threat to water quality or sensitive receptors, will be recommended for closure.

The California Regional Water Quality Control Board (CRWQCB), in cooperation with the Office of Emergency Services, maintains an inventory of leaking underground storage tanks (LUSTs) in a Statewide database called GeoTracker, which is available at http://geotracker.swrcb.ca.gov/. The database lists 20 reported LUST cases in the Menifee area. Of these, according to the LUST database, twelve (12) sites have been remediated and closed, leaving eight (8) cases still open (the open cases are in **bold**). All 20 cases are listed in Table 5-3, below, and their approximate location is shown on Plate 5-1. Please note, however, that the ongoing assessment and remediation of the current open cases will eventually get these sites signed off by the reviewing agencies. Furthermore, given that there are at least 23 permitted underground storage tanks (USTs) in the General Plan area (see Plate 5-1), new leaks from these USTs may be reported in the future. Therefore, the GeoTracker list should be reviewed periodically to determine the status of the currently open sites, and for information regarding any new leaks.

Because of the relatively shallow ground water table in several parts of the Menifee area, twelve of the leaks listed in Table 5-3 reportedly impacted groundwater in an aquifer used for drinking water purposes. Eight of the sites impacted soil only. Groundwater monitoring wells are being used at most of these open case sites to study the aerial distribution and concentration of the contaminants as part of the site assessment and remediation phases. Specific information about each of these sites is available from the GeoTracker site at http://geotracker.swrcb.ca.gov/.

Table 5-3: Leaking Underground Fuel Tanks Reported in the Menifee Area

Site Name	Address	State Case No.	Case Type	Status, Contaminant (Date Case Closed)	Date Leak Discovered
Bradley Auto Center	28200 Bradley Road, Sun City 92586	T0606500399	G	2, G	9/12/1995
Chevron #9-2959	26980 McCall Blvd., Sun City 92586	T0606500388	G	3, G	7/20/1994
Mobil #18-FNW	26820 McCall Blvd., Sun City 92581	T0606500316	G	4, G	4/16/1993

Site Name	Address	State Case No.	Case Type	Status, Contaminant (Date Case Closed)	Date Leak Discovered
Shell #26730	26730 McCall Avenue, Sun City	T0606500040	G	1, G	6/1/1983
Shell Menifee #12072	30107 Antelope Road, Menifee 92584	T0606519229	S	2, G	1/26/2006
Sun City SOCO	26771 McCall Blvd., Sun City	T0606500155	G	3, G	7/25/1989
Texaco Sun City	27181 McCall Blvd., Sun City 92585	T0606500614	G	2, G	6/14/1999
Unocal #5000	26980 Cherry Hills Blvd., Sun City 92586	T0606500407	G	2, S	10/18/1994
Baxendale Nursery	23895 Juniper Flats, Homeland 92567	T0606500284	S	5, G (6/1/1993)	7/22/1992
Bouris Ranch	33751 Zeiders Road, Sun City 92584	T0606500609	S	5, D (1/28/2000)	4/13/1999
Chaney's Automotive	27411 Ethanac Road, Romoland 92580	T0606500332	G	5, G (9/29/2000)	9/30/1992
Cherry Hills Golf Club, Inc.	26600 Sun City Blvd., Sun City 92381	T0606500044	S	5, G (4/4/1989)	7/20/1987
Circle K #346	31770 Highway 74, Homeland 92548	T0606500387	G	5, G (3/17/2010)	03/20/2001
Circle K #575	28968 Goetz Road, Quail Valley 92580	T0606500288	G	5, G (2/6/2003)	7/21/1992
Menifee Union School District	26301 Garboni Road, Menifee 92584	T0606500451	G	5, G (11/4/2003)	1/31/1996
Romoland Market	27856 Highway 74, Romoland 92580	T0606500088	S	5, G (07/25/1996)	3/19/1992
San Jacinto Valley District	26100 Menifee Road, Romoland 92580	T0606500038	S	5, G (4/4/1989)	12/5/1986
UniMart	31880 Highway 74	T0606500385	G	5, G (12/13/2004)	06/14/1994
United Parcel Service	25283 Sherman Road, Romoland	T0606500219	S	5, G (8/29/1991)	4/15/1991
Unocal #5597	27180 McCall Blvd., Sun City 92581	T0606500320	S	5, G (8/25/1993)	4/30/1993

Source: GeoTracker (http://geotracker.swrcb.ca.gov/)

Abbreviations Used for Case Type: **S** = Soil contaminated, groundwater not impacted; **G** = Aquifer used for drinking water supply impacted.
Abbreviations Used for Status: **1** = Case Opened; **2** = Site Assessment; **3** = Remediation; **4** = Assessment and Interim Remedial Action; **5** = Case Closed.
Abbreviations Used for Contaminant: **D** = Diesel; **G** = Gasoline; **S** = Other Solvent or Non-Petroleum Hydrocarbon.

5.4 Drinking Water Quality

Most people in the United States take for granted that the water that comes out of their kitchen taps is safe to drink. In most areas, this is true, thanks to the efforts of hundreds of behind-the-scene individuals that continually monitor the water supplies for contaminants, in accordance with the drinking water standards set by the EPA. Primary authority for EPA water programs was established by the 1986 amendments to the Safe Drinking Water Act (SDWA) and the 1987 amendments to the Clean Water Act (CWA).

The National Primary Drinking Water Standard protects drinking water quality by limiting the levels of specific contaminants that are known to occur or have the potential to occur in water and can adversely affect public health. All public water systems that provide service to 25 or more individuals are required to satisfy these legally enforceable standards. Water purveyors must monitor for these contaminants on fixed schedules and report to the EPA when a Maximum Contaminant Level (MCL) has been exceeded. MCL is the maximum permissible level of a contaminant in water that is delivered to any user of a public water system. Drinking water supplies are tested for a variety of contaminants, including organic and inorganic chemicals (minerals), substances that are known to cause cancer (carcinogens), radionuclides (such as uranium and radon), and microbial contaminants. The contaminants for which the EPA has established MCLs are listed at http://www.epa.gov/safewater/mcl.html. Changes to the MCL list are typically made every three years, as the EPA adds new contaminants or, based on new research or new case studies, revised MCLs for some contaminants are issued.

One of the contaminants checked for on a regular basis is the coliform count. Coliform is a group of bacteria primarily found in human and animal intestines and wastes. These bacteria are widely used as indicator organisms to show the presence of such wastes in water and the possible presence of pathogenic (disease-producing) bacteria. Pathogens in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. These pathogens may pose a special health risk for infants, young children, and people with compromised immune systems. One of the fecal coliform bacteria that water samples are routinely tested for is Escherichia coli (E. coli). To fail the monthly Total Coliform Report (TCR), the following must occur:

- For systems testing more than 40 samples, more than 5% tested positive for Total Coliform, or
- For those systems testing less than 40 samples, more than one sample tested positive for Total Coliform.

The Eastern Municipal Water District (EMWD) provides drinking water to most residents of the Menifee area. The EMWD, located at 2270 Trumble Road, in Perris, provides water to an estimated population of 687,000 in its current service area of 555 square miles that also includes the cities of Perris, Hemet, Moreno Valley, Murrieta, San Jacinto and Temecula, in addition to several school districts and water agencies in the region (http://www.emwd.org/emwd/history.html). Approximately 25 to 30% of the water distributed by the EMWD comes from groundwater wells. The rest of the water is imported by the Metropolitan Water District of Southern California from the Colorado River and northern California. Several residents have their own water wells on their property and are not tied to the main water system.

According to the EPA Safe Drinking Water Information System, available at www.epa.gov/enviro/html/sdwis/sdwis_ov.html, no health violations, or monitoring and reporting violations, have been reported for the Eastern Municipal Water District in at least the past ten years. This is a very good record, as the EPA indicates that in 2005, the last fiscal year for which the EPA has complete data, 24% of all water purveyors had a reporting/monitoring violation, 6.1% reported a MCL violation, and 1.5% reported a treatment technique violation.

A contaminant that California water agencies are increasingly testing for is **perchlorate**. Perchlorates are negatively charged molecules that are highly persistent in the environment, lasting decades under typical groundwater and surface conditions. Perchlorate salts are used extensively in several industries. For example, ammonium perchlorate is used as a booster or oxidant for solid fuel powering rockets and missiles, in explosives, and for chemical processes and pyrotechnics. Ammonium perchlorate typically constitutes 60 to 75% of missile propellant and about 70% of space shuttle rocket motors. Potassium perchlorate is also used as a solid rocket fuel oxidizer, and in flares and pyrotechnics. Sodium perchlorate is used as a precursor to potassium and ammonium perchlorate, and in explosives. Magnesium perchlorate is used in military batteries (Rogers, 1998). Perchlorate salts are used in automobile air bags, as a component of air bag inflators, and in nuclear reactors and electronic tubes. Other commercial and industrial uses of perchlorate salts include: as additives in lubricating oils; as fixatives (mordants) for fabrics and dyes, in the production of paints and enamels, tanning and finishing of leathers; electroplating; aluminum refining; and the manufacture of rubber (Siddiqui et al., 1998).

Humans exposed to perchlorate are likely to absorb this compound primarily through ingestion, either by drinking water with perchlorate, or possibly by ingesting produce (such as lettuce or other vegetables that store water) that has been irrigated with water containing perchlorate. Although studies indicate that most ingested perchlorate is eliminated rapidly in the urine without being metabolized (Eichler and Hackenthal, 1962; Anbar et al., 1959), small amounts of perchlorate can displace iodide in the thyroid gland. In adults, this can lead to hypothyroidism and goiter (enlarged thyroid). Symptoms and effects of hypothyroidism include depression and slow metabolism. In children, the thyroid plays a major role in proper development. Impairment of thyroid function in expectant mothers and newborns can result in delayed development and decreased learning capability. Even temporary disruptions in thyroid function can cause permanent physical and mental impairment, including mental retardation, speech impairments, deafness and/or mutism, impaired fine motor skills, delayed reflexes and gait disturbances.

In 2004, the California's Office of Environmental Health Hazard Assessment (OEHHS) established a public health goal (PHG) of 6.0 micrograms per liter (µg/L) for perchlorate (www.dhs.ca.gov/ps/ddwem/chemicals/perchl/perchlorateMCL.htm). Effective October 2007, perchlorate became a regulated drinking water contaminant in California, with a maximum contaminant level (MCL) of 6 µg/L. Testing for perchlorate has been done on water from wells in the Eastern Municipal Water District system since at least 2006. Results indicate that perchlorate at concentrations between 1.7 and 13.0 parts per billion (ppb, equivalent to µg/L) have been detected in water from twelve wells in the Eastern Municipal Water District system, although only in four of the wells have the measured concentrations of perchlorate exceeded the MCL of 6 µg/L. Furthermore, only three of these wells are used for water supply; the fourth well is a desalter well (a well used by the EMWD to slow the northward migration of groundwater rich in total dissolved solids into the Lakeview area, where groundwater of better quality occurs naturally). The EMWD blends the water from these three wells with water from other wells and with water from the Colorado River to achieve levels of perchlorate less than 4 μg/L. According to the EMWD, the water from these three wells represents less than 1.7% of the total water served by the District (http://www.emwd.org/water_service/perchlorate.html). The source of the perchlorate contamination in the EMWD groundwater wells has not been determined.

5.5 Household Hazardous Waste and Recycling

According to The American Red Cross (1994), most victims of chemical accidents are injured at home. These accidents usually result from ignorance or carelessness in using flammable, combustible or corrosive materials. This is not surprising considering that households do use environmentally significant quantities of hazardous materials. For example, FEMA estimates that in an average city of 100,000 residents, 23.5 tons of toilet bowl cleaner, 13.5 tons of liquid household cleaners, and 3.5 tons of motor oil are discharged into the sewer and storm drain systems each month (http://www.fema.gov/hazard/hazmat/backgrounder.shtm). However, with the development of new, "greener" products, and recognizing that sensitive individuals can react to many of the chemicals used in these products, many people find themselves with unused household hazardous waste that they need to dispose off properly. Good, usable leftovers of these products can be donated to willing recipients, such as family members, neighbors and community organizations like churches. But others will want to deliver these substances to an appropriate collection center.

The Riverside County Waste Management Department has adopted a Household Hazardous Waste and Oil-Recycling program free to residents, in accordance with the California Integrated Solid Waste Management Act of 1989 (AB 939). The County has established several permanent and temporary regional household hazardous waste collection centers, in addition to Regional Antifreeze, Batteries, Oil (and Filters), and Paint (Latex) (ABOP) Only Collection Centers. These facilities are listed in Table 5-4 below. Personnel who have been trained in hazardous waste handling and emergency response procedures operate these facilities.

At the permanent waste collection centers, a variety of household toxics are accepted, including: chlorine bleach, disinfectants, hair dyes, mercury devices, fiberglass and epoxy resins, paint stripper, paint thinner and turpentine, chemicals used in photo processing, insecticides, pesticides and herbicides, motor oils, rodent poisons, pool/spa chemicals, camp propane tanks, etc. The waste needs to be in its original container or labeled properly. Containers also need to be in good condition, sealed, and not leaking, and the total amount of waste cannot exceed 5 gallons or 50 pounds per trip. Proof of residency in Riverside County is usually required. **For a complete list of acceptable and non-acceptable materials and tips on how to transport these materials, refer to http://www.rivcowm.org/, or call the Household Hazardous Waste Information Hotline at (800) 304-2226**. At the ABOP Only centers, they accept only used motor oil and oil filters, various kinds of batteries including vehicle batteries, antifreeze, and latex paints.

Several other businesses in and around the city of Menifee, such as the Home Depot, UPS Mailing Centers, Office Depot and similar stores may receive and recycle certain kinds of materials such as used batteries, spent light bulbs, and old electronics. To obtain additional information regarding these facilities, their hours of operation, and the types of waste that they receive, call them directly.

Table 5-4: Regional Household Hazardous Waste Collection Centers

Type	Name	Address	Other Information
Permanent Site	Lake Elsinore Regional Permanent HHW Collection Facility	City Maintenance Facility 521 N. Langstaff St., Lake Elsinore 92530	Open 1st Saturday of each month except if holiday weekend; in that case, event is postponed to following Saturday. 9:00 am to 2:00pm. Closed in January and December.
Permanent Site	Agua Mansa Regional Permanent HHW Collection Facility	1780 Agua Mansa Road, Riverside 92509	Non-holiday Saturdays only; 9:00am to 2:00pm.
Temporary Site	Beaumont/ Calimesa/ Hemet/ San Jacinto Area	Lamb Canyon Sanitary Landfill 16411 Lamb Canyon Road, Beaumont 92223	Events held typically 2 times a year: March 20, 2010 and May 22, 2010. 9:00am to 2:00pm.
Temporary Site	Moreno Valley Area City Maintenance Facility	15670 Perris Blvd., Moreno Valley 92251	Events held on May 7 and 8, 2010. 9:00am to 2:00pm.
Regional ABOP Collection Center	Murrieta Area County Road Yard	25315 Jefferson Ave., Murrieta 92562	Non-holiday Saturdays only; 9:00am to 2:00pm

Waste collection, in the form of curbside pick-up, and recycling services in the City of Menifee is provided by **Waste Management**. Their phone number is **(800) 423-9986**, and their websites are http://www.wm.com and http:/www.keepinginlandempireclean.com. The City of Menifee and Waste Management have a series of programs designed to reduce the amount of waste that is taken to the landfill. Their waste reduction and recycling programs include separate containers for grass and composting materials, recyclable materials (paper, glass, aluminum, cardboard, etc.), and non-recyclable trash. Waste Management also picks up and recycles appliances (for an extra fee). Information on which items are recyclable and which are non-recyclable, motor oil recycling and the recycling of electronic waste is provided on Waste Management's websites. The non-recyclable trash is taken to El Sobrante Landfill, a waste disposal facility in Corona that accepts only non-hazardous municipal waste.

There are three land disposal sites in the Menifee General Plan area listed in GeoTracker. These are summarized in Table 5-5 below.

Table 5-5: Land Disposal Sites In and Near the Menifee General Plan Area

Name	Address	Status with Geotracker	GeoTracker ID No.	Comments
BP John Recycling Greenwaste	28700 Matthews, Romoland	Open	L10008871055	No information or site history available on the GeoTracker website.
Soil Treatment	27126 Watson Road,	Completed –	L10003942515	Case was open and closed

Name	Address	Status with Geotracker	GeoTracker ID No.	Comments
	Romoland	Case Closed	L10009809281	on 4/1/1999. No information or site history available on the GeoTracker website.
Double Butte Landfill	Grand Avenue, 600 ft west of Winchester, in Winchester	Open	L10004864228	Municipal solid waste landfill that operated between 1973 and 1994; 2.1 million tons of waste placed. Several groundwater wells are monitored semi-annually for the presence of inorganic compounds detected above background levels.

5.6 Releases due to Transportation Accidents and Pipeline Failures

Interstate 215 (I-215) traverses Menifee in a north-south direction. This freeway is used to transport hazardous materials, posing a potential for spills or leaks from non-stationary sources to occur within the area. Vehicles carrying hazardous materials are required to have placards that indicate at a glance the chemicals being carried, and whether or not they are corrosive, flammable or explosive. The conductors are required to carry detailed "material data sheets" for each of the substances on board. These documents are designed to help emergency response personnel assess the situation immediately upon arrival at the scene of an accident, and take the appropriate precautionary and mitigation measures. The California Highway Patrol is in charge of spills that occur in or along freeways, with Caltrans, and local sheriffs and fire departments responsible for providing additional enforcement and routing assistance.

Although railroad tracks extend across a portion of the city, currently there is no railroad traffic on these tracks. Therefore, train derailments, with the potential for hazardous materials releases, appear to not pose a current concern in Menifee. If the railroad tracks are rehabilitated in the future and used for freight traffic, including the transport of hazardous materials, this section should be revised appropriately.

Several gas transmission pipelines extend across and near the city (https://www.npms.phmsa.dot.gov/searchp/Application.asp). Rupture of any portion of these pipelines could adversely impact the surrounding area. Pipeline operators are responsible for the continuous maintenance and monitoring of their pipelines to evaluate and repair, when necessary, corroded sections of pipe that no longer meet pipeline-strength criteria. All excavations or drilling operations near pipelines, or anywhere else, for that matter, should be conducted only after proper clearance by the appropriate utility agencies or companies. California law requires that all excavations be cleared in advance. This is done locally by the **Underground Service Alert of Southern California,** or **DigAlert** (http://www.digalert.com or www.call811.com). Their telephone number is **8-1-1.** Calls need to be made at least two (2) working days before digging, and the proposed excavation area needs to be delineated or marked.

Pipeline and power line failures during an earthquake are more often the result of permanent ground deformations, including fault rupture, liquefaction, landslides, and consolidation of loose granular soils. Tectonic uplift or subsidence can also impact a pipeline. Seismic shaking typically has less of an impact on buried utilities than it does on aboveground structures. The city of Menifee is not intersected by any known active faults, so the hazard of surface fault rupture and its potential impact on the city's utilities distribution system is low. However, the city is located near two major seismic sources, the San Jacinto fault to the northeast, and the Elsinore fault to the southwest, both of which could generate significant ground shaking in the area. Liquefaction and earthquake-induced settlement as a result of an earthquake on any of these two sources have the potential to locally impact pipelines, power lines, communication towers, and other lifelines that service Menifee.

5.7 Earthquake-Induced Releases of Hazardous Materials

Isolated unauthorized releases of hazardous materials can occur at any time, but natural disasters, such as an earthquake or flood, have the potential to cause several incidents at the same time. For example, as a result of the Northridge earthquake, 134 locations reported hazardous materials issues, 60 of which required emergency responses. The majority of these events occurred where structural damage was minimal or absent (Perry and Lindell, 1995).

A key point to remember regarding the management of hazardous materials spills in the aftermath of an earthquake is that it is substantially more difficult to do so than under non-earthquake conditions. Hazardous material response teams responding to a release as a result of an earthquake have to deal with potential structural and non-structural problems of the buildings housing the hazardous materials, potential leaks of natural gas from ruptured pipes, and/or downed electrical lines or equipment that could create sparks and cause a fire. When two hazards with potentially high negative consequences happen coincidently, the challenges of managing each are greatly increased. During an earthquake response, hazardous material emergencies become an additional threat that must be integrated into the response management system.

5.8 Other Potential Hazardous Materials Release Incidents

Petroleum contains several components that are considered hazardous by the state of California, such as benzene, a known carcinogen. Oil field activities often include the use of hazardous materials like fuels and solvents. Day-to-day practices in some of the earlier oil fields were not environmentally sensitive, and oil-stained soils and other contaminants can often be found in and around oil fields. This typically becomes an issue when the oil field is no longer economically productive, and the property is developed, usually for residential purposes. Assessing the feasibility of developing an oil field property requires comprehensive site investigations in order to accurately identify and characterize any soil and groundwater contamination that may have resulted from the oil field operations. These site investigations are required by local and/or regional environmental laws and regulations, and vary in scope according to applicable government regulations, generally accepted standards of practice, and site-specific conditions (Fakhoury and Patton, 1992).

The major areas of potential environmental concern associated with oil and gas production include:

1. Oil-stained soil (often discolored) that occurs around oil wells and the pumping units.
2. Heavy metals and oil contained in sumps, pits and spill containment areas.
3. Wells and cellars, often built around wells to collect oil spilled during well maintenance or equipment malfunction.
4. Oil releases from above ground and underground storage tanks, often as a result of a pipeline rupture, damage to the tank, or during transfer of crude oil between the storage tank and transport vehicles.
5. Spilled refined fuels used in the operation and maintenance of oil-field vehicles and generators.
6. Tank bottom material used to oil roads. Road oiling was historically a common practice in some oil fields to control dust.
7. Formation water spilled onto the ground surface. Formation water, often containing high concentrations of total dissolved solids (approximating saline water), is often produced as part of the development of an oil field (oil wells typically produce oil, gas and water in varying quantities).

   At least one oil well has been drilled in the Menifee area, based on records from the California Division of Oil, Gas and Geothermal Resources (CDOGGR). A plugged well with API No. 06500080 is shown on the east face of the Double Butte Mountains, west of Cattle Drive. The CDOGGR provides no information on this well, except that it was operated by Ella Chisholm Dorn, and that it is plugged. That the well was plugged suggests that it was either non-producing or economically not significant. Therefore, issues associated with oil and gas production are not anticipated to be significant at this location. Nevertheless, if the area around this oil well is developed at a future date, such as for residential purposes, the area around this well should be evaluated to determine whether or not there are any potential environmental concerns associated with the drilling of this well that need to be addressed.

5.9 Hazard Analysis

The primary concern associated with a hazardous materials release is the short- and/or long-term effect to the public from exposure to the hazardous substance, especially if a toxic gas is involved. The best way to reduce the risk posed by a hazardous material release is enforcement of stringent regulations governing the storage, use, manufacturing, and handling of hazardous materials.

The City of Menifee observes the most current version of the California Fire Code (currently the 2007 edition, although implementation of the 2010 edition is anticipated by January 2011) for usage, storage, handling and transportation requirements for hazardous materials. Risk minimization criteria include secondary containment, segregation of chemicals to reduce reactivity during a release, sprinkler and alarm systems, monitoring, venting and auto shutoff equipment, and treatment requirements for toxic gas releases.

There are currently six reported Significant Hazardous Materials Sites in the Menifee General Plan area. A Significant Hazardous Materials Site includes facilities identified in Federal and/or State databases as Superfund-Active or Archived Sites (CERCLIS), RCRA/RCRIS-EPA registered Large-Quantity Hazardous Waste Generators, and Toxic Release Inventory Sites (TRIs). There are also 23 reported Small-Quantity Generators of hazardous materials in the Menifee General Plan area. Compared to other cities in southern California, Menifee at this time has a relatively small number of facilities that use or store hazardous materials. Nevertheless, several of the existing significant hazardous sites are located within about 1 mile of schools in the community (see Plate 5-1). Furthermore, this is a snapshot in time, and as the city continues to grow, more, especially small-quantity generators of hazardous materials are expected to be located in the area. City planners are advised to encourage the establishment of future significant hazardous materials sites in the city in areas far away from critical facilities with evacuation constraints, such as schools and nursing homes. Facilities that use, store, generate or transport hazardous materials are also expected to come and go; so these lists, or comparable lists, should be updated at least once a year. Residents and property and business owners that are interested in obtaining current data for a particular area or site should request it from the Riverside County Department of Environmental Health, Hazardous Materials Division, or by visiting the appropriate websites referenced herein.

The Menifee area is located within about 6 to 7 miles of both the San Jacinto and Elsinore faults, and about 22 miles, at its closest approach, from the San Andreas fault. The San Jacinto and San Andreas faults are both thought to have a relatively high probability of generating an earthquake in the next 30 years (see Chapter 1). Therefore, all hazardous materials sites in Menifee could be subject to moderate to severe seismic shaking. Their business plans should address, provide and implement mitigation measures designed to reduce the potential for releases of hazardous materials during an earthquake. It has been shown in previous urban earthquakes that hazardous materials spills can occur even when the building does not suffer significant damage. Hazardous material containers not properly secured and fastened could easily be punctured and/or tipped over, pipes may rupture, and storage tanks may fail. Containers may also explode if subject to high temperatures, such as those generated by a fire. Improperly segregated chemicals could react forming a toxic gas cloud. In a worst-case scenario, several hazardous materials releases could occur simultaneously.

Some of the hazardous materials facilities shown on Plate 5-1 are located within the 100-year floodplain (see Plate 3-1). Future hazardous materials facilities should be located outside of the flood zones, unless all standards of elevation, anchoring, and flood proofing have been satisfied, and hazardous materials are stored in watertight containers designed to not float.

5.10 Summary of Findings

National Pollutant Discharge Elimination System (NPDES)

Urban runoff from Menifee discharges into watersheds within both the Santa Ana Regional Board and the San Diego Regional Board jurisdictions; therefore, the city is regulated by municipal separate storm sewer system (MS4) permits issued by both Regional Boards. The City of Menifee is Co-Permittee on Order No. R8-2010-0033, NPDES Permit No. CAS618033, adopted by the Santa Ana Regional Board on January 29, 2010. Under this permit, the Riverside County Flood Control and Water Control District is the Principal Permittee, and the County of Riverside, together with the incorporated cities of Beaumont, Calimesa, Canyon Lake, Corona, Hemet, Lake Elsinore, Menifee, Moreno Valley, Murrieta, Norco, Perris, Riverside, San Jacinto, and Wildomar are Co-Permittees. The parts of the Menifee General Plan area draining into a watershed controlled by the San Diego Regional Board are regulated by Urban Runoff Management Program Order No. R9-2007-001, NPDES Permit No. CAS0108758. The City of Menifee, as Co-Permittee, has several responsibilities defined by the NPDES permit orders.

Superfund, Hazardous Waste, and Toxic Release Inventory Sites
According to EPA data, there are no Superfund (CERCLIS) sites in the Menifee General Plan area. The closest sites include a site in Perris, a site in Hemet, and March Air Force Base. The sites in Perris and Hemet are not considered significantly hazardous and are not on the National Priority List. March Air Force Base has been and is undergoing extensive cleanup. The EPA reports that there are five permitted Large Quantity Generators of hazardous materials, and one possible Toxic Release Inventory (TRI) site in the Menifee General Plan area. The TRI site is listed in the RCRA database, with the most recent information dating to the year 2005. It is possible that this site no longer releases to the environment the compounds that it reported in 2005, which would explain why it is not in the 2008 TRI database. These databases should be reviewed periodically to obtain the most recent information for the area. As of March 2010, there were 23 permitted Small-Quantity Generators of hazardous materials located throughout the city. This figure is expected to increase as the city grows. There are also four transporters of hazardous waste registered in the Menifee area.

Hazardous Materials Disclosure Program
Both the Federal government and the State of California require businesses that handle more than a specified amount of hazardous materials or extremely hazardous materials, termed a reporting quantity, to submit a business plan to the local Certified Unified Program Agency (CUPA). In Menifee, the local CUPA is the Riverside County Department of Environmental Health, Hazardous Materials Division, (RCDEH-HMD); they are responsible for reviewing the annually submitted business plans. For more information refer to their website (http://www.rivcoeh.org/), or contact them by phone at (888) 722-4234 (888-RC-CHA-EH).

Leaking Underground Fuel Tanks
According to data from the State Water Quality Control Board, 20 leaking underground storage tank (LUST) sites were reported in Menifee between 1983 and 2006. Twelve of these LUST sites have been remediated and/or considered to not pose a risk to human health and the environment; their cases have been closed by the appropriate regulatory agency. The remaining eight are in various states of assessment and/or remediation. Twelve of these sites reportedly impacted the groundwater in an aquifer used for drinking water purposes. The remaining sites impacted the surrounding soil only (see the Statewide database, GeoTracker, which is available at http://geotracker.swrcb.ca.gov/). The California Regional Water Quality Control Board (CRWQCB), in cooperation with the County of Riverside Department of Environmental Health – Hazardous Materials Division provides oversight and conducts inspections of all underground tank removals and installation of new ones (http://www.rivcoeh.org/opencms/rivcoeh/ProgServices/EPO_Division/EPO_Home.html). Given that there are at least 23 permitted underground storage tanks in the city, future leaks could be reported. The GeoTracker database should be reviewed periodically for updates.

Water Quality
The Eastern Municipal Water District (EMWD) provides drinking water to the residents of Menifee (with the exception of those residents that have their own water wells). According to the EPA Safe

Drinking Water Violation Report, the EMWD has not had any violations reported in the last ten years. Compared to State statistics for drinking water violations, the EMWD's record is very good. Perchlorate at concentrations between 1.7 and 13.0 parts per billion has been detected in some wells of the EMWD system. Thee of the wells have concentrations of perchlorate that exceed the Maximum Contaminant Level established by California of 6 μg/L (equivalent to parts per billion). Water from these wells is blended with that of other wells, or with water from the Colorado River, to achieve levels of perchlorate less than 4 μg/L. According to the EMWD, the water from these three wells represents less than 1.7% of the total water served by them. For additional information, and progress reports regarding this issue, refer to the EMWD's website at http://www.emwd.org/.

Household Hazardous Waste
Riverside County has adopted a Household Hazardous Waste and Oil-Recycling program that is free to county residents, in accordance with the California Integrated Solid Waste Management Act of 1989. There are a few permanent and temporary facilities in the region where residents from Menifee can drop off their unwanted household hazardous waste. For a list of collection sites, schedules, and types of materials accepted, refer to the Riverside County Waste Management Department at http://www.rivcowm.org/ or call the Household Hazardous Waste Information Hotline at (800) 304-2226. The City of Menifee, together with Waste Management, their trash hauler, have programs designed to reduce the amount of waste taken to the El Sobrante landfill in Corona. Waste reduction and recycling programs include: curb-side collection service with separate containers for grass clippings and composting materials, recyclables, and non-recyclable trash. For additional information regarding the services provided by Waste Management refer to their websites at http://www.wm.com and http:/www.keepinginlandempireclean.com, or call (800) 423-9986.

There is one now closed landfill in the Menifee General Plan area, the Double Butte Landfill. This facility operated as a municipal solid waste landfill between 1973 and 1994. Several groundwater wells onsite and offsite, near the landfill, are monitored semi-annually for the presence of inorganic compounds that may be leaking out of the landfill and impacting the local water resources. The California Regional Water Control Board has an open file on this site that can be accessed on the GeoTracker website. Two other land disposal sites in the General Plan area are identified by the Regional Water Board, but there is little information regarding these sites with the exception of their name and address.

Releases due to Transportation Accidents and Pipeline Failures
Interstate 215 is used to transport hazardous materials, including Class I explosives. Other internal roads may also be used to transport hazardous materials. This poses a potential for spills or leaks from a non-stationary source in the event of an accident involving a vehicle carrying hazardous substances. All transportation of hazardous materials needs to be conducted under strict protocol. Material data sheets for each substance being transported need to be carried by the conductor. These data sheets are designed to help emergency response personnel identify the most appropriate action to contain the specific substances involved in the spill. The California Highway Patrol is in charge of spills that occur in or along freeways, with Caltrans, the local sheriffs and fire departments providing additional resources as needed.

Although railroad tracks extend across a portion of the Menifee area, as of the writing of this document, it appears that there is no railroad traffic on these tracks. Therefore, train derailments, with the potential for hazardous materials releases, is currently not a concern in Menifee.

Several gas transmission lines extend across and near the Menifee General Plan area. Rupture of any portion of these pipes could adversely impact the surrounding area. Rupture of sections of these pipelines could occur if there is significant ground failure, in the form of liquefaction or slope failure, as a result of a large regional earthquake. Pipeline operators are responsible for the continuous maintenance and monitoring of their pipelines, including the repair, when necessary, of corroded sections of pipe. All excavations or drilling operations near pipelines should be conducted only after proper clearance by the appropriate utility agencies or companies. California law requires that all excavations be cleared – this is done by the Underground Service Alert of California or DigAlert (http://www.digalert.com or www.call811.com). Their telephone number is **8-1-1.** Calls need to be made at least two (2) working days before digging, and the proposed excavation area needs to be delineated or marked.

Oil Fields

There are no oil fields in or near Menifee, although one plugged well was mapped on the east side of Double Butte Mountain. Environmental issues associated with oil fields are not anticipated in the city.

Hazard Analysis

The primary concern associated with a hazardous materials release is the short- and/or long-term effect to the public from exposure to the hazardous materials released. The best way to reduce the possibility for a hazardous material release is by implementing and enforcing stringent regulations governing the storage, use, manufacturing and handling of hazardous materials. There are no known active faults in the Menifee area, so surface fault rupture is not considered a hazard for these sites.

However, the entire city of Menifee will be subjected to moderate to intense ground shaking as a result of an earthquake on any of several nearby earthquake sources, especially the San Jacinto, Elsinore and Andreas faults (for more information refer to Chapter 1). It has been observed in previous urban earthquakes that hazardous materials spills can occur even when the building housing the materials does not suffer significant damage. Hazardous material containers not properly secured and fastened can easily be punctured and/or tipped over. Improperly segregated chemicals could react, forming a toxic gas cloud. In a worst-case scenario, several hazardous materials releases could occur simultaneously. Therefore, hazardous material sites in Menifee should be designed with secondary containment systems, tank bracing systems, and other engineering solutions to reduce the potential for tanks and containers to tip over during an earthquake. All business plans for sites within the city should address the hazard of intense ground shaking and identify specific measures to be taken to reduce this hazard to an acceptable level.

Some of the significant hazardous materials sites identified in Menifee are located within or near the 100-year flood zones. It is recommended that future hazardous materials sites established in Menifee not be located in the floodplain, unless very specific containment measures are implemented to reduce the potential for hazardous materials to leak during a flood. Furthermore, street flooding as a result of intense storms and inadequate storm drain capacity could result in the flooding of some of the hazardous materials facilities not within the mapped floodplain. Therefore, the business plans for all hazardous materials businesses should address the hazards of flooding and of strong ground shaking during an earthquake, and provide for mitigation measures to be implemented to reduce the potential for hazardous materials to leak during a natural disaster.

Several of the existing significant hazardous materials sites are also located within 1 mile of schools and other facilities with populations with special evacuation needs (such as nursing homes). It is advisable to encourage the establishment of any future significant hazardous materials sites in areas far away from critical facilities with evacuation concerns. Furthermore, these critical facilities should have plans that include protocol to be followed in the event of a leak of hazardous materials that would require them to evacuate.

CHAPTER 6: WIND HAZARDS

6.1 Setting and Definitions

Severe windstorms can pose a significant risk to property and life by creating conditions that disrupt essential systems such as public utilities, telecommunications, and transportation routes. High winds can and do occasionally cause damage to local homes and businesses. This section discusses the specific hazards associated with unusual and potentially damaging wind activity based on scientific data and historical records. In the Menifee area, strong winds may be associated with Santa Ana conditions, thunderstorm-related strong winds and tornadoes, and macrobursts and microbursts. Each of these strong wind conditions is discussed further in the subsections below.

Wind is air that is in motion relative to the earth. It generally has both horizontal and vertical components, but the horizontal component generally dominates (National Research Council, Committee on Natural Disasters – NRC,CND, 1993). Due to friction, wind speed drops off at the ground surface, with approximately 50% of the transition in wind speed due to the frictional forces exerted by the ground surface occurring in the first 6 feet above the ground. As a result, "near-surface wind is the most variable of all meteorological events" (NRC,CND, 1993), and it generally consists of a combination of high-frequency oscillations in both speed and direction superimposed on a more consistent flow with a prevailing speed and direction. With an increase in wind speed, the high-frequency oscillations can become more abrupt and of greater amplitude – these are referred to as wind gusts. Because wind speeds vary as a function of height, time and the terrain upwind, it is difficult to obtain a value that is representative of the wind speeds over a large region. The recommended convention for measuring wind speed is at a height of 33 feet (10 m), in a flat, open terrain, such as that provided by an airport field. Temporal variations are taken into account by averaging speed and direction over a given time, typically 1-minute averages for sustained wind, and 2 to 5-second averages for peak or extreme winds. The mean annual wind speed for the contiguous 48 states is 8 to 12 miles per hour (mph), with most areas of the country frequently experiencing 50-mph winds (NRC,CND, 1993).

To better appreciate the impact that wind has on the sea and land, and the wind speeds required to move different objects, refer to the Beaufort Scale in Table 6-1, below. This scale was developed by Sir Francis Beaufort in 1805 to illustrate and measure the effect that varying wind speed can have on sea swells and structures. Note that the highest wind speeds in the Beaufort Scale approach the lowest wind speed on the Fujita Scale presented in Table 6-2.

Table 6-1: The Beaufort Scale

Beaufort Force	Wind Speed (mph/ knots)	Wind Description – State of Sea – Effects on Land
0	< 1; <1	Calm – Mirror-like – Smoke rises vertically.
1	1 - 3 / 1 - 3	Light – Scaly ripples; no foam crests – Smoke drifts show direction of wind, but wind vanes do not.
2	4 - 7 / 4 - 6	Light Breeze – Small but pronounced wavelets; crests do not break – Wind vanes move; leaves rustle; you can feel wind on face.
3	8 - 12 / 7 - 10	Gentle Breeze – Large wavelets; crests break; glassy foam; a few whitecaps – Leaves and small twigs move constantly; small, light flags are extended.
4	13 - 18 / 11 - 16	Moderate Breeze – Small (1-4 ft) waves; numerous whitecaps – Wind lifts dust and loose paper; small tree branches move.
5	19 - 24 /	Fresh breeze – Moderate (4-8 ft) waves taking longer to form; many whitecaps;

Beaufort Force	Wind Speed (mph/ knots)	Wind Description – State of Sea – Effects on Land
	17 - 21	some spray – Small trees with leaves begin to move.
6	25 - 31 / 22 - 27	Strong Breeze – Some large (8-13 ft) waves; crests of white foam; spray – Large branches move; wires whistle.
7	32 - 38 / 28 - 33	Near Gale – Sea heaps up; waves 13-20 ft; white foam from breaking waves blows in streaks with the wind – Whole trees move; resistance felt walking into the wind.
8	39 - 46 / 34 - 40	Gale – Moderately high (13-20 ft) waves of greater length; crests break into spin drift, blowing foam in well-marked streaks; Twigs and small branches break off trees; difficult to walk.
9	47 - 54 / 41- 47	Strong Gale – High waves (20 ft) with wave crests that tumble; dense streaks of foam in wind; poor visibility from spray – Slight structural damage; shingles blow off roofs.
10	55 - 63 / 48 - 55	Storm – Very high (20-30 ft) waves with long, curling crests; sea surface appears white from blowing foam; heavy tumbling of sea; poor visibility – Trees broken or uprooted; considerable structural damage.
11	64 – 73 / 56 - 63	Violent Storm – Waves high enough (30-45 ft) to hide small and medium-sized ships; sea covered with patches of white foam; edges of wave crests blown into froth; poor visibility – Seldom experienced inland; considerable structural damage.
12	> 74 / > 64	Hurricane – Sea white with spray; foam and spray render visibility almost non-existent; waves over 45 ft high – Widespread damage; very rarely experienced on land.

Sources: www.spc.noaa.gov/faq/tornado/beaufort.html; http://www.stormfax.com/beaufort.htm

6.1.1 Santa Ana Winds

Most incidents of high wind in southern California are the result of **Santa Ana wind** conditions. Santa Anas are generally dry, often dust-bearing, winds that blow from the east or northeast toward the coast, and offshore (Figure 6-1). These winds commonly develop when a region of high atmospheric pressure builds over the Great Basin – the arid high plateau that covers most of Nevada and parts of Utah, between the Sierra Mountains on the west and the Rocky Mountains to the east. Clockwise circulation around the center of this high-pressure area forces air downslope from the plateau. As the air descends toward the California coast, it warms at a rate of about 5 degrees Fahrenheit per 1,000 feet elevation. Since the air originates in the high deserts of Utah and Nevada, it starts out already very low in moisture; as it is heated, it dries out even further. The wind picks up speed as it hits the canyons and passes in the coastal ranges of southern California, blowing with exceptional speed through the Santa Ana Canyon (from where these strong winds derive their name). Forecasters at the National Weather Service usually reserve the use of "Santa Ana" winds for those with sustained speeds over 25 knots (1 knot = 1.15 mph); as they move through canyons and passes, these winds may reach speeds of 35 knots, with gusts of up to 50 to 60 knots (see Table 6-1).

6.1.2 Thunderstorm-Related Tornadoes

A variety of mechanisms give rise to **thunderstorms**, but most often, these develop when warm, moist air meets a cold front, often producing strong winds, tornadoes, and hail. More than 100,000 thunderstorms occur every year in the United States. Most of these occur in the central Great Plains and the southeastern coastal states, but thunderstorms do occur in every state. A thunderstorm is officially labeled as severe if 1) it produces a tornado, 2) has winds in excess of 58 mph, or 3) produces surface hail greater than 0.75 inch in diameter. According to the National Research Council's Committee on Natural Disasters (NRC-CND, 1993), about 10,000 severe thunderstorms occur in the United States each year, resulting in annual property losses in excess of $1 billion. An exceptionally severe thunderstorm can generate several tornadoes and downbursts.

Tornadoes are "violently rotating columns of air extending from a thunderstorm to the ground (http://www.nssl.noaa.gov/edu/safety/tornadoguide.html; see Figure 6-2). Although tornadoes occur in many parts of the world, they are most common during the spring and summer months in the Central Plains of the United States, east of the Rocky Mountains. In the spring, tornadoes often form where warm, moist air from the east meets hot, dry air from the west (this boundary is called a "dryline"). In the winter and early spring, tornadoes can form when strong frontal weather systems originating in the Central states move eastward. Thunderstorms, and associated tornadoes, can also form at the range front, where near-ground air is forced to move "upslope" along the ascending mountain slopes. In California, tornadoes are occasionally generated by strong storms. The worst of these in southern California have occurred in the fall or winter. Although the number of tornadoes reported in California is only a fraction of those reported in the central states, California does get its share of these. In the 30 years between 1959 and 1988, 133 tornadoes were reported in California, for an average of 4 tornadoes a year (NRC-CND, 1993).

Tornadoes can also accompany tropical storms and hurricanes as they move on land, where they usually occur ahead of the path of the storm center as it comes onshore (http://www.nssl.noaa.gov/edu/safety/tornadoguide.html). Weak tornadoes that form over warm water are called **waterspouts**. Occasionally, waterspouts can move on land and become tornadoes. **Funnel clouds** are cone-shaped or needle-like clouds that extend downward from the main cloud base but do not extend to the ground surface. If a funnel cloud touches the ground, it becomes a tornado; if it touches or moves across water, it is a waterspout. Waterspouts that have moved onto land are more often reported in southern California in the fall and winter, but some have also been reported in the spring. For example, on April 6, 1926, a waterspout that came on land at National City, near San Diego, unroofed several homes and injured eight people; one on February 12, 1936 unroofed two homes, blew down five oil derricks and injured six.

To measure the intensity, area and strength of a tornado, in 1973 Dr. Ted Fujita (then with the University of Chicago) and Allen Pearson (at the time director of the National Severe Storm Forecast Center) introduced the Fujita-Pearson Tornado Intensity Scale (see Table 6-2). An improvement over the scale first published by Dr. Fujita in 1971, this scale compared the estimated wind velocity with the corresponding amount of damage to human-built structures and vegetation observed (the component first introduced by Fujita) and the width and length of the tornado path (the component added by Pearson). The scale classified tornadoes into six practical levels (from F0 to F5) with larger numbers indicating more damaging and larger tornadoes (the Fujita scale smoothly divided wind speed between the highest Beaufort level and Mach 1.0 into 12 levels – F0 through F-12, but recognized that an F6 tornado would be inconceivable, and indeed no tornado above F5 has even been measured.

Figure 6-1: View From Space of Smoke from the October 2003 fires in Southern California, carried Offshore by Strong Santa Ana winds

Source: Image by Jacques Descloitres, MODIS Rapid Response Team at NASA/GSFC, obtained from the archives at http://visibleearth.nasa.gov/

Figure 6-2: View of a Tornado

Source:
http://www.photolib.noaa.gov/700s/nssl0123.jpg

The Fujita-Pearson scale was used to classify all tornadoes reported after its introduction, in addition to retroactively classify all tornadoes reported since 1950 that were contained in the National Oceanic and Atmospheric Administration's (NOAA) national tornado database.

Table 6-2: The Fujita-Pearson Tornado Damage Scale

Scale	Wind Speed Estimate (mph)	Average Damage Path Width (feet)	Typical Damage
F0	40 - 72	30 - 150	Light damage (gale tornado). Some damage to chimneys and television antennas; twigs and branches break off trees; winds push over shallow-rooted trees; sign boards are damaged.
F1	73 – 112	100 - 500	Moderate damage (weak tornado). Winds peel off roofs; windows break; light trailer homes are pushed off their foundations or overturned; some trees are uprooted or snap; moving autos are pushed off the road; attached garages may be destroyed. Hurricane speed starts at 74 mph.
F2	113 – 157	360 - 820	Considerable damage (strong tornado). Roofs are torn off frame houses, leaving strong walls upright; weak rural buildings are

Scale	Wind Speed Estimate (mph)	Average Damage Path Width (feet)	Typical Damage
			demolished; trailer homes are destroyed; large trees snap or are uprooted; railroad boxcars are pushed over; light objects become airborne missiles; cars are blown off highways.
F3	158 – 206	650 – 1,650	Severe damage (severe tornado). Roofs and some walls are torn off well-constructed frame structures; some rural buildings are completely demolished; trains are overturned; steel-framed hangars and warehouse-type structures are torn; cars are lifted off the ground; most trees are uprooted, snapped or leveled.
F4	207 – 260	1,300 – 3,000	Devastating damage (devastating tornado). Well-constructed frame houses are leveled, leaving piles of debris; steel structures are badly damaged; trees are de-barked by small flying objects; cars and trains are thrown some distances or roll considerable distances; large objects become missiles.
F5	261 – 318	~ 3,600	Incredible damage (incredible tornado). Strong, whole frame houses are lifted off their foundations and carried considerable distances; steel-reinforced concrete structures are badly damaged; automobile-sized missiles are generated and carried through the air > 100 meters; trees are debarked.
F6	319 – 379		Inconceivable damage: These winds are unlikely. Should a tornado with maximum speed in excess of F5 occur, the extent and type of damage may not be conceived. A number of airborne missiles, such as refrigerators, water heaters, storage tanks, automobiles, etc. create serious secondary damage on structures.

Fujita's wind estimates have since been found to be inaccurate, with the original wind speed estimates higher than the wind speeds actually required to incur the damage described in each category, especially for tornadoes classified as F3 or larger. In response to these criticisms, a new Enhanced Fujita (EF) Scale for tornado damage was developed between 2004 and 2006. The EF scale, which was officially implemented in the United States on February 1, 2007, is considered an improvement over the old scale: engineers and meteorologists estimated the wind speeds in the new scale (although actual speed winds have not been empirically measured), and records of past tornadoes were reviewed to better equate the wind speeds with the storm damage reported. The new scale also includes more types of structures and vegetation in the damage assessment, and better accounts for differences in construction quality. Similar to the original Fujita scale, the EF Scale also has six levels of tornado damage, EF-0 to EF-5 (see Table 6-3). A researcher assigning a level of damage to a tornado using the EF scale needs to refer to a list of 28 different damage indicators (DI) or types of structures and vegetation, and then the degree of damage (DoD) for ach. Damage indicators include barns or farm outbuildings, residences, manufactured homes (with distinctions made for single-wide and double-wide), apartments, masonry buildings, strip malls, automobile lots, elementary schools, low-, middle- or high-rise buildings (each a different category of indicator), electrical transmission lines, free-standing towers, and softwoods or hardwood trees. The new scale is likely to be modified or updated as new tornado data become available.

Table 6-3: Enhanced Fujita Scale

Scale	Wind Speed Estimate		Relative Frequency (%)
	mph	Km/h	
EF-0	65 - 85	105 - 137	53.5
EF-1	86 - 110	138 - 178	31.6
EF-2	111- 135	179 – 218	10.7
EF-3	136 – 165	219 – 266	3.4
EF-4	166 – 200	267 – 322	0.7
EF-5	> 200	> 322	< 0.1

6.1.3 Macrobursts and Microbursts

Storm researcher Dr. Ted Fujita first coined the term "**downburst**" to describe a strong, straight-direction surface wind in excess of 39 miles per hour (mph) caused by a small-scale, strong downdraft from the base of a thundershower and thunderstorm cell. Unlike tornadoes, the origin of a downburst is downward-moving air from a thunderstorm's core (as opposed to the upward movement of air associated with tornadoes). Downbursts are further classified into macrobursts and microbursts.

Macrobursts are downbursts with winds up to 117 mph that spread across a path greater than 2.5 miles wide at the surface, and which last from 5 to 30 minutes. **Microbursts** are confined to smaller areas, less than 2.5 miles in diameter from the initial point of downdraft impact. An intense microburst can result in winds near 170 mph but often last less than five minutes. Like tornadoes, microbursts can do significant damage: When a microburst hits an object on the ground, such as a house or tree, it can flatten the building and strip the limbs and branches off of the tree. After striking the ground, the powerful outward-running gust can generate significant damage along its path. Damage associated with a microburst appears to have been caused by a tornado, except that the damage pattern away from the impact area is characteristic of straight-line winds, rather than the twisted patter typical of tornado damage.

Microbursts are particularly dangerous to aircraft landing or taking off, and have caused several planes to crash, with resultant loss of life. Microbursts have also been responsible for capsizing and sinking ships, causing structural damage in many communities, lifting roofs off of structures, downing electrical lines, and generally causing millions of dollars in damage. Most of the microbursts reported have occurred in the northeastern and central parts of the United States, including New York, New Jersey, Massachusetts, Ohio, and Kansas, but microbursts have also been reported in Arizona and Utah (http://en.wikipedia.org/wiki/Microburst#Danger_to_aircraft). On March 29, 1998, in a Lake Elsinore neighborhood, an apparent microburst uprooted a tree and ripped two 20-foot sections of roofing tiles from a home. A funnel cloud was also spotted that afternoon near Dulzura, to the east-southeast of the city of San Diego.

6.2 Historic Southern California Windstorms

Santa Ana winds are common in the southern California area, with Santa Ana conditions expected yearly in the region, typically in the fall through early spring. Typically these winds are mostly a nuisance, bringing dust indoors, breaking tree branches, and causing minor damage. For people with respiratory ailments, however, Santa Ana winds often mean headaches, sinus pain, difficulty breathing, and even asthma. Strong Santa Ana winds can cause extensive damage to trees, utility poles, vehicles and structures, and can even be deadly. For example, in 2003, two deaths were blamed on these strong winds: a falling tree struck and killed a woman in San Diego, and a passenger in a vehicle was struck by a flying pickup truck cover (http://cbsnews.com/ January 8, 2003 article). Wildfires in the region often occur during Santa Ana wind conditions, when the air humidity is low to very low. Because the winds fan and help spread these fires, Santa Ana wind conditions are always a serious concern to fire fighters.

Strong winds are also reported in the winter, typically associated with winter storms emanating from Alaska and Canada. The high desert areas are subjected to high winds associated with short-duration tropical thunderstorms emanating from the south. These storms typically occur in the summer months, between July and September.

As of the writing of this document, the National Climatic Data Center (NCDC) lists 202 high wind events and thunderstorms in Riverside County between 1973 and October 31, 2009 (http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms). Starting around 1994, the database provides more specific location information for these storms. Storms that impacted the Menifee area and vicinity are listed below, in addition to exceptional historical storms that impacted the southern California area, causing extensive damage either directly, or indirectly, by fanning wildfires that consumed thousands of acres and destroyed many homes. Please note that this list will most likely not include all damaging windstorms that have impacted the Menifee area in the last three decades, as some events may have been so localized as to have not made it into the National Climatic Data Center database.

Table 6-4: Major Southern California Windstorms (1858-2008) and Strong Winds Reported in the Menifee Area (1993-2009)

Date	Location and Damage
October 2, 1858	Category 1 hurricane hits San Diego. Sustained winds to 75 mph are estimated based on the extensive damage to property reported.
May 23, 1932	Strong winds and low humidity result in 12 serious brush fires, blackening nearly 2,000 acres in San Diego County. The biggest fire was in Spring Valley.
September 24-25, 1939	Tropical storm that lost hurricane status shortly before moving onshore at San Pedro had sustained winds of 50 mph. At least 48 people died when the boats they were in sunk.
April 13, 1956	Strong storm-related winds hit Chula Vista caused roof damage to 60 homes and one school. Trees were uprooted, TV antennas were toppled and windows shattered. Flying glass injured 2. Fish sucked out of San Diego Bay and deposited on the ground. Possible tornado.
November 21-22, 1957	Extremely destructive Santa Ana winds produced a 28,000-acre brush fire west of Crystal Lake.
November 5-6, 1961	Strong Santa Ana winds fanned fires in Topanga Canyon, Bel Air and Brentwood; 103 firemen were injured; $100 million in economic losses, including 484 buildings (mostly residential) and 6,090 acres scorched.
January 18-28, 1969	Strong storm winds caused power outages and felled trees in southern California; 4 people were killed by downed trees.
September 26-29, 1970	Gusts to 60 mph in Cuyamaca Rancho State Park. Fires from Cuyamaca to Alpine, including the Laguna Fire, resulted in 400 homes destroyed, 185,000 acres burned, and 8 killed.

Date	Location and Damage
August 3, 1973	Thunderstorm winds with gusts to 88 knots (100 mph) reported in Riverside County.
September 10, 1976	Hurricane Kathleen brought to the Southwest the highest sustained winds associated with an eastern Pacific tropical cyclone ever recorded; sustained winds of 57 mph at Yuma, Arizona.
November 30 – December 1, 1982	Widespread strong winds associated with a big storm left 1.6 million homes without power.
March 26, 1984	Wind gusts to 60-90 mph in the Mojave Desert caused power outages and road closures. Car had its windows blown out; another had a door ripped off. Peak gusts of 103 mph at Mojave; 66 mph in Daggett.
September 8, 1986	Thunderstorm winds with gusts to 75 knots (86 mph) reported in Riverside County.
January 20, 1987	Wind gusts to 80 mph below Cajon Pass, 70 mph in San Bernardino, 60 mph in Mt. Laguna, and 40 mph at El Toro. Winds cause thick dust clouds; trucks blown over; trees toppled. 100 power poles downed in the Inland Empire. Numerous power outages force school closures. Brush fires started.
March 15, 1987	Widespread strong storm winds; winds to 25-35 mph sustained all day, gusts to 40 mph in San Diego. Power outages reported all over the San Diego metropolitan area; motor homes toppled in the desert; light standard fell over onto cars in Coronado; boats flipped over in harbors; a 22-foot boat turned over at Mission Beach jetty; Catalina cruise ships delayed, stranding 1,200 tourists there.
December 12-13, 1987	Strong Santa Ana winds in San Bernardino and Riverside counties, with 60-80 mph gusts. 38-mph winds recorded in San Diego. 80 power poles blown down within a ½-mile stretch in Fontana and Rancho Cucamonga; downed tree limbs damaged cars, homes and gardens; 1 injured when tree fell on truck; power poles and freeway signs damaged; parked helicopter blown down a hillside in Altadena; trees downed and power outages in San Diego County. In Spring Valley, 1 person died when eucalyptus tree fell on truck.
December 15, 1987	Strong storm winds with gusts to 100 mph at Wheeler Ridge, 80 mph in San Bernardino County; up to 70-mph gusts at Point Arguello; 60-mph gusts in Orange County and the San Gabriel Mountains. One truck overturned.
January 21-22, 1988	Strong offshore winds following a major Pacific storm with gusts to 80 mph at the Grapevine, 60 mph in Ontario, and 80 mph in San Diego County. Power poles, road signs and big rigs knocked down in the Inland Empire. In San Diego County, 6 injured; roofs blown off houses, trees toppled, and crops destroyed. Barn demolished and garage crushed by tree in Pine Valley; 20 buildings damaged or destroyed at Viejas; avocado and flower crops destroyed at Fallbrook and Encinitas, respectively, with 5 greenhouses damaged in Encinitas.
February 16-19, 1988	Very strong Santa Ana winds with gusts to 90 mph in Newport Beach, 70+ mph in the San Gabriel Mountain foothills; gusts to 76 mph at Monument Peak – Mt. Laguna; 63 mph at Ontario, and 50 mph at Rancho Cucamonga. Numerous trees and power lines downed resulting in power outages along the foothills of the San Gabriel and San Bernardino Mountains. Mobile home overturned and shingles torn off roofs in Pauma Valley; Fontana schools closed due to wind damage; 3 killed when truck overturned and burned; 1 killed when stepped on downed power line. Power outages impacted 200,000

Date	Location and Damage
	customers in Los Angeles and Orange Counties. Grass fires. Roof damage widespread in communities around Glendale and Burbank, and at John Wayne Airport. Boats torn from moorings at Newport Harbor.
December 8, 1988	Strong Santa Ana winds across southern California, with gusts to 92 mph at Laguna Peak. Winds fanned several major fires; buildings were unroofed; trees and power lines downed. $20 million in estimated damages.
November 28, 1989	Strong Santa Ana winds with gusts to 70 mph at the Rialto Airport. Several tractor-trailer trucks were overturned east of Los Angeles.
December 11, 1989	Strong Santa Ana winds with gusts to 100 mph near the Grapevine. Winds reduced visibility to near zero in the desert areas and closed major interstate highways east of Ontario.
August 11, 1990	Thunderstorm winds with gusts to 65 knots (75 mph) reported in Riverside County.
September 5, 1991	Thunderstorm winds with gusts to 60 knots (69 mph) reported in Riverside County.
October 26-27, 1993	Strong Santa Ana winds with gusts to 62 mph at Ontario. Twenty fires in the southern California area, including the Laguna Hills Fire. 4 dead, 162 injured, $1 billion in property losses alone; 194,000 acres destroyed.
November 25 and 29, 1996	Thunderstorms and strong winds throughout the southern California area, from San Diego to Ventura counties, and inland, with wind gusts to 85 knots (>100 mph). Strong northwest winds on the 29th developed across the region, with sustained northwest winds of 30-40 mph, and gusts up to 60 mph. Numerous trees and power lines were blown down.
December 14, 1996	Strong Santa Ana winds with gusts to 111 mph at Fremont Canyon, 92 mph in Rialto, toppled trees and electric poles, smashed windows, knocked out power to tens of thousands across southern California. 2 deaths in Fontana; one man killed by a live powerline that was blown on him; second died when a tree branch fell onto his van. Minor injuries (3 total) in Orange and San Diego counties. Injury in San Diego County occurred on Hwy. 78, just east of Ramona. In Crestline, radio tower was blown down and the roof blown off the transmitter building. I-15 near Devore, where two trailers flipped, closed for 15 hours. In San Diego County, winds knocked down 0.5 million pounds of avocados off of trees; most could not be marketed, resulting in great economic losses to avocado farmers.
December 17, 1996	Santa Ana winds with gusts to 66 knots downed trees and power poles. In Rancho Cucamonga, winds toppled a 500,000 kilovolt electric power, sparking a fire that burned 250 acres and forced evacuation of 80 homes. Elsewhere, including Riverside County, the winds toppled trees and power poles, which caused minor damage and power outages to thousands.
January 6, 1997	High winds to 86 knots throughout southern California injured four: three students at the CSU campus at San Bernardino and a man that suffered cuts when his trailer overturned. Fourteen tractor trailer rigs tipped over in the I-15 between Devore and Corona forcing closure of the freeway; over 900,000 customers lost power; vehicle pile-ups in the Coachella Valley.

Date	Location and Damage
January 29, 1997	Santa Ana winds with gusts to 100 mph in Fremont Canyon, 87 mph in Rialto cause big rigs on the freeway to be blown over.
September 2, 1997	Winds flowing around a strong upper-level high-pressure area over the southern United States brought several days of mountain and desert thunderstorms to southern California. Strong winds knocked out power and fires ignited by lightning occurred in San Bernardino and the **Hemet** area.
October 13-14, 1997	Santa Ana winds with sustained 30-40 mph winds and frequent gusts over 60 mph developed below Cajon Pass, in Orange County, and valley areas of San Bernardino and Riverside counties. Fire in Orange County burned almost 6,000 acres and destroyed two buildings. Trees and power lines blown down in Rialto and Fontana; a shed was destroyed at the Banning/Beaumont border.
December 10-12, 1997	Santa Ana winds with gusts to 96 mph at Pine Valley; 87 mph in Upland. Flying debris killed 2 construction workers, one in Riverside, another in Irvine. Fish farm in **Sun City** reported more than $1 million in structural damages; extensive damage to the avocado crop; boats damaged and sunk at Coronado and Avalon.
December 18-22, 1997	Gusts to 60 mph in Rialto; 67 mph at Idyllwild and below Cajon Pass. One person killed when he lost control of his van because of strong wind gust; passenger injured. Fires, downed trees, and widespread wind damage reported throughout the area. More than 9,500 homes and businesses without power in Ontario, Rancho Cucamonga, Fontana, and Chino. On the 22nd, strong winds toppled at least 6 trucks on the I-15 and 60 freeways.
December 28, 1997	Santa Ana winds snapped a dozen power poles near Corona, cutting power to dozens of rural customers. In Riverside, a tree crushed a parked vehicle and damaged a home. In Mira Loma, 12 power poles blew down, cutting power to hundreds and forcing the closure of Hamner Avenue for two days. Blowing dust and debris restricted visibility creating hazardous conditions on the I-15.
February 3-4, 1998	Strong storm winds with gusts to 60 mph and heavy downpours. The strongest winds were clocked in Orange County and the mountains of San Bernardino County in advance of the storm. Wind gusts to 60 mph downed trees and caused scattered power outages. Moderate to heavy rain flooded intersections in coastal areas; snow fell as low as 4,500 feet. Two young illegal immigrants near Campo died from exposure to strong winds, cold temperatures and rain.
August 9, 1998	High-pressure zone over the Southwest US fed moist, unstable air into the mountains of southern California. A thunderstorm moved over the **Hemet** area dropping one inch of rain in ½ hour. Trees were uprooted in Moreno Valley, and a motel in Riverside lost a 30x90 foot section of its composite roof and a tree snapped and fell on a car. 2,000 customers were without electric power as a result of downed power lines.
August 12, 1998	Strong thunderstorms developed over the mountains of Riverside County and moved through the San Jacinto Valley, producing 70-mph winds and ¾-inch diameter hail. The winds toppled trees and snapped power poles, disrupting electric service to some 12,000 customers for up to six hours. Winds at **Hemet**-Ryan Airport were clocked at 62 mph where the roof was lifted off the pilot ready-room. Extensive damage occurred to trees, and six trailer homes were damaged at the Hemet

Date	Location and Damage
	West Mobile Estates.
August 31, 1998	Strong thunderstorms caused extensive flooding in the inland areas of southern California. The hardest hit area was **Hemet**, where many massive trees were uprooted or torn apart, shingles were blown off roofs, and fences were toppled. Water was running over a foot deep through the streets, and flowed through the Hemet High School gymnasium. The combination of wind-blown power lines and lightning sparked numerous grass and brushfires. 4,800 acres were burned in Ramona, forcing the evacuation of hundreds of people. In the Juniper Flats area, 6,000 acres burned, destroying 44 residences, 46 other structures, and 98 vehicles. The cost of this fire was estimated at $4.45 million
December 9-10, 1998	Santa Ana winds with 101-mph gusts at Modjeska Canyon, 93-mph gusts at Fremont Canyon, 52-mph gusts in Santa Ana, and 83-mph gusts at Ontario disrupted transportation, power and daily activities. Winds toppled trees and power lines, overturned vehicles, and caused property damage. 180,000 customers left without electric power; 17 trucks were blown over along I-15 and Highway 60. 7 students at CSU in San Bernardino were knocked down and injured. Trees fell on passing motorists in Fontana. A total of 24 injuries reported, and property damage was estimated at $1.1 million.
January 8, 1999	Strong Santa Ana winds to 61 knots in Riverside and San Bernardino counties valleys broke tree braches, downed power lines and blew dust across freeways. $10K in property damage.
February 10-12, 1999	Santa Ana winds with gusts to 85 mph at Rialto and 80 mph on the I-8 forced the closure of several major roads and interstates. Extensive property damage throughout and west of San Gorgonio Pass. Trees and signs were blown down; large commercial building in Lake Elsinore was blown down; 150-foot tall tree was blown over and crushed a trailer home. $150K in property damage and $100K in crop damage were reported. 30 people in Beaumont were treated for breathing problems and skin rashes.
April 28, 1999	Strong winds destroyed a patio roof one mile south of Riverside Municipal Airport. Same storm to the north produced heavy rain and hail along the I-10 from Fontana to Colton. Motorists reacted to changing visibilities by braking suddenly. In a few minutes, more than 57 separate accidents occurred, involving 212 vehicles and injuring 81 people. Damage estimates, including cost of emergency agencies and responders, exceeded $1 million.
September 21, 1999	Thunderstorm-related downdrafts caused a 38 mph gust at March Air Force Base Reserve, snapped a power line in Highland, and knocked down a shallow-rooted tree in Moreno Valley.
October 17, 1999	Santa Ana winds caused wind damage in Orange County, Riverside County, and San Bernardino County mountains and valleys. In San Bernardino, 40 mph wind gusts caused a fire that damaged 11 houses and a 12-plex apartment building; gust winds fanned other fires in the Inland Empire. $30K in property damage reported.
October 30, 1999	Santa Ana winds throughout the Inland Empire. Blowing dust along the I- 215 near **Perris** caused visibility to drop to zero, leading to a 14-car pileup. The winds caused an estimated $140K in property damage.
November 21-22, 1999	Santa Ana winds with gusts to 54 knots caused power outages throughout the Inland Empire and the Santa Ana mountains and

Date	Location and Damage
	foothills. A semi-tractor trailer was toppled over at the I-15 and Highway 60 intersection. Farther south on I-15, tumbleweeds caused traffic hazards. $190K in property damage and 1 injury reported.
December 3-4, 1999	Strong Santa Ana winds with gusts to 90 mph at San Bernardino and 68 mph in Fontana. Ten power poles knocked down just below Cajon Pass, and in Muscoy, Rialto, Fontana, Murrieta and Lake Elsinore. Most major highways in the Inland Empire and through the Santa Ana Mountains were closed due to semi-tractor trailers overturned, blowing dust reducing visibility and road signs and debris blown around. Two barns were destroyed when their roofs were lifted off; six horses were injured. $210K in property damages reported.
December 10-11, 1999	Strong winds in the Coachella Valley, Riverside County valleys, San Bernardino County valleys, and Santa Ana mountains and foothills downed power lines and traffic signs. Blowing sand and dust caused poor visibility and forced road closures and cancellation of outdoor events. Several trees were knocked over. $50K in property damage and $10K in crop damages reported.
December 21-22, 1999	Strong Santa Ana winds; 68-mph gust at Campo, 53-mph gust at Huntington Beach; 44-mph gust in Orange. Widespread power and phone outages due to fallen trees knocking down lines and snapped poles. Large dust cloud over the **San Jacinto Valley** that reached height of 500 feet closed highways, and sandblasted cars. Three wildfires in San Diego County. $227K in property damage reported throughout the southern California region.
January 5-6, 2000	Santa Ana winds with 93-mph gust at Fremont Canyon; 60-mph gust at Ontario; 58-mph gust at Devore. Winds blew over four semi-tractor trailer rigs on I-10, I-15, I-215 and Highway 60 causing 10-hour delay between Apple Valley and the Inland Empire. Elsewhere in the Inland Empire, blowing sand and dust reduced visibilities to near zero. Roof damage in Rialto. Power outages to 10,000 customers due to downed power lines and poles. Two injuries and $400K in property damage reported.
March 20-21, 2000	Santa Ana winds in the Coachella Valley, Riverside County valleys, San Bernardino County valleys, San Diego County and Santa Ana Mountains and foothills downed power poles, felled trees on cars and houses, knocked fruit off of trees, and blew sand and dust lowered visibility to near zero. $425K in property damage and $865K in crop damage reported.
March 31-April 1, 2000	Strong winds toppled 25 power poles in the **Sun City** area, and several poles were also toppled in Yucaipa. A large tree was blown down in Beaumont. Reduced visibilities along most highways.
November 7, 2000	Santa Ana winds with 82-mph gust at Fremont Canyon caused damage in Orange, San Bernardino and Riverside counties. In San Bernardino County, strong winds knocked power lines together causing them to spark. The sparks ignited wildfires. In Colton, blowing sand covered the I-215. Two semi-tractor trailers overturned at the intersection of the I-15 and Highway 60. $167K in property damages reported.
November 10, 2000	A downdraft from a thunderstorm uprooted several trees, blew down a fence and ripped the shingles off of the roof of a house in **Perris**. $2,500 in property damage reported.
December 17, 2000	Santa Ana winds blew down electric, phone and cable lines in Fontana and Chino. A semi-tractor trailer was blown off an overpass on I-15 in

Date	Location and Damage
	Devore. Blowing dust south of March Air Force Base caused hazardous driving conditions in the area. Several small brush fires broke out long the Santa Ana River valley.
December 25-26, 2000	Santa Ana winds with 87-mph gust at Fremont Canyon. Damage and injuries reported in Mira Loma, and in Orange and Riverside counties. 50-mph winds in northern Orange County toppled utility poles leaving about 25,000 customers without power for a few hours. Across the Inland Empire, winds knocked down power poles, trees, signs and fences at 23 separate locations. Many trees were uprooted. Power interruption affected 9,000 homes and businesses. Many trees were uprooted, including one in Riverside County that fell onto a car, causing minor injuries to the occupants. Four injuries and $665K in property damage reported.
December 7-8, 2001	Santa Ana winds with gust to 87-mph at Fremont Canyon affected most of southern California. Trees, power lines and signs were toppled. Two construction workers were injured when a 20-foot high brick wall they were working next to collapsed. Several major freeways were closed to high-profile vehicles. Power outages affected about 40,000 customers. Three injuries and $250K in property damage. Winds fanned the Potrero Fire.
December 15, 2001	High winds to 50 knots blew down several power lines between **Romoland** and **Homeland**, affecting 2,400 customers. $30K in property damage reported.
January 23-24, 2002	Santa Ana winds to 61 knots reported throughout the mountains and valleys of Riverside, San Bernardino, San Diego and Orange counties. A semi-tractor trailer rig was blown over in Fontana. Strong winds fanned several wildfires. In San Bernardino, one house was damaged and a few outlying structures were destroyed by the wind-fanned flames. $190K in property damage.
February 8-13, 2002	Santa Ana winds with 80-mph gust at Descanso, 78-mph gust at Fremont Canyon, and 76-mph gust at San Bernardino. Blown-over semi-tractor trailer rigs forced closure of the I-15, I-215 and I-8 for a day. Twelve million pounds of avocados blown off of trees. Winds fanned several fires caused by downed power lines. In Orange County, a fire that started in Corona burned 2,400 acres. In Tijuana, a fire destroyed 50 buildings, and killed one woman. The Gavilan fire spread from Fallbrook to Camp Pendleton, torching 5,783 acres, destroying 44 houses and 40 vehicles, damaging 14 other houses, and injuring 19. $2 million in property damage and $7.8 million in crop damage.
September 1, 2002	Strong thunderstorm winds with gusts to 60 knots broke several large tree limbs, and knocked over several fences and two large water tanks in the Murrieta area, causing $30K in property damage. The same strong winds caused a downdraft in the **Hemet** area, where blowing dust brought visibility to near zero, resulting in several traffic accidents.
November 15, 2002	Dust storm reduced visibility to near zero from **Perris** to Moreno Valley. At Lake Elsinore, small rocks were blown across Highway 74. Trees and power lines were blown down in Moreno Valley, San Jacinto, **Hemet,** Redlands and many other areas in southern California. At least six people were injured in the region. $900K in property damage reported.

Date	Location and Damage
November 26-27, 2002	Strong winds with gusts between 50 and 70 knots blew down trees and signs in Escondido, Poway, El Cajon, **Hemet** and San Jacinto. Several cars and houses were damaged. The winds caused an estimated $640K in property damage in two days.
January 5-7, 2003	Strong, widespread Santa Ana winds with 100-mph gusts at Fremont Canyon, 90-mph gusts at Ontario; 80-mph gusts at Upland. I-8, I-10 and I-15 were blocked for several hours by toppled trucks. Blowing dust and sand reduced visibility to zero, forcing closure of the I-215. Winds toppled power poles in Orange; blew over a mobile derrick in Placentia that crushed two vehicles; and delayed Metrolink rail service. Two dead, 11 injured. Widespread property damage, road closures, wildfires, 20 million pounds of avocado lost. $3.3 million in property damage and $28 million in crop damage.
October 25-27, 2003	Strong Santa Ana winds; 45-mph at Ontario, 43-mph at Fremont Canyon. Extensive wildfires consumed hundreds of thousands of acres; killed more than 20 people, and caused more than $1 billion in damage.
December 16, 2004	Santa Ana winds with sustained speeds of 51 mph and 78-mph gusts at Fremont Canyon; gusts to 69-mph northwest of San Bernardino and 66-mph near Pine Valley. Four big rigs were blown over on Inland Empire Freeways, temporarily closing the I-15, and another big rig was blown over on the Ramona Expressway near San Jacinto; $150K in property damage reported.
December 29, 2004	Numerous trees were uprooted and blown over in **Winchester,** causing $50K in property damage, and in Murrieta, where $30K in property damage was reported.
January 7, 2005	Strong winds and thunderstorms throughout the southern California area. Very saturated soils and wind gusts in excess of 50 mph knocked down hundreds of trees. The felled trees knocked out power, blocked roads, and damaged many cars and property. One woman was injured when tree fell onto her car in Vista. $600K in property damage reported throughout the region.
February 3, 2005	Strong storm-related winds to 70-mph impact the region. At least 15 homes in Idyllwild were damaged by felled trees; downed power lines in the Inland Empire; big rig was overturned on the I-8. $1 million in property damage.
July 23-24, 2005	Thunderstorm wind with gusts to 54 knots accompanied by heavy rain caused damage to trees. The thunderstorm developed rapidly northeast of **Hemet**, along the Elsinore Convergence Zone, and traveled southwestward, dissipating near Murrieta. The storm produced a tornado, hail and flash flooding, causing downed trees and flooded roads and property. In **Hemet**, the storm downed several trees. In **Menifee**, the winds picked up various lawn furniture items, such as tables and chairs, and tossed them into the air. On the 24^{th}, in **Sun City**, a fence was blown over in Canyon Lake. Combined, the property damage reported in Hemet, Menifee and Sun City amounted to about $17K.
August 6, 2005	Severe thunderstorms along the Elsinore Convergence Zone started near San Jacinto, where gusty winds knocked down numerous small trees and branches. The thunderstorms then traveled westward toward **Perris** and **Sun City**. A severe microburst ripped up freeway signs along the I-215, blew down trees, caused roof damage to buildings, and

Date	Location and Damage
	knocked down more than 50 power poles. Up to 3,000 Edison customers were temporarily without power, and the I-215 was shut down for crews to clean up the downed power poles and other debris from the road. Several cars were stuck in mud near Murrieta and Ethanac roads. In **Romoland**, property damage was estimated at $300K.
January 2, 2006	Post-frontal 50+-mph winds widespread throughout the region. Winds downed trees, power lines, and power poles onto houses and cars. In Crestline, 20 houses were so damaged as to be uninhabitable. In San Diego Bay, boats broke loose from their moorings. In Apple Valley, winds toppled power poles, downed trees and caused damage to numerous homes. A trailer home was knocked off its supports in Hesperia. $310K in property damage reported.
January 22-24, 2006	Santa Ana winds; peak winds of 71 mph at Fremont Canyon on the 24^{th}; gusts exceeded 60 mph on 19 hourly observations. 7 big rigs overturned in Fontana; downed power lines and trees caused power outages and property damage. Dust storm closed a 2-mile stretch of the Ramona Expressway. In Hemet, the roof of a carport was torn off. $80K in property damage.
February 6-7, 2006	Santa Ana winds blew and the Sierra Fire in east Orange burned nearly 11,000 acres. 8 minor injuries.
September 3, 2006	A thunderstorm wind gust downed power lines and power poles along Briggs Road, at Chambers Road, and at Matthews Road in **Sun City** and **Menifee**. Power was knocked out and traffic was disrupted. $15K in property damage.
September 6, 2006	Severe thunderstorms formed at the intersection of the Elsinore Convergence Zone and the Banning Pass Arc/Convergence near **San Jacinto** and **Hemet**. A microburst caused damage to trees, buildings and power lines from San Jacinto to Temecula, while heavy rain caused flooding and mudslides. In **Menifee**, an advertising balloon that was blown into power lines sent burning streamers onto a bed of wood chips and started a small fire. Two Temecula wineries suffered damage to their buildings and outbuildings. Total property damage in the area was estimated at $75K.
October 26, 2006	Offshore winds blew to 40-mph in the Banning Pass. An arsonist started the Esperanza Fire; it burned 40,200 acres from Cabazon to San Jacinto, destroyed 43 homes, and killed 5 firefighters.
November 29, 2006	Offshore winds with sustained speeds of 54 mph and 73-mph gust at Fremont Canyon; 58-mph gust at Ontario, caused widespread property damage and power outages as a result of downed power lines, poles and trees. The strongest winds were measured in the Inland Empire where many downed street signs, trees and power lines were reported. A tree fell onto a second story apartment in Highland. About 15,000 people lost power in Orange County. $30K in property damage.
December 28, 2006	Santa Ana winds in the Inland Empire, with gusts to 56 mph, downed power lines and overturned a big rig on the I-15, in Fontana.
January 5- 8, 2007	Strong winds across southern California damaged or downed power poles in **Perris**, Nuevo and Yucaipa and damaged trees or tree limbs. Blowing dust reduced visibility to near zero along I-215 and the Ramona Expressway, and small, wind-driven wildfires were reported along I-15. Higher in the mountains, icy road conditions caused trouble for motorists. Property damage throughout the region was

Date	Location and Damage
	estimated at $700K.
August 31, 2007	A strong microburst in the Lake Elsinore area uprooted or damaged multiple trees, downed power lines, and caused roof damage to a health care center, causing $35K in property damage. The thunderstorm caused flash flooding in other areas along the Elsinore Convergence Zone, and dropped so much hail on the San Gorgonio Wilderness that it looked like it had snowed on the mountains.
September 2, 2007	Severe thunderstorms along the Elsinore Convergence Zone caused damage to an unspecified number of power poles in **Nuevo**. Severe weather and flash flooding were reported.
October 21-22, 2007	Strong Santa Ana winds caused widespread damage across the Inland Empire, with gusts in excess of 70 mph snapping power poles, toppling trees, overturning big rigs and damaging roofs. Sustained winds over 50 mph were recorded at several locations for several hours. The wind caused an estimated $2.6 million in damage to **Mt. San Jacinto College**. Winds fanned the flames of several large wildfires. Overall, more than $35 million in property damage reported.
December 25, 2007	Strong winds were reported throughout the Inland Empire area, with 58-mph gust at Ontario Airport. The winds downed power lines, uprooted trees and overturned several high-profile vehicles. About $50K in property damage was estimated.
January 17, 2008	Strong Santa Ana winds were reported throughout the Inland Empire area, with a 65-mph gust measured in San Bernardino. One hangar at the Corona airport suffered extensive damage, numerous tractor-trailers were overturned, hundreds of trees were knocked over, and hundreds of customers lost electric power. $250K in property damage.
March 2-3, 2008	Strong winds were reported throughout the Inland Empire area, and on the 3rd, in the San Diego County area. Gusts of 54 mph were measured at Ontario Airport, and 51 mph at Riverside. Winds caused the usual downed power lines, broken tree branches, and overturned rigs on the highways.
October 13, 2008	Santa Ana winds with sustained speeds of 40 mph, and gust to 55 mph downed trees in Orange, Riverside and San Bernardino counties. About 2,000 customers lost electric power in San Bernardino and Riverside counties. Three tractor-trailers were overturned by the winds on local freeways.
December 13-17, 2008	A pair of winter storms brought high winds, heavy rain and snow to the region, with gusts of 72 mph measured in Beaumont. The mountains received more than 1 foot of snow (54 inches at Big Bear), while the lower areas experienced heavy rain that caused significant flooding and a debris flow in the Santiago burn area.
January 9-13, 2009	Strong Santa Ana winds with gusts up to 83 mph were felt throughout the southern California area. On the 10th, strong winds snapped off small tree branches, caused minor roof damage, and tore a wooden fence off its hinges in Idyllwild. Downed trees and power lines, overturned semi-trucks and damaged roofs were reported elsewhere. The winds brought unusually high temperatures to the area, with the Santa Ana Fire Station reporting the highest minimum temperature (73° F) ever recorded for that station in January, as well as for the entire winter season.
January 29, 2009	Strong, gusty winds were reported in the mountains and valleys of southern California. The winds did some local damage to roofs, trees,

Date	Location and Damage
	power lines, and freeway signs. In Idyllwild, strong winds partially lifted off the roof of a hardware store. Other damage reported include a semi-tractor trailer that overturned on I-15 in Fontana, a large metal freeway sign was blown down on Highway 210 in San Bernardino, and power lines were downed in Ontario. Overall, about $25K in property damage was reported.

According to the NOAA database, between 1973 and 2009, strong winds have caused 8 direct fatalities, 73 injuries, $54 million in property damage, and $36.7 million in crop damage in Riverside County.

As discussed above, although most tornado activity in the United States occurs in the Midwest states, tornadoes do occur sporadically in the southern California area. The Tornado Project, a company that researches, compiles and makes tornado information available on the web at www.tornadoproject.com, indicates that 9 tornadoes have been reported in Riverside County between 1955 and 1998, whereas the National Oceanic and Atmospheric Agency (NOAA) lists 18 between 1955 and 2009. The tornadoes reported in Riverside County are listed in Table 6-5 below; notice that several of these occurred in the Perris Block.

Table 6.5: Tornadoes Reported in Riverside County Between 1955 and 2008

Date and Location	Time	Dead	Injured	Fujita Scale	Damage
April 6, 1955, in the hills north of Moreno Valley	13:30	0	0	F1	The tornado was reportedly 1 mile long and about 50 yards wide. No damage reported.
August 16, 1973, just west of Blythe	19:00	0	0	F2 or F3	$25K in property damage
July 20, 1974, in **Hemet**	13:49	0	1	F1	The tornado was reportedly 1 mile long and about 20 yards wide. $25K in property damage
January 20, 1982, in Riverside	02:05	0	0	F0	Of unknown length, its width was estimated at 60 yards. No damage or injuries reported.
September 18, 1985, along the NE shore of the Salton Sea	09:55	0	0	F0	10 yards wide, of unknown length. No damage or injuries reported.
March 20, 1991, in Riverside	11:30	0	0	F0	10 yards wide, of unknown length. No damage or injuries reported.
August 12, 1994, in Valley Vista, just east of **Hemet**	13:00	0	0	F0	The tornado touched down causing a tree to smash onto the living room of a residence. Several other funnel clouds reported in the area at the time, which uprooted trees and blew over utility poles. A trailer was also destroyed.
December 22, 1996 in Cabazon	09:00	0	0	F1	The tornado was first spotted near the corner of Dell and Lemon, and moved to the NE about 700 feet before dissipating. It lifted a 5-ton mobile home and deposited 30 feet

Date and Location	Time	Dead	Injured	Fujita Scale	Damage
					from its foundation, with roof and contents removed. Six other mobile homes suffered damage.
May 13, 1998 in **Homeland**	14:45	0	0	F0	Tornado touched down in the Highland Palms mobile home park, ripping awnings from several trailers.
July 23, 2005 in **Hemet**	17:11	0	0	F0	Tornado touched down in the Diamond Valley area, where it picked up a metal storage shed and tossed it onto a power pole. $5K in property damage
February 19, 2005 in Temecula	09:35	0	0	F1	The most devastating of two tornadoes that occurred in southern California that day, this tornado touched down in the Temecula Creek Golf Course Inn and Rainbow Canyon Villages. At least 100 trees, many more than 100 years old, were blown over. In the residential area of Rainbow Canyon Villages most fences and trees were blown over, and several homes lost roof shingles. $100K in property damage.
February 26, 2005 in Lake Elsinore	15:00	0	0	F0	A landspout was witnessed over Nichols Road in Lake Elsinore. It lasted about 5 minutes and developed under a cumulus cloud cover in the Elsinore Convergence Zone. It caused no damages or injuries.
July 23, 2005 in **Hemet**	13:06	0	0	F0	The tornado was first spotted near the intersection of Highways 74 and 79; it then traveled westward toward the Hemet-Ryan airport, causing mostly broken tree limbs. $2K in property damage
July 23, 2006 in **Menifee**	15:15	0	0	F0	A thunderstorm produced a landspout tornado that blew over a dozen pine trees and a few palm trees at the Menifee Lakes Country Club. A few homes were damaged by the fallen trees. $25K in property damage
May 22, 2008 in **March Air Force Base**	15:30	0	0	F0	This tornado touched down for approximately 6 minutes about 2 miles southeast of the base. There were no damage reports.
May 22, 2008 in **March Air Force Base**	15:42	0	1	F2	This tornado touched down on March Field and traveled three miles in a west-southwest direction for about 21 minutes. The tornado had a maximum width of about 75 yards.

Date and Location	Time	Dead	Injured	Fujita Scale	Damage
					As the tornado crossed the I-215, it lifted a semi-truck 30 to 40 feet into the air. The driver suffered extensive head injuries and was hospitalized for over 1 month. Nine empty BNSF railroad cars were derailed, and the tornado also damaged the roofs of several homes, and a trailer on Kuder Avenue. $350K in property damage
May 22, 2008 in Val Verde	15:50	0	0	F0	The third tornado produced by the same storm (see entries above); this one occurred just west of the I-215, near the Riverside National Cemetery, but its exact path is unknown. No damage or injuries were reported.
May 22, 2008 in Alessandro	16:40	0	0	F0	Fourth tornado produced by the same storm; this one was spotted near the Gavilan Hills, between Woodcrest and Lake Elsinore. No damages or injuries were reported.
Totals		**0**	**2**		**$535K in property damage**

6.3 Community Vulnerability to Windstorm Damage

Windstorm hazard identification is the first phase of the assessment process for this hazard. Identification involves: 1) the geographic extent of the hazard, 2) the intensity of the windstorms that may be expected in Menifee, and 3) the probability that a windstorm event will occur. A windstorm event in the region can range from a short-term microburst or tornado lasting only a few minutes, to either Santa Ana or thunderstorm-related wind conditions that can last for several days. Santa Ana wind conditions occur most often in the fall and winter months, between September and March, and impact a large geographic area. Interestingly, many of the storm-related winds that have impacted the southern California also occurred in the fall and winter months. Tropical storms that have made landfall in Baja California and moved north into Arizona and California have occurred primarily in August and September. The data in the two tables above show, however, that high winds can occur in Menifee at almost any time during the year, but primarily between August and March.

The data presented in Tables 6-4 and 6-5 would suggest that windstorm events have increased in frequency over time. However, the early historical record is often incomplete because 1) there were less people in the area that could be impacted by these natural hazards, and 2) only unusually damaging storms would be recorded in newspapers, journals and other sources. Using the record from the last decade only, the Riverside County area is impacted by windstorms thirteen times yearly, on average. In 2003, however, only eight windstorm events were recorded, whereas in 2005, 21 events were recorded.

The tornado record is less consistent: no tornadoes were reported in the area in some years, whereas in both 2005 and 2008 four tornadoes were recorded in the region. Tornadoes and microbursts usually impact a relatively small geographic area. Tornadoes in the southern

California area have for the most part been size F0 or F1, but even these tornadoes are capable of causing extensive property damage, injuries and loss of life.

Unlike flooding hazards, which are generally confined to a discrete area that can be mapped, windstorms may travel in any direction, and are only partly affected by topography (with stronger winds usually observed in canyons and passes, where the winds are funneled by the surrounding topographic highs). Given that we cannot predict when or where a windstorm will occur, nor its intensity, the conservative approach is to assume that a windstorm event can take place anywhere in the Menifee area anytime during the year, but preferentially in the fall or winter.

As past events show, windstorms in the Menifee area have the potential to impact life, property, utilities, infrastructure and transportation systems, causing damage to trees, power lines, utility poles, road signs, cars, trucks, and building roofs and windows. Structures and facilities can be impacted directly by high winds and/or can be struck by air-borne debris. Windstorms can disrupt power to facilities and disrupt land-based communications as well. In fact, historically, trees downed during a windstorm have been the major cause of power outages in the southern California area. Uprooted trees and downed utility poles can also fall across the public right-of-way disrupting transportation. These events can be major hindrances to emergency response and disaster recovery. For example, if transportation routes are compromised by fallen debris, and loss of power occurs in the area, emergency response facilities like hospitals, fire stations, and police stations may find it difficult to function effectively. Falling or flying debris, falling trees and downed power lines can also injure or kill motorists and pedestrians. As discussed previously, windstorms, especially Santa Ana winds, are often also associated with wildfires, which, if they occur in or near a populated area, can result in enormous losses to property, in addition to injuries and loss of life. Such an event may require the involvement of City maintenance personnel responding to cleanup and repairs during and following the windstorm. Similarly, maintenance crews may be required to secure certain facilities ahead of a potential windstorm, provided sufficient advanced notice is available, and that City crews are available to respond on short notice.

6.3.1 Structural Damage

Depending on its age, condition, and structural design, any structure may be susceptible to damage. However, buildings with weak reinforcements are most susceptible to windstorm damage. Wind pressure can create a direct and frontal assault on a structure, pushing walls, doors, and windows inward. Conversely, passing currents can create lift suction forces that pull building components and surfaces outward and/or upward. Under extreme wind forces, the roof or entire building can fail or sustain considerable damage. Mobile homes are particularly susceptible to windstorm damage. Debris carried by the wind may also contribute to loss of life and, indirectly, to the failure of building envelopes, sidings or walls.

A windstorm also has the potential to displace residents, which may require the City to provide short-term and/or long-term shelters to accommodate these individuals, in addition to providing for other emergency response activities such as cleanup and repair. This has the potential to impact the City economically, as City funds would have to be tapped into to respond adequately to the needs of the impacted members of the community.

6.3.2 Lifelines and Critical Facilities

Historically, downed trees have been a major cause of power outages in the region during windstorms. Some tree limbs can break in winds of about 45 mph, and the broken limbs can be carried by the wind more than 75 feet from their source. Thus, overhead power lines can be damaged even in relatively minor windstorm events. Downed trees can also bring electric power lines down to the pavement or ground, where they become serious, life-threatening, sources of electric shock. Lifelines and critical facilities should remain accessible, if possible, during a natural hazard event. The impact of closed transportation arteries may be increased if a blocked road or bridge is critical to access the hospital or other emergency facilities. Rising population growth, and new infrastructure in the region could result in a higher probability for damage to occur from windstorms as more lives and property are exposed to this hazard.

6.3.3 Infrastructure

Windstorms may damage buildings, power lines, and other property and infrastructure due to falling trees and branches. During wet winters, saturated soils cause trees to become less stable and more vulnerable to uprooting from high winds. Windstorms can also result in damaged or collapsed buildings, blocked roads and bridges, damaged traffic signals and streetlights, and damaged park facilities. Roads blocked by fallen trees during a windstorm may severely impact people attempting to access emergency services. Emergency response operations can be compromised when roads are blocked or when power supplies are interrupted. Industry and commerce can suffer losses from interruptions in electric services and from extended road closures. They can also sustain direct losses to buildings, personnel and other vital equipment.

In addition to the problems caused by downed trees and electrical wires blocking streets and highways, windstorms can also force the temporary closure of roads to vehicular traffic. This is especially true during extremely strong Santa Ana winds and winter storms.

Appendix A:
REFERENCES, SOURCES and WEBSITES

Ahrens M., 2009a, Home structure fires: National Fire Protection Association, Quincy, MA.

Ahrens M., 2009b, Smoke alarms in U.S. home fires: National Fire Protection Association, Quincy, MA.

Ahrens M., 2003, The U.S. fire problem overview report: leading causes and other patterns and trends: National Fire Protection Association, Quincy MA).

Alquist-Priolo Earthquake Fault Zoning Act, California Public Resources Code, Chapter 7.5 Earthquake Fault Zones, Section 2621 et seq., last updated October 2, 2007.

American Red Cross, 1994, Your Guide to Home Chemical Safety and Emergency Procedures, 24p.

American Society for Testing Materials (ASTM) E-108, Standard Test Methods for Fire Tests of Roof Coverings.

Anbar, M., Guttmann, S., and Lewitus, Z., 1959, The mode of action of perchlorate ions on the iodine uptake of the thyroid gland: International Journal on Application of Radiating Isotopes, Vol. 7, pp. 87-96.

Anderson, J.G., Rockwell, T.K., and Agnew, D.C., 1989, Past and possible future earthquakes of significance to the San Diego region: Earthquake Spectra, Vol. 5, No. 2, pp. 299-333.

Andrews, P. L., 1986, BEHAVE: Fire behavior prediction and fuel modeling system BURN subsystem, part 1: US Department of Agriculture, Forest Service, General Technical Report INT-194, Intermountain Research Station, Ogden, Utah, 130p.

Andrews, P.L., and Bevins, C.D., 1999, Update and expansion of the BEHAVE Fire Modeling System: Fire Management Notes.

Andrews, P.L., and Bradshaw, L.S., 1990, RXWINDOW: Defining windows of acceptable burning conditions based on desired fire behavior: US Department of Agriculture, Forest Service, General Technical Report INT-273, Intermountain Research Station, Ogden, Utah, 54p.

Andrews, P.L., and Chase, C.H., 1989, BEHAVE: Fire behavior prediction modeling system-BURN subsystem Part 2: U.S. Department of Agriculture, Forest Service, General Technical Report INT-260, Intermountain Research Station, Ogden, Utah, 93p.

Associated Soils Engineering, Inc., 2005, Report of Geotechnical Investigation, proposed Residential Subdivision Development, NW Corner of Garbani Road and Evans Road, Menifee Area, Riverside County, California, Project No. 05-5756, dated June 6, 2005.

Barrette, Brian, 1999, System for Rating Structural Vulnerability in SRA: Sacramento, California, dated September 1999.

Barrows, A.G., Irvine, P.J., and Tan, S.S, 1995, Geologic surface effects triggered by the Northridge earthquake *in* Woods, M.C., and Seiple, W.R. (editors), The Northridge, California, Earthquake of 17 January 1994: California Division of Mines and Geology Special Publication 116, pp 65-88.

Barrows, A.G., Tan, S.S., and Irvine, P.J., 1994, Investigation of Surface Geologic Effects and Related Land Movement in the City of Simi Valley Resulting from the Northridge Earthquake of January 14, 1994: California Division of Mines and Geology Open File Report 94-09, 41p., 1 plate.

Bergmann, M.C., and Rockwell, T.K., 1989, The Murrieta Creek fault, a new branch of the Elsinore fault, Rancho California area, Riverside County, California: Geological Society of America Abstracts with Programs, Vol. 21, No. 5, p. 57.

Bergmann, M., Rockwell, T.K., Miles, D.K., Hirabayashi, C.K., Hushebeck, M.A., Haraden, C.C., Thomas, A., and Patterson, A., 1993, Preliminary assessment of the late Holocene slip rate for the Wildomar fault, Murrieta, California: Technical report to the U.S. Geological Survey, Reston, Virginia, under Contract 14-08001-G2062, 12p.

Blake, T. F., 2000, EQFAULT, A Computer Program for the Estimation of Peak Horizontal Ground Acceleration from 3D Fault Sources.

Blake, T.F., Hollingsworth, R.A., and Stewart, J.P., (editors), 2002, Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Landslide Hazards in California: Southern California Earthquake Center, 110p. + Appendix A.

Bolt, Bruce A., 1999, Earthquakes: W.H. Freeman and Company, New York, Fourth Edition, 320p.

Bonilla, M.G., 1973, Trench exposures across surface fault ruptures associated with the San Fernando earthquake, in Geological and geophysical studies, Volume 3 of San Fernando, California, earthquake of February 9, 1971: U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, pp. 173-182.

Borchardt, G., and Kennedy, M.P., 1979, Liquefaction Potential in Urban San Diego – A Pilot Study: California Geology, Vol. 32, pp. 217-221.

Brake, J.F., 1987, Analysis of historic and prehistoric slip on the Elsinore fault at Glen Ivy Marsh, Temescal Valley, southern California: Unpublished M.Sc. Thesis, San Diego State University, San Diego, California, 107p.

Brake, J.F., and Rockwell, T.K., Magnitude of slip from historical and prehistorical earthquakes on the Elsinore fault, Glen Ivy Marsh, southern California (abstract): Geological Society of America Abstracts with Programs, Vol. 19, No. 6.

Bray, J.D., 2001, Developing Mitigation Measures for the Hazards Associated with Earthquake Surface Fault Rupture; in A Workshop on Seismic Fault-Induced Failures – Possible Remedies for Damage to Urban Facilities: Research Project 2000 Grant -in-Aid for Scientific Research

(No. 12355020), Japan Society for the Promotion of Science, Workshop Leader, Kazuo Konagai, University of Tokyo, Japan, pp. 55-79, January 11-12, 2001.

Brewer, L., 1992, Preliminary damage and intensity survey: Earthquakes and Volcanoes, Vol. 23, No. 5, pp. 219-226.

Brooks, M.L., and Minnich, R.A., 2006, Southeastern Deserts Bioregion; *in* Sugihara, N.G., van Wagtendonk, J.W., Shaffer, K.E., Fites-Kaufman, J., and Thode, A.E., (editors), 2006, Fire in California's Ecosystems: University of California Press, Berkeley and Los Angeles, California, pp. 391-414.

Brown, R.D., Jr., 1990, Quaternary Deformation; in Wallace, R.E. (editor), The San Andreas Fault System, California: U.S. Geological Survey Professional Paper 1515, pp. 83-114.

Building Technology, Inc., 1990a, Financial Incentives for Seismic Rehabilitation of Hazardous Buildings – An Agenda for Action. Volume 1: Findings, Conclusions and Recommendations: Federal Emergency Management Agency Publication No. 198, 104p.

Building Technology, Inc., 1990b, Financial Incentives for Seismic Rehabilitation of Hazardous Buildings – An Agenda for Action. Volume 2: State and Local Case Studies and Recommendations: Federal Emergency Management Agency Publication No. 199, 130p.

Building Technology, Inc., 1990c, Financial Incentives for Seismic Rehabilitation of Hazardous Buildings – An Agenda for Action. Volume 3: Applications Workshops Report: Federal Emergency Management Agency Publication No. 216, 200p.

Burgan, R.E., 1987, Concepts and interpreted examples in advanced modeling: U.S. Department of Agriculture, Forest Service, General Technical Report INT-238, Intermountain Research Station, Ogden, Utah, 40p.

Burgan, R.E. and Rothermel, R.C., 1984, BEHAVE: Fire prediction and fuel modeling system-FUELsubsystem: U.S. Department of Agriculture, Forest Service, General Technical Report INT-167, Intermountain Forest and Range Experiment Station, Ogden, Utah, 126p.

Burnett, J.L., and Hart, E.W., 1994, Holocene Faulting on the Cucamonga, San Jacinto and Related Faults, San Bernardino County: California Division of Mines and Geology Fault Evaluation Report FER-240.

California Board of Forestry, 1996, California Fire Plan: A Framework for Minimizing Costs and Losses from Wildland Fires: a report dated March 1996.

California Building Standards Commission (CBSC), 2007, California Building Code, Title 24, Part 2, 2 Volumes, 1,600p.

California Building Standards Commission (CBSC), 2007, California Historical Building Code, Title 24, Part 8.

California Building Standards Commission (CBSC), 2007, California Existing Building Code, Title 24, Part 10.

California Building Standards Commission, 2001, California Building Code.

California Department of Forestry and Fire Protection, Office of the State Fire Marshall, 2010, Wildland Urban Interface (WUI) Products, revised March 19, 2010, available at http://osfm.fire.ca.gov/strucfireengineer/pdf/bml/wuiproducts.pdf

California Department of Forestry and Fire Protection, 2009, Fire Perimeters Map, Version 08_2; from http://frap.fire.ca.gov/data/frapgisdata/select.asp and http://frap.cdf.ca.gov/projects/fire_data/fire_perimeters/, last updated on January 09, 2009.

California Department of Forestry and Fire Protection (CDF), Fire and Resource Assessment Program (FRAP), 2005a, Fire Threat Map, Scale: 1:1,100,000 at 34″ x 44″; Map ID: FTHREAT_MAP v05_1, published October 20, 2005.

California Department of Forestry and Fire Protection (CDF), Fire and Resource Assessment Program (FRAP), 2005b, Fuel Rank Potential Fire Behavior Map, Scale: 1:1,100,000 at 34″ x 44″; Map ID: FRNK_MAP v05_2, published July 07, 2005.

California Department of Forestry and Fire Protection (2001), California Fire and Resource Assessment Program (FRAP) available online at http://frap.cdf.ca.gov/data/frapgisdata/select.asp

California Department of Forestry, 1993, Rater Instruction Guide: Very High Fire Hazard Severity Zone.

California Department of Water Resources, 2006, San Jacinto Groundwater Basin, in California's Groundwater, Bulletin 118, updated January 20, 2006.

California Department of Water Resources, 1986, Statutes and Regulations Pertaining to Supervision of Dams and Reservoirs: Division of Safety of Dams, 46p.

California Division of Mines and Geology (CDMG), 1998, Maps of known active fault near-source zones in California and adjacent portions of Nevada, to be used with the 1997 Uniform Building Code: International Conference of Building Officials.

California Division of Mines and Geology (CDMG), 1997, Guidelines for Evaluating and Mitigating Seismic Hazards in California: Special Publication 117, 74p., revised September 11, 2008 and available online at http://www.conservation.ca.gov/cgs/shzp/Pages/shmppgminfo.aspx.

California Division of Mines and Geology (CDMG), 1992, Recommended Criteria for Delineating Seismic Hazard Zones in California: Special Publication 118, May 1992, revised July 1999.

California Environmental Quality Act, California Public Resources Code, Section 21000 et seq.

California Geological Survey, 2004, Hazards from "mudslides", debris avalanches and debris flows in hillside and wildfire areas, CGS Note 33, available online at http://www.consrv.ca.gov.cgs/information/publications/cgs_notes/note_33/index.htm.

California Geological Survey, 2004, Guidelines for Evaluating the Hazard of Surface Fault Rupture, CGS Note 49, available online at http://www.consrv.ca.gov/CGS/rghm/ap/index.htm

California Geological Survey (CGS), 2002, Alquist-Priolo Earthquake Fault Zones: CD-ROM 2001-05.

California Office of Planning and Research (OPR), 1987, General Plan Guidelines.

California Seismic Safety Commission (SSC), 2006, Status of the Unreinforced Masonry Building Law, 2006 Report to the Legislature, Adopted November 9, 2006, SSC Publication No. 2006-04, 12p. + 2 appendices.

California Seismic Safety Commission (SSC), 2003, Status of the Unreinforced Masonry Building Law, 2003 Report to the Legislature, Adopted June 12, 2003.

Campbell, K.W., and Bozorgnia, Y., 2003a Erratum, Updated Near-Source Ground-Motion (Attenuation) Relations for the Horizontal and Vertical Components of Peak Ground Acceleration and Acceleration Response Spectra: Bulletin of the Seismological Society of America, Vol. 93, No. 4., pp. 1872.

Campbell, K.W., and Bozorgnia, Y., 2003b, Updated Near-Source Ground-Motion (Attenuation) Relations for the Horizontal and Vertical Components of Peak Ground Acceleration and Acceleration Response Spectra: Bulletin of the Seismological Society of America, Vol. 93, No. 1., pp. 314-331.

Campbell, K.W., and Bozorgnia, Y., 2000, New empirical models for predicting near-source horizontal, vertical, and V/H response spectra: Implications for design, in Proceedings, 6th International Conference on Seismic Zonation, Palm Springs, California.

Campbell, R.H., 1975, Soil slips, debris flows, and rainstorms in the Santa Monica Mountains and vicinity, southern California: U.S. Geological Survey Professional Paper 851, 51p.

Cannon, S.H., 2001, Debris-Flow Generation from Recently Burned Watersheds: Environmental & Engineering Geosciences, Vol. VII, No. 4, November 2001, pp. 321-341.

Cao, T., Bryant, W.A., Rowshandel, B., Branum, D., and Wills, C.J., 2003, The revised 2002 California probabilistic seismic hazard maps, dated June 2003, 11p. Available at http://www.consrv.ca.gov/cgs/rghm/psha/index.htm

Centers for Disease Control and Prevention, 1998, Deaths resulting from residential fires and the prevalence of smoke alarms - United States 1991–1995: Morbidity and Mortality Weekly Report, Vol. 47, No. 38, pp. 803-806.

Chang, S.E., 2003, Evaluating disaster mitigations: methodology for urban infrastructure systems: American Society of Civil Engineers, Natural Hazards Review, Vol. 4, No. 4, November 1, 2003, pp. 186-196.

Chin, E.H., Aldridge, B.N., and Longfield, R.J., 1991, Floods of the February 1980 in Southern California and Central Arizona, U.S. Geological Survey Professional Paper 1494

Claypole, E.W., 1900, The Earthquake at San Jacinto, December 25, 1899: The American Geologist, Vol. XXV, Feb. 1900, pp. 106-108, plate III.

Coleman, Ronny J., 1994, Policy Context on Urban-Widland Fire Problem: California State and Consumer Services Agency, A Special Report for the Governor Pete Wilson, dated January 19, 1994, 13p.

Dibblee, T.W., Jr., 2003a, Geologic Map of the Hemet Quadrangle, Riverside County, California, Map #DF-118, published by the Santa Barbara Museum of Natural History, December 2003.

Dibblee, T.W., Jr., 2003b, Geologic Map of the Lakeview Quadrangle, Riverside County, California, Map #DF-115, published by the Santa Barbara Museum of Natural History, December 2003.

Dibblee, T.W., Jr., 2003c, Geologic Map of the Perris Quadrangle, Riverside County, California, Map #DF-112, published by the Santa Barbara Museum of Natural History, December 2003.

Dibblee, T.W., Jr., 2003d, Geologic Map of the Winchester Quadrangle, Riverside County, California, Map #DF-117, published by the Santa Barbara Museum of Natural History, December 2003.

Dolan, J.F., Sieh, K., Rockwell, T.K., Yats, R.S., Shaw, J., Suppe, J., Huftile, G., and Gath, E., 1995, Prospects for larger or more frequent earthquakes in greater metropolitan Los Angeles: Science, Vol. 267, pp. 188-205.

Eastern Municipal Water District, 2010, personal communication with John Daverin, Senior Engineering Geologist.

Eastern Municipal Water District, 2009, West San Jacinto Groundwater Basin Management Plan, 2008 Annual Report, dated October, 2009.

Eastern Municipal Water District, 2005, Urban Water Management Plan.

EERI (Earthquake Engineering Research Institute), 1995, Northridge, California, 1994 Earthquake, Vol. 11, Issues S1 and S2.

EERI (Earthquake Engineering Research Institute), 1994, Northridge Earthquake, January 17, 1994, Preliminary Reconnaissance Report: Oakland, California, 96p.

EERI (Earthquake Engineering Research Institute), 1992, Landers and Big Bear earthquakes of June 28 & 29, 1992, Special Report, Newsletter, August 1992, pp. 1-12.

Eichler, O., and Hackenthal, E., 1962, Uber Ausscheidung und Stoffwechsel von Perchlorat gemessen mit 36ClO4 [Secretion and metabolism of perchlorate measured with 36ClO4]: Naunyn-Schmidedberg's Arch. Exp. Pathol. Pharmakol., Vol. 243, pp. 554-565.

Ellen, S.D., and Fleming, R.W., 1987, Mobilization of debris Flows from soil slips, San Francisco Bay region, California; _in_ Costa, J.E. and Wieczorek, G.F. (editors), Debris flows/avalanches: Process, recognition, and mitigation: Geological Society of America Reviews in Engineering Geology, Vol. VII, pp. 31-40.

ENGEN Corporation, 2007, Geotechnical/Geological Engineering Study, Motte Romoland Ranch, Assessors Parcel No. 329-120-036, Antelope Road and Watson Road, Romoland Area, Riverside County, California, Project No. M3541-GS, dated June 29, 2007.

Engstrom, W.N., 1996, The California storm of January 1862: Quaternary Research, Vol. 46, pp. 141-148.

ESI, 2009, Preliminary Geotechnical Investigation, Lots 1-14, Tentative Tract Map 35143, APN 331-500-023 through 025, 3.84+/- Acres, Nora Lane & Evans Road, Project no. 09-0403-PL, dated May 4, 2009.

Federal Emergency Management Agency (FEMA), 2009, Guide to Flood Maps, FEMA 258, December 2009.

Federal Emergency Management Agency (FEMA), 2008, Flood Insurance Study, Riverside County, California and Unincorporated Areas, Vol. 1 of 4, latest revision dated August 28, 2008.

Federal Emergency Management Agency (FEMA), 2008, Flood Insurance Rate Maps (FIRMs) covering the Menifee General Plan area; Community Panel Nos. 06065C1440G, 06065C1445G, 06071C2055G, 06065C2060G, 06065C2061G, 06065C2062G, 06065C2070G, and 06065C2705G, dated August 28, 2008.

Federal Emergency Management Agency (FEMA), 1998, Home Builder's Guide to Seismic Resistant Construction: Earthquake Hazard Reduction Series, FEMA-232, 75p.

Federal Emergency Management Agency (FEMA), 1998, Seismic Rehabilitation of Buildings: Strategic Plan 2005: Earthquake Hazard Reduction Series FEMA-315, 40p.

Federal Emergency Management Agency (FEMA), 1995, (Second Edition), Typical Costs for Seismic Rehabilitation of Existing Buildings: Volume 2: Supporting Documentation. Second Edition: Prepared for FEMA by the Hart Consultant Group, Inc., Santa Monica, California, 102p., supersedes 1988 version.

Federal Emergency Management Agency (FEMA), 1994, (Second Edition), Typical Costs for Seismic Rehabilitation of Existing Buildings: Volume 1: Summary: Prepared for FEMA by the Hart Consultant Group, Inc., Santa Monica, California, 70p., supersedes 1988 version.

Federal Emergency Management Agency (FEMA), 1989, FEMA-178, A Handbook for Seismic Evaluation of Existing Buildings (Preliminary): Applied Technology Council (ATC-22); Earthquake Hazard Reduction Series No. 47, 169p.

Federal Emergency Management Agency (FEMA), 1989, FEMA-175, Seismic Evaluation of Existing Buildings: Supporting Documentation: Applied Technology Council (ATC-22-1); Earthquake Hazard Reduction Series No. 48, 160p.

Federal Emergency Management Agency (FEMA), 1989, FEMA-174, Establishing Programs and Priorities for the Seismic Rehabilitation of Buildings – A Handbook Building Systems Development, Inc., Integrated Design Services and Rubin, Claire B.; Earthquake Hazard Reduction Series No 45, 122p.

Federal Emergency Management Agency (FEMA), 1989, FEMA-173, Establishing Programs and Priorities for the Seismic Rehabilitation of Buildings – Supporting Report: Building Systems Development, Inc., Integrated Design Services and Rubin, Claire B.; Earthquake Hazard Reduction Series No 46, 190p.

Federal Emergency Management Agency (FEMA), 1988, FEMA-155, Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation: Applied Technology Council (ATC-21-1), Earthquake Hazards Reduction Series No. 42, 137p.

Federal Emergency Management Agency (FEMA), 1988, FEMA-154, Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook: Applied Technology Council (ATC21), Earthquake Hazards Reduction Series No. 41, 185p.

Federal Emergency Management Agency (FEMA), 1987, FEMA-139, Abatement of Seismic Hazard to Lifelines: Proceedings of a Workshop on Development of an Action Plan – Volume 5: Papers on Gas and Liquid Fuel Lifelines: Building Seismic Safety Council; Earthquake Hazard Reduction Series No. 30, 134p.

Federal Emergency Management Agency (FEMA), 1987, FEMA-135, Abatement of Seismic Hazard to Lifelines: Water and Sewer Lifelines and Special Workshop Presentations: Earthquake Hazard Reduction Series No. 2, 181p.

Federal Emergency Management Agency (FEMA), 1985, Comprehensive Earthquake Preparedness Planning Guidelines: City: Earthquake Hazard Reduction Series 2, FEMA-73, 80p.

Finney, M.A., 1998, FARSITE: Fire Area Simulator-model development and evaluation: US Department of Agriculture, Forest Service, Research Paper RMRS-RP-4, Rocky Mountain Research Station, Ft. Collins, Colorado, 47 pages.

Finney, M.A., 1995, FARSITE- A Fire Area Simulator for Managers; _in_ The Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems: US Department of Agriculture, Forest Service, General Technical Report PSW-158, Berkeley, California.

Fisher, Fred L., 1995, Building Fire Safety in the Wildland Urban Intermix: The Role of Building Codes and Fire Test Standards: Report prepared for the California/China Bilateral

Conference on Fire Safety Engineering held August 14-15, 1995 in Sacramento, California, 13p.

Fuis, G.S., and Mooney, W.D., 1990, Lithospheric structure and tectonics from seismic-refraction and other data; in Wallace, R.E., (editor), The San Andreas Fault System, California, U.S. Geological Survey Professional Paper 1515, pp. 207-238.

Garrison, T., 2002, Oceanography – An Invitation to Marine Science: Wadsworth Publishing House, Belmont, California, 4th Edition.

Geocon Geotechnical Consultants, 2007, Geotechnical Investigation, Scott Road Marketplace, Scott and Zeider Roads, Menifee Area, Riverside County, California, Project No. T2413-22-01, dated January 12, 2007.

Glowacka, E., Nava, F.A., Díaz de Cossío, G., Wong, V., Farfán, F., 2002, Fault slip, seismicity, and deformation in Mexicali Valley, Baja California, Mexico, after the M 7.1 1999 Hector Mine earthquake: Bulletin of the Seismological Society of America, Vol. 92, No. 4, pp. 1290-1299.

Gosnold, William D., Jr., LeFever, Julie A., Todhunter, Paul E., and Osborne, Leon F., Jr., 2000, Rethinking Flood Prediction: Why the Traditional Approach Needs to Change: Geotimes, Vol. 45, No. 5, pp. 20-23.

Greenlee, J., and Sapsis, D., 1996, Prefire effectiveness in fire management: A summary and a review of the state-of-knowledge: International Association of Wildland Fire, Fairfield, WA, dated August 1996.

Greenwood, R.B., 1998, Section 1 - Liquefaction Evaluation Report: Liquefaction zones in the Long Beach 7.5-Minute Quadrangle, Los Angeles County, California: California Division of Mines and Geology Seismic Hazard Zone Report for the Long Beach 7.5-Minute Quadrangle, Los Angeles County, California, Open File Report No. 98-19, pp. 3-20.

Griggs, G.B., Marshall, J.S., Rosenbloom, N.A., and Anderson, R.S., 1991, Ground Cracking in the Santa Cruz Mountains; in Baldwin, J.E. and Sitar, N. (editors), Loma Prieta Earthquake: Association of Engineering Geologists, Engineering Geologic Perspectives, Special Publication No. 1, pp. 25-41.

Hall, J.R., 2001, Burns, toxic gases, and other hazards associated with fires: Deaths and injuries in fire and non-fire situations: National Fire Protection Association, Fire Analysis and Research Division, Quincy, MA.

Hall, W. J, Hon, M., and O'Rourke, T. D., 1991, Seismic Behavior and Vulnerability of Pipelines; in Cassaro, Michael A., (editor), Lifeline Earthquake Engineering: American Society of Civil Engineers, Los Angeles, California, pp. 761-773.

Harp, E.L., and Jibson, R.W., 1996, Landslides triggered by the 1994 Northridge, California, Earthquake: Bulletin of the Seismological Society of America, Vol. 86, No. 1B, pp. S319-S332.

Hart, E.W., and Bryant, W.A., 2007 Interim Revision, Fault-Rupture Hazard Zones in California, Alquist-Priolo Earthquake Fault Zoning Act with Index to Earthquake Fault Zones Maps: California Division of Mines and Geology Special Publication 42, 42p., available from the web at http://www.consrv.ca.gov/cgs/rghm/ap/Pages/disclose.aspx

Hart, E.W., and Bryant, W.A., 1999, Fault-Rupture Hazard Zones in California, Alquist-Priolo Earthquake Fault Zoning Act with Index to Earthquake Fault Zones Maps: California Division of Mines and Geology Special Publication 42.

Hart, E.W., Bryant, W.A., Wills, C.J., Treiman, J.A., and Kahle, J.E., 1989, Summary Report: Fault Evaluation Program, 1987-1988, Southwestern Basin and Range Region and Supplemental Areas: Depart of Conservation, Division of Mines and Geology Open-File Report 89-16.

Hauksson, E., Gee, L., Given, D., Oppenheimer, D., and Shakal, T., 2004, The California Integrated Seismic Network: Abstract, Seismological Society of America Annual Meeting, April 14-16, Palm Springs, California.

Haukson, E., Jones, L.M., and Hutton, K., 2002, The 1999 Mw 7.1 Hector Mine, California, earthquake sequence: Complex conjugate strike-slip faulting: Bulletin of the Seismological Society of America, Vol. 92, No. 4, pp. 1154-1170.

Hauksson, E, and Jones, L.M., 1989, The 1987 Whittier Narrows earthquake sequence in Los Angeles, southern California: Seismological and tectonic analysis: Journal of Geophysical Research Vol. 94 pp. 9569-9589.

Helm, R., Neal, B., and Taylor, L., 1973, A Fire Hazard Severity Classification System for California's Wildlands: A report by the Department of Housing and Urban Development and the California Department of Conservation, Division of Forestry to the Governor's Office of Planning and Research, dated April 1, 1973.

Henry, A.J., 1916, Floods of January-February, 1916, in the lower Mississippi and in Southern California: Monthly Weather Review, Washington D.C., dated February 29, 1916.

Hereford and Longpre, 2009, Climate History of the Mojave Desert Region, 1982-1996, Including Data from 48 Long-Term Weather Stations and an Overview of Regional Climate Variation: U.S. Geological Survey, http://mojave.usgs.gov/climate-history/.

Holzer, T.L., 1984, Ground failure induced by ground-water withdrawal from unconsolidated sediment: man-induced land subsidence: Reviews in Engineering Geology, Vol. 6, pp. 67-105.

Hough, S. E., Moil, J., Sembera, E., Glassmoyer, G., Mueller, C. and Lydeen, S., 1993, Southern surface rupture associated with the 1992 M 7.4 Landers earthquake: did it all happen during the mainshock?: Geophysical Research Letters, Vol. 20, pp. 2615-2618.

Iida, K., 1963, Magnitude, energy, and generation mechanisms of tsunamis and a catalog of earthquakes associated with tsunamis; in Proceedings of the 10th Pacific Science Congress Symposium: International Union of Geodesy and Geophysics Monograph No. 24, pp. 7-18.

Imamura, A., 1949, List of Tsunamis in Japan: Journal of the Seismological Society of Japan, Vol. 2, pp. 22-28 (in Japanese, as referenced in McCulloch, 1985).

Insurance Services Office, Inc. (ISO), 2001, Guide for Determination of Needed Fire Flow: Edition 10-2001, 26p.

Insurance Services Office, Inc. (ISO), 1997, The Wildland/Urban Fire Hazard: ISO, New York, December 1997.

International Code Council (ICC), 2006, International Building Code.

International Code Council (ICC), 2006, Wildland-Urban Interface Code.

International Conference of Building Officials (ICBO), 2001, California Historical Building Code, California Building Standards Commission, Part 8, Title 24, California Code of Regulations.

International Conference of Building Officials (ICBO), 1998, California Building Code.

International Conference of Building Officials (ICBO), 1997, Uniform Building Code.

Jacoby, G.C. Jr., Sheppard, P.R., and Sieh, K.E., 1988, Irregular Recurrence of Large Earthquakes along the San Andreas Fault: Evidence from Trees: Science, Vol. 241, No. 4862, pp. 196-199.

Jennings, Charles W., 1994, Fault Activity Map of California and Adjacent Areas with Location and Ages of Recent Volcanic Eruptions: California Division of Mines and Geology, California Geologic Data Map Series, Map No. 6, Map Scale: 1:250,000. (CD-2000-06: Digital Database of Fault Activity Map of California and Adjacent Areas).

Johnson, I.A., 1998, Land Subsidence Due to Fluid Withdrawal in the United States - An Overview *in* Borchers, J.W. (editor), Land Subsidence, Case Studies and Current Research: Association of Engineering Geologists, Proceedings of the Dr. Joseph F. Poland Symposium on Land Subsidence, Special Publication 8, pp.51-57.

Jones, L.M., Bernknopf, R., Cox, D., Goltz, J., Hudnut, K., Mileti, D., Perry, S., Ponti, D., Porter, K., Reichle, M., Seligson, H., Shoaf, K., Treiman, J., and Wein, A., 2008, The ShakeOut Scenario: U.S. Geological Survey Open File Report 2008-1150, California Geological Survey Preliminary Report 25, version 1.0, 308p.

Jones, L.M., 1995, Putting Down Roots in Earthquake Country: Southern California Earthquake Center (SCEC) Special Publication, Los Angeles, California.

Jones, L., Mori, J., and Hauksson, E., 1995, The Landers Earthquake: Preliminary Instrumental Results: Earthquakes and Volcanoes, Vol. 23, No. 5, pp. 200-208.

Karter, M.J., 2009, Fire loss in the United States during 2008: National Fire Protection Association, Fire Analysis and Research Division, Quincy, MA.

Keefer, D.K., and Johnson, A.M., 1983, Earth flows: Morphology, mobilization, and movement: U.S. Geological Survey Professional Paper 1264, 55p.

Keeley, J.E., South Coast Bioregion; in Sugihara, N.G., van Wagtendonk, J.W., Shaffer, K.E., Fites-Kaufman, J., and Thode, A.E., (editors), 2006, Fire in California's Ecosystems: University of California Press, Berkeley and Los Angeles, California, pp. 391-414.

Krazan & Associates, Inc., 2008, Supplemental Geotechnical Engineering Investigation, proposed Newport Square, Southwest Corner Newport Road and Laguna Vista Drive, Menifee, California, Project No. 112-06064, dated July 29, 2008.

Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., Richardson, J.R., Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation No. FHWA-IP-90-014 Hydraulic Engineering Circular 20, 195p.

Lamar, D.L., Merifield, P.M., and Proctor, R.J., 1973, Earthquake recurrence intervals on major faults in southern California; in Moran, D.E., Slosson, J.E., Stone, R.O., and Yelverton, C.A., (editors), Geology, seismicity, and environmental impact: Association of Engineering Geologists Special Publication, pp. 265-276.

Lander, J.F., 1968, Seismological Notes: March and April 1968: Bulletin of the Seismological Society of America, Vol. 58, No. 5, pp. 1709-1714.

Langenheim, V.E., and Powell, R.E., 2009, Basin geometry and cumulative offsets in the Eastern Transverse Ranges, southern California: Implications for transrotational deformation along the San Andreas fault system: Geosphere (a publication of the Geological Society of America), Vol. 5, No. 1 (February edition), pp. 1-22; DOI: 10.1130/GES00177.1.

Larson, L., 2009, How Certain Are We About Our Flood Risk?: Nation Hazards Observer, Vol. XXXIII, No. 6, dated July 2009.

Lazarte, C.A., Bray, J.D., Johnson, A.M., and Lemmer, R.E., 1994, Surface Breakage of the 1992 Landers Earthquake and its Effects on Structures: Bulletin of the Seismological Society of America, Vol. 84, No. 3, pp 547-561.

Louderback, G.D., 1949, Seismological Notes, Desert Hot Springs Earthquake: Bulletin of the Seismological Society of America, Vol. 39, No. 1, pp. 57-65.

Louderback, G.D., 1954, Seismological Notes, 1954 San Jacinto Earthquake: Bulletin of the Seismological Society of America, Vol. 44, No. 3, pp. 529-542.

Louie, J.N., Allen, C.R., Johnson, D.C., Haase, P.C., and Cohn, S.N., 1985, Fault Slip in Southern California: Bulletin of the Seismological Society of America, Vol. 75, pp. 811-833.

Lund, Le Val, 1994, Lifelines Performance in the Landers and Big Bear (California) Earthquakes of 28 June 1992: Bulletin of the Seismological Society of America, Vol. 84, No. 3, pp. 562-572.

Lund, Le Val, 1996, Lifeline Utilities Performance in the 17 January 1994 Northridge, California Earthquake: Bulletin of the Seismological Society of America, Vol. 86, No. 1B, pp. S350-S361.

Magistrale, H., Jones, L., and Kanamori, H., 1989, The Superstition Hills, California, Earthquakes of 24 November 1987: Bulletin of the Seismological Society of America, Vol. 79, No. 2, pp. 239-251.

MAP IX – Mainland, 2009, Riverside County Essential Facilities Risk Assessment (RCEFRA) Project Report; Consulting Report prepared for the Department of Homeland Security – Federal Emergency Management Agency, EMF-2003-CO-0047, Task Order 040, dated June 2009.

Matti, J.C., Morton, D.M., Cox, B.F., 1992, The San Andreas Fault System in the Vicinity of the Central Transverse Ranges Province, Southern California: U.S. Geological Survey Open File Report 92-345.

Matti, J.C., Morton, D.M., and Cox, B.F., 1992, Distribution and geologic relations of fault systems in the vicinity of the central Transverse Ranges, southern California: U.S. Geological Survey Open-File Report 92-354, scale 1:250,000.

Matti, J.C., Tinsley, J.C., McFadden, L.D., and Morton, D.M., 1982, Holocene faulting history as recorded by alluvial history within the Cucamonga fault zone: a preliminary view; *in* Tinsley, J.C., McFadden, L.D., and Matti, J.C., (editors), Late Quaternary pedogenesis and alluvial chronologies of the Los Angeles and San Gabriel Mountains areas, southern California: Field Trip 12, Geological Society of America, Cordilleran section, 78th annual meeting, Anaheim, California, Guidebook, pp. 21-44.

McCulloch, D. S., 1985, Evaluating Tsunami Potential; *in* Ziony, I., (editor), Evaluating Earthquake Hazards in the Los Angeles Region: United States Geological Survey Professional Paper 1360, pp. 375-413.

McGarr, A., Vorhis, R. C., 1968, Seismic seiches from the March 1964 Alaska earthquake: U.S. Geological Survey Professional Paper 544-E, 43p.

McGlashan, H.D., and Ebert F.C., 1918, Southern California Floods of January 1916, U.S. Geological Survey Water Supply Paper 426.

Meisling, K.E., 1984, Neotectonics of the North Frontal fault system of the San Bernardino Mountains, southern California; Cajon Pass to Lucerne Valley: California Institute of Technology, unpublished Ph.D. dissertation.

Meisling, K.E., and Weldon, R.J., 1989, Late Cenozoic tectonics of the northwestern San Bernardino Mountains, southern California: Geological Society of America Bulletin, Vol. 101, pp.106-128.

Meltzner, A.J., Rockwell, T.K., and Owen, L.A., 2006, Recent and long-term behavior of the Brawley Fault Zone, Imperial Valley, California: An escalation in slip rate?: Bulletin of the Seismological Society of America, Vol. 96, No. 6, pp. 2304-2328; DOI: 10.1785/0120050233.

Millman, D.E., and Rockwell, T.K., 1986, Neotectonics of the Elsinore fault in Temescal Valley, California; in Ehlig, P., (editor), Guidebook and Volume on Neotectonics and Faulting in Southern California: Geological Society of America, Cordilleran Section, pp. 159-166.

Morton, D.M., 2004, Preliminary Digital Geological Map of the 30'x60' Santa Ana Quadrangle, southern California, Southern California Areal Mapping Project, Open-File Report 99-172 Version 2.0.

Morton, D.M., Campbell, R.H., Jibson, R.W., Wesson, R.L., and Nicholson, C., 1989, Ground fracturing and landsliding produced by the July 8, 1986 North Palm Springs Earthquake; *in* Sadler, P.M., and Morton, D.M., (editors), Landslides in a Semi-Arid Environment with Emphasis on the Inland Valleys of Southern California: Inland Geological Society, Volume 2, pp. 183-196.

Morton, D.M., and Matti, J.C., 1993, Extension and contraction within an evolving divergent strike-slip fault complex: The San Andreas and San Jacinto fault zones at their convergence in southern California: Geological Society of America Memoir 178, pp. 217-230.

Morton, D.M., and Matti, J.C., 1987, The Cucamonga fault zone: Geologic setting and Quaternary history; *in* Morton, D.M., and Yerkes R.F., (editors), Recent reverse faulting in the Transverse Ranges, California: U.S. Geological Survey Professional Paper 1339, pp. 179-203.

Morton, D.M., Matti, J.C., and Tinsley, J.C., 1987, Banning fault, Cottonwood Canyon, San Gorgonio Pass, southern California: Geological Society of America Centennial Field Guide-Cordilleran Section.

Morton, D.M., and Miller, F.K., 2006, Geologic map of the San Bernardino and Santa Ana 30'x60' quadrangles, California, Geology and Description of Map Units, U.S. Geological Survey Open-File Report 2006-1217, Version 1.0.

Morton, D.M., and Miller, F.K., 2003, Preliminary geologic map of the San Bernardino 30' x 60' quadrangle, California: USGS Open-File Report 03-293.

Morton, D.M., and Sadler, P.M., 1989, Landslides flanking the northeastern Peninsular Ranges and the San Gorgonio Pass area of southern California; *in* Sadler, P.M., and Morton, D.M., (editors), Landslides in a Semi-Arid Environment with Emphasis on the Inland Valleys of Southern California, Inland Geological Society, Vol. 2, pp. 338-255.

Mueller, K.J., 1984, Neotectonics, alluvial history and soil chronology of the southwestern margin of the Sierra de los Cucapas, Baja California Norte: Unpublished M.Sc. Thesis, San Diego State University, San Diego, California, 363p.

Mueller, K.J., and Rockwell, T.K., 1995, Late Quaternary activity of the Laguna Salada fault in northern Baja California, Mexico: Geological Society of America Bulletin, Vol. 107, No. 1, pp. 8-18.

National Climatic Data Center (NCDC), 2009, Event Details, flooding, http://www4.ncdc.noaa.gov.

National Earthquake Information Center (NEIC) USGS Earthquake Hazards Program http://neic.usgs.gov/neis/epic/epic_rect.html

National Fire Protection Association (NFPA), 2004, Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments: NFPA Standard 1710, 2004 Edition.

National Oceanic & Atmospheric Administration (NOAA), 2005a, NOAA identifies causes for latest wet weather in west, NOAA News Online (Story 2395) at www.noaanews.noaa.gov.

National Oceanic & Atmospheric Administration (NOAA), 2005b, Worsening drought in northwest, record rain in the southwest in January, NOAA News Online (Story 2389), at www.noaanews.noaa.gov.

National Climatic Data Center, 2010, Various Event Record Details, www4.ncdc.noaa.gov.

National Fire Protection Association (NFPA), 2010, Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments: NFPA Standard 1710, 2010 Edition, 24p.

National Research Council, Committee on FEMA Flood Maps, 2009, Mapping the Zone – Improving Flood Map Accuracy, National Academies Press, ISBN: 0-309-13058-1, 136p.

National Research Council, Committee on Alluvial Fan Flooding, 1996, Alluvial Fan Flooding, ISBN: 0-209-5542-3, 182p.

National Research Council, 2009, Mapping the Zone: Improving Flood Map Accuracy, ISBN: 0-309-13058-1, 136p.

O'Rourke, Michael J., and X. Liu, 1999, Response of Buried Pipelines Subject to Earthquake Effects: American Society of Civil Engineers, Multidisciplinary Center for Earthquake Engineering Research Monograph #3, Buffalo, New York, 249p.

Perry, R.W., and Lindell, M.K., 1995, Earthquake-initiated hazardous materials release: Lessons Learned from the Northridge Earthquake: George Washington University and Arizona State University.

Person, W. J., 1992, Earthquakes: March - April 1992: Earthquakes and Volcanoes, Vol. 23, No. 5, pp. 227-233.

Person, W. J., 1986, Earthquakes: July - August 1986: Earthquakes and Volcanoes, Vol. 19, No. 1, pp. 32-35.

Petersen, M.D., Bryant, W.A., Cramer, C.H., Cao, T., and Reichle, M.S., (California Division of Mines and Geology), Frankel, A.D., Lienkaemper, J.J., McCrory, P.A., and Schwartz, D.P., (U.S. Geological Survey), 1996, Probabilistic seismic hazard assessment for the State of California: California Division of Mines and Geology Open-File Report 96-08 and U.S. Geological Survey Open-File Report 96-706, 64 p.

Petersen, M. D. and Wesnousky, S.G., 1994, Fault slip rates and earthquake histories for active faults in southern California: Bulletin of the Seismological Society of America, Vol. 84, No. 5, pp. 1608-1649.

Phillips, Clinton B., 1983, Instructions for Zoning Fire Hazard Severity in State Responsibility Areas in California: California Department of Forestry, dated December 1983.

Pinault, C.T., and Rockwell, T.K., 1984, Rates and sense of Holocene faulting on the southern Elsinore fault: further constraints on the distribution of dextral shear between the Pacific and North American plates: Geological Society of America Abstract with Programs, Vol. 16, No. 6, p. 624.

Platte, M., and Brazil, J., 1993, Water Pressure Burned Laguna – Fire Distribution Problems, and Not Low Supply – Hindered Fight, Records Show: Los Angeles Times article, November 14, 1993; http://articles.latimes.com/1993-11-14/news/mn-56930_1_low-water-pressure.

Press-Enterprise, 1980, The Floods of February, Riverside County, 1980, collected photos and newspaper articles.

Reneau, S.L., and Dietrich, W.E., 1987, The importance of hollows in debris flow studies; examples from Marin County, California; *in* Costa, J.E. and Wieczorek, G.F. (editors), Debris flows/avalanches: Process, recognition, and mitigation: Geological Society of America Reviews in Engineering Geology, Vol. VII, pp. 165-179.

Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges (2d ed.): U.S. Department of Transportation Hydraulic Engineering Circular 18, 132p.

Rico, H., Hauksson, E., Given, D., Friberg, P., and Frechette, K., 2004, The CISN Display – Reliable delivery of real-time earthquake information and Shakemap to Critical End-users: Abstract, Seismological Society of America Meeting, April 14-16, Palm Springs, California.

Riverside County Transportation & Land Agency GIS, 2009, Flood zones in the Menifee area, http://www3.tlma.co.riverside.ca.us.

Riverside County Flood Control & Water Conservation District (RCFCWCD), 2009, District History, http://www.floodcontrol.co.riverside,ca.us

Riverside County, 2008, Sun City/Menifee Area Plan, County of Riverside General Plan, latest revision 2008.

Riverside County Flood Control & Water Conservation District (RCFCWCD), 2006, Romoland Master Drainage Plan, map scale 1″ = 600′, revised March 2006.

Riverside County Flood Control & Water Conservation District (RCFCWCD), 2006, Homeland Master Drainage Plan, map scale 1″ = 400′, revised March 2006.

Riverside County Flood Control & Water Conservation District (RCFCWCD), 1996, Salt Creek Channel Master Drainage Plan, map scale 1″ = 4000′, dated November 1996.

Riverside County Flood Control & Water Conservation District (RCFCWCD), 1988, Homeland/Romoland Area Drainage Plan, map scale 1″ = 800′, dated April 1988.

Riverside County Flood Control & Water Conservation District (RCFCWCD), 1987, Winchester Master Drainage Plan, map scale 1″ = 500′, dated September 1987.

Rockwell, T.K., Lindvall, S., Herzberg, M., Murbach, D., Dawson, T., and Berger, G., 2000, Paleoseismology of the Johnson Valley, Kickapoo and Homestead Valley faults: clustering of earthquakes in the Eastern California Shear Zone: Bulletin of the Seismological Society of America, Vol. 90, pp. 1200-1237.

Rockwell, T.K., McElwain, R.S., Millman, D.E., and Lamar, D.L., 1986, Recurrent late Holocene faulting on the Glen Ivy North strand of the Elsinore fault at Glen Ivy marsh; in Ehlig, P.L., (editor), Neotectonics and faulting in southern California: Geological Society of America, 82nd Annual Meeting of the Cordilleran Section, Guidebook and Volume, pp. 167-175.

Rogers, D. E., 1998, Perchlorate user and production information [memorandum with attachments to Annie M. Jarabek], Wright-Patterson Air Force Base, OH: Department of the Air Force, Air Force Materiel Command Law Office; October 30.

Rogers, T.H., 1967, Geologic map of California, San Bernardino Sheet, Olaf P. Jenkins Edition: California Division of Mines and Geology, Scale 1:250,000.

Rymer, M.J., 2000, Triggered surface slips in the Coachella Valley area associated with the 1992 Joshua Tree and Landers, California, earthquakes: Bulletin of the Seismological Society of America, Vol. 90, No. 4, pp. 832-848; DOI: 10.1785/0119980130.

Rymer, M.J., Boatwright, J., Seekins, L.C., Yule, J.D., and Liu, J., 2002, Triggered surface slips in the Salton Trough associated with the 1999 Hector Mine, California, earthquake: Bulletin of the Seismological Society of America, Vol. 92, No. 4, pp. 1300-1317.

San Bernardino County Flood Control District, 2009, Flood History, http://www.co.san-bernardino.ca.us.

Savage, W.U., 1995, Utility Lifelines Performance in the Northridge Earthquake; in Woods, M.C., and Seiple, W.R., (editors), The Northridge Earthquake of 17 January 1994: California Division of Mines and Geology Special Publication 116, p. 153-162.

Schlumberger Water Services, 2004, Mojave Water Agency 2004 Regional Water Management Plan, Volume 1: Report, dated September 2004.

Seed, R.B., Cetin, K.O., Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., Rimer, M.F., Sancio, R.B., Bray, J.D., Kayen, R.E., and Faris, A., 2003, Recent advances in soil liquefaction engineering: A unified and consistent framework: Earthquake Engineering Research Center, College of Engineering, University of California, Berkeley, EERC Report No. 2003-06, 71p.

Seismic Hazards Mapping Act, California Public Resources Code, Section 2690 et seq., last updated May 13, 2003.

Selingson, Hope, 2008, HAZUS Enhancements and Implementation for the ShakeOut Scenario: Supplemental Study for the ShakeOut Scenario, Report prepared for the U.S. Geological Survey and the California Geological Survey, to accompany U.S. Geological Survey Open File Report 2008-1150, California Geological Survey Preliminary Report 25 version 1.0, and U.S. Geological Survey Circular 1324, California Geological Survey Special Report 207 version 1.0.

Sharp, R.V., Budding, K.E., Boatwright, J., Ader, M.J., Bonilla, M.G., Clark, M.M., Fumal, T.E., Harms, K.K., Lienkaemper, J.J., Morton, D.M., O'Neil, B.J., Ostergren, C.L., Ponti, D.J., Rymer, M.J., Saxton, J.L., and Sims, J.D., 1989, Surface faulting along the Superstition Hills Fault Zone and nearby faults associated with the earthquakes of 24 November 1987: Bulletin of the Seismological Society of America, Vol. 79, No. 2, pp. 252-281.

Sharp, R.V., and Leinkaemper, J.J., 1982, Preearthquake and postearthquake near-field leveling across the Imperial fault and the Brawley fault zone; *in* The Imperial Valley, California, Earthquake of October 15, 1979, U.S. Geological Survey Professional Paper 1254, pp.169-182.

Shaw, J.H., and Shearer, P., 1999, An elusive blind-thrust fault beneath metropolitan Los Angeles: Science, Vol. 283, pp. 1516-1518.

Shelmon, R.J., 1995, Groundwater rise and hydrocollapse: technical and political implications of “Special Geologic Report Zones” in Riverside County, California, USA, in Land Subsidence, Proceedings of the Fifth International Symposium on Land Subsidence, IAHS Publication No. 234.

Shelmon, R.J., and Hakakian, M., 1992, Fissures produced both by groundwater rise and y groundwater fall: a geological paradox in the Temecula-Murrieta area, southwestern Riverside County, in Proceedings, Association of Engineering Geologists, 35th Annual Meeting, Long Beach, California.

Siddiqui, M., LeChevallier, M. W., Ban, J., Phillips, T., and Pivinski, J., 1998, Occurrence of perchlorate and methyl tertiary butyl ether (MTBE) in groundwater of the American water system: American Water Works Service Company, Inc., Vorhees, NJ, September 30.

Sieh, K., 1978, Slip along the San Andreas Fault associated with the great 1857 earthquake: Bulletin of the Seismological Society of America, Vol. 68, No. 4, pp. 1421-1448.

Sieh, K., Jones, L., Hauksson, E., Hudnut, K., Eberhart-Phillips, D., Heaton, T., Hough, S., Hutton, K., Kanamori, H., Lilje, A., Lindvall, S., McGill, S., Mori, J., Rubin, C., Spotila, J. A., Stock, J., Thio, H., Treiman, J., Wernicke, B., and Zachariasen, J., 1993, Near-field investigations of the Landers Earthquake sequence, April to July, 1992: Science, Vol. 260, pp. 171-176.

Sieh, K., and Matti, J.C., 1992, The San Andreas Fault System Between Palm Springs and Palmdale, Southern California: Field Trip Guidebook in Earthquake Geology, San Andreas Fault System, Palm Springs to Palmdale: Association of Engineering Geologists, 35th Annual Meeting, October 2-9, 1992, pp. 1-12.

Sieh, K., Stuiver, M. and Brillinger, D., 1989, A more precise chronology of earthquakes produced by the San Andreas Fault in southern California: Journal of Geophysical Research, Vol. 94, pp. 603-623.

Sieh, K. and Williams, P., 1990, Behavior of the southernmost San Andreas fault during the past 300 years: Journal of Geophysical Research, Vol. 95, pp. 6629-6645.

Sieh, K., Yule, D. and Spotila, J., 1996, Field Trip Along the Southern San Andreas and San Jacinto Faults: Southern California Earthquake Center Annual Meeting, unpublished notes, 21 figures.

Sneed, M., Stork, Ikehara, M.E., Stork, S.V., Amelung, F., and Galloway, D.L., 2003, Detection and Measurement of Land Subsidence Using Synthetic Aperture Radar and Global Positioning System, San Bernardino County, Mojave Desert, California,: U.S. Geological Survey, Water-Resources Investigations Report 03-4015, 60p.

Southern California Earthquake Center (SCEC), 2002, Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigation Landslide Hazards in California: Blake, T.F., Hollingsworth, R.A., and Stewart, J.P. (editors), 110p. + Appendix.

Southern California Earthquake Center (SCEC-DC), 2001, Big Bear earthquake, http://www.data.scec.org/chrono_index/bigbear.html

Southern California Earthquake Center, Southern California Earthquake Data Center, http://www.data.scec.org/catalog_search/date_mag_loc.php

Southern California Earthquake Center (SCEC), 1999, Recommended procedures for implementation of DMG SP117 Guidelines for Evaluating and Mitigating Seismic Hazards in California – Liquefaction Hazards in California: Martin, G.R., and Lew, M., (editors), 63p.

Spittler, T.E., Harp, E.L., Keefer, D.K., Wilson, R.C., and Sydnor, R.H., 1990, Landslide Features and other Coseismic Fissures Triggered by the Loma Prieta Earthquake, Santa Cruz Mountains, California; *in* McNutt, S.R., and Sydnor, R.H., (editors), The Loma Prieta (Santa Cruz Mountains), California, Earthquake of 17 October 1989: California Division of Mines and Geology Special Publication 104, pp. 59-66.

Stamos, C.L., Huff, J.A., Predmore, S.K., and Clark, D.A., 2004, Regional Water Table (2004) and Water-Level Changes in the Mojave River and Morongo Ground-water Basins, Southwestern Mojave Desert, California: U.S. Geological Survey Scientific Investigations Report No. 2004-5187, 7p. + plate.

Stamos, C.L., Martin, P., Nishikawa, T., and Cox, B.F., 2001, Simulation of ground-water flow in the Mojave River ground-water basin, California: U.S. Geological Survey Water-Resources Investigations Report 01-4002, 129p.

Stephens, S.L., and Sugihara, N.G., 2006, Fire Management and Policy Since European Settlement; in Sugihara, N.G., van Wagtendonk, J.W., Shaffer, K.E., Fites-Kaufman, J., and Thode, A.E., (editors), 2006, Fire in California's Ecosystems: University of California Press, Berkeley and Los Angeles, California, pp. 431-443.

Stermitz, F., 1964, Effects of the Hebgen Lake Earthquake on Surface Water: U.S. Geological Survey Professional Paper 435, pp. 139-150.

Stewart, C.A., Colby, N.D, Kent, R.T., Egan, J.A., and Hall, N.T., 1998, Earth Fissuring, Ground-Water Flow, and Ground-Water Quality in the Chino Basin, California; in Borchers, J.W., (editor), Land Subsidence, Case Studies and Current Research: Association of Engineering Geologists Special Publication No. 8, Proceedings of the Dr. Joseph F. Poland Symposium on Land Subsidence.

Stewart, J.P., Bray, J.D., McMahon, D.J., and Knopp, A.l., 1995, Seismic performance of hillside fills: Reprint from "Landslides under static and dynamic conditions-analysis, monitoring, and mitigation": Geotechnical Engineering Division/ASCE meeting held on October 23-27, 1995, San Diego, California.

Stewart, J.P., Bray, J.D., Seed, R.B., and Sitar, N., (editors), 1994, Preliminary report on the principal geotechnical aspects of the January 17, 1994 Northridge earthquake: University of California at Berkeley, College of Engineering Report No. UCB/EERC 94-08, 245p.

Sugihara, N.G., van Wagtendonk, J.W., Shaffer, K.E., Fites-Kaufman, J., and Thode, A.E., (editors), 2006, Fire in California's Ecosystems: University of California Press, Berkeley and Los Angeles, California, 596p.

Tan, S.S., 1998, Slope failure and erosion assessment of the fire areas at Fillmore (April 1996) and Piru (August 1997), Ventura County: California: California Division of Mines and Geology Open-File Report 98-32.

T&B Planning Consultants, 2005, Audie Murphy Ranch, Specific Plan No. 209, Amendment No. 4, Environmental Impact report No. 436, SC#2001101080, dated January 25, 2005.

T&B Planning Consultants, 2005, Menifee Specific Plan No. 158, Amendment No. 5, adopted by the Riverside County Board of Supervisors on January 11, 2005.

T&B Planning Consultants, 2002, Menifee Valley Ranch, Specific Plan No. 301 & EIR No. 423, Amendment No. 1, Final Technical Appendices, Volume 3 of 3.

T&B Planning Consultants, 1994, Menifee North, Specific Plan No. 260 & EIR No. 329, SCH No. 89100207, (Geotechnical Feasibility Investigation by Gary S. Rasmussen & Associates, March 1989).

Taylor, W.L., and Taylor, R.W., 2007, The Great California Flood of 1862: The Fortnightly Club of Redlands, California.

Tinsley, J.C., and Fumal, T.E., 1985, Mapping Quaternary Sedimentary Deposits for Aerial Variations in Shaking Response; *in* Ziony, J.I. (editor), Evaluating Earthquake Hazards in the Los Angeles Region – An Earth Science Perspective: U.S. Geological Survey Professional Paper 1360, pp. 101-125.

Tinsley, J.C., Youd, T.L., Perkins, D.M., and Chen, A.T.F., 1985, Evaluating Liquefaction Potential; *in* Ziony, J.I., (editor), Evaluating Earthquake Hazards in the Los Angeles Region – An Earth Science Perspective: U.S. Geological Survey Professional Paper 1360, pp. 263-316.

Toppozada, T.R., Borchardt, G., Hallstrom, C.L., and others, 1993, Planning Scenario for a Major Earthquake on the San Jacinto Fault in the San Bernardino Area: California Division of Mines and Geology, Special Publication 102, 221p.

Toppozada, T.R., and Parke, D.L., 1982, Areas damaged by California earthquakes 1900-1949: California Division of Mines and Geology Open File 82-17, 65p.

Toppozada, T.R., Real, C.R., and D.L. Parke, 1981, Preparation of Isoseismal Maps and Summaries of Reported Effects for Pre-1900 California Earthquakes: California Division of Mines and Geology Open File Report 81-11 SAC.

Townley, S.D., 1939, Earthquakes in California, 1769 to 1928: Bulletin of the Seismological Society of America, Vol. 29, No. 1, pp. 21-252.

Treiman, J.A., Kendrick, K.J., Bryant, W.A., Rockwell, T.K., and McGill, S.F., 2002, Primary surface rupture associated with the Mw 7.1 16 October 1999 Hector Mine earthquake, San Bernardino County, California: Bulletin of the Seismological Society of America, Vol. 92, No., 4, pp. 1171-1191.

Treiman, J.A. (compiler), 1998, Fault Number 126d, Elsinore fault zone, Temecula section; in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/regional/qfaults

Treiman, J.A., 1995, The San Gorgonio Pass, Banning and Related Faults, Riverside County, California: California Division of Mines and Geology Fault Evaluation Report FER-235, Supplement No. 1, dated May 15, 1995.

Treiman, J.A., 1994, The San Gorgonio Pass, Banning and Related Faults, Riverside County, California: California Division of Mines and Geology Fault Evaluation Report FER-235, dated September 27, 1994.

Troxell, H.C., 1942, Floods of March 1938 in southern California: U.S. Geological Survey Water-Supply Paper 844.

Unreinforced Masonry Law, California Public Resources Code, Chapter 12.2 Building Earthquake Safety, Section 8875 et seq.

U.S. Census Bureau, Population Division, 2008, Table 4: Annual Estimates of the Population for Incorporated Places in California, Listed Alphabetically; April 1, 2000 to July 1, 2007 (SUB-EST2007-04-06), released July 10, 2008.

U.S. Geological Survey, 1997, Lake Elsinore quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.

U.S. Geological Survey, 1979, Perris quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.

U.S. Geological Survey, 1967, El Casco quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.

U.S. Geological Survey, 1967, Lakeview quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.

U.S. Geological Survey, 1967, Riverside East quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.

U.S. Geological Survey, 1967, Steele Peak quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.

U.S. Geological Survey, 1967, Sunnymead quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.

U.S. Geological Survey, 1953, Bachelor Mountain quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.

U.S. Geological Survey, 1953, Murrieta quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.

U.S. Geological Survey, 1953, Romoland quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.

U.S. Geological Survey, 1953, Wildomar quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.

U.S. Geological Survey, 1953, Winchester quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.

U.S. Geological Survey, 2000, Landslide hazards, USGS Fact Sheet FS-071-00, available at http://pubs.usgs.gov/fs/fs-0071-00.

van Wagtendonk, J.W., and Cayan, D., 2008, Temporal and spatial distribution of lightning strikes in California in relation to large-scale weather patterns: Fire Ecology, Vol. 4, No. 1, pp.34-56.

Vaughan, P.R., Thorup, K., and Rockwell, T.K., 1999, Paleoseismology of the Elsinore fault at Agua Tibia Mountain, southern California: Bulletin of the Seismological Society of America, Vol. 89, pp. 1447-1457.

Waananen, A.O., 1969, Floods of January and February 1969 in central and southern California: U.S. Geological Survey, Water Resources Division, Open-File Report.

Wald, D.J., Quitorino, V., Heaton, T.H., and Kanamori, H., 1999, Relationships between peak ground acceleration, peak ground velocity, and Modified Mercalli Intensity in California: Earthquake Spectra, the Professional Journal of the Earthquake Engineering Research Institute (EERI), Vol. 15, No. 3, pp. 557-564.

Waring, G.A., 1919, Ground Water in the San Jacinto and Temecula Basins, California: U.S. Geological Survey Water Supply Paper 429, 113p.

Weldon, R.J., Fumal, T.E., and Biase, G.P., 2004, Implications from a long window of observation: the San Andreas fault at Wrightwood, California: Seismological Society of America, Abstracts, Annual Meeting, April 14-16, Palm Springs, California.

Wells, W.G., 1987, The effects of fire on the generation of debris flows in Southern California; *in* Costa, J.E. and Wieczorek, G.F., (editors), Debris flows/avalanches: Process, recognition, and mitigation: Geological Society of America, Reviews in Engineering Geology, Vol. VII, pp. 105-114.

Wesnousky, S.G., 1986. Earthquakes, Quaternary faults, and seismic hazards in southern California: Journal of Geophysical Research, Vol. 19, No. B12, pp. 12587-12631.

Wills, C.J., Weldon II, R.J., and Bryant, W.A., 2008, Appendix A: California fault parameters for the National Seismic Hazard Maps and Working Group on California Earthquake Probabilities 2007: U.S. Geological Survey Open File Report 2007-1437A, California Geological Survey Special Report 203A, Southern California Earthquake Center Contribution #1138A, Version 1.0, 48p.

2007 Working Group on California Earthquake Probabilities, 2008, The Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2): USGS Open File Report 2007-1437, CGS Special Report 203, SCEC Contribution #1138, Version 1.0.

Working Group on California Earthquake Probabilities (WGCEP), 1995, Seismic Hazards in Southern California: Probable Earthquakes, 1994 to 2024: Bulletin of the Seismological Society of America, Vol. 85, No. 2, pp. 379-439.

Working Group on California Earthquake Probabilities (WGCEP), 1992, Future Seismic Hazards in Southern California, Phase I, Implications of the Landers Earthquake Sequence: National Earthquake Prediction Council, California Earthquake Prediction Evaluation Council, and Southern California Earthquake Center, 42p.

Working Group on California Earthquake Probabilities (WGCEP), 1988, Probabilities of Large Earthquakes Occurring in California on the San Andreas Fault: U.S. Geological Survey Open-File Report 88-398, 62 pp.

Wyllie, D.C., and Norrish, N.I., 1996, Stabilization of rock slopes; *in* Turner, A.K., and Schuster, R.L. (editors), Landslides – investigation and mitigation: Transportation Research Board Special Publication 247, pp. 474-504.

Yashinsky, M., Simek, J., Murugesh, G., and Mualchin, L., 2002, Highway performance during the 16 October 1999 Hector Mine, California, earthquake: Bulletin of the Seismological Society of America, Vol. 92, No. 4, pp. 1621-1632.

Yule, D., and Sieh, K., 2003, Complexities of the San Andreas fault near San Gorgonio Pass: Implications for large earthquakes: Journal of Geophysical Research, Vol. 108, No. B11, pp. 2548.

Zappe, D.P., 1997, Testimony of David P. Zappe, General Manager-Chief Engineer, Riverside County Flood Control and Water Conservation District, Impact of the Endangered Species Act of Flood Control Activities; available online at www.House.gov/resources/105cong/fullcomm/apr10.97/zappe.htm.

Ziony, J.I., and Yerkes, R.F., 1985, Evaluating earthquake and surface-faulting potential; *in* Ziony, J.I. (editor), Evaluating Earthquake Hazards in the Los Angeles Region – An Earth-Science Perspective: U.S Geological Survey Professional Paper 1360, pp. 33-91.

Useful Websites

Geologic Hazards in General

http://geohazards.cr.usgs.gov/

USGS Hazard Team website. Hazard information on commonly recognized hazards such as earthquakes, landslides, and volcanoes. Contains maps and slide shows.

http://www.usgs.gov/themes/hazard.html

A webpage by the USGS on hazards such as hurricanes, floods, wildland fire, wildlife disease, coastal storms and tsunamis, and earthquakes. Also has information on their Hazard Reduction Program.

http://www.consrv.ca.gov/cgs/index.htm

Homepage for the California Geologic Survey (formerly the Division of Mines and Geology). Information their publications (geologic reports and maps), programs (seismic hazard mapping, Alquist-Priolo Earthquake Fault Study Zone maps); and other brochures (asbestos, natural hazard disclosure).

www.oes.ca.gov/

California Governor's Office of Emergency Services website. Contains information on response plans regarding natural disasters (earthquakes), terrorist attacks, and electrical outages, and information on past emergencies.

Geologic Maps

http://wrgis.wr.usgs.gov/wgmt/scamp/scamp.html

Homepage for the Southern California Aerial Mapping Project (SCAMP), which is the USGS' program to update geologic maps of Southern California at a 1:100,000 scale and release these in a digital GIS format.

Seismic Hazards, Faults, and Earthquakes

http://gmw.consrv.ca.gov/shmp/

Shows the current list of seismic hazard maps available from the California Geologic Survey. These can be downloaded in a pdf format.

www.scecdc.scec.org.

Southern California Earthquake data center (hosted by SCEC, USGS, and Caltech. Shows maps and data for recent earthquakes in Southern California and worldwide. Catalogs of historic earthquakes.

http://www.consrv.ca.gov/cgs/rghm/quakes/index.htm

List of California earthquakes (date, magnitude, latitude longitude, description of damage).

http://geohazards.cr.usgs.gov/eq/html/canvmap.html
Website at the USGS Earthquake Hazard's Program that lists seismic acceleration maps available for downloading.

www.seismic.ca.gov/
Homepage of the California Seismic Safety Commission. Contains information on California earthquake legislation, safety plans, and programs designed to reduce the hazards from earthquakes. Includes several publications of interest, including "The Homeowner's Guide to Earthquake Safety." Also contains a catalog of recent California earthquakes.

http://neic.usgs.gov/
Homepage of the National Earthquake Information Center. Maintains an extensive global seismic database on earthquake parameters. Its mission is to rapidly determine the location and size of all destructive earthquakes worldwide, and disseminate that information as quickly as possible to concerned national and international agencies, scientists, and the public in general.

http://www.scsn.org/
Site where Shakemaps for actual and scenario earthquakes can be obtained.

Landslides and Debris Flows

http://landslides.usgs.gov/index.html
USGS Landslide webpage. Links to their publications, recent landslide events, and bibliographic databases.

http://gmw.consrv.ca.gov/shmp/
California Geologic Survey website on Seismic Hazard maps.

http://vulcan.wr.usgs.gov/Glossary/Lahars/framework.html
USGS Volcanic Observatory website list of links regarding mudflows, debris flows and lahars.

http://www.fema.gov/hazards/landslides/landslif.shtm
Federal Emergency Management Agency (FEMA) fact sheet website about landslides and mudflows.

Flooding, Dam Inundation, and Erosion (Note: the information on some of these web sites has been removed due to safety concerns; but may be posted again in the future in limited form).

http://vulcan.wr.usgs.gov/Glossary/Sediment/framework.html
US Geological Survey Volcanic Observatory website list of links regarding sediment and erosion.

http://www.usace.army.mil/public.html#Regulatory
US Army Corps of Engineers website regarding waterway regulations.

http://www.fema.gov/fima/
FEMA website about the National Flood Insurance Program.

http://www.worldclimate.com/
Precipitation rates at different rain stations in the world measured over time.

http://waterdata.usgs.gov
Stream gage measurements for rivers throughout the US.

Fire Hazards, Wildfires and Related Topics

http://osfm.fire.ca.gov/FFLaws.html
Site that pertains to California laws about fires and firefighters.

http://www.fire.ca.gov/
California Department of Forestry and Fire Protection's Web Site

http://www.fire.ca.gov/FireEmergencyResponse/FirePlan/FirePlan.asp
California Fire Plan

http://www.fireplan.gov
National Fire Plan

http://nfpa.org/
National Fire Protection Association Web Site

http://firewise.org/
Site dedicated to providing information to homeowners about becoming firewise in the urban/wildland interface.

http://www.fema.gov/
Federal Emergency Management Agency Web Site; includes general information on how to prepare for wildfire season, current fire events, etc.

http://www.usfa.fema.gov/
U.S. Fire Administration Web Site.

http://www.iso.com
Insurance Services Office Web Site.

Others

http:// www.bsc.ca.gov
Site of the California Building Standards Commission. Provides information regarding the status of the building codes being considered for future approval in California.

APPENDIX B: GLOSSARY

Acceleration – The rate of change for a body's magnitude, direction, or both over a given period of time.

Active fault – For implementation of Alquist-Priolo Earthquake Fault Zoning Act (APEFZA) requirements, an active fault is one that shows evidence of having experienced surface displacement within the last 11,000 years. APEFZA classification is designed for land use management of surface rupture hazards. A more general definition by the National Academy of Sciences (1988) is "a fault that on the basis of historical, seismological, or geological evidence has the finite probability of producing an earthquake." The American Geological Institute (1972) defines an active fault as one along which there is recurrent movement, usually indicated by small, periodic displacements or seismic activity.

Acute – Quick, one-time exposure to a chemical.

Adjacent grade – Elevation of the natural or graded ground surface, or structural fill, abutting the walls of a building. See *highest adjacent grade* and *lowest adjacent grade*.

Aeolian – Related to or pertaining to the wind; carried, eroded or deposited by wind action.

Aftershocks – Minor earthquakes following a greater one and originating at or near the same location.

Aggradation – The building up of earth's surface by deposition of sediment.

Alluvial – Pertaining to, or composed, of alluvium, or deposited by a stream or running water.

Alluvial fan – A low, outspread relatively flat to gently sloping surface consisting of loose sediment that is shaped like an open fan, deposited by a stream at the place where the stream comes out of a narrow canyon onto a broad valley or plain. Alluvial fans are steepest near the mouth of the canyon, and spread out, gradually decreasing in gradient, away from the stream source.

Alluvium – Surficial sediments of poorly consolidated gravels, sand, silts, and clays deposited by flowing water.

Amplitude – The height of a wave between its crest (high point) and its mid-point

Anchor – To secure a structure to its footings or foundation wall in such a way that a continuous load transfer path is created and so that it will not be displaced by flood, wind, or seismic forces.

Aplite – A light-colored igneous rock with a fine-grained texture and free from dark minerals. Aplite forms at great depths beneath the earth's crust.

Apparatus – Fire apparatus includes firefighting vehicles of various types.

Aquifer – A body of rock or sediment that contains sufficient saturated permeable material to allow the flow of ground water and to yield economically significant quantities of ground water to wells and springs.

Argillic – Alteration in which certain minerals of a rock or sediments are converted to clay. Also said of a soil horizon characterized by the illuvial accumulation of clay.

Armor – To protect slopes from *erosion* and *scour* by *flood* waters. Techniques of armoring include the use of riprap, gabions, or concrete.

Artesian – An adjective referring to ground water confined under hydrostatic pressure. The water level in wells drilled into an **artesian** aquifer (also called a confined aquifer) will stand at some height above the top of the aquifer. If the water reaches the ground surface, the well is referred to as a "flowing" **artesian** well.

Aspect – The direction a slope faces.

Attenuation – The reduction in amplitude of a wave with time or distance traveled.

Automatic Aid Agreement – An agreement between two or more agencies whereby such agencies are automatically dispatched simultaneously to predetermined types of emergencies in predetermined areas.

A zone – Under the *National Flood Insurance Program*, area subject to inundation by the *100-year flood* where wave action does not occur or where waves are less than 3 feet high, designated Zone A, AE, A1-A30, A0, AH, or AR on a *Flood Insurance Rate Map* (FIRM).

Base flood – *Flood* that has as 1-percent probability of being equaled or exceeded in any given year. Also known as the *100-year flood*.

Base Flood Elevation (BFE) – Elevation of the *base flood* in relation to a specified datum, such as the *National Geodetic Vertical Datum* or the *North American Vertical Datum*. The Base Flood Elevation is the basis of the insurance and *floodplain management* requirements of the *National Flood Insurance Program*.

Basement – Under the *National Flood Insurance Program*, any area of a building having its floor subgrade on all sides. (Note: What is typically referred to as a "walkout basement," which has a floor that is at or above grade on at least one side, is not considered a basement under the *National Flood Insurance Program*.)

Beaufort Scale – A scale devised in 1805 by Admiral Francis Beaufort of the British Navy to classify wind speed based on the wind's effect on the seas and vegetation. The scale goes from 0 (calm) to 12 (hurricane).

Bedding – The arrangement of a sedimentary rock or deposit in beds or layers of varying thickness and character.

Bedrock – Designates hard rock that is in its natural intact position and underlies soil or other unconsolidated surficial material.

Bench – A grading term that refers to a relatively level step excavated into earth material on which fill is to be placed. A bench is also a long, narrow, relatively level or gently inclined platform of land or rock bounded by steeper slopes above and below.

Bioregion – A major, regional ecological community characterized by distinctive life forms and distinctive plant and animal species.

Biotite – A general term to designate all ferromagnesian micas. More specifically, biotite is a widely distributed and important rock-forming mineral that is usually black, brown or dark green, and that is an original constituent of igneous and metamorphic rocks, or a detrital constituent of sedimentary rocks.

Blind thrust fault – A thrust fault is a low-angle reverse fault (where the top block is being or has been pushed over the bottom block). A "blind" thrust fault refers to one that does not reach the surface.

Braided stream – A stream that divides into or follows an interlacing or tangled network of several, small, branching and reuniting shallow channels separated from each other by channel bars. Also referred to as an **anastomosing** stream.

Brush – A collective term that refers to stands of vegetation dominated by shrubby, woody plant, or low-growing trees.

Brushfire – A fire burning in vegetation that is predominantly shrubs, brush, and scrub growth.

Building code – Regulations adopted by local governments that establish standards for construction, modification, and repair of buildings and other structures.

Carcinogen – Material capable of causing cancer in humans.

Cast-in-place concrete – Concrete that is poured and formed at the construction site.

CEQA – The California Environmental Quality Act (Chapters 1 through 6 of Division 13 of the Public Resources Code). A state statute that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible.

Chronic – Continual or repeated exposure to a hazardous material.

Cladding – Exterior surface of the building envelope that is directly loaded by the wind.

Clay – A rock or mineral fragment having a diameter less than 1/256 mm (4 microns, or 0.00016 in.). A clay commonly applied to any soft, adhesive, fine-grained deposit.

Claystone – An indurated clay having the texture and composition of shale, but lacking its fine lamination. A massive mudstone in which clay predominates over silt.

Climate – The average condition of weather over time in a given region.

Code official – Officer or other designated authority charged with the administration and enforcement of the code, or a duly authorized representative, such as a building, zoning, planning, or *floodplain management* official.

Collapse – A relatively sudden change in the volume of a soil mass resulting in the local settlement of the ground surface, with the potential to cause significant damage to overlying structures. If due to strong ground shaking, the soil grains in the soil column are re-arranged by the shaking so that the pore space between grains is reduced and the grains become more tightly packed, resulting in the overall reduction of the thickness of the soil column. This is referred to as earthquake-induced subsidence. Collapse can also occur in certain types of sediments, where with the introduction of water (due to an increase in irrigation, for example), the cement between soil grains dissolves, allowing the soil particles to become more tightly packed, again resulting in the local settlement of the ground surface. This process is also referred to as **hydro-collapse** or **hydroconsolidation**.

Column foundation – Foundation consisting of vertical support members with a height-to-least-lateral-dimension ratio greater than three. Columns are set in holes and backfilled with compacted material. They are usually made of concrete or masonry and often must be braced. Columns are sometimes known as posts, particularly if the column is made of wood.

Compressible soil – Geologically young unconsolidated sediment of low density that may compress under the weight of a proposed fill embankment or structure.

Community at Risk – Wildland interface community in the vicinity of Federal lands that is at high risk from wildfire.

Complex (Fire) –Two or more individual incidents located in the same general area and assigned to a single incident commander or unified command.

Concrete Masonry Unit (CMU) – Building unit or block larger than 12 inches by 4 inches by 4 inches made of cement and suitable aggregates.

Conglomerate – A coarse-grained sedimentary rock composed of rounded to subangular fragments larger than 2 mm in diameter set in a fine-grained matrix of sand or silt, and commonly cemented by calcium carbonate, iron oxide, silica or hardened clay. The consolidated equivalent of gravel.

Connector – Mechanical device for securing two or more pieces, parts, or members together, including anchors, wall ties, and fasteners.

Consolidation – Any process whereby loosely aggregated, soft earth materials become firm and cohesive rock. Also the gradual reduction in volume and increase in density of a soil mass in response to increased load or effective compressive stress, such as the squeezing of fluids from pore spaces.

Corrosion-resistant metal – Any nonferrous metal or any metal having an unbroken surfacing of nonferrous metal, or steel with not less than 10 percent chromium or with not less than 0.20 percent copper.

Coseismic rupture - Ground rupture occurring during an earthquake but not necessarily on the causative fault.

Cretaceous – The final period of the Mesozoic era (before the Tertiary period of the Cenozoic era), thought to have occurred between about 136 and 65 million years ago.

Dead load – Weight of all materials of construction incorporated into the building, including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, *cladding*, and other similarly incorporated architectural and structural items and fixed service equipment. See *Loads*.

Debris – (Seismic) The scattered remains of something broken or destroyed; ruins; rubble; fragments. (Flooding, Coastal) Solid objects or masses carried by or floating on the surface of moving water.

Debris Burning – Any fire originally set for the purpose of clearing land or for burning rubbish, garbage, range, stubble, or meadow burning.

Debris impact loads – Loads imposed on a structure by the impact of floodborne debris. These loads are often sudden and large. Though difficult to predict, debris impact loads must be considered when structures are designed and constructed. See *Loads*.

Debris flow – A saturated, rapidly moving saturated earth flow with 50 percent rock fragments coarser than 2 mm in size which can occur on natural and graded slopes.

Debris line – Line left on a structure or on the ground by the deposition of debris. A debris line often indicates the height or inland extent reached by *flood* waters.

Defensible space – An area, either natural or manmade, where material capable of causing a fire to spread has been treated, cleared, reduced, or changed in order to provide a barrier between an advancing wildland fire and the loss to life, property, or resources. In practice, defensible space is defined as an area with a minimum of 100 feet around a structure that is cleared of flammable brush or vegetation. Distance from the structure and the degree of fuels treatment vary with vegetation type, slope, density, and other factors.

Deflected canyons – A relatively spontaneous diversion in the trend of a stream or canyon caused by any number of processes, including folding and faulting.

Deformation - A general term for the process of folding, faulting, shearing, compression, or extension of rocks.

Design flood – The greater of either (1) the *base flood* or (2) the *flood* associated with the *flood hazard area* depicted on a community's flood hazard map, or otherwise legally designated.

Design Flood Elevation (DFE) – Elevation of the *design flood*, or the flood protection elevation required by a community, including wave effects, relative to the *National Geodetic Vertical Datum*, *North American Vertical Datum*, or other datum.

Development – Under the *National Flood Insurance Program*, any manmade change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation, or drilling operations or storage of equipment or materials.

Differential settlement – Non-uniform settlement; the uneven lowering of different parts of an engineered structure, often resulting in damage to the structure. Sometimes included with liquefaction as ground failure phenomenon.

Dike – A tabular shaped, igneous intrusion that cuts across bedding of the surrounding rock.

Diorite – A group of igneous rocks that form at great depth beneath the earth's crust. These rocks are intermediate in composition between acidic and basic rocks.

Dispatch – The implementation of a command decision to move a resource or resources from one place to another.

Displacement - The length, measured in kilometers (km), of the total movement that has occurred along a fault over as long a time as the geologic record reveals.

DMA 2000 - Disaster Mitigation Act of 2000. Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by Public Law 106-390, October 30, 2000. DMA 2000 is intended to establish a continuing means of assistance by the Federal Government to State and local governments in carrying out their responsibilities to alleviate the suffering and damage which result from disasters by (1) revising and broadening the scope of existing disaster relief programs; (2) encouraging the development of comprehensive disaster preparedness and assistance plans, programs, capabilities, and organizations by the States and by local governments; (3) achieving greater coordination and responsiveness of disaster preparedness and relief programs; (4) encouraging individuals, States, and local governments to protect themselves by obtaining insurance coverage to supplement or replace governmental assistance; (5) encouraging hazard mitigation measures to reduce losses from disasters, including development of land use and construction regulations; and (6) providing Federal assistance programs for both public and private losses sustained in disasters .

Dynamic analysis – A complex earthquake-resistant engineering design technique (UBC - used for critical facilities) capable of modeling the entire frequency spectra, or composition, of ground motion. The method is used to evaluate the stability of a site or structure by considering the motion from any source or mass, such as that dynamic motion produced by machinery or a seismic event.

Earth flow – Imperceptibly slow-moving surficial material in which 80 percent or more of the fragments are smaller than 2 mm, including a range of rock and mineral fragments.

Earthquake – Vibratory motion propagating within the Earth or along its surface caused by the abrupt release of strain from elastically deformed rock by displacement along a fault.

Earth's crust – The outermost layer or shell of the Earth.

Effective Flood Insurance Rate Map (FIRM) – See *Flood Insurance Rate Map*.

El Niño – Phenomenon that originates, every few years, typically in December or early January, in the southern Pacific Ocean, off of the western coast of South America, characterized by warmer than usual water. This warmer water is statistically linked with increased rainfall in both the southeastern and southwestern United States, droughts in Australia, western Africa and Indonesia, reduced number of earthquakes in the Atlantic Ocean, and increased number of hurricanes in the Eastern Pacific.

Emergency Planning and Community Right to Know (EPCRA) – The portion of SARA that specifically outlines how industries report chemical inventory to the community.

Encroachment – Any physical object placed in a floodplain that hinders the passage of water or otherwise affects the flood flows.

Engineering geologist – A geologist who is certified by the State as qualified to apply geologic data, principles, and interpretation to naturally occurring earth materials so that geologic factors affecting planning, design, construction, and maintenance of civil engineering works are properly recognized and used. An engineering geologist is particularly needed to conduct investigations, often with geotechnical engineers, of sites with potential ground failure hazards.

Environmental Protection Agency (EPA) – Federal agency tasked with ensuring the protection of the environment and the nation's citizens.

Ephemeral stream – A stream or reach of a stream that flows only briefly in direct response to precipitation.

Epicenter – The point at the Earth's surface directly above where an earthquake originated.

Erodible soil – Soil subject to wearing away and movement due to the effects of wind, water, or other geological processes during a flood or storm or over a period of years.

Erosion – Under the *National Flood Insurance Program*, the process of the gradual wearing away of landmasses. In general, erosion involves the detachment and movement of soil and rock fragments, during a flood or storm or over a period of years, through the action of wind, water, or other geologic processes.

Erosion analysis – Analysis of the short- and long-term *erosion* potential of soil or strata, including the effects of wind action, *flooding* or *storm surge*, moving water, wave action, and the interaction of water and structural components.

Evacuation – Movement of people from an area, typically their homes, to another area considered to be safe, typically in response to a natural or man-made disaster that makes an area unsafe for people.

Expansive soil – A soil that contains clay minerals that take in water and expand. If a soil contains sufficient amount of these clay minerals, the volume of the soil can change significantly with changes in moisture, with resultant structural damage to structures founded on these materials.

Extremely hazardous substance – A substance that shows high acute or chronic toxicity, carcinogenity, bioaccumulative properties, is persistent in the environment, or is water reactive (California Code of Regulations, Title 22).

Fanglomerate – A sedimentary rock consisting of a heterogeneous mix of fragments of all sizes, originally deposited in an alluvial fan and subsequently cemented into a firm rock. Generally said of the coarser, consolidated rock material that occurs in the upper part of an alluvial fan.

Fault – A fracture (rupture) or a zone of fractures along which there has been displacement of adjacent earth material.

Fault segment – A continuous portion of a fault zone that is likely to rupture along its entire length during an earthquake.

Fault slip rate – The average long-term movement of a fault (measured in cm/year or mm/year) as determined from geologic evidence.

Federal Emergency Management Agency (FEMA) – Independent agency created in 1979 to provide a single point of accountability for all Federal activities related to disaster mitigation and emergency preparedness, response and recovery. FEMA administers the *National Flood Insurance Program*.

Federal Insurance Administration (FIA) – The component of the *Federal Emergency Management Agency* directly responsible for administering the flood insurance aspects of the *National Flood Insurance Program*.

Federal Responsibility Areas (FRA) – Areas within which a federal government agency has the financial responsibility of preventing and suppressing fires.

Feldspar – The most widespread of any mineral group; constitutes ~60% of the earth's crust. Feldspars occur as components of all kinds of rocks and, on decomposition, yield a large part of the clay of a soil.

Fill – Material such as soil, gravel, or crushed stone placed in an area to increase ground elevations or change soil properties. See *structural fill*.

Fire behavior – The manner in which a fire reacts to the influences of fuel, weather and topography.

Fire flow – The flow rate of a water supply expressed in gallons per minute (gpm), measured at 20 pounds per square inch (psi) residual pressure, that is available for fire fighting.

Fire frequency – The number of fires occurring within a defined area in a given time period.

Fire regime – The long-term fire pattern characteristic of a region or ecosystem described using a combination of seasonality, fire return interval, size, spatial complexity, intensity, severity, and fire type.

Fire resistant – A characteristic of a plant species that allows individuals to resist damage or mortality during a fire. Also used to describe construction materials that resist damage to fire.

FIRESCOPE – **FI**refighting **RES**ources of **C**alifornia **O**rganized for **P**otential **E**mergencies. A cooperative effort involving all agencies with fire fighting responsibilities in California. The goal of this group is to create and implement new applications in fire service management, technology and coordination, with an emphasis on incident command and multi-agency coordination. This dynamic state-wide program serves the needs of California fire service management as an ongoing program.

First responders – A group designated by the community as those who may be first to arrive at the scene of a fire, accident, or chemical release.

Fire weather – The weather conditions that influence fire behavior, including air temperature, atmospheric moisture, atmospheric stability, clouds and precipitation.

Five-hundred (500)-year flood – *Flood* that has as 0.2-percent probability of being equaled or exceeded in any given year.

Flash flood – A local and sudden flood or torrent overflowing a stream channel in an usually dry valley, carrying an immense load of mud and rock fragments, and generally resulting from a rare and brief but heavy rainfall over a relatively small area having steep slopes.

Flood – A rising body of water, as in a stream or lake, which overtops its natural and artificial confines and covers land not normally under water. Under the *National Flood Insurance Program*, either:

(a) a general and temporary condition or partial or complete inundation of normally dry land areas from:

(1) the overflow of inland or tidal waters,

(2) the unusual and rapid accumulation or runoff of surface waters from any source, or

(3) mudslides (i.e., mudflows) which are proximately caused by flooding as defined in (2) and are akin to a river of liquid and flowing mud on the surfaces of normally dry land areas, as when the earth is carried by a current of water and deposited along the path of the current, or

(b) the collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm, or by an unanticipated force of nature, such as flash flood or abnormal tidal surge, or by some similarly unusual and unforeseeable event which results in flooding as defined in (1), above.

Flood-damage-resistant material – Any construction material capable of withstanding direct and prolonged contact (i.e., at least 72 hours) with floodwaters without suffering significant damage (i.e., damage that requires more than cleanup or low-cost cosmetic repair, such as painting).

Flood elevation – Height of the water surface above an established elevation datum such as the *National Geodetic Vertical Datum*, *North American Vertical Datum*, or *mean sea level*.

Flood hazard area – The greater of the following: (1) the area of special flood hazard, as defined under the *National Flood Insurance Program*, or (2) the area designated as a flood hazard area on a community's legally adopted flood hazard map, or otherwise legally designated.

Flood insurance – Insurance coverage provided under the National Flood Insurance Program.

Flood Insurance Rate Map (FIRM) – Under the *National Flood Insurance Program*, an official map of a community, on which the *Federal Emergency Management Agency* has delineated both the special hazard areas and the risk premium zones applicable to the community. (Note: The latest FIRM issued for a community is referred to as the *effective FIRM* for that community.)

Flood Insurance Study (FIS) – Under the *National Flood Insurance Program*, an examination, evaluation, and determination of *flood* hazards and, if appropriate, corresponding *water surface elevations*, or an examination, evaluation, and determination of mudslide (i.e., mudflow) and/or flood-related erosion hazards in a community or communities. (Note: The *National Flood Insurance Program* regulations refer to Flood Insurance Studies as "flood elevation studies.")

Flood-related erosion area or flood-related erosion prone area – A land area adjoining the shore of a lake or other body of water, which due to the composition of the shoreline or bank and high water levels or wind-driven currents, is likely to suffer *flood*-related *erosion* damage.

Flooding – See *Flood*.

Floodplain – Under the *National Flood Insurance Program*, any land area susceptible to being inundated by water from any source. See *Flood*.

Floodplain management – Operation of an overall program of corrective and preventive measures for reducing *flood* damage, including but not limited to emergency preparedness plans, flood control works, and *floodplain management regulations*.

Floodplain management regulations – Under the *National Flood Insurance Program*, zoning ordinances, subdivision regulations, building codes, health regulations, special purpose ordinances (such as floodplain ordinance, grading ordinance, and erosion control ordinance), and other applications of police power. The term describes such state or local regulations, in any combination thereof, which provide standards for the purpose of *flood* damage prevention and reduction.

Floodway – The channel of a river or other watercourse, and the adjacent land areas that must be kept free of encroachment in order to discharge the base flood without cumulatively increasing the water surface elevation more than a certain height.

Flow failure – A type of liquefaction-induced failure that generally occurs in slopes greater than 3 degrees, and that is characterized by the displacement, often over tens to hundreds of feet, of blocks of soil riding on top of the liquefied substrate.

Footing – Enlarged base of a foundation wall, pier, post, or column designed to spread the load of the structure so that it does not exceed the soil bearing capacity.

Footprint – Land area occupied by a structure.

Freeboard – Under the *National Flood Insurance Program*, a factor of safety, usually expressed in feet above a *flood* level, for the purposes of *floodplain management*. Freeboard tends to compensate for the many unknown factors that could contribute to flood heights greater than the heights calculated for a selected size flood and floodway conditions, such as the hydrological effect of urbanization of the watershed.

Fuel – The source of heat that sustains the combustion process. In wildland fires, fuel is the combustible plant biomass, including grass, leaves, ground litter, shrubs, plants and trees.

Fuel load – The amount of fuel that is potentially available for combustion.

Fuel moisture – The moisture content expressed as a percentage of the dry weight of the fuel.

Gabbro – A group of dark-colored intrusive igneous rocks composed principally of plagioclase. The approximate intrusive equivalent of basalt.

Geomorphology – The science that treats the general configuration of the Earth's surface. The study of the classification, description, nature, origin and development of landforms, and the history of geologic changes as recorded by these surface features.

Geotechnical engineer – A licensed civil engineer who is also certified by the State as qualified for the investigation and engineering evaluation of earth materials and their interaction with earth retention systems, structural foundations, and other civil engineering works.

Gneiss – A metamorphic rock in which bands of granular minerals alternate with bands in which mineral have a flaky or prismatic habit, with less than 50 percent of the minerals showing preferred parallel orientation.

Grading – Any excavating or filling or combination thereof. Generally refers to the modification of the natural landscape into pads suitable as foundations for structures.

Granite – Broadly applied, any completely crystalline, quartz-bearing, plutonic rock.

Ground failure – Permanent ground displacement produced by fault rupture, differential settlement, liquefaction, or slope failure.

Ground lurching – A form of earthquake-induced ground failure where soft, saturated soils move in a wave-like manner in response to intense seismic ground shaking, forming ridges or cracks at the surface.

Ground oscillations – A type of liquefaction-induced failure where liquefaction occurs at depth, in an area where the ground surface is too level to permit the lateral displacement of the overlying soil blocks. The blocks instead separate from one another and oscillate above the liquefied layer. This may result in the opening and closing of fissures or cracks, and the formation of sand boils or volcanoes.

Ground rupture – Displacement of the earth's surface as a result of fault movement associated with an earthquake.

Hazardous material (HAZMAT) – Substance that has the ability to harm humans, property or the environment. The United States Environmental Protection Agency defines hazardous waste as substances that:

1) may cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness;
2) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of or otherwise managed; and
3) whose characteristics can be measured by a standardized test or reasonably detected by generators of solid waste through their knowledge of their waste.

Hazardous waste is also ignitable, corrosive, or reactive (explosive) (EPA 40 CFR 260.10). A material may also be classified as hazardous if it contains defined amounts of toxic chemicals.

Hazardous Waste Operations and Emergency Response (HAZWOPER) – The Occupational Safety and Health Agency (OSHA) regulation that covers safety and health issues at hazardous waste sites and response to chemical incidents.

Hazard reduction – Any treatment of a hazard that reduces the threat of ignition and fire intensity or rate of spread.

Highest adjacent grade – Elevation of the highest natural or regarded ground surface, or structural fill, that abuts the walls of a building.

Holocene – An epoch of the Quaternary period spanning from the end of the Pleistocene to the present time (the past about 11,000 years).

Hornblende – The most common mineral of the amphibole group. It is a primary constituent in many intermediate igneous rocks.

Hydrocompaction – Settlement of loose, granular soils that occurs when the loose, dry structure of the sand grains held together by a clay binder or other cementing agent collapses upon the introduction of water.

Hydrodynamic loads – Loads imposed on an object, such as a building, by water flowing against and around it. Among these loads are positive frontal pressure against the structure, drag effect along the sides, and negative pressure on the downstream side.

Hydrostatic loads – Loads imposed on a surface, such as a wall or floor slab, by a standing mass of water. The water pressure increases with the square of the water depth.

Hypocenter – The earthquake focus, that is, the place at depth, along the fault plane, where an earthquake rupture started.

Igneous – Type of rock or mineral that formed from molten or partially molten magma.

Ignition point – The location of the ignition.

Ignition source – The origin or source of a fire.

Infiltration – The process by which water seeps into the soil, as influenced by soil texture, soil structure, and vegetation cover.

Intensity – A measure of the effects of an earthquake at a particular place. Intensity depends on the earthquake magnitude, distance from the epicenter, and on the local geology.

Invasive plants – Plants that aggressively expand their ranges over the landscape, typically at the expense of native plants that are displaced or destroyed by the newcomers. Invasive species are typically considered a major threat to biological diversity.

ISO – Insurance Services Office. Private organization that formulates fire safety ratings based on fire threat and responsible agency's ability to respond to the threat. ISO ratings from one (excellent) to ten (no fire protection). Many insurance companies use ISO ratings to set insurance premiums. ISO may establish multiple ratings within a community, such as a rating of 5 in the hydranted areas and one of 8 in the non-hydranted areas.

Jet stream – A relatively narrow stream of fast-moving air in the middle and upper troposphere. Surface cyclones develop and move along the jet stream.

Jetting (of piles) – Use of a high-pressure stream of water to embed a pile in sandy soil. See *pile foundation*.

Joist – Any of the parallel structural members of a floor system that support, and are usually immediately beneath, the floor.

ka – thousands of years before present.

Lacustrine flood hazard area – Area subject to inundation by *flooding* from lakes.

Ladder fuels – Fuels that provide vertical continuity between strata, allowing fire to move from the surface fuels to the crowns of shrubs and trees with relative ease.

Landslide – A general term covering a wide variety of mass-movement landforms and processes involving the downslope transport, under gravitational influence, of soil and rock material en masse.

Lateral force – The force of the horizontal, side-to-side motion on the Earth's surface as measured on a particular mass; either a building or structure.

Lateral spreading – Lateral movements in a fractured mass of rock or soil which result from liquefaction or plastic flow or subjacent materials.

Left-lateral fault – A strike-slip fault across which a viewer would see the block on the opposite side of the fault move to the left.

Level-of-service standard (LOS standard) – Quantifiable measures against which services being delivered by a service provider can be compared. Standards based upon recognized and accepted professional and county standards, while reflecting the local situation within which services are being delivered. Levels-of-service standards for fire protection may include response times, personnel per given population, and emergency water supply. LOS standards can be used to evaluate the way in which fire protection services are being delivered, for use in countywide fire planning efforts.

Lifeline system – Linear conduits or corridors for the delivery of services or movement of people and information (e.g., pipelines, telephones, freeways, railroads)

Lineament – Straight or gently curved, lengthy features of earth's surface, frequently expressed topographically as depressions or lines of depressions, scarps, benches, or change in vegetation.

Liquefaction – Changing of soils (unconsolidated alluvium) from a solid state to weaker state unable to support structures; where the material behaves similar to a liquid as a consequence of earthquake shaking. The transformation of cohesionless soils from a solid or liquid state as a result of increased pore pressure and reduced effective stress.

Litter – Recently fallen plant material that is only partially decomposed, forming a surface layer on some soils.

Live loads – *Loads* produced by the use and occupancy of the building or other structure. Live loads do not include construction or environmental loads such as wind load, snow load, rain load, earthquake load, flood load, or dead load. See *Loads*.

Load-bearing wall – Wall that supports any vertical load in addition to its own weight. See *Non-load-bearing wall*.

Loads – Forces or other actions that result from the weight of all building materials, occupants and their possessions, environmental effects, differential movement, and restrained dimensional changes. Permanent loads are those in which variations over time are rare or of small magnitude. All other loads are variable loads.

Local Responsibility Area (LRA) – Lands in which the financial responsibility of preventing and suppressing fires is primarily the responsibility of the local jurisdiction.

Lowest floor – Under the *National Flood Insurance Program*, the lowest floor of the lowest enclosed area (including basement) of a structure. An unfinished or *flood*-resistant enclosure, usable solely for parking of vehicles, building access, or storage in an area other than a basement is not considered a building's lowest floor, provided that the enclosure is not built so as to render the structure in violation of *National Flood Insurance Program* regulatory requirements.

Lowest horizontal structural member – In an elevated building, the lowest beam, *joist*, or other horizontal member that supports the building. *Grade beams* installed to support vertical foundation members where they enter the ground are not considered lowest horizontal structural members.

Ma – millions of years before present.

Macroburst – A strong downdraft over 2.5 miles in diameter that can cause damaging winds lasting 5 to 20 minutes. Formed by an area of significantly rain-cooled air that after hitting ground levels spreads out in all directions.

Magnitude – A measure of the size of an earthquake, as determined by measurements from seismograph records. Also refers to both a fire's intensity and severity.

Main shock – The biggest earthquake of a sequence of earthquakes that occur fairly close in time and space. Smaller shocks before the main shock are called **foreshocks**; smaller shocks that occur after the main shock are called **aftershocks**.

Major earthquake – Capable of widespread, heavy damage up to 50+ miles from epicenter; generally near Magnitude range 6.5 to 7.0 or greater, but can be less, depending on rupture mechanism, depth of earthquake, location relative to urban centers, etc.

Manufactured home – Under the *National Flood Insurance Program*, a *structure*, transportable in one or more sections, which is built on a permanent chassis and is designed for use with or without a permanent foundation when attached to the required utilities. The term "manufactured home" does not include a "recreational vehicle."

Masonry – Built-up construction of combination of building units or materials of clay, shale, concrete, glass, gypsum, stone, or other approved units bonded together with or without mortar or grout or other accepted methods of joining.

Mass casualty – Incident in which the number of victims exceeds the capability of the emergency management system to manage the incident effectively.

Material Safety Data Sheets (MSDS) – Information sheets for employees that provide specific information about a chemical that they may come in contact at their place of work, with attention to health effects, handling, and emergency procedures.

Maximum Contaminant Level (MCL) – Federal drinking water standard: "the maximum permissible level of a contaminant in water which is delivered to any user of a public water system" (Code of Federal Regulations [CFR], Title 40, Part 141.2).

Maximum Magnitude Earthquake (Mmax) – The highest magnitude earthquake a fault is capable of producing based on physical limitations, such as the length of the fault or fault segment.

Maximum Probable Earthquake (MPE) – The design size of the earthquake expected to occur within a time frame of interest, for example within 30 years or 100 years, depending on the purpose, lifetime or importance of the facility. Magnitude/frequency relationships are based on historic seismicity, fault slip rates, or mathematical models. The more critical the facility, the longer the time period considered.

Mediterranean climate – The climate characteristic of the Mediterranean region and most of California, characterized by hot, dry summers, and cool, wet winters.

Metamorphic rock – A rock whose original mineralogy, texture, or composition has been changed due to the effects of pressure, temperature, or the gain or loss of chemical components.

Mean sea level (MSL) – Average height of the sea for all stages of the tide, usually determined from hourly height observations over a 19-year period on an open coast or in adjacent waters having free access to the sea. See *National Geodetic Vertical Datum*.

Microburst – A very localized zone of sinking air, less than 2.5 miles in diameter, producing damaging, straight-line, divergent winds at or near the ground surface lasting 2 to 5 minutes.

Mitigation – Any action taken to reduce or permanently eliminate the long-term risk to life and property from natural hazards.

Mitigation Directorate – Component of *Federal Emergency Management Agency* directly responsible for administering the flood hazard identification and *floodplain management* aspects of the *National Flood Insurance Program*.

Moderate earthquake – Capable of causing considerable to severe damage, generally in the range of Magnitude 5.0 to 6.0 (Modified Mercalli Intensity <VI), but highly dependent on rupture mechanism, depth of earthquake, and location relative to urban center, etc.

Modified Mercalli Intensity – A qualitative measure of the size of an earthquake based on people's description of how strongly the earthquake was felt, and the damage it caused to the built environment. The scale has 12 divisions, ranging from I (felt by only a very few people) to XII (total damage).

Mutual Aid Agreement – A reciprocal aid agreement between two or more agencies that defines what resources each will provide to the other in response to certain predetermined types of emergencies. Mutual aid response is provided upon request.

National Fire Protection Association (NFPA) – A group that issues fire and safety standards for industry and emergency responders.

National Fire Incident Reporting System (NFIRS) – A database of fire incident reports compiled at the local fire department level. NFIRS was an outgrowth of the 1974 National Fire Prevention and Control Act, Public Law 93–498. The U.S. Fire Administration (USFA), an entity of the Department of Homeland Security, developed NFIRS as a means of assessing the nature and scope of the fire problem in the United States.

National Flood Insurance Program (NFIP) – Federal program created by Congress in 1968 that makes *flood* insurance available in communities that enact and enforce satisfactory *floodplain management regulations*.

National Geodetic Vertical Datum (NGVD) – Datum established in 1929 and used as a basis for measuring flood, ground, and structural elevations, previously referred to as Sea Level Datum or *Mean Sea Level*. The *Base Flood Elevations* shown on most of the *Flood Insurance Rate Maps* issued by the *Federal Emergency Management Agency* are referenced to NGVD or, more recently, to the *North American Vertical Datum*.

Near-field earthquake – Used to describe a local earthquake within approximately a few fault zone widths of the causative fault which is characterized by high frequency waveforms that are destructive to above-ground utilities and short period structures (less than about two or three stories).

New construction – For the purpose of determining flood insurance rates under the *National Flood Insurance Program*, *structures* for which the start of construction commenced on or after the effective date of the initial *Flood Insurance Rate Map* or after December 31, 1974, whichever is later, including any subsequent improvements to such structures. (See *Post-FIRM structure*.) For *floodplain management* purposes, new construction means *structures* for which the *start of construction* commenced on or after the effective date of a *floodplain management regulation* adopted by a community and includes any subsequent improvements to such structures.

Non-coastal A zone – The portion of the *Special Flood Hazard Area* in which the principal source of *flooding* is runoff from rainfall, snowmelt, or a combination of both. In non-coastal A zones, *flood* waters may move slowly or rapidly, but waves are usually not a significant threat to buildings. See *A zone* and *coastal A zone*. (Note: the *National Flood Insurance Program* regulations do not differentiate between non-coastal A zones and *coastal A zones*.)

Non-load-bearing wall – Wall that does not support vertical loads other than its own weight. See *Load-bearing wall*.

North American Vertical Datum (NAVD) – Datum used as a basis for measuring flood, ground, and structural elevations. NAVD is used in many recent *Flood Insurance Studies* rather than the *National Geodetic Vertical Datum*.

Oblique-reverse fault – A fault that combines some strike-slip motion with some dip-slip motion in which the upper block, above the fault plane, moves up over the lower block.

Offset ridge – A ridge that is discontinuous on account of faulting.

Offset stream – A stream displaced laterally or vertically by faulting.

One hundred (100)-year flood – See *Base flood*.

Orthoclase – One of the most common rock-forming minerals; colorless, white, cream-yellow, flesh-reddish, or grayish in color.

Paleoseismic – Pertaining to an earthquake or earth vibration that happened decades, centuries, or millennia ago.

Peak flood – The highest discharge or stage value of a flood.

Peak Ground Acceleration (PGA) – The greatest amplitude of acceleration measured for a single frequency on an earthquake accelerogram. The maximum horizontal ground motion generated by an earthquake. The measure of this motion is the acceleration of gravity (equal to 32 feet per second squared, or 980 centimeter per second squared), and generally expressed as a percentage of gravity.

Pedogenic – Pertaining to soil formation.

Pegmatite – An igneous rock with extremely large grains, more than a centimeter in diameter.

Perched ground water – Unconfined ground water separated from an underlying main body of ground water by an unsaturated zone.

Perennial Stream – A stream that flows continuously throughout the year.

Plagioclase – One of the most common rock forming minerals.

Playa – Term used in the Southwestern US to describe a flat-floored, typically unvegetated area composed of thin, stratified sheets of fine clay, silt or sand that represent the bottom or central part of a shallow, completely closed or undrained desert lake basin where water accumulates after a rainstorm and quickly evaporates, leaving behind deposits of soluble salts.

Plutonic – Pertaining to igneous rocks formed at great depth.

Plywood – Wood structural panel composed of plies of wood veneer arranged in cross-aligned layers. The plies are bonded with an adhesive that cures on application of heat and pressure.

Pore pressure – The stress transmitted by the fluid that fills the voids between particles of a soil or rock mass.

Post foundation – Foundation consisting of vertical support members set in holes and backfilled with compacted material. Posts are usually made of wood and usually must be braced. Posts are also known as columns, but columns are usually made of concrete or masonry.

Post-FIRM structure – For purposes of determining insurance rates under the *National Flood Insurance Program*, structures for which the *start of construction* commenced on or after the effective date of an initial *Flood Insurance Rate Map* or after December 31, 1974, whichever is later, including any subsequent improvements to such structures. This term should not be confused with the term *new construction* as it is used in *floodplain management*.

Potentially active fault – According to the Alquist-Priolo Earthquake Fault Zone Act guidelines, a fault showing evidence of movement within the last 1.6 million years but that has not been shown conclusively whether or not it has ruptured in the past about 11,000 years ago. The U.S. Geological Survey considers a fault potentially active if it has moved in the time period between about 11,000 years ago (the Holocene) and 750,000 years ago, and that is thought capable of generating damaging earthquakes.

Precast concrete – Structural concrete element cast elsewhere than its final position in the structure. See *Cast-in-place concrete*.

Prescribed Fire – A fire ignited under known conditions of fuel, weather, and topography to achieve specific objectives.

Primary fault rupture - Fissuring and displacement of the ground surface along a fault that breaks in an earthquake.

Project – A development application involving zone changes, variances, conditional use permits, tentative parcel maps, tentative tract maps, and plan amendments.

Quartzite – A metamorphic rock consisting mostly of quartz.

Quartz monzonite – A plutonic rock containing major plagioclase, orthoclase and quartz; with increased orthoclase it becomes a granite.

Quaternary – The second period of the Cenozoic era, consisting of the Pleistocene and Holocene epochs; covers the last approximately 1.6 to 2 million years.

Rain shadow – A reduction in precipitation in an area on the leeward side of a mountain or range of mountains, caused by the release of moisture on the windward side.

Resonance – Amplification of ground motion frequencies within bands matching the natural frequency of a structure and often causing partial or complete structural collapse; effects may demonstrate minor damage to single-story residential structures while adjacent 3- or 4-story buildings may collapse because of corresponding frequencies, or vice versa.

Recurrence interval – The time between earthquakes of a given magnitude, or within a given magnitude range, on a specific fault or within a specific area.

Reinforced concrete – *Structural concrete* reinforced with steel bars.

Remote shutoff – Valve that can be used to shut off the flow of a substance or chemical from a location away from the spill or break.

Reportable quantity – A term used by the EPA and the Department of Transportation (DOT) to denote a quantity of chemicals that require some kind of action, such as reporting an inventory or reporting an accident involving a certain amount of chemicals.

Response spectra – The range of potentially damaging frequencies of a given earthquake applied to a specific site and for a particular building or structure.

Response Time – The time that elapses between the moment a 911 call is placed to the emergency dispatch center and the time that a first-responder arrives on scene. Response time includes dispatch time, turnout time (the time it takes firefighters to travel to the fire station, don their personal protection equipment, and prepare the apparatus), and travel time.

Retrofit – Any change made to an existing structure to reduce or eliminate damage to that structure from flooding, *erosion*, high winds, earthquakes, or other hazards.

Revetment – Facing of stone, cement, sandbags, or other materials placed on an earthen wall or embankment to protect it from *erosion* or *scour* caused by *flood* waters or wave action.

Rhyolite – A group of extrusive igneous rocks, generally exhibiting flow texture, with large crystals (phenocrysts) of quartz and alkali feldspar in a glassy to cryptocrystalline groundmass. The approximate extrusive equivalent of granite.

Ridgetop shattering – An earthquake-induced type of ground failure that occurs along at or along the top of ridges, forming linear, fault-like fissures, and leaving the area looking like it was plowed.

Right-lateral fault – A strike-slip fault across which a viewer would see the block on the opposite side of the fault move to the right.

Riprap – Broken stone, cut stone blocks, or rubble that is placed on slopes to protect them from *erosion* or *scour* caused by *flood* waters or wave action.

Rockfall – Free-falling to tumbling mass of bedrock that has broken off steep canyon walls or cliffs.

Sand boil – An accumulation of sand resembling a miniature volcano or low volcanic mound produced by the expulsion of liquefied sand to the sediment surface. Also called sand blows, and sand volcanoes.

Sandstone – A medium-grained, clastic sedimentary rock composed of abundant rounded or angular fragments of sand size set in a fine-grained matrix and more or less firmly united by a cementing material.

Santa Ana (or Santana) wind – Strong, typically extremely dry offshore winds that characteristically blow through southern California and northern Baja California in late fall and winter. They typically originate in the Great Basin or upper Mojave Desert, and can be either hot or cold. The winds tend to funnel down the valleys and canyons, where gusts can attain speeds of 60 to 90 miles per hour (mph). Several devastating wildfires in southern California have been associated with Santa Ana winds.

Saturated – Said of the condition in which the interstices of a material are filled with a liquid, usually water.

Scarp – A line of cliffs produced by faulting or by erosion. The term is an abbreviated form of escarpment.

Schist – A metamorphic rock characterized by a preferred orientation in grains resulting in the rock's ability to be split into thin flakes or slabs.

Scour – Removal of soil or fill material by the flow of *flood* waters. The term is frequently used to describe storm-induced, localized conical erosion around pilings and other foundation supports where the obstruction of flow increases turbulence. See *Erosion*.

Secondary fault rupture - Ground surface displacements along faults other than the main traces of active regional faults.

Sediment – Solid fragmental material that originates from weathering of rocks and is transported or deposited by air, water, ice, or that accumulates by other natural agents, such as chemical precipitation from solution, and that forms in layers on the Earth's surface in a loose, unconsolidated form.

Seiche – A free or standing-wave oscillation of the surface of water in an enclosed or semi-enclosed basin (such as a lake, bay, or harbor), that is initiated chiefly by local changes in atmospheric pressure, aided by winds, tidal currents, and earthquakes, and that continues, pendulum-fashion, for a time after cessation of the originating force.

Seismic Moment – A measure of the size of an earthquake that is associated with the amount of energy released (the force that was necessary to overcome the friction along the fault plane), the area of the fault rupture, and the average amount of slip.

Seismogenic – Capable of producing earthquake activity.

Seismograph – An instrument that detects, magnifies, and records vibrations of the Earth, especially earthquakes. The resulting record is a seismogram.

Shearwall – *Load-bearing wall* or *non-load-bearing wall* that transfers in-plane lateral forces from lateral *loads* acting on a structure to its foundation.

Sheet flow – An overland flow or downslope movement of water taking the form of a thin, continuous film over relatively smooth soil or rocks surfaces and not concentrated into channels larger than rills.

Shutter ridge – That portion of an offset ridge that blocks or "shutters" the adjacent canyon.

Sidehill fill – A wedge of artificial fill typically placed on the side of a natural slope to create a roadway or a level building pad.

Silt – A rock fragment or detrital particle smaller than a very fine sand grain and larger than coarse clay, having a diameter in the range of 1/256 to 1/16 mm (4-62 microns, or 0.00016-0.0025 in.). An indurated silt having the texture and composition of shale but lacking its fine lamination is called a siltstone.

Slip Rate – The speed at which a fault is moving, typically expressed in millimeters per year (mm/yr), and generally estimated by measuring the amount of offset that has occurred in a given, known amount of time.

Slope ratio – Refers to the angle or gradient of a slope as the ratio of horizontal units to vertical units. For example, in a 2:1 slope, for every two horizontal units, there is a vertical rise of one unit (equal to a slope angle, from the horizontal, of 26.6 degrees).

Slump – A landslide characterized by a shearing and rotary movement of a generally independent mass of rock or earth along a curved slip surface.

Soft-story building – Building with a story, generally the ground or first floor, lacking adequate strength or toughness due to too few shear walls. Examples of this type of structure include apartments above glass-fronted stores, and buildings perched atop parking garages.

Soil horizon – A layer of soil that is distinguishable from adjacent layers by characteristic physical properties such as structure, color, or texture.

Special Flood Hazard Area (SFHA) – Under the *National Flood Insurance Program*, an area having special *flood*, mudslide (i.e., mudflow) and/or flood-related erosion hazards, and shown on a

Flood Hazard Boundary Map or *Flood Insurance Rate Map* as Zone A, AO, A1-A30, AE, A99, AH, V, V1-V30, VE, M or E.

Spot fire – Ignition resulting from embers from the fireline transported aerially in front of the fireline and often increasing fire spread.

Standardized Emergency Management System (SEMS) – (Government Code § 8607). The group of principles developed for coordinating state and local emergency response in California. SEMS provides for organization of a multiple-level emergency response, and is intended to structure and facilitate the flow of emergency information and resources within and between the organizational levels--the field response, local government, operational areas, regions and the state management level. SEMS incorporates by reference: the Incident Command System (ICS); multi-agency or inter-agency coordination; the State's Mutual Aid Program; and Operational Areas.

State Responsibility Area (LRA) – Per California Public Resources Code 4125-4127, the lands in which the State has primary financial responsibility for preventing and suppressing fires.

Storage capacity – Dam storage measured in acre-feet or decameters, including dead storage.

Strike-slip fault – A fault with a vertical to sub-vertical fault surface that displays evidence of horizontal and opposite displacement.

Structural concrete – All concrete used for structural purposes, including *plain concrete* and *reinforced concrete*.

Structural engineer – A licensed civil engineer certified by the State as qualified to design and supervise the construction of engineered structures.

Structural fill – Fill compacted to a specified density to provide structural support or protection to a *structure*. See *Fill*.

Structure – Something constructed, such as a building, or part of one. For *floodplain management* purposes under the *National flood Insurance Program*, a walled and roofed building, including a gas or liquid storage tank, that is principally above ground, as well as a manufactured home. For insurance coverage purposes under the NFIP, structure means a walled and roofed building, other than a gas or liquid storage tank, that is principally above ground and affixed to a permanent site, as well as a *manufactured home* on a permanent foundation. For the latter purpose, the term includes a building while in the course of construction, alteration, or repair, but does not include building materials or supplies intended for use in such construction, alteration, or repair, unless such materials or supplies are within an enclosed building on the premises.

Subsidence – The sudden sinking or gradual downward settling of the Earth's surface with little or no horizontal motion.

Superfund Amendments and Reauthorization Act (SARA) – Law that regulates a number of environmental issues, predominantly for the chemical inventory reporting by industry to the local community.

Swale – In hillside terrace, a shallow drainage channel, typically with a rounded depression or "hollow" at the head.

Talus – The cone-shaped accumulation of angular fragments of rock or soil at the base of a cliff that has experienced rockfalls.

Tectonic plate – Any of several large pieces, or blocks, of the Earth's lithosphere that are slowly moving relative to each other as part of the process called plate tectonics.

Thrust fault – A fault, with a relatively shallow dip, in which the upper block, above the fault plane, moves up over the lower block.

Tornado – A localized but violently destructive windstorm occurring over land (at sea it is called a waterspout) characterized by a funnel-shaped cloud extending toward the ground.

Transform system – A system in which faults of plate-boundary dimensions transform into another plate-boundary structure when it ends.

Transpression – In crustal deformation, an intermediate stage between compression and strike-slip motion; it occurs in zones with oblique compression.

Tsunami – Great sea wave produced by submarine earth movement, volcanic eruption, oceanic meteor impact, or underwater nuclear explosion.

Typhoon – Name given to a *hurricane* in the area of the western Pacific Ocean west of 180 degrees longitude.

Unconfined aquifer – Aquifer in which the upper surface of the saturated zone is free to rise and fall.

Unconsolidated sediments – A deposit that is loosely arranged or unstratified, or whose particles are not cemented together, occurring either at the surface or at depth.

Undermining – Process whereby the vertical component of erosion or scour exceeds the depth of the base of a building foundation or the level below which the bearing strength of at the foundation is compromised.

Unreinforced Masonry (URM) structure – Building without adequate anchorage of the masonry walls to the roof and floor diaphragms and lack of steel reinforcement, of limited strength and ductility, and as a result, that tends to perform poorly when shaken during an earthquake.

Uplift – Hydrostatic pressure caused by water under a building. It can be strong enough lift a building off its foundation, especially when the building is not properly anchored to its foundation.

Upper bound earthquake – Defined as a 10% chance of exceedance in 100 years, with a statistical return period of 949 years.

Underground Storage Tank (UST) – Tank, commonly used to store gasoline, diesel or other chemical, that is buried under the ground.

Variance – Under the *National Flood Insurance Program*, grant of relief by a community from the terms of a *floodplain management regulation*.

Violation – Under the *National Flood Insurance Program*, the failure of a structure or other development to be fully compliant with the community's *floodplain management regulations*. A *structure* or other *development* without the elevation certificate, other certifications, or other evidence of compliance required in Sections 60.3(b)(5), (c)(4), (c)(10), (d)(3), (e)(2), (e)(4), or (e)(5) of the NFIP regulations is presumed to be in violation until such time as that documentation is provided.

Watershed – A topographically defined region draining into a particular river or lake.

Water surface elevation – Under the *National Flood Insurance Program*, the height, in relation to the *National Geodetic Vertical Datum* of 1929 (or other datum, where specified), of *floods* of various magnitudes and frequencies in the *floodplains* of coastal or riverine areas.

Water table – The upper surface of groundwater saturation of pores and fractures in rock or surficial earth materials.

Water year – The 12-month period from October 1 through September 30 of the following year.

Weather – The short-term state of the air or atmosphere with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness, or any other meteorologic phenomena.

X zone – Under the *National Flood Insurance Program*, areas where the *flood* hazard is less than that in the *Special Flood Hazard Area*. Shaded X zones shown on recent *Flood Insurance Rate Maps* (B zones on older maps) designate areas subject to inundation by the *500-year flood*. Unshaded X zones (C zones on older *Flood Insurance Rate Maps*) designate areas where the annual probability of flooding is less than 0.2 percent.