

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, and 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 increased.

The city of Hesperia and surrounding areas are, like most of southern California, subject to unpredictable seasonal rainfall. Most years, the scant 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. Flood events that occurred in southern California in 1862, 1884, 1916, 1938, 1969, 1978, 1980, 1983, 1988, 1992, 1995, 1998 and 2005 have caused an increased awareness of the potential for public and private losses as a result of this hazard, particularly in highly urbanized parts of floodplains and alluvial fans. As the population in the area increases, 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 the storm drainage systems are not designed or improved to convey these increased flows, areas that may 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 city of Hesperia and its Sphere of Influence (herein referred to as the city) encompass an area with sharp contrasts in terrain. High, steep slopes of the San Bernardino Mountains border the city on the south; deeply eroded foothills occupy the southern part of the city; and the central and northern parts are situated on a broad, moderately to gently sloping alluvial fan emanating from the adjacent mountain ranges.

Nearly all of the streams in the Hesperia high desert area eventually discharge into the Mojave River. Streams on the north flank of the San Bernardino Mountains form the headwaters of this great river, the largest drainage course in the Mojave Desert region. These streams include Horsethief Canyon, Little Horsethief Canyon, West Fork of the Mojave, Grass Valley Creek, Kinley Creek, Deep Creek, and many smaller, unnamed drainages (see Plate 2-1). The upper West Fork of the Mojave River flows into Silverwood Lake, a man-made reservoir formed by Cedar Springs Dam. Below the dam, the lower West Fork, along with flows from the Horsethief Canyon area, converge with Grass Valley Creek and Deep Creek above the Mojave Forks Dam, the only major flood control structure on the river.

After leaving the mountains, the Mojave River flows northward, along the eastern edge of the city, then bends eastward near Barstow, eventually reaching Soda Lake near Baker.

Along most of its length, water flows underground, rising only to the surface in areas where shallow, impermeable rock is present, such as the narrows near Victorville. During exceptional storms however, the Mojave River can carry flowing water along its entire length (Figure 3-1).

Figure 3-1: The Mojave River Bed Appears Dry Most of the Year as Water Travels Through Permeable Sands Below the Surface. During and after storms however, the river can carry fast-moving, sediment-laden waters the full width of its channel.
View is to the south from Calpella Avenue in Hesperia.



The largest tributary to the Mojave River within the developed part of the city is the Antelope Valley Wash, a broad, deeply incised drainage channel that collects runoff from the low hills north of Summit Valley. The lower reaches of the wash have significant development, including a golf course and many single-family homes. The upper reaches are largely undeveloped except for Summit Valley Road and a rail line. North of Antelope Valley Wash, in the central part of the city, the alluvial fan surface is incised with numerous small, relatively shallow drainages. Near the Mojave River, some of the tributary drainages are deeply incised, ranging up to about 50 feet in depth. The head of the fan, in the southwestern part of the city, is also deeply eroded, with major drainages as deep as 100 feet.

The western part of Hesperia is crossed by several major stream channels, the largest of which is the Oro Grande Wash. These drainages originate in the uplifted alluvial fans of the Oak Hills area, near the base of the mountains, then flow north to northeastward, merging with the Mojave River north of the city. Hesperia is also traversed by the East Branch of the California Aqueduct, which for the most part is an open canal.

Most of Hesperia's existing development is situated on the alluvial fan surface. Although some newer projects consist of closely spaced tract homes, mass graded developments are not common. Older construction, as well as a considerable amount of recent construction, has been completed with minimal alteration to the natural topography. As a result, natural

drainage courses meander through developed areas. Small channels pass through private yards, and many homes are built within the larger drainages. Most streets follow the natural contours of the land, commonly (although not entirely) without culverts or bridges across drainage channels.

Floods on alluvial fans have characteristics that are significantly different from those caused by river flooding. Although typically shallow in depth, mudflows can strike with little warning, travel at very high speeds, and carry tremendous amounts of sediment and debris (National Research Council, 1996). The Federal Emergency Management Agency (FEMA) defines an *active* alluvial fan flood hazard based on three related criteria: (1) unpredictable flow paths; (2) abrupt deposition and erosion; and (3) an environment where the combination of sediment availability, slope, and topography creates an ultra-hazardous condition. These characteristics make realistic assessments of flood risk and development of reliable mitigation particularly challenging. FEMA also defines an *inactive* alluvial fan flooding hazard as one that has relatively stable flow paths, and a low level of sedimentation/erosion such that it does not cause instability in the established flow paths. A particular alluvial fan may show characteristics of both active and inactive processes, especially if it has been modified by man-made structures. The fans in the Hesperia area largely fall into this mixed category.

3.1.2 Meteorological Setting

The high mountains flanking the city of Hesperia 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 south and west from the dry, desert regions to the east and northeast. Most of the precipitation occurs in the winter months, between November and April. However, high intensity, short duration tropical storms emanating from the Baja California area are common during the summer and fall.

The high mountains south of the city receive significantly more precipitation than the adjacent desert. Average yearly precipitation in the Hesperia area is about 5 to 6 inches (see Table 3-1), whereas more than 42 inches (average) of precipitation fall annually in the local mountains (Table 3-2).

Table 3-1: Average Annual Rainfall* by Month for Victorville Pump Plant (el. 2,857')

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Inches	1.0	0.9	1.0	0.4	0.1	0.0	0.1	0.2	0.3	0.3	0.5	0.8	5.6

Data based on 56 complete years between 1938 and 1995.

Source: <http://www.worldclimate.com/>

*Average rainfall = Mean monthly precipitation, including rain, snow, hail, etc.

Table 3-2: Average Annual Rainfall* by Month for Lake Arrowhead (el. 5,203')

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Inches	9.1	8.1	7.1	3.4	1.1	0.2	0.1	0.4	0.9	1.6	4.6	6.3	42.9

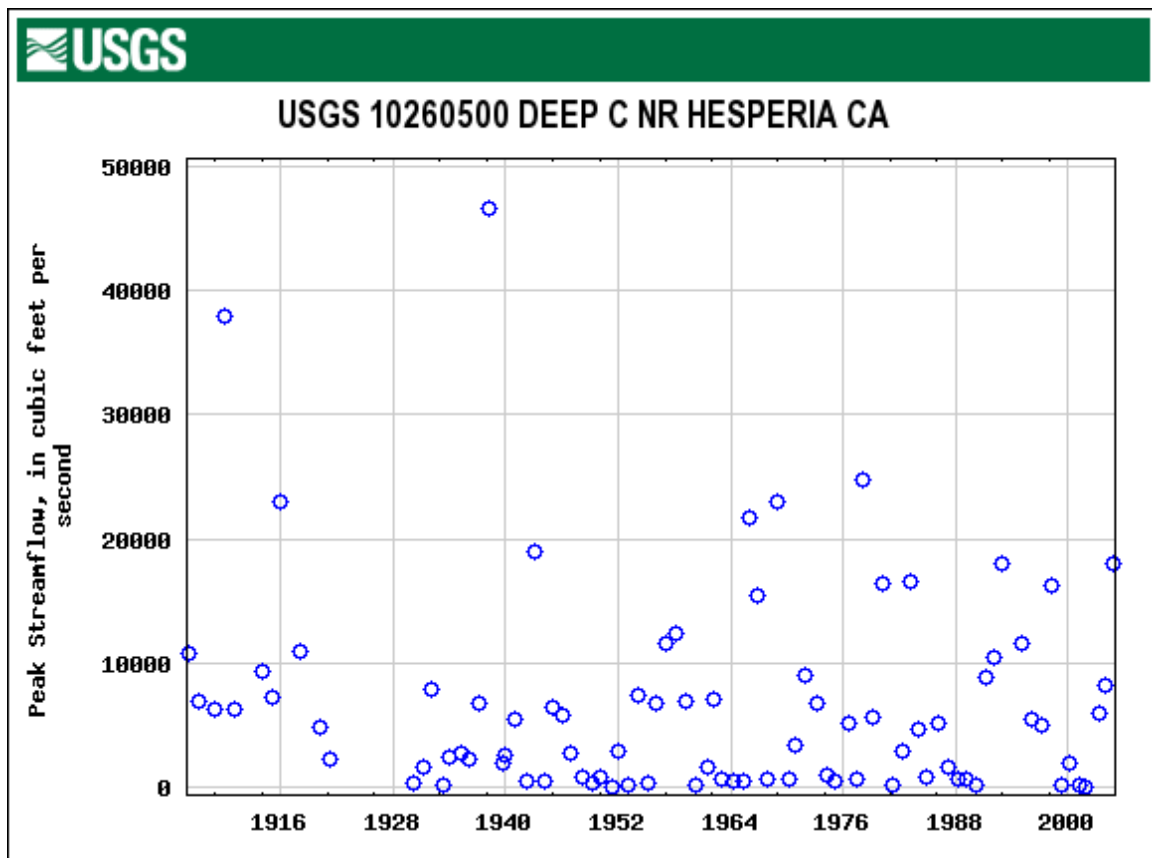
Data based on 52 complete years between 1931 and 1995.

Source: <http://www.worldclimate.com/>

*Average rainfall = Mean monthly precipitation, including rain, snow, hail, etc.

Not only does rainfall vary from one location to the next, often within short distances, but precipitation in southern California is also extremely variable from year to year, ranging from less than one-fourth the average amount to more than double the average amount. For instance, record-breaking rainfall has occurred periodically in the area, as illustrated in the peak stream flow graph for Deep Creek (see Figure 3-2). This gage is located slightly upstream from the Mojave Forks Dam and therefore best represents the extreme fluctuations in stream discharge that can occur above Hesperia. With peaks typically on the order of about 500 to 1,000 cubic feet per second (cfs) for most years, peak flows reached about 23,000 cfs in 1969 and 1978, and more than 37,000 cfs in 1910. During the winter that remains the benchmark for damaging storms – February and March of 1938 – peak streamflow for Deep Creek was estimated to be more than 46,000 cfs! Downstream from Hesperia, peak streamflow for the Mojave River in 1938 swelled to more than 70,000 cfs (USGS stream gage 10261500 near Victorville).

Figure 3-2: Peak Annual Streamflow Values for Gage Station 10260500 on Deep Creek, located near the base of the mountains.



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

There are three types of storms that produce precipitation in southern California: winter storms, local thunderstorms, and summer tropical storms. All of these have the potential to impact the Hesperia area.

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 Gabriel and San Bernardino 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 San Gabriel and San Bernardino Mountains as snow. If large storms are coupled with snowmelt from these 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. 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.

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." At the same time 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.

Local **thunderstorms** can occur at any time, but usually cover relatively small areas. These storms are usually prevalent in the higher mountains during the summer. **Tropical rains** typically occur in the summer or early fall, especially in the desert areas. These storms originate in the warm, southern waters off Baja California, in the Pacific Ocean, and move northward into southern California.

3.1.3. Past Floods: Implications for Existing Flood Hazard

Because of the arid, high desert 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 Hesperia area can be classified into two general categories: flash flooding down natural channels, including the Mojave River, and sheet flooding across the alluvial fans upon which most of the development in the city currently lies.

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 mountains south of Hesperia are very steep and consist of rock types that are fairly impervious to water. Consequently, little precipitation infiltrates the ground; rainwater instead flows across the surface as runoff, collecting in the major drainages that disperse water into the Summit Valley area, behind the Mojave Forks Dam. Storm water from the mountains eventually reaches the Mojave River, via controlled release at the dam, and flows along the eastern boundary of Hesperia. When a major storm moves in over the city, water collects rapidly in the many natural or modified channels that are present throughout the area. Because of the locally steep terrain and erodible soils, stormwater 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 and water flows over and into the adjacent areas.

The duration and frequency of winter storms also have a significant impact on flooding potential. Near-surface soils in Hesperia are generally sandy and permeable, allowing the ground to quickly absorb runoff from small or widely spaced storms. However, during winters with intense, closely spaced storms, such as those in 1969, severe flooding occurs when the ground is already saturated from previous storms. In January and February of 1969, a series of closely spaced, intense storms in the mountains released heavy rainfall on saturated ground. Total precipitation in the mountains above Hesperia (Lake Arrowhead rain gage) reached more than 80 inches for the two-month period. As a result, storm flows in the Mojave River reached all the way to Soda Lake, causing heavy damage to highways, bridges, and properties. Erosion of stream banks, channels, and flood plains, as well as the deposition of sediment was severe (Waananen, 1969).

Historical descriptions suggest the flood of 1862 was probably the largest event in southern California, although very little discharge or rainfall data are available. 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. Stream gages on rivers emanating from the mountains, including the Mojave River, logged record discharges, and losses were estimated to be 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 1938, citizens had already developed an awareness of the need for flood control and water conservation; however, the 1938 floods made it clear that growing cities in the region did not have adequate flood protection. This led to the formation of new flood

control districts in San Bernardino and Riverside counties, as well as in other areas of southern California.

3.1.4 National Flood Insurance Program

The Federal Emergency Management Agency (FEMA) is mandated by the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 to evaluate flood hazards. To promote sound land use and floodplain development, FEMA provides Flood Insurance Rate Maps (FIRMs) for local and regional planners. 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. 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 development.

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 (FISs). Using information gathered in these studies, FEMA engineers and cartographers delineate Special Flood Hazard Areas (SFHAs) on FIRMs. SFHAs are those areas subject to inundation by a “**base flood**” which FEMA sets as a 100-year flood. A **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 protecting the natural resources and functions of the floodplain. 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.

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. 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, as well as managing the erosion hazard. **The City of Hesperia has participated as a regular member in the NFIP since 1989 (City ID No. – 060733#). The city's most current effective FIRM maps date from August 8, 2008. Some of these maps have been amended by Letters of Map Change (LOMCs) since the maps' original publication.** Because the City is a participating member of the NFIP, flood insurance is available to any property owner in the city. In fact, to secure financing to buy, build, or improve structures in SFHAs, 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 SFHA and must provide written notice requiring flood insurance. FEMA recommends that all property owners purchase flood insurance. Keep in mind that approximately 25 percent of all flood claims occur in low to moderate risk areas. Flooding can be caused by a combination of heavy rains, inadequate drainage systems, and failed protective devices such as levees.

3.1.5 FEMA Flood Zone Mapping

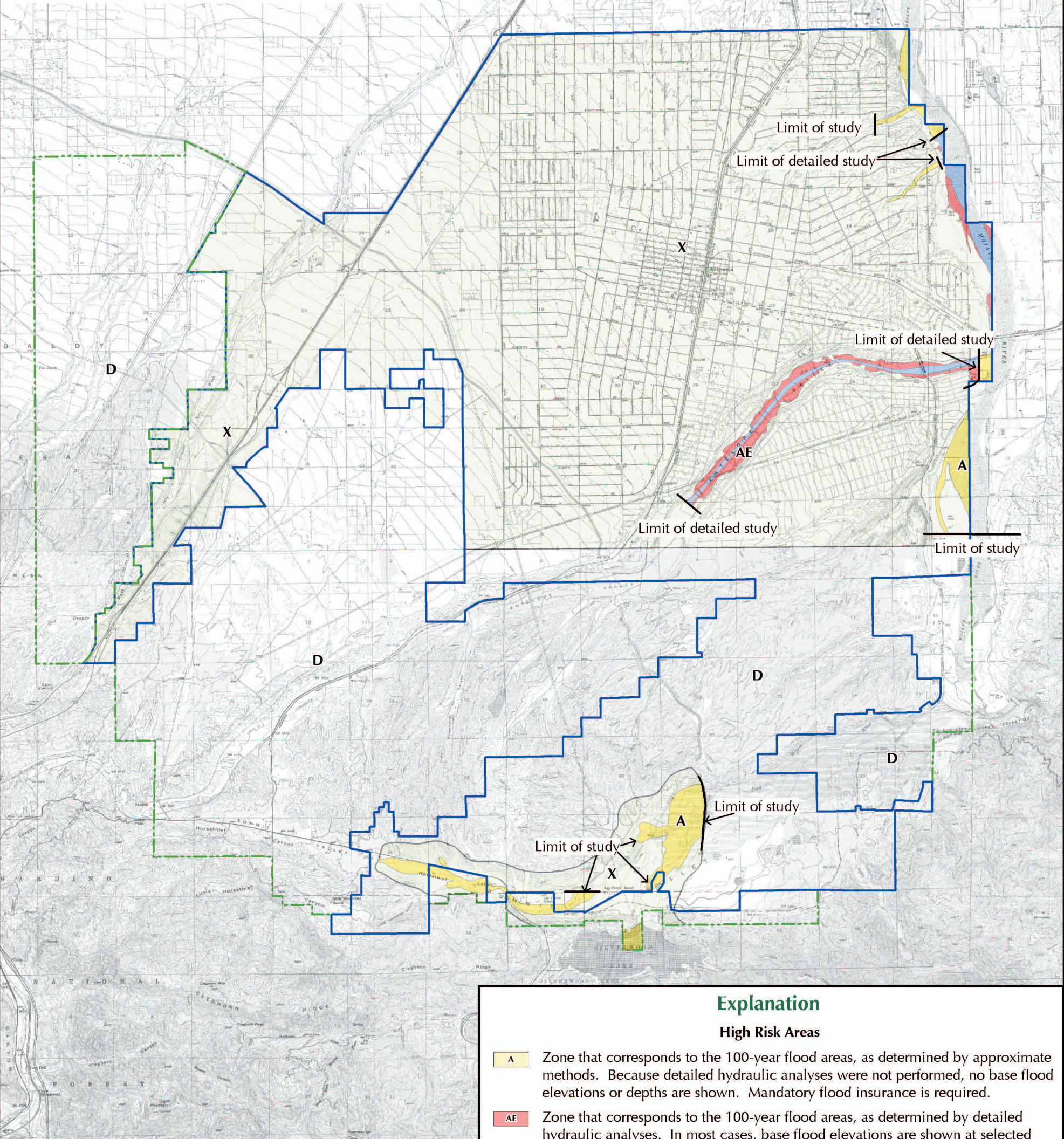
As mentioned above, Hesperia has participated in the National Flood Insurance Program since 1989. In the vicinity of Hesperia, the extent of flooding on the Mojave River, Antelope Valley Wash, the Oro Grande Wash, and the Summit Valley area has been analyzed through Flood Insurance Studies (FISs). The potential flood zones in the city mapped by FEMA are presented in Flood Insurance Rate Maps (FIRMs). Plate 3-1 shows the FIRM inundation limits for the 100-year flood, however it should be noted that the entire area was not studied and that the flood zones are incomplete. The FIRM maps are amended periodically to reflect changes in flood control facilities and/or changes in topography (usually as a result of development). Modifications to the FIRM maps typically accompany updated FISs or Letters of Map Revision (LOMRs) that FEMA issues in response to an agency supplying new hydraulic data that show that the flooding hazard in a specific area has changed or has been abated.

Plate 3-1 shows that portions of the Hesperia area are vulnerable to inundation during the 100-year flood along the Mojave River, Antelope Valley Wash, and Summit Valley. Except for the Antelope Valley Wash, most of the FEMA flood-prone areas are relatively undeveloped, or in the case of western Summit Valley, development is widely scattered. Although most of the existing homes in Summit Valley are above the flood zone, access to many of the homes would be cut off during severe flooding of the creek. Several major roadways in the 100-year flood zones would be affected, including Highways 138 and 173, Avenue I, Rock Springs Road, and Ranchero Road. The portion of the city adjacent to the Mojave River is now largely protected due to construction of the Mojave Forks Dam at the base of the mountains, however a few properties at the eastern boundary of the city are within the FEMA 100-year flood zone.

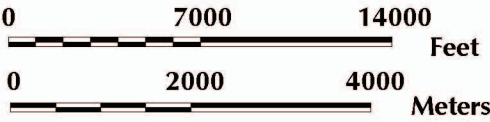
NOTES:

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.



Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: Federal Emergency Management Agency, San Bernardino,
Flood Insurance Rate Map (Panel Numbers: 06071C6480 H, 06071C6485 H,
06071C6495 H, 06071C6505 H, 06071C6515 H, and 06071C7225 H)



Scale: 1:84,000

Explanation

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 are shown. 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.

Low Risk Areas

- X** Zone that corresponds to areas outside of the 100-year flood or areas protected from the 100-year flood by levees. No base flood elevations or depths are shown. Flood insurance is available but not required.

Undetermined Risk Areas

- D** Zone that corresponds to unstudied areas where flood hazards are undetermined, but flooding is possible. Flood insurance is available but not required.

- Hesperia City Boundary
- Hesperia Sphere of Influence

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



Project Number: 2617
Date: February 2010

FEMA Flood Map
Hesperia, California

Plate
3-1

FEMA has analyzed the developed portion of Antelope Valley Wash, and identified the areas that would be inundated during the 100-year flood. From this analysis, FEMA also developed base flood elevations for the area. According to FEMA Map No. 06071C6495H, the Hesperia Golf Course, as well as numerous homes, streets, and associated improvements would be flooded by a 100-year flood event. The portion of the Oro Grande Wash that is within the city is considered by FEMA to be outside of the 100-year flood zone.

Figure 3-3: Development has Occurred Within Larger Drainages in Hesperia, Including Antelope Valley Wash, shown below. In spite of a leveed open flood control channel in the bottom of the wash, FEMA indicates many homes in Antelope Valley Wash are still vulnerable to flooding from the 100-year storm.



Copies of the Flood Insurance Study and FEMA maps are on file at the City. They can also be accessed at FEMA's website, <http://msc.fema.gov>. General provisions for flood hazard reduction are provided in the City's Municipal Code (Title 8, Chapter 8-28) and apply to all lands in Areas of Special Flood Hazard. The flood hazard areas are based on the FEMA maps, however these are the minimum areas of applicability. Additional areas may be included in the application of these provisions.

3.1.6 Local Flooding

Many storms smaller than the estimated 100-year event have caused localized flooding and sedimentation problems in Hesperia, particularly during and after intense precipitation that fell on already saturated ground. The City (including the unincorporated areas) does not have a comprehensive, interconnected storm drain system, nor does it have many bridges and culverts where streets cross numerous natural drainage channels. In addition,

flow in some drainages has been obstructed or altered by debris or construction – for example, the bermed or elevated rail lines, which pond water on the upstream side. The California Aqueduct has “overchutes” and drop inlets where it crosses natural drainages, but in some cases these are not adequate, and smaller drainages may be blocked all together. The city still has many dirt roads in older residential areas, and these, along with the natural channels, are vulnerable to erosion. Further, rapidly flowing storm water can carry significant amounts of sediment in suspension. Sediment loads are then deposited when the stream velocity slows due to an obstruction or when it reaches the Mojave River. These events can lead to property damage, or in some cases, parts of the community being temporarily isolated due to eroded or flooded access roads.

3.1.7 Bridge Scour

Scour at highway 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 to flow through a narrow opening at the bridge, where the resultant increase in the velocity of the surface water can produce scour. **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).

In the Hesperia area, bridge scour could occur along some of the roads and rail lines that extend across major drainage channels (such as the Mojave River and Horsethief Canyon). Furthermore, since the streams only flow 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 scouring 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.

The State’s Transportation Department (Caltrans) maintains a database on bridge scour. According their records, the State-owned bridges crossing waterways in Hesperia are stable with respect to the calculated scour. These include the Interstate 15 bridges, as well as State Routes 138 and 173 (Steve Ng, personal communication, 2006). Within the city, the only bridges across the Mojave River are the Bear Valley Road crossing, and the rail crossing at Rock Springs Road. Several other bridges are present within the city across tributaries to the Mojave River, and across the Aqueduct.

Figure 3-4: Bear Valley Road Bridge Across the Mojave River

3.1.8 Existing Flood Protection Measures

The alluvial fans in the Hesperia area have been greatly modified given that large portions are covered by development. Early development occurred in a piecemeal fashion over the years, without the benefit of a planned drainage network. Shortly after incorporation, the City adopted a policy of reducing flood damage in new developments by requiring the use of on-site retention basins and other methods, including engineered structures if warranted, until a comprehensive drainage system could be designed and constructed (Resolution No. 89-16). In the 1990s, the San Bernardino County Flood Control District published Master Plans of Drainage for the Hesperia area, thereby providing a regional “roadmap” for development of storm drain infrastructure. Since that time the City has constructed several of the recommended drainage facilities, in order to alleviate problematic flood areas. These include:

- The H-01 Line, Section 2 (located between Main Street, just east of Balsam Avenue, and Third Avenue, north of Mojave Street).
- The H-01 Line also drains the city’s industrial area to the Mojave River. Culverts were constructed under Santa Fe Avenue, “C” Avenue, “E” Avenue, “I” Avenue, Valencia Street, Talisman Street, and Peach Avenue to prevent closing of these streets due to flooding.

- The G-01 Line, running roughly parallel to and south of the H Line. This line currently terminates near Talisman and Choicena Avenue. The City is currently acquiring two properties to construct improvements to this outlet to the Mojave River, thereby eliminating recurring flood damage and repair.
- The D-02 Line is a 3.5-foot diameter pipe from Eleventh Avenue to Seventh Avenue. This pipe conveys storm runoff from developed residential areas across Ranchero Road. Another ¼ mile of 4-foot diameter pipe conveys these flows to the Antelope Valley Wash.
- The D-01-02 Line serves an area washed out during heavy storms in 1992. This 84-inch diameter pipe conveys flows from a basin adjacent to “E” Avenue to the Antelope Valley Wash.
- The A-01 Line serves the developing commercial area west of Interstate 15 on Main Street. This 54-inch diameter pipeline conveys storm flows from the new Hesperia Marketplace shopping center, as well as other existing hotels, gas stations, and restaurants. These flows are directed into the Oro Grande Wash, cross under the California Aqueduct, and continue northeast into the city of Victorville.

The City of Hesperia owns and maintains the localized storm-drain pipes, as well as the culverts, small bridges, and some small basins. In addition, it has added asphalt berms to a number of roadways where surface flows were problematic during major storm events. These include:

- “C” Avenue, between El Centro Street and Sage Street.
- “E” Avenue, between Fir Street and Joshua Street.
- Seventh Avenue, between Palm Street and Sultana Street.
- Oakwood Avenue, between Live Oak Street and Riverside Street.

One of the longest drainage structures in the city is a nearly 2-mile long, man-made channel with levees in the residential portion of the Antelope Valley Wash. This has reduced the flooding potential for homes near the bottom of the wash, but according to FEMA (2008), this channel still cannot accommodate the 100-year flood.

Much of Hesperia is rural or semi-rural in character. Where development is more widely spaced with larger lots, many private yards have their own flood control structures including basins, berms, improved channels, culverts, rock revetments, etc.

Along the western side of the Mojave River, in the northern part of the city, the San Bernardino County Flood Control District (SBCFCD) locally constructs levees of piled up sand. These are considered temporary structures that have to be rebuilt periodically. The only regional flood control structure protecting Hesperia from the Mojave River is the Mojave Forks Dam (discussed further in Section 3.2.1). Because the dam blocks the lower West Fork of the Mojave River, it increases the potential for flooding at the eastern end of

Summit Valley. Much of this area however, is within the Mojave River Forks Regional Park.

Figure 3-5: Drainage Canal in the Bottom of Antelope Valley Wash, near Ranchero Road.



The existing flood control structures have provided significant protection from flooding, such that recent storms have not had the catastrophic effect on homes and streets typical of earlier years, before these drainage projects were completed. Nevertheless, as indicated by the current FEMA maps, additional protection is needed. The Hesperia Master Plan of Drainage published by the SBCFCD (1996) indicates many new structures need to be constructed, including detention basins, open channels, storm drains and permanent levees for the Mojave River.

3.1.9 Future Flood Protection

The Master Plan of Drainage (MPD) for Hesperia addresses the area east of Interstate 15 (excluding Summit Valley). The MPD for Victorville covers the area west of Interstate 15, including the Oro Grande Wash. The Hesperia MPD concluded that at the time of the study, none of the existing facilities within the study area had the capacity to convey the anticipated 100-year flows (Williamson & Schmid/Huitt-Zollars, 1996). The infrastructure plan recommended for Hesperia generally included two large detention basins and numerous open channels, most of which were sited to take advantage of existing drainage easements. The plan assumed that the Mojave River would be fully improved with levees, and that the new channels would outlet to the river at eight locations through the levees. Four basins were recommended in the Victorville MPD. Two of these are within Hesperia; one is recommended for the Oro Grande Wash just south of the Aqueduct, and one is recommended for the East Oro Grande Wash, south of the rail line crossing. The MPDs

are intended to be used as a guidelines only, and will need to be modified as the area continues to grow.

The Ranchero Road Grade Separation Project will significantly improve east-west travel across the city, for citizens and emergency personnel, by providing a much-needed second access road across the BNSF railroad tracks. The project will not only provide continuity of Ranchero Road beneath the tracks, but will elevate the road where it crosses the Antelope Valley Wash, thereby reducing the potential for road closures due to flooding. The Ranchero Road improvements are scheduled for completion in 2010.

Hesperia has also been actively improving streets within its corporate boundaries, paving many of the dirt roads and adding paved shoulders to direct water flow. New storm drains will also be constructed in the near future, as funding is available. In addition, the City of Hesperia General Land Use Map (dated March 7, 2006) indicates several major drainages, including Oro Grande Wash, East Oro Grande Wash, and parts of Antelope Valley Wash, are zoned as open space.

Hesperia has also joined the Storm Ready program with the National Weather Service. This program, which is staffed by volunteers from the city, establishes a local weather monitoring and communication system. The program includes public education, an important element of flood protection in Hesperia, given its rural characteristics. The City of Hesperia will also provide sandbags to residents and has flood preparedness information on its website (www.ci.hesperia.ca.us).

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 the 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 SBCFCD. 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 SBCFCD, while the local storm drains and other structures outside of the regional system and within the corporate boundary of Hesperia will be with the City of Hesperia. Therefore, both agencies must be involved in the planning and approval of mitigation measures, along with the City of Victorville, to assure compatibility.

For new commercial and tract developments in Hesperia, the applicants are required to perform hydrologic studies and design structures that will retain the additional runoff created by the development onsite, so that downstream properties are not adversely

impacted. The goal is to allow an amount of runoff from the project site equal to the natural, predevelopment condition – not to retain all runoff. This has been addressed in recent developments by including small to large retention basins in private yards or in the lower end of the project. The addition of gravel-filled seepage pits in the basins has helped to percolate the collected water more rapidly and alleviate the problem of standing water in the basins. New construction cannot be permitted without review by the City's Floodplain Administrator for compliance with Chapter 8-28 of the City's Municipal Code.

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

- 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 San Bernardino 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. Zappe (1997) argues that reform of environmental laws is necessary to ease the burden on local governments, and ensure the health and safety of the public. In particular, Zappe calls for a categorical exemption from the Federal laws for routine maintenance and emergency repair of all existing flood control facilities.

3.1.10 Flood Protection Measures for Property Owners

As discussed above, flooding remains a significant risk to structures and residents in Hesperia. The City and property owners in susceptible areas can take measures, however, to promote safety during future floods and reduce damages from flooding and from flood-related erosion. Some of these measures are described further below.

At the City level:

- Continue enforcing the City's Municipal Code provisions for flood hazard reduction (Title 8 Safety, Chapter 8.28 Flood Hazard Protections and Regulations). This chapter includes 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 Code applies to new construction or substantial improvements, and includes provisions for anchoring, placement of utilities, elevating the lowest floors, flood resistant materials, and other methods to minimize damage.
- Develop a system to conduct real-time storm warnings and a protocol to carry out evacuations when 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.
- Encourage residents to purchase flood insurance for areas outside of the 100-year flood zone.
- Create an atmosphere of working with nature and the natural processes inherent in the high desert environment.

For Property Owners:

- Elevate new homes on pads, foundations, or piers.
- 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 the home 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 local conditions surrounding and upstream from the lot.
- Some lots may require special engineering studies to determine the extent of the hazard and 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 dam height or have more than 50 acre-feet in storage capacity. Three structures in the Hesperia area meet these requirements: Mojave Forks Dam (Mojave Reservoir), Cedar Springs Dam (Silverwood Lake), and Lake Arrowhead Dam.

Mojave Forks Dam is located at the base of the San Bernardino Mountains, where Deep Creek and the West Fork of the Mojave River merge to form the Mojave River. The dam was constructed in 1971 to control flooding in desert communities downstream along the river. The entire Mojave River basin encompasses about 4,700 square miles, yet nearly all of the runoff that reaches the river is contributed by the 215-square miles of mountainous terrain above the dam (U.S. Army Corps of Engineers, 2006). The dam consists of a 200-foot-high embankment (height above the original streambed) constructed of compacted fill. During storm events, water can be retained temporarily in the reservoir, then released through a single outflow tunnel at a rate that will not overwhelm the downstream channel. Peak outflow for the reservoir design flood is 23,500 cubic feet per second (cfs), and 131,300 cfs for the spillway. To date, the maximum release from the dam was 16,600 cfs on January 11, 2005. That date also holds the record for the highest water elevation in the reservoir: 73 feet below the spillway crest.

Specific Information for the Mojave Forks Dam:

NPDP* ID Number:	CA10021
State ID Number:	60130
Owner:	U.S. Army Corps of Engineers, Los Angeles District
Type:	Earth fill
Purpose:	Flood Control and Storm Water Management
Drainage Basin Area:	215 square miles
Dam Height:	200 feet
Crest Length:	2,223 feet
Crest Width	20 feet
Freeboard:	6.6 feet
Storage Capacity:	179,400 acre-feet (normal and maximum)
Year Completed:	1971
NPDP Hazard Classification:	High

*National Performance of Dams Program

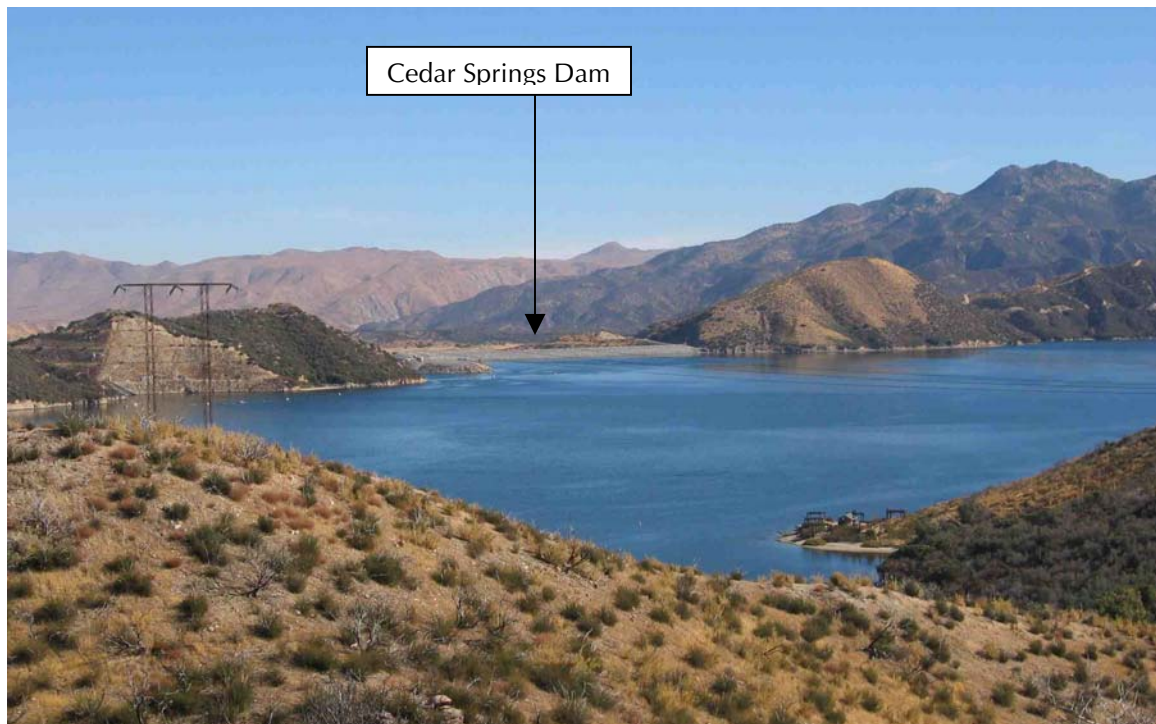
Figure 3-6: Aerial View of the Mojave Forks Dam

Source: US Army Corps of Engineers

Cedar Springs Dam is located in Summit Valley, at the southern edge of Hesperia. Constructed across the West Fork of the Mojave River, the dam impounds a large water supply reservoir (Silverwood Lake) that is also a popular recreation destination. The dam captures runoff from a 34-square mile drainage area and receives additional water from the California Aqueduct.

Specific Information for Cedar Springs Dam:

NPDP ID Number:	CA00049
State ID Number:	02426-03-01
Owner:	California Department of Water Resources
Type:	Earth Rockfill
Primary Purpose:	Water Supply
Secondary Purpose:	Hydroelectric
Drainage Basin Area:	34 square miles
Reservoir Surface Area:	976 acres
Dam Height:	226 feet
Crest Length:	2,230 feet
Freeboard:	23 feet
Storage Capacity:	75,000 acre-feet (normal and maximum)
Year Completed:	1971
NPDP Hazard Classification:	High

Figure 3-7: View of Silverwood Lake, with Cedar Springs Dam in the Background

Work began on **Lake Arrowhead Dam** in 1893, with the intention of building a reservoir to supply water to the San Bernardino Valley. Due to legal difficulties and changes in ownership, the project was not completed until 1922.

Specific Information for Lake Arrowhead Dam:

NPDP ID Number:	CA00759
State ID Number:	805-000
Owner:	Arrowhead Lake Association
Type:	Hydraulic Fill (Earth)
Primary Purpose:	Water Supply
Secondary Purpose:	Hydroelectric
Drainage Basin Area:	6.85 square miles
Reservoir Surface Area:	780 acres
Dam Height:	190 feet
Crest Length:	720 feet
Dam Width:	140 feet
Crest Elevation:	5,116 feet
Freeboard Height:	9 feet
Storage Capacity:	48,000 acre feet (normal), 56,400 acre feet (max)
Year Completed:	1922
NPDP Hazard Classification:	High

A worst-case scenario for Hesperia would be the failure of the Mojave Forks Dam (most likely during a severe earthquake) when it is near capacity. Plate 3-2 shows the inundation path the water would take. Water from failure of the Mojave Forks Dam would likely be confined to the existing Mojave River bed and the mouth of the Antelope Valley Wash channel, as well as several smaller tributary channels. Failure of the Cedar Springs Dam would flood a significant portion of eastern Summit Valley between Silverwood Lake and Mojave Forks Dam in less than 30 minutes; however, this area is presently undeveloped except for Highway 173 and a few ranch structures. If the Lake Arrowhead Dam failed, water would travel down the Deep Creek drainage, eventually reaching the Mojave Forks Dam. A flood from Lake Arrowhead would be contained within the Mojave Forks Reservoir area, unless the dam was near capacity. In this case, floodwaters would spill over into the river.

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 pipes. These types of damages occurred during southern California’s 1992 Landers, 1992 Big Bear, and 1994 Northridge 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 recent earthquakes, new standards for design of steel water tanks were adopted in 1994 (Lund, 1994). The new tank design includes flexible joints at the inlet/outlet connections to accommodate movement in any direction.

All of the City’s 17 water reservoirs are above-ground steel tanks. Most of the tanks have been constructed in recent years. The City has evaluated the water tanks under its jurisdiction and nine of the tanks have seismic connections. The remaining eight require retrofitting of the inlet connections in order to meet current standards. The connections will need to be flexible to withstand the effects of ground shaking and not break, thereby preventing the loss of critical water supplies at a time when the city may be isolated and must rely on its own resources for several days. The overflows will be air-gapped to permit movement of the tank while maintaining its function.

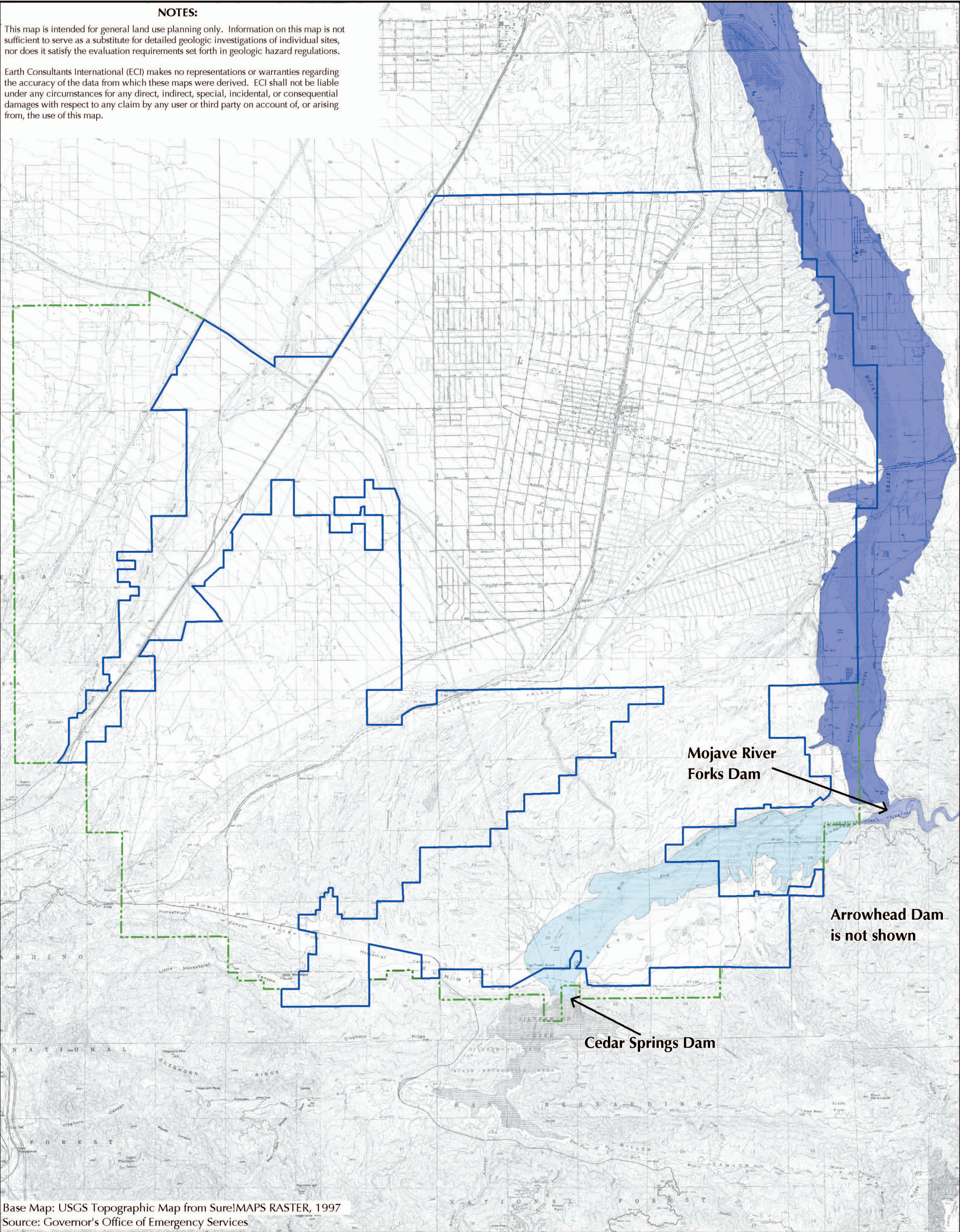
If there is the potential for a water tank to fail catastrophically during an earthquake, its inundation path should be identified to evaluate whether or not habitable structures are located within the floodway. The evaluation should also address whether a water reservoir is self-contained. In the event of a catastrophic breakage, will the water be contained within the site, or will it pose a hazard to properties downstream?

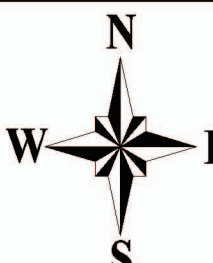
Water lost from tanks during an earthquake not only affects structures down slope from the tanks, but can also significantly reduce the water resources available to suppress earthquake-induced fires. Damaged tanks and water mains can also limit the amount of water available to residents. The California Aqueduct could suffer extensive damage if a major earthquake occurs on either the San Andreas or other nearby active faults.

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.





0700014000

Feet

020004000

Meters

Scale: 1:84,000

Explanation	
 Mojave River Forks Dam Failure Inundation Pathway	 Hesperia City Boundary
 Cedar Springs Dam Failure Inundation Pathway	 Hesperia Sphere of Influence
 Lake Arrowhead Dam Failure Inundation Pathway	

Aqueduct repairs 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.

3.3 Summary of Issues, Planning Opportunities and Mitigation Measures

Hesperia is situated on gently sloping alluvial fans at the base of the San Bernardino Mountains. The pattern of alluvial fan flooding can be unpredictable, and floodwaters can travel at dangerously high speeds, be highly erosive, and often carry large amounts of sediment and other debris. Major sources of potential flooding are the Mojave River, Antelope Valley Wash, and the streams within Summit Valley. Development in the Hesperia area has occurred over the years in a piecemeal fashion, and although some structures have been installed since incorporation, the City and its Sphere of Influence lack a comprehensive storm drain system. Much of the developed area is rural to semi-rural, and has been built out with only minor alterations to the natural topography. As a result, existing facilities, such as underground pipelines, culverts, bridges, and basins are present, but are not common. This leads to localized flooding, road closures, erosion damage, and sedimentation during and following strong storms, particularly if the ground is already saturated.

Consequently, analyzing and mitigating floods can be challenging. Construction of the Mojave Forks Dam in 1971 greatly reduced the impact of flooding along the Mojave River, although a few parcels adjacent to the river are still at risk. Flood losses in other parts of the city are caused by structures that are inadequately protected, as well as the cumulative effect of obstructions in flood hazard areas that leads to increased flood heights and velocities. Maintenance of the numerous natural drainages is also challenging, since many channels meander through private properties. Improvements to the City's drainage infrastructure are planned, and the City should continue with street improvements and public education to help alleviate local flooding and its effects.

The 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 all 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. Estimates indicate that nationwide, 75 percent of households located in the 100-year floodplain do not have insurance. In addition, between 20 and 25 percent of the National Flood Insurance Program claims come from structures located outside the designated 100-year flood zone, where insurance is not required. As a comparison, structures located in the 100-year flood zone have a 26 percent chance of being flooded over the course of a 30-year mortgage, and only a 4 percent chance of being impacted by fire during the same time frame. National Flood Insurance is available in the city of Hesperia; homeowners within the 100-year flood zones, and even outside these zones should be encouraged to buy flood insurance.

To ensure public participation in the National Flood Insurance Program and support of City-

funded mitigation measures, property owners need to be informed about the potential for flooding in their area, including flooding of access routes to and from their neighborhoods. This is especially true for wet years following wildfires in the local mountains, when runoff is greater and the canyons are likely to be choked with debris, compounding the potential for flooding. Community outreach and public information programs that not only identify the hazards but also provide potential solutions need to be prepared and made available. The Federal Emergency Management Agency (FEMA) has excellent materials that describe specific mitigation measures that can be implemented to reduce flood damage to residential structures. A community's success in responding to a natural disaster is also dependent on how well its government officials, residents, businesses, and institutions (schools, churches, social organizations) cooperate and coordinate together to make effective decisions. To accomplish this, the City can prepare and manage a list of businesses, organizations and individuals that can be called in to help during emergencies.

The City has joined the "Storm Ready" program through the National Weather Service. Elements of this program include monitoring of local weather, establishing storm warnings, creating an emergency operation center, and educating the public. For those portions of the city where flood zones have already been developed, 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.

Land use planning is the key to reducing future flood losses and protecting the environment. Flood risk mapping in areas of future development, along with flood zone overlays on zoning and land use maps will help the City and project applicants achieve a safer community that is more compatible with the natural environment. 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 planning in undeveloped areas should consider leaving watercourses natural, wherever possible. 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 continue to develop them as parks, nature trails, golf courses or other types of recreation areas that could withstand inundation.

Because many of the natural drainages cross backyards, driveways, and other parts of private yards, the citizens of Hesperia 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 the flow is obstructed or significantly changed.

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 and have been part of the natural environment for millennia. 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. Many native plants require periodic burning to germinate and recycle nutrients that enrich the soils.

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 percent of the wildland fires (519,193 human-caused fires vs. 95,294 lightning-caused 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 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 potential and limit the destruction caused by fires. These mitigation measures are discussed in detail in this document.

Fires usually last only a few hours or 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 off the recently burned hillsides can develop. 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. This happened in San Bernardino County during the 2004 storms that followed the 2003 fire season; 16 people lost their lives as a result of debris flows. During the January 2010 storms, thousands of people were evacuated from their homes in the foothills of the Los Angeles National Forest amid numerous mud and debris flows emanating from upstream canyons that burned in 2009.

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 270,000 acres, destroyed 2,820 structures, damaged 63 others, and caused 14 fatalities. The fire was caused by a signal flare set off by a lost hunter.



Figure 4-2: View of One of the Many Fires that Ravaged the Southern California Area in the Fall of 2003, forcing the evacuation of entire neighborhoods, and the closing of roads.



The hazard of post-fire mudflows can be reduced significantly if remedial measures following a wildfire are taken in anticipation of the next winter. 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 prevent water from percolating into the soil.)

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. Native desert plants, on the other hand, typically take more than a decade to recover after a fire.

Other effects of wildfires are economical and social. Homeowners who lose their house to a wildfire may not be able to recover financially and emotionally for years to come. Recreational areas that have been affected may be forced to close or operate at a reduced scale. In addition, the buildings that are destroyed by fire are usually eligible for re-assessment, which reduces income to local governments from property taxes.

4.1.1 Wildfire Susceptibility and Historical Wildland Fires in the Hesperia Area

The fire hazard of an area is typically based on the combined input of several parameters. These conditions include:

- fuel loading (that is, the type of fuel or vegetation, and its density and continuity),
- topography (elevation and slope),
- weather,
- dwelling density,
- wildfire history, and
- existing local mitigation measures in place that help reduce the zone's fire rating (such as an extensive network of fire hydrants, fire-rated construction, fuel modification zones, etc.).

These conditions, as they pertain to the City of Hesperia, are discussed in more detail in the paragraphs and sections below.

Hesperia is located in the lower Mojave section of the Southeastern Deserts Bioregion, an area characterized by isolated, steep-sided mountain ranges separated by broad alluvial basins. The predominant natural vegetation assemblage in the lower elevation areas of the Mojave section is desert shrub, which may include alkali sink vegetation, creosote bush scrub, and succulent scrub (Brooks and Minnich, 2006). Other important vegetation types include Joshua Tree woodland (Figure 4-3), shad-scale scrub, creosote bush scrub, blackbrush scrub, and desert scrub-steppe. Importantly, about one-third of the desert floor

in the Mojave section is typically barren of vegetation (Figure 4-4). The limited amount of vegetation and low surface fuel loads typically hinder the spread of fire.

Figure 4-3: Undeveloped slopes along the Mojave River and Hesperia Lake Park, showing some of the vegetation common to the area. (Photograph from www.city-data.com.)



Figure 4-4: Typical Fuel Loads in Hesperia, consisting of scattered tree stands and scrubland separated by areas barren of vegetation.



Unlike the primary vegetation types common in other bioregions of southern California, desert plants do not need fire to reproduce, and many of the native plants common to this area are highly susceptible to fire. Furthermore, native desert plant communities may take a decade or more to re-establish after a fire, whereas non-native grasses are quick to invade burned areas, generally at the expense of the native plants. Researchers have argued that the introduction, in the early 20th century, of non-native annual grasses to the desert has resulted in a marked increase in the number and size of the fires reported in the region. This trend has been particularly noticeable since the mid 1970s: before about 1977, fires in the eastern deserts generally burned less than 300 acres; fires since then have typically burned thousands of acres.

In San Bernardino County, wildland fires have been common in the undeveloped or slightly developed portions of the hills and mountains that surround the more developed valleys. In comparison with the more developed valleys, in the undeveloped to slightly developed areas there is a greater diversity of surface fuel, higher fuel loads and more continuity of loads (less barren areas between vegetation stands). This, combined with the steep topographic gradients, results in a larger number of fires and a higher probability of fire spread. Fires starting in these highland areas can then easily spread into the developed foothills, especially if conditions are windy and dry. Even if the flames do not reach the urban area, the smoke, ashes, and soot generated by the fire can pose a health hazard, and a nuisance to motorists and residents.

The Hesperia area is predominantly arid due to the rain-shadow effect caused by the Peninsular Ranges. Average annual precipitation in Hesperia is about 5 to 6 inches, with nearly 70 percent of this precipitation measured in the winter months, between December and March. About 10 percent of the precipitation falls in the summer, between July and September, associated with thundershowers triggered by the North American monsoon that originates in the Gulfs of California and Mexico. Variations in the annual precipitation for this region are relatively high compared to other California regions, however, and as a result, there is a significant variation in the frequency and extent of wildland fires in the area. In years when rainfall is above average, an increased amount of fine fuels in the desert floor can result in an increase in fire spread. Long-term variations in rainfall rates have also been noted in this region, with alternating periods of high rainfall and drought, each lasting 20 to 30 years. For example, a mid-century drought was reported between 1946 and 1977, followed by a high-rainfall period between 1977 and 1998. More recently, below-average rainfall was recorded between 1999 and 2004, suggesting that the region has entered a new drought cycle. If this is the case, it may be that the region may see a reduction in frequency and size of wildland fires in the next several years (Brooks and Minnich, 2006).

The summer thunderstorms that come through the Mojave Desert often include lightning. In fact, lightning frequency is higher in the desert than in any other bioregion in California, with the Mojave section averaging 30 lightning strikes per 100 square kilometers per year (based on Bureau of Land Management detection data by van Wagendonk 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: between 1980 and 2001, human-caused fires in the Mojave region were 3.6 times more common than

lightning-caused fires (Brooks and Minnich, 2006).

According to the California Department of Forestry and Fire Protection (CDF, also known as Cal FIRE; see <http://frap.cdf.ca.gov/data/frapgisdata/select.asp>), several large (greater than 300 acres) historical wildland fires between 1930 and 2008 have occurred in the city of Hesperia, its Sphere of Influence, and the areas to the south (Plate 4-1). Those wildland areas that have not burned in more than 30 years are at higher risk of burning again in the near future, due to the higher density and continuity of the fuel load.

Many smaller wildland fires have occurred in Hesperia that are not captured by the CDF database. Some of the most recent fires (both large and small) to have impacted Hesperia and adjacent areas are described further below, in Table 4-1. Although not all of these fires occurred in Hesperia, some are mentioned because they either impacted the major roadways that provide access in and out of Hesperia, or had an impact on the air quality in the General Plan area.

Table 4-1: Some Historical Wildland Fires Reported In and Around the Hesperia Region

Date	Location	Description
July 6, 1999	11 miles south of Hesperia	Fire burned 2,576 acres, destroyed one mobile home and two sheds. Residents from Summit Valley and Oak Hills were forced to evacuate. Highway 138 was closed. Caused about \$100K in property damage.
Aug. 28 - Sept. 9, 1999	Lucerne and Apple Valleys, east and south of Hesperia	Fire consumed 63,486 acres starting 3 miles south of Lucerne Valley, and extending to within 4 miles northwest of Fawnskin. Thirteen firefighters sustained minor injuries. Property damage was estimated at \$11.7 million.
May 11, 2001	Mojave River Bed, Apple Valley	Brush fire that started on the riverbed burned 25 acres. One nearby school was evacuated. One firefighter was treated for heat exhaustion. Although the fire came close to one house and another building, no structures were damaged.
June 19, 2001	Cajon Pass	The "Baldy Fire" started near the intersection of Interstate 5 and Highway 138. It burned 125 acres, and forced the closure of both roadways and the Union Pacific railroad tracks.
July 22, 2002	Hesperia	Strong winds and extremely dry conditions fanned a house fire in Hesperia. Five outbuildings were destroyed for an estimated \$55K in property damages.
June 15, 2003	Hesperia	A brush fire burned 80 acres. One firefighter was injured when a boulder rolled down the hill and broke his leg.
July 27, 2003	Hesperia	Brush fire burned 10 acres before it was contained.
Sept. 17, 2003	Hesperia	Brush fire consumed 40 acres and briefly threatened several homes in the Oak Hills section of Hesperia. The fire was contained in a short period of time, in part because there were no winds to fan the flames and spread the fire.
Oct. 1, 2003	Mojave Riverbed, 3 miles E to SE of Victorville	Brush fire consumed 10 acres. No structures were damaged.

Date	Location	Description
Oct. 25 - Nov. 14, 2003	6 miles S of Hesperia to 7 miles N of Lake Arrowhead	The "Old Fire" was started by an arsonist on Oct. 25 th and consumed 91,200 acres before it was fully contained on November 5. The fire destroyed 993 houses, 10 commercial buildings, 1,460 power poles, 220 electrical transformers, and several miles of highway and utility infrastructure. It also damaged another 35 houses. Six deaths and 12 injuries were directly attributed to the fire. An estimated 80,000 people were evacuated the first day from the San Bernardino Mountain range, causing a 28-mile traffic jam on Highway 18. Over the next few days the communities of Silverwood Lake, South Hesperia, Oak Hills, Summit Valley, Telephone Canyon, and Las Flores were also evacuated. On the second day, the fire merged with the east flank of the Grand Prix fire. On the third day it burned through Cajon Pass and onto the foothills toward Hesperia. Rain, sleet and snow that fell between 11/1 and 11/3 slowed fire growth. The fire caused an estimated \$975 million in property damage; the cost of fighting the fire was estimated at more than \$42.3 million.
Sept. 7, 2004	Cajon Pass to Baldy Mesa	The "Runway Fire" was started by a car accident, and eventually burned 1,007 acres of brush in the San Bernardino National Forest. The fire forced the closure of 7 miles of Highway 138. One home in the Baldy Mesa area was damaged slightly by the heat, causing about \$1K in property damage.
April 1, 2007	Hesperia	The fire burned more than 1,400 acres and forced the evacuation of more than 500 residents. Damage was limited to the roof of one residential structure, and the destruction of one outbuilding.

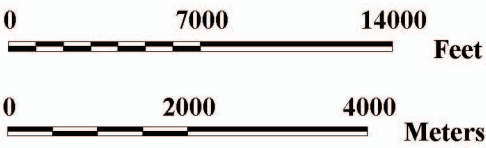
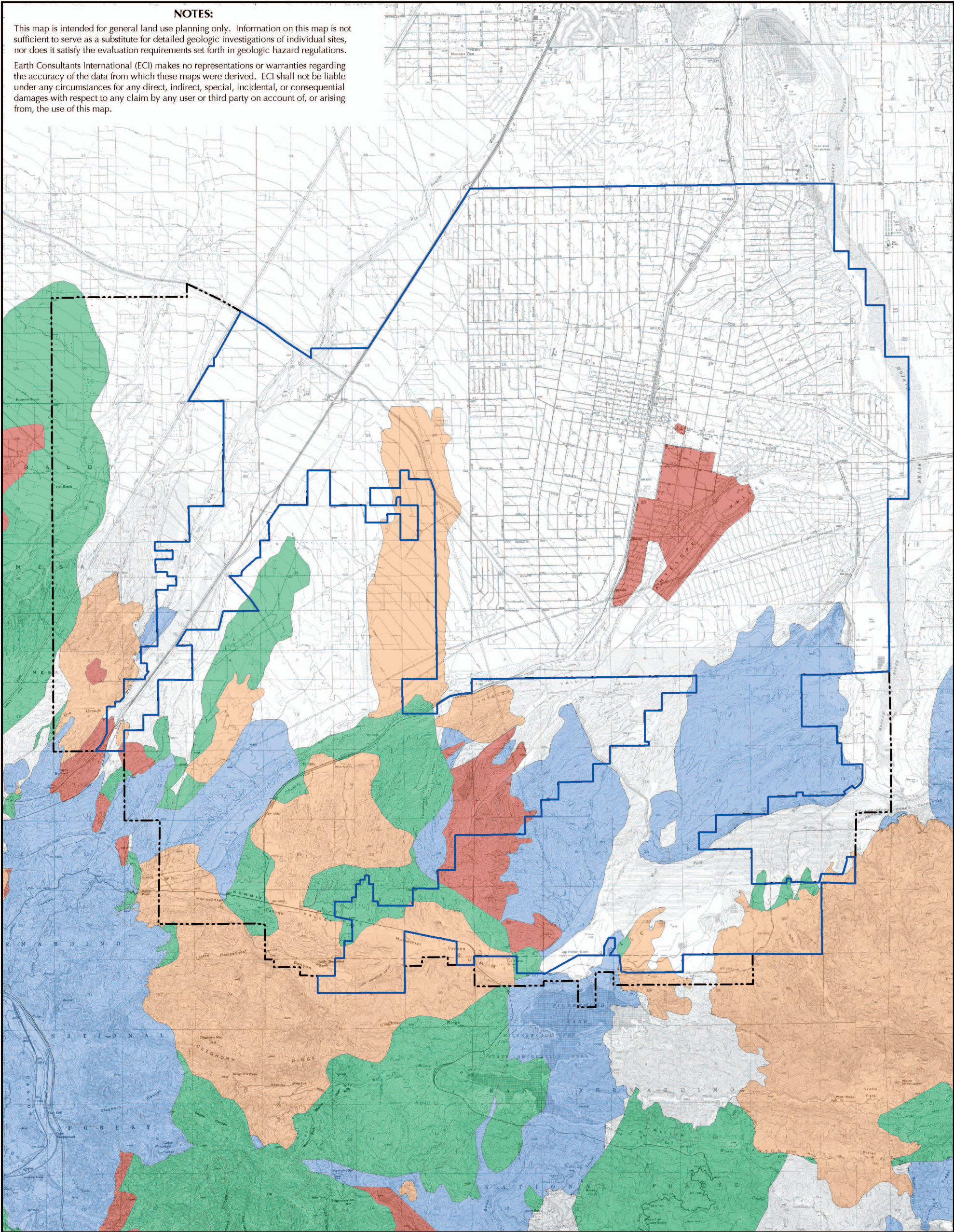
Sources: National Environmental Satellite, Data and Information Service (NESDIS) at <http://www4.ncdc.noaa.gov/cgi-win/wwcgl.dll?wwevent~storm>; Los Angeles Times, April 1, 2007 at <http://articles.latimes.com/2007/apr/01/local/me-hesperia1>

Many much smaller wildland fires occur in Hesperia annually, as indicated by the National Fire Incident Reporting System (NFIRS), and the San Bernardino County Fire Department. Specifically, according to the NFIRS, in 2006 there were 16 brush or vegetation fires in Hesperia that the Fire Department responded to. All of these fires burned less than 1 acre of land (<http://www.city-data.com/fire/fire-Hesperia-California.html>). Statistics provided by the San Bernardino County Fire Department show that there were 104 vegetation fires reported in the city of Hesperia in 2007, and 58 in 2008. Therefore, the fires included in Table 4-1 represent a small population of the overall fire record in the area.

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.



Scale: 1:84,000

Explanation

Year of Last Burn			
	1990-2008		1950-1969
	1970-1989		1930-1949
			Hesperia City Limit
			Hesperia Sphere of Influence

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



Project Number: 2617
Date: February 2010

Historical Wildland Fires

in and near
Hesperia, California

Plate
4-1

4.1.2 Regulatory Context and Fire Risk Areas

Since the early 1970s, several fire hazard assessment systems have been developed for the purpose of quantifying the severity of the 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 or Cal FIRE) 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.

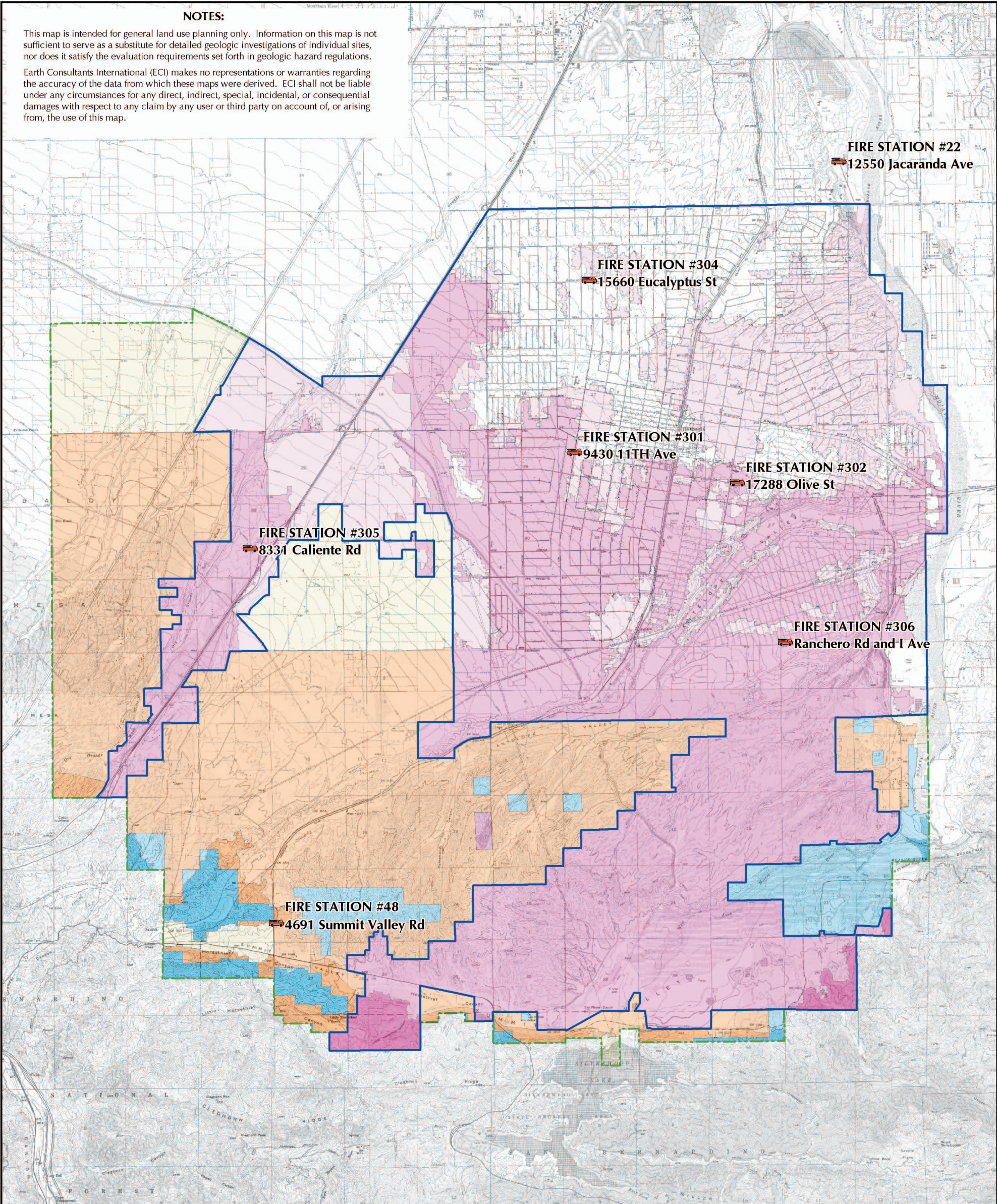
California Department of Forestry and Fire Protection – State Responsibility Areas System: Legislative mandates passed in 1981 (Senate Bill 81, Ayala, 1981) and 1982 (Senate Bill 1916, Ayala, 1982) that became effective on July 1, 1986, required the California Department of Forestry and Fire Protection (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. SRAs in and around the city of Hesperia and its Sphere of Influence are shown on Plate 4-2.

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 has 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 three years or so, however, the CDF has been re-mapping both SRAs and LRAs using GIS technology and new data and science to better

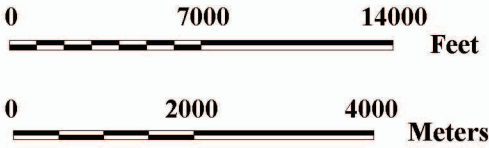
NOTES:

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.



Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: Fire and Resource Assesment Program, California Department of Forestry and Fire Protection (2008)



Scale: 1:84,000

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

- Fire Station (existing and proposed)
- Hesperia City Limit
- Hesperia Sphere of Influence



Project Number: 2617
Date: February 2010

High Fire Hazard Areas
Hesperia, California

Plate
4-2

describe the potential fire behavior and fire probability for a give area. Areas are being mapped in the Moderate, High and Very High categories. Typically, once the CDF delineates the boundaries of a VHFHSZ, it notifies the local fire authorities. Since the State is not financially responsible for Local Responsibility Areas, local jurisdictions have final say regarding whether or not an area should be included in a VHFHSZ (Government Code Section 50022; <http://frap.cdf.ca.gov/projects/hazard/hazard.html#VHFHSZupdate>).

The LRAs identified in the city of Hesperia by the CDF (2008) are shown on Plate 4-2. On November 13, 2008, the City Council of Hesperia adopted Ordinance No. 2009-01 defining (and therefore agreeing with) the location of the Very High Fire Hazard Severity Zones (VHFHSZs) in LRAs recommended by the California Department of Forestry and Fire Prevention within the City. These are the areas that the City is responsible for in terms of fire prevention and fire suppression.

Areas near Hesperia specifically known for their high to very high wildland fire susceptibility include the mountainous region of the San Bernardino National Forest to the south, and the foothills, which encroach from the south onto the city and its Sphere of Influence. In the developed, relatively flat areas of the city, vegetation fires are not considered a hazard, as the topography, lack of fuel loading (either as a result of no vegetation, or due to carefully maintained and regularly watered landscaping), and effective fire suppression services combine to mitigate the potential for wildland fires. Undeveloped portions of the city or its Sphere of Influence, especially along the Mojave River, Summit Valley, the area north and west of Summit Valley, and the undeveloped areas west of the I-15, are the most susceptible to wildland fire (see Figure 4-2). However, the conditions along the Interstate are deemed temporary as urban development spreads westward, with a resultant increase in landscaping that is maintained and watered regularly, reducing the possibility for vegetation fires to ignite and spread. 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. Furthermore, there are specific mitigation measures that homeowners can implement in their properties to reduce the hazard of vegetation fires. These measures are discussed in Section 4.1.3.

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). 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 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. The 1996 plan is now undergoing review by the CDF. For more information refer to http://cdfdata.fire.ca.gov/fire_er/fpp_planning_cafireplan.

As part of the Fire Plan program, the CDF developed a fuel ranking methodology that evaluates the fire behavior expected for a region, given the topography and vegetative fuels available. This allows the CDF to identify and prioritize pre-fire projects designed to minimize the costs of fire suppression and losses from wildfire. Most of Hesperia is

mapped as having a **moderate** potential fire behavior, with areas near the San Bernardino National Forest to the south mapped as having a high to very high potential fire behavior (http://frap.cdf.ca.gov/webdata/maps/statewide/frnk_map.pdf; map dated July 7, 2005).

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.fireplan.gov/>). 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 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 city of Hesperia is included in the list (http://www.cafirealliance.org/communities_at_risk/).

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; see section above on the California Fire Plan) 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://frap.cdf.ca.gov/data/frapgismaps/accept.asp>) shows that most of Hesperia is delineated with a **moderate** threat, with only those areas of the city near the San Bernardino National Forest to the south mapped as **high to very high**. Any wildland fires in these undeveloped, upland areas could spread into the Hesperia area if fire fighters were to lose control of them. More information on the National Fire Plan is available at http://frap.cdf.ca.gov/projects/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). 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.

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.

FARSITE, BehavePlus and FlamMap: These are PC-based computer programs that can be used by local 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 (Finney, 1995, 1998) “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, 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. As of writing of this document, FlamMap was available only in Beta format – the software has not been formally released yet.

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 therefore a good candidate for specific fire hazard mitigation measures.

4.1.3 Wildland Fire Protection Strategies

4.1.3.1 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 an Urban-Wildland 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 2009. The code contains provisions addressing fire spread, accessibility, defensible space, and water supply for buildings constructed near wildland areas.

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.

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 100-foot wide 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 new communities or developments proposed 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.

In Hesperia, proposals for fuel modification treatments are being developed for the Rancho Las Flores area, given its extensive fuel modification zones. Other areas in the city at this time do not have fuel modification or defensible space requirements. However, the San Bernardino County Fire Department recommends homeowners to maintain a 30-foot defensible space around their residences. Also, the Fire Department recommends planting fire-retardant plants within this 30-foot critical zone, and in extremely hazardous areas, a clearance of flammable vegetation for a minimum distance of 30 to 100 feet from structures is recommended. For more information please contact the San Bernardino County Fire Department at **(760) 244-2138**, or http://www.sbcfire.org/phone_directory.asp#Hesperia_-_Station_301_.

4.1.3.2 Notification and Abatement

Typically, city codes specify that property owners are required to mitigate the fire hazard in their properties by implementing vegetation management practices. The City of Hesperia contracts with the San Bernardino County Land Use Services Department for assistance in weed abatement. If uncontrolled or high weeds, brush, plant material, or other prohibited items are present on a property, the Fire Marshal of the County's Code Enforcement Division has the authority to give the property owner of record a notice to abate the hazard. If the owner does not abate the hazard during the time period specified in the notice, the City may take further action to reduce the fire hazard. Enforcement options may include notices of violation, correction or inspection; citations for criminal infraction or misdemeanor; temporary restraining orders; civil litigation; or the use of an Administrative Appeals Process. Property owners are given 30 days from when the notice to abate was issued to clear the overgrown vegetation on their property in accordance with Chapter I.12.130(B)(7) and Section 23.038 of the City and County Municipal Codes, respectively. If the property owner does not comply, the City has the ability to abate the fire hazard by mowing the weeds, and charging the property owner for the costs. This in fact occurs often.

For additional information refer to <http://municipalcodes.lexisnexis.com/codes/hesperia/> (Hesperia's Municipal Code) and www.sbcounty.gov/countycodes (County Code).

4.1.3.3 *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. 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.

The City of Hesperia has adopted code that requires, at a minimum, Class C roofing materials. The City also requires that roofing be made of materials customarily used in the area and all roofing materials used in the city need to be approved by the Building Official. The roofing materials need to be durable and fire resistant. Generally acceptable roofing materials include metal standing seam, concrete tile, ceramic tile, and slate or slate-like materials.

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 City of Hesperia does not have specific requirements regarding attic ventilation openings or windows. However, exterior wall construction shall consist of stucco, wood,

brick, stone, or decorative concrete block. Synthetic products of a similar appearance, equivalent durability and providing equivalent fire resistance may be permitted. Metal siding, if utilized, shall be non-reflective and horizontally lapping. The exterior covering material shall extend to a point at or near grade except if an approved solid wood, metal, concrete or masonry perimeter foundation is used; the exterior covering material need not extend below the top of the foundation. Every proposed construction project in the city is reviewed by the San Bernardino County Fire Department for compliance with the most recent California Fire Code adopted by the City, including City-amendments to the Code (referred to as the Hesperia Fire Code). For information regarding the most recent California Fire Code and City-specific requirements, contact the City's Building and Safety Department.

4.1.3.4 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.

4.1.3.5 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 structural modifications that could be a detriment to the fire-resistant qualities of the structure, with potentially negative consequences.

4.1.3.6 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 take on several measures to reduce their fire risk. Some of these tasks are listed below:

- Mow and irrigate your lawn regularly, but do not mow during the hottest time of the day.
- Dispose of cuttings and debris promptly, according to local regulations.
- Store firewood away from the house.
- Be sure the irrigation system is well maintained.
- Use care when refueling garden equipment and maintain it regularly.
- 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.
- For roof construction, the City of Hesperia requires roofing materials to be approved by the Building Official, however, Class-A asphalt shingles, slate or clay tile, metal, cement and concrete products, or terra-cotta tiles are preferred and are recommended by the City.
- Constructing a fire-resistant sub-roof can add protection.
- On exterior wall cladding, fire-resistive materials such as stucco or masonry are much better than vinyl, which can soften and melt.
- Install an approved automatic fire sprinkler system. The City of Hesperia has specific sprinkler requirements, as discussed further later in this chapter.
- 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. The City of Hesperia has specific requirements regarding roadway widths for fire engine access that are discussed further later in this chapter.
- 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.

4.1.3.7 Other Fire Hazard Reduction Techniques

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 percent 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 increase in fuel loads, with a resultant increase in fire risk – wildfires that impact areas with fuel buildup are more intense and significantly more damaging to the ecosystem than periodic, low-intensity fires.

To summarize, fire suppression and increasing populations have produced these results:

- Increased losses of life, property, and resources;
- Increased difficulty in suppressing fires, increased safety problems for firefighters, and reduced productivity by fire crews on perimeter lines;
- Longer periods between recurring fires;
- Increased volume of fuel per acre; and
- Increased taxpayer costs and property losses.

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 100 years of common practice and beliefs. Prescribed fire does carry a risk, as recent experiences in New Mexico, Arizona, and Orange County have shown. 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. 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. 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.

4.2 Structure Fires

Hesperia's permanent residential population as of 2009 was 88,184, with more than 28,500 housing units (Mr. Dave Reno, City of Hesperia Principal Planner, 2009, written communication). A large percentage of the housing stock in Hesperia consists of single-family, detached structures. When a structure fire develops in this type of occupancy, the fire is generally contained in the building of origin. There are some areas of the city, however, where high-density residential structures, such as apartments, are also present. Fire can spread from one structure or unit to the next more easily in this type of occupancy. Therefore, multiple-family units have special fire protection needs, including the requirement to have fire and life-safety systems in place, such as automatic fire sprinklers and smoke detectors, in conformance with the City's Building and Fire Codes.

In order to quantify the structural fire risk in a community, it is necessary for local fire departments to evaluate all occupancies based upon their type, size, construction type, built-in protection (such as internal fire sprinkler systems) and risk (high-occupancy versus low-occupancy) to assess whether or not they are capable of controlling a fire in the occupancy types identified. Simply developing an inventory of the number of structures present within a fire station's response area is not sufficient, as those numbers do not convey all the information necessary to address the community's fire survivability. In newer residential areas where construction includes fire-resistant materials, most structural fires can be confined to the building or property of origin. In older residential areas where the building materials may not be fire-rated, there is a higher probability of a structural fire impacting adjacent structures, unless there is ample distance between structures, there are no strong winds, and the Fire Department is able to respond in a timely manner. As discussed in detail below, in some areas of Hesperia older structures are relatively close to each other, increasing the probability of a structural fire not being confined to its building of origin only.

The previous section described in detail the wildfire risk in the city. Review of the maps provided show that a large portion of Hesperia has a moderate to high (wildland) fire hazard, whereas its northwestern portion is mapped as not having a wildfire hazard. In this area, however, as anywhere else in the developed portions of the city, there is the potential for structure fires to occur. Building fires, although only a small percentage of the incidents that the Fire Department responds to on an annual basis (between 0.5% and 2% of all emergency calls between 2007 and 2009 were for structure fires), account for a high percentage of the yearly losses in the city. The following sections discuss the potential fire targets in the city (Section 4.2.1), and the City's fire suppression capabilities (Section 4.3).

There is also a potential for chemical fires to occur in some areas of the city, where industrial and commercial occupancies are present, with the potential to impact nearby residential areas and critical facilities. 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. 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 Structural 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 use of 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, auditorium or night club). Typically, 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 be high or 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** (Example: multi-family dwellings and residential buildings (i.e., condominiums and apartments), older attached residential homes, high-occupancy facilities like theatres, hazardous materials occupancies (see Chapter 5), and large shopping centers.
- **Low Probability/High Consequences** (Example: medical facilities, mid-size shopping malls, industrial occupancies, and large office complexes).
- **High Probability/Low Consequences** (Example: older, detached single-family dwellings).
- **Low Probability/Low Consequences** (Example: newer, detached single-family dwellings and small office buildings).

In order to address the Fire Department’s capability to respond effectively to the structural fire risk in Hesperia, “Standards of Coverage” need to be determined based upon the various risks. Those risks are: Single-family detached residential, multi-family attached residential, commercial and industrial. Some of these risks exist in various areas throughout the city. For example, residential areas adjoining, and intermixed with commercial areas occur both east and west of Hesperia Road, between Orange Street to

the south, and Bear Valley Road to the north. High-density developments occur on the north side of Sequoia Street, and medium-density developments are present south of Eucalyptus Street and west of Maple Avenue. For the location and distribution of fire stations in the city of Hesperia, refer to Plate 4-2.

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 required to have several redundant fire and life safety systems in place, including automatic fire sprinklers, fire alarms and smoke and carbon monoxide detectors.

4.2.2 Model Ordinances and Fire Codes

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 ease of accessibility by fire equipment, and proper signage of streets and individual addresses. The City of Hesperia currently enforces the 2007 California Fire Code. (The 2010 California Fire Code has been adopted by the State and Cal FIRE and is expected to become effective in all jurisdictions by January of 2011.) The Fire Chief is authorized and directed to enforce the provisions of the California Fire Code throughout the city.

These provisions include constructions standards and 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 construction requirements are a function of building size, purpose, type, material, location, proximity to other structures, and the type of fire suppression systems installed. Given the detailed fire prevention requirements that the City of Hesperia has for building construction standards, it is best to refer to the City's most current Fire and Building Codes, available from the Hesperia Building and Safety Department. Information on the latest codes enforced by the City is also available from the City's website at <http://www.cityofhesperia.us>.

Some of the more significant Fire Code items that help reduce the hazard of structural fire in the city 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 City of Hesperia has very specific requirements regarding the installation of automatic fire-sprinklers depending on the type of occupancy and floor area. For more information regarding your specific needs, visit the City's Building and Safety Department. Code information is also available in the City's web site at <http://www.cityofhesperia.us>.

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) residual pressure. Available fire flow is the total water flow available at the fire hydrants, also measured in gallons per minute. As of the writing of this report, Hesperia had adopted the section of the 2007

California Fire Code (Appendix B) that lists the minimum required fire-flow and flow duration for buildings of different floor areas and construction types, except that a reduction in required fire flow of up to 50 percent may be allowed when the building is provided with an approved automatic sprinkler system. The resulting fire flow cannot be less than 1,500 gallons per minute. Local water districts are required to test their fire protection capability for various land-uses per the flow requirements of the California Fire Code. The Hesperia Water Department conducts inspections of all public fire hydrants in the city to make sure that they are working properly at the appropriate flows for the area. The Water Department also maintains the test records performed on private hydrants (which are to be tested annually). For additional information regarding the required fire-flow for your building, contact the Hesperia Water 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.

Existing water tanks in Hesperia are located to the south and southwest, and therefore at relatively higher surface elevations than most development in the city. This allows for a gravity-fed mechanism for water distribution. However, as the city grows to the south and west, and into higher elevations, these water tanks will not be able to provide water to those regions, unless the water is pumped. During and after an earthquake, if there is loss of electric power with a resultant failure of the water pumps, and there are substantial breaks in the water mains due to ground shaking and surface deformation, the city may find itself with a limited water supply (see Section 1.8.4.6 in Chapter 1). Leaking irrigation lines and open valves in destroyed homes can also reduce the amount of water available to fire fighters. Although most water districts consider a three-day supply of water to be good to excellent, a seven-day emergency storage supply is recommended, especially in areas likely to be impacted by fires after earthquakes, due to the anticipated damage to the main water distribution system as a result of ground failure and/or weaknesses in the pipes due to corrosion or age.

4.3 Fire Suppression Responsibilities

The City of Hesperia is a contract city with the San Bernardino County Fire Department, which provides all fire services including prevention, disaster preparedness and education in Hesperia. The County Fire Department also provides ambulance services to the three local High Desert hospitals. Fire-fighting resources in and near Hesperia include six fire stations; these are listed in Table 4-2 below. One of these facilities, #302, will be replaced with #306, as indicated. The locations of these fire stations are shown on Plate 4-2. The general telephone number for the Hesperia Fire Department is **(760) 947-1601. For emergencies, dial 911.**

Table 4-2: Fire Stations Serving the City of Hesperia

Station	Address	Equipment, Personnel
#301	9430 11 th Avenue	1 type-one engine (4 firefighters) and 2 ambulances (2 paramedics)
#302 (Headquarters)	17288 Olive Street (to be moved to Willow and I Avenue)	1 type-one engine (4 firefighters) and 2 ambulances (2 paramedics)
#304	15660 Eucalyptus Street	1 type-one engine (4 firefighters) and 2 ambulances (2 paramedics)
#305	8331 Caliente	1 type-one engine (4 firefighters), 1 fire truck (5 firefighters), and 1 ambulance (2 paramedics)
#48	4545 Summit Valley Road (currently a paid call station, but to be upgraded to a full-time engine station sometime in the future, no timeframe for this upgrade has been established)	1 type-three brush engine (2 firefighters) and 1 water tender (2 firefighters)
#22	12550 Jacaranda, in Victorville (but serving northeast Hesperia)	1 type-one engine (4 firefighters) and 2 ambulances (2 paramedics)
#306 (future)	Ranchero Road and I Avenue, in Rancho Las Flores	1 type-one engine (4 firefighters) and two ambulances (2 paramedics)
#303	17443 Lemon Street "on-call station," and Household Hazardous Waste Drop-Off Facility	

With the High Desert's rapid increase in population, and associated rise in traffic over the past few years, emergency calls to the Fire Department have steadily risen by about 3% to 5% each year. In 2003, the Department received 7,695 calls for service, whereas in 2005 they received 8,179 calls. By 2008, there were 9,382 calls. The calls include fires (structure, vegetation and others), ruptures/explosions, emergency management services (EMS)/rescue, traffic collisions, hazardous conditions, service calls, good intent calls, and false calls.

The National Fire Protection Association (NFPA Standard 1710, 2001) 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, which can result in total destruction, and this typically occurs within 8 to 10 minutes after ignition. Based on data provided by the City, average fire department response time in Hesperia was 7 minutes, 16 seconds in 2007; 7 minutes, 5 seconds in 2008; and 7 minutes, 27 seconds in 2009.

Actual response times are generally a function of traffic congestion and emergency unit availability. Other factors that may affect response time include access obstructions, traffic calming devices and median strips on major roadways, weather, multiple alarms, winding access roads in hillside developments, road grades, and gated communities. In Hesperia, fire department response times are primarily controlled by distance from the responding fire station to the site, and obstructions provided locally by the aqueduct and the railroad lines.

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 below.

4.3.1 Automatic and Mutual Aid Agreements

Although the San Bernardino County Fire Department is tasked with the responsibility of fire prevention and fire suppression in Hesperia, 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 City of Hesperia is one of 24 cities and towns that make up the San Bernardino County Operational area. The Operational Area is part of the Standardized Emergency Management System (SEMS), further described below, in Section 4.3.2, which promotes effective disaster management, response and cooperation across jurisdictional boundaries. As a result of being part of an Operational Area group, all of the jurisdictions have mutual aid agreements that allow them to obtain additional emergency resources, as needed, from non-affected members in the group. Given their geographic location, fire stations in Victorville (which also contracts with the County for emergency response) are the first responders to requests for additional assistance with incidents in Hesperia.

Numerous other agencies are available to assist the San Bernardino County Fire Department if needed. These include the County's Sheriff Department and 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. These agencies 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.

4.3.2 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 in 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 to 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 tribal 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>.

4.3.3 ISO Rating for the City of Hesperia

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. Hesperia currently has a Class 5 ISO rating in the developed portions of the city, and a rating of 9 in its outlying areas (in the Summit Valley area). These numbers reflect, in part, the lack of permanent fire stations in the southern, higher fire hazard areas of the city. Establishment of Fire Station #48 as a full-time station should help improve the City's ISO rating for the Summit Valley area.

However, as development in the area increases, additional fire stations will be required to serve the increasing population in a timely manner. Currently, the Fire Protection District staffing levels equal 0.57 per 1,000 of the population. The long-term goal is to increase staff to 0.75 per 1,000 population (Mr. Dave Reno, City of Hesperia Principal Planner, 2010, written communication).

4.4 Chemical Fires

Chemical substances are often unstable under high temperatures. Other chemicals react 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 held. 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 they are to 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 Section 5.2.5 (see 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 CO₂ 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.
- **CO₂ (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. CO₂ 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 CO₂ is a bad choice for flammable metal fires such as Grignard reagents, alkyllithiums and sodium metal because CO₂ reacts with these materials. CO₂ 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 the storm drains. Containing the water runoff from a fire is difficult but possible, especially if the special equipment to do so is available.

4.5 Earthquake-Induced Fires

Although wildland fires can be devastating, 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. In addition, if fire fighters are involved with search and rescue operations, they are less available to fight fires, and the water distribution system could be impaired, limiting even further the fire suppression efforts. If earthquake-induced fires occur during strong wind conditions, the results can be far worse.

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; 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 discussed in the Seismic Hazards section of this report (Chapter 1), there are several major earthquake-generating faults that could affect the Hesperia area. Some of the faults that could cause significant ground shaking in Hesperia include the San Andreas, North Frontal, Cleghorn, Cucamonga, San Jacinto, and Helendale faults. A strong earthquake on any of these faults could trigger multiple fires and disrupt lifelines services (such as the water supply) in Hesperia. In Hesperia and in the San Bernardino National Forest to the south, an earthquake on any of these sources could also trigger other geologic hazards, such as surface fault rupture, liquefaction and landslides, that could disrupt regional water and communication services, block roads, dam drainage channels and hinder disaster response. Specifics about the estimated losses to lifelines and other services in Hesperia in the event of an earthquake are discussed further in Chapter 1.

These losses mirror the results of a study published by the California Division of Mines and Geology in 1988 (now the California Geological Survey; Topozada and others, 1988) that identified projected damages in the Los Angeles area as a result of an earthquake on the Newport-Inglewood fault. The 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, the Southern California Gas Company reported 35 breaks in its natural gas transmission lines and 717 breaks in distribution lines. About 74 percent of the leaks were corrosion related. Furthermore, in the aftermath of the earthquake, 122,886 gas meters were closed by customers or emergency personnel. The majority of the leaks were small and could be repaired at the time of service restoration.

History indicates that fires following an earthquake have the potential to severely tax the local fire suppression agencies, and develop into a worst-case scenario. 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. Earthquake-induced fires can place extraordinary demands on fire

suppression resources because of multiple ignitions. 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). Water availability in Hesperia following a major earthquake will most likely be reduced due to damage to the water distribution system — damage to the water reservoirs, damaged groundwater pumping stations, and broken water mains (see Chapter 1 – Seismic Hazards). Casualties, debris and poor access can also limit fire-fighting effectiveness. Losses resulting from two fire-after-earthquake scenarios were estimated for this report. The results of these analyses are presented in Section 1.8.4 of Chapter 1.

4.6 Summary and Recommended Programs

The San Bernardino County Department manages the fire hazard in the city of Hesperia 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 very large, at times hindering the Fire Department's response time to emergency calls. Hesperia's ISO ratings of 5 for the city and 9 for the outlying (Summit Valley) areas reflect the Insurance Services Office's assessment that fire suppression capabilities in the city are still in need of improvement.

The southern approximately two-thirds of the city and its Sphere of Influence are mapped as having a high fire hazard. The southernmost portion of the city and its Sphere of Influence are mapped as having a very high fire hazard, whereas the northern one-third has a moderate to low fire hazard (see Plate 4-2). Different areas of the city and its Sphere are classified as Federal, State or Local Responsibility Areas. The boundaries of these regions are shown on Plate 4-2. The City of Hesperia has adopted Ordinance 2009-01 recognizing the Very High Fire Hazard Severity Zones in the Local Responsibility Area (LRA) mapped and recommended by the CDF.

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 City and the County 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 Hesperia represent a very small percentage of the annual emergency calls that the Fire Department receives and responds to. However, the fires that do occur in the city 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 thoroughways for fire equipment, clarity of addresses and street signs, and maintenance.
- Should consider encouraging 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 improve the adequacy of the city's water storage capacity and distribution network in the event of an earthquake. Redundant systems should be considered and implemented in those areas of the city where ground failure (as a result of liquefaction, or seismically induced settlement or slope failure) could result in breaks to both the water and gas mains, with the potential for significant conflagrations. This includes considering alternate sources of water, such as swimming pools.
- Should encourage the local gas and water purveyors to continue reviewing and retrofitting, as needed, their main distribution pipes, with priority given first to older lines, and lines located across areas susceptible to liquefaction, slope instability or other types of ground failure that may therefore be more susceptible to breakage during an earthquake.
- 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.

CHAPTER 5: HAZARDOUS MATERIALS MANAGEMENT

5.1 Introduction

A high standard of living has driven our increasing dependence on chemicals. Chemicals like hydrocarbon fuels that power our cars, chlorine that disinfects our drinking water, and pesticides and herbicides that help yield larger food crops 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, scientists have discovered that exposure to many of these chemicals 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 safe 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 that may cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness; 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 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 government agencies.

The State of California 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, carcinogenicity, bioaccumulative properties, is persistent in the environment, or is water reactive (California Code of Regulations, Title 22).

This chapter will address hazards associated with the presence of hazardous materials and wastes in the city of Hesperia. Various Federal and State programs that regulate the use, storage, and transportation of hazardous materials are also discussed in this chapter.

5.1.1 Hazardous Materials Releases as a Result of a Natural Disaster

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 coincidentally, 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.

5.2 Regulations Governing Hazardous Materials, and Environmental Profile of the City of Hesperia

Various Federal and State programs regulate the use, storage, and transportation of hazardous materials. These will be discussed in this chapter as they pertain to the city of Hesperia 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 Hesperia'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 below.

5.2.1 National Pollutant Discharge Elimination System (NPDES)

"Out of sight, out of mind" has traditionally been a common approach to dealing with 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 onto the ground, or into the sewer, can eventually make their way into the groundwater or waterways, with the potential to contaminate our drinking water resources. In other parts of California and the United States, substances dumped into the storm drains or sewer can eventually 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.

The Clean Water Act of 1972 originally established 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 "nonpoint-source" (NPS) pollution. NPS pollution refers to the introduction of bacteria, sediment, oil and grease, heavy metals, pesticides, fertilizers and other chemicals 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, such as roadways, parking lots, yards, and farms. As a result of rain and urban runoff, these pollutants enter the storm drains, from where they are ultimately conveyed to the area's water bodies and the ocean. Nonpoint sources of pollution are now thought to account for most of the 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 nonpoint source pollution, can make a significant difference.

The NPDES program is handled at the State-level by the California State Water Resources Control Board, with regional offices of the Board overseeing implementation and enforcement of the program at the local level. The type of NPDES permits issued depends on the size of the community. In the case of Hesperia, the California State Water Resources Control Board issued a NPDES General Permit (No. CAS000004) and an accompanying Fact Sheet for regulated small Municipal Separate Storm Sewer Systems (MS4s). The State Board has elected to utilize the General Permit approach for implementing the United States Environmental Protection Agency (USEPA) Phase II Storm Water requirements for small MS4s rather than regional permits, which have been the norm for Phase I MS4 permits. With the General Permit approach, the SWRCB writes a single statewide permit and the individual Regional Boards manage and enforce the permit for agencies subject to the permit within their individual jurisdictions. Accordingly, the Lahontan Regional Water Quality Control Board oversees the regulated small MS4s within the Mojave Watershed, governing the cities of Hesperia, Victorville, and the Town of Apple Valley. The Lahontan Regional Water Quality Control Board office is located at 14440 Civic Center Drive, in Victorville 92392. Their general telephone number is (760) 241-6583. For additional information regarding this program, refer to <http://www.epa.gov/npdes/stormwater/menuofbmps>.

Under NPDES, the local regulator is responsible for the following control measures:

- Public education and outreach on storm water impacts,
- Public involvement/participation,
- Illicit discharge detection and elimination,
- Construction of site storm-water runoff control,
- Post-construction storm-water management in new development and redevelopment, and
- Pollution prevention and good housekeeping for municipal operations.

Specific programs that cities and counties typically implement in support of their NPDES permits include:

- Regular maintenance of public rights-of-way, including street sweeping and litter collection, and maintenance of the existing storm drain facilities;
- Implementation of spill response procedures;
- Periodic screening of water samples collected from the local streams and storm drain system to test for specific contaminants;
- Adoption and enforcement of an ordinance prohibiting the discharge of pollutants onto the ground surface, and into the streams and local storm drain system;

- Plan review procedures to ensure that unauthorized connections to the storm drain and sewer systems are not made; and
- Public education efforts to inform residents about storm water quality. In Hesperia, these efforts typically include publishing the City's water quality report every September 15th that summarizes and assesses the NPDES program activities and stormwater pollution prevention measures implemented by the City during the previous year. Other educational efforts often utilized by cities and counties include holding public meetings, conducting presentations at businesses and schools, and meeting with citizens one-on-one to discuss measures that can be taken by businesses and individuals to reduce the potential for contamination of the local waters.

In conformance with the Federal requirements listed above, one of the major tasks of San Bernardino County is to educate the local population about keeping the water that flows into our rivers and ocean clean by eliminating discharges of hazardous materials into storm drains and other point sources. Hesperia, Victorville, and the Town of Apple Valley, in collaboration with San Bernardino County, have accomplished this by developing a Storm Water Management Program (SWMP). The program pools together staff and resources to prepare informational materials that are distributed to the public, schools and businesses; conduct workshops and community events; and sponsor free presentations to civic/rotary/group organization to discuss the prevention of stormwater pollution. Through this program, the County and City also prepare and place displays at local libraries, in county and city buildings, and booths in local events. Information regarding this program can be found at <http://www.ci.hesperia.ca.us/article.cfm?id=246>.

The Regional Board also monitors development projects during the construction stage. Specifically, 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. 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, there are no Superfund sites in the Hesperia area; however, the EPA database lists one CERCLIS site in Hesperia (see Table 5-1). The approximate location of this site in Hesperia is shown on Plate 5-1. The EPA database did not list the specific contaminants, if any, found at this site, but states that no site assessment work is needed at this site.

Table 5-1: CERCLIS Sites in the Hesperia Area

Facility Name	Facility Address	EPA ID	Status
Hesperia Drug Lab Fire	16395 Allthorn Street	CAN000906019	Not on NPL

Source: <http://www.epa.gov/superfund/sites/cursites/index.htm>

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 accurate 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
- 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 three (3) TRI facilities in Hesperia (see Table 5-2) listed in the most recent EPA database of 2008 (released to the public in December 2009), in addition to one facility in Victorville that is located about ½-mile from Hesperia. The EPA web site (<http://www.epa.gov/tri/>) should be reviewed periodically for updates to this information. The approximate location of these facilities is shown on Plate 5-1.

Table 5-2: Toxic Release Inventory Facilities in the Hesperia Area

Facility Name, Address	TRI ID	Chemicals (total on-site and off-site disposal or other releases in pounds)
AllTech Associates Inc. 17434 Mojave Street, Hesperia	92345VYDCG17434	mercury (1), methanol (4,057), toluene (994)
3M Oak Hills 8981 State Highway 395, Hesperia	92345TPCNC8981S	Di(2-ethylhexyl) phthalate (70), diisocyanates (64)
Unlimited Products 8770 Caliente Street, Hesperia	92345NLMTD8770C	Styrene (1,937)
Sherwin-Williams Co. 12401 Industrial Blvd., Victorville	90745LDQKR21243	1,2,4-trimethylbenzene (125), certain glycol ethers (22), copper compounds (1,080), ethylbenzene (259), methanol (1,373), methyl isobutyl ketone (696), n-butyl alcohol (242), toluene (368), xylene (mixed isomers) (1,437)

Source: U.S. EPA, 2009, TRI On-site and Off-site Reported releases in Hesperia, California (Zip Codes 92340, 92344 and 92345 for Hesperia; and 92392, 92393 and 92394 for Victorville); List of EPA-regulated Facilities in Envirofacts (<http://www.epa.gov/triexplorer/facility.htm>).

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.

The EPA lists two (2) registered transporters of hazardous waste with addresses in Hesperia, as shown on Table 5-3 below. These companies, and others registered elsewhere, including in neighboring Victorville and Apple Valley, are likely to transport hazardous waste through Hesperia, using Interstate 15, a prescribed route for all types of non-radioactive hazardous materials (NRHM) and Class 7 Highway Route Controlled Quantity (HRCQ) radioactive materials since 1992, and Toxic Inhalation Hazard (TIH) materials since 1994 (National Hazardous Materials Route Registry).

Table 5-3: Transporters of Hazardous Waste with Addresses in Hesperia

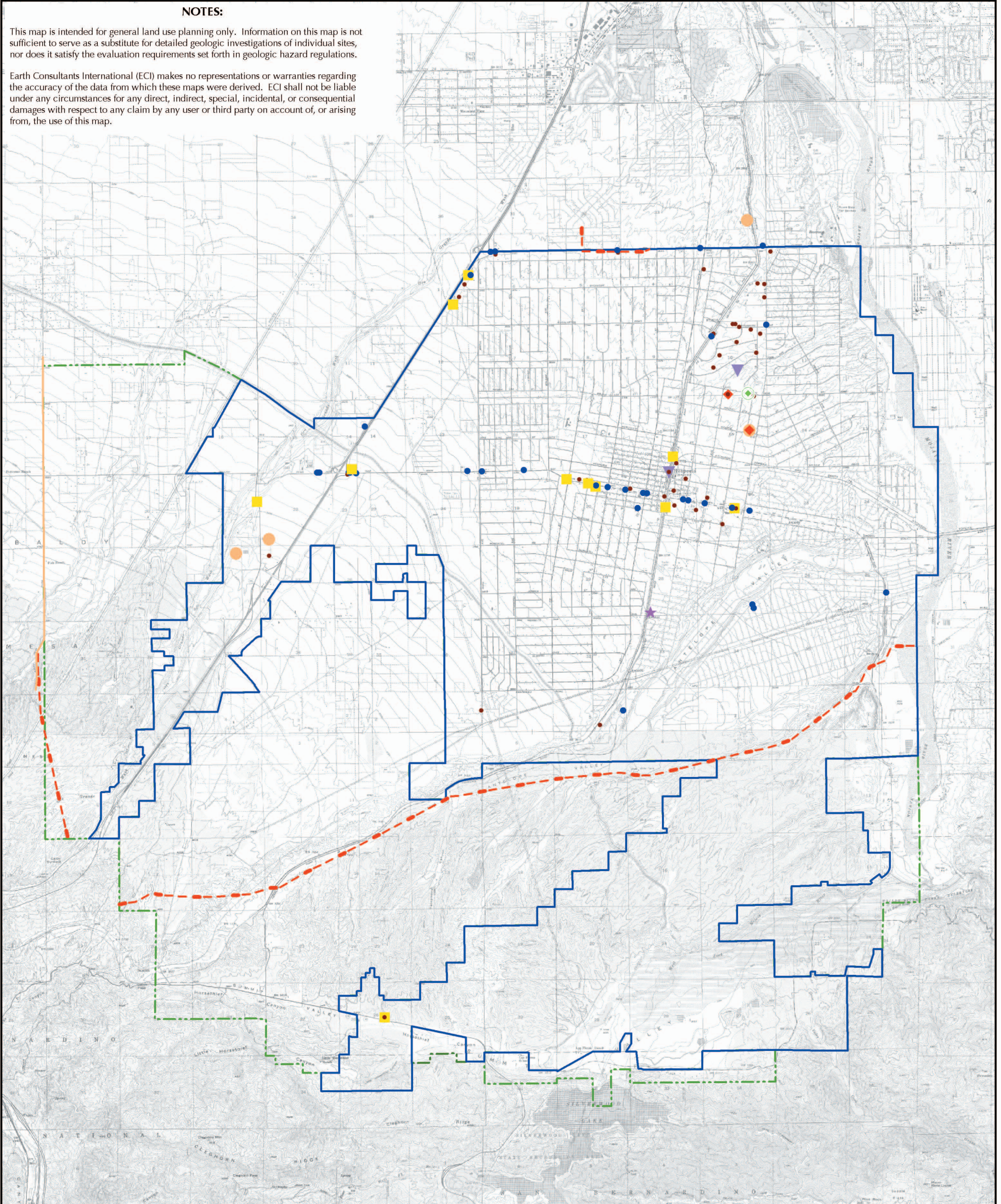
Name	Address
RLT Enterprises	17525 Alder Street #12/13, Hesperia 92345
Wickerink Property Preservation	15555 Main Street #4, Hesperia 92345

Source: California Department of Toxic Substances Control
(http://www.dtsc.ca.gov/database/Transporters/trans_cnty.cfm)

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 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).

Since many of these facilities are small, start-up businesses that come and go, the list of small-quantity generators in a particular area changes significantly over time. Often, a facility remains, but the name of the business changes with new ownership. For this reason, these businesses are not listed in this report. However, as of January 2010, there were approximately 46 small-quantity generators of hazardous materials in the Hesperia area (see <http://www.epa.gov/enviro/html/rcris/> – search for small quantity generators under the RCRA Info database). For specific, up-to-date information and location of small-quantity generators in the city, contact the San Bernardino County Fire Department, Hazardous Materials Division (<http://www.sbcfire.org/hazmat/cesqg.asp>).

Larger businesses are sometimes generators of large quantities of hazardous waste. These include chemical manufacturers, large electroplating facilities, and petroleum refineries. 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 two large-quantity generators in the city of Hesperia as of 2007 (National Biennial RCRA Hazardous Waste Report; http://www.epa.gov/enviro/html/brs/brs_query.html). These facilities are shown on Table 5-4 below, and their general locations are shown on Plate 5-1. Additional information on these permitted sites is available at <http://www.epa.gov/enviro/html/rcris/>. Please note that these lists change every other year; therefore, to determine whether the list has been updated, and obtain a more recent list, if available, contact the San Bernardino County Fire Department, Hazardous Materials Division (<http://www.sbcfire.org/hazmat/cesqg.asp>), or refer to the EPA website.



Base Map: USGS Topographic Map from Sure!MAPS RASTER, 1997
Source: City of Hesperia, 2006.

N

W

E

S

0

7000

14000

Feet

0

2000

4000

Meters

Scale: 1:84,000

★ Super Fund (CERCLIS) Site

◆ EPA-Registered Large Quantity Hazardous Waste Generator (LQG) Facility

● Toxic Release Inventory (TRI) Facility

■ Leaking Underground Storage Tank (LUST) Site

● Permitted (UST) Site

● Small Quantity Hazardous Waste Generator (SQG) Facility

--- Approximate Location of Gas Transmission Pipeline

--- Approximate Location of Hazardous Liquid Pipeline

⬢ Hazardous Material Drop Off Site

▼ Landfill

— Hesperia City Limit

--- Hesperia Sphere of Influence



Earth Consultants International

Project Number: 2617

Date: February 2010

Hazardous Materials Sites

in and near

Hesperia, California

Plate

5-1

Table 5-4: EPA-Registered Large-Quantity Generator (LQG) Facilities in Hesperia

Facility Name, Address	EPA ID	RCRA Tons Generated (Compounds)
The Separations Group (also known as AllTech Associates, Inc.) 17434 Mojave Street	CAR000089573	63 (Mercury, methanol, toluene)
High Tech Etch* 17229 Lemon Street, Bldg. E, Suite 4	CAD983661885	12.7 (not listed; corrosive waste)

Source: List of Large Quantity Generators in the United States: The National Biennial RCRA Hazardous Waste Report (2007 data extracted January 30, 2010). * High Tech Etch is in some lists identified as a Small-Quantity Generator.

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 Hesperia is the San Bernardino County Fire Department, Hazardous Materials Division (SBCFD-HMD).

According to the SBCFD-HMD guidelines, the preparation, submittal and implementation of a business plan is required by any business that handles 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 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.
- 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. However, there are some exceptions, such as

retail gas stations with up to 75,000 gallons of gasoline, or 100,000 gallons of diesel fuel in underground storage tanks that meet the 1998 upgrade requirements.

- 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 SBCFD-HMD:

- 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 business address;
- 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 SBCFD-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 SBCFD-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 company 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 CUPA forms in the city of Hesperia can be obtained from the San Bernardino County Fire Department.

Business plans are designed to be used by responding agencies, such as the SBCFD-HMD during a release to allow for a quick and accurate evaluation of each situation for appropriate response. The SBCFD-HMD currently reviews submitted business plans and updates. 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, 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 SBCFD-HMD is charged with the responsibility of conducting compliance inspections of regulated facilities in San Bernardino County. Regulated facilities are those that handle hazardous materials, generate or treat a hazardous waste and/or operate an underground storage tank. 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. Knowledgeable employees present onsite can also provide information.

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 San Bernardino County's Office of Emergency Services (OES), the San Bernardino County Fire Department and the City of Hesperia's Office of Emergency Services 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 San Bernardino County Fire Department that deals with the planning for and response to the natural and technological disasters in the county and in the city of Hesperia, whereas the Hazardous Materials Division (HMD) of the San Bernardino County Fire Department deals with the coordination and inspection of hazardous materials facilities in the city. The City and the County Fire Department have developed a Community Emergency Response Training program (CERT) to help Hesperia's citizens and visitors prepare for potential disasters; this CERT course is taught by the Fire Department with assistance from local businesses. The CERT course, which is taught over a several sessions (for a total of 24 hours), is certified by the Federal Emergency Management Agency (FEMA) and the State OES. For more information on the CERT program, contact the City's Emergency Preparedness Coordinator at (760) 947-1245.

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.

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 San Bernardino is designated as the Administering Agency for hazardous materials in the city of Hesperia.

5.3 Leaking Underground Storage Tanks (LUSTs)

Leaking underground storage tanks (USTs) 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 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.

Older tanks are typically single-walled steel tanks. Many of these have 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 for the 2009-2010 period 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 a 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, as of January 2010, lists twelve (12) reported LUST cases in Hesperia. (A thirteenth site, referred to as Hayward Lumber, is incorrectly located in Hesperia. Officials from the San Bernardino County Hazardous Materials Division have acknowledged that this site is not located in the City.) All twelve LUSTs correctly assigned to Hesperia (see Table 5-5 below and Plate 5-1) have been remediated; therefore additional actions, in the form of monitoring, testing, and remediation, are not necessary. Please note, however, that additional leaks may be reported, as there are at least 31 permitted underground storage tanks in the city. The State's GeoTracker list should be referenced at least bi-annually to obtain the most current information possible on leaking underground storage tanks in Hesperia.

With the exception of one case that impacted groundwater not used for drinking purposes (Lake Silverwood SRA), all other cases listed in Table 5-5 reportedly impacted the surrounding soil only. Information on the LUST sites in Hesperia can be obtained from the State's CRWQCB website <http://geotracker.swrcb.ca.gov/>.

Table 5-5: Leaking Underground Storage Tanks Reported in the Hesperia Area

Site Name	Address	State Case No.	Case Type	Status, Contaminant	Report Date
Affordable RV	11854 Mariposa Rd.	6B3601032T	S	8, D	Case Closed: 24-Oct-04
Arco AM/PM	16815 Main Street	6B3600998T	S	8, G	Case Closed: 21-Aug-01
Cedar Dam Maintenance Station	16051 Highway 173	T0607100851	S	8, G	Case Closed: 28-Sept.-1995
Circle K #1034	15853 Main Street	6B3600186T	S	8, G	Case Closed: 20-Jan.-2010
Firestone	17320 Main Street	6B3600254T	S	8, O	Case Closed: 12-Aug-87
Goodspeed Auto Fuel Systems	9269 Santa Fe Avenue	6B3601037T	S	8, D&G	17-Aug-05 Case Closed: 15-Dec-06
Goodyear Tire & Rubber	15787 Main Street	6B3600799T	S	8, O	27-Jan-97 Case Closed: 11-Aug-08
Hesperia Towing	9531 Santa Fe Street	6B3600471T	S	8, G	9-May-91 Case Closed: 4-Jun-09
Lake Silverwood SRA	14651 Cedar Circle	6B3600815T	O	8, G	Case Closed: 12-Jul-02
Shell Service Station	13105 W. Main Street	6B3600208T	S	8, G	15-Aug-90 Case Closed: 20-Nov-08
Timothy Lane	8685 US Hwy. 395	6B3600962T	S	8, G	Case Closed: 01-Jul-99
US Rentals	11612 Mariposa Road	6B3600798T	S	8, D	24-Jan-97 Case Closed: 11-Aug-08

Source: GeoTracker (<http://geotracker.swrcb.ca.gov/>)

Abbreviations Used for Case Type: S = Soil contaminated, groundwater not impacted; O = Other Groundwater, uses other than drinking water; W = Groundwater impacted. **Abbreviations Used for Status:** 8 = Case Closed. **Abbreviations Used for Contaminant:** G = Gasoline; D = Diesel; O = Oil.

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 many 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 to infants, young children, and people with severely 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 five percent test positive for Total Coliform, or
- For those systems testing less than 40 samples, more than one sample test positive for Total Coliform.

Drinking water is provided to the residents of Hesperia by the Hesperia Water District, although many residents have their own water wells on their property and are not tied to the main water system. Hesperia Water District's water comes from a network of 14 water wells located throughout the city. According to the EPA Safe Drinking Water Information System Violation Report, available at www.epa.gov/enviro/html/sdwis/sdwis_ov.html, two health violations have been reported for the City's water system since 1993, when records were first kept. The first incident occurred in September 1999 and was a non-significant monitoring violation for Total Coliform in which sampling was not conducted in a timely manner. The second incident occurred in February 2005 and was a health-based violation in which the concentration for Total Coliform exceeded the MCL. Although a public water system strives not to exceed a MCL for any contaminant, the fact this has occurred only once since 1993 is a particularly good record: the EPA indicates that in 2005, the last fiscal year for which the EPA has complete data, 24 percent of all water purveyors had a reporting/monitoring violation, 6.1 percent reported a MCL violation, and 1.5 percent reported a treatment technique violation.

A contaminant that local water agencies are now 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 percent of missile propellant and about 70 percent 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 ($\mu\text{g/L}$) 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 $\mu\text{g/L}$. Perchlorate at concentrations between 6.8 and 8.8 $\mu\text{g/L}$ was detected in three of Hesperia Water District water wells tested in 2006 (<http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Perchlorate.aspx>). Regular monitoring of these wells is required to determine whether these tests were anomalous, or whether these wells are indeed impacted and need to be remediated. Please note that the drinking water provided to the community by the Hesperia Water District reportedly does not contain perchlorate, as shown on both the 2007 and 2008 drinking water quality Consumer Confidence Reports issued by the District. For additional and/or the latest information regarding the quality of the drinking water provided by the Water District, refer to <http://www.cityofhesperia.us/index.aspx?nid=496>.

5.5 Household Hazardous Waste and Recycling

According to FEMA (1999), 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 use environmentally significant quantities of hazardous materials. For example, 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 its city drains each month (<http://www.fema.gov/hazard/hazmat/backgrounder.shtml>).

San Bernardino County and the City of Hesperia have 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 local drop-off facility is located at 17443 Lemon Street** and it is open Tuesdays and Thursdays (9:00 am to 1:00 pm) and Saturdays from 9:00 am to 3:00 pm (see the City's website for more information <http://www.ci.hesperia.ca.us/>). Employees who have been trained in hazardous waste handling and emergency response procedures operate the facility. A variety of household toxics are accepted. Acceptable wastes include used oil filters, various kinds of batteries including vehicle batteries, antifreeze, water- and oil-based paints, and other similar chemicals. Information about the collection center can be obtained from Hesperia's website (<http://www.cityofhesperia.us/index.aspx?NID=138>) or the Household Hazardous Waste facility at (800) 645-9228. You can also contact the San Bernardino County Fire Department Hazardous Materials Division by calling (909) 382-5401 or (800) OILY-CAT (645-9228). Free curbside service is available for senior citizens and disabled residents. The County also sponsors site collection services for Conditionally Exempt Small-Quantity Generators (CESQG) who are not able to take their waste to the collection site.

The City of Hesperia has a series of programs designed to reduce the amount of waste that is taken to the County's landfills. These waste reduction and recycling programs include curbside service for collecting grass and composting material, implementing recycling and reuse of construction and demolition materials, collecting and recycling used tires (free service), and recycling unwanted holiday paper, boxes and Christmas trees. Information on the City's waste reduction and recycling programs can be obtained at the following web address: <http://www.ci.hesperia.ca.us/>, or by calling Advance Disposal, the City's local trash hauler, at (760) 244-9773.

There are no active landfills in the Hesperia area. Solid waste generated in Hesperia is collected by Advanced Disposal, Hesperia's trash hauler and taken to their Material Recovery Facility (MRF). Here the waste is separated from the recyclables before it is taken to a landfill. The Hesperia Sanitary Landfill (Class III Landfill) at 5500 Hesperia Dump Road (also listed as on C Street, south of Community) was closed in 2005. Semi-annual testing of soil-pore gas samples indicates that volatile organic compounds in the landfill gas have not impacted the groundwater at this site (GeoLogic Associates, 2009). The Shaharold Mine at 10730 E Avenue, in Hesperia, is included in the GeoTracker (2009) database as a land disposal site that has been open since 1965, but no site history or cleanup status is provided for this facility.

5.6 Oil Fields

The map "Oil, Gas, and Geothermal Fields in California, 2001" published by the California Department of Conservation, Division of Oil and Gas shows that no oil fields are present or have been present in Hesperia. The map is available in pdf format from the Division of Oil and Gas website at: www.consrv.ca.gov/dog/. There are no known reservoirs of natural gas or petroleum under or near the city of Hesperia, so issues associated with the development and redevelopment of oil fields (such as oil-impacted soils that need to be treated or disposed of offsite, or the proper re-abandonment of oil wells, or methane production) do not apply to the Hesperia area.

5.7 Hazardous Materials Incidence Response along Transportation Routes and Due to Pipeline Failures

Interstate I-15 and Highway CA-395 traverse along the western part of Hesperia and a Burlington Northern Santa Fe (BNSF) railroad line cuts across the downtown area from south to north (with the Cushenbury Branch extending east-southeastward from its junction with the main line north of Main Street) (see Plate 1-5). A Union Pacific (UP RR) railroad line extends in a northwesterly direction through the city's southwestern corner. The interstate, highway and railroad lines are used to transport hazardous materials, posing a potential for spills or leaks from non-stationary sources to occur within the area. Trucks and trains carrying hazardous materials are required to have placards that indicate, at a glance, the chemicals being carried, and whether they are corrosive, flammable and/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.

While train derailment can occur at anytime, it is during an earthquake that a derailment and hazardous materials release would result in the greatest impact. According to the California Public Utilities Commission (1994), it is standard operating procedure to stop all trains within one hundred miles of the epicenter of a magnitude 6.0 or greater earthquake. The stoppage of trains in the area of the 1994 Northridge earthquake took approximately 14 minutes to implement. A derailment in the Northridge earthquake included a train with 29 cars and one locomotive. One of 13 tank cars spilled an estimated 2,000 gallons of sulfuric acid, and 1,000 gallons of diesel fuel spilled from the locomotive.

Additionally, pipelines and electrical transmission lines extend across the city (see Plates 1-5 and 5-1). A high-pressure gas transmission line extends through the south-central portion of the city, subparallel to Summit Valley Road; other, smaller segments of a high-pressure gas line extend along the city's northern boundary, parallel to Bear Valley Road. A hazardous liquid pipeline follows Baldy Mesa Road, along the City's Sphere of Influence western boundary (<https://www.npms.phmsa.dot.gov/searchp/Application.asp>). Rupture of any portion of a pipeline 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 the 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**. Their telephone number is **1-800-227-2600**. 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 above-ground structures.

Given that there are no active faults mapped through the central and northern portions of Hesperia, the risk of pipeline damage in the city due to surface fault rupture is low to none. Rupture of the San Andreas fault south of Hesperia, 4 miles from the city at its closest approach, is expected to damage the pipelines that extend across it in the Cajon Pass area. This could impact Hesperia residents that commute south of the Interstate 15. Given that Hesperia is located near several significant seismic sources, liquefaction and earthquake-induced settlement may occur locally as a result of strong ground shaking, with the potential to impact pipelines, power lines, communication towers, and other lifelines that service Hesperia.

5.8 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 Hesperia observes the most current version of the California Fire Code (currently the 2007) 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 five reported Significant Hazardous Materials Sites in the Hesperia 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 about 46 reported Small-Quantity Generators of hazardous materials in Hesperia. Compared to other cities in southern California, Hesperia 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 Plates 1-4 and 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 San Bernardino County Fire Department, Hazardous Materials Division or the EPA.

The city is located within about 4 to 16.5 miles of the San Andreas fault, a fault that has a relatively high probability of generating an earthquake in the next 30 years (see Chapter 1). Therefore, all hazardous materials sites in Hesperia 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.

The hazardous materials facilities shown on Plate 5-1 are not located within the 100-year floodplain (see Plate 3-1). Future hazardous materials facilities should be located outside of the floodplain zones also, unless all standards of elevation, anchoring, and flood proofing have been satisfied, and hazardous materials are stored in watertight containers designed to not float.

5.9 Summary of Findings

National Pollutant Discharge Elimination System (NPDES)

The City of Hesperia was issued a NPDES General Permit (No. CAS000004) and an accompanying Fact Sheet for regulated small Municipal Separate Storm Sewer Systems (MS4s). The Lahontan Regional Water Quality Control Board oversees the regulated small MS4s within the Mojave Watershed governing the cities of Hesperia, Victorville, and the Town of Apple Valley.

Superfund, Hazardous Waste, and Toxic Release Inventory Sites

According to EPA data, there are no Superfund sites in Hesperia, nor have there ever been in the past. The EPA reports that there is one (1) CERCLIS site, one or two (1-2) permitted Large Quantity Generators of hazardous materials, and four (4) Toxic Release Sites in or near the Hesperia area. The TRI list changes at least annually, so for the most current information refer to the EPA's web page. As of 2008, there were 46 permitted Small-Quantity Generators of hazardous materials located throughout the city. This figure is expected to increase as the city grows.

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 Hesperia, the local CUPA is the San Bernardino County Fire Department, Hazardous Materials Division, (SBCFD-HMD); they are responsible for reviewing the annually submitted business plans. For more information refer to their website (<http://www.sbcfire.org/hazmat/index.asp>), or contact them by phone at (909) 386-8401.

Leaking Underground Fuel Tanks

According to data from the State Water Quality Control Board, twelve leaking underground storage tank (LUST) sites were reported in Hesperia between 1988 and 2006 (a 13th site that according to the database is in Hesperia is actually not in the city, and was therefore not included herein). All twelve 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. Eleven of these sites reportedly impacted the surrounding soil only; one site impacted groundwater that is not used for drinking purposes (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 Office of Emergency Services provides oversight and conducts inspections of all underground tank removals and installation of new ones. Given that there are at least 31 permitted underground storage tanks in the city, future leaks could be reported. The GeoTracker database should be reviewed periodically for updates.

Water Quality

The Hesperia Water District provides drinking water to the residents of Hesperia (with the exception of those residents that have their own water wells). According to the EPA Safe Drinking Water Violation Report, the Hesperia Water District has had two health violations reported since 1993, when they started keeping records. The first incident occurred in September 1999 and was a non-significant monitoring violation for Total Coliform in which sampling was not conducted in a timely manner. The second occurred in February 2005 and was a health-based violation in which the concentration for Total Coliform exceeded the MCL. Compared to State statistics for drinking water violations, Hesperia's record is very good.

Household Hazardous Waste

San Bernardino County and the City of Hesperia have adopted a Household Hazardous Waste and Oil-Recycling program that is free to residents, in accordance with the California Integrated Solid Waste Management Act of 1989. **The Hesperia drop-off facility is located at 17443 Lemon Street**, and it is open Tuesdays and Thursdays from 9:00 am to 1:00 pm, and on Saturdays from 9:00 am to 3:00 pm (see the City's website for more information <http://www.ci.hesperia.ca.us/>). Free curbside service is available for senior citizens and disabled residents. The County also sponsors site collection services for Conditionally Exempt Small-Quantity Generators who are not able to take their waste to the collection site. The County also provides a recycle and reuse program, as well as other outreach and education programs that encourage recycling and conservation. The City of Hesperia has programs designed to reduce the amount of waste taken to landfills. Waste reduction and recycling programs include: curb-side service for collecting grass and composting material, implementing recycling and reuse of construction and demolition materials, collecting and recycling used tires (free service), and recycling unwanted holiday paper, boxes and Christmas trees. Information on the City's waste reduction and recycling programs can be obtained at the following web address: <http://www.ci.hesperia.ca.us/>, or by calling (760) 244-9773.

Oil Fields

There are no oil fields in or near Hesperia, so environmental issues associated with oil fields are not a concern 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. None of the hazardous materials sites in Hesperia are located on or near the

mapped traces of active faults, so surface fault rupture is not considered a hazard for these sites.

However, the entire city of Hesperia will be subjected to intense ground shaking as a result of an earthquake on any of several nearby earthquake sources, especially the San Andreas fault, located at its closest about 4 miles from the city's southern boundary, and approximately 13 miles from City Hall (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 Hesperia 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.

At present, none of the significant hazardous materials sites identified in Hesperia are located within the 100-year flood zones. Future hazardous materials sites established in Hesperia should be similarly not 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.

Incidence Response for Transportation Routes and Pipeline Failures

Hazardous materials are transported through the city of Hesperia along Interstate I-15, highway CA-395, and the BASF and UP railroad lines. Releases of hazardous materials from trucks or trains can occur during an accident. Hazardous material releases can also occur if a train derailment occurs in response to an earthquake. The California Highway Patrol is the responding agency in the event of a spill on the freeways, but local emergency response agencies, such as police and fire departments are responsible for additional enforcement and routing assistance. 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.

APPENDIX A: REFERENCES

- 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., Guttman, 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, K., 2006, The Use of Fire by Native Americans in California; *in* Sugihara, N.G., van Wagtenonk, 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. 417-430.
- Andrews, P. L., 1986, BEHAVE: Fire behavior prediction and fuel modeling system BURN subsystem, part 1: U.S. 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: U.S. 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.
- 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.

- 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.
- 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 Wagtenonk, 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.
- Bryan K. A., and Rockwell, T. K., 1995, Holocene character of the Helendale fault zone, Lucerne Valley, San Bernardino County, California: Geological Society of America, Abstracts with Programs, Vol. 27, pp. 7.
- Bryant, W. A., 1987, Fault Evaluation Report for the Recently active traces of the Harper, Blackwater, Lockhart and related faults near Barstow, San Bernardino County, California: California Division of Mines and Geology FER-189.
- Bryant, W.A., 1986, Fault Evaluation Report for the Western North Frontal Fault Zone and Related Faults, San Bernardino County, California: California Division of Mines and Geology FER-186, 16p. + figures.

- 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-FUELS subsystem: 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 (CBSC), 2001, California Building Code.
- California Department of Forestry and Fire Protection (CDF), 2008, San Bernardino County (South East) Fire Hazard Severity Zones Map, Local Responsibility Area (LRA), recommended November 2008; available from www.fire.ca.gov/fire_prevention/fhsz_maps/fhsz_maps_sanbernardinose.php.
- California Department of Forestry and Fire Protection (CDF), 2007, San Bernardino County (South East) Fire Hazard Severity Zones Map, State Responsibility Area (SRA), adopted November 2007; available from www.fire.ca.gov/fire_prevention/fhsz_maps/fhsz_maps_sanbernardinose.php.

- 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 (CDF), 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, 2004, California's Groundwater, Bulletin 118, last updated February 27, 2004.
- 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, 2008, Guidelines for Evaluating and Mitigating Seismic Hazards in California: Special Publication 117A, Revised and Re-adopted September 11, 2008 by the State Mining and Geology Board, 98p. Available from <http://www.conservation.ca.gov/cgs/shzp/webdocs/Documents/sp117.pdf>
- 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. Official Map of Alquist-Priolo Earthquake Fault Zones, Cajon (1974), Devore (1995),

- Harrison Mountain (1974), San Bernardino North (1974), and Apple Valley South (1988) Quadrangles.
- 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>
- Carollo Engineers, 2005, City of Hesperia 2005 Urban Water Management Plan, dated December 2005.
- 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.
- 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-Wildland Fire Problem: California State and Consumer Services Agency, A Special Report for the Governor Pete Wilson, dated January 19, 1994, 13p.
- Crook, R., Jr., Allen, C.R., Kamb, B., Payne, C.M., and Proctor, R.J., 1987, Quaternary geology and seismic hazard of the Sierra Madre and associated faults, western San Gabriel Mountains, in Recent reverse faulting in the Transverse Ranges, California: U.S. Geological Survey Professional Paper 1339, pp. 27-64.
- 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 36ClO_4 [Secretion and metabolism of perchlorate measured with 36ClO_4]: Naunyn-Schmiedberg's Arch. Exp. Pathol. Pharmacol., 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.
- Federal Emergency Management Agency (FEMA), 2008, Flood Insurance Study, San Bernardino 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) for the City of Hesperia, California; Community Panel Nos. 06071CIND1B, 06071CIND2B, 06071C6480H, 06071C6485H, 06071C6495H, 06071C6505H, 06071C6515H, and 06071C7225H, 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.
- Field, E.H., Seligson, H.A., Gupta, N, Gupta, V., Jordan, T.H., and Campbell, K.W., 2005, Loss Estimates for a Puente Hills Blind-Thrust Earthquake in Los Angeles, California: Earthquake Spectra, Vol. 21, No. 2, pp. 329-338.

- 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: U.S. 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.
- Fratessa, P.F., 1994, Buildings; in Practical Lessons from the Loma Prieta Earthquake – Report from a Symposium Sponsored by the Geotechnical Board and the Board on Natural Disasters of the National Research Council: National Academy Press, pp. 69-99.
- 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.
- 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.
- 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.
- 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.
- 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.
- 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: Review in Engineering Geology, Vol. 6, pp. 67-105.
- 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), 2009, International 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), 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.
- 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., 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.
- Keefer, D.K., and Johnson, A.M., 1983, Earth flows: Morphology, mobilization, and movement: U.S. Geological Survey Professional Paper 1264, 55p.
- 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.
- 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.
- 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.
- McGarr, A., Vorhis, R. C., 1968, Seismic seiches from the March 1964 Alaska earthquake: U.S. Geological Survey Professional Paper 544-E, 43p.
- 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.
- 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., 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.
- National Earthquake Information Center (NEIC) USGS Earthquake Hazards Program
http://neic.usgs.gov/neis/epic/epic_rect.html
- 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 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 Research Council, Committee on Alluvial Fan Flooding, 1996, Alluvial Fan Flooding, ISBN: 0-209-5542-3, 182p.
- 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.
- 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.
- 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.
- 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.
- Rubin, C.M., Lindvall, S., and Rockwell, T., 1998, Paleoseismic Evidence for Large Slip Earthquakes Along the Sierra Madre Fault in the Greater Los Angeles Region: Science, Vol. 281, pp. 398-402.
- San Bernardino County, 2009, Land Use Plan, General Plan, “B” Hazard Overlays.
- San Bernardino County, 2009, Land Use Plan, General Plan, “C” Geologic Hazard Overlays.
- San Bernardino County, 2007, Development Code, Adopted March 13, 2007, Effective April 12, 2007.
- San Bernardino County Flood Control District, 2006, Flood History, updated October 5, 2006, <http://www.co.san-bernardino.ca.us/flood>.
- San Bernardino County, 2005, Safety Background Report of the General Plan, dated June 15, 2005.

- San Bernardino County Flood Control District, 1996, Hesperia Master Plan of Drainage for Antelope Valley Wash and Adjacent Areas that are Tributary to the Mojave River, Final Report, Volume 1, dated May 1996, and prepared by Williamson & Schmid/Huitt-Zollars, Inc.
- San Bernardino County Flood Control District, 1996, Victorville Master Plan of Drainage for Oro Grande Wash and Adjacent Watersheds that are Tributary to the Mojave River, Final Report, Volume 1, dated March 1992, and prepared by Williamson & Schmid.
- 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.
- Seismic Safety Commission (SSC), 2003, Status of the Unreinforced Masonry Building Law, 2003 Report to the Legislature, Adopted June 12, 2003.
- 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 Lienkaemper, 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.
- 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 Wagtenonk, 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.I., 1995, Seismic performance of hillside fills: Reprint from Landslides under static and dynamic conditions-analysis, monitoring, and mitigation: Geotechnical Engineering Division/ASCE, 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 Wagtenonk, 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.
- 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., and others, 1988, Planning Scenario for a Major Earthquake on the Newport-Inglewood Fault (Los Angeles and Orange Counties): California Division of Mines and Geology Special Publication No. 99.
- 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., 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., 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.
- Tucker, A.Z., and Dolan, J.F., 2001, Paleoseismologic evidence for a >8 ka age of the most recent surface rupture on the eastern Sierra Madre fault, northern Los Angeles metropolitan region, California: Bulletin of the Seismological Society of America, Vol. 91, pp. 232-249.
- Unreinforced Masonry Law, California Public Resources Code, Chapter 12.2 Building Earthquake Safety, Section 8875 et seq.
- URS Corporation, 2007, County of San Bernardino 2007 General Plan, Adopted March 13, 2007, Effective April 12, 2007.
- U.S. Army Corps of Engineers, Los Angeles District, Reservoir Regulation Section, 2006, Mojave River Dam, <http://www.spl.usace.army.mil/resreg/htdocs/mojv.html>, updated February 9, 2006.
- U.S. Army Corps of Engineers, 1986, Mojave River Dam emergency plan, inundation maps, Plate Nos. 1 and 2, dated March 1986.

- 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, 2002, Lithologic and Ground-Water Data for Monitoring Sites in the Mojave River and Morongo Ground-Water Basins, San Bernardino County, California, 1992-98: U.S. Geological Survey Open File Report 02-354.
- U.S. Geological Survey, 2001, Water Supply in the Mojave River Ground-Water Basin, 1931-99, and the Benefits of Artificial Recharge, USGS Fact Sheet 122-01, dated November 2001.
- U.S. Geological Survey, 2000, Landslide hazards, USGS Fact Sheet FS-071-00, available at <http://pubs.usgs.gov/fs/fs-0071-00>.
- U.S. Geological Survey, 1996, Lake Arrowhead quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.
- U.S. Geological Survey, 1996, Baldy Mesa quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.
- U.S. Geological Survey, 1996, Cajon quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.
- U.S. Geological Survey, 1996, Silverwood Lake quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.
- U.S. Geological Survey, 1993, Adelanto quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.
- U.S. Geological Survey, 1993, Apple Valley North quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.
- U.S. Geological Survey, 1980, Apple Valley South quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.
- U.S. Geological Survey, 1980, Hesperia quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.
- U.S. Geological Survey, 1956, Photorevised 1993, Victorville quadrangle, 7.5 Minute Series (Topographic) Scale 1:24,000.
- van Wageningen, 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, F.F., 1922, Geology of San Bernardino Mountains north of San Geronio Pass: University of California, Berkeley, Bulletin of the Department of Geological Sciences, Vol. 13, No. 9, pp. 319-411.

- 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.
- 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.
- Williamson & Schmid/Huitt-/Zollars, Inc., 1996, Hesperia master plan of drainage for Antelope Valley Wash and adjacent areas that are tributary to the Mojave River: Final Report, Volume 1, prepared for the San Bernardino County Flood control District, May, 1996.
- 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.

- Wright, T.L., 1991, Structural geology and tectonic evolution of the Los Angeles basin; *in* Biddle, K., (editor), Active margin basins: American Association of Engineering Geologists Memoir 52, pp. 35-134.
- 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., 1995, Damage to Bridges and Highways from the Northridge Earthquake; in Woods, M.C., and Ray, S.W., (editors), The Northridge, California Earthquake of 17 January 1994: California Department of Conservation, Division of Mines and Geology Special Publication 116, pp. 163-185.
- Yeats, R.S., 1982, Low-shake faults of the Ventura Basin, California; *in* Cooper, J.D., (compiler), Neotectonics of Southern California: Fieldtrip Guidebook prepared for the 78th Annual Meeting of the Geological Society of America, Anaheim, California, April 19-21, 1982, pp. 3-23.
- Yule, D., and Sieh, K., 2003, Complexities of the San Andreas fault near San Geronio 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.

APPENDIX B: GLOSSARY

Acceleration – The rate of change for a body’s magnitude, direction, or both over a given period of time. In this report, it generally refers to the standard value of the Earth’s gravitational acceleration, g, equal to ~9.81 meters per second square, or ~32.2 feet per second squared. Ground shaking produced by an earthquake is often measured as a percentage of the gravitational acceleration, g.

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, carcinogenicity, 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 – **F**irefighting **RE**sources 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 32.2 feet per second squared, or 981 centimeters 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.