

Appendix H: Safety Element Technical Background Report

Table 4-1: Twenty Largest California Wildland Fires (Ranked By Structures Lost)

| Rank | Name (Cause) | Date | County | Acres | Structures Lost | Deaths |
|-----------|--------------------------------|------------------|------------------|---------------|-----------------|----------|
| 1 | Tunnel (Rekindle) | Oct. 1991 | Alameda | 1,600 | 2,900 | 25 |
| 2 | Paint (Arson) | Sept. 1990 | Santa Barbara | 4,900 | 641 | 1 |
| 3 | Fountain (Arson) | Aug. 1992 | Shasta | 63,960 | 636 | 0 |
| 4 | Berkeley (Powerlines) | Sept. 1923 | Alameda | 130 | 584 | 0 |
| 5 | Bel Air (Undetermined) | Nov. 1961 | Los Angeles | 6,090 | 484 | 0 |
| 6 | Laguna (Powerlines) | Sept. 1970 | San Diego | 175,425 | 382 | 5 |
| 7 | Laguna (Arson) | Oct. 1993 | Orange | 14,437 | 441 | 0 |
| 8 | Panorama (Arson) | Nov. 1980 | San Bernardino | 23,600 | 325 | 4 |
| 9 | Topanga (Arson) | Nov. 1993 | Los Angeles | 18,000 | 323 | 3 |
| 10 | 49ER (Burning Debris) | Sept. 1988 | Nevada | 33,700 | 312 | 0 |
| 11 | Sycamore (Kite) | July 1977 | Santa Barbara | 805 | 234 | 0 |
| 12 | Kannan (Arson) | Oct. 1978 | Los Angeles | 25,385 | 224 | 0 |
| 13 | Old Gulch (Equipment Use) | Aug. 1992 | Calaveras | 17,386 | 170 | 0 |
| 14 | Kinneloa (Campfire) | Oct. 1993 | Los Angeles | 5,485 | 196 | 1 |
| 15 | Mt. Tamalpais (Smoking) | July. 1929 | Marin | 2,500 | 117 | 0 |
| 16 | California (Powerlines) | Oct. 1993 | Riverside | 25,100 | 107 | 0 |
| 17 | Harlow (Arson) | July 1961 | Mariposa | 41,200 | 106 | 2 |
| 18 | Wright (Burning Debris) | Sept. 1970 | Los Angeles | 27,952 | 103 | 0 |
| 19 | Hanly (Smoking) | Sept. 1964 | Napa | 52,770 | 102 | 0 |
| 20 | Coyote (Burning Debris) | Sept. 1964 | Santa Barbara | 67,000 | 94 | 1 |

source: California Department of Forestry and Fire Prevention (CDF)

Table 4-2: Disaster Declarations Impacting Riverside County

| Date | Affected Counties | Damage Summary |
|----------------------|---|--|
| Fall '70 | Declared: City of Oakland (Alameda County 9/24/70), Los Angeles, Ventura, San Diego (9/28/70), Kern (10/1/70), San Bernardino (10/2/70), Monterey, Riverside (10/20/70) , San Bernardino (11/14/70) | Damage: public-\$52,862,000; watershed-\$24,826,000; private-\$145,923,000 TOTAL-\$223,611,000; 576,508 acres, 19 deaths, 722 bldgs. |
| December 1970 | Declared: Riverside (12/22/70) | Damage \$3.2 million |
| November 1980 | Declared: San Bernardino (11/25/80), Los Angeles, Orange, Riverside (11/18/80) | Damage: public-\$13,982,700; private-\$50,812,500; TOTAL-\$64,795,200. San Bernardino—65 buildings, 5482 acres destroyed, Additionally, 355 buildings, 41,472 acres destroyed. |
| August 1987 | Declared: Colusa, Del Norte (9/10/87), Butte, Fresno, Humboldt, Inyo, Kern, Lake, Lassen, Mariposa, Mendocino, Modoc, Mono, Nevada, Placer, Plumas, Riverside , San Bernardino, Shasta, Sierra, Siskiyou, Trinity, Tulare, Tuolumne (9/3/87) | Damage: \$18 million (estimated); 1,070 fires. 534,661 acres burned, 835 sq. miles, 3 deaths (firefighters), 76 injuries (firefighters) 38 homes destroyed |
| June 1990 | Declared: Los Angeles, Santa Barbara (6/28/90), Riverside , San Bernardino (6/29/90) | Damage: \$300 million+; 3 deaths (1 civilian, 2 firefighters), 89 injuries (46 civilians, 43 firefighters) 22,500 blackened acres, 492 homes destroyed, 28 apartments destroyed, 15 businesses and 10 public buildings destroyed, plus 30 additional structures. |
| October 1993 | Declared: Los Angeles, Ventura (10/27/93), San Diego, Orange (10/27/93), Riverside (10/27/93) , San Bernardino (10/28/93) | Damage: total property estimate-\$1 billion; 4 deaths, 162 injuries, 1078 destroyed structures, 193,814 acres destroyed. Fires: arson (12), power lines (6), campfires (2) |

source: California Governor's Office of Emergency Services

4.2 Fire Safety Regulations

The fire safety provisions denoted in the Safety Element should be prepared and adopted in conjunction with fire safety regulations issued by the State Board of Forestry (Irwin, 1989). Public Resources Code section 4290 requires minimum statewide fire safety standards pertaining to:

- Road standards for fire equipment access;
- Standards for signs identifying streets, roads, and buildings;
- Minimum private water supply reserves for emergency fire use;
- Fuel breaks and greenbelts.

With certain exceptions, all new construction after July 1, 1991 in potential wildland fire areas has been required to meet the statewide standards. The State requirements, however, do not supersede more restrictive local regulations.

As defined by the California Department of Forestry and Fire Protection (CDF), wildland areas may contain substantial forest fire risks and hazards. These areas are also called "State Responsibility Areas" (SRAs). They consist of lands exclusive of cities, and Federal lands regardless of ownership. The primary financial responsibility for preventing and suppressing fires belongs to the State. However, it is not the State's responsibility to provide fire protection services to any building or structure located within the wildlands unless the CDF has entered into a cooperative agreement with a local agency for those purposes pursuant to Section 4142 of the Public Resources Code. Wildland areas require disclosure for real estate transactions, and owners of properties in wildland areas are subject to the maintenance requirements of Section 4291 of the Public Resources Code.

Every fifth year beginning July 1, 1991, the CDF must provide maps identifying the boundaries of lands classified as SRAs to the Riverside County assessor. The CDF is also required to notify Riverside County of any changes to SRAs within the County resulting from periodic boundary modifications approved by the CDF.

Government Code Section 51178 specifies that the Director of the CDF, in cooperation with local fire authorities, shall identify areas that are Very High Fire Hazard Severity Zones (VHFHSZ) in Local Responsibility Areas (LRAs), based on consistent statewide criteria and the expected severity of fire hazard. This requirement is based on the Bates Bill (Assembly Bill 337, adopted September 29, 1992) that was initiated following the 1991 Oakland Hills "Tunnel" fire (Table 4-1). VHFHSZ consider fuel loading, slope, fire weather and other relevant factors. Under Assembly Bill 3819, passed in 1994 (AB 3819 – Willie Brown), "Class A" roofing, minimum clearances of 30 feet around structures, and other fire defense improvements are required for these zones.

Per Government Code Section 51178, a local agency may, at its discretion, exclude from the requirements of Section 51182 an area within its jurisdiction that has been identified as a VHFHSZ, if it provides substantial evidence in the record that the requirements of Section 51182 are not necessary for effective fire protection within the area. Alternatively, local agencies like Riverside County may include areas not identified as VHFHSZ by the CDF, following a finding supported by substantial evidence in the record that the requirements of Section 51182 are necessary for effective fire protection within the new area. According to Section 51182, such changes made by a local agency shall be final and shall not be rebuttable by the CDF.

During adoption of the 1997 Uniform Fire Code, the County of Riverside Board of Supervisors (1999) found that additional requirements and standards of fire hazard reduction were needed to properly protect the health, safety, and welfare of the existing and future residents and workers of Riverside County. They based these finding on:

- ***Climate:*** Generally, Riverside County is arid. Annual rainfall varies from three inches in Blythe to over thirty inches in Pine Cove. Hot, dry Santa Ana winds are common and necessitate increased fire protection. Added protection includes but is not limited to, on-site protection such as sprinklers. On-site protection supplements normal Fire Department response, and provides immediate fire protection for life and safety of multiple-occupancy structures.
- ***Geography and Topography:*** Riverside County includes deserts, mountains, brush-covered wildlands, and agricultural lands. Elevations range from three hundred feet below sea level (Salton Sea) to ten thousand feet above it. In areas of habitable land, slopes range from flat to 25% (*Slope measures variation from the horizontal. A flat terrain is 0% and a vertical cliff is a 100% slope.*). Traffic and congestion in urban areas, and great travel distances in rural and wildland areas, often hinder Fire Department response time. Thus, enhanced on-site protection for property occupants is necessary.
- ***Geology and Societal Realities:*** Several major earthquake faults bisect the County, including the San Andreas, the San Jacinto and the Elsinore. Numerous minor active faults add to the hazard. There are many areas within Riverside County at risk from landslides, wind erosion, blowing sand, flooding, and wildfires. Most of these disasters can also be triggered by earthquakes. Placement of multiple-occupancy buildings, location of arterial roads, and State revenue limits all complicate fire department efforts. Locations of fire stations and numbers of staff may be insufficient to control fires in multiple locations simultaneously. Thus, enhanced on-site, built-in protection is necessary.

4.2.1 Real Estate Disclosure and Maintenance Requirements

Assembly Bill 6 (AB6) requires disclosure in real estate transactions for two types of fire hazard areas.

- *Wildland Areas that may contain substantial forest fire risks and hazards (Wildland Areas)*
- *Very High Fire Hazard Severity Zones (VHFHSZ)*

Thus, AB6 fire maps are prepared by the California Department of Forestry and Fire Prevention (CDF).

Civil Code Section 1103(c)(6) requires real estate sellers to inform prospective buyers whether or not a property is located within a Wildland Fire Area that could contain substantial fire risks and hazards. The latest update to these requirements occurred in 1999 with the passage of Assembly Bill 248 (Torlakson). This disclosure has actually been required for Wildland Fire Areas since 1990, pursuant to Public Resources Code (PRC) Section 4136. The State Board of Forestry identifies those lands where the California Department of Forestry and Fire Protection (CDF) has the primary duty for wildland fire prevention and suppression. Many people know these lands as "State responsibility areas" or "SRA" lands. The CDF sends maps to the affected counties, and county officials must post notices at the offices of the county recorder, the county assessor, and the county planning agency that explain where the CDF maps are available.

Current Real Estate disclosure requirements ask two yes or no questions concerning fire hazards, which are formatted as follows:

THIS REAL PROPERTY LIES WITHIN THE FOLLOWING HAZARDOUS AREA(S):

- A VERY HIGH FIRE HAZARD SEVERITY ZONE pursuant to Section 51178 or 51179 of the Government Code. *(The owner of this property is subject to the maintenance requirements of Section 51182 of the Government Code.)*
- A WILDLAND AREA THAT MAY CONTAIN SUBSTANTIAL FOREST FIRE RISKS AND HAZARDS pursuant to Section 4125 of the Public Resources Code. *(The owner of this property is subject to the maintenance requirements of Section 4291 of the Public Resources Code. Additionally, it is not the State's responsibility to provide fire protection services to any building or structure located within the wildlands unless the Department of Forestry and Fire Protection has entered into*

a cooperative agreement with a local agency for those purposes pursuant to Section 4142 of the Public Resources Code.)

This study's digital Wildfire Susceptibility Map (Plate 4-1) should replace the CDF mapping, as it provides more accurate and complete natural hazards disclosure in Riverside County, and thus provides current and future buyers of County real estate with an estimation of the wildland fire risk associated with the property.

The hillside terrain of the County of Riverside is predominantly mapped as having a substantial fire risk. Therefore, much of the County of Riverside is subject to Public Resources Code, Section 4291-4299, which requires property owners in these areas to conduct maintenance to reduce the fire danger. Public Resources Code, Section 4291-4299 affects any person who owns, leases, controls, operates, or maintains any building or structure in, upon, or adjoining any mountainous area or forest-covered lands, brush-covered lands, or grass-covered lands, or any land which is covered with flammable material. That person shall at all times do all of the following:

- Maintain around and adjacent to such building or structure a firebreak made by removing and clearing away, for a distance of not less than 30 feet on each side thereof or to the property line, whichever is nearer, all flammable vegetation or other combustible growth. This subdivision does not apply to single specimens of trees, ornamental shrubbery, or similar plants which are used as ground cover, if they do not form a means of rapidly transmitting fire from the native growth to any building or structure.
- Maintain around and adjacent to any such building or structure additional fire protection or firebreak made by removing all brush, flammable vegetation, or combustible growth which is located from 30 feet to 100 feet from such building or structure or to the property line, whichever is nearer. Grass and other vegetation located more than 30 feet from such building or structure and less than 18 inches in height above the ground may be maintained where necessary to stabilize the soil and prevent erosion.
- Remove that portion of any tree which extends within 10 feet of the outlet of any chimney or stovepipe.
- Maintain any tree adjacent to or overhanging any building free of dead or dying wood.
- Maintain the roof of any structure free of leaves, needles, or other dead vegetative growth.

- Provide and maintain at all times a screen over the outlet of every chimney or stovepipe that is attached to any fireplace, stove, or other device that burns any solid or liquid fuel. The screen shall be constructed of nonflammable material with openings of not more than one-half inch in size.

- A person is not required under this section to maintain any clearing on any land if that person does not have the legal right to maintain the clearing, nor is any person required to enter upon or to damage property that is owned by any other person without the consent of the owner of the property.

4.3 Development of a GIS Wildland Fire Susceptibility Map for Riverside County

As part of this study, a Geographic Information Systems coverage was developed for Riverside County that used vegetation, weather, slope and proximity to urbanization to estimate the relative susceptibility zones in a digital format (Figure 4-2). The GIS mapping is generally accurate to 1:100,000. The susceptibility zones are represented at 1:250,000 on Plate 4-1, and summarized on Figure 4-3. The zones on Plate 4-1 are defined as:

- Very High
- High
- Moderate
- Low
- Very Low
- None

One use of this map would be to restrict roofing material based on relative hazard. For example, "Type A" materials should be required in Very High, High and Moderate zones, while "Type B" materials can be required in Low, Very Low and None susceptibility zones. In addition, defense zones can be increased based on increasing fire hazard susceptibility. Plate 4-1 should replace existing maps (such as the CDF map described in 4.4.2), as Plate 4-1 provides a more accurate and complete hazard assessment for Riverside County.

Fire hazard potential was determined by evaluating vegetation density and type, slope, and their relation to urbanization. Vegetation data were obtained from the California Gap Analysis Project (CGAP) at the University of California Santa Barbara. These data consist of land coverage and vegetation information for the State of California, including canopy dominant species, canopy density, presence of regional endemic species, and inclusion of wetland habitats (Table 4-3). All reference and attribute information for this dataset may be found at this website:

<http://www.biogeog.ucsb.edu/projects/gap/data/meta/landcovdd.html#section1>

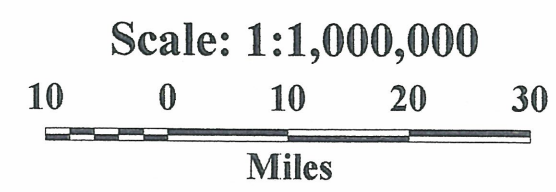
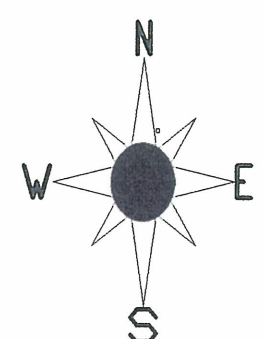
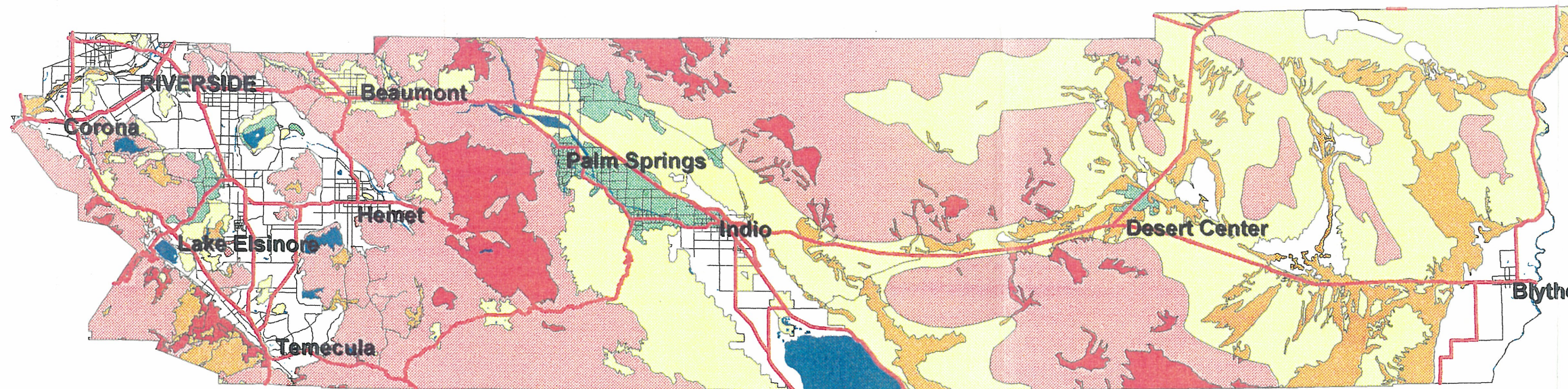
CGAP vegetation data were evaluated by identifying the primary, secondary and tertiary vegetation community types for each digital polygon and then rating the potential fire hazard based on fuel loading (Table 4-3), in accordance with the HUD Study System (1973) and the Bates Bill Process (AB337, 1992). These methods are described below.

Initial assignments of fuel hazard ratings for grasslands, shrublands, and woodlands consisted of light, medium, and heavy, respectively. The ratings were then normalized based on the primary, secondary and tertiary types of vegetation communities. Some data were further modified based on degree of urbanization and angles of slope (0-40%, 41-

60%, and over 60%). Increasing slope increases fire spreading potential. Modifications to the initial fuel hazard ratings produced seven fire hazard potential ratings of none, very low, low, moderate-low, moderate, high, and very high (Table 4-3).

**Figure 4-3:
Wildfire Susceptibility
Riverside County
California**

(Summary of GIS Data, for additional detail see Plate 4-1 in-pocket)



Wildfire Zones

- Very High
- High
- Moderate
- Low
- Very Low
- None

Water Bodies

Lake, Pond, Sea

Highways

Major Roads

Table 4-3: Rating Systems Used for Development of GIS Map

| VEGETATION DATA, LISTING BY CALIFORNIA GAP ANALYSIS PROJECT U.C. SANTA BARBARA | HUD* Study System | Bates* Bill Process | Wildfire Potential | Wildfire Potential Rating |
|--|-------------------------|---------------------------|-----------------------|---------------------------------|
| URBAN OR BUILT-UP LAND | 0 | 0 | low | 2 |
| AGRICULTURAL LAND | 0 | 0 | low | 2 |
| ORCHARDS AND VINEYARDS | 0 | 0 | low | 2 |
| PERMANENTLY-FLOODED LACUSTRINE HABITAT | 0 | 0 | none | 0 |
| SANDY AREAS OTHER THAN BEACHES | 0 | 0 | none | 0 |
| BARE EXPOSED ROCK | 0 | 0 | none | 0 |
| STRIP MINES, QUARRIES AND GRAVEL PITS | 0 | 0 | none | 0 |
| DESERT DUNES | 0 | 0 | none | 0 |
| VENTURAN COASTAL SAGE SCRUB | 8 | 2 | high | 4 |
| VENTURAN COASTAL SAGE SCRUB | 8 | 2 | high | 4 |
| DIEGAN COASTAL SAGE SCRUB | 8 | 2 | high | 4 |
| RIVERSIDEAN SAGE SCRUB | 8 | 2 | high | 4 |
| SONORAN CREOSOTE BUSH SCRUB | 8 | 2 | low | 2 |
| SONORAN DESERT MIXED SCRUB | 8 | 2 | low | 2 |
| MOJAVE CREOSOTE BUSH SCRUB | 8 | 2 | low | 2 |
| MOJAVE MIXED WOODY SCRUB | 8 | 2 | low | 2 |
| MOJAVE MIXED STEPPE | 8 | 2 | moderate-low | 3 |
| MOJAVE MIXED WOODY AND SUCCULENT SCRUB | 8 | 2 | low | 2 |
| BLACKBUSH SCRUB | 8 | 2 | low | 2 |
| BIG SAGEBRUSH SCRUB | 8 | 2 | low | 2 |
| DESERT SALT BUSH SCRUB | 8 | 2 | low | 2 |
| SOUTHERN MIXED CHAPARRAL | 8 | 2 | high | 4 |
| CHAMISE CHAPARRAL(CHAMISAL) | 8 | 2 | high | 4 |
| REDSHANK CHAPARRAL | 8 | 2 | high | 4 |
| SEMI-DESERT CHAPARRAL | 8 | 2 | high | 4 |
| MIXED MONTANE CHAPARRAL | 8 | 2 | high | 4 |
| MONTANE CEANOTHUS CHAPARRALS | 8 | 2 | high | 4 |
| BUCK BRUSH CHAPARRAL | 8 | 2 | high | 4 |
| HOARY-LEAFED CHAPARRAL | 8 | 2 | high | 4 |
| BIG POD CHAPARRAL | 8 | 2 | high | 4 |
| SCRUB OAK CHAPARRAL | 8 | 2 | high | 4 |
| INTERIOR LIVE OAK CHAPARRAL | 8 | 2 | high | 4 |
| UPPER SONORAN MANZANITA CHAPARRAL | 8 | 2 | high | 4 |
| COASTAL SAGE-CHAPARRAL SCRUB | 8 | 2 | high | 4 |
| VALLEY NEEDLEGRASS GRASSLAND | 1 | 1 | very high | 5 |
| NON-NATIVE GRASSLAND | 1 | 1 | very high | 5 |
| ALKALI PLAYA | 0 | 0 | very low | 1 |

| VEGETATION DATA, LISTING BY CALIFORNIA GAP ANALYSIS PROJECT U.C. SANTA BARBARA | HUD* Study System | Bates* Bill Process | Wildfire Potential | Wildfire Potential Rating |
|--|-------------------|---------------------|--------------------|---------------------------|
| COASTAL AND VALLEY FRESHWATER MARSH | 1 | 2 | low | 2 |
| SOUTHERN COAST LIVE OAK RIPARIAN FOREST | 16 | 3 | moderate-low | 2 |
| SOUTHERN COTTONWOOD-WILLOW RIPARIAN | 16 | 3 | moderate-low | 2 |
| DESERT DRY WASH WOODLAND | 16 | 3 | low | 2 |
| SOUTHERN SYCAMORE-ALDER RIPARIAN | 16 | 3 | low | 2 |
| MULE FAT SCRUB | 8 | 2 | moderate | 3 |
| COAST LIVE OAK WOODLAND | 16 | 3 | moderate- | 3 |
| DENSE ENGELMANN OAK WOODLAND | 16 | 3 | moderate- | 3 |
| MOJAVEAN PINYON AND JUNIPER WOODLANDS | 16 | 3 | moderate- | 4 |
| PENINSULAR PINYON AND JUNIPER WOODLANDS | 16 | 3 | moderate- | 4 |
| COAST LIVE OAK FOREST | 16 | 3 | moderate- | 4 |
| CANYON LIVE OAK FOREST | 16 | 3 | moderate- | 4 |
| COULTER PINE FOREST | 16 | 3 | high | 4 |
| BIGCONE SPRUCE-CANYON OAK FOREST | 16 | 3 | high | 4 |
| WESTSIDE PONDEROSA PINE FOREST | 16 | 3 | high | 4 |
| SIERRAN MIXED CONIFER FOREST | 16 | 3 | high | 4 |
| JEFFREY PINE-FIR FOREST | 16 | 3 | high | 4 |
| SOUTHERN CALIFORNIA WHITE FIR FOREST | 16 | 3 | high | 4 |
| SOUTHERN CALIFORNIA SUBALPINE FOREST | 16 | 3 | high | 4 |
| No secondary or tertiary type | 0 | 0 | NA | 0 |

*: descriptions of the rating systems are summarized in the sections below, additional detail may be found at: <http://www.prefire.ucfpl.ucop.edu>

4.3.1 HUD Study System

As a result of concerns about fire hazards in California, in April of 1973 the California Department of Forestry and Fire Protection (CDF) published a study funded by the Department of Housing and Urban Development (HUD) under agreement with the Governor's Office of Planning and Research. As is often true, it came as a response to a disaster; in this case the September and October 1970 wildfires which burned more than 580,000 acres in 773 fires. The HUD study uses fuel loading, fire weather, and slope as rating factors.

Fuel loading includes three classes of vegetation based on U.S. Geological Survey (USGS) life forms. These types can easily be determined from USGS maps, and thus a fairly accurate determination of fuels can be made without undertaking a major vegetation mapping project. The vegetative types are considered accurate to the nearest acre.

Light fuels occupy the uncolored areas on the USGS maps and include flammable grass and annual herbs. *Medium* fuels are shown as "scrub" on the USGS maps and include brush and other perennial shrubs less than six feet tall and with a crown density of 20 percent or more. *Heavy* fuels are shown as "woods-brushwood" on the USGS maps and include the heavier brush species, woodland types, and timber types over six feet tall with a crown density of 20 percent or more. HUD weights fuel loading in these vegetative types as follows:

- *Light* (grass): average of 2.22 tons/acre; *Fuel Severity Factor* = 1
- *Medium* (scrub): average of 17.33 tons/acre; *Fuel Severity Factor* = 8
- *Heavy* (woods, brushwood): average of 36.96 tons/acre; *Fuel Severity Factor* = 16.

The vegetative types are considered accurate to the nearest acre. This system was developed because the three types listed above could easily be determined from the USGS maps, and they represented a fairly accurate description of fuels found in California without having to undertake a major vegetation mapping project.

Fire Weather Severity is based on the California Wildland Fire Danger Rating System (CWFDRS). There are three classes of severity distinguished by the annual average frequency of critical fire weather days. To determine this, from June through December, fire weather ratings were analyzed in the State's 3 Fire Danger Rating Areas over a 10-year period. In the *Low* class (Class I) are Fire Danger Rating Areas which have experienced fire weather in the "very high" or "extreme" ranges an annual average of less than one day. In the *High* class (Class II) is an annual average of 1 to 9.5 days, and the *Extreme* class (Class III) has an annual average of more than 9.5 days. The fire weather severity weights are defined as follows:

- *Low*, Class I (<1 day per year); *Fire Weather Severity Factor* = 1
- *High*, Class II (1-9.5 days per year); *Fire Weather Severity Factor* = 2
- *Extreme*, Class III (>9.5 days per year); *Fire Weather Severity Factor* = 8.

To test the predictive powers of these ratings, analyses were made at 354 stations throughout California, in all 151 Fire Danger Rating Areas for the time period 1959-1969. During this time, there were 678 fires of 300 acres or more, and 75% of these occurred in Class III areas. For the 109 fires that burned at least 5,000 acres, 79% occurred in the same areas. HUD listed Fire Weather Severity for each of the USGS Quadrangle maps for California.

Slope: Like Fire Weather Severity, slope classes are taken from the CWFDRS. Each class covers a range of slopes: 0-40 percent, 41-60 percent, and over 60 percent. Because an increase in slope produces an increase in the rate of fire spread, slope often determines how a wildland fire is fought. The slope class weights are assigned as follows:

- *Class I (>40%); Slope Severity Factor = 1.0*
- *Class II (41-60%); Slope Severity Factor = 1.6*
- *Class III (>60%); Slope Severity Factor = 2.0.*

Once the severity factors are assigned to the fuel loading, fire weather, and slope classes the values are multiplied together to determine a numerical rating, the Fire Hazard Severity Scale. The fire severity hazard defined by the HUD Study System is as follows:

- Moderate Hazard, 1 - 12.8 Points
- High Hazard, 16 - 32 Points
- Extreme Hazard 51 - 256 Points.

Numerical gaps between categories exist because multiplying the factors does not produce all numbers. The slope can be either mechanically calculated or automatically calculated with a software program containing the USGS Quadrangle data (e.g. TopoScout©).

4.3.2 Bates Bill Process

The Bates Bill Process determines Very High Fire Hazard Severity Zones (VHFHSZs) in Local Responsibility Areas (LRAs). Assembly Bill 337 (the Bates Bill) was a direct result of the great loss of lives and homes in the Oakland Hills Tunnel Fire of 1991. It gave the California Department of Forestry and Fire Prevention (CDF) the responsibility-but not the resources-to map Very High Fire Hazard Severity Zones (VHFHSZs). The CDF formed a working group, comprised of State and local representatives. They devised a weighting system that considered fuel, slope, weather, and dwelling density. The raters were usually one local representative and one CDF or County representative. They could reduce the score by one point for certain mitigation measures, and increase the score one point for certain factors known to contribute to fire spread. Scores can range from 1-16 points. To qualify as a Very High Fire Hazard Severity Zone (VHFHSZ), an area had to score 10 or more points. The recommended system was given extensive field tests by different members of the working group before implementation. A copy of the rating form is found in Table 4-4 below.

4.3.2.1 Classification Points for Basic Factors

A. Fuel: A Fuel Hazard Rating is assigned based on the predominant fuel type.

- Small, light fuels (Grass, Weeds, Shrubs) +1
- Medium fuels (Brush, Large Shrubs, Small Trees) +2
- Heavy fuels (Timber, Woodland, Large Brush, Heavy Planting of Ornamentals) +3.

B. Topography—Slope: A Slope Hazard Rating is chosen to best represent the predominant slope range.

- Flat to Mild Slope (0-9.9%) +1
- Mild to Medium Slope (10-19.9%) +2
- Medium to Moderate Slope (20-39.9%) +3
- Moderate to Extreme Slope (40%+) +4.

C. Dwelling Density: Local ordinances regarding dwelling density must be checked before setting this factor.

- Low (less than one structure per 10 acres) +1
- Medium (one structure per 5 to 10 acres) +2
- High (one structure per 0 to 5 acres) +3.

D. Weather: This information is obtained for each county by using the Burning Index (BI). Weather is a major part of the BI system, BI data come from weather stations throughout the state.

- Moderate +1
- High +2
- Very High +3.

For these basic factors, points can range from 4 to 13 points. Ten (10) or more points are required to designate a Very High Fire Hazard Severity Zone.

4.3.2.2 Additional Weighting Factors

Downgrading Hazard: A local agency may use the mitigation measures outlined below to reduce a zone's rating:

- Infrastructure—meets or exceeds minimums of ISO 8, NFPA 1231, PUC 103, or PRC 4290 -1
- Ordinances in place regarding housing, roofing (Class A, B, or better roof), sprinklers, firesafe construction, or fuel modification. -1
- PRC 4291 ordinance or better (Natural Resource Protection) -1.

Upgrading Hazard:

- Rough topography with steep canyons or draws that would impede responding personnel and equipment. +1
- Area with a history of relatively high fire occurrence, because of heavy lightning, railroad fires, debris burning, arson, etc. +1
- Area subject to severe fire weather (such as strong winds and lightning) or recurring seasonal weather patterns that can increase fire activity (such as the Santa Ana winds) +1
- Heavy concentration of flammable ornamentals or vegetation introduced by humans +1.

The various factors are tallied on the form illustrated in Table 4-4 to determine whether or not an area is a Very High Fire Hazard Severity Zone.

Table 4-4: Sample Form for Bates Bill Process Determination of Very High Fire Hazard Severity Zone.

| | |
|---|-----------------------------------|
| TOTAL POINTS _____ | |
| VERY HIGH FIRE HAZARD SEVERITY ZONE ? YES / NO | |
| DESCRIPTION OF ZONE: | |
| 1. | LATITUDE AND LONGITUDE _____ |
| 2. | TOWNSHIP, SECTION, RANGE _____ |
| 3. | NARRATIVE OF ZONE _____ |
| | |
| DATE _____ | |
| SIGNATURE OF RATER _____ | |
| | |

The Bates rating system could be adopted as is, or with minor modifications, in most of California. The fuel types are easy to determine using the descriptions provided. The slope can be ascertained with field work or maps from planning departments, the USGS or the CDF. The minimum size of the rated area could be reduced from 640 acres to, say, 320 acres, or even the size of a subdivision. The weather component could be adjusted to reflect local conditions rather than county-wide conditions. Currently some coastal areas get rated too high and other areas, too low. Of greater concern is subjectivity in the rating process. For example, in Riverside County the most recent CDF map (January 6, 2000) illustrates very few VHFHSZs, yet it identifies VHFHSZs in areas which this study rates as having no susceptibility. However, topography and weather could be mapped using remote sensing to increase objectivity and thus uniformity.

Although the Bates system can make hazard maps that are useful to individual jurisdictions, and has the advantage of being applicable statewide, a large number of local agencies decided not to acknowledge it. Thus the actual number of Very High Fire Hazard Severity Zones is much higher than total provided as part of the original Bates review.

4.4 Previous Fire Hazard Maps for Riverside County

In addition to the comprehensive County map done for this study, two other fire hazard maps exist for the western portion of Riverside County.

4.4.1 Environmental Hazards Map for Riverside County

The **Environmental Hazards Map** for Riverside County, dated June 10, 1997, scale 1"=6 miles, was prepared by the County of Riverside, Transportation and Land Management Agency. This map illustrates "Highfire Areas" for the portion of Riverside County west of the Coachella Valley, and is cited by the County Board of Supervisors in the adoption of Ordinance 787, the amended 1997 Uniform Fire Code (Riverside County, 1999). The map is applicable to real estate disclosure requirements for fire hazards, but does not include a more detailed severity ranking.

Riverside County (1999) amended the 1997 Uniform Fire Code to define "Hazardous Fire Areas". The Hazardous Fire Areas are delineated on the Environmental Hazards Map and defined as land which is covered with grass, grain, brush, or forest, whether privately or publicly owned, which is so situated or is of such inaccessible location that a fire originating upon such land would present an abnormally difficult job of suppression or would result in great and unusual damage through fire or resulting erosion. Such areas are designated on the maps entitled "Hazardous Fire Areas of Riverside County" on file in the office of the Fire Chief (County of Riverside, Transportation and Land Management Agency, 1997). The hazardous fire areas shall be reviewed from time to time to determine whether any changes in classification are appropriate.

4.4.2 California Department of Forestry and Fire Protection Fire Hazard Mapping

The California Department of Forestry (CDF) and Fire Protection Map of West Riverside County, **Natural Hazard Disclosure (Fire)**, dated January 6, 2000, available from <http://www.fire.ca.gov/ab6/ab6lst.html> in Arcview® or Adobe Acrobat® formats. It defines "Wildland Areas" and "Very High Fire Hazard Severity Zones" within the western portion of Riverside County including the Coachella Valley.

4.5 Prefire Management

Over time, all California's wildlands *will* burn. Just as certainly, there are conditions and behaviors that will increase the likelihood that fires will occur; that will make them larger, more intense and more damaging, and thus more costly to fight; and that will take a higher toll. Not all of these factors can be controlled, but most can be anticipated and mitigated.

Riverside County's extreme diversity and complex patterns of land use and ownership require equally diverse and complex techniques to effectively manage the fire environment. Some options fall under the jurisdiction of State, Federal and local governments; others fall to private citizens or businesses; most are joint responsibilities. Custom strategies can be created through combinations of prefire management, suppression, and postfire management. They should lessen the costly impacts of future wildfires. As a starting point, the California Department of Forestry and Fire Prevention (2000) prefire management initiative includes a systematic application of risk assessment, fire safety, fire prevention and fire hazard reduction techniques.

The County has many fire fighting allies. For example, numerous Federal Agencies have roles in fire hazard mitigation, response and recovery, including:

- Fish and Wildlife Service
- National Park Service
- U.S. Forest Service
- Bureau of Land Management
- Bureau of Indian Affairs
- Office of Aviation Services
- National Weather Service
- National Association of State Foresters.

4.5.1 Fire Prevention

Firefighters often repeat that "it is not if, but when, fire will burn through an area, and, there are not enough fire engines to protect every house". Therefore, firefighters need help in reducing the fire danger.

Comprehensive programs to reduce fire risk and hazard consist of engineering, education and law enforcement contributions. Of key importance is a planning process focused on ignition management and loss reduction. Tactics include biomass harvesting, fire resistant landscaping, mechanical and chemical fuels treatments, building construction standards, infrastructure, and land use planning.

The single most important mitigation strategy for structures is fire- safe landscape, which creates a defensible space around structures.

4.5.2 Vegetation Management

Before European settlement began, vegetation in California's Mediterranean climate was dominated by a complex succession ecology of more, smaller and less damaging wildfires. The evolution of fire suppression since then has produced these results:

- Increased losses to life, property, resources and ecology.
- Difficulty of fire suppression, increased safety problems for firefighters and reduced productivity by fire crews on perimeter lines.
- Longer periods between recurring fires in many vegetation types by a factor of 5 or more.
- Increased volumes of fuel per acre.
- Increased fire intensities.
- Increased taxpayer costs and asset losses.

Recognition of these problems has led to vegetation management programs.

Since 1981, prescribed fire has been the primary means of fuels management. Approximately 500,000 acres — an average of 30,000 acres a year — have been treated with prescribed fire under the vegetation management program throughout the State. However, 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.

In the past, the typical vegetation management project targeted large wildland areas without assessing all of the values protected. Now, increasing population and development often preclude the use of large prescribed fires. The CDF proposes:

- A shift in emphasis to smaller projects closer to new developments, and to alternatives to fire, such as mechanical fuel treatment. In some instances, programs may be limited to providing wildland safety and protection zones around high value assets.
- Emphasis on quality over quantity of acres treated. Projects will be chosen to provide the most cost-effective means of protecting assets at risk from disastrous wildfires.

- The Board of Forestry and the State Air Resources Control Board will develop a joint policy on the use of prescribed fire. The policy will recognize the value of prescribed fire in reducing air emissions of wildfire during the high-impact summer period.

4.5.3 Fire-Safe Construction and Land Use Planning

The ultimate objectives of fire-safe planning and construction are to (1) improve the ability of communities and other high-value assets to survive a large, high-intensity wildfire with minimal fire suppression effort and (2) provide for improved citizen and firefighter safety.

State and local authorities must implement clearance laws, zoning, and related fire safety requirements that address these factors:

- **Fire-resistant construction standards:** The increases in people and structures provide extra ignition sources for fire which can spread into nearby wildland. Building construction standards for such items as roof covering, opening protection and fire resistant materials must protect the structure from external fires *and* contain internal fires for longer periods.
- **Hazard reduction near structures (defensible space):** Emphasis should be on defensible space 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.
- **Infrastructure:** 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, routes or thoroughways for fire equipment, addresses and street signs, and maintenance.

4.5.4 Greenness Mapping

Since the early 1990's, the EROS Data Center (EDC) in Sioux Falls, South Dakota, has produced weekly and biweekly maps for the 48 contiguous states and Alaska. These maps display plant growth and vigor, vegetation cover, and biomass production, using multispectral data from satellites of the National Oceanic and Atmospheric Administration (NOAA). EDC also produces maps that relate

vegetation conditions for the current 2-weeks to average (normal) 2-week conditions during the past 7 years. EDC maps provide comprehensive growing season profiles for forests, rangelands and grasslands, and agricultural areas. With these maps, fire 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.

4.5.5 Fire Potential Index

The Fire Potential Index (FPI) is a valuable fire management tool that has been collaboratively developed by the U.S. Geological Survey and U.S. Forest Service. The FPI characterizes relative fire potential for forests, rangelands, and grasslands, regionally and locally. It combines multispectral 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.

Fire management staffs in California use the FPI daily to supplement traditional information sources. They use these data to establish regional prevention priorities that will reduce the risk of wildland fire ignition and spread; and to improve the allocation of suppression forces, which can lead to quicker control of fires in areas of high concern.

4.5.6 Riverside Fire Laboratory

An excellent local resource for Riverside County is the Riverside Fire Laboratory (RFL) of the U.S. Forest Service. Located in the city of Riverside, the laboratory researches:

- Air Pollution and Climate Impacts on Western Forest Ecosystems
- Meteorology for Fire Severity Forecasting
- Wildland Recreation and Urban Cultures

- Prescribed Fire and Fire Effects
- Fire Management in the Wildland/Urban Interface.

Good fire management planning requires fire weather predictions on time scales ranging from hours to months. Fire weather forecasts that extend beyond a few days are generally unavailable. However, research at the RFL aims to provide forecast tools for the medium-range (10-15 days), extended-range (30 days), and seasons (90 days). Because the accuracy of weather forecasts varies with season, location, and other factors, the RFL is exploring the addition of forecast reliability maps.

Monthly fire weather forecasts provide fire managers with a quick and easy planning tool. Although scientifically based, these long-range forecasts are inherently less accurate. Thus, the user must consider the impact of variable forecast accuracy. Also, average weather conditions may vary rapidly over short distances, as happens in complex terrain. The scale of these forecasts may be too coarse to capture such variations accurately.

The RFL is developing a computer model to help minimize risk to structures from wildland fires. Houses in areas of flammable wildland fuel are often not located, constructed, or maintained to minimize the risk posed by wildfires in surrounding vegetation. The model assesses the potential for structures to ignite from wildland fire. The model is based on site-specific characteristics, surrounding fuels, and the planned or existing structure. Information from this assessment will help guide developers and home owners in the construction, maintenance and protection of homes in wildlands.

The RFL is investigating methods to forecast management impacts. Fire and resource managers must make decisions based on the complex interaction of resource, environmental, social, political, economic, and fire behavior parameters. Technology such as geographic information systems, expert systems, risk analysis, and modeling methods allows us to improve the availability and test the usefulness of complex data. The RFL is investigating how population growth and changes in land use patterns will affect fire management. The objective is to improve future zoning, residential development, fuels management, and planning.

4.5.7 Prescribed Fire

Fire ecologists now recognize that fire is as vital to the health of a forest as water. They have suggested that crown fires -- the spectacular tree-consuming infernos that make headlines -- should be intentionally set in wilderness areas to help restore a healthier patchwork of trees of different ages. Yet many find the notion of "prescribed fire" difficult to accept. For the last 100 years, humans have suppressed and battled fires. As a result, more acres will someday burn in uncontrollable blazes, or die of disease, unless fire is reintroduced to the landscape in measured doses with carefully crafted goals.

A prescribed fire is deliberately set under 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, property, and values 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 analysis.

Prescribed fire carries its own risk, as recent experiences in New Mexico and Arizona prove. The Cerro Grande fire began when a prescribed burn escaped destroying several hundred homes in Los Alamos, New Mexico and burned more than 50,000 acres. It will likely lead to revisions of guidelines for performance of prescribed burns. An interagency investigative team will assist in understanding what went wrong and in determining whether current prescribed fire policy and procedures are sound.

The Bureau of Land Management (2000) recommends the following guidelines for prescribed burn projects:

- The safety of firefighters and the public is the number one priority when planning and implementing a prescribed fire project.
- All prescribed fire projects should have an approved prescribed fire plan prior to ignition.
- All prescribed fire plans should contain measurable objectives, a predetermined prescription, and an escaped fire contingency plan to be implemented in the event of an escape.
- All prescribed fire projects should be conducted in compliance with Federal and State regulations.

Based on Bureau of Land Management (2000) standards, three prescribed fire complexities are possible. Each may require different procedures, precautions, and numbers of assigned personnel:

- **High:** Prescribed fires (other than pile burning) in the wildland/urban interface. The wildland/urban interface is more than a area or zone where structures meet or intermingle with wildland fuels. It is a set of conditions where structures and/or other improvements are reasonably within the reach of an escaped prescribed fire. This determination must take into account fuel type, fire behavior prescription, topography and containment opportunities.
- **Moderate:** All aerial ignitions must be classified as at least moderate complexity.
- **Low:** These types of operations typically would require few personnel, have a very low threat of escape, and present a minimal risk to the people involved in the operation.

4.5.8 Hazardous Fire Area Designation

Based on drought and other conditions, it may become necessary to close an area to the public due to extreme fire hazard potential. Riverside County (1999) outlines the procedures for "Hazardous Fire Area Designation" as follows:

The chief is given the authority to officially determine and publicly announce the closure of any hazardous fire area or portion thereof. However, any closure by the chief for a period of more than fifteen (15) days must be approved by the Board of Supervisors within fifteen (15) days of the chief's original order of closure. No person is permitted in any hazardous fire area, except on public roadways and inhabited areas, during such time as the area is closed to entry. This shall not prohibit residents or owners of private property within any closed area, or their invitees, from going in or being upon their lands. This does not apply to any entry, in the course of duty by a peace officer or any other duly authorized public officer, member of any fire department, or member of the U.S. Forest Service or California Department of Forestry and Fire Protection, nor does it apply to National Forest Land in any respect. During periods of closure, the chief shall erect and maintain at all entrances to the closed areas sufficient signs giving adequate notice of closure.

4.5.9 Hazard Abatement Notices

Each spring, the California Department of Forestry and Fire Protection (CDF) and Riverside County Fire Department distribute hazard abatement notices. These notices, which currently go to about 30,000 County citizens, request that property owners reduce the fuels around their property. Requirements for hazard reduction around improved parcels (those with structures) are set forth in Riverside County Ordinance No. 787, and Public Resources Code Section 4291. A minimum 30 foot clearance is required around all structures, which can be extended to 100 feet in areas where severe fire hazard exists. On unimproved parcels as set forth in Riverside County Ordinance No. 695, the property owner is required to disc or mow 100 feet along the perimeter of the property.

4.5.10 Fire Flow

Riverside County uses the Uniform Fire Code, Division III, Appendix III-A for establishing fire flow, duration and pressure requirements for fire flow. The requirements are a function of building size, type, material, purpose, location, proximity to other structures, and the type of fire suppression systems installed. The various water districts in the County are required to test fire protection capability for the various land uses per the flow requirements of the Uniform Fire Code (Table 4-5).

Table 4-5: Uniform Fire Code Minimum Fire Protection Flows

| Land Use | Flow (gallons per minute) | Duration (hours) | Fire Suppression Storage (million gallons) | Residual Pressure (psi) |
|---|---------------------------------|---------------------|--|-------------------------------|
| Residential Single-Family | 2,000 | 4 | 0.48 | 20 |
| Residential-Estate, Single Family Frontier | 2,500 | 4 | 0.60 | 30 |
| Residential Multi-Family | 3,000 | 4 | 0.72 | 20 |
| Commercial/Industrial | 4,000 | 4 | 0.96 | 20 |
| Schools | 3,500 | 4 | 0.84 | 20 |

Emergency Storage is required in the event of an interruption of the Metropolitan Water District (MWD) primary supply. MWD recommends a seven day emergency storage supply.

4.5.11 Model Fire Hazard Reduction Ordinance

To assist local jurisdictions in adopting ordinances to reduce fire hazard, the State Fire Marshal, Fire Engineering Division has developed a model ordinance checklist. This development was required by Assembly Bill 3819, on September 27, 1994. The model ordinance checklist addresses the following standards:

- Road Standards for Fire Equipment Access (Table 4-6)
- Structural Standards (Table 4-7)
- Fuel Modification Standards (Table 4-8).

Table 4-6: Road Standards for Fire Equipment Access

| | |
|------------------------------|--|
| Width | Two 9' lanes |
| Surface | 40,000 lb. Load |
| Grades | Not to exceed 16% |
| Horizontal Inside Radius | No less than 50' |
| Vertical Curves | 100' |
| Turnarounds | Required, 40' from center |
| Hammerhead/"T" | Top of "T" 60' long |
| Turnouts | 10' x 30' |
| | 25' taper each end |
| Roadway Structures (Bridges) | Load and clearance per Vehicle Code Sections 35550, 35750, 35250 |
| Bridge Signage | Load, clearance, one-way, single lane |
| One-way Roads | One 10' lane |
| | Must connect to 2 lanes at each end |
| | Serve no more than 10 dwellings |
| | Not to exceed 2640' |
| | Turnout at midpoint |
| Dead-end Roads | Not to exceed: |
| <1 acre parcels | 800' |
| 1-4.99 acre parcels | 1320' |
| 5-19.99 acre parcels | 2640' with turnaround at 1320' interval |
| 20+ acre parcels | 5280' with turnaround at 1320' intervals |
| Driveways | 10' wide, 15' vertical clearance |
| If >150' but <800' | Turnout at midpoint |
| If >800' | Every 400' |
| If >300' | Turnaround w/in 50' of all building sites |
| Gate Entrances | 2' wider than lane |
| | 30' from roadway |

developed by the Office of the State Fire Marshal, Fire Engineering Division

Table 4-7: Structural Standards

| | |
|---------------------------------------|---|
| Eaves | 1 hour fire rated |
| | Fascias required, must be backed by 1 hour or 2" lumber |
| Roofs | Class B or better |
| Underfloor Areas | Enclosed to ground |
| Exception | If exposed materials are 1 hour rated |
| Unenclosed Accessory Structures | Non-combustible or 1 hour rated |
| Exception (If 100' defensible space) | patio roofs > 2"x4" or open lattice > 2"x2" is OK |
| Underfloor Areas (Attached Structure) | If over a descending slope, enclose within 6" of ground |
| Windows | Tempered or multi-layered glass |
| Doors | Non-combustible or solid core > 1-3/4" |
| Attic Openings | Not to exceed 144 square inches |
| | Noncombustible corrosion-resistant mesh < 1/4" holes |
| | Not to be in soffits, eave overhangs, etc. |
| | Gable/dormer vents 10' from property line |
| Walls | Any habitable space must be 1 hour rated |
| Underfloor Areas (Detached Structure) | If over a descending slope, enclose within 6" of ground |

Table 4-8: Model Ordinance Checklist, Fuel Modification Standards

| | |
|------------------------|---------------------------------------|
| Clearance (Structure) | 30' on each side or to property line |
| Additional Clearance | 30'-100' when needed |
| Trees | 10' from chimney |
| Dead or Dying Wood | Remove if overhangs structure |
| Accumulated Vegetation | Clear roof |
| Chimney and Stovepipe | Screen < 1/2" holes |
| Setback If >1 acre | 30' |
| If <1 acre | Same practical effect |
| Disposal | Prior to acceptance |
| Greenbelts | Locate strategically-must be approved |

developed by the Office of the State Fire Marshal, Fire Engineering Division

4.6 Earthquake-Induced Fires

Fires following earthquakes can cause severe losses. These losses can sometimes outweigh the total losses from direct damage (such as collapse of buildings). The most dramatic United States example occurred when much of San Francisco was destroyed by fire following the 1906 earthquake.

Many factors affect the severity of fires following an earthquake, including ignition sources, types and density of fuel, weather conditions, functionality of water systems, and the ability of fire-fighters to suppress the fires. Casualties, debris and poor access can all limit fire-fighting effectiveness. Water availability in Riverside County following a major earthquake would likely be curtailed due to breaks in water lines across faults, in liquefiable regions and in areas susceptible to landslides. (See Chapter 1 – Earthquake Hazards.) In addition, above-ground reservoirs are vulnerable and damage to them would also affect fire flow.

Earthquake-induced fires make extraordinary demands on fire suppression resources because of multiple ignitions (as discussed in 4.1). The principal causes of earthquake-related fires are open flames, electrical malfunctions, gas leaks, and chemical spills. Downed power lines may ignite fires in the unlikely event 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 immobilized.

The California Division of Mines and Geology Newport-Inglewood Earthquake Scenario (Topozada and others, 1988) indicates that fire units should prepare for thousands of damaged and leaking mains, valves, and service connections including broken pipelines. These will occur along, and adjacent to, fault rupture. The Southern California Gas Company has prepared by replacing distribution supply pipelines with resistant (flexible) plastic polyethylene pipe, and has an overall ability to isolate and shut off sections of supply lines when breaks are serious.

4.6.1 Natural Gas Fires -- Northridge Earthquake

The moderately-sized, M_w 6.7 Northridge earthquake of 1994 caused were 15,021 natural gas leaks. In the aftermath of the earthquake, 122,886 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. The Southern California Gas Company (1994) reported 35 breaks in its natural gas transmission lines and 717 breaks in distribution lines. About 74% of its 752 leaks were corrosion related.

Natural gas leaks in the Southern California Gas Company service area 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 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 let them fall from foundations, severing gas lines and igniting fires. There was a much greater incidence of mobile home fires (49.1 per thousand) than other structure fires (1.1 per thousand). Earthquake-induced fires greatly threaten Riverside County, in part due to the County's large number of mobile homes.

4.6.2 Earthquake-Induced Fire Scenarios for the Riverside County Area using HAZUS

HAZUS™, a standardized methodology for earthquake loss estimation based on a geographic information system (GIS), is a project of the National Institute of Building Sciences, funded by the Federal Emergency Management Agency (FEMA). HAZUS, and the earthquake threat to Riverside County, are discussed at length in Chapter 1 – Earthquake Hazards. This section reports on earthquake-induced fire loss estimation made with HAZUS.

Loss estimation is an invaluable tool, but must be used with discretion. Loss estimation results are best taken as broad indications of a disaster's severity. For example, a fire station with 60% functionality has clearly fared better than one at 30% functionality, but that 30% is probably equivalent to one at 20%.

Loss estimation is a new methodology. Our data and thus understanding of fires following earthquakes are limited. Furthermore, a fully accurate, fire-following-earthquake evaluation requires extensive knowledge of the level of readiness of local fire departments, as well as the types and availability (functionality) of water systems. For all these reasons, there will undoubtedly be future improvements in forecasting ability.

Based upon current data and best judgment, it is estimated that about 70% of all earthquake-induced fire ignitions occur immediately, as the fire is discovered within a few minutes of the earthquake. The remaining ignitions occur about an hour to a day after the earthquake. A typical cause of later ignitions is the restoration of electric power. When power is restored, short circuits caused by the earthquake

become energized and can start fires. Also, items which have overturned, fallen onto stove tops, etc., can ignite. If no one is present at the time electric power is restored, ignitions can grow to fires requiring fire department response.

HAZUS loss estimations were made using two scenario earthquakes, listed in Table 4-9 and described in Chapter 1. Two wind velocities were used for each scenario earthquake. A velocity of 30 miles per hour (mph) was assigned to evaluate fire spread as a result of Santa Ana winds. A value of 10 mph was used to model normal wind conditions.

Table 4-9: Scenario Earthquakes for Riverside County

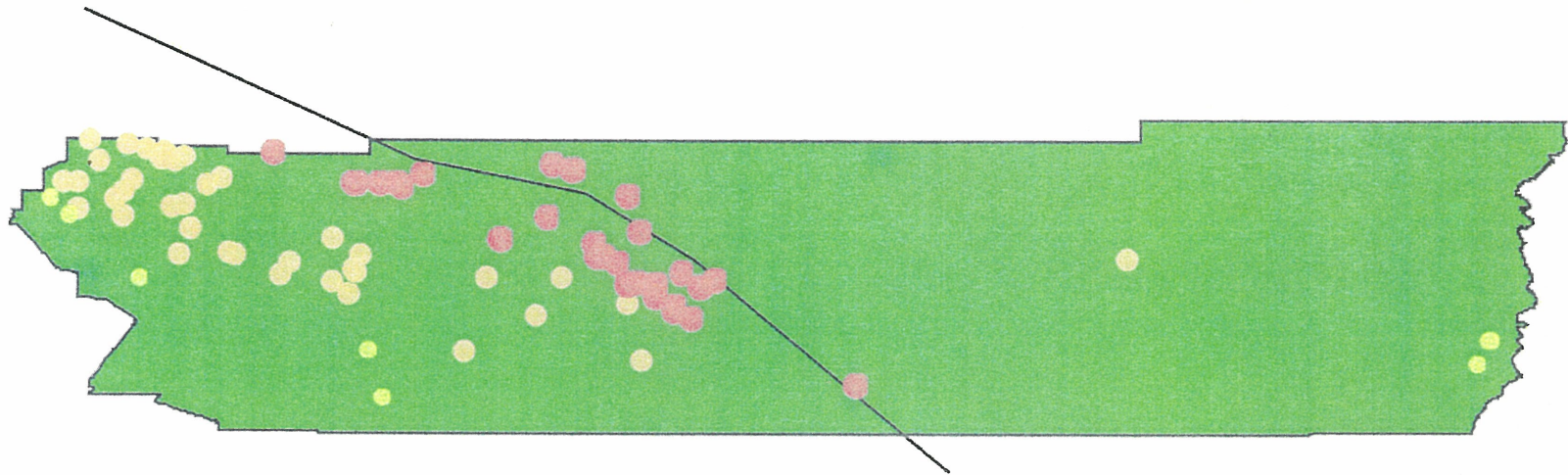
| Event | Location | Size | Description |
|-----------------------------------|---|--------------------|---|
| Maximum Credible Earthquake (MCE) | San Andreas fault | M _w 7.9 | Based on a rupture of the entire segment between Cajon Pass and the Salton Sea (probably the worst-case scenario for Riverside County, see Chapter 1) |
| Maximum Probable Earthquake (MPE) | San Jacinto fault, San Jacinto Valley segment | M _w 6.9 | Rated most likely fault segment in southern California to produce a large earthquake (44% probability in 30 years, see Chapter 1) |

A summary of loss estimation results is presented in Table 4-10. Note that Santa Ana wind conditions cause a substantial, 4- to 6-fold increase in losses. For each scenario earthquake, the relative likelihood of emergency response facilities to be exposed to at least moderate damage is illustrated on Figures 4-4 and 4-5.

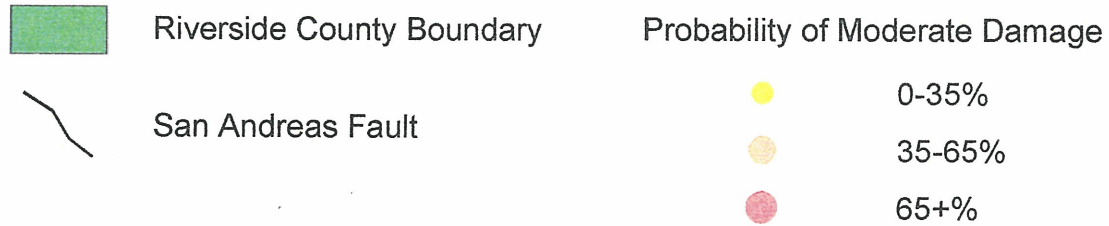
An estimate of County-wide fire station functionality is included in Table 4-10. Estimates for the functionality at each station in the HAZUS database are presented in Table 4-11. Here, functionality is based entirely on building damage due to estimated peak ground accelerations at each station. Note that the HAZUS loss estimation does not consider effects of reduced water pressure due to breaks in the water distribution system. These are expected to be widespread where ground failure occurs, such as due to fault rupture or liquefaction, and could further reduce functionality at some stations.

While the fire station database requires updating, the functionality estimates provide credible guidelines for response planning and exercises.

Probability (in %) of at least moderate damage as a result of a Mw 7.9 Southern San Andreas Earthquake



Map Explanation

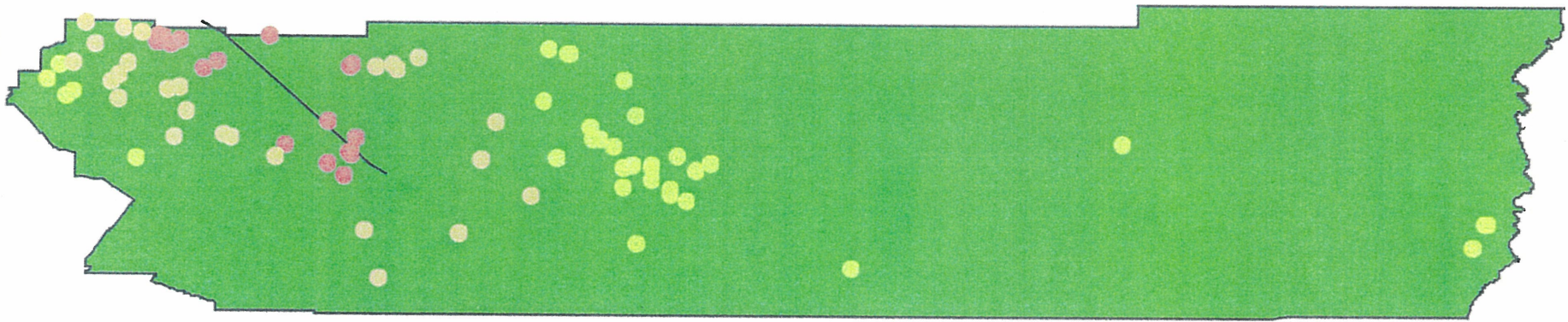


Natural Hazard Mapping, Analysis, and Mitigation: a Technical Background Report in Support of the Safety Element of the New Riverside County 2000 General Plan

Emergency Response Facility Damage Based on Mw 7.9 San Andreas Scenario Earthquake

Figure 4 - 4

Probability (in %) of moderate or greater damage as a result of a Mw 6.9 San Jacinto Valley Earthquake



Map Explanation



Riverside County Boundary



San Jacinto Valley Fault

Probability of Moderate or Greater Damage



0-13%



13-32%



32+%



Natural Hazard Mapping, Analysis, and Mitigation: a Technical Background Report in Support of the Safety Element of the New Riverside County 2000 General Plan

Emergency Response Facility Damage Based on Mw 6.9 San Jacinto Valley Scenario Earthquake

Figure 4 - 5

**Table 4-10: Earthquake Induced Fire Losses in Riverside County
HAZUS Scenario Earthquakes**

| Event | No. of Ignitions | Population Exposed (Wind Velocity of 10 mph) | Population Exposed (Wind Velocity of 30 mph, Santa Ana Conditions) | Value Exposed (Wind Velocity 10 mph) | Value Exposed (Wind Velocity 30 mph, Santa Ana Conditions) | Fire Station Functionality* |
|--|------------------|--|---|--|---|-----------------------------|
| Mw 7.9 San Andreas Earthquake | 74 | 832 | 3,663 | \$50,713,000 | \$209,658,000 | 25% |
| Mw 6.9 San Jacinto Earthquake | 43 | 358 | 2,225 | \$18,640,000 | \$116,238,000 | 44% |
| *: estimate of County-wide fire station functionality at 24 hours after earthquake | | | | | | |

**Table 4-11: Estimated Functionality (in percent)
of County Fire Response Facilities
Based on Scenario Earthquakes at One Day After Event**

| NAME/LOCATION | San Jacinto M _w 6.9 | San Andreas M _w 7.9 |
|--|-----------------------------------|-----------------------------------|
| ANZA VOLUNTEER FIRE & RESCUE, 56520 HWY 371 | 36 | 30 |
| BANNING FIRE DEPARTMENT ALTERN, 172 N MURRAY ST | 30 | 7 |
| BANNING FIRE DEPARTMENT BUSINE, 3900 W WILSON ST | 27 | 8 |
| BEAUMONT FIRE DEPT BUSINESS OF, 628 MAPLE AVE | 20 | 9 |
| BLYTHE FIRE DEPT, 201 N COMMERCIAL ST | 100 | 72 |
| BLYTHE FIRE DEPT BUSINESS CALL, 201 COMMERCIAL ST | 100 | 70 |
| CALIFORNIA OFFICE OF EMERGENCY, 2524 MULBERRY ST | 18 | 15 |
| CORONA FIRE DEPT BUSINESS | 63 | 39 |
| DESERT HOT SPRINGS FIRE DEPT B, 65958 PIERSON BLVD | 77 | 6 |
| FIRE DEPT, BLYTHE | 100 | 70 |
| FIRE SPRINKLER SERVICE CO, RIVERSIDE | 19 | 15 |
| HEMET FIRE DEPARTMENT, 220 N CARMALITA ST | 10 | 22 |
| HEMET FIRE DEPARTMENT, 220 N JUANITA ST | 10 | 22 |
| HIGHGROVE VOLUNTEER FIRE DEPT, 910 W CENTER | 19 | 15 |
| HOME GARDENS FIRE STATION, 1148 E 6TH ST, CORONA | 58 | 36 |
| IDYLLWILD FIRE DEPT, 54160 MARANATHA DR | 87 | 68 |
| INDIAN WELLS FIRE DEPT BUS CAL, 44950 EL DORADO DR | 84 | 7 |
| INDIO FIRE DEPT FIRE STATION N, 43715 JACKSON ST | 91 | 6 |
| INDIO FIRE DEPT FIRE STATION N, 46621 MADISON AVE | 90 | 6 |
| LA QUINTA FIRE DEPT BUSINESS C, AVE 52 | 87 | 9 |
| LA QUINTA FIRE DEPT BUSINESS C, PGA WEST | 88 | 9 |
| LAKE TAMARISK , 43880 LAKE TAM. DR, DESERT CENTER | 99 | 26 |
| MORONGO FIRE DEPT, 11581 POTRERO RD, BANNING | 40 | 6 |
| NORCO FIRE DEPT BUSINESS AND I, 3367 CORYDON AVE | 57 | 34 |

| | | |
|--|----|----|
| PALM DESERT FIRE DEPT, 44400 TOWN CENTER WAY | 80 | 8 |
| PINE COVE FIRE DEPT, 24419 HWY 243, IDYLLWILD | 31 | 14 |
| RIVERSIDE FIRE DEPARTMENT EMER, PERRIS | 45 | 33 |
| RIVERSIDE FIRE, 20320 TEMESCAL CANYON RD, CORONA | 62 | 43 |
| RIVERSIDE FIRE, CAJALCO FI, 17650 CAJALCO RD PERRIS | 33 | 26 |
| RIVERSIDE FIRE, EDGEMONT, 22055 COTTONWOOD AVE, MORENO VALLEY | 18 | 17 |
| RIVERSIDE FIRE, 4080 LEMON ST, RIVERSIDE | 21 | 17 |
| RIVERSIDE FIRE DEPT EMERGENCY, 3601-9TH, RIVERSIDE | 21 | 16 |
| RIVERSIDE FIRE, 132 S SN JACINTO AVE, SAN JACINTO | 8 | 18 |
| RIVERSIDE FIRE, 24220 JUNIPER FLATS RD, HOMELAND | 19 | 25 |
| RIVERSIDE FIRE DEPT, 24919 MARION RDGE DR, IDYLLWILD | 31 | 14 |
| RIVERSIDE FIRE DEPT, 25175 FAIRVW AVE, HEMET | 15 | 27 |
| RIVERSIDE FIRE, 25730 SULTANAS RD, HOMELAND | 25 | 29 |
| RIVERSIDE FIRE DEPT FIRE STNS, 25954 STANFRD, HEMET | 15 | 27 |
| RIVERSIDE FIRE, 36850 STETSON AVE, HEMET | 15 | 26 |
| RIVERSIDE FIRE DEPT FIRE STNS, 37381 SAGE RD HEMET | 27 | 38 |
| RIVERSIDE FIRE, 44422 SAGE RD, AGUANGA | 47 | 50 |
| RIVERSIDE FIRE DEPT FIRE STNS, 56560 HWY 371, ANZA | 36 | 30 |
| RIVERSIDE FIRE DEPT FIRE STNS, 59200 MORRIS RANCH RD, MOUNTAIN CENTER | 51 | 17 |
| RIVERSIDE FIRE DEPT GLEN AVON, 10400 SAN SEVAINE WAY, MIRA LOMA | 43 | 24 |
| RIVERSIDE FIRE DEPT LAKE HILLS, 17452 LAKEPOINTE DR | 47 | 30 |
| RIVERSIDE FIRE, 9270 LIMONITE AVE, MIRA LOMA | 41 | 25 |
| RIVERSIDE FIRE DEPT PERRIS HDQ, 210 W SAN JACINTO | 31 | 28 |
| RIVERSIDE FIRE, RUBIDOUX F, 3590 RUBIDOUX BLVD | 24 | 17 |
| RIVERSIDE FIRE, 23770 SUNNYMEAD, MORENO VALLEY | 14 | 15 |
| RIVERSIDE FIRE WEST RIVER, 7545 MISSION BLVD | 29 | 19 |

| | | |
|--|----|----|
| RIVERSIDE FIRE WOODCREST, 17800 VAN BUREN BLVD | 31 | 23 |
| SAN JACINTO FIRE DEPARTMENT BU, 160 W 6TH ST | 8 | 19 |

4.7 Postfire Effects

Wildfires leave problems behind. An intense wildfire may destroy all vegetation; also, the organic material in the soil may be burned away or decompose into water-repellent substances that prevent water from percolating into the soil. As a result, even normal rainfall can cause exceptional erosion or flooding from a burned area; heavy rain can produce destructive debris flows.

In 1997, wildfires charred many areas of southern California, leaving them bare before the next winter's heavy El Niño rainfall. Of the 25 large southern California wildfires, ten produced debris flows after the first major winter storm, and flooding plagued eight other areas. Only four burn areas showed little erosion or runoff. This study has compiled digital databases to depict the relative importance of topography, vegetation conditions, and geologic engineering properties. These should be used to help mitigate post-fire debris flow hazards.

Fires can also hurt watersheds of Riverside County. The loss of ground-surface cover and the chemical transformation of burned soils make watersheds more susceptible to erosion from rainstorms. Erosion in turn impairs water quality.

4.8 Fire Response Resources

Any discussion of fire hazard reduction hinges on the County's efforts to prevent fires and to suppress them once they have started. Fire-fighting readiness can be partially gauged by the following:

- **Minimum Safety Standards for Peak Load Water Supply, Road Width, and Turning Radius:** These function as safeguards to ensure public safety and prevent unsafe development. Peak load water supply standards ensure sufficient water flow is available to fight fires. Peak water flow requirements are based on building type, design, and use.
- **Planning:** The National Board of Fire Underwriters recommends a three-day emergency supply of water, while the Metropolitan Water District of Southern California recommends a seven-day emergency water supply.
- **Fire and Building Code Enforcement:** The County of Riverside presently administers the 1997 Uniform Fire Code (UFC) and Uniform Building Code (UBC); updated versions are adopted every three years. Some relevant fire safety code standards and programs include:
 - Section 8109.2 requires that buildings or structures more than three stories or 30 feet in height, or more than 15,000 square feet, shall be provided with an approved fully automatic sprinkler system. In addition, buildings or structures of more than 5,000 square feet to be used primarily for public assembly shall be provided with a fully automatic sprinkler system. Installation of sprinkler systems is also required in existing buildings where emergency access for fire apparatus or equipment is restricted. These requirements apply to existing as well as future developments.
 - New construction restrictions for Class B roofing materials. As defined in the Uniform Building Code, Class B roofs are pressure treated, wood-shake shingles. They are not as resistant to fire as Class A roofs, which include generally non-flammable products.

4.8.1 California Department of Forestry

The State agency with the greatest number of resources for firefighting capabilities is the California Department of Forestry and Fire Protection (CDF). CDF is primarily a wildland fire protection agency with the legal responsibility for protection

of approximately 33 million acres of private and State lands in California. The Riverside Ranger Unit of CDF (with headquarters in Perris) provides direct protection for 1,070,000 acres of "wildland." These vegetation-covered, watershed lands are designated by the State Board of Forestry as State Responsibility Areas. This is generally private land, outside of the cities and federal land where protection is at maximum strength during the declared "fire season".

The CDF has extensive ground forces, including a volunteer prisoner population, and an air force that includes: 15 Grumman S-2A 800 gallon airtankers, four S-2T 1200 gallon airtankers, two 2,000 gallon contract airtankers, 11 Super Huey Bell UH-1H helicopters, six O-2A air attack aircraft, 11 OV-10A air attack aircraft, and one C-26B fire mapping airplane. From 13 air attack and nine helitack bases located statewide, aircraft can reach any California fire within 20 minutes. The air attack planes fly overhead directing the airtankers and helicopters to critical areas of the fire for retardant and water drops. The retardant used to suppress fires is Di-Ammonium Phosphate + Iron Oxide which acts as a fertilizer as well as suppressant.

4.8.2 Riverside County Fire Department

The County of Riverside contracts with the State of California for fire protection. Public Resources Code (PRC) 4142 affords legal authority for the California Department of Forestry and Fire Protection to enter into agreements with local government entities to provide fire protection services with the approval of the Department of General Services. By virtue of this authority, CDF administers the Riverside County Fire Department.

The Riverside County Fire Department (RCOFD) provides fire suppression, emergency medical, rescue, and fire prevention services. It is one of the largest regional fire service organizations in California. The Department responded to 73,999 incidents during the 1998 calendar year. It is staffed with 696 career and 1,225 volunteer personnel, and currently serves approximately 800,000 residents in an area of 7,004 square miles. This service area consists of the unincorporated county areas and fifteen contract cities (Banning, Beaumont, Calimesa, Canyon Lake, Coachella, Desert Hot Springs, Lake Elsinore, Indian Wells, Indio, La Quinta, Moreno Valley, Palm Desert, Perris, Rancho Mirage, San Jacinto, and Temecula). The assessed value of real property in the area served exceeds \$40.8 billion.

The RCOFD operates out of fire department headquarters in the city of Perris. It is organized into two operational areas and six divisions, which currently contain

16 battalions and 85 fire stations. The equipment used by the department has the versatility to respond to both urban and wildland emergency conditions. The RCOFD inventory includes structural engines, brush engines, telesquirts, trucks, paramedic units, a helicopter, hazardous materials unit, incident command units, water tenders, fire crew vehicles, mobile communications centers, breathing support units, lighting units, power supply units, fire dozers, mobile training vans, and mobile emergency feeding units.

The RCOFD is the Operational Area Coordinator for the California Fire and Rescue Mutual Aid System for all fire service jurisdictions in the County of Riverside. It also has several mutual and automatic aid agreements with other city jurisdictions as well as the adjacent National Forests. The Operational Area is responsible for controlling and suppressing all unwanted fires in the department's jurisdiction. RCOFD/CDF personnel frequently respond to large-scale emergencies. Recent examples include the Landers, Loma Prieta and Northridge earthquakes, the Dunsmuir hazardous materials spill/train derailment at Lake Shasta, the 1997 and 1998 California Floods and the Oakland Hills, Yellowstone, and Yosemite fires. Response to large-scale emergencies or disasters is managed by twelve Major Incident Management Teams located throughout the state.

Riverside County Fire Department Responsibilities:

Fire Control: Due to increasing population the County Fire Department is faced with a growing structural fire problem, and it is one of the most active wildland fire counties in the state.

Air Attack Program: The CDF and the U.S. Forest Service (USFS) operate a joint air tanker base at the Hemet/Ryan Airport. Ryan Air Attack Base is statistically the most active in the nation, deploying one CDF, and two USFS air tankers. Two air coordination aircraft and one CDF helicopter are stationed at Ryan Air Attack Base.

Fire Protection-Planning and Engineering: Fire protection specialists review plans for all new developments, commercial and industrial buildings located within the contract cities and unincorporated areas of Riverside County. Requirements are established to provide a high degree of life safety and property protection. Common requirements include the installation of fire hydrants, sprinkler systems, early warning fire detection systems, and fire safety zones in remote areas.

Emergency Services: Disaster and recovery planning are the key elements. The Emergency Services Division maintains two underground Emergency Operation Centers with communications, for government use during major events.

4.9 Fire Safety

Individuals can make an enormous contribution to fire hazard reduction and need to be educated about their important role. Homeowners are generally especially easy to enlist.

4.9.1 Homeowners Checklist to Reduce Fire Risk

Design and install a firewise landscape. Be sure to consider:

- Local area fire history;
- Site location and overall terrain;
- Prevailing winds and seasonal weather;
- Property contours and boundaries;
- Native vegetation;
- Plant characteristics and placement (water and salt retention ability, aromatic oils, fuel load per area, and size);
- Irrigation requirements.

The primary goal of a fire-resistant landscape is fuel reduction. It helps to assign zones:

- **Zone 1:** This well-irrigated area encircles the structure for at least 30' on all sides, providing space for fire suppression equipment in the event of an emergency. Plantings should be limited to carefully spaced fire resistant species.
- **Zone 2:** Fire-resistant plant materials should be used here. Plants should be low-growing, and the irrigation system should extend into this section.
- **Zone 3:** Place low-growing plants and well-spaced trees in this area, remembering to keep the volume of vegetation (fuel) low.
- **Zone 4:** Furthest from the structure is a natural area. Thin vegetation selectively here, and remove highly flammable vegetation.

Always remember to:

- Leave a minimum of 30' around the house to accommodate fire equipment, if necessary.
- Carefully space the trees you plant.
- Take out the "ladder fuels" — vegetation that serves as a link between grass and tree tops. It can carry fire to a structure or from a structure to vegetation.
- Give yourself added protection with "fuel breaks" like driveways, gravel walkways, and lawns.

When maintaining a landscape:

- Keep trees and shrubs pruned. Prune all trees 6' to 10' from the ground.
- Remove leaf clutter, and dead and overhanging branches.
- Mow your lawn regularly.
- 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.
- Become familiar with local regulations regarding vegetative clearances, disposal of debris, and fire safety requirements for equipment.
- Follow manufacturers' instructions when using fertilizers and pesticides.

When building, selecting or maintaining a home, remember:

- Slope of terrain. Be sure to build on the most level portion of the land, since fire spreads rapidly, even on minor slopes.
- Ridges and cliffs. Keep a single-story structure at least 30 feet away from edges; increase distance if structure exceeds one story.
- Use construction materials that are fire-resistant or non-combustible whenever possible.
- For roof construction, recommended materials are Class-A asphalt shingles, slate or clay tile, metal, cement and concrete products, or terra-cotta tiles.
- Constructing a fire-resistant sub-roof can add protection, as well.
- On exterior wall cladding, fire-resistive materials such as stucco or masonry are much better than vinyl which can soften and melt.
- Consider size and materials for windows; smaller panes hold up better in their frames than larger ones; double-pane glass and tempered glass are more effective than single pane glass; plastic skylights can melt.
- Cover windows and skylights with non-flammable screening shutters.
- To prevent sparks from entering your home through vents, cover exterior attic and underfloor vents with wire mesh no larger than 1/8 of an inch.
- A driveway should provide easy access for fire engines, be at least 12 feet wide with a vertical clearance of 15 feet and a slope that is less than 12 percent. The driveway and access roads should be well-maintained, clearly marked, and include ample turnaround space near the house.
- 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 roof 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.
- Also, inspect your property, keep 30 feet around your house clear of dead and dense vegetation. Move firewood away from the house and its attachments, like fences or decks.
- 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 with high-moisture, non-flammable vegetation.
- Prevent combustible materials and debris from accumulating beneath patio deck or elevated porches. Screen, or box in, areas that lie below ground level with wire mesh no larger than 1/8 of an inch.
- 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. Consider a terrace instead.

4.10 Summary

Much of the County of Riverside is rated as a potential wildland fire area by the State of California Department of Forestry and Fire Prevention and this study. A significant portion of the County of Riverside is undeveloped and consists of rugged topography with potentially highly flammable indigenous vegetation. As a result, State and County Statutes apply to development and maintenance in these regions.

Fire potential for Riverside County is typically greatest in the months of August, September and October, while dry vegetation combined with offshore dry Santa Ana winds coexist.

The threat of earthquake induced fire is emphasized because widespread fires following an earthquake, coupled with Santa Ana winds, essentially constitute a worst-case fire suppression scenario for the County of Riverside. Despite the fact that the most common cause of urban and wildland fires is man, fire safety can be readily gauged using such a scenario as a standard.

Water availability in Riverside County following a major earthquake would likely be curtailed due to breaks in water lines across major fault systems, liquefiable regions or areas susceptible to landsliding. In addition, above ground reservoirs have been shown to be vulnerable in recent earthquakes, which would also impact fire flows.

Mobile home fires erupted at a greater rate (49.1 per thousand) than other structure fires (1.1 per thousand) as a result of the Northridge earthquake. Because the County of Riverside has a large number of mobile homes, earthquake induced fires may occur at a greater rate.

The hillside terrain of the County of Riverside is predominantly mapped as having a substantial fire risk. Therefore, much of the County of Riverside is subject to codes that requires property owners to conduct maintenance to reduce the fire danger.

Emergency water storage in the County will be more that doubled by the completion of the East Side Reservoir, south of Hemet. However, the County's aqueducts cross major fault systems at numerous locations, which will decrease the availability of new water following a major earthquake disaster. This and other reservoir projects are discussed in more detail within Chapter 3-Flood Hazards of this Technical Background Report.

Government Code Section 51178 specifies that the Director of the California Department of Forestry (CDF) shall identify areas in the state that are Very High Fire Hazard Severity Zones (VHFHSZ) utilizing consistent statewide criteria and based on the severity of fire

hazard that is expected to prevail in those areas. VHFHSZ are based on fuel loading, slope, fire weather, and other relevant factors. Riverside County, however, can change areas designated as VHFHSZ by the State, following a finding supported by substantial evidence.

General Conditions: During adoption of the 1997 Uniform Fire Code, the County of Riverside Board of Supervisors (1999) found that additional requirements and standards of fire hazard reduction were needed to properly protect the health, safety, and welfare of the existing and future residents and workers of Riverside County.

- **Climatic Conditions:** Generally Riverside County has an arid climate. Annual rainfall varies from three to over thirty inches. Hot, dry Santa Ana winds are common to areas within Riverside County. These winds constitute a contributing factor that cause small fires to spread quickly and create the need for an increased level of fire protection.
- **Geographic and Topographic:** Riverside County includes deserts, mountains, brush covered wildlands, and agricultural lands. Traffic and circulation congestion in urban areas and extreme travel distances in rural and wildland areas, often place Fire Department response time to emergencies at risk.
- **Earthquake Potential:** There are several major earthquake faults which bisect the County, including southern California's most active, the San Andreas and the San Jacinto.

Riverside County Fire Disasters: Gubernatorial Proclamations of a State of Emergency and Presidential Major Disaster Declarations affecting Riverside County have been declared on six occasions.

Development of a GIS Wildland Fire Susceptibility Map for Riverside County: As part of this study, a Geographic Information Systems coverage was developed for Riverside County that used vegetation, weather, slope and proximity to urbanization to estimate the relative susceptibility zones in a digital format. Roofing material restrictions can be assigned based on relative hazard. For example, "Type A" materials should be required in Very High, High and Moderate zones, while "Type B" materials can be required in Low, Very Low and None susceptibility zones. In addition, defense zones can be increased based on increasing fire hazard susceptibility.

Remote Sensing: Mapping wildland fire susceptibility using remote sensing techniques might assure objectivity and uniformity. This system could produce a much more accurate hazard assessment. The information could then be used by local agencies, perhaps with additional criteria, to produce hazard maps that are useful to individual jurisdictions.

Prefire Management

Over time, all California's wildlands *will* burn. However, various factors contribute to increased risks that fires will occur; that they will be larger, more intense and more damaging; that fighting them will cost more; and that they will take a higher toll (in economic and non-economic terms). The County's extreme diversity and complex pattern of land use and ownership require equally diverse and complex techniques to effectively manage the fire environment. Custom strategies for each situation can be created through combinations of prefire management, suppression, and postfire management. They should lessen the costly impacts of future wildfires and offer alternatives to continually increasing suppression forces.

Prescribed Fire: Prescribed fire is the term used for occasions when a fire is deliberately set, under carefully controlled and monitored conditions. The purpose is to remove brush and other undergrowth which can provide fuel for naturally occurring fires. Fire is an essential ecological process in many ecosystems. However, the recent experiences in New Mexico and Arizona with prescribed burns escaping and destroying several hundred homes in Los Alamos, New Mexico (Cerro Grande fire) and more than 50,000 acres, will likely lead to revisions of guidelines for performance of prescribed burns.

Real Estate Disclosure: Civil Code Section 1103(c)(6) requires real estate sellers to inform prospective buyers whether or not a property is located within a Wildland Fire Area that could contain substantial fire risks and hazards. The digital Wildfire Susceptibility Map developed for this study should replace the CDF mapping in providing for more accurate natural hazards disclosure in the County. The mapping associated with this study provides current and future buyers of real estate in the County an estimation of the wildland fire risk associated with the property. In addition, the entire County is covered by this mapping, rather than just the western portion.

Wildland/Urban Interface: The wildland/urban interface is more than a geographic area or zone where structures meet or intermingle with wildland fuels. It is a set of conditions where flammable structures exist within the reach of ignition sources, primarily firebrands, from burning wildland and structural fuels. The potential exists in areas of wildland/urban interface conditions for extremely dangerous and complex fire conditions which pose a tremendous threat to public and firefighter safety.

Santa Ana Winds: Named by the early settlers at Santa Ana, the "Santa Ana Winds" enhance the fire danger throughout southern California. Channeled by the many canyons in the Great Basin and getting stronger, the hot, intense and very dry winds break through and blow through southern California, especially through the mountain passes.

Hazardous Fire Area Designation: Based on drought and other conditions, it may become necessary to close an area to the public due to extreme fire hazard potential. The Riverside County Fire Chief is given the authority by the County Board of Supervisors to officially determine and publicly announce the closure of any hazardous fire area or portion thereof.

Hazard Abatement Notices: Each spring, the California Department of Forestry and Fire Protection (CDF) and Riverside County Fire Department distribute hazard abatement notices currently to about 30,000 County citizens. These notices request that property owners reduce the fuels around their property. Requirements for hazard reduction include a minimum of 30 foot clearance around all structures, which can be extended to 100 feet in areas where a severe fire hazards exist. On unimproved parcels the property owner is required to disc or mow 100 feet along the perimeter of the property.

Fire Response Resources

Riverside County Fire Department: The Riverside County Fire Department (RCOFD) is one of the largest regional fire service organizations in California. The Department is staffed with 696 career and 1,225 volunteer personnel, and currently serves approximately 800,000 residents in an area of 7,004 square miles. The assessed value of the real property in the area served is in excess of \$40.8 billion.

Postfire Effects

Fire and Debris Flows: Wildfires leave problems behind them, even when the last ember is extinguished. During an intense wildfire, all vegetation may be destroyed; also the organic material in the soil may be burned away or may decompose into water-repellent substances that prevent water from percolating into the soil. As a result, even normal rainfall may result in unusual erosion or flooding from a burned area; heavy rain can produce destructive debris flows. The relative importance of topography, vegetation conditions, and geologic engineering properties underlying the County of Riverside have been compiled into digital databases as a result of this study, and should be used to assist in the mitigation of post-fire debris flow hazards.

Effects of Fire on Watersheds: The watersheds of Riverside County may also be negatively affected by fire. The loss of ground-surface cover, and the chemical transformation of burned soils make watersheds more susceptible to erosion from rainstorms, and impairs water quality.

Earthquake-Induced Fires

An earthquake-induced fire and fire associated with Santa Ana winds pose the most extraordinary demands on fire suppression resources because of potential for multiple ignitions. Riverside County is susceptible to both phenomena.

Natural Gas Fires as a Result of the Northridge Earthquake: As a result of the 1994 M 6.7 Northridge earthquake, there were 35 breaks reported in natural gas transmission lines and 717 breaks in distribution lines. About 74% of the 752 leaks were corrosion related. There were a total of 15,021 natural gas leaks as a result of the Northridge earthquake. Natural gas leaks resulted in three street fires, 51 structure fires (23 were totally destroyed), and the fire destruction of 172 mobile homes. Many of the mobile home fires erupted when inadequate bracing permitted them to fall from foundations, severing gas lines and igniting fires. Because the County of Riverside has a large number of mobile homes, earthquake induced fires may occur at a greater rate.

Earthquake Scenario Loss Estimations: A HAZUS loss estimation was run based on two scenario earthquakes, including a major San Andreas (Mw 7.9) and a major San Jacinto (Mw 6.9) earthquake. In addition, two wind velocities were used for each scenario earthquake for the fire-following model. A velocity of 30 mph was assigned to evaluate fire spread as a result of Santa Ana wind conditions and a value of 10 mph was used to model the normal wind. A substantial (4 to 6 fold) increase in the losses associated with earthquake induced fire is noted for earthquakes during Santa Ana conditions. Although the database of fire stations used in the analyses clearly requires updating, the general functionality estimates provide credible guidelines for response planning and exercises.

4.11 Recommended Programs

The County of Riverside should:

- require property owners to conduct maintenance to reduce fire danger in accordance with the property owner's checklist presented herein. The single most important mitigation measure for a single-family residence is to maintain a fire safe landscape, thereby creating a defensible space around structures. The width of these defense zones should be increased based on relative wildland fire susceptibility, as digitally mapped for this study.
- support the new State-level shift in its vegetation management program. Emphases are on smaller projects closer to new developments, and alternatives to fire treatment, such as weed abatement using mechanical treatments.
- develop education and mitigation strategies that focus on enhanced hazard in the months of August, September and October, when dry vegetation and Santa Ana winds coexist.
- evaluate specific fire hazard areas and adopt reasonable safety standards, covering such elements as adequacy of nearby water supplies, routes or throughways for fire equipment, clarity of addresses and street signs, and maintenance.
- adopt ordinances to reduce the fire hazard using the model ordinance checklist presented herein.
- require staff, as well as elected officials, to conduct earthquake-induced fire scenario exercises based on this study's HAZUS loss estimates.
- require review of its above ground reservoirs for structural safety in an earthquake.
- conduct an inventory of its mobile homes and require mitigation consisting of seismic bracing of foundation supports, automatic gas shut-off valves and flexible utility connections, as well as an earthquake-induced fire hazard education program for tenants of mobile homes.

**Natural Hazard Mapping, Analysis, and Mitigation:
a Technical Background Report in Support of the Safety Element
of the New Riverside County 2000 General Plan**

CHAPTER 5: POLICIES

A government is tasked with the protection of the health, safety and welfare of its citizens. The Safety Element is integral to this mandate. Traditionally, governments have provided emergency response and post-disaster assistance after a natural event devastated its citizens. As the causes of these disasters became better understood, governments undertook efforts to protect citizens through construction efforts designed to overcome and defeat the natural phenomenon. Unfortunately, what government designs, nature can overcome, often leading to a disaster even worse than had the construction never been attempted. The most sustaining form of government intervention in hazard prevention is land use zoning and development restrictions. Each method has costs associated with it. Some costs are immediate, some are deferred. Government on behalf of its citizens, needs to make decisions on how to prioritize its resources to maximize return on protecting its citizens health, safety and welfare.

Planning and managing land use are essential to reduce the County's vulnerability to disasters. Land use planning enables Riverside County to analyze the suitability of land for development. This has also been known for a long time. In 1950, the Truman Administration developed flood mitigation recommendations that adjusted land use through zoning and other measures. Rather than trying to keep the flood out of people's way, the government would work to keep people out of the flood's way. It was simple to explain, but remains difficult to enact. For many reasons, from economic to aesthetic, hazardous areas have appeal. However desirable they may seem, though, policy makers and citizens must understand and accept the limitations of hazard-prone areas.

Flood control programs and methods are currently undergoing dramatic change. Softer, non-structural solutions utilizing flood plain management principles are replacing concrete-based structural measures of the past. But millions of citizens of Riverside County still rely on the existing flood control systems that have been constructed to ensure protection of their lives and property. However, environmental legislation that protects rare and endangered species will continue to make construction and maintenance of flood control structures difficult. In arid environments, twice as many species and about 250 percent more plant cover are associated with natural wash areas, compared with surrounding land.

A "Hazard-Prone Land Acquisition Program" may reduce the costs associated with hazards and mitigation, in addition, home buyers will often pay premiums to live near these open spaces.

5.1 STATE LAWS AND ADMINISTRATIVE GUIDELINES

A General Plan Safety Element provides a comprehensive local plan for mitigating the negative effects of earthquakes, landslides, fire, floods, tsunamis, toxic spills and other hazards. A Safety Element is one of seven mandatory elements in a General Plan, required by State law.

The County of Riverside is updating its Safety Element to reflect new knowledge and conditions. The updated Safety Element will enable the County to integrate the required subjects more completely, and thus provide a stronger base of public safety policy. Achieving a maximum degree of public safety is consistent with Riverside County's long-range vision for the future, represented by the General Plan as a whole.

5.1.1 Basic General Plan Law

Under California law, each city and county must prepare a comprehensive, long-range General Plan that serves as a guide to future development. The General Plan must include a Land Use Element that describes, in text and diagrams, the future distribution of land uses, population density and housing intensities. The General Plan must also include six other elements: Circulation, Housing, Conservation, Open Space, Noise and Safety.

All General Plan elements must be mutually consistent. As an example, if the Open Space Element designates land as a future nature preserve, the Land Use Element cannot designate it for high intensity commercial development. In addition, zoning must remain consistent with the General Plan. For instance, a county cannot adopt commercial zoning on land designated in the Land Use Element for single family homes, unless a General Plan amendment is adopted to redesignate the land. Therefore, recommendations associated with Safety Element hazard mitigation affect both land use and zoning.

A Safety Element can be broadly interpreted as:

- a statement of policy direction addressing the relationship between existing and potential hazards and future development;
- a source of guidance to other elements of the General Plan, most particularly the Land Use Element;
- a foundation for the legal reasoning behind zoning and other development regulations that are designed to constrain, mitigate or permit development because of existing or potential hazards; and,
- a database of geological conditions and associated hazard management zones within which mitigation policies are implemented.

5.1.2 Legislative Background

As presently written, Section 65302(g) of the Government Code requires a Safety Element to protect the community from unreasonable risks associated with the effects of seismic hazards, flooding and fire. The safety element must include maps of known seismic and other geologic hazards, such as seismically-induced surface rupture, ground shaking, ground failure, dam failure, slope instability and subsidence, as well as related phenomena such as tsunami, seiche, flooding, and wildland and urban fire hazards. It must address evacuation routes, peak load water supply requirements, and minimum road widths and clearances around structures, as those items relate to identified fire and geologic hazards. It also may address any other subjects that the local governing body considers pertinent to the physical development of the community.

First adopted by the California legislature in the early 1970s, General Plan Safety Element provisions originally addressed only earthquake-related hazards. Fire, flood and other geologic hazards were not considered. Because of similarity of subject matter among these issues, in 1984 the California legislature required that they be combined into a single element.

5.1.3 State Safety Element Review

Before initiating a review and revision of its Safety Element, a local jurisdiction must consult with the California Division of Mines and Geology of the Department of Conservation (Division), as well as the Office of Emergency Services, to see if these agencies request pertinent information. Although the law is not explicit on this point, it implies that if either agency requests information to be included in a local Safety Element, then the local jurisdiction must include it.

At least 45 days prior to adoption of a Safety Element, a local jurisdiction must submit a draft of the Safety Element or its amendment to the Division, which then has 30 days after receipt of the draft to report its findings to the local jurisdiction. Prior to final adoption of the revision, the local jurisdiction must consider the Division's findings. If the Division's comments are not available within those 30 days after receipt, the local jurisdiction may consider the Division's findings during future amendments to the Safety Element.

5.1.4 Safety Element Guidelines

In addition to the mandatory provisions of General Plan law, to which local governments must adhere, the Governor's Office of Planning and Research also issues advisory guidelines to assist localities in the preparation of General Plans. The General Plan Guidelines include a variety of ideas for data, analysis and policy development, including suggestions on how to interrelate the Safety Element with other General Plan elements and with development regulations.

The General Plan Guidelines stress the importance of the Safety Element in reducing death, injuries, property damage, and economic and social dislocation from natural hazards. It is identified as the principal vehicle for relating local safety planning to local government land use decisions. It first provides routine administration of regulatory decisions relating to zoning, conditional use permits, subdivisions and building permits. It also establishes the technical and policy base to support and justify potentially controversial mitigation measures such as adoption and enforcement of a seismic retrofit ordinance.

The Guidelines stress that Safety Element revision represents an opportunity to address other relevant safety issues, such as crime, vehicular accidents, power failures, storm drainage and hazardous waste storage and spills. Some local governments chose to incorporate hazardous materials management planning within the framework of their Safety Elements. Some counties and cities address issues such as waste minimization and recycling. This Safety Element does not address hazardous materials issues in a thorough manner.

Dozens of Federal and State laws related to public safety have some bearing on the preparation and administration of a Safety Element. However, only a handful directly relate to Safety Element content. These are summarized in the next two sections.

5.1.5 Related Federal Laws

Two important pieces of Federal legislation are relevant to local Safety Element preparation. Public Law 93-288, amended in 1988 as the Stafford Act, establishes basic rules for Federal disaster assistance and relief. The Earthquake Hazards Reduction Act of 1977, amended in 1990, establishes the National Earthquake Hazards Reduction Program (NEHRP).

Stafford Act. The Stafford Act requires that 15% of the total assistance dollars be spent on disaster mitigation—with the hope of reducing the costs associated with future disasters. The Stafford Act briefly mentions "construction and land use" as possible mitigation measures to be used after a disaster to forestall repetition of damage and destruction in subsequent events. However, the Federal Emergency Management Agency (FEMA) that implements Section 409 of the Stafford Act (44 CFR Part 206, Subparts M and N) require post-disaster, State and local hazard mitigation plans. Preparation of these plans is a prerequisite for local governments to receive disaster assistance funds to repair and restore damaged or destroyed public facilities. A county or city must adopt a hazard mitigation plan acceptable to FEMA if it is to receive facilities restoration assistance authorized under Section 409 of the Stafford Act. In recent disasters, FEMA has recognized Safety Elements of California local governments as fulfilling Section 409 hazard mitigation plan requirements.

National Earthquake Hazards Reduction Act. The National Earthquake Hazards Reduction Act exists to reduce seismic risks to life and property, through activities such as: hazard identification and vulnerability studies; development and dissemination of seismic design and construction standards; development of an earthquake forecasting capability; preparation of national, State and local plans for mitigation, preparedness and response; conduct of basic and applied research into causes and implications of earthquake hazards; and, education of the public about earthquakes. Much of the recent advancement in earthquake-related scientific and engineering understanding comes from NEHRP-funded research. Such knowledge can then be used to improve Safety Elements. For example, the NEHRP has funded studies of Riverside County fault systems and earthquake hazards.

An important direct outgrowth of the National Earthquake Hazards Reduction Act was establishment of the Southern California Earthquake Center (SCEC) through a consortium of universities and National Science Foundation grants. SCEC specifically funds research pertaining to seismic conditions in the southern California region and its research results have directly aided this update of the Riverside County Safety Element.

Earthquake hazard research and preparedness in southern California received substantial boosts after the 1994 Northridge earthquake. As a result of the Stafford Act, 15% of the total Federal aid of more than \$10 billion was spent on mitigation of future earthquake hazards. While Riverside County did not directly receive any of these mitigation funds, projects such as the TriNet network indirectly benefit Riverside County. TriNet is a collaborative project among the United States Geological Survey, California Division of Mines and Geology and the California

Institute of Technology to improve the real-time earthquake information system for southern California. TriNet incorporates new technologies to quickly provide vital, WEB-accessible information. Earthquake size, location, and maps of areas most likely to have sustained strong ground motion damage are available to emergency response personnel within minutes of an earthquake.

5.1.6 Related State Laws and Guidelines

At the state level, out of hundreds of safety related bills adopted over several decades, several stand out as relevant to Safety Element preparation.

The **Alquist-Priolo Earthquake Fault Zone Act** of 1971 requires the State Geologist to prepare maps showing study zones around active faults. Within Alquist-Priolo zones, local governments must require geological reports to be submitted for proposed development projects. The State must be provided copies of these geological reports. Note: When passed, the Alquist-Priolo Act was originally titled the Alquist-Priolo Special Study Zone Act. The name was later changed to the Alquist-Priolo Earthquake Fault Zone Act.

Seismic Hazards Mapping Act. A recent expansion of state legislation dealing with geological hazards is the Seismic Hazards Mapping Act of 1990 (S.B. 3897), which requires the State Division of Mines and Geology (DMG) to map areas with potential for strong ground shaking, liquefaction and seismically induced landslides. The DMG must also develop guidelines for the preparation of maps of seismic hazard zones. Within hazardous zones, as designated by DMG maps or guidelines, the Act mandates:

- submission of geotechnical reports for proposed development projects;
- adherence to State policy and criteria in determining appropriate hazard mitigation techniques or in waiving the requirement for geotechnical reports on individual projects;
- geotechnical reports and local actions in response to them must go through advisory review by the DMG.

No DMG mapping under the 1990 Act has yet been completed for Riverside County, nor is any funded in the near future (CDMG, 2000).

The California Earthquake Hazards Reduction Act of 1986 established the California Earthquake Hazards Reduction Program under the guidance of the Seismic Safety Commission. This umbrella program proposes overall policy and tracks progress in State earthquake hazard mitigation, preparedness, response and recovery programs geared to the objective of significantly reducing earthquake hazards in California by January 1, 2000.

The Building Earthquake Safety Act of 1986 requires all local governments to identify all potentially hazardous buildings within their jurisdictions and to establish a program for mitigation of identified hazards. It is the legislative basis for the inventory of hazardous unreinforced masonry buildings and Unreinforced Masonry Ordinances adopted by most counties and cities in California.

The Recovery (and) Reconstruction Act of 1986 authorizes local governments to prepare before a disaster for expeditious and orderly recovery and reconstruction afterward. It enables localities to prepare pre-disaster plans and ordinances which may include: an evaluation of the vulnerability of specific areas to damage from a potential disaster, streamlined procedures for appropriate modification of existing General Plans or zoning ordinances affecting vulnerable areas; a contingency plan of action; organization for post-disaster, short-term and long-term recovery and reconstruction; and, a pre-disaster ordinance to provide adequate local authorization for post-disaster activities.

Over time, this law will prove increasingly valuable, as more experience is gained in California from earthquakes and other major disasters. At present, only a few other jurisdictions are utilizing the provisions of this Act, including the cities of Los Angeles, Santa Monica and Whittier, as well as the counties of Los Angeles and San Bernardino. It is recommended that Riverside County prepare a recovery ordinance and adopt it in conjunction with this updated Safety Element.

Since 1979, Riverside County has had an ordinance (No. 538) that provides tax relief in disasters. If the damage to a property reduces its evaluation by more than \$5,000, the County Assessor will tax the property based on the lower evaluation. The County should update this ordinance to provide tax and permit fee exclusions for rehabilitation or mitigation work.

5.2 INSURANCE PROGRAMS

Natural hazard insurance and voluntary mitigation successfully reduces harm to homeowners in risk-prone regions, and significantly reduces the cost to society. Yet only a small percentage of homeowners in risk-prone regions purchase hazard insurance or adopt mitigation measures voluntarily, even though the insurance is often offered at rates below actual cost (Li, 1998). Few private insurance companies provide coverage for natural hazards as part of their regular homeowners' package. Hazard insurance is highly limited in coverage and variety even among the private insurers who underwrite such service. This absence of supply and demand for natural hazard insurance will impose heavy costs on Riverside County in future disasters.

After the 1994, magnitude 6.7 Northridge earthquake, property owners could not buy homeowners insurance, because the insurers no longer wanted to sell earthquake insurance. Back in 1986, the California Legislature passed a law requiring every insurer selling homeowners insurance to offer earthquake insurance. The homeowner did not have to buy it, but the insurance company did have to offer it. This law was passed because of a court case. Although a higher court eventually overruled the court case, the law is still in effect (Roth, 1998). The only way an insurer can legally avoid selling earthquake insurance is to not sell homeowner insurance.

Also after the 1994 Northridge earthquake, California companies raised deductibles from 10 to 15 percent, lowered coverage for residential earthquake insurance, and increased the cost of premiums dramatically. The number of earthquake insurance policy holders dropped from an estimated 1.68 million in 1994 to approximately 1.3 in 1996 (McCarthy and others, 1998).

Loss estimation has improved sufficiently in the past decade, however, that some insurance companies are today better able to distinguish the level of risk by geographic area. Computerized methods, including Geographic Information Systems (GIS), have made it possible for some of the more sophisticated companies to model and forecast potential losses, based upon information gathered and maintained about localized areas and the structures now being insured. (The Federal Emergency Management Agency (FEMA) has sponsored a similar loss estimation software, HAZUS, which is designed for use by local government and other disaster planning and mitigation agencies. HAZUS is used in this Technical Background Report.) As insurance company uncertainties diminish, so should their reluctance to provide hazard insurance.

5.2.1 Challenges Faced by Private Insurers

There are many reasons why private insurance companies dislike hazard insurance, including earthquake coverage. Because of the uncertainties surrounding hazard analyses, insurance companies have found it difficult to reasonably estimate what maximum loss they might incur by insuring against a catastrophic disaster. Therefore, they cannot be sure that they can remain in business after such an event, since claims payments plus operating costs could far exceed premiums collected. The difficulties facing private insurers are summarized below:

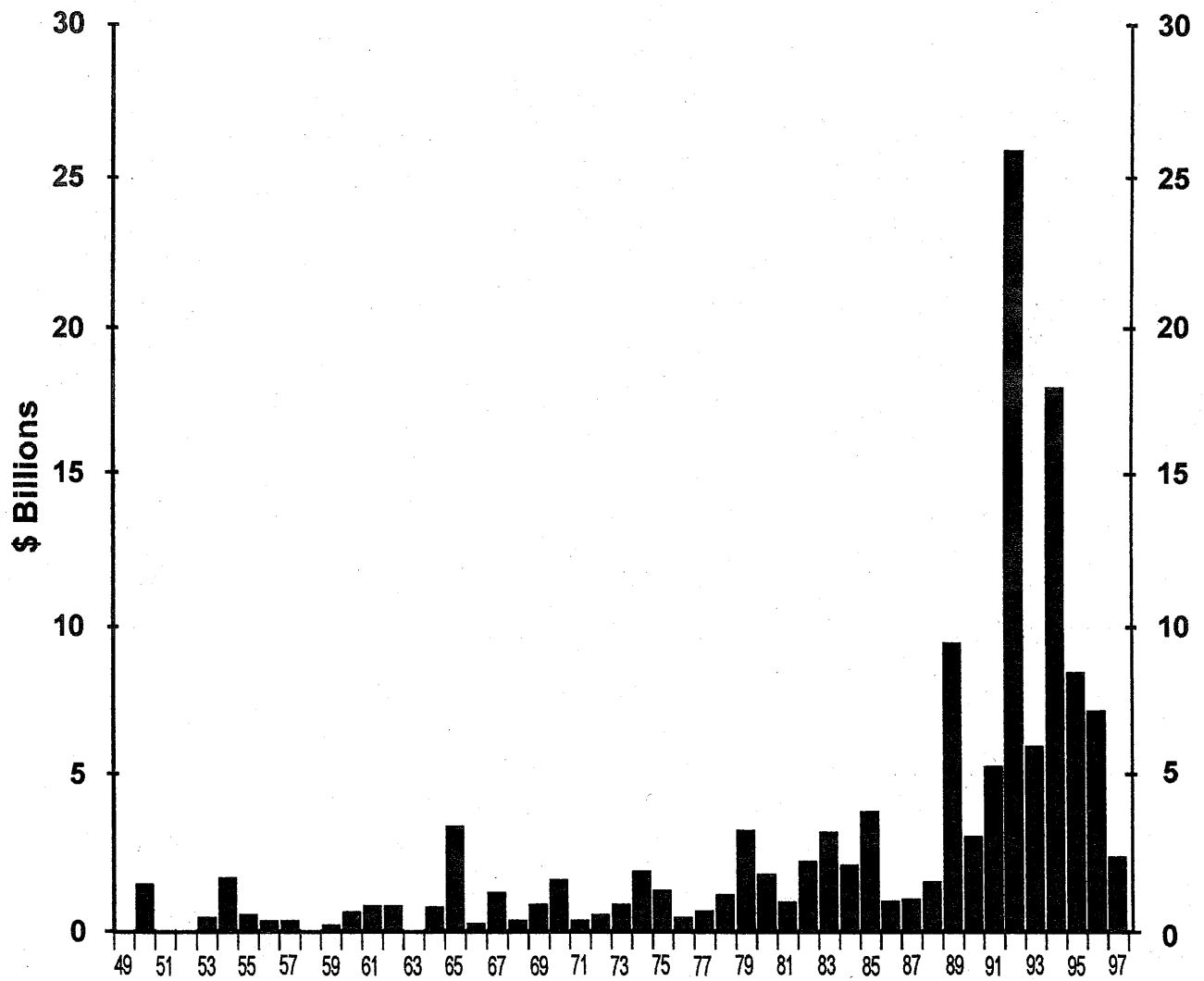
High Correlation of Claims from a Single Event - Because earthquakes are geographically focused events, when one occurs many claims are concentrated in a single area. Because losses from a single event can be tremendous, insurers are hesitant to offer many policies in an area facing the same hazard.

Low Probability/High Consequence Events - Major earthquakes seldom occur, but when they do, catastrophic consequences follow. Because of the limited data spanning a very short stretch of geologic time, scientific findings can be highly uncertain and ambiguous. For example, scientists forecast that there is a low probability that a catastrophic earthquake will occur in Riverside County. At some point it will definitely occur. However, no one can say if it will occur tomorrow, or in 50 years, or in 200 years.

Difficulty in Identifying What Losses May Occur - Although scientists are able to identify the probabilities of an earthquake occurring for a given location, and they can estimate the magnitude and duration of ground shaking, no one can accurately predict the damage to any specific neighborhood or given structure. Homes adjacent to each other can sustain substantially different damage from the same earthquake. Specific site conditions and construction standards can cause wide variations. The large number of variables involved makes it difficult and expensive to more accurately estimate losses.

Lack of Incentive to Take Preventative Action - Because hazard insurance reduces the cost of rebuilding after an earthquake, it makes the homeowner feel more secure and less interested in adopting mitigation measures. This helps to explain the lack of voluntary loss prevention measures among the insured. For instance, after purchasing earthquake insurance, the owner of a wood-frame home may never get around to bolting the home to its foundation, nor adequately brace the water heater.

Adverse Selection - Higher-risk consumers often purchase policies at premiums more appropriate for lower-risk consumers. In the case of earthquake insurance, higher risk is associated with unbolted foundations, unfastened water heaters, and unbraced chimneys. Insurers set a rate schedule to capture the varying risk among policyholders. However, they often fail to differentiate the premium schedule widely enough, due to regulatory controls or other reasons. Therefore, insurers will still incur losses because the premium differential fails to separate out high-risk consumers.



Source: Insurance Services Office



**Earth
Consultants
International**
Natural Hazard Mapping, Analysis, and
Mitigation: a Technical Background Report
in Support of the Safety Element of the New
Riverside County 2000 General Plan

**Insured Catastrophe Losses in the
United States from 1949 to 1997
in 1997 dollars**

**Figure
5 - 1**

5.2.2 Need for Government-Assisted Earthquake Insurance

After every major disaster, the problem of financing recovery and reconstruction emerges. As urban settlement has expanded, disasters have been experienced with increasing frequency and publicity. Figure 5-1 illustrates how rapidly insured catastrophe losses are increasing in the United States. Private and public sector organizations need to plan for such contingencies.

Yet disaster relief and recovery resources are not consistently adequate or timely. Federal and State disaster assistance covers only a portion of the losses encountered in major earthquakes. Sometimes it is not received until long after the critical needs for such assistance are experienced. Consequently, many households, businesses and industries are significantly disrupted and many smaller enterprises go out of business after a major disaster.

The optimum solution is to build communities of strength and wise location, that can withstand the worst damage caused by natural disasters. Gradually, this goal will be approached, as older cities are renewed with rebuilding and reinvestment; and as newer cities develop with better codes and land use practices. But, given the experience of hazard mitigation to date, the slowness with which older communities are mitigated, the evolving state of scientific knowledge, and incomplete Federal and State disaster assistance, additional sources of financial support for post-disaster recovery and reconstruction will be needed for the foreseeable future. One possible source is earthquake insurance.

Less than a third of all property owners in earthquake-prone areas are estimated to have earthquake insurance. Moreover, sophisticated new loss estimation technology cannot soften the nationwide impact of a catastrophic event. When a key urban economy is hurt, many others will also suffer. This is a widely-recognized problem. However, destruction anticipated in various catastrophic earthquake scenarios is so large and difficult to estimate that a national program to cover seismically induced losses has been slow to evolve and faces serious difficulties in enactment. Estimated losses from a catastrophic event have varied, but have been in the tens of billions of dollars.

5.2.3 Federal Earthquake Insurance Proposals

In recent years, the insurance industry has approached the Federal government to enact legislation requiring 100% mandatory coverage in all homeowner and commercial risk insurance, backed by a Federally-sponsored reinsurance pool, to which loans could be made by the Federal government to offset losses incurred in

a catastrophic event. Such loans would be paid back through future premium receipts.

Passage of such legislation has been stalled by disagreement over whether Federally-required earthquake insurance should be accompanied by hazard mitigation in high-risk areas, to reduce the potential magnitude of losses over time. Similar principles underlie the Federal flood insurance program that has been in place for nearly two decades. That program has identified high-risk areas by issuance of Flood Insurance Rate Maps. Where the maps indicate high flood hazard areas, cities and counties must require hazard mitigation in their planning and zoning practices.

The argument in favor of mandatory mitigation says, those who are outside high-risk areas should not have to absorb costs of losses which might be avoided through proper hazard mitigation. The counter argument is that mandatory mitigation would increase local development costs in many communities where earthquake losses may not occur during the lifetime of those developments. Although the debate about required mitigation is far from over, as the probabilities of a catastrophic earthquake disaster increase each year, so does expectation that a compromise will be worked out.

5.2.4 State Earthquake Insurance

In 1996, the State legislature authorized formation of the California Earthquake Authority (CEA) to provide protection for homeowners' property. Total funding is \$10.5 billion. Private insurers contribute up to \$6 billion and the remainder comes from the reinsurance industry and Berkshire Hathaway (Kunreuther, 1999). With creation of the CEA, rates were raised and deductibles increased from 10% to 15%. This means that a homeowner who purchases insurance on a house valued at \$200,000 would have to pay the first \$30,000 in repairs. Under the CEA, the demand for insurance has declined dramatically, probably in part because of these changes. Market penetration of the CEA is estimated at one-quarter to one-half of the level prior to 1996. This raises questions about the cost of the CEA reinsurance, as it was based on assumptions of greater insurance sales and risk. According to the CEA, only 17% of California homeowner's have earthquake insurance. Regardless, as shown by the loss estimations prepared in Chapter 1 of this Technical Background Report, and those prepared for other scenarios (Shah, 1994), \$10 billion coverage is inadequate.

5.2.5 Improvements Still Needed

Federal and State legislative trends toward establishing earthquake insurance programs hold out the promise of augmenting financial resources for disaster recovery. Such legislation could provide a valuable means by which to facilitate recovery and reconstruction. First, though, the efforts must be strengthened. There must be a pool of policyholders of adequate size to handle the problem of catastrophic losses; the pool must be expanded to include small businesses, and the programs must be directly or indirectly tied to structural retrofitting.

It benefits the County of Riverside to advocate strengthening of State and Federal earthquake insurance legislation. The County must understand that although California has in place a relatively comprehensive insurance plan, there must be Federal involvement to provide adequate catastrophic coverage. The County should track and seek passage of a version of the proposed Federal program, to be administered by the Federal Emergency Management Administration.

5.3 DISINCENTIVES TO UNSAFE DEVELOPMENT

In the past, development in hazardous areas occurred for economic or aesthetic reasons. For transportation, fishing and recreation, early settlements grew on oceanfront land susceptible to liquefaction or flooding. Many cities are built along waterways, and thus on flood plains. Residential developments cover faulted or geologically unstable hillsides where the views can be spectacular.

Sometimes, the hazards were known and ignored. In other instances, the historical record of disaster was fragmented or nonexistent, and the presence of the hazard was revealed long after initial settlement. In yet other cases, the hazard eluded understanding, such as variability of earthquake shaking intensity across different geographic locations. Sometimes an undiscovered hazard is belatedly, tragically revealed. A large number of reinforced masonry buildings failed during strong ground shaking in the 1933 Long Beach earthquake, which led to the first important seismic updating of the building codes.

Good progress has been made in regulating new development to withstand strong ground shaking. Progress has been much slower in mitigation of other natural hazards and in strengthening of older buildings constructed under less stringent standards.

As the threat of a catastrophic earthquake in southern California has become clearer, it is equally apparent that many communities need to accelerate mitigation of natural and structural hazards. This is more easily accomplished in relatively new, suburban communities where development frequently occurs on raw land. It is more desperately needed in existing communities where land use and construction decisions did not recognize the hazards at hand.

A public policy framework is needed that offers economic incentives for natural and structural hazard mitigation as well as disincentives to unsafe construction. Use of incentives and disincentives has grown in recent decades as scientific, engineering and public policy research have focused on better hazard mitigation and loss reduction techniques. The following discussion outlines a variety of regulatory and economic disincentives and incentives, some of which are in use, under consideration, or appropriate in Riverside County.

5.3.1 Seismic Design Codes

Within the framework of local government, disincentives are sometimes indirect, i.e., unmodified and implemented through written or unwritten policy. Yet most significant reduction of building damage and casualties in earthquakes comes from written and adopted building codes. A discussion of the improvements associated

with the 1997 Uniform Building Code (UBC) and the proposed 2000 International Building Code are presented in Chapter 1 of this Technical Background Report.

When the number of Northridge earthquake insurance claims were compared to ages of structures, there is less damage in structures governed by UBC improvements. For the UBC, 1940 and 1970 are benchmark years when code changes were implemented. Figure 5-2 illustrates these comparisons, from which several important observations can be made:

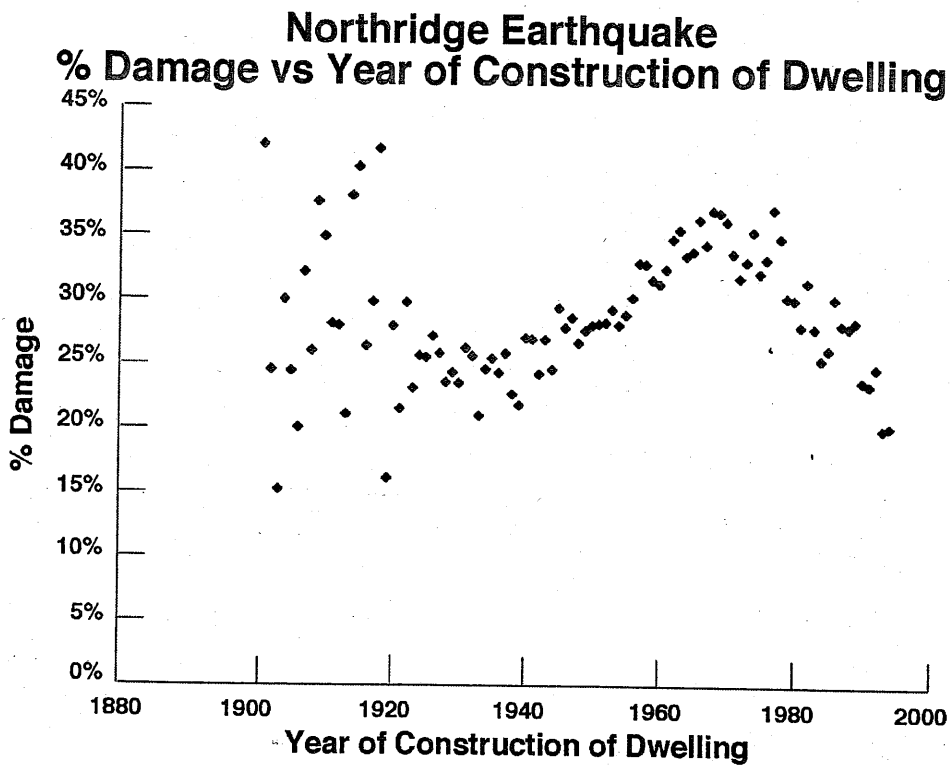


Figure 5-2: Insurance Claims versus Age of Structure as a Result of the 1994 Northridge Earthquake (modified from Roth, personal communication 1999).

Performance of pre-1940 buildings varies widely, from worst- to best-performing structures. This is likely related to a wide variation in construction quality, as well as the influence of other earthquake damage factors, such as ground motion variability.

Prior to 1971, a steady decrease in damage is observed with age. This is counter-intuitive, and may be attributable to changes in architectural home design such as cathedral ceilings and other features that performed more poorly in earthquakes and were more expensive to repair.

Consistently good performance is observed for structures that benefitted from the Code improvements of the early 1970s.

There is a time lag between code improvement and building performance improvement. Many projects are already planned or in progress when codes change, and are often exempted from the changes.

In matters involving public safety, disincentives tend to be regulatory to establish a legally defensible basis for substantial limitations on private activity. The most commonly disincentives to unsafe development practices are building codes, grading codes, soils analysis requirements and zoning restrictions.

The State of California has intervened in various aspects of seismic safety codes. Shortly after the Long Beach earthquake of 1933, the legislature passed the Riley Act, which established the first lateral force standards for structures, and the Field Act, which created structural standards for public schools. Subsequently, laws were passed requiring seismic design standards for dams, hospitals and other critical facilities. Hospitals (1972) addressed hospital seismic safety, Garrison (1969) mandated further seismic upgrade of public schools, and the Education Code (1986) required that new private schools meet seismic design regulations. In 1986, the State legislature enacted S.B. 547 requiring all local governments to inventory potentially unsafe buildings, establish a mitigation program and provide a copy to the Seismic Safety Commission. Because of the relatively small number of URMs in the unincorporated areas of Riverside County, the County has not addressed their mitigation through an ordinance.

To provide for minimum standards of safety in new development, about every four years the County has adopted updated versions of the Uniform Building Code (UBC), and has enforced the codes through the County Department of Building and Safety. UBC requirements set minimum standards for resistance to lateral force from ground shaking. In order to reduce their large inventories of URM buildings, cities like Long Beach and Los Angeles have adopted and implemented separate ordinances requiring structural strengthening through mandatory retrofit provisions.

The County of Riverside can do more. There are other buildings that also pose substantial risk, such as various older concrete buildings. The County should ensure that no structures will collapse in an earthquake. The County needs to

inventory unsafe buildings, and require seismic upgrading at reasonable junctures such as changes in occupancy. Notice of substandard condition should be recorded on titles of buildings not meeting the requirements of the State Riley Act, or other standards set by the County to determine potentially unsafe buildings.

5.3.2 Geological Hazards Mapping

Another disincentive to seismically unsafe construction lies with geologic hazards mapping, such as the Alquist-Priolo Earthquake Fault Zones along active faults. Zoning of active fault systems in Riverside County is described in Chapter 1 of this Technical Background Report and GIS mapping has been provided with this study.

Disincentives are also built into 1990's Seismic Hazards Mapping Act, which extends State intervention into areas of potential liquefaction, strong ground shaking and earthquake-induced landsliding. To date, no State mapping has been completed in Riverside County, which reflects realities of funding, not degree of hazard. This study provides detailed GIS mapping and hazard evaluation within the Technical Background Report.

Riverside County can continue to reduce hazards by refining these maps as new data become available. Several important ground motion studies are in progress in southern California, with results germane to Riverside County. Also, while it would be prohibitively expensive to go out and map the whole County at finer scale, required geotechnical reports can be compiled and used to improve zonation in portions of each map. The expense of these detailed studies, combined with the expense of mandated mitigation measures, might push new development into safer areas.

5.3.3 Density Restrictions

Using seismic, ground instability, flood and fire hazards maps provided in this Technical Background Report, restrictive changes can be made to zoning and General Plan land use designations to limit densities and land use intensities within hazardous areas. Such disincentives are more readily administered in communities having remaining vacant lands. Depending upon the nature of the policy adopted in the revised Safety Element, the County could choose to revise land use designations on the Land Use Element and modify zone boundaries to reflect new density restrictions.

These broad-brush General Plan and zoning restrictions are best used in combination with a more specific approach to require extra measures in overlay zones that delineate known or suspected geologic hazards. Developments within overlay zones must make geotechnical reports, which could lead to mitigation measures such as structural strengthening, special site preparation or site plan modification. Restriction of on-site density will also be justified in some cases.

5.3.4 Impact Fees

Overlay zones are based on best available information, and thus their boundaries will be adjusted with time. This raises questions about adjoining land. Should there be design or density restrictions on other nearby parcels? An equitable way to answer this and minimize the cost of geological investigation to get answers is for the County to sponsor such studies through collection of an impact fee.

The fee could be levied as a service charge on all properties within a given distance from an overlay zone. In this scenario, a geologic hazards assessment district would be formed around each overlay zone. Or, a fee could be exacted on proposed development within the defined, adjoining area. Separate developer fees may act as a disincentive to any development, leaving the exact nature of any geologic threat unresolved.

The principal constraint on use of impact fees is the statutory requirement that any fee collected have its basis in identifiable and justifiable local governmental costs. The County is prohibited from establishing a fee to serve only as a disincentive to development. It may create such fees only when a public service related to a legitimate public goal - in this case, safety - can be measurably identified and financially described.

5.3.5 Proposition 218

This measure was adopted in November 1996 and dramatically revised local government finance. Previously, local elected officials had the power to establish new revenue sources, in addition to use fees. Proposition 218 requires voter or property owner approval. It has replaced representative democracy in local government finance with direct democracy.

Proposition 218 affects most local government revenues, including garbage collection fees, fire assessments, and utility user taxes. The only local revenues not affected directly by Proposition 218 are: fees for local services not related to property, gas and electric charges, fees collected as a condition of property development, and intergovernmental transfers (Colantuono, 1997).

5.4 INCENTIVES FOR SAFER DEVELOPMENT

Various economic and administrative incentives for safer development have been employed by other communities to induce voluntary compliance with safety objectives and standards. In theory, economic incentives hold out the promise of allowing local jurisdictions to avoid increased regulation. In practice, they tend to be used in combination with regulation in a "carrot-and-stick" approach. The following sections describe standard approaches as well as some innovative techniques that might be useful but require further exploration. Ultimately it all comes down to how strongly Riverside County wants to build a safe community.

5.4.1 Project Impact: Building Disaster Resistant Communities

This nationwide FEMA initiative, Project Impact, operates on this common-sense damage-reduction approach, basing its work and planning on three simple principles: preventive actions must be decided at the local level; private sector participation is vital; and long-term efforts and investments in prevention measures are essential. FEMA partnered with seven pilot communities across the country and was encouraged by the benefits seen and the determined commitment that flourished at the local level. This has been a unique experiment: FEMA has offered expertise and technical assistance from the national and regional level and included other Federal agencies and states in the equation. FEMA has used all the available mechanisms to get the latest technology and mitigation practices into the hands of the local communities. Now, FEMA has nearly 200 Project Impact communities, as well as over 1,100 businesses that have joined on as Project Impact partners.

There is no doubt that Project Impact is a common sense approach for the way communities deal with disasters. The incentive is clear: a disaster resistant community is able to bounce back from a natural disaster with far less loss of property and consequently much less cost for repairs. Moreover, the time lost from productive activity is minimized for both businesses and their employees. Indeed, FEMA estimates that for every dollar spent in damage prevention, two are saved in repairs.

5.4.2 Retrofit Financing Incentives

Some jurisdictions have used Federal Community Development Block Grant (CDBG) funds to create loans for retrofitting URM buildings. Sometimes such loans are available in the form of gap financing, which supplements loans obtained from

commercial banks and extends the amortization period. Reduced rates on CDBG loans lower the overall cost of borrowing money and lower payments as well. Most important, the loans have a pay-back period of seven to ten years rather than two or three years, which can make a significant difference to building owners and tenants.

5.4.3 Assessment District Formation

A recent application of assessment district financing is exemplified by the formation of a district and issuance of a bond by the County of Long Beach in 1991. This was done to cover \$17.3 million in seismic upgrading to approximately 200 URM buildings. Retrofitting work was done by 1994, but assessment district payments are spread over 24 years, resulting in a low monthly cost. The program has been well-supported by property owners involved.

Another form of assessment district incentive is the Geologic Hazard Abatement Act. Adopted in 1979, this law spells out the procedures by which property owners may form a special assessment district to pay for abatement of a geologic hazard found on their properties. While there are a few successful applications of this law statewide, it has been difficult to implement due to stringent provisions and the emotion often encountered after property damage has occurred. The California Seismic Safety Commission is studying how to encourage property owners to apply in advance of damage.

5.4.4 Historic Preservation Incentives

Under the Mills Act, enacted by the State legislature in 1976 and amended in 1985, owners of historical properties can qualify for property tax relief by entering into a contract with a local government. Similar in many ways to the Williamson Act that is geared to agricultural land preservation, the Mills Act requires a mandatory ten-year contract. After one year, a notice of non-renewal provisions begins a nine-year phase-out of the contract. Mills Act contract procedures let the County choose which properties to include in the program and what seismic upgrading or other conditions to require, while at the same time providing property owners an incentive for offsetting retrofitting costs with property taxes saved.

5.4.5 Extended Nonconforming Rights

Some unsafe buildings also may be nonconforming to present zoning regarding

setbacks, height, parking or use. Repair and restoration of such buildings or uses following fire or earthquake can be tied to the owner's willingness to pursue seismic retrofitting. For example, where damage is less than 50% of replacement cost, nonconforming buildings or uses will be allowed to return to their "original condition" or "original state." However, where damage is beyond 50% of replacement costs, nonconforming buildings or uses must not be repaired or replaced. Such buildings and uses may also have set time limits for termination as a result of zone change. However, these provisions may serve as disincentives to reinvestment in older buildings and owners might be inclined to let them deteriorate or be demolished.

5.4.6 On-site Density Transfer Incentives

A commonly-used incentive for mitigating geologic hazards on individual project sites is density transfer. Where a site has known geologic hazards, General Plan and/or zoning densities are transferred from the part of the site with the hazard to the portions of the site where the hazard is minimally present or nonexistent. Density transfer is more difficult on smaller sites due to height and setback limitations, as well as more direct impacts on adjoining properties. However, provisions may be made in the zoning code for modification of height and setback provisions to enable density transfer, taking into account possible impacts on the neighborhood.

5.4.7 Transfer of Development Rights

Transfer of Development Rights (TDR) is a similar concept that extends the transfer incentive beyond property boundaries. With TDR, the unused increment of building bulk from a "donor" site is added to allowable maximum bulk at a "receiver" site, through County review of the transfer. The proceeds from purchase of the unused increment benefit the owner of the "donor" site, and the developer gains increased project value at the "receiver" site. The purchase transaction can be entirely private, regulated or public.

Because it is complex, difficult to administer and sometimes opposed by property owners neighboring the receiver, the TDR concept has not been widely used. However, it has been employed successfully in downtown Los Angeles, as a combined development and historic preservation incentive.

Certainly, Riverside County is an entirely different setting than downtown Los Angeles, yet the TDR concept might be useful, in three regards. First, TDR could provide unsafe building owners a source of income to offset costs of seismic upgrading. Second, it could be used to compensate property owners in geologically

hazardous areas for loss of future development potential. Third, TDR could provide an economic incentive for development in locations where it is desired, under terms defined by the County.

To implement TDR successfully, careful attention would need to be given to planning principles and procedures. The most common problems are to identify acceptable receiver areas and to create equitable standards for approval of transferred densities or floor area.

The principal drawback of TDR is that it is entirely market-dependent. Private sector interest is likely to wax and wane with economic fluctuations. Therefore, it cannot be applied as a single solution incentive.

5.4.8 Severe Development Restrictions

The most significant court challenge of development restrictions involved *Lucas vs. The State of California*. In 1986, The State of California attempted to improve public access and visitor appreciation of its beaches by prohibiting development within 40 feet of the farthest landward extent of the coastline, based on old coastal photographs. A developer, David Lucas, found his lots to be completely within the setback zone, and sued the State for compensation, alleging an illegal takings. After several years and appeals, the US Supreme Court eventually found for Mr. Lucas, and The State purchased the lots from him for \$1.5 million. While a loss to the environmental movement, a closer reading of the Supreme Court decision makes it apparent that the Court ruled strictly on the basis of economic issues. The State of California regulation was based on improving the tourism industry, not in improving public safety. Two aspects of the Court's decision are worthy of consideration in Riverside County. First, the Court differentiated between a taking that eliminated all value, versus regulations that only diminish value. Diminution does not necessarily require compensation. Second, the Court indicated that taking of a property to prevent harm does not require compensation. It is in the government's mission to protect the health, safety, and welfare of its citizens. Development prohibition based on natural hazards may be required under this mission.

While it is a difficult course to steer, there are a few steps to take to fall within the decision in the Lucas Case:

- do not eliminate all economic value of a property;
- identify other, more appropriate land uses based on public safety considerations;
- work with adjoining property owners to transfer development rights

- from impacted properties to less impacted properties;
- be prepared to defend a more public utilization of the property based also on public safety considerations; and,
- be very accurate and forth right with the basis for the hazard delineation

5.4.9 Property Acquisition

Perhaps one of the most far-reaching solutions to promote safer development is to prohibit development through public acquisition of unsafe properties. Parcels thus acquired could be turned to public uses that are more in harmony with the natural hazards inherent in the property. Open space and habitat protection are ideal uses for properties in high wildfire, floodplain, landslide, or active fault hazard zones. While initially more expensive, the costs associated with property acquisition will be less than the costs of the disaster after the natural hazard event occurs.

5.5 HAZARD INFORMATION MANAGEMENT SYSTEMS

Advances in electronic media and computer technology are revolutionizing the manner in which information is prepared and maintained in all walks of life, including business, industry, government and individual households. The public and private sectors now increasingly rely on automated data management for day-to-day operational needs. Computerized methods of information storage and retrieval, previously thought to be prohibitively expensive, are coming within range of local government budgets.

Automated information management has been shown to substantially increase productivity, efficiency and levels of service. Primary obstacles appear to be initial outlays for computer hardware, system design, data input and staff training. Once functioning and maintained, such systems can enhance the effectiveness of various organizations.

5.5.1 Geographic Information System

Among the advances in computer technology is the growing development of Geographic Information Systems (GIS) as a technical tool for planning, engineering, geology, emergency management and a variety of other disciplines upon which efficient government management relies. New GIS applications encompass a variety of purposes, from conversion of simple road maps and commercial atlases to demographic analyses that shape marketing and political redistricting decisions. Improved scanning of data from remote sensing and aerial photographic sources has increased efficiency of natural resource and land use mapping. Hardware diversification and software improvements have decreased dependence on mainframe computers. User-friendly software is opening up GIS applications to professionals and technicians in many fields, especially with the proliferation of personal computers.

The two great values of GIS development have been in improved mapping efficiency and flexibility, and in the new capability to link mapped data to statistical and written records. GIS enables users to quickly compare mapped features such as vegetation, topography, slope, soils, drainage, housing, land use, transportation and utilities to aid in planning, engineering, emergency management, environmental review and community development decision-making. It also allows for quantitative data to be generated from mapped features and vice versa. Once the data are entered, it is a matter of seconds to determine, for example, the number of day cares housed in URMs, or the locations of residences in high risk fire areas that have changed owners since the last fire, and thus are in most need of education about wildfire safety.

Traditional cartography is tied to tedious photographic methods of map scale modification, whereas GIS offers instantaneous portrayal of mapped features at variable scales. A tremendous amount of public domain data is available in GIS formats. Additionally, automated storage enables a variety of users, including the public, to quickly obtain desired information through computer video display terminals stationed at strategic locations such as public information counters, or through electronic transmission including modem access.

Also important is the relative ease of maintenance. Updates can be made in GIS databases at relatively low unit costs. This enables GIS users to track changing information about local conditions that may be of concern. With regard to public safety, GIS enables communities to accurately track progress on abatement of hazards and to shape policy direction for improvements in emergency management.

5.5.2 Riverside County's Land-Based Data Systems

Preparation of this Safety Element and Technical Background Report, we have developed a GIS for storage, management, and retrieval of data on natural hazards and other features important to planning, building, community development, engineering, police and fire functions. This GIS provides an excellent foundation for a digitally mapped emergency management database. Now is an excellent time to phase out the manual methods of information management.

The Riverside County Transportation and Land Management Agency (TLMA) is responsible for the County's Land Management System (LMS) and Geographic Information System (GIS). The Transportation and Land Management Agency consists of three departments: Building & Safety, Planning and Transportation.

At the core of the County's GIS is the parcel base that is used to reference property information. More than 400,000 Assessor Parcel Numbers (APNs) have been entered. The type of data that may be viewed from an internet browser associated with the APN includes: County Supervisor district and name, zoning, acreage, owner and mailing address, assessment and/or district information, legal description, sub-division and lot.

A primary purpose of the system is to develop a common mapping base, thus reducing duplication of labor in all county departments that produce maps. The County's map base is organized into five major libraries including: Book, Census, Quad, County, and Township. Each of these libraries contains multiple layers that include the graphic and attribute data necessary to create both reports and maps. For example, the Township library presently contains four active layers: Contour

(topography), Monument, Slope, and Survey (section, township, and range). Over 100 layers of information are available for County departments (Riverside County TLMA, 2000). Many applications have been developed from the common base including: community plans, special district mapping, transportation improvement plans, environmental mapping, and parcel information for research and public information.

The County TLMA also has online an Environmental Hazards Map, illustrating general fire, faulting, and liquefaction. The GIS data generated for preparation of this Safety Element provides an opportunity to update the hazards data for the County. In addition, the County could improve its interface, from a system where tax assessor parcel numbers are required, to a graphical interface. For example, Louisville, Kentucky (<http://www.lojic.org/ims/standard1024.html>) provides a graphical interface with hazard layers and progressively more detail as users zoom in to an area of interest.

For the most part, information on Riverside County's geography, topography, land use, utilities, emergency management and hazardous conditions (including structural, geologic, flood, fire and toxics) is developed and maintained in a variety of manual records. As is true in many, similar-sized communities, many County maps were prepared with painstaking, hand-drawn cartographic methods that relied on photographic enlargement, reduction and reproduction processes. Such maps cannot be generated from, nor directly correlated with, numerical databases or written records, or vice versa. Moreover, separately mapped features cannot be readily compared with each other without the use of clumsy plastic or vellum overlays.

5.5.3 Implementing an Emergency Management GIS

The County has a functioning GIS mapping system with relational databases. A variety land-based data files are in use, and are updated by this study. Now is the time to create an emergency management GIS.

Among the data layers prepared in conjunction with this Safety Element are a series of maps describing natural hazards. Hazardous conditions include fault zones, shaking intensity zones, areas susceptible to liquefaction, landslide and settlement areas, flood and wildland fire hazard areas. The HAZUS database utilized in the earthquake scenario loss estimations prepared for this Technical Background Report includes hazardous materials sites, bridges, dams, fire stations, police stations, Emergency Operation Centers, hospitals, as well as estimates about general building stock. This inventory can be overlain on ground shaking maps,

including TriNet (SHAKE) maps that are computer-generated based on instrumental recordings of southern California earthquakes. The County has the capability to conduct near-real-time loss estimation. This can be a great aid in distributing resources and responding to a disaster. To make and keep this capacity, the County GIS inventory must be kept current and an interface established with the near-real-time TriNet data.

If all these available data were integrated and used, the Safety Element database would be one of the most ambitious automated local government emergency management GIS programs in California, and would set a model for other jurisdictions to follow. As is true for all major undertakings, a great deal of investigation and analysis is needed to make this possibility a reality. Issues requiring attention include careful review of long-range system development priorities, future hardware and software enhancements, sequencing of data inputs, and a user-based review of database integration requirements.

5.5.4 User Responsive System Development

A common complaint about computer system applications is that they overlook specific user needs. Great effort has been expended in recent years to include users in the design of the database and other details of development and maintenance. This is a healthy trend that does not just apply to commercial software. As the County automates various Safety Element data layers and designs an emergency management GIS component, responding to ongoing user input will guarantee the most effective system.

To determine emergency management GIS system development priorities, it is important that developers and potential users consider both the worst-case, long-term disaster scenarios, for which the community will be conducting long-range mitigation, as well as short-term, critical data requirements which would be needed should a disaster occur tomorrow. For example, in a long-term scenario, the County might want to decide among retrofit compliance periods, say, three years versus seven, by analyzing inventories of unsafe structures in conjunction with geographic shaking intensity predictions to project the likely locations and degrees of loss associated with each time frame. A critical data requirement, on the other hand, might be the establishment of a basic street network layer, including vulnerable bridges, which would allow on-line routing of emergency vehicles and recording and updating of actual damage conditions during the critical hours following a disaster.

Such priorities cannot be determined by systems analysts alone, whether County staff or expert consultants. Some priorities will depend on the revised Safety

Element itself. All priorities must be examined with the full involvement of all departments that will use the emergency management GIS data. This should be done, even if it involves greater short-term costs, to enhance the system's credibility among prospective users, and, more importantly, because it will be more expensive later to face costs associated with loss of life or property damage and system revisions, should such critical priorities be overlooked now.

5.6 HAZARDS OVERLAY ZONES

Hazardous conditions vary greatly in character and geographic distribution. Structural hazards, such as URM buildings, may be scattered through a community or concentrated within a few blocks, depending upon historical building patterns. Flood hazards are often widespread. Fault rupture hazards are localized, while strong ground shaking potential may be extensive. Contamination from chemical spills can be highly localized, while releases of hazardous gases can affect entire neighborhoods. Sometimes, these hazard conditions are found in combination and may interact. For example, a hazardous spill can dump toxics into a river during a flood.

Whether separate or combined, such structural, geological and technological hazards all call for specific types of mitigation or abatement procedures. Mitigation measures required for one type of hazard may have no relation to those needed for another. Liquefaction potential might require special foundation treatment, but if the site is on a flood plain, perhaps the development should not occur at all.

Similarly, mitigation measures needed to abate a certain type of hazard might not be reasonable if applied on all properties throughout the jurisdiction. It would be impossible, for instance, to justify the cost of adding foundation requirements to offset liquefaction effects in areas not susceptible to that condition.

In a trend toward more sophisticated regulatory practice, many cities have adopted special hazard-specific regulations, in addition to normal zoning, building, and subdivision codes and ordinances. Special measures needed to mitigate a given hazard cannot help other hazards, cannot be required in situations where such hazards do not exist, and should not be imposed upon all properties in the jurisdiction. Specialized mitigation measures tailored to each hazard in each area, such as special site preparation, setbacks, site layout, or structural design, would be applied only to the locations described by overlay zone boundaries.

- Overlay zones applied to hazard zone mapping can reduce the hazard through several routes:
- Special investigation requirements that may lead to a recommendation of mitigation measures.
- Land use zoning policy recommendations. For example, no- or low-density land uses would be appropriate for fault special study zones, where building setbacks may have to be implemented.

- Real estate disclosure. Disclosure of potential hazardous conditions can be attached to the property title.
- Flexible means of amendment. Preliminary studies leading to the initial definition of boundaries can be supplemented over time as understanding grows.
- Contribution to the state of scientific knowledge. Studies required within overlay zones can help advance understanding of the hazard.
- Public education. Overlay zones flags conditions of which citizens should be aware for their own education, preparedness and well-being.

Adoption of overlay zones may require more planning and zoning guidance, additional staffing and sometimes, greater controversy. The alternative is to impose jurisdiction-wide mitigation standards that deal with specific hazards as they are encountered, case-by-case. The following discussion explores these alternative approaches.

5.6.1 Overlay Zones as a Planning Tool

Section 65852 of the California Government Code requires local jurisdictions to apply zoning so that it is "uniform for each class or kind of building or use of land throughout each zone." This means, for example, that an additional requirement to set-back a house from a fault surface rupture cannot be enforced unless the zoning ordinance specifically sets forth fault setback provisions applicable to any property in that zone facing such hazard.

The overlay zone concept has become popular among local governments seeking to regulate specific problems applicable only to certain portions of their jurisdiction. It enables a County to isolate an issue, such as the scenic quality of a road or neighborhood, and "overlay" regulations dealing specifically with that feature.

Precise provisions and boundaries of the overlay zone are adopted by ordinance after public hearings before the Planning Commission and County Council. Provisions may be geared toward aesthetics, urban design or public safety purposes, which are described in the ordinance.

Overlay zones allow a County to meet three fundamental objectives:

1. Create restrictions on development that are geared specifically toward solving a particular problem or protecting an identifiable and/or measurable resource;
2. Avoid placing unreasonable additional restrictions and costs on development of properties where the problem does not exist or the resource is not present;
3. Identify precisely, through a public review process, the applicability of additional development restrictions to specific parcels of land.

Although overlay zones add regulations and therefore additional complexity to the development process, they are simpler to deal with than across-the-board amendments to the zoning ordinance. In the latter approach, a host of special restrictions to the zoning ordinance are added to each applicable zone. It becomes the burden of the parcel developer to conduct a multiple-hazard assessment. This tends to create additional "shotgun" requirements on ill-defined problem areas. It also increases the possibility of the problem being overlooked in cases where zone boundaries are not precisely defined. Such oversights can be extremely costly and expose the County to legal liability if the problem arises later, or worse, results in injury or severe property damage. This has been the experience of some jurisdictions with landslides.

5.6.2 Hazards Management Zoning

The same principles and procedures used in adoption and application of other overlay zones can be extended for use in creating hazards management zones. Many jurisdictions have adopted overlay zones to manage specific types of hazards, such as fault surface rupture. For example, the County of San Bernardino has adopted and applied a Safety-Geologic (SG) overlay zone for active fault areas, defined as "those delineated on the Alquist-Priolo Earthquake Fault Zone Act maps or maps within the County General Plan." Special development standards applicable within that overlay zone include the mandatory minimum setback from the fault trace of fifty (50) feet for all structures used for human occupancy and one hundred fifty (150) feet for critical facilities.

5.6.3 State Seismic Overlay Zones

The Alquist-Priolo Earthquake Fault Zones Act maps have functioned as a de facto form of overlay zoning since the first maps were issued in 1973. Although the Act only applies to about 84 cities and 33 counties, or 23% of all local jurisdictions in the state, and to a small percentage of the state's total land area, it has kept structures off fault lines throughout the state.

State geologic hazards mapping was expanded as a result of the Seismic Hazards Mapping Act of 1990. The new hazard maps are to show strong ground shaking, liquefaction and seismically-induced landslide potential.

Because of the significantly greater land area covered by these hazards, many more cities will be affected. Over a period of time, State mapping will require a growing number of cities and counties to administer the provisions of the Act. For any project proposed within seismic hazards study zones boundaries, mapped on USGS quad sheets at a 1:24,000 scale, developers must submit geotechnical reports and local jurisdictions must review them. Localities wishing to waive the required geotechnical reports will have to justify such waivers to the State. The geotechnical reports must describe geology and soils conditions, and address mitigation measures that might appropriately handle the identified hazard.

The relatively small scale and generalized mapping will require local interpretation to determine the specific boundaries of the State seismic hazards zones, so that individual parcels of land can be determined to be included or excluded. Rather than attempt this case-by-case, local jurisdictions may prefer to adopt local overlay zones. These provide clear procedures for local interpretation. By delineating State-mapped hazard zone boundaries in relation to local land parcels, the requirements for geotechnical reports may be more efficiently administered.

5.6.4 Disadvantages of Local Safety Overlay Zoning

Adopting and applying overlay zones may generate controversy from the objections of property owners, builders and developers. Opposition may derive from many sources. Concern for short-term profitability rather than uncertain, long-term negative consequences; lack of confidence in scientific appraisals of hazard; or fear about potential devaluation value of the land may all contribute.

There will also be opposition to additional hazard mitigation costs. Short-term costs would be offset in the long-term by reduced losses in future disasters. However,

those bearing the short-term costs may not be the same people receiving long-term safety benefits. Adding to frustration are the uncertainty in scientific forecasting of disasters, imprecision of mapping many geologic features because precision requires costly site-specific investigation, and questions about the effectiveness of certain mitigation measures, usually due to incomplete data.

Using hazards management overlay zones could add additional cost of implementation. The most obvious costs would relate to processing new development applications in the overlay zones. Such costs could be passed along to the development through application processing fees, thus avoiding an additional cost to the general taxpayer.

Perhaps the toughest policy question is retroactive abatement of nonconforming buildings and uses. This issue would need careful consideration during the preparation and adoption of such an overlay zone. However, the hazard exists regardless. Having an overlay zone simply forces the community to decide on acceptable levels of risk *before* a disaster strikes.

5.7 RECOVERY AND RECONSTRUCTION

Need for Recovery Planning: After major disasters around the world, local governments have been beset with pressures to act quickly to put their communities back together and restore normalcy. Businesses and governments alike are generally unprepared to deal efficiently and wisely with the flood of decisions about how best to recover and reconstruct. Poor timing of disaster assistance leads to failure of businesses that might otherwise survive. Buildings are rebuilt in an unsafe way or in hazardous locations so that similar destruction is likely to reoccur.

Hard experience from recent California earthquakes has demonstrated the importance of preparing in advance of disaster for actions taken after. Local government has a major responsibility to prepare in advance to handle community recovery efficiently and wisely. Delays and confusion are caused by competing priorities for action and resources and can be diminished by planning. Management systems and policies must confront pre-event hazard mitigation as well as post-event short-term recovery and long-term reconstruction actions.

5.7.1 The Safety Element and Recovery Planning

As a comprehensive policy framework for community hazard reduction, the Safety Element provides an ideal foundation for pursuing recovery and reconstruction issues. Pre-event mitigation of structural and natural hazards directly reduces post-event expenditure of human and financial resources for emergency response, and then recovery and reconstruction. The State's General Plan Guidelines encourage local governments to include "contingency plans for immediate post-earthquake response and longer term reconstruction activities in areas potentially subject to significant damage." Moreover, incorporation of disaster recovery and reconstruction policies in local Safety Elements can help communities to see their critical importance.

It is necessary to face the reality that all known hazards will not be fully mitigated by the time disaster strikes. To the extent that a County has prepared itself to deal with the sudden onslaught of emergency, recovery and reconstruction requirements, it will be in a good position to facilitate restoration of normalcy. All levels and departments of County government must be willing to look beyond the more familiar emergency response functions to the less well-known recovery and rebuilding issues. There will probably be a need for staff guidance and training.

A Safety Element cannot fully equip a community to perform well in recovery from a real disaster. That requires more in-depth planning and a comprehensive study

of real disaster recovery experiences, worldwide. A Safety Element can set the stage and provide the informational and policy foundation for more detailed recovery and reconstruction planning and training. A Safety Element can also assign post-event recovery and reconstruction organization and duties.

5.7.2 Status of Recovery Planning in Riverside County

In recent years, the County of Riverside has expanded its emergency preparedness planning. The County is required under State law to prepare and maintain a Standardized Emergency Management System (SEMS) Multihazard Functional Plan. The California Governor's Office of Emergency Services (OES, 1999) has extensive guidelines outlining the requirements of the County SEMS. These guidelines establish policies and procedures and assigns responsibilities to ensure the effective management of emergency operations under the SEMS. Effective management depends on the emergency management structure and how the emergency management team is activated.

The SEMS does not address long-range recovery planning issues.

5.7.3 Recovery Planning Issues

Among the many, specialized post-event issues and operations that must be considered are recovery organization, extraordinary powers, temporary and replacement housing, business and industrial resumption, fiscal reserves, Federal and State disaster assistance, damage assessment, hazards evaluation, expedited permit processing for repairs, nonconforming rights, illegal uses, moratorium procedures, handling of damaged historical buildings, restoration of infrastructure, rebuilding plans, redevelopment procedures, General Plan revisions, public review, and return to standard operating procedures.

Few of these issues are recognized in the standard operational guidance and training provided by State and Federal emergency agencies. Most such training deals with recovery operations in the first weeks or months after a disaster. Complete recovery and reconstruction planning, however, must anticipate issues and decisions for years after the event. For example, although pre-event hazard identification such as the Safety Element mapping can help local jurisdictions anticipate probable damage patterns, no one really knows the actual damage until the event happens. Thus, the exact geographic distribution of repair and rebuilding needs cannot be foreseen. However, the general character, magnitude and probable distribution can be anticipated, which enhances the community's response.

In Riverside County, it can be anticipated that a major earthquake would produce severe damage in areas of liquefiable sediments topped by high-population-density buildings constructed of older, inadequate design (such as URMs, tilt-up concrete wall, nonductile concrete frame or soft story construction). While we cannot predict which ground will liquefy, nor which particular buildings will fail catastrophically, we can guarantee that evacuation and reoccupancy of such buildings are issues that will arise.

During the short-term recovery period, which can last up to two years, decisions would have to be made about demolition vs. repair and the financing found to do either. As was the case with the community of Santa Cruz, which was heavily damaged by the 1989 Loma Prieta earthquake, discussions will be heated when considering demolition or repair of buildings of historic value. Equally as difficult is branding whole neighborhoods as too damaged to repair. Restoration of infrastructure can also be a long-term concern.

Long-term reconstruction issues emerge early in the short-term recovery period, but characteristically continue for several years. In a heavily-damaged community, major rebuilding can last up to ten years. During such periods, County personnel and leadership will see greater than normal job turn-over, accelerated by the early and sustained stress of recovery decisions. In Santa Rosa, after a major earthquake in the 1960's that leveled 20 blocks in the downtown area, a number of top officials took early retirement and, in a few cases, were reported to have died from the stress. Santa Rosa ultimately rebuilt a better downtown area, but property owner lawsuits took years to settle.

For all of these things, a community can prepare. But such preparation requires commitment at the policy level to undertake such substantial pre-event planning effort. The new Riverside County Safety Element provides the policy framework for the initiation of such an undertaking.

5.7.4 Recovery Ordinance as a First Step

The California Disaster Recovery (and) Reconstruction Act of 1986 authorizes local governments to plan, organize and prepare in advance for speedy recovery and reconstruction after a disaster. Among the activities authorized is the pre-event adoption of an ordinance, to be activated with the declaration of emergency, which clearly spells out the recovery organization and the duties and responsibilities of its member departments and officials.

Such an ordinance can be extremely useful in organizing recovery efforts. It saves

time when time is at a premium, makes plans at a time when thinking is clearer, and provides a stronger legal basis for potentially controversial post-event decisions. The ordinance can dictate authorities and powers of different County officers, distribution of responsibility and accountability, authorization of extraordinary procedures for streamlining repair permit issuance and simplifying public notice, interim joint powers and contract procedures, criteria for establishing building moratoria, standards for expedited repair permit processing, criteria for restoration of standard operating procedures, and organization for planning and implementation of long-term reconstruction and redevelopment programs.

The new Safety Element should be accompanied by such an ordinance, for consideration by the County Board of Supervisors. This ordinance should structure the framework of a recovery and reconstruction planning effort as well as all post-event organization and duties that can be anticipated. There will still be many long hours required to work out and maintain a detailed recovery and reconstruction plan. The ordinance provides a springboard to a comprehensive emergency and disaster management strategy.

5.8 Summary

- Riverside County must adopt a hazard mitigation plan acceptable to the Federal Emergency Management Agency (FEMA) if it is to receive facilities restoration assistance authorized under Section 409 of the Stafford Act. In recent disasters, FEMA has recognized Safety Elements of California local governments as fulfilling Section 409 hazard mitigation plan requirements.
- Natural disasters are currently under-insured, and government assistance is incomplete. Insurers face many uncertainties with natural hazards coverage and have been resistant to supplying it. Instead, they have lobbied the government to create a Federally-sponsored reinsurance pool for earthquakes, to spread earthquake disaster costs over more manageable lengths of time and payees.
- The County has available a range of disincentives to unsafe development and incentives to mitigate natural and structural hazards. The choice of particular disincentives and incentives will depend on the direction and character of public safety policies adopted in the Safety Element. The most effective approach will probably be to use several in concert. Each has relative advantages and disadvantages, which must be weighed before implementation of them as a package.
- Digitized in an integrated GIS database, Safety Element hazard data provide a mechanism to: 1) present selected information at a variety of scales and formats; 2) facilitate availability of identical databases to all interested agencies, from a planning agency issuing permits, to a fire department accessing hazardous materials business emergency plans; 3) simplify update of the database with new information, such as newly identified or mitigated hazardous buildings, changes in occupancy of dependent facilities, or current river levels; and, 4) create an interactive, on-line emergency management GIS for use in disaster preparedness, response, recovery and reconstruction.
- An emergency management GIS system will be most useful to the widest array of County and other users if users are fully consulted in the system's formation and prioritization. This system can be further enhanced by data sharing and database development with regional entities, other local governments, and private organizations such as utilities. This will minimize costs and accelerate GIS development.

- Hazard overlay zones can be controversial but are a proven method of isolating and systematically dealing with problem areas. When evaluated from the standpoint of their prime purpose -- enhancement of public safety -- they provide a reasonable and equitable means of creating safer development and reducing hazards. Their prospective application and utility in Riverside County will be dependent upon the general thrust and character of policy in the revised Safety Element. Like all mitigation techniques, overlay zones are not perfect nor all-encompassing. They should be viewed as one in a group of useful hazard reduction tools, which together can strengthen safety and reduce the chance of unnecessary loss of life and property.
- Pre-event planning for post-disaster recovery and reconstruction is strongly advised. Emergency and disaster management literature, reflecting the experiences of communities around the world, demonstrate common patterns of recovery activity that can be fashioned into preventative planning. In preparing a Safety Element for adoption, Riverside County is well positioned to shape the overall directions of future recovery planning and action. A Recovery and Reconstruction Ordinance would be a solid step toward a comprehensive disaster preparedness, response and recovery program.

**APPENDIX A
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APPENDIX B GLOSSARY

100-year Flood Event- A flood that has a 1/100 chance of occurring in any one year, and a 26% chance of occurring during a typical 30 year home mortgage.

500-year Flood Event- A flood that has a 0.2 percent annual chance of occurring in any one year.

Abatement- Reduction or elimination of a hazardous condition, including but not limited to strengthening, occupancy restrictions, or demolition.

Acre- A measure of land area in the United States and England containing 43,560 square feet.

Active Fault- For implementation of Alquist-Priolo Earthquake Fault Zoning Act (APEFZA) requirements, an active fault is one that shows evidence of, or is suspected of having experienced surface displacement (relative movement of the two sides of a fault) within the last 11,000 years. APEFZA classification is designed for land use management of surface rupture hazards. A more general definition (National Academy of Science, 1988, states "a fault that on the basis of historical, seismological, or geological evidence has the finite probability of producing an earthquake" (see potentially active fault).

AEG- Association of Engineering Geologists. www.aegweb.org

Aftershocks- Smaller earthquakes following a greater one and originating at or near the same place; Frequency of aftershocks decreases with time.

Air Attack Program- The California Department of Fire (CDF) and the U.S. Forest Service (USFS) operate a joint air tanker base.

Alluvial Fan- An outspread, gently sloping mass of poorly compacted gravels, sand, silts, and clays deposited by a stream, especially in an arid or semiarid region where a stream issues from a narrow long, deep, steep-sided valley onto a plain or valley floor. Viewed from above it has a shape of an open fan, the apex or highest point being the valley mouth.

Alluvium- Surficial sediments of poorly consolidated gravels, sand, silts, and clays deposited by flowing water.

Alquist-Priolo Special Studies Zone Act (APSSZ)- The Alquist-Priolo Special Studies Zones Act was signed into law in 1972 (in 1994 it was renamed the Alquist-Priolo Earthquake Fault Zoning Act). The primary purpose of the Act is to mitigate the hazard of fault rupture by prohibiting the location of structures for human occupancy across the trace of an active fault (Hart and Bryant, 1997). The Act requires the State Geologist (Chief of the Division of Mines and Geology) to delineate "Earthquake Fault Zones" along faults which are "sufficiently active" and "well-defined." These faults show evidence of Holocene surface displacement along one or more of their segments (sufficiently active) and are clearly detectable by a trained geologist as a physical feature at or just below the ground surface (well defined). The boundary of an "Earthquake Fault Zone" is generally about 500 feet from major active faults, and 200 to 300 feet from well-defined minor faults. The Act dictates that cities and counties withhold development permits for sites within an Earthquake Fault Zone within their jurisdiction until geologic investigations demonstrate that the sites are not threatened by surface displacements from future faulting (Hart and Bryant, 1997). The Act addresses the hazard of surface fault rupture and is not directed toward other earthquake hazards, such as ground shaking or liquefaction.

fault rupture and is not directed toward other earthquake hazards, such as ground shaking or liquefaction.

Angle of Repose- The maximum slope or angle at which loose, cohesionless material remains stable. It commonly ranges between 33° and 37° on natural slopes (hillsides).

APEFZA- Alquist-Priolo Earthquake Fault Zoning Act. The new name for Alquist-Priolo Special Studies Zone Act (APSSZ).

APN- Assessor Parcel Numbers.

APSSZ- Alquist-Priolo Special Studies Zone Act.

Assessor Parcel Numbers (APN)- The type of data that may be viewed from an internet browser associated with the APN includes: County Supervisor district and name, zoning, acreage, owner and mailing address, assessment and/or district information, legal description, sub-division and lot.

Aquifer- Any water bearing formation; A geologic formation which contains sufficient saturated permeable material to yield significant quantities of ground water to a spring or well.

Arid- Climate characterized by dryness; Defined as rainfall insufficient for plant life or for crops without supplying water by means of ditches, pipes or streams; Less than 25 cm of annual rainfall; or a higher vapor) rate than precipitation rate.

Aseismic Region- Said of an area that is not subject to earthquakes; Where no or only very low seismic activity has been registered, with the exception of some intraplate (mid-continent) earthquakes.

ASTM- American Society of Testing and Materials. www.astm.org

Atmosphere- The mixture of gases that surround the Earth: chiefly oxygen and nitrogen, with some argon and carbon dioxide and minute quantities of helium, krypton, neon, and xenon.

Basement Rock- Undifferentiated rocks, commonly igneous and metamorphic of Precambrian age or younger that underlie the rocks of interest, commonly sedimentary, in a given area.

Basin- A depressed area with no surface outlet. The term is applied to a lake basin, to a ground water basin, or to a shallow depression on the sea floor; The drainage area of a stream; A low area in the earth's crust, of tectonic origin, in which sediments have accumulated. Such features were drainage basins at the time of sediment accumulation but are not necessarily so today.

Bates Bill Process- The Legislation is utilized to determine Very High Fire Hazard Severity Zones (VHFHSZs) in Local Responsibility Areas (LRAs). The legislation was a direct result of the great loss of homes and lives in the Tunnel Fire of 1991 in the Oakland/Berkeley Hills. The California Department of Forestry and Fire Prevention (CDF), was given the responsibility but not the resources to carry out the state instruction, which included mapping of Very High Fire Hazard Severity Zones (VHFHSZs). The CDF formed a working group to determine how to proceed. The group, comprised of state and local representatives, decided upon a workable system involving fuel, topography (slope), weather, and dwelling density (definition below) as the foundation for the system, and added additional mitigation factors both plus and minus to adjust the score upward or downward. The basic system has a four-point minimum score with a thirteen-point maximum.

Becker Hammer System- Quantitative (susceptible of measurement) evaluation using a very large scale; of liquefaction resistance of sandy, silty and some gravelly soils based on in-situ penetration resistance.

Bedding- The arrangement of a sedimentary rock in beds or layers of varying thickness and character.

Bedding Plane- The division plane in sedimentary or stratified (deposits in layers) rocks, that separates each successive layer or bed from the one above or below. It commonly marks a visible change in the physical character of the rock or its color; A term commonly applied to a plane of discontinuity (interruption in sediment accumulation) along which a rock tends to split or break readily.

Bedrock- The solid rock that lies beneath soil and other loose surface materials; Designates hard rock that is in its natural intact position and underlies soil or other unconsolidated (loose) surficial material (deposits on earth's surface other than bedrock e.g. alluvial).

Bench- Modification of the natural landscape that refers to a relatively level step excavated into earth material on which man-made deposits of natural earth materials and waste materials (fill) is to be placed.

Biomass- The amount of any living plant or animal (organism) in a particular area, stated in terms of the weight or volume of organisms per unit area or of the volume of the environment.

Blind Thrust Fault- A thrust fault is a low-angle reverse fault (top block pushed over bottom block). A "blind" thrust fault refers to one that does not reach the surface.

BLM- Bureau of Land Management. www.blm.gov

Borehole (boring)- A circular hole made by drilling by the rotary motion of a cutting tool; A deep vertical hole of a small diameter, such as a shaft, a well, or a hole made to ascertain the nature of the underlying formations, to obtain samples of the rocks penetrated, or to gather other kinds of geologic information.

Boulder- A rock mass larger than a cobble (2.5- 10 inches), having a diameter greater than 256mm (10 inches- about the size of a volleyball) being somewhat rounded or otherwise distinctly shaped by abrasion in the course of transport.

Branding- The wind transport of burning debris (accumulation of loose material) outward from a fire. The debris can be carried a mile or more ahead of a fire.

Breached Dam- Rupture or breakage of a dam where water flows freely. Dams under State jurisdiction (e.g. over 50 feet in height or 50 acre-feet in storage capacity) are required to have inundation (flooding) maps that show the potential flood limits in the remote possibility a dam is catastrophically broken.

Bridge Scour- The process of renewal of stream bottom sediment during major flood events. Process could undermine bridge foundation supports if they are not emplaced deep enough below the scour depth.

Building Earthquake Safety Act (1986)- This Act requires all local governments to identify all potentially hazardous buildings within their jurisdictions and to establish a program for mitigation of identified hazards. It is the legislative basis for the inventory of hazardous unreinforced masonry buildings and Unreinforced Masonry Ordinances adopted by most counties and cities in California.

Bureau of Land Management (BLM) 2000 Standards- Suggested guidelines for prescribed burn projects that included: a)The safety of firefighters and the public is the number one priority when planning and implementing a prescribed fire project; b)All prescribed fire projects should have an approved prescribed fire plan prior to ignition; c) All prescribed fire plans should contain measurable objectives, a predetermined prescription, and an escaped fire contingency plan to be implemented in the event of an escape; d)All prescribed fire projects should be conducted in compliance with the Federal and State regulations.

Calcareous Soil- A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce or bubble visibly when treated with cold, dilute hydrochloric acid.

California Department of Forestry and Fire Protection Response Plan- The State agency with the greatest number of resources for fire fighting capabilities. The CDF have extensive ground forces, including a volunteer prisoner population, the CDF fields an air force that includes: 15 Grumman S-2A 800 gallon airtankers, four S-2T 1200 gallon airtankers, two 2,000 gallon contract airtankers, 11 Super Huey Bell UH-1H helicopters, six O-2A air attack aircraft, 11 OV-10A air attack aircraft, and one C-26B fire mapping airplane. From 13 air attack and nine helitack bases located statewide, aircraft can reach any fire within 20 minutes. The air attack planes fly overhead directing the airtankers and helicopters to critical areas of the fire for retardant and water drops. The retardant used to suppress fires is Di-Ammonium Phosphate + Iron Oxide which acts as a fertilizer as well as a suppressant.

California Earthquake Authority (CEA)- Authorized by the State Legislature in 1996 providing protection for homeowners' property. Total funding is \$10.5 billion with private insurers providing up to \$6 billion and the remainder from the reinsurance industry and Berkshire Hathaway (Kunreuther, 1999).

California Earthquake Hazard Reduction Act (1986)- This Act established the California Earthquake Hazards Reduction Program under the guidance of the Seismic Safety Commission.

California Earthquake Hazards Reduction Program- An umbrella program that proposes overall policy and tracks progress in state earthquake hazard mitigation, preparedness, response and recovery programs geared to the objective of significantly reducing earthquake hazards in California by January 1, 2000.

California Environmental Quality Act (CEQA)- Original legislation (1970) and amendments passed by State Legislature which set forth procedures for assessing the impact of a certain project or proposal on the physical, social, and cultural environment. Also defined the content of Environmental Impact Report (EIR), which discusses significant environmental impacts. Under CEQA, a county is required to prepare initial studies addressing potential adverse impact of proposed projects.

California Gap Analysis Project- Vegetation data obtained from the University of California Santa Barbara consisting of land coverage and vegetation information for the state of California, including canopy dominant species, canopy density presence of regional endemic species, and inclusion of wetland habitats. <http://www.biogeog.ucsb.edu/projects/gap/data/meta/landcovdd.html#section1> Evaluation of the California Gap Analysis vegetation data was performed by identifying the primary, secondary and tertiary vegetation community type for each digital polygon and then assigning a rating

for the potential for fire hazard based on fuel loading, in accordance with the HUD Study System (1973) and the Bates Bill Process (AB337, 1992).

California Government Code Section 65852- Requires local jurisdictions to apply zoning in such a manner that it is "uniform for each class or kind of building or use of land throughout each zone." This means, for example, that an additional requirement for setting back a house a certain distance from an identified fault surface rupture on an R-1 zoned property cannot be enforced unless the zoning ordinance specifically sets forth fault setback provisions applicable to any property in that zone on which such a hazard condition is encountered.

California Wildland Fire Danger Rating System (CWFDRS)- Assigned Fire Weather ratings and slope classes for the HUD Study System.

Caliche- A more or less cemented deposit of calcium carbonate in soils of warm-temperate, subhumid to arid areas.

California Department of Fire (CDF)- Primarily a wildland fire protection agency with the legal responsibility for protection of approximately 33 million acres of private and state lands in California. CDF is in charge of handing out hazard abatement notices, providing fire services, administering the Riverside County Fire Department, and identifying areas in the state that are Very High Fire Hazard Severity Zones (VHFHSZ).

Canals- An artificial watercourse of relatively uniform dimensions, cut through an inland area, and designed for navigation, drainage, or irrigation (artificial distribution of water over the ground surface) by connecting two or more bodies of water.

Canopy- High vegetation coverage such as large trees.

Canopy Density- The degree or a measure of the degree of foliage filled or occupied in an area.

Canyon- A long, deep, relatively narrow, steep-sided valley confined between lofty and precipitous walls in a plateau (flat area of great extent) or mountainous area, often with a stream at the bottom; characteristic of arid and semiarid areas where stream downcutting (stream erosion in a downward direction) greatly exceeding weathering or physical and/or chemical changes).

Carbonate- A sediment formed by the organic or inorganic precipitation from aqueous solution of carbonates of calcium, magnesium, or iron.

Catastrophic Earthquake- A great earthquake generally near Magnitude 8.0 or greater, capable of widespread tremendous damage in epicentral (point at the Earth's surface directly above where an earthquake originated) area accompanied by localized severe damage 100's of miles from earthquake source.

CDBG- Community Development Block Grant Program.

CDMG- California Division of Mines and Geology. www.consrv.ca.gov/dmg

CDF- California Department of Fire.

Cementation- (sed) The diagenetic process by which coarse clastic sediments become lithified or consolidated into hard, compact rocks through the deposition or precipitation of minerals in the spaces among the individual grains of the sediment. (soil) The binding together of the particles of a soil by such cementing agents as colloidal clay (a mixture of humus and clay), hydrates (mineral compound in which water is part of the chemical composition) or iron or aluminum, or carbonates.

Census Tract Data- An official count of population.

CEA- California Earthquake Authority.

CEQA -California Environmental Quality Act.

Channel- The deepest portion of a stream, bay (inlet), or strait (narrow water way connecting two larger bodies of water).

Class A Roofs- As defined by the Uniform Building Code, a roof that is generally non-flammable, fire-resistant products.

Class B Roofs- As defined by the Uniform Building Code, a roof that is pressure treated, with wood-shake shingles. A Class B roof is not as resistant to fire as Class A roof.

Clay- Mineral particle in soil having a diameter less than 0.002mm; A rock or mineral fragment having a diameter less than 1/256 mm (4 microns, or 0.00016 in.); Any soft, adhesive, fine-grained deposit; As a soil textural class, a soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay Film (clay skin)- A thin coating of oriented clay on the surface of a soil ped or lining pores or root channels .

Claystone- A hardened clay having the texture and composition of shale (finely stratified sedimentary rock of clay, silt or mud), but lacking its fine lamination; A massive mudstone in which clay predominates over silt.

Climate- A characteristic condition of the various elements of weather of a given region, such as temperature, humidity, rainfall or other atmospheric elements that prevail in a given area.

Coarse Fragment- A mineral or rock particle larger than 2 mm in diameter.

Coarse-grained- (geol) Said of a sediment or sedimentary rock, and of its texture, in which the individual constituents are large enough to see with the naked eye (diameter > 2 mm). (soil) Said of a soil in which gravel and/or sand predominate.

Cobble- A rock fragment larger than a pebble and smaller than a boulder, having a diameter in the range of 64-256mm (2.5-10in-that of a size between a tennis ball and a volleyball), being somewhat round or otherwise modified by abrasion in the course of transport.

Cohesion- Shear strength in a sediment not related to inter-particle friction

Collapsible Soils- Typically found in arid environments and associated with Holocene-aged or slightly older deposits on alluvial fans collapsible soils, which have undergone settlement when exposed to development practices such as construction and artificial irrigation.

Colluvium- A general term applied to a loose, heterogeneous, and incoherent mass of soil material or rock fragments deposited chiefly by mass-wasting. Colluvium is usually at the base of a steep slope or cliff; deposited by unconcentrated surface runoff, sheet erosion or slope wash.

Community Development Block Grants (CDBG)- Grants awarded by the Federal Department of Housing and Urban Development to cities and counties to fund community development activities such as housing programs, and economic development facilities such as streets, sewers, and water systems.

Compaction- (soil) Any process such as by weight of the upper part of a sedimentary deposit, compressing or consolidating material below, whereby a soil mass loses pore space and achieves a higher density. Compaction increases the bearing capacity and reduces the tendency to settle or deform under the weight of the overlying material, and increases the general stability of the soil. (sed) Pore spaces within a body of fine-grained sediments in response to the increasing weight of overlying material that is continually being deposited, or to the pressures resulting from earth movements within the crust. It is expressed as a decrease in porosity (percentage of pore spaces or openings) brought about by a tighter packing of the sediment particles; The process whereby fine-grained sediment is converted to consolidated rock, such as clay lithified to a shale.

Composition- The general makeup of a rock based on the specie type and number of minerals present.

Concealed Fault- An inferred fault usually covered by deposits younger than the last displacement event on the fault.

Conditionally Active Fault- A fault showing evidence of movement in the Quaternary but greater than 750,000 years ago (considered only for certain critical facilities).

Cone Penetration Test (CPT)- Soil penetration test in which a standard steel cone is pushed into the soil by hand (mechanically) or hydraulically (movement using water) and the required to advance the cone at a slow constant rate or a specified distance, or in some designs the penetration at various loads is recorded.

Conflagration- A large fire, usually in excess of 1,000 acres that advances along a front.

Conglomerate- A coarse-grained sedimentary rock composed of rounded to subangular fragments larger than 2 mm in diameter set in a fine-grained (less than 2 mm diameter) matrix of sand or silt, and commonly cemented by calcium carbonate, iron oxide, silica or hardened clay.

Conjugate Fault- Faults that are of the same age and deformational episode as a primary fault.

Consistence- The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are: Terms such as loose, friable, firm, plastic, sticky, hard, soft, and/or cemented are often associated with consistence.

Consistency- Development of a parcel must be within the range of allowable uses and density (numbers of houses per acre) that is enumerated in the text of the General Plan and the Land Use Plan Map.

Consolidation - Any process whereby loose particles, soft earth materials become firm and cohesive (having relatively high shear strength) rock. Also the gradual reduction in volume and increase in of a soil mass in response to increased amount of overlying material or effective compressive stress, such as the squeezing of fluids from pore spaces (open spaces in rock or soil).

Contour- An imaginary line, or a line on a map or chart, that connects points of equal value, e.g. elevation of a land surface. Contours are commonly used to depict topographic or structural surfaces.

Coseismic Rupture- Ground rupture occurring during an earthquake but not necessarily on the causative fault.

CPT- Cone Penetration Test.

Creep- The slow, imperceptible downslope movement of mineral, rock, and soil particles under gravity; Continuously increasing, slow deformation (strain) of solid rock resulting from a small constant stress acting over a long period of time.

Critical Facilities- Facilities that are a part of a community's infrastructure that must remain operational after an earthquake, or that pose unacceptable risks to public safety if severely damaged. Critical facilities that are needed during an emergency include hospitals, fire and police stations, emergency operation centers (EOC's) and communication centers.

Critical Fire Weather Frequency Class- A numerical rating obtained by multiplying fuel loading , fire weather. HUD lists the Critical Fire Weather Frequency Class assigned to each of the USGS Quadrangle Maps for California to determine a severity scale.

Cross Section- A diagram showing the features transected by a vertical plane e.g. a vertical section through a mineral deposit, an anticline (convex fold upward containing stratigraphically older rock, or a fossil; An actual exposure or cut that shows transected geologic features.

Crown Fires- Tree-consuming infernos with spectacular flames as fire jumps from tree crown to tree crown very rapidly.

Crustal Plate- One of the six blocks into which the lithosphere (solid or crust portion of the earth) is divided, according to the scheme of global tectonics A crustal plate is about 100 km thick.

Crustal Plate Strain System- A group of crustal plates or blocks dividing the earth's crust that change in shape or volume with the onset of stress. For example, the Whittier-Elsinore fault parallels the San Jacinto and is part of the same right-lateral crustal plate strain system as the San Andreas and the San Jacinto.

CRWQCB- California Regional Water Quality Control Board.

CSD - Community Service District.

Culvert- Any covered structure not classified as a bridge, that constitutes a transverse drain, waterway, or other opening under a road, railroad, canal, or similar structure.

Curtain Wall- Cladding or metal coating bonded onto another metal.

Cut and Fill- In engineering, the excavation of earth material from one place and its deposition as compacted fill (man-made deposits of natural earth materials) in an adjacent place, as in road-building or infrastructure locations.

CWFDRS - California Wildland Fire Danger Rating System.

Dam- An artificial barrier or wall constructed across a watercourse or valley to obstruct or confine a flow of water to create a reservoir, divert water into a conduit or channel, to create a hydraulic head (the height of the free surface of a body of water above a given subsurface point) that can be used to generate power, control floods, or retention of debris.

Danger- An exposure to injury or loss: Hazard.

Debris- Any surficial accumulation of loose material detached from rock masses by chemical and mechanical means, as by decay and disintegration, and occurring in the place where it was formed, or transported by water or ice and redeposited. It consists of rock fragments, soil material, and sometimes organic matter.

Debris Basins- An area in which sediments accumulate; A sunken area caused by the accumulation of sediments on it.

Debris Falls- Occurs when a mixture of soil, regolith vegetation, and rocks on a steep slope become dislodged and drops down the slope.

Debris Flow- Rapidly moving saturated earth material with 50 percent rock fragments coarser than 2 mm in size which can occur on natural and graded slopes. Debris flows occur when sufficient force is applied to rocks and regolith that they begin to flow down slope. It is a mixture of rock, and/or regolith with some water or air. The debris-flow scenario depends on numerous factors: soil depth and composition, the kind of vegetation and the size of tree roots, subtle variations in slope shape, road cuts, drainage pipes, incongruities in underlying bedrock, even the presence of small animal burrows. Water can collapse a slope after traveling beneath the surface from miles away.

Debris Slides- Results when debris descends down a pre-existing surface, such as a bedding plane, foliation surface (planar arrangement of textural or structural features), or joint surface. Piles of talus (coarse angular rock fragments) are common at the base of a slide. Slides differ from slumps in that there is no rotation of the sliding rock mass along a curved surface.

Decomposition-Chemical weathering, or the breaking down of rocks, minerals, or organic matter by chemical processes. Usually complex compounds are broken down into simpler ones that are more stable under the prevailing conditions at or near the Earth's surface.

Deflected Canyon - A 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 the rocks as a result of various Earth forces.

Degree of Confidence- A comparison or succession of reliance in, and of limitations in data and conclusions.

Dekameters- Unit of dam storage capacity where 1 Dam³ is equal to 0.8 acre-feet. An acre-foot is the volume of an acre of area that is one foot in thickness.

Demography- The study of the characteristics of people such as growth, size, and vital statistics.

Density- The quantity or amount of something per unit measure, area, volume, or length.

Density Transfer- A commonly used incentive for mitigating geologic hazards on an individual project. Where a site has known geologic hazards, general plan and/or zoning densities are transferred from the part of the site with the hazard to the portions of the site where the hazard is minimally present or nonexistent. Density transfer is more difficult on smaller sites due to height and setback limitations and more direct impacts on adjoining properties. However, provisions may be made in the zoning code for modification of height and setback provisions to enable density transfer, taking into account possible impacts on the neighborhood.

Dependent Care Facilities- Facilities that house populations with special evacuation considerations, such as preschools and schools, rehabilitation centers, prisons, group care homes, and nursing and convalescent homes.

Desert- An area of low moisture due to low rainfall, (less than 10 inches annually), high evapotranspiration or extreme cold and which supports only one specialized vegetation, not that typical of the and is generally unsuitable for human habitation under natural conditions. Deserts are not characterized by uniformity of elevation but wind often produces distinctive erosional features.

Design Earthquakes- The more critical the project, the longer the time period chosen and the larger the design earthquake. The largest earthquake likely to occur on a fault or fault segment is termed the maximum credible (MCE) or characteristic earthquake. Depending on the planned use, lifetime, or importance of a facility, a maximum probable earthquake (MPE) is the earthquake most likely to occur in a specified period of time, (such as 30 to 500 years).

Design Flood- The amount of a rising body of water that overtops its natural or artificial confines and that covers land not normally under water's magnitude for which a specific project was designed.

Detritus- A collective term for loose rock and mineral material that is worn off or removed directly by mechanical means, as by disintegration (the breaking down of vegetable matter by slow burning in which only volatile or vaporable substances are produced) or by abrasion; esp. fragmental material, such as sand, silt, and clay, derived from older rocks and moved from its place of origin.

Dewatering- To remove water from a waste produce or streambed, for example; The extraction of a portion of the water present in sludge or slurry producing a dewatered product which is easier to handle.

Differential Settlement- Nonuniform settlement; the uneven lowering of different parts of an engineering structure, often resulting in damage to the structure. Sometimes included with liquefaction as a ground failure phenomenon.

Dip- (seismic) The angle between a reflecting or refracting seismic wave and the horizontal; the angle between a seismic discontinuity surface and the horizontal. (struc geol) A measure of the angle between the flat horizon and the slope of a sediment layer, fault plane, metamorphic foliation, or other geologic structures; The angle that a structural surface e.g. a bedding or fault plane, makes with the horizontal, measured perpendicular to the strike of the structure (angle of dip).

Dip Slip- The component of the movement or slip that is parallel to the dip of the fault.

Displaced Households/Shelter Requirements- Earthquakes can cause loss of function or habitability of buildings which contain housing units, resulting in people driven from their households. These households may need alternative short-term havens, provided by family, friends, renting apartments or houses, or public shelters provided by relief organizations such as the Red Cross, Salvation Army, and others.

Displacement- The relative movement of the two sides of a fault, measured in any chosen direction; also, the specific amount of such movement. Displacement in an apparently lateral direction includes strike slip and strike separation; displacement in an apparently vertical direction includes dip slip and dip separation.

Dissolution- A space or cavity in or between rocks, formed by the dissolving of part of the rock material.

DMG- Division of Mines and Geology.

Drainage Patterns- The configuration or arrangement map view of the natural stream courses in an area. It is related to local geologic and geomorphologic features and history.

Drought-Tolerant Grass or Ground Cover- Grass, vegetation or foliation able to withstand or endure during long periods without rain.

Ductile- Said of a rock that is able to sustain under a given set of conditions, 5-10% deformation before fracturing or faulting (brittle).

Dune- A low mound, ridge, bank, or hill of loose, windblown granular material (generally sand and sometimes volcanic ash), either bare or covered with vegetation, capable of movement from place to place but always retaining its own characteristic shape.

Duration- Interval of time. (stream) The interval of time from high water to low water, or from low water to high water (falling and rising of tide).

Dwelling Density- The number of homes that can be built per one acre; It is expressed on the Land Use Plan in six residential categories each allowing a range of living units per acre (Du/Ac).

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's Crust - The outermost layer or shell of the Earth.

Earth Materials/Earth Units- Rock, soil, sand, and gravels.

Earthquake Fault Zone (EFZ)- Regulatory zones around and along faults which are "sufficiently active" and "well-defined" (to be zoned by the State Geologist under the EFZ Act). The zones are defined by turning points connected by straight lines. Most of the turning points are identified by roads, drainages, and other features on the ground. These faults show evidence of Holocene surface displacement along one or more of their segments (sufficiently active) and are clearly detectable by

a trained geologist as a physical feature at or just below the ground surface (well defined). The boundary of an "Earthquake Fault Zone" is generally about 500 feet from major active faults, and 200 to 300 feet from well-defined minor faults. EFZs are plotted on topographic maps at a scale of 1 inch equals 2,000 feet. They vary in width, but average about one-quarter mile wide.

Earthquake Loss Estimates- The probability of earthquake damage the state will incur determined and averaged for each census tract.

EFZ- Earthquake Fault Zone.

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.

Earthquake Related Fires- Fires induced by an earthquake that include: open flames, electrical malfunctions, natural gas leaks, severed gas lines, inadequate bracing of mobile homes, and chemical spills. Commonly affected are unanchored gas heaters or gas-fired hot water heaters or appliances that tend to tip over during strong ground shaking.

Ecology- The study of the relationships between organisms and their environments, including the study of communities, patterns of life, natural cycles, relationships of organisms to each other, and population changes.

Economic Facilities- Facilities that should remain operational to avoid severe economic impacts, such as banks, archiving and vital record keeping facilities, airports and ports, and large industrial and commercial centers.

Economic Loss- The methodology that provides estimates of the structural and nonstructural repair costs caused by building damage and the associated loss of building contents and business inventory. Building damage can also cause additional losses by restricting the building's ability to function properly. To account for this, business interruption and rental income losses are estimated.

EDC- EROS Data Center. <http://edcwww.cr.usgs.gov/eros-home.html>

EERI- Earthquake Engineering Research Institute

EIR- Environmental Impact Report.

Elevation- A general term for a topographic feature of any size that rises above the adjacent land or the surrounding ocean bottom; The vertical distance from a datum(usually mean sea level) to a point or object on the Earth's surface; esp. the height of a ground point above the level of the sea.; often times used synonymously with altitude except that altitude is used to indicate the heights of points in space above the Earth's surface.

Emergency Operation Center (EOC)- A room or building equipped and staffed to monitor and direct the response to an emergency situation.

EOC- Emergency Operation Centers.

Endemic- Said of an organism or group of organisms that is restricted to a particular region or environment; native.

En echelon- Said of geologic features that are in an overlapping or staggered arrangement; e.g. en echelon faults are relatively short but collectively they form a linear zone, in which the strike of the individual feature is oblique to that of the zone as a whole.

Engineered Slope- Designed to resist seismically induced failure. Uses soil engineering parameters based on static stability analyses established on a site-specific basis from detailed geotechnical investigations that include subsurface soil sampling and laboratory testing. The stability analyses should factor in the intensity of ground shaking expected.

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.

Engineering Geology- Geology as applied to engineering practice, esp. mining and civil engineering. As defined by the Association of Engineering Geologists it is the application of geologic data, techniques, and principles to the study of naturally occurring rock and soil materials or ground water for the purpose of assuring that geologic factors affecting the location, planning, design, construction, operation, and maintenance of engineering structures, and the development of ground-water resources, are properly recognized and adequately interpreted, utilized, and presented for use in engineering practices.

Engineering Properties- Properties such as rock type, age, degree of consolidation (soft soil materials becoming firm and cohesive), depositional environment, texture, and structure were used for the development of GIS Engineering Geology Map for Riverside.

Epicenter- The point at the Earth's surface directly above where an earthquake originated.

EROS Data Center (EDC)- In Sioux Falls, South Dakota, EDC produces weekly and biweekly maps for the 48 contiguous states and Alaska that display plant growth and vigor, vegetation cover, and biomass production, using multispectral data from satellites of the National Oceanic and Atmospheric Administration (NOAA). EDC also produces maps that relate current vegetation conditions for 2-week periods to average (normal) conditions for the same period during the past 7 years.

Erosion- Removal of material loosened, dissolved, or worn away of soil and rock by mass wasting, the action of streams, glaciers, waves, wind, and underground water by natural agencies that include solution, corrosion, and transportation. Weathering, although sometimes is included here, is a distant process which does not imply removal of any material. (geol) Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains.

Essential Facilities- Facilities that provide services to the community and should be functional in times of emergencies. Essential facilities include hospitals, police stations, fire stations, communication centers, and schools.

Evapotranspiration- Water withdrawn from a land area by evaporation from water surfaces and moist soil and by plant transpiration.

Expansive Soil- Soil with a significant amount of clay particles that have the ability to give up water (shrink) or take on water (swell). When these soils swell, the change in volume exerts significant pressures on loads (such as buildings) that are placed on them. Expansion testing and mitigation are required by the current grading and building codes.

Extension- (fault) A fault in which there has been tension-type displacement in the plane of bedding. (fracture) A fracture that develops perpendicular to the direction of greatest stress; and parallel to the direction of compression. (joint) A joint that forms parallel to the direction of compression. (see definitions of fracture and joint).

Fabric- The spatial and geometrical configuration of all those components that make up a deformed rock, including texture, structure, and preferred orientation; The orientation in space of the particles, crystals, and cement of which a sedimentary rock is composed; The physical nature of a soil according to the spatial arrangement of its particles and voids.

Falls- Occurs when material on steep slopes or cliffs become dislodged and drop down the slope.

Fault- A fracture or rupture, or zone of fractures along which there has been displacement of adjacent earth material; A fracture in the crust of the earth along which rocks on one side have moved relative to those on the other side. Most faults are the result of repeated displacements over a long period of time

Fault Creep- Slow, gradual, nonrecoverable deformation of the earth's crust sustained by fault rupture

Fault Hazard Zones- Delineated by the California Department of Mines and Geology (CDMG) as "zones of required investigation" whereby site-specific geotechnical hazard investigations are required by the Seismic Hazard Mapping Act (SHMA). The zone is an area where there is potential for infrastructures designed for human occupancy need to be setback away from any potential ground rupture hazards esp. in areas with faults with high rates of displacement (>5 mm/yr).

Fault Plane- A fault surface that is more or less planar. Generally referred to as "the fault".

Fault Plane Solution- A model of the sense and orientation of the generating fault displacement.

Fault Rupture- The process of fault movement that generates an earthquake as frictional energy is released by the movement.

Fault Segment - A continuous portion of a fault zone that is likely to rupture(displacement as a result of movement on a fault) along its entire length during an earthquake.

Fault Slip Rate - The average long-term rate of movement of a fault (measured in cm/year or mm/year) as determined from geologic evidence.

Fault Strand- A small or minor fault either connected to or subparallel to a primary fault.

Fault Trace- Line on the earth's surface defining the fault.

Fault Zone- A system of fault strands that when taken together define a zone of primary and secondary faults, generally aligned roughly along trend of the primary fault. Can also refer to the width of the crushed zone by the primary fault.

FEMA- Federal Emergency Management Agency. [www,fema.gov](http://www.fema.gov)

Field Act- Act set up for structural standards for public school that passed after the Long Beach earthquake of 1933.

Fill- Man-made deposits of natural earth materials (rocks and soil particles) and waste materials such as tailings or spoil from dredging, or sediment deposited by any agent (i.e. stream, glacier, slope movement, etc.) used for leveling or filling low places or valleys, extending a shoreline into a lake, building embankments, roads or for infrastructure grades.

Fine-grained- (geol) Said of a sediment or sedimentary rock, and of its texture, in which the individual constituents are too small to distinguish with the naked eye. **(soil)** Said of a soil in which silt and/or clay predominates.

Fire- The chemical reaction of burning, which releases heat and light; To ignite or cause to become ignited.

Fire and Land Managers- One who assesses the condition of all vegetation throughout the growing season to provide a foundation for planning fire suppression, schedule prescribed burns, or study long-term vegetation changes resulting from human or natural factors.

Fire Codes- Requirements and standards of fire hazard reduction to protect the health, safety, and welfare of the existing and future residents.

Fire Ecologist- One who is trained and works in the field of fire ecology by studying the relationships between fire and organisms and their environments including the study of communities, patterns of life, natural cycles, relationships of organisms to each other, biogeography and population changes., and population changes as they relate to fire.

Fire Emergency Division- The Emergency Services Division that maintains two underground Emergency Operating Center's (EOC's) with communications, for government use during major events.

Fire Flow- Duration and pressure requirements as a function of building size, type, material, purpose, location, proximity to other structures, and the type of fire suppression systems installed. The various water districts are required to test fire protection capability for the various land uses per the flow requirements of the Uniform Fire Code.

Fires Following Earthquakes- Cause severe losses that can sometimes outweigh the total losses from the direct damage caused by the earthquake, such as collapse of buildings and disruption of lifelines. Many factors affect the severity of the fires following an earthquake, including but not limited to: ignition sources, types and density of fuel, weather conditions, functionality of water systems, and the ability of fire fighters to suppress the fires.

Fire-Following Earthquake Model- Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area with input with respect to the level of readiness of local fire departments and the types and availability (functionality) of water systems. To reduce the input requirements and to account for simplifications in the lifeline module, the fire following earthquake model presented are simplified.

Fire Hazard Mapping and Real Estate Distribution Law- Civil Code Section 1103(c)(6) requires real estate sellers to inform prospective buyers whether or not a property is located within a Wildland Fire Area that could contain substantial fire risks and hazards.

Fire Hazard Severity Scale- Each class of fuel loading, fire weather, and slope is assigned a severity factor. The values are multiplied to produce a Fire Hazard Severity Scale. The scale is determined by multiplying the three factors together to determine a numerical rating. HUD lists the Critical Fire Weather Frequency Class assigned for each of the USGS Quadrangle Maps for California. The Fuel Loading is captured directly from the Quadrangle Maps. The slope can be either mechanically calculated or automatically calculated with a software program containing the USGS Quadrangle data (e.g. TopoScout8).

Fire Hazards- Suburban or rural areas of which contain uncultivated lands, timber, range, watershed, brush or grasslands; weather, topography and fuel type can effect the intensity of the fires.

Fire Potential Index (FPI)- FPI is a valuable fire management tool that has been developed by USGS scientists in collaboration with scientists at the United States Fire Service (USFS). The FPI characterizes relative fire potential for forests, rangeland, and grasslands, both regionally and locally, so that land managers can develop plans for minimizing the threat from fires. The FPI combines multispectral satellite data from National Oceanic and Atmospheric Administration (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 or fuel type derived from vegetation maps, plus the water content of the dead vegetation, and the fraction of the total fuel load that is live vegetation.

Fire Prevention- Scenario analysis for major earthquake induced for both wildland and earthquake induced fires, for mitigation, planning and preparedness, and state mandates that includes mapping of Very High Fire Hazard Severity Zones (VHFHSZs).

Fire Protection Flow and Emergency Water Storage- Uniform Fire Code fire flow requirements as a function of building size, type, material, purpose, location, proximity to other structures, and the type of fire suppression systems installed, and a seven day emergency storage supply.

Fire Response Resources- Include Riverside County Fire Department (RCOFD), Community Service District (CSD), California Department of Forestry, and Emergency Services Division.

Fire-Retardant Ground Cover- Low-growing plants or other material such as burlap mat, straw mulch, or chemical nutrients, that forms a dense, extensive layer used to impede fires.

Fire Safety (Homeowner)- A checklist to reduce fire risk that should consider the following: Local area fire history; Site location and overall terrain; Prevailing winds and seasonal weather; Property contours and boundaries; Native vegetation; Plant characteristics and placement; Irrigation requirements; Designing and installing fire-wise landscapes; and Maintenance.

Fire Safety and Land Use Planning- Clearance laws, zoning, and related fire safety requirements prevention, and reduction techniques.

Fire Severity Forecasting Predictions- For good fire management planning fire weather predictions on several time scales ranging from hours to months is required. Research aims to provide forecast tools for the medium-range (daily forecasts out to 10-15 days), extended-range (30 days), and for seasons (90 days). The accuracy of weather forecasts can vary with season, location, and parameter

Fire Weather Class- There are three fire weather classes. Each class is related to the frequency of critical fire weather days occurring in each of the state's Fire Danger Rating Areas over a 10-year period. The Low class (Class I) includes all those Fire Danger Rating Areas which have experienced fire weather in the "very high" or "extreme" ranges with an annual average of less than one day. The High class (Class II) has an annual average of 1 to 9.5 days. While the Extreme class (Class III) has an annual average of more than 9.5 days. Each USGS topographic map in the state is keyed to one of the Fire Danger Rating Areas and assigned that Area's critical fire weather frequency classification.

Firebreak- A firebreak is made by removing and clearing away all flammable vegetation or other combustible growth for a distance of not less than 30 feet on each side thereof or to the property line, whichever is nearer.

Firestorm- A large fire that stays in one place and has cyclonic attributes such as strong in-rushing winds and a grossly rotational motion.

Fissure- (joint) A surface of fracture or crack in rock along which there is a distinct separation. Generally caused by extensional forces in the rock (or sediment).

Flash Flood- A local and sudden flood or torrent of relatively great volume and short duration that overflows a stream channel in a usually dry valley such as in a semiarid area. Flash floods tend to carry an immense load of mud and rock fragments, and generally result from a rare and brief but heavy rainfall over a relatively small area. It may also be caused by ice jams and by dam failure.

Flood-A rising body of water that overtops its natural or artificial confines and that covers land not normally under water. Flooding is the number-one natural disaster in the United States in terms of number of lives lost and property damage.

Flood Hazards- Normally associated with large amounts of precipitation or snow melt that cause floods, landslides, and debris flows. Most lives are lost when people are swept away by flood currents, whereas most property damage results from inundation (flooding) by sediment-laden water. Flood currents also possess tremendous destructive power, such as lateral forces that can demolish buildings and erosion can undermine bridge foundations and footings leading to the collapse of structures.

Flood Inundation- A rising of water and its spreading over land not normally submerged.

Flood Inundation Maps- State of California Government Code Section 65302 (g) requires local governments to assess the potential impact that flooding, and failure of dams or other water retention structures, might have on their jurisdiction, and assess the impact of flooding from storm activity such as a 100-year flood event.

Flood Plain- The portion of a river valley, adjacent to the channel, which is built of sediments deposited during the present regimen of the stream and is covered with water when the river overflows its banks at flood stages.

Flood Plain, 100 Year- Flat tracts of land bordering a river or channel which can expect to be flooded in a storm that has a one-percent chance of occurring each year or will happen on the average of once every one hundred years. Federal legislation requires that the City have a flood management program for areas that are within the 100 Year Flood Plain.

Flow Failure- A mass movement of unconsolidated material that exhibits a continuity of motion and a plastic or semifluid behavior resembling that of a viscous (sticky and gluey) fluid. i.e. creep, earthflow, mudflow. Water is usually required for most types of flow movement.

Foliation- A general term for a planar arrangement of textural or structural features in any type of rock, e.g. cleavage in slate or schistosity in a metamorphic rock. This term is most commonly applied to metamorphic rock.

Footwall- The underlying side of a fault, an orebody, or of a mine floor.

Foothill- A lower, subsidiary hill at the base of a mountain or higher hills; A region of relatively low, rounded hills at the base of or fringing a mountain range.

Force- That which tends to put a stationary body in motion or to change the direction or speed of motion of a moving body.

Foreshock- A small tremor that commonly precedes a larger earthquake or main shock by seconds to weeks and that originates at or near the focus of the larger earthquake.

Forest- A large tract of land covered with trees; Something resembling a forest, as in quantity or density.

Foundation- The lower, man-made, supporting part of an engineering structure, in contact with the underlying soil or rock and transmitting the weight of the structure and its included loads to the underlying earth material; A term that is sometimes applied to the upper part of the soil or rock mass in contact with, and supporting the loads of, an engineering structure.

FPI- Fire Potential Index.

Fracture- A general term for any break in a rock, whether or not it causes displacement, due to mechanical failure by stress. Fracture includes cracks, joints, and faults; Deformation due to a momentary loss of cohesion or loss of resistance to differential stress and a release of stored elastic energy.

Frequency Composition- The range of frequencies (the number of times a specified phenomenon occurs within a specified interval) as measured at a site, including high frequency earthquake ground motion (greater than 1 Hz) and lower frequency energy (less than 1 Hz).

Friction- Mechanical resistance to the relative motion of contiguous bodies or of a body and a medium.

Fuel- A combustible matter consumed to generate energy, especially a material such as wood, coal, or oil burned to generate heat.

Fuel Hazard Ratings- Primary, secondary and tertiary vegetation community types with assigned ratings for potential fire hazard based on fuel loading, slope angle, and where they occur in relation to urbanization. The California Gap Analysis vegetation data in accordance with the HUD Study System (1973) and the Bates Bill Process (AB337, 1992) are used to determine the fuel loads. Fuel hazard ratings for grasslands, shrublands, and woodlands consist of light, medium, and heavy, respectively. These ratings are then normalized based on the primary, secondary and tertiary type of vegetation communities.

Fuel Loading- Management of onsite volumes of vegetation or other combustible material. Fuel loading includes three classes. Light fuels (occupy the uncolored areas on the USGS maps) represent flammable grass and annual herbs. Medium fuels (shown as "scrub" on the USGS maps) include brush and other perennial shrubs less than six feet in height and having a crown density of 20 percent or more. Heavy fuels (shown as "woods-brushwood" on the USGS maps) include the heavier brush species, woodland types, and timber types over six feet in height and having a crown density of 20 percent or more.

Fuel Types- Include grass, weeds, shrubs, brush, large shrubs, small trees, timber, woodland, large brush, or heavy planting of ornamentals.

Generalized Liquefaction Susceptibility Map- Research into the process and consequences of liquefaction in past earthquakes have linked liquefaction to certain hydrologic and geologic settings, characterized by water-saturated cohesionless (not holding together), granular materials situated at depths of less than 50 feet. In simplified terms, the procedure used to delineate areas having significant potential for liquefaction areas where the geology and hydrology are favorable for liquefaction.

Geodetic Leveling- Spirit leveling of a high order of accuracy, usually extended over large areas (and with proper applications of orthometric corrections), to furnish accurate vertical control for surveying and mapping operations.

Geologic Constraints- Restrictions or hazard to life or property such as earthquakes, landslides, wind erosion, blown sand, flooding, and wildland fires.

Geologic Hazard- A naturally occurring or man-made geologic condition or phenomenon that presents a risk or is a potential danger to life and property. Examples include: landsliding, flooding, earthquakes, ground subsidence, coastal and beach erosion, faulting, dam leakage and failure, mining disasters, pollution and waste disposal, and seawater intrusion.

Geologic Hazard Abatement- Adopted in 1979, this law spells out the procedures by which property owners wishing to abate a geologic hazard found on their properties may form a special assessment district to pay for correction of that hazard. While there are a few successful applications of this law in the state, it has been difficult to implement due to stringent provisions and the emotion often encountered after property damage has occurred. The California Seismic Safety Commission is studying how to make it more attractive to apply in advance of damage.

Geologic Record- The "documents" or "archives" of the history of the Earth, represented by bedrock, regolith, and the earth's morphology (changes occurring on rocks and the accessible solid part of the Earth). Also, the geologic history based on inferences from a study of the geologic record.

Geologic Setting- The physical geography of an area or place.

Geologist- One who is trained and works in any of the geological sciences.

Geology- The study of the planet earth and the materials of which it is made; The processes that act on these materials, the products formed, and the history of the planet and its life forms since its origin.

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.

Geoscience- A short form denoting the collective disciplines of the geological sciences. The term, as such, is synonymous with geology.

Geotechnical- Pertaining to soil and soil mechanics that involves the properties of soil such as compaction, strengths, stabilization, and chemical reactivity.

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.

Geotechnical Investigations- The application of scientific methods and engineering principles to the acquisition, interpretation, and use of knowledge of materials of the Earth's crust to the solution of civil-engineering problems; the applied science of making the Earth more habitable. It embraces the fields of soil mechanics and rock mechanics, and many of the engineering aspects of geology, geophysics, hydrology, and related sciences.

Geothermal- Pertaining to the heat of the interior of the Earth.

GIS- Geographical Information System.

Government Code Section 65302- Requires a safety element for the purpose of protecting the community from unreasonable risks associated with the effects of seismic hazards, flooding and fire. The safety element must include maps of known seismic and other geologic hazards, such as seismically-induced surface rupture, ground shaking, ground failure, dam failure, slope instability and subsidence, as well as related phenomena such as tsunamis, seiche, flooding, and wildland and urban fire hazards. It must address evacuation routes, peak load water supply requirements, and minimum road widths and clearances around structures, as those items relate to identified fire and geologic hazards. It also may address any other subjects that the local governing body considers pertinent to the physical development of the community.

Graben- An elongate, relatively depressed crustal unit or block that is bounded by faults on its long sides. It is a structural form that may or may not be geomorphically expressed as a rift valley (elongated trough or tectonic depression bounded by faults).

Grading- Any excavation or filling or combination thereof. Generally refers to the modification of the natural landscape into pads suitable as foundations for structures.

Grain Size Distribution (Particle Size)- The percentage, usually by weight and sometimes by number or count, of particles of defined size fractions of a soil, sediment, or rock.

Grassland- A prairie; Land in which grasses are the main vegetation.

Gravel- Round or angular fragments of rock up to 3 inches (2 mm-7.6 cm) in diameter. An individual piece is a pebble.

Gravity- The force exerted by the earth and its rotation on unit mass, or the acceleration imparted to a freely falling body in the absence of friction; The resultant effect upon which any body of matter in the universe of the inverse square law attraction between it and all other matter lying within the frame of reference and of any centrifugal force (the component of apparent force on a body in a curvilinear motion as directed away from the center of curvature of axis of rotation) which may act on the body because of its motion in any orbit.

Gravity Gradient- The partial derivative of the acceleration of gravity with respect to distance in a particular direction, for which purpose the acceleration of gravity is considered as a scalar; for example, regional settlements can damage pipelines by changing the gravity gradient on water and sewer lines and canals.

Great Basin High- The formation of Santa Ana wind is a typical pressure configuration that consists of a stalled but intense high pressure called the Great Basin High near Idaho and Salt Lake, and a weak low pressure system just off shore of southern California (Chen, 2000).

Greenness Mapping- Mapping used to help reduce wildland fire hazards weekly and biweekly maps for the 48 contiguous states and Alaska display plant growth and vigor, vegetation cover, and biomass (amount of vegetation in weight) production, using multispectral data from to measure vegetation greenness over time. They are used by fire and land managers to assess the condition of all vegetation throughout the growing season to provide a foundation for planning for fire suppression, scheduling prescribed burns, or studying long-term vegetation changes resulting from human or natural factors.

Ground Acceleration- The acceleration of an earth particle, usually as measured by an accelerometer.

Ground Failure- Permanent ground displacement produced by fault rupture, differential settlement, liquefaction, or slope failure.

Ground Oscillation- Liquefaction-related effects via shifting patterns of the earth's surface or the sediments, bringing about changes in the character of the earth's surface.

Ground Rupture- Displacement of the earth's surface as a result of fault movement associated with an earthquake.

Ground Shaking- Ground motion. Seismic ground shaking at any given site is a function of several factors, but primarily the magnitude of the earthquake, the distance from the epicenter to the area of concern, the type of bedrock or soil materials between the epicenter and the site, and the topographic conditions of the site (whether it is located in a valley, or at the top of a hill or mountain). The amount of damage is also controlled to a certain extent by the size, shape, age, and engineering characteristics of the affected structures.

Ground Shaking Risks- Several factors control how ground motion interacts with structures, making the hazard of ground shaking difficult to predict. In general, however, long-period seismic waves, characteristic of earthquakes that occur about 10 miles (15 kilometers) and farther from the area of concern, interact with and damage preferentially long-period structures such as high-rise buildings and bridges. Short-period seismic waves, characteristic of earthquakes that occur less than 10 miles from the area of concern, have the potential for damaging preferentially short-period structures, such as one- and two-story buildings.

Ground Subsidence- Typically a gradual settling or sinking of the ground surface with little or no horizontal movement. In the areas of southern California where ground subsidence has been reported, this phenomenon is usually associated with the extraction of oil, gas or ground water from below the ground surface, or the organic decomposition of peat deposits, with a resultant loss in volume. Ground subsidence can also occur as a response to natural forces such as earthquake movements, and the folding and subsiding activity of sedimentary basins.

Ground-Surface Cover- Low-growing plants that form a dense, extensive growth and tend to prevent soil erosion.

Ground Water- 1. That part of the subsurface water that is the zone of saturation (at full capacity -not allowing anymore moisture), including underground streams. 2. Underground water that occupies the pore spaces in soil or fissures (joints) in rock. 3. Loosely, all subsurface water (excluding internal water) as distinct from surface water. 4. Water found in that portion of the soil which is always saturated or below the water table. Also called the "phreatic water."

Groundwater Table- The surface between the zone of saturation and the zone of aeration; that surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere.

Habitat- Environment. All those external factors and conditions which may influence an organism or a community.

Hanging Wall- The overlying side of a fault, orebody, or other structure.

Hard Rock- A term used loosely for an igneous rock or a metamorphic rock, as distinguished from sedimentary rock.

Hazard- Expresses the menace or threat imposed by potential natural phenomena, such as hurricanes, floods and earthquakes, that can cause adverse consequences to human activities, negative social impact, and severe human and economic losses; A risk; Source of danger.

Hazard Abatement Notices- These notices request that property owners reduce the fuels around their property. Requirements for hazard reduction include a minimum of a 30 foot clearance around all structures, which can be extended to 100 feet in areas where a severe fire hazards exist. On unimproved parcels the property owner is required to disc or mow 100 feet along the perimeter of the property.

Hazardous Fire Area- Fire risk area based on drought and other conditions.

Hazardous Fire Area Designation- Areas that require closure based on potentially fire hazardous conditions. The fire chief is given the authority to officially determine and publicly announce the closure of any hazardous fire area or portion thereof. However, if closure is of a period of more than fifteen (15) days it must be approved by the Board of Supervisors within fifteen (15) days of the chiefs original order of closure. No person is permitted in any hazardous fire area, except on public roadways and inhabited areas during such time as the area is closed to entry. During periods of closure, the chief shall erect and maintain at all entrances to the closed areas sufficient signs giving adequate notice of closure.

Hazardous Materials- Dangerous waste material that can cause serious illness, injury, or death, and environmental damage; Any substance designated pursuant to the Federal Water Pollution Control Act; Any hazardous waste having the characteristics identified under or listed in the Clean Air Act; Any imminently hazardous chemical substance or mixture with respect to which the Administrator of the U.S. EPA has taken pursuant to Toxic Substances Control Act; A designated substance or material that has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce.

HAZUS/HAZUSTM- The standardized methodology based on a geographic information system (GIS) for earthquake loss estimation, is a project of the National Institute of Building Sciences, with funding from the Federal Emergency Management Agency (FEMA). Designed to produce loss estimates for use by state, regional and local governments in planning for earthquake loss mitigation, emergency preparedness and response and recovery. The methodology deals with nearly all aspects of the built environment, and with a wide range of different types of losses. These HAZUS loss estimations are based on current scientific and engineering knowledge, they are improved by mapping of soil type, liquefaction and landslide susceptibility as part of this study, and can be further improved by enhancing building and infrastructure inventory. (see soil type, liquefaction, landslide and landslide susceptibility).

HAZUS Earthquake Induced Fire Scenarios- Fires following earthquakes can cause severe losses. These losses can sometimes outweigh the total losses from the direct damage caused by the earthquake, such as collapse of buildings and disruption of lifelines (e.g. 1906 San Francisco). Many factors affect the severity of the fires following an earthquake, including but not limited to: ignition sources, types and density of fuel, weather conditions, functionality of water systems, and the ability of fire fighters to suppress the fires.

Heavy Urban Search and Rescue Teams- Victim extrication and survivability Implementation. The establishment of Heavy Urban Search and Rescue teams as recommended by (FEMA) Federal Emergency Management Agency (1985). Location and extrication of victims trapped under the rubble is generally a dangerous process that requires equipment to tunnel and lift heavy debris. Extrication of trapped victims within the first 24 hours after the earthquake becomes critical for victim survivability.

High Loss Facilities- Examples include nuclear power plants, dams and flood control structures, freeway interchanges, bridges, and industrial plants that use or store explosives, toxic materials or petroleum products. High-loss facilities, if severely damaged, may result in a disaster far beyond the facilities themselves.

High Occupancy Facilities- Facilities such as high-rise buildings, large assembly public and private facilities and large multifamily residential complexes that have the potential for catastrophic fatalities and crowd control problems.

Hill- A natural elevation of the land surface, rising rather prominently above the surrounding land, usually of limited extent and having a well-defined outline (rounded rather than peaked or rugged), and generally considered to be less than 300 m (1000 ft) from base to summit.

Historic Building Code Design Functions- Estimates of building damage are provided for both "High", "Moderate" and "Low" seismic design criteria. Buildings of newer construction (e.g., post-1973) are best represented by "High" design functions. Buildings built after 1940, but before 1973, are best represented by "Moderate" design functions. If built before about 1940 (i.e. before significant seismic codes existed), "Low" seismic design criteria are more appropriate. The vast majority of buildings in the County of Riverside are considered of "High" seismic design.

Hollows- Bowl-shaped geomorphic scars located at the top of swales and serve as source areas for certain types of debris flows.

Holocene- An epoch of the geologic Quaternary time period, from the end of the Pleistocene- about 10,000 years ago to the present time; Also, the corresponding series of rocks and deposits. When the Quaternary is designated as an era, the Holocene is considered a period.

Homeowner Checklist to Reduce Fire Risk- Designing and installing a fire wise landscape, consider the following: Local area fire history; Site location and overall terrain; Prevailing winds and seasonal weather; Property contours and boundaries; Native vegetation; Plant characteristics; Irrigation requirements; fire resistant landscape (well-irrigated, low growing, and well-spaced); Leave a minimum of 30' around the house to accommodate fire equipment; Take out "ladder fuels" -- vegetation that serves as a link between grass and tree tops. It can carry fire to a structure or from a structure to vegetation; Give yourself added protection with "fuel breaks" like driveways, gravel walkways, and lawns; Keep trees and shrubs pruned; Remove leaf clutter and dead and overhanging branches; Mow lawn regularly; Dispose of cuttings and debris promptly; Store firewood away from the house; irrigation system is well maintained; Use care when refueling garden equipment and maintain it regularly; Store and use flammable liquids properly; build on the most level portion of the land; Use construction materials that are fire-resistant or non-combustible whenever possible; consider using materials such as Class-A asphalt shingles, slate or clay tile, metal, cement and concrete products, or terra-cotta tiles; fire resistive materials such as stucco or masonry; prevent sparks from entering your home through vents, cover exterior attic and underfloor vents with wire mesh no larger than 1/8 of an inch; driveway that is wide enough 12 feet wide with a vertical clearance of 15 feet and a slope that is less than 12 percent - to provide easy access for fire engines; and at least two ground level doors for safety exits and at least two means of escape either a door or window.

HUD Study System- Combines Fuel loading based on U. S. Geological Survey (USGS) life forms, fire weather based on the California Wildland Fire Danger Rating System (CWFDRS), and three Slope Classes taken from CWFDRS.

Hydroconsolidation- Soil collapse that typically occurs in recently deposited, Holocene soils that were deposited in an arid or semi-arid environment. Soils prone to collapse are commonly associated with wind-laid sands and silts, and alluvial fan and mudflow sediments deposited during flash floods. The soils typically contain minute pores and voids. The soil particles may be partially supported by clay, silt, or carbonate bonds. When saturated, the soils (collapsible soils) undergo a rearrangement of their grains and a loss of cementation.

Hydrologic Budget B- An accounting of the inflow to, outflow from, and storage in a hydrologic unit such as drainage basin, aquifer, soil zone, lake, or reservoir; the relationship between evapotranspiration precipitation, runoff, and the change in water storage, expressed by the hydrologic equation.

Hydrologic System- A complex of related parts-physical, conceptual, or both-forming an orderly working body of hydrologic units and their man-related aspects such as the use, treatment and reuse, and disposal of water and the costs and benefits thereof, and the interaction of hydrologic factors with those of sociology, economics, and ecology .

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. Hydroconsolidation.

Hydrology- The science that deals with continental water (both liquid and solid), its properties, circulation, and distribution, on and under the earth's surface and in the atmosphere, from the moment of its precipitation until it is returned to the atmosphere through evapotranspiration or is discharged into the ocean.

Igneous- Said of a rock or mineral that solidified from molten or partly molten material; Also applied to processes leading to, related to, or resulting from the formation of such rocks.

IBCO- International Conference of Building Officials.

Ignition Management- Biomass harvesting, fire resistant landscaping, mechanical and chemical fuels treatments, building construction standards, infrastructure, and land use planning.

Imbricate- A stacked sequence of overlapping; subsurface faults.

Impact- To affect force; An initial usually strong force; The impetus or force produced by a collision.

Incendiary Fire- A fire deliberately set in grass, brush, or woodland areas using a highly flammable substance for ignition.

Inclination- A general term for the slope of any geological body or surface, measured in the upward or downward direction and from the horizontal or the vertical. It is often used synonymously with dip; A deviation from the true vertical or horizontal. Also, the amount of such deviation; the rate of slope or grade; an inclined surface- slope.

Indirect Economic Loss- Earthquakes may produce dislocations in economic sectors not sustaining direct damage. All businesses are forward-linked (rely on regional customers to purchase their output) or backward-linked (rely on regional suppliers to provide their inputs) and are thus potentially vulnerable to interruptions in their operation. Such interruptions are called indirect economic losses. Note that these losses are not confined to immediate customers or suppliers of damaged enterprises. All of the successive rounds of customers of customers and suppliers of suppliers are impacted.

Indurated- Said of a compact rock or soil hardened by the action of pressure, cementation, and especially heat; Said of an impure, hard, slaty variety of talc.

Inertia- The tendency of a body to remain at rest or to stay in motion unless acted upon by an external force; resistance to motion or change.

Infiltration- The movement of water or solutions, especially ore-bearing (profitably mined or extracted) solutions, into a rock through interstices or fractures in or crevasses upon the melting of glacier ice.

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.

International Conference of Building Officials (IBCO)- Maps of known Near-Source Zones in California and adjacent portions of Nevada published by the International Conference of Building Officials and prepared by the California Division of Mines and Geology for use with the 1997 UBC. The changes to the 1997 UBC represent the most significant increases in ground shaking criteria in the last 30 years. In addition, to the new code, soil effects now impact buildings of short predominant period of ground shaking (low-rises).

Inundation- A rising of water and its spreading over land not normally submerged.

Irrigation- The artificial distribution of water over the ground surface, as by canals, pipes, or flooding, in order to promote plant growth.

Isoseismal (isoseismal line)- A line connecting points on the earth's surface at which earthquake intensity is the same. It is usually a closed curve around the epicenter.

Joint- Regularly spaced fractures in rock that result from expansion during cooling or uplift of the rock mass.

Land Subsidence- The loss of surface elevation due to removal of subsurface support; land slip.

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; The down-slope movement of material, whether it be bedrock, regolith, or a mixture of these.

Landslide Management Zones (LMS)- Represents regions susceptible to slope instability. Without the presence of extensive flood control devices, including large debris basins, the areas outlined by the LMZ's may be subject to debris flow inundation.

Landslide Susceptibility Zone Map- Map of yielded potential landslide areas or regions. Seismically induced landsliding and rock falls can be expected to occur in a major earthquake. Development policies, based on the Geographical Information System (GIS) mapping, include avoidance and mitigation of the hazard during construction to help in reducing the potential losses associated with this hazard.

Land-Use- The solid, exposed surface of the earth as distinguished from waters employed or utilized for a certain purpose.

Large Fire- A fire that is out of control at first arrival.

Large Occupancy Structure- Infrastructure that allows for a high volume of people used to live in or employ such as high-rises.

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 that results from liquefaction or plastic flow or subjacent materials.

Latitude- Angular distance of a point on the Earth's surface north or south of equator, measured along the meridian through 90 degrees.

Load- (sed) The material that is actually carried by a natural transporting agent, such as by a stream, wind, waves, etc. The actual quantity or amount of such material at any given time. **(struct geol)** Vertical pressure caused by the weight of the overlying rocks, as a result of gravity alone.

Loess- A widespread, homogeneous, commonly nonstratified, porous, friable, unconsolidated but slightly coherent, usually highly calcareous, fine-grained, blanket deposit of loam consisting predominantly of silt with subordinate grain-sizes ranging from clay to fine sand. It is buff to light yellowish or yellowish brown in color thought to be windblown dust of Pleistocene age lying south of the limits of the ice sheets or from unconsolidated glacial deposits.

LUST- Leaking Underground Storage Tank.

LUSTIS- Leaking Underground Storage Tank Information Systems.

Left-Lateral Strike Slip Fault- A fault, the displacement of which is of left-lateral separation, with movement of a lateral fault along which, in map view, the side opposite the observer appears to have moved to the left.

Left-Lateral Separation- Movement of a lateral fault along which, in plan view, the side opposite the observer appears to have moved to the left

Levee- An artificial embankment of earth fill, built along the bank of a water course or an arm of the sea in design to protect land from inundation (flooding).

Lifelines- Such as the control tower in an airport, or the buildings housing the computers and telephone circuits central to the communication lifelines of a district, bridges, highways and freeways.

Lifeline Categories- A hazard analysis focuses on four lifeline categories: (1) water and sewer facilities, (2) transportation facilities, (3) electric power facilities, and (4) gas and liquid fuel lines.

Lifeline System- Linear conduits or corridors for the delivery of services or movement of people and information (e.g. pipelines, telephones, freeways, railroads).

Lifeline System Facilities- Facilities whose operations are necessary at all times of emergencies, such as emergency transmission systems, major utility lines, evacuation and disaster routes, and warehouses storing heavy rescue and debris cleanup equipment.

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 non-binding soils from a solid or liquid state as a result of increased pore pressure and reduced effective stress. Liquefaction occurs primarily in saturated loose, fine to medium-grained soils in areas where the ground water table is 50 feet or less below the ground surface. When these sediments are shaken, such as during an earthquake, a sudden increase in pore water pressure causes the soils to lose strength and behave as a liquid. Excess water pressure is vented upward through fissures and soil cracks causing a water-soil slurry to bubble onto the ground surface. The resulting features are called sand boils, sand blows or "sand volcanoes." Liquefaction-related effects include loss of bearing strength, ground oscillations, lateral spreading, and flow failures or slumping.

Liquefaction-Induced Ground Failure Map- These maps attempt to characterize permanent ground displacements associated with liquefaction. These maps may be either of the scenario earthquake type or the probabilistic (see definition of probability) type.

Liquefaction Opportunity Map- Research into the process and consequences of liquefaction in past earthquakes have linked liquefaction to certain hydrologic and geologic settings, characterized by water-saturated, cohesionless, granular materials situated at depths of less than 50 feet. In simplified terms, the procedure used to delineate areas having significant potential for liquefaction requires development of a liquefaction opportunity and summarizes information about the potential for strong earthquake shaking.

Liquefaction Potential- Using the Liquefaction Opportunity Map and the Liquefaction Susceptibility Map to determine the relative likelihood that an earthquake will cause liquefaction in an area.

Liquefaction Potential Map- Incorporates considerations of both the susceptibility of the soils and the earthquake potential in a region. One kind of liquefaction potential map expresses the likelihood of liquefaction in the various geologic deposits for one or more selected regional scenario earthquakes. A second kind of potential map expresses either the likelihood of liquefaction of the geological deposits during a certain time period (for example, 10% probability of liquefaction in 50 years) or a return period for liquefaction (for example, average 500-yr return period for liquefaction occurrence).

Liquefaction Resistance- In areas of Holocene and Pleistocene deposition, geotechnical and hydrologic data are compiled. Standard Penetration Test (SPT) and/or Cone Penetration Test (CPT) and grain size distribution data can be used for liquefaction resistance evaluations.

Liquefaction Severity Index (LSI)- Expresses estimated maximum amounts of ground displacement due to lateral spreading in gently sloping, highly liquefaction-susceptible deposits for selected probabilities of exceedance and time periods.

Lithology- The description of rocks, esp. sedimentary rock types and esp. in hand specimen and in outcrop (a portion of bedrock or other stratum protruding through the soil level), on the basis of such characteristics as color, structures, mineralogical composition and grain size; The physical character of a rock.

LSI- Liquefaction Severity Index map.

LMS- Land Management System.

LMZ- Landslide Management Zones.

Local Response Areas (LRAs)- The Bates Bill Process is utilized to determine Very High Fire Hazard Severity Zones (VHFHSZs) in LRAs.

Long Period Structure- High-rise buildings and bridges. Several factors control how ground motion interacts with structures, making the hazard of ground shaking difficult to predict. In general, however, long-period seismic waves, characteristic of earthquakes that occur about 10 miles (15 kilometers) and farther from the area of concern, interact with and damage preferentially long-period structures.

Low Probability/High Consequence Events- For example -Major earthquakes seldom occur, but when they do, catastrophic consequences follow. Because the limited number of past events and the difficulty in accurately predicting future events, insurers need to utilize the risk assessments from experts. However, these estimates are highly uncertain and ambiguous. For example, scientists forecast that a catastrophic earthquake will occur in Riverside County, but they do not know if it will occur next year, or if it will occur in 100 years, or which specific communities will be most affected.

LRAs- Local Response Areas

Magnitude- A measure of the size of an earthquake, as determined by measurements from seismograph records.

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.

Mandatory- Required by, having the nature of, or relating to a mandate; Obligatory

Marine Deposits- Of pertaining to, existing in, or formed by the sea; Typically marsh-like silt, sand, and fine gravel

Marsh- An area of low, wet land; a swamp; A water-saturated, poorly drained area, intermittently or permanently water-covered, having aquatic and grass-like vegetation, essentially without peat-like accumulation.

Mass-Wasting- The down slope movement of rock and regolith near the earth's surface mainly due to the force of gravity. Mass-wasting is an important part of the erosional process, as it moves material from higher elevations down to lower elevations where transporting agents like streams can then pick up the material and move it to even lower elevations.

Master Fault- Such as the San Andreas Fault that controls the seismic hazard for Southern California.

Matrix- (sed) The smaller or finer-grained, continuous material enclosing, or filling the interstices between, the larger grains or particles of a sediment or sedimentary rock; the natural material in which a sedimentary particle is embedded. The term refers to the relative size and disposition of the particles, and no particular particle size is implied. **(ign)** The fine-grained interstitial material of an igneous rock; e.g. the material surrounding the phenocrysts (large grains found set in finer-grained groundmass) of a porphyritic (texture term describing igneous rocks with phenocrysts) rock.

Maximum Credible Earthquake (MCE)- 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 Moment Magnitude (MMM)- Calculated from rupture area regressions (type "all") from Wells and Coppersmith (1994); Largest magnitude events which have the highest rate of seismicity.

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.

MCE - Maximum Credible Earthquake.

Meander (stream) One of a series of somewhat regular, sharp, freely developing, and sinuous curves, bends, loops, turns, or winding in the course of a stream. It is produced by a mature stream swinging from side to side as it flows across its flood plain or shifts its course laterally toward the convex side of an original curve.

Mercalli Intensity Scale (MMI)- An arbitrary scale of earthquake intensity, ranging from I (detectable only instrumentally) to XII (causing almost total destruction). It is named after Giuseppe Mercalli (d. 1914), the Italian geologist who devised it in 1902. Its adaptation to North American conditions is known as the Modified Mercalli Scale.

Metamorphic Rock- Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement. Nearly all such rocks are crystalline.

Metamorphism- The processes by which changes are brought about in rocks within the earth's crust by the agencies of heat, pressure, and chemically active.

Meteorology- The study of the earth's atmosphere, including its movements and other phenomena, especially as they relate to weather forecasting.

Microzonation- The detailed mapping of various seismic hazards for use in urban and disaster planning.

Mills Act- Enacted by the state legislature in 1976 and amended in 1985. Owners of historical properties can enter into a contract with a local government in order to qualify for property tax relief. The Mills Act requires a mandatory ten-year contract, subject to annual notice of non-renewal provisions that then starts a phase-out of the contract over the remaining nine-year period. Mills Act contract procedures provide the County the choice of which properties to include in the program and what seismic upgrading or other conditions to require, while at the same time providing property owners an incentive for offsetting retrofitting costs with property taxes saved.

Mitigation- To make or become less severe or painful by planning to result in reduction of life and property using building codes and hazard studies; Any action taken before an earthquake that has the potential to reduce the consequences of an earthquake. Non-construction actions, such as reducing the number of people in a building or removing hazardous contents, and construction actions that are not strengthening per se, such as removing the upper floors of a building or adding base isolation, are considered mitigation, as are all types of seismic strengthening or upgrading. This definition is intended for general use and is not to be confused with Federal Emergency Management Agency (FEMA's) legal definition.

MMI- Mercalli Intensity Scale.

MMLW- Mean Low-Low Water.

MMM- Maximum Moment Magnitude.

Mobile Home- Prefabricated housing units that are trucked to the site and then placed on isolated piers, jackstands, or masonry block foundations (usually without any positive anchorage). Floors and roofs of mobile homes usually are constructed with plywood and outside surfaces are covered with sheet metal. Mobile homes typically do not perform well in earthquakes.

Model Fire Hazard Reduction Ordinance To assist local governments in adopting ordinances to reduce fire hazard in local jurisdictions, the State Fire Marshal, Fire Engineering Division has developed a model checklist. The development of this model was required by Assembly Bill 3819, on September 27, 1994. The model ordinance addresses the following standards: Road Standards for Fire Equipment Access, Structural Standards, and Fuel Modification Standards.

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.

Moisture- Water diffused in the atmosphere or the ground, including soil water.

Mojave Desert- The Mojave Desert province consists of the eastern approximately one-half of the County, and includes the Blythe area. This province in Riverside County has a moderate to low rate of seismicity and very few mapped faults. However, north of the County, the Mojave Desert province was the location of the 1992 Landers MW 7.3, and the 1999 Hector Mine MW 7.1 earthquakes and numerous active right-lateral strike-slip faults .

Monte Carlo Simulation Model- A procedure in statistics by which random numbers are used to approximate the solution to intractable mathematical or physical problems. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area.

Moratorium- A deferment or delay of any action.

Mottling- (soil) Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage.

Mountain Range- A single, large mass consisting of a succession of mountains or narrowly spaced mountain ridges, with or without peaks, closely related in position, direction, formation, and age; a component part of a mountain system or of a mountain chain.

MPE- Maximum Probable Earthquake.

Mudflood- Refers to a flood in which the water carries heavy loads of sediment (as much as 50 percent by volume) including coarse debris. Mudfloods typically occur in drainage channels and on alluvial fans adjacent to mountainous regions, although they may occur on floodplains as well.

Mudflow- Wet earth flow containing 50% fragments smaller than 2 mm (Varnes, 1978).

Munsell Notation- A designation of color by degrees of the three simple variables hue, value, and chroma. I.e. 10YR 6/4 whereas 10YR hue, value of 6, and chroma of 4.

MWD- Metropolitan Water District. Emergency storage is required in the event of an interruption of the Metropolitan Water District (MWD) primary supply. MWD recommends a seven day emergency storage supply.

National Flood Insurance Program- Individuals and business owners can protect themselves from property losses by purchasing flood insurance through Federal Emergency Management Agency - FEMA's National Flood Insurance Program.

National Institute of Building Sciences- The development of HAZUSTM, the standardized methodology based on a geographic information system for earthquake loss estimation, is a project of the National Institute of Building Sciences.

National Oceanic and Atmospheric Administration (NOAA)- Since the early 1990's, the EROS Data Center (EDC) has been producing weekly and biweekly maps for the 48 contiguous states and Alaska that display plant growth and vigor, vegetation cover, and biomass production, using multispectral data from satellites of NOAA.

National Seismic Hazard Mapping Program- Consists of USGS and CDMG scientists that have produced maps indicating the probabilistic ground shaking parameters. Probabilistic Earthquake Hazard Assessment is utilized by the U.S. Geological Survey in producing national seismic hazard maps that are modified and adopted into the Uniform Building Code (UBC). Mapping produced for the 1997 UBC includes data from the California Division of Mines and Geology (CDMG, 1996). Development of these maps requires three steps: 1) delineating earthquake sources; 2) defining the potential distribution of seismicity for each of these sources; and 3) calculating the potential ground motions from attenuation relations for all the model earthquakes.

National Weather Service- Federal agency that plays a role in fire hazard mitigation, response and recovery. www.nws.noaa.gov

Natural Deposits- Material of any type or from any source that has accumulated or produced or existing by nature.

Natural Gas- Any of the gaseous hydrocarbons generated below the earth's surface. Methane is usually found as a product of decaying vegetable matter; ethane, propane, and butane in association with liquid hydrocarbons and distilled within the lithified crust.

Natural Hazard Disclosure Statement- If a property is located in a Seismic Hazard Zone the seller or the seller's agent must disclose this fact to potential buyers as provided in Section 1102.6c of the California Civil Code or to use the Local Option Real Estate Disclosure Statement as provided in Section 1102.6a of the California Civil Code.

Natural Hazards- A risk; chance; An accident; Source of danger produced or existing in nature; e.g. wildland fire, flooding, or earthquakes.

Natural Hazards Disclosure Act- Requires that sellers of real property and their agents provide prospective buyers with a "Natural Hazard Disclosure Statement" when the property being sold lies within one or more state-mapped hazard areas. If a property is located in a Seismic Hazard Zone as shown on a map issued by the State Geologist (Division of Mines and Geology), the seller or the seller's agent must disclose this fact to potential buyers. The law specifies two ways in which this disclosure can be made. One is to use the new Natural Hazards Disclosure Statement as provided in Section 1102.6c of the California Civil Code. The other way is to use the Local Option Real Estate Disclosure Statement as provided in Section 1102.6a of the California Civil Code. The Local Option Real Estate Disclosure Statement can be substituted for the Natural Hazards Disclosure Statement only if the Local Option Statement contains substantially the same information and substantially the same warning as does the Natural Hazards Disclosure Statement.

NEHRP - National Earthquake Hazard Reduction Program.

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).

Near-Source- Identification, location, and directivity of fault rupture within a designated hazard zone.

Net Slip- On a fault, the distance between two formerly adjacent points on either side of the fault, measured on the fault surface or parallel to it. It defines both the direction and relative amount of displacement (total slip).

NOAA- National Oceanic and Atmospheric Administration. Since the early 1990's, the EROS Data Center (EDC) has been producing weekly and biweekly maps for the 48 contiguous states and Alaska that display plant growth and vigor, vegetation cover, and biomass production, using multispectral data from satellites of NOAA.

Nonductile- Refers to concrete construction using columns and beams with insufficient steel reinforcing, making a structure likely to break and prone to collapse during earthquakes.

Non-structural- Damage to buildings is commonly classified as either structural or non-structural. Non-structural damage does not affect the integrity of the structural support system. Examples of non-structural damage include broken windows, collapsed or rotated chimneys, and fallen ceilings.

Normal Fault- A fault in which the hanging wall appears to have moved downward relative to the footwall. The angle of the fault is usually 45-90°. There is dip separation but there may or may not be dip slip .

North American Plate- Earthquakes in Southern California occur as a result of movement between the Pacific and North American plates. The boundary between these plates bisects Riverside County. However, movement is broadly distributed across the area, and is accommodated by several faults that are located both onshore and offshore. Most of the movement (about 70%) between these plates is accommodated by the San Andreas fault. The rest of the motion is distributed between the Eastern Mojave Shear Zone (a series of faults east of the San Andreas, responsible for the 1992 Landers and the 1999 Hector Mine earthquakes), the northwest-trending San Jacinto, Whittier-Elsinore, Newport-Inglewood and Palos Verdes fault zones, and several east-trending thrust faults along the southern boundary of the Transverse Ranges .

Not Active- A fault that does not show evidence of, or is suspected of having experienced surface displacement within the last 11,000 years; A fault that on the basis of historical, seismological, or geological evidence does not have the finite probability of producing an earthquake.

Oblique Slip- In a fault, movement or slip that is intermediate in orientation between the dip slip and strike slip .

Oblique Slip Fault- A fault, the slip (movement) of which is oblique to, rather than parallel or perpendicular to, the dip of the constituent rocks or dominant structure.

Offset ridge- A ridge that is discontinuous on account of faulting.

Offset stream- A stream displaced laterally or vertically by faulting.

Operational Area Coordinator for the California Fire & Rescue Mutual Aid- Riverside County Fire Department (RCOFD) is the Operational Area Coordinator for the California Fire and Rescue Mutual Aid System for all fire service jurisdictions in the County of Riverside. It also has several automatic aid agreements with other city jurisdictions as well as the adjacent National Forests. The County of Riverside contracts with the State of California for fire protection. Public Resources Code (PRC) 4142 affords legal authority for the California Department of Forestry and Fire Protection to enter into agreements with local government entities to provide fire protection services with the approval of the Department of General Services. By virtue of this authority, California Department of Fire (CDF) administers the Riverside County Fire Department.

Ordinance- Laws adopted as specific implementation measures to General Plan goals, objectives or policies.

Organic Matter- Plant and animal residue in the soil in various stages of decomposition

Outcrop- A portion of bedrock or other stratum protruding through the soil level. That part of a geologic formation or structure that appears at the surface of the Earth; also, bedrock that is covered only by surficial deposits such as alluvium.

Overdraft- Withdrawal of ground water in excess of replenishment.

Overdrafted Valley- Where subsidence typically occurs, with differential displacement and fissures (joints) manifested at or near the valley margin.

Pacific Plate- Earthquakes in Southern California occur as a result of movement between the Pacific and North American plates. The boundary between these plates bisects Riverside County. However, movement is broadly distributed across the area, and is accommodated by several faults that are located both onshore and offshore. Most of the movement (about 70%) between these plates is accommodated by the San Andreas fault. The rest of the motion is distributed between the Eastern Mojave Shear Zone (a series of faults east of the San Andreas, responsible for the 1992 Landers and the 1999 Hector Mine earthquakes), the northwest-trending San Jacinto, Whittier-Elsinore, Newport-Inglewood and Palos Verdes fault zones, and several east-trending thrust faults along the southern boundary of the Transverse Ranges .

Paleoseismology- The study of ancient seismic (earthquake) events.

Parameters (stat) Any arbitrary numerical constant derived from a population or a probability distribution and characterizing by each of its particular values some particular member of a system; a quantity related to one or more variables in such a system; a quantity related to one or more variables in such a way that it remains constant for any specified set of values of the variable or variables; Any measurable characteristic of a sample or population; any of a set of physical properties whose values determine the characteristics or behavior of a system.

Parent Material- The unconsolidated organic and mineral material in which soil forms.

Parapet- The portion of any wall which extends above the roof line, or a wall that serves as a guard at the edge of a balcony or roof.

Particle Size- The general dimensions (such as average diameter or volume) of the particles in a sediment or rock, or of the grains of a particular mineral that make up a sediment or rock, based on the premise that the particles are spheres or that the measurements made can be expressed as diameters of equivalent spheres. It is commonly measured by sieving, by calculating settling velocities, or by determining areas of microscopic images.

Pathogen- Any agent that causes disease, especially a microorganism (animal or plant of microscopic size) such as a bacterium or fungus.

Peak Ground Acceleration (PGA)- The greatest amplitude of acceleration measured for a single frequency on an earthquake accelerogram (the record of the detection of acceleration of earth particles). The maximum horizontal ground motion generated by an earthquake. The measure of this motion is the acceleration of gravity (equal to 32 feet per second squared, or 980 centimeter per second squared), and generally expressed as a percentage of gravity.

Peak Flood- The highest discharge or stage value of a flood.

Peak Load Water Supply- Maximum quantity of water available for use.

Peak Water Flow Requirements- Sufficient water flow available to fight fires. Peak water flow requirements are based on building type, design, and use.

Peninsular Ranges- This province is characterized by major right-lateral strike-slip faulting associated with the San Jacinto and Elsinore faults and includes the Santa Ana and San Jacinto Mountain ranges in the County.

Perched ground water- Unconfined ground water separated from an underlying main body of ground water by an unsaturated zone.

Permeability- (geol) The property or capacity of a porous rock, sediment, or soil for transmitting a fluid without impairment of the structure of the medium; A measure of the relative ease of fluid flow under unequal pressure.

Petroleum- A naturally-occurring complex liquid hydrocarbon that may contain varying degrees of impurities (sulfur, nitrogen) which alter distillation yields a range of combustible fuels, petrochemicals, and lubricants.

Petrologic- Of pertaining to petrology.

Petrology- That branch of geology dealing with the origin, occurrence, structure, and history of rocks, esp. igneous and metamorphic rocks. Petrology is broader in scope than petrography, which is concerned with the description and classification of rocks.

PGA- Peak Ground Acceleration.

Physiographic Setting- Landforms and features considered with regard to its origin, cause, or history.

Piling- Used to pin a structure to stable bedrock below using long piles emplaced through an unstable zone of potential ground failure; commonly utilized for landslide and liquefaction mitigation. Commonly made of steel-reinforced concrete, steel or wood.

Pilot and Calibration Studies- Economic loss module to calculate a loss estimate for earthquakes and their effect upon buildings and facilities. Of course, uncertainties are inherent in any loss estimation methodology arising in part from incomplete scientific knowledge and in part from the approximations and simplifications necessary for comprehensive analyses. Pilot and calibration studies have as yet not provided an adequate test concerning the possible extent and effects of landsliding .

Planned Community- Are large, often multi-purpose development projects which implement the General Plan over a defined area of over 300 acres.

Plate- One of the large, nearly rigid, but still mobile segments or thin blocks involved in plate tectonics, with a thickness (50-250 km) that includes both crust and some part of the upper mantle (zone between the earth's crust and core).

Plastic- (struct) Said of a body in which strain produces continuous, permanent deformation without rupture.

Pleistocene- The earliest Epoch of the Quaternary Period beginning about 1.6 million years ago and ending 10,000 years ago. Commonly known as the "Ice Age" a time with episodes of widespread continental glaciation. When the Quaternary is designated as an era, the Pleistocene is considered to be a period.

Pliocene- An epoch of the Tertiary period, after the Miocene and before the Pleistocene; Also, the corresponding worldwide series of rocks. It is sometimes considered to be a period, when the Tertiary is designated an era.

Poorly Graded- Refers to a coarse- grained fragments or coarse-grained consisting mainly of particles of nearly the same size.

Pore Pressure- The stress transmitted by the fluid that fills the voids between particles of a soil or rock mass.

Pore Water Pressure- Neutral stress; The stress transmitted through the fluid that fills the voids between particles of a soil or rock mass; e.g. that part of the total normal stress in a saturated soil due to the presence of interstitial water.

Postfire Effects- Wildfires leave problems behind them, even when the last ember is extinguished. During an intense wildfire, all vegetation may be destroyed; also the organic material in the soil may be burned away or may decompose into water-repellent substances that prevent water from percolating into the soil. As a result, even normal rainfall may result in unusual erosion or flooding from a burned area; heavy rain can produce destructive debris flows. The watersheds of Riverside County may also be negatively affected by fire. The loss of ground-surface cover, and the chemical transformation of burned soils make watersheds more susceptible to erosion from rainstorms, and impairs water quality.

Postfire Management- To lessen the costly impacts of future wildfires and offer alternatives to continually increase suppression forces.

Potential Flood Limit- Capable but not yet in existence of the boundary of rising water and its spreading over land not normally submerged in the remote possibility a dam is catastrophically breached. Under State jurisdiction dams over 50 feet in height or 50 acre-feet in storage capacity are required to have inundation (flood) maps.

Potentially Active Fault- Under the APE a fault showing evidence of movement within the last 1.6 million years (750,000 years according to the U.S. Geological Survey) but before about 11,000 years ago, and that is capable of generating damaging earthquakes.

Power Intertie- Terminal facilities in a lifeline network system, such as water and sewage pumping stations, electrical power substations, and power generating facilities.

Pre-cast Components- Steel frame or concrete frame buildings with unreinforced masonry walls, reinforced concrete wall buildings with no special detailing or reinforcement,

Precipitation-(meteor) The discharge of water (as rain, snow, hail, or sleet) from the atmosphere upon the Earth's surface. It is measured as a liquid regardless of the form in which it originally occurred; in this sense, it may be called rainfall.

Pre-fabricated Elements- A constituent part or parts that are trucked to the site. Mobile homes are prefabricated housing units and then placed on isolated piers, jackstands, or masonry block foundations (usually without any positive anchorage). Pre-cast frames are often weakened due to a combination of the accumulated stresses that may result from shrinkage and creep, and due to stresses incurred during transportation. Vertical support may fail if the building was designed with an inadequate bearing area and/or with insufficient connections between floor elements and columns. Corrosion of the metal connectors between prefabricated elements may also occur weakening the structure.

Prefire Management- Includes a systematic application of risk assessment, fire safety, fire prevention and fire hazard reduction techniques. The County's extreme diversity and complex pattern of land use and ownership require equally diverse and complex techniques to effectively manage the fire environment. Some options are the responsibilities of state, federal and local governments; others fall to private citizens or businesses; most are joint responsibilities. They should lessen the costly impacts of future wildfires and offer alternatives to continually increasing suppression forces.

Prescribed Fire (burns)- Term used for occasions when a fire is deliberately set, under carefully controlled and monitored conditions. The purpose is to remove brush and other undergrowth which can provide fuel for naturally occurring fires. Fire is an essential ecological process in many ecosystems. Prescribed fire is used to alter, maintain or restore vegetative communities, achieve desired resource conditions, and to protect life, property, and values 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 analysis.

Pressure- The force exerted across a real or imaginary surface divided by the area of that surface; the force per unit area exerted on a surface by the medium in contact with it.

Private Streets- Streets or roads not dedicated for public usage and, therefore, not maintained by the City; usually within planned developments or condominiums.

Probability- A statistical measure (where zero is impossibility and one is certainty) of the likelihood of occurrence of an event.

Probabilistic Seismic Hazard Assessment- Takes into account the recurrence rates of potential earthquakes on each fault in the area and the potential ground motion that may result from each of these earthquakes.

Project- A development application involving zone changes, variances, conditional use permits, tentative parcel maps, tentative tract maps, and plan amendments.

Proposition 218- This measure was adopted in November 1996 and dramatically revised local government finance. Proposition 218 transfers from local elected officials the power to establish new revenue sources, other than use fees, and requires voter or property owner approval to do so. It can be understood as replacing representative democracy in local government finance with direct democracy; Affects most local government revenues, including garbage collection fees, fire assessments, and utility user taxes. The only local revenues not affected directly by Proposition 218 are: fees for local services not related to property, gas and electric charges, fees collected as a condition of property development, and intergovernmental transfers (Colantuono, 1997).

Province- An extensive region all parts of which are characterized by similar geologic history or by particular structural, petrographic, or physiographic features.

Pseudostatic- A simplified engineering analyses of the stability of a site or structure that translates earthquake ground motion into a static force in performing stability calculations.

P wave- Primary body wave that arrives before the S wave; The type of seismic body wave which is propagated by alternating compression and expansion of material in the direction of propagation. It is the fastest of the seismic waves (traveling 6.0-6.7 km/sec in the crust and 8.0-8.5 km/sec in the upper mantle), and it is the type carrying sound.

Quaternary- The second period of the geologic Cenozoic era, following the Tertiary; also, the corresponding system of rocks. It began two to three million years ago and extends to the present. It consists of two grossly unequal epochs the Pleistocene and the Holocene. The Quaternary may also be incorporated into the Neogene, when the Neogene (incorporating the Miocene and Pliocene) is designated as a period of the Tertiary Era.

Range/Rangeland- A tract of land over which animals such as cattle and horses graze; an extended line or row especially of mountains.

RCOFD- Riverside County Fire Department..

Rebound- In relation to subsidence said to occur when land springs back during intervening periods of water level recovery.

Recharge- The processes involved in the absorption and addition of water to the zone of saturation. This does not include water reaching the belt of soil water or the intermediate belt. Also, the amount of water added.

Reconstruction- To construct or assemble again and has the meaning of demolishing an existing building, partially or totally, and to rebuild and refashion it, due to damage, deterioration, change of function and use or due to other causes.

Recovery Reconstruction Act (1986)- Authorizes local governments to prepare before a disaster for expeditious and orderly recovery and reconstruction afterward. It enables pre-disaster plan preparedness and ordinances which may include: an evaluation of the vulnerability of specific areas under its jurisdiction to damage from a potential disaster, together with streamlined procedures for the appropriate modification of existing general plans or zoning ordinances affecting those areas after a disaster; a contingency plan of action and organization for post-disaster short-term and long-term recovery and reconstruction; and, a pre-disaster ordinance to provide adequate local authorization for post-disaster activities.

Recurrence Earthquake Interval- (fault) The average temporal duration between actual occurrences of a fault event of a given or greater magnitude. (hydrol) In an annual flood series, the average interval in which a flood of a given size recurs as an annual maximum. In a partial duration series, the average interval between floods of a given size, regardless of their relationship to the year or any other period of time. This distinction holds even though for large floods recurrence intervals are nearly the same on both scales.

Recurrence Rate- Probabilistic seismic hazard assessment that takes into account the time between events of potential earthquakes on each fault in an area and the potential ground motion that may result from each of these earthquakes.

Recycle- To extract and reuse; To extract useful materials.

Regional Statistical Area- Primarily for census and population purposes, areas within the five County areas of Southern California Association of Governments are divided into Regional Statistical Areas (RSAs).

Regolith- A general term for the entire layer of fragmental and loose, incoherent, or unconsolidated rock material, of whatever origin (residual or transported) and of very varied character, that nearly everywhere forms the surface of the land and overlies or covers the more coherent bedrock. It includes rock debris (weathered in place) of all kinds, volcanic ash, glacial drift (rock and soil material carried by glacier), alluvium, loess, and eolian deposits, vegetal accumulations, and soils.

Rehabilitation- Pre-earthquake construction actions that improve the seismic resistance of a structure to its original capacity by repairing, architectural remodeling and restoration. The term "rehabilitation" is used in this sense by the federal government in FEMA's series of publications on existing buildings.

Reinforced Masonry- Masonry construction with steel reinforcement.

Reinforcement- The act or process of giving more force or effectiveness to strengthen or support.

Relative Density- The ratio of the difference between the void ratio of a cohesionless soil in the loosest state and any given void ratio to the difference between its void ratios in the loosest and the densest states.

Relative Humidity- The ratio, expressed as a percentage, of the actual amount of water vapor in a given volume of air to the amount that would be present if the air were saturated at the same temperature.

Remodeling- To alter the structure, to make anew or in different form; Reconstruction, renewal, or restoration of an existing building due to change of usage, function or occupancy.

Repair- Post-earthquake restoration of what is broken or torn apart. Providing to the structural and non-structural elements the same level of resistance and capacity they had before damage occurred; repair of damage that does not increase the seismic resistance of a structure beyond its pre-earthquake state; also repair of damage due to other causes that returns the building to its original seismic resistance.

Reservoir- A body of water collected and stored in natural or artificial lake. Types of reservoirs include flood control, water supply and power generation.

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.

Response spectra - The range of potentially damaging frequencies of a given earthquake applied to a specific site and for a particular building or structure.

Retrofit- Post-earthquake improvement of the seismic resistance of a structure, including repair of damage and upgrading of structural and/or nonstructural systems to provide a higher level of resistance than existed before the earthquake; Seismic upgrading or seismic improvement; To restore pre-1971 infrastructure for seismic upgrade in response building codes for hazard mitigation.

Reverse Fault- Thrust fault with a high angle ($>30^\circ$) dipping fault where one side is pushed relatively up and over the other side.

Right-lateral Strike Slip Fault- A fault, the displacement of which is right-lateral separation, with movement of a lateral fault along which, in map view, the side opposite the observer appears to have moved to the right.

Riley Act- Act which established the first lateral force standards for structures after the Long Beach earthquake of 1933.

Risk- The possibility or chance of suffering loss or injury and to the degree of probability of such loss; danger; A factor, element, or course involving uncertain danger; hazard. The danger or possibility of loss with respect to a person or thing.

Riverbed- The channel containing or formerly containing the water of a river.

Riverside County Fire Department (RCOFD)- RCOFD is one of the largest regional fire service organizations in California. It operates out of fire department headquarters in the city of Perris and 85 fire stations in 16 battalions, providing fire suppression, emergency medical, rescue, and fire prevention services. The department's service area is organized into two operational areas and six divisions. RCOFD is the Operational Area Coordinator for the California Fire and Rescue Mutual Aid System for all fire service jurisdictions in the County of Riverside. It also has several automatic aid agreements with other city jurisdictions as well as the adjacent National Forests.

Riverside Fire Laboratory- Of the U.S. Forest Service the laboratory conducts research on: Air Pollution and Climate Impacts on Western Forest Ecosystems; Meteorology for Fire Severity Forecasting; Wildland Recreation and Urban; Prescribed Fire and Fire Effects; and Fire Management in the Wildland/Urban Interface.

Riverside Ranger Unit- of CDF (with headquarters in Perris) provides direct protection for 1,070,000 acres of "wildland." These vegetation-covered, watershed lands are designated by the State Board of Forestry as state responsibility areas. This is generally private land, outside of incorporated cities and federally owned land, where the organized protection force is at maximum strength during the declared "fire season."

Roadcut- Geology, soil, stratigraphic units and/or geologic structures observed from an incision made from construction of a road or passageway for vehicles..

Rockfall- The relatively free falling or precipitous movement of newly detached segment of bedrock (usually massive, homogeneous, or jointed) of any size from a cliff or other very steep slope. Occurs when a piece of rock on a steep slope becomes dislodged and drops down the slope. It may be a single rock or a mass of rocks, and the falling rocks can dislodge other rocks as they collide with the cliff. Because this process involves the free fall of material, falls commonly occur where there are steep cliffs.

Rockfall Hazards- Areas susceptible to rockfall. Usually, located below steep, resistant outcrops of relatively well-cemented materials. Such materials underlie much of Riverside County's mountain ranges. The rockfall hazard in the County is considered high for hillside development, as well as for development located adjacent to steeply ascending slopes.

Rock Avalanche- Rapidly moving and large volume of debris fall (wet or dry).

Rock Fragments- Rock or mineral fragments having a diameter of 2 mm or more. i.e. pebbles, cobbles, stones, and boulders.

Rockslides- Results when rocks slide down a pre-existing surface, such as a bedding plane, foliation surface, or joint surface. Piles of talus (coarse angular rock fragments) are common at the base of a rock slide. Slides differ from slumps in that there is no rotation of the sliding rock mass along a curved surface.

RSAs- Regional Statistical Areas.

Rubble- A loose mass, layer, or accumulation of rough, irregular, or angular rock fragments broken from larger masses usually by physical (natural or artificial) forces, coarser than sand.

Runoff- (water) That part of precipitation appearing in surface streams. It is more restricted than streamflow as it does not include stream channels affected by artificial diversions, storage, or other works of man. With respect to promptness of appearance after precipitation, it is divided into direct runoff and base runoff; with respect to source, it is divided into surface runoff, storm seepage, and ground-water runoff. It is the same as total runoff used by other workers.

Saltation- (sed) A mode of sediment transport in which the particles are moved progressively forward in a series of short intermittent leaps, jumps, hops, or bounces from a bottom surface; e.g. sand particles skipping downwind by impact and rebound along a desert surface, or bounding downstream under the influence of eddy (circular motion with a different direction from that of the main current) currents that are not turbulent enough to retain the particles in suspension (supporting the weight of undissolved sediment particles and keeping them held in the body of the surrounding fluid) and thereby return them to the stream bed at some distance downstream. It is intermediate in character between suspension and the rolling or sliding of traction.

Salton Trough- The trough is a broad structural depression under which oceanic-type sea floor spreading is occurring, and is considered the northward extension of the Gulf of California. Although tectonically similar to the Gulf of California, the trough is filled with as much as three miles of sediment derived primarily from the Colorado River. During the last 10,000 years, the trough has been periodically inundated by bodies of water, the latest being the formation of the Salton Sea in 1905. At present the trough is cut off from the Gulf of California by the accumulation of sediment at the mouth of the Colorado River.

San Andreas Fault- The principal boundary between the Pacific and North American Plates. In southern California, the San Andreas fault system is comprised of three segments: 1) the San Bernardino Mountains segment, 2) the Coachella Valley segment, and 3) the Mojave Desert segment; Considered the "Master Fault", controlling the seismic hazard for Southern California.

Sand- (soil) A term used in the U.S. for a rock or mineral particle in the soil, having a diameter in the range of 0.05-2 mm. The diameter range recognized by the International Society of Soil Science is 0.02-2 mm. As a soil textural class, a soil that is 85 percent or more sand and not more than 10% clay.

(eng) A round fragment having a diameter in the range of 0.074mm (retained on U.S., standard sieve no.200) to 4.76 mm (passing U.S. standard sieve no.4).

(sed) A rock fragment or detrital particle smaller than a granule and larger than a coarse silt grain, having a diameter in the range of 1/16 to 2 mm (62-2000 microns) or a size between that at the lower limit of visibility of an individual particle with the unaided eye and that of the head of a small wooden match, being somewhat rounded by abrasion in the course of transport. (b) A loose aggregate of un lithified mineral or rock particles of sand size; an unconsolidated or moderately consolidated sedimentary deposit consisting essentially of medium-grained fragment. The material is most commonly composed of quartz resulting from rock wearing away.

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 (broken fragments of preexisting rocks) 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 Watershed Project (SAWPA)- Groundwater mapping for Riverside used data from this agency to obtain highest recorded groundwater elevation.

Santa Ana Winds- Named by the early settlers at Santa Ana. The formation of Santa Ana wind is a typical pressure configuration that consists of a stalled but intense high pressure called the Great Basin High near Idaho and Salt Lake, and a weak low pressure system just off shore of southern California (Chen, 2000). These winds constitute a contributing factor that cause small fires to spread quickly and create the need for an increased level of fire protection.

Saturated- Said of the condition in which the spaces between the materials are filled with a liquid, usually water.

SAWPA- Santa Ana Watershed Project Authority.

Scarp (scars/escarpment)- A long, more or less continuous cliff or relatively steep slope facing in one general direction, breaking the general continuity of the land by separating two level or gently sloping surfaces, produced by erosion or by faulting. The term is often used synonymously with "escarpment" which is more often applied to a cliff formed by differential erosion; A high, steep, abrupt face of rock, often presented by the upward termination of strata in a line of cliffs, and generally marking the outcrop of a resistant layer occurring in a series of gently dipping softer strata

SCEPP- Southern California Earthquake Preparedness Project.

Sea Floor Spreading- A hypothesis that the oceanic crust is increasing by convective (movement and mixing of water masses in the ocean) upwelling of magma along the mid-oceanic ridges or world rift system (deep central cleft in the crest with a mountainous floor), and a moving away of the new material at a rate of from one to ten centimeters per year. This movement provides the source of power in the hypothesis of plate tectonics. This hypothesis supports the continental displacement hypothesis.

Secondary Earthquake Hazards- Accidents or source of danger brought upon by earthquakes such as liquefaction, seiches, slope instabilities, fires, flooding.

Sediment- Solid fragmental material, or a mass of such either organic or inorganic, that originates from weathering of rocks and is transported by, suspended in, or deposited by, air, water, or ice, or that is accumulated by other natural agents, such as chemical precipitation from solution or secretion by organisms, and that forms in layers on the earth's surface at ordinary temperatures in a loose, unconsolidated form; e.g. sand, gravel, silt, mud, till, loess, alluvium; Strictly, solid material that has settled down from a state of suspension in a liquid.

Sediment Flow- Debris flows down hill mixed with water or air.

Sedimentary- Pertaining to or containing sediment ; e.g. a "sedimentary deposit" or a "sedimentary complex"; Formed by the deposition of sediment (e.g. a "sedimentary clay"), or pertaining to the process of sedimentation.

Sedimentary Rock- Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel, sandstone, formed from sand, shale, formed from clay, and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Sediment-laden Waters- Material held in suspension in water or recently deposited from suspension. During floods most property damage results from inundation by sediment-laden water.

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 Capacity- The measure of resistance of a structure to strong earthquake shaking, or seismic loading as commonly used when applying lateral forces to a structure.

Seismic Event- An earthquake or a somewhat similar transient earth motion.

Seismic Hazards- Related to the menace or threat imposed by the future seismic activity of a region or country (not the consequences caused by a future seismic event); i.e. seismic ground shaking, liquefaction, seismically induced landslides, and surface fault rupture. It is measured in terms of probability that certain parameters, such as intensity of ground motion or peak ground acceleration, may be exceeded in a given place and in a given time.

Seismic Hazards Mapping Act (SHMA)- The Seismic Hazards Mapping Act passed in 1990, addresses non-surface fault rupture earthquake hazards, including liquefaction and seismically induced landslides.

The principal State agency charged with implementation of the provisions Pursuant to the SHMA the California Division of Mines and Geology (CDMG) is directed to provide local governments with seismic hazard zone maps that identify areas susceptible to amplified shaking, liquefaction, earthquake-induced landslides, and other ground failures. The seismic hazard zones delineated by the CDMG are referred to as "zones of required investigation."

Seismic Intensity- A qualitative estimate of the damage caused by an earthquake at a given location.

Seismic Risk- Expresses the "possibility or chance of damage, economic loss, victims, and injuries due to occurrence of a destructive earthquake and the degree of probability of such loss; Measured in terms of probability that, in a given place and a given period of time, the estimated loss or number of victims may be exceeded; Given the location and magnitude of future earthquakes in a region, and a means for specifying the return period for each fault, the cumulative risk for a site to experience a certain level of ground shaking in a given period of time can be ascertained. Expressed as a probability for design and planning considerations, seismic risk factors depend on the type of development. ATC 3-06 (1978) recommends that a 10 percent chance of exceeding a design ground motion in 50 years (0.002 percent probability of exceedance), which is equivalent to a 500 year return interval, be used for the design of critical structures such as lifelines, dams, and bridges. A 50 or 100 year return period, which is equivalent to a 0.01 percent probability of exceedance, is recommended for regional planning purposes or noncritical structures.

Seismic Risk Mitigation- Denotes any preventative actions taken before the occurrence of a destructive earthquake intended to reduce its consequences. All measures undertaken to increase the seismic resistance and performance of buildings and lifelines, as well as to increase the safety of people and to reduce economic losses and social impact.

Seismic Source Types- Near source factors also include a classification of seismic sources based on slip rate and maximum magnitude potential. These parameters are used in the classification of three seismic source types A, B and C (Type A: Faults that are capable of producing large magnitude events and which have a high rate of seismicity. Maximum Moment Magnitude (M) > 7.0 and Slip Rate (SR mm/yr) > 5; Type B: All faults other than Types A and C; Type C: Faults which are not capable of producing large magnitude earthquakes and which have a relatively low rate of seismic activity M < 6.5 and SR < 2).

Seismic Strengthening- Construction actions that improve the seismic resistance of a building by increasing the strength or stiffness. Both rehabilitation and retrofit can include seismic strengthening.

Seismic Upgrading- All actions undertaken to improve the overall seismic performance of existing buildings and may include repair and strengthening of structural elements, the redesign of the lateral load resistant system, improvement of non-structural elements and fixing of electrical and mechanical systems and equipment.

Seismic Vulnerability- A term related to a building or structure prone or susceptible to suffer damage or collapse due to a potential earthquake. The results of seismic vulnerability studies can be expressed in terms of the probability that, in a given period or exposure time, the estimated damage and losses can be exceeded.

Seismic Wave- A general term for all elastic sea waves produced by earthquakes or generated artificially by explosions. It includes both body waves and surface waves; A seismic sea wave, or tsunami (earthquake wave).

Seismically-Induced Settlement- In some situations, strong ground shaking can cause the densification of soils, with a resultant local or regional settlement of the ground surface.

Seismically-Induced Slope Instability- Seismically induced landsliding and rock falls can be expected to occur throughout the County in a major earthquake. Factors controlling the stability of slopes include: 1) the slope height and inclination, 2) the engineering characteristics of the earth materials comprising the slope, and 3) the intensity of ground shaking.

Seismicity- The phenomenon of seismic earth movements; Earthquakes.

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.

Seismology- The study of earthquakes; The study of the structure of the interior of the Earth via both natural and artificially generated seismic signals.

Semi-Arid- Said of a type of climate in which there is slightly more precipitation (10-20 inches or 12-16 inches) than in an arid climate, and in which grasses are the characteristic vegetation. In Thornthwaite's classification, the moisture index is between B20 and B40 (subarid).

SEMS- Standard Emergency Management Systems.

Setback- Dwelling units put away from ground rupture hazards to establish structural avoidance zones. To determine if a setback is necessary is typically accomplished by excavation of a trench across the site, determining the location of faulting and establishing building setbacks.

Settlement- The gradual downward movement of an engineering structure, due to compression of the soil below the foundation; The gradual lowering of the overlying strata in mine, due to extraction of the mined material; The subsidence of surficial material (such as coastal sediments) due to compaction.

Shear- A strain resulting from stresses that cause or tend to cause contiguous parts of a body to slide relatively to each other in a direction parallel to their plane of contact; Specifically, the ratio of the relative displacement of these parts to the distance between them. In geologic literature the term refers to strain rather than stress. It is also used to refer to surfaces and zones of failure by shear, and to surfaces along which differential movement has taken place (shear strain).

Shear Failure- It is the mode of failure of a body or mass whereby the portion of the mass on one side of a plane or surface slides past the portion on the opposite side.

Shear Strength- The internal resistance of a body to shear stress; cohesion.

Shear Stress- The component of stress which acts tangential to a plane through any given point on a body; any of the tangential components of the stress tensor.

Shear Velocity- The square root of the product of the acceleration due to gravity, the hydraulic mean depth of flow, and the slope of the energy grade line (ASCE, 1962).

Shear Wave- See S wave.

Shear Zone- A tabular zone of rock that has been crushed and brecciated (crushing rock into angular fragments) by many parallel fractures due to shear strain. Such an area is often mineralized by ore-forming solutions

SHMA- Seismic Hazard Mapping Act (1990).

Shrink-Swell- The shrinking (loss of water) of soil when dry and the swelling (taking up water) when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Shrubland- Bush and clump vegetation in an area.

Silt- (soil) As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 mm) to the lower limit of very fine sand (0.05). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

(eng) Nonplastic or slightly plastic material exhibiting little or no strength when air-dried, consisting mainly of particles having diameters less than 0.074 mm (passing U.S. standard sieve no. 200). An indurated silt having the texture and composition of shale but lacking its fine lamination is called a siltstone.

Site-Specific- The collection of facts, data, and the testing of, surface and subsurface features (including physical nature, thickness, geologic structure, and other engineering properties) for the purpose of determining information for that particular location.

Slip- On a fault, the actual relative displacement along the fault plane of two formerly adjacent points on either side of the fault. Slip is three-dimensional, whereas separation is two-dimensional.

Slip Rate- To specify the measured quantity in mm/yr of the relative displacement along a fault plane.

Slope- (geomorph) Gradient; A measurement of the steepness of a hillside or other landform normally expressed as a percentage slope or a ratio; The inclined surface of any part of the Earth's surface, as a hillslope; Also, a broad part of a continent descending toward an ocean, as the Pacific slope.

Slope Failure- A sudden failure of the slope resulting in transport of debris down hill by sliding, rolling, falling, or slumping.

Slope Stability- The gradient or inclined surface's resistance to sudden change. It is dependent on many factors and their interrelationships. Rock type and pore water pressure are possibly the most important factors, followed by slope steepness due to natural or man-made undercutting.

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. Types of slides with downward rotation of rock or regolith occurring along a concave-upward curved surface. The upper surface of each slump block remains relatively undisturbed, as do the individual blocks. Slumps leave arcuate (curved or bowed) scars or depressions on the hill slope. Slumps can be isolated or may occur in large complexes covering thousands of square meters. They often form as a result of human activities, and thus are common along roads where slopes have been over-steepened during construction. Heavy rains and earthquakes can also trigger slumps.

Soft Ground- (eng) Ground that is too moist or too yielding to support weight and thereby allows an object to sink in; Rock that does not stand well and requires heavy timbering, such as that about an underground opening.

Soft-Story- A structure that has at least one story, often the ground level, with significantly less rigidity or strength than other floors in the structure during seismic loading, e.g. apartment dwellings with garages on the lower floor, etc. Buildings with a story, generally the first floor, lacking adequate strength or toughness, due to few shear walls, i.e., buildings where the first floor is the garage. The State Legislature passed Senate Bill 547 encouraging identification and mitigation of seismic hazards associated with potentially hazardous buildings that includes soft-stories.

Soil- (eng geo) All unconsolidated earthy material over bedrock. It is approximately equivalent to regolith (soil) The natural medium for growth of land plants; A term used in soil classification for the collection of natural bodies on the earth's surface, in places modified or even made by man of earthy materials, containing living matter, and supporting or capable of supporting plants out-of-doors. The lower limit is normally the lower limit of biological activity, which generally coincides with the common rooting of native perennial plants.

Soil Engineer- A civil engineer who applies the knowledge and behavior of soil properties to engineering practice, esp. mining and geotechnical.. It is the application of soil data, techniques, and principles to the study of naturally occurring soil materials for the purpose of assuring that geologic factors affecting the location, planning, design, construction, operation, and maintenance of engineering structures.

Soil Erosion- Detachment and movement of topsoil, or soil material from the upper part of the profile, by the action of wind or running water, esp. as a result of changes brought about by human activity (such as unsuitable or mismanaged agricultural methods). It includes: rill erosion, gully erosion, sheet erosion, and wind erosion.

Soil Horizon- A layer of soil that is distinguishable from adjacent layers by characteristic physical properties such as structure, color or texture, or by chemical composition, including content of organic matter, or degree of acidity soil pH < 7.0) or alkalinity (soil pH > 7.0). Soil horizons are generally designated by a capital letter, with or without a numerical annotation, e.g. A horizon, A₂ horizon.

Soil Profile- A vertical section of a soil which displays all its horizons and its parent material

Soil Sampling- Channel sampling. Soil segments taken from a soil profile to represent the distribution of soil types, processes, and their characteristics.

Soil Structure- (soil) The combination of aggregation of primary soil particles into compound particles, or clusters of primary particles (peds), which are separated from adjoining peds by surface of weakness. Soil structure is classified on the basis of size, shape, and distinctness into classes, types, and grades respectively.

Soil Type- A phase or subdivision of a soil series based primarily on texture of the surface soil to a depth at least equal to plow depth (about 6 inches). In Europe, the term is roughly equivalent to the term great soil group.

Special Boulevard- Designated major roadways and avenues in the city which require special treatment in regards to building setbacks, landscaping and pedestrian paths (sidewalks).

Special Studies Zone (SSZ)- Initial site specific studies indicating if fissuring coincides with active (Holocene) faulting. State Division of Mines and Geology began a study in accordance with the Alquist-Priolo Special Studies Zone Act (APSSZ). This resulted in establishment of a state Special Studies Zone (SSZ) to locate where fissures coincided with active (Holocene) faulting. These special studies zones are 0.2-0.3 km wide and 2.0-4.0 km long.

Specific Plans- Are legal implementation tools used to further define the General Plan. Generally, specific plans cover large areas; the Planned Communities are a form of specific plans.

Sphere of Influence- An unincorporated area directly adjacent to the city which the city expects in the future to annex and is recognized by the Local Agency Formation Commission.

Splays- A series of minor faults at the extremities of a major fault; the fault pattern formed by splaying out (breakup of a fault into a dispersal of minor faults). It is associated with rifts.

SPT- Standard Penetration Tests.

SRA- State Responsibility Areas.

SSC- Seismic Safety Commission. www.seismic.ca.gov

SSZ- Special Studies Zone.

Stafford Act- Established basic rules for federal disaster assistance and relief, and the Earthquake Hazards Reduction Act of 1977, (amended in 1990, which establishes the National Earthquake Hazards Reduction Program (NEHRP)); Briefly mentions "construction and land use" as possible mitigation measures to be used after a disaster to forestall repetition of damage and destruction in subsequent events. However, the final rules promulgated by the Federal Emergency Management Agency (FEMA) to implement the Stafford Act (44 CFR Part 206, Subparts M and N) require post-disaster state-local hazard mitigation plans to be prepared as a prerequisite for local governments to receive disaster assistance funds to repair and restore damaged or destroyed public facilities. Under the regulations implementing Section 409 of the Stafford Act, a county or city must adopt a hazard mitigation plan acceptable to FEMA if it is to receive facilities restoration assistance authorized under Section 409. In recent disasters, FEMA has recognized safety elements of California local governments as fulfilling Section 409 hazard mitigation plan requirements. The Stafford Act also requires that 15% of the total assistance dollars be spent on disaster mitigation--with the hope of reducing the costs associated with future disasters.

Standard Cone Penetrometer- An engineering borehole measurement, which among other applications, is able to translate penetration resistances (as gauged from a narrow cylindrical instrument of standard weight dropped from a standard height) of unconsolidated earth materials into a measure of liquefaction susceptibility.

Standardized SPT- Seed and others (1971, 1983, 1985), provide guidelines for performing "standardized" SPT, and also provide correlation for conversion of penetration resistance obtained using most of the common alternate combinations of equipment and procedures in order to develop equivalent "standardized" penetration - basis for evaluation of liquefaction resistance.

Standard Emergency Management Systems (SEMS)- The County is required under State law to prepare and maintain a Standardized Emergency Management System (SEMS) Multihazard Functional Plan. The California Governor's Office of Emergency Services (OES, 1999) has extensive guidelines outlining the requirements of the County SEMS. These guidelines establish policies and procedures and assigns responsibilities to ensure the effective management of emergency operations under the SEMS. Effective management consists of the emergency management structure and how the emergency management team is activated. However, the SEMS does not address long-range recovery planning issues.

Standard Project Flood- As used by the U.S. Corps of Engineers, a flood that may be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographic areas in which the drainage is located.

State Board of Forestry and the Department of Forestry and Fire Protection- Identifies those lands where the California Department of Forestry and Fire Protection (CDF) has the primary duty for wildland fire prevention and suppression. These lands are "state responsibility areas" (SRA). They are vegetated-covered, watershed lands that are generally private land, outside of incorporated cities and federally owned land, where the organized protection force is at maximum strength during the declared "fire season." The fire safety provisions denoted in the Safety Element is prepared and adopted in conjunction with the State Board of Forestry's fire safety regulations. Public Resources Code section 4290 that requires minimum statewide fire safety standards pertaining to: Road standards for fire equipment access; Standards for signs identifying streets, roads, and buildings; Minimum private water supply reserves for emergency fire use; And fuel breaks and greenbelts. The State Board of Forestry and the Department of Forestry and Fire Protection are excellent sources of information regarding fire hazard abatement planning and regulatory measures.

State Division of Mines and Geology- Began a study in accordance with the Alquist-Priolo Special Studies Zone Act (APSSZ).

State Fire Marshal- Assists local governments in adopting ordinances to reduce fire hazard in local jurisdictions. The State Fire Marshal, Fire Engineering Division has developed a model checklist. The development of this model was required by Assembly Bill 3819, on September 27, 1994. The model ordinance addresses the following standards: Road standards for fire equipment access; Structural standards; And fuel modification standards.

State Geologist- The Chief of the Division of Mines and Geology delineates "Earthquake Fault Zones" (based on The Alquist-Priolo Earthquake Fault Zoning Act) along faults which are "sufficiently active" and "well-defined."

State Legislature Senate Bill 547- Addressing the identification and seismic upgrade of Unreinforced Masonry (URM) buildings. In addition, the law encourages identification and mitigation of seismic hazards associated with other types of potentially hazardous buildings, including: pre-1971 concrete tilt-ups, soft-stories, mobile homes, pre-1940 homes, etc.

State Natural Hazards Disclosure Act- Requires that sellers of real property and their agents provide prospective buyers with a "Natural Hazard Disclosure Statement" when the property being sold lies within one or more state-mapped hazard areas. If a property is located in a Seismic Hazard Zone as shown on a map issued by the State Geologist, the seller or the seller's agent must disclose this fact to potential buyers.

State of California Department of Forestry and Fire Protection- Rates counties as potential wildland fire areas (based on undeveloped and rugged topography with potentially highly flammable indigenous vegetation). Special State Statutes govern development in these regions as well as maintenance requirements of property owners.

State Responsible Areas (SRAs)- They are vegetated-covered, watershed lands that are generally private land, outside of incorporated cities and federally owned land, where the organized protection force is at maximum strength during the declared "fire season."

Statistical Analysis- Devising and applying techniques to determine the uncertainty of numerical data and their interrelationships to make comprehensible summaries or parameters .

STATSGO- U.S. Department of Agriculture State Soil Geographic Map.

Stone- Crushed or naturally angular rock particles that will pass a 3-inch sieve (76 mm) and be retained on U.S. standard sieve no. 4 (4.74 mm).

Stony- A name for something that consists dominantly of stone particles or contains at least 25% stones.

Storage Capacity- Dam storage measured in acre-feet or decameters, including dead storage.

Storm- (meteorol) A general term for any meteorological disturbance of the atmosphere, e.g. precipitation (rainstorm), wind (windstorm).

Storm Drain- A device, pipe or channel for carrying off rainwater.

Strain- Change in shape or volume of a body as a result of stress, Defined as the ratio of the change to the original shape or volume; A change in relative configuration of the particles of a substance.

Stratigraphy- The geologic study of the form, arrangement, geographic distribution, chronologic succession, classification, and esp. correlation and mutual relationships of rock strata "in normal sequence with respect to any or all of the characters, properties, and attributes which rocks may possess." It thereby involves interpretation of these features of rock strata in terms of their origin, occurrence, environment, thickness, lithology, composition, fossil content, age, history, paleogeographic conditions, relation to organic evolution, and relation to other geologic concepts; The arrangement of strata esp. to geographic position and chronological order of sequence.

Stream- Any body of running water, great or small (from a large river to a small rill), moving under gravity flow to progressively lower levels in a relatively narrow but clearly defined channel on the surface of the ground, in subterranean cavern (cave formed beneath the earth's surface), or beneath or in a glacier; esp. a body flowing in a natural channel. It is a mixture of water and of dissolved, suspended, or entrained matter. A term used in quantitative geomorphology interchangeably with channel.

Stream Flood- A flood of water in an arid region, characterized by the "spasmodic and impetuous flow" of a sheetflood but confined to a definite, shallow channel that is normally dry (Davis, 1938).

Stress- In a solid, the force per unit area, acting on any surface within it, and variously expressed as pounds or tons per square inch, or dynes or kilograms per square centimeter; also, by extension, the external pressure which creates the internal force. The stress at any point is mathematically defined by nine values: three to specify the normal component and six to specify the shear component, relative to three mutually perpendicular reference axes.

Strike- (struc geol) The direction or trend that a structural surface, e.g. a bedding or fault plane, takes as it intersects the horizontal.

Strike-slip fault- A fault with a vertical to subvertical fault surface that displays evidence of horizontal and opposite displacement.

Strip Mining- Open-cut mining; Surficial mining, in which the ore is exposed to the sky by removing the overburden. Both coal and metalliferous ores (of iron, copper) are worked in this way.

Structural Damage- The building's structural support has been impaired. Structural support includes any vertical and lateral force-resisting systems, such as the building frames, walls, and columns.

Structural Depression- A hollow in the land surface caused by structural deformation of the Earth's crust.

Structural Engineer- A licensed civil engineer certified by the State as qualified to design and supervise the construction of engineered structures.

Structural Redesign- Modifying the lateral load resistant system using other kinds of structural elements; concrete structural or shear walls and steel bracing systems, or adopt other mitigation measures such as base isolation system.

Structural Strengthening- Actions undertaken in order to increase the resistance of structural elements for beyond the original capacity. Strengthening may consist in increasing the dimensions of and adding steel bars to reinforced concrete elements, (jacking of columns and girders) or welding plates or rolled sections to steel structural elements. Strengthening does not imply all actions in order to increase the rigidity and seismic capacity of the structural system.

Subsidence- The sudden sinking or gradual downward settling of the earth's surface with little or no horizontal motion. Is one of the most diverse forms of ground failure, ranging from small or local collapses to broad regional lowering of the earth's surface. The causes (mostly due to human activities) of subsidence are as diverse as the forms of failure, and include dewatering of peat or organic soils, dissolution in limestone aquifers, first-time wetting of moisture-deficient low-density soils (hydrocompaction), natural compaction, liquefaction, crustal deformation, subterranean mining, and withdrawal of fluids (ground water, petroleum, geothermal).

Subsidence Hazard Map- Riverside County Subsidence Hazard Map was prepared at a scale of 1:250,000. The accuracy of the Subsidence Hazard Map is about 1:100,000. Certain areas of Riverside County are prone to regional downwarping and rapid subsidence. Withdrawal of underground fluids, and tectonic elevation changes produced during extremely large earthquakes are most important in terms of potential causes. The map presented focused on land subsidence (see above) initiated exclusively by the withdrawal of ground water from alluvial valleys.

Subsidence Report Zone-- An area or region based on natural hydrologic and political boundaries created in 1991 in the Murrieta area, as a result of ground cracking at the California Oaks project. This cracking was determined to be a result of a rising ground water table, rather than a falling ground water table. Shlemon and Hakakian (1992) attribute the cracking at California Oaks to be the result of saturation of collapsible alluvium that was left in-place beneath the affected homes. Shortly after creation of this zone, the area was adopted into the city of Murrieta and continues to be enforced by the city.

Subsurface Geology- Geology and correlation of rock formations, stratigraphy and structures, and other features beneath the land or seafloor surface as revealed or inferred by exploratory drilling, underground workings, and geophysical evidence.

Subterranean- Formed or occurring beneath the Earth's surface, or situated in the Earth.

Superstructure (tect) The upper structural layer in an orogenic belt (linear region that has been subjected to folding and other deformation during the interval of time of their formative stages with most later becoming mountain belts), subjected to relatively shallow or near-surface deformational processes, in contrast to an underlying and more complexly deformed and metamorphosed infrastructure. Also spelled suprastructure.

Surface Rupture- Same as ground rupture; Displacement of the earth's surface as a result of fault movement associated with an earthquake; Movement on a fault deep within the earth breaks through to the surface that almost always follows preexisting faults which are zones of weakness.

Surficial Deposits/Materials- Unconsolidated and residua (developed in place) alluvial, or glacial deposits lying on bedrock or occurring on or near the earth's surface; It is generally unstratified and represents the most recent of geologic deposits.

Susceptible Types- Pursuant to the Seismic Hazard Mapping Act (SHMA) the Division of Mines and Geology (CDMG) is directed to provide local governments with seismic hazard zone maps that identify areas susceptible to amplified shaking, liquefaction, earthquake-induced landslides, and other ground failures include:

- **Susceptible liquefaction during historic earthquakes:** Areas of uncompacted fills containing liquefaction susceptible material that are saturated, nearly saturated, or may be expected to become saturated; Areas where sufficient existing geotechnical data and analyses indicate that the soils are potentially liquefiable; Areas containing young (less than 15,000 years) soils where there is limited or no geotechnical data that include generally granular sediments Ground water depth is based on the historic high measurement at < 30 feet in depth.
- Structures **susceptible** to damage during an earthquake, including pre-cast tilt-up concrete buildings, soft-story structures, unreinforced concrete buildings, as well as pre-1952 single-family structures. Other potentially hazardous buildings include irregular-shaped structures and mobile homes.

- Areas most susceptible to rockfall are located below steep, resistant outcrops of relatively well-cemented materials. Such materials can underlie mountain ranges.
- Fine-grained sedimentary rocks are susceptible to mud-flows or debris flows, especially during exceptionally high rainfall periods. The areas most susceptible to debris flows include: Canyon bottoms, stream channels, areas near the outlets of canyons or channels, roadcuts and other altered or excavated areas of slopes, and areas where surface runoff is channeled, such as along roadways and below culverts
- The regions in Riverside County that may be susceptible to subsidence include all the alluvial valley regions, esp. the Elsinore trough, including the communities of Temecula and Murrieta., the San Jacinto Valley from the community of Hemet to Moreno Valley, and the southern Coachella Valley. These valleys contain generally unconsolidated sand and silty sand with interbeds of silt and clayey silt. Fine grained alluvium and organic matter is often encountered underlying the fissure areas (Kupferman, 1995).
- The loss of ground-surface cover, and the chemical transformation of burned soils make watersheds more susceptible to erosion from rainstorms, and impairs water quality.

Suspension- A mode of sediment transport in which the upward currents in eddies (circular motion with a different direction from that of the main current) of turbulent flow are capable of supporting the weight of undissolved sediment particles and keeping them indefinitely held in the body of the surrounding fluid (such as silt in water or dust in air); The state of a substance in such a mode of transport; also the substance itself.

Swale- A slight depression, sometimes swampy, in the midst of generally level land; A shallow depression in an undulating ground moraine due to uneven glacial deposition; A long, narrow, generally shallow, trough-like depression between two beach ridges, and aligned roughly parallel to the coastline.

S wave- That type of seismic body wave which is propagated by a shearing motion of material, so that there is oscillation perpendicular to the direction of propagation. It does not travel through liquids, or through the outer core of the Earth. Its speed is 3.0-4.0 km/sec in the crust and 4.4-4.6 km/sec in the upper mantle. The S stands for secondary; it is so named because it arrives later than the P wave.

System- (geol) A group of related features, objects, or forces; e.g. a fault system, drainage system, or a mountain system.

Talus- Coarse angular detrital material accumulation of loose rock fragments composing a steep, concave slope esp. at the base of a cliff or steep slope with a constant angle of repose close to 35°.

TDR- Transfer of Development Right.

Tectonic- Said of or pertaining to the forces involved in, or the resulting structures or features of tectonics. The process of active faults, earthquakes, and how they shape the geomorphology and structure of the earth

Tensile Stress- A normal stress that tends to cause separation across the plane on which it acts.

Terrain (terrane) An obsolescent term applied to a rock or group of rocks and to the area in which it outcrops. The term is used in a general sense and does not necessarily imply a specific rock unit or group of rock units.

Tertiary Period- The earliest Period of the Cenozoic Era. Encompasses the time interval of 1.6 million years ago through today.

Threat- Anything holding a possible source of danger.

Threshold- Beginning; the point at which a process or effect commences.

Threshold Velocity- The minimum velocity at which wind or water, in a given place and under specified conditions, will begin to move particles of soil, sand, or other material.

Thrust Fault- A fault with a dip of 45° or less in which the hanging wall appears to have moved upward relative to the footwall. Horizontal compression rather than vertical displacement is its characteristic feature.

Tilt-up- A poured concrete-and-steel reinforced wall raised or lifted into place and tied to other walls, and the roof and floor

Tip Resistance- (qc) May be used as a basis for evaluation of liquefaction resistance by direct empirical comparison between qc-values to "equivalent" SPT resistance and use of correlation between (N1) 60 data and case histories of seismic performance (Robertson, et al., 1985; Seed and De Alba, 1986).

TLMA- Transportation and Land Management Agency.

Topographic Map- A map on a sufficiently large scale showing, in detail, selected man-made and natural features of a part of a land surface, including its relief (generally by means of contour lines) and certain physical and cultural features (vegetation, roads, drainage, etc.). Its distinguishing characteristic is the portrayal of the position (horizontal and vertical), relation, size, shape, and elevation of the features of the area. Topographic maps are frequently used as base maps.

Topography- The general configuration of a land surface or any part of the earth's surface, including its relief (shape, configuration considered with reference to variations of height and slope to irregularities of the land surface) and the position of its natural and man-made features; The natural or physical surface features of a region, considered collectively as to form; the features revealed by the contour lines of a map.

Torsion- The state of stress produced by two force couples of opposite moment acting in different but parallel planes about a common axis.

Total Freeboard- The vertical distance in feet and meters from the dam crest to the lowest point of the spillway control section (excluding flashboards and gates).

Toxic Chemical Releases- Harmful, deadly, or poisonous hazardous material agents circulating.

Transfer of Development Right (TDR)- A similar concept that extends the transfer incentive beyond property boundaries. This procedure consists of the allowance by the County of the transfer of unused densities from a "donor" site to a designated "receiver" site. The unused increment of building bulk from the donor site is added to allowable maximum bulk on the receiver site through County review of the transfer. The financial incentives include proceeds from purchase of the unused increment gained by the owner of the donor site, and the increased value of the project on the receiver site gained by the developer. The purchase transaction can be entirely private, regulated or public.

Transform Fault- A strike slip fault characteristic of mid-oceanic ridges and along which the ridges are offset. Analysis of transform faults is based on the concept of sea-floor spreading .

Transport- (sed) Sediment transport or mass transport B the movement and carrying away of sediment by natural agents; esp. the conveyance of a stream load by suspension, saltation, solution, or traction.

Transportation and Land Management Agency (TLMA)- Is responsible for the County's Land Management System (LMS) and the Geographic Information System (GIS). The Transportation and Land Management Agency consists of three departments: Building & Safety, Planning and Transportation.

Transportation System Management Program (TSMP)- A program designed to facilitate the flow of traffic on an existing street system by improving roadways, signalization and the traffic management procedures.

Transverse Ranges- Geomorphic block is characterized by east-west trending mountain ranges and includes the easternmost San Bernardino Mountains located in the north-central portion of the County. The name "Transverse" is derived from the east-west fabric, rather than the more common northwesterly trend in California that is associated with the boundary of the North American and Pacific plates.

Trench (fault investigation) Any long, narrow cut or excavation to look at soil stratigraphy .

Trenching Investigation- A paleoseismic approach to determine deposition, erosion, displacement deformation, and geometry of strata within a trench(es) to interpret fault history for an area.

Trench Plate Boundary- Subduction of one crustal plate under or descending beneath another at line of convergence.

Trend- Direction or bearing of a geologic feature.

TriNet Maps- Maps generated by actual instrumental recordings following a major earthquake. This near-real-time potential of loss estimating can provide County officials and emergency managers with accurate damage patterns and projections for distribution of resources in a timely manner.

Trough- (geomorph) Any long and narrow depression in the earth's surface, such as one between hills or with no surface outlet for drainage; esp. a broad, elongated, U-shaped valley, such as a glacial trough or a trench; The channel in which a stream flows. (marine geol) An elongate depression of the sea floor that is wider and shallower than a trench, with less steeply dipping sides. Troughs and trenches are gradational forms; a trough may develop from a trench by becoming filled with sediment. (fault) Graben.

TSMP- Transportation System Management Program.

Tsunami- A gravitational sea wave produced by any large-scale, short-duration disturbance of the ocean floor, principally by a shallow submarine earthquake, but also by submarine earth movement, subsidence, or volcanic eruption, characterized by great speed of propagation (up to 950 km/hr), long wavelength (up to 200 km), long period (varying from 5 min to a few hours), and low observable amplitude on the open sea although it may pile up to great heights (30 m or more) and cause considerable damage on sands of kilometers from the source.

Tsunami Runup- The height of the tsunami wave as it crosses mean low-low water (MMLW) at shoreline.

Type A- Type A faults are active and capable of producing large magnitude events. The Type A slip rate (>5 mm/yr) and magnitude (M_w 7.0 or greater) is common only to faults near boundaries of tectonic plates (Pacific and North American), and is approximate to the rate at which a human fingernail grows. Most segments of the San Andreas, associated faults and most of the San Jacinto faults are classified as Type A, including those in the County of Riverside.

Type B- Type B sources include most of the active faults in California and include all faults that are neither Type A nor C.

Type C- Type C Seismic sources are considered to be sufficiently inactive and not capable of producing large magnitude events such that potential ground shaking effects can be ignored. Type B sources include most of the active faults in California and include all faults that are neither Type A nor C.

UBC- Uniform Building Code.

UFC- Uniform Fire Code.

UBC Source Zone Classification- Classification of seismic sources based on slip rate and maximum magnitude potential. These parameters are used in the classification of three seismic source types A, B and C (Type A: Faults that are capable of producing large magnitude events and which have a high rate of seismicity. Maximum Moment Magnitude (M) > 7.0 and Slip Rate (SR mm/yr) > 5; Type B: All faults other than Types A and C; Type C: Faults which are not capable of producing large magnitude earthquakes and which have a relatively low rate of seismic activity $M < 6.5$ and $SR < 2$).

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.

Undergrowth- Low-growing plants, saplings, and shrubs beneath trees in a forest.

Uniform Building Code (UBC)- Building code enforcement. Building and Safety adopted the 1997 UBC in July 1999. The first change was a revision to soil types and amplification factors, and the second change was the incorporation of the proximity of earthquake sources in UBC seismic zone 4.

Uniform Fire Code (UFC)- Fire and building code enforcement. Relevant fire safety code standards and programs requires that buildings or structures more than three stories or 30 feet in height, or more than 15,000 square feet shall be provided with an approved fully automatic sprinkler system and new construction requirements for Class B roofing materials

Unreinforced Masonry Building (URM)- Unless the URM buildings have been appropriately reinforced and strengthened, an earthquake may cause irreparable damage, and even collapse of some URMs, with the resultant threat to human life and property. Deterioration of the mortar (often of lime and sand with little or no cement, having very little shear strength , and of the wood framing as a result of weather exposure may also contribute to the weakening and poor performance of these structures during an earthquake.

USFS- U.S. Forest Service.

USGS -United States Geological Survey.

URM- Unreinforced Masonry Building.

Uplift- A structurally high area in the crust, produced by positive movements that raise or upthrust the rocks, as in a dome or arch.

URRNSF- Urban Regional Research for the Natural Science Foundation.

USGS Quadrangle Maps- A map of a quadrangle, the size being given in minutes or degrees; e.g. a 7.5 minute quadrangle map (scale: 1/24,000) having dimensions of 7.5 minutes in both latitude and longitude, the bounding parallels of latitude and meridians of longitude being integral multiples of 7.5 minutes. The U.S. Geological Survey has also published 15-minute (scale: 1/62,500) and 30-minute (scale: 1/125,000) quadrangle maps.

U.S. Department of Agriculture State Soil Geographic (STATSGO)- data base captured as 1:250,000 scale USGS topographic quadrangle units. STATSGO included a soils map of the state of California that was refined for Riverside County. These data included a classification of the soil within each polygon for wind erodibility. This wind erodibility number was used to assign each polygon a WER (Wind Erodibility Rating).

Valley- (geomorph) Any low-lying land bordered by higher ground; esp. an elongate, relatively large, gently sloping depression of the earth's surface, commonly situated between two mountains or between ranges of hills or mountains, and often containing a stream with an outlet. It is usually developed by stream erosion, but may be formed by faulting; A broad area of generally flat land extending inland for a considerable distance, drained or watered by a large river and its tributaries; A river basin.

Vegetation- Plant or plant life which grow from the soil.

Vegetation Management- Weed abatement using mechanical treatments and prescribed fires to keep risk from major disastrous wildfires low.

Velocity- A vector quantity, the magnitude of which is a body's speed and the direction of which is the body's direction of motion; Distance traveled in a specified amount of time. (seismic velocity) The rate of propagation of an elastic wave, usually measured in km/sec. The wave velocity depends upon the type of wave, as well as the elastic properties and density of the Earth material, which it travels.

Veneer- A covering layer of material for walls, which is attached to the wall, but not bounded adequately so as to act with it during earthquake shaking.

Very High Fire Hazard Severity Zones (VHFHSZ)- Utilizes consistent statewide criteria and on the severity of fire hazard that is expected to prevail in areas. VHFHSZ are based on fuel loading, slope, fire weather, dwelling density and other relevant factors; and as the foundation for the system, and added additional mitigation factors both plus and minus to adjust the score upward or downward. The basic system had a four-point minimum score with a thirteen-point maximum. Potentially, the range of scores (including the mitigating factors) could range from a low of 1 to a high of 16, but to qualify as a Very High Fire Hazard Severity Zone (VHFHSZ), an area had to score 10 or more points. (see definitions for fuel loading, slope, fire weather, dwelling density, and mitigation)

VHFHSZ - Very High Fire Hazard Severity Zones.

Volume- The size or extent of any three dimensional object or region of space.

Wash- (stream) A term applied in the western U.S. (esp. in the arid and semiarid regions of the SW) to the broad, shallow, gravelly or stony, normally dry bed of an intermittent stream, often situated at the bottom of a canyon; it is occasionally filled by a torrent of water. (sed) Loose or eroded surface material (such as gravel, sand, silt) collected, transported, and deposited by running water, as on the lower slopes of a mountain range esp. coarse alluvium. A fan-shaped deposit, as an alluvial fan or an alluvial cone, or a mound of detritus below a cliff opening.

Watershed- A topographically defined region draining into a particular water course. The usage of the term, esp. in the U.S. and by several international agencies, has been changed to signify the region drained by, or contributing water to, a stream, lake, or other body of water.

Watershed Management- Administration and regulation of the aggregate resources of a drainage basin for the production of water and the control of erosion, streamflow, and floods. Also includes the operational functions.

Water table- The upper surface of ground water saturation of pores and fractures in rock or surficial earth materials .

Weathering- All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Well (water) An artificial excavation (pit, hole, tunnel), generally cylindrical in form and often walled in, sunk (drilled, dug, driven, bored, or jetted) into the ground to such a depth as to penetrate water-yielding rock or soil and to allow the water to flow or to be pumped to the surface; A term originally applied to a natural spring or to a pool formed by or fed from a spring; esp. a mineral spring. (oil) A borehole or shaft sunk into the ground for the purpose of introducing water or gas under pressure into an underground formation.

Wetland- A lowland area, such as a marsh or swamp, that is saturated with moisture, especially when thought of as the natural habitat of wildlife.

WER -Wind Erodibility Ratio.

WGCEP- Working Group on California Earthquake Probabilities.

Wildland- Uncultivated land, or land that is unfit for cultivation; e.g. a wasteland or a desert.

Wildland Fire Area- Suburban or rural areas that contain uncultivated lands, timber, range, watershed, brush or grasslands. This includes areas where there is a mingling of developed and undeveloped lands. (see definitions for uncultivated lands, range, watershed, and grassland).

Wildland Fire Aspects- Based on geographical makeup and climatic conditions. Riverside County is statistically one of the most active wildland fire (see below) counties in the state.

Wildland Fires- Also called chaparral or bush, are a result of the indigenous (native) vegetation in the mountain and foothill areas of southern California. This vegetation typically has a very high oil content that makes them a high fire danger.

Wildland/Urban Interface- An area or zone where structures meet or intermingle with wildland fuels with a set of conditions where structures and/or other improvements are reasonably within the reach of an escaped prescribed fire. This determination must include the factors of fuel type, fire behavior prescription, topography and containment opportunities.

Williamson Act- Geared to agricultural land preservation requiring a mandatory ten-year contract, subject to annual notice of non-renewal provisions that then starts a phase-out of the contract over the remaining nine-year period.

Wind Erosion- Weathering-away (loosened, dissolved, worn away) of soil and rock by wind. A serious environmental problem attracting the attention of many across the globe. It is a common phenomenon occurring mostly in 1) flat, bare areas, 2) dry, sandy soils, or 3) anywhere the soil is loose, dry, and finely granulated. Wind erosion damages land and natural vegetation by removing soil from one place and depositing it in another. It causes soil loss, dryness and deterioration of soil structure, nutrient and productivity losses, air pollution, and sediment transport and deposition.

Wind Erodibility Ratio (WER)- Wind Erodibility Rating classification assigned wind erodibility numbers to polygons and used as follows: 1 = Very Highly erodible 2 = High erodibility 3 = Moderate erodibility 4 = Low erodibility 5 = Water.

Wind-blown Sand- Sediment or loess deposited by wind that is vulnerable to collapse and hydroconsolidation.

Zoning- Used to implement the General Plan; Zoning normally is associated with what specific uses are allowable in an area and site specific criteria such as setbacks, building height, lot width, lot depth, etc. By law, the city must have a zoning ordinance that is consistent with the General Plan.

**APPENDIX C
FAULT DATA**

Fault Descriptions

This section provides a summary of current technical data and professional views pertaining to surface fault rupture hazards in Riverside County. Most of the faults in Riverside County that are considered a seismic hazard are part of the San Andreas Fault System, which is composed of a number of major fault zones. These include the Elsinore, San Jacinto, San Geronio Pass, and San Andreas fault zones. Where applicable, the numerous faults that are collectively grouped within a major "fault zone" are described within the section for their respective zones. In addition, there are numerous faults and smaller scale fault zones within Riverside County that are located outside of the major fault zones, which have been described separately.

The fault information below emphasizes the faults associated with the San Andreas Fault System, and starts with the faults in the west and moves eastward.

CONVERSIONS: 1 mile ~ 1.7 km; 1 inch = 2.54 millimeters.

ELSINORE FAULT ZONE

Classification (age): Historic/Active

Type of fault zone: Right-lateral strike-slip

Total Length: 250 km

Width: 1.5 to 15 km

Dip: Typically vertical- 90 degrees, except for the Whittier segment, which is a north-dipping thrust/reverse fault.

Slip Rate: ~5 mm/yr (Millman and Rockwell, 1986; Rockwell et al., 2000; Rockwell, 1990; Vaughan and Rockwell, 1986).

Recurrence Time: 240 to 760 years; average 400 years (WGCEP, 1995).

Total Displacement:
10 to 15 km (Hull, 1990; Morton and Miller, 1975; Webber, 1977; Woyski, 1998; Woyski et al., 1991)

Alquist-Priolo quadrangles:

Prado Dam, Corona South, Lake Mathews, Alberhill, Elsinore, Wildomar, Murrieta, Temecula, Pechanga, Pala.

Fault Strands:

Chino (Holocene)
Central Avenue Fault (Pre-Quaternary (?))
Fresno Fault (Holocene (?) to Late Pleistocene)
Tin Mine Fault (Holocene (?) to Late Pleistocene)
Eagle Mountain Fault (Holocene (?) to Late Pleistocene)
Joseph Canyon Fault (Pre-Quaternary)
Glen Ivy North (Holocene)
Glen Ivy South (Holocene)
Walker Fault (Late Quaternary ?)
Wildomar (Holocene)
Willard (Late Quaternary; Holocene ?)
Murrieta Hot Springs (Holocene)
Murrieta Creek (Holocene)
Wolf Valley (Holocene)
Aguanga (Late Pleistocene)
Agua Caliente (Late Pleistocene)
Lancaster/Hot Springs (age unknown; Quaternary?)
Buck Mesa (Quaternary)
Pechanga Jeep Trail (Quaternary or older)
Agua Tibia Mtn. (age unknown)

The Elsinore Fault Zone is a major northwest-trending right lateral strike-slip fault, which accommodates approximately 10 to 25 % of the plate-boundary slip in southern California (Working Group, 1995). The fault zone strikes northwestward and extends approximately 250 km from the Los Angeles basin area southeastward into northern Baja California in Mexico. Faults within the Elsinore Fault Zone, including those within Riverside County, are capable of producing events of magnitude 7 or greater. The Elsinore Fault Zone exists in the western-most portion of Riverside County for approximately 75 km along the eastern escarpment of the Santa Ana Mountains.

The Elsinore Fault Zone is divided into five segments (from north to south): Whittier, Glen Ivy, Temecula, Julian, and Coyote Mountain (WGCEP, 1995). The segments that reside in Riverside County include the southeastern end of the Whittier, the Glen Ivy, the Temecula, and the northwest end of the Julian. All of these segments are active and with the possible exceptions of the M-6 1910 Temescal Valley event on the Glen Ivy segment, the Elsinore Fault in Riverside

County has not produced a major earthquake with surface rupture during the past 200 years (WGCEP, 1995).

One historical surface rupture earthquake has occurred on the Elsinore Fault Zone within Riverside County, which was the M ~ 6.0 Temescal Valley Earthquake in 1910, which occurred in the area of the Glen Ivy faults. For more information regarding these earthquakes, visit the Southern California Earthquake Center (SCEC) on the web: <http://www.scecdc.scec.org/clickmap.html>

SAN JACINTO FAULT ZONE

Classification (age): Historic/Active

Type of fault: Right-lateral strike-slip

Total Length: ~230 km

Width: 0.5 to 15 km

Dip: Typically vertical (90 degrees)

Slip Rate: 10 to 12 mm/yr (Rockwell et al., 1990; Sharp, 1981).

Recurrence Time: 140 to 250 years (WGCEP, 1995).

Total Displacement: 16 to 27 km (Powell, 1993; Sharp, 1967).

Alquist Priolo quadrangles:

Sunnymead, San Bernardino South, El Casco, San Jacinto, NE 1/4 Hemet, NW 1/4 Idyllwild, SW 1/4 and SE 1/4 Idyllwild, Bucksnot Mtn., Collins Valley, Clark Lake NE, Clark Lake, Fonts Point, SW 1/4 Palm Desert, Borrego, Palm Canyon, Borrego Sink, Borrego Mountain, Shell Reef, Borrego Mountain SE, Harpers Well.

Fault Strands:

Claremont (Holocene)
Casa Loma & Park Hill (Holocene)
Clark (Holocene)
Hot Springs (Late Quaternary; Holocene)
Thomas Mountain (Holocene)
Buck Ridge (Late Quaternary)

Coyote Creek (Holocene)
Potrero (Quaternary)
Mt. Eden (Quaternary)
Toro Peak (Late Quaternary)
Lost Valley (Pre-Quaternary); located west of SJFZ.
Terwilliger Valley (Quaternary ?); located west of SJFZ.

The northwest trending San Jacinto Fault Zone accommodates between 15 to 25% of the strike-slip motion between the Pacific and North American Plates in southern California (WGCEP, 1995). The fault zone is approximately 230 km long, strikes northwestward, and extends from the southern San Gabriel Mountains in the northwest, to northern Baja California toward the southeast. It is capable of producing earthquakes of greater than 7.0, and is exposed for approximately 100 km in Riverside County. Within Riverside County, the San Jacinto Fault Zone is located on the west side of San Timoteo Canyon, and the San Jacinto and the Santa Rosa Mountains.

The slip rate on the San Jacinto Fault Zone is estimated in the range of 10 to 12 mm/yr. This value is second only to the San Andreas Fault in southern California, which exhibits slip rates in the range of 25-37 mm/yr. To assist in putting these numbers in perspective, a slip rate of 10 mm/yr produces 10 km of offset in 1 million years. The San Jacinto Fault Zone has the highest rate of microseismicity (small earthquakes) and historic (past 200 years) earthquakes of any other fault zone in southern California.

Based on fault geometry, historical seismicity, and slip rate the Working Group on California Earthquake Probabilities (WGCEP, 1995) divided the fault zone into 5 segments. The segments, include, from north to south, the San Bernardino Valley, San Jacinto Valley, Anza, Coyote Creek, Superstition Hills, and Superstition Mountain (WGCEP, 1995). All of these segments are active, and many have produced surface rupture during the past 200 years.

Notable historical earthquakes occurring in the San Jacinto Fault Zone in Riverside County include events in 1899 (M ~ 6.5) and 1918 (M ~ 6.8) that occurred near San Jacinto-Hemet, an event in 1923 (M ~ 6.3) located near southern San Bernardino Valley, an event in 1937 (M ~ 6.0) near Clark Valley, and an earthquake in 1980 (M = 5.5) located near Anza. For more information regarding these earthquakes, visit the Southern California Earthquake Center (SCEC) on the web: <http://www.scecdc.scec.org/clickmap.html>

SAN ANDREAS FAULT ZONE

Classification: Historic/Active

Type of fault: Right-lateral strike-slip

Total Length: ~1000 km

Width: 0.5 to 15 km

Dip: Typically vertical- 90 degrees, possibly 75 degrees toward the northeast in the San Gorgonio Pass region where the fault may not reach the surface.

Slip Rate:

~12 - 28 mm/yr (Harden and Matti, 1989; Keller et al., 1982; Rasmussen, 1982; Seitz, 1999; Sieh, 1986). Best estimates are likely in the range of ~25 mm/yr.

Total Displacement:

~300 km during the past 10 to 15 million years in central California. The San Andreas Fault Zone in southern California has accrued approximately 150 km of right-lateral offset during the past 4.5 to 5 million years (Powell, 1993).

Alquist-Priolo quadrangles:

SE 1/4 Morongo Valley, Desert Hot Springs, Seven Palms Valley, NE 1/4 Thousand Palms, Cathedral City, Myoma, SW 1/4 Lost Horse Mtn., Indio, Thermal Canyon, Mecca, Mortmar, Orocopia Canyon, Salton, Durmid, Frink NW.

Fault strands:

Garnet Hill (late Quaternary, possibly Holocene)
South Branch or Banning Fault (Holocene)
North Branch or Mission Creek Fault (Holocene)
Indio/Coachella Valley segment (Holocene)
Indio Hills (Holocene)
Hidden Springs (Late Quaternary)
Skeleton Canyon (Late Quaternary)
Eagle Canyon (Late Quaternary)
Platform (Late Quaternary)
Painted Canyon (Late Quaternary)
Salt Creek (Late Quaternary)
South Grotto (Late Quaternary)

North Grotto (Late Quaternary)
Dry Lake (Late Quaternary)
Sheephole (Late Quaternary)
Hot Springs (Holocene)

The northwest trending San Andreas Fault Zone (SAFZ) is over 1000 km long and extends from near Cape Mendocino in northern California, to the Salton Sea region in southern California. Like the Elsinore and San Jacinto Fault Zones, the SAFZ is a right-lateral strike-slip fault that typically dips greater than 80 degrees. The SAFZ accommodates approximately 55 - 70% of the relative motion between the North American and Pacific Plates. This fault has been mapped continuously on the surface along its entire length except for the structurally complex region near and just north of the San Gorgonio Pass Fault Zone (SGPFZ; Allen, 1957) in Riverside County. The SGPFZ trends nearly east-west and represents a series of northward dipping compressional (reverse) faults located between San Gorgonio Mountain in the San Bernardino Mountains, and the northern San Jacinto Mountains. In this region, the San Andreas Fault may connect between the southern San Bernardino and northern Coachella segments at depth beneath the north-dipping reverse faults in the SGPFZ (Allen, 1957; Seeber and Armbruster, 1995).

The SAFZ in southern California is composed of numerous segments: the Mojave segment resides north of Riverside County; however, most of the Coachella Valley segment, and the southern most portion of the San Bernardino segment exists within the county. The Coachella Valley segment comprises the southern 100 km of the SAFZ and extends from San Gorgonio Pass to the southeastern edge of the Salton Sea (WGCEP, 1995). The San Bernardino segment is located along the western escarpment of the San Bernardino Mountains and in the northwest region of the San Gorgonio Pass Fault Zone where appears to "die out" on the surface.

The WGCEP (1995) indicated that the Coachella Valley segment has experienced the longest elapsed time since its last surface rupturing earthquake of any on the fault zone, and last experienced a large event around 1680. The 1988 Working Group estimated a recurrence interval for this segment using paleoseismic records of 220 ± 13 yr. Thus this section of the fault zone is considered "overdue" for another earthquake.

Notable historical earthquakes on the southern San Andreas fault include the 1948 Desert Hot Springs (M=6.0), and the 1986 North Palm Springs (M=5.6). For more information regarding these earthquakes visit the Southern California Earthquake Center (SCEC) on the web: <http://www.scecdc.scec.org/clickmap.html>

SAN GORGONIO PASS FAULT ZONE

Classification: Active

Type of fault: Imbricate oblique-reverse and thrust faults possibly associated with high-angle strike-slip tear faults.

Length: ~ 30 km

Width: 3 to 7 km

Dip: The reverse and thrust faults dip northward

Slip Rate: unknown

Total Displacement:

Unknown, however, displacement has been mostly vertical during the late Quaternary, and has accommodated only ~1-2 km of right lateral motion during this time (Allen, 1957).

Alquist Priolo quadrangles:

Beaumont, Cabazon, Whitewater, Desert Hot Springs

Fault strands:

San Gorgonio Pass
Banning

The San Gorgonio Pass Fault Zone (SGPFZ) is approximately 30 km long, 3-5 km wide, east-west trending, and consists of a complex series of active north-dipping thrust and reverse faults which have been active during the Pleistocene (past 11,000 years). The SGPFZ represents a series of faults that accommodate compression across the San Andreas Fault Zone due to a restraining bend in the San Gorgonio Pass region. The restraining bend is referred to as the San Gorgonio Pass Knot, and has developed during the Pleistocene. This fault zone has created new faults to accommodate the Quaternary compression associated with the San Gorgonio Pass Knot, which we refer to as the San Gorgonio Fault(s), and has reactivated the Banning Fault, which accrued at least 16-25 km of late Cenozoic right slip in the San Gorgonio Pass region (see Allen, 1957, and Matti et al. 1992). As speculated by Allen (1957), and later supported by Seeber and Armbruster (1995), the San Andreas Fault may continue at depth below the north-dipping reverse (high angle dip) and thrust (low angle dip) faults of the SGPFZ. Allen (1957) indicated that recent displacements (Late Quaternary) on the

SGPFZ have probably been largely vertical with less than 1 mile of strike-slip movement.

BEAUMONT FAULT ZONE

Matti et al. (1992) applied the name Beaumont Plain Fault Zone to a series of northwest-trending en-echelon fault scarps that traverse late Quaternary alluvial deposits in the vicinity of Beaumont. They indicate that most of the scarps face northwest that they appear to have formed by normal dip-slip displacements. The fault zone is approximately 11 km long, 3 km wide, and consists of approximately 3 to 4 sub-faults.

FAULTS IN THE SOUTHWESTERN MOJAVE DESERT

Late Cenozoic faults east of the San Andreas Fault in eastern Riverside County principally fall into two types: North to north-northwest trending high angle right lateral strike-slip, and east-west trending high angle left lateral.

The north to north-northwest trending high angle strike-slip faults consist of the Long Canyon, Burnt Mountain and Eureka Peak Faults, which are active (Holocene), and the Coxcomb Mountain, Sheep Hole, Palen Mountain, Iron Mountain, Little Maria Mountain Faults which are possibly Pliocene to Pleistocene in age. These faults are discussed below.

The east-west trending left lateral faults in this region vary in activity, with the youngest unit's offset representing older alluvial units of Pleistocene age. Thus, these faults pose little seismic hazard to the sparse population in the region, however few specific studies for each of these faults have been conducted. The most active of these faults is the Blue Cut Fault.

These faults are discussed below:

LONG CANYON, BURNT MOUNTAIN, EUREKA PEAK FAULTS

The northern sections of the Burnt Mountain and Eureka Peak Faults were associated with the 1992 Landers earthquake (Historic; Jennings, 1994; Treiman, 1992). These faults pose a seismic threat to the communities of Yucca Valley and as far south as Desert Hot Springs.

Long Canyon: The long Canyon Fault is a north trending, high angle, right lateral strike-slip fault which is approximately 11 km long and located just north of the

North Branch of the San Andreas Fault east of Desert Hot Springs. Jennings (1994) indicates that this fault has been active in the Holocene (Active; referenced work done by Mark Rymer, 1993).

Burnt Mountain: This fault is a north trending, high angle, right lateral strike-slip fault. As delineated by ground rupture during the 1992 Landers Earthquake in Yucca Valley, the Burnt Mountain Fault is approximately 7 km long and extends south from State Highway 62. The fault probably continues southward to the southern escarpment of the Little San Bernardino Mountains just north of the San Andreas Fault. Thus, the fault may be as long as 20 km.

Eureka Peak: The Eureka Peak Fault is a north trending, high angle, right lateral strike-slip fault, and extends to the southeast from near State Highway 62 following the Lower Covington Flat Wash area along much of its trace. The Landers earthquake ruptured the ground along this fault with maximum horizontal displacements of approximately eight inches (Treiman, 1993).

SHEEP HOLE, COXCOMB MOUNTAIN, PALEN MOUNTAIN, LITTLE MARIA MOUNTAIN, GRANITE MOUNTAIN, RICE VALLEY, DRY WASH, AND BLYTHE FAULTS

Powell (1981) indicated that a series of northwest-trending right-lateral faults likely exist in the southwestern Mojave Desert in eastern Riverside County that may exhibit between 60 to 140 km of cumulative displacement, however, this number is not well resolved. These types of faults probably continue toward the northwest, north of Riverside County and terminate near the Garlock Fault in the southern Sierra Nevada Mountains.

The age and total amount of displacement across these faults is not well understood at this time, however, none appear to have had Holocene displacement. Some of these faults are discussed below.

Sheep Hole and Coxcomb Mountain: Sheep Hole and Coxcomb Mountain Faults northwest have been proposed to reside along the western flank of the Coxcomb Mountains (Hope, 1966; Powell, 1981). These faults are mostly concealed beneath valley fill and are suggested primarily based on right-laterally offset basement rock units exposed in the local ranges; however, Hope (1966) indicated that at one locality, the Sheep Hole Fault offsets an olivine basalt capped by alluvium which may be Pleistocene in age. Hope (1966) indicated that the Sheep Hole Fault [and Coxcomb Mountain Fault] probably represents a major fault break which has right-laterally offset a pendant of metasediments approximately 0.8 miles.

Palen Mountain: Powell (1981) suggested that this fault exhibits about 3 kilometers of right-lateral separation based on offset crystalline basement rocks exposed in the Palen and McCoy Mountains.

BLUE CUT, PORCUPINE WASH-SUSBSTATION, SMOKE TREE WASH-VICTORY PASS, CHIRIACO, CORN SPRINGS, SHIP CREEK, AND SALT CREEK-AZTEC MINE WASH FAULTS

Other faults that pose a seismic hazard in eastern Riverside County include a series of parallel, east-west trending, left lateral strike-slip faults, which include from north to south, the Blue Cut, Porcupine Wash-Substation, Smoke Tree Wash-Victory Pass, Chiriaco, Corn Springs, Ship Creek, and Salton Creek-Aztec Mine Wash Faults (Powell, 1981; Treiman, J.A., 1992; Treiman, J.A., 1993; Jennings, 1994). These faults are described below:

Blue Cut Fault: The Blue Cut Fault has an approximately 80 km trace stretching from the western foot of the Little San Bernardino Mountains to the eastern edge of Pinto Basin, and terminates at both ends against northwest-trending faults (Hope, 1966; Powell, 1981). Where not buried by recent alluvium, the fault zone has a marked surface expression and is typically 90-300 meters wide (Hope, 1966). At the western Little San Bernardino Mountains and Hexie Mountains, the Blue Cut Fault exhibits left-lateral separation of nearly 6 km, and a small dip-slip component (Hope, 1966; also see Powell, 1981). At the eastern end in the Pinto and Eagle Mountain region, the Blue Cut Fault exhibits ~8 km of left lateral separation (Hope, 1966). The fault terminates eastward prior to the Coxcomb Mountains because no trace of the fault occurs within the crystalline rocks of that range (Powell, 1981). Fault deformation features presented by Hope (1966), indicate that the Blue Cut Fault was active during the Pleistocene, and possibly in the Holocene depending on the upper age of deformed alluvial fans which is uncertain.

Porcupine and Substation Faults: The east-west trending Porcupine Fault exhibits approximately 3 km of left lateral separation, and some small scarps in older alluvium which indicates slight Quaternary activity (Hope, 1966; also see Powell, 1981). The Porcupine Fault may extend eastward beneath sediments and connect with the Substation Fault. This is supported by the nearly identical left-slip separation of basement rock units of 3 km (Hope, 1966; Powell, 1981), and that the two faults line up in map view. However, Powell (1981), indicates that the lithologies and contacts between the two faults are not broken, suggesting that the two faults may not align.

Smoke Tree Wash and Victory Pass Faults: The Smoke Tree Wash fault offsets crystalline rock contacts about 1 km in a left lateral sense, and has produced scarps in all but the youngest alluvium (Powell, 1981). This fault may be as long as 25 km (Powell, 1981). The Victory Pass Fault resides east of the Smoke Tree Wash Fault in the southeastern Eagle Mountains, about 4 km south of the Substation Fault (Powell, 1981). The fault left laterally offsets a quartz latite dike swarm and a trace of the early Red Cloud thrust 1.5 km (Powell, 1981). At its eastern end, the fault passes beneath the alluvium of Chuckwalla Valley; at its western end, it dies out along the north margin of Big Wash (Powell, 1981). As with the Porcupine Wash and Substation Faults, the Victory Pass and Smoke Tree Wash Faults are not continuous at the surface (Powell, 1981).

Chiriaco Fault: The east-west trending Chiriaco Fault exhibits approximately 11 km of left lateral separation and 0.5 km of vertical separation determined by offset contacts and structures in the exposed basement rocks of the surrounding hills (Powell, 1975). No surface expression of the Chiriaco Fault has been found (Powell, 1981), however, the offset of basement rock features, the linearity of the valley and its bounding escarpments, and an east-west negative Bouguer gravity anomaly at the eastern end of the valley (Biehler et al., 1964; Rotstein et al., 1976), have been interpreted to reflect the presence of a fault in the subsurface. The fault is covered by undeformed Holocene sediments (Powell, 1975). The fault truncates Eocene Maniobra and lower Miocene Diligencia formations, and is covered by Pleistocene Ocotillo conglomerate west of Chiriaco Summit (Powell, 1975). Thus, the fault has not been active during the Holocene (10,000yrs), and possibly may not have been active during the Pleistocene (1.6 Ma to 10,000 years ago; Powell, 1975, 1981).

Corn Springs Wash Faults: The Corn Springs Wash Fault exhibits 2.5 to 3.0 km of left lateral offset of several contacts and lithologies associated with the Mesozoic batholithic rocks (Powell, 1981). The western end of the fault swings northwestward to disappear beneath alluvium, after which it may either merge with the Chiriaco Fault, or swing westward to connect with a fault along the north flank of the Orocopia Mountains (Powell, 1981). Fault activity postdates three geomorphic events: a colluvial unit a meter or two thick, deposition of caliche, and fluvial down cutting to the present stream level (Powell, 1981). These data indicate that the fault is older than Holocene.

Ship Creek Fault: The Ship Creek Fault is located in the Chuckalla Mountains and left laterally offsets Precambrian and Mesozoic lithologic units and contacts approximately 2 kilometers (Powell, 1981). Alluvial material is faulted against crystalline rock at least two localities, and at its west end, fault displacement dies out in a fold which left laterally bends steeply dipping lithologic units in older

basement rocks (Powell, 1981). The east end of the fault disappears beneath alluvial material east of the Chuckwalla Mountains (1981).

Salton Creek (wash) and Aztec Mine Wash Faults: The Salton Creek Fault trends east-west and is located in the wash region south of the Orocopia Mountains and north of the northernmost Chocolate Mountains. Jennings (1994) indicates that this fault offsets Quaternary age units (< 1.6 Ma). No surface break in the alluvium has been recognized east of the Salton Creek Fault, however, a lineament visible from orbital photographs does occur (Powell, 1981).

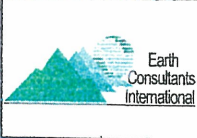
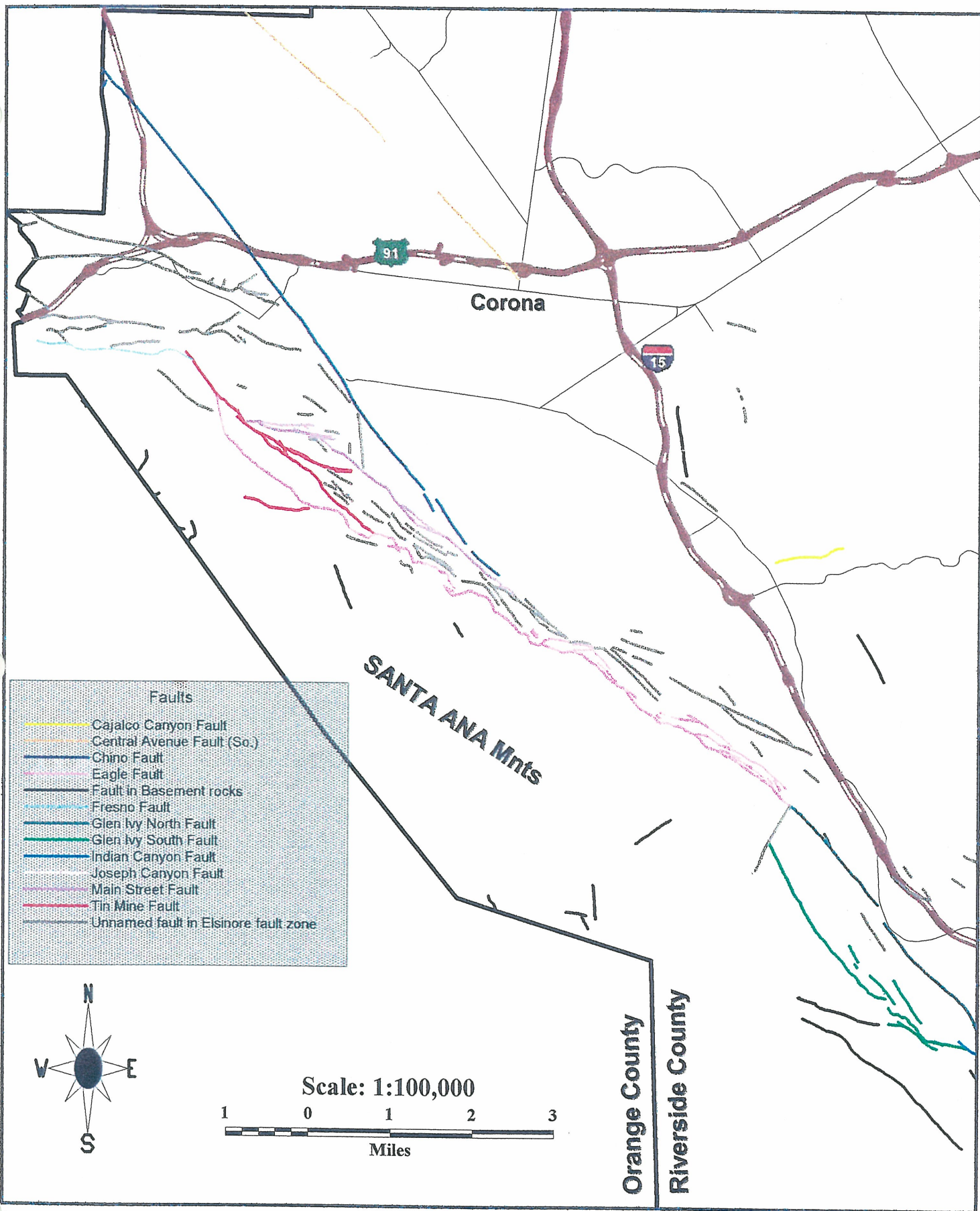
The Aztec Mine Wash Fault (Powell, 1981) is located east of the Salton Creek Fault in the southern Chuckawalla Mountains. This fault offsets an intrusive contact in crystalline basement rocks left laterally approximately 8 km (Powell, 1981). The fault also truncates lower Miocene rocks which overlie the crystalline basement (Powell, 1981). The fault does not appear to significantly offset the relatively old alluvial unit exposed at the drainage divide southeast of Gulliday Wash, and does not offset younger alluvium (Holocene ?)(Powell, 1981).

PRE-QUATERNARY "BASEMENT" FAULTS THROUGHOUT RIVERSIDE COUNTY

Quite a few Pre-Quaternary faults exist in Riverside County that are no longer active and were involved in deformation with either earlier phases of the San Andreas Fault System or tectonics that pre-date the San Andreas Fault System. These faults are not considered a fault hazard in terms of producing an earthquake, however, they may require some consideration during development of a site. For example, an onsite fault may influence issues regarding slope stability, groundwater, or clay soils within the zone of shear.

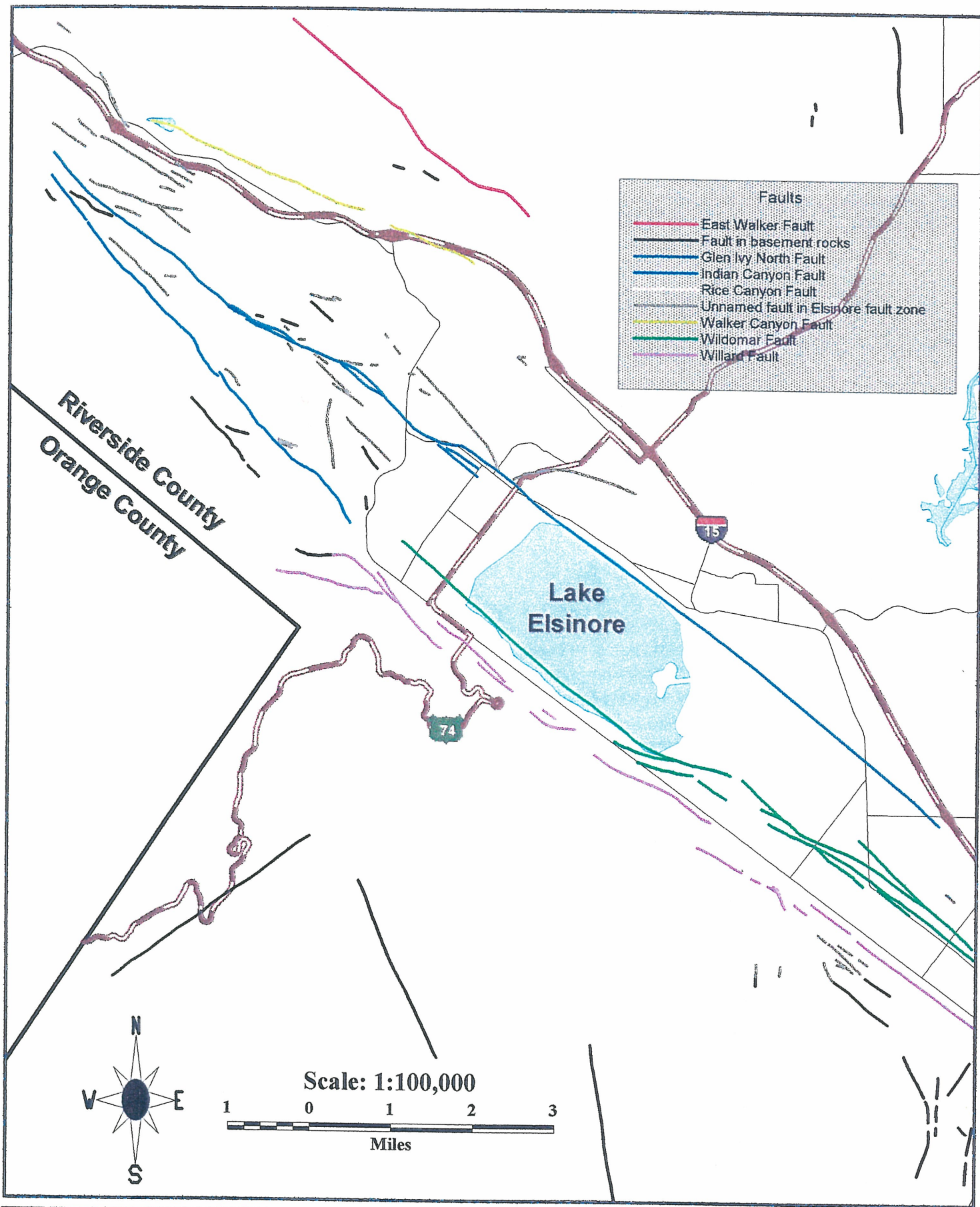
Selected faults that fall into this category include:

- Palm Canyon (South of Palm Springs).
- Deep Canyon Fault (South of Palm Springs)
- Indio Mountain (SE of Palm Desert).
- Martinez (Santa Rosa Mountains).
- Santa Rosa Shear Zone (Santa Rosa Mountains).
- Dillon (Parallel and east of San Andreas Fault).
- Clemens Well (East of Mecca Hills).
- Whipple Mountain Detachment (NE Riverside County).
- Slaughter Tree Wash (NE Riverside County)
- Orocopia Thrust/Detachment (Orocopia Mountains)
- Numerous Unnamed faults contained in older crystalline basement rocks.



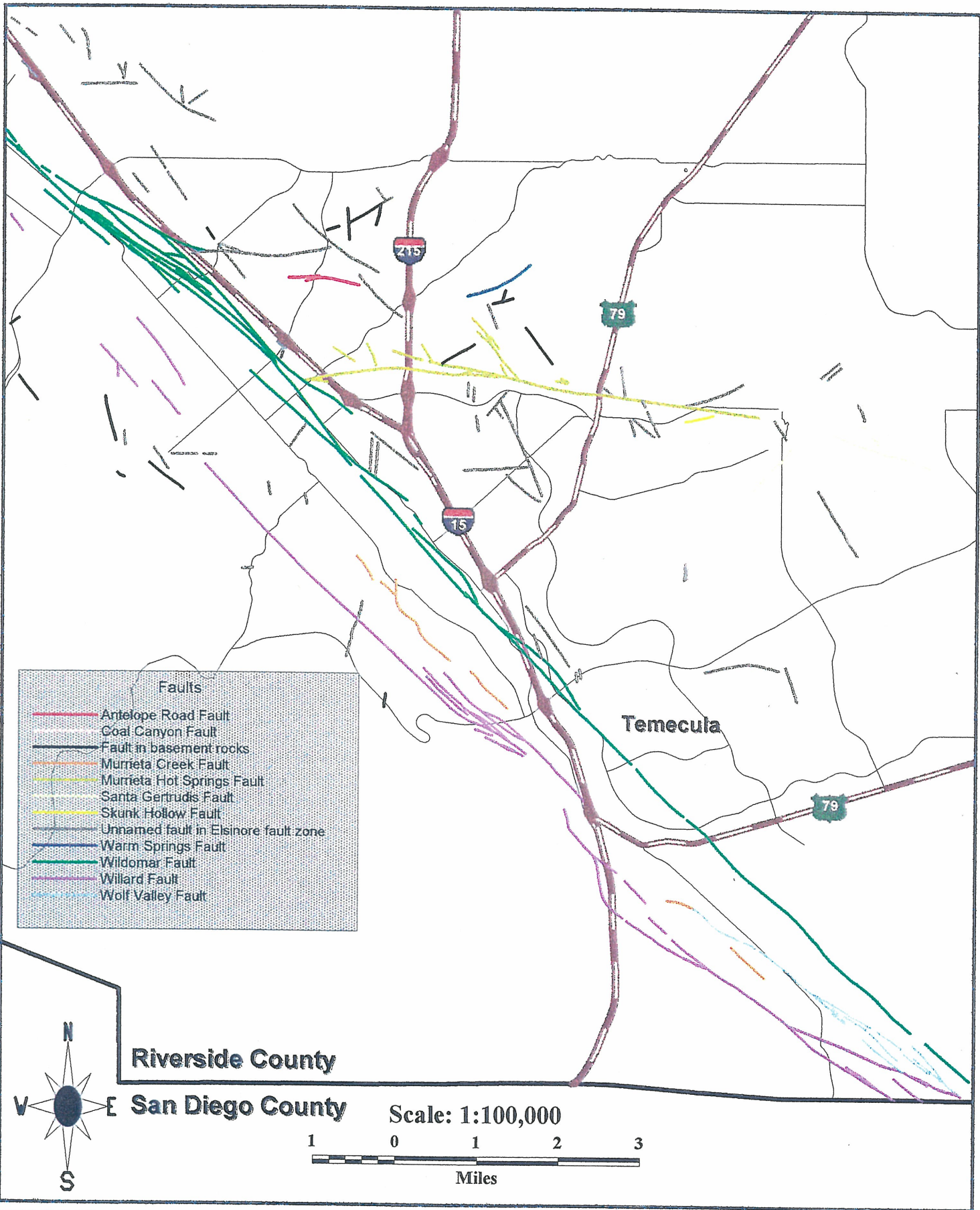
NORTHWEST ELSINORE FAULT ZONE in Riverside County

Figure C-1



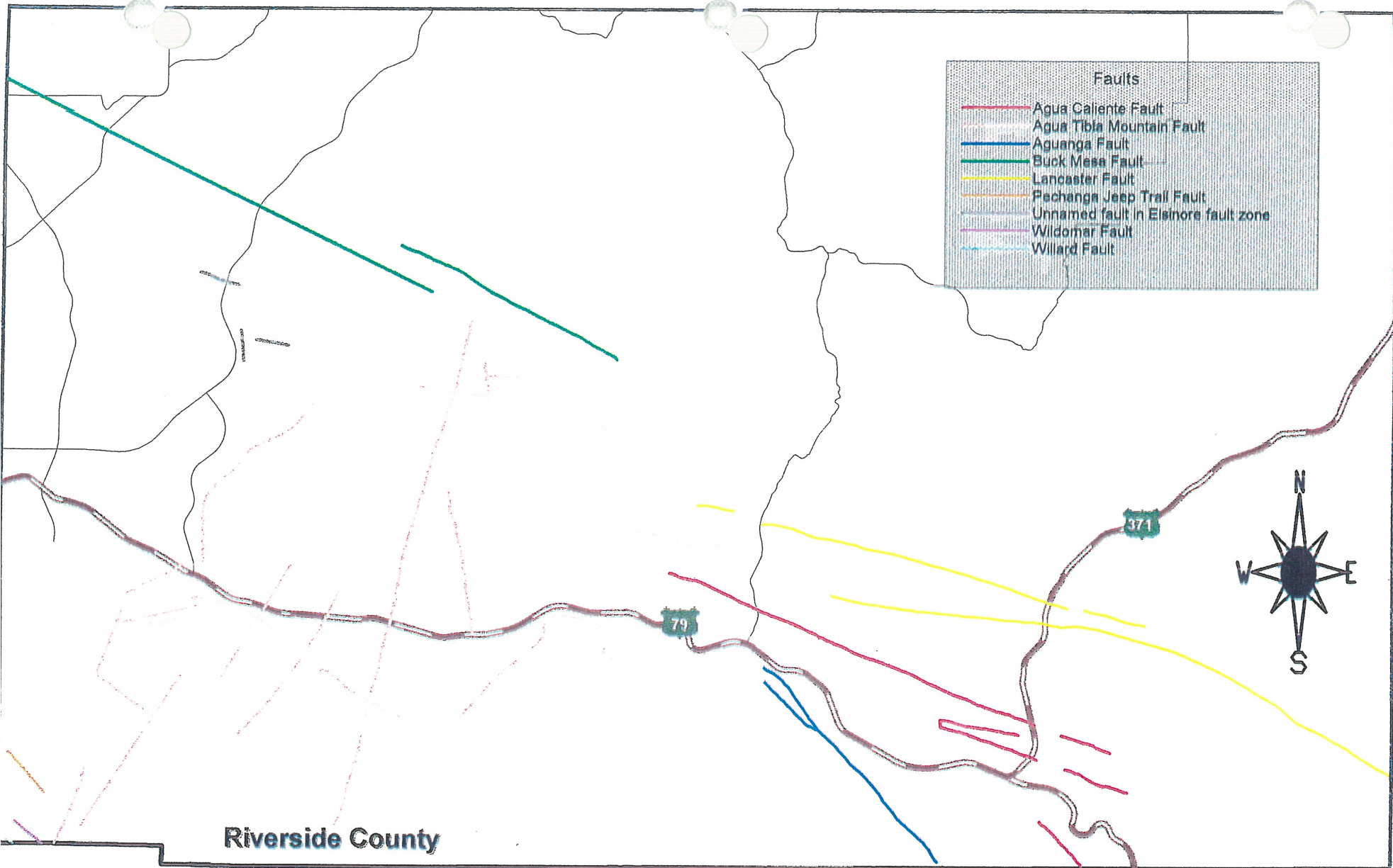
CENTRAL ELSINORE FAULT ZONE in Riverside County

**Figure
C-2**



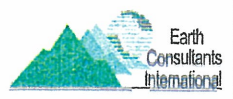
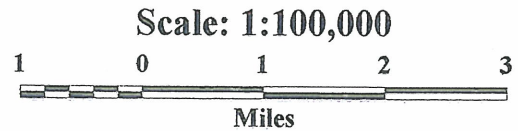
SOUTH ELSINORE FAULT ZONE in Riverside County

**Figure
C-3**



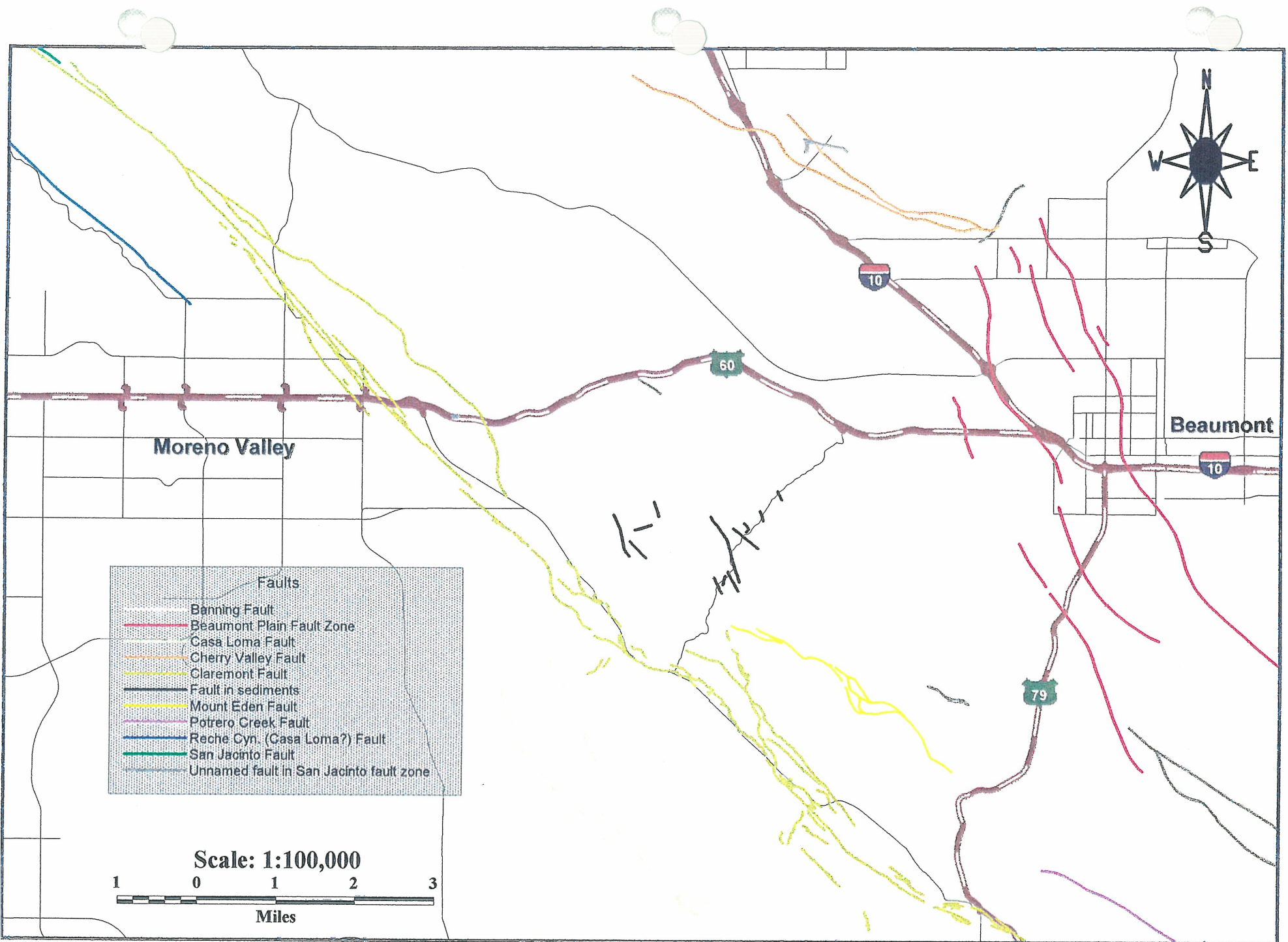
- Faults**
- Agua Caliente Fault
 - Agua Tibia Mountain Fault
 - Aguanga Fault
 - Buck Mesa Fault
 - Lancaster Fault
 - Pechanga Jeep Trail Fault
 - Unnamed fault in Elsinore fault zone
 - Wildomar Fault
 - Willard Fault

Riverside County
San Diego County



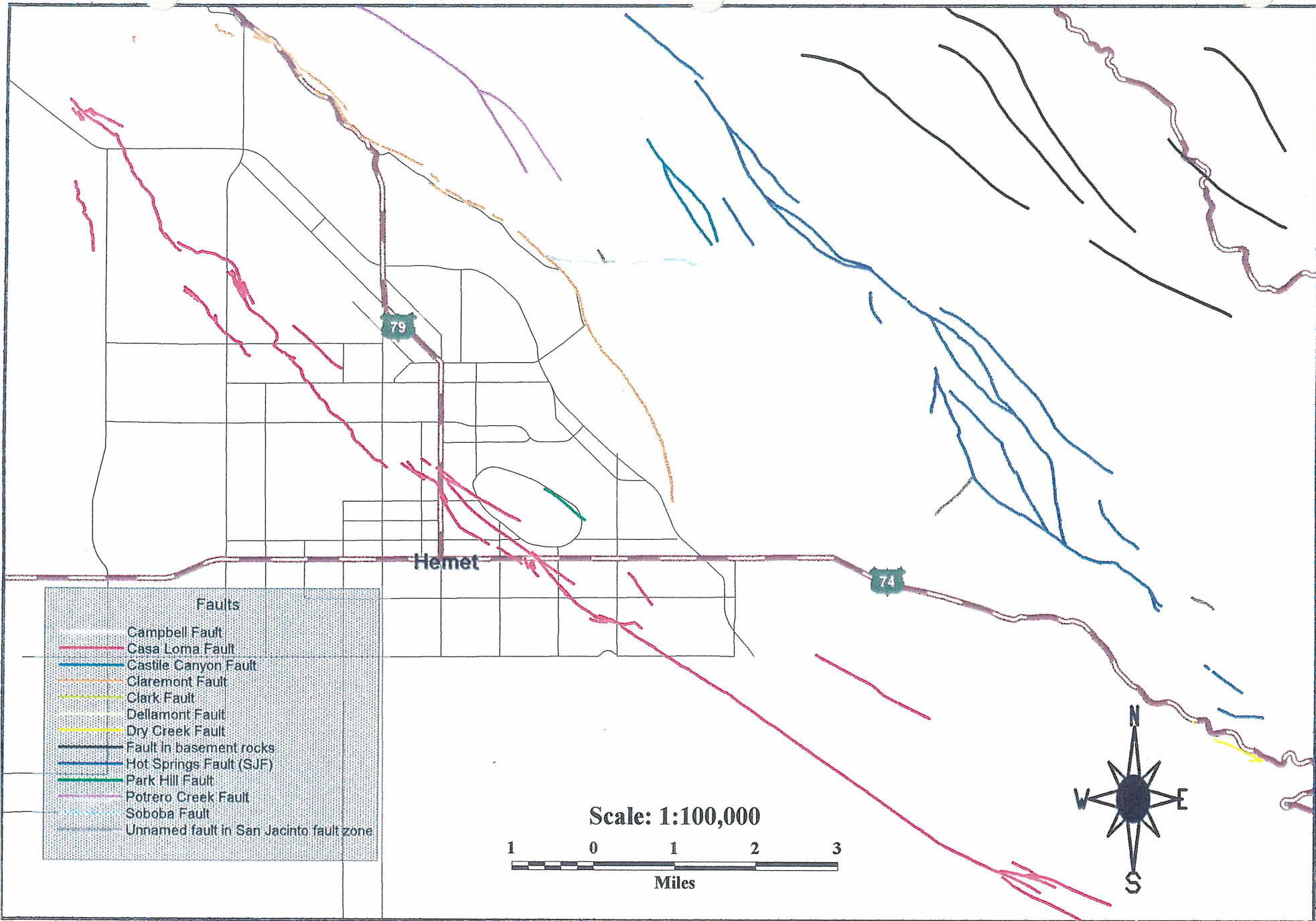
SOUTHEAST ELSINORE FAULT ZONE
in Riverside County

Figure
C-4



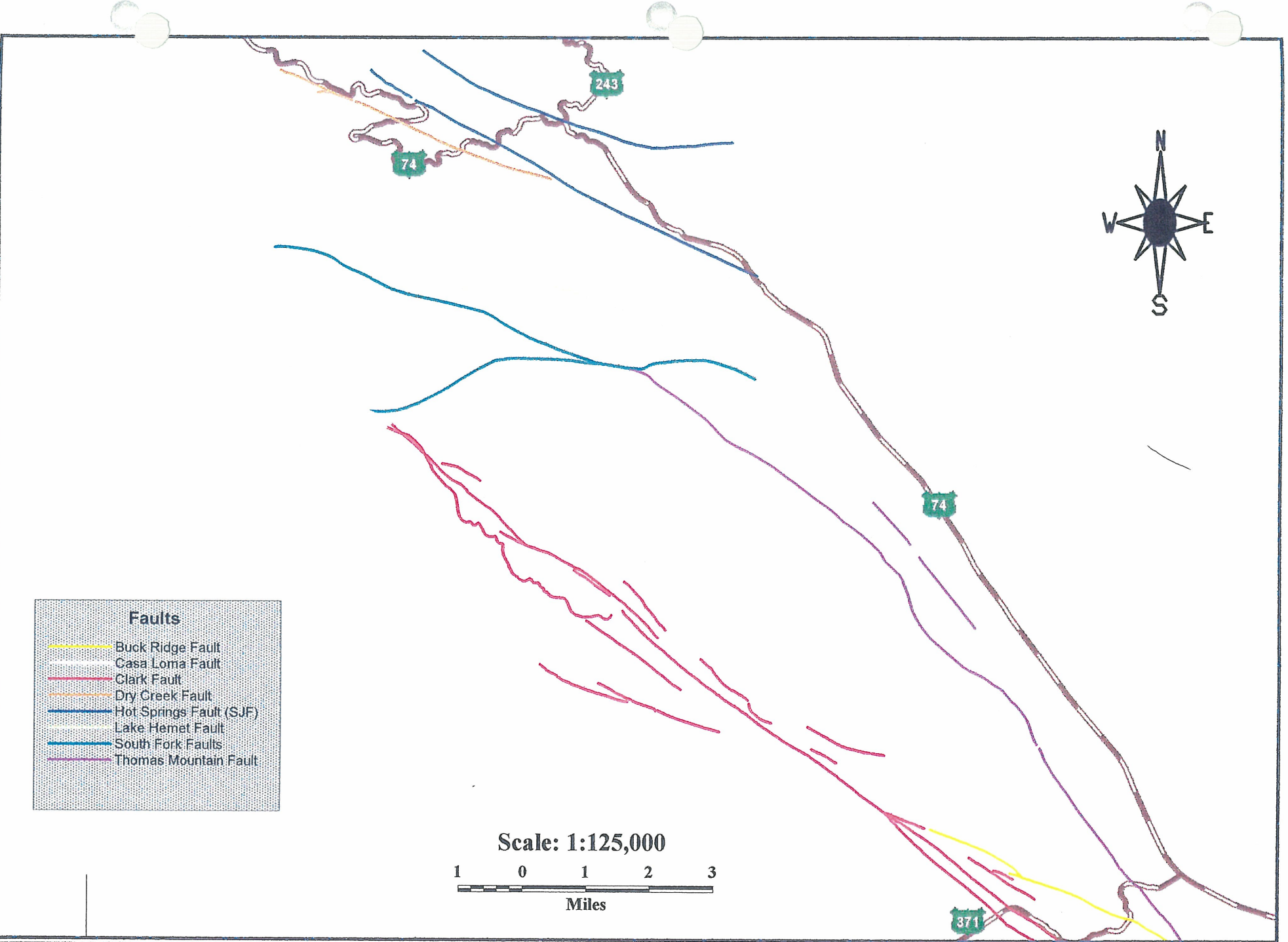
NORTHWEST SAN JACINTO FAULT ZONE
in Riverside County

**Figure
C-5**



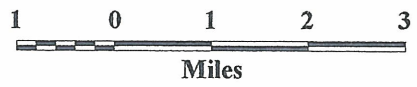
NORTH CENTRAL SAN JACINTO FAULT ZONE in Riverside County

Figure C-6



- Faults**
- Buck Ridge Fault
 - Casa Loma Fault
 - Clark Fault
 - Dry Creek Fault
 - Hot Springs Fault (SJF)
 - Lake Hemet Fault
 - South Fork Faults
 - Thomas Mountain Fault

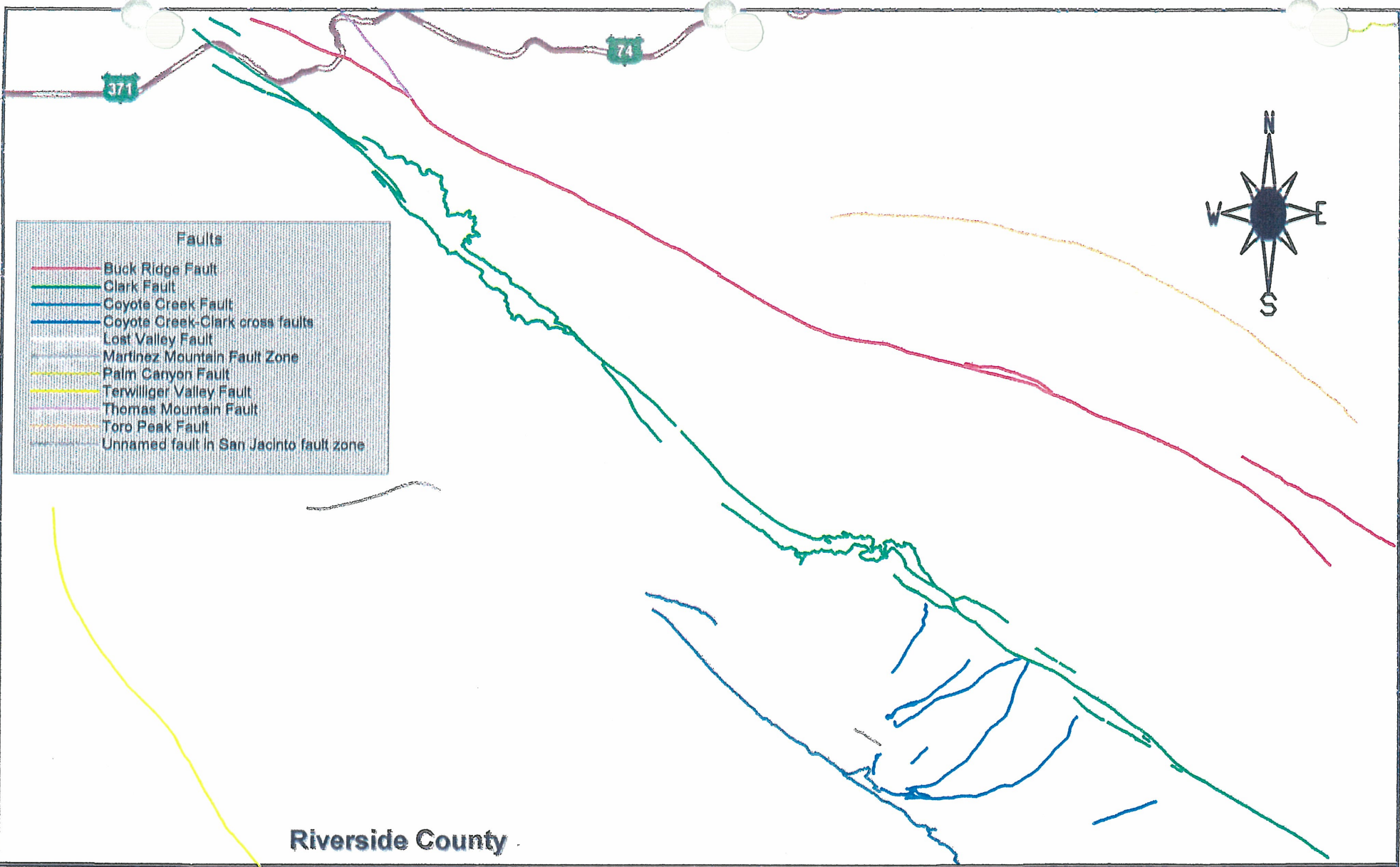
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**SOUTH CENTRAL SAN JACINTO FAULT ZONE
in Riverside County**

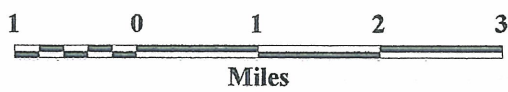
**Figure
C-7**





Riverside County
 San Diego County

Scale: 1:100,000



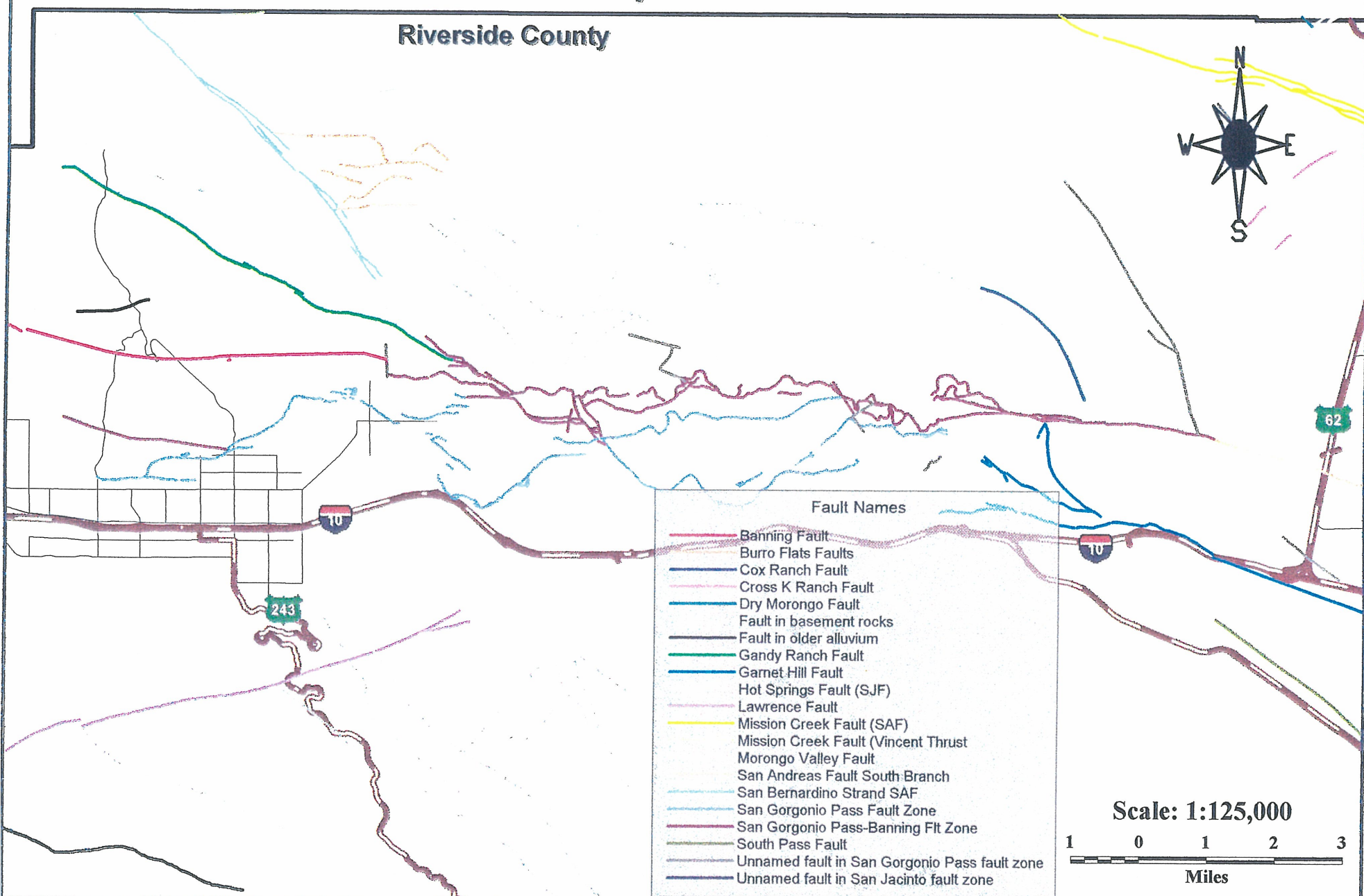
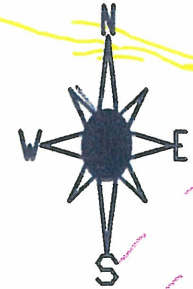
SOUTH SAN JACINTO FAULT ZONE
 In Riverside County



Figure
 C-8

San Bernardino County

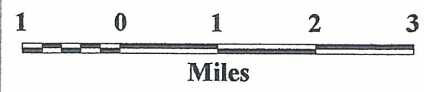
Riverside County



Fault Names

- Banning Fault
- Burro Flats Faults
- Cox Ranch Fault
- Cross K Ranch Fault
- Dry Morongo Fault
- Fault in basement rocks
- Fault in older alluvium
- Gandy Ranch Fault
- Garnet Hill Fault
- Hot Springs Fault (SJF)
- Lawrence Fault
- Mission Creek Fault (SAF)
- Mission Creek Fault (Vincent Thrust)
- Morongo Valley Fault
- San Andreas Fault South Branch
- San Bernardino Strand SAF
- San Gorgonio Pass Fault Zone
- San Gorgonio Pass-Banning Ft Zone
- South Pass Fault
- Unnamed fault in San Gorgonio Pass fault zone
- Unnamed fault in San Jacinto fault zone

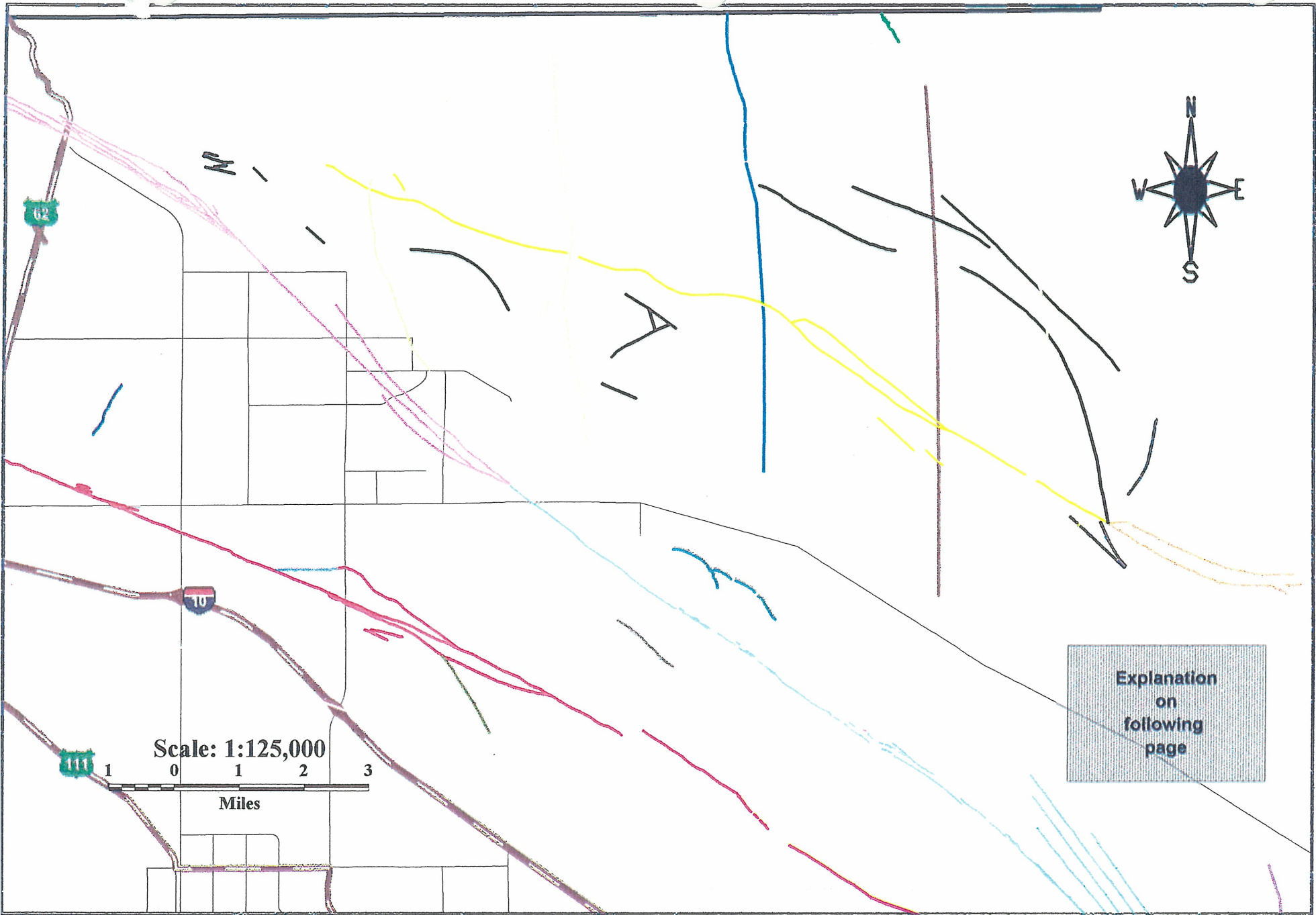
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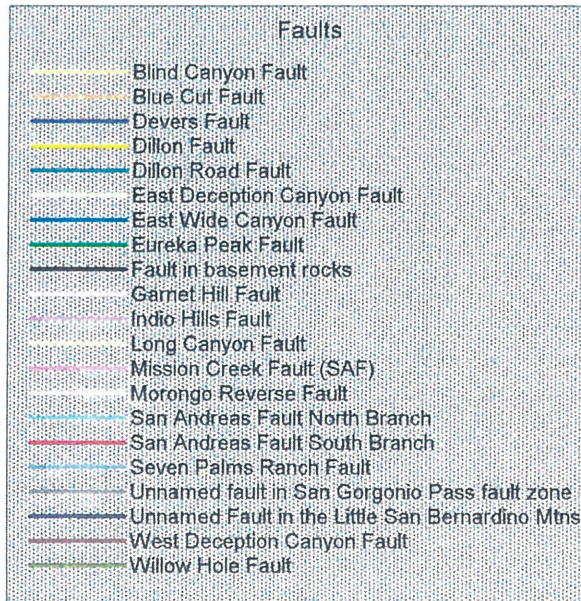


SAN GORGONIO PASS FAULT ZONE

in Riverside County

Figure C-9

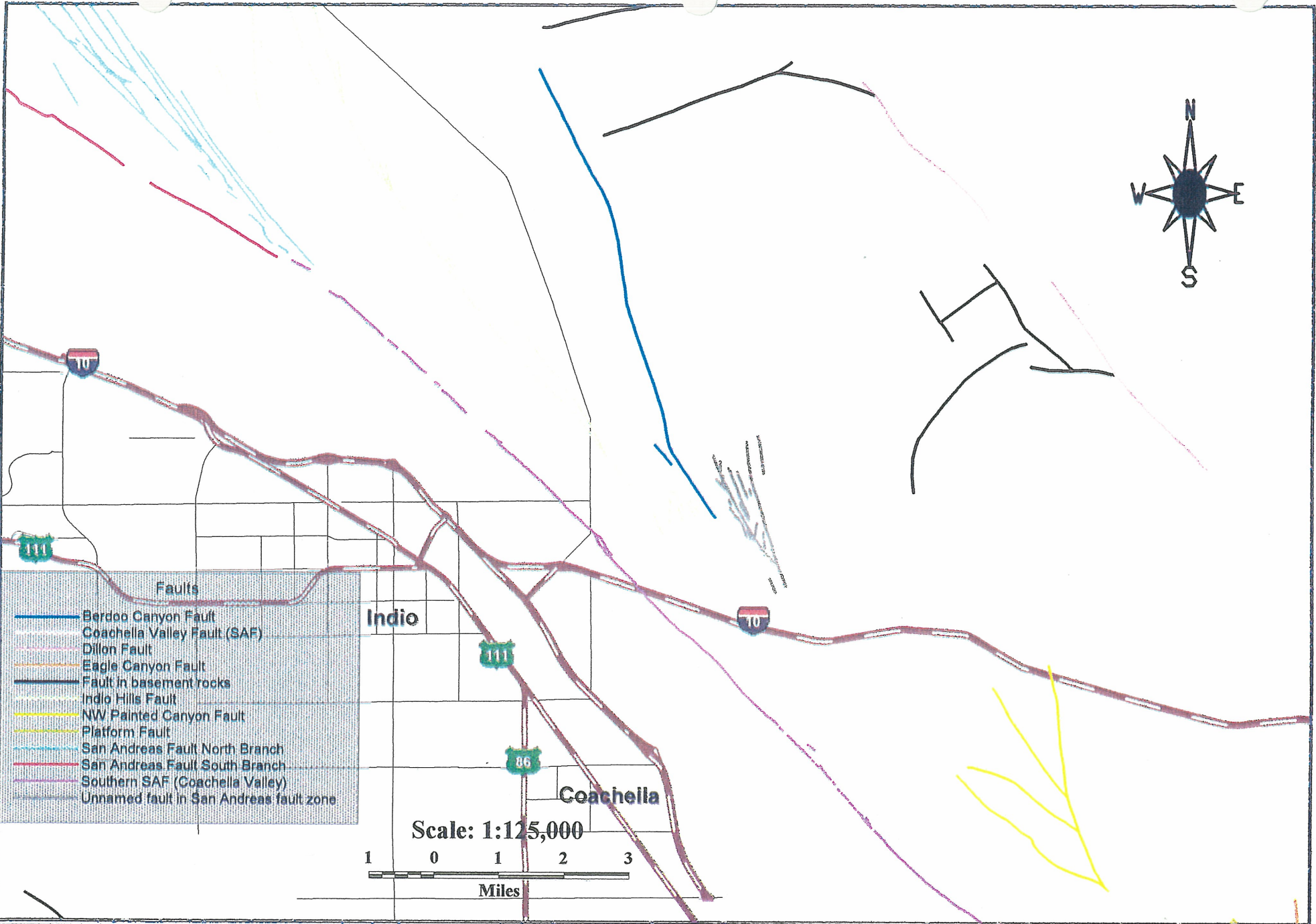




**LEGEND FOR NORTHERN SAN ANDREAS FAULT ZONE
in Riverside County**



**Figure
C-10a**



- Faults**
- Berdoo Canyon Fault
 - Coachella Valley Fault (SAF)
 - Dillon Fault
 - Eagle Canyon Fault
 - Fault in basement rocks
 - Indio Hills Fault
 - NW Painted Canyon Fault
 - Platform Fault
 - San Andreas Fault North Branch
 - San Andreas Fault South Branch
 - Southern SAF (Coachella Valley)
 - Unnamed fault in San Andreas fault zone

Scale: 1:125,000

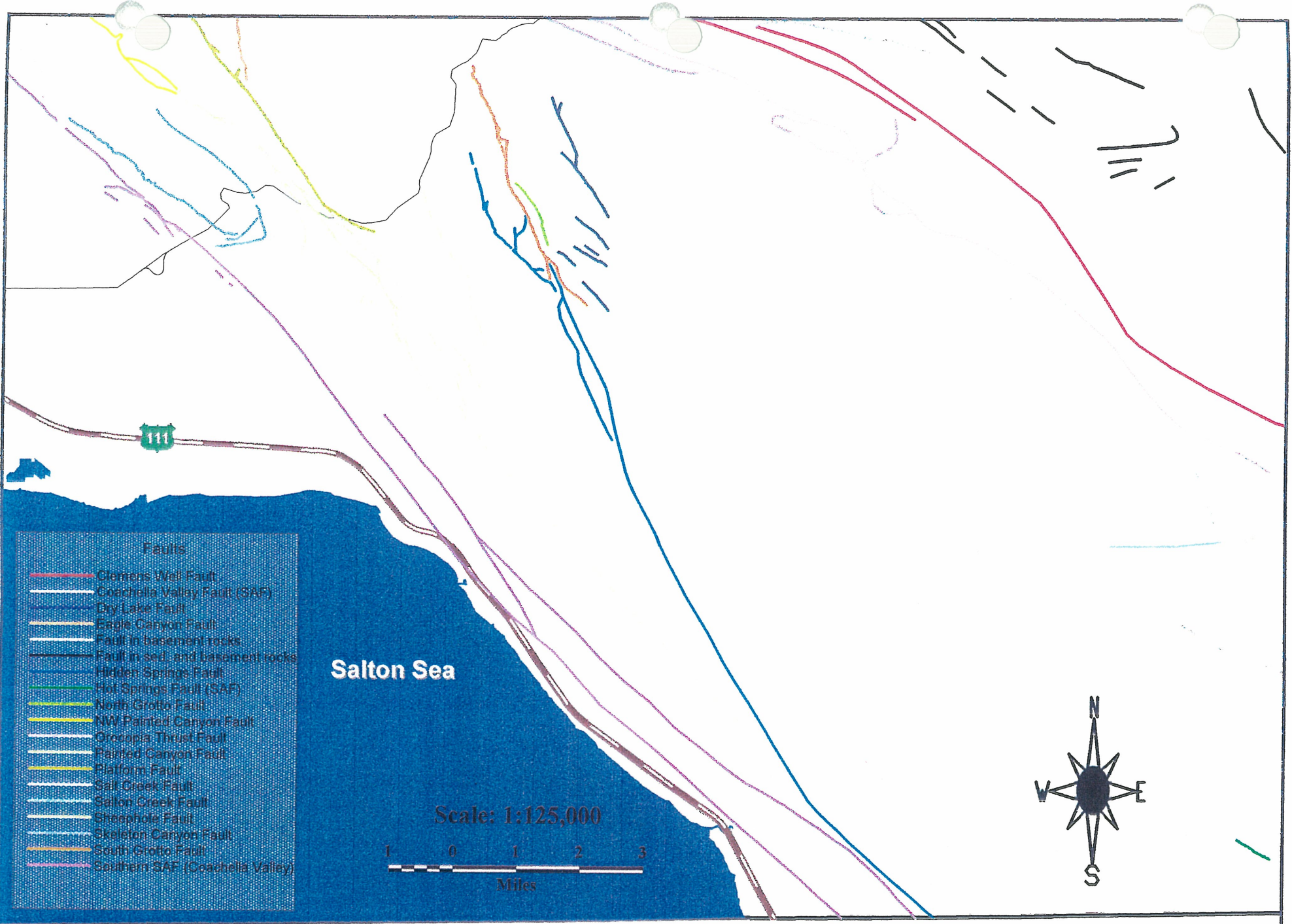
1 0 1 2 3

Miles



CENTRAL SAN ANDREAS FAULT ZONE
in Riverside County

Figure C-11



SOUTH SAN ANDREAS FAULT ZONE
in Riverside County

Figure C-12

San Bernardino County
Riverside County

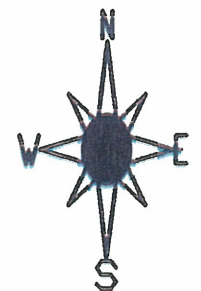
Figure 10

Joshua Tree
National Park

Figure 11

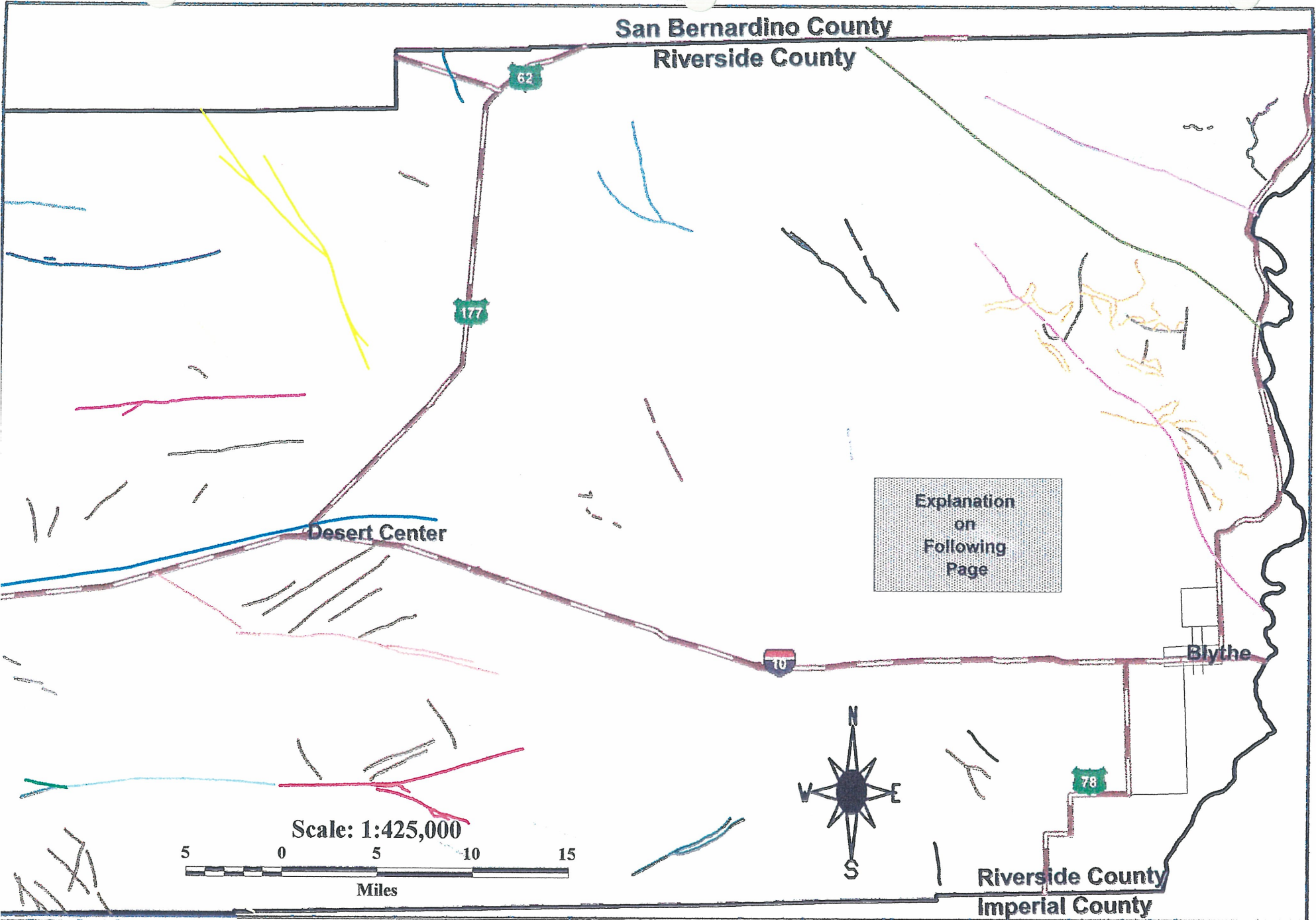
- Faults**
- Beacon Canyon Fault
 - Blue Cut Fault
 - Chiricaco Fault
 - Clemens Well Fault
 - Dillon Fault
 - Eagle Canyon Fault
 - Fault in basement rocks
 - Fault in sed. and basement rocks
 - Hexie Mountain Fault
 - Indio Hills Fault
 - Orocopia Thrust Fault
 - Porcupine Wash Fault
 - Smoketree Wash Fault
 - Sunrise Mill Fault

Scale: 1:250,000



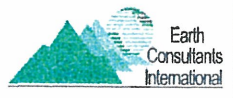
NORTHWEST MOJAVE DESERT FAULTS in Riverside County

Figure
C-13



FAULTS IN THE MOJAVE DESERT
East Riverside County

Figure C-14





**LEGEND FOR FAULTS IN THE MOJAVE DESERT
East Riverside County**

**Figure
C-14a**

