APPENDIX F

GEOLOGY AND SOILS

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Kenneth L. Finger, Ph.D.
Consulting Paleontologist

18208 Judy St., Castro Valley, CA 94546-2306 510.885.1585 klfpaleo@comcast.net

October 27, 2012

Michael Dice
First Carbon Solutions
Michael Brandman Associates
220 Commerce, Suite 200
Irvine, CA 92602-1326

Re: Paleontological Records Search for the City of Fresno General Plan and Development Code Update, Fresno County, California (MBA Project #31680016)

Dear Michael:

As per your request, I have conducted a thorough search of the University of California Museum of Paleontology (UCMP) vertebrate paleontology database for the City of Fresno General Plan and Development Code Update project. The geologic maps of Matthews and Burnett (1965), Page and LeBlanc (1969), and Marchand and Allwardt (1978) indicate that the entire area of concern consists of Quaternary alluvium. The portion of the Matthews and Burnett (1965) map shown here with the project area outlined differentiates surficial deposits as Pleistocene nonmarine (Qc, orange areas) and Quaternary nonmarine terrace (Qt, yellow areas). These two units are basically Pleistocene and undifferentiated Pleistocene-Holocene alluvial sediments, respectively. The late Pleistocene sediments have more recently been referred to the Riverbank Formation.

The UCMP database records three Pleistocene localities (V4401, V65100, and V81121) in Fresno County, all of which yielded elements of the Rancholabrean (late Pleistocene) fauna. V4401 ("Tranquility") accounts for 149 of the 151 specimens. Numerous specimens have been have been published, several of which are types for their species. The recovered faunal assemblage includes pond turtle (*Clemmys marmorata*, rattlesnake (*Crotalus*), loon (*Gavia*), broad-footed mole (*Scapanus latimanus*), jackrabbit (*Lepus*), vole (*Microtus*), wood rat (*Neotoma*), pocket gopher (*Thomomys*), badger (*Taxidea*), grey fox (*Urocyon*), true fox (*Vulpes*), coyote (*Canis latrans*), horse (*Equus*), bison (*Bison*), elk (*Cervus*), and mule deer (*Odocoileus*). Among these are type specimens of *Clemmys marmorata*, *Scapanus latimanus*, and *Canis latrans* that have been documented in scientific publication.

All undisturbed alluvium in the surface and subsurface of the target area have the potential of containing vertebrate fossils; therefore, any excavations of these deposits have the potential of impacting significant paleontological resources. This potential, however, is low because vertebrate fossils occurrences in alluvium tend to be spottily distributed, primarily in pointbar and floodplain deposits. Nevertheless, all Pleistocene alluvium should be considered as having a high paleontological sensitivity.

In accordance with CEQA guidelines, paleontological mitigation measures will be needed on all projects that involve excavations of previously undisturbed deposits. Pre-construction surveys by a professional paleontologist are recommended for those future project areas that include undisturbed terrain, especially where an alluvial section has been exposed by stream dissection. It would also be prudent to have a qualified cultural resources specialist monitor all project-related excavations. If any vertebrate fossils or potentially significant finds (e.g., numerous well-preserved invertebrate or plant fossils) are discovered by anyone working on a construction site, all activities in the immediate vicinity of the find are to cease until a qualified paleontologist evaluates the find for its scientific value. Paleontological resources deemed significant will be efficiently salvaged for deposition in an accredited and permanent scientific institution (e.g., UCMP) where they can be properly curated and preserved for the benefit of current and future generations.

If I can be of further assistance on this project, please do not hesitate to contact me.

Sincerely,

Ken Finger

<u>References Cited</u>

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Page, R.W., and LeBlanc, R.A., 1969, Geology, Page, R.W. and LeBlanc, R.A., 1969, Geology, hydrology, and water quality in the Fresno area, California. U.S. Geological Survey, Open-File Report OF-69-328, scale 1:126720.

GEOLOGIC HAZARDS INVESTIGATION
FRESNO GENERAL PLAN UPDATE
CITY AND SPHERE OF INFLUENCE
FRESNO, FRESNO COUNTY, CALIFORNIA

PROJECT NO. 012-12054
JUNE 15, 2012

Prepared for:

MR. MICHAEL HOULIHAN
MICHAEL BRANDMAN ASSOCIATES
220 COMMERCE SUITE 200
IRVINE, CALIFORNIA 92602

Prepared by:

KRAZAN & ASSOCIATES, INC.
GEOLOGIC HAZARDS DIVISION
215 W. DAKOTA AVENUE
CLOVIS, CALIFORNIA 93612
(559) 348-2200

Krazan & ASSOCIATES, INC.

GEOTECHNICAL ENGINEERING • ENVIRONMENTAL ENGINEERING
CONSTRUCTION TESTING & INSPECTION

June 15, 2012

KA Project No. 012-12054

Mr. Michael Houlihan
Michael Brandman Associates
220 Commerce Suite 200
Irvine, California 92602

RE: Geologic Hazards Investigation
Fresno General Plan Update
City and Sphere of Influence
Fresno, Fresno County, California

Dear Mr. Houlihan:

In accordance with your request, we have completed a Geologic Hazards Investigation for the above-referenced site. The results of our investigation are presented in the attached report.

If you have any questions, or if we may be of further assistance, please do not hesitate to contact our office at (559) 348-2200.

PROFESSIONAL GEOLOGIST
STEPHEN J. NELSON
No. 2146
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

Respectfully submitted,
KRAZAN & ASSOCIATES, INC.

Stephen J. Nelson
Certified Engineering Geologist
CEG No. 2146

SJN:amk

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GEOLOGIC HAZARDS INVESTIGATION
FRESNO GENERAL PLAN UPDATE
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FRESNO, FRESNO COUNTY, CALIFORNIA

1.0 INTRODUCTION

This report presents the results of our Geologic Hazards Investigation for the Fresno General Plan Update-Proposed City and Sphere of Influence located at the intersection of State Highway 99 and State Highway 180 in central Fresno County, California (refer to Vicinity Map, Figure 1). Discussions regarding regional and site geologic/seismic conditions are presented herein, together with an analysis and conclusions pertaining to potential geologic hazards. Krazan & Associates, Inc. reviewed information obtained from exploratory soil borings previously advanced within the City of Fresno and Sphere of Influence (SOI). Information obtained in conjunction with the previous exploratory soil borings is referenced herein. References cited and considered in preparation of this report are listed in Appendix A.

2.0 PURPOSE AND SCOPE

The purpose of the Geologic Hazards Investigation has been to assess potential geologic hazards at the subject site. Our scope of services was outlined in our proposal dated November 29, 2011 (Proposal No. P413-11) and included the following:

- A geologic reconnaissance to evaluate the surface conditions at the project site.
- A review of available subsurface data for evaluation of the subsurface conditions at the project site.
- Aerial photograph interpretation.
- A review of geologic and seismologic literature pertinent to the area of the site.
- Evaluation of potential geologic hazards.
- Preparation of this report summarizing the results, conclusions, recommendations, and findings of our investigation.

3.0 PROPOSED DEVELOPMENT

We understand that design of the proposed development is currently underway and some of the final details pertaining to the development are unavailable. On a preliminary basis, it is understood that the City of Fresno is preparing a new General plan for the City, along with the associated Environmental Impact Report. The General plan will cover the existing City and Sphere of Influence (SOI) consisting of approximately 166 square miles (refer to Community Plan Boundary Map, Figure 1). As part of the expanded Fresno SOI, the City of Fresno will be incorporating several area plans approved by Fresno County which would become part of the new General Plan. City staff will be preparing some General Plan Elements in-house, and has done some preliminary work. The City expects the revisions to the existing General Plan to provide an updated, unified planning document that addresses the existing City and Fresno SOI as a whole, while incorporating new policies and implementation measures that address the growth and development issues associated with the expanded planning area.

In the event that the general nature or location of the proposed construction changes from that described herein, we should be notified so that we may update this report as applicable.

4.0 SITE LOCATION

The subject site is located in Fresno County within the eastern portion of the San Joaquin Valley in California (refer to Vicinity Map, Figure 2). The Proposed Fresno SOI consists of approximately 160 acres and is located in the central portion of Fresno County. Sub-Communities to be included in this SOI include all or portions of Herndon, Townsite, Highway City, Pinedale, Sunnyside, and Calwa. The Fresno SOI is generally bounded on the east by Willow and Highland Avenues; on the south by American, Central, and North Avenues; on the west by Garfield, Grantland, and Marks Avenues; and on the north by the San Joaquin River. Portions of the Fresno SOI are included on the following United States Geological Survey, California, 7.5 Minute Series Topographic Quadrangle Maps:

Quadrangle Map	Dates
Clovis	1964, Photo-revised 1981, 2012
Fresno North	1965, Photo-revised 1981, 2012
Fresno South	1963, Photo-revised 1981, 2012
Friant	1964, 2012
Herndon	1964, Photo-revised 1978, 2012
Kearney Park	1963, Photo-revised 1981, 2012
Lanes Bridge	1964, Photo-Inspected 1973, 2012
Malaga	1964, Photo-revised 1981, 2012

Review of the topographic quadrangle maps indicate that surface elevations range from on the order of 260 feet above mean sea level (amsl) in the southwest portion of the Fresno SOI to 394 feet amsl in the northeast portion of the Fresno SOI. A major water course, identified as the San Joaquin River, trends along the northern edge of the Fresno SOI. Elevations in the river bottom range from 240 feet to 280 feet amsl within the SOI area. Numerous concrete lined canals and unlined canals trend throughout the entire SOI area. These canals are predominately used for agricultural irrigation and flood control. The Southern Pacific, Atchison-Topeka, and Santa Fe Railroads trend through the Fresno SOI area.

The Fresno SOI area and adjoining foothills are characterized by hot summers, mild winters and relatively low to moderate precipitation which occurs mostly during the winter. The southern portion of the San Joaquin Valley lies in the rain shadow of the Coast Ranges. Moisture-laden air moving eastward from the Pacific Ocean is cooled by the orographic effect of passing over the mountains west of the valley, resulting in condensation of water vapor and precipitation. Consequently, when the air masses have passed over the mountains and descend to cross the San Joaquin Valley, they contain less moisture, and a relatively smaller amount of rain falls on the valley floor.

5.0 GEOLOGIC SETTING

5.1 General

The Fresno SOI is located along the east margin of the southern San Joaquin Valley portion of the Great Valley Geomorphic Province of California. The San Joaquin Valley is bordered to the north by the Sacramento Valley portion of the Great Valley, to the east by the Sierra Nevada, to the west by the Coast Ranges, and to the south by the Transverse Ranges. The San Joaquin sedimentary basin is separated from the Sacramento basin to the north by the buried Stockton arch and associated Stockton Fault. The 450-mile long Great Valley is an asymmetric structural trough that has been filled with a prism of Mesozoic and Cenozoic sediments up to 5 miles thick.

The Sierra Nevada, located east of the San Joaquin Valley, is gently southwesterly tilted fault block comprised of igneous and metamorphic rocks of pre-Tertiary age that comprise the basement beneath the San Joaquin Valley. The Coast Ranges, located west of the San Joaquin Valley, are comprised of folded and faulted sedimentary and metasedimentary rocks of Mesozoic and Cenozoic age.

The San Joaquin River and the Kings River are the principal rivers in the area. Alluvial fans formed by these rivers are the predominant geomorphic features in the Fresno area. The area of the subject site is characterized by low alluvial fans and plains, which constitute a belt of coalescing alluvial fans of low relief between the dissected uplands, adjacent to the Sierra Nevada and the valley trough. According to the map entitled "Geomorphic Features of the Fresno Area, San Joaquin Valley, California" (Page and Leblanc, 1969), the site is located in the "Compound Alluvial fan of Intermittent Streams North of the Kings River Geomorphic Area". Recent alluvial fan deposits from streams emerging from highlands surrounding the Great Valley and Pleistocene non-marine sedimentary deposits (Riverbank Formation) composed of older alluvium and dissected fan deposits underlain the subject site area (refer to Regional Geologic Map, Figure 3 and Regional Geologic Cross Section, Figure 4).

5.2 Lithology

The thick accumulation of deposits within the San Joaquin Valley range in age from Jurassic to Holocene and include both marine and continental rocks and deposits. The 1965 Geologic Map of California, Fresno Sheet, indicates that the near-surface deposits in the area of the Fresno SOI consist of Quaternary recent fan deposits and Quaternary Older alluvium (Pleistocene Nonmarine Sedimentary deposits).

The subsurface information obtained in conjunction with previous subsurface Investigation(s) performed within the Fresno SOI indicates that the surface and near-surface deposits generally consist of sandy silts, silty sands, sands, clayey sands, sandy clays and clayey silts. These observed deposits are consistent with those mapped in the area, and are further described in Section 6.3 of this report.

5.3 Structure and Faults

The general area of the Fresno SOI is underlain by a homoclinal series of Cenozoic deposits dipping 4 degrees to 6 degrees to the southwest toward the center of the San Joaquin Valley. The contact between the Cenozoic and basement rocks dips nearly 8 degrees southwest, or at a slightly greater inclination than does the on-lapping homoclinal Cenozoic sequence. No active faults are mapped within the Fresno SOI area. Based on mapping and historical seismicity, the seismicity of the Fresno SOI area is considered low by the scientific community.

Adjacent to the San Joaquin Valley, the Sierra Nevada and Coast Ranges are geologically young mountain ranges that possess active and potentially active fault zones. Major active faults and fault zones occur at some distance to the east, west, and south of the Fresno SOI (refer to Fault Map, Figure 5). Table I is a listing of significant active faults within 90 miles of the Fresno SOI.

Numerous active faults are present within the central Coast Ranges west of the site including the San Andreas Fault located approximately 61 miles west of the subject site. The fault is considered active and is of primary concern in evaluating seismic hazards throughout western Fresno County. The 684-mile-long San Andreas Fault Zone is the principal element of the San Andreas Fault system, a network of faults with predominately dextral strike-slip displacement that collectively accommodates the majority of relative north-south motion between the North America and Pacific plates. The San Andreas Fault zone is the most extensively studied fault in California and perhaps the world. The creeping section of the San Andreas Fault is about 61 miles from the site at its closest point. The San Andreas Fault Zone is considered to be the Holocene and historically active dextral strike-slip fault that extends along most of coastal California from its complex junction with the Mendocino Fault zone on the north, southwest to the northern Transverse Range and inland to the Salton Sea, where a well defined zone of seismicity transfers the slip to the Imperial fault along a right-releasing step.

Two major surface-rupturing earthquakes have occurred on the San Andreas Fault in historic time: the 1857 Forth Tejon and 1906 San Francisco earthquakes. Additional historic surface rupturing earthquakes include the unnamed 1812 earthquake along the Mojave section and the northern part of the San Bernardino Mountains section, and a large earthquake in the San Francisco Bay area that occurred in 1838 that was probably on the Peninsula section. Historic fault creep rates are as high as 32 millimeters per year for the 82-mile-long creeping section in central California with creep rates gradually tapering to zero at the northwestern and southeastern ends of the section.

One of the nearest seismotectonic source is the Great Valley Fault Zone (Coast Ranges-Central Valley boundary zone), located approximately 34 miles west of the site. The Great Valley Fault zone is the geomorphic boundary of the Coast Ranges and the Central Valley and is underlain by a 300-mile long seismically active fold and thrust belt that has been the source of recent earthquakes, such as the 1983 magnitude 6.5 Coalinga and the 1985 magnitude 6.1 Kettleman Hills earthquakes. Nearly the entire thrust system is concealed or "blind". The basal detachment of this thrust system dips at a shallow angle to the west. East-directed thrusting over ramps in the detachment and west-directed thrusting on backthrusts are responsible for the uplift along the eastern range front of the Coast Ranges. Based on earthquake focal mechanisms, movement on the thrust zone is generally perpendicular to the strike of the geomorphic boundary and trend of the San Andreas Fault system. Shortening along the geomorphic boundary is driven by a component of the Pacific-North American Plate motion that is normal to the plate boundary. The Great Valley Fault Zone is considered the dominant seismic feature with potential for affecting the Fresno SOI.

The Ortigalita Fault zone is a major Holocene dextral strike-slip fault in the central Coast Ranges that is an eastern part of the larger San Andreas Fault system. The Ortigalita Fault zone is about 54 miles west of the site. The Ortigalita Fault zone extends from about 12.4 miles northwest of San Luis Reservoir southeast to the vicinity of Panoche Valley. The Ortigalita Fault zone is characterized by echelon fault traces separated by pull-apart basins. The fault zone is divided into four sections. The Little Panoche Valley section is the southern most section and is closest to the site. The Little Panoche Valley section is late Holocene active. Late Quaternary slip rates and recurrence intervals are unknown, although the recurrence interval for the entire Ortigalita Fault zone is about 2,000 to 5,000 years.

Regional structure within the Western Sierra Nevada north of the subject site is complex and generally consists of blocks separated by steeply eastward-dipping, north and northwest striking reverse faults of the Foothills Fault system. The Foothills Fault system is located within approximately 32 miles north of the subject site. Based on mapping and historical seismicity, the seismicity of the Sierra Nevada foothills has been generally considered low by the scientific community. However, on August 1, 1975, a 5.7 Richter magnitude earthquake occurred near Oroville within the northern Sierra Nevada. Surface rupture along the Cleveland Hill Fault (part of the Foothills Fault System) was associated with 1975 Oroville earthquake. As a result of this event, numerous studies were undertaken to further evaluate the seismicity of the Sierra Nevada foothills. Of particular note are the geologic and seismicity studies conducted by Woodward-Clyde Consultants (WCC) to evaluate the proposed Auburn Dam site. Based on these studies, WCC concluded that seismic events in the Sierra Nevada foothills are associated with very small, geologically infrequent, incremental displacements having minor geomorphic surface expression.

In addition, the eastern border of the southern San Joaquin Valley is cut by a series of en-eschelon range-front faults. These faults are mainly northwest trending normal faults, down dropped to the west and with a near vertical dip. One of the range-front faults, the Clovis Fault, is mapped extending from an area just south of the San Joaquin River to a few miles south of Francher Creek approximately 6 miles northeast of the Fresno SOI. No evidence has been found of historic ground movement along this feature. These range-front faults have generally been considered inactive, with no recognized Quaternary displacement, however a September 1973 magnitude 4.4 earthquake that occurred approximately 4.3 miles north of the Fresno SOI may be related to this fault system.

The Nunez Fault is located approximately 6 to 7 miles northwest of Coalinga and is about 48 miles southwest of the Fresno SOI. The fault is about 2.6 miles long and is considered active based on surface rupture associated with the 1983 Coalinga earthquake. The fault is divided into two north and south trending segments. About 2.1 miles of right-reverse surface rupture occurred on the segments. Total displacement and timing of past fault movements are poorly constrained.

Tensional forces resulting in normal faults are reported to be related to crustal stress relief in the southeast portion of the San Joaquin Valley. Numerous relatively short, normal faults traverse this region. Creep activity is the prominent mode of slip on those faults in this region that are active. These movements have continued on an intermittent basis from the early Miocene to Recent time. This faulting is directly related to and controls the accumulation of oil in several oil fields within the westerly portion of the valley. Most authors agree that current creep movements can be ascribed to subsidence promoted by extensive withdrawal of petroleum, and in some cases, groundwater. Those faults considered to be active in the southern valley are Kern Front and Pond Faults located at least 70 miles south of the Fresno SOI.

The Sierra Nevada and Owens Valley Fault Zones bound the eastern edge of the Sierra Nevada block more than 90 miles east of the site. The Owens Valley Fault zone branches to the east of the Sierra Nevada Fault zone about 2 miles south of the Alabama Hills. The Owens Valley Fault zone is approximately 75 miles long and extends to the west side of Owens Lake to a few miles north of Big Pine. The maximum width of the fault zone is approximately 2 miles. The Owens Valley Fault generated one of California's greatest historical earthquakes (Owens Valley Earthquake of 1872) and poses a significant hazard to the communities on the eastern side of the Sierra Nevada Mountains

The White Wolf Fault, responsible for a 1952 earthquake that caused extensive damage in the Bakersfield area, is located in the tectonically active Tehachapi Mountains at the southerly terminus of the valley, over 100 miles south of the Fresno SOI.

As noted above, several dominant faults with seisomgenic structures are located in the vicinity of the Fresno SOI. Table I is a listing of active faults or seismogenic structures within 90 miles of the Fresno SOI, and a Fault Map is provided on Figure 5.

6.0 SITE DESCRIPTION/GEOLOGY

6.1 General/Surface Features

Site reconnaissance was performed in April through June 2012. The Fresno SOI area encompasses an approximate 156 square miles, just south of the San Joaquin River, in the central portion of Fresno County, California (refer to Regional Geologic Map, Figure 3). The areas were observed to be predominately developed land consistent with the characteristics of historic and older, residential, commercial, and industrial areas in the downtown portion of the Fresno SOI. Further from the downtown area, single and two-story single family homes, single and multi-storied residential apartment complexes are located throughout the area. Areas not developed with structures generally contained paved streets, sidewalks, parking lots, parks, and landscaped areas. Commercial development generally was observed to be located along major thoroughfares.

The natural topography within the Fresno SOI area generally trends from the northeast towards the southwest. The historically natural, agricultural and manmade flow for drainage channels predominately follows the northeast to southwest trend. However, because the area was historically developed for agricultural use, there also many subchannels designed to transport water in a northwest-southeast direction. Within developed areas the natural surface runoff has been modified to flow along the curbs and gutters to a storm water collection system. Water is then piped underground to a storm water retention basin.

No evidence of surface faulting was observed on the property during our reconnaissance. The majority of the subject site and surrounding properties are relatively flat. However slopes associated with the San Joaquin River bluff were on the order 5 feet to greater than 100 feet high. The bluff slopes in the vicinity of existing developments were generally well maintained and appeared to be relatively stable. However, the bluff slopes in predominately undeveloped and/or agricultural areas generally appeared to be in relatively good to poor condition with varying degrees of instability and disrepair.

6.2 Aerial Photograph Interpretation

Stereoscopic and monolithic aerial photographs, dated 1937 through 2011, of the subject site were examined (Scale: 1"=660' to 1"=2000; California State University – Fresno, Henry Madden Library). Site conditions shown on the more recent photographs are generally similar to those observed during our site reconnaissance. The central portion of the Fresno SOI area is occupied by predominately developed communities consisting of residential, commercial, and industrial developments. Along the edges of the Fresno SOI, the area predominately consists of agricultural land, and rural residential developments. With the exception of several lineal features identified as drainage channels, streets, and vehicle parking areas, no distinct lineaments, tonal variations, or other potential fault related features are shown on or adjacent to the property in the aerial photographs.

6.3 Subsurface Conditions

Subsurface investigations consisting of exploratory drilling has been performed by Krazan & Associates, Inc., within the Fresno SOI area for over 30 years. Subsurface soil conditions were explored by drilling hundreds of geotechnical borings to depths ranging from approximately 5 to 150 feet below existing site grade, using a truck-mounted drill rig. During drilling operations, penetration tests were performed at regular intervals to evaluate soil consistency and to obtain information regarding engineering properties of the subsoils. Soil samples were retained for laboratory testing. The soils encountered were continuously examined and visually classified in accordance with the Unified Soil Classification System.

Laboratory tests were performed on selected soil samples to evaluate their physical characteristics and engineering properties. The laboratory testing program was formulated with emphasis on the evaluation of natural moisture, density, gradation, expansion potential, shear strength, consolidation potential, and moisture-density relationships of the materials encountered.

Based on our findings, the subsurface conditions encountered appear typical of those found in the geologic region of the site. In general, the upper soils consisted of approximately 6 to 12 inches of very loose silty sand, silty sand with trace clay, sandy silt, clayey sand, or clayey gravel. These soils are disturbed, have low strength characteristics, and are highly compressible when saturated.

Below the loose surface soils, approximately 2 to 4 feet of loose/soft to very dense/hard clays, silts, sands, and gravels are typically encountered. Field and laboratory tests suggest that these soils are typically moderately strong and slightly to moderately compressible. The clayey soils had a low to high expansion potential. Penetration resistance ranged from less than 5 to greater than 100 blows per foot. Dry densities ranged from 80 to 120 pcf. Representative soil samples typically consolidate approximately ½ to 12 percent under a 2 ksf load when saturated. Representative soil samples had angles of internal friction ranging from 11 to 40 degrees. Representative samples of the clayey soils had expansion indices ranging from 0 to 100+.

Below 3 to 5 feet, predominately clays, silts, sands, and gravels are usually encountered. Field and laboratory tests suggest that these soils are typically moderately strong and slightly compressible. Penetration resistance ranges from 10 to greater than 100+ blows per foot. Dry densities ranged from 90 to 140 pcf. Representative soil samples typically consolidate approximately 2 to 3 percent under a 2 ksf load when saturated. These soils usually have slightly stronger strength characteristics than the upper soils and extend to the termination depth of our borings.

Test boring locations were checked for the presence of groundwater during and immediately following the drilling operations. Groundwater was encountered near the surface in the vicinity of existing ponds, lakes, ditches, and canals, to depths greater than 100 feet below site grade during the field investigations. Review of groundwater elevation maps prepared by the Department of Water Resources dating from 1961 to 2012 indicates that depth to free groundwater in the vicinity of the site ranged from 1 foot to greater than 100 feet below site grade. It should be recognized that water table elevations may fluctuate with time, being dependent upon seasonal precipitation, irrigation, land use, and climatic conditions as well as other factors. Therefore, existing and historical high groundwater depths should be determined during site specific investigations on development projects.

7.0 GEOLOGIC HAZARDS

7.1 Fault Rupture Hazard Zones in California

The Alquist-Priolo Geologic Hazards Zones Act went into affect in March, 1973. Since that time, the act has been amended 10 times (Hart, 1994). The purpose of the Act, as provided in DMG Special Publication 42 (SP 42), is to prohibit the location of most structures for human occupancy across the traces of active faults and to mitigate thereby the hazard of fault-rupture." The act was renamed the Alquist-Priolo Earthquake Fault Zoning Act in 1994, and at that time, the originally designated "Special Studies Zones" was renamed the "Earthquake Fault Zones."

As indicated by SP 42, "the State Geologist is required to delineate "earthquake fault zones" (EFZs) along known active faults in California. Cities and counties affected by the zones must regulate certain development 'projects' within the zones. They must withhold development permits for sites within the zones until geologic investigations demonstrate that the sites are not threatened by surface displacement from future faulting. The State Mining and Geology Board provides additional regulations (Policies and Criteria) to guide the cities and counties in their implementation of the law (CCR, Title 14, Division 2)."

Special Publication 42 also provides definitions of certain terms, which are important to the evaluation of seismic hazards. These include the definitions for a fault and a fault trace. They also include the following:

Active Fault: One which has had surface displacement within Holocene time (about the last 11,000 years), hence constituting a potential hazard to structures that might be located across it.

Potentially Active Fault: Initially, faults were defined as *potentially active*, and were zoned, if they showed evidence of surface displacement during Quaternary time (last 1.6 million years). The term "recently active" was not defined, as it was considered to be covered by the term "potentially active."...the term "potentially active" continued to be used as a descriptive term on map explanations on EFZ maps until 1988.

Sufficiently Active and Well-Defined: There are so many potentially active faults in the State that it would be meaningless to zone all of them. The State Geologist made a policy decision to zone only those potentially active faults that have a relatively high potential for ground rupture. To facilitate this, the terms "sufficiently active" and "well-defined," were defined for zoning faults other than the 4 named in the Act. These two terms constitute the present criteria used by the State Geologist in determining if a given fault should be zoned under the Alquist-Priolo Act.

Sufficiently active: A fault is deemed sufficiently active if there is evidence of Holocene surface displacement along one or more of its segments or branches. Holocene surface displacement may be directly observable or inferred.

Well-defined: A fault is considered well-defined if its trace is clearly detectable by a trained geologist as a physical feature at or just below the ground surface. The fault may be identified by direct observation or by indirect methods. The critical consideration is that the fault, or some part of it, can be located in the field with sufficient precision and confidence to indicate that the required site-specific investigations would meet with some success.

The Fresno SOI subject site area does not lie on a Fault Rupture Hazard Zones Map, and accordingly, the site is not within a Fault-Rupture Hazard Zone. The nearest zoned fault is a portion of the Nunez Fault located approximately 48 miles southwest of the Fresno SOI.

7.2 Seismic Hazard Zones in California

In 1990, the California State Legislature passed the Seismic Hazard Mapping Act to protect public safety from the effects of strong shaking, liquefaction, landslides, or other ground failure, and other hazards caused by earthquakes. The Act is codified in the Public Resources Code as Division 2, Chapter 7.8, Sections 2690-2699.6 and became operative on April 1, 1991. The program and actions mandated by the Seismic Hazards Mapping Act closely resemble those of the Alquist-Priolo Earthquake Fault Hazards Zones Act (described above in Section 7.1). The Act requires that the State Geologist delineate various seismic hazards zones on Seismic Hazards Zones Maps. Specifically, the maps identify areas where soil liquefaction and earthquake-induced landslides are most likely to occur. The Act directs cities, counties, and state agencies to use the maps in their land use planning and permitting processes. A site-specific geotechnical evaluation is required prior to permitting most urban developments within the mapped zones. The Act also requires sellers of real property within the zones to disclose this fact to potential buyers.

Due to the relatively recent promulgation of the Act, a limited number of Seismic Hazard Zone Maps have been prepared as of this writing. Areas covered by the maps released to date include portions of the immediate San Francisco Bay area and several areas in Los Angeles, Orange, and Ventura Counties. The Fresno SOI area is not included on any of the maps released to date.

7.3 Characteristic Earthquake and Moment Magnitude

It has been observed that faults or fault segments tend to generate a certain type of earthquake on a repeated basis. Fault rupture zones opposite weaker material will tend to generate low to moderate sized earthquakes while those in stronger materials accumulate energy and generate larger earthquakes when the accumulated energy becomes larger than the strength of the materials. The characteristic earthquake concept has direct implications to fault-specific recurrence relationships. Due to the tendency of a fault or fault segment to generate the characteristic earthquake, moderate-sized events will occur less frequently.

The use of moment magnitude, M_W, to describe energy released by a fault during an earthquake has replaced the more commonly known Richter magnitude. Due to saturation of energies, the Richter magnitude has difficulty in differentiating between larger earthquakes; that is, earthquakes with a magnitude greater than about 7.5. The moment magnitude is proportional to the area of the fault surface rupture. For this report, magnitudes used are reported as moment magnitude.

7.4 Maximum Considered Earthquake (MCE)

For most regions of the nation, the Maximum Considered Earthquake (MCE) ground motion is defined with a uniform probability of exceedance of 2 percent in 50 years (return period of about 2500 years). While stronger shaking than this could occur, it was judged that it would be economically impractical to design for such very rare ground motions and the selection of the 2 percent probability of exceedance in 50 years as the maximum considered earthquake ground motion would result in acceptable levels of seismic safety for the nation.

In regions of high seismicity, such as coastal California, the seismic hazard is typically controlled by large-magnitude events occurring on a limited number of well-defined fault systems. Groundshaking calculated at a 2 percent probability of exceedance in 50 years would be much larger than that which would be expected based on the characteristic magnitudes of earthquakes on these known active faults. This is because these major active faults can produce characteristic earthquakes every few hundred years. For these regions, it is considered more appropriate to directly determine maximum considered earthquake ground motions based on the characteristic earthquakes of these defined faults. In order to provide for an appropriate level of conservatism in the design process, when this approach to calculation of the maximum considered earthquake ground motion is used, the median estimate of ground motion resulting for the characteristic event is multiplied by 1.5.

7.5 Upper-Bounds Earthquake (UBE)

The Upper-Bounds Earthquake (UBE) ground motion is the largest rational and believable ground motion that can occur within the presently known tectonic framework. UBE is defined as, ≅the motion having a 10 percent probability of being exceed in a 100-year period or maximum level of motion which may ever be expected at the building site within the known geological framework.≅ The UBE has a statistical return period of about 1,000 years.

7.6 Design-Basis Earthquake (DBE)

The Design-Basis Earthquake ground motion (DBE) is synonymous with Maximum Probable Earthquake (MPE) and is defined to have a 10 percent chance of exceedance in 50 years, with a statistical return period of about 475 years.

7.7 Historic Seismicity/Earthquake Epicenter Distribution

The Fresno area has historically experienced a low to moderate degree of seismicity. A listing of historic earthquakes with magnitudes greater than 4.0 within approximately 60 miles (96 kilometers) of the subject site was obtained from the comprehensive California Geological Survey computerized earthquake catalog for the State of California, the Townley and Allen (1939) catalog and the U.S. Geological Survey Earthquake Data Base System. In addition, a listing of historic earthquakes with magnitudes greater than 5.0 within approximately 100 miles of the subject site was obtained. The listings include the date, time, location, depth, magnitude, and intensity all recorded events within the search radius between 1800 and 2012. A review of the literature for pre-1900 earthquakes (Toppozada, 1991) does not reveal any significant recorded seismic events in the vicinity of the subject site prior to the period covered by the above noted listings.

The historic earthquake listings are included in Appendix B. A plot of epicenters associated with historic earthquakes in the region of the site with magnitudes greater than 5 is shown on Figure 8, Epicenter Map. The earthquake data indicated that 114 events with magnitudes greater than 4.0 occurred within 60 miles of the subject site between 1800 and 2012. The data indicates that 136 events exceeded magnitudes 5.0 within 100 miles of the subject site. The nearest listed event was estimated to have occurred in 1864 with a magnitude of 4.3. The epicenter was estimated to be at Latitude 36.75 and Longitude -119.75, in the vicinity of formerly agricultural land, which is now in the neighborhood of Belmont Avenue, Boron Avenue, residential neighborhoods and commercial developments. The 1864 event may have occurred on a system of range-front faults which trend along the easterly margin of the San Joaquin Valley (described in Section 5.3 of this report). None of the listed earthquakes with magnitudes greater than 4.6 occurred within 20 miles of the site. Numerous earthquakes are listed with magnitudes between 5.0 and 6.0 beyond about 40 miles of the site. No events were recorded with magnitudes greater than 6.0 within 40 miles of the site.

The geologic literature indicates that groundshaking of VII intensity (Modified Mercalli Scale) was felt in Fresno from the 1872 Owens Valley Earthquake. This is the largest known earthquake event to have affected the Fresno area. The most recent earthquake significant to the Fresno area, was the Coalinga seismic event which occurred on May 2, 1983 within the Coast Ranges-Sierran Block Boundary Seismotectonic structure. The Coalinga seismic event had a magnitude of M_w 6.7. The initial shock had a Modified Mercalli Intensity of VII in the Fresno area. This earthquake and aftershocks had a substantial affect on Coalinga area but no significant damage, either architectural or structural, was reported in the area of the subject site.

7.8 Geologic Subgrade

Information obtained from the geologic literature, as well as data from the above-described Fresno SOI area, indicate the general soil profile within the Fresno SOI area consists predominately of silty sands, sandy silts, clayey sands, sandy clayey silts, and sands. With the exception of a limited occurrence of near-surface loose soils, penetration resistance and laboratory testing indicate that these materials are typically at least medium dense. The Site Class per Table 1613.5.2 of the 2010 California Building Code is based upon the site soil conditions. It is our opinion that Site Class D is most consistent with the Fresno SOI soil conditions. However, within isolated locations through the planning area, and in close proximity to water features such as: streams, ditches, canals, ponds and lakes, Site Class E conditions may be encountered.

7.9 Soil Liquefaction

Soil liquefaction is a state of soil particles suspension caused by a complete loss of strength when the effective stress drops to zero. Liquefaction normally occurs in soils such as sand in which the strength is purely friction. However, liquefaction has occurred in soils other than clean sand. Liquefaction usually occurs under vibratory conditions such as those induced by seismic event.

To evaluate the liquefaction potential of a site, the following items are evaluated:

1) Groundwater depth;
2) Soil type;
3) Relative density;
4) Initial confining pressure;
5) Intensity and duration of groundshaking.

The predominant soils anticipated to be encountered within the Fresno SOI consist of varying combinations of very loose/very soft to very dense/hard silts, clays, sands, and gravels. Moderate cohesion strength is associated with the clayey soils. Groundwater has been encountered near the surface during our exploratory drilling, in close proximity to water filled features such as canals, ditches, ponds, and lakes. Available groundwater depth mapping, as well as our experience within the Fresno SOI area, indicates that historically groundwater in the vicinity of the Fresno SOI area has been encountered at depths as shallow as 0 feet to greater than 100 feet below site grade.

Based on our findings, it is our opinion that the potential for soil liquefaction within the Fresno SOI area ranges from very low to moderate due to the variable density of the subsurface soils and the presence of shallow groundwater. Therefore, liquefaction analysis should be performed in areas where historical groundwater has been less than 50 feet in accordance with the State of California Department of Conservation, California Geological Survey, Special Publication 117A (March 2009) Guidelines for Evaluating and Mitigation Liquefaction in California.

7.10 Seismic Settlement and Lateral Spread

One of the most common phenomena during seismic shaking accompanying any earthquake is the induced settlement of loose unconsolidated soils. Based on the nature of the subsurface materials, and the relatively low to moderate seismicity of the region, we would not expect seismic settlement or lateral spread to represent a significant geologic hazard to the majority of the Fresno SOI area. However, it is recommended that seismic settlement and lateral spread analysis be performed as needed as part of each development in the Fresno SOI area.

7.11 Land Subsidence

Portions of the San Joaquin Valley have been subject to land subsidence due to fluid withdrawal (groundwater and petroleum). Land subsidence affects 3,500 square miles of productive farm land in the San Joaquin Valley as intense pumping of groundwater continues. Over 20 feet of subsidence has occurred in western Fresno County. Subsidence was first recognized in the valley in 1935, when surveys discovered differential settlements in areas of intensive pumping. With the accelerated use of groundwater for agriculture, subsidence has continued to the present. Today one-third of the entire San Joaquin valley is subsiding and damage costs and remedial expenditures represent many millions of dollars. Damage caused by subsidence has been restricted principally to significant changes in gradients of canals, aqueducts, and drainage systems, and breakage of deep water-well casings.

Within the San Joaquin Valley, subsidence is concentrated in the southern part and west side of the valley where rainfall is sparse and groundwater recharge is minimal. The subsidence has been greatest in 3 areas. Maximum subsidence is an elongate trough close to the mountains west of Fresno, where more than 20 feet of subsidence occurred between 1920 and 1963 and total subsidence is about 28 feet. A second center is 30 miles south of Tulare, where more then 12 feet of subsidence has occurred. The third center, located south of Bakersfield, has subsided more then 8 feet. Subsidence rates vary greatly from year to year, Subsidence continues in all areas except south of Tulare where surface water imports have reversed the downward trends of water levels.

Although subsidence is a significant concern in western Fresno County, as well as other portions of the San Joaquin Valley, the Fresno SOI area is not known to be subject to such subsidence hazards.

7.12 Expansive Soils

The surface and near-surface soils observed throughout the SOI area consist of varying combinations of clays, silts, sands, gravels, and cobbles. The clayey soils are considered to be slightly to moderately expansive. Therefore, it is recommended that mitigation measures to reduce the potential problems associated with expansive soils be included, as needed, in subsequent Geotechnical Engineering Investigation Report(s) for specific development and redevelopment projects within the Fresno SOI area. We would not expect the expansive nature of these clayey soils to present a significant geologic hazard to developments within the Fresno SOI area, provided that the recommendations of previous and future Geotechnical Engineering Investigation(s) are followed.

7.13 Inundation Hazards

The Fresno SOI area receives inflows of regional runoff from a large watershed to the east and is in the path of natural drainage from the valley floor, the adjacent foothills, and the Sierra Nevada Range. The San Joaquin River comprises the northern boundary of the Fresno SOI area. Precipitation in the Fresno SOI comes in episodic storm events which may be severe and cause localized flooding. Due to a series of river floods in the 1980s and 1990s, the Federal Emergency Management Agency reevaluated and developed new National Flood Insurance Protection rate maps for the area

A review of Federal Emergency Management Agency (FEMA) Flood Insurance Mapping for the Fresno SOI indicates that 20 maps have become effective February 18, 2009. These maps cover Fresno County unincorporated areas and incorporated areas. The Community Panel Numbers that affect the Fresno SOI area include the following:

Community Panel No.	Community Panel No.
06019CIND0B	06019C1590H
06019C1020H	06019C1595H
06019C1040H	06019C2085H
06019C1535H	06019C2100H
06019C1545H	06019C2105H
06019C1555H	06019C2110H
06019C1560H	06019C2125H
06019C1565H	06019C2130H
06019C1570H	06019C2135H
06019C1580H	06019C2140H

Review of the Community Panels indicates that there is a potential for flooding throughout portions of the Fresno SOI area. These maps should be reviewed during the planning stages of development and redevelopment projects in the Fresno SOI area.

A review of the Office Of Emergency Services and Corps of Engineers Dam Inundation Mapping for the area of the subject site indicates that some portions of the Fresno SOI are within an "Inundation Area" should a failure occur at the Friant Dam, Pine Flat Dam, Red Bank-Francher Creek Project, or Big Dry Creek Dam located east of the Fresno SOI.

According to the California Department of Water Resources, there are 33 dams located within Fresno County. Four major dams that could cause substantial flooding in Fresno County in the event of a failure are Friant Dam, Big Dry Creek Dam, Pine Flat Dam, and Redbank-Fancher Creek Project Dam.

Friant Dam - The San Joaquin River is impounded at Friant Dam in Fresno County, forming Millerton Lake. Friant Dam is operated primarily as an irrigation facility of the Central Valley Project. Irrigation waters are stored in Millerton Lake, and released through irrigation canals to irrigation districts. A 1992 Bureau of Reclamation study conducted in 1992 concluded that the structural classification for Friant Dam is "satisfactory."

The storage capacity at Millerton Lake (impounded by Friant Dam) is inadequate for full flood protection during wet years and emergency releases have resulted in levee breaks and flooding along the San Joaquin River. From Friant Dam to Gravelly Ford, the San Joaquin River is part of the Designated Floodway Program administered by the State Reclamation Board.

An inundation study completed in 1997 by the Bureau of Reclamation redefined a worst-case scenario dam break of Friant Dam to include inundation of a significant portion of the City of Fresno and a much larger portion of Fresno County than previously described. In addition, failure of upstream dams such as Shaver Lake, Lake Thomas A. Edison, Huntington, and Florence and Mammoth Pool Reservoir, Wishon, and Courtright Reservoir could contribute to flooding conditions on the San Joaquin and Kings Rivers, respectively, if downstream dam capacity of the major dams is exceeded. However, comprehensive analysis of the potential for dam failure and possible downstream effects for these upstream dams has not been undertaken.

Pine Flat Dam - completed in 1954 on the Kings River is operated by the Army Corps of Engineers (Corps) for the primary purpose of flood control and emergency spillage is usually avoided. During storm events, excess flows are diverted to sloughs and irrigation canals. Flow management on the Kings River is carefully coordinated and considers factors such as anticipated weather, upstream flows, and the ability of downstream users to receive water.

Redbank-Fancher Creek Projects - constructed by the Corps are managed by the Fresno Metropolitan Flood Control District. The project consists of two dams and three detention basins located in the Fresno-Clovis vicinity. The flooding potential from creeks and streams between the San Joaquin and Kings Rivers in the east has been substantially eliminated in the last few years with the completion of the Redbank-Fancher Creeks Flood Control Project. The Corps conducted a dam breach analysis of Redbank and Fancher Creek Projects and concluded that failure of either of these two facilities would result in a broad sheet flow of approximately two feet over much of north central and central Fresno SOI area. According to the Revised Public Review Draft Background Report of the Fresno County General Plan Update, dated 2000, the initial flood water would reach the area near the intersection of Sierra and Chestnut Avenues within 3 hours and the California State University, Fresno, campus in 4 hours and Fashion Fair Mall in 6 hours. Additional flooding would occur across the eastern portion of the community with flooding taking place at the Fresno Air Terminal within 10 hours.

Big Dry Creek Dam - impounds storm water runoff from Big Dry Creek in the Big Dry Creek Reservoir. The Dry Creek Reservoir is owned and operated by the Fresno County Metropolitan Flood Control District, and is intended primarily for flood control of winter runoff from the Dry Creek and Dog Creek watersheds. The reservoir has a storage capacity of approximately 30,000 ac-ft and a surface area of approximately 3,500 acres. The reservoir was designed for a 200-year standard project flood. The maximum height of the inundation pool is 432.7 feet above mean sea level.

Under wet weather conditions, the Dry Creek Reservoir captures runoff and controls releases into artificial ditches and canals, which drain into either Little Dry Creek, located north of the reservoir or in a southerly direction into Mill Ditch. Flows from Little Dry Creek and Mill Ditch eventually drain to the San Joaquin River. Flows from the Reservoir can also be diverted into Dog Creek, which also eventually drains to the San Joaquin River. During dry weather conditions, the reservoir does not discharge water and is normally empty with the exception of a 156 ac-ft residual pool. The top of the pool remains below the elevation of an existing discharge gate.

Dam failure can result from a number of natural or human activities, such as earthquakes, erosion, improper siting, rapidly rising flood waters, and structural and design flaws. Flooding due to dam failure can cause loss of life, damage to property, and other ensuing hazards. Damage to electric generating facilities and transmission lines associated with hydroelectric dams could also affect life support systems in communities outside the immediate hazard area. There is no historical data to support the effects of a flood from dam failure inundation. The likelihood of such an event affecting the Fresno SOI is extremely low. However, should such an event occur, the affect on areas of the Fresno SOI and Fresno County's surrounding communities would be substantial.

7.14 Tsunamis and Seiches

A tsunami is a series of ocean waves generated in the ocean by an impulsive disturbance. Due to the inland location of the Fresno SOI, tsunamis are not considered a threat to the area. Seiches are standing waves in a body of water such as a lake or reservoir. One of the largest recorded seiches was 1.2 feet high during the 1964 Alaska earthquake. Since this is less than wave heights that could be expected from wind-induced waves, earthquake-induced seiches are not considered a significant risk in the Fresno SOI area. Although unlikely due to the relatively low seismicity of the Fresno SOI area, any structure, dam, or levee located at the edge of a lake or reservoir has the potential to be affected by a seiche.

7.15 Slope Stability and Potential for Slope Failure

Landslides are the release of rock, soil, or other debris and its subsequent movement down a slope or hillside. They are generally caused or controlled by a combination of geology, topography, weather, and hydrology and can be influenced by development practices. Landslides vary greatly in size and composition: from a thin mass of soil a few yards wide to deep-seated bedrock slides miles across. The travel rate of a landslide can range from a few inches per month to many feet per second depending on the slope, type of materials, and moisture content.

California's proliferation of mountains and hills puts it at high risk for landslides. Any slope of 15 degrees or greater is susceptible to mud or landslides.

Landslides and other ground failures occur during earthquakes, triggered by the strain induced in soil and rock by groundshaking vibrations, and during non-earthquake conditions, moist frequently during the rainy season. Both natural and man-made factors contribute to these slope failures.

Ground failure occurs when stresses in the ground exceed the resistance of earth materials to deformation or rupture. This instability can be triggered by earthquake shaking, which instantaneously places high stresses on earth materials by loss of soil strength due to saturation or seismic shaking. Ground failure can also be triggered by man-man changes, such as loading a steep slope or unstable soils.

Landslides are perhaps the most common form of ground failure that is not caused by earthquakes. In areas where a severe slope stability problem exists, landslide damage can best be avoided by simply not building on the unstable ground. In some landslide-prone areas, landslides can be totally removed or stabilized. Through good planning and careful controlled design, landslide losses can be all but eliminated.

Although landslides due to slope failure are most frequent in “wet years” with above average rainfall, they can occur at any time. Landslides may also occur on slopes of 15 percent or less; however, the probability is greater on steeper slopes, with old landslide deposits being the most likely to experience failure.

Slope failures are not expected to produce a disaster affecting hundreds or thousands of persons. Rather, there is a persistent risk of damage to public and private properly including individual residences, roads, canals, reservoirs, and other facilities. The two most important factors influencing the performance of slopes are the nature of the bedrock or surficial deposits and the slope angle. However, there are a number of other factors which have a profound effect on the stability of a particular hillside. These include the presence or absence of deep-rooted vegetation; surface and subsurface drainage conditions; thickness and engineering characteristics of soils and underlying weathered, partially decomposed rock; orientation of bedding; or locally high rainfall can exert a controlling effect on the intensity of natural processes occurring on a particular hillside.

City and County General Plans historically have recognized that major slope areas in excess of 26 percent are “not readily available” and “undevelopable,” recognizing the cost and engineering difficulties of grading steep slopes as well as their inherent unsuitability. This development limit in general agrees with customary limits throughout the State, and varies only slightly from the 30 percent standard reference developed by the State Division of Mines and Geology as the maximum developable slope. This is a State-wide reference which does not reflect special conditions such as clayey soils.

Landslides and ground slippages are another form of ground failure which may be precipitated by significant ground motion produced by earthquakes. Areas that are subject to slides and slippages from other natural causes may be very hazardous under earthquake conditions. This is also to say that earthquake effects will be more extensive if a major earthquake occurs during the rainy season when ground conditions are favorable to landsliding and ground slippage.

Whether a landslide will or will not occur at any specific, presently stable slope usually cannot be predicted under “natural conditions” because of the range of natural conditions and changes which occur with time. However, land which has experienced landsliding in the past is believed to be generally more slide-prone, and also is more sensitive to man-induced changes, such as grading, watering, removing or changing the type of vegetation, and changing drainage patterns, among many possible factors.

There is no risk of large landslides in the valley area of the Fresno SOI due to its relatively flat topography. There is, however, the potential for small slides and slumping along the steep banks of rivers, creeks or drainage basins such as the San Joaquin River Bluff and the many unlined basins and canals that trend throughout the Fresno SOI area.

The City of Fresno Municipal Code requires special geotechnical engineering investigations be performed in the vicinity of the San Joaquin River Bluff prior to any new developments or modifications to the bluff area. These special investigations are identified as Bluff Zone I, II, and III Investigations which have specific requirements for evaluation of existing slope stability; post-development slope stability; documentation of existing conditions for rock falls, block caving, creep failures, shear failures, excessive erosion and sloughing; evaluation of slope angles, subsurface drainage, proposed grading, structures, utility trenches, potential rodent population, storm drain disposal, surface irrigation and drainage, erosion, traffic vibration, potential seismic hazards, on-site sewage disposal approximate to the bluffs; influence of future development and grading along the bluff toe for its effect on slope stability; and the adverse effect of increased surface and subsurface drainage.

Due to the generally flat-lying nature of the site and surrounding areas, problems from landslides are not anticipated to affect the majority of the Fresno SOI provided developments in the vicinity of the San Joaquin River Bluff, basins, and canals are constructed properly with an appropriate setback from the slope(s) edge.

7.16 Volcanic Hazards

The subject site is not within an area known to be affected by volcanic hazards (Miller, 1989, U.S. Geological Survey Bulletin, 1847). However, 2 mildly explosive volcanic vents of Holocene age (less than 11,000 years) are located about 55 miles northeast of the Fresno SOI, in the vicinity of Mammoth lakes, within Mono County, California. These 2 volcanic vents have previously erupted basaltic and basaltic-andesitic lavas. The Fresno SOI is outside the areas immediately affected by lava or debris flow hazards, However, in the event of an eruption, flows and/or debris from the vents would likely flow south and west toward the Middle Fork and North Fork of the San Joaquin River within Madera County. Within the northern most portion of Fresno County, lava flows or steam blasts could occur.

With increased distance from a volcano, there is decreased affect from volcanic eruption. However, should a volcanic eruption occur, it is likely that a significant amount of ash (volcanic debris less than 44 millimeters in diameter) would be released into the atmosphere. Geologists estimate up to 2 inches of ash could fall within 50 miles of an eruption.

According to the U.S. Geological Survey, historic wind directions and wind speeds suggest that, like smaller eruptions, most volcanic ash from large to very large eruptions in California would be deposited to the east of the volcanic events. The likelihood that ash would affect the Fresno SOI depends on the frequency with which winds at various heights above the volcano or vent blow toward the Fresno SOI. The thickness of ash that may fall within the Fresno SOI area is dependent on the volume of erupted ash and wind speed. The majority of ash beds from volcanic eruptions in California are deposited to the east of their source vents. This would suggest that ash would not likely deposit on the Fresno SOI.

7.17 County Seismic Safety Element

Documentation and mapping included in the Seismic Safety Element of the Fresno County General Plan, dated 1975 and Draft 2025 Fresno General Plan dated 2002 were reviewed. In addition, we reviewed the seismic safety supplement to the safety element (dated 1974) and the Draft Safety Element dated 2002. The seismic information contained within the Seismic Safety Element is somewhat dated and/or generalized and is superseded by more recent information and analyses described herein. The referenced documents generally indicate that the site area is subject to relatively low to moderate seismicity and related hazards.

8.0 BUILDING CODE DESIGN PARAMETERS

8.1 Seismic Parameters - 2010 California Building Code

The Fresno SOI is located between Longitudes of 119.6100° to 119.9334° West and Latitudes 36.6635° to 36.9105° North. The site class per Table 1613.5.2, 2010 California Building Code (CBC) is based upon the site soil conditions. Although other Site Classes were found, it is our opinion that Site Class D is most consistent with the soil conditions within the majority of the SOI area.

For seismic design of structures based on the seismic provisions of the 2010 CBC we determined the following range of seismic parameters assuming Site Class D conditions:

Seismic Parameters – 2010 CBC		
Seismic Item	**Value Range**	**CBC Reference**
Site Class	D	Table 1613.5.2
Site Coefficient F_a	1.334 to 1.431	Table 1613.5.3 (1)
S_s	0.462 to 0.583	Figure 1613.5 (3)
S_{MS}	0.661 to 0.742	Section 1613.5.3
S_{DS}	0.441 to 0.518	Section 1613.5.4
Site Coefficient F_v	1.924 to 1.978	Table 1613.5.3 (2)
S_1	0.211 to 0.238	Figure 1613.5 (4)
S_{M1}	0.417 to 0.457	Section 1613.5.3
S_{D1}	0.278 to 0.305	Section 1613.5.4

It is recommended that site specific Seismic Parameters be determined for each development site as needed in accordance with Chapter 16 of the 2010 California Building Code.

9.0 CONCLUSIONS

Krazan and Associates, Incorporated, has completed a Geologic Hazards Investigation for the Fresno General Plan – Sphere of Influence project located in Fresno, California. Based on our investigative work and that of others, no evidence has been found that would indicate that a fault or other geologic hazard exists on the site, which would preclude the intended construction or use of the subject site. Several slopes are located along the San Joaquin River bluff within the Fresno SOI. Special geotechnical/geologic investigations will need to be performed for developments planned in the vicinity of these bluffs to determine appropriate mitigation measures and setback distances. Seismic ground shaking is expected to affect the site; however the seismicity of the region is considered relatively low. Provided that the proposed structures conform to current design criteria and the recommendations of current and future Geotechnical Engineering Investigation(s), we have found no geologic reason to discourage the proposed development within the Sphere of Influence.

10.0 LIMITATIONS

The above conclusions are based on conditions observed and geologic information available as of the date of this report. If future seismic occurrences show nearby fault activity other than that described above, if future events show geologic conditions differing from those indicated above, or if present state-of-the-art geologic information should change materially, then the conclusions of this report should be reviewed by a Certified Engineering Geologist, and the conclusions modified or approved in writing.

This report is applicable only to the Fresno General Plan – Sphere of Influence property as described herein, and should not be utilized for any other site.

If there are any questions or if we can be of further assistance, please do not hesitate to contact our office at (559) 348-2200.

PROFESSIONAL GEOLOGIST
STEPHEN J. NELSON
No. 2146
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

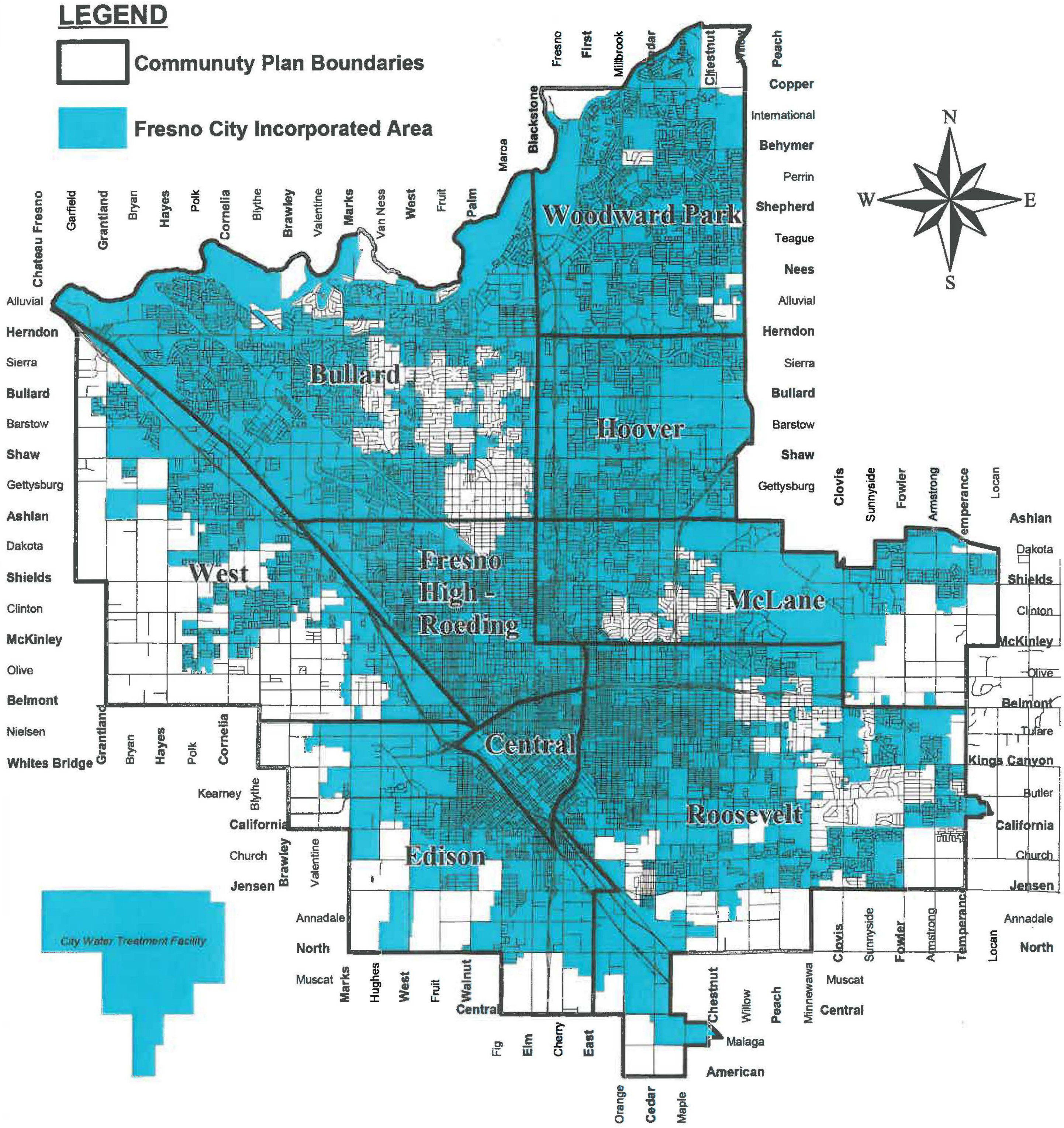
Respectfully submitted,
KRAZAN & ASSOCIATES, INC.

Stephen J. Nelson
Certified Engineering Geologist
CEG No. 2146

REGISTERED PROFESSIONAL ENGINEER
DAVID R. JAROSZ, II
NO. 2698
Expires June 30, 2010
GEOTECHNICAL
STATE OF CALIFORNIA

David R. Jarosz, II
Managing Engineer
RGE No. 2698/~~RCE No. 60185~~

SJN/DRJ:amk

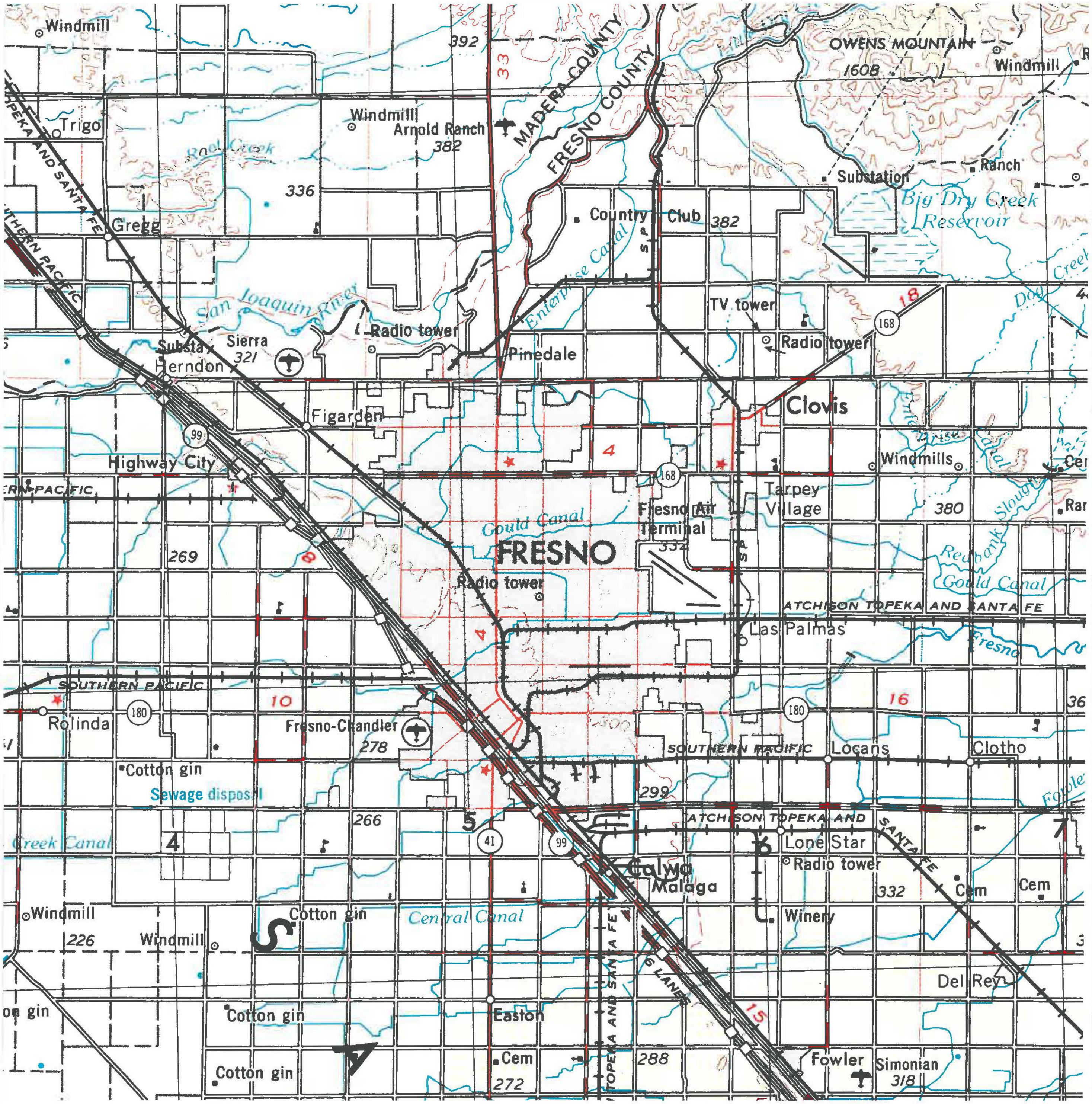


COMMUNITY PLAN BOUNDARY MAP

MAP SOURCE:

CITY OF FRESNO, COMMUNITY PLAN BOUNDARY MAP, PLANNING & DEVELOPMENT DEPARTMENT – PLANNING DIVISION, UPDATED: MARCH 2007

GEOLOGIC HAZARDS INVESTIGATION FRESNO GENERAL PLAN UPDATE FRESNO CITY AND SPHERE OF INFLUENCE	Scale: AS SHOWN	Date: 7/12	Krazan ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SPECIALISTS *Offices Serving the Western United States*
	Drawn by: MN	Approved by: SN	
FRESNO COUNTY, CA	Project No. 012-12054	Figure No. 1	



VICINITY MAP

NORTH

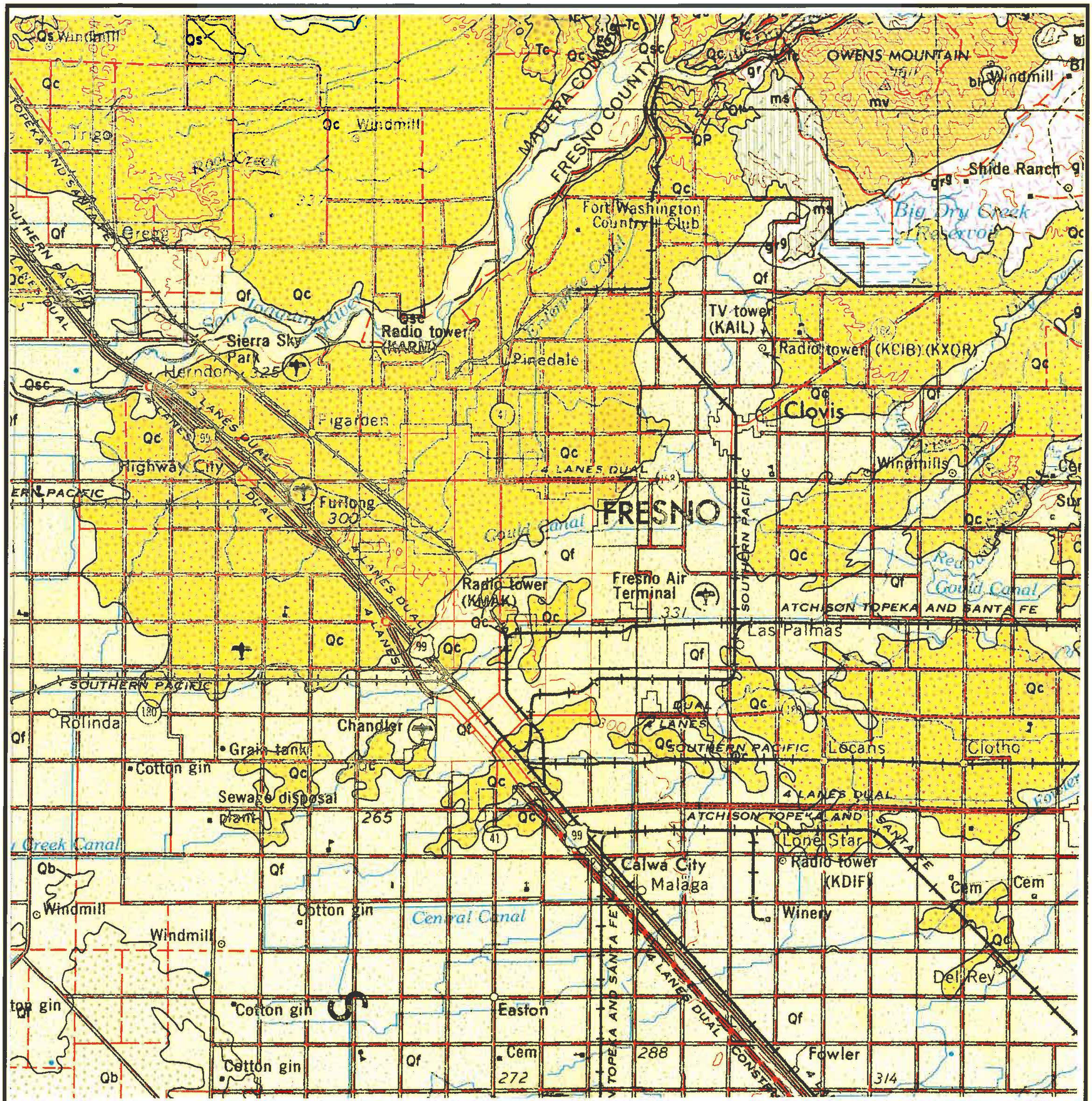
0 3 6

SCALE IN MILES (±)

MAP SOURCE:

MAP OF THE FRESNO, CALIFORNIA QUADRANGLE,
U.S.G.S. 1:250,000 SERIES (TOPO),
DATED: 1962, REVISED 1971

GEOLOGIC HAZARDS INVESTIGATION FRESNO GENERAL PLAN UPDATE FRESNO CITY AND SPHERE OF INFLUENCE	Scale: AS SHOWN	Date: 7/12	Krazan ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SPECIALISTS
	Drawn by: MN	Approved by: SN	
FRESNO COUNTY, CA	Project No. 012-12054	Figure No. 2	*Offices Serving the Western United States*



REGIONAL GEOLOGIC MAP

NORTH

MAP SOURCE:

GEOLOGIC MAP OF CALIFORNIA - FRESNO SHEET,
U.S.G.S. 1:250,000 SERIES (TOPO),
COMPILATION BY JOHN L. BURNETT, DATED: 1965

0 3 6
SCALE IN MILES (±)

GEOLOGIC HAZARDS INVESTIGATION FRESNO GENERAL PLAN UPDATE FRESNO CITY AND SPHERE OF INFLUENCE	Scale: AS SHOWN	Date: 7/12	Krazan ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SPECIALISTS *Offices Serving the Western United States*
	Drawn by: MN	Approved by: SN	
FRESNO COUNTY, CA	Project No. 012-12054	Figure No. 3	

CENOZOIC

QUATERNARY

Recent
- Qs Dune sand
- Qal Alluvium
- Qsc Stream channel deposits (GREAT VALLEY)
- Qf Fan deposits (GREAT VALLEY)
- Qb Basin deposits (GREAT VALLEY)
- Qrv Recent volcanic: Qrv^r —rhyolite; Qrv^a —andesite; Qrv^b —basalt; Qrv^p —pyroclastic rocks
- Qst Salt deposits
- Ql Quaternary lake deposits
- Qg Glacial deposits
- Qt Quaternary nonmarine terrace deposits

Pleistocene
- Qm Pleistocene marine and marine terrace deposits
- Qpv Pleistocene volcanic: Qpv^r —rhyolite; Qpv^a —andesite; Qpv^b —basalt; Qpv^p —pyroclastic rocks
- Qc Pleistocene nonmarine
- QP Plio-Pleistocene nonmarine
- Quaternary and/or Pliocene cinder cones

TERTIARY

Pliocene
- Pc Undivided Pliocene nonmarine
- Puc Upper Pliocene nonmarine
- Pu Upper Pliocene marine
- Pv Pliocene volcanic: Pv^r —rhyolite; Pv^a —andesite; Pv^b —basalt; Pv^p —pyroclastic rocks
- Pmlc Middle and/or lower Pliocene nonmarine
- Pml Middle and/or lower Pliocene marine

Miocene
- Mc Undivided Miocene nonmarine
- Muc Upper Miocene nonmarine
- Mu Upper Miocene marine
- Mv Miocene volcanic: Mv^r —rhyolite; Mv^a —andesite; Mv^b —basalt; Mv^p —pyroclastic rocks
- Mmc Middle Miocene nonmarine
- Mm Middle Miocene marine
- Ml Lower Miocene marine

Oligocene
- Φc Oligocene nonmarine
- Φ Oligocene marine
- Φv Oligocene volcanic: Φv^r —rhyolite; Φv^a —andesite; Φv^b —basalt; Φv^p —pyroclastic rocks

Eocene
- Ec Eocene nonmarine
- E Eocene marine
- Ev Eocene volcanic: Ev^r —rhyolite; Ev^a —andesite; Ev^b —basalt; Ev^p —pyroclastic rocks

Paleocene
- Epc Paleocene nonmarine
- Ep Paleocene marine

Undivided
- QTc Cenozoic nonmarine
- QTv Cenozoic volcanic: QTv^r —rhyolite; QTv^a —andesite; QTv^b —basalt; QTv^p —pyroclastic rocks
- Tc Tertiary nonmarine
- Tgr Tertiary granitic rocks
- Tl Tertiary lake deposits
- Ti Tertiary intrusive (hypabyssal) rocks: Ti^r —rhyolite; Ti^a —andesite; Ti^b —basalt
- Tm Tertiary marine
- Tv Tertiary volcanic: Tv^r —rhyolite; Tv^a —andesite; Tv^b —basalt; Tv^p —pyroclastic rocks

MESOZOIC

CRETACEOUS
- K Undivided Cretaceous marine
- Ku Upper Cretaceous marine
- Kl Lower Cretaceous marine
- KJf Franciscan Formation
- KJfv Franciscan volcanic and metavolcanic rocks
- gr Mesozoic granitic rocks: gr^g -granite and adamellite; gr^g -granodiorite; gr^t -tonalite and diorite
- bi Mesozoic basic intrusive rocks
- ub Mesozoic ultrabasic intrusive rocks

JURASSIC
- Jk Knoxville Formation
- Ju Upper Jurassic marine
- Jml Middle and/or Lower Jurassic marine
- JRv Jura-Trias metavolcanic rocks

TRIASSIC
- R Triassic marine

UNDIVIDED
- m / ls Pre-Cretaceous metamorphic rocks (ls = limestone or dolomite)
- mv Pre-Cretaceous metavolcanic rocks
- ms Pre-Cretaceous metasedimentary rocks
- gr-m Pre-Cenozoic granitic and metamorphic rocks
- P / ls Paleozoic marine (ls = limestone or dolomite
- Pv Paleozoic metavolcanic rocks

PALEOZOIC

PERMIAN
- P Permian marine
- Pmv Permian metavolcanic rocks

CARBONIFEROUS
- C Undivided Carboniferous marine
- Cv Carboniferous metavolcanic rocks
- CP Pennsylvanian marine
- CM Mississippian marine

DEVONIAN
- D Devonian marine
- Dv Devonian metavolcanic rocks
- Dv? Devonian and pre-Devonian? metavolcanic rocks

SILURIAN
- S Silurian marine
- pSs Pre-Silurian metasedimentary rocks
- pS Pre-Silurian metamorphic rocks
- pSv Pre-Silurian metavolcanic rocks

ORDOVICIAN
- O Ordovician marine

CAMBRIAN
- € Cambrian marine

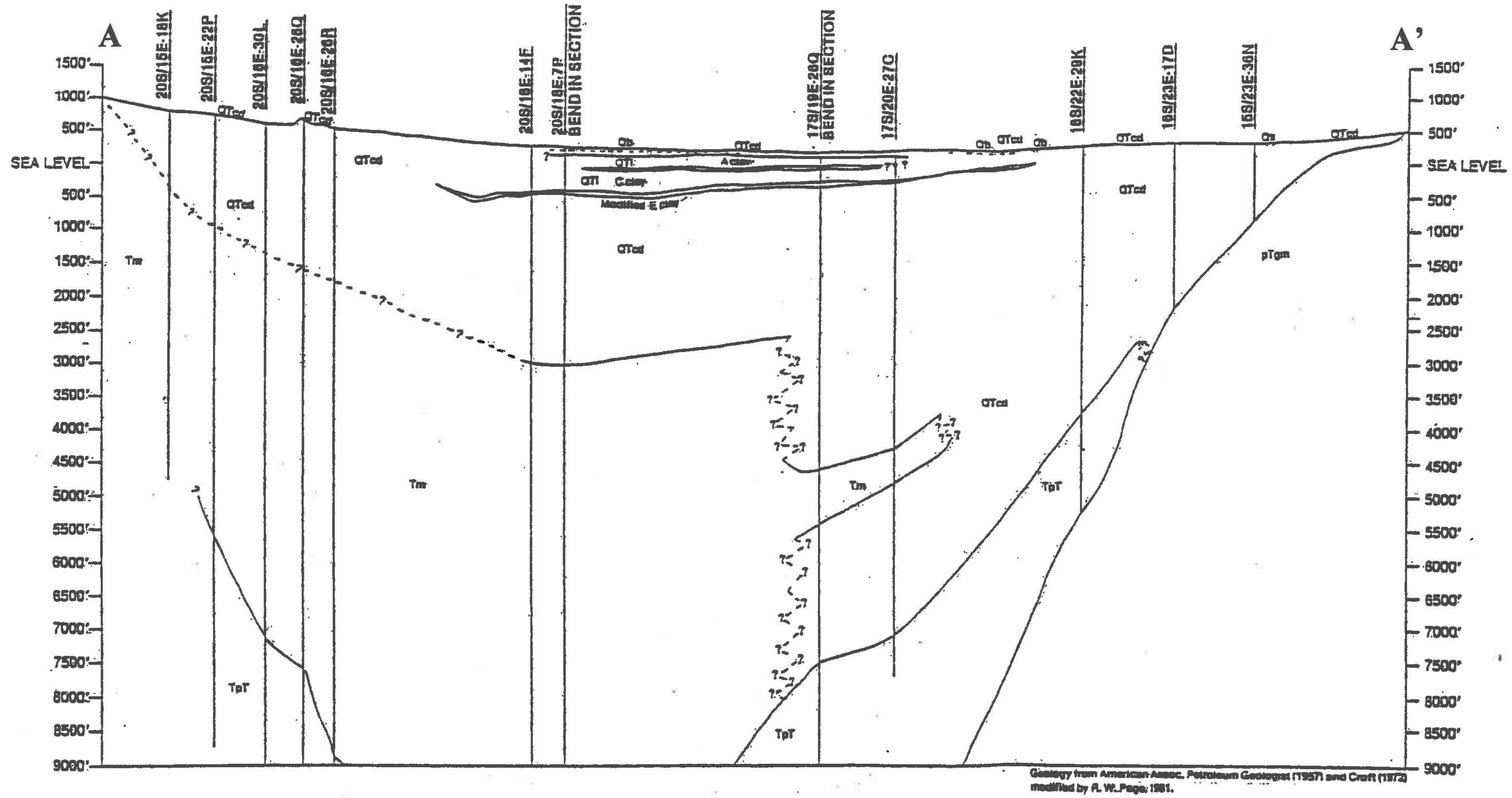
PRECAMBRIAN
- €? Cambrian – Precambrian marine
- p€c Precambrian igneous and metamorphic rock complex
- p€ Undivided Precambrian metamorphic rocks; p€g = gneiss, p€s = schist
- p€gr Undivided Precambrian granitic rocks
- lp€ Later Precambrian sedimentary and metamorphic rocks
- p€an Precambrian anorthosite
- ep€ Earlier Precambrian metamorphic rocks

HEAVY BORDER ON BOXES INDICATES UNITS THAT APPEAR ON THIS SHEET

REGIONAL GEOLOGIC MAP
EXPLANATION

FROM:
GEOLOGIC MAP OF CALIFORNIA–FRESNO SHEET
U.S.G.S. 1:250,000 SERIES TOPO
COMPILATION BY JOHN L. BURNETT, DATED 1965

GEOLOGIC HAZARDS INVESTIGATION FRESNO GENERAL PLAN UPDATE CITY AND SPHERE OF INFLUENCE	Scale: AS SHOWN	Date: 7/12	Krazan
	Drawn by: MN	Approved by: SN	ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SPECIALISTS
FRESNO COUNTY, CA	Project No. 012-12054	Figure No. 3a	Offices Serving the Western United States



EXPLANATION

Qs	*SAN DUNES (HOLOCENE) (HOLOCENE)*
Qb	*FLOOD BASIN DEPOSITS (HOLOCENE)*
QTl	*LACUSTRINE & MARSH DEPOSITS (PLIOCENE TO HOLOCENE)*
Qtcd	*CONTINENTAL ROCKS & DEPOSITS (OLIGOCENE TO HOLOCENE)*
Tm	*MARINE ROCKS & DEPOSITS (EOCENE, OLIGOCENE, MIOCENE, & PLIOCENE)*
TpT	*CONTINENTAL & MARINE ROCKS & DEPOSITS (PRE-TERTIARY TO OLIGOCENE)*
pTgm	*GRANITE & METAMORPHIC ROCKS (PRE-TERTIARY)*
	STRATIGRAPHIC UNIT CONTACT APPROXIMATELY LOCATED; QUERIED WHERE DATA ARE INCONCLUSIVE

NOTE:

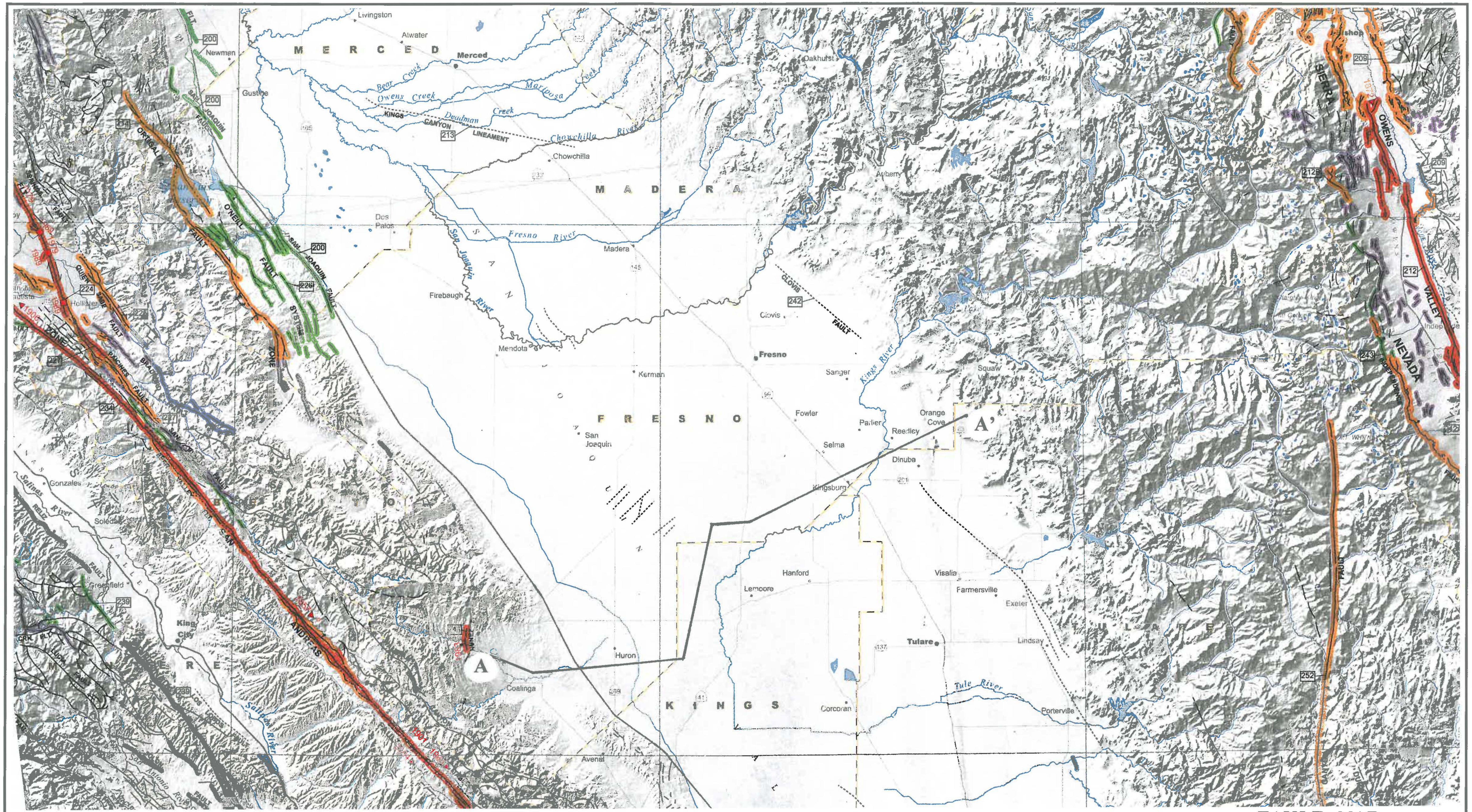
SEE FAULT MAP FOR LOCATION OF GEOLOGIC CROSS SECTION

REGIONAL GEOLOGIC CROSS-SECTION SHOWING THE SAN JOAQUIN VALLEY

SCALE

HORIZONTAL: 1" = 7.0 MILES
VERTICAL: 1" = 2,400 FEET

GEOLOGIC HAZARDS INVESTIGATION FRESNO GENERAL PLAN UPDATE FRESNO CITY AND SPHERE OF INFLUENCE	Scale: AS SHOWN	Date: 7/12	Krazan
	Drawn by: MN	Approved by: SN	ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SPECIALISTS
FRESNO COUNTY, CA	Project No. 012-12054	Figure No. 4	*Offices Serving the Western United States*



FAULT MAP

PREPARED FROM THE C.G.S. "FAULT ACTIVITY MAP OF CALIFORNIA" JENNINGS AND BRYANT, 2010

FAULT TRACES ON LAND ARE INDICATED BY SOLID LINES WHERE WELL LOCATED, BY DASHED LINES WHERE APPROXIMATELY LOCATED OR INFERRED AND DOTTED LINES WHERE CONCEALED BY YOUNGER ROCKS OR BY LAKES OR BAYS. FAULT TRACES ARE QUERIED WHERE CONTINUATION OR EXISTENCE IS UNCERTAIN.

NORTH

0 12 24

SCALE IN MILESS (±)

GEOLOGIC HAZARDS INVESTIGATION FRESNO GENERAL PLAN UPDATE FRESNO CITY AND SPRERE OF INFLUENCE	Scale: AS SHOWN	Date: 7/12	Krazan
	Drawn by: MN	Approved by: SN	ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SPECIALISTS
FRESNO COUNTY, CA	Project No. 012-12054	Figure No. 5	*Offices Serving the Western United States*

FAULT CLASSIFICATION COLOR CODE
(Indicating Recency of Movement)

Fault along which historic (last 200 years) displacement has occurred and is associated with one or more of the following:

(a) a recorded earthquake with surface rupture. (Also included are some well-defined surface breaks caused by ground shaking during earthquakes, e.g. extensive ground breakage, not on the White Wolf fault, caused by the Arvin-Tehachapi earthquake of 1952). The date of the associated earthquake is indicated. Where repeated surface ruptures on the same fault have occurred, only the date of the latest movement may be indicated, especially if earlier reports are not well documented as to location of ground breaks.

(b) fault creep slippage - slow ground displacement usually without accompanying earthquakes.

(c) displaced survey lines.

A triangle to the right or left of the date indicates termination point of observed surface displacement. Solid red triangle indicates known location of rupture termination point. Open black triangle indicates uncertain or estimated location of rupture termination point.

Date bracketed by triangles indicates local fault break.

No triangle by date indicates an intermediate point along fault break.

Fault that exhibits fault creep slippage. Hachures indicate linear extent of fault creep. Annotation (creep with leader) indicates representative locations where fault creep has been observed and recorded.

Square on fault indicates where fault creep slippage has occured that has been triggered by an earthquake on some other fault. Date of causative earthquake indicated. Squares to right and left of date indicate terminal points between which triggered creep slippage has occurred (creep either continuous or intermittent between these end points).

Holocene fault displacement (during past 11,700 years) without historic record. Geomorphic evidence for Holocene faulting includes sag ponds, scarps showing little erosion, or the following features in Holocene age deposits: offset stream courses, linear scarps, shutter ridges, and triangular faceted spurs. Recency of faulting offshore is based on the interpreted age of the youngest strata displaced by faulting.

Late Quaternary fault displacement (during past 700,000 years). Geomorphic evidence similar to that described for Holocene faults except features are less distinct. Faulting may be younger, but lack of younger overlying deposits precludes more accurate age classification.

Quaternary fault (age undifferentiated). Most faults of this category show evidence of displacement sometime during the past 1.6 million years; possible exceptions are faults which displace rocks of undifferentiated Plio-Pleistocene age. Unnumbered Quaternary faults were based on Fault Map of California, 1975. See Bulletin 201, Appendix D for source data.

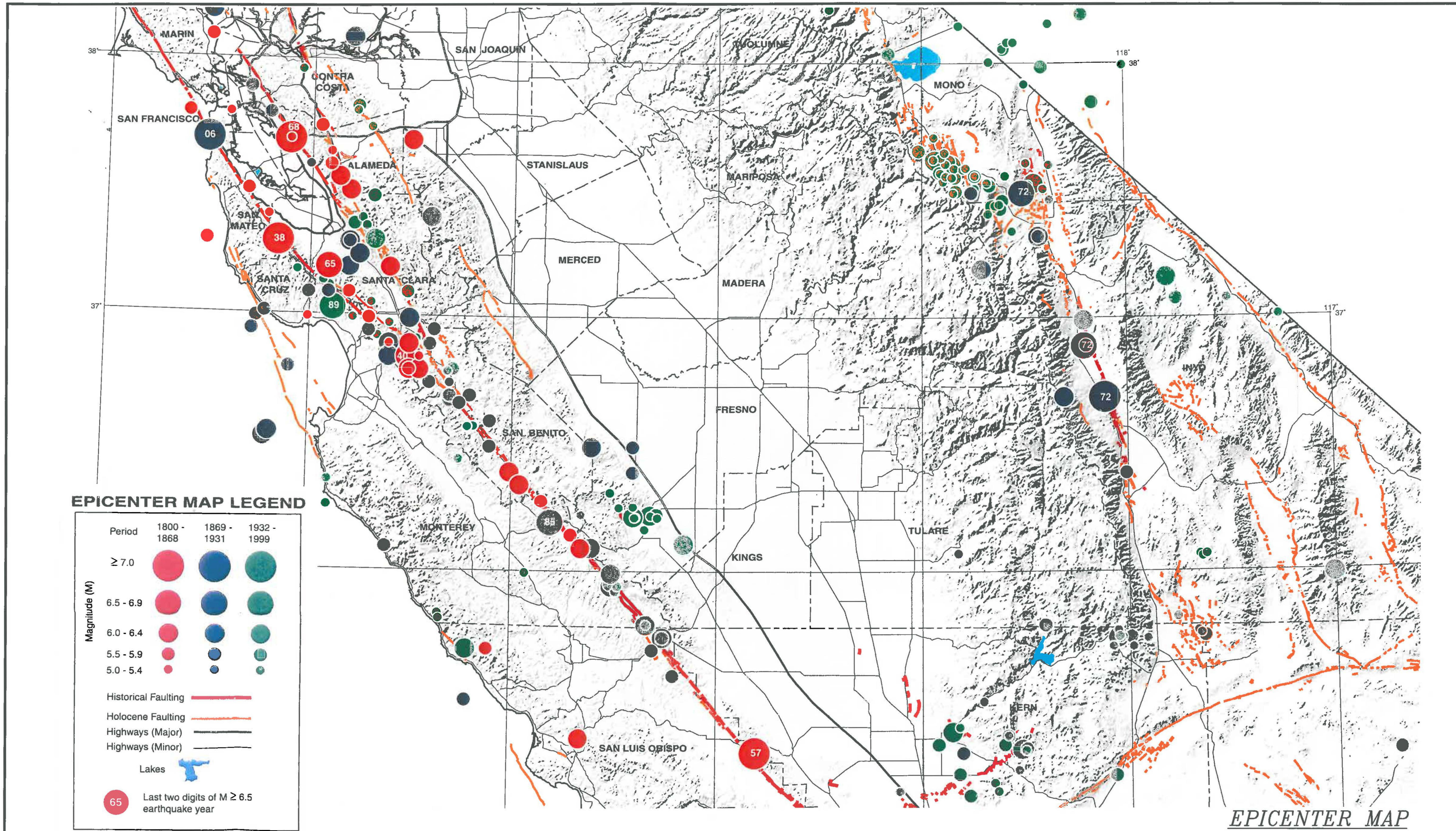
Pre-Quaternary fault (older that 1.6 million years) or fault without recognized Quaternary displacement. Some faults are shown in this category because the source of mapping used was of reconnaissnce nature, or was not done with the object of dating fault displacements. Faults in this category are not necessarily inactive.

FAULT MAP EXPLANATION

PREPARED FROM THE C.G.S. "FAULT ACTIVITY MAP OF CALIFORNIA" JENNINGS AND BRYANT, 2010

FAULT TRACES ON LAND ARE INDICATED BY SOLID LINES WHERE WELL LOCATED, BY DASHED LINES WHERE APPROXIMATELY LOCATED OR INFERRED AND DOTTED LINES WHERE CONCEALED BY YOUNGER ROCKS OR BY LAKES OR BAYS. FAULT TRACES ARE QUERIED WHERE CONTINUATION OR EXISTENCE IS UNCERTAIN.

GEOLOGIC HAZARDS INVESTIGATION TAFT GENERAL PLAN UPDATE CITY AND SPHERE OF INFLUENCE	Scale: AS SHOWN	Date: 7/12	Krazan ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SPECIALISTS *Offices Serving the Western United States*
	Drawn by: MN	Approved by: SN	
FRESNO COUNTY, CA	Project No. 012-12054	Figure No. 5a	



MAP SOURCE:
CGS MAP SHEET 49
EPICENTERS OF AND AREAS DAMAGED BY M > 5 CALIFORNIA EARTHQUAKES, 1800–1999
BY TOPPOZADA, BRANUM, PETERSEN, HALLSTROM, CRAMER & REICHLE, 2000

GEOLOGIC HAZARDS INVESTIGATION FRESNO GENERAL PLAN UPDATE FRESNO CITY AND SPERE OF INFLUENCE	Scale: AS SHOWN	Date: 7/12
	Drawn by: MN	Approved by: SN
FRESNO COUNTY, CA	Project No. 012-12054	Figure No. 6

Krazan
ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SPECIALISTS
Offices Serving the Western United States

USGS science for a changing world

Earthquake Hazards Program

2008 National Seismic Hazard Maps - Fault Parameters

Output Selected Faults (Excel)

Output	Distance in Miles	Name	St	Fault parallel slip rate	Preferred Dip (degrees)	Dip Dir	Slip Sense	Rupture Top (km)	Rupture Bottom (km)	Length (km)
☑	42.56	Great Valley 11	CA	1.5	15	W	thrust	7	9.6	25
☑	42.64	Great Valley 12	CA	1.5	15	W	thrust	7	9.6	17
☑	44.16	Great Valley 13 (Coalinga)	CA	1.5	15	W	thrust	9.1	15.3	32
☑	49.62	Great Valley 10	CA	1.5	15	W	thrust	7	9.6	22
☑	49.66	Great Valley 14 (Kettleman Hills)	CA	1.5	22	W	thrust	8.1	22.3	24
☑	54.1	Great Valley 9	CA	1.5	15	W	thrust	7	9.6	39
☑	62.33	Ortigalita	CA	1	90	V	strike slip	0	11	70
☑	68.58	San Andreas fault - creeping segment	CA	34	90	V	strike slip	0	12	125
☑	69.74	S. San Andreas;PK+CH+CC+BB+NM+SM+NSB+SSB+BG	CA		86		strike slip	0.1	13.1	479
☑	69.74	S. San Andreas;PK+CH+CC+BB+NM+SM+NSB+SSB+BG+CO	CA		86		strike slip	0.1	13.1	549
☑	69.74	S. San Andreas;PK+CH+CC+BB	CA		90	V	strike slip	0.1	12.1	208
☑	69.74	S. San Andreas;PK+CH+CC+BB+NM	CA		90	V	strike slip	0.1	12.1	245
☑	69.74	S. San Andreas;PK+CH+CC+BB+NM+SM	CA		90	V	strike slip	0.1	13.1	343
☑	69.74	S. San Andreas;PK+CH+CC+BB+NM+SM+NSB	CA		90	V	strike slip	0.1	13.1	378
☑	69.74	S. San Andreas;PK+CH+CC+BB+NM+SM+NSB+SSB	CA		90	V	strike slip	0.1	13.1	422
☑	69.74	S. San Andreas;PK+CH+CC	CA		90	V	strike slip	0.2	11.2	158
☑	69.74	S. San Andreas;PK+CH	CA		90	V	strike slip	0.4	8.4	99
☑	69.74	S. San Andreas;PK	CA	34	90	V	strike slip	4	6	36
☑	70.49	Great Valley 8	CA	1.5	15	W	thrust	7	9.6	41
☑	70.85	Round Valley	CA	1	50	E	normal	0	13	43
☑	72.71	Hartley Springs	CA	0.5	50	E	normal	0	13	25
☑	73.99	Hilton Creek	CA	2.5	50	E	normal	0	13	29
☑	77.32	S. San Andreas;CH	CA	34	90	V	strike slip	0	12	63
☑	77.32	S. San Andreas;CH+CC+BB+NM+SM+NSB+SSB+BG	CA		86		strike slip	0	14	443
☑	77.32	S. San Andreas;CH+CC+BB+NM+SM+NSB+SSB+BG+CO	CA		86		strike slip	0.1	13.1	512
☑	77.32	S. San Andreas;CH+CC	CA		90	V	strike slip	0	14	122
☑	77.32	S. San Andreas;CH+CC+BB	CA		90	V	strike slip	0	14	171
☑	77.32	S. San Andreas;CH+CC+BB+NM	CA		90	V	strike slip	0	14	208
☑	77.32	S. San Andreas;CH+CC+BB+NM+SM	CA		90	V	strike slip	0	14	306
☑	77.32	S. San Andreas;CH+CC+BB+NM+SM+NSB	CA		90	V	strike slip	0	14	342

☑	77.32	S. San Andreas;CH+CC+BB+NM+SM+NSB+SSB	CA	90	V	strike slip	0	14	385
☑	77.98	Birch Creek	CA0.7	50	E	normal	0	13	15
☑	79.86	Quien Sabe	CA1	90	V	strike slip	0	10	23
☑	80.35	Independence	CA0.2	50	E	normal	0	14.6	48
☑	81.88	San Juan	CA1	90	V	strike slip	0	13	68
☑	85.34	Owens Valley	CA1.5	90	V	strike slip	0	14	86
☑	85.87	Fish Slough	CA0.2	50	E	normal	0	13	26
☑	87.37	Mono Lake	CA2.5	50	E	normal	0	13	26
☑	89.2	White Mountains	CA1	90	V	strike slip	0	13	111
☑	89.4	Great Valley 7	CA1.5	15	W	thrust	7	9.6	45
☑	89.55	Rinconada	CA1	90	V	strike slip	0	10	191
☑	89.88	Calaveras;CN+CC+CS	CA	90	V	strike slip	2.2	7.2	123
☑	89.88	Calaveras;CC+CS	CA15	90	V	strike slip	4.2	7.2	78
☑	89.88	Calaveras;CS	CA15	90	V	strike slip	4.4	6.4	19
☑	93.64	Zayante-Vergeles	CA0.1	90	V	strike slip	0	12	58
☑	94.63	N. San Andreas;SAN+SAP+SAS	CA	90	V	strike slip	0.2	12.2	336
☑	94.63	N. San Andreas;SAO+SAN+SAP+SAS	CA	90	V	strike slip	0.2	12.2	472
☑	94.63	N. San Andreas;SAP+SAS	CA	90	V	strike slip	0.4	13.4	147
☑	94.63	N. San Andreas;SAS	CA17	90	V	strike slip	0.8	14.8	62
☑	94.78	Calaveras;CN+CC	CA	90	V	strike slip	2	8	104
☑	94.78	Calaveras;CC	CA15	90	V	strike slip	4.2	7.2	59
☑	99.3	Deep Springs	CA0.8	50	NW	normal	0	13	25

APPENDIX A

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APPENDIX B

EARTHQUAKE DATA FILE

```
*************************
*                       *
*    E Q S E A R C H    *
*                       *
*     Version 3.00      *
*                       *
*************************
```

ESTIMATION OF
PEAK ACCELERATION FROM
CALIFORNIA EARTHQUAKE CATALOGS

JOB NUMBER: 01212054

DATE: 04-16-2012

JOB NAME: Fresno General Plan Update

EARTHQUAKE-CATALOG-FILE NAME: ALLQUAKE.DAT

MAGNITUDE RANGE:
   MINIMUM MAGNITUDE: 4.00
   MAXIMUM MAGNITUDE: 9.00

SITE COORDINATES:
   SITE LATITUDE: 36.7869
   SITE LONGITUDE: 119.7843

SEARCH DATES:
   START DATE: 1800
   END DATE: 2012

SEARCH RADIUS:
   60.0 mi
   96.6 km

ATTENUATION RELATION: 3) Boore et al. (1997) Horiz. - NEHRP D (250)
   UNCERTAINTY (M=Median, S=Sigma): M   Number of Sigmas: 0.0
   ASSUMED SOURCE TYPE: DS [SS=Strike-slip, DS=Reverse-slip, BT=Blind-thrust]
   SCOND: 0 Depth Source: A
   Basement Depth: 5.00 km   Campbell SSR: Campbell SHR:
   COMPUTE PEAK HORIZONTAL ACCELERATION

MINIMUM DEPTH VALUE (km): 0.0

EARTHQUAKE SEARCH RESULTS

Page 1

FILE CODE	LAT. NORTH	LONG. WEST	DATE	TIME (UTC) H M Sec	DEPTH (km)	QUAKE MAG.	SITE ACC. g	SITE MM INT.	APPROX. DISTANCE mi [km]
T-A	36.7500	119.7500	08/16/1864	553 0.0	0.0	4.30	0.143	VIII	3.2(5.1)
T-A	37.0000	119.5000	07/14/1894	450 0.0	0.0	4.30	0.043	VI	21.5(34.6)
MGI	37.0000	120.0700	09/12/1928	120 0.0	0.0	4.60	0.050	VI	21.6(34.7)
DMG	36.6020	119.3750	09/15/1973	1 315.4	8.0	4.40	0.039	V	26.0(41.8)
DMG	36.5830	120.3330	11/30/1963	225548.0	0.0	4.50	0.034	V	33.5(53.9)
BRK	36.4600	120.3400	08/03/1975	638 0.0	0.0	4.40	0.029	V	38.2(61.4)
BRK	36.4600	120.3400	08/03/1975	63516.0	0.0	4.90	0.038	V	38.2(61.4)
BRK	36.4700	120.3500	08/03/1975	55717.0	0.0	4.00	0.024	IV	38.2(61.5)
BRK	36.5000	120.4000	08/15/1975	222751.0	0.0	4.60	0.032	V	39.4(63.5)
UNR	37.3730	119.9560	08/10/1975	51640.5	5.5	4.40	0.027	V	41.6(66.9)
PAS	36.2200	120.1360	09/24/1980	8 839.1	6.7	4.40	0.026	V	43.7(70.4)
BRK	36.3000	120.3100	05/03/1983	93947.0	0.0	4.00	0.021	IV	44.5(71.6)
PAS	36.2600	120.2590	05/03/1983	142656.0	1.2	4.10	0.022	IV	44.9(72.3)
PAS	36.2050	120.1760	05/03/1983	0 022.1	9.0	4.00	0.021	IV	45.7(73.5)
PAS	36.2500	120.2670	05/03/1983	01629.1	9.0	4.50	0.027	V	45.7(73.6)
BRK	36.1800	120.1200	08/12/1983	22 236.0	0.0	4.00	0.021	IV	45.9(73.8)
BRK	36.2500	120.2800	05/03/1983	018 1.0	0.0	4.40	0.025	V	46.2(74.3)
PAS	36.1510	120.0490	08/04/1985	12 156.0	6.0	5.80	0.053	VI	46.3(74.5)
BRK	36.2500	120.2900	05/03/1983	154142.0	0.0	4.80	0.031	V	46.5(74.8)
PAS	36.2740	120.3310	02/19/1984	94310.6	7.4	4.40	0.025	V	46.6(75.0)
BRK	36.2800	120.3400	05/04/1983	161120.0	0.0	4.30	0.024	IV	46.6(75.1)
BRK	36.2400	120.2800	05/03/1983	05034.0	0.0	4.00	0.020	IV	46.7(75.2)
PAS	36.1450	120.0520	08/04/1985	112915.4	6.0	4.30	0.024	IV	46.7(75.2)
BRK	36.2700	120.3300	05/03/1983	05745.0	0.0	4.80	0.031	V	46.8(75.3)
PAS	36.1310	119.9970	08/05/1985	144538.3	6.0	4.30	0.024	IV	46.8(75.3)
USG	36.2300	120.2710	05/19/1983	11 530.1	12.9	4.16	0.022	IV	47.0(75.6)
USG	36.2380	120.2850	05/03/1983	21514.9	8.8	4.08	0.021	IV	47.0(75.6)
BRK	36.2400	120.2900	05/09/1983	24912.0	0.0	5.20	0.038	V	47.0(75.7)
PAS	36.3130	120.3960	10/25/1982	231217.8	6.0	4.30	0.024	IV	47.1(75.8)
BRK	36.2500	120.3100	05/24/1983	9 219.0	0.0	4.60	0.028	V	47.2(75.9)
BRK	36.2200	120.2600	09/09/1983	91614.0	0.0	5.40	0.042	VI	47.2(76.0)
BRK	36.2300	120.2800	09/09/1983	92133.0	0.0	4.00	0.020	IV	47.3(76.1)
BRK	36.2600	120.3300	05/03/1983	43233.0	0.0	4.30	0.024	IV	47.3(76.2)
BRK	36.2600	120.3300	05/04/1983	72840.0	0.0	4.70	0.029	V	47.3(76.2)
PAS	36.1770	120.1750	05/03/1983	635 3.1	5.0	4.00	0.020	IV	47.4(76.2)
BRK	36.2800	120.3600	05/05/1983	102045.0	0.0	4.60	0.028	V	47.4(76.2)
PAS	36.2190	120.2640	05/08/1984	192113.1	15.3	4.20	0.022	IV	47.4(76.3)
PAS	36.1190	119.9890	08/04/1985	12 841.8	6.0	4.10	0.021	IV	47.5(76.4)
PAS	36.3210	120.4160	10/25/1982	231554.2	6.0	4.00	0.020	IV	47.6(76.5)
USG	36.2320	120.2990	05/03/1983	15546.4	6.9	4.00	0.020	IV	47.8(76.9)
DMG	37.0700	120.5800	11/01/1954	64240.0	0.0	4.00	0.020	IV	48.1(77.4)
BRK	36.2200	120.2900	05/02/1983	2346 6.0	0.0	5.60	0.046	VI	48.2(77.5)
BRK	36.2200	120.2900	05/02/1983	234239.0	0.0	6.70	0.082	VII	48.2(77.5)
USG	36.2910	120.4010	08/12/1983	11441.1	9.8	4.04	0.020	IV	48.4(77.9)
BRK	36.2200	120.3000	05/09/1983	32638.0	0.0	4.40	0.024	V	48.5(78.0)
DMG	36.2300	120.3200	08/13/1940	22 729.0	0.0	4.00	0.020	IV	48.6(78.2)
BRK	36.2900	120.4100	08/14/1983	124337.0	0.0	4.20	0.022	IV	48.8(78.5)
GSB	36.3000	120.4270	04/21/1994	163715.3	10.0	4.50	0.025	V	49.0(78.9)
PAS	36.2860	120.4130	10/25/1982	2226 4.0	6.0	5.60	0.045	VI	49.1(79.0)
DMG	36.2200	120.3300	10/22/1955	7 413.0	0.0	4.20	0.022	IV	49.5(79.6)
USG	36.1800	120.2600	05/03/1983	13 914.6	12.5	4.04	0.020	IV	49.5(79.7)
PAS	36.1820	120.2680	02/14/1987	72650.8	6.0	5.10	0.035	V	49.6(79.9)
T-A	36.1700	119.3200	07/25/1868	230 0.0	0.0	5.00	0.033	V	49.8(80.1)

EARTHQUAKE SEARCH RESULTS

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FILE CODE	LAT. NORTH	LONG. WEST	DATE	TIME (UTC) H M Sec	DEPTH (km)	QUAKE MAG.	SITE ACC. g	SITE MM INT.	APPROX. DISTANCE mi [km]
GSB	36.1920	120..2930	02/02/1997	022020.3	9.0	4.10	0.020	IV	49.8(80.2)
BRK	36.2600	120.4000	07/09/1983	74052.0	0.0	5.30	0.038	V	49.9(80.3)
BRK	36.1400	120.1900	05/22/1983	83923.0	0.0	4.00	0.019	IV	50.0(80.5)
USG	36.1800	120.2800	07/18/1983	1928 5.4	10.9	4.16	0.021	IV	50.1(80.7)
USG	36.1540	120.2320	05/02/1983	235529.1	8.6	4.24	0.022	IV	50.3(80.9)
BRK	36.2500	120.4000	05/03/1983	6 447.0	0.0	4.30	0.022	IV	50.4(81.1)
BRK	36.1400	120.2100	06/07/1983	51839.0	0.0	4.00	0.019	IV	50.5(81.3)
PAS	36.2400	120.3900	07/22/1983	24910.7	8.7	4.20	0.021	IV	50.5(81.3)
PAS	36.2400	120.3900	07/22/1983	24910.7	8.7	4.20	0.021	IV	50.5(81.3)
DMG	36.8000	120.7000	12/05/1937	137 0.0	0.0	4.00	0.019	IV	50.6(81.5)
BRK	36.1300	120.1900	05/03/1983	14147.0	0.0	4.50	0.025	V	50.6(81.5)
T-A	37.5000	120.0000	01/22/1857	0 0 0.0	0.0	4.30	0.022	IV	50.6(81.5)
DMG	37.5000	120.0000	08/23/1937	032 0.0	0.0	4.00	0.019	IV	50.6(81.5)
BRK	36.2300	120.3800	09/11/1983	1148 7.0	0.0	4.30	0.022	IV	50.7(81.6)
BRK	36.2100	120.3500	05/03/1983	03947.0	0.0	4.20	0.021	IV	50.7(81.6)
GSP	36.1810	120.3010	03/31/1994	195959.7	10.0	4.40	0.024	IV	50.7(81.6)
USG	36.1340	120.2040	05/05/1983	43748.6	11.2	4.01	0.019	IV	50.7(81.7)
GSB	36.1720	120.2880	03/31/1994	200229.7	9.0	4.20	0.021	IV	50.8(81.8)
GSB	36.1740	120.2920	12/16/2006	061405.0	9.0	4.20	0.021	IV	50.8(81.8)
BRK	36.1500	120.2500	05/12/1983	1341 8.0	0.0	4.50	0.025	V	51.0(82.1)
UNR	37.4650	119.4120	11/18/1981	161548.5	10.1	4.20	0.021	IV	51.1(82.2)
BRK	36.3000	120.4800	08/26/1983	32118.0	0.0	4.00	0.019	IV	51.2(82.4)
BRK	36.1100	120.1600	01/14/1976	214359.0	0.0	4.90	0.030	V	51.2(82.4)
GSB	36.1630	120.2870	04/24/1984	045251.5	10.0	4.00	0.019	IV	51.3(82.6)
GSB	36.1580	120.2800	05/11/1985	085923.8	5.0	4.00	0.019	IV	51.4(82.7)
PAS	36.1760	120.3220	01/03/1985	112228.0	7.8	4.30	0.022	IV	51.7(83.2)
BRK	36.2100	120.3800	07/25/1983	223140.0	0.0	5.10	0.034	V	51.8(83.3)
PAS	36.2450	120.4310	07/22/1983	329 2.3	3.0	4.10	0.020	IV	51.8(83.4)
PAS	36.2450	120.4310	07/22/1983	329 2.3	3.0	4.10	0.020	IV	51.8(83.4)
PAS	36.0520	119.9780	08/04/1985	151539.5	6.0	4.40	0.023	IV	51.9(83.5)
DMG	36.1700	120.3200	12/27/1926	919 0.0	0.0	5.00	0.032	V	51.9(83.6)
BRK	36.2200	120.4000	07/22/1983	23955.0	0.0	6.00	0.054	VI	52.0(83.6)
DMG	36.3000	120.5000	11/30/1943	215718.0	0.0	4.00	0.019	IV	52.0(83.7)
PAS	36.1760	120.3370	01/03/1985	104522.8	6.0	4.10	0.020	IV	52.2(83.9)
BRK	36.1300	120.2500	05/03/1983	855 3.0	0.0	4.50	0.024	V	52.2(84.0)
BRK	36.1000	120.1800	05/03/1983	01557.0	0.0	4.00	0.019	IV	52.3(84.1)
BRK	36.1000	120.1800	05/03/1983	01537.0	0.0	4.20	0.021	IV	52.3(84.1)
BRK	36.1400	120.2800	05/03/1983	0 924.0	0.0	4.00	0.019	IV	52.5(84.4)
DMG	36.5300	120.6800	08/19/1974	124719.1	0.0	4.40	0.023	IV	52.7(84.8)
DMG	36.4170	120.6170	04/15/1963	841 2.3	0.0	4.70	0.027	V	52.7(84.9)
DMG	36.4200	120.6200	04/15/1962	841 2.3	21.0	4.70	0.027	V	52.8(85.0)
BRK	36.2000	120.4000	07/22/1983	343 2.0	0.0	5.00	0.031	V	53.0(85.3)
BRK	36.2500	120.4700	06/11/1983	3 954.0	0.0	5.10	0.033	V	53.1(85.5)
GSG	36.0460	120.0420	01/28/2005	130326.3	10.0	4.00	0.018	IV	53.1(85.5)
DMG	36.7800	120.7500	04/22/1932	0 816.0	0.0	4.00	0.018	IV	53.4(85.9)
PAS	36.0910	120.2080	08/04/1985	112924.5	6.0	4.30	0.021	IV	53.5(86.1)
PAS	36.0760	120.1820	05/03/1983	6 456.2	5.0	4.10	0.019	IV	53.8(86.6)
PAS	36.0620	120.1630	01/14/1976	214259.4	7.0	4.70	0.026	V	54.3(87.4)
BRK	36.0700	120.1900	12/21/1983	18 4 9.0	0.0	4.20	0.020	IV	54.4(87.5)
GSB	36.0070	119.9400	09/27/1992	165914.1	13.0	4.00	0.018	IV	54.5(87.8)
PAS	36.0270	120.0560	08/07/1985	016 3.5	6.0	4.40	0.022	IV	54.6(87.9)
GSB	36.0030	119.9160	09/16/1992	061433.4	11.0	4.30	0.021	IV	54.6(87.9)
BRK	36.1000	120.2900	06/12/1983	13128.0	0.0	4.00	0.018	IV	55.1(88.7)

EARTHQUAKE SEARCH RESULTS

FILE CODE	LAT. NORTH	LONG. WEST	DATE	TIME (UTC) H M Sec	DEPTH (km)	QUAKE MAG.	SITE ACC. g	SITE MM INT.	APPROX. DISTANCE mi [km]
DMG	36.0000	120.0000	11/08/1964	11919.0	14.0	4.00	0.018	IV	55.6(89.5)
DMG	36.2000	120.5000	02/25/1947	114518.0	0.0	4.20	0.019	IV	56.7(91.3)
DMG	35.9800	120.0400	09/19/1965	1542 7.8	0.0	4.80	0.026	V	57.5(92.5)
DMG	36.6000	120.8000	07/25/1926	175749.0	15.0	5.00	0.029	V	57.7(92.8)
MGI	36.3300	120.6700	07/31/1919	2131 0.0	0.0	4.00	0.017	IV	58.4(93.9)
BRK	36.6800	120.8500	02/05/1983	12 127.0	0.0	4.20	0.019	IV	59.4(95.6)
PAS	37.4510	119.0880	05/25/1980	44938.0	4.0	4.00	0.017	IV	59.8(96.2)
GSB	36.7770	120.8670	01/06/1988	224948.3	6.0	4.20	0.019	IV	59.9(96.4)

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-END OF SEARCH- 114 EARTHQUAKES FOUND WITHIN THE SPECIFIED SEARCH AREA.

TIME PERIOD OF SEARCH: 1800 TO 2012

LENGTH OF SEARCH TIME: 213 years

THE EARTHQUAKE CLOSEST TO THE SITE IS ABOUT 3.2 MILES (5.1 km) AWAY.

LARGEST EARTHQUAKE MAGNITUDE FOUND IN THE SEARCH RADIUS: 6.7

LARGEST EARTHQUAKE SITE ACCELERATION FROM THIS SEARCH: 0.143 g

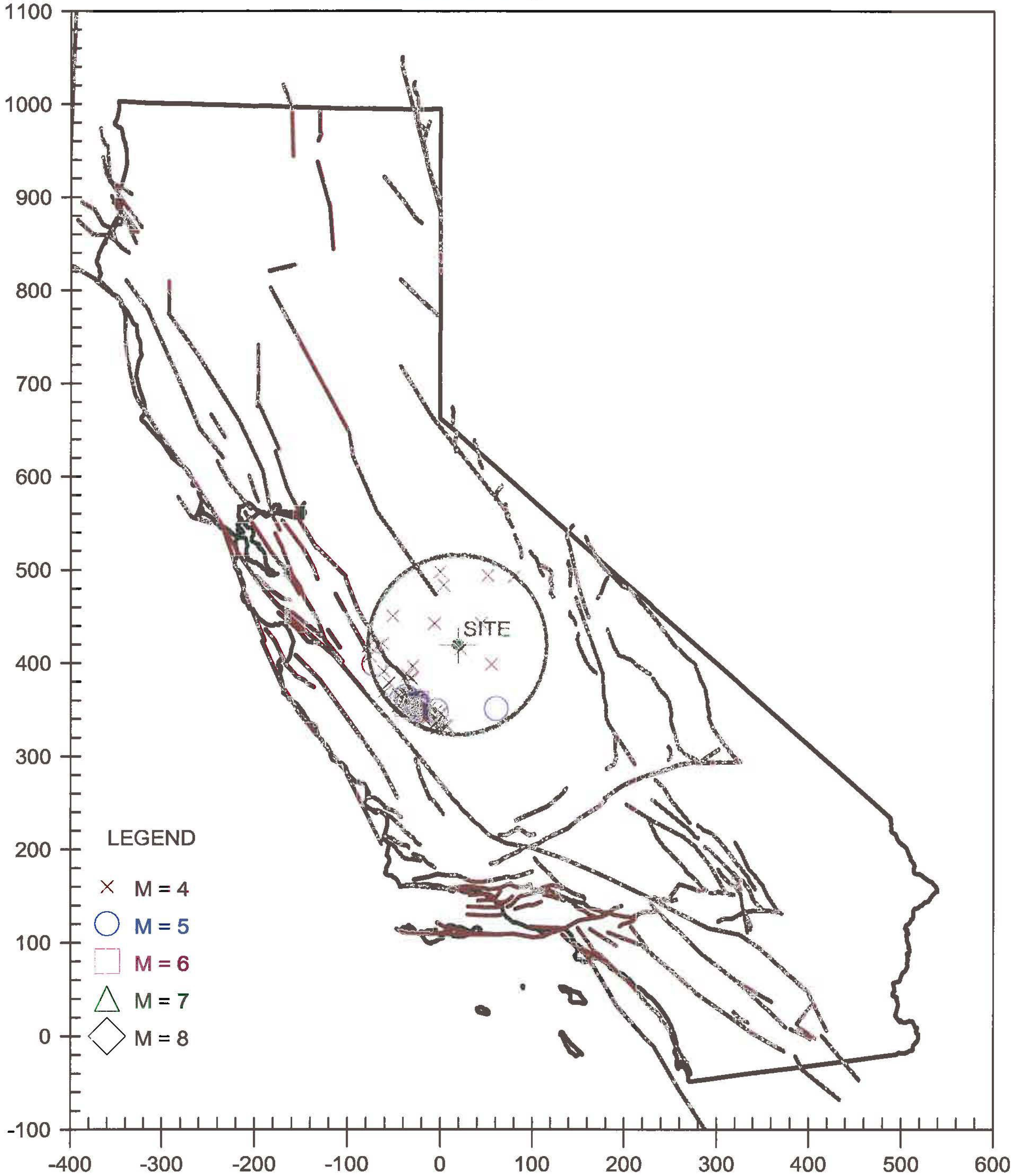
COEFFICIENTS FOR GUTENBERG & RICHTER RECURRENCE RELATION:
a-value= 3.169
b-value= 0.869
beta-value= 2.001

TABLE OF MAGNITUDES AND EXCEEDANCES:

Earthquake Magnitude	Number of Times Exceeded	Cumulative No. / Year
4.0	114	0.53774
4.5	34	0.16038
5.0	15	0.07075
5.5	5	0.02358
6.0	2	0.00943
6.5	1	0.00472

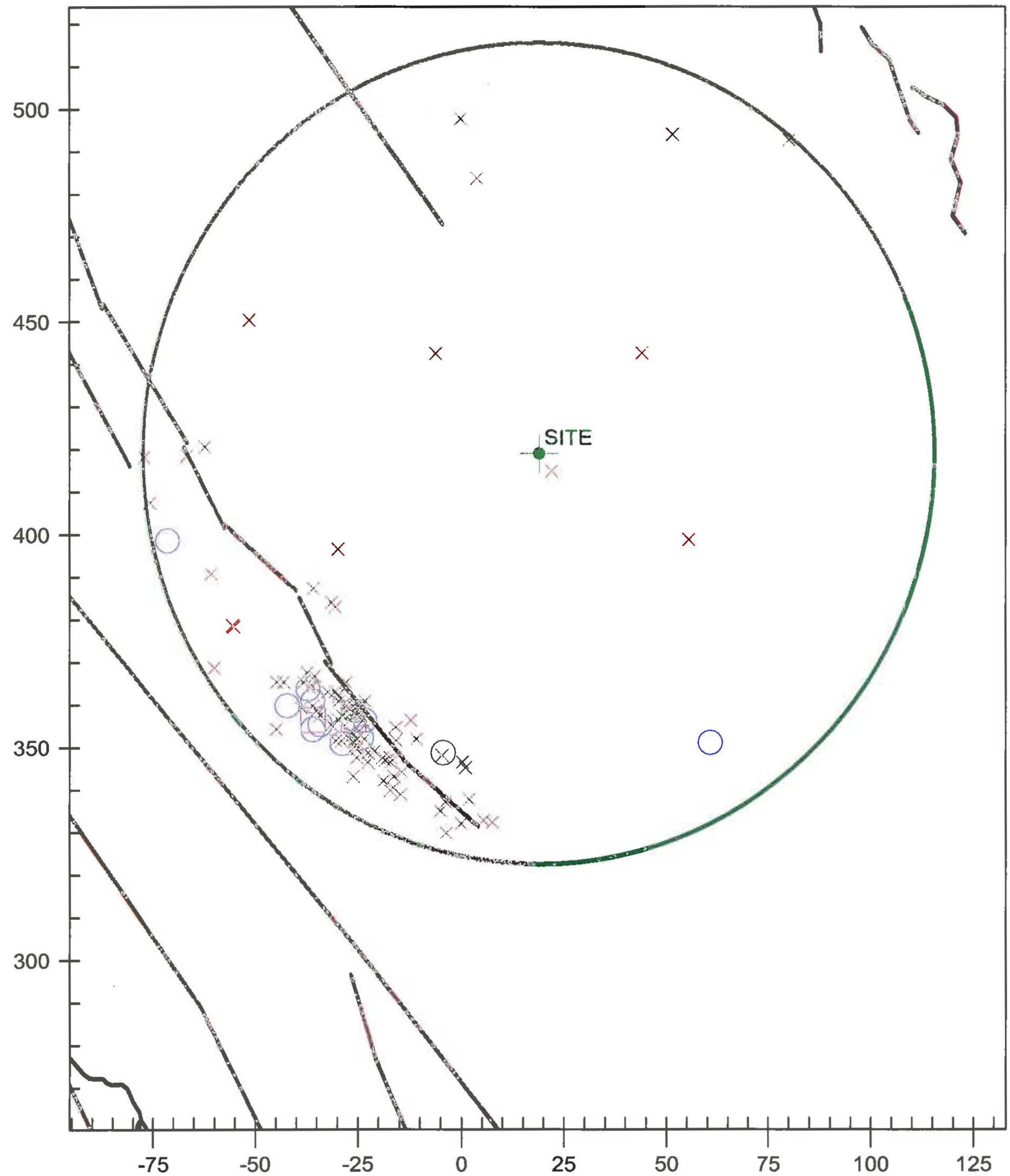
EARTHQUAKE EPICENTER MAP

Fresno General Plan Update



EARTHQUAKE EPICENTER MAP

Fresno General Plan Update



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*                       *
*    E Q S E A R C H    *
*                       *
*     Version 3.00      *
*                       *
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ESTIMATION OF
PEAK ACCELERATION FROM
CALIFORNIA EARTHQUAKE CATALOGS

JOB NUMBER: 01212054

DATE: 04-16-2012

JOB NAME: Fresno General Plan Update

EARTHQUAKE-CATALOG-FILE NAME: ALLQUAKE.DAT

MAGNITUDE RANGE:
MINIMUM MAGNITUDE: 5.00
MAXIMUM MAGNITUDE: 9.00

SITE COORDINATES:
SITE LATITUDE: 36.7869
SITE LONGITUDE: 119.7843

SEARCH DATES:
START DATE: 1800
END DATE: 2012

SEARCH RADIUS:
100.0 mi
160.9 km

ATTENUATION RELATION: 3) Boore et al. (1997) Horiz. - NEHRP D (250)
UNCERTAINTY (M=Median, S=Sigma): M Number of Sigmas: 0.0
ASSUMED SOURCE TYPE: DS [SS=Strike-slip, DS=Reverse-slip, BT=Blind-thrust]
SCOND: 0 Depth Source: A
Basement Depth: 5.00 km Campbell SSR: Campbell SHR:
COMPUTE PEAK HORIZONTAL ACCELERATION

MINIMUM DEPTH VALUE (km): 0.0

EARTHQUAKE SEARCH RESULTS

FILE CODE	LAT. NORTH	LONG. WEST	DATE	TIME (UTC) H M Sec	DEPTH (km)	QUAKE MAG.	SITE ACC. g	SITE MM INT.	APPROX. DISTANCE mi [km]
PAS	36.1510	120.0490	08/04/1985	12 156.0	6.0	5.80	0.053	VI	46.3(74.5)
BRK	36.2400	120.2900	05/09/1983	24912.0	0.0	5.20	0.038	V	47.0(75.7)
BRK	36.2200	120.2600	09/09/1983	91614.0	0.0	5.40	0.042	VI	47.2(76.0)
BRK	36.2200	120.2900	05/02/1983	2346 6.0	0.0	5.60	0.046	VI	48.2(77.5)
BRK	36.2200	120.2900	05/02/1983	234239.0	0.0	6.70	0.082	VII	48.2(77.5)
PAS	36.2860	120.4130	10/25/1982	2226 4.0	6.0	5.60	0.045	VI	49.1(79.0)
PAS	36.1820	120.2680	02/14/1987	72650.8	6.0	5.10	0.035	V	49.6(79.9)
T-A	36.1700	119.3200	07/25/1868	230 0.0	0.0	5.00	0.033	V	49.8(80.1)
BRK	36.2600	120.4000	07/09/1983	74052.0	0.0	5.30	0.038	V	49.9(80.3)
BRK	36.2100	120.3800	07/25/1983	223140.0	0.0	5.10	0.034	V	51.8(83.3)
DMG	36.1700	120.3200	12/27/1926	919 0.0	0.0	5.00	0.032	V	51.9(83.6)
BRK	36.2200	120.4000	07/22/1983	23955.0	0.0	6.00	0.054	VI	52.0(83.6)
BRK	36.2000	120.4000	07/22/1983	343 2.0	0.0	5.00	0.031	V	53.0(85.3)
BRK	36.2500	120.4700	06/11/1983	3 954.0	0.0	5.10	0.033	V	53.1(85.5)
DMG	36.6000	120.8000	07/25/1926	175749.0	15.0	5.00	0.029	V	57.7(92.8)
DMG	36.2300	120.6500	02/05/1947	614 0.0	0.0	5.00	0.028	V	61.5(99.0)
PAS	37.5090	119.0430	06/11/1980	441 1.1	14.1	5.00	0.027	V	64.4(103.7)
DMG	37.2000	118.7000	09/30/1889	520 0.0	0.0	5.60	0.036	V	66.2(106.6)
DMG	36.0000	120.5000	03/03/1901	745 0.0	0.0	5.50	0.034	V	67.3(108.4)
DMG	36.0000	120.5000	02/02/1881	011 0.0	0.0	5.60	0.036	V	67.3(108.4)
DMG	35.9700	120.5000	06/28/1966	4 856.2	0.0	5.10	0.027	V	69.0(111.1)
DMG	35.9500	120.4700	11/16/1956	323 9.0	0.0	5.00	0.025	V	69.2(111.4)
GSB	35.9530	120.5020	09/29/2004	171004.0	11.0	5.10	0.027	V	70.0(112.7)
DMG	35.9500	120.5000	06/28/1966	42613.4	0.0	5.50	0.033	V	70.2(112.9)
PAS	37.4640	118.8230	05/27/1980	145057.1	2.4	6.30	0.050	VI	70.6(113.6)
DMG	35.9300	120.4800	12/24/1934	1626 0.0	0.0	5.00	0.025	V	70.7(113.8)
GSB	35.9170	120.4650	12/20/1994	102747.2	8.0	5.00	0.025	V	71.0(114.2)
DMG	35.9500	120.5300	06/29/1966	195325.9	0.0	5.00	0.025	V	71.1(114.4)
USG	37.4980	118.8380	06/06/1980	141817.2	2.0	5.27	0.029	V	71.6(115.2)
UNR	37.5580	118.9110	06/19/1980	71931.5	0.4	5.00	0.025	V	71.7(115.4)
USG	37.5420	118.8830	06/05/1980	20 452.3	1.6	5.05	0.025	V	72.0(115.8)
PAS	37.5540	118.8970	08/01/1980	163856.3	4.7	5.40	0.030	V	72.0(115.9)
DMG	36.0800	118.8200	05/29/1915	646 0.0	0.0	5.00	0.024	V	72.5(116.6)
UNR	37.5160	118.8370	06/18/1980	185537.7	6.3	5.30	0.029	V	72.5(116.6)
DMG	36.4000	121.0000	04/12/1885	4 5 0.0	0.0	6.20	0.046	VI	72.5(116.7)
UNR	37.5360	118.8510	06/20/1980	152459.6	8.7	5.30	0.029	V	72.9(117.3)
USG	37.5610	118.8740	08/01/1980	164745.9	1.9	5.15	0.026	V	73.2(117.9)
PAS	37.4860	118.7830	05/25/1980	164930.3	4.7	5.80	0.037	V	73.3(117.9)
GSG	37.5290	118.8170	05/15/1999	132210.7	5.0	5.60	0.033	V	73.9(118.9)
PAS	37.6640	119.0080	01/07/1983	32419.1	5.0	5.60	0.033	V	74.1(119.2)
GSB	35.8190	120.3640	09/28/2004	171524.2	8.0	6.00	0.041	V	74.2(119.4)
DMG	35.8000	120.3300	06/05/1934	2148 0.0	0.0	5.00	0.024	V	74.6(120.0)
DMG	35.8000	120.3300	12/28/1939	121538.0	0.0	5.00	0.024	V	74.6(120.0)
DMG	35.8000	120.3300	06/08/1934	430 0.0	0.0	5.00	0.024	V	74.6(120.0)
DMG	35.8000	120.3300	06/08/1934	447 0.0	0.0	6.00	0.041	V	74.6(120.0)
DMG	37.5000	118.7500	09/18/1927	2 7 7.0	0.0	6.00	0.040	V	75.3(121.1)
DMG	37.4170	118.6670	02/02/1961	0 742.0	0.0	5.10	0.025	V	75.4(121.3)
GSG	37.5640	118.8050	07/15/1998	045319.2	6.0	5.10	0.025	V	76.0(122.4)
PAS	37.6220	118.8810	09/30/1981	115327.0	6.0	5.80	0.036	V	76.1(122.5)
USG	37.5270	118.7590	06/08/1980	61139.6	1.3	5.12	0.025	V	76.1(122.5)
DMG	35.7500	120.2500	03/10/1922	112120.0	0.0	6.50	0.052	VI	76.1(122.5)
PAS	37.5560	118.7910	05/25/1980	194452.2	6.4	6.50	0.052	VI	76.2(122.6)
PAS	37.6560	118.9290	01/07/1983	13810.6	5.7	5.70	0.034	V	76.2(122.7)

EARTHQUAKE SEARCH RESULTS

FILE CODE	LAT. NORTH	LONG. WEST	DATE	TIME (UTC) H M Sec	DEPTH (km)	QUAKE MAG.	SITE ACC. g	SITE MM INT.	APPROX. DISTANCE mi [km]
PAS	37.5170	118.7430	05/26/1980	122427.3	2.0	5.20	0.026	V	76.3(122.8)
DMG	37.5170	118.7330	06/05/1960	747 7.0	0.0	5.20	0.026	V	76.7(123.5)
PAS	37.4490	118.6530	11/26/1984	162141.4	6.0	5.50	0.030	V	77.3(124.3)
PAS	37.6080	118.8210	05/25/1980	163344.8	3.7	6.40	0.049	VI	77.6(124.9)
GSB	37.5890	118.7950	06/09/1998	052440.2	6.0	5.20	0.026	V	77.6(124.9)
MGI	36.6000	118.4000	09/04/1868	0 0 0.0	0.0	5.00	0.023	IV	77.7(125.1)
DMG	35.7500	120.3300	08/18/1922	512 0.0	0.0	5.00	0.023	IV	77.8(125.1)
UNR	37.6360	118.8470	06/19/1980	14430.2	8.3	5.20	0.026	V	78.1(125.6)
DMG	37.4500	118.6330	02/02/1961	0 416.0	0.0	5.30	0.027	V	78.2(125.8)
PAS	37.4230	118.6080	11/23/1984	191235.3	6.0	5.40	0.028	V	78.3(125.9)
DMG	37.3500	118.5500	08/04/1959	73659.0	0.0	5.20	0.026	V	78.3(126.0)
PAS	37.5370	118.7130	05/25/1980	203551.0	5.0	5.50	0.030	V	78.5(126.3)
DMG	36.5800	121.1800	07/29/1951	105345.0	0.0	5.00	0.023	IV	78.6(126.5)
DMG	36.9000	121.2000	03/06/1882	2145 0.0	0.0	5.70	0.033	V	78.6(126.5)
PAS	37.5140	118.6830	10/04/1978	164248.7	5.6	5.80	0.035	V	78.7(126.6)
DMG	37.5670	118.7330	09/14/1941	182118.7	0.0	5.50	0.030	V	79.0(127.2)
DMG	37.5670	118.7330	09/14/1941	183911.9	0.0	6.00	0.039	V	79.0(127.2)
DMG	37.5670	118.7330	12/31/1941	64844.0	0.0	5.40	0.028	V	79.0(127.2)
DMG	37.5670	118.7330	09/14/1941	164331.8	0.0	5.80	0.035	V	79.0(127.2)
DMG	37.5670	118.7330	09/14/1941	2116 1.0	0.0	5.00	0.023	IV	79.0(127.2)
PAS	37.6040	118.7700	05/27/1980	19 1 8.3	3.8	5.00	0.023	IV	79.3(127.7)
GSB	36.6030	121.2010	04/23/1995	084136.6	7.0	5.00	0.023	IV	79.4(127.9)
DMG	37.4530	118.6040	12/03/1938	174252.6	10.0	5.70	0.033	V	79.6(128.1)
PAS	37.5380	118.6750	10/04/1978	1739 3.3	6.3	5.30	0.027	V	80.1(128.9)
DMG	36.5780	121.2090	02/24/1972	155651.0	7.5	5.10	0.024	IV	80.2(129.0)
PAS	37.4700	118.5970	11/23/1984	18 825.6	6.0	6.20	0.042	VI	80.6(129.7)
DMG	36.6700	121.2500	08/06/1916	1938 0.0	0.0	5.50	0.029	V	81.5(131.2)
T-A	36.6700	121.2500	04/01/1857	1135 0.0	0.0	5.00	0.022	IV	81.5(131.2)
PAS	37.4480	118.5450	03/25/1985	16 513.6	6.0	5.00	0.022	IV	82.1(132.1)
DMG	36.7000	118.3000	08/17/1896	1130 0.0	0.0	5.90	0.036	V	82.3(132.5)
GSB	36.8100	121.2750	01/26/1986	192051.2	7.0	5.50	0.029	V	82.4(132.6)
DMG	36.0000	120.9200	11/02/1955	1940 6.0	0.0	5.20	0.024	V	83.3(134.0)
GSB	36.8030	121.3020	02/20/1988	083957.5	9.0	5.30	0.026	V	83.9(135.0)
DMG	37.3300	118.4200	05/06/1910	1640 0.0	0.0	5.50	0.028	V	84.0(135.2)
DMG	37.3300	118.4200	01/05/1912	354 0.0	0.0	5.50	0.028	V	84.0(135.2)
DMG	36.7000	121.3000	04/09/1961	72541.0	0.0	5.50	0.028	V	84.1(135.3)
DMG	36.7000	121.3000	03/31/1885	756 0.0	0.0	5.50	0.028	V	84.1(135.3)
DMG	36.6800	121.3000	04/09/1961	72316.0	0.0	5.60	0.030	V	84.2(135.5)
DMG	36.4500	121.2500	09/27/1938	1223 0.0	0.0	5.00	0.022	IV	84.5(136.0)
DMG	37.5670	118.5830	12/28/1951	24927.0	0.0	5.20	0.024	V	85.3(137.2)
DMG	37.5000	118.5000	04/11/1872	19 0 0.0	0.0	6.60	0.050	VI	86.1(138.6)
DMG	36.0000	121.0000	02/26/1932	1658 0.0	0.0	5.00	0.021	IV	86.7(139.5)
T-A	38.0000	120.2500	04/11/1872	12 0 0.0	0.0	5.00	0.021	IV	87.6(140.9)
DMG	36.9000	118.2000	03/26/1872	14 6 0.0	0.0	6.50	0.046	VI	87.9(141.4)
DMG	36.9000	118.1900	11/28/1929	1949 0.0	0.0	5.50	0.027	V	88.4(142.3)
DMG	37.0000	118.2000	04/03/1872	1215 0.0	0.0	6.10	0.037	V	88.7(142.8)
T-A	36.8300	118.1700	07/12/1871	330 0.0	0.0	5.00	0.021	IV	89.3(143.7)
T-A	36.8300	118.1700	02/28/1895	825 0.0	0.0	5.00	0.021	IV	89.3(143.7)
DMG	36.8000	121.4000	04/02/1885	1525 0.0	0.0	5.40	0.026	V	89.3(143.8)
PAS	37.5420	118.4440	07/21/1986	144226.7	6.0	5.90	0.033	V	90.3(145.3)
MGI	37.0000	118.1700	12/08/1929	1245 0.0	0.0	5.30	0.024	V	90.3(145.4)
MGI	37.0000	118.1700	12/02/1929	7 0 0.0	0.0	5.30	0.024	V	90.3(145.4)
DMG	36.8300	121.4200	12/31/1910	1211 0.0	0.0	5.00	0.021	IV	90.5(145.6)

EARTHQUAKE SEARCH RESULTS

FILE CODE	LAT. NORTH	LONG. WEST	DATE	TIME (UTC) H M Sec	DEPTH (km)	QUAKE MAG.	SITE ACC. g	SITE MM INT.	APPROX. DISTANCE mi [km]
DMG	36.7800	121.4300	01/20/1960	32553.0	0.0	5.00	0.021	IV	91.0(146.4)
PAS	37.4730	118.3720	07/31/1986	72240.5	6.0	5.90	0.033	V	91.0(146.5)
PAS	37.5830	118.4500	07/20/1986	142946.3	6.0	5.90	0.033	V	91.7(147.6)
DMG	36.8000	121.4500	06/24/1939	13 2 0.0	0.0	5.50	0.026	V	92.1(148.2)
PAS	37.6470	118.5020	07/21/1986	22 718.7	6.0	5.40	0.025	V	92.2(148.3)
GSB	36.7550	121.4640	08/12/1998	141025.1	8.0	5.40	0.025	V	92.9(149.5)
DMG	36.7000	118.1000	03/26/1872	1030 0.0	0.0	7.80	0.088	VII	93.4(150.3)
GSB	38.0470	119.1570	10/24/1990	061520.7	12.0	5.70	0.029	V	93.6(150.6)
GSB	37.0250	121.4580	01/16/1993	062934.9	5.0	5.30	0.023	IV	93.9(151.0)
DMG	36.9100	121.4800	11/28/1974	23 124.7	0.0	5.20	0.022	IV	94.1(151.4)
MGI	36.6000	118.1000	05/17/1872	21 0 0.0	0.0	5.00	0.020	IV	94.1(151.5)
DMG	36.8000	121.5000	11/13/1892	1245 0.0	0.0	5.60	0.027	V	94.9(152.7)
DMG	37.0200	121.4800	03/09/1949	122839.0	0.0	5.20	0.022	IV	95.0(152.9)
MGI	36.5800	118.0800	07/06/1917	11 1 0.0	0.0	5.70	0.029	V	95.4(153.6)
PAS	37.6200	118.3980	07/22/1986	134859.0	6.0	5.20	0.022	IV	95.5(153.7)
DMG	37.0000	121.5000	06/20/1897	2014 0.0	0.0	6.20	0.037	V	95.9(154.3)
T-A	36.5800	118.0700	08/13/1882	0 0 0.0	0.0	5.00	0.020	IV	96.0(154.5)
T-A	36.5800	118.0700	04/18/1872	0 0 0.0	0.0	5.00	0.020	IV	96.0(154.5)
PAS	37.6270	118.3860	07/22/1986	133358.9	6.0	5.00	0.020	IV	96.3(155.0)
DMG	37.6100	118.3680	05/10/1936	174013.2	10.0	5.00	0.020	IV	96.4(155.2)
DMG	37.5000	121.3000	07/15/1866	630 0.0	0.0	5.80	0.030	V	96.9(155.9)
BRK	37.1000	121.5000	08/06/1979	17 522.0	0.0	5.80	0.030	V	97.1(156.3)
PAS	37.5990	118.3200	07/21/1986	1451 8.8	6.0	5.40	0.024	IV	98.1(157.9)
DMG	37.4000	121.4000	04/10/1881	10 0 0.0	0.0	5.90	0.031	V	98.5(158.6)
DMG	35.6000	118.8000	06/30/1926	1331 0.0	0.0	5.00	0.019	IV	98.6(158.7)
T-A	36.8300	121.5700	10/18/1800	0 0 0.0	0.0	7.00	0.055	VI	98.8(158.9)
DMG	37.2000	121.5000	07/06/1899	2010 0.0	0.0	5.80	0.029	V	98.8(159.0)
T-A	37.0000	121.5700	03/25/1859	0 0 0.0	0.0	5.00	0.019	IV	99.7(160.4)
MGI	37.0000	121.5700	01/09/1928	250 0.0	0.0	5.30	0.022	IV	99.7(160.4)
MGI	35.5000	120.6000	01/01/1830	0 0 0.0	0.0	5.00	0.019	IV	99.8(160.6)

****

-END OF SEARCH- 136 EARTHQUAKES FOUND WITHIN THE SPECIFIED SEARCH AREA.

TIME PERIOD OF SEARCH: 1800 TO 2012

LENGTH OF SEARCH TIME: 213 years

THE EARTHQUAKE CLOSEST TO THE SITE IS ABOUT 46.3 MILES (74.5 km) AWAY.

LARGEST EARTHQUAKE MAGNITUDE FOUND IN THE SEARCH RADIUS: 7.8

LARGEST EARTHQUAKE SITE ACCELERATION FROM THIS SEARCH: 0.088 g

COEFFICIENTS FOR GUTENBERG & RICHTER RECURRENCE RELATION:

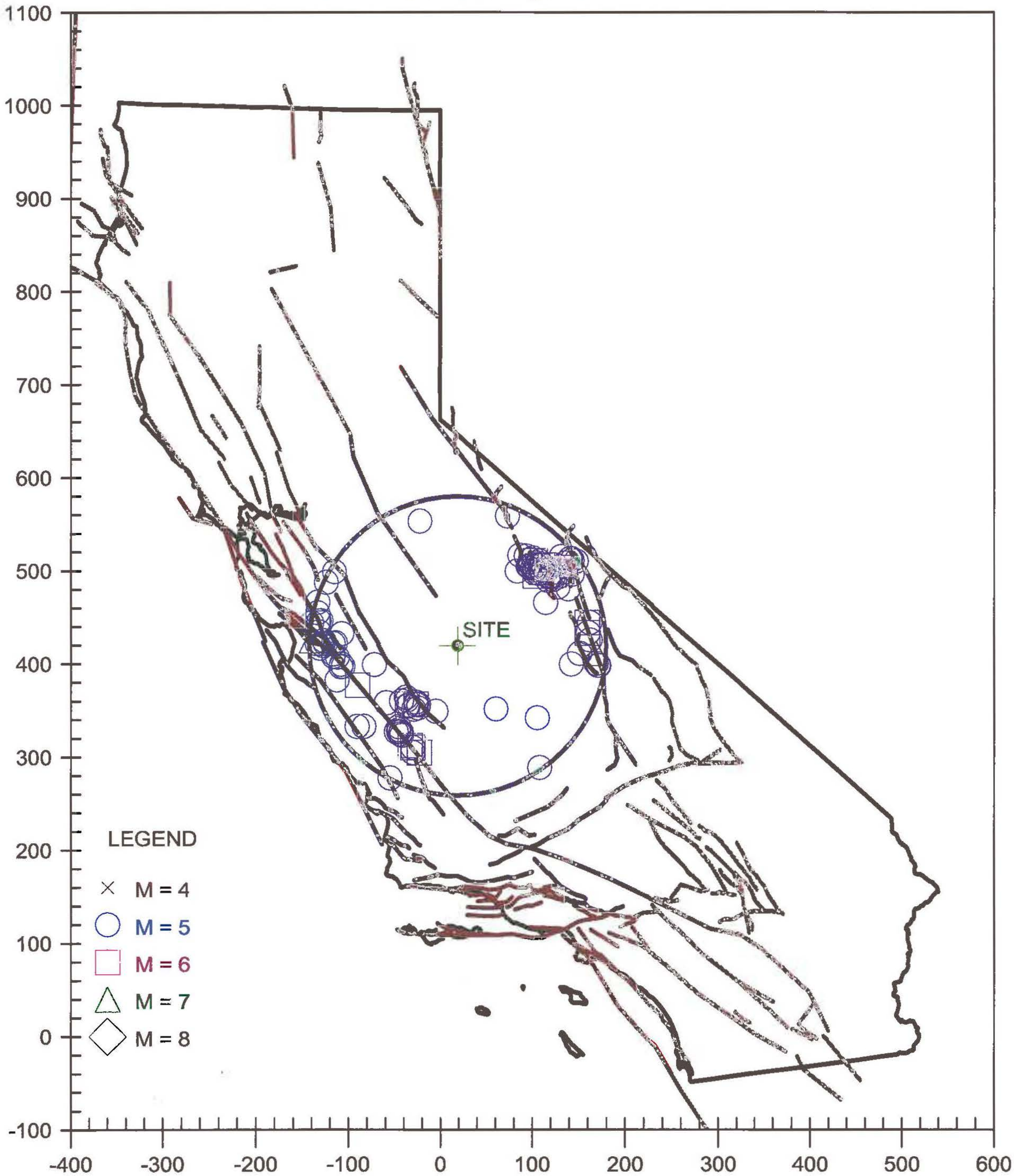
a-value= 1.688
b-value= 0.427
beta-value= 0.983

TABLE OF MAGNITUDES AND EXCEEDANCES:

Earthquake Magnitude	Number of Times Exceeded	Cumulative No. / Year
4.0	136	0.64151
4.5	136	0.64151
5.0	136	0.64151
5.5	57	0.26887
6.0	18	0.08491
6.5	7	0.03302
7.0	2	0.00943
7.5	1	0.00472

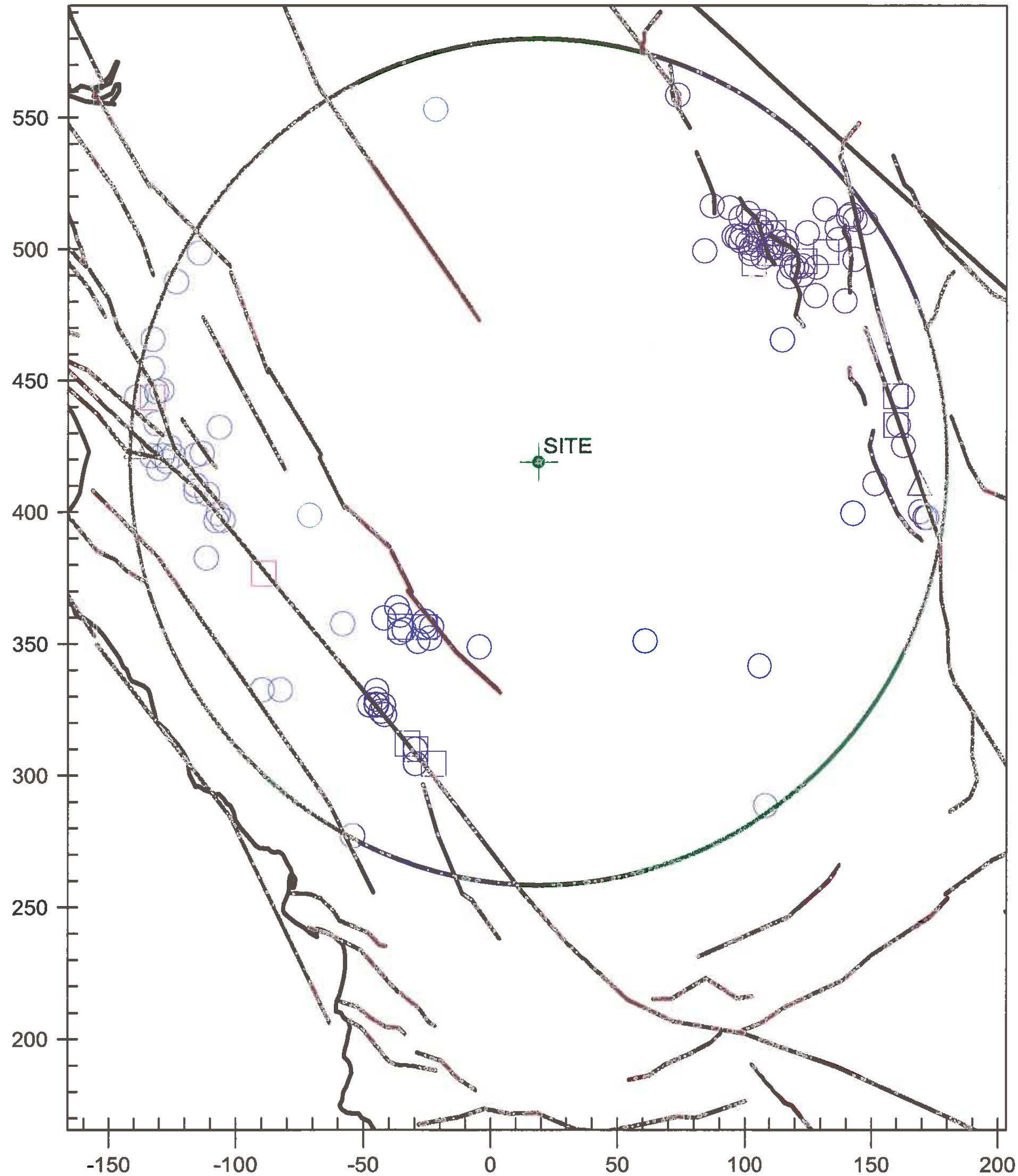
EARTHQUAKE EPICENTER MAP

Fresno General Plan Update

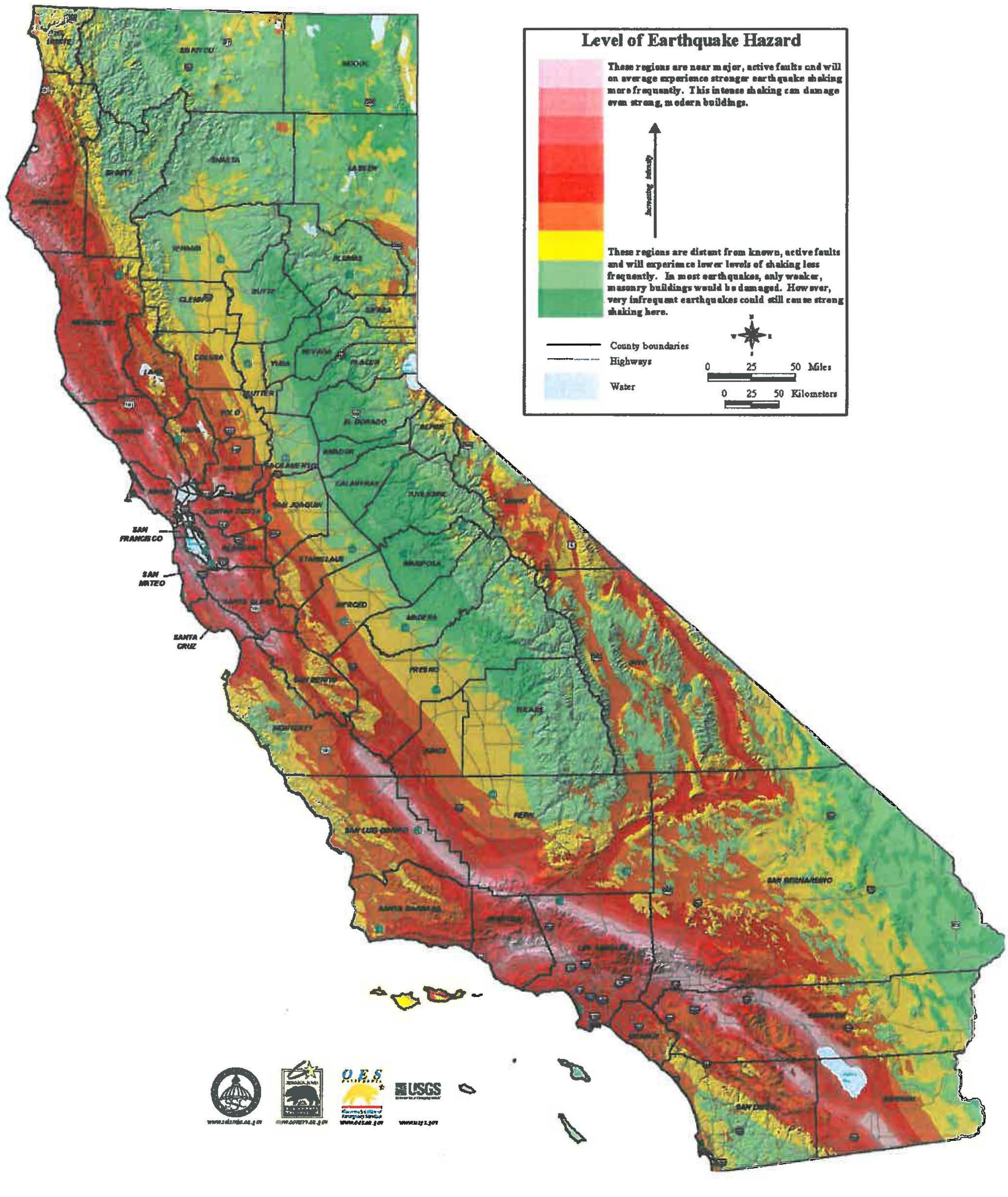


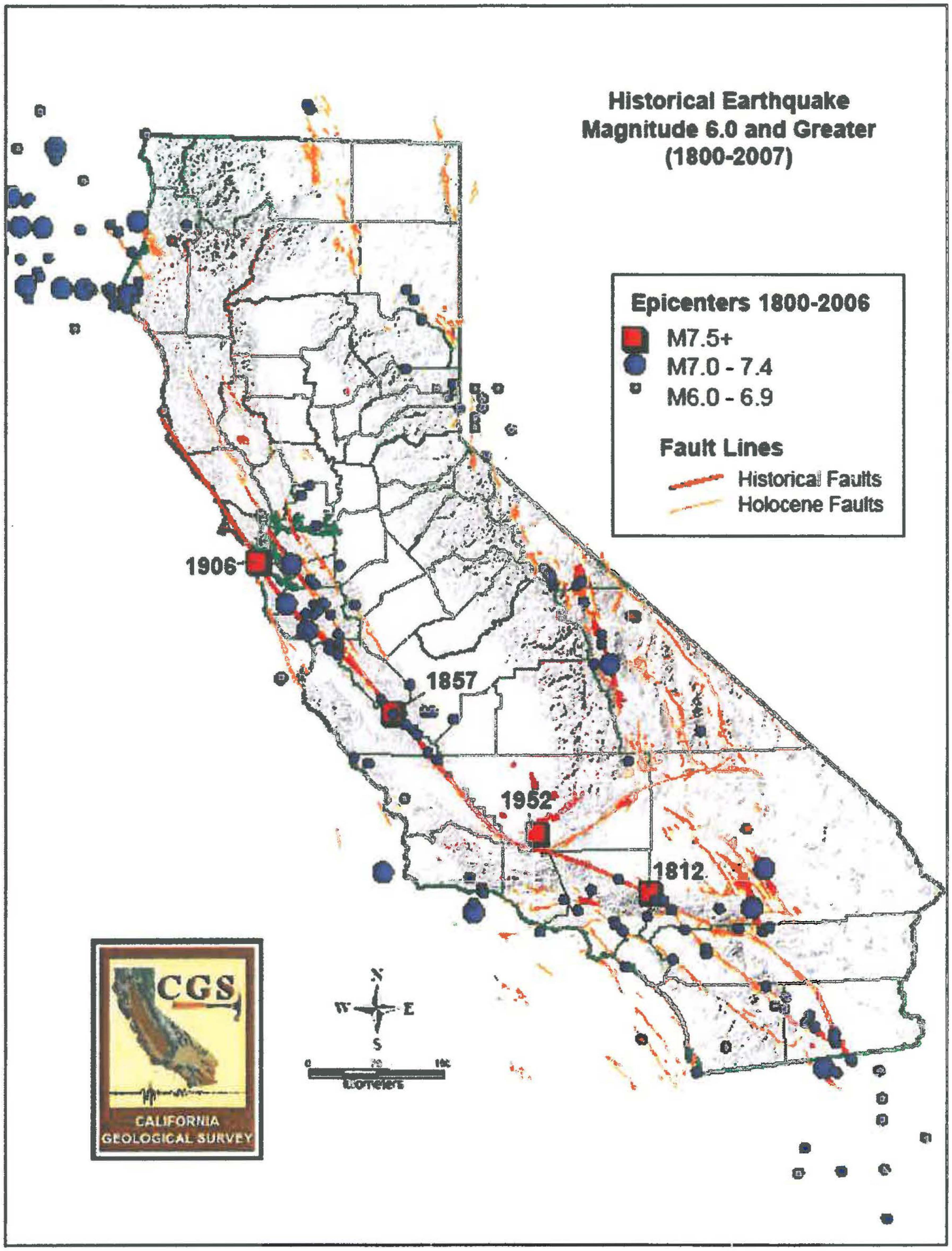
EARTHQUAKE EPICENTER MAP

Fresno General Plan Update

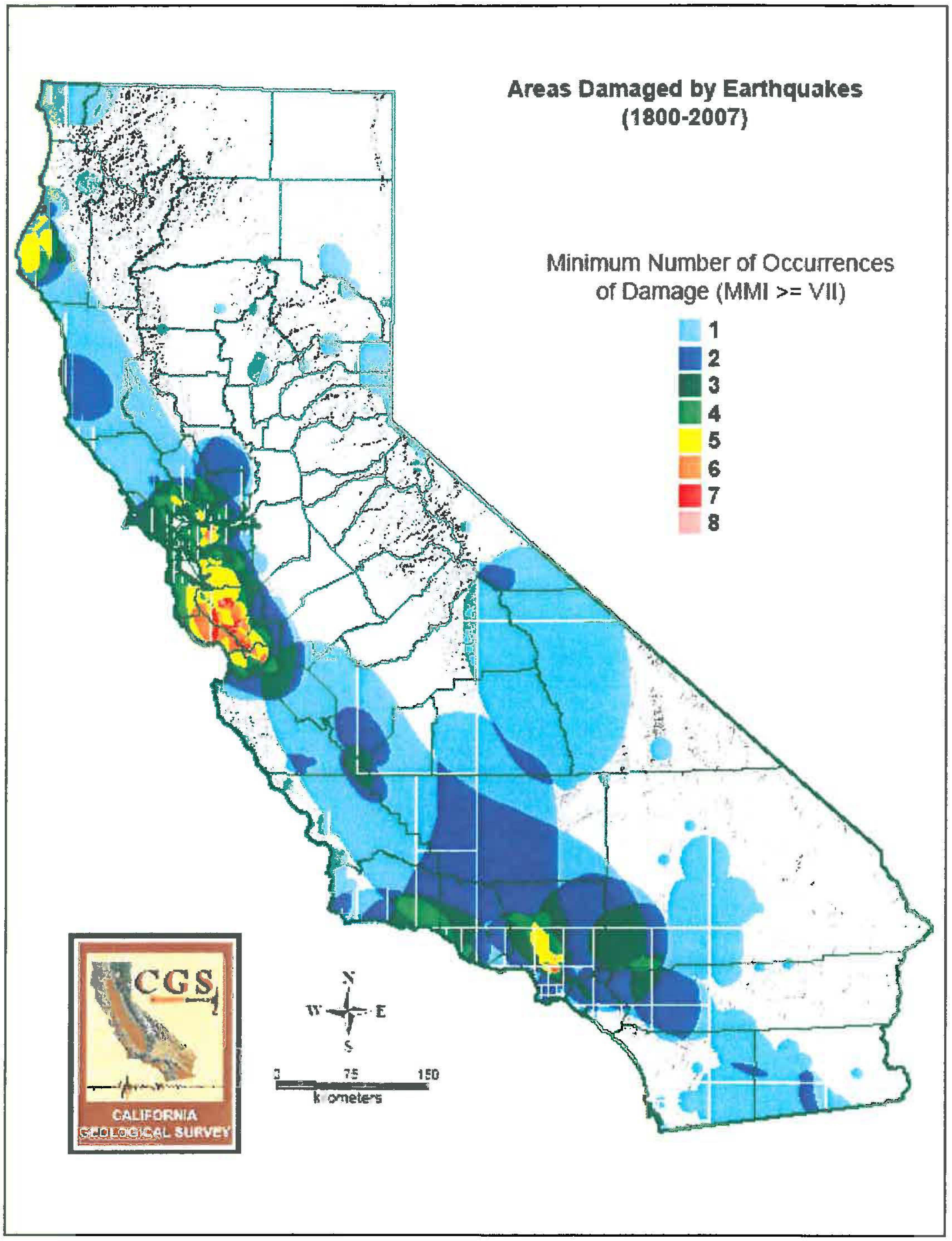


Levels of Earthquake Hazards in California



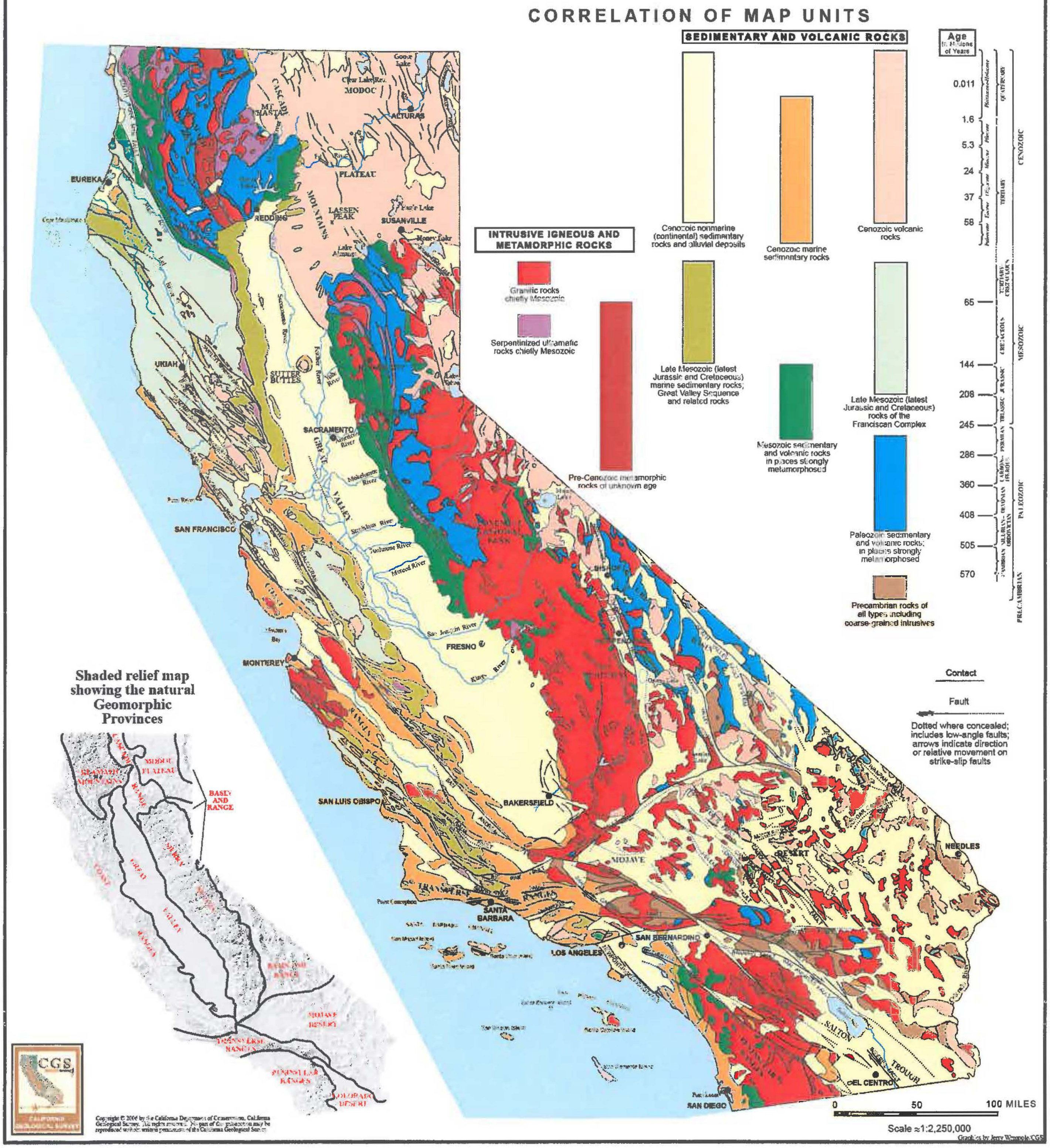


Historical Earthquake
Magnitude 6.0 and Greater
(1800-2007)
Epicenters 1800-2006
M7.5+
M7.0 - 7.4
M6.0 - 6.9
Fault Lines
Historical Faults
Holocene Faults
1906
1857
1952
1812
N
W
E
S
CGS
CALIFORNIA
GEOLOGICAL SURVEY



Areas Damaged by Earthquakes
(1800-2007)
Minimum Number of Occurrences
of Damage (MMI >= VII)
1
2
3
4
5
6
7
8
N
W
E
S
0
75
150
kilometers
CGS
CALIFORNIA
GEOLOGICAL SURVEY

SIMPLIFIED GEOLOGIC MAP OF CALIFORNIA



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