

SPECIAL PUBLICATION 42
Interim Revision 2007

FAULT-RUPTURE HAZARD ZONES IN CALIFORNIA

Alquist-Priolo Earthquake Fault Zoning Act
with Index to Earthquake Fault Zones¹ Maps

¹ Name changed from Special Studies Zones January 1, 1994



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SPECIAL PUBLICATION 42

FAULT-RUPTURE HAZARD ZONES IN CALIFORNIA

**Alquist-Priolo Earthquake Fault Zoning Act
With Index to Earthquake Fault Zones Maps**

by

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Interim Revision 2007

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PREFACE

The purpose of the Alquist-Priolo Earthquake Fault Zoning Act is to regulate development near active faults so as to mitigate the hazard of surface fault rupture.

This report summarizes the various responsibilities under the Act and details the actions taken by the State Geologist and his staff to implement the Act.

This is the eleventh revision of Special Publication 42, which was first issued in December 1973 as an "Index to Maps of Special Studies Zones." A text was added in 1975 and subsequent revisions were made in 1976, 1977, 1980, 1985, 1988, 1990, 1992, 1994, and 1997. The 2007 revision is an interim version, available in electronic format only, that has been updated to reflect changes in the index map and listing of additional affected cities. In response to requests from various users of Alquist-Priolo maps and reports, several digital products are now available, including digital raster graphic (pdf) and Geographic Information System (GIS) files of the Earthquake Fault Zones maps, and digital files of Fault Evaluation Reports and site reports submitted to the California Geological Survey in compliance with the Alquist-Priolo Act (see Appendix E).

On January 1, 1994, the name of the Alquist-Priolo Special Studies Zones Act was changed to the Alquist-Priolo Earthquake Fault Zoning Act, and the name Special Studies Zones was changed to Earthquake Fault Zones as a result of a July 25, 1993 amendment.

Information on new and revised Earthquake Fault Zones maps will be provided as supplements until the next revision of this report.

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SUPPLEMENT NO. 1 TO SPECIAL PUBLICATION 42 (2007 Interim Edition)

NEW AND REVISED OFFICIAL MAPS OF EARTHQUAKE FAULT ZONES OF SEPTEMBER 21, 2012

Official Maps of new and revised Earthquake Fault Zones, indexed hereon, are issued pursuant to the Alquist-Priolo Earthquake Fault Zoning Act. Revised maps supersede earlier Official Maps.

Copies of these maps may be examined at the offices of affected cities and counties, at the Public Information offices of the California Geological Survey (CGS), and on the CGS website (http://www.quake.ca.gov/gmaps/ap/ap_maps.htm). Both GIS and pdf files can be downloaded from this website. Printed maps may be purchased from ARC-Bryant (formerly BPS Reprographic Services), 945 Bryant Street, San Francisco, California 94103, telephone (415) 495-8700.

For information on Official Maps of Earthquake Fault Zones previously issued, and for provisions of the Alquist-Priolo Earthquake Fault Zoning Act, the reader should consult the 2007 edition of Special Publication 42, "Fault-rupture Hazard Zones in California." This publication is available online only from the California Geological Survey at <ftp://ftp.consrv.ca.gov/pub/dmg/pubs/sp/Sp42.pdf>.

Official Maps issued September 21, 2012 (Map numbers keyed to index map):

- | | | |
|---------------------|------------------|------------------|
| 1. Hayward.* | 6. Salton* | 11. Coyote Wells |
| 2. Piru | 7. Durmid* | 12. Yuha Basin |
| 3. Mecca* | 8. Carrizo Mtn.* | 13. Mount Signal |
| 4. Mortmar* | 9. Painted Gorge | |
| 5. Orocopia Canyon* | 10. Plaster City | |

* Revised zone map

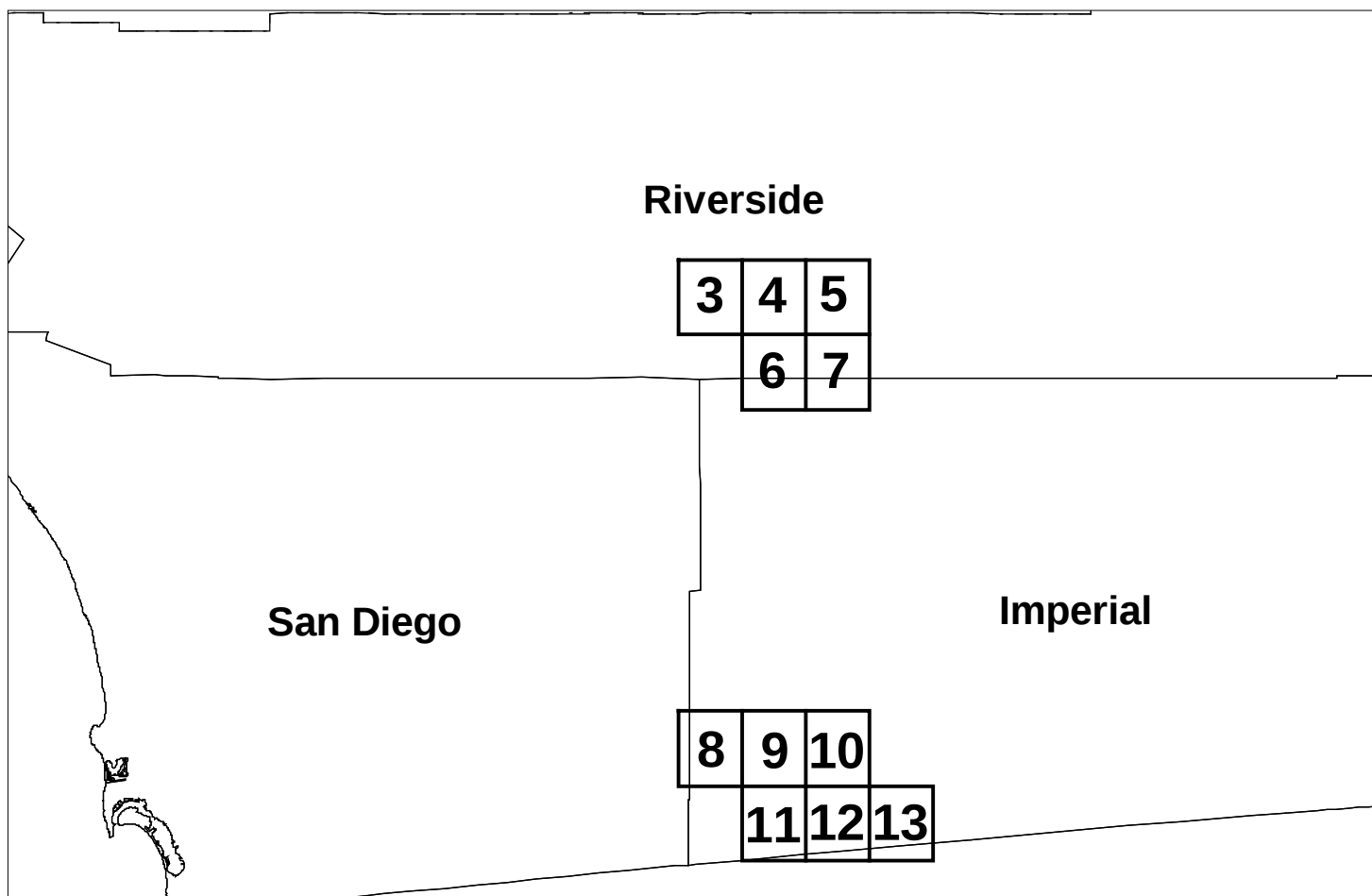
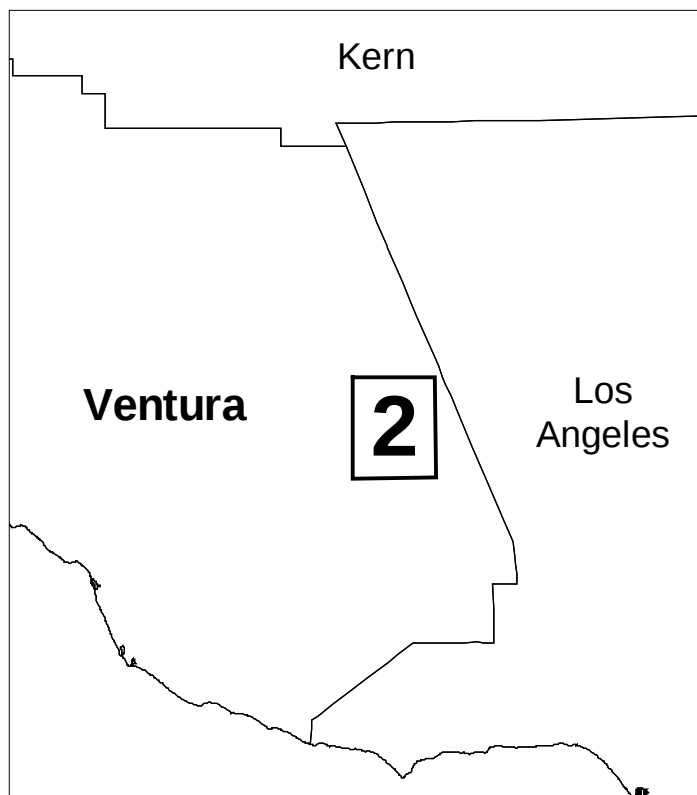
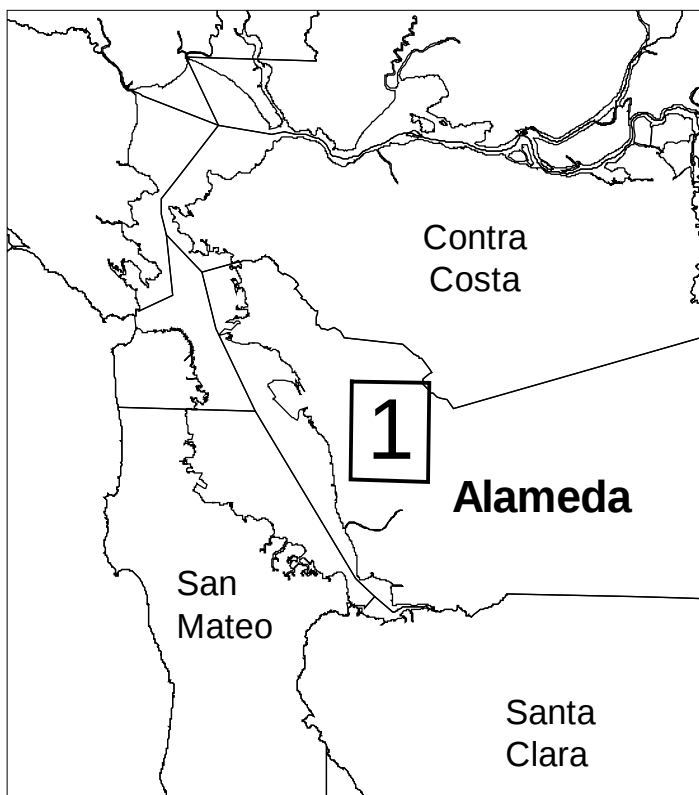
Cities and counties affected by new or revised Earthquake Fault Zones shown on Official Maps of September 19, 2012:

Cities

Hayward
Oakland
San Leandro

Counties

Alameda
Imperial
Riverside
San Diego
Ventura



SUPPLEMENT NO. 1 INDEX MAP
NEW AND REVISED OFFICIAL MAPS OF EARTHQUAKE FAULT ZONES OF SEPTEMBER 21, 2012
 (See List for Names of Maps)

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FAULT-RUPTURE HAZARD ZONES IN CALIFORNIA

By

William A. Bryant and Earl W. Hart

INTRODUCTION

The Alquist-Priolo Earthquake Fault Zoning Act was signed into law December 22, 1972, and went into effect March 7, 1973. The Act, codified in the Public Resources Code as Division 2, Chapter 7.5, has been amended ten times. A complete text of the Act is provided in Appendix A. The purpose of this Act is to prohibit the location of most structures for human occupancy across the traces of active faults and to thereby mitigate the hazard of fault rupture (Section 2621.5).

This law initially was designated as the Alquist-Priolo Geologic Hazard Zones Act. The Act was renamed the Alquist-Priolo Special Studies Zones Act effective May 4, 1975 and the Alquist-Priolo Earthquake Fault Zoning Act effective January 1, 1994. The original designation "Special Studies Zones" was changed to "Earthquake Fault Zones" when the Act was last renamed.

Under the Act, the State Geologist (Chief of the California Geological Survey [CGS]) 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 cities and counties in their implementation of the law (California Code of Regulations, Title 14, Div. 2). A summary of principal responsibilities and functions required by the Alquist-Priolo Act is given in Table 1. The Policies and Criteria are summarized in Table 2, and the complete text is provided in Appendix B.

This publication identifies and describes (1) actions taken by the State Geologist to delineate Earthquake Fault Zones, (2) policies used to make zoning decisions, and (3) Official Maps of Earthquake Fault Zones issued to date. A continuing program to evaluate faults for future zoning or zone revision also is summarized. Other aspects of the Alquist-Priolo Earthquake Fault Zoning Act and its implementation are discussed by Hart (1978 and 1986). The effectiveness of the AP Act and program was evaluated by Reitherman and Leeds (1990). The program is implementing many of the recommendations in that report.

Information presented here is based on various in-house documents and publications of the authors and others of the CGS (see Appendix E).

Table 1. Summary of responsibilities and functions under the Alquist-Priolo Earthquake Fault Zoning Act (see Appendix A for full text of Act).

State Mining and Geology Board	
1.	Formulates policies and criteria to guide cities and counties (Sec. 2621.5 and 2623). (See Appendix B.)
2.	Serves as Appeals Board (Sec. 673).
State Geologist	
1.	Delineates Earthquake Fault Zones; compiles and issues maps to cities, counties, and state agencies (Sec. 2622). a. Preliminary Review Maps. b. Official Maps.
2.	Reviews new data (Sec. 2622). a. Revises existing maps. b. Compiles new maps.
3.	Approves requests for waivers initiated by cities and counties (Sec. 2623).
Cities and Counties	
1.	Must adopt zoning laws, ordinances, rules, and regulations; primary responsibility for implementing Act (Sec. 2621.5).
2.	Must post notices of new Earthquake Fault Zones Maps (Sec. 2621.9 and 2622).
3.	Regulates specified "projects" within Earthquake Fault Zones (Sec. 2623). a. Determines need for geologic reports prior to project development. b. Approves geologic reports prior to issuing development permits. c. May initiate waiver procedures. (See Appendix F.)
Other	
1.	<i>Seismic Safety Commission</i> - advises State Geologist and State Mining and Geology Board (Sec. 2630).
2.	<i>State Agencies</i> - prohibited from siting structures for human occupancy across active fault traces (Sec. 2621.5).
3.	<i>Disclosure</i> - prospective buyers of any real property located within an Earthquake Fault Zone must be notified of that fact (Sec. 2621.9).

Table 2. Summary of policies and criteria adopted by the State Mining and Geology Board and codified in California Code of Regulations (see Appendix B for full text).

Policies	
1.	Defines active fault (equals potential hazard) as a fault that has had surface displacement during Holocene time (last 11,000 years) (Sec. 3601).
2.	Defines "structure for human occupancy" and other terms (Sec. 3601).
3.	Requires cities and counties to notify property owners within proposed new and revised Earthquake Fault Zones (Sec. 3602).
4.	Provides opportunity for public to comment on Preliminary Review Maps of Earthquake Fault Zones (Sec. 3602).
5.	Provides for comments and recommendations to State Geologist regarding Preliminary Review Maps (Sec. 3602).
Specific Criteria for Lead Agencies (Sec. 3603)	
1.	No structure for human occupancy defined as a "project" is permitted on the trace of an active fault. Unless proven otherwise, the area within 50 feet of an active fault is presumed to be underlain by active branches of the fault.
2.	Requires disclosure of Earthquake Fault Zones to the public.
3.	Requires that buildings converted to structures for human occupancy comply with provisions of the Act.
4.	Requires geologic reports directed at the problem of potential surface faulting for all projects defined by the Act.
5.	Requires cities and counties to review geologic reports for adequacy.
6.	Requires that geologic reports be submitted to the State Geologist for open-file.

PROGRAM FOR ZONING AND EVALUATING FAULTS Requirements of the Act

Section 2622 of the Alquist-Priolo Earthquake Fault Zoning Act (Appendix A) requires the State Geologist to:

1. "Delineate ... appropriately wide earthquake fault zones to encompass all potentially and recently active traces of the San Andreas, Calaveras, Hayward, and San Jacinto faults, and such other faults, or segments thereof, as the State Geologist determines to be sufficiently active and well-defined as to constitute a potential hazard to structures from surface faulting or fault creep."

2. Compile maps of Earthquake Fault Zones and submit such maps to affected cities, counties, and state agencies for their review and comment. Following appropriate reviews, the State Geologist must provide Official Maps to the affected cities, counties, and state agencies.

3. Continually review new geologic and seismic data to revise the Earthquake Fault Zones or delineate additional zones.

These requirements constitute the basis for the State Geologist's fault-zoning program and for many of the policies devised to implement the program.

Initial Program for Zoning Faults

As required under the Act, the State Geologist initiated a program early in 1973 to delineate Earthquake Fault Zones to encompass potentially and recently active traces of the San Andreas, Calaveras, Hayward, and San Jacinto faults, and to compile and distribute maps of these zones. A project team was established within the CGS to develop and conduct a program for delineation of the zones.

Initially, 175 maps of Earthquake Fault Zones were delineated for the four named faults. These zone maps, issued as Preliminary Review Maps, were distributed for review by local and state government agencies on December 31, 1973. Following prescribed 90-day review and revision periods, Official Maps were issued on July 1, 1974. At that time, the Earthquake Fault Zones became effective and the affected cities and counties were required to implement programs to regulate development within the mapped zones. A second set of Official Maps -- 81 maps of new zones and five maps of revised zones -- was issued on January 1, 1976 to delineate new and revised zones. Additional Official Maps of new and revised zones were issued in succeeding years, as summarized in Table 3.

Table 3. Official Maps of Earthquake Fault Zones issued 1974 through August 2007.

DATE OF ISSUE	NEW MAPS	REVISED MAPS	WITHDRAWN MAPS
July 1, 1974	175	-	-
January 1, 1976	81	5	-
January 1, 1977	4	3	-
January 1, 1978	1	-	-
July 26, 1978	2	-	-
January 1, 1979	4	7	-
January 1, 1980	21	9	-
January 1, 1982	13	27	2
July 1, 1983	18	12	-
January 1, 1985	33	10	-
July 1, 1986	18	14	-
March 1, 1988	58	4	-
January 1, 1990	60	25	-
November 1, 1991	46	8	-
July 1, 1993	1	10	2
June 1, 1995	8	13	-
May 1, 1998	2	1	-
May 1, 1999	3	1	-
May 1, 2003	3	11	-
August 16, 2007	-	1	-
Totals	551	161	4

As of August 16, 2007, 551 Official Maps of Earthquake Fault Zones have been issued. Of these, 161 have been revised since their initial issue and four have been withdrawn. The maps are identified by quadrangle map name and the date of issue or revision on the Index to Maps of Earthquake Fault Zones (Figure 4).

The maps delineate regulatory zones for the faults generally identified in Figure 1. Additional faults will be zoned in the future, and some zones will be revised. Thirty-six counties and 104 cities are affected by the existing Earthquake Fault Zones. These jurisdictions are listed in Table 4.

Definitions, Policies, Rationale

For the State Geologist to carry out the mandate to establish regulatory zones, certain terms identified in Section 2622 of the Act had to be defined and policies had to be

developed to provide a consistent and reasonable approach to zoning. After the zoning program was underway and the surface fault-rupture process was better understood, other terms were defined and some zoning policies were modified.

Fault and Fault Zone

A *fault* is defined as a fracture or zone of closely associated fractures along which rocks on one side have been displaced with respect to those on the other side. Most faults are the result of repeated displacement that may have taken place suddenly and/or by slow creep. A fault is distinguished from those fractures or shears caused by landsliding or other gravity-induced surficial failures. A *fault zone* is a zone of related faults that commonly are braided and subparallel, but may be branching and divergent. A fault zone has significant width (with respect to the scale at which the fault is being considered, portrayed, or investigated), ranging from a few feet to several miles.

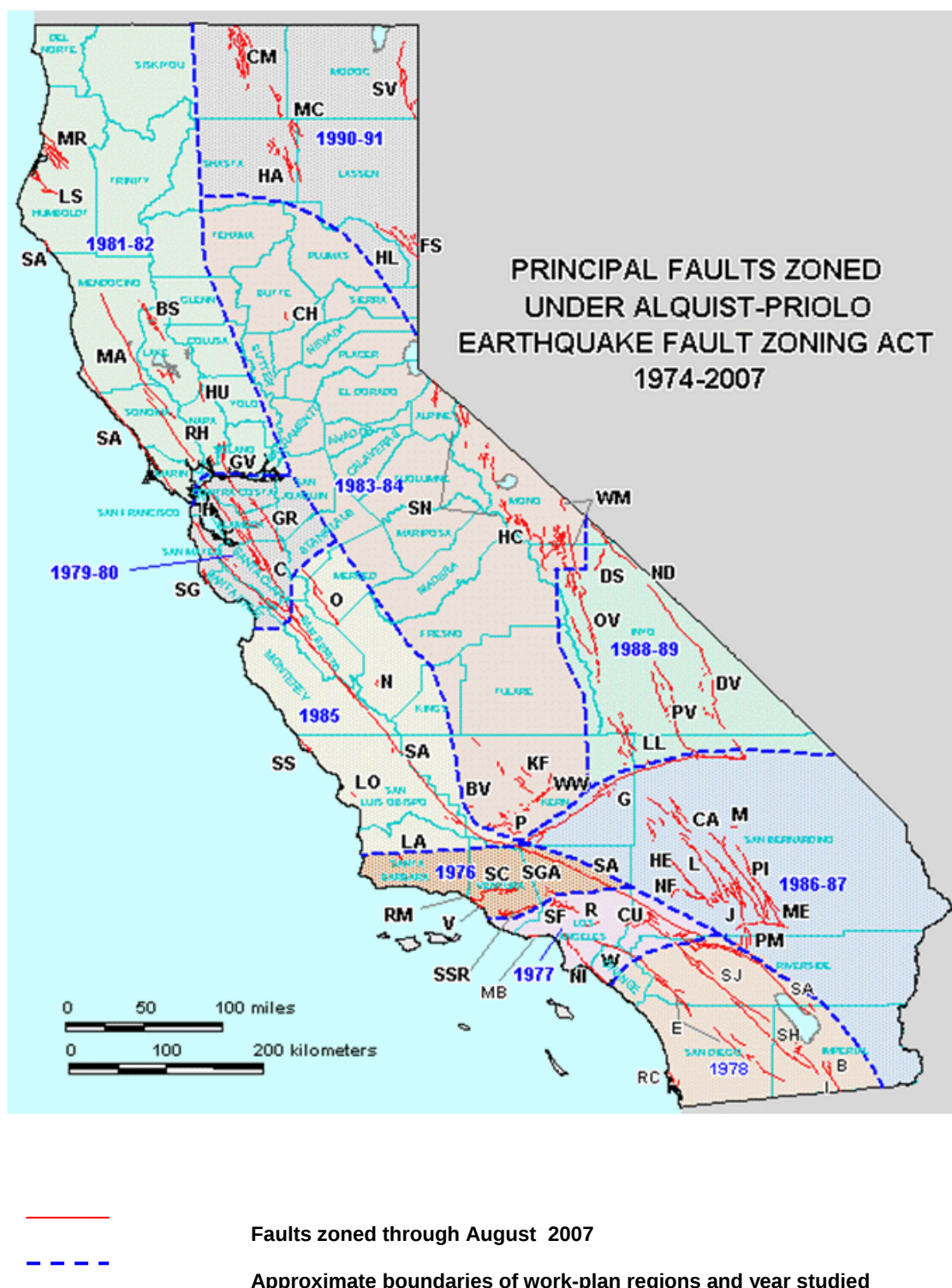
Table 4. Cities and counties affected by Earthquake Fault Zones as of August 16, 2007*

CITIES (104)**			COUNTIES (36)	
American Canyon	Hayward	Rosemead	Alameda	Stanislaus
Arcadia	Hemet	San Bernardino	Alpine	Ventura
Arcata	Highland	San Bruno	Butte	Yolo
Arvin	Hollister	San Diego	Contra Costa	
Bakersfield	Huntington Beach	San Fernando	Fresno	
Banning	Indio	San Jacinto	Humboldt	
Barstow	Inglewood	San Jose	Imperial	
Beaumont	La Habra	San Juan Bautista	Inyo	
Benicia	La Habra Heights	San Leandro	Kern	
Berkeley	Lake Elsinore	San Luis Obispo	Lake	
Bishop	Livermore	San Marino	Lassen	
Brea	Loma Linda	San Pablo	Los Angeles	
Calimesa	Long Beach	San Ramon	Marin	
Camarillo	Los Angeles	Santa Clarita	Mendocino	
Carson	Malibu	Santa Rosa	Merced	
Cathedral City	Mammoth Lakes	Seal Beach	Modoc	
Chino Hills	Milpitas	Signal Hill	Mono	
Coachella	Monrovia	Simi Valley	Monterey	
Colton	Moorpark	South Pasadena	Napa	
Compton	Moreno Valley	South San Francisco	Orange	
Concord	Morgan Hill	Temecula	Riverside	
Corona	Murrieta	Trinidad	San Benito	
Coronado	Oakland	Twentynine Palms	San Bernardino	
Culver City	Pacifica	Union City	San Diego	
Daly City	Palmdale	Upland	San Luis Obispo	
Danville	Palm Springs	Ventura (San Buenaventura)	San Mateo	
Desert Hot Springs	Palo Alto	Walnut Creek	Santa Barbara	
Dublin	Pasadena	Whittier	Santa Clara	
El Cerrito	Pleasanton	Willits	Santa Cruz	
Fairfield	Portola Valley	Windsor	Shasta	
Fontana	Rancho Cucamonga	Woodside	Siskiyou	
Fortuna	Redlands	Yorba Linda	Solano	
Fremont	Rialto	Yucaipa	Sonoma	
Gardena	Richmond	Yucca Valley		
Glendale	Ridgecrest			

* To inquire about local government policies and regulations or to consult (obtain) copies of specific Earthquake Fault Zones maps, address the Planning Director of each county or city. Some jurisdictions have replotted the EFZ boundaries on large-scale parcel maps.

** Additional cities may be affected by the zones as new cities are created, city boundaries are expanded, or new zones are established

MAP SYMBOL	NAME OF PRINCIPAL FAULT
B	*Brawley
BS	Bartlett Springs
BV	*Buena Vista
C	*Calaveras
CA	Calico
CH	*Cleveland Hill
CM	Cedar Mtn.
CU	Cucamonga
DS	Deep Springs
DV	Death Valley
E	Elsinore
FS	*Fort Sage
G	*Garlock
GR	*Greenville
GV	*Green Valley and Concord
H	*Hayward
HA	Hat Creek
HC	*Hilton Creek & related
HE	Helendale
HL	Honey Lake
HU	Hunting Creek
I	*Imperial
J	*Johnson Valley & related
KF	*Kern Front & related
L	Lenwood
LA	Los Alamos
LL	*Little Lake
LO	Los Osos
LS	Little Salmon
M	*Manix
MA	*Maacama
MB	Malibu
MC	McArthur
ME	Mesquite Lake
MR	Mad River
N	*Nunez
ND	Northern Death Valley
NF	North Frontal
NI	*Newport-Inglewood
O	Ortogonalita
OV	*Owens Valley
P	Pleito & Wheeler Ridge
PI	*Pisgah-Bullion
PM	Pinto Mountain
PV	Panamint Valley
R	Raymond Hill
RC	Rose Canyon
RH	Rodgers Creek-Healdsburg
RM	Red Mountain
SA	*San Andreas
SC	San Cayetano
SF	*San Fernando
SG	San Gregorio
SGA	San Gabriel
SH	*Superstition Hills
SJ	*San Jacinto
SN	Sierra Nevada (zone)
SS	San Simeon
SSR	Simi-Santa Rosa
SV	Surprise Valley
W	Whittier
WM	*White Mtns
WW	*White Wolf
V	Ventura



Note: Other faults may be zoned in the future and existing zones may be revised when warranted by new fault data

Figure 1. Principal active faults in California zoned under the Alquist-Priolo Earthquake Fault Zoning Act. Asterisk indicates faults with historic surface rupture.

Fault Trace

A *fault trace* is the line formed by the intersection of a fault and the earth's surface. It is the representation of a fault as depicted on a map, including maps of the Earthquake Fault Zones.

Active Fault

For the purposes of this Act, an *active fault* is defined by the State Mining and Geology Board as one which has "had surface displacement within Holocene time (about the last 11,000 years)" (see Appendix B, Section 3601). This definition does not, of course, mean that faults lacking evidence for surface displacement within Holocene time are necessarily inactive. A fault may be presumed to be inactive based on satisfactory geologic evidence; however, the evidence necessary to prove inactivity sometimes is difficult to obtain and locally may not exist.

Potentially Active Fault

Because the Alquist-Priolo Act requires the State Geologist to establish Earthquake Fault Zones to encompass all "potentially and recently active" traces of the San Andreas, Calaveras, Hayward, and San Jacinto faults, additional definitions were needed (Section 2622). 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, Figure 2). Exceptions were made for certain Quaternary (i.e., Pleistocene) faults that were presumed to be inactive based on direct geologic evidence of inactivity during all of Holocene time or longer. The term "recently active" was not defined, as it was considered to be covered by the term "potentially active." Beginning in 1977, evidence of Quaternary surface displacement was no longer used as a criterion for zoning. However, 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

A major objective of the CGS's continuing Fault Evaluation and Zoning Program is to evaluate the hundreds of remaining potentially active faults in California for zoning consideration. However, it became apparent as the program progressed that there are so many potentially

active (i.e., Quaternary) faults in the state (Jennings, 1975) that it would be meaningless to zone all of them. In late 1975, 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," from Section 2622 of the Act, were defined for application in zoning faults other than the four 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; it need not be present everywhere along a fault to qualify that fault for zoning.

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 (e.g., geomorphic evidence; Appendix C). 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.

Determining if a fault is sufficiently active and well-defined is a matter of judgment. However, these definitions provide standard, workable guidelines for establishing Earthquake Fault Zones under the Act.

The evaluation of faults for zoning purposes is done with the realization that not all active faults can be identified. Furthermore, certain faults considered to be active at depth, because of known seismic activity, are so poorly defined at the surface that zoning is impractical. Although the map explanation indicates that "potentially active" (i.e., Quaternary) faults are identified and zoned (with exceptions) on the Official Maps of Earthquake Fault Zones until 1988, this is basically true only for those maps issued July 1, 1974 and January 1, 1976. Even so, all of the principal faults zoned in 1974 and 1976 were active during Holocene time, if not historically. Beginning with the maps of January 1, 1977, all faults zoned meet the criteria of "sufficiently active and well-defined."

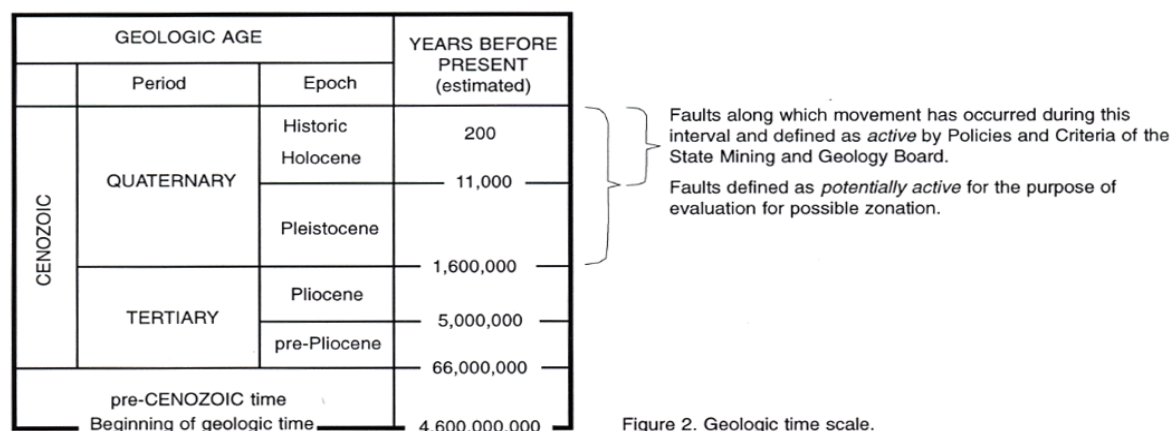


Figure 2. Geologic time scale.

Delineating the Earthquake Fault Zones

Earthquake Fault Zones are delineated on U.S. Geological Survey topographic base maps at a scale of 1:24,000 (1 inch equals 2,000 feet). The zone boundaries are straight-line segments defined by turning points (Figure 3). Most of the turning points are intended to coincide with locatable features on the ground (e.g., bench marks, roads, streams). Neither the turning points nor the connecting zone boundaries have been surveyed to verify their mapped locations.

Locations of Earthquake Fault Zone boundaries are controlled by the position of fault traces shown on the Official Maps of Earthquake Fault Zones. With few exceptions, the faults shown on the 1974 and 1976 Earthquake Fault Zones maps were not field-checked during the compilation of these maps. However, nearly all faults zoned since January 1, 1977 have been evaluated in the field or on aerial photographs to verify that they do meet the criteria of being sufficiently active and well-defined.

Zone boundaries on early maps were positioned about 660 feet (200 meters) away from the fault traces to accommodate imprecise locations of the faults and possible existence of active branches. The policy since 1977 is to position the EFZ boundary about 500 feet (150 meters) away from major active faults and about 200 to 300 feet (60 to 90 meters) away from well-defined, minor faults. Exceptions to this policy exist where faults are locally complex or where faults are not vertical.

Fault Evaluation and Zoning Program

The Fault Evaluation and Zoning Program was initiated in early 1976 for the purpose of evaluating those "other faults" identified in the Act as "sufficiently active and well-defined" (see definition above) after it was recognized that effective future zoning could not rely solely on the limited fault data of others. Justification of this program is discussed in more detail in Special Publication 47 of the Division of Mines and Geology (1976; also see Hart, 1978).

The program was originally scheduled over a 10-year period. The state was divided into 10 regions or work areas (Figure 1), with one region scheduled for evaluation each year. However, the work in some regions was extended due to heavy workloads. Fault evaluation work includes interpretation of aerial photographs and limited field mapping, as well as the use of other geologists' work. A list of faults to be evaluated in a target region was prepared and priorities assigned. The list included potentially active faults not yet zoned, as well as previously zoned faults or fault-segments that warranted zone revisions (change or deletion). Faults also were evaluated in areas outside of scheduled regions, as the need arose (e.g., to map fault rupture immediately after an earthquake). The fault evaluation work was completed in early 1991. The work is summarized for each region in Open-File Reports (OFR) 77-8, 78-10, 79-10, 81-3, 83-10, 84-52, 86-3, 88-1, 89-16, and 91-9 (see Appendix E). Appendix E is a complete list of publications and products of the Fault Evaluation and Zoning Program.

For each fault evaluated, a Fault Evaluation Report (FER) was prepared, summarizing data on the location, recency of activity, and sense and magnitude of displacement. Each FER contains recommendations for or against zoning. These in-house reports are filed at the CGS Sacramento Regional Office at 801 K Street, MS 12-31, Sacramento, 95814, where they are available for reference. Reference copies of the FERs are filed in the CGS's Los Angeles and San Francisco Bay regional offices. An index to FERs prepared 1976 to April 1989 is available as OFR 90-9 (see Appendix E). This list and an index map identify the faults that have been evaluated. Digital files of all FER's are available in pdf format (CGS CD 2002-01; CD 2002-02; CD 2002-03) (see Appendix E).

Under the AP Act (Sec. 2622), the State Geologist has an on-going responsibility to review "new geologic and seismic data" in order to revise the Earthquake Fault Zones and to delineate new zones "when warranted by new information."

As a result of the fault evaluations made since 1976, 295 new and 155 revised Earthquake Fault Zones Maps have been issued and four maps have been withdrawn (Table 3). The faults zoned since 1976 are considered to meet the criteria of "sufficiently active and well-defined" (see Definitions above). Many other faults did not appear to meet the criteria and were not zoned. It is important to note that it is sometimes difficult to distinguish between slightly active faults and inactive ones, because the surface features formed as a result of minor, infrequent rupture are easily obliterated by geologic processes (erosion, sedimentation, mass wasting) or people's activities. Even large scale fault-rupture can be obscured in complex geologic terranes or high-energy environments. Recent fault-rupture also is difficult to detect where it is distributed as numerous breaks or warps in broad zones of deformation. As a consequence of these problems, it is not possible to identify and zone all active faults in California. For the most part, rupture on faults not identified as active is expected to be minor.

Since zones were first established in 1974, there have been 25 earthquakes or earthquake sequences associated with surface faulting in various parts of California (Table 5). This is an average of 0.75 fault-rupture events per year. Most of the recent surface faulting has been relatively minor; either in terms of amount of displacement or length of surface rupture (Table 5). However, one foot (30 cm) or more displacement occurred during seven events. Earlier records (incomplete) suggest that displacements of 3 feet (one meter) or more occur at least once every 15 to 20 years in California (Bonilla, 1970; Grantz and Bartow, 1977). Many of the recent coseismic events occurred on faults that were not yet zoned, and a few were on faults not considered to be potentially active or not even mapped. However, coseismic rupture also occurred on faults mostly or entirely within the Earthquake Fault Zones in nine of the rupture events (Table 5). A sequence of four rupture events occurred in the Lompoc diatomite quarry and presumably was triggered by quarrying (see event #10, Table 5). In addition, aseismic fault creep has occurred on many zoned faults in the last 30 years (see footnote, Table 5). Most fault creep is tectonically induced, although some is induced by people (mainly by fluid withdrawal).

Table 5. Surface faulting associated with earthquakes in California, 1974–June 2007. List excludes fault creep and faulting triggered by shaking or movement on a different fault¹. See Bonilla (1970), Jennings (1985), and Grantz and Bartow (1977) for earlier faulting events.

Fault (County where located)	Year of rupture	Magnitude of earthquake	Surface rupture ² Max. displacement (cm)	Total length ² (km)	Main sense of displacement ³	Comments
1. Brawley (Imperial)	1975	4.7	20	10.4	N	Also ruptured in 1940 and 1979, fault creep in part.
2. Galway Lake (San Bernardino)	1975	5.3	1.5	6.8	RL	Fault previously unknown.
3. Cleveland Hill (Butte)	1975	5.7	5	5.7	N	Fault not previously known to be Holocene-active.
4. Stephens Pass (Siskiyou)	1978	4.3	30	2+	N	Fault previously unknown.
5. Homestead Valley (San Bernardino)	1979	5.2	8	3.3	RL	Also minor rupture on Johnson Valley fault.
6. *Calaveras (San Benito, Santa Clara)	1979	5.9	1	39 (?)	RL	Minor, discontinuous rupture mostly in creep-active segment.
7. *Imperial (Imperial)	1979	6.6	55 15 10	30 13 1	RL N N	Creep triggered on San Andreas and Superstition Hills faults; also ruptured in 1940. Rico fault not previously known.
8. Greenville (Alameda)	1980	5.6	3	6.5	RL	Minor left-lateral slip also occurred on Las Positas fault.
9. Hilton Creek-Mammoth Lakes (Mono)	1980	6.0-6.5	30	20	N	Rupture on many minor faults, may relate to volcanic activity. Minor ruptures also in 1981.
10. *Lompoc quarry (Santa Barbara)	1981	2.5	25	0.6	R	Flexural slip on flank of syncline triggered by quarrying; do not plan to zone. Similar earthquake-associated ruptures occurred in 1985, 1988, and 1995.
11. Little Lake (Kern)	1982	5.2	0+	10	RL/N	Fracture zones on monoclines.
12. *Coalinga Nose (Fresno)	1983	6.7	5	.005	R	Secondary fault (?) associated with 43 cm of antinormal uplift; too minor to zone.
13. Nunez (Fresno)	1983	5.2-5.9	60	3.3	R	Aftershocks associated with event (12) above.
14. *Calaveras (Santa Clara)	1984	6.1	20 (?)	1.2	RL	Questionable faulting; triggered afterslip in 15-km long creep-zone to south.
15. *Banning (Riverside)	1986	5.9	7	9	RL	Minor slip also triggered locally on Garnet Hill and Desert Hot Springs (?) faults as well as more distant faults.
16. *White Mountains (Mono, Inyo)	1986	6.4	11	13	RL/N	Also extensional cracks on faults in Volcanic Tableland in 40km x 12km area.
17. Elmore Ranch (Imperial)	1987	6.2	12	12	LL	Also lesser left-lateral rupture on nearby faults.
18. *Superstition Hills (Imperial)	1987	6.6	90	28	RL	Much of rupture occurred as afterslip; associated with event 17.
19. *San Andreas (Santa Cruz)	1989	7.1	2.5	1?	RL	Surface rupture possibly triggered slip; slip also triggered on nearby Calaveras and San Andreas faults outside of aftershock zone. Secondary faulting may have occurred with ridgetop spreading fissures.
20. *Johnson Valley (San Bernardino)	1992	7.3	460-600	85	RL	Most significant fault rupture since 1906; ruptures connected several separate faults; triggered slip also occurred on at least 10 other faults.
21. *Eureka Valley (Inyo)	1993	6.1	2	5+	RL/N	Two zones of left-stepping fractures along pre-existing fault scarps; incompletely mapped; remote area, not zoned.
22. *Stevenson Ranch (Los Angeles)	1994	6.7	19	0.6	R	Flexural slip faults on limb of fold near Newhall; related to blind thrust faulting. Minor slip also triggered on Mission Wells fault, which ruptured in 1971.
23. Airport Lake (Kern and Inyo)	1995	5.4-5.8	1	2.5	RL/N	Discontinuous cracks along pre-existing scarp.
24. Lavic Lake (Bullion)	1999	7.1	525	45	RL	Bullion and Mesquite Lake faults previously zoned; Lavic Lake had not ruptured in Holocene.
25. *San Andreas (Monterey, San Luis Obispo)	2004	6.0	15	32	RL	Parkfield section of San Andreas fault zone; also ruptured in 1966. Much of rupture occurred as afterslip.

¹ Tectonic (aseismic) fault-creep and triggered slip have occurred along various segments of the San Andreas, Hayward, Calaveras, Concord, Green Valley, Imperial, Superstition Hills, Maacama, Garlock, and more than 10 other faults. People-induced fault-creep has been reported on at least 12 other faults due to withdrawal of groundwater or oilfield fluids. See Jennings (1994) for map locations.

² Includes some afterslip. Rupture length measured from distal ends of rupture, which often is discontinuous.

³ N=normal displacement; R=reverse displacement; RL=right-lateral displacement; LL=left-lateral displacement.

* Cosismic surface faulting occurred mostly or entirely within existing Earthquake Fault Zones during eight events

In addition to evaluating and zoning faults, program staff also perform other functions necessary to the implementation of the APEFZ Act. Regulations (Section 3603, Appendix B) require that cities and counties file geologic reports for “project” sites in Earthquake Fault Zones with the State Geologist. By the middle of 2006, over 4000 site-specific geologic reports investigating the hazard of surface-fault rupture had been filed for public reference. Site reports on file with CGS through 2000 are available as digital images in pdf format (CGS CD 2003-01; CD 2003-02). Reports filed after 2000 are available for reference at the Geologic Information and Publications Office in Sacramento (see Appendix E).

In order to improve the quality of site investigations and reports, guidelines were prepared in 1975 to assist others in evaluating faults. These guidelines have been revised and appear as Appendix C.

General guidelines for reviewing geologic reports for adequacy, required by Section 3603 of the regulations, are provided in Appendix D.

If a city or county considers that a geologic investigation of a proposed “project” is unnecessary, it may request a waiver from the State Geologist (Section 2623, Appendix A). A waiver form detailing the procedures used is provided in Appendix F. Through 2006, 84 waiver requests have been processed by program staff.

Another important activity is to provide information on the APEFZ Act, the Division’s Fault Evaluation and Zoning Program, and fault-rupture hazards to both the public and private sectors. Program staff responds to about 1,500 inquiries each year from geologists, planners, building officials, developers, realtors, financial institutions, and others.

Uses and Limitations of Earthquake Fault Zones Maps

The Earthquake Fault Zones are delineated to define those areas within which fault-rupture hazard investigations are required prior to building structures for human occupancy. Traces of faults are shown on the maps mainly to justify the locations of zone boundaries. These fault traces are plotted as accurately as the sources of data permit; yet the plots are not sufficiently accurate to be used as the basis for building set-back requirements, and they should not be so used.

The fault information shown on the maps is not sufficient to meet the requirement for fault-rupture hazard investigations. Local governmental units must require developers to have project sites within the Earthquake Fault Zones evaluated to determine if a potential hazard from any fault, whether heretofore

recognized or not, exists with regard to proposed structures and their occupants.

The surface fault-ruptures associated with historic earthquake and creep events are identified where known. However, no degree of relative potential for future surface displacement or degree of hazard is implied for the faults shown. Surface ruptures resulting from the secondary effects of seismic shaking (e.g., landsliding, differential settlement, liquefaction) are omitted from the map and do not serve as a basis for zoning.

Active faults may exist outside the Earthquake Fault Zones on any zone map. Therefore, fault investigations are recommended for all critical and important developments proposed outside the Earthquake Fault Zones.

INDEX TO MAPS OF EARTHQUAKE FAULT ZONES

The following pages (Figures 4A to 4J) indicate the names and locations of the Official Maps of Earthquake Fault Zones delineated by the California Geological Survey under the Alquist-Priolo Earthquake Fault Zoning Act (Appendix A). These index pages identify all Official Maps of Earthquake Fault Zones released by the State Geologist through August 2007. The official maps are compiled on U.S. Geological Survey 7.5-minute topographic quadrangle maps at a scale of 1 inch equals 2,000 feet (Figure 3). Cities and counties affected by these maps are listed in Table 4.

Because Earthquake Fault Zones maps are issued every year or two to delineate revised and additional zones, users of these maps should check with the California Geological Survey for up-to-date information on new and revised Earthquake Fault Zones maps. A change in zones also may affect different local governments. This index to Official Maps of Earthquake Fault Zones (Figures 4A to 4J) will be revised in future years as new maps are issued.

The Earthquake Fault Zones maps are available for purchase as indicated under Availability of Earthquake Fault Zones Maps. Also, they may be consulted at any office of the California Geological Survey and at the planning departments of all cities and counties affected locally by Earthquake Fault Zones (Table 4).

Availability of Earthquake Fault Zones Maps

Reproducible masters, from which copies of local Earthquake Fault Zones maps (scale 1:24,000) can be made, have been provided to each of the cities and counties affected by the zones. Requests for copies of

particular Earthquake Fault Zones maps of local areas should be directed to the Planning Director of the appropriate city or county. Refer to the index of Earthquake Fault Zones maps for the quadrangle names of the maps needed.

Arrangements also have been made with ARC-Bryant (formerly BPS Reprographic Services), San Francisco, to provide paper copies of the Earthquake Fault Zones maps to those who cannot get them conveniently from the cities and counties.

ARC-Bryant
945 Bryant Street
San Francisco, CA 94103
Telephone: (415) 495-8700

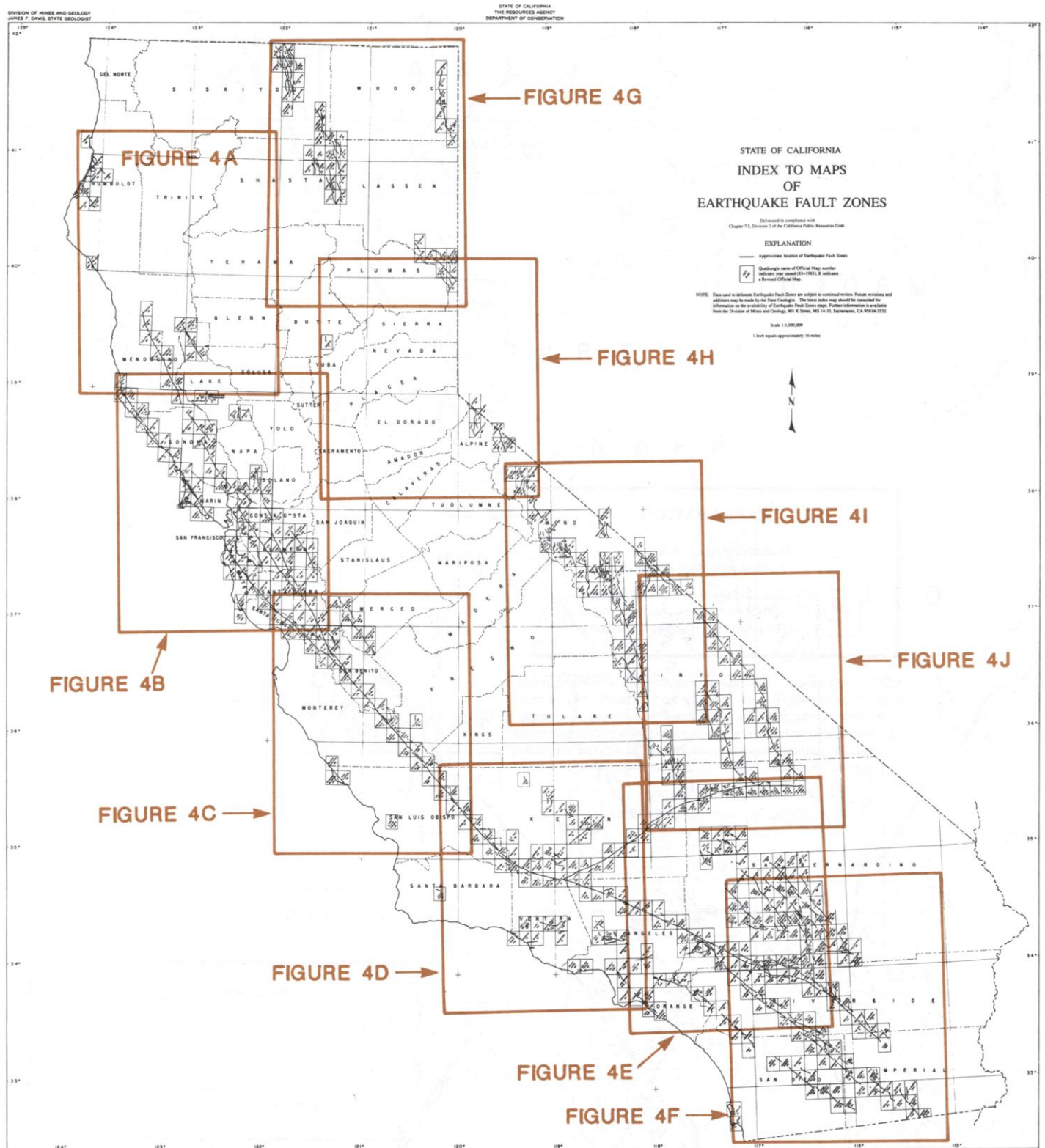
Each map must be ordered by quadrangle name as shown on the index map. The cost of the maps is nominal; handling and C.O.D. charges are extra. These maps are not sold by the California Geological Survey.

Digital files of the maps can be obtained from the California Geological Survey in both digital raster (pdf) and Geographic Information System (GIS) format. Refer to Appendix E for more information on obtaining digital files of the maps.

REFERENCES

(See Appendix E for Complete List of AP Products)

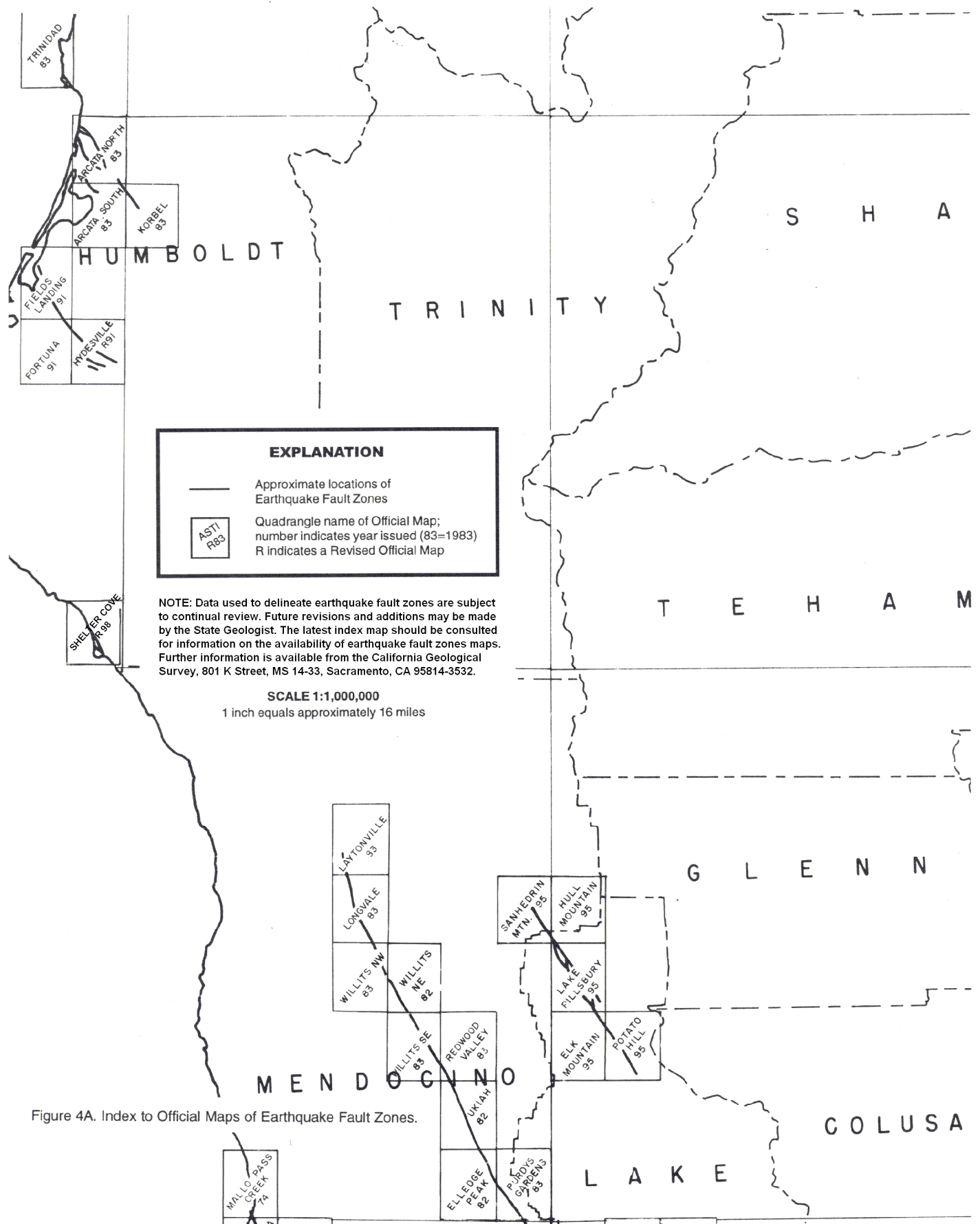
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- Jennings, C.W., 1985, An explanatory text to accompany the 1:750,000 scale Fault and Geologic Maps of California: Division of Mines and Geology Bulletin 201, 197 p., 2 plates.
- Jennings, C.W., 1994, Fault activity map of California and adjacent areas: California Department of Conservation, Division of Mines and Geology Geologic Data Map No. 6, scale 1:750,000 (appendices).
- Reitherman, R. and Leeds, D.J., 1990, A study of the effectiveness of the Alquist-Priolo program: California Division of Mines and Geology Open-File Report 90-18, 131 p.



Data used to delineate Earthquake Fault Zones are subject to continual review. Future revisions and additions may be made by the State Geologist. Future supplements to this report should be consulted for information on the availability of Earthquake Fault Zones maps.

These Earthquake Fault Zones maps are delineated in compliance with Chapter 7.5, Division 2 of the California Public Resources Code.

Figure 4. Index to Official Maps of Earthquake Fault Zones.



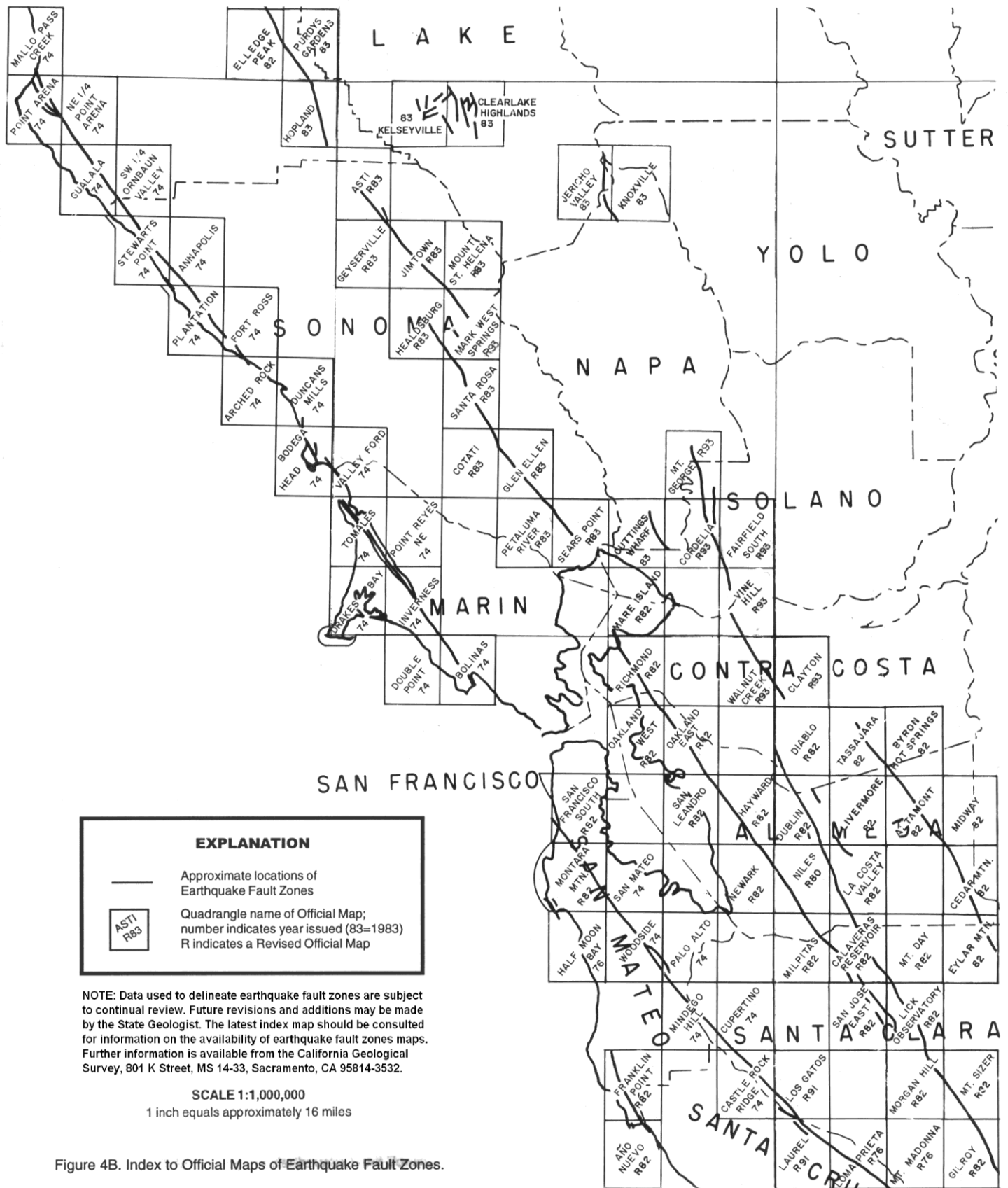
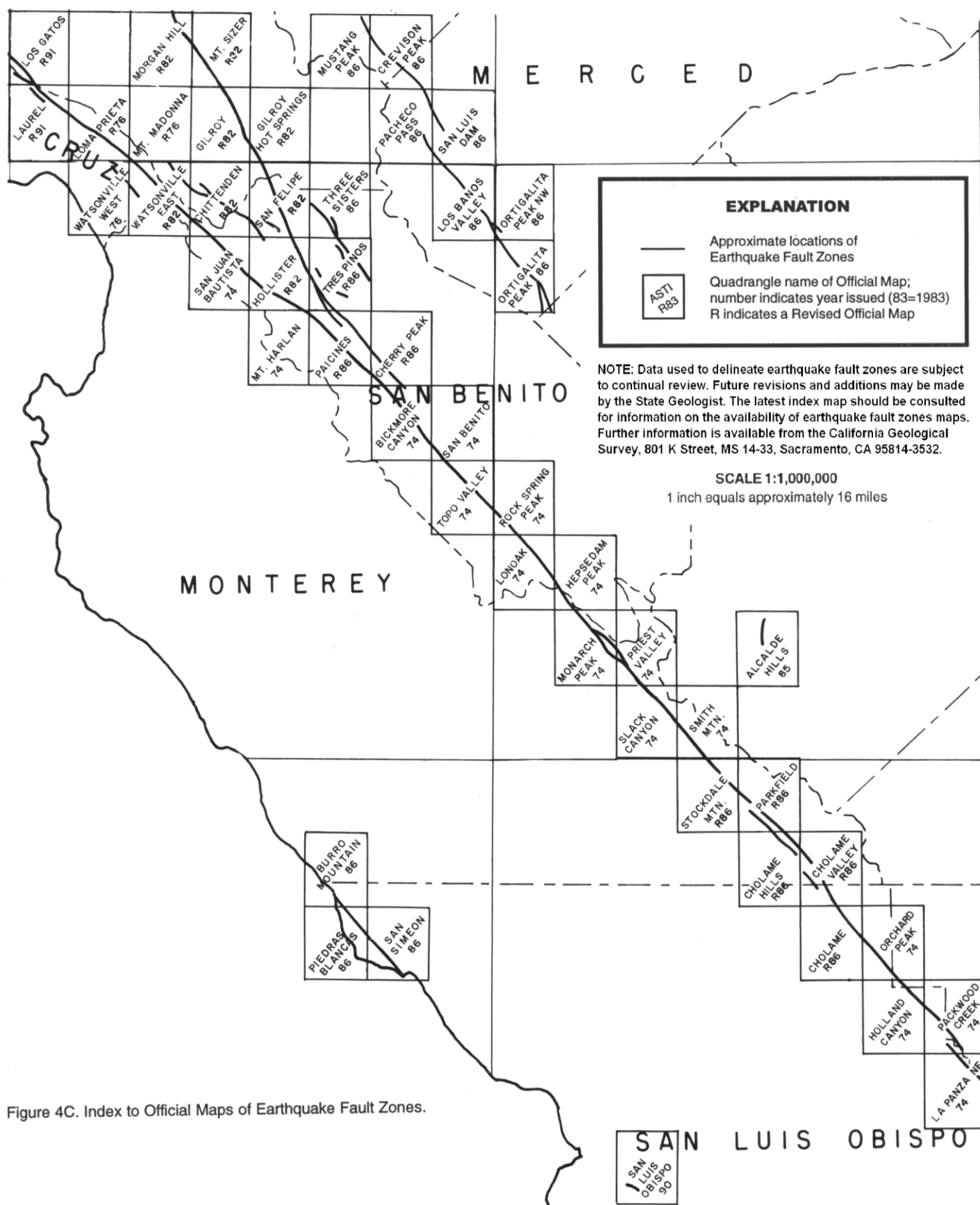
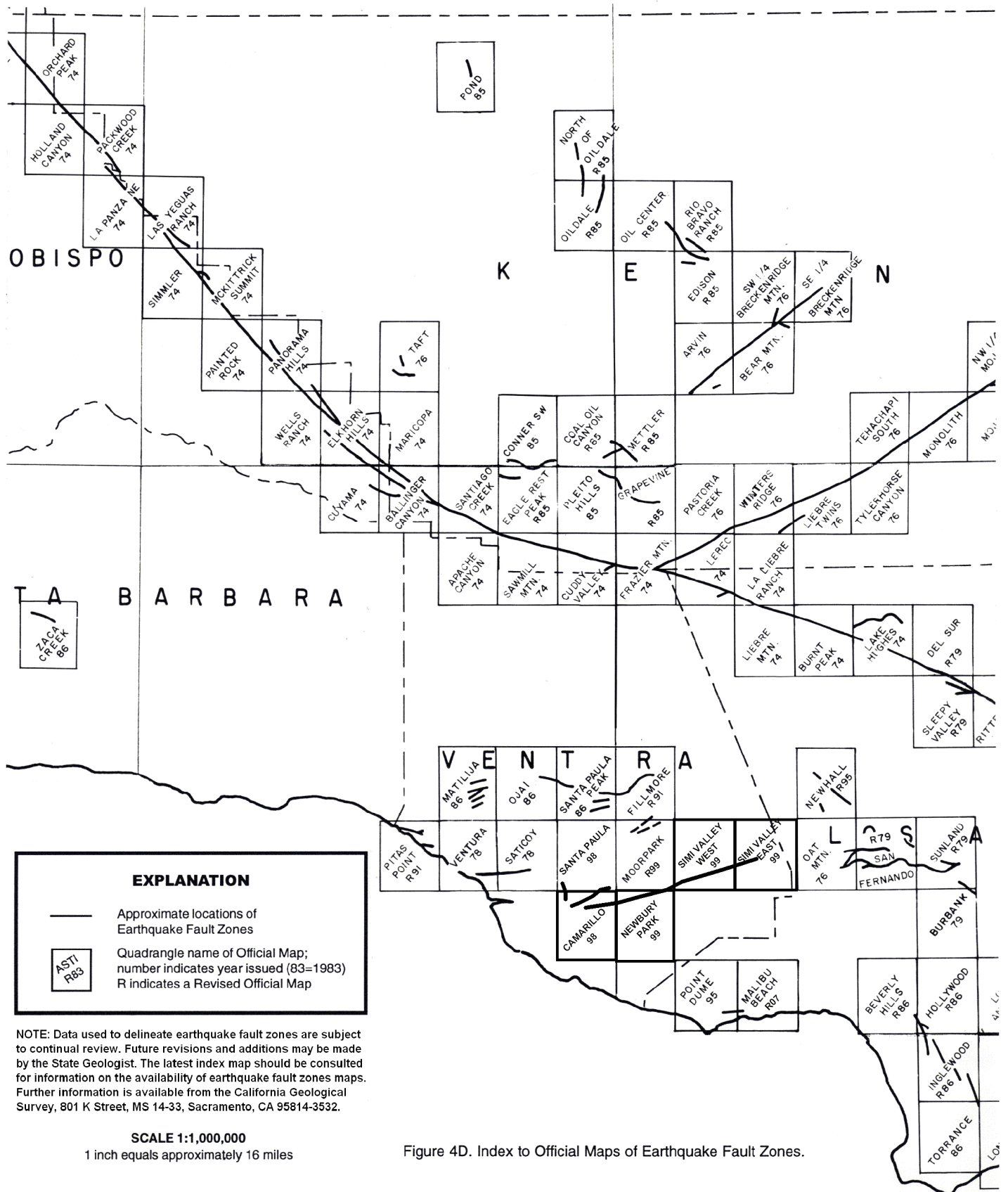


Figure 4B. Index to Official Maps of Earthquake Fault Zones.





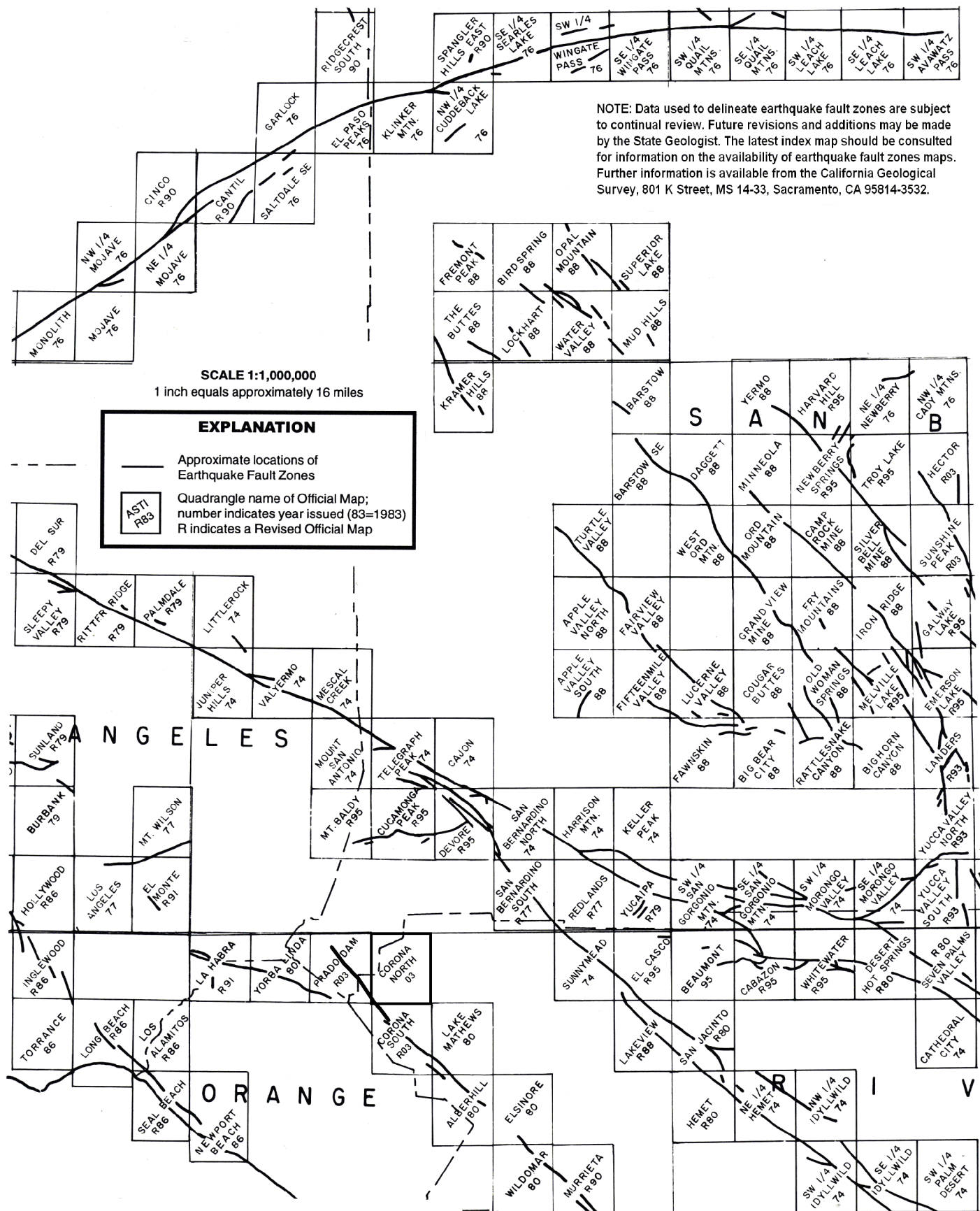
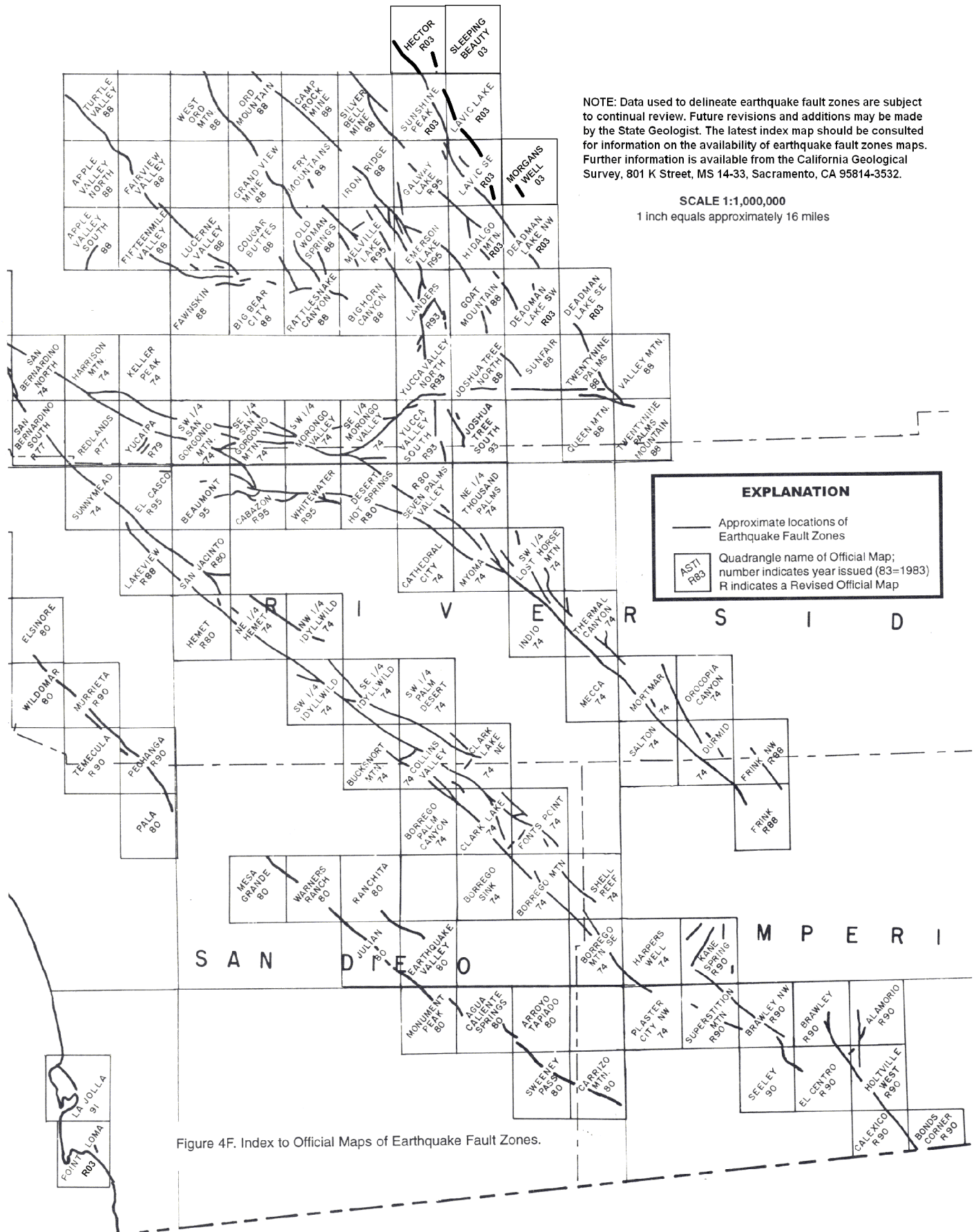


Figure 4E. Index to Official Maps of Earthquake Fault Zones.



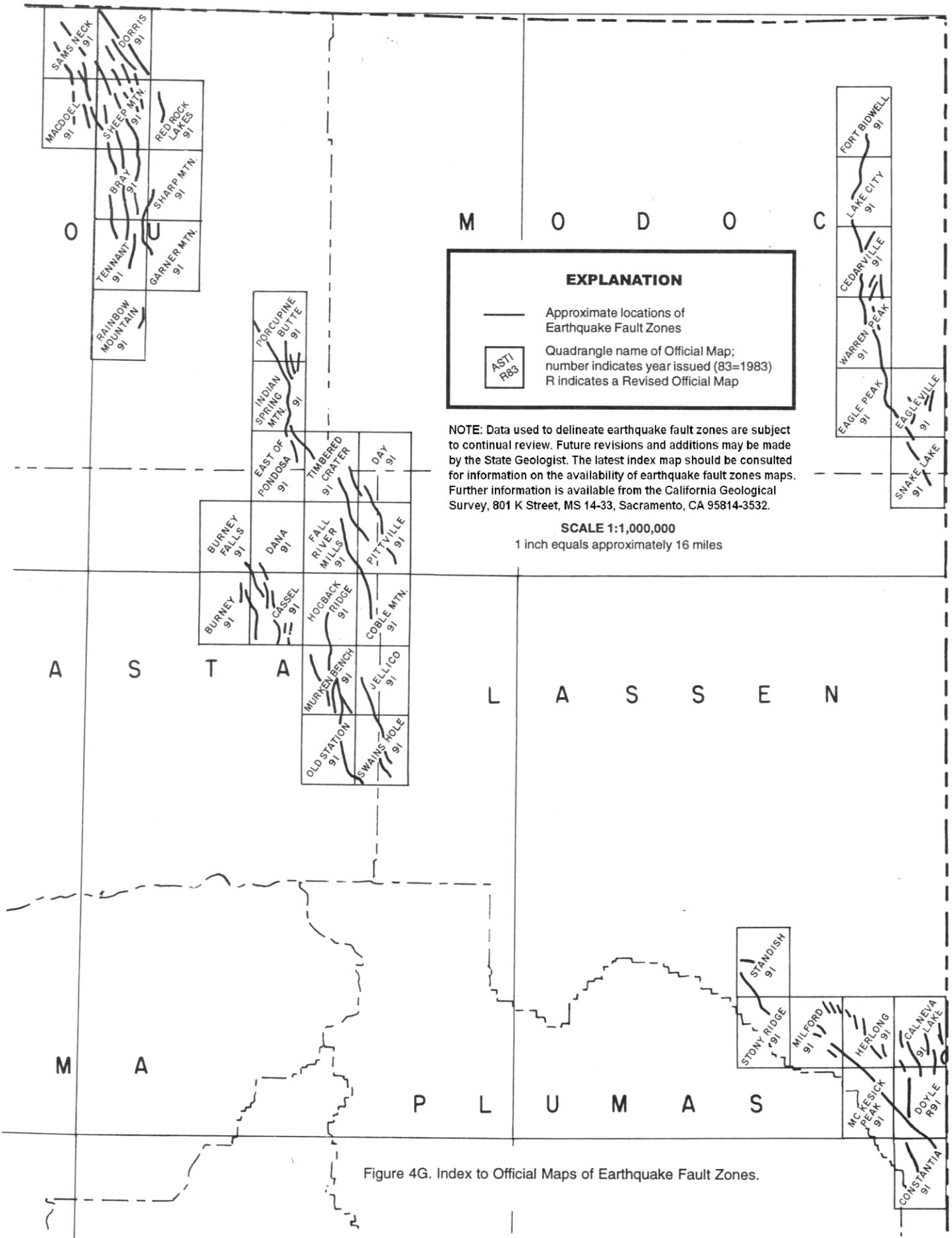




Figure 4H. Index to Official Maps of Earthquake Fault Zones.

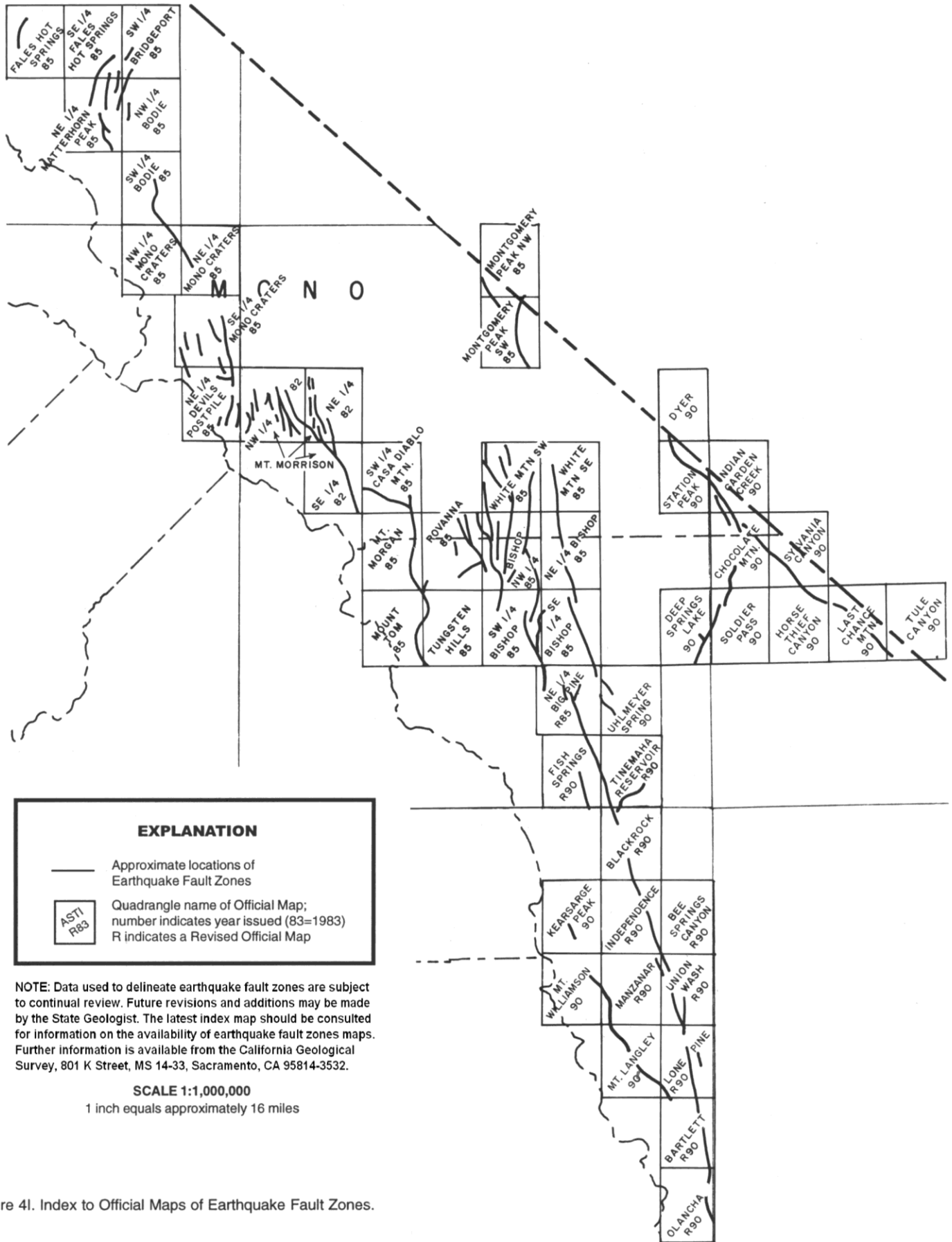


Figure 4I. Index to Official Maps of Earthquake Fault Zones.

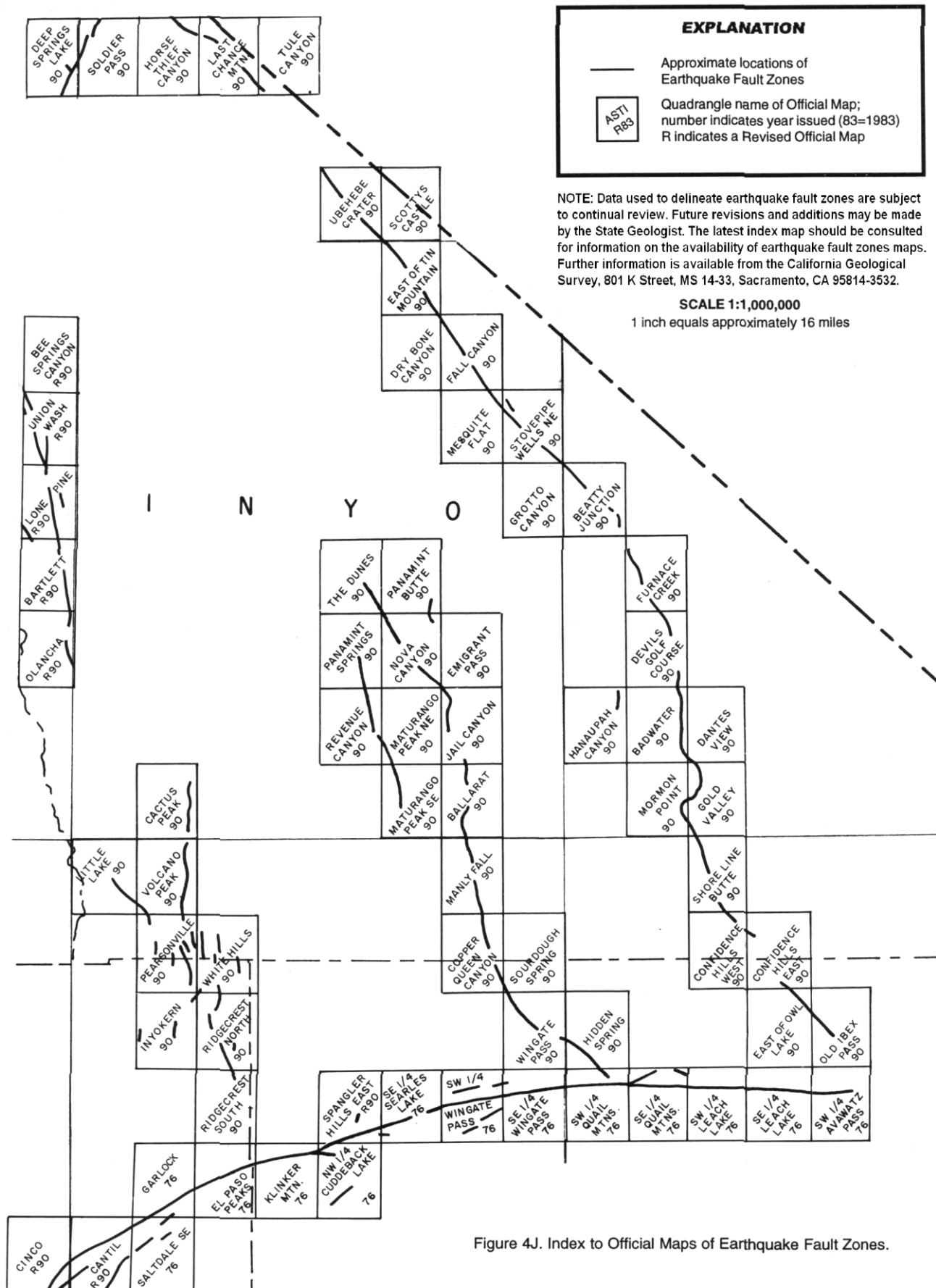


Figure 4J. Index to Official Maps of Earthquake Fault Zones.

APPENDICES

Data are presented herein to provide city and county officials, property owners, developers, geologists, and others with specific information they may need to effectuate the Act.

Because the Act must be implemented at the local government level, it is imperative that the local entities understand its various aspects.

Appendix A ALQUIST-PRIOLO EARTHQUAKE FAULT ZONING ACT¹ Excerpts from California Public Resources Code

DIVISION 2. Geology, Mines and Mining CHAPTER 7.5 Earthquake Fault Zones²

2621. This chapter shall be known and may be cited as the Alquist-Priolo Earthquake Fault Zoning Act¹.

2621.5. (a) It is the purpose of this chapter to provide for the adoption and administration of zoning laws, ordinances, rules, and regulations by cities and counties in implementation of the general plan that is in effect in any city or county. The Legislature declares that this chapter is intended to provide policies and criteria to assist cities, counties, and state agencies in the exercise of their responsibility to prohibit the location of developments and structures for human occupancy across the trace of active faults. Further, it is the intent of this chapter to provide the citizens of the state with increased safety and to minimize the loss of life during and immediately following earthquakes by facilitating seismic retrofitting to strengthen buildings, including historical buildings, against ground shaking.

(b) This chapter is applicable to any project, as defined in Section 2621.6, which is located within a delineated earthquake fault zone, upon issuance of the official earthquake fault zones maps to affected local jurisdictions, except as provided in Section 2621.7.

(c) The implementation of this chapter shall be pursuant to policies and criteria established and adopted by the Board³

2621.6. (a) As used in this chapter, "project" means either of the following:

(1) Any subdivision of land which is subject to the Subdivision Map Act, (Division 2 (commencing with Section 66410) of Title 7 of the Government Code), and which contemplates the eventual construction of structures for human occupancy.

(2) Structures for human occupancy, with the exception of either of the following:

(A) Single-family wood-frame or steel-frame dwellings to be built on parcels of land for which geologic reports have been approved pursuant to paragraph (1).

(B) A single-family wood-frame or steel-frame dwelling not exceeding two stories when that dwelling is not part of a development of four or more dwellings.

(b) For the purposes of this chapter, a mobilehome whose body width exceeds eight feet shall be considered to be a single-family wood-frame dwelling not exceeding two stories.

2621.7. This chapter, except Section 2621.9, shall not apply to any of the following:

(a) The conversion of an existing apartment complex into a condominium.

(b) Any development or structure in existence prior to May 4, 1975, except for an alteration or addition to a structure that exceeds the value limit specified in subdivision (c).

(c) An alteration or addition to any structure if the value of the alteration or addition does not exceed 50 percent of the value of the structure.

(d) (1) Any structure located within the jurisdiction of the City of Berkeley or the City of Oakland which was

¹ Known as the Alquist-Priolo Special Studies Zones Act prior to January 1, 1994.

² Known as Special Studies Zones prior to January 1, 1994.

³ State Mining and Geology Board.

damaged by fire between October 20, 1991, and October 23, 1991, if granted an exemption pursuant to this subdivision.

- (2) The city may apply to the State Geologist for an exemption and the State Geologist shall grant the exemption only if the structure located within the earthquake fault zone is not situated upon a trace of an active fault line, as delineated in an official earthquake fault zone map or in more recent geologic data, as determined by the State Geologist.
 - (3) When requesting an exemption, the city shall submit to the State Geologist all of the following information:
 - (A) Maps noting the parcel numbers of proposed building sites that are at least 50 feet from an identified fault and a statement that there is not any more recent information to indicate a geologic hazard.
 - (B) Identification of any sites within 50 feet of an identified fault.
 - (C) Proof that the property owner has been notified that the granting of an exemption is not any guarantee that a geologic hazard does not exist.
 - (4) The granting of an exemption does not relieve a seller of real property or an agent for the seller of the obligation to disclose to a prospective purchaser that the property is located within a delineated earthquake fault zone, as required by Section 2621.9.
 - (e) (1) Alterations which include seismic retrofitting, as defined in Section 8894.2 of the Government Code, to any of the following listed types of buildings in existence prior to May 4, 1975:
 - (A) Unreinforced masonry buildings, as described in subdivision (a) of Section 8875 of the Government Code.
 - (B) Concrete tilt-up buildings, as described in Section 8893 of the Government Code.
 - (C) Reinforced concrete moment resisting frame buildings as described in Applied Technology Council Report 21 (FEMA Report 154).
 - (2) The exemption granted by paragraph (1) shall not apply unless a city or county acts in accordance with all of the following:
 - (A) The building permit issued by the city or county for the alterations authorizes no greater human occupancy load, regardless of proposed use, than that authorized for the existing use permitted at the time the city or county grants the exemption. This may be accomplished by the city or county making a human occupancy load determination that is based on, and no greater than, the existing authorized use, and including that determination on the building permit application as well as a statement substantially as follows: "Under subparagraph (A) of paragraph (2) of subdivision (e) of Section 2621.7 of the Public Resources Code, the occupancy load is limited to the occupancy load for the last lawful use authorized or existing prior to the issuance of this building permit, as determined by the city or county."
 - (B) The city or county requires seismic retrofitting, as defined in Section 8894.2 of the Government Code, which is necessary to strengthen the entire structure and provide increased resistance to ground shaking from earthquakes.
 - (C) Exemptions granted pursuant to paragraph (1) are reported in writing to the State Geologist within 30 days of the building permit issuance date.
 - (3) Any structure with human occupancy restrictions under subparagraph (A) of paragraph (2) shall not be granted a new building permit that allows an increase in human occupancy unless a geologic report, prepared pursuant to subdivision (d) of Section 3603 of Title 14 of the California Code of Regulations in effect on January 1, 1994, demonstrates that the structure is not on the trace of an active fault, or the requirement of a geologic report has been waived pursuant to Section 2623.
 - (4) A qualified historical building within an earthquake fault zone that is exempt pursuant to this subdivision may be repaired or seismically retrofitted using the State Historical Building Code, except that, notwithstanding any provision of that building code and its implementing regulations, paragraph (2) shall apply.
- 2621.8.** Notwithstanding Section 818.2 of the Government Code, a city or county which knowingly issues a permit that grants an exemption pursuant to subdivision (e) of Section 2621.7 that does not adhere to the requirements of paragraph (2) of subdivision (e) of Section 2621.7, may be liable for earthquake-related injuries or deaths caused by failure to so adhere.
- 2621.9.** (a) A person who is acting as an agent for a transferor of real property that is located within a delineated earthquake fault zone, or the transferor, if he or she is acting without an agent, shall disclose to any prospective transferee the fact that the property is located within a delineated earthquake fault zone.

(b) Disclosure is required pursuant to this section only when one of the following conditions is met:

- (1) The transferor, or the transferor's agent, has actual knowledge that the property is within a delineated earthquake fault zone.
- (2) A map that includes the property has been provided to the city or county pursuant to Section 2622, and a notice has been posted at the offices of the county recorder, county assessor, and county planning agency that identifies the location of the map and any information regarding changes to the map received by the county.

(c) In all transactions that are subject to Section 1103 of the Civil Code, the disclosure required by subdivision (a) of this section shall be provided by either of the following means:

- (1) The Local Option Real Estate Transfer Disclosure Statement as provided in Section 1102.6a of the Civil Code.
- (2) The Natural Hazard Disclosure Statement as provided in Section 1103.2 of the Civil Code.

(d) If the map or accompanying information is not of sufficient accuracy or scale that a reasonable person can determine if the subject real property is included in a delineated earthquake fault hazard zone, the agent shall mark "Yes" on the Natural Hazard Disclosure Statement. The agent may mark "No" on the Natural Hazard Disclosure Statement if he or she attaches a report prepared pursuant to subdivision (c) of Section 1103.4 of the Civil Code that verifies the property is not in the hazard zone. Nothing in this subdivision is intended to limit or abridge any existing duty of the transferor or the transferor's agents to exercise reasonable care in making a determination under this subdivision.

(e) For purposes of the disclosures required by this section, the following persons shall not be deemed agents of the transferor:

- (1) Persons specified in Section 1103.11 of the Civil Code.
- (2) Persons acting under a power of sale regulated by Section 2924 of the Civil Code.

(f) For purposes of this section, Section 1103.13 of the Civil Code shall apply.

(g) The specification of items for disclosure in this section does not limit or abridge any obligation for disclosure created by any other provision of law or that may exist in order to

avoid fraud, misrepresentation, or deceit in the transfer transaction.

2622. (a) In order to assist cities and counties in their planning, zoning, and building-regulation functions, the State Geologist shall delineate, by December 31, 1973, appropriately wide earthquake fault zones to encompass all potentially and recently active traces of the San Andreas, Calaveras, Hayward, and San Jacinto Faults, and such other faults, or segments thereof, as the State Geologist determines to be sufficiently active and well-defined as to constitute a potential hazard to structures from surface faulting or fault creep. The earthquake fault zones shall ordinarily be one-quarter mile or less in width, except in circumstances which may require the State Geologist to designate a wider zone.

(b) Pursuant to this section, the State Geologist shall compile maps delineating the earthquake fault zones and shall submit the maps to all affected cities, counties, and state agencies, not later than December 31, 1973, for review and comment. Concerned jurisdictions and agencies shall submit all comments to the State Mining and Geology Board for review and consideration within 90 days. Within 90 days of such review, the State Geologist shall provide copies of the official maps to concerned state agencies and to each city or county having jurisdiction over lands lying within any such zone.

(c) The State Geologist shall continually review new geologic and seismic data and shall revise the earthquake fault zones or delineate additional earthquake fault zones when warranted by new information. The State Geologist shall submit all revised maps and additional maps to all affected cities, counties, and state agencies for their review and comment. Concerned jurisdictions and agencies shall submit all comments to the State Mining and Geology Board for review and consideration within 90 days. Within 90 days of that review, the State Geologist shall provide copies of the revised and additional official maps to concerned state agencies and to each city or county having jurisdiction over lands lying within the earthquake fault zone.

(d) In order to ensure that sellers of real property and their agents are adequately informed, any county that receives an official map pursuant to this section shall post a notice within five days of receipt of the map at the offices of the county recorder, county assessor, and county planning commission, identifying the location of the map and the effective date of the notice.

2623. (a) The approval of a project by a city or county shall be in accordance with policies and criteria established by the State Mining and Geology Board and the findings of the State Geologist. In the development of such policies and criteria, the State Mining and Geology Board shall seek the comment and advice of affected cities, counties,

and state agencies. Cities and counties shall require, prior to the approval of a project, a geologic report defining and delineating any hazard of surface fault rupture. If the city or county finds that no undue hazard of that kind exists, the geologic report on the hazard may be waived, with the approval of the State Geologist.

(b) After a report has been approved or a waiver granted, subsequent geologic reports shall not be required, provided that new geologic data warranting further investigations is not recorded.

(c) The preparation of geologic reports that are required pursuant to this section for multiple projects may be undertaken by a geologic hazard abatement district.

2624. Notwithstanding any provision of this chapter, cities and counties may do any of the following:

- (1) Establish policies and criteria which are stricter than those established by this chapter.
- (2) Impose and collect fees in addition to those required under this chapter.

- (3) Determine not to grant exemptions authorized under this chapter.

2625. (a) Each applicant for approval of a project may be charged a reasonable fee by the city or county having jurisdiction over the project.

(b) Such fees shall be set in an amount sufficient to meet, but not to exceed, the costs to the city or county of administering and complying with the provisions of this chapter.

(c) The geologic report required by Section 2623 shall be in sufficient detail to meet the criteria and policies established by the State Mining and Geology Board for individual parcels of land.

2630. In carrying out the provisions of this chapter, the State Geologist and the board shall be advised by the Seismic Safety Commission.

SIGNED INTO LAW DECEMBER 22, 1972; AMENDED SEPTEMBER 16, 1974, MAY 4, 1975, SEPTEMBER 28, 1975, SEPTEMBER 22, 1976, SEPTEMBER 27, 1979, SEPTEMBER 21, 1990, JULY 29, 1991, AUGUST 16, 1992, JULY 25, 1993, OCTOBER 7, 1993, AND OCTOBER 7, 1997

Appendix B

POLICIES AND CRITERIA OF THE STATE MINING AND GEOLOGY BOARD

With Reference to the Alquist-Priolo Earthquake Fault Zoning Act

(Excerpts from the California Code of Regulations, Title 14, Division 2)

3600. Purpose.

It is the purpose of this subchapter to set forth the policies and criteria of the State Mining and Geology Board, hereinafter referred to as the "Board," governing the exercise of city, county, and state agency responsibilities to prohibit the location of developments and structures for human occupancy across the trace of active faults in accordance with the provisions of Public Resources Code Section 2621 et seq. (Alquist-Priolo Earthquake Fault Zoning Act). The policies and criteria set forth herein shall be limited to potential hazards resulting from surface faulting or fault creep within earthquake fault zones delineated on maps officially issued by the State Geologist.

NOTE: Authority cited: Section 2621.5, Public Resources Code. Reference: Sections 2621-2630, Public Resources Code.

3601. Definitions.

The following definitions as used within the Act and herein shall apply:

(a) An "active fault" is a fault that 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.

(b) A "fault trace" is that line formed by the intersection of a fault and the earth's surface, and is the representation of a fault as depicted on a map, including maps of earthquake fault zones.

(c) A "lead agency" is the city or county with the authority to approve projects.

(d) "Earthquake fault zones" are areas delineated by the State Geologist, pursuant to the Alquist-Priolo Earthquake Fault Zoning Act (Public Resources Code Section 2621 et seq.) and this subchapter, which encompass the traces of active faults.

(e) A "structure for human occupancy" is any structure used or intended for supporting or sheltering any

use or occupancy, which is expected to have a human occupancy rate of more than 2,000 person-hours per year.

(f) "Story" is that portion of a building included between the upper surface of any floor and the upper surface of the floor next above, except that the topmost story shall be that portion of a building included between the upper surface of the topmost floor and the ceiling or roof above. For the purpose of the Act and this subchapter, the number of stories in a building is equal to the number of distinct floor levels, provided that any levels that differ from each other by less than two feet shall be considered as one distinct level.

NOTE: Authority cited: Section 2621.5, Public Resources Code. Reference: Sections 2621-2630, Public Resources Code.

3602. Review of Preliminary Maps.

(a) Within 45 days from the issuance of proposed new or revised preliminary earthquake fault zone map(s), cities and counties shall give notice of the Board's announcement of a ninety (90) day public comment period to property owners within the area of the proposed zone. The notice shall be by publication, or other means reasonably calculated to reach as many of the affected property owners as feasible. Cities and counties may also give notice to consultants who may conduct geologic studies in fault zones. The notice shall state that its purpose is to provide an opportunity for public comment including providing to the Board geologic information that may have a bearing on the proposed map(s).

(b) The Board shall also give notice by mail to those California Registered Geologists and California Registered Geophysicists on a list provided by the State Board of Registration for Geologists and Geophysicists. The notice shall indicate the affected jurisdictions and state that its purpose is to provide an opportunity to present written technical comments that may have a bearing on the proposed zone map(s) to the Board during a 90-day public comment period.

(c) The Board shall receive public comments during the 90-day public comment period. The Board shall

conduct at least one public hearing on the proposed zone map(s) during the 90-day public comment period.

(d) Following the end of the 90-day public comment period, the Board shall forward its comments and recommendations with supporting data received to the State Geologist for consideration prior to the release of official earthquake fault zone map(s).

NOTE: Authority cited: Section 2621.5, Public Resources Code. Reference: Section 2622, Public Resources Code.

3603. Specific Criteria.

The following specific criteria shall apply within earthquake fault zones and shall be used by affected lead agencies in complying with the provisions of the Act:

(a) No structure for human occupancy, identified as a project under Section 2621.6 of the Act, shall be permitted to be placed across the trace of an active fault. Furthermore, as the area within fifty (50) feet of such active faults shall be presumed to be underlain by active branches of that fault unless proven otherwise by an appropriate geologic investigation and report prepared as specified in Section 3603(d) of this subchapter, no such structures shall be permitted in this area.

(b) Affected lead agencies, upon receipt of official earthquake fault zones maps, shall provide for disclosure of delineated earthquake fault zones to the public. Such disclosure may be by reference in general plans, specific plans, property maps, or other appropriate local maps.

(c) No change in use or character of occupancy, which results in the conversion of a building or structure from one not used for human occupancy to one that is so used, shall be permitted unless the building or structure complies with the provisions of the Act.

(d) Application for a development permit for any project within a delineated earthquake fault zone shall be accompanied by a geologic report prepared by a geologist registered in the State of California, which is directed to the problem of potential surface fault displacement through the project site, unless such report is waived pursuant to Section 2623 of the Act. The required report shall be based on a geologic investigation designed to identify the location, recency, and nature of faulting that may have affected the project site in the past and may affect the project site in the future. The report may be combined with other geological or geotechnical reports.

(e) A geologist registered in the State of California, within or retained by each lead agency, shall evaluate the geologic reports required herein and advise the lead agency.

(f) One (1) copy of all such geologic reports shall be filed with the State Geologist by the lead agency within thirty (30) days following the report's acceptance. The State Geologist shall place such reports on open file.

NOTE: Authority cited: Section 2621.5, Public Resources Code. Reference: Sections 2621.5, 2622, 2623, and 2625(c), Public Resources Code.

ADOPTED NOVEMBER 23, 1973; REVISED JULY 1, 1974, AND JUNE 26, 1975.
CODIFIED IN CALIFORNIA CODE OF REGULATIONS JANUARY 31, 1979;
REVISED OCTOBER 18, 1984, JANUARY 5, 1996, AND APRIL 1, 1997.

Appendix C

GUIDELINES FOR EVALUATING THE HAZARD OF SURFACE RUPTURE

(These guidelines, also published as DMG Note 49 (1997), are not part of the Policies and Criteria of the State Mining and Geology Board. Similar guidelines were adopted by the Board for advisory purposes in 1996.)

These guidelines are to assist geologists who investigate faults relative to the hazard of surface fault rupture. Subsequent to the passage of the Alquist-Priolo Earthquake Fault Zoning Act (1972), it became apparent that many fault investigations conducted in California were incomplete or otherwise inadequate for the purpose of evaluating the potential of surface fault rupture. It was further apparent that statewide standards for investigating faults would be beneficial. These guidelines were initially prepared in 1975 as DMG Note 49 and have been revised several times since then.

The investigation of sites for the possible hazard of surface fault rupture is a deceptively difficult geologic task. Many active faults are complex, consisting of multiple breaks. Yet the evidence for identifying active fault traces is generally subtle or obscure and the distinction between recently active and long-inactive faults may be difficult to make. It is impractical from an economic, engineering, and architectural point of view to design a structure to withstand serious damage under the stress of surface fault rupture. Once a structure is sited astride an active fault, the resulting fault-rupture hazard cannot be mitigated unless the structure is relocated, whereas when a structure is placed on a landslide, the potential hazard from landsliding often can be mitigated. Most surface faulting is confined to a relatively narrow zone a few feet to a few tens of feet wide, making avoidance (i.e., building setbacks) the most appropriate mitigation method. However, in some cases primary fault rupture or rupture along branch faults can be distributed across zones hundreds of feet wide or manifested as broad warps, suggesting that engineering strengthening or design may be of additional mitigative value (e.g., Lazarte and others, 1994).

No single investigative method will be the best, or even useful, at all sites, because of the complexity of evaluating surface and near surface faults and because of the infinite variety of site conditions. Nonetheless, certain investigative methods are more helpful than others in locating faults and evaluating the recency of activity.

The evaluation of a given site with regard to the potential hazard of surface fault rupture is based extensively on the concepts of *recency* and *recurrence* of faulting along existing faults. In a general way, the more recent the faulting the greater the probability for future faulting (Allen, 1975). Stated another way, faults of known historic activity during the last 200 years, as a class, have a greater probability for future activity than faults classified as Holocene age (last 11,000 years) and a much greater probability of future activity than faults classified as Quaternary age (last 1.6 million years). However, it should be kept in mind that certain faults have recurrent activity measured in tens or hundreds of years whereas other faults may be inactive for thousands of years before being reactivated. Other faults may be characterized by creep-type rupture that is more or less on-going. The magnitude, sense, and nature of fault rupture also vary for different faults or even along different strands of the same fault. Even so, future faulting generally is expected to recur along pre-existing faults (Bonilla, 1970, p. 68). The development of a new fault or reactivation of a long-inactive fault is relatively uncommon and generally need not be a concern in site development.

As a practical matter, fault investigations should be directed at the problem of locating existing faults and then attempting to evaluate the recency of their activity. Data should be obtained both from the site and outside the site area. The most useful and direct method of evaluating recency is to observe (in a trench or road cut) the youngest geologic unit faulted and the oldest unit that is not faulted. Even so, active faults may be subtle or discontinuous and consequently overlooked in trench exposures (Bonilla and Lienkaemper, 1991). Therefore, careful logging is essential and trenching needs to be conducted in conjunction with other methods. For example, recently active faults may also be identified by direct observation of young, fault-related geomorphic (i.e., topographic) features in the field or on aerial photographs. Other indirect and more interpretive methods are identified in the outline below. Some of these methods are discussed in Bonilla (1982), Carver and McCalpin (1996), Hatheway and Leighton (1979), McCalpin

(1996a, b, c), National Research Council (1986), Sherard and others (1974), Slemmons (1977), Slemmons and dePolo (1986), Taylor and Cluff (1973), the Utah Section of the Association of Engineering Geologists (1987), Wallace (1977), Weldon and others (1996), and Yeats and others (1997). McCalpin (1996b) contains a particularly useful discussion of various field techniques. Many other useful references are listed in the bibliographies of the references cited here.

The purpose, scope, and methods of investigation for fault investigations will vary depending on conditions at specific sites and the nature of the projects. Contents and scope of the investigation also may vary based on guidelines and review criteria of agencies or political organizations having regulatory responsibility. However, there are topics that should be considered in all comprehensive fault investigations and geologic reports on faults. For a given site some topics may be addressed in more detail than at other sites because of the difference in the geologic and/or tectonic setting and/or site conditions. These investigative considerations should apply to any comprehensive fault investigation and may be applied to any project site, large or small. Suggested topics, considerations, and guidelines for fault investigations and reports on faults are provided in the following annotated outline. Fault investigations may be conducted in conjunction with other geologic and geotechnical investigations (see DMG Notes 42 and 44; also California Department of Conservation, Division of Mines and Geology, 1997). Although not all investigative techniques need to be or can be employed in evaluating a given site, the outline provides a checklist for preparing complete and well-documented reports. Most reports on fault investigations are reviewed by local or state government agencies. Therefore it is necessary that the reports be documented adequately and written carefully to facilitate that review. The importance of the review process is emphasized here, because it is the reviewer who must evaluate the adequacy of reports, interpret or set standards where they are unclear, and advise the governing agency as to their acceptability (Hart and Williams, 1978; DMG Note 41).

The scope of the investigation is dependent not only on the complexity and economics of a project, but also on the level of risk acceptable for the proposed structure or development. A more detailed investigation should be made for hospitals, high-rise buildings, and other critical or sensitive structures than for low-occupancy structures such as wood-frame dwellings that are comparatively safe. The conclusions drawn from any given set of data, however, must be consistent and unbiased. Recommendations must be clearly separated from conclusions, because recommendations are not totally dependent on geologic factors. The final decision as to whether, or how, a given project should be

developed lies in the hands of the owner and the governing body that must review and approve the project.

CONTENTS OF GEOLOGIC REPORTS ON FAULTS

Suggested topics, considerations, and guidelines for investigations and reports

The following topics should be considered and addressed in detail where essential to support opinions, conclusions, and recommendations, in any geologic report on faults. It is not expected that all of the topics or investigative methods would be necessary in a single investigation. In specific cases it may be necessary to extend some of the investigative methods well beyond the site or property being investigated. Particularly helpful references are cited parenthetically below.

I. Text.

- A. Purpose and scope of investigation; description of proposed development.
- B. Geologic and tectonic setting. Include seismicity and earthquake history.
- C. Site description and conditions, including dates of site visits and observations. Include information on geologic units, graded and filled areas, vegetation, existing structures, and other factors that may affect the choice of investigative methods and the interpretation of data.
- D. Methods of investigation.
 1. Review of published and unpublished literature, maps, and records concerning geologic units, faults, ground-water barriers, and other factors.
 2. Stereoscopic interpretation of aerial photographs and other remotely sensed images to detect fault-related topography (geomorphic features), vegetation and soil contrasts, and other lineaments of possible fault origin. The area interpreted usually should extend beyond the site boundaries.
 3. Surface observations, including mapping of geologic and soil units, geologic structures, geomorphic features and surfaces, springs, deformation of engineered structures due to fault creep, both on and beyond the site.
 4. Subsurface investigations.

- a. Trenching and other excavations to permit detailed and direct observation of continuously exposed geologic units, soils, and structures; must be of adequate depth and be carefully logged (see Taylor and Cluff, 1973; Hatheway and Leighton, 1979; McCalpin, 1996b).
 - b. Borings and test pits to permit collection of data on geologic units and ground water at specific locations. Data points must be sufficient in number and spaced adequately to permit valid correlations and interpretations.
 - c. Cone penetrometer testing (CPT) (Grant and others, 1997; Edelman and others, 1996). CPT must be done in conjunction with continuously logged borings to correlate CPT results with on-site materials. The number of borings and spacing of CPT soundings should be sufficient to adequately image site stratigraphy. The existence and location of a fault based on CPT data are interpretative.
5. Geophysical investigations. These are indirect methods that require a knowledge of specific geologic conditions for reliable interpretations. They should seldom, if ever, be employed alone without knowledge of the geology (Chase and Chapman, 1976). Geophysical methods alone never prove the absence of a fault nor do they identify the recency of activity. The types of equipment and techniques used should be described and supporting data presented (California Board of Registration for Geologists and Geophysicists, 1993).
- a. High resolution seismic reflection (Stephenson and others, 1995; McCalpin, 1996b).
 - b. Ground penetrating radar (Cai and others, 1996).
 - c. Other methods include: seismic refraction, magnetic profiling, electrical resistivity, and gravity (McCalpin, 1996b).
6. Age-dating techniques are essential for determining the ages of geologic units, soils, and surfaces that bracket the time(s) of faulting (Pierce, 1986; Birkeland and others, 1991; Rutter and Catto, 1995; McCalpin, 1996a).
- a. Radiometric dating (especially ^{14}C).
 - b. Soil-profile development.
 - c. Rock and mineral weathering.
 - d. Landform development.
 - e. Stratigraphic correlation of rocks/minerals/fossils.
 - f. Other methods -- artifacts, historical records, tephrochronology, fault scarp modeling, thermoluminescence, lichenometry, paleomagnetism, dendrochronology, etc.
7. Other methods should be included when special conditions permit or requirements for critical structures demand a more intensive investigation.
- a. Aerial reconnaissance overflights.
 - b. Geodetic and strain measurements.
 - c. Microseismicity monitoring.
- E. Conclusions.
1. Location and existence (or absence) of hazardous faults on or adjacent to the site; ages of past rupture events.
 2. Type of faults and nature of anticipated offset, including sense and magnitude of displacement, if possible.
 3. Distribution of primary and secondary faulting (fault zone width) and fault-related deformation.
 4. Probability of or relative potential for future surface displacement. The likelihood of future ground rupture seldom can be stated mathematically, but may be stated in semiquantitative terms such as low, moderate, or high, or in terms of slip rates determined for specific fault segments.
 5. Degree of confidence in and limitations of data and conclusions.

F. Recommendations.

1. Setback distances of proposed structures from hazardous faults. The setback distance generally will depend on the quality of data and type and complexity of fault(s) encountered at the site. In order to establish an appropriate setback distance from a fault located by indirect or interpretative methods (e.g. borings or cone penetrometer testing), the area between data points also should be considered underlain by a fault unless additional data are used to more precisely locate the fault. State and local regulations may dictate minimum distances (e.g., Sec. 3603 of California Code of Regulations, Appendix B).
2. Additional measures (e.g., strengthened foundations, engineering design, flexible utility connections) to accommodate warping and distributive deformation associated with faulting (Lazarte and others, 1994).
3. Risk evaluation relative to the proposed development.
4. Limitations of the investigation; need for additional studies.

traverses, locations of faults, and other data; recommended scale is 1:2,400 (1 inch equals 200 feet), or larger.

- C. Geologic map -- show distribution of geologic units (if more than one), faults and other structures, geomorphic features, aerial photographic lineaments, and springs; on topographic map 1:24,000 scale or larger; can be combined with III(A) or III(B).
- D. Geologic cross-sections, if needed, to provide 3-dimensional picture.
- E. Logs of exploratory trenches and borings -- show details of observed features and conditions; should not be generalized or diagrammatic. Trench logs should show topographic profile and geologic structure at a 1:1 horizontal to vertical scale; scale should be 1:60 (1 inch = 5 feet) or larger.
- F. Geophysical data and geologic interpretations.

IV. Appendix: Supporting data not included above (e.g., water well data, photographs, aerial photographs).

V. Authentication: Investigating geologist's signature and registration number with expiration date.

II. References.

- A. Literature and records cited or reviewed; citations should be complete.
- B. Aerial photographs or images interpreted -- list type, date, scale, source, and index numbers.
- C. Other sources of information, including well records, personal communications, and other data sources.

III. Illustrations -- these are essential to the understanding of the report and to reduce the length of text.

- A. Location map -- identify site locality, significant faults, geographic features, regional geology, seismic epicenters, and other pertinent data; 1:24,000 scale is recommended. If the site investigation is done in compliance with the Alquist-Priolo Act, show site location on the appropriate Official Map of Earthquake Fault Zones.
- B. Site development map -- show site boundaries, existing and proposed structures, graded areas, streets, exploratory trenches, borings, geophysical

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Appendix D

GENERAL GUIDELINES FOR REVIEWING GEOLOGIC REPORTS

(These general guidelines are published as DMG Note 41 (1997). Similar guidelines were adopted by the State Mining and Geology Board for advisory purposes in 1996).

The purpose of this article is to provide general guidance for those geologists who review geologic reports of consultants on behalf of agencies having approval authority over specific developments. These general guidelines are modified from an article titled, "Geologic Review Process" by Hart and Williams (1978).

The geologic review is a critical part of the evaluation process of a proposed development. It is the responsibility of the reviewer to assure that each geologic investigation, and the resulting report, adequately addresses the geologic conditions that exist at a given site. In addition to geologic reports for tentative tracts and site development, a reviewer evaluates Environmental Impact Reports, Seismic Safety and Public Safety Elements of General Plans, Reclamation Plans, as-graded geologic reports, and final, as-built geologic maps and reports. In a sense, the geologic reviewer enforces existing laws, agency policies, and regulations to assure that significant geologic factors (hazards, mineral and water resources, geologic processes) are properly considered, and potential problems are mitigated prior to project development. Generally, the reviewer acts at the discretion or request of, and on behalf of a governing agency -- city, county, regional, state, federal -- not only to protect the government's interest but also to protect the interest of the community at large. Examples of

the review process in a state agency are described by Stewart and others (1976). Review at the local level has been discussed by Leighton (1975), Berkland (1992), Larson (1992), and others. Grading codes, inspections, and the review process are discussed in detail by Scullin (1983). Nelson and Christenson (1992) specifically discuss review guidelines for reports on surface faulting.

THE REVIEWER

Qualifications

In order to make appropriate evaluations of geologic reports, the reviewer should be an experienced geologist familiar with the investigative methods employed and the techniques available to the profession. Even so, the reviewer must know his or her limitations, and at times ask for the opinions of others more qualified in specialty fields (e.g., geophysics, mineral exploitation and economics, ground water, foundation and seismic engineering, seismology). In California, the reviewer must be licensed by the State Board of Registration for Geologists and Geophysicists in order to practice (Wolfe, 1975). The Board also certifies engineering geologists and hydrogeologists, and licenses geophysicists. Local and regional agencies may have additional requirements.

The reviewer must have the courage of his or her convictions and should not approve reports if an inadequate investigation has been conducted. Like any review process, there is a certain “give-and-take” involved between the reviewer and investigator. If there is clear evidence of incompetence or misrepresentation in a report, this fact should be reported to the reviewing agency or licensing board. California Civil Code Section 47 provides an immunity for statements made “in the initiation or course of any other proceedings authorized by law.” Courts have interpreted this section as providing immunity to letters of complaint written to provide a public agency or board, including licensing boards, with information that the public board or agency may want to investigate (see *King v. Borges*, 28 Cal. App. 3d 27 [1972]; and *Brody v. Montalbano*, 87 Cal. App. 3d 725 [1978]). Clearly, the reviewer needs to have the support of his or her agency in order to carry out these duties.

The reviewer should bear in mind that some geologic investigators are not accomplished writers, and almost all are working with restricted budgets. Also, the reviewer may be limited by their agency’s policies, procedures, and fee structures. Thus, while a reviewer should demand that certain standards be met, he or she should avoid running rough-shod over the investigator. The mark of a good reviewer is the ability to sort out the important from the insignificant and to make constructive comments and recommendations.

A reviewer may be employed full time by the reviewing agency or part-time as a consultant. Also, one reviewing agency (such as a city) may contract with another agency (such as a county) to perform geologic reviews. The best reviews generally are performed by experienced reviewers. Thus, the use of multiple, part-time reviewers by a given agency tends to prevent development of consistently high-quality and efficient reviews. One of the reasons for this is that different reviewers have different standards, which results in inconsistent treatment of development projects. The primary purpose of the review procedure should always be kept in mind -- namely, to assure the adequacy of geologic investigations.

Other Review Functions

Aside from his or her duties as a reviewer, the reviewing geologist also must interpret the geologic data reported to other agency personnel who regulate development (e.g., planners, engineers, inspectors). Also, the reviewing geologist sometimes is called upon to make investigations for his or her own agency. This is common where a city or county employs only one geologist. In fact, some reviewers routinely divide their activities between

reviewing the reports of others and performing one or several other tasks for the employing agency (such as advising other agency staff and boards on geologic matters; making public presentations) (see Leighton, 1975).

Conflict of Interest

In cases where a reviewing geologist also must perform geologic investigations, he or she should never be placed in the position of reviewing his or her own report, for that is no review at all. A different type of conflict commonly exists in a jurisdiction where the geologic review is performed by a consulting geologist who also is practicing commercially (performing geologic investigations) within the same jurisdictional area. Such situations should be avoided, if at all possible.

GEOLOGIC REVIEW

The Report

The critical item in evaluating specific site investigations for adequacy is the resulting geologic report. A report that is incomplete or poorly written cannot be evaluated and should not be approved. As an expediency, some reviewers do accept inadequate or incomplete reports because of their personal knowledge of the site. However, unless good reasons can be provided in writing, it is recommended that a report not be accepted until it presents the pertinent facts correctly and completely.

The conclusions presented in the report regarding the geologic hazards or problems must be separate from and supported by the investigative data. An indication regarding the level of confidence in the conclusions should be provided. Recommendations based on the conclusions should be made to mitigate those geology-related problems which would have an impact on the proposed development. Recommendations also should be made concerning the need for additional geologic investigations.

Report Guidelines and Standards

An investigating geologist may save a great deal of time (and the client’s money), and avoid misunderstandings, if he or she contacts the reviewing geologist at the initiation of the investigation. The reviewer should not only be familiar with the local geology and sources of information, he or she also should be able to provide specific guidelines for investigative reports and procedures to be followed. Guidelines and check-lists for geologic or geotechnical reports have been prepared by a number of reviewing agencies and are available to assist the reviewer in his or her evaluation of reports (e.g., DMG Notes 42, 44, 46, 48, and 49; California Department of Conservation, Division of

Mines and Geology, 1997). A reviewer also may wish to prepare his or her own guidelines or check-lists for specific types of reviews.

If a reviewer has questions about an investigation, these questions must be communicated in writing to the investigator for response. After the reviewer is satisfied that the investigation and resulting conclusions are adequate, this should be clearly indicated in writing to the reviewing agency so that the proposed development application may be processed promptly. The last and one of the more important responsibilities of the reviewer should be implementation of requirements assuring report recommendations are incorporated and appropriate consultant inspections are made.

The biggest problem the reviewer faces is the identification of standards. These questions must be asked: "Are the methods of investigation appropriate for a given site?" and "Was the investigation conducted according to existing standards of practice?" Answers to these questions lie in the report being reviewed. For example, a reported landslide should be portrayed on a geologic map of the site. The conclusion that a hazard is absent, where previously reported or suspected, should be documented by stating which investigative steps were taken and precisely what was seen. The reviewer must evaluate each investigative step according to existing standards. It should be recognized that existing standards of practice generally set minimum requirements (Keaton, 1993). Often the reviewer is forced to clarify the standards, or even introduce new ones, for a specific purpose.

Depth (Intensity) of Review

The depth of the review is determined primarily by the need to assure that an investigation and resulting conclusions are adequate, but too often the depth of review is controlled by the time and funds available. A report on a subdivision (e.g., for an EIR or preliminary report) may be simply evaluated against a check-list to make certain it is complete and well-documented. Additionally, the reviewer may wish to check cited references or other sources of data, such as aerial photographs and unpublished records.

Reviewers also may inspect the development site and examine excavations and borehole samples. Ideally, a field visit may not be necessary if the report is complete and well-documented. However, field inspections are of value, and generally are necessary to determine if field data are reported accurately and completely. Also, if the reviewer is not familiar with the general site conditions, a brief field visit provides perspective and a visual check on the reported conditions. Whether or not on-site reviews are made, it is

important to note that the geologic review process is not intended to replace routine grading inspections that may be required by the reviewing agency to assure performance according to an approved development plan.

Review Records

For each report and development project reviewed, a clear, concise, and logical written record should be developed. This review record may be as detailed as is necessary, depending upon the complexity of the project, the geology, and the quality and completeness of the reports submitted. At a minimum, the record should:

1. Identify the project, permits, applicant, consultants, reports, and plans reviewed;
2. Include a clear statement of the requirements to be met by the parties involved, data required, and the plan, phase, project, or report being considered or denied;
3. Contain summaries of the reviewer's field observations, associated literature and aerial photographic review, and oral communications with the applicant and the consultant;
4. Contain copies of any pertinent written correspondence; and
5. The reviewer's name and license number(s), with expiration dates.

The report, plans, and review record should be kept in perpetuity to document that compliance with local requirements was achieved and for reference during future development, remodeling, or rebuilding. Such records also can be a valuable resource for land-use planning and real-estate disclosure.

Appeals

In cases where the reviewer is not able to approve a geologic report, or can accept it only on a conditional basis, the developer may wish to appeal the review decision or recommendations. However, every effort should be made to resolve problems informally prior to making a formal appeal. An appeal should be handled through existing local procedures (such as a hearing by a County Board of Supervisors or a City Council) or by a specially appointed Technical Appeals and Review Panel comprised of geoscientists, engineers, and other appropriate professionals. Adequate notice should be given to allow time for both sides to prepare their cases. After an

appropriate hearing, the appeals decision should be in writing as part of the permanent record.

Another way to remedy conflicts between the investigator and the reviewer is by means of a third party review. Such a review can take different paths ranging from the review of existing reports to in-depth field investigations. Third party reviews are usually done by consultants not normally associated with the reviewing/permitting agency.

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- DMG NOTE 41 - General guidelines for reviewing geologic reports, 1997.
- DMG NOTE 42 - Guidelines to geologic/seismic reports, 1986.
- DMG NOTE 44 - Recommended guidelines for preparing engineering geologic reports, 1986.
- DMG NOTE 46 - Guidelines for geologic/seismic considerations in environmental impact reports, 1986.
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Appendix E

PRODUCTS OF THE FAULT EVALUATION AND ZONING PROGRAM

Since the passage of the AP Act, staff of the Fault Evaluation and Zoning Program have published numerous reports on the Act and the surface fault rupture hazard. These, as well as unpublished files of geologic information, are listed below. A notation next to each entry is the publication number: CD – California Geological Survey compact disc, CG -- California Geology, N – DMG/CGS Note, SP -- Special Publication, SR -- Special Report, o.p. -- report is out of print, * -- an outside publication not available from CGS. Numbers alone (e.g., 89-16) are Open-File Report numbers. The publications are listed chronologically by groups below.

AVAILABILITY

Reports listed here are available for reference at offices of the California Geological Survey in Sacramento, Menlo Park, and Los Angeles. Some reports are also available for reference at county and university libraries. Copies of available CGS reports may be purchased by mail order or over-the-counter from any office (see exceptions below):

OFFICES OF THE CALIFORNIA GEOLOGICAL SURVEY

GEOLOGIC INFORMATION AND PUBLICATIONS

801 K Street, MS 14-34
Sacramento, CA 95814
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BAY AREA REGIONAL OFFICE

345 Middlefield Road, MS 520
Menlo Park, CA 94025
(650) 688-6327

SOUTHERN CALIFORNIA REGIONAL OFFICE

888 South Figueroa Street, Suite 475
Los Angeles, CA 90017
(213) 239-0878

IMPLEMENTATION OF THE ALQUIST-PRIOLO ACT

Official Maps of Earthquake Fault Zones, by California Geological Survey, 1974-2007. As of August 2007, 547 new and revised Official APEFZ maps have been issued. Special Publication 42 provides an index to these maps and describes how they can be purchased.

- SP 42** **Fault-rupture hazard zones in California**, by W.A. Bryant and E.W. Hart, 2007, 42 p. (pdf version only). Includes an index map which identifies all 7.5-minute topographic maps in which AP Earthquake Fault Zones are located. (Revised periodically).
- CG** **Zoning for surface fault hazards in California -- The New Special Studies Zones maps**, by E.W. Hart, 1974: v. 27, n. 10, p. 227-230.
- SP 47** **Active fault mapping and evaluation program -- 10-year program to implement Alquist-Priolo Special Studies Zones Act, 1976.**
o.p.
- CG** **The review process and the adequacy of geologic reports**, by R.M. Stewart, E.W. Hart, and P.Y. Animoto, 1976: Bulletin of the International Association of Engineering Geology, n. 14, p. 83-88. (Reprinted in California Geology, v. 30, n. 10, p. 224-229).
- CG** **Geologic review process**, by E.W. Hart and J.W. Williams, 1978: v. 31, n. 10, p. 235-236.
- *** **Zoning for the hazard of surface fault rupture in California**, by E.W. Hart, 1978, *in* Proceedings of the Second International Conference on Microzonation, San Francisco, November 26-December 1, 1978: NSF Special Publication, p. 635-645.
- CG** **Fault Evaluation and Zoning Program**, by E.W. Hart, 1980: v. 33, n. 7, p. 147-152.
- *** **Zoning for surface-faulting in California**, by E.W. Hart, 1986, *in* Proceedings of Conference XXXII -- Workshop on future directions in evaluating earthquake hazards in southern California, November 12-13, 1985: U.S. Geological Survey Open-File Report 86-401, p. 74-83.
- 90-18** **A study of the effectiveness of the Alquist-Priolo Program**, by R. Reitherman and D.J. Leeds, 1990.
- N 41** **General guidelines for reviewing geologic reports**, by E.W. Hart and W.A. Bryant, 1997. (Also Appendix D in SP 42).

N 49 Guidelines for evaluating the hazard of surface fault rupture, by E.W. Hart and W.A. Bryant 1997. (Also Appendix C in SP 42).

CD 2000-03 - Digital images of official maps of Alquist-Priolo Earthquake Fault Zones of California, Southern Region, by DMG staff, 2000.

CD 2000-04 - Digital images of official maps of Alquist-Priolo Earthquake Fault Zones of California, Central Coastal Region, by DMG staff, 2000.

CD 2000-05 - Digital images of official maps of Alquist-Priolo Earthquake Fault Zones of California, Northern and Eastern Region, by DMG staff, 2000.

CD 2001-04 - GIS files of official Alquist-Priolo Earthquake Fault Zones, Central Coastal Region, developed by W.A. Bryant, R. Martin, P.Wong, D. Maldonado, J. Wampole, and D. Dixon, 2001.

CD 2001-05 - GIS files of official Alquist-Priolo Earthquake Fault Zones, Southern Region, developed by W.A. Bryant, R. Martin, P.Wong, D. Maldonado, J. Wampole, and D. Dixon, 2001.

CD 2001-06 - GIS files of official Alquist-Priolo Earthquake Fault Zones, Northern and Eastern Region, developed by W.A. Bryant, R. Martin, P.Wong, D. Maldonado, J. Wampole, and D. Dixon, 2001.

POST-EARTHQUAKE INVESTIGATIONS

CG Ground rupture associated with faulting -- Oroville earthquake, August 1975, by E.W. Hart, 1975: v. 28, p. 274-276.

SR 124 Ground rupture along the Cleveland Hill fault, by E.W. Hart and J.S. Rapp, 1975, *in* Sherburne, R.W. and Hauge, C.J., editors, Oroville, California, Earthquake 1 August 1975, p. 61-72.

*** Geologic setting, historical seismicity and surface effects of the Imperial Valley earthquake, October 15, 1979, Imperial County, California**, by E. Leivas, E.W. Hart, R.D. McJunkin, and C.R. Real, 1980, *in* Imperial County, California, Earthquake October 15, 1979: EERI Reconnaissance Report, February 1980, p. 5-19.

81-5 Preliminary map of October 1979 fault rupture, Imperial and Brawley faults, Imperial County, California, by E.W. Hart, 1981.

80-12 Preliminary map of surface rupture associated with the Mammoth Lakes earthquakes, May 25 and 27, 1980, by W.A. Bryant, G.C. Taylor, E.W. Hart, and J.E. Kahle, 1980.

SR 150 Surface rupture associated with the Mammoth Lakes earthquakes of 25 and 27 May, 1980, by G.C. Taylor and W.A. Bryant, 1980, *in* Sherburne, R.W., editor, Mammoth Lakes, California earthquakes of May 1980, p. 49-67.

SR 150 Rockfalls generated by the Mammoth Lakes earthquakes of May 25 and 27, 1980, by W.A. Bryant, 1980, *in* Sherburne, R.W., editor, Mammoth Lakes, California earthquakes of May 1980, p. 69-73.

SR 150 Planned zoning of active faults associated with the Mammoth Lakes earthquakes of May 1980, by E.W. Hart, 1980, *in* Sherburne, R.W., editor, Mammoth Lakes, California earthquakes of May 1980, p. 137-141.

CG Ground rupture, Coalinga earthquake of 10 June 1983, by R.D. McJunkin and E.W. Hart, 1983: v. 36, n. 8, p. 182-184.

SP 66 Surface faulting northwest of Coalinga, California, June and July 1983, by E.W. Hart and R.D. McJunkin, 1983, *in* Bennett, J.H. and Sherburne, R.W., editors, The 1983 Coalinga, California earthquakes, p. 201-219.

SP 68 Evidence for surface faulting associated with the Morgan Hill earthquake of April 24, 1984, by E.W. Hart, 1984, *in* Bennett, J.H. and Sherburne, R.W., editors, The 1984 Morgan Hill, California earthquake, p. 161-173.

CG Fault rupture associated with the July 21, 1986 Chalfant Valley Earthquake, Mono and Inyo counties, California, by J.E. Kahle, W.A. Bryant, and E.W. Hart, 1986: v. 39, n. 11, p. 243-245.

CG Magnitude 5.9 North Palm Springs earthquake, July 8, 1986, Riverside County, California: Lifeline damage, by G. Borchardt and M.W. Manson, 1986: v. 39, n. 11, p. 248-252.

CG Preliminary report: Surface rupture, Superstition Hills earthquakes of November 23 and 24, 1987, by J.E. Kahle, C.J. Wills, E.W. Hart, J.A. Treiman, R.B. Greenwood, and R.S. Kaumeyer, 1988: v. 41, n. 4, p. 75-84.

- CG Liquefaction at Soda Lake: Effects of the Chittenden earthquake swarm of April 18, 1990, Santa Cruz County, California**, by C.J. Wills and M.W. Manson, 1990: v. 43, n. 10, p. 225-232.
- * Surface fissures and the mapping of CDMG Special Studies Zones**, by E.W. Hart, 1990, *in* Reid, G., editor, What we have learned from the October 17, 1989 7.1M Loma Prieta earthquake: 16th Annual Saber Society Symposium Proceedings Volume, p. 87-99.
- SP 104 The search for fault rupture and the significance of ridge-top fissures, Santa Cruz Mountains, California**, by E.W. Hart, W.A. Bryant, C.J. Wills, and J.A. Treiman, 1990, *in* McNutt, S.R. and Sydnor, R.H., editors, The Loma Prieta Earthquake of October 17, 1989, p. 83-94.
- CG The Mono Lake earthquake of October 23, 1990**, by S.R. McNutt, W.A. Bryant, and R. Wilson, 1991: v. 44, n. 2, p. 27-32.
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- CG Surface faulting associated with the June 1992 Landers earthquake, California**, by E.W. Hart, W.A. Bryant, and J.A. Treiman, 1993, v. 46, p. 10-16.
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- FERs Fault Evaluation Reports**, by Fault Evaluation and Zoning Project Staff, 1976-2007, copies of the FERs are available for reference in the Bay Area and Southern California regional offices of CGS. An index to FERs and copies of FERs through 1989 on microfiche are available as Open-File Reports 90-9 to 90-14 (see below). FERs completed through 2000 have been digitally archived and are available for purchase (see below).
- 81-6 Evidence of Holocene movement of the San Andreas fault zone, northern San Mateo County, California**, by T.C. Smith, 1981.
- 81-7 Sargent, San Andreas, and Calaveras fault zones: Evidence for recency in the Watsonville East, Chittenden and San Felipe quadrangles, California**, by W.A. Bryant, D.P. Smith, and E.W. Hart, 1981.
- 81-8 Recently active strands of the Greenville fault, Alameda, Contra Costa and Santa Clara counties, California**, by E.W. Hart, 1981.
- 81-9 Evidence for recent faulting, Calaveras and Pleasanton faults, Diablo and Dublin quadrangles, California**, by E.W. Hart, 1981.
- SP 62 Southern Hayward fault zone, Alameda and Santa Clara counties, California**, by W.A. Bryant, 1982, *in* Proceedings -- Conference on earthquake hazards of the eastern San Francisco Bay area, p. 35-44.
- * Self-guided field trip No. 4 -- Fault creep along the Hayward fault in the Richmond-San Pablo area**, by T.C. Smith, 1982, *in* Conference on earthquake hazards of the [eastern] San Francisco Bay area, Field Trip Guidebook: California State University, Hayward.
- 84-54 Evidence of recent faulting along the Owens Valley, Round Valley, and White Mountains fault zones, Inyo and Mono counties, California**, by W.A. Bryant, 1984.
- 84-55 Evidence of recent faulting along the Mono Lake fault zone, Mono County, California**, by W.A. Bryant, 1984.

- 84-56 Evidence of recent faulting along the Antelope Valley fault zone, Mono County, California**, by W.A. Bryant, 1984.
- 88-14 Recently active traces of the Newport-Inglewood fault zone, Los Angeles and Orange counties, California**, by W.A. Bryant, 1988.
- CG A neotectonic tour of the Death Valley fault zone**, by C.J. Wills, 1989: v. 42, n. 9, p. 195-200.
- CG Deep Springs fault, Inyo County, California, An example of the use of relative-dating techniques**, by W.A. Bryant, 1989: v. 42, n. 11, p. 243-255.
- * The Rose Canyon fault zone; a historical review**, by J.A. Treiman, 1989, *in* Seismic risk in the San Diego region, a workshop on the Rose Canyon fault system: Proceedings volume of a workshop sponsored by the Southern California Earthquake Preparedness Project, June 29-30, 1989.
- 90-9 Index to fault evaluation reports prepared 1976-1989 under the Alquist-Priolo Special Studies Zones Act**, by C.J. Wills, P. Wong, and E.W. Hart, 1990.
- 90-10 Microfiche copies of Fault Evaluation Reports for northern California**, by Division of Mines and Geology staff.
- 90-11 Microfiche copies of Fault Evaluation Reports for the southern Coast Ranges**, by Division of Mines and Geology staff.
- 90-12 Microfiche copies of Fault Evaluation Reports for the Transverse Ranges**, by Division of Mines and Geology staff.
- 90-13 Microfiche copies of Fault Evaluation Reports for the Peninsular Ranges**, by Division of Mines and Geology staff.
- 90-14 Microfiche copies of Fault Evaluation Reports for eastern California**, by Division of Mines and Geology staff.
- CG Active faults north of Lassen Volcanic National Park**, by C.J. Wills, 1991, v. 44, p. 51-58.
- * The Green Valley Fault**, by W.A. Bryant, *in* Field trip guide to the geology of western Solano County: Northern California Geological Society, 1991, p. 1-10.
- SP 113 Progress in understanding the Concord fault through site specific studies**, by C.J. Wills and E.W. Hart, *in* Proceedings -- Conference on earthquake hazards in the eastern San Francisco Bay area, 1992, p. 311-317.
- SP 113 The elusive Antioch fault**, by C.J. Wills, *in* Proceedings -- Conference on earthquake hazards in the eastern San Francisco Bay area, 1992, p. 325-331.
- SP 113 Pseudo-mole tracks from clay beds east of Healdsburg**, by M.D. Malone, G. Borchardt, E.W. Hart, and S.R. Korbay, *in* Proceedings -- Conference on earthquake hazards in the eastern San Francisco Bay area, 1992, p. 419-425.
- 92-7 Recently active traces of the Rodgers Creek fault, Sonoma County, California**, by E.W. Hart, 1992, 14 p.
- 93-2 The Rose Canyon fault zone, southern California**, by J.A. Treiman, 1993, 45 p.
- * Holocene slip rate and earthquake recurrence on the Honey Lake fault zone, northeastern California**, by C.J. Wills and G. Borchardt, 1993, *Geology*, v. 21, p. 853-856.
- CD 2002-01 - Fault evaluation reports prepared under the Alquist-Priolo Earthquake Fault Zoning Act, Region 1 – Central California**, developed by W.A. Bryant and P. Wong, 2002.
- CD 2002-02 - Fault evaluation reports prepared under the Alquist-Priolo Earthquake Fault Zoning Act, Region 2 – Southern California**, developed by W.A. Bryant and P. Wong, 2002.
- CD 2002-03 - Fault evaluation reports prepared under the Alquist-Priolo Earthquake Fault Zoning Act, Region 3 – Northern and Eastern California**, developed by W.A. Bryant and P. Wong, 2002.

REGIONAL SUMMARY REPORTS

- 77-8 Summary report -- Fault evaluation program, 1976 area (western Transverse Ranges)**, by E.W. Hart, E.J. Bortugno, and T.C. Smith, 1977.
- 78-10 Summary report -- Fault evaluation program, 1977 area (Los Angeles Basin region)**, by E.W. Hart, D.P. Smith, and T.C. Smith, 1978.
- 79-10 Summary report -- Fault evaluation program, 1978 area (Peninsular Ranges-Salton Trough region)**, by E.W. Hart, D.P. Smith, and R.B. Saul, 1979.

- 81-3 Summary report -- Fault evaluation program, 1979-1980 area (southern San Francisco Bay region),** by E.W. Hart, W.A. Bryant, and T.C. Smith, 1981.
- SP 62 California's fault evaluation program -- southern San Francisco Bay region,** by E.W. Hart, T.C. Smith, and W.A. Bryant, 1982, *in* Proceedings -- Conference on earthquake hazards in the eastern San Francisco Bay area, p. 395-404.
- 83-10 Summary report -- Fault evaluation program, 1981-1982 area (northern Coast Ranges region),** by E.W. Hart, W.A. Bryant, and T.C. Smith, 1983.
- 84-52 Summary report -- Fault evaluation program, 1983 area (Sierra Nevada region),** by E.W. Hart, W.A. Bryant, and T.C. Smith, 1984.
- 86-3 Summary report -- Fault evaluation program, 1984-1985, southern Coast Ranges region and other areas,** by E.W. Hart, W.A. Bryant, M.W. Manson, and J.E. Kahle, 1986.
- 88-1 Summary report -- Fault evaluation program, 1986-1987, Mojave Desert region and other areas,** by E.W. Hart, W.A. Bryant, J.E. Kahle, M.W. Manson, and E.J. Bortugno, 1987.
- 89-16 Summary report -- Fault evaluation program, 1987-1988, southwestern Basin and Range region and supplemental areas,** by E.W. Hart, W.A. Bryant, C.J. Wills, J.A. Treiman, and J.E. Kahle, 1989.
- 91-9 Summary report -- Fault evaluation program, 1989-1990, northeastern California and supplemental areas,** by E.W. Hart, W.A. Bryant, J.A. Treiman, C.J. Wills, and R.H. Sydnor, 1991.
- are available for purchase (see below). Reports filed after 2000 are available for reference at the Geologic Information and Publications Office in Sacramento.
- C File,** reports by consulting geologists that predate the Earthquake Fault Zones or are outside the Zones at the time of the study. Over 600 reports on file. Reports are available for reference at the Bay Area and Southern California regional offices of CGS, and the Geologic Information and Publications Office in Sacramento.
- 77-6 o.p. Index to geologic reports for sites within Special Studies Zones,** by W.Y.C. Lo and J.G. Moreno, 1977 (superseded by OFR 84-31).
- 84-31 Index to geologic reports for sites within Special Studies Zones,** by P. Wong, 1984. (Index map to the AP File reports).
- 89-5 Index to geologic reports for development sites within Special Studies Zones in California, July 1, 1984 to December 31, 1988,** by P. Wong, 1989. (Update for OFR 84-31).
- 90-15 Directory of fault investigation reports for development sites within Special Studies Zones in California, 1974-1988,** by P. Wong, E.W. Hart, and C.J. Wills, 1990. (Listing of all AP File reports through December 1988).
- 95-9 Index to geologic reports for development sites within Earthquake Fault Zones in California, January 1, 1989 to December 31, 1994,** by P. Wong, 1995 (Update for OFR 89-5).
- CD 2003-01 - Fault investigation reports for development sites within Alquist-Priolo Earthquake Fault Zones in Northern California, 1974-2000,** developed by P. Wong, W.A. Bryant, and J.A. Treiman, 2003.

CONSULTANTS REPORTS

A-P File, reports by consulting geologists, 1974-2007; reports for sites within Earthquake Fault Zones submitted to the California Geological Survey in compliance with the APEFZ Act. Over 4,000 reports on file. Reports filed with CGS through 2000 have been digitally archived and

CD 2003-02 - Fault investigation reports for development sites within Alquist-Priolo Earthquake Fault Zones in Southern California, 1974-2000, developed by P. Wong, W.A. Bryant, and J.A. Treiman, 2003.

Appendix F

WAIVER PROCEDURE FOR THE ALQUIST-PRIOLO ACT

Section 2623 of the Act states, "If the city or county [having jurisdiction over the lands] finds that no undue [fault] hazard...exists, the geologic report on such hazard may be waived, with approval of the State Geologist." The location of the proposed development or structure may be approved following such waiver.

The State Geologist will review waiver requests only after receiving the Waiver Form completed by the city or county geologist and the property owner, and accompanied by supporting statements and data in writing that would justify approval of the waiver request.

WAIVER FORM FOR THE ALQUIST-PRIOLO ACT (Pursuant to Chapter 7.5, Div. 2, California Public Resources Code)					
1. City or County Geologist, State Registered					
I, _____, Registered Geologist, (Print Name) representing _____, recommend that the (City/County) property: _____ (Description, size, proposed development) _____ (Location of Site - also show location on "Earthquake Fault Zones" maps) _____, be granted a waiver from geologic studies (Permit Number) relating to active faults*. Supporting statements that no undue hazard relative to faults exists at the site are attached to this form in writing on City or County letterhead with the City or County Geologist's signature and registration number, and that the Geologist representing the City or County is in agreement with the data:					
Attached Data Includes:	YES	NO	YES	NO	
1. Geologic Fault Map(s)	_____	_____	4. Aerial Photo(s)	_____	_____
2. Geologic Report(s)	_____	_____	5. Reference to Report(s)	_____	_____
3. Subsurface Geologic Data	_____	_____	6. Other information	_____	_____
(City or County Registered Geologist's Signature)		(R.G. No.)		(Date)	
2. Owner of the Property					
I, _____, acknowledge that the property is within an Earthquake Fault Zone associated with the _____ fault. (Owner's Signature) (Date)					
3. State Geologist					
Date Received by CGS _____ (Date) Reviewer _____ (Registered Geologist's Signature) (R.G. No.) (Date) Recommendation of Waiver: Approved: ☐ Not Approved: ☐ (Explanation attached)					
State Approval of Review: _____ (State Geologist) (Date) *Defined in Policies and Criteria of the State Mining and Geology Board (See Appendix B)					
Mail form to: State Geologist California Geological Survey 801 K Street, MS 12-30 Sacramento, California 95814-3531					