SPECIAL PUBLICATION 42
Revised 2018

EARTHQUAKE FAULT ZONES

A GUIDE FOR GOVERNMENT AGENCIES, PROPERTY OWNERS / DEVELOPERS, AND GEOSCIENCE PRACTITIONERS FOR ASSESSING FAULT RUPTURE HAZARDS IN CALIFORNIA

DEPARTMENT OF CONSERVATION
CALIFORNIA GEOLOGICAL SURVEY

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JOHN G. PARRISH, PH.D.
STATE GEOLOGIST

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California Department of Conservation
California Geological Survey
801 K Street, MS 12-31
Sacramento, CA 95814

Photo: Cottage destroyed by surface fault rupture on the Kekerengu Fault during the Mw 7.8 2016 Kaikoura earthquake, New Zealand. Approximately 10 meters of right-lateral fault displacement occurred under this house, tearing it from its foundation. Photo credit: VML 190573, Julian Thomson, GNS Science / Earthquake Commission

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. The stated intent of the Act is 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."* The Act also requires the State Geologist to compile maps delineating earthquake fault zones and to submit maps to all affected cities, counties and state agencies for review and comment. For the last 44 years, Special Publication 42 has been the vehicle by which the State Geologist, through the California Geological Survey, has informed affected agencies and the general public how and where Alquist-Priolo Earthquake Fault Zones are prepared.

This is the twelfth revision of Special Publication 42, which was first issued in December 1973 as an "Index to Maps of Special Studies Zones." Explanatory text was added in 1975 and subsequent revisions were made between 1976 - 2007. Since 2007, five supplements to Special Publication 42 have been issued to show the locations, names, and release dates of Earthquake Fault Zone maps released between 2012 - 2017.

This latest version of Special Publication 42 represents a significant departure from previous versions. Rather than serve simply as a source of background information and an index of 7.5-minute quadrangle maps containing Earthquake Fault Zones, this revised document is specifically intended to provide state-of-the-practice guidelines for affected permitting agencies and their reviewers, as well as for geoscience consulting practitioners representing property owners and developers. Such guidance has previously been presented in California Geological Survey Note 41, "General Guidelines for Reviewing Geologic Reports" and Note 49, "Guidelines for Evaluating the Hazard of Surface Fault Rupture," which traditionally have been included as appendices to Special Publication 42. The information presented in those notes has been significantly updated, expanded, and incorporated into this new version. As with the zone maps themselves, it is anticipated that this document will continue to be revised as major advances in the sciences associated with surface fault rupture occur. Background material regarding the California Geological Survey's Fault Evaluation and Zoning Program, which made up the bulk of previous versions of Special Publication 42, has been updated and now appears in Appendix C.

Maps of Earthquake Fault Zones are now available in multiple formats. Most recently, these maps have been made available through a web application (https://maps.conservation.ca.gov/cgs/EQZApp/) that allows users to navigate to an individual parcel and determine whether or not it is affected by any of CGS's regulatory zones (fault rupture, soil liquefaction, or earthquake landslides). Institutional users, such as cities and counties, can access the zone maps on their systems through an interactive web map service: (https://spatialservices.conservation.ca.gov/arcgis/rest/services/CGS_Earthquake_Hazard_Zones)

Those who prefer geographic information files (GIS) or portable document format (PDF) versions of maps, or wish to see how the zone maps were prepared through the associated fault evaluation report, can download these from the CGS Information Warehouse: (http://maps.conservation.ca.gov/cgs/informationwarehouse/).

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ACKNOWLEDGEMENTS

In 2016, the California Geological Survey convened an expert panel to focus on the development of an update to Special Publication 42. The intent was to prepare a guidance document for fault rupture hazards similar to CGS Special Publication 117A, which addresses hazards from soil liquefaction and earthquake-triggered landslides. This panel was composed of geoscience researchers, consultants and reviewers, as well as representatives of state, regional and local government agencies. Their willing participation in the preparation of this document significantly improved its quality and is greatly appreciated.

2016 to 2017 California Geological Survey Special Publication 42 Advisory Panel

- Robert Anderson – Alfred E. Alquist Seismic Safety Commission
- Dana Brechwald – Association of Bay Area Governments
- Dr. Alan Hull – Golder Associates Inc.
- Scott Lindvall – Lettis Consultants International, Inc.
- Sandra Potter – County of Sonoma; Chair, Geohazards Committee, State Mining and Geology Board
- Dr. Tom Rockwell - San Diego State University, Department of Geological Sciences
- Ted Sayre – Cotton, Shires and Associates, Inc.
- Dr. David Schwartz – U.S. Geological Survey

2016 to 2017 California Geological Survey Staff

- Timothy Dawson – Senior Engineering Geologist
- Timothy McCrink – Supervising Engineering Geologist
- Dr. Gordon Seitz – Engineering Geologist
- Ron Rubin – Engineering Geologist
- Eleanor Spangler – Engineering Geologist
- Jennifer Thornburg – Senior Engineering Geologist
- Christopher Tran – Student Assistant

SECTION 1: DEFINITIONS AND ACRONYMS

1.1 Definitions

Notes: Hyperlinks for references to statutes and regulations are linked to either the California Public Resources Code as published on the leginfo.legislature.gov website or the California Code of Regulations as published on the website maintained by Thomas Reuters Westlaw under the authority of the California Office of Administrative Law. Appendices A and B in this document are excerpts from the California Public Resources Code and California Code of Regulations.

Text in *italics* are terms that are defined in this section.

Alquist–Priolo Earthquake Fault Zoning Act: State of California law that addresses the hazard of *surface fault rupture* to *structures for human occupancy*. The provisions of the law are codified in the California Public Resources Code, Division 2, Chapter 7.5. In this document, the Alquist-Priolo Earthquake Fault Zoning Act will be abbreviated to "A-P Act."

Earthquake Fault Zones: Regulatory zones (also known as A-P Zones) that encompass traces of *Holocene-active faults* to address hazards associated with *surface fault rupture*. Earthquake Fault Zones are delineated by the State Geologist and implemented by *lead agencies* through permitting, inspection and land-use planning activities. (California Public Resources Code Division 2, Chapter 7.5, Section 2621.).

Earthquake Fault Zone Map: A map depiction of regulatory Earthquake Fault Zones. Traditionally prepared as paper printed products on a 7.5-minute topographic base, the authoritative Earthquake Fault Zone maps are now the geographic information system (GIS) representations available through the California Geological Survey's website (http://www.conservation.ca.gov/cgs). Portable document format (PDF) and web services are also available.

Earthquake Zones of Required Investigation Map: When an *Earthquake Fault Zone Map* is displayed or released with other regulatory seismic hazard zones as delineated under the Seismic Hazards Mapping Act, it is collectively referred to as an Earthquake Zones of Required Investigation Map (EZRIM). Site-specific investigations are required for certain developments within the zones depicted on these maps and, if the potential for the hazard is found to exist, plans to mitigate the hazard must be provided prior to a *lead agency* issuing a permit for construction.

fault: A shear or zone of closely associated shears across which earth materials on one side have been displaced with respect to those on the other side because of tectonic forces. A fault is distinguished from those fractures or shears caused by landsliding or other gravity-driven surficial failures.

> **age-undetermined fault:** A *fault* whose age of most recent movement is not known or is unconstrained by dating methods or by limitations in stratigraphic resolution.

Holocene-active fault: A *fault* that has had surface displacement within *Holocene* time (the last 11,700 years)**.** (California Code of Regulations, Title 14, Division 2, Section 3601.(a)) See Section 2 for more details.

pre-Holocene fault: A *fault* whose recency of past movement is older than 11,700 years, and thus does not meet the criteria of *Holocene-active fault* as defined in the *State Mining and Geology Board* regulations (California Code of Regulations, Title 14, Division 2, Section 3601.(a)). See Section 3 on Geochronology.

fault investigation: A geologic investigation conducted by a *project geologist* designed to identify the location, recency, and nature of faulting at a *project* site (California Code of Regulations, Title 14, Division 2, Section 3603.(d)).

fault investigation report: A report produced by a *project geologist* that addresses the potential for *surface fault rupture* for a *project* (California Code of Regulations, Title 14, Division 2, Section 3603.(d)).

fault trace: 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 *Earthquake Fault Zones* (California Code of Regulations, Title 14, Division 2, Section 3601.(b)).

fault-related (tectonic) ground deformation: Surface and near-surface deformation caused by fault rupture at depth or at some horizontal distance away from the fault that is not expressed as discrete surface faulting, including both brittle (fissures and tension cracks) and non-brittle (folding, warping, or tilting) deformation. Although not specifically addressed by the A-P Act, for the purposes of these Guidelines fault-related deformation encompasses any deformation that may impact the ability of a *structure for human occupancy* to perform as engineered in terms of life-safety and serviceability.

lead agency: The city, county, or state agency with the authority to approve *projects* and exercise "…their responsibility to prohibit the location of developments and structures for human occupancy across the trace of active faults" (California Public Resources Code, Division 2, Chapter 7.5, Section 2621.5.(a).

mitigation: The act of reducing the hazard of *surface fault rupture* either through avoidance or engineered design. Under the *Alquist–Priolo Earthquake Fault Zoning Act*, the only mitigation allowed for *Holocene-active faults* is avoidance.

owner/developer: The party seeking permits to undertake a *project* as defined in the *Alquist–Priolo Earthquake Fault Zoning Act* (California Public Resources Code, Division 2, Chapter 7.5, Sections 2621.6.(a)).

professional geologist: A person licensed in the State of California with the Board for Professional Engineers, Land Surveyors, and Geologists as a geologist and entitled to practice geology in California, and use the title "Professional Geologist (PG)."

project geologist: A *professional geologist* in the State of California who is retained by an *owner/developer* and charged with conducting a *fault investigation* and producing a *fault investigation report*.

reviewing geologist: A *professional geologist* in the State of California who is an agent of the *lead agency* and charged with reviewing the *fault investigation report* produced for a *project* by the *project geologist.*

project: Any *structures for human occupancy*, or any subdivision of land that contemplates the eventual construction of *structures for human occupancy*. For a structure in existence prior to May 4, 1975, if an addition or alteration to that structure exceeds 50% of the value of that structure, then it is considered a *project*. Unless a *lead agency* imposes more stringent requirements, single family frame dwellings are exempt unless part of a permitted development of four or more dwellings (California Public Resources Code, Division 2, Chapter 7.5, Section 2621.6.).

setback: The mitigation technique for *surface fault rupture* that avoids placing structures across traces of *Holocene-active faults* and may include *age-undetermined faults*.

single-family dwelling: A single family dwelling is a residence that houses one family or household, or one that is designed for one family only.

State Geologist: The head of the California Geological Survey.

State Mining and Geology Board: The state entity responsible for developing regulations that provide guidance to *lead agencies* and the geologic community in complying with the *Alquist-Priolo Earthquake Fault Zoning Act*. The State Mining and Geology Board, together with the *State Geologist*, also participates in the review process of *Earthquake Fault Zone Maps*.

story: "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 the building included between the upper surface of the topmost floor and the ceiling or roof above. For 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" (California Code of Regulations Title 14, Division 2, Section 3601.(f)).

structure for human occupancy: "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" (California Code of Regulations, Title 14, Division 2, Section 3601 (e)).

surface fault rupture: The displacement on a *fault* that occurs at the surface of the earth.

waiver: If a *lead agency* finds that no undue hazard of surface fault rupture exists for a *project*, a waiver of the requirement of a *fault investigation* may be granted by the *lead* *agency* with the approval of the *State Geologist* (California Public Resources Code, Division 2, Chapter 7.5, Section 2623.(a))

1.2 Acronyms

A-P Act: Alquist – Priolo Earthquake Fault Zoning Act

CCR: California Code of Regulations

CGS: California Geological Survey

CPRC: California Public Resources Code

EFZ: Earthquake Fault Zone

EZRIM: Earthquake Zones of Required Investigation Map

GIS: Geographic Information System

lidar: Light Detection and Ranging

SMGB: State Mining and Geology Board

SECTION 2: INTRODUCTION (FOR ALL AUDIENCES)

Note: Terms in *italics* are defined in Section 1, Definitions and Acronyms

2.1 Section Outline

2.2 Objectives of these Guidelines

The objectives of these Guidelines are two-fold:

1. To promote uniform and effective statewide implementation of the evaluation and mitigation elements of the *Alquist-Priolo Earthquake Fault Zoning Act*.
2. To assist affected parties in the evaluation and mitigation of *surface fault rupture* hazard for *projects* within designated *Earthquake Fault Zones*.

2.3 How to use these Guidelines

This document is intended to assist multiple audiences: *Lead agencies*, *project geologists and reviewing geologists*, as well as property *owners/developers*. Each audience has a different role with respect to the *A-P Act* and this publication is designed with sections targeted to these specific audiences so that pertinent information can be easily accessed as indicated by the section titles. *Lead agencies* will find these Guidelines useful for understanding how to implement the *A-P Act* and associated regulations. *Owners/developers* will find this document useful to understand how the *A-P Act* applies to them for their *projects* within *EFZs*. Finally, for *professional geologists*, which includes the *project geologist* and *reviewing geologist,* these Guidelines are intended to summarize the current state-of-practice for *fault investigations* conducted under the *A-P Act*.

This document is not necessarily designed to be read linearly, but rather the reader should be directed to the sections based on who they represent within the structure of the *A-P Act*: *Lead agency* (Section 3)*, owner/developer* (Section 4)*, and professional* *geologists* (Sections 5 and 6). Flow charts and illustrative figures are utilized in this document in order to simplify the seemingly complex language of the *A-P Act* and associated regulations. Terminology specific to the *A-P Act* and regulations are defined in Section 1: Definitions and Acronyms and defined terms are *italicized* throughout the document for easy reference.

The methods, procedures, and references contained herein are those that the Technical Advisory Panel compiled for this update and believe are currently representative of quality state-of-practice. *Surface fault rupture* hazard assessment and *mitigation* is an evolving field and it is recognized that additional approaches and methods will be developed.

2.4 What is *surface fault rupture* and why is it a hazard?

Surface fault rupture is the result of *fault* movement that breaks to the surface of the earth either suddenly during earthquakes (Figure 2-1), or slowly due to a process known as fault creep, and is the result of tectonic movement that originates deep in the Earth. *Surface fault rupture* is different from other types of earthquake-related ground deformation, such as that caused by soil liquefaction or earthquake-triggered landslides. The energy released during an earthquake is a direct result of fault rupture at depth, and when that rupture extends to the ground surface it manifests as displacements expressed as fractures, fissures and related tectonic deformation. The release of energy during an earthquake will also cause shaking which can trigger liquefaction and landslides.

Surface fault rupture poses a hazard to structures and infrastructure because the displacement that occurs, where one side of the fault moves relative to the other, can severely damage buildings (Figure 2-2). In extreme cases, this damage can result in the structural collapse of a building, potentially resulting in injuries or loss of life. In less extreme cases, structural damage may render a building uninhabitable and require costly repairs (Figure 2-2b). This hazard became widely recognized following the 1971 San Fernando (also known as the Sylmar) earthquake, where damage to many buildings was attributed to *surface fault rupture* (Youd and Olsen, 1971; Yerkes, 1973). Since 1971, other earthquakes around the world have continued to demonstrate the potential for extensive damage to structures caused by *surface fault rupture* and the hazard it poses to life and property.

2.5 The *Alquist-Priolo Earthquake Fault Zoning Act*

The purpose of the *Alquist-Priolo Earthquake Fault Zoning Act* (hereafter referred to simply as the "*A-P Act*") is to address the hazard of *surface fault rupture* through the regulation of development in areas near *Holocene-active faults*. As a result of the 1971 San Fernando earthquake and the recognition that *surface fault rupture* poses a hazard to structures, the *Alquist-Priolo Earthquake Fault Zoning Act* was signed into law on December 22, 1972, and went into effect on March 7, 1973. The complete text of the *A-P Act* is provided in Appendix A and relevant portions are included throughout the body of this document.

Figure 2-1. Example of *surface fault rupture* from the M 6.0 August 24, 2014 South Napa earthquake. Displacement at this location was about 0.5 meters (1.6 feet).

Figure 2-2a-b. 2a. Impact of *surface fault rupture* on a home during the November 14, 2016 M 7.8 Kaikoura earthquake, New Zealand. Fault displacement at this location was about 10 meters (33 feet) of horizontal offset. Photo credit: Pilar Villamor, GNS Science / Earthquake Commission. 2b. House damaged by surface rupture during the August 14, 2014 M 6.0 South Napa earthquake. Total displacement on the fault was less than 1 foot, yet even relatively modest amounts of fault offset required expensive (>$100,000) repairs including the replacement of the foundation of the house. Red arrows show relative trend of faulting and sense of horizontal movement.

The purpose of the *A-P Act* is to prevent the construction of *structures for human occupancy* across traces of active faults (California Public Resources Code (CPRC), Division 2, Chapter 7, Section 2621.5). For purposes of the *A-P Act*, active faults are defined by the *State Mining and Geology Board (SMGB)* as those faults that have *"…had surface displacement during Holocene time…"*(1) (California Code of Regulations (CCR), Title 14, Division 2, Section 3601 (a)). In order to provide clarity regarding the term active fault, this document uses the term *Holocene-active fault* to describe faults that are specifically regulated by the *A-P Act*. Additionally, this document considers the Holocene as the geological epoch that began 11,700 years before present, as defined by the International Commission on Stratigraphy (http://www.stratigraphy.org).

It is important to note that the *A-P Act* only addresses the hazard of *surface fault rupture* for *Holocene-active faults*; faults that have moved prior to the Holocene, referred to in this document as *Pre-Holocene faults*, may also have the potential to rupture but are not addressed by the *A-P Act*. Additional discussion regarding *Holocene-active faults,* as well as *pre-Holocene faults,* can be found in Section 5. Additionally, the *A-P Act* only addresses the hazard of *surface fault rupture* and not other types of earthquake-caused ground deformation such as from liquefaction and earthquake-induced landslides. These other types of earthquake-induced hazards are addressed by the Seismic Hazards Mapping Act (CPRC , Division 2, Chapter 7.8, Sections 2690 – 2699.6).

2.6 Rationale for zoning *Holocene-active Faults*

The decision to include *Holocene-active faults* in *Earthquake Fault Zones* (*EFZ*) was made in the 1970's soon after the zoning program started. The concept is based on the observation that faults that have shown relatively recent rupture are typically those with short recurrence intervals (the time elapsed between significant earthquakes) and therefore have a higher likelihood of rupturing again in the near-future. This approach is deterministic and provides a relatively simple metric and reasonable threshold for *project geologists* conducting *fault investigations* and *lead agencies* reviewing those investigations, but it is not perfect. In particular, some faults and fault systems with long recurrence intervals are problematic using this deterministic approach. For example, a fault with a 12,000 to 13,000-year recurrence interval that has not ruptured in the Holocene might not be included in an *EFZ*, while a fault that has a 30,000-year recurrence that ruptured 500 years ago would be included. In the former case, where the fault might be near failure and more likely to produce a large earthquake, the *A-P Act* does not account for a higher probability that the fault might rupture in the near future. In the latter case, the *A-P Act* is similarly blind to relative probability; some might consider the fault unlikely to produce another earthquake, therefore is unlikely to be a significant hazard for structures built on or near it. In the administration of the *A-P Act*, a *lead agency* might prohibit the construction of *structures for human occupancy* across the latter fault that

[1] The current SMGB regulations states that the Holocene epoch is "…about the last 11,000 years" (CCR, Title 14, Division 2, Section 3601 (a)). However, while the SMGB definition has been essentially unchanged since 1974, the age of the Holocene epoch has since been refined through geological studies (e.g., Walker and others, 2009) and is currently recognized as starting about 11,700 years ago. A recommendation to update the SMGB definition of Holocene has been forwarded by the SP42 Technical Advisory Panel to the SMGB for consideration.

ruptured 500 years ago, while there would be no such prohibition, or even the requirement for a *fault investigation* for that matter, across the potentially more dangerous former fault that has not ruptured in the Holocene.

The state-of-the-science in paleoseismic work in California is such that there is rarely enough detailed knowledge of the recurrence intervals of faults that rupture frequently, and even less for those with moderate to long recurrence intervals. To develop this higher level of information on any given fault requires detailed paleoseismic research at sites with ideal stratigraphic conditions that allow the recognition and dating of multiple earthquake events. The ability to develop site-specific data to address earthquake recurrence is difficult, as most sites where development is proposed are not amenable to these types of studies. Additionally, such detailed paleoseismic studies are beyond the scope and cost constraints of most development projects. In summary, the Holocene-active age criteria provide a practical approach to addressing fault rupture hazards for public safety.

2.7 Roles and responsibilities under the *Alquist – Priolo Earthquake Fault Zoning Act*

Three entities are responsible for the administration and implementation of the *A-P Act*: The *State Geologist*, the *lead agency,* and the *State Mining and Geology Board*. The property *owner/developer* represents a fourth group that is impacted most directly by the *A-P Act*. Figure 2-3 summarizes the roles and responsibilities of each of these groups.

The *State Geologist* (Chief of the California Geological Survey) is required by the *A-P Act* to delineate *Earthquake Fault Zones* (*EFZ*) along known *Holocene-active faults* in California. The *EFZs* are distributed as *Earthquake Fault Zone maps* (Figure 2-4), as well as Geographic Information System (GIS) shapefiles. The zones are regulatory in nature, and are one class of *Earthquake Zones of Required Investigation*, which include other geologic hazards such as liquefaction and earthquake-induced landslides (Figure 2-4c). Any proposed *projects* within these *EFZ* must address the potential for *surface fault rupture* through a *fault investigation* prior to a permit being issued by the *lead agency*. The *EFZs* are intended to encompass *Holocene-active* and potentially *Holocene-active faults* that may exist in the vicinity of the mapped faults used to establish the *EFZs*. The *EFZs* are provided by *CGS* to affected *lead agencies* in the form of GIS Shapefiles, which constitute the official regulatory *EFZs*. CGS also provides an interactive web application that uses a statewide parcel database to identify individual properties affected by *EFZ*s (https://maps.conservation.ca.gov/cgs/EQZApp/) and provides *EFZ*s as GIS web services to lead agencies and other institutional users: https://spatialservices.conservation.ca.gov/arcgis/rest/services/CGS_Earthquake_Hazard_Zones.

Other products CGS produces include digital images of the *EFZ* maps, provided on a 1:24,000-scale U.S. Geological Survey topographic base map in a portable document format (PDF), which can be used as reference maps by interested parties without access

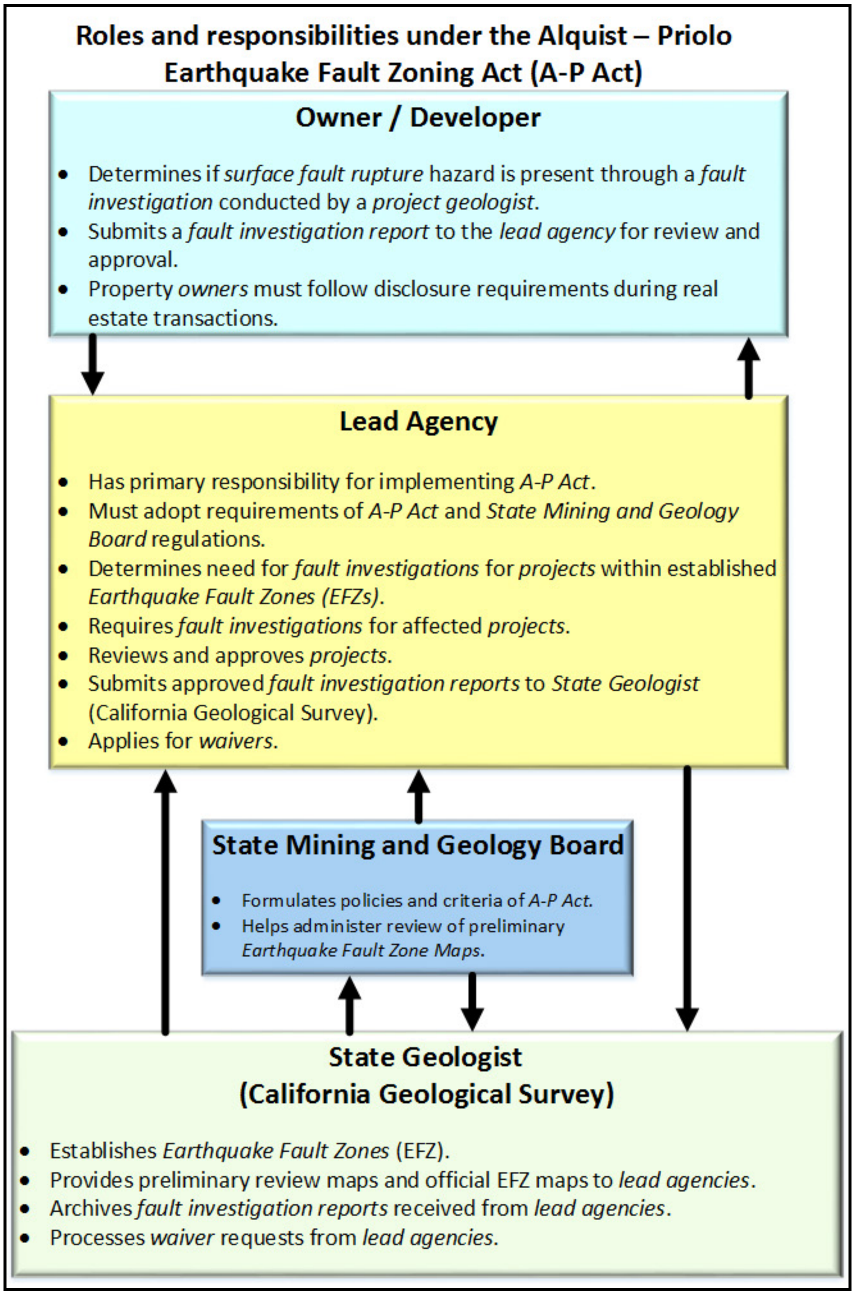


Figure 2-3. Bulleted items represent the primary roles and responsibilities of the four groups engaged in the *Alquist - Priolo Earthquake Fault Zoning Act*.

to a GIS platform. Appendix C describes the criteria and methods CGS uses to compile *Earthquake Fault Zone Maps*.

Lead agencies affected by the *EFZs* must regulate certain development *projects* within the zones. Before a *project* within an *EFZ* can be permitted, the *lead agency* must require a *fault investigation*. Section 3 more fully describes the role of the *lead agency* in the implementation of the *A-P Act*. Section 5 is a discussion regarding the current state-of-practice for *fault investigations* as applied to the *A-P Act* and will be of interest to the *reviewing geologists* for local *lead agencies*. Both the *project geologist* retained by the *owner/developer* and the *reviewing geologist* representing the *lead agency* should be familiar with Section 5 in order to have a common frame of reference during the review process.

Owner/Developers are the group most directly impacted by the *A-P Act* as they bear the cost of site-specific *fault investigations* and may be required to revise development plans to avoid construction on *Holocene-active fault* traces. If a *project* proposed by an *owner/developer* is located within an *EFZ*, a *fault investigation* will need to be conducted by a *project geologist*, and the *fault investigation report,* produced as part of this study, will need to be reviewed by the *lead agency's reviewing geologist*. *Owner/Developers* are referred to Section 4 of this document, which contains additional information pertinent to the *owner/developer* of *projects* within *Earthquake Fault Zones*.

Finally, the *State Mining and Geology Board* (SMGB) provides additional regulations (Policies and Criteria) to guide *lead agencies* in their implementation of the *A-P Act* (CCR, Title 14, Div. 2, Chapter 8.1.3). These regulations are included in Appendix B and are incorporated where appropriate in the body of this document. The SMGB also plays a role in the review of preliminary *Earthquake Fault Zone Maps*, and is responsible for receiving public review comments, forwarding these comments to the *State Geologist* for consideration of changes to the *Earthquake Fault Zone Maps*, as well as conducting public hearings regarding the preliminary review maps. The Geohazards Committee of the SMGB assisted in the development of this revision to Special Publication 42.

2.8 Uses and Limitations of *Earthquake Fault Zone Maps*

Earthquake Fault Zones (EFZ) are delineated to define those areas where *fault investigations* are required prior to building *structures for human occupancy*. The *Earthquake Fault Zone maps* include both the *EFZ* (Figure 2-4a) as well as the mapped traces of faults that are used to delineate zone boundaries (Figure 2-4b). These fault traces are plotted as accurately as the sources of data permit; however, no degree of the relative potential for future surface displacement or hazard is implied for the faults shown on the *EFZ maps*.

Fault traces shown on *Earthquake Fault Zone maps* are not mapped at a scale suitable to meet the requirement for site-specific *fault investigations*, nor should the faults depicted be used as the basis for defining building *setback* requirements. *Lead agencies* must require *owners/developers* with *projects* within the *EFZ* to determine if a potential hazard from any *fault,* whether heretofore recognized or not, exists with regard to proposed structures.

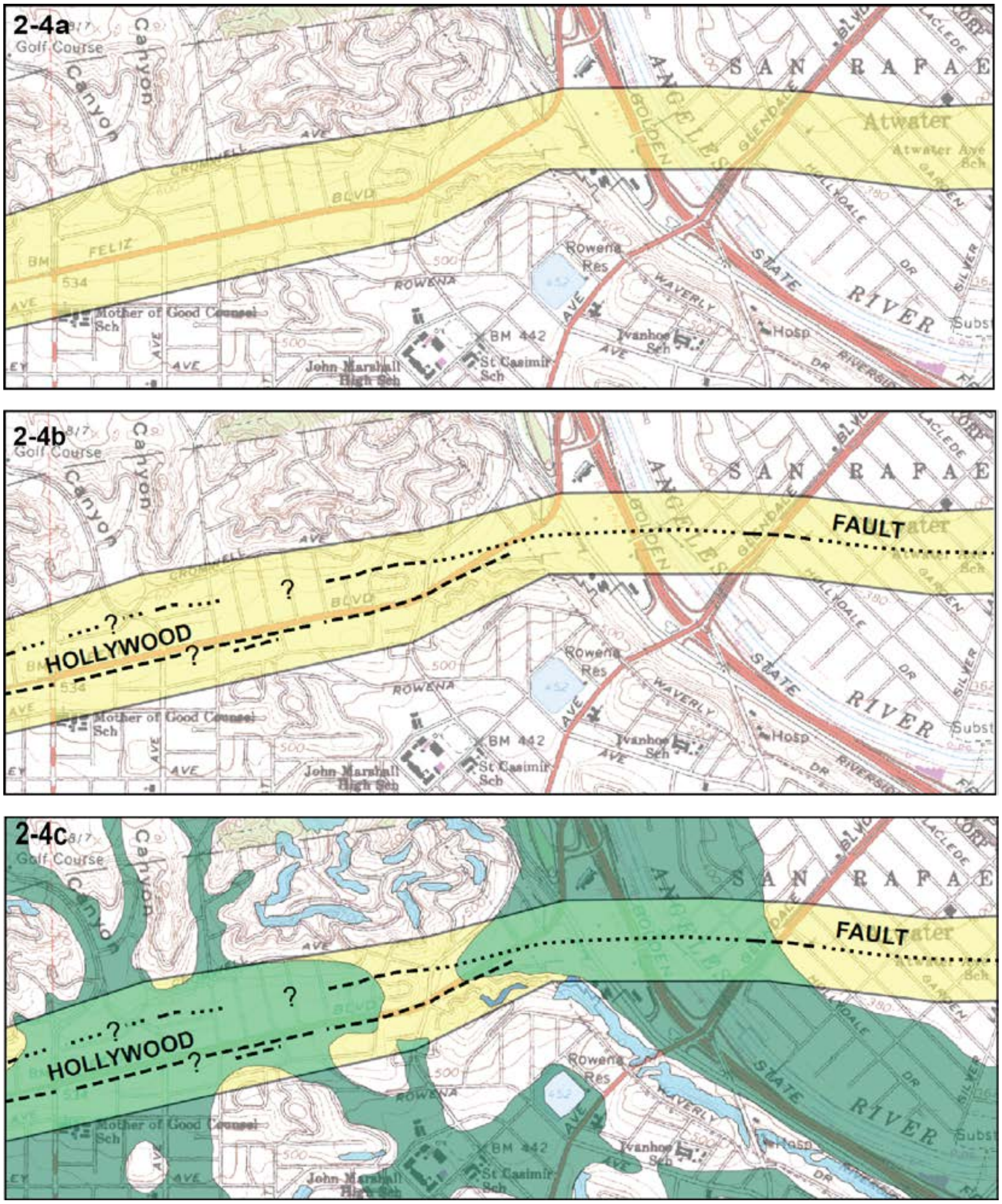


Figure 2-4. Portion of and *Earthquake Fault Zone* (EFZ) map on the Hollywood Fault from the Hollywood 7.5-minute Quadrangle. 4a. EFZ is shown as the yellow polygon. This is the default view for recent EFZ maps, available as downloadable files in Portable Document Format (pdf). 4b. *Earthquake Fault Zone* map showing both EFZ (yellow polygon) and faults (black lines). Faults can be toggled on using the layer control in Adobe Acrobat®. Solid lines - Accurately located; Long dashed lines - Approximately located; Short dash lines - Inferred; Dotted lines - Concealed. 4c. Map showing all *Earthquake Zones of Required Investigation*. Blue areas are zones for earthquake-induced landslides; Dark green areas are for liquefaction zones. Lighter green areas are zones with overlapping *Earthquake Fault Zones* and liquefaction zones.

Faults with the potential to rupture the ground surface, which include both *Holocene-active* and *pre-Holocene faults*, may exist outside the *EFZ* depicted on an *Earthquake Fault Zone map*. If a *Holocene-active* fault is found outside of an EFZ, for example, during a site-specific geologic investigation, that fault must still be avoided according to the *A-P Act*. *Pre-Holocene faults* outside of established *Earthquake Fault Zones* are not regulated by the *A-P Act*, although an evaluation by a *project geologist,* which may include a *fault investigation,* is recommended for all critical and significant developments proposed outside established *EFZs,* where there is an indication from available mapping and geologic data that *surface fault rupture* presents a potential hazard to a *project*.

2.9 How to determine if a *project* is regulated by the *Alquist – Priolo Earthquake Fault Zoning Act*?

Determining if a *project* is regulated by the *A-P Act* requires asking a number of questions, the first of which is "Is the *project* located within a regulatory *Earthquake Fault Zone*?" This question is best answered by contacting the *lead agency* (typically the local city or county) which can determine if a parcel within its jurisdiction is located within an *Earthquake Fault Zone (EFZ)*. Alternatively, the CGS regulatory zone web service (https://maps.conservation.ca.gov/cgs/EQZApp/) can provide guidance if a parcel is in, or near an *Earthquake Fault Zone*. If the answer is "yes," then several additional questions must be asked in order to determine if the *project* is regulated by the *A-P Act*. The subsequent questions are dependent on additional criteria such as the type of development, characteristics of the proposed or existing structure, the value of existing structures if they are being renovated, as well as consideration of any local regulations. Plate 1 is a flow chart intended to aid the *owner/developer* and the *lead agency* in determining if a *project* is regulated by the *A-P Act*.

2.10 Relationship of these Guidelines to Local General Plans and Permitting Ordinances

The CPRC, Division 2, Section 2621.5 describes the purpose of the *A-P Act* is 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. Similarly, the CCR, Title 14, Division 2, Chapter 8.1, Section 3603 directs affected *lead agencies* to provide for disclosure of delineated *Earthquake Fault Zones (EFZ)* to the public and that such disclosure may be by reference in general plans, specific plans, property maps, or other appropriate local maps. Cities and counties should consider the information presented in these guidelines when adopting or revising these plans and ordinances.

It is recognized that lead agencies need to develop local policies and regulations regarding the A-P Act and existing policies and regulations should be routinely reviewed and, if necessary, updated. Appendix D provides web links to several *lead agency* implementations of the *A-P Act* and is provided to assist *lead agencies* in these responsibilities.

2.11 Relationship of these Guidelines to the CEQA Process and Other Site Investigation Requirements

Nothing in these guidelines is intended to negate, supersede, or duplicate any requirements of the California Environmental Quality Act (CEQA) or other state laws and regulations. At the discretion of the *lead agency*, some or all of the investigations required by the *A-P Act* may occur either before, concurrent with, or after the CEQA process or other processes that require site investigations.

For hospitals, public schools, and essential service buildings, additional requirements are prescribed by the California Building Code (California Code of Regulations (CCR), Title 24). For such structures, the requirements of the *A-P Act* apply, with additional requirements specific to these types of structures specified in CCR Title 24.

2.12 References

Walker, M., Johnsen, S., Rasmussen, S. O., Popp, T., Steffensen, J.-P., Gibbard, P., Hoek, W., Lowe, J., Andrews, J., Bjorck, S., Cwynar, L. C., Hughen, K., Kershaw, P., Kromer, B., Litt, T., Lowe, D. J., Nakagawa, T., Newnham, R., and Schwander, J., 2009, Formal definition and dating of the GSSP (Global Stratotype Section and Point) for the base of the Holocene using the Greenland NGRIP ice core, and selected auxiliary records. J. Quaternary Sci., Vol. 24 pp. 3–17.

Youd, T. L.; Olsen, H. W., 1971, "Damage to constructed works, associated with soil movements and foundation failures", The San Fernando, California, earthquake of February 9, 1971; a preliminary report published jointly by the U.S. Geological Survey and the National Oceanic and Atmospheric Administration, Geological Survey Professional Paper 733, United States Government Printing Office, pp. 126–129.

Yerkes, R. F., 1973, Effect of San Fernando earthquake as related to geology, in San Fernando, California, Earthquake of February 9, 1971, U.S. Dept. of Commerce, Washington, D.C.

SECTION 3: GUIDELINES FOR LEAD AGENCIES

Note: Terms in *italics* are defined in Section 1, Definitions and Acronyms

3.1 Section Outline

3.2 *Lead agency* responsibilities under the *Alquist - Priolo Earthquake Fault Zoning Act*

This section is intended to provide an overview regarding the role of affected *lead agencies*, which are responsible for the implementation and enforcement of the *Alquist-Priolo Earthquake Fault Zoning Act* (*A-P Act*) within their jurisdictions. This section is not meant to be comprehensive but is intended to highlight the more important roles and responsibilities of *lead agencies*. *Lead agencies* should review and understand the text of the *Alquist-Priolo Earthquake Fault Zoning Act*, as well as the policies and criteria of the *State Mining and Geology Board* (SMGB), which are reproduced in Appendices A and B of this document. Nothing within this document is intended to supersede either the *A-P Act* or the policies of the SMGB.

Lead agencies (Cities, Counties and State agencies) have three primary responsibilities under the *A-P Act* which include:

1. Responsibility for adoption and administration of zoning laws, ordinances, rules, and regulations in the General Plan of any city or county affected (California Public Resources Code (CPRC), Division 2, Chapter 7.5, Section 2621.5).
2. Regulating specified "*projects*" within *Earthquake Fault Zones* (CPRC, Division 2, Chapter 7.5, Section 2623).
3. Other administrative requirements under the *A-P Act* such as posting public notices of new *Earthquake Fault Zone Maps* (CPRC, Division 2, Chapter 7.5, Sections 2621.9 and 2622 (d)), initiating *waiver* requests (Section 2623), and filing approved *fault investigation reports* with the *State Geologist* (Section 2625).

In practice, these specific requirements can be described as a linear progression starting from when: 1) The Preliminary Earthquake Fault Zone (EFZ) maps are released to the *lead agency* by the *State Geologist*; 2) The enforcement of the *A-P Act* by the *lead* *agency* once Official *EFZ Maps* are released; and 3) Compliance by the *lead agency* with other administrative requirements of the *A-P Act*. These topics are discussed in further detail in the following sections.

3.3 *Lead agency* roles and responsibilities in the review of Preliminary *EFZ* Maps and release of Official *EFZ* Maps

As provided in the *A-P Act*, a *lead agency* is responsible for the implementation and administration of the *A-P Act* and associated *SMGB* regulations. This is done through the adoption of a local ordinance into the *lead agency*'s general plan. Appendix D contains links to examples of local ordinances by some lead agencies in California and Utah, another state with significant fault rupture hazards. The examples in Appendix D are intended to assist other lead agencies in developing or updating their safety elements, ordinances, policies, and other documents to better implement the *A-P Act*.

A *lead agency*'s role in the day-to-day administration of the *A-P Act* typically begins upon issuance of Preliminary *Earthquake Fault Zone Maps* by the *State Geologist*. The *State Geologist* is required to provide an affected *lead agency* proposed new and revised *EFZ Maps* for its review and comment prior to the issuance of the Official *Earthquake Fault Zone maps*. These Preliminary *EFZ Maps* are released to the *lead agency* and the public to solicit technical comments on the proposed *EFZ*s. Once the Preliminary *EFZ Maps* are issued, the *lead agency* has 90 days to submit all technical comments to the *SMGB*, which then forwards those comments to the *State Geologist* for consideration in revisions to the Official *Earthquake Fault Zone Maps*. In practice, the *lead agency* will typically have its *reviewing geologist* review the Preliminary *EFZ Maps* as well as the supporting materials such as CGS Fault Evaluation Reports that justify the establishment of the *EFZ*s. CPRC, Division 2, Chapter 7.5, Sections 2622 (b) and (c) of the *A-P Act* describe the requirements of the review and comment period and issuance of the Official *Earthquake Fault Zone Maps*.

The *SMGB* also has additional regulations regarding the review of Preliminary *EFZ Maps*, which are in Section 3602 of the California Code of Regulations (CCR), Title 14, Division 2, Chapter 8.1.3 (see Appendix B). *SMGB* regulations require that the *lead agency* give public notice of receipt of the Preliminary *EFZ Map*s to property *owners* within the proposed *EFZ*s by reasonable means of communication within 45 days following the issuance of Preliminary *EFZ Maps*. CCR, Title 14, Division 2, Chapter 8.1.3, Section 3602 also suggests the *lead agency* give notice to *professional geologists* who conduct *fault investigations*. This provision is intended to solicit additional technical comments from *professional geologists* who are familiar with the local area and may be aware of additional data that should be considered for the establishment of the *EFZ*s. All public comments should be sent directly to the *SMGB* by the end of the 90-day public comment period. The *SMGB* is then responsible for forwarding the comments to the *State Geologist* for consideration in any revisions to the proposed *EFZ*s. Finally, during the 90-day comment period, the *SMGB* is required to hold at least one public hearing on the proposed *EFZ Maps*. This public meeting is typically, but not required to be, conducted in a local jurisdiction affected by the proposed *EFZ*.

After the 90-day public comment period and upon receipt of the comments by the *State Geologist*, the *State Geologist* has 90 days to consider the comments, incorporate necessary revisions, and release the Official *Earthquake Fault Zone Maps* to the *lead agency* affected by the *Earthquake Fault Zones*. Upon receipt of the Official maps, the *lead agency* is required to post a public notice at the county recorder, county assessor, and county planning commission offices, identifying the location of the *EFZ map* and effective date (CPRC, Division 2, Chapter 7.5, Section 2622 (d), see Appendix A).

3.4 When is a *project* subject to the *Alquist-Priolo Earthquake Fault Zoning Act*?

The *lead agency* ultimately is responsible for determining whether a *project* lies within an *Earthquake Fault Zone*. When the Official *EFZ*s are released, the *State Geologist* provides the *lead agency* with GIS files of *Earthquake Fault Zones*, which the *lead agency* can overlay with its official parcel boundary maps to determine whether a *project* lies within an *EFZ*. Alternatively, the *lead agency* can access CGS's GIS web services for the most recent version of the *EFZ*: https://spatialservices.conservation.cagov/arcgis/rest/services/CGS_Earthquake_Hazard_Zones. With certain exceptions, a *project* located within an *Earthquake Fault Zone* and regulated by the *A-P Act* generally includes new *structures for human occupancy*, as well as subdivisions of land that will eventually include *structures for human occupancy*. *Projects* exempted by the *A-P Act* are dependent on additional criteria such as the type of development, characteristics of the proposed or existing structure, and the value of existing structures if they are being renovated. Plate 1 is a decision flow chart intended to aid *lead agencies* and *owner/developers* in determining if a *project* within an *EFZ* requires a *fault investigation* under the provisions of the *A-P Act*.

3.5 *Lead agency* roles and responsibilities in the implementation and enforcement of the *Alquist-Priolo Earthquake Fault Zoning Act*

Once an Official *Earthquake Fault Zone Map* is released by the *State Geologist*, the primary role of the affected *lead agency* is to require and review *fault investigations* that address the hazard of *surface fault rupture* for any proposed *projects* within *EFZ*s before issuing a construction permit. The approval of those *projects* must be in accordance with the policies and criteria established by the *SMGB* (CPRC, Division 2, Chapter 7.5, Section 2623 (a)). *SMGB* regulations require that *fault investigation reports* must be prepared by a *professional geologist* registered in the State of California (CCR, Title 14, Division 2, Chapter 8.1.3, Section 3603 (d)), referred to in this document as the *project geologist*. These reports must also be reviewed by the *lead agency* (or its designee) and this review must be conducted by a *professional geologist* registered in the State of California, referred to in this document as the *reviewing geologist*. Plate 2 is a decision flow chart to help determine if a *fault investigation report* meets the minimum requirements of the *A-P Act*. Sections 5 and 6 in this publication, intended for *project geologists* and *reviewing geologists*, discuss in further detail the technical aspects and expectations of *fault investigations* and the content of *fault investigation reports*.

The *A-P Act* contains other important provisions relevant to the *lead agency*. First, a *lead agency* may impose and collect reasonable fees on individual *projects* in order to recover the costs of administering and complying with the *A-P Act* (CPRC, Division 2, Chapter 7.5, Section 2625). Second, a *lead agency* may establish policies and criteria that are more stringent than those of the *A-P Act* and the policies of the *SMGB*. A *lead agency* may simply adopt the minimum standards required by the *A-P Act* and *SMGB* regulations, as well as impose additional requirements, often included in the General Plan or local ordinances. Appendix D includes several ordinances, guidelines and other documents from *lead agencies* around the state that represent their implementation of the *A-P Act*. A *lead agency* that lacks local ordinances regarding geologic hazards in general and earthquake hazards in particular, or whose ordinances have become outdated, is encouraged to use the information contained in this publication to prepare or update these documents.

Enforcement of the *A-P Act* is solely the responsibility of the *lead agency*. Failure to comply with the requirements of the *A-P Act* can, under some circumstances, incur liability on the part of the *lead agency* in the event of earthquake-related injuries or death (CPRC, Division 2, Chapter 7.5, Section 2621.8).

3.6 ***Fault investigation report*** **filing requirements**

CCR, Title 14, Division 2, Chapter 8.1.3, Section 3603 (f) requires cities and counties to submit one copy of each approved *fault investigation report* to the *State Geologist* within 30 days of report approval and the *State Geologist* is required to place these reports "on open file." These reports of site-specific *surface fault rupture* hazard investigations serve several purposes: CGS uses the information provided in these reports to revise existing *EFZ Maps* when enough new information becomes available. When evaluating the requirements for a new *project* within an *EFZ*, *lead agencies*, *owner/developers*, and *project geologists* can refer to *fault investigation reports* that have been submitted to CGS using an online map service:

https://spatialservices.conservation.ca.gov/arcgis/rest/services/CGS

In some cases, the body of existing *fault investigation reports* in an area could provide the basis for the *waiver* process (see below).

Fault Investigation Reports in digital formats, such as a portable document file (PDF), can be sent by email to SHMP@Conservation.ca.gov if they are no larger than 10 MB. Larger files can be uploaded by the *lead agency* to a CGS server following the instructions described at:

http://www.conservation.ca.gov/cgs/rghm/ap/Pages/Index.aspx

Reports can also be sent by mail to:

California Department of Conservation
California Geological Survey
Attn: Earthquake Fault Zone Reports
801 K Street, MS 12-31
Sacramento, CA 95814-3531

3.7 *Waiver* process: What is it? When should it be initiated? And how?

The *A-P Act* contains a provision for a *waiver* process by which the requirement for *fault investigation reports* can be waived for *projects*, with approval of the *State Geologist* (CPRC Division 2, Chapter 7.5, Section 2623). To initiate the *waiver* process, the *lead agency* must first find that no undue hazard related to *surface fault rupture* exists for a *project*. If this is the case, then the *lead agency* is responsible for initiating the *waiver* request and provide supporting documentation to the *State Geologist*, who will direct CGS staff to conduct a review of the supporting data and recommend the *waiver* request be approved or denied based on the findings of the review.

In practice, the *waiver* process is typically only initiated for *projects* where enough locally-generated geologic data exists in the surrounding area to ensure that the site is effectively “cleared” of *Holocene-active faults* and *age-undetermined faults*. Supporting documents submitted by the *lead agency* may include *fault investigation reports* conducted for other *projects* in the surrounding vicinity and these reports should demonstrably show that faults do not project to the site of interest. If a *lead agency* is interested in initiating the *waiver* process, they are encouraged to contact the Seismic Hazards Program Manager at the California Geological Survey to discuss the process and requirements prior to submitting a *waiver* request (SHMP@conservation.ca.gov).

3.8 Safety element updates and local hazard mitigation plans

A *lead agency* should use the most up-to-date *EFZ* data for updates to its General Plan Safety Element, as well as in other land use planning and zoning documents. The California Office of Emergency Services (Cal OES), in cooperation with the California Natural Resources Agency and CGS, have built a convenient online map service (http://myplan.calema.ca.gov) to assist the *lead agency* in preparing these updates. The *lead agencies* can use this website to display various earthquake, fire and flood hazards, upload local map information, and prepare custom maps for use in local jurisdiction planning documents, such as General Plan Safety Elements and Local Hazard Mitigation Plans.

CGS also has a variety of online map services in addition to those provided to Cal OES for the MyPlan website. *Lead agencies* are encouraged to contact the CGS Seismic Hazard Program Manager (SHMP@conservation.ca.gov) to see what custom products can be prepared to assist in updating these important planning documents.

SECTION 4: GUIDELINES FOR PROPERTY OWNERS AND DEVELOPERS

Note: Terms in *italics* are terms defined in Section 1, Definitions and Acronyms

4.1 Section Outline

4.2 Objectives of this section

Within the framework of the *Alquist-Priolo Earthquake Fault Zoning Act* (*A-P Act*), it is the *owner/developer* who is most directly affected by the regulations associated with the *A-P Act*. The *owner/developer* (or their agent) must work with the local *lead agency* in order to understand if the *project* is subject to the *A-P Act* and, if it is, how to comply with the law. Furthermore, it is the *owner/developer* who must hire a *project geologist* to conduct the *fault investigation*, and submit a *fault investigation report* to the *lead agency* for review. Therefore, it is important that the *owner/developer* have a basic understanding of the *A-P Act* to ensure compliance and to facilitate approval of the *project* by the *lead agency*.

4.3 Is my *project* regulated by the *Alquist-Priolo Earthquake Fault Zoning Act*?

Determining if a *project* is regulated by the *A-P Act* requires first asking: "Is the *project* located within a regulatory *Earthquake Fault Zone*?" This question is best answered by contacting the *lead agency* (typically the local city or county, or other permitting entity) that can determine if a parcel within their jurisdiction is located within an *Earthquake Fault Zone* (*EFZ*). *Lead agencies* should be the first place to go for this information because they will have the most up-to-date parcel information and can identify any local hazards or zones not addressed by the *EFZ*. *EFZ*s are provided by CGS to affected *lead agencies* in the form of geographic information system (GIS) shapefiles, which constitute the official *EFZ*s. These GIS files, as well as portable document format (PDF) files for those without GIS software, are available for download from the CGS Information Warehouse (http://maps.conservation.ca.gov/cgs/informationwarehouse/). CGS also provides an interactive web application that uses a statewide parcel database to identify individual properties affected by EFZs: https://maps.conservation.ca.gov/cgs/EQZApp/ This web application provides a convenient, though possibly less up-to-date, way to determine if a project site is regulated by the *A-P Act*. Because this information may not be up-to-date, the *lead agency* should always make the final determination if a *project* is within and *Earthquake Fault Zone*. Figure 4.1 shows examples of hypothetical *projects* within, outside, and near an *Earthquake Fault Zone* as depicted on an *Earthquake Fault Zone Map*.

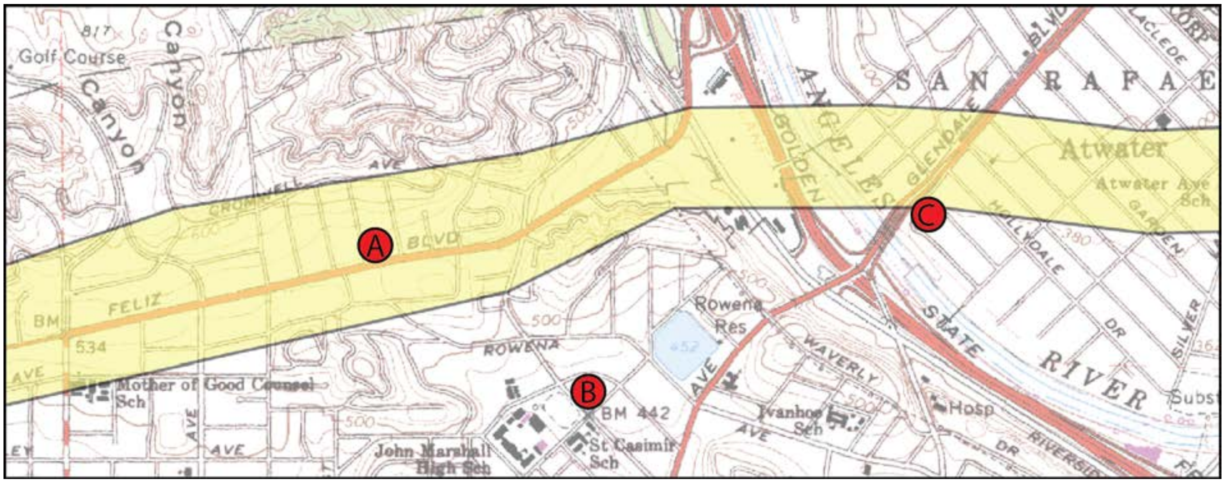


Figure 4-1. Illustration of *projects* (red circles) in, outside, or near, an *Earthquake Fault Zone (EFZ),* shown as the yellow shaded area. Site A (red circle with letter A) is within the *EFZ*, Site B is outside of the *EFZ* and Site C is near the *EFZ*. In this example, Site A would be regulated by the *A-P Act* and Site B is not regulated by the *A-P Act*. For Site C the *lead agency* should be consulted to determine if the *project* is located within the *EFZ*. The *EFZ* map is a portion of the Hollywood 7.5-minute Quadrangle *Earthquake Zones of Required Investigation Map*.

With certain exceptions, a *project* located within an *Earthquake Fault Zone* and regulated by the *A-P Act* generally includes new *structures for human occupancy* and subdivisions of land that will eventually include *structures for human occupancy*. Structures exempted by the *A-P Act* are dependent on additional criteria such as the type of development, characteristics of the proposed or existing structure, and the value of existing structures if they are being renovated. Plate 1 is a decision flow chart intended to aid *owners/developers* and *lead agencies* in determining if a *project* is regulated by the *A-P Act*.

4.4 What does it mean when a *project* is regulated by the *A-P Act*?

Earthquake Fault Zones are regulatory zones that address the hazard of *surface fault rupture* and are just one type of regulatory zone that address earthquake-related geologic hazards. Other types of regulatory zones address the potential for liquefaction and seismically-induced landslides, which are regulated by the Seismic Hazards Mapping Act. Collectively, these hazard zones are referred to as "Earthquake Zones of Required Investigation." Within Earthquake Zones of Required Investigation, geologic investigations are required prior to the construction of buildings or, prior to the subdivision of land for certain types of developments referred to in this document as "*projects.*" If a site-specific *fault investigation* finds a geologic hazard exists, appropriate mitigation measures must be proposed in the report prior to project approval by the *lead agency*.

The *A-P Act* addresses the hazard of *surface fault rupture* and, because the *A-P Act* explicitly prohibits the construction of *structures for human occupancy* across traces of *Holocene-active faults*, the only mitigation the *A-P Act* allows for is avoidance. This means that if a *Holocene-active fault* is found during a *fault investigation*, a *structure for human occupancy* will not be allowed to be built across that fault.

4.5 Steps that the *owner/developer* should take if their *projec*t is regulated by the *A-P Act*.

If a proposed *project* is regulated by the *A-P Act*, the *owner/developer* should discuss with the *lead agency* the scope of the *project* and identify what will be required by the *lead agency* to meet the requirements of the *A-P Act*. Additionally, *lead agencies* are able to enact regulations that are more restrictive than the minimum standard of the *A-P Act*. For example, *lead agencies* may establish their own regulatory hazard zones, as well as have additional regulations that include structures that are exempted by the *A-P Act*. It is always best to check with the local *lead agency* to determine what additional local requirements may exist.

The *owner/developer* will also need to retain, at his or her expense, the services of a *professional geologist*. A *professional geologist* who is the agent of the *owner/developer* is known as the *project geologist*. The *project geologist* is responsible for conducting the *fault investigation*, preparing the *fault investigation report*, as well as interacting with the *lead agency*'s *reviewing geologist* during the review of the *fault investigation report*. Early in the process, the *project geologist* will also work with the *owner/developer*, as well as the *lead agency*, to develop the scope of the *fault investigation* for the *project*. Finally, based on the results of the *fault investigation*, the *project geologist* will designate areas where structures can be located, as well as recommending *setbacks* from faults with the potential for *surface fault rupture*.

The *owner/developer* should be aware that in addition to bearing the cost of the *fault investigation*, the *owner/developer* may also be responsible for costs incurred by the *lead agency* for administering the *A-P Act* for individual *projects*, which can include expenses related to the review of the *fault investigation report*. Because the *fault investigation report* will be reviewed by the *lead agency*, it is recommended that the *project geologist* consult with the *reviewing geologist* regarding the scope of the *project* before the *fault investigation* begins, as well as during the *fault investigation*. Review of field exposures by the *reviewing geologist*, in conjunction with the *project geologist*, can aid the review of the *fault investigation report* by allowing the *reviewing geologist* to be more familiar with the *project* and identifying potential areas of disagreement prior to the review of the final *fault investigation report*. A collaborative approach between the *project geologist* and *reviewing geologist* can save the *owner/developer* time and money by minimizing multiple iterations of review comments and responses. Finally, the *owner/developer* should consider allowing the *project geologist* to invite geologists from the California Geological Survey to attend field reviews. While CGS does not play a role in the review of a *project* by a *lead agency*, site visits can help improve and inform updates to existing *Earthquake Fault Zone Maps* if important data regarding fault locations and activity are found at a site.

4.6 Real estate disclosure requirements

The *A-P Act* requires that all real estate parcel transactions within an *Earthquake Fault Zon*e be disclosed by the seller to prospective buyers before the sales process is complete (California Public Resources Code (CPRC) Division 2, Chapter 7.5, Section 2621.9). The real estate agent representing the property owner is legally bound to present this information to the buyer. When no realtor is involved in a transaction, the seller must inform the buyer directly. This is usually done at the time an offer is made or accepted. As part of the Natural Hazards Disclosure Act, this information is presented in a "Natural Hazard Disclosure Statement," which also includes other types of State-mapped and local hazard zones.

SECTION 5: GUIDELINES FOR GEOSCIENCE PRACTITIONERS (PROJECT AND REVIEWING GEOLOGISTS): EVALUATING THE HAZARD OF SURFACE FAULT RUPTURE

Note: Terms in *italics* are defined in Section 1, Definitions and Acronyms

5.1 Section Outline

5.2 Introduction

The purpose of this section is to provide guidance to *project geologists*, *reviewing geologists*, and *lead agencies* that have approval authority over *projects* based on *fault investigations* and *fault investigation reports*.

For the purposes of the *A-P Act*, an active fault is defined as one which has "had surface displacement within Holocene time" (the last 11,700 years). This definition does not mean that faults lacking evidence for surface displacement within Holocene time are necessarily inactive. A fault may only 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. By virtue that fault investigations are required by the *A-P Act* to assess the recency of fault movement implies that faults within an EFZ are presumed to be active until determined otherwise.

Terms such as "potentially active" and "inactive" have been commonly used in the past to describe faults that do not meet the SMGB definition of "active fault." However, these terms have the potential to cause confusion from a regulatory perspective, as they are not defined in the *A-P Act*, and may have other non-regulatory meanings in the scientific literature or in other regulatory environments. In order to avoid these issues, introduced below are terms that provide added precision when used in classifying faults regulated by the *A-P Act.* Faults are classified into three categories on the basis of the absolute age of their most recent movement and are shown on Figure 5.1 on a hypothetical trench log:

1) *Holocene-active faults*: Faults that have moved during the past 11,700 years. This age boundary is an absolute age (number of years before present) and is not a radiocarbon (^{14}C) age determination, which requires calibration in order to derive an absolute age.

2) *Pre-Holocene faults*: Faults that have not moved in the past 11,700 years, thus do not meet the criteria of "*Holocene-active fault*" as defined in the *A-P Act* and SMGB regulations. This class of fault may be still capable of surface rupture, but is not regulated under the *A-P Act*. Depending on available site-specific and regional data such as proximity to other active faults, average recurrence, variability in recurrence, the timing of the most recent surface rupturing earthquake, and case studies from other surface rupturing earthquakes, the *project geologist* may, but is not required to, recommend *setbacks*. Engineered solutions can also be considered by a licensed engineer operating within his or her field of practice.

3) *Age-undetermined faults*: Faults where the recency of fault movement has not been determined. Faults can be "age-undetermined" if the fault in question has simply not been studied in order to determine its recency of movement. Faults can also be age-undetermined due to limitations in the ability to constrain the timing of the recency of faulting. Examples of such faults are instances where datable materials are not present in the geologic record, or where evidence of recency of movement does not exist due to stripping (either by natural or anthropogenic processes) of Holocene-age deposits. Within the framework of the *A-P Act*, *age-undetermined faults* within regulatory *Earthquake Fault Zones* are considered Holocene-active until proved otherwise.

It is worth reiterating that a *project* located outside of an *Earthquake Fault Zone* is still regulated by the *A-P Act* if a *Holocene-active fault* is found at that site. This can happen if a *lead agency* has established its own regulatory zone requiring an assessment of *surface fault rupture* hazard or in a situation where a *Holocene-active fault* is discovered during a geologic investigation for that *project*. If located outside of an *Earthquake Fault Zone*, *age-undetermined faults* are not regulated by the *A-P Act*. However, the *project geologist* may want to consider all available data and provide recommendations regarding whether *setbacks* or other engineered solutions should be considered in the placement or design of a structure crossing these faults.

5.3 Items to Consider in the Site Investigation Study

The following concepts are provided to help focus the *fault investigation*:

1. The fact that a *project* lies within a designated *Earthquake Fault Zone* does not necessarily indicate that a hazard requiring *mitigation* is present at that site. Instead, it indicates that regional (that is, not site-specific) information suggests that the probability of a hazard is great enough to warrant a site-specific investigation. However, the working premise for the planning and execution of a site investigation within an *Earthquake Fault Zone* (EFZ) is that ***the suitability of the site must be demonstrated***. This premise will persist until either: (a) the *fault investigation* satisfactorily demonstrates the absence of *surface fault rupture* hazard, or (b) the site investigation satisfactorily defines the *surface fault rupture* hazard and provides a suitable *setback* recommendation for its *mitigation*.

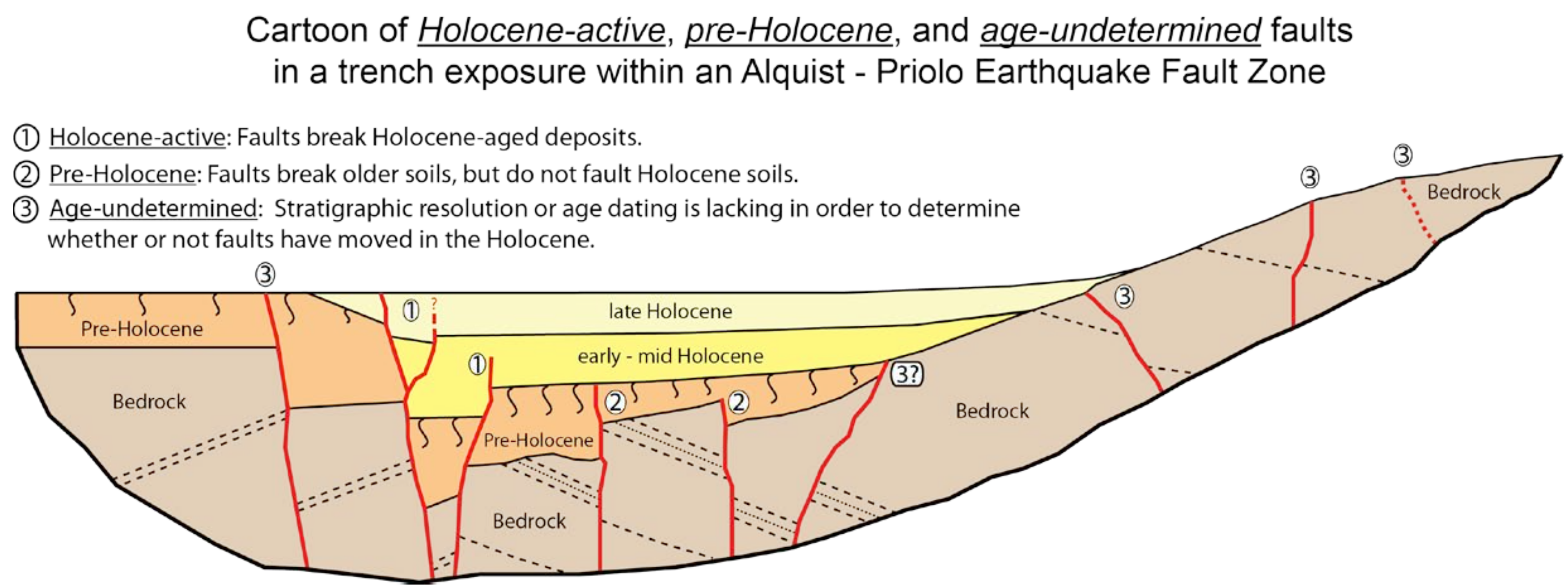


Figure 5-1. Fault classifications in a hypothetical trench log where *Holocene-active faults* break Holocene-age deposits and *pre-Holocene faults* break pre-Holocene age deposits, but not Holocene age deposits. The recency of movement for *age-undetermined faults* are unconstrained due to a lack of overlying deposits to determine the timing of the most recent fault displacement.

2. The fact that a *project* lies outside a mapped *EFZ* does not necessarily mean that the site is free from seismic or other geologic hazards, nor does it preclude *lead agencies* from adopting regulations or procedures that require site-specific fault and/or geologic investigations and mitigation of seismic or other geologic hazards. It is not always possible for CGS geologists mapping at a regional scale to identify all *Holocene-active faults*; not all faults, including *Holocene-active faults,* meet the criteria of well-defined. Furthermore, in California there have been examples of *faults* that were understood to be *pre-Holocene* that have ruptured in historical time. These instances of faulting underscore the importance of considering the *surface fault rupture* hazard to *projects*, even when they are not regulated by the *A-P Act*. It is the responsibility of the *project geologist* to inform his or her client and the *lead agency* of the presence of a *Holocene-active fault* on a site and it is the responsibility of the *lead agency* to prohibit *structures for human occupancy* across the trace of *Holocene-active faults*, whether that fault is found inside or outside of an *EFZ*.

3. *Lead agencies* have the right to approve, and the obligation to reject, a proposed *project* based on the findings contained in the *fault investigation report* and the *lead agency's* technical review. The task of the *owner/developer's project geologist* is to demonstrate, to the satisfaction of the *lead agency,* which is advised by the *lead agency*'s *reviewing geologist*, that:

    - The site-specific *fault investigation* is sufficiently thorough;
    - The findings regarding *surface fault rupture* hazards are valid and persuasive; and,
    - Any proposed *setbacks* are sufficient to account for both *Holocene-active fault traces* and *fault-related ground deformation*.

5.4 Site-Specific *Fault Investigations*

The primary purpose of a site-specific *fault investigation* is to determine the presence or absence of existing faults and evaluate the recency of their past activity, which can be a deceptively difficult geologic task. Most faults are complex, consisting of multiple breaks and can exhibit both brittle and plastic (e.g. folding) deformation. The evidence for identifying *Holocene-active fault* traces sometimes is subtle or obscure and the evidence necessary to conclude the lack of Holocene activity may be difficult to obtain and locally may not exist. A basic assumption in this discussion is that a *fault investigation* is being conducted because of the presence of an *A-P Earthquake Fault Zone* (EFZ), a *lead agency's* requirement for it based on local information, or some other regional evidence of *Holocene-active faulting* on or near the site. A *project geologist* ideally will have a high level of experience in conducting *fault investigations* and will be familiar with and employ the current state-of-the-practice techniques. Because the existing literature on conducting fault investigations is quite robust (e.g. see, Lund and others, 2016, and McCalpin, 2009), these guidelines will only briefly cover the topic.

Whenever a *fault investigation* is initiated, the *project geologist* should contact the *lead agency* and its *reviewing geologist*. The purpose for this initial contact is three-fold:

1. The *lead agency* may have records of previous *fault investigations* on or in the vicinity of the *project* site that can be useful to the site investigation and the *fault investigation report*.

2. The *lead agency or reviewing geologist* can inform the *project geologist* of local ordinances, such as differences in exemptions to *projects* than what are specified in the *A-P Act*, or specified *setbacks* from *Holocene-active faults*.

3. The *reviewing geologist* can inform the *project geologist* about local investigations, reporting requirements, and expectations. The *project geologist* can inform the *reviewing geologist* what investigation methods are to be used and when those methods will be conducted, and both parties can discuss how to handle possible complications that can arise from investigation results, such as how the *lead agency* will want to handle *age-undetermined faults* or *fault-related ground deformation*.

It is highly recommended that the *project geologist* consult with the *reviewing geologist* regarding the scope of the *project* before the *fault investigation* begins, as well as during the *fault investigation*. Review of field exposures by the *reviewing geologist*, in conjunction with the *project geologist*, can aid the review of the *fault investigation report* by allowing the *reviewing geologist* to be more familiar with the *project* and identifying potential areas of disagreement prior to review of the *fault investigation report*. A collaborative approach between the *project geologist* and *reviewing geologist* can save the *owner/developer* time and money by minimizing multiple iterations of review comments and responses. Finally, the *owner/developer* should consider allowing the *project geologist* to invite geologists from the California Geological Survey to attend field reviews. While CGS does not play a role in the review of a *project* by a *lead agency*, site visits can help improve and inform updates to existing *Earthquake Fault Zone maps* if important data regarding fault locations and activity exist at a site.

Surficial Investigations

Surficial geologic and geomorphic mapping should be conducted early in the investigation and include an area surrounding the immediate vicinity of the *project* site. The purpose of the surficial mapping is to identify fault-related geomorphic features and should begin with a compilation of existing literature on the local geology and any previous fault-related studies in the area. In particular, previous *fault investigation reports* on the current and nearby sites should be sought out and the results incorporated. CGS maintains an online database of *fault investigations* that *lead agencies* submit as part of the *A-P Act*:

https://spatialservices.conservation.ca.gov/arcgis/rest/services/CGS/

Observations, measurements and mapping ideally employ the use of both remotely sensed imagery and field-based work. This work can provide a sense of past fault movement and is critical for locating fault trenches and other subsurface investigations in order to yield the most beneficial results.

The traditional remote sensing technique for *fault investigations* has been the use of stereo-paired aerial photography. Ideally, multiple sets of variable vintage photographs, including pre-development photos, are used to interpret fault-related geomorphic features, vegetation and soil contrasts, lineaments, and other features of possible fault origin. Lidar-based (Light Detection and Ranging) imagery (e.g. hillshade and slopeshade maps, topographic profiles) processed from high-resolution elevation measurements has become an important tool for geomorphic interpretation. Most *EFZ*s have had lidar flown as part of the B4 Project at OpenTopography (http://www.opentopography.org/) and other important lidar elevation datasets for California are also available through this organization. In addition, a number of counties have had lidar elevation data flown and have made them available (e.g. Los Angeles County - https://egis3.lacounty.gov/dataportal/tag/lidar/). The USGS also hosts some lidar datasets for California (https://nationalmap.gov/3DEP/). Another recent technique that has been employed in geomorphic interpretation is photogrammetric-based "structure-from-motion" (Westoby and others, 2012). This method uses multiple, overlapping photographs to create 3-dimensional models of the ground surface that, when coupled with high-precision ground control, can provide accurate, high resolution imagery for fault investigations.

Field-based surficial observations include mapping the distribution of geologic and soil units, geomorphic features indicative of possible faulting, springs, deformation of engineered structures due to fault creep, and any other features or anomalies identified with remote sensing techniques.

Subsurface Investigations

Subsurface *fault investigations* are primarily conducted through the use of fault trenches to expose *fault traces* and their effects on shallow stratigraphic units. However, other methodologies are often used, either in conjunction with trenching or as substitutes where trenching is not feasible. In some cases, it will be necessary to extend some of the investigative methods well beyond the site or property being investigated. These can be broken into two broad categories: 1) physically drilling and sampling subsurface geologic materials, and 2) using geophysical techniques to measure subsurface material properties. The subsurface methods are discussed in more detail below.

Trenching

Trenching is the most common type of subsurface fault investigation and offers several advantages over other methods including direct observation of subsurface geologic relationships and the ability to easily sample geologic materials for chronologic dating (Taylor and Cluff, 1973; Hatheway and Leighton, 1979; McCalpin, 2009b). Trenches excavated for the purpose of determining recency of fault activity should be excavated as orthogonal to the trend of a mapped fault as feasible because faulting relations become increasingly difficult to identify and measure if the exposure is oblique to the local trend of faults. Siting trench locations should also consider possible projections of nearby mapped faults and possible unmapped splay faults, to ensure that areas within, and close to, the building footprint are not affected by *Holocene-active faults*.

Trench walls should be cleaned to expose key stratigraphic and structural relations including marker horizons and faults. While cleaning of trench walls can be labor and time intensive, fault-related features can be subtle and often require careful and repeated scraping in order to create an exposure that can be interpreted with confidence. Techniques to clean trench exposures typically include scraping, picking, and brushing. In general, faults, especially those with minor apparent displacements, are most readily identifiable when the trench wall is scraped as smooth as possible. In some investigations, pressure washing with water or using a leaf blower has been successful in etching mappable layers with subtle differences in grain size. The *project geologist* should consider and employ the cleaning technique that will best create an interpretable exposure.

Stratigraphic and structural relations should be logged at a scale appropriate to record the characteristics that demonstrate the presence or absence of faulting. The *project geologist* should consider whether or not the stratigraphic relations are adequate to resolve whether faulting can be confidently identified within the exposed section. Observations regarding continuity of key units, ability to identify key marker horizons and degree of bioturbation that may obscure faulting relations should be recorded on the logs. Care should be taken to document even minor faulting: Faults with small apparent offsets, especially vertical offsets along dominantly strike slip faults, can have significant true net displacements.

Photographic documentation of trench exposures is now a common practice and offers the advantage of the visual documentation of trench exposures that provides additional objective documentation of geologic relationships in a subsurface exposure. Photographs of key geologic relationships provide supporting documentation that aids in the review of the *fault investigation report*. Furthermore, with the advent of modern easy to use, affordable structure-from-motion (e.g. softcopy photogrammetry) software, ortho-rectified photo-mosaiced trench logs can be quickly produced. These type of trench logs offer the advantage of giving the *project geologist* a synoptic view of the structural and stratigraphic relations, which may not be readily apparent in a narrow slot trench.

Where the ability to preclude Holocene faulting through trenching is limited by high groundwater or thick Holocene deposits, borings can be used to supplement trenching. However, in many cases, trenching to the maximum feasible depth will still be valuable in order to make direct observations regarding the character of subsurface deposits. It also provides the opportunity to collect samples for dating to constrain the age of shallow materials and develop a comprehensive chronologic model.

Drilling and Sampling

Large-diameter borings, which can be accessed and logged by a geologist, can provide a detailed picture of subsurface stratigraphy and opportunities for the selection of age-datable samples. Small-diameter borings that capture continuous core also can provide stratigraphy and material for age dating. The cone penetrometer test (CPT) measures a deposit's resistance to penetration, or tip resistance, and the granular nature of soils, or sleeve friction, as it is pushed into the ground (Grant and others, 1997; Edelman and others, 1996). Generally, the CPT is not used to collect soil samples but the continuous measurement of "soil behavior" provides a reliable stratigraphic section. Because of the relatively low cost of the CPT, this tool is frequently used in urban environments where trenching and other drilling methods are difficult. However, CPT is best done in conjunction with one or more continuously logged borings to correlate CPT results with on-site materials. As with boring transects, CPT borings should be appropriately spaced in order to address the type of faulting that is anticipated. For example, strike-slip faults may require borings that are more closely spaced than other types of faulting (normal faulting, reverse faulting). Some *lead agencies* may specify minimum requirements for the spacing of borings along transects for *fault investigations*. The *project geologist* should check with the *lead agency* for any requirements when planning a *fault investigation* for a *project*.

All three of these boring methods can be used to measure ground water levels useful for identifying fault-related ground water barriers, but large-diameter borings are often susceptible to collapse and typically cannot safely be downhole logged below the water table. Without the continuous exposure provided by a trench, direct observation of a fault in any of these drilling methods may not be possible, and the reliable identification of faulting is more uncertain. The strength of these methods lies in creating a stratigraphic cross-section across a faulted area with a line of closely spaced borings and/or CPT soundings that provides evidence of faulting through vertical separation of stratigraphic units. Because the spacing required to prepare an adequate cross-section depends on the stratigraphy, type of faulting, ground water conditions, and presence of local infrastructure, it is recommended that the *project geologist* consult with the *reviewing geologist* to see if the *lead agency* has requirements for this type of investigation and to assist in the development of an appropriate exploration plan. Caution should be exercised when employing these methods on strike-slip faults, as two-dimensional cross-sections may not provide adequate resolution if a fault has little-to-no vertical separation. Both the *project geologist* and the *reviewing geologist* should also be aware that geologic cross-sections are often non-unique interpretations of data, and that multiple working hypotheses should be considered when working with these types of subsurface data. For example, distinguishing channel margins from faulting without the advantage of direct observation can be challenging and may require deeper or additional more closely spaced borings. It is the responsibility of the *project geologist* to provide both the interpretation of the feature in question and the data that supports the interpretation, as well as an explicit discussion regarding the uncertainties in interpretation.

Geophysical Techniques

Geophysical methods provide a non-invasive way to measure certain properties of subsurface deposits that can help locate fault traces. Chase and Chapman (1976), Stephenson and others (1995), Cai and others (1996), and McCalpin (2009) provide examples of the use of seismic reflection, seismic refraction, magnetic, gravity, electrical resistivity, and ground penetrating radar methods in fault studies. Because geophysical methods alone can only provide a range of alternative interpretation for what exists in the subsurface, they should be used to guide and/or augment geologic data derived from mapping, trenching, and drilling in fault investigations (Chase and Chapman, 1976). While geophysical methods have value in locating potential faults and connections between mapped faults, they rarely provide information on the recency of activity unless accompanied by a subsurface investigation method that retrieves samples for dating.

5.5 Geochronology (Age-Dating) Methods

Estimating the age of fault activity relies on dating geologic units that predate and postdate faulting (Pierce, 1986; Birkeland and others, 1991; Rutter and Catto, 1995; McCalpin, 2009a). Site-specific *fault investigations* expose the fault zone at the *project* site to determine which *fault traces* are *active. However, t*he evaluation of a *fault* may not be limited to information derived solely from a *project* site, especially if higher-quality relevant information exists elsewhere. It is common that structural relationships pertaining to *fault* rupture timing exist onsite while quantitative chronologic data may be better defined offsite, or the opposite situation may exist. When there is a potential to acquire quantitative chronological data at the site of interest, it should be obtained. All chronological data pertaining to the project from on- and offsite sources should be considered and reported in the investigation, and a comprehensive case for the chronology of faulting specific to the project should be the presented.

There are many Quaternary age-dating methods that can be applied to characterizing fault activity (Noller and others, 2000; Lettis and Kelson, 2000; Preusser et al, 2008; McCalpin, 2009) but only a subset of these are applicable to deposits in the late Pleistocene to present age range (roughly the last 130,000 years). Table 5-1 provides a list of the most commonly used methods, their age and uncertainty ranges, the property measured and sample material, and criteria for choosing a methodology. Because accuracy and precision are valued criteria in fault investigations, quantitative (chronometric) dating methods are preferred if samples for dating can be obtained. Radiocarbon (^{14}C) dating is the most widely used dating method and the *project geologist* should use it when possible or justify why it was not used. Radiocarbon dating has proven to be very reliable and cost effective, and is the most widely understood and applied method for active fault characterization. Relative dating methods, such as soil profile development index, are prone to subjectivity and significantly greater uncertainty. Ideally, relative dating methods are used to complement quantitative dating methods, or when they are the only methods that can be utilized. Often the relative methods provide chronology guidance during the initial phase of fault investigations. Other methods that have been used in *fault investigations* but will not be covered in these guidelines include: landform development, stratigraphic correlation of rocks/minerals/fossils, archeological artifacts, historical records, tephrochronology, fault scarp modeling, paleomagnetism, dendrochronology, and rock and mineral weathering.

Geochronology Uncertainty

The *project geologist* should understand the uncertainty associated with any age determination in the evaluation of fault activity. All sources of uncertainty should be considered and addressed in the *fault investigation report*. The three primary sources of uncertainty in age determinations are:

Context Uncertainty

Context uncertainty generally represents the largest uncertainty in dating fault activity, and consists of the generally poorly known relationship of the chronologic measurement of an individual sample to the faulting event of interest. For example, a ^{14}C date derived from a detrital charcoal sample may have a considerable inherited age because it was either reworked from an older sedimentary unit or because it was derived from older wood that does not represent the deposit age, such as the core of a long-lived tree. For all quantitative dating methods, the context uncertainty can be thought of as the unknown age difference between the event of interest and the dated samples.

Laboratory Uncertainty

There are inherent laboratory uncertainties associated with each quantitative dating method that need to be considered in any chronological assessment. These uncertainties are difficult to reduce, although, dating of additional samples can improve accuracy and confidence.

Chronologic Modeling Uncertainty

All chronological data must be interpreted to assess the age of faulting. In general, this requires some extrapolation or interpolation, or bracketing of the event of interest. How the data are related to the event of interest is a “chronologic model.” The type of model used will influence the chronological result. For example, when evaluating a scatter of different sample ages from one geologic unit, a decision must be made as to how to use the results. One may have sample ages from two different sample types, or different dating methods, or there may be stratigraphically inconsistent results. A careful consideration of each chronological constraint must go into the development of the chronologic model.

Common Dating Methods for Determining Fault Activity

Radiocarbon Dating (^{14}C)

Radiocarbon dating is by far the most common age-dating method applied to *fault investigations* because it is accurate within an age-range extending to 50,000 years before present, and datable samples are generally available. With fast laboratory turn-around times possible (days to about a week), it is often feasible to get results while the field work is ongoing and thus provide valuable guidance for completing the investigation. Radiocarbon dating consists of an isotopic method based on measuring the ratio of unstable ^{14}C isotope to stable ^{12}C in organic compounds (Taylor and others, 1992). The method is based on the fact that all living organisms exchange carbon with the surrounding environment, a small fraction of which is the unstable isotope ^{14}C as opposed to the stable ^{12}C isotope (Trumbore, 2000). When an organism dies, the exchange of fixed carbon between the organism and the environment stops and the amount of ^{14}C starts decreasing at a known rate due to radioactive decay. This ^{14}C decay provides a clock that is used to calculate a quantitative age.

Table 5-1. Most Applicable Age Dating Methods for Fault Activity Investigations.

Method	Age Range / Uncertainty Range	Property Measured / Sample Materials	Application Criteria
Radiocarbon Dating	0 to 50,000 years 2 to 5%	^{14}C Organic matter	Most favored method due to its proven reliability to provide objective results. • multiple sample analyses allow an increase in confidence and accuracy • fast turn around • single dates can be misleading due to the difficulty in evaluating the context uncertainty
Luminescence	100 to 100,000 years Greater than 10%	Luminescence Quartz or Feldspar Crystals	Often suitable where sand-size material exists and when little C-14 dateable material can be found. Often requires research level effort to properly integrate all aspects of the method. Can provide reliable age estimate if done correctly. • strict sampling protocol • may complement ^{14}C well, as it can help assess context uncertainty
Cosmogenic nuclide	1,000 to 2,000,000 years Greater than 10%	^{10}Be, ^{26}Al, ^{36}Cl Quartz Feldspars Carbonates	Unique for its ability to date surfaces or burial events. Often requires research level effort to properly integrate all aspects of the method. Can provide reliable age estimate if done correctly. • strongly influenced by sampling protocol • accurate results are model dependent
Soil Profile Development Index (SDI)	500 to 500,000 Greater than 30%	Numerous Alteration of parent material	Requires quantitative dating of similar soil profiles in the area as calibration. Significant expertise is required for SDI age estimates.

In the case of plant material, where the original amount of ^{14}C in the atmosphere has varied through time, an additional calibration with known age samples from tree rings provides an accurate calendar age correction called "dendrocalibration" (Stuiver and others, 1993). Radiocarbon dating can be more challenging with other types of samples; aquatic-based (marine or fresh water) organisms, such as invertebrate shells, can obtain carbon from water with a significant "reservoir effect," resulting in a lag time (biasing the sample to be older than its true age by several hundred years or more) that requires a correction factor. In this case, the resulting ages may be too old and are termed "apparent ages." These apparent ages can be calibrated but are associated with additional uncertainties.

Currently, two laboratory methods are used in radiocarbon dating (Trumbore, 2000): decay counting, and the more recent Accelerator Mass Spectrometry (AMS) measurement. The main difference of concern to the practitioner is that AMS methods can be more readily used because the sample size requirement is orders of magnitude less: 0.2 to 2 milligrams with AMS versus 3 grams with decay counting of carbon remaining after pretreatment. Because normal pretreatment procedures remove 25% to 80% of the original sample material, a sample larger than 3 grams is required for the decay counting method, which can be difficult to obtain. The most common sample type used for ^{14}C dating is detrital charcoal, which is most commonly found in sand to clay-sized sediments.

<u>^{14}C Sample Contamination</u>

Sample contamination is a process that can shift ^{14}C age-dating results. However, the phenomenon is widely misunderstood and in some investigations has erroneously been used to justify the rejection of otherwise valid results or to justify not using ^{14}C dating at all. The process of sample contamination consists of adding material of a different age to the carbonaceous sample after deposition. In general, as carbonaceous material in the ground gets older, samples become increasingly susceptible to "rejuvenation contamination," due mostly to younger plant roots penetrating the older deposited material. In almost all cases, contaminant material can be visually detected with a microscope and all samples are physically and chemically pretreated to remove contaminant compounds. These pretreatment procedures are very effective and provide reliable results. Sample contamination in which laboratory results of younger material return older dates is relatively rare.

A common misconception is that ground water contamination of detrital charcoal is a contributes to radiocarbon ages that do not represent the true age of the sample. In reality, nearly all detrital charcoal experiences some degree of wetting from ground water and standard laboratory pretreatments have been proven to be highly effective in removing contamination from this source. Research by Pigati and others (2007) has shown that contamination can significantly affect samples that are already very old, while the impact of contamination for samples less than 20 ka old, which includes the time frame of interest for most *A-P Act* triggered fault investigations, is negligible.

It is useful to examine samples with a microscope in order to assess their composition prior to submitting to a laboratory for dating and communicate to the laboratory the objective of what event one is trying to date, which may influence the laboratory procedures. For example, samples often contain multiple carbon fractions that can be of different ages. If one does not know with certainty what carbon fraction to measure, they can instruct the laboratory to preserve various extracted carbon fractions for potential dating after initial results are evaluated.

One type of contamination from which samples and laboratories cannot recover is the introduction of artificial ^{14}C into a sample. Artificial ^{14}C is used in biological research as a tracer. The concentration of artificial ^{14}C can be 100,000 times more than bio-based materials and the laboratory detection methods are simply overwhelmed by the abundance. Because the ^{14}C tracer is not visible it is very difficult to avoid and easily spread unintentionally. The only remedy is complete avoidance of any sources, or facilities where ^{14}C tracers have been used (Zermeno and others, 2004). Some laboratories will request information regarding sample storage prior to submission in order to screen samples that may have been exposed to ^{14}C tracer, as this type of contamination can be detrimental to a dating laboratory's operations.

Radiocarbon Sample Collection

The following sample collection procedures, or "best practices", will facilitate obtaining accurate chronologic age control of faulting:

- Collect multiple samples from layers of interest.
- Collect more samples than anticipated for laboratory testing. This practice provides a back-up if laboratory results or development of the chronologic model could benefit from additional laboratory determinations after trenches are backfilled.
- Individual samples are preferable to bulk or combined samples. Bulk or combined samples result in average ages with increased context uncertainties.
- Bulk samples of organic-bearing sediments should be collected, especially when individual organic samples are not discernable in the field. Bulk samples can be sieved and microscopically inspected to find individual samples. As such, bulk samples also provide a backup to individual samples. However, dating bulk samples may introduce larger contextual uncertainties due to the mixing of organic materials that may have different ages.
- Minimize the context uncertainty by collecting organic material formed in place (*in situ*). These sample materials, such as peat, are preferable to samples that are often associated with significant context uncertainty such as detrital charcoal.
- Sample storage and transport must avoid contaminating samples. Contact with artificial ^{14}C will render samples useless and cause expensive damage to laboratory facilities. If there is any question about the integrity of the samples, communication with the dating laboratory is essential.

Considerations in Evaluating Radiocarbon Results

A large body of published research related to dating of samples and development of chronologic models applied to paleoseismic studies exists in the literature (e.g. Scharer et al, 2011). Listed below are several guidelines a *project geologist* and *reviewing geologist* should keep in mind when evaluating results obtained from radiocarbon dating:

- Several dates may be required to identify a representative depositional age of a stratigraphic layer.
- Several individual detrital charcoal samples from a single layer may result in a spread of ages of several hundred years or more. This spread may

indicate that either the source of charcoal is derived from long-lived trees or that depositional reworking is significant. If bioturbation does not affect the area from which the sample was collected from, then the youngest age is the most representative of the deposit age.

- Results from bulk sample dating are usually more difficult to interpret because they generally consist of an unknown mixture of various-aged organic materials. Bulk sample ages may be significantly older than the depositional age of the layer. However, bulk sample dating results, in the absence of other quantitative dates, can be valuable as limiting ages in context with other chronological data.
- Consider the sample context, sample material, and other chronological information when assessing the age of faulting. Considerations include:

    - Are radiocarbon sample ages within individual units consistent with each other?
    - Are radiocarbon ages from successive layers in the correct stratigraphic age order?
    - Do layers that have been correlated across the site exhibit consistent ages?
    - Are different sample materials providing consistent results?
    - Which samples are outliers?
    - Is there consistency with other dating methods? If not, then what are the possible explanations for the inconsistencies?

Luminescence Dating

Luminescence techniques (Forman, 2000, Preusser and others, 2008) measure the time since mineral grains were exposed to sunlight (Optically Stimulated Luminescence - OSL; Infrared stimulated luminescence - IRSL) or heat (Thermoluminescence - TL). The luminescence signal accumulates in minerals such as feldspars and quartz, being induced by naturally occurring radioactivity from the material surrounding the sample. The radioactivity excites electrons within the minerals, which are trapped in defects within the crystal lattice. The controlling factors are the dose rate and the time since exposure. The dose rate varies at each sample site and thus requires, in order of preference, either an in-place measurement, or a sample for neutron activation measurement. Another controlling parameter is the number of crystal defects within the mineral grains which has a significant influence on the suitability of this method. The effective age range of luminescence dating methods is from hundreds of years to more than 100,000 years, depending on the number of crystal defects and the local dose rate. Considerable research-level effort is required for these methods and involving an expert will likely improve the potential for successful outcomes.

<u>Considerations in Luminescence Sample Collection</u>

Luminescence methods require a particular prescribed sampling protocol, which includes detailed information about the geological context, depositional history, environment, and hydrological conditions (moisture content). The various methods and laboratories have sampling protocols, and it is recommended that the *project geologist* consult with an expert before samples are collected. In particular, samples need to be collected in a fashion that prevents the sediment from being exposed to light during sampling and transport to the laboratory. In addition, the dose rate must be determined at each individual sample location, either by in-place measurement or by taking a bulk sample for laboratory measurement.

Cosmogenic Nuclide Methods

Cosmogenic nuclide dating methods, mostly surface exposure applications (e.g., Ivy-Ochs and Kober, 2008, Benedetti and Van der Woerd, 2014) have been applied to characterize fault activity. These radio isotopic methods use isotopes such as ^{10}Be, ^{26}Al, or ^{36}Cl, as an accumulation clock, with a secondary decay clock based on the half-life decays of these same isotopes. Using multiple isotopes can improve the accuracy of these applications. The isotopes are measured by accelerator mass spectrometry (AMS). As with luminescence dating, considerable research-level effort is required for these methods and involving an expert will likely improve the potential for successful outcomes.

Soil Profile Development Dating

Soils result from the chemical and physical alteration of sediments and rocks at Earth's surface, and are strongly influenced by the interaction of the soil parent material with organic compounds and water. Many factors control the degree of soil development, of which time since deposition is perhaps the most significant to fault studies (Birkeland, 1984, 1990, Rockwell, 2000, Sauer and others, 2014). Soil profiles consist of horizons, which are the characteristic layers that distinguish one type of soil from another, and they form in relatively stable (non-erosional) conditions during times of non-deposition of sediments.

There are many measures of the strength of a soil profile, such as thickness and amount of alteration as measured by accumulation or depletion of chemical elements compared to the original parent material. Field description procedures have standards that should be used (*Schoeneberger, Wysocki, Benham, and Soil Survey Staff, 2012*). Regardless of whether one uses soils to arrive at an age estimate, every practitioner using trenches for investigating faults should have a basic understanding of soil formation (Birkeland, 1984. Borchardt, 2010, Rockwell, 2000) as they can inform on the general age of the sediment exposed in the trench, as well as provide mappable horizons to evaluate the presence or absence of faulting.

To obtain an age estimate for a soil, a semi-quantitative soil development index (SDI) has been developed (Harden, 1982) and refined by McFadden and Weldon (1987), McFadden (1988), Rockwell and others, (1985, 1994), and Birkeland and others (1991). However, the rate of soil-profile development must be locally calibrated by quantitative dating methods before reliable age estimates can be made. Poor application or lack of this crucial step has often downgraded the useful application of this method and made it unreliable. In practice, and in light of the availability and improvements of quantitative dating methods, soils expertise is a valuable complement to fault investigations.

Chronological Modeling

To assess the age of fault activity, the *project geologist* should develop a chronological model that considers all relevant chronological data and the relative uncertainties associated with the methods used. This can be as simple as bracketing the age of the most recent fault activity between quantitative dates but can become a complicated undertaking when several chronological inputs, including uncalibrated ^{14}C dates, are considered. To the extent possible, the *project geologist* should have a working chronological model before the trench is closed so that it can be presented to the *reviewing geologist* and discussed in the field.

Chronological modeling software such as Oxcal (Bronk Ramsey, 1994) provides an efficient web-based tool that provides a controlled method to incorporate multiple types of chronological data. A primer for paleoseismic applications using Oxcal is provided by Lienkaemper and Bronk Ramsey (2009). Another, ^{14}C-specific, online calibration tool is CALIB (Stuiver and others, 2017).

5.6 Contents of *Fault Investigation Reports*

The following topics should be considered and addressed in detail where essential to support opinions, conclusions, and recommendations, in any *fault investigation*. It is not expected that all of the topics or investigative methods outlined below will be necessary in a single investigation.

I. Text.
   A. Purpose and scope of investigation; description of proposed development.
   B. Geologic and tectonic setting, including seismicity and historical accounts of earthquakes.
   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. Surficial investigations
         a. Geomorphic interpretation: description of methods used and findings.
         b. Field-based observations: description of methods used and findings.
      3. Subsurface investigations.
         a. Trenching and other exposures providing detailed and direct observation of continuously exposed geologic units, soils, faults, and geologic structures.
         b. Borings and cone penetrometer testing (CPT) providing measurements and physical samples of geologic units and

ground water at specific locations. The number and spacing of borings and CPT soundings should be sufficient to adequately image site stratigraphy.

c. Geophysical investigations: description of equipment and techniques used, data processing methods, and findings; supporting data should be presented.

4. Fault Activity and Chronology: description of methods used and findings. If radiometric dating (especially 14C) is not used, the report should state reasons why.
5. Other methods should be discussed when special conditions permit or requirements for critical structures demand a more intensive investigation, such as aerial reconnaissance overflights, and microseismicity monitoring.

E. Conclusions.

1. Location and existence (or absence) of all faults on or adjacent to the site; ages of past rupture events where determined or estimated.
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 ground deformation*.
4. Probability of, or relative potential for, future surface displacement. The likelihood of future ground rupture seldom can be stated quantitatively, but may be stated in semi-quantitative 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, including a discussion regarding stratigraphic resolution and ability to confidently identify faulting within the exposed stratigraphic section.

F. Recommendations.

1. Setback distances of proposed structures from *Holocene-active* or *age-undetermined faults*. The setback distance generally will depend on the quality of data, type and complexity of fault(s), and extent and severity of *fault-related ground deformation* encountered at the site. Lead agency regulations may dictate minimum distances (e.g., see Appendix D).
2. Additional measures (e.g., strengthened foundations, ground improvement, flexible utility connections) to accommodate warping and distributed deformation associated with faulting.
3. Limitations of the investigation; need for additional studies.

II. References.

A. Literature and records cited or reviewed; citations should be complete.

B. Aerial photographs, lidar data or other imagery used in geologic and geomorphic interpretations - 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. Regional location maps - 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 traverses, locations of faults, and other data; recommended scale is 1:2,400 (1 inch equals 200 feet), or larger.
   C. Site geologic and geomorphic maps - show distribution of geologic and/or soil units, 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. Logs should be drawn on mosaicked and rectified color photographs whenever possible. 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. Appendices: Supporting data not included above (e.g., water well data, photographs, aerial photographs, lab reports).

V. Authentication: Geologic reports require both the *Project geologist's* signature and must be stamped with his or her seal, per the Geologist and Geophysicist Act (Business and Professions Code section 7800-7887).

5.7 References

Allen, C.R., 1975, Geologic criteria for evaluating seismicity: Geological Society of America Bulletin, v. 86, p. 1041-1056.

Athanassas, C.D., Wagner, G.A., 2016, Geochronology Beyond Radiocarbon: Dating of Paleoenvironments and Archeological Sites, Elements, vol. 12, p. 27-32.

Benedetti, L., C., Van der Woerde, J., 2014, Cosmogenic Nuclide Dating of Earthquakes, Faults, and Toppled Blocks, Elements, vol. 10, p. 357-361.

Birkeland, P.W., 1984, Soils and Geomorphology: Oxford University Press, New York, 372 p.

Birkeland, P.W., 1990, Soil geomorphic research – A selective overview: Geomorphology, v. 3, p. 207-224.

Birkeland, P.W., Machette, M.N., and Haller, K.M., 1991, Soils as a tool for applied Quaternary geology: Utah Geological and Mineral Survey Miscellaneous Publication 91-3, 63 p.

Bonilla, M.G., 1970, Surface faulting and related effects, in Wiegel, R.L., editor, Earthquake Engineering, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, p. 47-74.

Bonilla, M.G., 1982, Evaluation of potential surface faulting and other tectonic deformation: U.S. Geological Survey Open-File Report 82-732, 58 p.

Bonilla, M.G., and Lienkaemper, J.J., 1991, Factors affecting the recognition of faults in exploratory trenches: U.S. Geological Survey Bulletin 1947, 54 p.

Borchardt, G., 2010, Determining Relative Age of Faulting by Using Soil Stratigraphy: Problems and Misconceptions, Environmental & Engineering Geoscience, vol. XVI, no.1, p. 31-39.

Bronk Ramsey, C. 1994. Analysis of Chronological Information and Radiocarbon Calibration: The Program OxCal. *Archaeological Computing Newsletter, 41*, 11-16.

Cai, J., McMecham, G.A., and Fisher, M.A., 1996, Application of ground-penetrating radar to investigation of near-surface fault properties in the San Francisco bay region: Bulletin of the Seismological Society of America, v. 86, p. 1459-1470.

California Geological Survey Notes:
CGS NOTE 41 - General guidelines for reviewing geologic reports, 1997.
CGS NOTE 49 - Guidelines for evaluating the hazard of surface fault rupture, 1997.

California Geological Survey, 2008, Guidelines for evaluating and mitigating seismic hazards in California: Special Publication 117A, 98p.

Carver, G.A., and McCalpin, J.P., 1996, Paleoseismology of compressional tectonic environments, in McCalpin, J.P., editor, Paleoseismology: Academic Press, p. 183-270.

Chase, G.W. and Chapman, R.H., 1976, Black-box geology -- uses and misuses of geophysics in engineering geology: California Geology, v. 29, p 8-12.

Edelman, S.H., and Holguin, A.R., 1996, Cone Penetrometer Testing for characterization and sampling of soil and groundwater, in Morgan, J.H, editor, Sampling Environmental Media ASTM STP 1282: American Society for Testing Materials, Philadelphia, Pennsylvania.

Forman S. L, Pierson, J., and Lepper, K. 2000, Luminescence Geochronology, Quaternary Geochronology: Methods and Applications, AGU Reference Shelf 4, p. 157-176.

Grant, L.B., Waggoner, J.T., Rockwell, T.K., and von Stein, C., 1997, Paleoseismicity of the North Branch of the Newport-Inglewood fault zone in Huntington Beach, California, from cone penetrometer test data: Bulletin of the Seismological Society of America, v. 87, no. 2, p. 277-293.

Harden, J.W., 1982, A quantitative index of soil development from field descriptions: Examples from a chronosequence in central California: Geoderma, v. 28, p. 1-28.

Hart, E.W., and Williams, J.W., 1978, Geologic review process, California Geology, v. 31, n. 10, p. 235-236.

Hatheway, A.W., and Leighton, F.B., 1979, Trenching as an exploratory tool, in Hatheway, A.W. and McClure, C.R., Jr., editors, Geology in the siting of nuclear power plants: Geological Society of America Reviews in Engineering Geology, v. IV, p. 169-195.

Ivy-Ochs, S., Kober, F., 2008, Surface exposure dating with cosmogenic nuclides, Special Issue: Recent progress in Quaternary dating methods, E&G (Eiszeitalter und Gegenwart) Quaternary Science Journal, vol 57, no. ½., p. 178-209.

Lazarte, C.A., Bray, J.D., Johnson, A.M., and Lemmer, R.E., 1994, Surface breakage of the 1992 Landers earthquake and its effects on structures: Bulletin of the Seismological Society of America, v. 84, p. 547-561.

Lettis, W.R., and Kelson, K.I., 2000, Applying Geochronolgy in Paleoseismology, Quaternary Geochronology: Methods and Applications, AGU Reference Shelf 4, p. 479-496.

Lienkaemper, J.J, and Bronk Ramsey, C., 2009, OxCal: Versatile Tool for Developing Paleo Earthquake Chronologies-A Primer, seism. Res. Let., v.80, n.3. p. 431-434, doi: 10.1785/gssrl.80.3.431

McCalpin, J.P., 2009, editor, Paleoseismology (second edition): Burlington, Massachusetts, Academic Press (Elsevier), 613 p.

McCalpin, J.P., 2009a, Field techniques in paleoseismology, in McCalpin, J.P., editor, Paleoseismology (second edition): Burlington, Massachusetts, Academic Press, p. 29-118.

McCalpin, J.P., 2009b, Paleoseismology in extensional tectonic environments, in McCalpin, J.P., editor, Paleoseismology (second edition): Burlington, Massachusetts, Academic Press, p. 171-269.

McFadden, L.D., 1988, Climatic influences on rates and processes of soil development in Quaternary deposits of southern California: Geological Society of America Special Paper 216, p. 153-177.

McFadden, L.D., and Weldon, R., 1987, Rates and processes of soil development on Quaternary terraces in Cajon Pass, California: Geological Society of America Bul., v. 98, p. 280-293.

National Research Council, 1986, Studies in geophysics -- active tectonics: National Academy Press, Washington, D.C., 266 p. (Contains several articles evaluating active faulting).

Noller, J. S., Sowers, J.M. and Lettis, W.R., 2000, Quaternary Geochronology: Methods and Applications, AGU Reference Shelf 4, 582 p.

Pierce, K.L., 1986, Dating Methods, in Studies in geophysics -- active tectonics: National Academy Press, Washington, D.C., p. 195-214.

Pigati, J. S., Quade, J., Wilson, J., Jull, A. J. T., and Lifton, N. A., 2007, Development of low-background vacuum extraction and graphitization systems for radiocarbon dating of old (40-60 ka) samples: Quaternary International, v. 16, p. 4-14.

Preusser, F, Hajdas, I., and Ivy-Ochs, S., 2008, Luminescence dating: dating, basics, methods, and applications, Special Issue: Recent progress in Quaternary dating methods, E&G (Eiszeitalter un Gegenwart) Quaternary Science Journal, vol 57, no. ½., p. 95-149.

Preusser, F, Hajdas, I., and Ivy-Ochs, S., 2008, Special Issue: Recent progress in Quaternary dating methods, E&G (Eiszeitalter un Gegenwart) Quaternary Science Journal, vol .57, no. 1/2.

Ramsey, C.R., and Lee, S., 2013, Recent and Planned Developments of the Program Oxcal, Radiocarbon, vol. 55, n.2-3, p. 720-730.

Rockwell, T.K., 2000, Use of Soil Geomorphology in Fault Studies, Quaternary Geochronology: Methods and Applications, AGU Reference Shelf 4.

Rutter, N.W., and Catto, N.R., 1995, Dating methods for Quaternary deposits: Geological Society of Canada, GEOTEXT 2, 308 p.

Sauer, D., Schülli-Maurer, Wagner, S., Scarciglia, F., Sperstad, R., Svendgård-Stokke, Sørensen, R., Schellmann, G., 2014, Soil development over millennial timescales – a comparison of soil chronosequences of different climates and lithologies, Soil Change Matters, IOP Conf. Series: Earth and Environmental Science 25 (2015) 012009, doi:10.1088/1755-1315/25/1/012009

Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and Soil Survey Staff. 2012. Field book for describing and sampling soils, Version 3.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052523.pdf

Sherard, J.L., Cluff, L.S., and Allen, C.R., 1974, Potentially active faults in dam foundations: Geotechnique, Institute of Civil Engineers, London, v. 24, n. 3, p. 367-428.

Scharer, K. M., G. P. Biasi, and R. J. Weldon, 2011, A reevaluation of the Pallett Creek earthquake chronology based on new AMS radiocarbon dates, San Andreas fault, California, J. Geophys. Res., 116, B12111, doi:10.1029/2010JB008099.

Slemmons, D.B., 1977, State-of-the-art for assessing earthquake hazards in the United States: Report 6, faults and earthquake magnitude: U.S. Army Engineer Waterways Experiment Station Miscellaneous Paper S-73-1, 129 p. with 37 p. appendix.

Slemmons, D.B. and dePolo, C.M., 1986, Evaluation of active faulting and associated hazards, in Studies in geophysics -- active tectonics: National Academy Press, Washington, D.C., p. 45-62.

Stephenson, W.J., Rockwell, T.K., Odum, J.K., Shedlock, K.M., and Okaya, D.A., 1995, Seismic reflection and geomorphic characterization of the onshore Palos Verdes fault zone, Los Angeles, California: Bulletin of the Seismological Society of America, v. 85, p. 943-950.

Stuiver, M., Reimer, P.J., and Reimer, R.W., 2017, CALIB 7.1 http://calib.org, accessed 2017-2-7.

Taylor, C.L., and Cluff, L.S., 1973, Fault activity and its significance assessed by exploratory excavation, in Proceedings of the Conference on tectonic problems of the San Andreas fault system: Stanford University Publication, Geological Sciences, v. XIII, September 1973, p. 239-247.

Walker, M.; Johnsen, S.; Rasmussen, S. O.; Popp, T.; Steffensen, J.-P.; Gibbard, P.; Hoek, W.; Lowe, J.; Andrews, J.; Bjo; Cwynar, L. C.; Hughen, K.; Kershaw, P.; Kromer, B.; Litt, T.; Lowe, D. J.; Nakagawa, T.; Newnham, R.; Schwander, J. 2009. Formal definition and dating of the GSSP (Global Stratotype Section and Point) for the base of the Holocene using the Greenland NGRIP ice core, and selected auxiliary records, *J. Quaternary Sci*. 24: 3–17. doi:10.1002/jqs.1227.

Wallace, R.E., 1977, Profiles and ages of young fault scarps, north-central Nevada: Geological Society of America Bulletin, v. 88, p. 1267-1281.

Weldon, R.J., II, McCalpin, J.P., and Rockwell, T.K., 1996, Paleoseismology of strike-slip tectonic environments, in McCalpin, J.P., editor, Paleoseismology: Academic Press, p. 271-329.

Westoby, M. J., Brasington, J., Glasser, N. F., Hambrey, M. J., Reynolds, J. M., 2012, 'Structure-from-Motion' photogrammetry: a low-cost, effective tool for geoscience applications: Geomorphology, v. 179, p. 300–314.

Yeats, R.S., Sieh, K.E., and Allen, C.A., 1997, Geology of Earthquakes: Oxford University Press, New York, N.Y., 576 p.

Zermeňo, P., Kurdyla, D.K., Buchholz, B.A., Heller, S.J., Kashgarian, M, Frantz, B.R., 2004, Prevention and removal of elevated radiocarbon contamination in the LLNL/CAMS natural radiocarbon sample preparation laboratory, Nuclear Instruments and Methods in Physics Research, Section B: Beam Interactions with Materials and Atoms, v. 223-224, p. 290-297, Elsevier Press.

SECTION 6: GUIDELINES FOR GEOSCIENCE PRACTITIONERS (REVIEWING AND PROJECT GEOLOGISTS): REVIEWING SITE-INVESTIGATION REPORTS

Note: Terms in *italics* are terms defined in Section 1, Definitions and Acronyms

6.1 Section Outline

6.2 Objectives of this section

The purpose of this section is to provide general guidance to *lead agencies* that have approval authority over *projects* and for those geologists (*reviewing geologists*) who review *fault investigation reports* on behalf of those agencies. *Project geologists* will also find this section useful as a guide to the expectations of the *lead agency* review process. 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. The *reviewing geologist* ensures compliance with existing laws, regulations, ordinances, codes, policies, standards, and technically sound practice, helping to assure that significant geologic factors (hazards and geologic processes) are properly considered, and potential problems are mitigated prior to project development. In addition to geologic reports for tentative tracts and site development, a reviewer may also evaluate 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. Generally, the reviewer acts at the discretion or request of, and on behalf of a *lead 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. Because the *A-P Act* requires that the *lead agency* "…prohibit the location of developments and structures for human occupancy across the trace of active faults.", it is important to recognize that the *reviewing geologist*, as the *lead agency's* technical representative, is assessing the *lead agency's* exposure to liability resulting from non-compliance with the requirements of the *A-P Act* and regulations. 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; 2015), and others. Grading codes, inspections, and the review process are discussed in detail by Scullin (1983). Nelson and Christenson (1992) and Lund and others (2016) specifically discuss review guidelines for reports on surface faulting.

The review process will be streamlined if the expectations of the *lead agency* are clear and consistently applied. As noted in Section 5, discussions between the *project* *geologist* and the *lead agency*'s *reviewing geologist* during all phases of a *project* can benefit all parties involved. Some *lead agencies* may also choose to publish required minimum standards for surface fault rupture hazard studies. Appendix D contains examples of state, county, and city policies, actions, guidelines and ordinances to assist the *reviewing geologist* in developing clear expectations of what constitutes a thorough fault investigation. These examples can also be used to update *lead agency* ordinance documents or guidelines.

6.3 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., paleoseismology, radiometric dating, soils, geophysics, ground water, foundation and seismic engineering, seismology). With respect to the *A-P Act*, the *reviewing geologist* is required by the State Mining and Geology Board (SMGB) to be licensed by the Board for Professional Engineers, Land Surveyors, and Geologists in order to review *fault investigation reports*. The SMGB also certifies engineering geologists and hydrogeologists, and licenses geophysicists and engineers. Local and regional agencies may have additional requirements.

The reviewer has an ethical obligation to ensure a *fault investigation report* has thoroughly addressed the potential for *surface fault rupture* for any *fault investigation* triggered by the *A-P Act* or local regulations. Like any review process, there is a certain "give-and-take" involved between the *reviewing geologist* and *project geologist*. The reviewer should bear in mind that some *project geologists* are not accomplished writers, and almost all are working with restricted budgets. Also, the reviewer may by limited by his or her agency's policies, procedures, and fee structures. The mark of a good reviewer is the ability to sort out the important from the insignificant and to make constructive comments and recommendations and maintain a professional tone.

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.

A reviewer may be employed full time by the *lead agency* or serve as a contractor to the *lead agency*. 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. The use of multiple, part-time reviewers by a given agency may contribute to an inconsistent treatment of development projects because different reviewers may have different standards or levels of experience. 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, and 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.

6.4 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 accept inadequate or incomplete reports based on familiarity or direct experience at, or near a 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 reviewer performs four principal functions in the technical review:

1. Identifies any known potential hazards and impacts that are not addressed in the consultant's report. The reviewer should require investigation of the potential hazards and impacts;
2. Determines whether the report contains sufficient data to support and is consistent with the stated conclusions;
3. Determines whether the conclusions identify the potential impact of known and reasonable anticipated geologic processes and site conditions; and,

4. Determines whether the recommendations are consistent with the conclusions and can reasonably be expected to mitigate those anticipated earthquake-related problems that could have a significant impact on the proposed development. The included recommendations also should address the need for additional geologic and engineering investigations (including any site inspections to be made as site remediation proceeds).

The conclusions presented in the report regarding the geologic hazards 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 issues that would have an impact on the proposed development. Recommendations also should be made concerning the need for additional geologic investigations if necessary.

Report Guidelines and Standards

A *project geologist* may save a great deal of time 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, but 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., CGS Notes 41, 48; California Geological Survey, 1997; 1997; 2013). 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 *project geologist* for response. After the reviewer is satisfied that the investigation and resulting conclusions are adequate, this should be clearly indicated in writing to the *lead agency* so that the proposed development application may be processed promptly. 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.

A significant challenge 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 nearby mapped fault 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 observed. 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. If the *project geologist* concludes that fault is absent, this conclusion should be based on the <u>evidence of absence</u> and not the absence of evidence for *surface fault rupture* hazard.

Scope of Review

The scope of the review is determined primarily by the need to assure that an investigation and resulting conclusions are supported by the geologic data developed during the investigation. 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. Field reviews of trench exposures and inspection of cores and samples are of value and may help to identify and resolve different interpretations. 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.

As important as reviewing a report for completeness, the reviewing geologist should keep in mind that the conclusions in the report must be data driven in order for the report to be technically sound. Primary questions the *reviewing geologist* should ask during the course of the review are:

1. Are the conclusions in the *fault investigation report* reasonable given the data presented?
2. Is there a clear distinction between data and observations versus interpretations and/or models?
3. If a conclusion is model driven, are there alternative models that also satisfy the available data?
4. If one model is preferred over others, what supporting data allow the alternative models to be down-weighted or rejected?

Review Records

For each report and development project reviewed, a clear, concise, and logical written record should be developed. This review record should 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;
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 California Professional Geologist license number(s), with expiration dates and stamped with his or her seal.

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. In addition, the Policies and Criteria of the *State Mining and Geology Board* (Appendix B) requires that copies of all approved *fault investigation reports* be submitted to the *State Geologist* within 30 days of project approval (CCR, Title 14, Division 2, Chapter 8.1.3, 3603(f)).

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.

6.5 References

Berkland, J.O., 1992, Reviewing the geologic review process at the county level, *in* Stout, M.L., editor, Association of Engineering Geologists Proceedings, 35th Annual Meeting, p. 333-336.

California Geological Survey Notes:
CGS NOTE 41 - General guidelines for reviewing geologic reports, 1998.
CGS NOTE 48 - Checklists for the review of geologic/seismic reports for California public schools, hospitals and essential services buildings, 2013.
CGS NOTE 49 - Guidelines for evaluating the hazard of surface fault rupture, 2002.

California Geological Survey, 2008, Guidelines for evaluating and mitigating seismic hazards in California: Special Publication 117A, 98 p.

Hart, E.W., and Williams, J.W., 1978, Geologic review process: California Geology, v. 31, p. 235-236.

Keaton, J.R., 1993, Environmental and engineering geology practice from the technical-professional society perspective: AEG News, Fall 1993, v. 36, no. 4, p. 19-21.

Larson, R.A., 1992, A philosophy of regulatory review, *in* Stout, M.L., editor, Association of Engineering Geologists Proceedings, 35th Annual Meeting, p. 224-226.

Larson, R.A., 2015, Reviewing fault surface-rupture and earthquake-hazard mitigation reports for regulatory compliance, in Lund, W.R., editor, Proceedings Volume, Basin and Range Province Seismic Hazards Summit III: Utah Geological Survey Miscellaneous Publication 15-5, variously paginated, DVD.

Leighton, F.B., 1975, Role of geotechnical consultants and reviewers for the County of San Mateo: California Geology, v. 28, p. 178-181.

Lund, W.R., Christenson, G.E., Batatian, L.D., and Nelson, C.V., 2016, Guidelines for evaluating surface-fault-rupture hazards in Utah, *in* Bowman, S.D., and Lund, W.R., editors, Guidelines for investigating geologic hazards and preparing engineering-geology reports, with a suggested approach to geologic-hazard ordinances in Utah: Utah Geological Survey Circular 122, p. 31–58.

Nelson, C.V., and Christenson, G.E., 1992, Establishing guidelines for surface fault rupture hazard investigations -- Salt Lake County, Utah, *in* Stout, M.L., editor, Association of Engineering Geologists Proceedings, 35th Annual Meeting, p. 242-249.

Rogers, J.D,. and Olshansky, R.B., 1992, Science versus advocacy -- the reviewers role to protect the public interest, *in* Stout, M.L., editor, Association of Engineering Geologists Proceedings, 35th Annual Meeting, p. 371-378.

Scullin, C.M., 1983, Excavation and grading code administration, inspection, and enforcement: Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 405 p.

Stewart, R.M., Hart, E.W., and Amimoto, P.Y., 1976, The review process and the adequacy of geologic reports: Bulletin of the International Association of Engineering Geology, n. 14, p. 83-88. (Reprinted in California Geology, October 1977, v. 30, p. 224-229).

Wolfe, J., 1975, More on registration: California Geology, v. 28, p. 155-156.

APPENDIX A: ALQUIST-PRIOLO EARTHQUAKE FAULT ZONING ACT

Disclaimer: The excerpted text of the Alquist-Priolo Earthquake Fault Zoning Act is for informational purposes only and may not the most current version of the statute. For the most current version of the statues, please refer to:

http://leginfo.legislature.ca.gov/faces/codes.xhtml

CALIFORNIA PUBLIC RESOURCES CODE

DIVISION 2. Geology, Mines and Mining

CHAPTER 7.5 Earthquake Fault Zones

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

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 Board.

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 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

Disclaimer: The excerpted text from the California Code of Regulations, Title 14, Division 2 is for informational purposes only and may not the most current version of the regulations. For the most current version of the regulations, please refer to the online version of the California Code of Regulations:

https://govt.westlaw.com/SiteList

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: THE CALIFORNIA GEOLOGICAL SURVEY'S FAULT EVALUATION AND ZONING PROGRAM

C.1 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 definitions below) 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 originally was scheduled over a 10-year period. The state was divided into 10 regions or work areas, with one region scheduled for evaluation each year. However, the work in some regions was extended because of heavy workloads. Fault evaluation work includes interpretation of aerial photographs and limited field mapping, as well as the use of other geologists' works. 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.

For each fault evaluated by CGS since 1976 a Fault Evaluation Report (FER) has been prepared, summarizing data on the location, recency of activity, sense and magnitude of displacement, and providing recommendations for or against zoning. FERs that resulted in *Earthquake Fault Zones (EFZ)* are available through the Information warehouse on the CGS web page (http://maps.conservation.ca.gov/cgs/informationwarehouse/). FERs that did not recommend *EFZs* be delineated are available from CGS by request.

Faults zoned since 1976 are considered to meet the criteria of "sufficiently active and well-defined" (see Definitions below). Many other faults do not appear to meet the criteria and have not been 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 human activities. Even large scale fault-rupture can be obscured in complex geologic terranes or high-energy environments. Recent fault-rupture is challenging 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.

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 *EFZ* and to delineate new zones "when warranted by new information." Much of this new information comes to the State Geologist through fault investigation reports triggered as a result of existing *EFZs*, but also from fault investigations conducted where zones have not been delineated. These investigation reports are used to update existing zones as well as prepare new *EFZs*. They have also been used to file waivers and are often sought by *project geologists* when designing site-specific fault investigations. In accordance with the policies and Criteria of the State Mining and Geology Board (California Code of Regulations, Title 14, Division 2, Section 3603(f)), these reports are available on the CGS website: (https://spatialservices.conservation.ca.gov/arcgis/rest/services/CGS).

C.2 Fault Zoning Criteria

A major objective of 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 or geophysical techniques). 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 sometimes a matter of experienced 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 as active. Furthermore, certain faults considered to be active at depth, because of known seismic activity, are so poorly defined at the surface that zoning becomes too uncertain. 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."

C.3 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). On older Earthquake Fault Zone maps, the zone boundaries are straight-line segments defined by turning points. Most of the turning points were 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. EFZ maps prepared as of 2012 or later, and those revised/combined with Seismic Hazard Zone Maps, do not portray turning points. This change was made because the GIS data that serve as the official zone maps and modern GPS technology has made the need to locate cultural features in the field to identify zone boundaries obsolete.

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.

C.4 Products of the A-P Program

Reports listed in this Appendix that are publications of the California Geological Survey are available from the California Geological Survey website:
http://www.conservation.ca.gov/cgs/publications/Pages/index.aspx

For more information on the A-P Program at CGS please go to the CGS website:
http://www.conservation.ca.gov/cgs/rghm/ap/Pages/Index.aspx

Earthquake Fault Zone Maps are available as GIS Shapefiles or GeoPDF files and Fault Evaluation Reports are available as PDF files, all downloadable from the CGS Information Warehouse:
http://maps.conservation.ca.gov/cgs/informationwarehouse/

Earthquake Fault Zones are available as web-based services that can be viewed on your GIS platform or in Google Earth from the following URL:
https://spatialservices.conservation.ca.gov/arcgis/rest/services/CGS_Earthquake_Hazard_Zones

and associated metadata can be found at:
https://maps.conservation.ca.gov/cgs/metadata/SHP_Fault_Zones.html

The CGS web application that allows one to determine if a parcel lies within Earthquake Fault Zones or Seismic Hazard Zones can be found here:
https://maps.conservation.ca.gov/cgs/EQZApp/

Fault Investigation Reports prepared by *project geologists* can be found at:
https://spatialservices.conservation.ca.gov/arcgis/rest/services/CGS

APPENDIX D: MODEL ORDINANCE AND EXAMPLES OF LEAD AGENCY IMPLEMENTATION OF THE ALQUIST-PRIOLO EARTHQUAKE FAULT ZONING ACT

Appendix D contains examples of approaches to implementation of the *A-P Act* by some *lead agencies* in California as links to the jurisdiction's websites. The examples in this Appendix are intended to assist other *lead agencies* in developing or updating their safety elements, ordinances, policies, and other documents to better implement the *A-P Act* within their jurisdictions. This is not an exhaustive compilation but simply the results from an internet search of lead agencies known to have earthquake fault zones within their jurisdictions. These links were last tested in December, 2017.

California State Agencies

The California Department of General Services, Division of the State Architect, has been responsible for overseeing school construction in California since the 1933 Long Beach earthquake, which destroyed or severely damaged many school buildings in Los Angeles and Orange counties. The provisions for addressing fault rupture hazards are found in the California Administrative Code 2016, Group 1 Safety of Construction of Public Schools, Article 3 Approval of Drawings and Specifications, 4-1317 Plans, specifications, calculations and other data, (e) Site Data.

https://up.codes/viewer/california/ca-administrative-code-2016/chapter/group_1/safety-of-construction-of-public-schools#4-317

California Counties

Alameda County:

Safety Element; see Chapter 1: Natural Hazards.
https://www.acgov.org/cda/planning/generalplans/documents/SafetyElementAmendmentFinal.pdf

Municipal Code, Chapter 15.36; see Section 15.36.240 – Preliminary grading plans, and Section 15.36.320 – Geotechnical/geologic investigation required.
https://library.municode.com/ca/alameda_county/codes/code_of_ordinances?nodeId=TIT15BUCO_CH15.36GRERSECO_ARTVPERE

Alpine County:

Safety Element; see Section B – Seismic, page 44.
http://www.alpinecountyca.gov/DocumentCenter/View/51

Butte County:

Health and Safety Element; see Section III – Seismic and Geologic Hazards, page 299.
http://www.buttegeneralplan.net/products/2012-11-06_GPA_ZO_Adopted/General_Plan_Seperate_Chapters/11_Health_Safety_PRR.pdf

Butte County Code; see Section 20-255 – Filing and processing.
https://library.municode.com/ca/butte_county/codes/code_of_ordinances?nodeId=CH20SU_ARTXESREVETEMARESU_20-255FIPR

Contra Costa County:

Safety Element; see page 10-7.
http://www.co.contra-costa.ca.us/DocumentCenter/View/30920

Contra Costa County Code; see Section 92-4.035 - Geologic hazard or potentially hazardous soil conditions.
https://library.municode.com/ca/contra_costa_county/codes/ordinance_code?nodeId=TIT9SU_DIV92GEPR_CH92-4DE_92-4.035GEHAPOHASOCO

Humboldt County:

Safety Element, see page 14-2.
http://www.humboldtgov.org/DocumentCenter/Home/View/61990

Title III, Land Use and Development, Division 3, Building Regulations, Chapter 6 – Geologic Hazards.
http://www.humboldtgov.org/DocumentCenter/Home/View/210

Imperial County:

Seismic and Public Safety Element.
http://www.icpds.com/CMS/Media/Seismic-and-Public-Safety-Element.pdf

County of Imperial, California – Codified Ordinances; see Title 9 – Land Use Code sections 91502.00 - Standards for residential dwelling unit in special studies zones, 91502.01 – Application Requirements, 91502.02 – Approvals, 90803.02 - Tentative map to conform to rules of planning director, planning commission and the board of supervisors, 91701.01 - General standards.

https://library.municode.com/ca/imperial_county/codes/code_of_ordinances?nodeId=COUNTY_IMPERIAL_CALIFORNIACOOR

Inyo County:

Inyo County Plans, Laws, and Ordinances, see Alquist-Priolo Earthquake Fault Zoning Act.
http://inyoplanning.org/plans_laws.htm

Los Angeles County:

Safety Element.
http://planning.lacounty.gov/assets/upl/project/gp_web90-safety-element.pdf

Los Angeles County, California – Code of Ordinances; see Title 26 – Building Code sections 111 – Engineering Geology and Soils Engineering Reports, 112 – Earthquake Fault Maps, 113 – Earthquake Faults.
https://library.municode.com/CA/los_angeles_county/codes/code_of_ordinances?nodeId=TIT26BUCO_CH1AD_S111ENGESOENRE

County of Los Angeles Department of Public Works, Manual for Preparation of Geotechnical Reports.
http://dpw.lacounty.gov/gmed/permits/docs/manual.pdf

Marin County:

Marin Countywide Plan; see Chapter 2 – The Natural Systems and Agriculture Element, section 2.6 – Environmental Hazards (EH).
https://www.marincounty.org/~/media/files/departments/cd/planning/currentplanning/publications/county-wide-plan/cwp_2015_update.pdf

Mendocino County:

Health and Safety; see 8-13 – Mendocino County 2008-2010 Phase I Strategic Plan.
https://www.mendocinocounty.org/home/showdocument?id=11881

Merced County:

Health and Safety Element.
http://web2.co.merced.ca.us/pdfs/planning/generalplan/DraftGP/MCGPU_2030/MCGPU_2030GP_Part_II-10_HEALTH_SAFETY_PRD_2012-11-30.pdf

Mono County:

Safety Element, see II. Issues/Opportunities/Constraints – Seismic Hazards.
https://www.monocounty.ca.gov/sites/default/files/fileattachments/planning_division/page/9617/safety_element_final_12.08.15.pdf

Monterey County:

Safety Element.
http://www.co.monterey.ca.us/home/showdocument?id=45806

2007 General Plan DEIR, Geology, Soils, and Seismicity; see 4.4.3.2 State Regulations.
http://www.co.monterey.ca.us/home/showdocument?id=43992

Napa County:

Napa County General Plan; see Safety Element.
http://www.countyofnapa.org/GeneralPlan/

Napa County, California – Code of Ordinances, see Title 15 – Buildings and Construction section 15.08.050 Building Permit-Geologic Hazard report.
https://library.municode.com/ca/napa_county/codes/code_of_ordinances?nodeId=TIT15BUCO_CH15.08BUEXPE

Riverside County:

Safety Element, see S-7 Hazard Specific Issues and Policies.
http://planning.rctlma.org/Portals/0/genplan/general_Plan_2017/elements/OCT17/Ch06_Safety_DEC2016.pdf?ver=2017-10-06-093651-757

Ordinance of the County of Riverside; AP Earthquake Fault Zoning Act.
http://www.rivcocob.org/ords/500/547.7.pdf

San Diego County:

Safety Element, see 7-11 – Geological Hazards.
http://www.sandiegocounty.gov/pds/gpupdate/docs/BOS_Aug2011/C.1-6_Safety.pdf

Geologic Hazards Guidelines for Determining Significance; see 2.0 Existing Regulations and Standards and 4.0 Guidelines for Determining Significance.
http://www.sandiegocounty.gov/dplu/docs/Geologic_Hazards_Guidelines.pdf

San Benito County:

Seismic Safety/Safety Elements.
http://cosb.us/wp-content/uploads/SBC-ExistingGP-Seismic.pdf

2035 General Plan Update 2015 Revised DEIR, Geology, Soils, and Mineral Resources; see 10.1.2 Regulatory Setting.
http://cosb.us/wp-content/uploads/10-Geology-Soils-Mineral-Resources.pdf

Santa Clara County:

Santa Clara County General Plan; see Part 2: Countywide Issues and Policies, I-7 – Safety and Noise Chapter.
https://www.sccgov.org/sites/dpd/DocsForms/Documents/GP_Book_A.pdf

Santa Clara County, California – Code of Ordinances; see Title C – Construction, Development, and Land Use, Division C12 – Subdivisions and Land Development, Chapter IV. Geologic Provisions Article 2 – County Geologic Hazard Zones.
https://library.municode.com/ca/santa_clara_county/codes/code_of_ordinances?nodeId=TITCCODELAUS_DIVC12SULADE_CHIVGEPR_ART2COGEHAZO

Santa Cruz County:

Santa Cruz County General Plan; Chapter 6: Public Safety and Noise, see Page 6-3 – Seismic Hazards.
http://www.sccoplanning.com/Portals/2/County/Planning/policy/1994GeneralPlan/chapter6.pdf?ver=2011-03-02-000000-000

Santa Cruz County Geologic Hazards; see 16.10.050 – Requirements for Geologic Assessment and 16.10.105 – Notice of Geologic Hazards in Cases of Dangerous Conditions.
http://www.codepublishing.com/CA/SantaCruzCounty/html/SantaCruzCounty16/SantaCruzCounty1610.html

Shasta County:

General Plan, Public Safety Group, Seismic and Geologic Hazards.
https://www.co.shasta.ca.us/docs/libraries/resource-management-docs/docs/51seismic.pdf?sfvrsn=0

San Luis Obispo County:

San Luis Obispo County General Plan, Safety Element; see Chapter 5 page 17 – Geologic and Seismic Hazards.
http://www.slocounty.ca.gov/getattachment/893b6c58-7550-4113-911c-3ef46d22b7c8/Safety-Element.aspx

San Luis Obispo County Code, Title 22 – Land Use Ordinance, Article 3 – Site Planning and Project Design Standards, Chapter 22.14 – Combining Designation Standards, 22.14.070 – Geologic Study Areas.
https://library.municode.com/ca/san_luis_obispo_county/codes/county_code?nodeId=TIT22LAUSOR_ART3SIPLPRDEST_CH22.14CODEST_22.14.070GESTARGS

San Luis Obispo County Code, Title 23 – Coastal Land Use, Chapter 23.07 – Combining Designation Standards, 23.07.080 – Geologic Study Areas.

https://library.municode.com/ca/san_luis_obispo_county/codes/county_code?nodeId=TIT23COZOLAUS_CH23.07CODEST_23.07.080GESTARGS

San Luis Obispo County Code, Title 23 – Coastal Land Use, Chapter 23.07 – Combining Designation Standards, 23.07.084 – Application Content – Geologic and Soils Report.
https://library.municode.com/ca/san_luis_obispo_county/codes/county_code?nodeId=TIT23COZOLAUS_CH23.07CODEST_23.07.084APCOEOSORERE

San Luis Obispo County Code, Title 23 – Coastal Land Use, Chapter 23.07 – Combining Designation Standards, 23.07.086 – Geologic Study Area Special Standards.
https://library.municode.com/ca/san_luis_obispo_county/codes/county_code?nodeId=TIT23COZOLAUS_CH23.07CODEST_23.07.086GESTARSPST

County Guidelines for Engineering Geology Reports.
http://www.slocounty.ca.gov/getattachment/f58bc2f2-cb40-45b8-8fb8-f19fc804ffec/Guidelines-for-Engineering-Geology-Reports.aspx

Ventura County:

Ventura County General Plan Goals, Policies and Programs; see Chapter 2 on Hazards, Page 29.
http://venturawatershed.org/wp-content/uploads/2015/04/VCPD_Gen_Plan_2013.pdf

California Cities

City of Walnut Creek:

General Plan, Chapter 6 Safety and Noise.
http://www.walnut-creek.org/home/showdocument?id=5010

Municipal Code, Title 9 Building Regulations, Chapter 9 Site Development; 9-9.06 Soils and Engineering Geology Report, c.6.
http://www.codepublishing.com/CA/WalnutCreek/#!/WalnutCreek09/WalnutCreek0909.html

Municipal Code, Title 10 Planning and Zoning, Chapter 1 Subdivisions; 10-1.702 Requirements and Procedures, 2.c.
http://www.codepublishing.com/CA/WalnutCreek/#!/WalnutCreek10/WalnutCreek1001.html

Municipal Code, Title 10 Planning and Zoning, Chapter 2 Zoning; 10-2.3.402 Definitions, D. High Risk Area; 10-2.3.407 Property Development Standards, G. Creek, Landslide, and Fault-Line Setbacks.
http://www.codepublishing.com/CA/WalnutCreek/#!/WalnutCreek10/WalnutCreek1002C.html

City of Los Angeles:

General Plan, Safety Element.
https://planning.lacity.org/cwd/gnlpln/saftyelt.pdf

City of Los Angeles Preliminary Fault Rupture Study Areas.
http://geohub.lacity.org/datasets/9a1a1c350c9043a2b2fce10c0530f769_2?geometry=-118.819%2C33.731%2C-117.717%2C33.902

Information Bulletin / Public – Building Code, Surface Fault Rupture Hazard Investigations.
https://www.ladbs.org/docs/default-source/publications/information-bulletins/building-code/ib-p-bc2014-129surfacefaultrupturehazardinvestigations.pdf?sfvrsn=13

Information Bulletin / Public – Building Code, Exemptions from Liquefaction, Earthquake Induced Landslide, and Fault-Rupture Hazard Zone Investigations.
http://www.ladbs.org/docs/default-source/publications/information-bulletins/building-code/exemptions-from-liquefaction-earthquake-induced-landslide-and-faullt-rupture-hazard-zone-investigations-ib-p-bc2014-044.pdf?sfvrsn=19

City of Los Angeles Municipal Code, Chapter IX Building Regulations, Article 1 Buildings (Building Code); 91.106.4. Permits Issuance, Exceptions, 4.
http://library.amlegal.com/nxt/gateway.dll?f=templates&fn=default.htm&vid=amlegal:la_all_mc

City of Los Angeles Municipal Code, Chapter I General Provisions and Zoning, Article 3 Specific Plan – Zoning Supplemental Use Districts; Section 13.04. “RPD” Residential Planned Development Districts, C. Requirements for Filing, 3. Preliminary Geological and Soils Engineering Reports.
http://library.amlegal.com/nxt/gateway.dll?f=templates&fn=default.htm&vid=amlegal:la_all_mc

City of Santa Monica:

Guidelines for Geotechnical Reports; 3.3.1 Fault Rupture Hazards, page 21.
https://www.smgov.net/uploadedFiles/Departments/PCD/Permits/Guidelines-for-Geotechnical-Reports.pdf

City of San Diego:

General Plan, Public Facilities, services and Safety Element; Q. Seismic Safety, PF -66.
https://www.sandiego.gov/sites/default/files/pf_2015.pdf

San Diego Municipal Code, Chapter 14: General Regulations, Article 5: Building Regulations, §145.1803 Local Additions and Modifications to Section 1803 “Geotechnical

Investigations" of the California Building Code.
http://docs.sandiego.gov/municode/MuniCodeChapter14/Ch14Art05Division18.pdf

City of San Diego Guidelines for Geotechnical Reports.
https://www.sandiego.gov/sites/default/files/legacy/development-services/pdf/industry/geoguidelines.pdf

City of Rancho Cucamonga:

General Plan Chapter 8: Public Health and Safety; Seismic Hazards, page PS-12. Goal PS-6: Minimize the potential damage to structures and loss of life that may result from earthquakes and other seismic hazards, page PS-53.
https://www.cityofrc.us/civicax/filebank/blobdload.aspx?BlobID=6819

Rancho Cucamonga Municipal Code, **Title 16 Subdivisions**, Chapter 16.16 Tentative Maps – Five or more Parcels, 16.16.030 Accompanying data and Reports, C. Engineering Geology and/or Seismic Safety Report. Chapter 16.20, Tentative Parcel Maps – Four or Less Parcels, 16.20.030 Contents, T. Engineering Geology and/or Seismic Safety Report. **Title 17 Development Code**, Article VII. Design Standards and Guidelines, Chapter 17.122 Design Provisions by Development Type, 17.122.020 Hillside Development, K. Public Safety, 1.i.
http://qcode.us/codes/ranchocucamonga/

Town of Woodside:

General Plan, Natural Hazards and Safety Element.
https://www.woodsidetown.org/sites/default/files/fileattachments/5_natural_hazards_and_safety_element_4.pdf

General Plan 2012 Maps.
https://www.woodsidetown.org/planning/general-plan-2012-maps-0

Municipal Code, § 153.153 Seismic Safety.
https://www.woodsidetown.org/municipalcode/%C2%A7-153153-seismic-safety

Municipal Code, § 153.301 Limitations Applicable to Alterations, Additions, Replacement, or Paved Area and Surface Coverage.
https://www.woodsidetown.org/municipalcode/%C2%A7-153301-limitations-applicable-alterations-additions-replacement-or-paved-area-and-su

Municipal Code, § 151.20 Permits Required.
https://www.woodsidetown.org/municipalcode/%C2%A7-15120-permits-required

Geotechnical / Soils Report Requirements Matrix.
https://www.woodsidetown.org/building/geotechnicalsoils-report-requirements-matrix

Please note:

Plates 1 and 2 are oversized plates that should be printed out at full size using a large scale plotter, or be viewed electronically using the zoom tools available in Adobe Acrobat.

Plate 1

IS MY PROJECT REGULATED BY THE ALQUIST – PRIOLO EARTHQUAKE FAULT ZONING ACT?

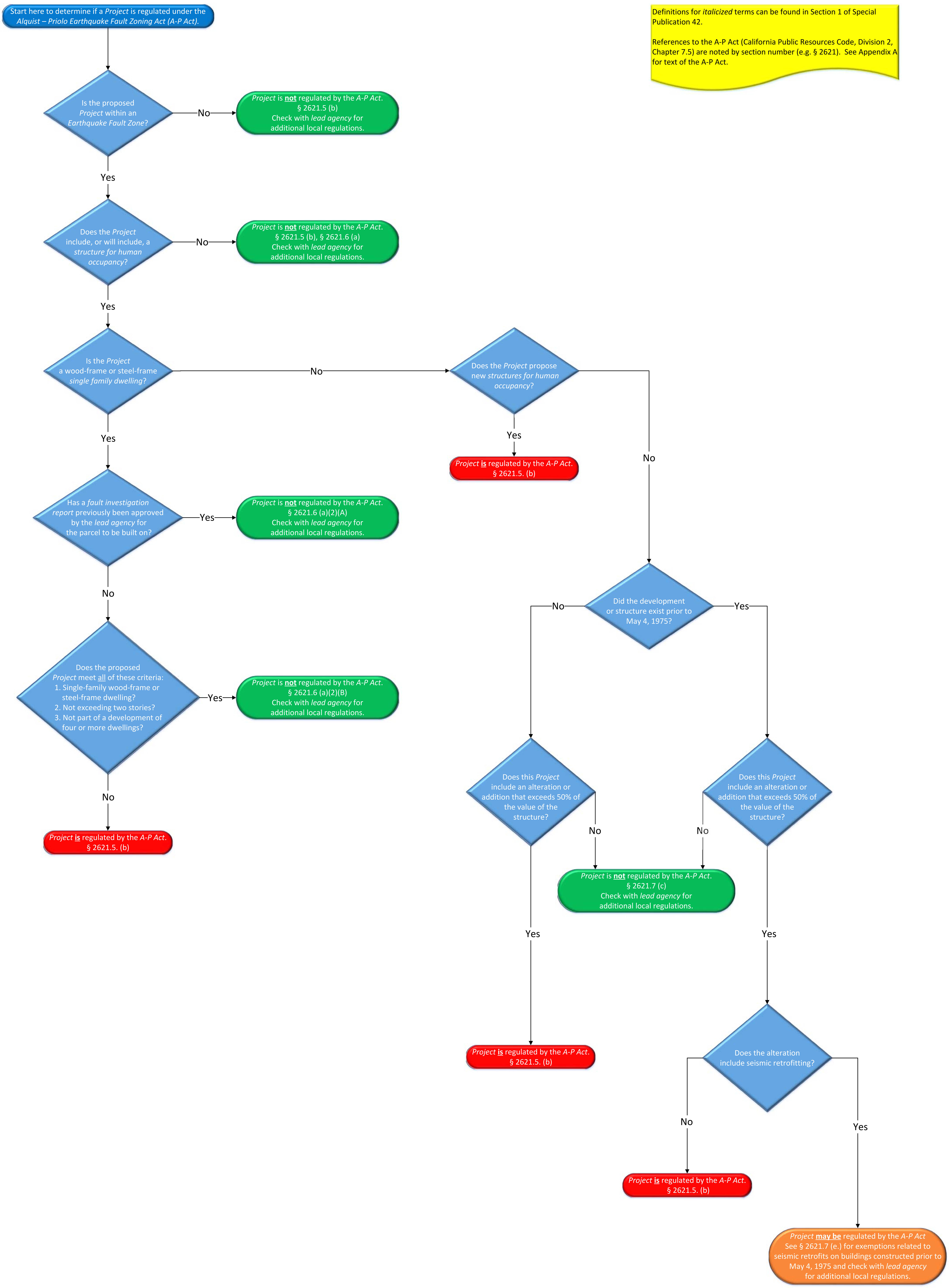
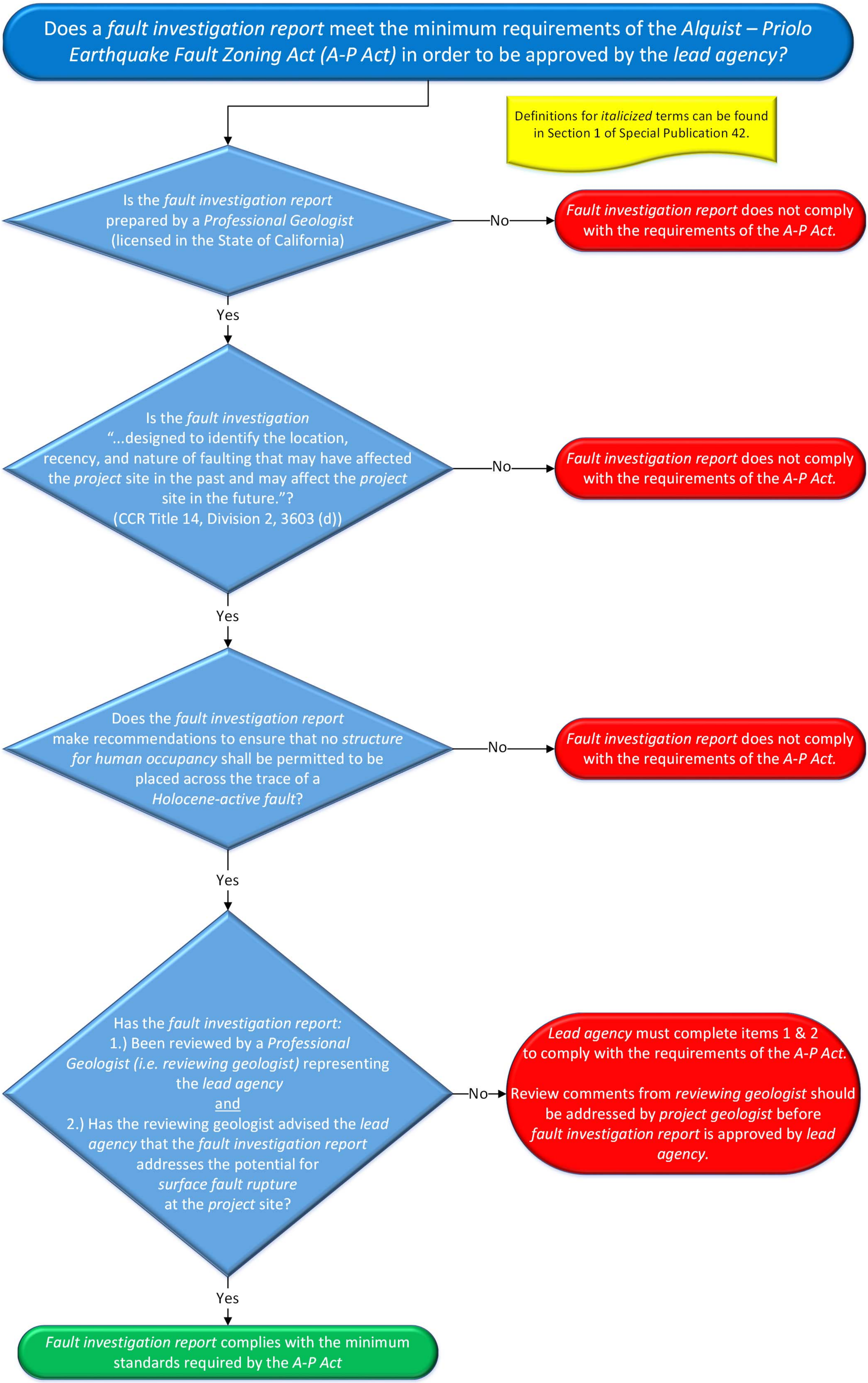


Plate 2


Does a *fault investigation report* meet the minimum requirements of the *Alquist – Priolo Earthquake Fault Zoning Act (A-P Act)* in order to be approved by the *lead agency?*
Definitions for *italicized* terms can be found in Section 1 of Special Publication 42.
Is the *fault investigation report* prepared by a *Professional Geologist* (licensed in the State of California)
No
Fault investigation report does not comply with the requirements of the *A-P Act.*
Yes
Is the *fault 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."? (CCR Title 14, Division 2, 3603 (d))
No
Fault investigation report does not comply with the requirements of the *A-P Act.*
Yes
Does the *fault investigation report* make recommendations to ensure that no *structure for human occupancy* shall be permitted to be placed across the trace of a *Holocene-active fault*?
No
Fault investigation report does not comply with the requirements of the *A-P Act.*
Yes
Has the *fault investigation report:* 1.) Been reviewed by a *Professional Geologist (i.e. reviewing geologist)* representing the *lead agency* and 2.) Has the reviewing geologist advised the *lead agency* that the *fault investigation report* addresses the potential for *surface fault rupture* at the *project* site?
No
Lead agency must complete items 1 & 2 to comply with the requirements of the *A-P Act.*
Review comments from *reviewing geologist* should be addressed by *project geologist* before *fault investigation report* is approved by *lead agency.*
Yes
Fault investigation report complies with the minimum standards required by the *A-P Act*