

## CGS NOTE 53 - REGULATORY EARTHQUAKE HAZARD ZONES: SAN FRANCISCO BAY AREA



*Damage to the Marina District from the 1989 Loma Prieta Earthquake. Photo: USGS*

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### CGS studies

earthquake hazards to  
help Californians plan  
and build earthquake-  
resistant communities

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The California Geological Survey (CGS) establishes zones that delineate areas where ground failure due to liquefaction, landslides or surface fault rupture is more likely to increase earthquake damage (the hazard of strong earthquake shaking is addressed separately by the California Building Code). These areas are commonly referred to as “Earthquake Zones of Required Investigation” (EZRI).

Cities and counties are required by state law to withhold building permits within these zones until geologic/geotechnical investigations are conducted to assess seismic hazards on a site-specific basis. If a liquefaction or earthquake-induced landslide hazard is identified, appropriate design and/or ground improvement measures must be applied in order to reduce the potential for structural failures. Additionally, proposed structures must not be built across the trace of an active fault.

In all cases, sellers of real property are required to check earthquake zone maps produced by CGS to determine whether property being sold falls within a seismic hazard zone or earthquake fault zone. The seller is required to provide a “Natural Hazard Disclosure Statement” to the buyer.



Liquefaction damage in the Marina District. Photo: USGS



Landslide near Fort Funston. Photo: USGS



Surface fault rupture in Napa. Photo: CGS

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## Earthquake-Induced Ground Failure Hazards:

### LIQUEFACTION

Liquefaction, as a geologic term, refers to the loss of strength of saturated soils during shaking. An earthquake can cause soil particles to shift and lose contact with one another as increased water pressure in the pore spaces pushes them apart, resulting in their weakened ability to support structures. As shown in the top photo (courtesy of USGS), liquefaction caused some of the damage to buildings in San Francisco's Marina District following the 1989 Loma Prieta earthquake.

### LANDSLIDES

Landslides are the downhill movement of ground caused primarily by gravity acting on weakened rock or soil. Slopes are weakened by weathering, erosion, saturation, and the addition of weight in the form of artificial fill, structures, snow, or rock. Landslides that occur during earthquakes typically originate from these steep and weakened slopes. The 1906 San Francisco earthquake triggered more than 10,000 landslides, such as the one north of Fort Funston in the middle photo (courtesy of USGS).

### SURFACE FAULT RUPTURE

Surface fault rupture occurs when movement on a fault deep within the earth breaks through to the surface. Fault rupture almost always follows pre-existing faults, which are zones of weakness. Rupture may occur suddenly during an earthquake or slowly in the form of fault creep. Sudden ruptures are more damaging to structures because they are accompanied by shaking. The bottom photo shows surface fault rupture following the magnitude 6.0 Napa earthquake in 2014 (photo by CGS).

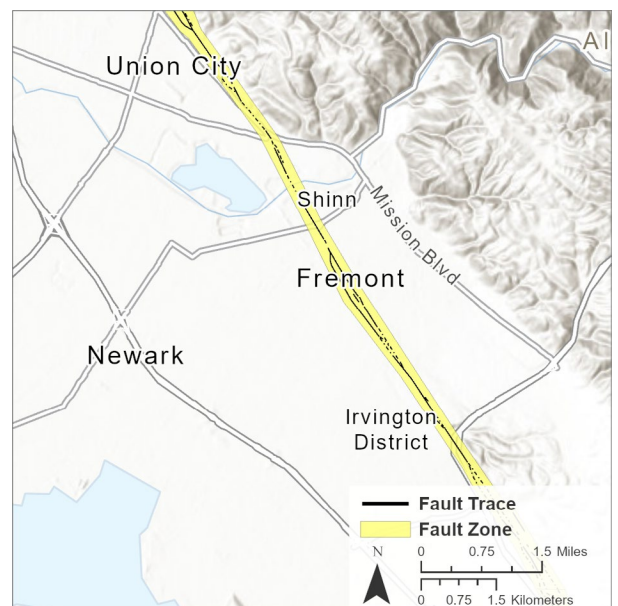
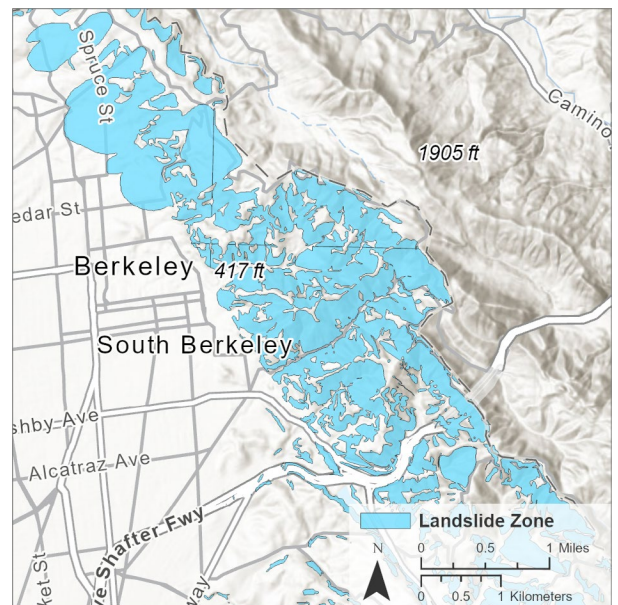
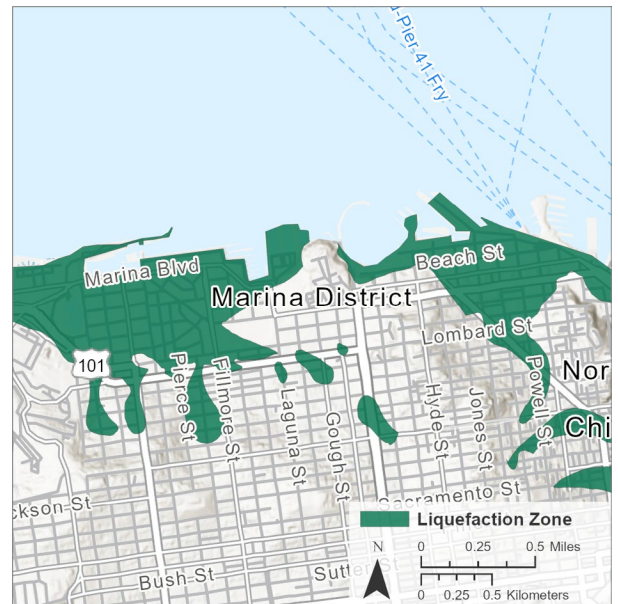
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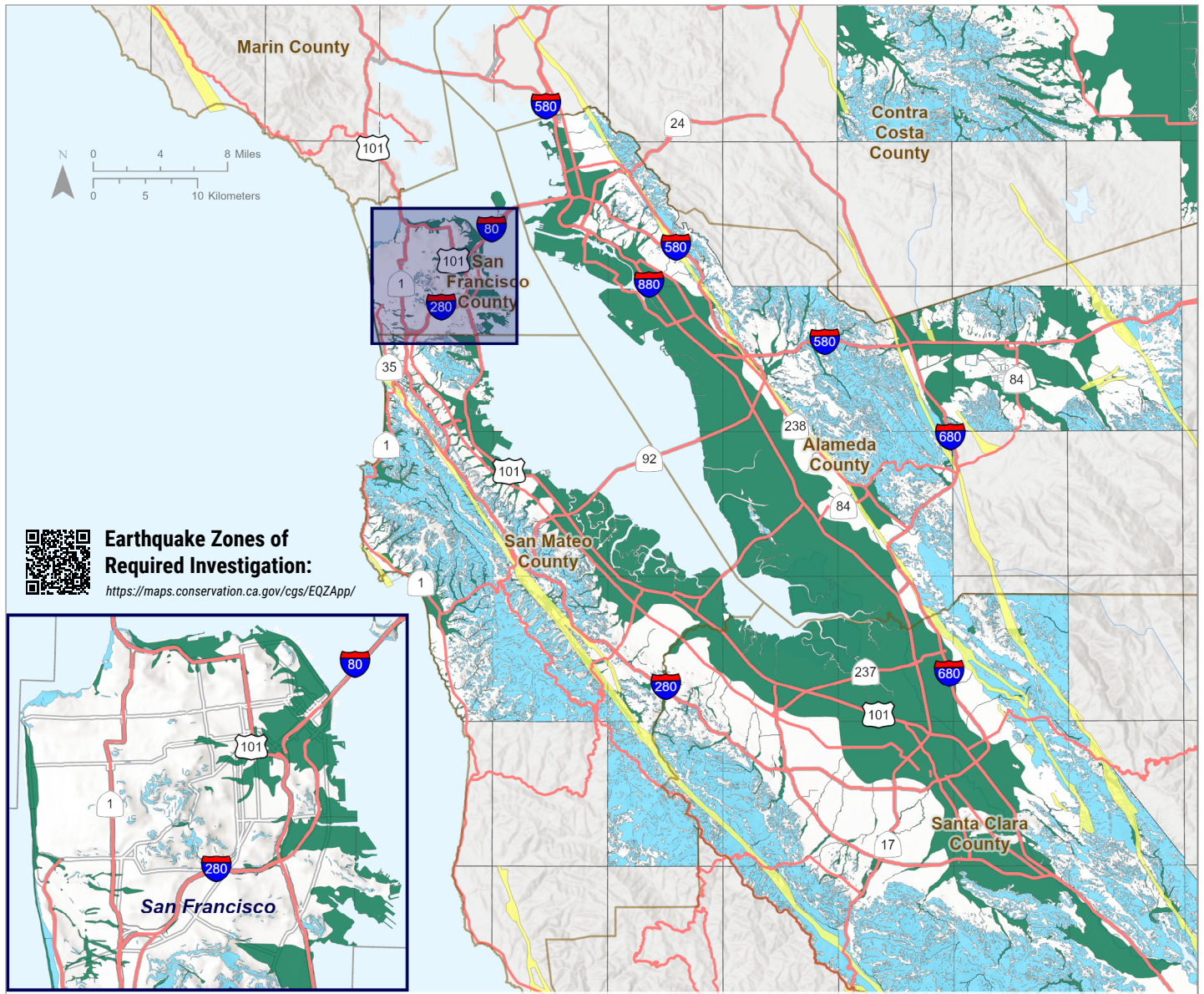
CGS geologists delineate liquefaction zones by assessing the engineering behavior of soils based on: surface geology and geomorphology; soil properties from subsurface borings; highest historical groundwater levels; and potential ground shaking from future earthquakes. Earthquake-induced landslide zones are delineated by mapping locations of existing landslides and analyzing rock strength, geologic structure, and surface topography in order to assess the stability of slopes under future earthquake shaking.

CGS has released over 100 official liquefaction and landslide zone maps covering thousands of square miles. The top figure shows a detailed map of seismic hazard zones for potential liquefaction (in green) for San Francisco's Marina District, whereas the middle figure shows the seismic hazard zones for potential earthquake-induced landslides (in blue) for Berkeley. Forty of the completed maps cover parts of San Francisco, Santa Clara, San Mateo, Alameda, and Contra Costa counties; these seismic hazard maps are compiled into one map inside this CGS Note (page 4). CGS will continue producing earthquake zone maps for liquefaction and earthquake-induced landslides in the Bay region.

CGS geologists place earthquake fault zones around traces of faults where mapping demonstrates surface fault rupture has occurred within the past 11,000 years (Holocene time). Construction within these zones cannot be permitted until a geologic investigation has been conducted to prove that a building planned for human occupancy will not be constructed across an active fault. These site-specific investigations evaluate the location and recency of surface fault rupture and are typically based on observations made in trenches excavated across fault traces. The bottom figure shows an earthquake fault zone (in pale yellow) for a portion of the Hayward fault in the City of Fremont, Alameda County. CGS has released over 500 official fault zone maps statewide.







**Earthquake Zones of Required Investigation:**  
<https://maps.conservation.ca.gov/cgs/EQZApp/>

**MAP EXPLANATION**

- Earthquake-Induced Landslides**  
 Areas where previous occurrence of landslide movement, or local topographic, geological, geotechnical and sub-surface water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code 2963(c) would be required.
- Liquefaction**  
 Areas where historic occurrence of liquefaction, or local geological, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.
- Surface Fault Rupture**  
 Regulatory zones encompassing active faults so as to define those areas within which fault-rupture hazard investigations are required prior to building structures for human occupancy.
- Area Not Evaluated for Seismic Hazard Zones**  
 Area has not been evaluated for liquefaction or seismic landslides because: it is not developable for significant structures for human occupancy in the foreseeable future; it is not anticipated to experience levels of earthquake shaking high enough to generate these hazards; or CGS plans to delineate hazard zones in the future but has not prepared maps at this time.

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