

El Niño 1997–98: Damaging Landslides in the San Francisco Bay Area

Preparation for El Niño

In the fall of 1997, in anticipation of landsliding associated with forecasted, heavy, El Niño precipitation, U.S. Geological Survey (USGS) scientists prepared maps showing landslide deposits, debris-flow source areas, and rainfall thresholds for the 10-county San Francisco Bay region. These maps were used in cooperation with the California Office of Emergency Services (OES) and the National Weather Service (NWS) to provide an advisory system for landslide hazards in the San Francisco Bay Area. The NWS provided rainfall forecasts and quantitative precipitation data, and the OES coordinated conference calls among emergency units, the USGS, and various NWS stations.

Major Landslide Events

El Niño-driven rainfall triggered many landslides and debris flows in the San Francisco Bay Area during the winter of 1997–98. Debris flows triggered by heavy rains on February 2–3, 1998, damaged a number of homes and properties. In San Mateo County, one fatality resulted from a debris flow that destroyed a house in Loma Mar, and a preexisting landslide deposit near La Honda was reactivated, affecting roadways and causing extensive damage to a number of residences. The La Honda slide has been mapped in detail by the USGS. Debris flows originating from the toe of an active rotational landslide destroyed and damaged houses in the small town of Rio Nido

in Sonoma County. No fatalities occurred there, but 140 houses in the canyon below the debris flow were evacuated as a precaution. The USGS installed a real-time, data-collection system on the remaining landslide mass to detect possible catastrophic failure.

Because most of the Bay Area experienced about 200 percent of normal rainfall by mid-winter 1997–98, a number of slow-moving landslides were activated in the late winter and spring of 1998. For example, on about March 22, a portion of a preexisting landslide deposit on Mission Peak in Alameda County failed and initiated an earthflow approximately 0.3 km by 1.2 km in size. On April 22, another slow-moving landslide near Aromas, Calif., severed two Pacific Gas and

Electric Company natural-gas pipelines, cutting off gas service for several days to 60,000 customers in Santa Cruz County and parts of Monterey County.

Reconnaissance

In April and May 1998, USGS scientists conducted a field reconnaissance study in the San Francisco Bay Area to provide a general overview of the landslide damage resulting from the 1997–98 sequence of El Niño-related storms. Seven scientists from the USGS Landslide Hazards Program based in Reston, Va., Golden, Colo., and Menlo Park, Calif., and five scientists from the USGS Geologic Mapping Program's San Francisco Bay Mapping Team based in Menlo Park, Calif., cooperated in the landslide



Structures destroyed by a landslide along 19th Street in Oakland, Calif. The landslide extends from the left side of the photo, downslope to the right. (Photo: USGS/J. Coe)



Map showing locations of damaging landslides in the 10-county San Francisco Bay Area. A total of 441 locations that sustained damage during the winter and spring of 1997–98 have been identified.

damage assessments. These teams were greatly assisted by public works, planning and building departments, OES personnel, consultants, and homeowners. The assessments were done for 10 counties in the Bay Area: San Francisco, San Mateo, Santa Cruz, Santa Clara, Alameda, Contra Costa, Solano, Napa, Sonoma, and Marin. The landslide damage data are now being compiled in preparation for a published report and Internet presentation.

Although the landslide damage data are preliminary, the direct costs of landslide damage in the 10 counties from the 1997–98 El Niño storms can be estimated: San Francisco County, \$4.0M; San Mateo County, \$45.4M; Santa Cruz County, \$9.3M; Santa Clara County, \$7.8M; Alameda County, \$20.0M; Contra Costa County, \$27.0M; Solano County, \$6.0M; Napa County, \$1.1M; Sonoma County, \$21.0M; and Marin County, \$3.0M. Total direct costs for 1997–98 El Niño-related landslide

damage for the 10 Bay Area counties are conservatively estimated at \$140.9M. These figures can be compared with those from a particularly severe 1982 storm that triggered 18,000 debris flows and landslides across the region, killing 25 people and costing at least \$112.9M (in 1998 dollars) in property damage. From the field reconnaissance data, it appears that 1997–98 El Niño-related damage from deep-seated, slow-moving landslides in the Bay Area was more prevalent than debris flow damage, in contrast with the 1982 storm. This contrast is attributed to the prolonged rainfall throughout 1997–98 compared with the one intense storm in 1982.

Indirect costs of landslide damage can be substantial and include costs incurred from interference of water, electric, and sewer services. These costs are difficult to determine because landslide losses are not generally covered or tracked by the insurance industry. The subjective nature of assessing indirect costs adds to the difficulty of estimating the total cost of landslide damage.

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