



***Cal* OES**

GOVERNOR'S OFFICE
OF EMERGENCY SERVICES

**Appendix T.
Current State
Landslide Hazard
Mitigation Efforts**

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**CALIFORNIA
STATE HAZARD
MITIGATION PLAN**

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Gavin Newsom
Governor

Nancy Ward
Director
California Governor's
Office of Emergency Services

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Appendix T. Current State Landslide Hazard Mitigation Efforts



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T. CURRENT STATE LANDSLIDE HAZARD MITIGATION EFFORTS

T.1. LOCAL GOVERNMENT RESPONSIBILITIES

Managing landslide risk is primarily the responsibility of local governments where planning and building departments serve as lead agencies. Over 80 percent of California cities have landslide/mudslide ordinances, design standards, or guidelines for hillside development. California's Seismic Hazards Mapping Act designates landslide zones wherein cities and counties are required to condition construction permits upon adequate landslide site investigation and agreed-upon mitigation. These efforts have proven effective in reducing losses over the past decades, but not all jurisdictions that face potential landslide hazards have such instruments, nor has zoning of all landslide-prone areas been completed under the State program.

T.2. CALIFORNIA LANDSLIDE HAZARD MAPPING

Since the 1970s, the California Geological Survey (CGS) has produced numerous maps that show landslide features and delineate potential slope-stability problem areas. Preparation of these maps has been episodic, often driven by landslide disasters and subsequent legislative mandates. Many CGS landslide maps and related products have been produced for local or State agencies in response to their specific needs.

California's Landslide Hazard Identification Act established the Landslide Hazard Identification Program (LHIP) in 1986 under the jurisdiction of CGS, which prepared maps of landslide hazards and distributed them to local governments. Since the LHIP terminated by sunset law in 1995, some landslide hazard identification mapping is being conducted under the Seismic Hazards Mapping Act. However, there has been no State program to evaluate or map the types of landslides that cause the most casualties. Although the Alluvial Fan Task Force provided some guidance on where runout could affect developing areas in southern California, the need for a statewide assessment of debris flow potential on hillsides and alluvial fans is not being met. This assessment could include the hazard of post-fire debris flow potential as well as include possible effects due to climate change.

Progress Summary as of 2023: Landslide Hazard Mapping

The California Geological Survey (CGS) has released maps of zones of requiring investigation for seismically induced landslides under the Seismic Hazards Mapping Act since 1997. In addition, CGS has been producing maps of landslides since the 1970s.

CGS is in the process of digitizing maps of landslides. Hundreds of these landslide inventory maps, covering much of coastal California, are now available on the CGS Landslide Inventory Viewer:

<http://maps.conservation.ca.gov/cgs/informationwarehouse/index.html?map=landslides>.

The map viewer index includes landslide maps produced over many years and for a variety of purposes. Mapping of landslides reflects the standards of the project and time the map was prepared. The amount of information recorded about each landslide has increased over time, so more information is available for more recently mapped landslides. Updates to the database are continuing, both to include more existing maps and to add current landslides as they occur. The Landslide Inventory Viewer is a work in progress and is being updated continuously as CGS produces new maps, adds more information, and corrects existing maps.

CGS prepares the following types of landslide hazard focused maps:

1. Landslide inventory maps
2. Reported landslide maps database
3. Landslide susceptibility maps
4. Landslides, geology, and geomorphology in California's timber lands
5. Landslide zone maps

For a more detailed discussion on the types of CGS landslide maps, current CGS mapping programs, and the history of CGS landslide mapping, visit:

<http://www.conservation.ca.gov/cgs/landslides>

Maps showing the locations of existing landslides in a community are useful for land use decision-making because they target areas to be avoided or remediated before construction can safely proceed. The maps indicate not only the location, but also activity status and direction of slope movement to provide a better understanding of where landslides are most likely to be triggered, either by winter storms or earthquakes.

Progress Summary as of 2023: Landslide Hazard Mapping (Continued)

Because of the value of landslide maps for hazard mitigation projects, many communities have prepared such maps as part of the safety elements of their general plans or for local hazard mitigation plans (LHMPs). Advanced knowledge of slope instability can help to assure that proper consideration will be included in grading plans and that safe foundations will be constructed. CGS has also built a database showing recently reported landslides, with data sent by government agencies, media, and citizens scientists. The addition of this database furthers the understanding of slope stability for project planning and hazard mitigation. The Reported Landslide Database can be found at:

<https://cadoc.maps.arcgis.com/apps/webappviewer/index.html?id=bc48ad40e3504134a1fc8f3909659041>

Figure T-1 is an example of a landslide inventory map from the CGS landslide map viewer showing boundaries of existing landslides in a portion of the Los Gatos/Highway 17 area. Landslides mapped by CGS and others are shown as colored areas when data is available.

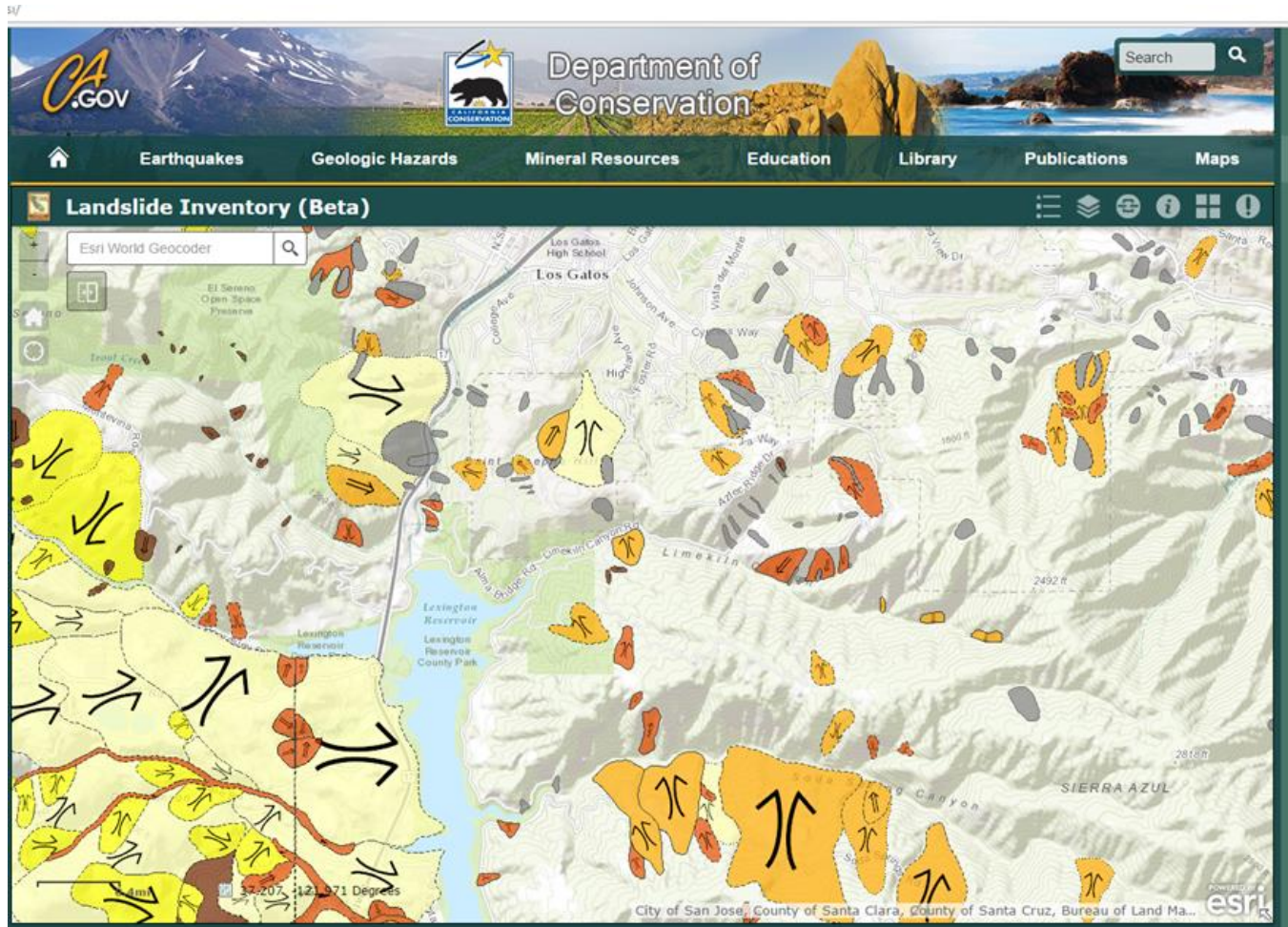
The background yellow-red colors indicate areas of weak rocks and/or steep slopes leading to susceptibility to deep landslides. Darker red as background indicates higher susceptibility. Landslides are color-coded as:

- Brown – Active or Historic Movement
- Orange – Dormant: Some Indication of Historic Movement
- Yellow – Dormant: Old, No Evidence of Historic Movement

Arrows show direction of landslide movement. When using the viewer online, greater detail can be viewed by zooming in.

T.3. LANDSLIDE PREDICTIVE MODELING AND PRELIMINARY SITE ASSESSMENT

Landslide predictive modeling and preliminary site assessment can be vital for identifying hazards and directing mitigation efforts. Regional modeling of burn areas around the State is being conducted by State and federal agencies that respond to post-fire hazards to assess post-fire conditions for risk from debris flows that could affect vulnerable areas. The most recent link to the report detailing these modeling efforts (SR 234) is available at <https://maps.conservation.ca.gov/cgs/publications/>

Figure T-1. CGS Landslide Inventory Viewer – Showing Los Gatos/Highway 17 Area

Source: (CGS 2015)

Pre-fire modeling of areas across the State prone to wildfire would allow for, at a minimum, the identification of risk areas, emergency planning, and post-fire evacuation warnings. CGS is working on a pilot project to develop a methodology for a future statewide assessment of post-wildfire debris flow risk.

In 2015, CGS prepared a special publication guiding assessment of alluvial fan depositional environments to determine areas that may be impacted by alluvial fan flooding. The publication provides direction for regional planning including:

- Data requirements
- Mapping standards
- Clarification of terminology
- Information for preliminary design

For a copy of this report, contact CGS at: cgspubs@consrv.ca.gov. For more information about U.S. Geological Survey (USGS) assessment of post-fire debris-flow hazards, visit: https://landslides.usgs.gov/hazards/postfire_debrisflow/index.php.

Additional predictive modeling efforts are being explored that incorporate critical geohazard inputs and scenarios. This includes expansion of probabilistic landslide models that can better reflect more realistic geologic and hydrologic parameters. Climate scenario evaluation is an important part of this work to better understand and plan for future landslide vulnerabilities. Predictive modeling for landslides also includes runout modeling to understand how downstream areas may be affected by debris flows. The runout models are important for both fire and non-fire-related debris flow events.

T.4. WATERSHED EMERGENCY RESPONSE TEAM POST-WILDFIRE DEBRIS FLOW AND FLOOD ASSESSMENTS

Following selected wildfires, California, in coordination with federal agencies, deploys Watershed Emergency Response Teams (WERTs) to conduct post-fire assessments. The WERT assessments identify types and locations of threats to life-safety and property (collectively known as “values-at-risk” or VARs) from debris flows, flooding, rockfall, and erosion that are elevated due to wildfire. As part of the WERT assessment, the team develops preliminary emergency protection measures for the identified locations in a detailed report with maps and communicates the findings to responsible emergency management agencies.

WERT post-fire assessments are generally limited to large wildfires that pose significant threat to lives and property from post-fire debris flows and flooding. While similar in some ways to the U.S. Forest Service’s Burned Area Emergency Response (BAER) Team assessments, the WERT assessments have less emphasis on natural and cultural resources and only recommend emergency measures for life safety and property protection.

Most wildfires, including small fires, fires located mostly on federal lands, fires in areas with short gentle slopes or low landslide potential, and fires not in proximity to housing developments or other VARs, typically do not require a WERT assessment. Fires greater than 500 acres on U.S. Forest Service lands trigger a separate BAER assessment. WERT assessments are typically established based on the recommendation of the California Department of Forestry and Fire Protection (CAL FIRE) Director, Unit Chief, IMT Incident

Commander, or Unit Forester. A federal disaster declaration or State emergency proclamation may also make WERT deployment more likely.

When making the determination to deploy WERT for post-fire assessment work, the following key factors are considered:

- The presence of life safety-related VARs (e.g., homes, businesses, other infrastructure) downslope and/or downstream of steep hillslopes and catchments burned at moderate to high soil burn severity
- High likelihood of debris flows and flooding based on soil burn severity, topography, geology, and likely rainfall rates
- Historical occurrence of debris flows and flooding during burned and/or unburned conditions
- Presence of transportation networks (e.g., highways, rail lines), water supply systems, power generating plants and conveyance systems, campgrounds, resorts, and other high value sites expected to be at high risk due to post-fire debris flows and flooding
- A high percentage of SRAs included in the fire area

WERT assessments are a collaborative effort between primary agencies and other additional agencies, which require interagency cooperation at the State, federal, and local level. Primary agencies include CAL FIRE, CGS, the California Department of Water Resources (DWR), and the U.S. Geological Survey (USGS). Additional agencies may include the RWQCBs, the Natural Resources Conservation Service (NRCS), and local jurisdictions. CAL FIRE acts as the lead agency coordinating WERT in cooperation with all contact agencies. Specialized personnel with qualifications in engineering geology, civil engineering, hydrology, geographic information systems (GIS), forestry (including fire line safety), and water quality are required to rapidly identify life safety hazards. Which specific agencies are involved in a WERT assessment and the size of the team typically depend on the size and complexity of the fire and post-fire threats. Team size can range from one to 20 individuals. CAL FIRE provides the funding for agency involvement through memorandum of understanding (MOUs) and other pending agreements.

When a WERT assessment is determined to be necessary, the process involves:

- Assembling an interdisciplinary team of engineering geologists, civil engineers, hydrologists, foresters, soil scientists, GIS specialists, and others, as required

- Meeting with county and/or city officials and others with local knowledge of potential high-risk locations within or downstream of the fire area
- Obtaining the satellite-derived burned area reflectance classification (BARC) map indicating preliminary burn severity and field-verify soil burn severity determinations shown on the map
- Submitting the field-verified soil burn severity map to the USGS, allowing their scientists to produce the debris flow model basin and segment probability map using a 15-minute rainfall intensity design storm event. USGS debris flow model results are presented in terms of combined hazard, reflecting both the probability of debris flows and the magnitude of potential debris volume
- Conducting flood modeling and calculating debris volumes for specific watersheds located above identified VARs
- Conducting surface erosion modeling before and after the fire
- Compiling all collected data and modeling results as GIS layers and load them onto tablets and smart phones for field use
- Determining the location of potential VARs within and downstream of fire perimeter
- Field-checking and recording VAR locations digitally as points or polygons and develop preliminary emergency protection measures
- Summarizing VAR information in a detailed Excel table and GIS map format and compiling a draft report documenting the physical setting, methods utilized, modeling results, general and specific observations, and general recommendations
- Conducting a meeting with local emergency response agencies to present the draft report findings and answering questions regarding report information and recommendations
- Following review of the draft report by senior CAL FIRE and CGS staff, the report is finalized and approved by CAL FIRE, posted on CAL FIRE's website, and distributed to local agencies and other contacts made during the field investigation

The field assessment process typically takes between one to two weeks, with additional time required for draft report generation and agency approval. Following completion of the report, a WERT closeout meeting is held with local governments to go over the findings of the WERT field assessment process and the identified VARs.

Once the closeout meeting is completed, the California Governor's Office of Emergency Services (Cal OES) assembles the Post-Fire Watershed Task Force. The Cal OES-led Post-Fire Watershed Task Force coordinates with local county offices of emergency services and other State and federal agencies to facilitate and support implementation of VAR emergency protection measures and mitigation projects.

Typical WERT recommended emergency protection measures include:

- Early warning systems—Issue cell phone warnings using National Weather Service (NWS) flash flood and post-fire debris flow “watch” and “warning” notifications for burned areas based on radar-derived forecasts
- Storm patrols—Monitor road drainage infrastructure during strong storm events
- Structure protection/debris barrier—Install k-rails, sandbags, silt fences, temporary culverts, straw bale check dams, muscle walls, etc., where appropriate
- Debris clearance—Monitor and/or remove debris from debris basins, and from within channels subject to post-fire flooding
- Notification—Post temporary signage in areas of potential hazard
- Closure of high-risk areas—Close areas such as campgrounds during strong storm events
- Emergency Action Plans (EAPs)—Encourage local agencies to develop EAPs for very high-risk VARs potentially impacting large numbers of people
- Improved agency communication—When appropriate, encourage local flood control and public works departments to assist in communicating the high potential and high risk/consequences of post-fire watershed hazards to local emergency management agencies

Where wildfires include both federal and non-federal lands and an assessment is determined to be necessary, WERT and BAER teams work closely and collaboratively to share data and avoid redundant efforts. From 2015 to August 2018, WERT was deployed 16 times, including following the North Bay wildfires in 2017, the Thomas Fire in January 2018, and the Carr Fire and Holy Fire in the summer of 2018. Final WERT reports are posted on the CAL FIRE website.

In many cases, local jurisdictions may be able to obtain funding for some longer-term VAR emergency protection measures or mitigation projects from the Federal Emergency Management Agency (FEMA) Hazard Mitigation Assistance Program

(HMA), either through a Hazard Mitigation Grant Program (HMGP) or Public Assistance (PA) grant. HMGP grants that prioritize shovel-ready wildfire and watershed mitigation projects or other post-wildfire mitigation activities or PA grants that prioritize immediate threat erosion control measures to address post-wildfire soil conditions may be applicable sources of funding for eligible VAR emergency protection measures and mitigation projects by local jurisdictions. Additionally, emergency management agency coordination with NRCS may be appropriate since funding for post-fire recovery measures for exigent work may be available under NRCS' Emergency Watershed Protection Program.

T.5. FLASH FLOOD AND DEBRIS-FLOW DEMONSTRATION EARLY WARNING SYSTEM

In Southern California, USGS has identified the rainfall conditions required to trigger post-wildfire debris flows. Based on that data, the National Oceanic and Atmospheric Administration (NOAA) and USGS have established a demonstration flash flood and debris-flow early warning system for recently burned areas covering eight counties in Southern California.

The early warning system uses the National Weather Service Flash Flood Monitoring and Prediction (FFMP) system. The FFMP system identifies when both flash floods and debris flows are likely to occur based on comparisons between radar precipitation estimates and established rainfall intensity-duration threshold values.

When predicted rainfall rates exceed defined thresholds, the early warning system is triggered to send advisories, watches, and warnings to regional emergency management personnel using the NWS Advanced Weather Information Processing System. This information can then be disseminated to local residents to give warning of potential of landslide risks or evacuation requirements.

This demonstration system improves on former warning systems that were based on local precipitation tracking and were not able to trigger alerts with sufficient lead time for evacuation.

For more information regarding the demonstration early warning system and participating Southern California counties, visit the program web page: <https://landslides.usgs.gov/hazards/warningsys.php>.

The following link provides information on early warning progress for the NOAA-USGS Flash Flood and Debris Flow Early Warning System:

- <https://pubs.usgs.gov/fs/2005/3104/pdf/FS-2005-3104.pdf>

While the NOAA-USGS Flash Flood and Debris Flow Early Warning System is a significant effort for the triggering of advisories, watches, and warnings for flash floods and debris flows in southern California, there remains the need for a statewide assessment of risk from pre- and particularly post-wildfire flash flood and debris flows.

CGS was awarded FEMA disaster funds in 2021 (FEMA-4407-DR, <https://www.fema.gov/disaster/4407/designated-areas>) to conduct a pilot project for the development of a statewide landslide early warning system for post-wildfire flash flood and debris flow risk to vulnerable populations. The pilot project, which will study three separate alluvial fan areas in different geomorphic and climatic regimes across the State, will establish a methodology for a much-needed statewide assessment of post-wildfire debris flow risk and will implement a statewide web-based alluvial fan burn area information management system and monitoring database to enhance the USGS post-wildfire debris flow model. Dedicated resources will be needed to deploy the resulting methodology statewide to provide these critical data to State, federal, and community emergency managers.