

**WESTERN STATES SEISMIC POLICY COUNCIL
POLICY RECOMMENDATION 18-1**

Earthquake and Tsunami Planning Scenarios

Policy Recommendation 18-1

WSSPC strongly encourages states, provinces, territories, First Nations, tribes, and local governments to establish an active program to produce Earthquake and/or Tsunami Planning Scenarios for areas with high risk and vulnerability. WSSPC also recommends that state and federal agencies and potential private partners support the production of these Planning Scenarios through their funding resources and in-kind services.

Executive Summary

Earthquake and tsunami planning scenarios provide policy makers, stakeholders, and emergency preparedness personnel with realistic assessments of the areas and types of structures and lifelines that are at most risk of damage, and estimated human casualties. Equally important, scenarios identify areas and infrastructure that are most likely to sustain little or no damage and remain functional following an earthquake, thereby minimizing the placement of valuable response assets in areas where they may not be needed.

The cost to prepare planning scenarios, and to update them regularly, is insignificant compared to the information gained and the future savings from reduced losses to infrastructure, business economics, and human life when the information is used to develop effective seismic-safety policies. Minimizing future earthquake and tsunami damage through prior planning, loss-reduction measures, and providing information to facilitate quick recovery is critical for promoting resilient communities.

Background

The U.S. Geological Survey indicates that losses to the U.S. built environment and to the U.S. economy from natural geologic hazards amount to tens of billions of dollars every year, and the cost of these losses continues to increase. A fundamental reason for this increase is the continued development of population centers and infrastructure in areas known to have significant natural hazards. Policy makers and public agencies at all levels of government must balance the desired needs for community growth and development with concerns for ensuring the safety of the citizenry. Knowledgeable professionals must provide government decision makers, community planners, and developers with factual, timely, and unbiased scientific and engineering assessments of a community's vulnerability to geologic hazards. Planning scenarios have proven to be an effective means for communicating these risks.

Earthquake and Tsunami Planning Scenarios have been prepared for several areas in the western U.S. over the past two decades and have resulted in numerous initiatives to reduce future losses (see Appendix 1). A planning scenario describes a realistic event and the estimated resulting damage and casualties in the affected areas. A scenario may describe the fault rupture that initiates the earthquake, expected ground motion and acceleration, secondary effects triggered by the earthquake, potential extent of tsunami inundation and flow depths, anticipated emergency response activities and needs, expected structural losses to the building stock and lifelines, and human casualties, as well as areas and types of infrastructure least likely to be damaged or destroyed. The purpose of a scenario is to provide accurate information that can assist governments and developers in engineering, planning, and protecting vulnerable facilities from the destructive effects of a future earthquake; prioritizing emergency relief operations in areas likely to suffer the greatest damage; or planning and conducting emergency response training exercises.

Appendix 1: Completed earthquake and tsunami planning scenarios

Following the devastating eruption of Mount St. Helens in 1980, President Carter requested the National Security Council to consider the implications of the occurrence of a large damaging earthquake in California. The results of this analysis were presented by FEMA in 1981. One of the major conclusions was that it was unlikely that the collective emergency response capabilities of all levels of government and the private sector would be adequate to cope with a major destructive earthquake in metropolitan areas of California.

In response, the California Governor's Emergency Task Force on Earthquake Preparedness was established in February, 1981. Some 30 committees were formed to deal with improvement of the many emergency response functions that would be needed in such an earthquake emergency: e.g., communications, search and rescue, fire services, medical services, air transport, etc. Working with the Task Force, the California Geological Survey (CGS) developed the first two earthquake planning scenarios for the San Francisco Bay Area and the Greater Los Angeles Area. These two scenarios, funded by FEMA, were readily accepted, and a demand for additional scenarios covering other California metropolitan areas resulted in the production of eight more scenarios to date.

The State of Washington, through its Emergency Management Division of the Military Department, and the Earthquake Engineering Research Institute, prepared its first earthquake disaster scenario for the Seattle-Tacoma metropolitan area in 2001. This scenario described potential damage from the Seattle Fault, and predicts 1,600 deaths, 24,000 injured, police and fire departments overwhelmed, inadequate emergency and shelter services, nearly 40,000 buildings destroyed or rendered uninhabitable, \$33 billion in damages and loss, more than 130 fires, and years of rebuilding and recovery. Since that time, the State released its digital Earthquake Scenario Catalog that includes 20 earthquake scenarios using sources that are consistent with the U.S. National Seismic Hazard Map. The project was a collaboration between the Federal Emergency Management Agency, the U.S. Geological Survey, the Washington State Department of Natural Resources, Western Washington University, and URS Corporation.

In 1996, the Nevada Bureau of Mines and Geology (NBMG) produced a detailed scenario for a Reno-Sparks-Carson City earthquake (NBMG Special Report 20) and in 2014, published the results of a HAZUS study of potential losses from multiple earthquake scenarios for thirty eight communities (NBMG OFR 14-5). The Nevada Earthquake Safety Council (NESC) in conjunction with the Federal Emergency Management Agency developed the Nevada Earthquake Risk

Mitigation Plan (2001) outlining public awareness, preparedness, emergency response, and recovery plans that will contribute towards making Nevada a seismically resilient state.

More recently, the USGS, in collaboration with the California Governor's Office of Emergency Services (CalOES) and California Geological Survey (CGS) and many community agencies and organizations, has published *The ShakeOut Scenario – Effects of a Potential M7.8 Earthquake on the San Andreas Fault in Southern California* (USGS Open File Report 2008-1150; CGS Preliminary Report 25). Under this scenario, if no additional preparedness and mitigation actions are taken, the resulting damage will cause 2,000 deaths, 50,000 injuries, and \$200 billion in damage along with severe, long-lasting disruptions. In 2014, the same groups at the USGS, CGS, and CalOES also completed a similar scenario evaluating the impacts from a large statewide tsunami originating from the Alaska Subduction Zone, which was published in *The SAFRR (Science Application for Risk Reduction) Tsunami Scenario* (USGS Open File Report 2013-1170 and CGS Special Report 229). The USGS SAFRR group and its state partners continue to work on similar useful scenarios for various hazards and vulnerable regions.

Other states with earthquake potential have also prepared these types of scenarios on a formal basis. In Washington, the Cascadia Region Earthquake Workgroup (CREW), a coalition of private and public representatives, developed several scenario reports detailing the potential effects of a hypothetical magnitude 9.0 Cascadia subduction zone earthquake, as well as shallow crustal earthquakes in the forearc. In 2007, Oregon completed an initial step in quantifying structures in the state that would be susceptible to damage from an earthquake in its publication *Statewide Seismic Needs Assessment Using Rapid Visual Screening*. In 2015, the Earthquake Engineering Research Institute (EERI) and the Utah Seismic Safety Commission completed a scenario report outlining potential hazards and loss estimates from a hypothetical magnitude 7.0 earthquake on the Salt Lake City Segment of the Wasatch fault.

The ASHSC has produced a report describing a set of guidelines for developing community specific earthquake scenarios including specific data needs and resources to assist such efforts (http://seismic.alaska.gov/download/ashsc_meetings_minutes/Guide_Concept_Level_Scenario_Alaska.pdf). An earthquake planning scenario is being developed for the City of Kodiak. This scenario is a cooperative effort involving the Alaska Seismic Hazards Safety Commission (ASHSC), Alaska Division of Homeland Security & Emergency Management, city and borough government, FEMA, and U.S. Coast Guard. Additionally, the ASHSC has recently completed several studies funded by

EERI on the vulnerability of schools (Fairbanks North Star and Kenai Peninsula Boroughs) to earthquake damage based on rapid visual screening.

Hypothetical tsunami studies have been conducted for coastal communities throughout the western U.S. and other parts of the Pacific to provide guidance to local emergency management agencies in tsunami inundation assessment, evacuation planning, and public outreach. These studies have largely been funded through the National Tsunami Hazard Mitigation Program of the U.S. Department of Commerce/National Oceanic and Atmospheric Administration (NOAA) and involve collaborative efforts between state government agencies, universities, and emergency planning scientists. Tsunami inundation maps depicting both local- and distant-source tsunami inundation scenarios are now available for nearly every populated region of the California, Oregon, Hawaii, Washington, American Samoa, Guam, and CNMI coasts, as well as for over 25 coastal communities in Alaska.

The Montana Bureau of Mines and Geology estimated geometries and slip amounts for 18 Quaternary faults in Montana. The U.S. Geological Survey used these parameters to derive scenario earthquakes. EERI coordinated this effort and the resulting scenario earthquakes (plus two others for planning exercises) are available at: <https://earthquake.usgs.gov/scenarios/catalog/mt2016/>.

Appendix 2: Resources for scenario development

State emergency management agencies and geological surveys as well as the USGS have numerous maps and products which can help form the foundation for earthquake and tsunami planning and mitigation scenarios. Because these products are familiar to and vetted by many of the communities they are prepared for, scenarios based on these products will be simpler and more effective for communities, utilities, and businesses to utilize. These resources may also provide a cost savings to the scenario developers in their hazard assessments, and provide a bridge for improving collaboration between state and federal agencies working on the scenarios.

The Quaternary Fault and Fold Database for the Nation is a valuable resource for identifying credible earthquake sources and seismic zones to incorporate into realistic earthquake scenarios. Probabilistic earthquake-induced ground motions can be evaluated by region from various web sites maintained by the USGS Earthquake Hazards Program. Surficial geologic maps are available from state geological surveys, locally prepared hazard mitigation plans can provide a foundation for scenario development, and a wealth of geotechnical information can be obtained from state departments of transportation and local government engineering geologic investigation archives.

Other valuable analytical tools are available for incorporation into earthquake and tsunami planning and mitigation scenarios. HAZUS is a powerful risk assessment software program developed by FEMA for analyzing potential losses from earthquakes and tsunamis (as well as from other types of natural hazards). HAZUS combines current scientific and engineering knowledge with geographic information systems (GIS) technology to produce estimates of hazard-related damage before or after an earthquake. For HAZUS to be most effective, users should employ the latest census information and a current inventory of the built environment, including transportation and lifeline infrastructure.

Two other analytical tools are available from the USGS; these are ShakeMap and PAGER. ShakeMap combines measurements of ground shaking (actual or modeled) with information about local geology and earthquake location and magnitude to estimate shaking intensity variations within a geographic region. Produced maps are a valuable tool for emergency response, public information, loss estimation, earthquake planning and modeling, and post-earthquake engineering and scientific analyses.

PAGER (Prompt Assessment of Global Earthquakes for Response) is an automated system designed to rapidly estimate the number of people, cities, and regions that have been exposed to severe ground

shaking by an earthquake. PAGER products can be sent automatically to affected emergency responders, government agencies, and others with information as to the estimated scope of a potential disaster.

Over the past decade, NOAA has developed a suite of tsunami exercise handbooks for various sources around the Pacific. These handbooks start with earthquake and tsunami scenarios which are used to create a full set of information statements. States and communities use these handbooks and statements as background for response exercises. Past exercise handbooks are available on the NOAA website: <https://tsunami.gov/?page=exercises>.