Using Geologic Maps to Reduce Landslide Risk

Protecting public safety and infrastructure

A major landslide in Big Sur, California in 2017 covered a quarter-mile of Highway 1. It was not the only landslide to limit access to the highway in 2017, and repair estimates exceed $40 million.
Image credit: Bob Van Wagenen (Public Domain)

Ongoing Work

The U.S. Geological Survey (USGS) and National Park Service (NPS) are actively mapping surface geology and associated natural hazards in Channel Islands National Park (CHIS) in California as part of a National Cooperative Geologic Mapping Program (NCGMP) FEDMAP project.

The park is known for its steep, fractured sea cliffs, which have a high potential for landslides and rockfalls. Through mapping, USGS and NPS found that a popular hiking trail skirts the edge of a cliff section that is visibly slumping, indicating that a landslide could be imminent. With this knowledge, NPS is able to limit access to this trail and to public safety.

Geologic Maps and Landslide Hazards

A geologic map is key to understanding landslide risk. The U.S. Geological Survey (USGS) and numerous state geological surveys around the nation prioritize the mapping of landslide-prone areas. Understanding landslide risk is crucial in making decisions around safety, infrastructure, and land use. Although it is impossible to predict exactly when a landslide will occur, geologic and landslide maps can identify and provide information on areas with high potential for landslides.

Landslides occur when soil, rock, and surface debris (including varying amounts of water), are moved down a slope by gravity. The term 'landslide' is an umbrella term used for many different types of slope movements such as debris flows (sometimes called mudslides), debris slides, rock slides, rock falls, and more. Washington, Oregon, California, Alaska, Hawaii, and areas in the Appalachians and mountainous West are particularly prone to landslides due to their abundance of large, steep slopes, but landslides occur in all 50 states and many different types of terrain, from large cliffs to gentle hills. Weaknesses in the rocks or soils of a slope, Earth processes, and human activity can all cause landslides. Rainfall is one of the most common triggers of landslides across the United States.

Geologists and engineers plot slope steepness and shape, bedrock and surface geology, past landslide locations, soil data, and groundwater levels on maps to determine which areas are most susceptible to landslides. Detailed topographic information provided by tools like Light Detection and Ranging (lidar) add important information on the boundaries, movement, and susceptibility of landslides. Experts can then conduct targeted investigations at high-potential sites to evaluate whether or not a landslide is likely to occur and what the impacts of a landslide might be. Policy makers, planners, emergency managers, and the public can then make land-use decisions based on this information.

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Maps and Planning for Major Disasters

Because other natural disasters, such as wildfires, hurricanes, volcanic activity, floods, and earthquakes, can lead to landslides. Emergency response plans for these events need to factor in the possible impact of landslides on evacuation routes and infrastructure.

In 2013 and 2014, geologists in Washington State investigated and mapped areas vulnerable to landslides if a magnitude 9+ earthquake were to occur on the Cascadia Subduction Zone (CSZ) offshore of the Pacific Northwest. An earthquake of that size would cause a tsunami, forcing an evacuation of parts of Coastal Washington, but some of the roads out of the danger zone could be blocked by landslides triggered by the same earthquake. For example, several evacuation routes around Grays Harbor County, Washington, are in danger of both small and large landslides in the event of a large earthquake. By knowing where landslides are most likely to occur, town officials and emergency managers can now create alternative evacuation plans that improve their community's preparedness for disasters.

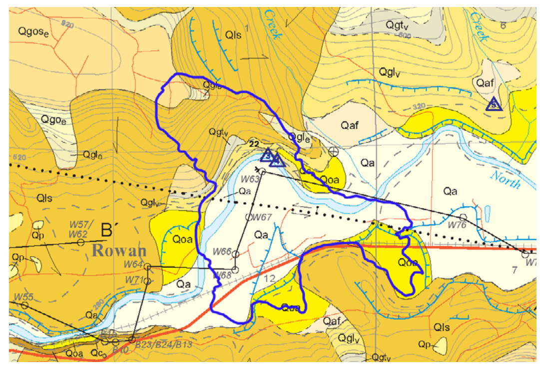
Case Study: Mapping Major Landslides in Washington State

The chance of a landslide is known to be markedly higher on or near the sites of previous landslides. Two recent major landslides in Washington State caused severe damage to nearby communities. In March of 2014, the devastating Oso landslide and resultant debris flow—a mass movement of loose rock, soil, organic matter, air, and water— claimed the lives of 43 people, destroyed 49 homes, and shut down a portion of a major road in the area for almost two months. Overall, the landslide covered about 262 acres of northwestern Washington. Comparatively smaller, the 2013 Ledgewood-Bonair landslide covered about 12 acres and resulted in no fatalities. However, the smaller landslide did put 20 homes at risk of structural damage or property loss and cut off access to a major roadway.

New geologic maps of both areas show previous landslides near the locations of the 2013 and 2014 landslides, and that the two landslides reactivated portions of older slides. The slope that failed in the 2014 Oso landslide had failed before, causing an estimated 15 major and many minor landslides over the past 6,000 years—including one as recently as 2006—but had never moved such a large volume of material. In 1997, reactivation of the 11,000-year-old Ledgewood-Bonair landslide – similar to the one that occurred in 2013 – destroyed a home. Detailed mapping undertaken since these landslides will inform future landslide hazard management decisions and may help the community, working with local and state authorities, to reduce the risk to lives and property.

The 2014 Oso landslide moved an estimated 270 million ft^3 of rocks, dirt, trees, and other debris down the slope. The direct costs for repair are greater than $80 million.

Image Credit: Jonathan Godt, U.S. Geological Survey (Public Domain)



Geologic map of the region where the Oso landslide occurred. The blue outline indicates the extent of the area moved by the landslide. The darker orange areas on the map labelled "Qls" are deposits from recent landslides. Areas that experienced landslides in the past are more likely to experience landslides in the future.

Image credit: Washington Department of Natural Resources

References & More Resources:

U.S. Geological Survey National Cooperative Geologic Mapping Program (NCGMP): ncgmp.usgs.gov

For a complete listing of references and more resources please visit the web version of this factsheet at www.americangeosciences.org/critical-issues/factsheet/using-geologic-maps-to-reduce-landslide-risk

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