Debris flow and lahar management in the Pacific Northwest

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ABSTRACT

Large-scale volcanic debris flows, known as lahars, pose the greatest volcanic hazard in the Pacific Northwestern United States. Although lahars may have relatively long recurrence intervals compared with other engineering problems, lahars can attain sufficient magnitude and travel long distances to create a risk to far-lying urban centers. Management of the risks associated with these flows includes hazard zonation, real-time monitoring systems, public education, and partnerships with agencies that have a long -term local commitment to public safety.

1 INTRODUCTION

The string of Cascades volcanoes that stands close to many metropolitan centers in the Pacific Northwest has been the source for volcanic debris flows, known as lahars, both during and in the absence of eruptive activity. During eruptions, lahars are generated as a consequence of rapidly melting snow and ice stored on the slopes, whereas large landslides or debris avalanches can occur and transform into debris flows in the absence of accompanying volcanic or seismic activity. In addition, catastrophic failures of debris dammed lakes can entrain sufficient materials to bulk into large-scale far-reaching flows.

Although large-scale lahars have long recurrence intervals, they nonetheless pose a significant risk to downstream urban centers. Lahars are considered to be the greatest hazard associated with the Cascades volcanoes because of their potential for direct inundation of populated areas, as well as disruption of transportation, water supplies, hydroelectric power generation and power transmission infrastructure. Management of the risks posed by lahars is accomplished through programs that assess and delineate the hazards, communicate the hazards to the public, partner with locally-vested agencies, and may use real-time monitoring systems where warnings to a prepared public may be of value.

2 HAZARD DELINEATION

A principal component of volcanic hazard assessment is the production of hazard zonation maps. Such maps are a crucial tool to communicate the hazards to the public and cooperating agencies and also provide an objective basis with which to evaluate risks to urban and other resources. Such maps are developed from rigorous geologic investigations or in certain cases, from empirical modeling.

2.1 Geologic Investigations

Although the written history of volcanic activity in the Pacific Northwest is far too brief to be the basis for determining magnitude and frequency of relatively rare events, geologic field studies of downstream sediments are typically used to unravel the sequence of prehistoric flows. This approach is based on the observation that volcanoes tend to repeat their activity patterns. Thus, their future activity will mimic their past behaviour. Although investigation of the deposits in the valley bottoms leading from a volcano is a time consuming and expensive undertaking, it yields the most valuable information of the type, size and timing of large lahars. This has been the primary technique used by the USGS Volcano Hazards Program to produce volcano hazard assessments in the Cascades.

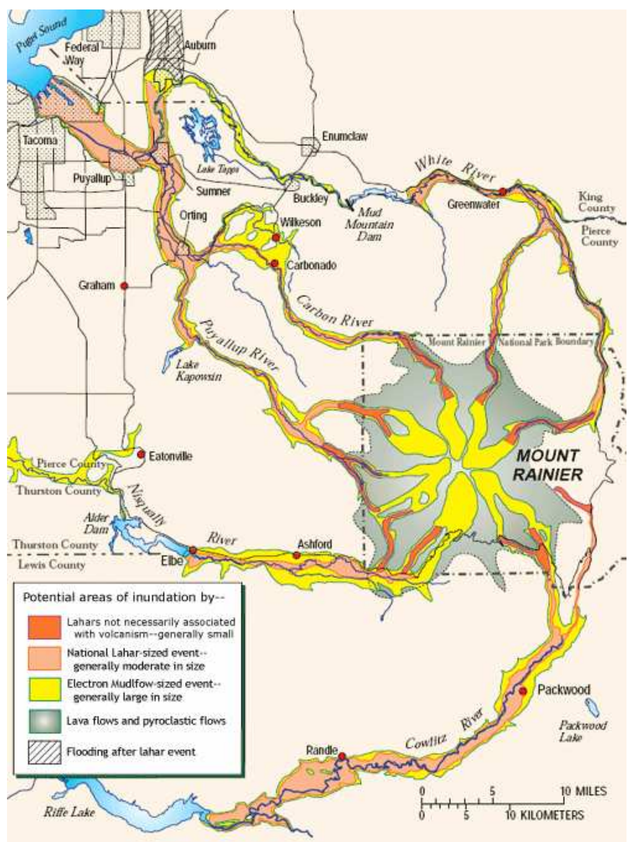

Figure 1. Lahar hazard zonation map for Mount Rainier, WA from Hoblitt, et al, 1998.

2.2 Empirical Models

Where suitable geologic records are not accessible, time is not available, or other constraints preclude lengthy geologic investigation, an empirical model can be used to generate a rapid, objective and reproducible inundation map. One such model, LAHARZ (Iverson , and others, 1998) uses a geographic information system (GIS) with a digital elevation model (DEM). The model takes an input volume and location provided by the user then uses statistical relationships between lahar volume, cross-sectional area and planimetric area derived from a database of numerous lahars. This tool is particularly useful to create a series of nested inundation maps that denote the hazard posed by a range of flow magnitudes by completing a series of runs using a range of source volumes for a particular source location.

3 REAL-TIME MONITORING

Monitoring for rare large-scale debris flows emanating from volcanoes differs from other debris flow monitoring systems that generate warnings of increased debris flow probability based on rainfall intensity. Lahar monitoring systems typically are not able to be tested nor calibrated on multiple events over time; they must remain effective and reliable for long periods without any events occurring.

Presumably, lahars triggered during eruptions will be preceded by some volcanic unrest that will be detected by seismic, deformation and gas monitoring systems operated by the USGS and Pacific Northwest Seismic Network (PNSN). Such activity will draw attention to the higher probability of lahars.

In contrast, some very large prehistoric lahars have originated on Cascades volcanoes seemingly in the absence of accompanying eruptive activity. Fortunately, the long travel times for lahars to pass from the volcano to populated urban centers offer adequate time to warn a knowledgeable population in time to evacuate low-lying areas.

The Acoustic Flow Monitor (AFM) is a proven system that uses geophones to detect debris flows after initiation (LaHusen, 1996) Because the sensor does not directly contact flows, minimal maintenance is needed and the system is not destroyed if large lahars do occur so it remains operational during a series of events. The system is in operation at more than a dozen volcanoes around the world.

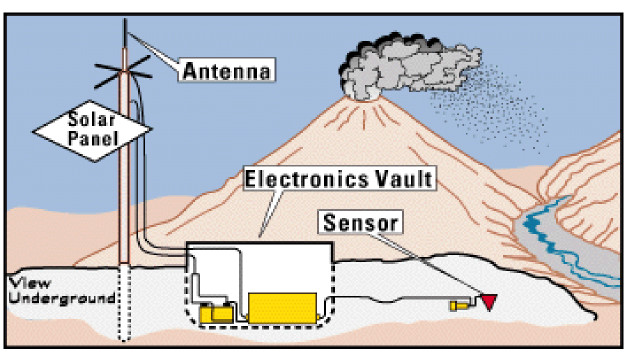

Figure 2. Acoustic Flow Monitor (AFM)

4 PUBLIC EDUCATION

The utility of understanding and delineating hazards and risks is useless unless it is effectively communicated to the public and they understand how to apply that knowledge to minimize or escape risk. Public education is an ongoing process as people move into areas at risk or forget the message. Also as populations grow and transportation options change, new evacuation plans may need to be designated and the public re-educated. Most effective public education programs target special interest groups and educational institutions to get the message into homes. Lahar evacuation exercises at public schools near Mount Rainier not only served as a mitigation strategy, it also brought significant media attention to the issue and reached a much larger audience that just the school children and their families.

5 PARTNERSHIPS

Because the recurrence interval of large lahars is relatively long, it is crucial to develop long-term relationships between public agencies that have a commitment to maintain public safety and awareness. Agencies that have a local interest in hazard management may be more vigilant over the long term than more distant government entities. For example, The USGS and Pierce County have collaborated on a technology development and transfer program to install, operate and maintain a real-time lahar warning system for Mount Rainier, Washington.

Other important partnerships can be with the public agencies that have the responsibility and resources to communicate public safety warnings. In the United States, the National Weather Service (NWS) maintains 24/7 flood forecasting offices that will issue flash flood watches and warnings over a National Weather Alert Radio System. This service has been extended in cooperation with other agencies operating debris flow monitoring systems. Alternatively, local community law enforcement agencies may be best situated to rapidly communicate public warnings as in the Pierce County Rainier Lahar Warning System.

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