USGS
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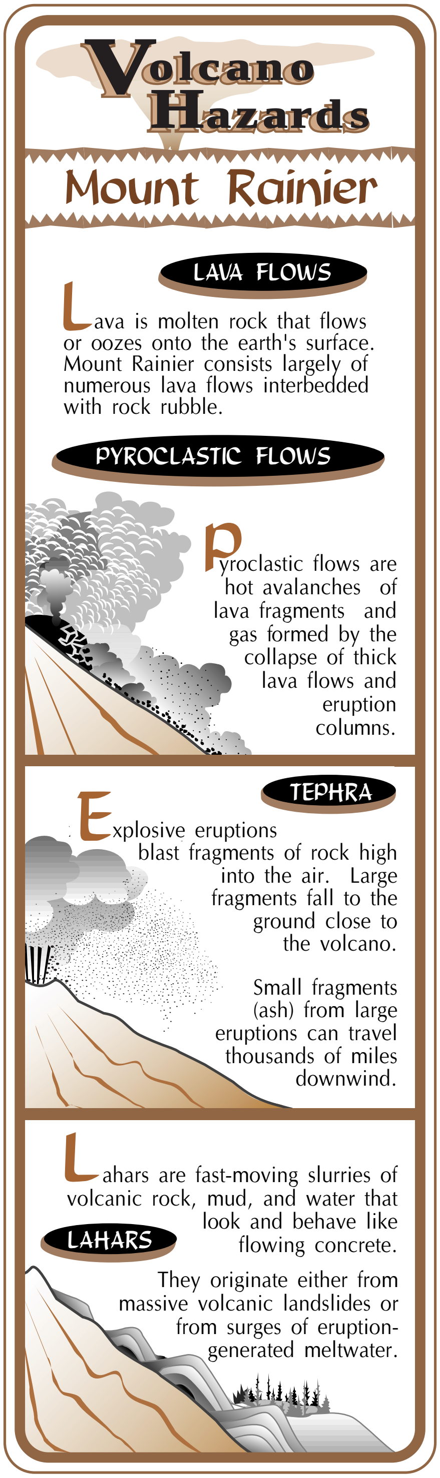
U.S. GEOLOGICAL SURVEY— REDUCING THE RISK FROM VOLCANO HAZARDS

Mount Rainier–
Living with Perilous Beauty



Mount Rainier is an active volcano reaching more than 2.7 miles (14,410 feet) above sea level. Its majestic edifice looms over expanding suburbs in the valleys that lead to nearby Puget Sound. USGS research over the last several decades indicates that Mount Rainier has been the source of many volcanic mudflows (lahars) that buried areas now densely populated. Now the USGS is working cooperatively with local communities to help people live more safely with the volcano.

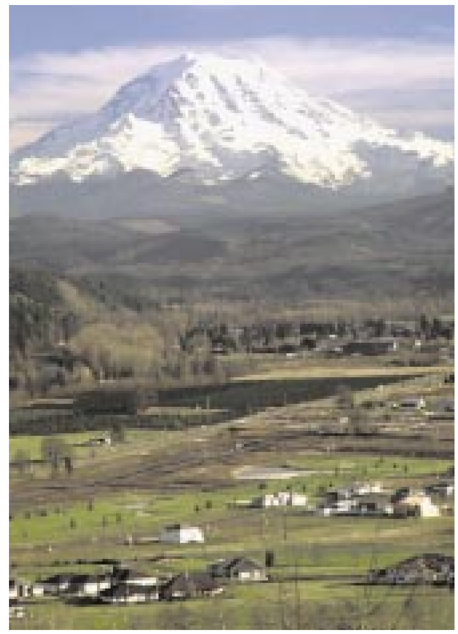


FIGURE 1.—*View across Puyallup River valley toward Mount Rainier*

What are the hazards?

Mount Rainier (fig. 1) is an active volcano that is currently at rest between eruptions. Its next eruption may produce volcanic ash, lava flows, or pyroclastic flows. The latter can rapidly melt snow and ice, and the resulting meltwater torrent may produce lahars (the widely used Indonesian word for volcanic mudflows) that travel down valleys beyond the base of the volcano to areas now densely populated. Lahars may also occur during non-eruptive times–without the profound seismicity and other warnings that normally precede eruptions.

Lahars look and behave like flowing concrete, and their impact forces destroy most man-made structures. At Mount Rainier, they have traveled 45-50 miles/hr at depths of 100 feet or more in confined valleys, slowing and thinning in the wide, now-populated valleys.

At Mount Rainier, lahars are a greater hazard than other volcanic products such as lava and poisonous gases that have been popularized by TV and film. Lava flows and pyroclastic flows are unlikely to extend more than a few miles beyond the National Park boundaries. Volcanic ash (tephra) will be distributed downwind, 80 percent of the time toward the east away from large populations (fig. 2).

The USGS, in cooperation with the University of Washington, monitors many Cascade Range volcanoes, including Mount Rainier, to detect precursors to eruptive activity. Mount Rainier was last active in the 19th century; one or more small eruptions produced local ashfall from one of the summit craters.

Why is Mount Rainier the most dangerous volcano in the United States?

Although Mount Rainier has erupted less often and less explosively in recent millennia than its neighbor, Mount St. Helens, the proximity of large populations makes Mount Rainier a far greater hazard to life and property.

1. *The population at risk*--More than 100,000 people reside on the deposits of previous lahars. The risk that an individual structure will be impacted by a lahar from Mount Rainier in much of this area is comparable to its risk of damage by fire.
2. *The size and frequency of lahars*--During the past few millennia lahars that have reached well into the Puget Sound lowland have recurred, on average, at least every 500 to 1,000 years. Smaller flows occur more frequently. A flow with a 500-yr return period has about a one in seven chance of occurring in an average human life-span.
3. *We may not have advance warning*–USGS research shows that some lahars may occur with little or no warning. Our only warning could be a report that a flow is under way.

How are lahar deposits identified?

A lahar flowing down valley from Mount Rainier leaves a thick valley-bottom deposit of boulders and hardened mud that may envelop stumps and logs of a buried forest. Some of the deposits can be traced upstream to the volcano's flanks, and all contain volcanic fragments unique to Mount Rainier. Geologists map the deposits and determine the tree ages to learn when the trees were engulfed and killed by the lahar. Old-timers recall encountering huge buried stumps and logs when plowing fields and digging wells. The youngest such forest was buried about 500 years ago and uncovered during excavations for new homes in the Puyallup River valley.

How and why do lahars form?

The most dangerous lahars start as enormous landslides--flank collapses--from the slopes of the volcano. Hot, acid water percolates through the volcano and slowly changes hard volcanic rock into soft rock that is clay-rich in a process called hydrothermal alteration. The mountain progressively weakens, like a house infested with termites. Eventually, a section of the volcano collapses, perhaps unexpectedly, and the muddy, water-rich mass transforms rapidly into a muddy slurry--a clay-rich, or cohesive, lahar (Case 1 in figure 3)--that is funneled at high speed into one or more surrounding valleys.

Probability of Tephra Accumulation

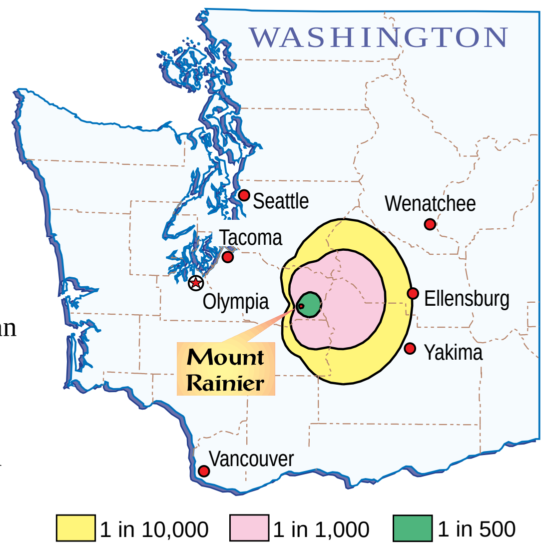


FIGURE 2.—*Map showing the annual probability that volcanic ash will be deposited to a thickness of 1/3 inch or more from an eruption of Mount Rainier. Volcanic ash, of this thickness or less, can cause disruption of ground and air transportation, and can cause damage to electronics and machinery.*

Sand-rich, or noncohesive, lahars form during eruptions of Mount Rainier when hot pyroclastic flows melt snow and ice. (Mount Rainier supports more than one cubic mile of glacial ice--as much as all other Cascade Range volcanoes combined.) These lahars may be less of a risk than cohesive lahars because they commonly have been smaller, although more frequent in the volcano's history (Case 2 in figure 3). Because noncohesive lahars occur with volcanic activity, they are likely to be preceded by events that will warn of an impending eruption; thus, they will be expected.

Small lahars, only a few miles long are caused by local avalanches of rock debris, sudden releases of glacial meltwater, or storms. These lahars (Case 3 in figure 3) happen commonly–many times each century.

New lahar deposits may get redistributed downstream over a period of many years as the disrupted drainage network becomes re-established. Thus valley-floor areas that were not impacted by the initial lahar deposits may suffer enhanced flooding and progressive burial by remobilized sediment (zone of post-lahar sedimentation in figure 3).

What triggers a flank collapse?

Flank collapses can be triggered when magma intrudes into a volcano and destabilizes it, as happened at Mount St. Helens in 1980. However, scientists studying the timing of flank collapses find that some flank collapses were apparently not accompanied by eruptions. They fear that a collapse could happen suddenly during non-eruptive periods and without the swarms of small earthquakes and other detectable phenomena that typically accompany rising magma.

A large earthquake unrelated to rising magma could trigger a flank collapse on Mount Rainier. At least one flank collapse at Mount Rainier could have been caused by a great prehistoric earthquake that occurred at about the same time.

A neighboring volcano--Mount Baker--produced flank collapses in the 1840's that were apparently triggered by steam explosions. Steam explosions at Mount Rainier could possibly trigger flank collapses and lahars with no advance warning.

Some flank collapses and lahars may happen with no obvious trigger. They may simply result from progressive hydrothermal alteration of the rock, saturation by groundwater, and the continuing pull of gravity.

What areas are at risk?

The courses of lahars will be the river valleys that drain Mount Rainier. Four of the five major river systems flow westward into suburban areas of Pierce County. These flow pathways are mapped by the USGS (fig. 3), just as flood-inundation maps show the areas at risk of flooding. Lahars occurring during

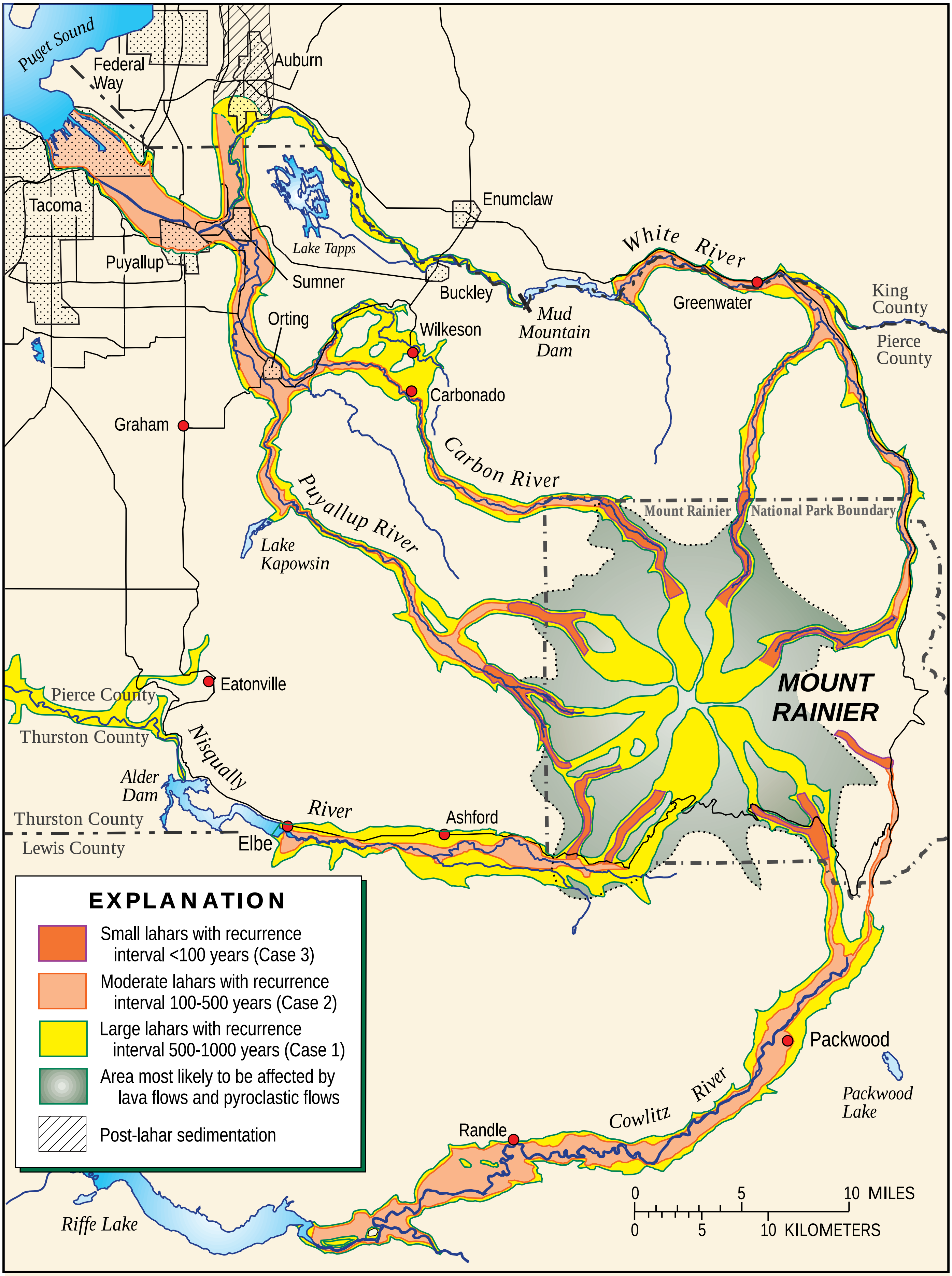


FIGURE 3.—*Hazard zones for lahars, lava flows, and pyroclastic flows from Mount Rainier (Hoblitt and others, 1998; US Geological Survey Open-File Report 98–428).*

an eruption may affect valley areas miles from the volcano, but a precursory warning should allow ample time to prepare for evacuation.

A catastrophic flow will likely spread into multiple drainages. The largest known flow entered all five drainage sectors, and most of the known large flows have entered two or more. Drainage sectors converge toward the summit and are separated by sharp, unstable divides. Lahars have been as much as 800-1000 feet deep on the flanks of Mount Rainier, overtopping divides even when originating in one drainage.

Are all parts of the volcano susceptible to landslides?

All flanks of the volcano are susceptible to landslides and rockfalls. However, the east and west flanks are the least stable and have been the source of the largest landslide-generated lahars because of an east-west-trending dike and fracture zone that promotes circulation of hydrothermal fluid in those sectors. In addition, large lahars commonly enter more than one drainage, placing multiple valleys at risk.

How are we responding to the risks?

The USGS, in cooperation with the University of Washington, monitors the state of the volcano and assesses eruptive and hydrologic hazards stemming from volcanic activity.

The lahar pathways mapped by the USGS guide the hazard-area regulations of the comprehensive land-use plan for Pierce County. The plan's urban growth boundary and its proposed land uses in unincorporated areas are designed to minimize population growth, where possible, within hazard zones.

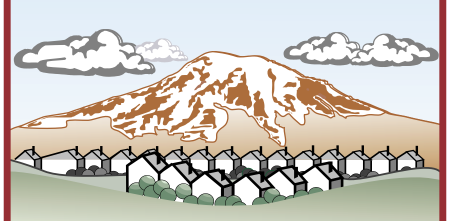
Local, county, state, and federal agencies including the USGS have joined to develop a Mount Rainier volcanic hazards plan that, when complete, will address such issues as emergency-response operations and strategies for expanded public awareness and mitigation of volcanic hazard.

What about a lahar-warning system?

A system for automatic detection and notification of an unanticipated flank-collapse lahar could reduce, but not eliminate, the risk in the lahar pathways. Two critical parts of such a detection and warning system include: (1) seismic detection and automatic notification of a major collapse event on Mount Rainier; and (2) detection, location, and automatic notification of a lahar in progress.

1. Seismic detection of collapse—work is under way to structure the seismic network run cooperatively by the University of Washington and the USGS to discriminate the seismic signal of a major collapse event on Mount Rainier and issue an automatic notice.
2. Lahar detection—the acoustic flow monitor (AFM) developed by USGS scientists can detect the ground vibrations of a lahar. The USGS and Pierce County Department of Emergency Management, together, are installing a pilot lahar-detection system in the Puyallup and Carbon River valleys. Computerized evaluation of data from arrays of five AFM's in each valley are expected to confirm either presence or absence of a flowing lahar and issue an automatic alert.

Mount Rainier is an active volcano...



Reducing population growth in the paths of lahars, implementing a warning system, and planning and practicing evacuations can lower the potential loss of life and property during future eruptions and lahars. These actions can reduce the risk from lahars and provide a measure of safety for those who enjoy living, working, and playing in valleys surrounding Mount Rainier.

How much warning will we have?

Travel time of a lahar increases with distance. Thus the travel time of a large lahar from Mount Rainier to the lowland valleys is estimated at 1 to 2 hours, whereas the travel time to the nearest area of large population may be as little as 45 minutes. However, as the AFM arrays must be located beyond the volcano flanks, as little as 30 minutes, after warning from the pilot lahar-detection system, may be available for evacuation of urban areas closest to Mount Rainier in the Puyallup valley. Time is short, and successful evacuation will depend on detection of the approaching lahar, effective notification of people at risk, public understanding of the hazard, and practiced response by citizens.

What can you do?

Learn: Determine whether you live, work, or go to school in a lahar hazard zone. Learn about all volcanic processes that could affect your community.

Plan: Develop an emergency plan with your family so that you are prepared for natural hazards and emergencies.

Inquire: Ask public officials to advise you about how to respond during any emergency.

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See also *Volcano Hazards from Mount Rainier, Washington* (U.S. Geological Survey Open-File Report 98–428