MOUNT HOOD
COORDINATION PLAN

Coordinating Efforts Among Governmental Agencies in the Event of Volcanic Unrest at Mount Hood, Oregon

Cover Sheet

Prepared by:
The Mount Hood Facilitating Committee

January 2004

This page intentionally left blank

FOREWORD

Oregon Emergency Management and Washington Military Department sincerely appreciate the cooperation and support from the agencies and local jurisdictions that have contributed to the development and publication of the **Mount Hood Coordination Plan**.

The plan provides vital Mount Hood volcanic event response and recovery information that will greatly enhance the hazard planning efforts of 4 Oregon counties, 2 Washington counties and the Confederated Tribes of Warm Springs and multiple state and Federal agencies. The Plan supports and complements local response plans, the *Federal Response Plan*, the *Oregon State Emergency Management Plan,* and the *Washington State Comprehensive Emergency Management Plan*.

The *Mount Hood Coordination Plan* is an important element in a coordinated effort to enhance our region's preparedness for emergencies and disasters. This plan embraces the philosophy and vision of a *Disaster Resistant State* and will empower local communities to minimize the impacts of volcanic activity on people, property, the environment and the economy of the Pacific Northwest.

Approved by (planned signatories):

Oregon State Police, Oregon Emergency Management, Washington Military Department Emergency Management Division, Oregon Department of Geology and Mineral Industries, Clark County, Clackamas County, Hood River County , Multnomah County, Wasco County, Confederated Tribes of Warm Springs, US Geological Survey, US Forest Service, FEMA Region 10

Table of Contents

This Page Intentionally Left Blank

PURPOSE

The purpose of this plan is to coordinate the actions that various agencies must take to minimize the loss of life and damage to property before, during, and after hazardous geologic events at Mount Hood volcano. The plan strives to ensure timely and accurate dissemination of warnings and public information. The plan also includes the necessary legal authorities as well as statements of responsibility of County, State and Federal agencies.

INTRODUCTION

Volcanoes dominate the skyline in many parts of the Pacific Northwest, although their fiery past is often unrecognized. These familiar snow-clad peaks are part of a 1,000-mile-long chain of volcanoes, the Cascade Range, which extends from northern California to southern British Columbia. Seven of those volcanoes have erupted since the birth of this nation about 230 years ago. These include Mount Baker, Glacier Peak, Mount Rainier, Mount St. Helens, Mount Hood, Mount Shasta, and Lassen Peak. These and many others could erupt again. Many people do not consider the Cascade volcanoes to be hazardous because the time between eruptions is often measured in centuries or millennia, and volcanic activity is not part of our everyday experience. However, the vast destructive power unleashed by the 1980 eruption of Mount St. Helens reminds us of what can happen when they do erupt. As populations increase in the Pacific Northwest, areas near the Cascade volcanoes are being developed and recreational use is expanding. Consequently, more and more people and property are at risk from future volcanic activity.

Mount Hood volcano is close to small but rapidly growing communities and recreation areas, and is within 70 miles of metropolitan Portland, Oregon. It has erupted intermittently for hundreds of thousands of years—its most recent major eruption occurred about 200 years ago, shortly before Lewis and Clark explored the area in 1805-1806. Because there are no written chronicles of past major eruptions, most of our information about Mount Hood's past comes from geologic study of deposits produced during those eruptions. We also use observations of recent eruptions at other similar volcanoes around the world to help us understand how future eruptions of Mount Hood may develop and to help delineate areas that are likely to be at risk during future eruptions.

Earthquake swarms beneath Mount Hood occur yearly and hot steam vents near the summit remind us that this volcano is not extinct. It's not a question of whether Mount Hood will erupt again, but when. For this reason, the Mount Hood Coordination Plan was drawn up by emergency managers from Clackamas, Multnomah, Wasco, Hood River and Clark counties, the City of Portland, the Confederated Tribes of Warm Springs, and the States of Oregon and Washington, Federal Emergency Management Agency (FEMA), the U.S. Forest Service (USFS), and the U.S. Geological Survey (USGS).

VOLCANIC HISTORY AND HAZARDS

The eroded snow- and ice-covered cone of Mount Hood is composed primarily of andesitic lava flows and fragmental rock debris. The present cone started growing about half a million years ago, although its size and shape have changed through time as eruptions and erosion have alternately added and subtracted material. Since glacial times (about 15,000 years ago) there have been three major periods of eruptive activity at Mount Hood.

- Polallie eruptive period – approximately 12,000 to 15,000 years ago
- Timberline eruptive period – approximately 1,500 years ago (possibly several centuries in length
- Old Maid eruptive period – approximately 200 years ago (several decades in length)

Eruptions during Timberline and Old Maid times were from a vent beneath the current position of Crater Rock. Crater Rock is, in fact, the remnant of a **lava dome** (see Appendix A for definitions of terms in bold) that grew and collapsed during the Old Maid eruptive period. North of Mount Hood, in the Hood River valley, a basaltic andesite eruption produced a rubbly **lava flow** called the Parkdale lava flow, about 7,500 years ago.

The past three eruptive periods were in many ways very similar. Lava erupted relatively slowly and non-explosively to form lava domes. These lava domes collapsed repeatedly to form fast-moving, extremely hot **pyroclastic flows** and **ash clouds**. The ash clouds were carried downwind and formed ash-fall deposits that in places on the east flank of the volcano accumulated to over 3 feet thick. The hot pyroclastic flows eroded and melted large quantities of snow and ice to form **lahars** that flowed down river valleys, in some cases all the way to the Columbia River. Erosion of the fresh pyroclastic-flow deposits following the eruptions resulted in enormous quantities of sand and gravel being washed downriver. In the Sandy River during the Timberline and Old Maid times, this resulted in lateral channel shifting and burial of the valley floor in sediment up to 50 feet thick.

The Polallie eruptive period lasted for a few thousand years and consisted of several domes that grew and collapsed on all flanks of the volcano. This dome growth and collapse generated lahars that affected all the major river channels around Mount Hood. In addition, the Mississippi Head lava flow on the southwest flank was extruded at this time. In contrast, the Timberline and Old Maid eruptive periods lasted a much shorter period of time and consisted solely of lava dome growth and collapse from the vent location.

At the beginning of the Timberline eruptive period, a large flank failure (**debris avalanche**) above present day Crater Rock on the volcano's southwest side catastrophically affected the entire Sandy River valley to the Columbia River. An even larger flank failure on the north side of the volcano on the order of 100,000 years ago affected the entire length of the Hood River valley to the Columbia River.

Because of the volcano's present-day geometry and because the vent for the last two eruptive periods has been on the south side of the volcano, we feel that the areas and river valleys (Sandy, Salmon and White) on the south side of the volcano are at greater risk from eruptive activity than areas and river valleys on the north side. This assessment could change, however, if monitoring data were to indicate a shift in vent location another flank or on the summit of the volcano. Based on the history of the volcano, hazardous processes and the areas that they could affect are the following:

- **Pyroclastic flows** from dome collapse could extend 5-6 miles down the south flank of the cone. These could reach the base of the volcano in about 10 minutes and would burn (temperatures to 1100°F) and bury objects in their path and potentially cause forest fires.
- **Lahars**, in places up to 100 feet deep, could flow down the Sandy River to the Columbia and down the White River to (and part way down) the Deschutes River. How fast the lahars will flow depends on many parameters, but in the Sandy River it likely would take at least 3 hours to reach the Columbia River. Lahars bury or smash objects in their paths and could damage or affect:
    - Communities along the river
    - Transportation corridors along Interstate 84, and Highways 26 and 35
    - Aqueducts from Bull Run watershed that cross the Sandy River
    - Shorefront property on the north bank of Columbia River (from increased erosion caused by increased sedimentation at the mouth of the Sandy River)
    - River traffic on the Columbia River by filling the channel with sediment

- **Ash clouds** would drift downwind (most likely northeast) and cause ash falls miles from the volcano. Even minor ash fall can be a nuisance and make driving treacherous by reducing visibility and making roads slippery if wet. Ash is especially damaging to jet airplanes and could affect air traffic at distances of more than 100 miles from the volcano and at Portland International Airport and other area airports. Fortunately there is no geologic evidence for large explosive eruptions at Mount Hood, similar to those witnessed in 1980 at Mount St. Helens, which would send large amount of ash and pumice for hundreds of miles downwind.
- **Lava flows** could generate small-scale pyroclastic flows and, if they occur during the summer or fall, cause forest fires. In general though, lava flows move too slowly to be an immediate hazard to humans or animal life, but they will bury and burn everything in their path.
- Small **debris avalanches** can generate lahars that could affect people and infrastructure for many miles downstream of the volcano. Debris avalanches of the size that preceded the Timberline eruptive period are unlikely, owing to the volcano's present geometry.
- **Riverbed aggradation**—the gradual process of channel shifting (including pronounced bank erosion) and burial of river valley floors with volcanic sediment can occur years to decades following an eruption. The entire length of the Sandy, Zigzag, Salmon and White Rivers would be susceptible to this long-term hazard.

Not all hazardous events around volcanoes occur during eruptions. Intense rain-on-snow events, glacial outbursts, and landslides can all generate lahars that cause local damage to infrastructure. In the past two decades, such events have caused millions of dollars of damage to State Highway 35 in the areas around Polallie Creek, Newton Creek and White River and the death of one camper at the mouth of Polallie Creek. Small lahars Eliot Branch have destroyed local bridges and roads. Although such events can be costly, most are small compared to eruption-induced events. More information regarding hazardous events at Mount Hood can be found in Scott and others, 1997, Volcano hazards in the Mount Hood Region, Oregon: U.S. Geological Survey Open-File Report 97-89 (http://vulcan.wr.usgs.gov/Volcanoes/Hood/Hazards/).

A generalized hazard map and other information about hazards Mount Hood poses to downstream areas is summarized in the USGS Mount Hood Fact Sheet which is included in this plan as Appendix B.

NOTE: **The USGS-Cascade Volcano Observatory (CVO) maintains summary volcano information on its public website** http://vulcan.wr.usgs.gov/

Warning time and duration of eruption--long or short?

At volcanoes around the world, the amount of warning time between the first appearance of volcanic unrest and the onset of a hazardous eruption has ranged from about one day to several years. At Redoubt Volcano in Alaska, increased steaming was noted in early November 1989; but seismic activity remained low until December 13, about 25 hours before the onset of a major explosive eruption. Three more explosive events on December 15 were followed by six months of dome growth and dome collapse until activity ceased in early summer of 1990. At Soufriere Hills Volcano on the island of Montserrat, British West Indies, the initial seismic unrest in January 1992 preceded the first eruption by three years. The first small steam explosion in July 1995 was followed by the appearance of a lava dome in September of that year. Pyroclastic flows from the growing dome began spilling into surrounding valleys in March 1996, leading to the gradual destruction of Plymouth, the capital city, and surrounding towns and farmland over the next two years. Dome growth and periodic explosions continue at Montserrat today (2003).

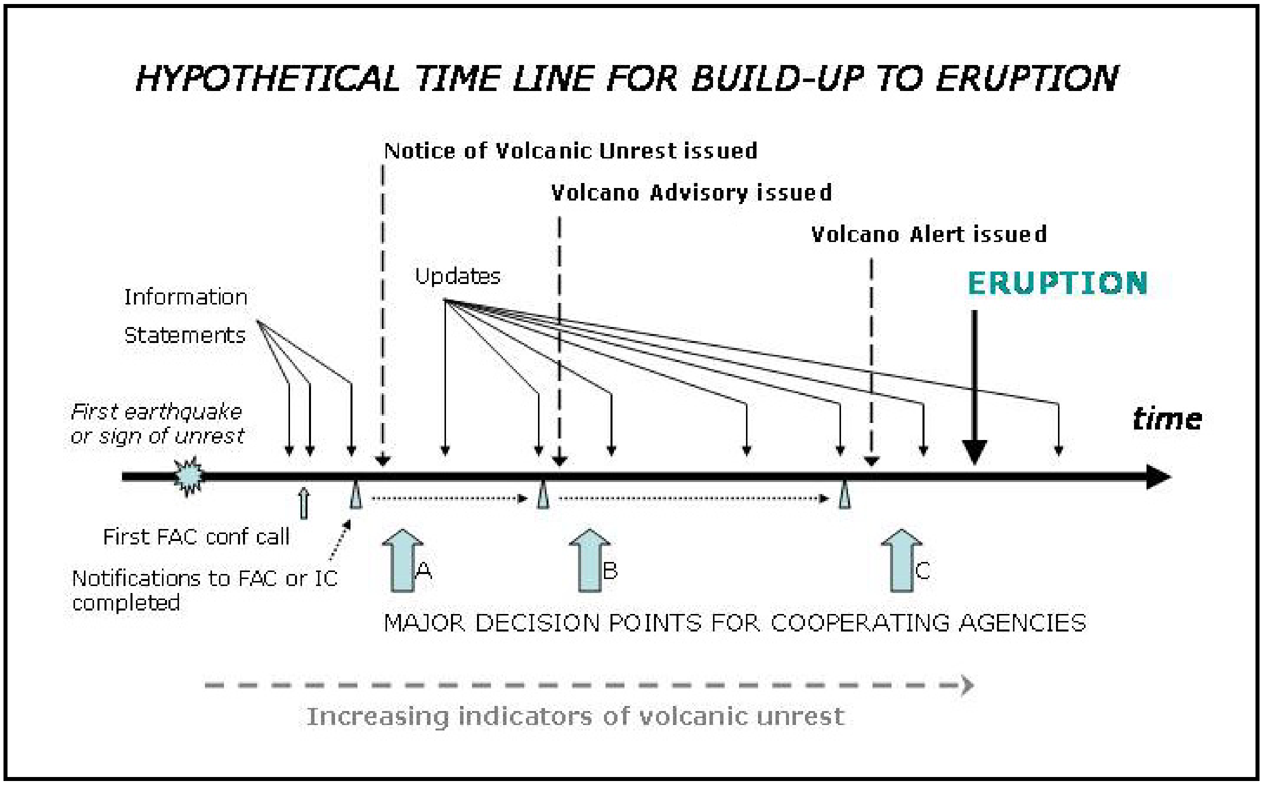
For a variety of reasons, hazardous magmatic eruptions at Mount Hood will probably be preceded by weeks or more of unrest. Chief among those reasons is that Mount Hood has been dormant for more than a century; the conduit system that conveys magma to the surface has solidified and will have to be fractured and reopened for the next magma to reach the surface. In the Cascade Range, two volcanoes have produced magmatic eruptions during the twentieth century. At Mount St. Helens, the climactic eruption of May 18, 1980, was preceded by increased seismicity, ground deformation and steam eruptions that began in late March of that year. At Lassen Peak in California, small steam and ash explosions began on June 30, 1914, and continued sporadically for almost a year before the onset of large magmatic eruptions in May 1915.

EFFORTS TO MONITOR VOLCANIC UNREST

In response to developing volcanic unrest at Mount Hood, a USGS response team expects to:

1. ***Establish a temporary volcano observatory*** with the USFS, most likely at their headquarters in Sandy, Oregon. The observatory will maintain close contact with emergency managers and will be sited to allow efficient daily helicopter access to the volcano. The primary function of the USGS response team is to monitor all volcanic developments and to provide eruption-forecasting and hazard-assessment information to support decisions by public officials. If the volcanic activity is on other flanks of the peak than anticipated, alternate locations will likely be identified.

2. ***Install additional monitoring instruments*** to collect and analyze visual, seismic, lahar-detection, deformation, and gas-emission data. As an important element of redundancy, critical seismic data will be received and analyzed at the Pacific Northwest Seismograph Network at the University of Washington, the USGS Cascades Volcano Observatory, and the local temporary volcano observatory.



This figure is intended to provide perspective on how a volcanic crisis might unfold. Many other potential scenarios exist. The first sign of significant earthquake activity or other signs of unusual unrest will prompt the USGS to issue an Information Statement. If significant unrest continues, then eventually a Notice of Unrest may be issued, etc.

EVENT NOTIFICATION

Volcanic activity at Mount Hood may have dramatically different affects depending on the type of eruption and the direction in which hazards (lahars or tephra plumes are transported. Local agencies require information on hazards that affect nearby areas, whereas airlines and the Federal Aviation Administration (FAA) require information on tephra plumes that can be hazardous to aircraft hundreds of miles from source. The information required by these two groups is not always the same and therefore the Cascades Volcano Observatory, in cooperation with various agencies, has developed two hierarchies of alert levels; one directed toward emergency response on the ground and the other toward ash hazards to aircraft. These two hierarchies are described below.

Notification of Ground-Based Hazards

Event notification by the USGS may occur under two distinctly different circumstances:

(1) In response to unexpected short-lived events;
(2) In response to developing volcanic unrest that may culminate in eruptive activity with attendant volcanic and hydrologic hazards.

The former is handled through information statements, the latter through Staged Alert Levels. These are both issued by the USGS.

Information Statements

Events such as steam bursts (with or without minor ashfall), small avalanches, rock falls, and minor lahars often attract media and public-interest inquiry. This type of event is short-lived, usually concluding within minutes. Since this type of event almost always occurs without specifically recognized precursors, there is no opportunity to provide warning or evacuation. Thus, persons in proximity to such an event are at some personal risk and will need to make their own safety decisions.

Information about a discrete natural event may come from a variety of sources. Owing to frequent public and media inquiries that result from such events, USGS-CVO will attempt to verify the nature and extent of the event, issuing commentary as appropriate in "Information Statements". Information Statements may also be issued to provide commentary about notable events occurring within any alert level during volcanic unrest. The USGS will convene the Facilitating Committee (FAC) prior to issuing a second Information Statement due to any single event/incident.

Stated Alert Levels

A system of staged alert levels ("Notice of Volcanic Unrest", "Volcano Advisory" and "Volcano Alert") indicates the level of volcanic unrest and degree of imminence of hazardous volcanic activity. Alert-level notifications will be accompanied by brief explanatory text to clarify hazard implications as fully as possible. Updates may be issued to supplement any alert-level statement.

Alert-level assignments depend upon observations and interpretations of changing phenomena at the mountain. Some volcanic events may not be preceded by obvious changes or the observed changes may not be well understood; thus, surprises are possible, and uncertainty about timing and nature of anticipated events is likely. Alert levels are not always issued sequentially.

Notice of Volcanic Unrest (first recognition of conditions that could lead to a hazardous event*)*
This alert level is declared when USGS-CVO can first confirm changes that could lead to hazardous volcanic activity. This type of statement expresses concern about volcanic unrest or hydrologic conditions but does not imply imminent hazard. Among the possible outcomes are: (1) symptomatic activity could wane leading to cancellation of the "Notice of Volcanic Unrest", (2) conditions could

evolve so as to indicate progress towards hazardous volcanic activity, leading to issuance of a "Volcano Advisory" or "Volcano Alert", or (3) conditions could remain at this condition for months or years.

Volcano Advisory (hazardous volcanic event is likely but no necessarily imminent)
This alert level is declared when monitoring and evaluation by USGS-CVO indicate that processes are underway that could culminate in hazardous volcanic activity but the evidence does not indicate that a life- or property-threatening event is imminent. This alert level is used to emphasize heightened potential hazard. Among the possible outcomes are: (1) precursory activity could wane, leading to cancellation of the "Volcano Advisory," (2) conditions could evolve so as to indicate that a life- or property-threatening volcanic or hydrologic event is imminent or underway, leading to issuance of a "Volcano Alert", or (3) conditions could remain at this condition for months or years. "Volcano Advisory" statements, supplemented as appropriate by "Updated Volcano Advisory" statements will clarify as fully as possible USGS' understanding of the hazard implications.

Volcano Alert (hazardous volcanic event appears imminent or is underway)
This alert level is declared by USGS-CVO when monitoring and evaluation indicate that precursory events have escalated to the point where a volcanic or hydrologic event threatening life or property appears imminent or is underway. Depending on further developments, a "Volcano Alert" will be maintained, updated, downgraded to a "Volcano Advisory" or canceled. The "Volcano Alert" statement will indicate, in as much detail as possible, the time window, place, and expected impact of an anticipated hazardous event. "Updated Volcano Alert" statements" will amplify hazardous information as dictated by evolving conditions.

NOTE: **Alert-levels are not always followed sequentially. Updates may be issued to supplement any alert-level statement(s).**

Notification of Ash Hazard to Aircraft

Tephra plumes from volcanic eruptions can travel hundreds to thousands of miles from their source. Even when the concentration of ash is so low that it is of little interest or concern to populations on the ground, it can severely affect aircraft, especially large commercial jet aircraft. The USGS will issue to FAA, NOAA, and other appropriate agencies, separate notice about anticipated or existing atmospheric-ash hazards. Those notices will be given in terms of a color code:

- Green – Volcano is quiet, no eruption is anticipated
- Yellow – Volcano is restless; eruption is possible but not known to be imminent
- Orange – Small explosive eruption(s) either imminent or occurring; tephra plume(s) not expected to reach 25,000 feet (7600 meters) above sea level

- Red – Major explosive eruption imminent or occurring; large tephra plumes expected to reach at least 25,000 feet (7,600 meters) above sea level

ORGANIZATION AND RESPONSIBILITIES

MOUNT HOOD FACILITATING COMMITTEE (FAC)

The FAC has been established to maintain preparedness during times of volcanic quiescence and to review plan implementation after an incident has ended. It is composed of members from each jurisdiction with statutory responsibility for emergency response (Table 1). Additional agencies (Associate Members in Table 1) may also attend meetings of the FAC. The FAC may be called together by any member who identifies a need for coordinated discussions. The FAC will be responsible for maintaining the plan, including exercises, as needed. Oregon Emergency Management has the responsibility to assemble the FAC for an annual review of this plan. Although agencies represented on the FAC will be involved in management of volcanic incidents on Mount Hood, the FAC itself does not have a response role. Onset of volcanic activity will trigger FAC notification and a conference call among members. If the FAC determines that an Incident Command organization needs to be established, that recommendation will be made to the USFS Supervisor and Oregon OEM. The determination to activate an Incident Command organization for a volcanic incident at Mount Hood will terminate FAC activities per se until after-action activities at the close of the response phase.

Table 1. FAC Membership

Members shall include	Associate Members may include
Clackamas County Emergency Management Multnomah County Division of Emergency Management Hood River County Department of Emergency Management Wasco County Emergency Management Confederated Tribes of Warm Springs City of Portland Oregon Emergency Management Washington Emergency Management Division Clark Regional Emergency Services Agency Oregon Department of Geology and Mineral Industries U.S. Geological Survey U.S Forest Service FEMA Region X	Oregon Department of Transportation Other concerned jurisdictions, agencies and/or organizations

INTERAGENCY ORGANIZATIONS

The overriding principle in a volcanic emergency is that preservation of human life takes precedence over protection of property. Federal, State and/or local jurisdictional authorities may protect life and property by, among other actions, closing high-risk areas to public access, or evacuating local residents from hazard zones.

During a response, each agency and organization will provide resources and administrative support, and will conduct operations within an Incident Command System (ICS) structure. Interagency operations will be conducted under a Unified Command structure. County emergency management agencies, Oregon Emergency Management (OEM), and the US Department of Homeland Security's (DHS) Federal Emergency Management Agency (FEMA) have primary responsibilities for coordinating local, regional, State and Federal responses, respectively. In Washington State, the Emergency Management Division (EMD) coordinates the response for that state in a similar manner. The responsibilities of local, State and Federal agencies are summarized in Table 2. The authorities under which these agencies operate are described in Appendix C.

Table 2. Responsibilities and contact information for members of the Mount Hood FAC

Jurisdiction and Responsibilities	Contact Information (phone)
LOCAL GOVERNMENT Local jurisdictions are responsible for the overall direction and control of emergency activities undertaken within their jurisdictions. Each County may activate their emergency operations center.	Clackamas County 503-655-8378 Multnomah County 503-793-3305 Hood River County 541-386-2098 Wasco County 541-296-6424 Confederated Tribes of Warm Springs 541-553-1634 City of Portland 503-823-4375 Clark Regional Emergency Services Agency 360-737-1911
STATE GOVERNMENT The Governor, the Governor's cabinet, composed of Directors of State agencies or their representatives, and staff from the State Emergency Management Agency, are responsible for the conduct of emergency functions and will exercise overall direction and control of state government operations	**Oregon Emergency Management** Emergency Coordination Center (ECC) Salem 503-378-2911 **Oregon Department of Geology and Mineral Industries** (DOGAMI) Portland, OR 503-731-4100 x-232 **Washington Emergency Management Division** Emergency Operations Center (EOC) Camp Murray 253-512-7000
FEDERAL GOVERNMENT The **Federal Emergency Management Agency (**FEMA; part of DHS) is responsible for federal agency coordination and operations of the Regional Operations Center (ROC) The **U.S. Geological Survey** (USGS) will conduct field operations and monitoring, and provide information regarding the status of the volcano. The USGS may locate with the USFS in Sandy or with an appropriate county. The **U.S. Forest Service** (USFS), Mount Hood National Forest, is responsible for management of lands within the Mount Hood National Forest.	**FEMA Region 10,** Bothell, WA 425-487-4600 **U.S. Geological Survey** Cascades Volcano Observatory, Vancouver, WA, 360-993-8900 **U.S. Forest Service** Mount Hood National Forest, Sandy, OR 503-668-1700

INCIDENT MANAGEMENT

Incident Command System

A volcano-related incident demands coordinated response. The Incident Command System (ICS) shall be used to establish incident goals, priorities, and strategies, to coordinate incident resource management, and to provide incident support for eruptions, lahars, or other significant volcanic events. The Incident Commander will provide initial strategic guidance and decisions on emergency needs until a Unified Command organization can be established (see next section). S/he has ultimate responsibility for management of assigned resources to effectively accomplish stated objectives and strategies pertaining to a volcanic event at Mount Hood. The Incident Commander initially will report directly to the Forest Supervisor. The Incident Commander should have key positions filled as soon as possible to meet known and projected incident needs.

Unified Command

Unified Command is a multi-agency expansion of the Command function of ICS, allowing principal agencies with geographic, functional, and/or statutory responsibility to establish common incident strategy, objectives, and priorities. This process does not remove agency authority, responsibility, or accountability. As any volcanic event requiring activation of an ICS organization will involve multiple agencies, jurisdictions, and potential incident management complexities, a Unified Command organization shall be established as soon as possible.

For a volcanic incident at Mount Hood, Unified Command will likely comprise USGS, USFS, FEMA, affected local jurisdictions (i.e., one or more among Clackamas, Hood River, Multnomah, Wasco, Clark and Skamania Counties, possibly cities as well), and the Confederated Tribes of Warm Springs. The Unified Command Incident Command Post (ICP) is planned to be based out of the USFS Sandy facility due to the likelihood of volcanic activity occurring on the west/south sides of the peak. If the volcanic activity is on other flanks of the peak, alternate locations will likely be identified.

AGENCY RESPONSIBILITIES

Local Divisions or Departments of Emergency Management

Information about the status of a volcano would normally be transmitted from the USGS through OEM to county Emergency Management agencies (DEM's). The DEM's would then relay the information to local jurisdictions and agencies. As needed, the county DEM's would:

a) Implement Emergency Operations Plans, maintain and activate Emergency Operations Centers (EOC).
b) Provide local public warnings and information.
c) Activate the Emergency Alert System (EAS).
d) Assist Incident Commander(s).
e) Participate in establishing a unified command structure.
f) Support a regional coordination center.
g) Provide Public Information Officer(s) (PIOs) for a Joint Information Center (JIC.)
h) Assist the USGS in establishing a temporary Volcano Observatory.
i) Provide for the welfare of citizens affected by a volcanic event.

j) Initiate and coordinate local declarations of emergency or requests for assistance from mutual aid partners, state and/or federal resources.
k) Implement response and recovery plans in their jurisdiction.
l) Provide information and training on volcano-hazard response to emergency workers and the public.
m) Assess volcanic risks as part of a comprehensive Hazard Identification and Vulnerability Analysis.

State Emergency Management: OEM and EMD

Oregon Emergency Management (OEM), through its 24-hour Oregon Emergency Response System (OERS), is responsible for providing alert and warning to local jurisdictions within the state. Additionally, OEM/OERS will notify specific state and federal agencies that have a response role during a volcanic event. OEM would then work with other entities in order to coordinate resources to support local and state agency response. The Washington Emergency Management Division (EMD) has similar responsibilities and resources for Washington State.

OEM's and EMD's responsibilities in support of this plan include:

a) Coordinating the acquisition and distribution of resources to support response.
b) Developing plans and procedures.
c) Acting as the central point of contact for local government requests for specific State and Federal disaster related assets and services.
d) Activating and staffing the State Emergency Coordination Center (ECC) /Emergency Operations Center (EOC).
e) Supporting EAS activations by local jurisdictions as necessary by serving as a backup activation point.
f) Support DOGAMI public information efforts.
g) Coordinate with the Federal government on supplemental disaster assistance necessary to preserve life and property, and on recovery assistance.
h) Activating, if necessary, the Emergency Management Assistance Compact (EMAC) for interstate assistance.
i) Deploying County Liaison Officers to affected jurisdictions.
j) Calling the yearly meeting of the FAC to review and update this plan.

United States Geological Survey

The Disaster Relief Act of 1974 (PL 93-288) assigns to the U. S. Geological Survey (USGS) the responsibility of providing timely warnings of volcanic eruptions and related activity. This responsibility is achieved by monitoring active and potentially active volcanoes, assessing their hazards, responding to crises, and conducting research on how volcanoes work. More specifically, these activities include:

a) Issuing timely warnings of potential geologic hazards to responsible emergency management authorities and to the populace affected via the media and the CVO web site.
b) Monitoring volcanic unrest, tracking its development, forecasting eruptions, and evaluating the likely hazards.
c) Deploying staff and monitoring equipment during times of volcanic activity.

d) Establishing a temporary volcano observatory located so as to provide ready access to the volcano for the USGS hazard-assessment team and ready access to the hazard-assessment team for technical assistance to the emergency managers. (See Appendix D for temporary volcano observatory requirements.)

United States Forest Service

The U.S. Forest Service (USFS) manages public lands on and around Mount Hood. Authorities include land management responsibilities related to use, management and protection of these lands. Roles and responsibilities during a disaster or emergency include protection of life, property and natural forest resources on USFS-managed lands. Control of access and use of national forest lands is regulated by the USFS in coordination with adjoining landowners and agencies. USFS responsibilities include:

a) Restrict access to hazard areas within the Mount Hood National Forest
b) Employee and National Forest visitor safety
c) Coordinate with Oregon Department of Transportation (ODOT) on road closures
d) Sandy facility for USGS and staff
e) PIO support
f) Other activities necessary based on volcanic conditions

Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) roles and responsibilities during a disaster are governed by the Robert T. Stafford Disaster Assistance and Emergency Relief Act, as amended, 42 USC 5121, et seq., and the Federal Response Plan (FRP) of Public Law 93-288, as amended. The primary disaster relief responsibility of FEMA is to coordinate and deliver assistance and support to state and local governments when requested. This is typically through the Governor as a Request for a Presidential Disaster Declaration. A volcanic eruption would be handled in much the same way as any other natural disaster. FEMA's responsibilities include:

a) Monitoring situations with the potential for widespread impacts.
b) Coordinating Federal level emergency planning, management, mitigation and assistance functions of Federal agencies in support of State and local efforts.
c) Providing and maintaining the Federal and State National Warning System (NAWAS).
d) Providing liaison staff to the Unified Command organization and the State ECC.
e) Following a Presidential Disaster Declaration:
    1. Establishing a Disaster Field Office.
    2. Coordinating public information activities for all federal agencies and disseminating releases to the news media.
    3. Coordinating state requests for Federal or military assistance.
    4. Coordinating Federal Assistance operations and programs.

How to cope--Logistical problems during volcanic crises

Volcanic crises pose problems to communities that may not exist during other types of catastrophes. Below are two problems that are inherent in volcanic crises. Appendix F. lists some publications describing case studies.

Uncertainty: Once a volcano shows signs of life, it is not clear whether or when it could produce a major hazardous eruption. In 1975, Mount Baker, Washington, increased the steam output from its summit crater for a few months, and then subsided with no indication of magma movement. Popocatepetl Volcano near Mexico City has periodically threatened nearby communities since 1993, causing nearby villagers to evacuate more than once, only to return after large eruptions fail to take place. At St. Pierre in Martinique (French West Indies), local authorities in 1902 opted not to evacuate in spite of four months of seismicity and steam explosions at Mont Pelee, five miles to the north. On May 8, a major eruption produced a pyroclastic flow that destroyed the town and killed 29,000 residents. In 1982, in response to earthquake swarms and uplift at Long Valley, California, the USGS issued a notice of potential volcanic hazard. Activity subsided and the USGS was branded the “U.S. Guessing Society” by local residents. Authorities in these circumstances are generally in a “no-win” situation. Their best hope of maintaining public trust is to convey the uncertainty inherent in volcanic crises, and to maintain extremely close and open relations with community leaders.

Controlling access: During the crisis at Mount St. Helens in March and April, 1980, volcano-watchers would bypass road blocks to view the volcano, stage illegal climbs to the summit, even land helicopters at the summit to film advertisements. The difficulty in controlling access to the mountain was compounded by the checkerboard pattern of public and private land ownership, and the network of logging roads. Unlike at Mount St. Helens, access control around Mount Hood would necessitate traffic restriction on major regional thoroughfares, US Hwy 26 and OR 35.

CONCEPT OF OPERATIONS

This plan is based on the premise that each agency with responsibility for preparedness, response or recovery activities has, or will develop, an operations plan or Standard Operating Guidelines that cover its organization and emergency operations. Since Mount Hood is located within the Mount Hood National Forest, under the management of the USFS, the Forest Supervisor for the Mount Hood National Forest is the official responsible for managing the lands surrounding Mount Hood, including during times of emergency. The USFS practices coordinated management of incidents with surrounding landowners and expects to do so in a volcanic event as well consistent with the Unified Command discussion above. This plan establishes a mechanism for coordination of each agency’s efforts.

The Concept of Operations can be defined with respect to the three phases of volcanic activity: (1) *preparedness* (2) *response* and (3) *recovery*.

PREPAREDNESS PHASE (When volcanoes are in repose)

Members of the FAC shall prepare emergency plans and programs to ensure continuous readiness and response capabilities. The FAC shall meet yearly to:

1. Coordinate, write, revise, and exercise this plan
2. Develop and evaluate alert and warning capabilities for the volcanic hazard risk areas
3. Review public education and awareness requirements and implement an outreach program on volcano hazards.

RESPONSE PHASE

Members of the FAC shall:

1. Confer whenever any member deems it necessary.
2. Share information on the current activity of Mount Hood and coordinate data relating to hazard assessment, evaluation and analysis.
3. Coordinate any needed public information and/or establish a JIC for this purpose.
4. Assess the need for an ICS organization and activate one as necessary.

Upon activation, members of the Unified Command team shall:

1. Facilitate accurate and timely collection and exchange of regional incident information.
2. Coordinate regional objectives, priorities and resources.
3. Analyze and anticipate future agency/regional resource needs.
4. Coordinate regional information through a JIC.
5. Communicate decisions to jurisdictions/agencies.
6. Review need for other agency involvement in the command team.
7. Provide necessary liaison with out-of-region facilities and agencies as appropriate.
8. Designate regional mobilization centers as needed.
9. Coordinate damage assessment and evaluation
    a. Evaluate disaster magnitude and local disaster assistance and recovery needs.
    b. Obtain detailed data on casualties, property damage and resource status.

RECOVERY PHASE

When hazardous geologic activity has subsided to a point where reconstruction and restoration activities may be initiated, even if the mountain is still in an eruptive state and response activities continue, recovery efforts may be initiated and carried out. In addition to the functions previously noted, the Unified Command team shall:

1 Coordinate recovery and reconstruction efforts.
2. Assist Incident Commander(s) in demobilization.
3. Continue to coordinate the collection and dissemination of disaster information including informing the public about hazardous conditions, health, sanitation, and welfare problems, recovery services and the need for volunteers.
4. Determine when to terminate Unified Command operations.

The FAC shall:

1. Conduct an After Action Review of the event and make changes to this plan as necessary.

NOTIFICATION LIST FOR MOUNT HOOD EVENTS

- **USGS**
  - USFS
  - Oregon ECC
  - Federal Aviation Administration (FAA) Seattle and Portland Offices
  - Washington EOC

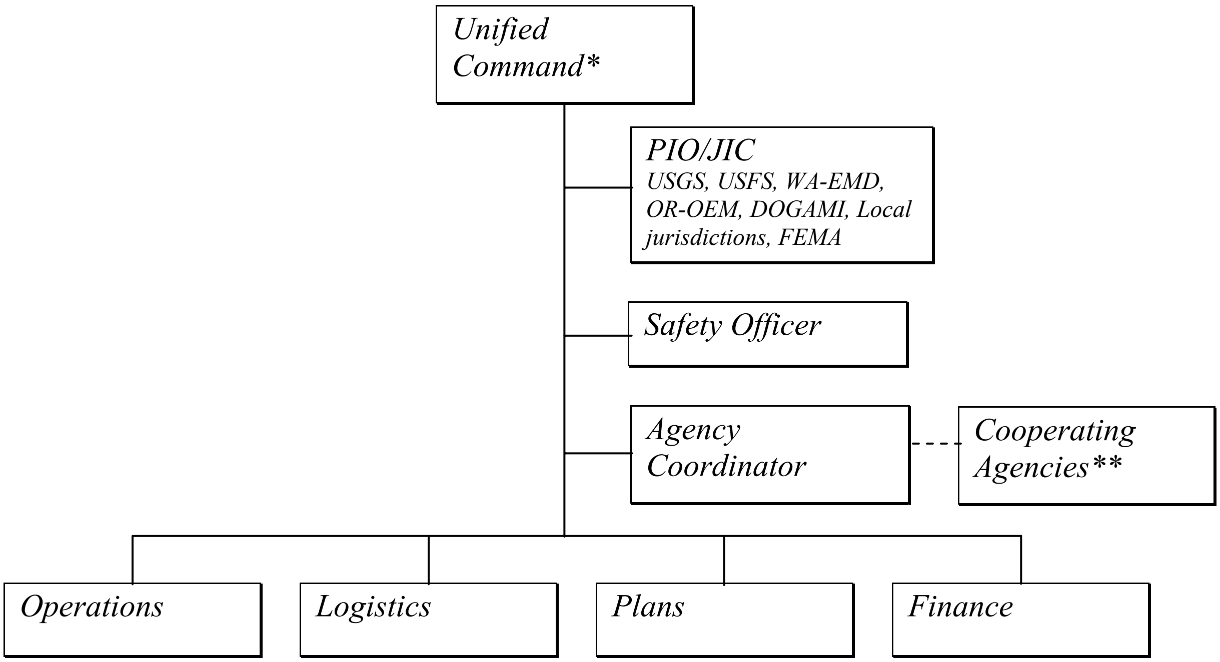
- **USFS**
  - Internal Notifications (Special Agent, Unit Managers)
  - Northwest Interagency Coordination Center (NWCC)
  - Confederated Tribes of Warm Springs
  - National Weather Service (NWS) Portland
  - US Coast Guard
  - US Army Corps of Engineers (Portland District)
  - Bonneville Power Administration (BPA)
  - Others as appropriate

- **State EOCs**
  - State agencies
  - Counties
  - FEMA Region 10
  - Neighboring states
  - Others as appropriate

- **County EOCs**
  - Internal agencies as appropriate
  - Cities
  - Others as appropriate

- **Joint Information Center (JIC)**
  - Media (following coordination among the FAC members)
  - Others as appropriate

Organizational Chart: Volcano Incident at Mount Hood



* Unified Command: USGS, USFS, FEMA, impacted local jurisdiction (e.g., Clackamas/Hood River/Multnomah/Wasco/Clark/Skamania Counties), Confederated Tribes of Warm Springs.

**Cooperating Agencies: FAA (Seattle, Portland), NWS (Portland), U.S. Army Corps of Engineers, U.S. Coast Guard (Portland), Northwest Coordination Center (NWCC), ODOT/WSDOT, DOGAMI, OSP/WSP, OR-OEM, WA-EMD and local jurisdictions. Other entities could be included depending on the circumstances of the incident.

ORGANIZATION AND RESPONSIBILITIES ACCORDING TO LEVELS OF UNREST

Following are the detailed responsibilities and tasks of jurisdictions and agencies at the various volcano alert levels.

A. FOLLOWING A NOTICE OF VOLCANIC UNREST:

1. **Local jurisdictions and agencies:**
    - Convene the FAC
    - Review plans and procedures for response to the volcanic hazard threat.
    - Designate staff that will be responsible for filling positions in the local ICS and/or Unified Command Structure as requested, including a JIC.
    - Provide orientation sessions on current plans and organizational structure.
    - Update call-up procedures and listings for response staff.
    - Conduct briefings as needed.

2. **Oregon OEM and Washington EMD**
    - Convene the FAC
    - Review internal plans and procedures
    - Implement notifications.
    - Provide technical assistance to local jurisdictions.
    - Coordinate with Emergency Support Function agencies that may be called upon to provide assistance.
    - Coordinate mutual aid agreements with neighboring states.
    - Evaluate the need for assistance from additional agencies.
    - Evaluate resource requirements.
    - Issue advisories and state-level policies in consultation with the FAC.
    - Conduct hazard specific training.
    - Conduct briefings as necessary.

3. **USGS**
    - Convene the FAC.
    - Monitor the status of the volcano and determine the need for additional instrumentation and/or other resources.
    - Issue alert-level notifications and updates.
    - Consider establishing a temporary field observatory.
    - Conduct briefings as necessary.

4. **USFS**
    - Convene the FAC
    - Provide public education
    - Evaluate need for access control and implement as needed.
    - Evaluate the need for air space controls and implement as needed.
    - Authorize placement of additional instrumentation as needed.

5. **FAC**
    - Discuss and evaluate developing events and information.
    - Review this plan.
    - Disseminate public information.
    - Consider recommending the USFS implement an Incident Command System organization.

B. FOLLOWING A VOLCANO ADVISORY (during a period of increased volcanic unrest):

1. **Local jurisdictions and agencies:**
    - Establish local Incident Command and consider the possible need for Unified Command with other jurisdictions.
    - Conduct surveys on resource availability and reaffirm prior commitments.
    - Test communications systems and assess communications needs.

- Begin procurement of needed resources.
- Assign PIO's to the JIC as needed.
- Provide briefings and direction to all response personnel.
- Request all assigned personnel to stand by for orders to activate the jurisdiction's emergency plan.
- Coordinate support requirements for USGS Field Observatory.
- Take readiness and precautionary actions to compress response time and to safeguard lives, equipment and supplies.

2. **Oregon OEM and Washington EMD**
    - Implement plans for state level communications support for the affected area.
    - Coordinate joint public education programs.
    - Increase, as needed, the staffing at the ECC.
    - Establish a Joint Information Center (JIC) and support local government with PIO information
    - Ensure state agencies are alerted to potential problems and review their operational responsibilities.
    - Assign liaison(s) to local Incident Command and/or Unified Command organization upon request.

3. **USGS**
    - Establish field observatory if not already established.

4. **USFS**
    - Provide space for the Unified Command structure.
    - Identify staff to support Unified Command structure.

5. **FAC**
    - Consider recommending USFS implement an Incident Command System organization if not already established.
    - Consider requesting the participation of the Mobilization Incident Commander (MIC) of the Incident Management Team (IMT).

C. ***FOLLOWING A VOLCANO ALERT*** *(during a period of significant volcanic unrest or following a notice that an eruption is imminent or occurring):*

1. **Local jurisdictions and agencies:**
    - Fully mobilize all assigned personnel and activate all or part of the Mount Hood Coordination Plan.
    - Activate Comprehensive Emergency Management Plans.
    - Continually broadcast emergency public information.
    - Direct and control emergency response activities in each jurisdiction in accordance with ICS procedures.
    - Ensure Incident Command Post (ICP) is adequately staffed and equipped.
    - Consider requesting state mobilization and possible activation of an IMT.

2. **Oregon OEM and Washington EMD**
    - Activate the State of Oregon Emergency Management Plan (Volume II Emergency Operations Plan) and Washington State Comprehensive Emergency Management Plan.
    - Coordinate interstate mutual aid.
    - Coordinate Federal response.

3. **USGS**
    - Monitor status of volcanic activity in the hazard area.
    - Issue alert-level notifications and updates.
    - Provide Liaison to the Unified Command Structure to provide on-going information and advice.

4. **USFS**

    Implement plans to participate directly in the following coordinated response operations within the affected areas:
    - Fire
    - Evacuation
    - Security
    - Access Control
    - Search and Rescue
    - Alert and Notification
    - Provide personnel for Unified Command Structure
    - Support operations, logistics and planning functions with personnel and resources.

5. **FEMA**
    - Activate the Federal Response Plan.
    - Administer disaster relief programs following declaration of Emergency or Major Disaster by the President.
    - Coordinate Federal response efforts.

6. **Federal Aviation Administration (FAA)**
    - Issue airspace alert warning of restricted or prohibited space.
    - Coordinate use of affected airspace by aircraft involved in emergency response.

PREPAREDNESS AND EDUCATION

No living person in the Northwest has experienced an eruption of Mount Hood; nor has any local official or scientist yet dealt with significant levels of activity at this volcano. When renewed volcanic activity strikes, it is vital that public officials and citizens alike know what actions to take to protect life and property.

Of great importance is the need for emergency managers, local officials and scientists to be familiar and comfortable with their roles in the event of volcanic unrest. Development of specific plans like this one is only a first step. The plan must be reviewed regularly and revised to meet the changing needs of the region's rapidly growing communities and increased recreation usage. Although a volcanic eruption in the Cascades may be a once-in-a-lifetime event, those individuals charged with public safety must train themselves and their organizations through exercising the plan in order to ensure that coordination will be smooth and seamless.

Residents of northern Oregon and southwestern Washington will be able to receive information provided in partnership by the USGS and government agencies. The goals of this effort will be educating citizens, public officials and businesses on and around Mount Hood of the hazards, vulnerabilities and preparedness steps associated with the volcano.
.

APPENDIX A U.S. Geological Survey Fact Sheet 002-97

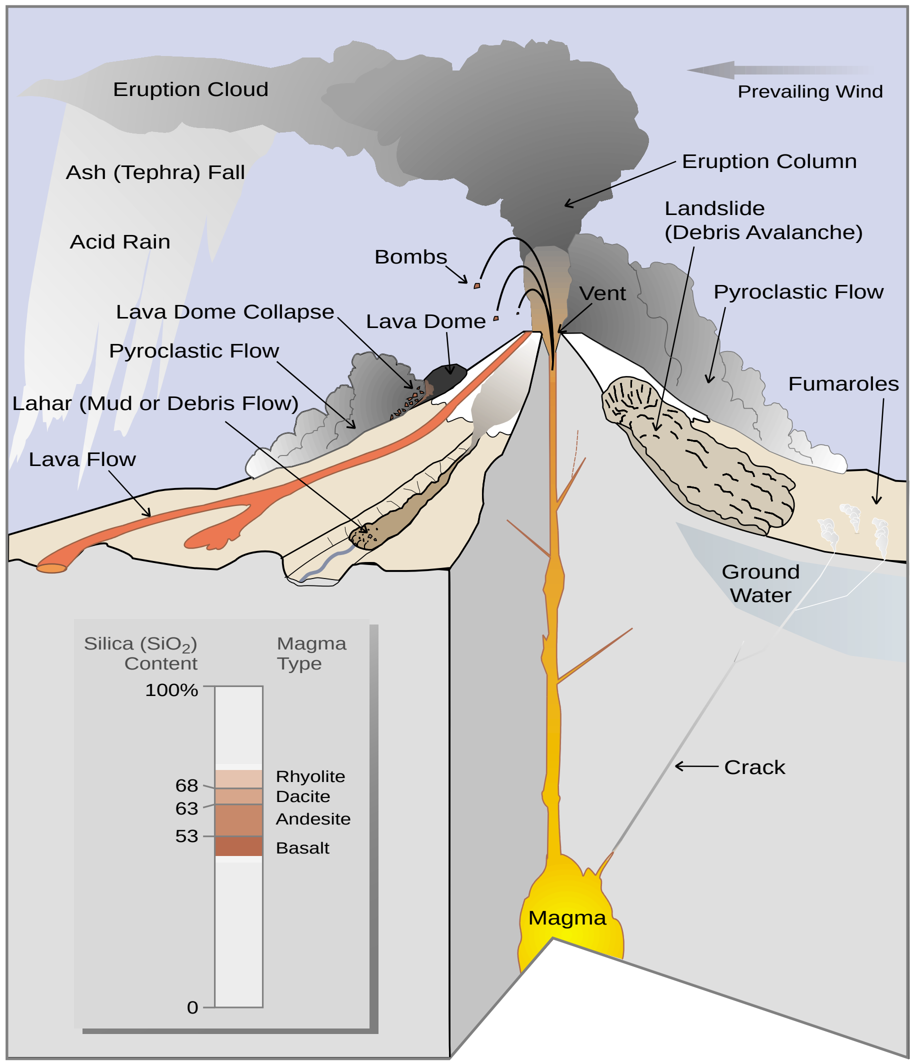
U.S. Geological Survey Fact Sheet 002-97
Online Version 1.1

What Are Volcano Hazards?

What are Volcano Hazards?

Volcanoes give rise to numerous geologic and hydrologic hazards. U.S. Geological Survey (USGS) scientists are assessing hazards at many of the almost 70 active and potentially active volcanoes in the United States. They are closely monitoring activity at the most dangerous of these volcanoes and are prepared to issue warnings of impending eruptions or other hazardous events.

More than 50 volcanoes in the United States have erupted one or more times in the past 200 years. The most volcanically active regions of the Nation are in Alaska, Hawaii, California, Oregon, and Washington. Volcanoes produce a wide variety of hazards that can kill people and destroy property. Large explosive eruptions can endanger people and property hundreds of miles away and even affect global climate. Some of the volcano hazards described below, such as landslides, can occur even when a volcano is not erupting.



Volcanoes produce a wide variety of natural hazards that can kill people and destroy property. This simplified sketch shows a volcano typical of those found in the Western United States and Alaska, but many of these hazards also pose risks at other volcanoes, such as those in Hawaii. Some hazards, such as lahars and landslides, can occur even when a volcano is not erupting. (Hazards and terms in this diagram are highlighted in bold where they are discussed in the text below.)

Eruption Columns and Clouds

An explosive eruption blasts solid and molten rock fragments (**tephra**) and volcanic gases into the air with tremendous force. The largest rock fragments (**bombs**) usually fall back to the ground within 2 miles of the **vent**. Small fragments (less than about 0.1 inch across) of volcanic glass, minerals, and rock (**ash**) rise high into the air, forming a huge, billowing **eruption column**.

Eruption columns can grow rapidly and reach more than 12 miles above a volcano in less than 30 minutes, forming an **eruption cloud**. The volcanic ash in the cloud can pose a serious hazard to aviation. During the past 15 years, about 80 commercial jets have been damaged by inadvertently flying into ash clouds, and several have nearly crashed because of engine failure. Large eruption clouds can extend hundreds of miles downwind, resulting in **ash fall** over enormous areas; the wind carries the smallest ash particles the farthest. Ash from the May 18, 1980, eruption of Mount St. Helens, Washington, fell over an area of 22,000 square miles in the Western United States. Heavy ash fall can collapse buildings, and even minor ash fall can damage crops, electronics, and machinery.

Volcanic Gases

Volcanoes emit gases during eruptions. Even when a volcano is not erupting, **cracks** in the ground allow gases to reach the surface through small openings called **fumaroles**. More than ninety percent of all gas emitted by volcanoes is water vapor (steam), most of which is heated **ground water** (underground water from rainfall and streams). Other common volcanic gases are carbon dioxide, sulfur dioxide, hydrogen sulfide, hydrogen, and fluorine. Sulfur dioxide gas can react with water droplets in the atmosphere to create **acid rain**, which causes corrosion and harms vegetation. Carbon dioxide is heavier than air and can be trapped in low areas in concentrations that are deadly to

U.S. Department of the Interior
U.S. Geological Survey

USGS Fact Sheet-002-97
Revised June 1998

people and animals. Fluorine, which in high concentrations is toxic, can be adsorbed onto volcanic ash particles that later fall to the ground. The fluorine on the particles can poison livestock grazing on ash-coated grass and also contaminate domestic water supplies.

Cataclysmic eruptions, such as the June 15, 1991, eruption of Mount Pinatubo (Philippines), inject huge amounts of sulfur dioxide gas into the stratosphere, where it combines with water to form an aerosol (mist) of sulfuric acid. By reflecting solar radiation, such aerosols can lower the Earth's average surface temperature for extended periods of time by several degrees Fahrenheit (˚F). These sulfuric acid aerosols also contribute to the destruction of the ozone layer by altering chlorine and nitrogen compounds in the upper atmosphere.

Lava Flows and Domes

Molten rock (**magma**) that pours or oozes onto the Earth's surface is called lava and forms **lava flows**. The higher a lava's content of **silica** (silicon dioxide, SiO_2), the less easily it flows. For example, low-silica **basalt** lava can form fast-moving (10 to 30 miles per hour) streams or can spread out in broad thin sheets up to several miles wide. Since 1983, Kilauea Volcano on the Island of Hawaii has erupted basalt lava flows that have destroyed nearly 200 houses and severed the nearby coastal highway.

In contrast, flows of higher-silica **andesite** and **dacite** lava tend to be thick and sluggish, traveling only short distances from a vent. Dacite and **rhyolite** lavas often squeeze out of a vent to form irregular mounds called **lava domes**. Between 1980 and 1986, a dacite lava dome at Mount St. Helens grew to about 1,000 feet high and 3,500 feet across.

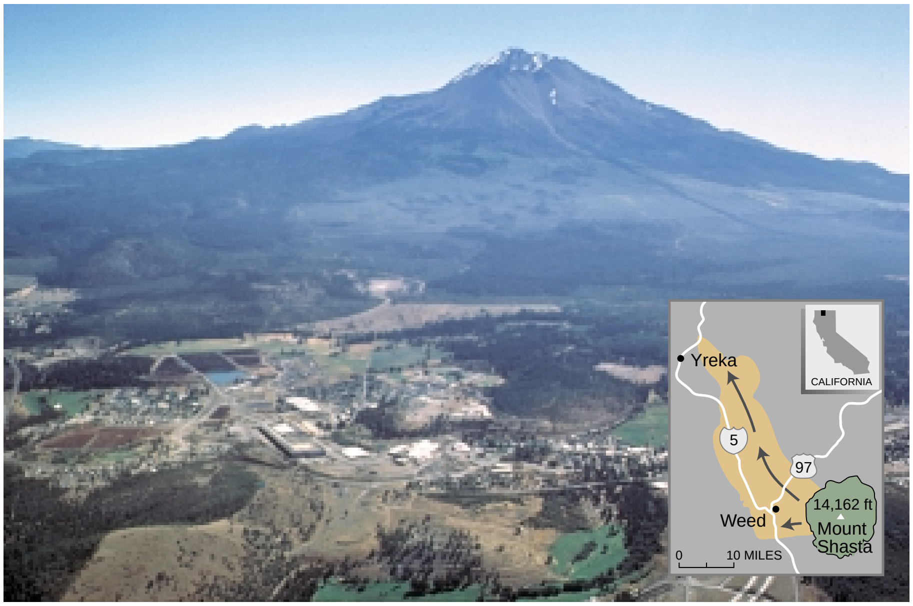
Pyroclastic Flows

High-speed avalanches of hot ash, rock fragments, and gas can move down the sides of a volcano during explosive eruptions or when the steep side of a growing **lava dome collapses** and breaks apart. These **pyroclastic flows** can be as hot as 1,500˚F and move at speeds of 100 to 150 miles per hour. Such flows tend to follow valleys and are capable of knocking down and burning everything in their paths. Lower-density pyroclastic flows, called pyroclastic surges, can easily overflow ridges hundreds of feet high.

The climactic eruption of Mount St. Helens on May 18, 1980, generated a series of explosions that formed a huge pyroclastic surge. This so-called "lateral blast" destroyed an area of 230 square miles. Trees 6 feet in diameter were mowed down like blades of grass as far as 15 miles from the volcano.

Volcano Landslides

A **landslide** or **debris avalanche** is a rapid downhill movement of rocky material, snow,



The town of Weed, California, nestled below 14,162-foot-high Mount Shasta, is built on a huge debris avalanche that roared down the slopes of this volcano about 300,000 years ago. This ancient landslide (brown on inset map; arrows indicate flow directions) traveled more than 30 miles from the volcano's peak, inundating an area of about 260 square miles. The upper part of Mount Shasta volcano (above 6,000 feet) is shown in dark green on the map.

and (or) ice. Volcano landslides range in size from small movements of loose debris on the surface of a volcano to massive collapses of the entire summit or sides of a volcano. Steep volcanoes are susceptible to landslides because they are built up partly of layers of loose volcanic rock fragments. Some rocks on volcanoes have also been altered to soft, slippery clay minerals by circulating hot, acidic ground water. Landslides on volcano slopes are triggered when eruptions, heavy rainfall, or large earthquakes cause these materials to break free and move downhill.

At least five large landslides have swept down the slopes of Mount Rainier, Washington, during the past 6,000 years. The largest volcano landslide in historical time occurred at the start of the May 18, 1980, Mount St. Helens eruption.

Lahars

Mudflows or **debris flows** composed mostly of volcanic materials on the flanks of a volcano are called **lahars.** These flows of mud, rock, and water can rush down valleys and stream channels at speeds of 20 to 40 miles per hour and can travel more than 50 miles. Some lahars contain so much rock debris (60 to 90% by weight) that they look like fast-moving rivers of wet concrete. Close to their source, these flows are powerful enough to rip up and carry trees, houses, and huge boulders miles downstream. Farther downstream they entomb everything in their path in mud.

Historically, lahars have been one of the deadliest volcano hazards. They can occur both during an eruption and when a volcano is quiet. The water that creates lahars can come from melting snow and ice (especially water from a glacier melted by a pyroclastic flow or surge), intense rainfall, or the breakout of a summit crater lake. Large lahars are a potential hazard to many communities downstream from glacier-clad volcanoes, such as Mount Rainier.

To help protect lives and property, scientists of the USGS Volcano Hazards Program maintain a close watch on the volcanic regions of the United States, including the Pacific Coast States, Wyoming, Hawaii, and Alaska. This ongoing work enables the USGS to detect the first signs of volcano unrest and to warn the public of impending eruptions and associated hazards.

Bobbie Myers, Steven R. Brantley, Peter Stauffer, and James W. Hendley II
Graphic design by
Sara Boore, Bobbie Myers, and Susan Mayfield

COOPERATING ORGANIZATIONS
Alaska Div. of Geological and Geophysical Surveys
Federal Aviation Administration
National Oceanic and Atmospheric Administration
National Park Service
National Weather Service
U.S. Dept. of Agriculture, U.S. Forest Service
University of Alaska
University of Hawaii
University of Utah
University of Washington

For more information contact:
U.S. Geological Survey
Cascades Volcano Observatory
5400 Mac Arthur Blvd., Vancouver, WA 98661
Tel: (360) 696-7693, Fax: (360) 696-7866
e-mail: cvo@usgs.gov
URL: http://vulcan.wr.usgs.gov/

APPENDIX B: Mount Hood—History and Hazards of Oregon's Most Recently Active Volcano

Section 1 Mount Hood Fact Sheet

U.S. Geological Survey Fact Sheet 060-00   Online Version 1.0

Mount Hood—History and Hazards of Oregon's Most Recently Active Volcano

Mount Hood's last major eruption occurred in the 1790's not long before Lewis and Clark's expedition to the Pacific Northwest. In the mid-1800's, local residents reported minor explosive activity, but since that time the volcano has been quiet. Someday, however, Mount Hood will erupt again. What will those eruptions be like and how will they affect us? Scientists from the U.S. Geological Survey (USGS) are studying the volcano's past eruptive behavior to better anticipate and prepare for future eruptive activity.

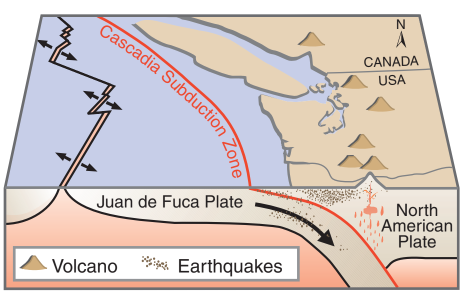
Mount Hood from Portland, Oregon. When Mount Hood next erupts, Portland could be affected by light ashfalls similar to those it experienced during the 1980 eruptions of Mount St. Helens. The city will not be directly affected by lava flows, pyroclastic flows, or lahars, but regional transportation and water supplies could be disrupted. (Photo by David Wieprecht, USGS)

Past Eruptive Behavior

Mount Hood is more than 500,000 years old. The volcano has grown in fits and starts, with decades to centuries of frequent eruptions separated by quiet periods lasting from centuries to more than 10,000 years. In the recent past, Mount Hood has had two significant eruptive periods, one about 1,500 years ago and the other about 200 years ago.

Unlike its neighbor to the north, Mount St. Helens, Mount Hood does not have a history of violent explosive eruptions. Instead, **lava flows** (see inside pages for definitions of bold terms), rarely traveling more than 6 to 8 miles from their source, have built up the flanks of the volcano one sector at a time. Sometimes, instead of flowing slowly downhill, lava piles up over its vent forming a **lava dome** many hundreds of feet high. On the steep upper slopes of Mount Hood, growing lava domes have repeatedly collapsed to form extremely hot, fast-moving **pyroclastic flows**. Few of these pyroclastic flows have traveled more than 8 miles. But because they are extremely hot, such flows can melt significant quantities of snow and ice to produce **lahars** that flow down river valleys, often far beyond the flanks of the volcano. Over the past 30,000 years, growth and collapse of lava domes and generation of lahars have dominated Mount Hood's eruptive activity.

Throughout Mount Hood's history, rapid landslides, called **debris avalanches**, of various sizes have occurred. The largest ones removed the summit and sizable parts of the volcano's flanks and formed lahars that flowed to the Columbia River. Large debris avalanches occur infrequently and are usually triggered by eruptive activity. But small ones not associated with eruptive activity occur more frequently. Small avalanches can occur when rocks, altered and weakened by acidic volcanic fluids or by weathering, such as freezing and thawing, fail spontaneously.

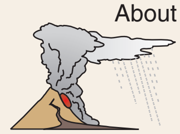


Subduction of the Juan de Fuca Plate under the North American Plate controls the distribution of earthquakes and volcanoes in the Pacific Northwest. Mount Hood is just one of several recently active, major volcanic centers in the Cascade Range.

Eruptions at Mount Hood During the Past 30,000 Years

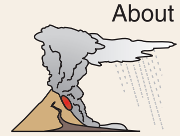
Mid-1800's

Small steam and ash explosions



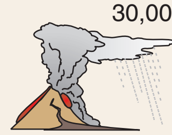
About 200 years ago

Lava dome at Crater Rock; pyroclastic flows, lahars in south and west valleys, and minor tephra falls



About 1,500 years ago

Debris avalanche from upper south flank; lava dome near Crater Rock, pyroclastic flows, lahars in south and west valleys; substantial tephra falls near volcano



30,000 to 15,000 years ago

Multiple episodes of lava dome growth, pyroclastic flows, lava flows, lahars, and tephra fall; valleys on all flanks affected

U.S. Department of the Interior
U.S. Geological Survey

USGS Fact Sheet 060-00
August 2000

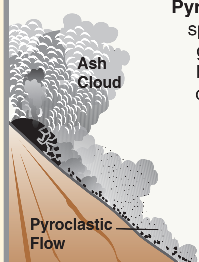
Are You at Risk from the Next Eruption of Mount Hood?

Volcano Hazards

Lava Flows and Domes

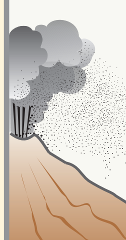
Lava is molten rock that flows onto the Earth's surface. **Lava flows** move downslope away from a vent and bury or burn everything in their paths. **Lava domes** form when lava piles up over a vent.

Pyroclastic Flows



Pyroclastic flows are high-speed avalanches of hot rock, gas, and ash that are formed by the collapse of lava domes or eruption columns. They can move up to 100 miles per hour and have temperatures to 1500°F. They are lethal, burning, burying, or asphyxiating all in their paths.

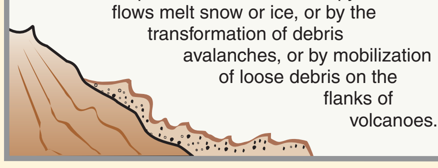
Tephra



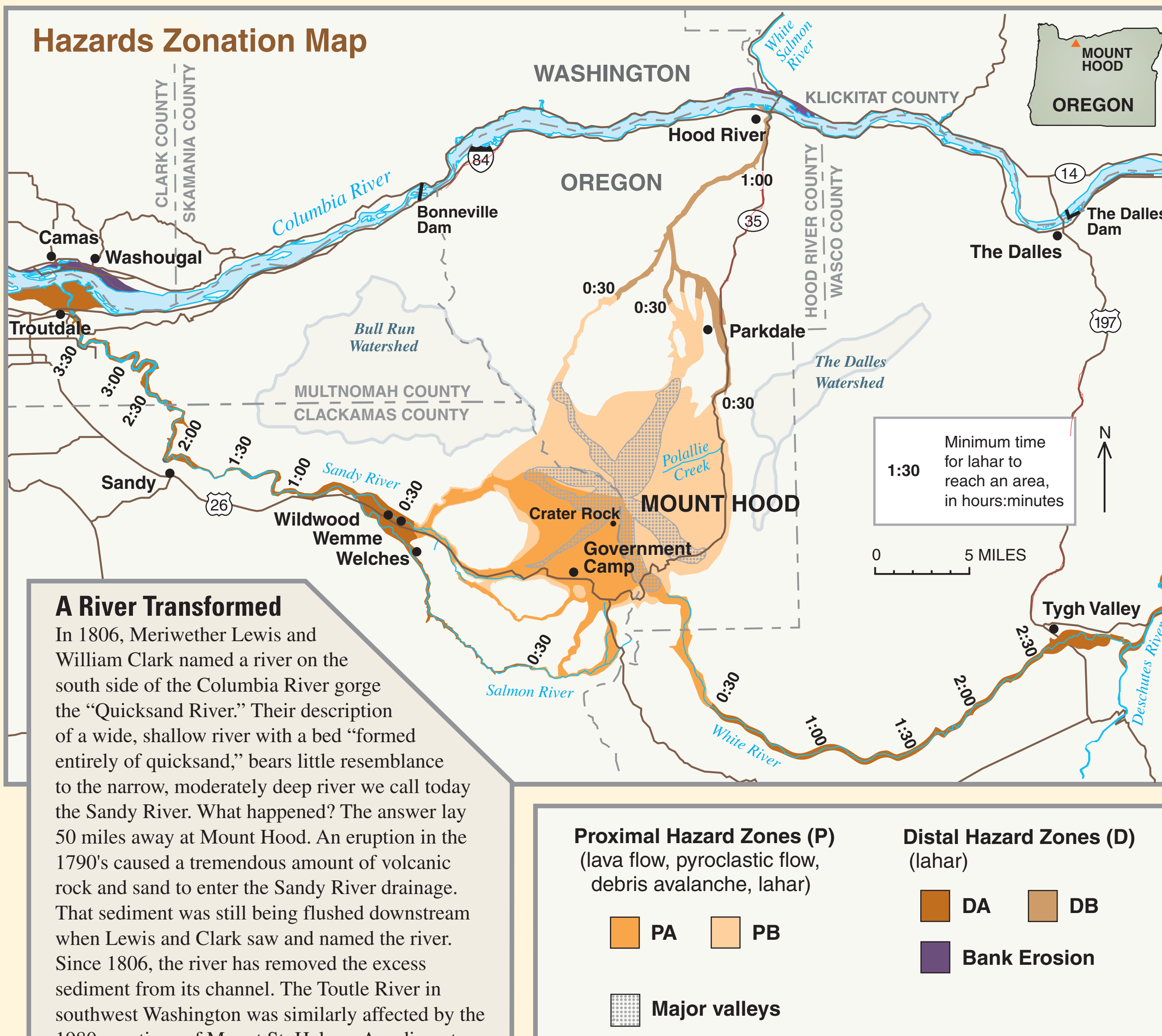
Explosive eruptions blast lava fragments (**tephra**) and gas into the air. Tephra can also be carried aloft in billowing ash clouds above pyroclastic flows. Large fragments fall to the ground close to the volcano, but smaller fragments (**ash**) can travel hundreds to thousands of miles downwind.

Debris Avalanches and Lahars

Debris avalanches are rapid landslides of rock, soil and overlying vegetation, snow, or ice. They can bury or smash objects in their path. All or some portion of debris avalanches can transform into lahars. **Lahars** are fast-moving slurries of rock, mud, and water that move down river valleys. They can bury, move, or smash objects in their path. Lahars form when pyroclastic flows melt snow or ice, or by the transformation of debris avalanches, or by mobilization of loose debris on the flanks of volcanoes.



Hazards Zonation Map



Simplified volcano-hazards-zonation map for Mount Hood, Oregon. For more information on hazard zones see text or for a more detailed map and description see Scott and others, 1997, Volcano Hazards in the Mount Hood Region, Oregon, U.S. Geological Survey Open-File Report 97-89.

A River Transformed

In 1806, Meriwether Lewis and William Clark named a river on the south side of the Columbia River gorge the "Quicksand River." Their description of a wide, shallow river with a bed "formed entirely of quicksand," bears little resemblance to the narrow, moderately deep river we call today the Sandy River. What happened? The answer lay 50 miles away at Mount Hood. An eruption in the 1790's caused a tremendous amount of volcanic rock and sand to enter the Sandy River drainage. That sediment was still being flushed downstream when Lewis and Clark saw and named the river. Since 1806, the river has removed the excess sediment from its channel. The Toutle River in southwest Washington was similarly affected by the 1980 eruptions of Mount St. Helens. A sediment-retention dam was built in the late 1980's to trap sediment and ease flooding in the lower Toutle River below the dam.

The Next Eruption of Mount Hood

Scientists expect the next eruption to consist of small explosions and the growth and collapse of lava domes, generating pyroclastic flows, ash clouds, and lahars. Lahars pose the greatest hazard because more people live downstream in lahar-prone river valleys than live on the volcano's flanks. Thus, it is important to know where one lives, works, and plays in relation to Mount Hood's hazard zones.

Hazardous Areas

Hazard zones shown on the map were determined on the basis of distance from the volcano, vent location, and type of hazardous evens. Proximal hazard zones (**P**) are areas subject to rapidly moving debris avalanches, pyroclastic flows, and lahars that can reach the hazard boundary in less than 30 minutes, as well as to slow-moving lava flows. Areas within proximal hazard zones should be evacuated before an eruption begins, because there is little time to get people out of harm's way once an eruption starts. Most pyroclastic flows, lava flows, and debris avalanches will stop within the proximal hazard zone, but lahars can travel much farther.

Distal hazard zones (**D**) are areas adjacent to rivers that are pathways for lahars. Estimated travel time for lahars to reach these zones is more than 30 minutes, which may allow individuals time to move to higher ground and greater safety if given warning. Shown are inundation areas for lahars of a size similar to lahars that swept through the Sandy River 1,500 year ago. Smaller or larger lahars will affect smaller or larger areas, respectively. Lahars could affect transportation corridors by damaging or destroying bridges and roads. Water from the Bull Run Watershed, vital to Portland, is transported in pipes that cross distal hazard zones along the Sandy River.

Proximal and distal hazard zones are subdivided into zones **A** and **B** on the basis of the vent location during the next eruption. During the past two eruptive episodes, the vent was located near Crater Rock. Scientists anticipate that the vent for the next eruption will most likely be in the same area. Thus, areas within hazard zones **PA** and **DA** have a higher probability of being affected during the next eruption than do areas within hazard zones **PB** and **DB**, which reflect a vent located on the volcano's west, north, or east flank.

House partly buried by lahars from the 1980 eruption of Mount St. Helens. Note the high mud line on the house and large amounts of woody debris carried by the lahars. (Photo by Lyn Topinka, USGS)

During and after an eruption, large amounts of sediment could be carried by rivers and discharged into the Columbia River. This sediment could narrow the Columbia's channel, forcing it to the north and potentially causing bank erosion along the river's north bank.

Tephra Hazards

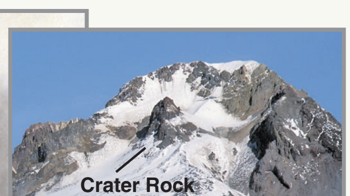
Mount Hood does not have a history of large explosive eruptions. Therefore, it is unlikely that communities downwind (typically east of the volcano) will receive tephra accumulations thick enough to collapse roofs. However, even minor amounts of tephra can damage machinery and electronic equipment or make driving hazardous. Ash clouds from small explosions or from pyroclastic flows can reach tens of thousands of feet in altitude, endangering jet aircraft by causing engine failure. Minor amounts of tephra can make breathing difficult for those with respiratory problems, the elderly, and infants. For most residents, however, tephra will be a nuisance and can be mitigated by such actions as shutting down and covering equipment, frequently replacing air filters in machinery, wearing dust masks, and avoiding unnecessary travel.

Planning for the Future

Scientists do not know when Mount Hood will erupt again or whether it will erupt in our lifetimes, but, as Mount St. Helens taught us, it is best to be prepared. Scientists continuously monitor Mount Hood for signs of unrest and are in communication with responsible local, State, and Federal agencies. Individuals too can prepare by doing the following:

- **Learn** about the volcano hazards that could affect your community and determine whether you live, work, or go to school in a volcano hazard zone.
- **Plan** what you and your family will do if a hazardous volcanic event occurs.
- **Participate** in helping your community be prepared.

A few moments spent now could help keep the next eruption of Mount Hood from becoming a disaster for you, your family, and your community.



Mount Hood's last major eruption occurred 200 years ago and consisted of growth and collapse of a lava dome that sent numerous pyroclastic flows down the south and west flanks. Crater Rock (above) is the remnant of that dome. The left photo shows a pyroclastic flow during the August 7, 1980, eruption of Mount St. Helens. A billowing ash cloud rises from the pyroclastic flow. Future pyroclastic flows from Mount Hood could devastate areas on the flanks of the volcano, and fallout of ash from the ash cloud could disrupt transportation and prove a nuisance to residents downwind. (Photos by Peter Lipman and David Wieprecht, USGS)

Hazards Can Occur Even Without Eruptive Activity

Lahars are often associated with eruptive activity, but they can also be generated by rapid erosion of loose rock during heavy rains or by sudden outbursts of glacial water. On Christmas Day 1980, an intense rainstorm rapidly melted snow and triggered a small landslide in fragmental debris in upper Polallie Creek. The resulting lahar moved downvalley at 25 to 35 miles per hour. At the mouth of Polallie Creek, the lahar spread out, killing a camper and temporarily damming the East Fork Hood River. Flooding after failure of this temporary dam destroyed 5 miles of highway, three bridges, and a state park—at a cost of at least $13 million. Small lahars such as this occur every few years at Mount Hood, but few have been as destructive.

Past Catastropic Events

Two past eruptions at Mount Hood provide perspective on the impact of future large events. Both were associated with eruptive activity that triggered debris avalanches and were accompanied by lava extrusion, pyroclastic flows, and lahars. One represents a truly catastrophic event.

About 100,000 years ago, a large portion of the volcano's north flank and summit collapsed. The resulting debris avalanche transformed into a lahar that swept down the Hood River valley. At the river's mouth, where the town of Hood River now stands, the lahar was 400 feet deep. The lahar crossed the Columbia River and surged up the White Salmon River valley on the Washington side. Since that time lava has filled in the scar left by the debris avalanche.

On the south side of the volcano, the scar from a 1,500-year-old debris avalanche is still visible, forming the amphitheater around Crater Rock. A lahar formed by this event traveled the length of the Sandy River valley, depositing boulders as large as 8 feet in diameter, 30 feet above present river level where the towns of Wemme and Wildwood now stand. The lahar spread out over the delta at the mouth of the Sandy River and pushed the Columbia River to the north. This event, although large by Mount Hood's standards, was only about one-tenth the size of the 100,000-year-old event.

Mount Hood's next eruption is much more likely to be smaller than or similar in size to the 1,500-year-old event. An eruption similar in size to the 100,000-year-old event, although possible, is much less likely.

Mount Hood Today

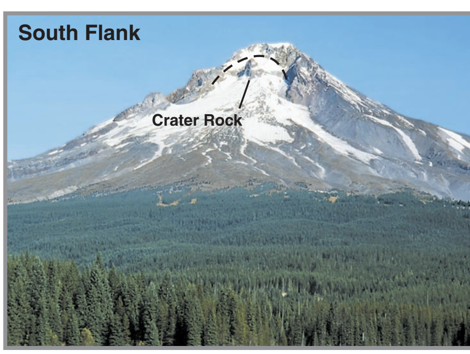
Today Mount Hood shows no signs of imminent volcanic activity, but hot steam vents, or fumaroles, near Crater Rock attest to heat below. On clear, cold, windless days, a steam plume is often seen rising from the fumaroles. Visitors to Mount Hood frequently smell the "rotten egg" odor of the fumarole gas, whose composition indicates that magma lies a few miles below the summit.

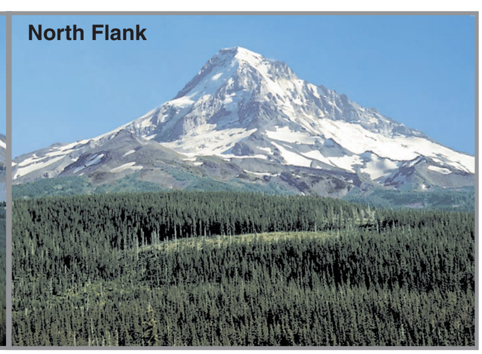
Monitoring for the Next Eruption

Renewed activity at most volcanoes begins with increasing numbers of earthquakes beneath the volcano as magma moves towards the surface. Since 1977 the University of Washington's Geophysics Program and the USGS have continuously monitored earthquakes at Mount Hood. Typically, one to three small earthquake swarms (tens to more than one hundred earthquakes lasting 2 to 5 days) occur every year. What scientists are looking for as a sign of renewed activity is for a swarm to persist, for the number of earthquakes to increase dramatically, or for the depths of earthquakes to become shallower. Such signs of reawakening might also be accompanied by changes in composition or temperature of fumarole gases, or by deformation of the volcano's flanks.

Geologist examining 100,000-year-old lahar deposit exposed along Underwood Hill Road, near the mouth of the White Salmon River in Washington. The lahar, derived from a large debris avalanche off the north side of Mount Hood, flowed down the Hood River, crossed the Columbia River, and traveled several miles up the White Salmon River before stopping. Here, the deposit is about 40 feet thick and about 300 feet above present river level. (Photo by William Scott, USGS)

Scientists can generally detect when a volcano becomes "restless," thereby providing some warning to officials and the public. But they cannot say precisely when an eruption will begin, how big it will be, or how long it will last. Thus, we will all have to confront many uncertainties when Mount Hood reawakens. Recent eruptions around the world reveal that lava-dome eruptions, like those typical of Mount Hood, can begin after weeks to months of restlessness, last for time periods of months to years, and generate tens to hundreds of pyroclastic flows and lahars of varying size. Unfortunately, the end of an eruption doesn't always mean the end of eruption-related problems. New deposits of rock debris on the volcano's slopes and in river valleys can be reworked to form lahars for many years after an eruption ends.





The two faces of Mount Hood. In the photo of the south flank taken from Trillium Lake, the dashed line marks the steep scarp above Crater Rock formed by a landslide 1,500 years ago. Dome growth and collapse from Crater Rock during the last two eruptive episodes (1,500 and 200 years ago) sent numerous pyroclastic flows down the south flank, resulting in the smooth south-facing slope. On the north flank, lack of recent volcanic activity has preserved the deeply carved glacial landscape on this side of the mountain. In its long history, Mount Hood has experienced numerous ice ages, each lasting for thousands of years, when glaciers were more extensive than today. During the last one, which ended about 15,000 years ago, glaciers extended 4 to 5 miles beyond their present limits. (Photos by William Scott, USGS)

Cynthia A. Gardner, William E. Scott, Jon J. Major, and Thomas C. Pierson

Graphics and Design by

Bobbie Myers, Lisa Faust, and Christine Janda

COOPERATING ORGANIZATIONS
U.S. Department of Agriculture, Forest Service
University of Washington, Geophysics Program

For more information contact:
U.S. Geological Survey
Cascades Volcano Observatory
5400 MacArthur Blvd., Vancouver, WA 98661
Tel: (360) 993-8900, Fax: (360) 993-8980
http://vulcan.wr.usgs.gov/
or
USGS Volcano Hazards Program
http://volcanoes.usgs.gov/

See also *Volcano Hazards in the Mount Hood Region, Oregon* (USGS Open-File Report 97-89), *At Risk: Volcano Hazards from Mount Hood, Oregon* (USGS Open-File Report 98-492, video), and *What are Volcano Hazards?* (USGS Fact Sheet 002-97)

Printed on recycled paper

APPENDIX C: AUTHORITIES

Federal – United States

Public Law 93-288 Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1974 as amended
Public Law 920 Federal Civil Defense Act of 1950 as amended
Public Law 96-342 The Improved Civil Defense Act of 1980
Public Law 84-99 Flood control and Coastal Emergencies
Federal Response Plan 1999
Flood Control Act of 1950
Department of Transportation Act of 1966
Federal Aviation Administration Act of 1958
Federal Energy Regulation Commission Order 122
USFS Incident Management Team Delegation of Authority Letter

State of Oregon

Oregon Revised Statute Chapter 401
Oregon Administrative Rules Chapter 104
Oregon Emergency Management Plan, Volume II , 2001
Emergency Management Assistance Compact (EMAC)

State of Washington

RCW 38.08 Powers and Duties of the Governor
RCW 38.52 Emergency Management
RCW 38.54 State Fire Service Mobilization
RCW 43.06 Governor's Emergency Powers Act
WAC 118 Emergency Management
WAC 296 Washington Industrial Safety and Health Act
Washington State Comprehensive Emergency Management Plan
Emergency Management Assistance Compact (EMAC)

Local Government

Each of the counties has established authorities governing emergency management and operations.

APPENDIX D: FIELD VOLCANO OBSERVATORY REQUIREMENTS

The following is a rough guide to USGS requirements for a field observatory in, or close to, an established EOC. There is flexibility in these requirements. For example, if necessary, the USGS could set up operations in a temporary structure (e.g., trailer in the parking lot) if government owned or leased office space is not available. The bottom line is: The USGS can probably adapt to most situations, especially for the first few weeks of an incident. If an Incident/Unified Command structure has been established, USGS staff would work with the Logistics Section for facilities, supplies, and other support needed to establish a field observatory.

Space Requirements:

Space requirements can be separated into 5 areas; (1) Roof or tower space for mounting radio communications antennas; (2) an "operations" room that would be the focus of the real-time monitoring activities and coordination of field work; (3) an area where staff could set up desks and computers for data analysis, preparations for field activities, and hold staff meetings; (4) storage space for items such as batteries, spare parts and helicopter sling equipment; and (5) a media area separate from the other work areas.

1) *Antennas*: Real-time data from the volcano will be radio-telemetered to our field observatory. We will need space to mount approximately ten (10) yagi antennas, with a minimum of 4 feet separation between antennas. Line-of-sight access to the volcano is necessary as well as being within 100-foot proximity of the Operations room.
2) *Operations Room*: Approximately 300 sq. ft of space required. All data are funneled into the Operation room for coordination and display. Voice radios for communication with field crews as well as telephones for both voice and data are necessary in the Operations room. Space requirements should also take into account that it will be available to the media for photo opportunities and backdrops for interviews during slow periods of activity.
3) *Staff Office Area*: Approximately 400 sq. ft. of space required. Staff will use this area not only for office functions but also to store limited field supplies, rock samples, equipment, etc. The Staff area should be sufficiently large so as to contain some chairs, desks, tables and still have room to hold a meeting of 15-20 people. Close proximity to Operations Room desirable and phones desirable.
4) *Storage Space*: Approximately 300 sq. ft. of space required. A secure area for field equipment, supplies (batteries, concrete mix, water jugs, spare parts, etc.) and materials that is separate from the Operations Room and Staff Office Area. This could be commercial leased space but would need to be in close proximity to Operations.
5) *Media Area*: It is anticipated that a suitable media briefing area at the proximal EOC will already be in place. If none exists, the more physically separated from the Operations and Staff offices, the better.

Communication requirements:

- Six (6) standard voice phone lines (1 for fax, 2 'hot' lines, 1 for recorded volcano information, and 2 for normal use)
- Two (2) standard lines for data communications. Either dial-up access to the USGS computer network or remote colleagues dialing into the temporary observatory's computer network.

Concurrent with setting up the observatory, USGS will negotiate the installation of a dedicated relatively high-speed data link between the observatory and the nearest Department of Interior facility.

Power requirements:
Observatory equipment does not draw large current loads, but does require reliable power. Approximately 15 computers (approx. 5kW), Doppler radar (1kW), plus radio and other equipment will be supported. If reliable commercial AC power is not available, it will be necessary to obtain an emergency generator and quality uninterruptible power supply(s) (UPS)

Doppler radar:
Doppler radar may be deployed to support operations. It requires a 6' x 6' secure roof area capable of supporting about 300 lbs. Line-of-sight access to the volcano is essential for proper operation of the system. Ideally, the radar would be located within a few hundred feet of the Operations room. The radar requires about 1kw of power.

Parking:
Workers will travel frequently between the volcano, a local heli-pad, motel rooms, etc. Convenient parking for 8-10 vehicles will support efficient operations.

APPENDIX E: GLOSSARY OF ACCRONYMS and ABBREVIATIONS

CVO: Cascades Volcano Observatory

DEM: (local) Department (or Division) of Emergency Management

DFO: (FEMA/State) Disaster Field Office

DoD: Department of Defense

DOGAMI: (Oregon) Department of Geology and Mineral Industries

EAS: Emergency Alert System

ECC: Emergency Coordination Center

EMAC: Emergency Management Assistance Compact

EMD: (Washington) Emergency Management Division

EOC: Emergency Operations Center

ERT: Emergency Response Team

ESF: Emergency Support Function

FAA: Federal Aviation Administration

FAC: (Mount Hood) Facilitating Committee

FEMA: Federal Emergency Management Agency

FRP: Federal Response Plan

HIVA: Hazard Identification Vulnerability Assessment

ICS: Incident Command System

IMT: Incident Management Team

ICP: Incident Command Post

JIC: Joint Information Center

NAWAS: (FEMA's) NAtional WArning System

NWCC: NorthWest Coordination Center

NWS: National Weather Service

ODOT: Oregon Department of Transportation

OEM: Oregon Emergency Management

OERS: Oregon Emergency Response System

OSP: Oregon State Police

PIO: Public Information Officer

PNSN: Pacific Northwest Seismograph Network

ROC: (FEMA) Regional Operations Center

SOG: Suggested Operating Guidelines

UPS: Uninterruptible Power Supply

USFS: United States Forest Service

USGS: United States Geological Survey

WSDOT: Washington State Department of Transportation

WSP: Washington State Patrol

APPENDIX F: JOINT INFORMATION CENTER PURPOSE AND STRUCTURE

Coordination of Information Flow

The purpose of the Joint Information Center (JIC) is to coordinate the flow of information about volcanic activity and related response issues among agencies, and to provide a single information source for the media, general public and businesses. The JIC is an element of the Emergency Operations Center(s) (EOC) where the emergency response is being coordinated. Communications between agencies and to the media/public must be rapid, accurate and effective. A JIC provides a forum for the necessary information exchange. Public information between and from all responding agencies, EOCs, political jurisdictions, and the media is handled through this one center, thereby allowing the coordination of information from all sources, and reducing or eliminating conflicting information and rumors. Temporary and alternate media offices will be identified. All participants will be encouraged to facilitate an efficient flow of information from the JIC.

A JIC may be necessary in one or more of the following circumstances:

- Multiple local, state and/or Federal agencies are involved in an incident.
- The volume of media inquiries overwhelms the capacities of the Public Information Officer(s) (PIOs) within the EOC.
- A large-scale public phone team effort must be mounted over an extended period of time.

When conditions warrant, or when a Volcano Advisory (or Alert) is declared, a JIC will be activated by the FAC or Unified Command. A JIC must have:

- Office space for the PIOs,
- Facilities for communication by phone, fax and email
- Briefing rooms
- Easy access for the media
- Proximity to restaurants or available food service
- Security

Recommended Structure of JIC during Volcanic Incidents

A. Potential Participants:

Oregon Emergency Management
US Geological Survey
US Forest Service
Counties on the FAC
City of Portland
DOGAMI
FEMA
Others as required or conditions dictate

B. Operating Assumptions

1. All information will be coordinated among the JIC staff in order to ensure timely and accurate information flow to the public, to quell rumors and to prevent impediments to the response effort.
2. The JIC will operate under the Incident Command System
3. The JIC will adjust its size and scope to match the size and complexity of the incident.
4. State and local agencies may be requested to provide staff for the JIC, including augmentation.
5. The JIC will be established (at least via conference call) prior to the issuance of a second *Information Statement* by USGS on an incident.

APPENDIX G: REFERENCES AND WEB SITES

References:

Mount Hood

U.S. Geological Survey, Mount Hood Fact Sheet (dated ??) (see Appendix B)

On Volcanic Crises and Volcanic Hazards

Blong, R.J., 1984, Volcanic Hazards: New York, Academic Press, 424p.

Foxworthy, B.L., and Hill, M., 1982, Volcanic eruptions of 1980 at Mount St. Helens: The first 100 days. USGS Prof. Paper 1249: Washington, DC, U.S. Government Printing Office.

Harnley, C.D., and Tyckoson, D.A., 1984, Mount St. Helens: An Annotated Bibliography, Scarecrow Press, Inc., Metuchen NJ and London, 248 p.

International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI), 1995, Understanding Volcanic Hazards [video], Distributed by Northwest Interpretive Association, (360) 274-2127

Mader, G.G., Blair, M.L., and Olson, R.A., 1987, Living with a volcano threat: Response to volcanic hazards, Long Valley, California, William Spangle and Associates, Inc., 105p.

Newhall, C.G., and Punongbayan, eds., 1996, Fire and Mud: eruptions and Lahars of Mount Pinatubo, Philippines, 1126 p.

Tilling, R.I., ed., 1989, Volcanic Hazards. American Geophysical Union Short Course In Geology: Volume 1, American Geophysical Union, Washington, D.C., 123 p.

Web Sites:

American Red Cross	http://www.redcross.org
FEMA	http://www.fema.gov
Clark Regional Emergency Services Agency	http://www.co.clark.wa.us/emergency/index.htm
Clackamas County Emergency Management	http://www.co.clackamas.or.us/emergency/
Confederated Tribes of Warm Springs	http://www.warmsprings.com/
DOGAMI	http://www.oregongeology.com/
Hood River County	http://www.co.hood-river.or.us/
Multnomah County Emer. Mgmt.	http://www.co.multnomah.or.us/dbcs/emergency_mgmt/
Oregon Department of Transport.	http://www.odot.state.or.us/home/
Oregon Emergency Management	http://www.osp.state.or.us/oem/index.htm
City of Portland	http://www.portlandonline.com/
Skamania County Emer. Mgmt.	http://www.emergency-management.org/
USFS-Mount Hood National Forest	http://www.fs.fed.us/r6/mthood/
USGS-Cascades Volcano Observatory (CVO)	http://vulcan.wr.usgs.gov/
Wasco County	http://www.co.wasco.or.us/
Washington Emergency Management Division	http://emd.wa.gov/