3.5 Volcano

The peaks surrounding Multnomah County are famous landmarks of the region, but also serve as reminders of a volcanic story that is still being written. Mount Hood has erupted in the last 300 years and remains geologically active. Multnomah County residents were able to watch the 1980 eruption of Mount St. Helens from their homes, considered the most destructive volcanic eruption in the modern history of the United States. Many severe eruptions are also known to have occurred before Oregon statehood. Those earlier eruptions profoundly changed Oregon's current geology and impacted the lives of indigenous residents.

The Pacific Northwest has a number of volcanoes (Mt. Hood, Mt. Saint Helens, Mt. Baker, Mt. Rainier) considered to be among the most dangerous in the United States because of their activity and proximity to populated areas. Fortunately, volcanic eruptions are rare events, with often extremely long periods between severe eruptions. But another Mount Hood eruption could be an extremely dangerous event, especially along the Sandy River, where a dangerous, fast-moving mudflow called a *lahar* could damage portions of east county communities. Falling ash from the eruptions across the region exists as the other significant threat to public health and infrastructure.

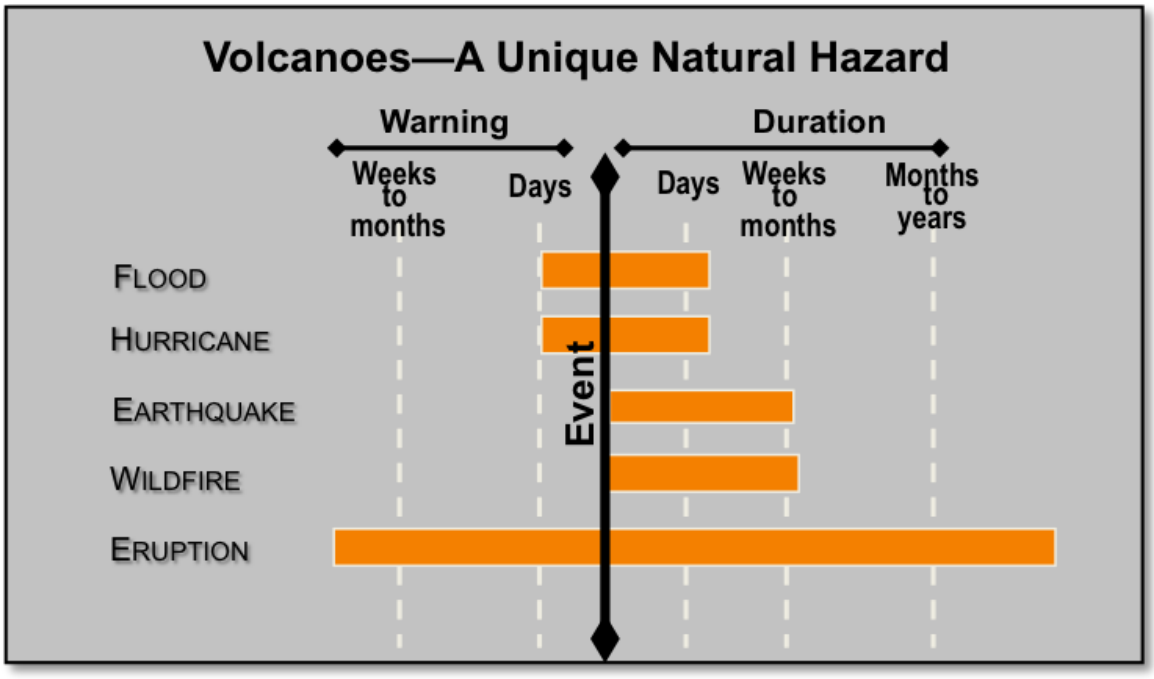

Figure 82 - Graphic shows how volcanoes differ from other hazards, by giving much more warning but also having a long duration of occurrence.

Overall, the risk from volcanoes is serious but not considered a high priority for any of the participants of this plan. The Cities of Fairview and Troutdale and levee districts with operations in and around the mouth of the Sandy River have identified the highest levels of concern. A severe event would be extremely damaging, but advances in eruption forecasting mean there is likely to be more warning of an event, the geographic scope of lahar damage is more limited than other hazards, and ash impacts are difficult to estimate in probability and impact. An extreme Mount Hood eruption event would be impactful for a very long period of time, so

attention continues to be required to maintain risk awareness and to support continuing work in volcano monitoring technology.

Five-Year Report, 2017-2022

- *Events*

No significant volcanic events have affected Multnomah County since the 2017 edition of this plan was published. Minor earthquake swarms have continued, including a magnitude 3.9 earthquake below Mt. Hood on June 5, 2021. These small earthquakes indicate the continuing geologic activity of the mountain, but this earthquake swarm was not considered to be indicative of magma movement that would foreshadow an eruption.

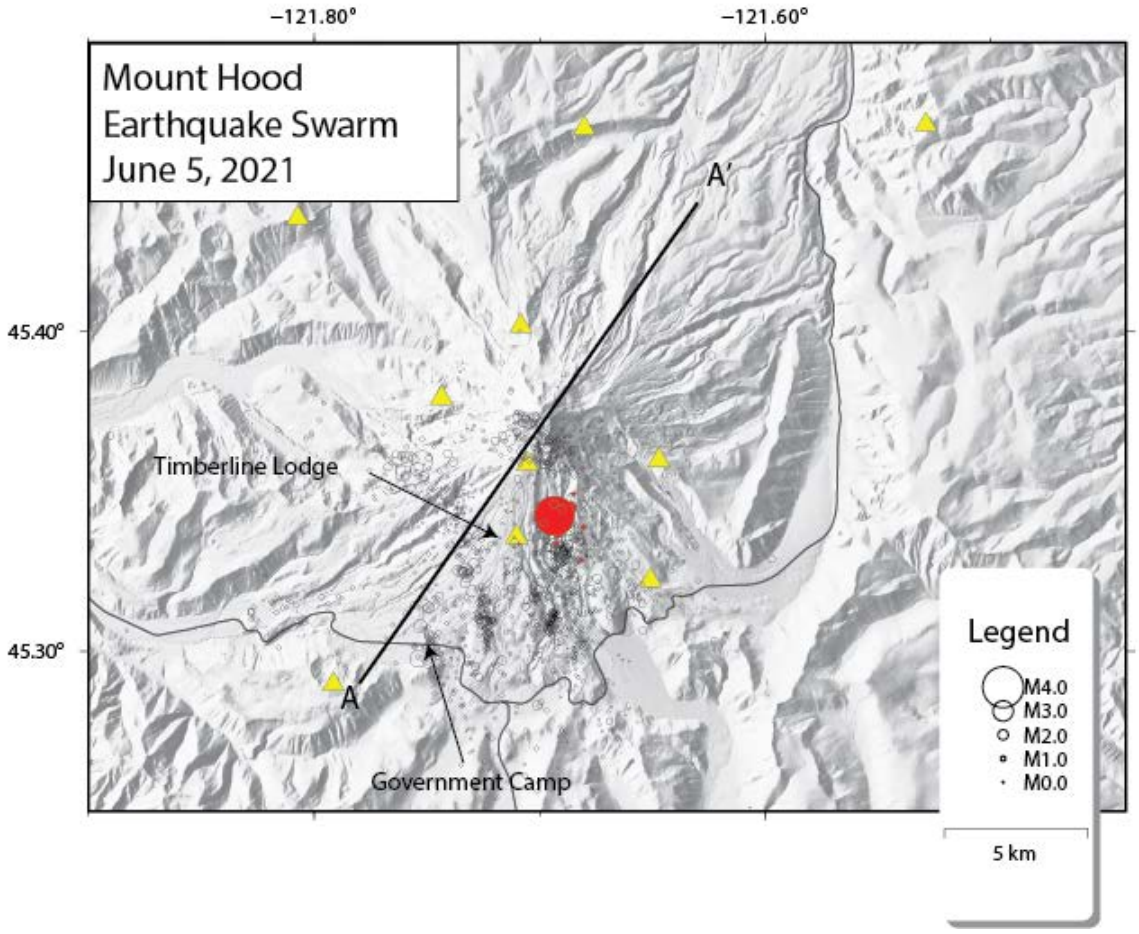

Figure 83 - Location and size of volcanic earthquakes at Mount Hood in June 2021. These earthquakes were not considered to be a precursor of heightened volcanic activity. Graphic from the US Geological Survey

As of 2014, Mount Saint Helens has also remained active, with small ground movements and earthquakes indicating activity below the surface. However, there is no current sign of impending eruption according to the United States Geological Survey.

- *Data and Risk Analysis*

Advancements in the last five years have continued in eruption forecasting, primarily through seismic monitors and other sensors to measure ground changes, pressure, and changes in gas emissions. The United States Geological Survey is currently attempting to place additional early detection and monitoring sensors at Mount Hood.

The best risk and vulnerability data continues to be based on work published before 2017. The National Volcano Threat Index was updated in 2018, and maintained threat levels for all regional volcanoes.

DOGAMI published a *Natural Hazard Risk Report for the Lower Columbia-Sandy Watershed* in 2020, which collected lahar damage study information to create a more detailed vulnerability analysis for this single watershed, which is the only portion of Multnomah County with lahar vulnerability.

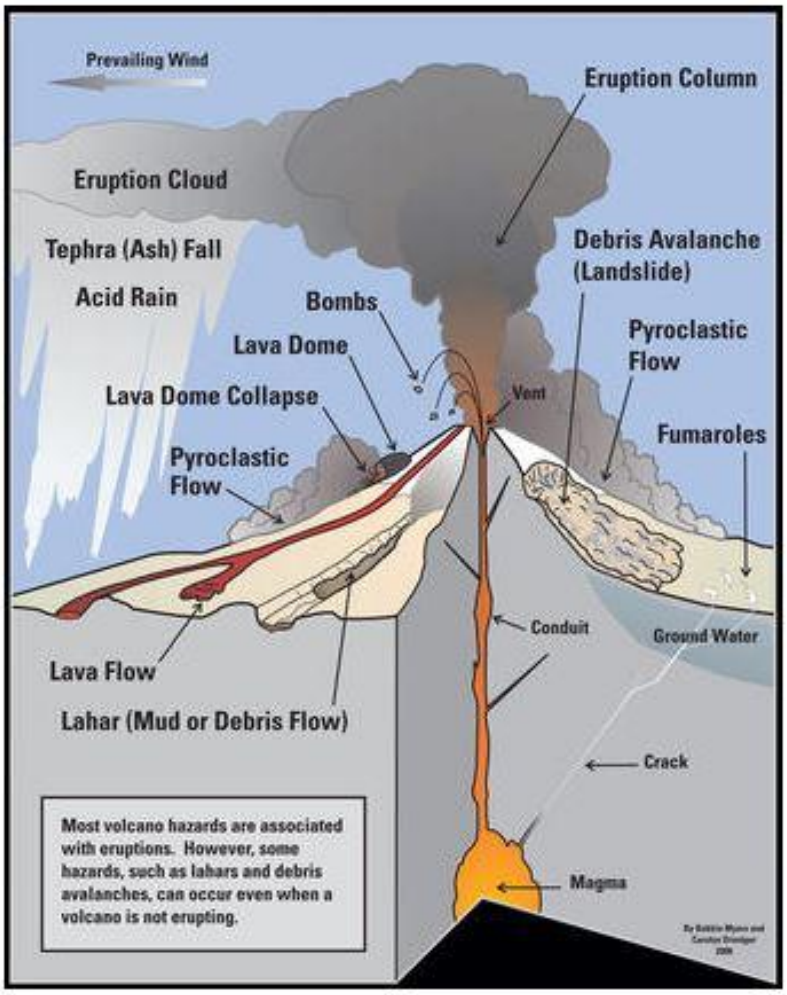

Figure 84 - Graphic showing types of volcanic impacts. Graphic from the US Geological Survey.

3.5.1 Volcano Impacts, Locations, and Extents

Volcanic hazards are varied and have different impacts depending on distance from the eruption. The hazards are categorized as either *distal hazards* (farther away) or *proximal hazards* (closer in). Although Mount Hood and Mount St. Helens loom large in the Multnomah County skyline, they are far enough away that they would only impact the county with distal hazards.

The direction of projected distal and proximal hazards at Mount Hood are based on the past two eruptions occurring at Crater Rock[78], which is also considered to be the most likely location of the next eruption. If a different vent is the eruption source, debris flows may be carried to the north or east and threaten other counties.

[78] Crater Rock on the south-facing side of the mountain, is the location of a lava dome formed during the last eruptive period.

Lahars

Lahars are mixtures of water, debris, ice, and sediment that form huge mudflows after an eruption. These dangerous flows are often made more dangerous when volcanoes are covered in snow which rapidly melts due to the heat of the eruption. Lahars can travel 20-40 miles an hour and extend as much as 50 miles, as they pick up additional debris and water along the way and consolidate in large river channels before slowing down and spreading out at major river confluences. Lahars are one of the primary volcanic threats faced by Multnomah County, as flows are expected to travel down the Sandy River and inundate land where the Sandy River meets the Columbia River.

Figure 85 - The Saint Helens Bridge on Highway 504 in Washington was carried over a quarter mile downstream by a lahar from the 1980 Mount St. Helens eruption. Photo by R.L. Schuster for the United States Geological Survey.

Tephra (Volcanic Ash)

Tephra, or volcanic ash, is tiny rock and glass fragments that is ejected during an eruption. While larger particles have different names (bombs, blocks, or others) and stay fairly close to the eruption site, tephra rises into the atmosphere and can be carried hundreds or even thousands of miles by winds. After the 1980 Mount St. Helens eruption, tephra was carried by eastern winds across the Midwest. Tephra carries significant respiratory health impacts and can also damage buildings and infrastructure and affect transportation.

Figure 86 - Tephra from the 1980 Mount St. Helens eruption at a farm in Connell, Washington, 180 miles east of the eruption. Photo Lyn Topinka, Public Domain

Proximal Hazards

Lava flows destroy everything in their path and completely change the landscape as they cool into new rock formations. Lava flows move slowly and would only threaten those very close to the eruption.

Pyroclastic flows are avalanches of rock, gas and ash that travel down the slopes of volcanoes at tremendous speeds. These flows are extremely dangerous to anyone in their path, and were the primary cause of death in the 1980 Mount St. Helens eruption. Pyroclastic flows are believed to travel up to nine miles from an eruption, but this is not far enough to create risk to Multnomah County.

Volcanic landslides are the same type of movement of rock and earth as other landslides, but may be huge as volcanic cones collapse during an eruption. Mount St. Helens dropped 1,300 feet in elevation after the 1980 eruption, leaving the horseshoe-shaped crater seen now. Landslides may also start because of shaking and sudden snowmelt—if enough water is mixed in with debris, volcanic landslides may become lahars. Volcanic shaking is not expected to cause significant landslides in Multnomah County.

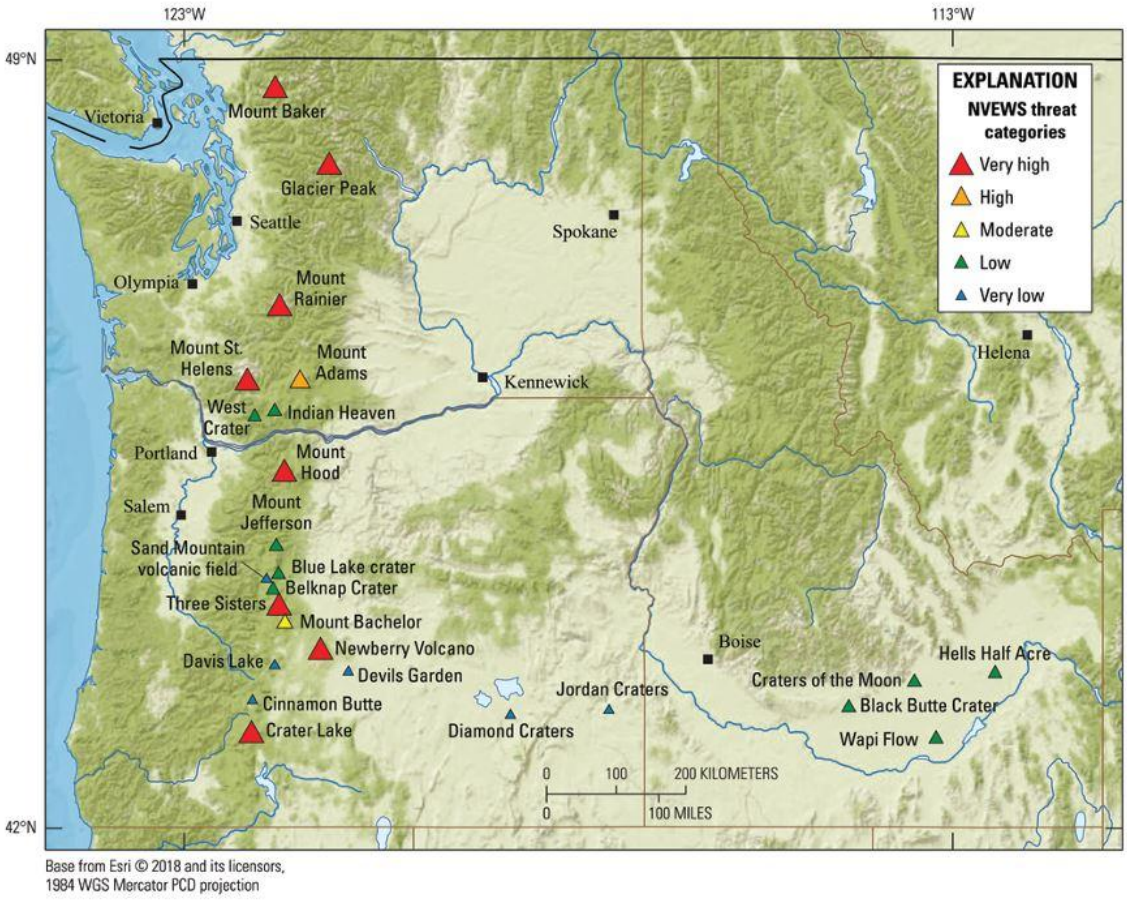

Figure 87 - Map showing volcanoes and their threat categories across the Pacific Northwest. Map from the 2018 National Volcano Threat Index.

The most recent National Volcano Threat Index was published in 2005 and revised in 2018. In the 2018 revision, there were no changes to the threat ratings of the volcanoes most likely to impact Multnomah County.

Eighteen volcanoes in the United States are rated as being of very high risk—three of those are in close enough proximity to threaten Multnomah County with severe distal hazards. The overall risk rating shown below uses a product of hazard probability and vulnerability factors to assign a numerical overall score. The risk rating is not designed to indicate relative risk to Multnomah County.

The aviation threat score is a measurement of potential impacts to aviation from airborne tephra and ashfall onto airports. Mount St. Helens has the highest threat to aviation of any volcano in the United States. The score is reflective of the higher probability and size of future eruptions, as well as the large amount of air traffic and airport operations that could be impacted.

Table 38 – Local Volcanoes and their Risk and Threat Ratings – (2018 National Volcano Threat Index)

Volcano	Overall Risk	Aviation Threat Score
Mount Saint Helens (WA)	Very High (263, 2nd highest in US)	59 (Highest in United States)
Mount Rainier (WA)	Very High (203, 3rd highest in US)	37
Mount Hood (OR)	Very High (178, 6th highest in US)	30
Mount Adams (WA)	High (92, 34th highest in US)	15

Low-threat volcanoes (overall risk score below 30) are located at Mount Jefferson, Indian Heaven and West Crater. These volcano sources are considered low threat because of limited volcanic activity, small size and/or their distance from populated areas. Other very high risk volcanoes in Central and Southern Oregon such as Three Sisters and the Newberry Volcano could also impact Multnomah County with falling tephra, depending on wind patterns at the time of eruptions.

Mount Hood

As noted above, the most likely eruption scenario at Mount Hood is another eruption at Crater Rock, shown on the Hazards Zonation Map below. An eruption at this location would create a lahar event on the Sandy River. The less likely locations of lahar hazard would come from an eruption on a vent to the north or east, which could threaten Hood River all the way to its confluence with the Columbia River, or move east on the White River through southern Wasco County.

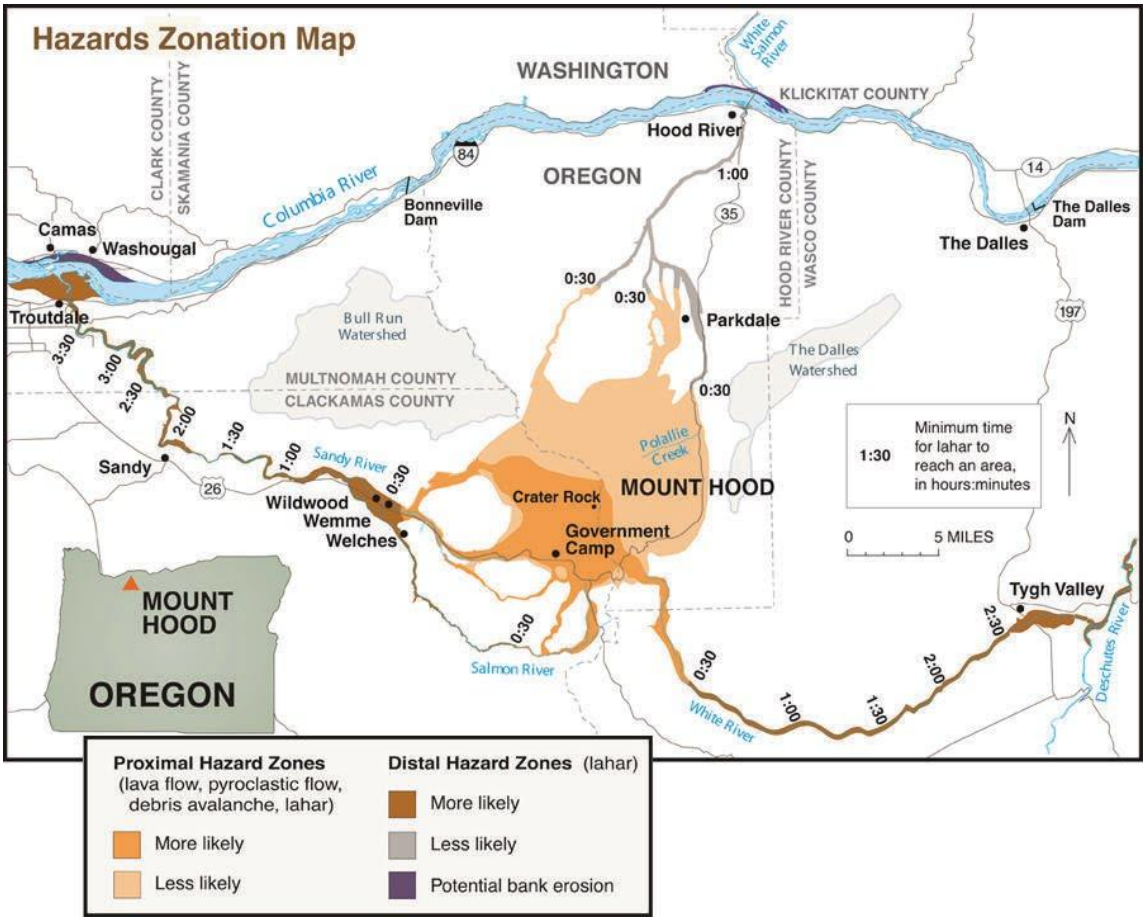

Figure 88 - Hazards Zonation Map shows potential lahar paths and the time it would take the debris flows to reach different areas in the region. Map from U.S. Geological Survey

Falling ash would likely be a significant hazard across Multnomah County, but locations of impacts would be dependent on wind direction and speed.

Mount St. Helens

Lahars from Mount St. Helens are most likely to travel west on river channels and potentially reach the Columbia River at Kalama, across from Columbia County in Oregon. There is no theorized event where lahars from Mount St. Helens would impact Multnomah County.

Falling ash from Mount St. Helens could be a significant hazard to Multnomah County, and given its activity and size of eruptions, this remains one of the major volcanic threats.

The eruption in 1980 had very favorable wind patterns for Multnomah County. Tephra was carried immediately to the north and east of the eruption and settled in highest amounts in central and eastern Washington. The only place in Oregon to receive more than trace amounts was in the northeastern corner of the state.

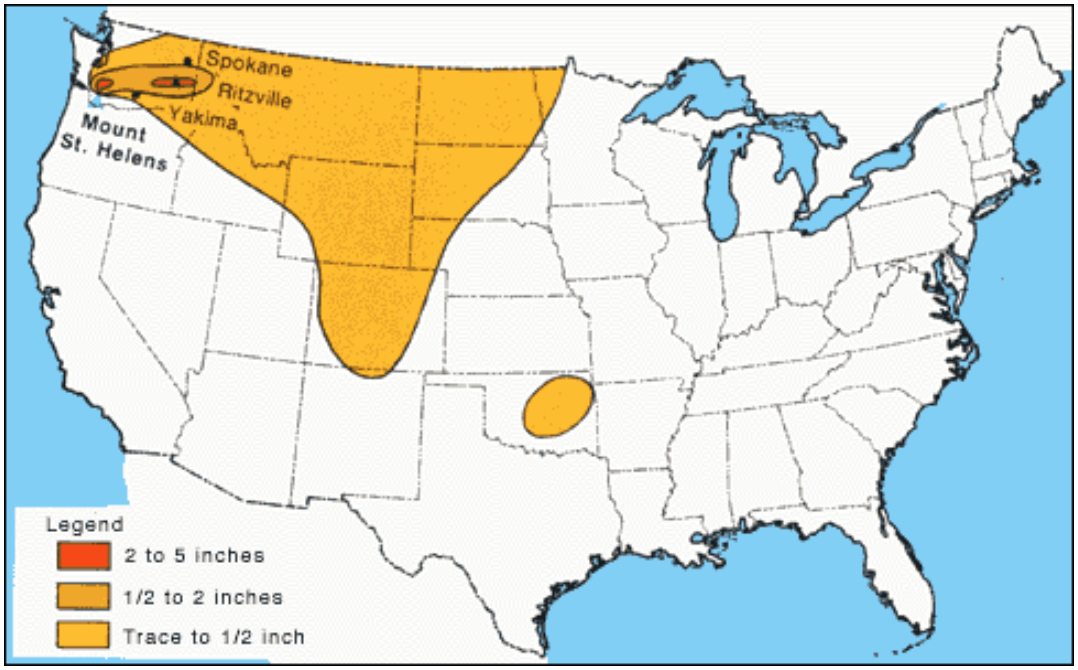

Figure 89 - Map showing location and amount of ashfall after the 1980 Mount St. Helens eruptions. Map from the United States Geological Survey.

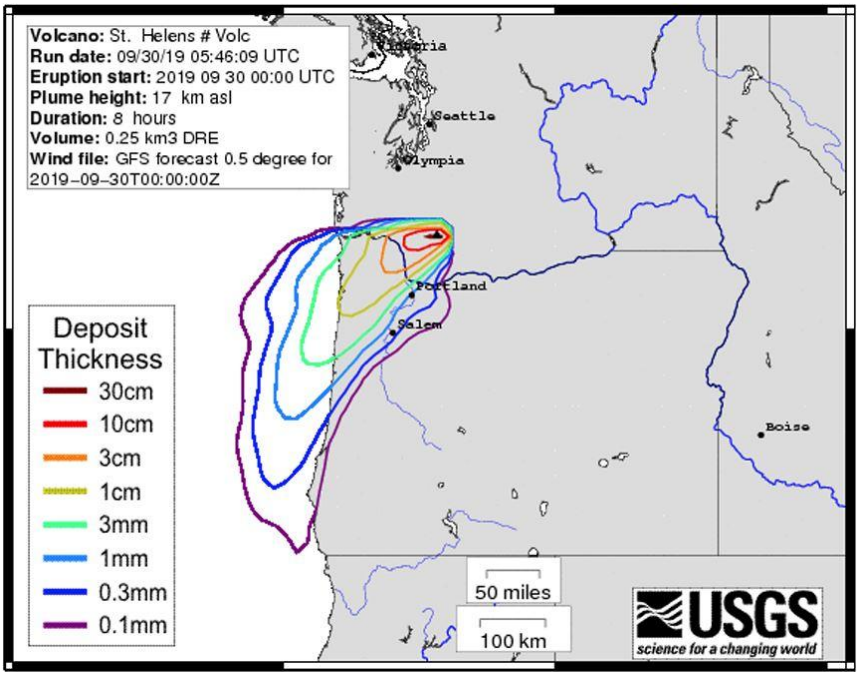

Figure 90 - Model of ashfall if Mount St. Helens had erupted on September 30, 2019, based on wind and weather conditions from that day. The US Geological Survey maintains a dynamic map showing potential movement of tephra every day based on weather conditions.

The westerly winds that carried tephra away from Multnomah County are the prevailing winds at the mountain, making it the most likely direction for the ash to travel in future events. However, non-prevailing winds are possible, and alternate weather scenarios have been modeled. The example to the left is one possible scenario, presented here to better convey the possible extent of tephra hazard.

Other regional volcanoes also only threaten Multnomah County with ash hazards. Risk is roughly equivalent across the county, if wind directions are unfavorable.

3.5.2 Volcano Probability and History

Probabilities for volcano risk are difficult to determine broadly, because they are controlled by movements of magma below the surface that are difficult to study. Eruptive histories provide a snapshot of future potential, but it is not unusual for an active volcano to go dormant for long periods of time, or for long-dormant volcanoes to suddenly reactivate. Mount Hood is not considered 'overdue' for an eruption because volcanoes do not have a set regularity of eruption probability in the same way that earthquake faults build pressure and can have anticipated periods of time between ruptures.

Current activity levels can be measured at volcanoes, based on earthquakes, ground movement and release of gasses. Improved forecasting can indicate when these processes signify the formation of eruptive potential that might occur in a matter of months or weeks. However, long-term projections of future activity remain elusive. Before Mount Hood erupted in the 1790s, it had been dormant for over 1,000 years. After that eruption, it continued to have eruptive periods through the mid 1800's, but has not had significant activity since 1866.

This unpredictability makes planning challenging. An extra-large Mount Hood eruption would be a catastrophic level event in east Multnomah County. If winds were to blow ash towards Multnomah County, impacts to public health and risk of building and infrastructure damage would also be catastrophic. However, an extra-large eruption is one of the least probable events contained in this plan, so participating entities mostly have this classified as a low-risk hazard and most do not have mitigation strategies directly for volcano risk.

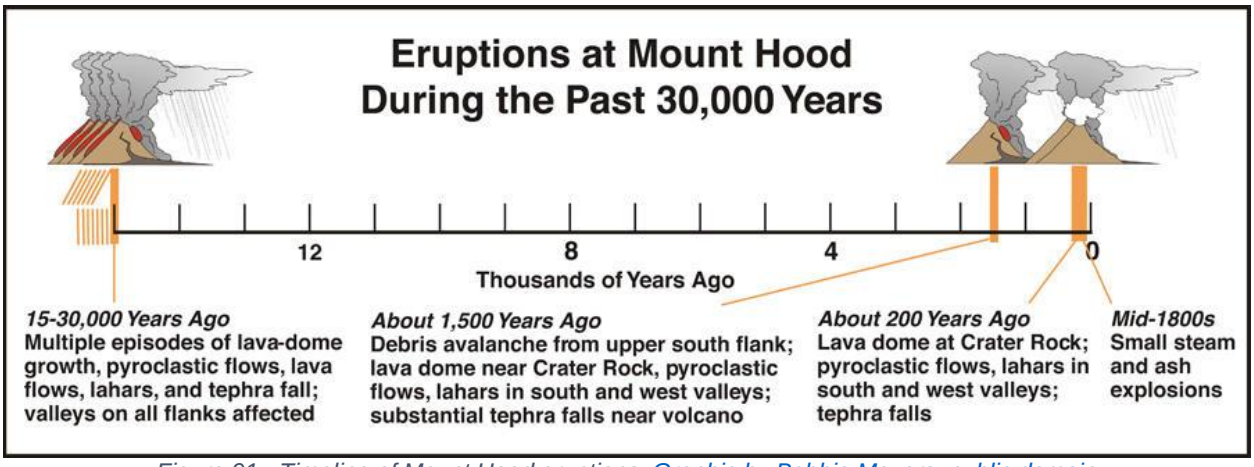

Figure 91 - Timeline of Mount Hood eruptions. Graphic by Bobbie Meyers, public domain

Geological records indicate that the eruptive period of the late 1700s deposited debris along the Sandy River, but was much smaller than eruptions 1,500 years ago that moved massive boulders and so much debris that it altered the flow of the Columbia River. However, even that eruption was only about 10% as large as eruptions 100,000 years ago that buried the area where the City of Hood River is now in 400 feet of debris. A future eruption is not likely to be that size, but can be considered to be the worst possible scenario.

Mount Hood eruption probabilities used for analyzing volcanic impacts in the Lower Columbia-Sandy Watershed Risk Report are shown below. Only a 'large' or 'extra-large' event would cause structural lahar damage in Multnomah County. Greater impacts would be present farther upstream in Clackamas County.

- ‘Small’ – 10-year event (10% annual chance)
- ‘Medium’ – 100-year event (1% annual chance)
- ‘Large’ – 500-1,000 year event (0.1-0.2% annual chance)
- ‘Extra Large’ – 100,000 year event (0.001% annual chance)

Table 39 – Volcano History of Multnomah County

	Volcano	Eruptions
Oregon		
	Mount Hood	1859 and 1865; Small events without known lahar deposits
	Mount Hood	1781; Old Maid Eruptive Period; lahar deposits widespread in Sandy River
	Mount Hood	~500 (1,500 years ago); Timberline Eruptive Period; Major lava dome formation and lahar deposits; Eruptive events lasting decades
	Mount Hood	15,000-30,000 years ago; Polallie Eruptive Period
Washington		
	Mount St Helens	2004-2008; Renewed Activity; Small eruptions in January and March 2005, including dusting of ash over 90 miles to the east; New lava domes refill 7% of crater
	Mount St Helens	1989-1991; Six small ash-producing explosions, including avalanches and minor debris flows.
	Mount St Helens	1980-1986; Smaller episodic eruptions that rebuilt lava domes in the new crater; Ash impacts ocurred in parts of Oregon in 1980 from these eruptions, in locations that were not impacted by the May 1980 eruption.
	Mount St Helens	May 18, 1980; Most destructive volcanic eruption in the history of the United States, 57 killed, widespread damage from blast effects, lahars, and ash.
	Mount St Helens	1800-1857; Goat Rocks Eruptive Period; Small series of eruptions creating the Goat Rocks Dome
	Mount St Helens	1479-1720; Kalama Eruptive Period; Large explosive eruptions in 1479 and 1482
	Mount Rainier	1825 (?)
	Mount Adams	950 (?)
	Mount St. Helens	1980 - 2008
	West Crater	5760 BCE (?)
	Indian Heaven	6250 $\pm$ 100 BCE

3.5.3 Volcano Vulnerability

Lahars

Lahars generated in an eruption of Mount Hood are the most significant threat to Multnomah County, especially the Cities of Troutdale and Fairview and Drainage Districts at the mouth of the Sandy River. Lahar vulnerability to buildings and critical facilities was included in the *Lower Columbia-Sandy Watershed Risk Report* performed by DOGAMI in 2020.

An interactive version of this map can be found here (Volcanic Hazard – Moderate Hazard)

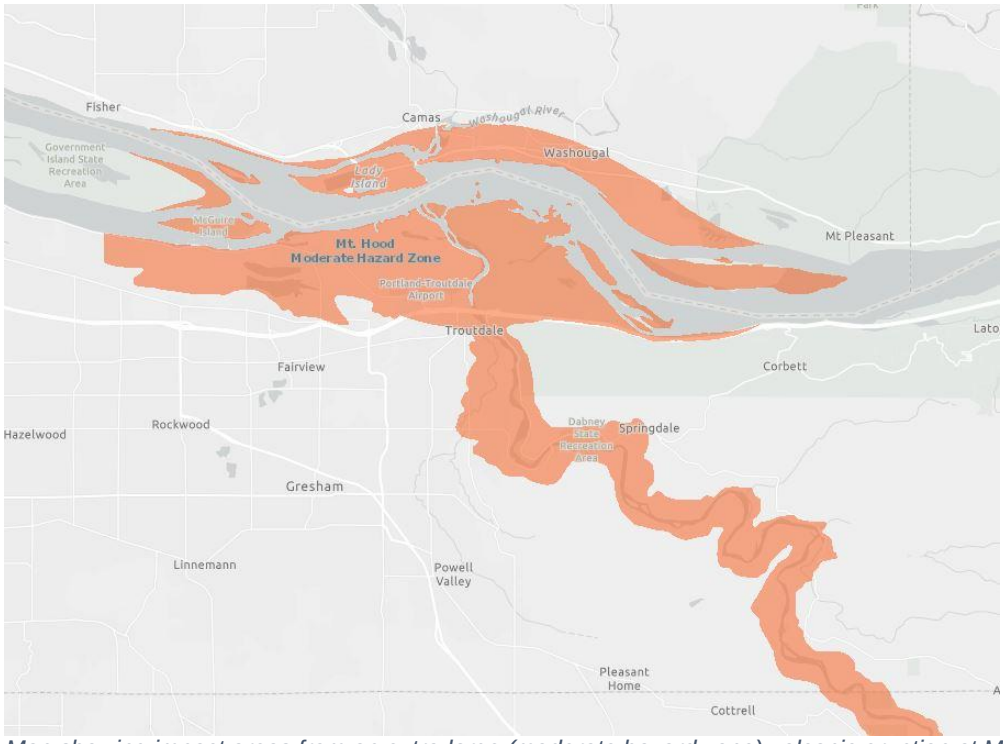

Figure 92 - Map showing impact areas from an extra-large (moderate hazard zone) volcanic eruption at Mount Hood. Map from DOGAMI HazVu.

This study provides extremely useful vulnerability data since the Sandy River is the lone Multnomah County location with lahar threat. This analysis ends at the watershed boundary—yet it is also known that an extra-large event described below would also cause significant debris effects to lakes, sloughs and low-lying shoreline areas in Fairview, Wood Village, Portland and across the Columbia River into Washington.

Most of the Multnomah County residents of the watershed are not threatened by even a large event. If a large to extra-large event occurs (predicted to occur every 100,000 years, or having a .001% annual chance of occurrence), buildings in lower-lying areas would be damaged and destroyed, including 37% of Troutdale's structures located within the watershed. Such a lahar is predicted to cause half a billion dollars in structural damage in Troutdale and another $75 million dollars in damage in unincorporated Multnomah County. Damage to flood-control structures for the SDIC (located entirely in the lahar zone), MCDD, and UFSWQD (partially located) are included in the city or county jurisdictions where they reside, but loss estimates do not include the cost of levee damage and non-structural levee infrastructure.

Table 39 – Buildings Impacted and Loss Estimate from Large and Extra-Large Mount Hood Eruption – Lower Columbia-Sandy Watershed Only – (DOGAMI O-20-06, Natural Hazard Risk Report for the Lower Columbia-Sandy Watershed)

	'Large' lahar event		'Extra-Large' lahar event	
Community (Watershed Portion Only)	**Number of Buildings Impacted**	**Loss Estimate**	**Number of Buildings Impacted**	**Loss Estimate**
City of Gresham	0	$0	1	$319,000
City of Troutdale	0	$0	1,588	$522,890,000
Unincorporated Multnomah County	0	$0	228	$75,738,000

The analysis showed that lesser lahar events from less violent eruptions would not damage buildings in Gresham, Troutdale, or Unincorporated Multnomah County, but would cause damage at higher elevations along rivers in Clackamas County. Even in cases where buildings are not damaged by a smaller lahar event (1% annual chance), there could be impacts to recreational areas and natural resources, levee operations and river transportation activity. 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. The effects of lahars may take months or even years for recovery and restoration.

Lahars move swiftly and an extra-large event would require quick notice and evacuation, even given the distance from Multnomah County to Mount Hood. It is estimated that a lahar coming down the Sandy River could reach Multnomah County in about two-and-a-half hours, and reach Troutdale an hour after that.

Tephra (Ashfall)

Falling tephra from a local or regional eruption could significantly impact Multnomah County, depending on wind directions during the eruption.

Volcanic ash is abrasive and corrosive and does not dissolve in water. It will irritate eyes and respiratory systems, and will require the use of masks to prevent inhalation, especially among those with pre-existing health conditions. Health risks will be similar to those from severe wildfire smoke. Populations living or working outside or in spaces without effective air filtration and with limited access to preventative equipment will face the most health risks.

Ash also is disruptive to buildings and other infrastructure, including damaging roofs and HVAC systems. Damage can range from minor cosmetic damage to catastrophic structural damage. In rare cases, thick ashfall has fully collapsed roofs and it becomes especially heavy when

combined with precipitation with long, low-pitched roofs being most vulnerable. Wet ash can weigh 10-15 pounds per square foot and 5-10 pounds per square foot when dry.

Summary of Potential Building Impacts from Volcanic Ash[79]

- Damage to interior equipment and flooring
- Abrasion to roofing and cladding
- Obstructed HVAC filters, condensers and air intakes
- Blockage of gutters and downpipes, including internal gutters
- Paint damage

Transportation Impacts

Ash can cause shutdowns of airports because of its impact on airplane engines, instruments, and other surfaces. In 2010, there was a major disruption at over 300 airports for a week across Europe due to the eruption of Eyjafjallajökull in Iceland in 2010. Over 100,000 flights were canceled, and work has since been done to better understand low tephra concentration impacts on planes.

Airports themselves have also been impacted across the world by ashfall. Accumulations of just a few millimeters of ash on runways has caused temporary airport closures, as well as impacts to buildings as noted above.

Figure 93 - Ash at the Quito International Airport in Ecuador after the 2002 eruption of Reventador, about 60 miles away. The airport closed for eight days. Photo - Ecuador Geophysical Institute

Roads may also be closed during ash events due to loss of visibility and increased danger caused by reduction of traction, obscuring of road signs, and clogging ditches and culverts. Ash may clog air filters and water intakes, restricting marine and rail activities.

Utility System Impacts

[79] Summary of Ash Impacts to Buildings and Building Support Systems, Volcanic Ashfall Impacts Working Group

Ashfall can cause power systems to shut down because of insulator damage, line breakage, equipment corrosion, power generation disruption and controlled outages to clean and repair damage. Sustained power loss creates significant vulnerabilities to those with acute medical needs, as noted throughout this plan.

Ash will degrade water quality for uncovered water system reservoirs and increase maintenance at utility pumping stations. As ash is swept into stormwater and sewer networks, it can cause damage to water treatment equipment