UNDERSTANDING EARTHQUAKE HAZARDS IN WASHINGTON STATE

Modeling a Magnitude 7.0 Earthquake on the Mount St. Helens Seismic Zone

Geologic Description

The magnitude 7.0 earthquake scenario for the Mount St. Helens seismic zone is based on an approximately 50 kilometer (30 mile)-long rupture within this seismic zone. The zone itself is 100 kilometers (60 miles) long, trending north-to-northwest. It produces earthquakes of moderate magnitude (up to M5.5) that have mostly strike-slip focal mechanisms on north-trending fault planes. This zone of shallow crustal seismicity is not correlated with mapped geological structures, in part because the geology around the zone is shrouded beneath a dense vegetation canopy. The seismic zone appears to stop at about the Cowlitz River—mainly based on a large area of seismic quiescence that developed in the region in the late 1970s—but the zone may extend northward into the Puget Lowland. Regionally, north-trending to northwest-trending seismicity correlates with north-trending and northwest-trending faults mapped in southwestern and south-central Washington.

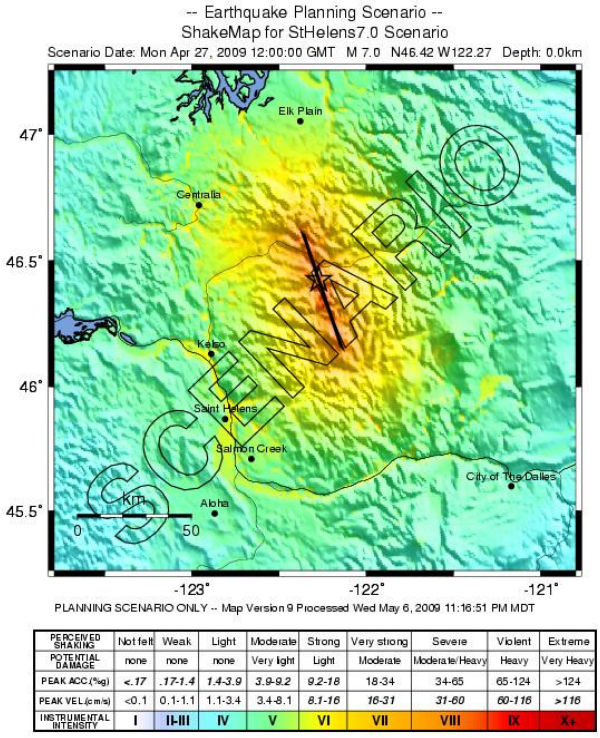

Figure 1. ShakeMap for a M7.0 earthquake on the St. Helens seismic zone. The heavy black line is the modeled fault for this scenario.

Type of Earthquake

Most earthquake hazards result from ground shaking caused by seismic waves that radiate out from a fault when it ruptures. Seismic waves transmit the energy released by the earthquake: the bigger the earthquake, the larger the waves and the longer they last. Several factors affect the strength, duration, and pattern of shaking:

- The type of rock and sediment layers that the waves travel through.
- The dimensions and orientation of the fault and the characteristics of rapid slippage along it during an earthquake.
- How close the rupture is to the surface of the ground.

Deep vs. Shallow: The M7.0 scenario earthquake modeled for the St. Helens seismic zone is a shallow or crustal earthquake. Shallow earthquakes tend to be much more damaging than deep quakes of comparable magnitude (such as the deep M6.8 Nisqually earthquake in 2001). This is primarily because in deeper earthquakes, the seismic waves have lost more energy by the time they reach the surface.

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Aftershocks: Unlike deep earthquakes, which usually produce few or no aftershocks strong enough to be felt, a M7.0 shallow earthquake like the one in this scenario would likely be followed by many aftershocks, a few of which could be large enough to cause additional damage.

Other Earthquake Effects

Liquefaction: If sediments (loose soils consisting of silt, sand, or gravel) are water-saturated, strong shaking can disrupt the grain-to-grain contacts, causing the sediment to lose its strength. Increased pressure on the water between the grains can sometimes produce small geyser-like eruptions of water and sediment called *sand blows*. Sediment in this condition is liquefied and behaves as a fluid. Buildings on such soils can sink and topple, and foundations can lose strength, resulting in severe damage or structural collapse. Pipes, tanks, and other structures that are buried in liquefied soils will float upwards to the surface.

Artificial fills, tidal flats, and stream sediments are often poorly consolidated and tend to have high liquefaction potential. For example, in the St. Helens scenario, the liquefaction susceptibility of the land on either side of the Toutle and Lewis rivers is rated moderate to high.

Landslides: Earthquake shaking may cause landslides on slopes, particularly where the ground is water-saturated or has been modified (for example, by the removal of stabilizing vegetation). Steeper slopes are most susceptible, but old, deep-seated landslides may be reactivated, even where gradients are as low as 15%. Catastrophic debris flows can move water-saturated materials rapidly and for long distances, mostly in mountainous regions. Underwater slides are also possible, such as around river deltas.

Figure 2. The M6.8 Nisqually earthquake in 2001 caused this road failure at Sunset Lake in Tumwater, Washington.

(Photo: Steven Kramer, University of Washington)

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Hazus Results for the Mount St. Helens Scenario

Hazus is a nationally applicable standardized methodology developed by FEMA to help planners estimate potential losses from earthquakes. Local, state, and regional officials can use such estimates to plan risk-reduction efforts and prepare for emergency response and recovery.

Hazus was used to estimate the losses that could result from a M7.0 scenario earthquake on the St. Helens seismic zone, which crosses Lewis, Cowlitz, and Skamania counties. Such an event is expected to impact 14 counties in Washington, with the most significant effects apparent in Lewis County, followed by Cowlitz, Clark, and Thurston.

Injuries: In general, people are more likely to be injured if the earthquake occurs during or at the end of the business day. The overall number of people injured in this scenario is low. The number will be highest in Lewis County; some injuries are also expected in Clark, Cowlitz, and Thurston counties. Although most of these injuries will not be life-threatening, a few will require hospitalization.

Damage: The highest number of damaged buildings will be in Lewis County (over 4,000), followed by Thurston, Clark, and Cowlitz counties (about 1,800 buildings each). Most of this damage will be slight to moderate, but extensive damage is also expected, particularly in Lewis County, which accounts for 108 of the buildings in this category. While most of the damaged buildings will be residential, buildings of all types and occupancy classes (including commercial and industrial structures) are represented in the damage totals. Unreinforced masonry buildings are especially vulnerable.

Economic Losses Due to Damage: Capital stock losses are the direct economic losses associated with damage to buildings, including the cost of structural and non-structural damage, damage to contents, and loss of inventory. Lewis County accounts for the largest portion of the capital stock loss estimate (over $39.6 million), but for two other counties, the loss estimate is nearly as high: Clark (over $36.5 million) and Cowlitz (about $28.5 million).

ST. HELENS SCENARIO EARTHQUAKE	
End-to-end length of fault (kilometers)	51
Magnitude (M) of scenario earthquake	7.0
Number of counties impacted	14
Total injuries (*severity 1, 2, 3, 4) at 2:00 PM	25
Total number of buildings extensively damaged	119
Income losses in millions	$19
Displaced households	10
Capital stock losses in millions	$162
Debris total in millions of tons	0.03
Truckloads of debris (25 tons per truckload)	1,120

Table 1. Summary of significant losses in the M7.0 St. Helens earthquake scenario. The counties most likely to be affected are Clark, Cowlitz, Lewis, Pacific, Skamania, Thurston, and Wahkiakum.

***Injury severity levels: 1—requires medical attention, but not hospitalization; 2—not life-threatening, but does require hospitalization; 3—hospitalization required; may be life-threatening if not treated promptly; 4—victims are killed by the earthquake**

Income losses, including wage losses and loss of rental income due to damaged buildings, are also highest in Lewis County (nearly $8.5 million) and Cowlitz County (over $4 million).

Impact on Households and Schools: In this scenario, Lewis, Cowlitz, and Clark counties account for all of the displaced households and individuals in need of shelter. Overall, the functionality of schools is not expected to be significantly affected by the earthquake, with the possible exception of schools in Lewis County.

Debris Removal: Following an earthquake, debris consisting of brick, wood, concrete, and steel will have to be removed and disposed of. Much of this will come from Lewis and Cowlitz counties (about 18,000 tons).

Estimates vs. Actual Damage: Although this M7.0 earthquake scenario was modeled using the best scientific information available, it represents a simplified version of expected ground motions. The damage resulting from an actual earthquake of similar magnitude is likely to be even more variable and will depend on the specific characteristics and environment of each affected structure.

Other Tools: Community planners can also look at how a large earthquake may impact local resources and people's lives and livelihoods. The following graphs illustrate variations in such impacts: The first shows the levels of shaking that residents are likely to experience; the second shows the possible impact on different services and business sectors. Note that in Pierce County, a greater number of residents will be exposed to less severe shaking, whereas Lewis County, although less populated, will experience more intense ground motions.

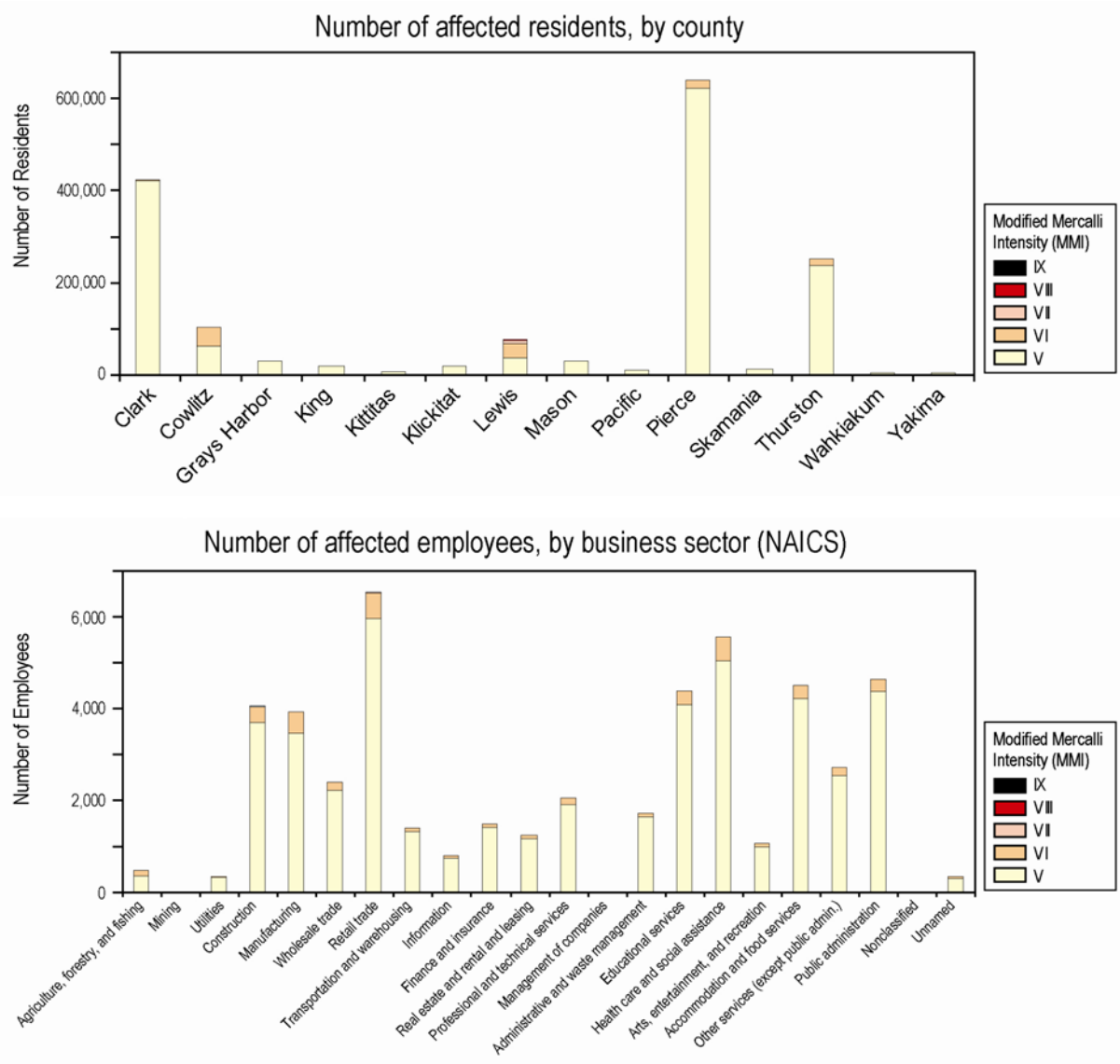

Figure 3. Number of residents and employees affected by the M7.0 earthquake on the St. Helens seismic zone. The Modified Mercalli Intensity (MMI) classes indicate peak ground acceleration (PGA) values and the impact of the shaking.

V. Rather Strong (PGA 3.9–9.2 *g*)	Felt outside by most. Dishes and windows may break. Large bells ring. Vibrations like large train passing close to house.
VI. Strong (PGA 9.2–18 *g*)	Felt by all; people walk unsteadily. Many frightened and run outdoors. Windows, dishes, glassware broken. Books fall off shelves. Some heavy furniture moved or overturned. Cases of fallen plaster. Damage slight.
VII. Very Strong (PGA 18–34 *g*)	Difficult to stand. Furniture broken. Damage negligible in buildings of good design & construction; slight-moderate in other well-built structures; considerable in poorly built/badly designed structures. Some chimneys broken.
VIII. Destructive (PGA 34–65 *g*)	Damage slight in specially designed structures; considerable in ordinary substantial buildings (partial collapse); great in poorly built structures. Fall of chimneys, factory stacks, columns, walls. Heavy furniture moved.
IX. Violent (PGA 65–124 *g*)	General panic; damage considerable in specially designed structures; well designed frame structures thrown out of plumb. Damage great in substantial buildings: partial collapse. Buildings shifted off foundations.