Earthquake Threats to Resiliency Hazards in Washington

by

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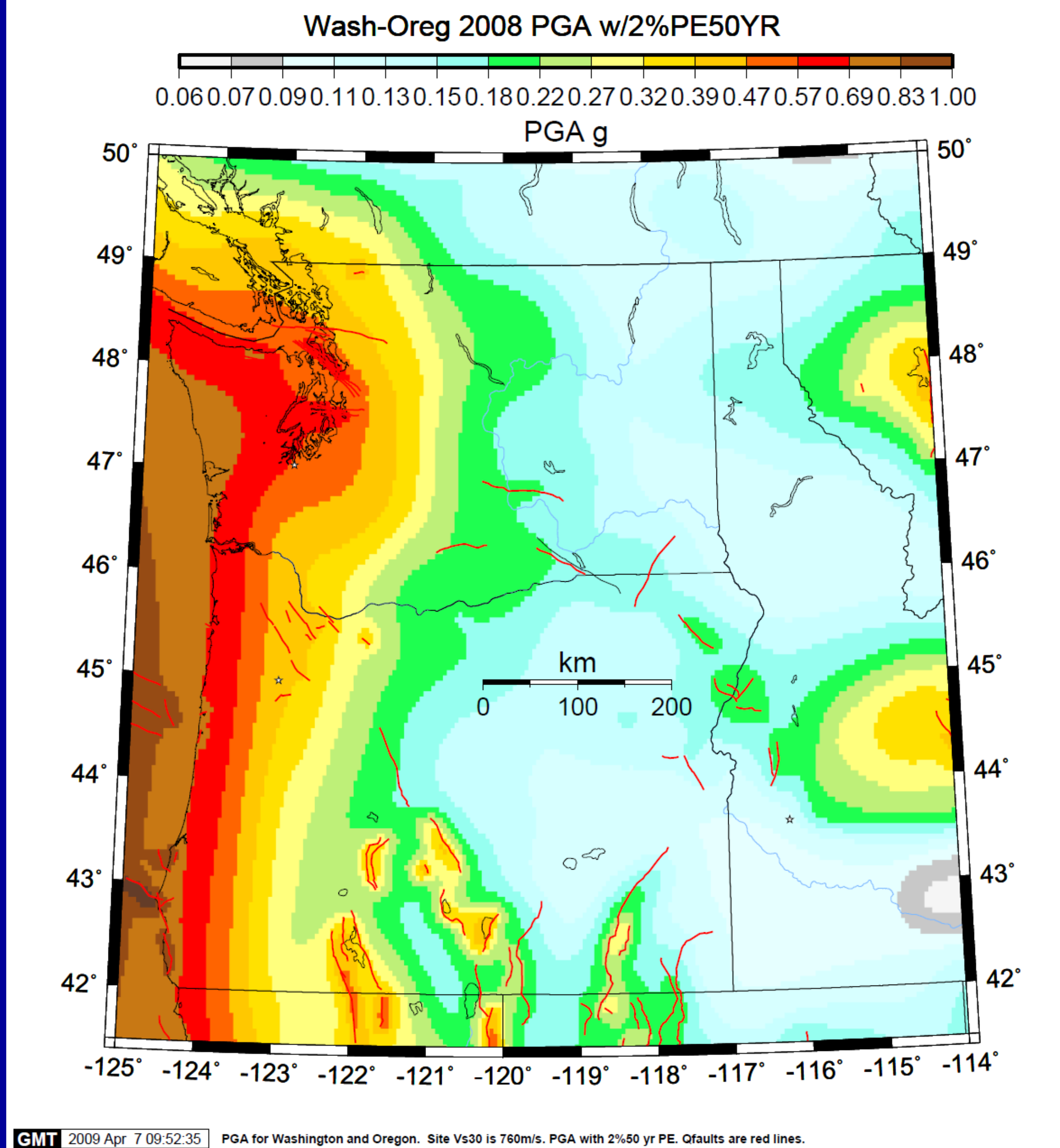
Recent research has demonstrated that seismic hazards in Washington are larger and more widespread than was known thirty years ago. This map illustrates the current understanding of the potential for strong ground shaking in the northwest, but new research is continuing to reveal previously unrecognized earthquake sources. Only a few will be discussed as threats to the resiliency of the state but there are others as well.



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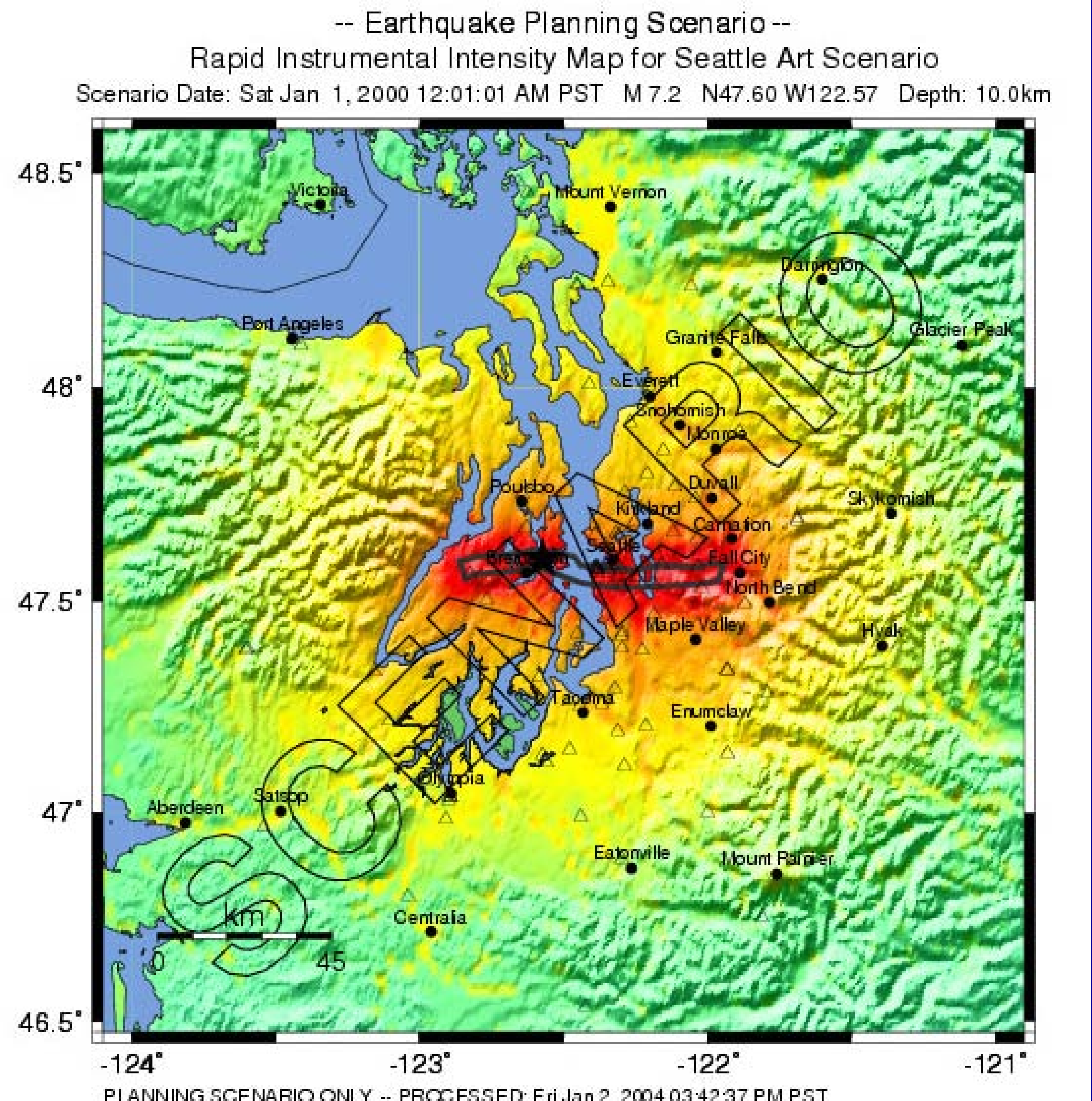
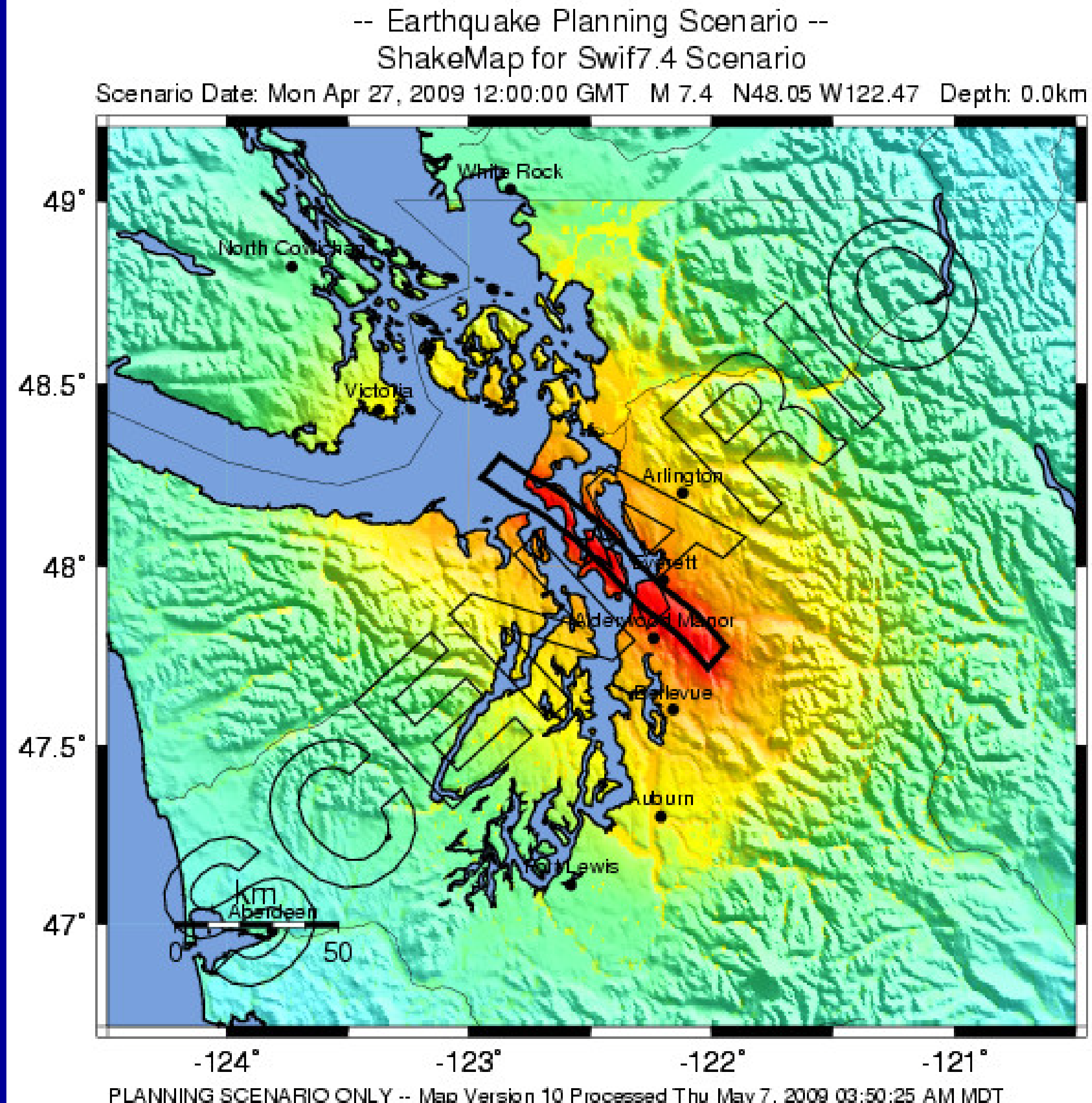
An earthquake on the Seattle fault could generate ground shaking levels comparable to or greater than the recent earthquakes in Haiti and New Zealand. And while the largest shaking intensities would be limited to western Washington, the economic disruption caused by damage to port facilities could affect not just all of Washington but Alaska as well.



Recent work on the southern Whidbey Island fault has demonstrated that it is capable of large (~M7.4) earthquakes, but that it may be considerably more extensive than shown here. Damage from this scenario would not only be severe in northern Puget Sound but on Vancouver Island as well.



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

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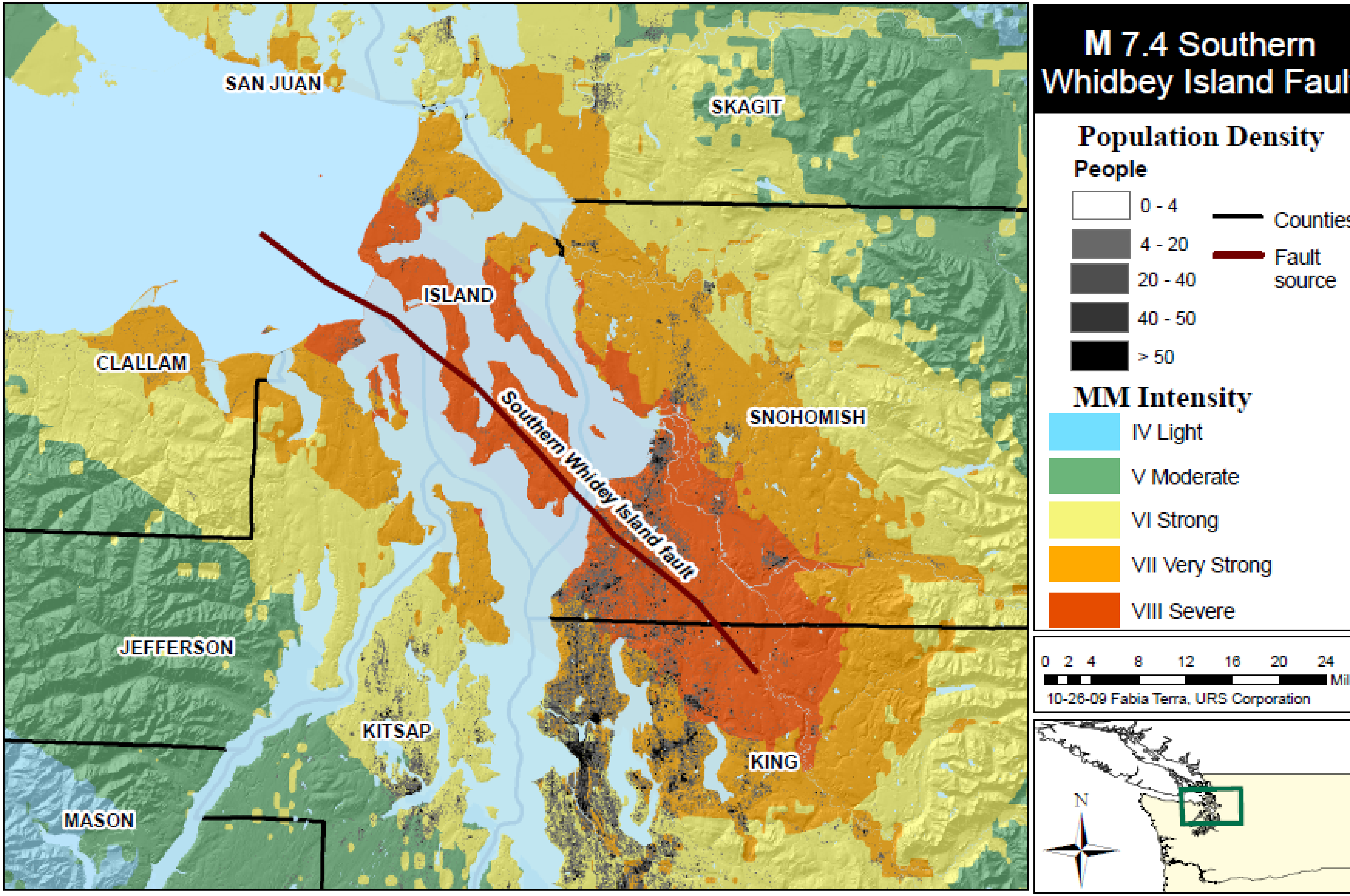
Population Density and Ground Shaking Intensities - Earthquake Scenario: Washington



Sources: 2009 HAZUS runs by URS Corporation, MMI Map USGS 2009
Projection: NAD83 Harn State Plane Washington 4602 (feet)

Figure 1

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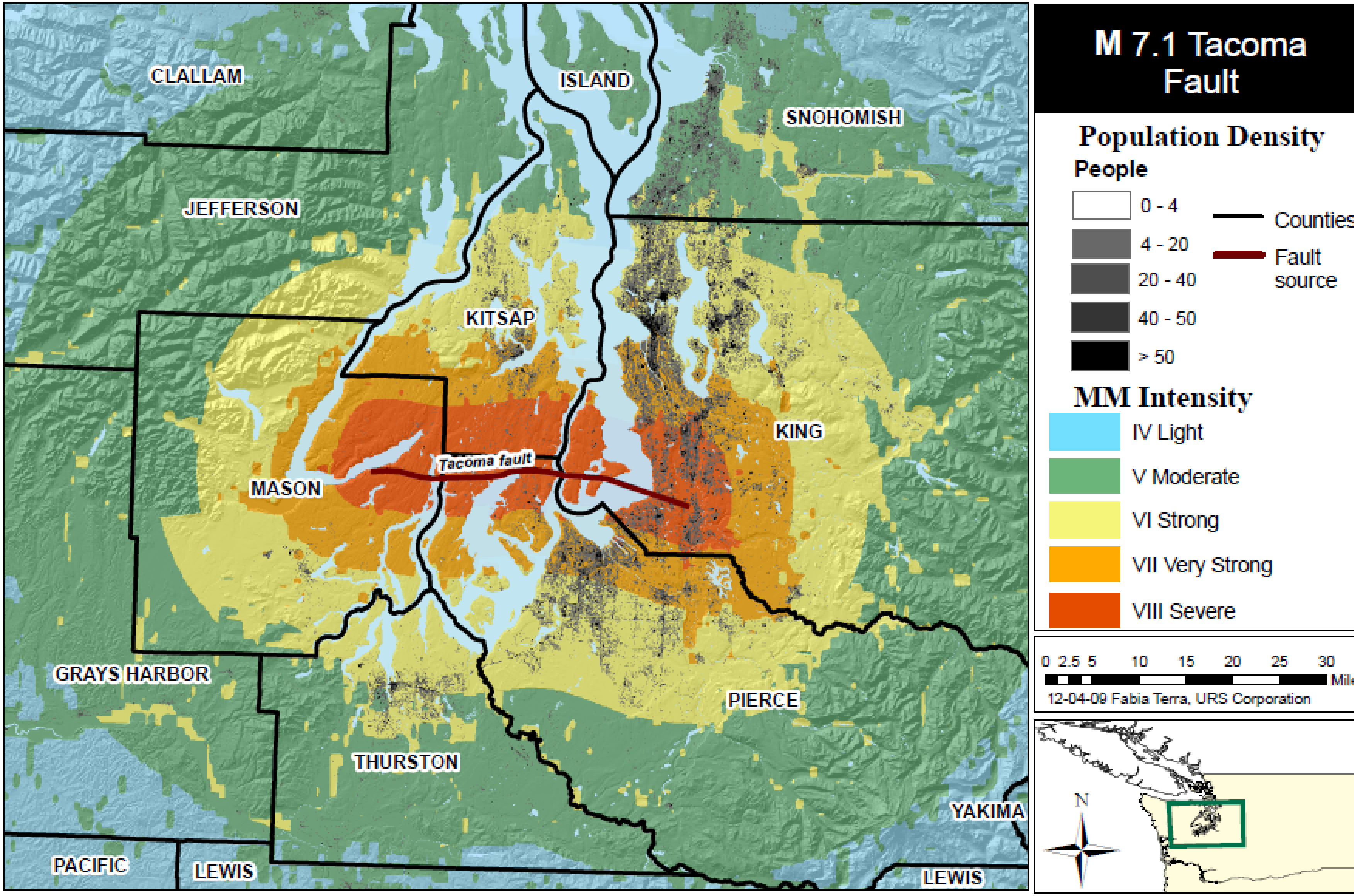

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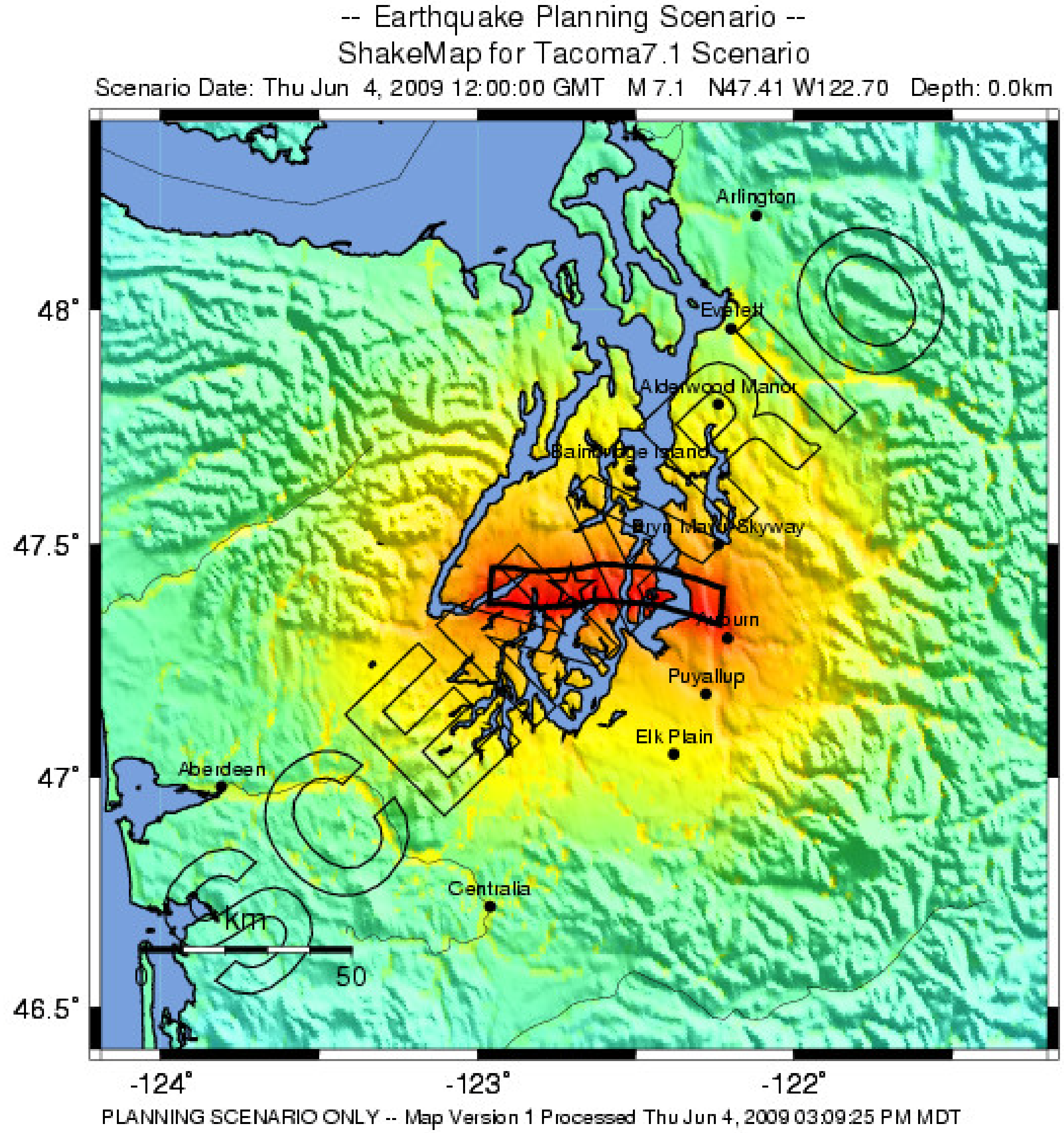
Figure 1

The Tacoma fault has been shown to be active as well and probably capable of ~M7 earthquakes which would cause severe damage in southern Puget Sound.



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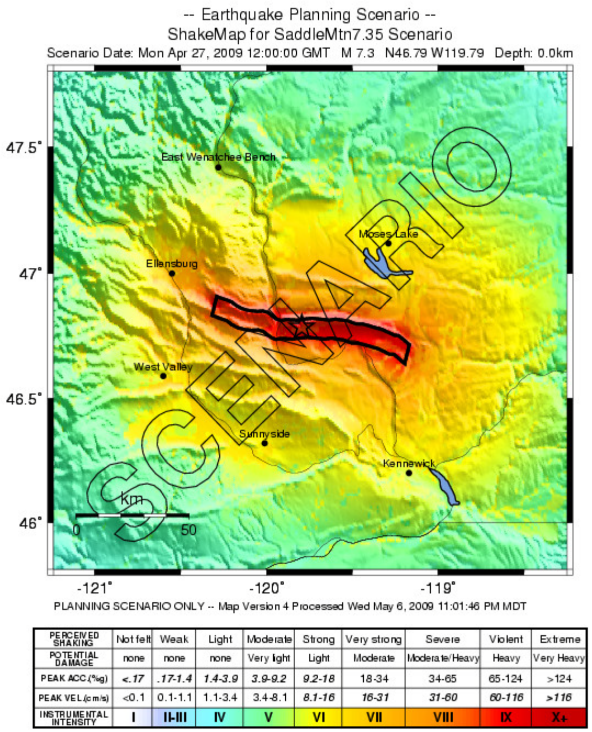

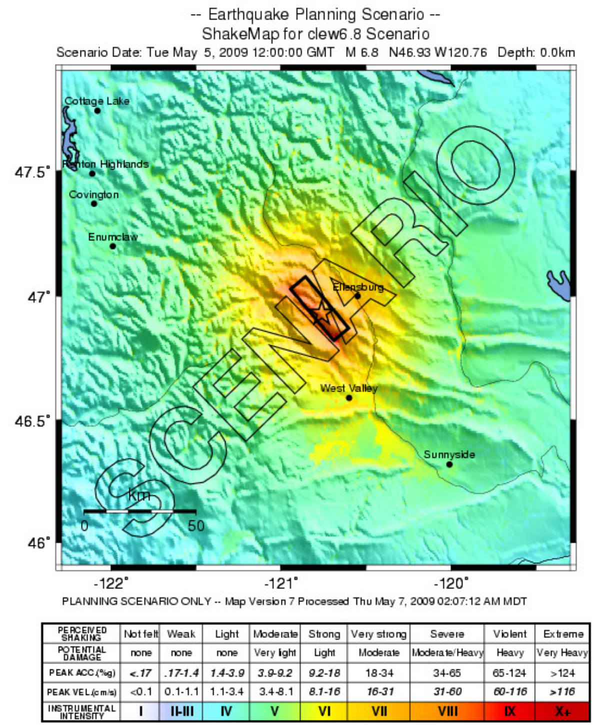

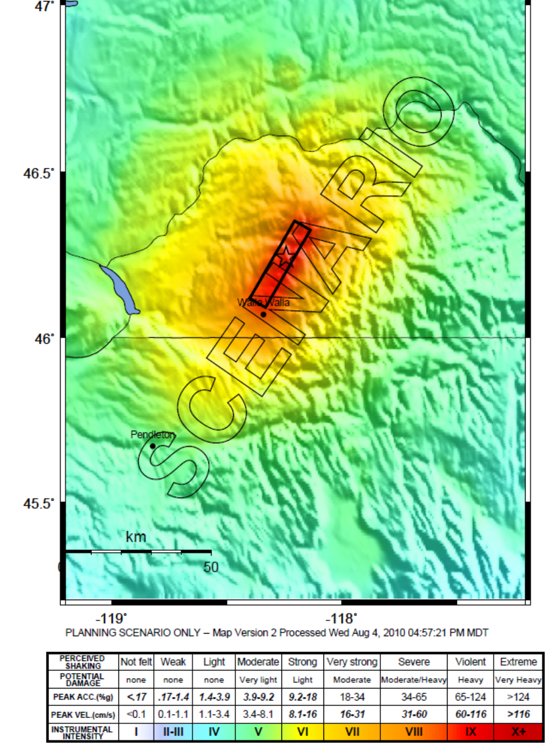

Eastern Washington has significant, though not huge, sources that could severely disrupt traffic and electrical transmission on the Columbia River.

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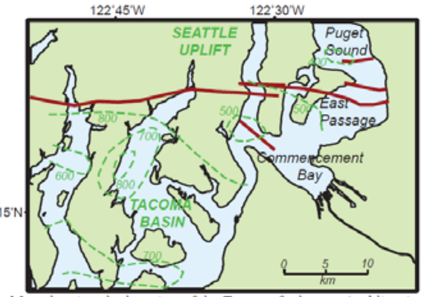
A MAGNITUDE 7.1 EARTHQUAKE SCENARIO FOR THE TACOMA FAULT ZONE, PIERCE COUNTY, WASHINGTON

Characterizing the Tacoma Fault

Linear features identified in geological and geophysical data run west-northwest across the south-central Puget Lowland from the Tacoma region to Hood Canal. Local and regional experts likely have identified most of the strands of theTacoma fault (shown in the map below), although the eastern extent of the fault zone remains uncertain. Some researchers suggest that the Tacoma fault is connected to the Seattle fault at depth and that the total amount it has moved over time increases westward. A large earthquake (M~7) occurred on the Tacoma fault about 1100 years ago, evidenced by changes in elevation coastal marshes surrounding the fault.



Map showing the location of the Tacoma fault zone (red lines). The zone consists of a strand cutting across Puget Sound, and strands cutting through Commencement Bay and the East Passage. The basin structure of the subsurface is shown by the depth of the sediments (green contours); these sediments may amplify ground shaking.

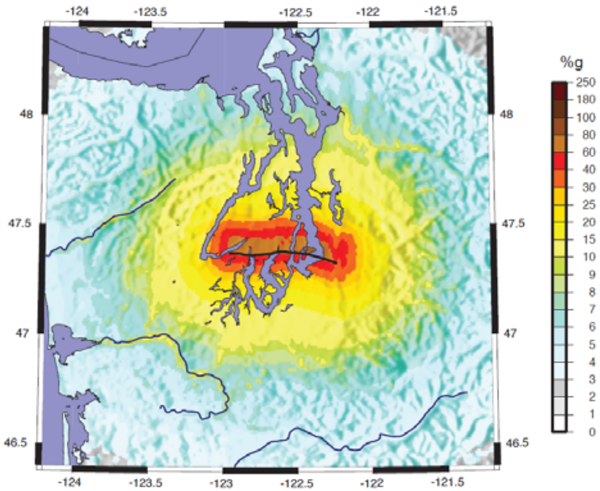
Scenario Earthquake

A 'scenario' displays the ground motion amplitudes expected for a hypothetical earthquake (see the ShakeMap below). These are derived using computer models with inputs from geological and geophysical observations specific to the region and fault of interest. This scenario shows the shaking expected for a M7.1 earthquake on the Tacoma fault zone . The fault break extends along 56 km (~35 miles) of the fault between Belfair, runs through Vashon Island, and ends near Federal Way (black line on ShakeMap). While this scenario is based on the best information available, it still represents a simplified and highly smoothed version of the true ground motion. Even more important to note is that the damage resulting from these motions is likely to be even more variable, depending on the specific characteristics of each affected structure.

Ground Motions

Most of the hazards associated with earthquakes result from the shaking, or ground motions, caused by seismic waves that radiate out from the fault as it breaks. Seismic waves transmit the energy released by the earthquake, so bigger earthquakes generate larger and longer-lasting waves. The dimension and orientation of the fault and characteristics of the rapid slippage that occurs during the earthquake affect the pattern of shaking. In addition, the materials the waves travel through affect their strength and duration.

Earthquake ground motions typically are measured in units of acceleration (expressed as the percentage of gravity, or % of 'g'). This unit is used because it is proportional to force, which is what engineers need to know to estimate the likely impact of earthquake ground motions on buildings and other structures. Accelerations can also be qualitatively related to the effects of the shaking. For example, light damage might be expected for motions in the range 9-18 %g, and 34-65 %g motions would likely cause heavy damage It is important to remember that ground motions alone do not determine their impact, and the type and quality of construction of the structures shaken also are key.



ShakeMap showing hypothetical horizontal ground motions for the M7.1 scenario event. Strongest shaking occurs in a band close to the fault (warm colors) and in low lying areas filled with sediments that amplify the ground motions.

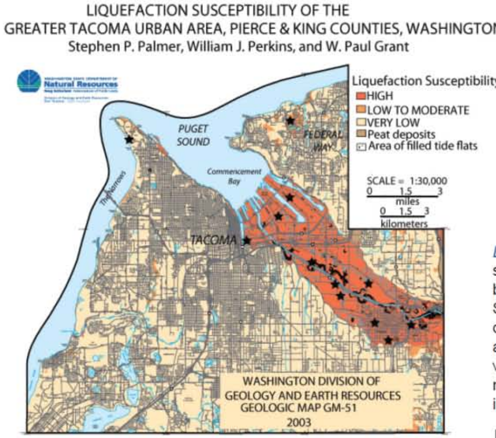
Other Earthquake Effects

Tsunamis - Geologic and historic evidence show that landslides and delta failures generated tsunamis within Puget Sound. We anticipate that a M7.1 earthquake on the Tacoma fault that breaks the surface could offset the floor of Puget Sound and generate a tsunami. Furthermore, delta failures & landslides caused by the shaking will likely create or exacerbate tsunamis.

Computer simulations of tsunamigenic earthquakes show that most of the low lying areas in the Puyallup River delta will be subject to tsunami inundation. The maximum tsunami inundation for a simulated Tacoma fault earthquake shows runup reaching about 4 meters (see map on right) . Initial flooding in the Tacoma area occurs ~5 minutes after the earthquake.

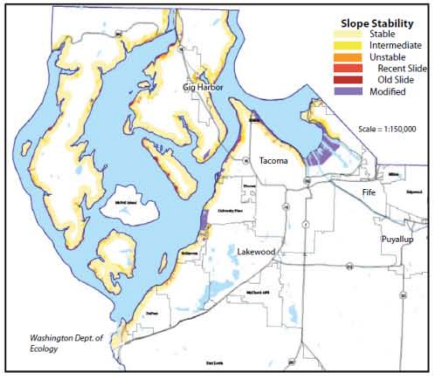
Photo from the National Agriculture Imagery Program (NAI

Liquefaction - Severe shaking during an earthquake can cause a soil to loose strength. In saturated soils, groundwater fills the pores between sand grains, and the weight of overlying soil and structures is supported by grain-to-grain contacts. Strong shaking during an earthquake can disrupt the grain-to-grain contacts and cause the soil to loose strength. Once this happens, the pressure of the pore water increases until sometimes it erupts as sand blows.



Soil in this condition is liquefied and behaves as a fluid. Buildings can sink and topple, or foundations lose strength and cause collapse or severe damage. High liquefaction potential exists for areas covered by artificial fill, peat deposits, tidal flats, and water-deposited sediments (map on left). Some locations are particularly susceptible, such abandoned channels (black swirls) of the Puyallup River and Wapato Creek, and have liquefied repeatedly in past earthquakes (stars). Liquefaction failure from the 1949 earthquake caused 2 fatalities at the Port of Tacoma.

Landslides - Earthquake shaking may cause landsliding on slopes, particularly where the ground is saturated or has been modified (e.g. had stabilizing vegetation removed). Steeper topographic gradients are most susceptible, but old, deep-seated landslides may be re-activated where gradients are as low as 15%. Catastrophic debris flows can move water-saturated materials rapidly & long distances, mostly in mountainous regions. Underwater slides also have occurred in the delta of the Puyallup River.



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This scenario of a major Cascadia subduction zone earthquake shows significant damage everywhere west of the cascades

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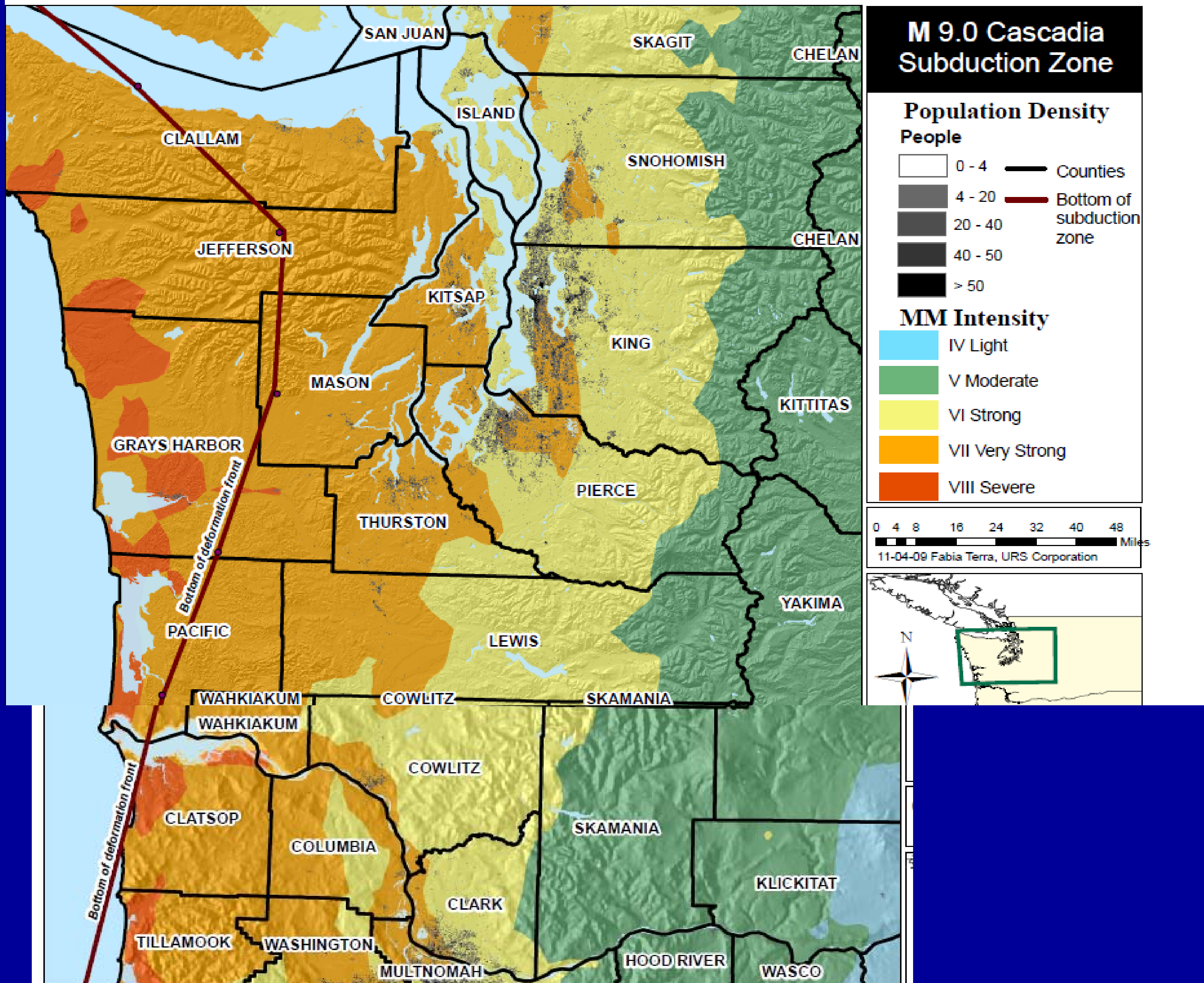
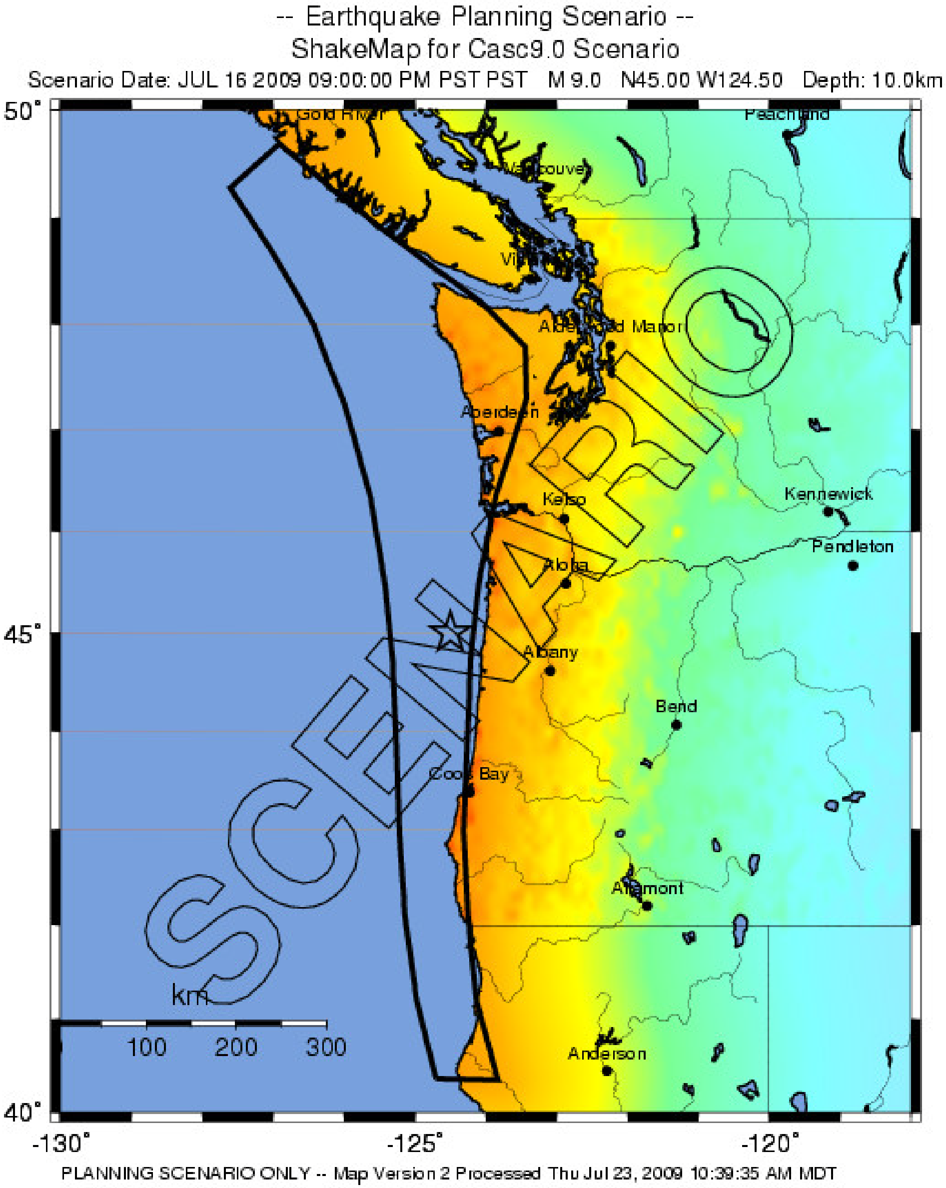


A Cascadia subduction zone earthquake would generate the most widespread damage of any scenario. Although the maximum intensity of shaking would be less than for a large shallow earthquake, such as on the southern Whidbey Island fault, Seattle fault or Tacoma fault, strong ground shaking would be felt from northern California to northern Vancouver Island. In addition it would be accompanied by a tsunami that would be devastating within a few miles of the coast.



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In addition to strong shaking damage to buildings, nonstructural damage and ground failure can result in widespread disruption to utilities, transportation and the economy as a whole, as demonstrated by these pictures of damage from the recent earthquake in New Zealand. .