Earthquake and Liquefaction

Is a Devils Mountain Earthquake really possible?

*It's not a matter of if, but rather **when** it will happen again!*

Hazard Description

An earthquake is the vibration of the earth's surface following a release of energy in the earth's crust. This energy can be generated by a sudden dislocation of the crust or by a volcanic eruption. Its epicenter is the point on the earth's surface directly above the hypocenter of an earthquake. The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth.

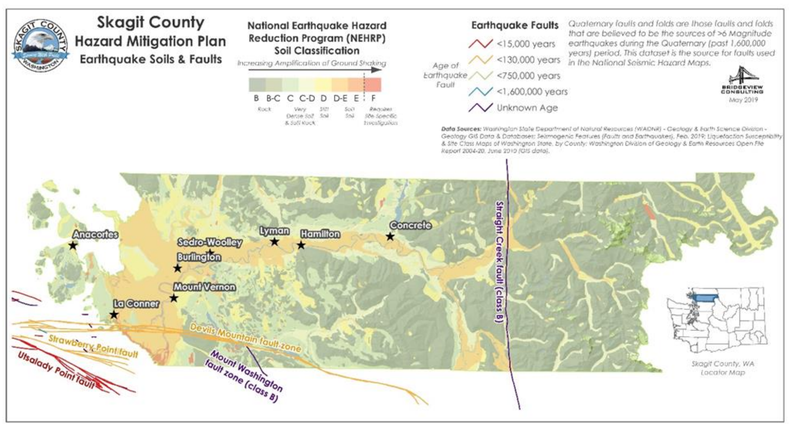
Most destructive quakes are caused by dislocations of the crust. The crust may first bend and then, when the stress exceeds the strength of the rocks, break and snap to a new position. In the process of breaking, vibrations called "seismic waves" are generated. These waves travel outward from the source of the earthquake at varying speeds.

Earthquakes tend to reoccur along faults, which are zones of weakness in the crust. Even if a fault zone has recently experienced an earthquake, there is no guarantee that all the stress has been relieved. Another earthquake could occur. Faults are more likely to have earthquakes on them if they have more rapid rates of movement, have had recent earthquakes along them, experience greater total displacements, and are aligned so that movement can relieve accumulating tectonic stresses.

There are a number of faults running near or through Skagit County - the Bellingham Bay—Lake Chaplain Fault, the Ross Lake Fault and the Hamilton Fault, which may or may not be active (Skagit County HMP, 2015), and the Devils Mountain Fault.

A direct relationship exists between a fault's length and location and its ability to generate damaging ground motion at a given site.

The map below illustrates the active earthquake faults in the area, as well as the various types of soils which can be found throughout the county.



Three source zones exist for Pacific Northwest quakes: a shallow (crustal) zone; the Cascadia Subduction Zone; and a deep, intraplate "Benioff" zone. More than 90% of Pacific Northwest earthquakes occur along the boundary between the Juan de Fuca plate and the North American plate. See graphic below.

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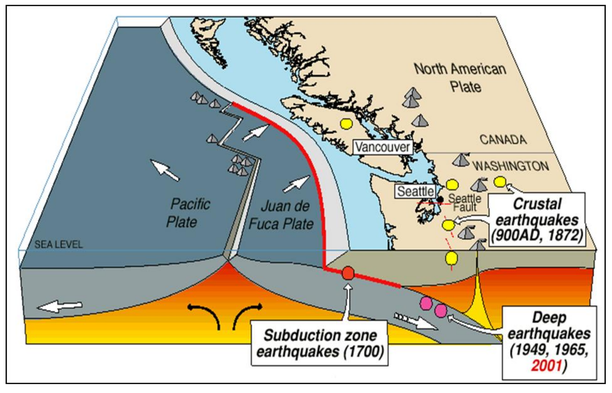


Devils Mountain

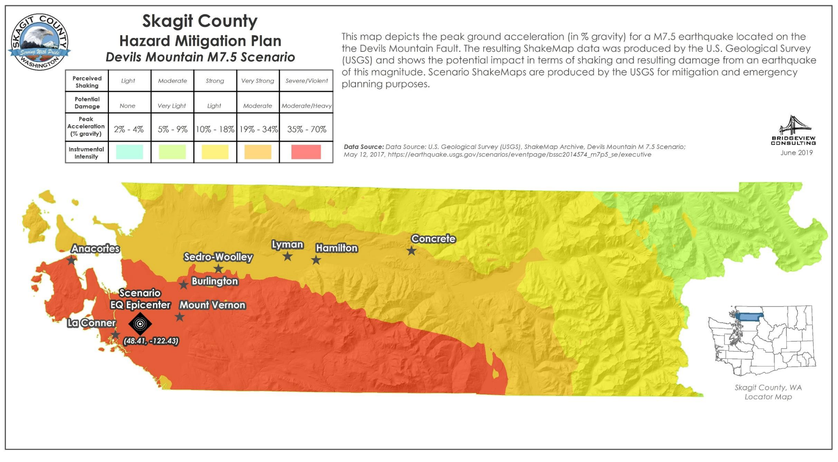
One of the most notable faults in Skagit County is the Devils Mountain Fault. Lying near Mt. Vernon, it is roughly 78 miles long, runs east to west through Darrington in Snohomish County to Vancouver Island, Canada. It is an active fault, with at least one earthquake about 2,000 years ago (Personius and others, 2014).

If a magnitude seven (M7) or greater the event were to occur, it would affect 15 counties with Skagit County being the greatest impacted. Any moderate or large earthquake on the fault will likely be followed by numerous felt aftershocks and hundreds to thousands of smaller ones detectable only by sensitive instruments.

Damage levels experienced in an earthquake vary with the intensity of ground shaking and with the seismic capacity of structures. Generalized observations provide qualitative statements about the likely extent of damage for earthquakes with various levels of ground shaking (PGA) at a given site:

- Ground motions of 1% g or 2% g are widely felt; hanging plants and lamps swing strongly; damage levels are low.
- Ground motions below 10% g usually cause slight damage.
- Ground motions between 10% g and 30% g may cause minor to moderate damage in well-designed buildings, with higher levels of damage in more vulnerable buildings. At this level of ground shaking, some poorly built buildings may be subject to collapse.
- Ground motions above about 30% g may cause significant damage in well-designed buildings and very high levels of damage (including collapse) in poorly designed buildings.
- Ground motions above about 50% g may cause significant damage in most buildings, even those designed to resist seismic forces.

What can you expect the ground motion to be like in a Devils Mountain earthquake? The map below identifies the potential intensity based on USGS studies.



Potential Ground Shaking for a Devils Mountain M7.5 Earthquake

Over the course of time, scientists recognized that increased building codes can help reduce the impacts of earthquakes. Higher building codes are now in place throughout all of Washington; however, older buildings are still at greater risk to damage. The older the building, the greater the risk of injury and damage. The table below talks about the history of building codes in the State of Washington. Skagit County has adopted building codes intended to withstand the level of potential impact countywide. See the box to the right for more information!

How often do Earthquakes occur in our area?

Earthquakes occur nearly every day in Washington. Most are too small to be felt. Large earthquakes are less common but can cause significant damage to the things we count on in everyday life, such as buildings, roads, bridges, dams, and utilities. Washington has the second highest risk in the U.S. to large and damaging earthquakes because of its geologic setting. The table below identifies significant earthquakes of M5.0 or greater occurring in the planning region.

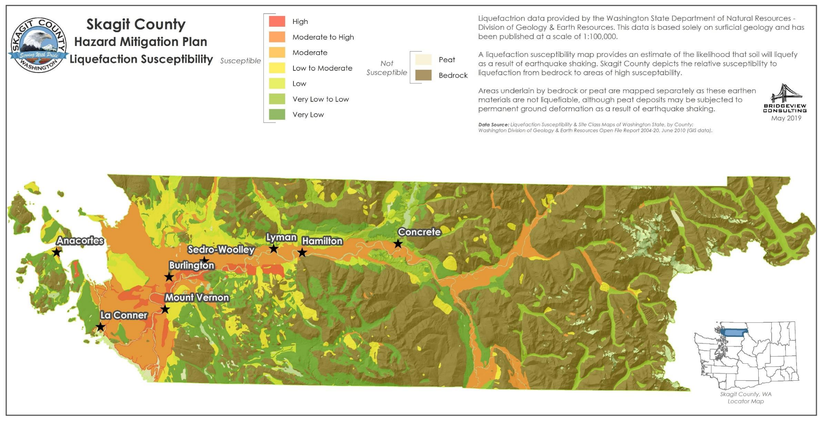
Historical Earthquakes in the Planning Area

Year	Magnitude	Epicenter	Type
8/26/2004	3.5	Unknown*	Shallow Crustal
2/28/2001 (DR 1361)	6.8	Olympia (Nisqually)	Benioff
6/10/2001	5.0	Matlock	Benioff
7/3/1999	5.8	8.0 km N of Satsop	Benioff
8/1997	3.4	Unknown*	Unknown
6/23/1997	4.7	Bremerton	Shallow Crustal
5/3/1996	5.5	Duvall	Shallow Crustal
1/29/1995	5.1	Seattle-Tacoma	Shallow Crustal
10/25/1991	3.4	Unknown*	Unknown
4/14/1990	5.0	Deming Area	Crustal
8/23/1982	3.6	Unknown*	Unknown
2/14/1981	5.5	Mt. St. Helens (Ash)	Crustal
9/9/76	4.5	Union	Benioff Zone (28 miles deep)
12/13/1971	3.6	Unknown*	Unknown
5/11/1965 (DR 196)	6.6	18.3 KM N of Tacoma	Benioff
4/29/1965	6.5	12 miles North of Tacoma	Benioff
4/13/1949	7.1	Olympia*	Unknown
1/13/1949	7.0	12.3 KM ENE of Olympia	Benioff
6/23/1946	7.3	Strait of Georgia	Benioff
2/14/1946	6.3	Puget Sound	Benioff
4/29/1945	5.7	Northbend (8 miles south/southeast)	Unknown
11/13/1939	5.8	Puget Sound – Near Vashon Island	Unknown
5/15/1936	5.7	Southwest Washington	Crustal
7/17/1932	5.3	Central Cascades	Unknown
1/23/1920	5.5	Puget Sound	Unknown
12/6/1918	7.0	Vancouver Island	Unknown
8/18/1915	5.6	North Cascades	Unknown
1/11/1909	6.0	Puget Sound (Grays Harbor Earthquake)	Unknown
3/6/1904		Washington coastline and Olympic Mountains	Unknown
11/30/1891		Slight earthquake felt in County*	Unknown
3/27/1884		Hoquiam*	Unknown
4/30/1882	5.8	Olympia area	Unknown
12/12/1880		2 shocks felt*	Unknown
12/15/1872	6.8	Pacific Coast	Unknown

*Earthquake Events identified in 2011; no further data available.
Source: Pacific Northwest Seismic Network

What causes Earthquake Damage?

Earthquakes cause damage by moving and shaking the ground, sometimes for several minutes. The shaking can damage or destroy buildings. Most damage and loss of life is a result of ground shaking. The shaking can cause landslides, ground cracks, liquefaction, and tsunamis. The combination of all of these is what makes earthquakes such a powerful hazard. Even when an earthquake happens on a fault that doesn't reach the surface, the ground still shows signs of cracking. This cracking happens because a soft part of the ground liquefies during shaking, a process called liquefaction. Liquefaction is when wet soil loses strength because it is being shaken during an earthquake. The material becomes so weak that it behaves more like a liquid than a solid. Liquefaction has caused significant damage during earthquakes in Washington. The map below shows the type of soil in Skagit County. The softer, or more liquefiable the soil, the greater the damage.



Timeline of Building Code Standards

Time Period	Code Significance for Identified Time Period
Pre-1974	No standardized earthquake requirements in building codes. Washington State law did not require the issuance of any building permits, or require actual building officials
1975-2003	UBC seismic construction standards were adopted in Washington.
1994-2003	Seismic Risk Zone 3 was established within the Uniform Building Code in 1994, requiring higher standards.
2004-Present	Washington State upgrades its building codes to follow the International Building Code Standard. As upgrades occur, the State continues to adopt said standards.