Section 4: EARTHQUAKE

RATINGS	
Probability	HIGH
Vulnerability	MEDIUM
Risk	HIGH

HAZARD OVERVIEW

An earthquake is a sudden release of stored energy generally caused by a sudden slip on a fault. Stresses in the earth's outer layer push the sides of the fault together. Stress builds up and the rock slips suddenly, releasing energy in waves that travel through the earth's crust and cause the shaking that we feel during an earthquake. A fault is a fracture or zone of fractures between two blocks of rock. Faults allow the blocks to move relative to each other. This movement may occur rapidly, in the form of an earthquake - or may occur slowly, in the form of creep. Most faults produce repeated displacements over geologic time. [**1**]

Earthquake magnitude is a logarithmic measure of its size. [**1**] Minor earthquakes occur frequently, but larger magnitude earthquakes, which can cause significant damage, do not. Seismic monitors exist throughout the region to alarm us when an earthquake is occurring and measure the magnitude of the earthquake. Unfortunately, it is not possible to predict when an earthquake might strike Walla Walla County. We are not able to predict when a larger earthquake might occur, but we do know that there is a high probability that one will hit Walla Walla County.

The effects from earthquakes are caused by ground shaking, surface faulting and ground failure.

A geological system called the Olympic-Wallowa Lineament (OWL) stretches from the Olympic Mountains to the Wallowa Mountains through Walla Walla County. The OWL is a series of geological features that indicate a history of earthquake action.

Two fault systems are located in Walla Walla County. The Hite Fault System is located along the foothills of the Blue Mountains stretching generally north and south. The Wallula Fault Zone stretches from the Wallula Gap on the Columbia River toward Touchet. A map showing the location of these faults is included in Appendix A.

LANDSLIDES

Only a small portion of Walla Walla County is likely to experience landslides. The Washington State Department of Natural Resources (WADNR) has stated that landslides are generally confined to areas with slopes that exceed 40% [**8**]. This means that the primary landslide hazard areas are limited to the southeastern part of the County in the foothills of the Blue Mountains. Landslide hazards were assessed through the County's critical areas ordinance update in 2008. The Best Available Science document states the following regarding landslide hazards within Walla Walla County:

*"Based on S&W work experience in the area, the high concentration of landslides at the northwest edge of the Blue Mountains generally consisted of shallow, surficial slumps of fine-grained, virtually saturated, loess materials immediately underlain by sloping bedrock conditions. We believe landslides of this frequency pose a very low hazard due to their relatively small size and the extreme event required to trigger such occurrences. Based on the information above, we consider the potential for damaging landslides to be low and generally contained to a relatively small region of the County." [**8**]*

Experience has shown that several types of landslides take place in conjunction with earthquakes, confirming the above statements. The most abundant types of earthquake-induced landslides are rock falls and slides of rock fragments that form on steep slopes. Shallow debris slides forming on steep slopes and soil and rock slumps and block slides forming on moderate to steep slopes also take place, but they are less abundant. Significant landslides are most likely to occur during a significant earthquake event which is why landslide hazards have not been addressed separately in the HIVA.

HISTORY AND PROBABILITY OF OCCURRENCE

A summary of historical earthquake events and information on probability is included below. The following table provides background on intensity and potential damage levels for different earthquakes using both the Richter Scale and the Modified Mercalli Scale.

TABLE 3: SUMMARY OF EARTHQUAKE SCALES AND LEVELS AND DAMAGE [1]

Modified Mercalli Scale		Level of Damage	Richter Scale
1 – 4	Instrumental to Moderate	No damage.	≤ 4.3
5	Rather Strong	Damage negligible. Small unstable objects displaced or upset; some dishes and glassware broken.	4.4 – 4.8
6	Strong	Damage slight. Windows, dishes, glassware broken. Furniture moved or overturned. Weak plaster and masonry cracked.	4.9 – 5.4
7	Very Strong	Damage slight-moderate in well-built structures; considerable in poorly-built structures. Furniture and weak chimneys broken. Masonry damaged. Loose bricks tiles, plaster, and stones will fall.	5.5 – 6.1
8	Destructive	Structure damage considerable, particularly to poorly-built structures. Chimneys, monuments, towers, elevated tanks may fail. Frame houses moved. Trees damaged. Cracks in wet ground and steep slopes.	6.2 – 6.5
9	Ruinous	Structural damage severe; some will collapse. General damage to foundations. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground; liquefaction.	6.6 – 6.9

Modified Mercalli Scale		Level of Damage	Richter Scale
10	Disastrous	Most masonry and frame structures/foundations destroyed. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Sand and mud shifting on beaches and flat land.	7.0 – 7.3
11	Very Disastrous	Few or no masonry structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Rails bent. Widespread earth slumps and landslides.	7.4 – 8.1
12	Catastrophic	Damage nearly total. Large rock masses displaced. Lines of sight and level distorted.	8.1

History has recorded earthquakes that would be considered "strong," "very strong" and "destructive on the Modified Mercalli scale which implies intensity up to 6.5 magnitudes on the Richter Scale. Since those earthquakes recorded in Walla Walla County are generally shallow earthquakes, significant damage should be expected. Two earthquakes were felt in Walla Walla County in November 1991 and July 1992. They were centered about five miles south of Walla Walla and measured 4.3 and 4.1 on the Richter scale. A map showing the full history of earthquakes impacting Walla Walla County is included in Appendix A.

> *"It is not a question of if; it is question of when a 6.5 magnitude earthquake strikes Walla Walla County."*
>
> *John Winter, Ph.D.*
> *Professor of Geology*
> *Whitman College*

The largest recorded earthquake in the State of Washington occurred in Eastern Washington near Lake Chelan December 15, 1872. It was estimated at a magnitude 7.0. This earthquake was felt from British Columbia, Canada, to Oregon and from the Pacific Ocean to Montana. It occurred in a wilderness area, which in 1872 had only a few inhabitants - local Indian tribes, trappers, traders, and military men. Because there were few man-made structures in the epicenter area near Lake Chelan, most of the information available is about ground effects, including huge landslides, massive fissures in the ground, and a 9-meter-high geyser. Extensive landslides occurred in the slide-prone areas of the Columbia River. One massive slide, at Ribbon Cliff (between Entiat and Winesap), blocked the Columbia River for several hours. A field reconnaissance to the Ribbon Cliff landslide area in August 1976 showed remnants of a large landslide mass along the west edge of Lake Entiat (Columbia River Reservoir), below Ribbon Cliffs and about 3 kilometers north of Entiat. Although the most spectacular landslides occurred in the Chelan-Wenatchee area, land sliding was reported throughout the Cascades. [**13**]

Another significant earthquake occurred west of Walla Walla in 1882. Its intensity is not known, but it has been estimated to have been about magnitude 6.

THE 1936 MILTON-FREEWATER EARTHQUAKE

*The last major earthquake affecting Walla Walla County occurred in 1936 and was centered near Milton-Freewater. The following excerpt from Washington State Earthquake Hazards provides a summary of the damage that resulted from this event. [**14**]*

> *"At 11:05 P.M., July 15, 1936, the region around Walla Walla was so shaken by an earthquake that many persons left their beds for the outdoors in haste and perturbation. The writer's house at the northern city limits of Walla Walla shook, rattled, rumbled, groaned and squeaked, but suffered no permanent damage. Many chimneys were broken, several houses were moved on their foundations, stacks of boxed and canned goods and shelf wares were scattered over floors with some damage."*
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> "The Milton Freewater earthquake was the most destructive earthquake of the eastern Washington-Oregon border region since the late 1800s (Shannon and Wilson, Inc., 1975). Its intensity was greatest at Milton Freewater, State Line and Umapine in Oregon. Moderate damage occurred in Athena and Milton. Windows broke, walls cracked, chimneys collapsed, a two-story concrete house near Umapine lost part of its second story, and some standing railroad cars near Milton were derailed. Two schools in Umapine were damaged. Water issued from cracks as much as 60 meters long. Numerous aftershocks were reported until November 1936. This earthquake was felt widely in parts of Idaho

This earthquake was estimated to have been a magnitude of 6.1 on the Richter scale.

Minor earthquakes occur frequently in and near Walla Walla County. Although many are not felt, the historical occurrence indicated that the area is an active earthquake zone. The Earthquake History Map in Appendix A shows the location and strength of measured earthquakes from 1970 to 2010. Many of these were not of sufficient magnitude to cause damage, but they do indicate that we are in an active geologic area, which is prone to earthquakes.

There is a HIGH likelihood that a "strong" earthquake will occur within the next 25 years in Walla Walla County.

VULNERABILITY

The Washington State Hazard Mitigation Plan used two criteria to assess vulnerability and identify counties most at risk within the state [**1**]:

1. The Annualized Earthquake Loss, as calculated by the HAZIS-MH software, of at least $1 million; or
2. The Annualized Earthquake Loss Ratio, as calculated by the HAZUS-MH software, of greater than or equal to the State's ratio of 0.05.

Walla Walla County is not one of the 22 counties that met either of these criterions because it lacks building stock like many other Eastern Washington counties, but the County was added to the list by

recommendation of seismologist and federal and state geologists because of our significant seismic risk [**1**].

According to Dr. Kevin Pogue, a geologist with Whitman College, "a magnitude 6.0 or greater earthquake on [the Wallula] fault zone would cause widespread minor to moderate damage in the Walla Walla area especially to older unreinforced masonry buildings and structures built on soft sediment or in areas prone to liquefaction. Damage in Walla Walla from a magnitude 6.0 earthquake on the Wallula fault zone would likely be as severe as the damage in Seattle caused by the recent 6.8 event."

LIQUEFACTION SUSCEPTIBILITY

Liquefaction occurs when soil becomes soft and liquid-like during very strong ground shaking. Wet or low-lying areas are susceptible to liquefaction. As a result, the soil may be unable to fully support structures on the surface. What we feel as ground shaking during an earthquake is really waves of energy passing through the ground. These waves are much like the waves that radiate outward from a stone thrown into a pool of water.

If liquefaction-susceptible soil is water saturated, strong earthquake shaking causes the water pressure in the soil to increase as the waves of energy pass. If the ground shakes long enough, the water pressure may increase until it equals the weight of the overlying soil. When this occurs, soil and water mix and the soil floats. The shockwaves passing through the soil are not attenuated by the soil and the likelihood of damage to structures increases.

Areas which are rated as moderate to high liquefaction susceptibility are considered geologically hazardous areas [**8**]. Most new construction in these areas requires additional review and design under the County's critical areas regulations. This is consistent with the State Growth Management Act (GMA) and recommendations of the Washington State Department of Natural Resources (WADNR) who generated the liquefaction susceptibility maps and data we use to assess liquefaction potential [**15**]. To estimate your susceptibility to liquefaction, refer to the Liquefaction Susceptibility Map in Appendix A.

HAZUS LOSS ESTIMATE

HAZUS-MH, a GIS software program developed by FEMA and the National Institute of Building Sciences to estimate potential losses due to earthquakes, was utilized during the 2010 HIVA update. Conversations with Kevin Pogue, a geologist with Whitman College, lead the County to run an earthquake scenario similar to the 1936 Milton-Freewater earthquake. Parameters were set as follows:

- Type of Earthquake: Arbitrary
- Longitude of Epicenter: -118.39
- Latitude of Epicenter: 46.00
- Earthquake Magnitude: 6.0
- Depth (km): 10.00
- Rupture Length (km): 7.76
- Rupture Orientation (degrees): 0.00
- Attenuation Function: WUS Shallow Crustal Event - Extensional

This HAZUS-MH scenario produced the following lost estimates:

- About 5, 287 buildings (23% of total) will be at least moderately damaged.
- About 212 buildings will be damaged beyond repair.
- Only minor damage is expected to critical and essential facilities.
- Moderate damage is expected to occur to utility systems.
- Fire will occur after the earthquake. The model estimates that fires will displace about 132 people and burn about $8 million of building value.
- Significant debris generation is not likely to occur.
- The model estimates that 365 households will be displaced due to the earthquake and of those, 278 people will seek temporary shelter in public shelter facilities.
- Between 4 and 9 people will be killed by the earthquake. Between 20 and 35 people will require hospitalization and an additional 97 to 131 will require some medical attention. More injuries and deaths are likely to occur if the earthquake occurs during the day rather than in the middle of the night.
- Total building-related losses were estimated to be $425.51 million; 24% of these losses would be attributable to business interruption not structural loss. Residential losses would make up the largest segment at around 54% of total building loss.
- Significant loss ratios were estimated for bus, airport, wastewater, natural gas, and communication facilities.

Overall Vulnerability

The entire population, property, commerce, infrastructure and services of Walla Walla County are vulnerable to an earthquake. The scope of damage is a function of the earthquake magnitude and level of preparedness. Damage could range from minimal to high loss of life and destruction of property. The level of preparedness is assessed at very low in Walla Walla County. Most residents are unprepared for an earthquake. Little mitigation has occurred. Since 1984 when building codes placed Walla Walla County in Seismic Zone 2-B, additional seismic reinforcement is required, but buildings built before that were built with little consideration for seismic reinforcement.

Much of the County's infrastructure and buildings are located in areas of moderate to high liquefaction risk. Although the County has adopted new standards for construction in areas of significant geologic hazard, these protections do not apply to existing development.

It is likely that an earthquake of a 6.0 magnitude (strong) will some loss of life and significant damage to structures.

The ratio of population, property, commerce, infrastructure and services at risk is rated at a MEDIUM vulnerability. An important segment of population, property, commerce, infrastructure or service would be exposed to the effects of a hazard. In a worst case scenario there could be a disaster of moderate to major, though not catastrophic, proportions.

RISK RATING

The overall risk rating for earthquakes in Walla Walla County is rated at HIGH. This rating warrants a significant program effort to prepare for, respond to, recover from, and mitigate this hazard.