Section 5:
Earthquake

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Why Are Earthquakes a Threat to Douglas County?

While Douglas County has no significant recent history of Earthquake activity, there is a concern due to the Pacific Northwest's geologic history.

The most recent earthquake event to affect Douglas County was the September 20th,1993 Klamath Falls earthquake. Two earthquakes shook Klamath Falls causing two deaths and $10 million in damage. Douglas County felt the quake very slightly with only a rattle of lampshades and glasses

Oregon ranks third in the nation for future earthquake damage estimates. Projected losses in the Northwest could exceed $12 billion, with over 30,000 destroyed buildings, and 8,000 lives lost in the event of a magnitude 8.5 Cascadia Subduction Zone earthquake.[1]

Social and geological records show that Oregon has a history of seismic events. Recent research suggests that the Cascadia Subduction Zone is capable of producing magnitude 9 earthquakes. Furthermore, there is evidence of the existence of faults along the Douglas County Coast, as well as other areas of the state. Where known to exist, it is believed that they are capable of generating magnitude 7 earthquakes.

Earthquakes pose a serious threat to many Oregon communities. Local governments, planners, and engineers must consider the threat as they seek to balance development and risk. Identifying locations susceptible to seismic activity generated by local faults or the Cascadia Subduction Zone, adopting strong policies and implementing measures, and using other mitigation techniques are essential to reducing risk from seismic hazards in Douglas County.

Most of the earthquake mapping and mitigation efforts made in Oregon have been accomplished in the past two decades, and public awareness has risen remarkably during this time. Major federal, state, and local government agencies and private organizations support earthquake risk reduction, and have made significant contributions in reducing the adverse impacts of earthquakes. Despite the progress, there is still a great need for earthquake hazard education in Oregon communities.

To better understand the earthquake hazard, the scientific community has looked at historical records and accelerated research on crustal faults, which are among the sources of the earthquakes occurring in the Douglas County region. Historical earthquake records can generally be divided into records of the pre-instrumental period and the instrumental period. In the absence of instrumentation, earthquake detection is based on observations and felt reports, and dependent upon population density and distribution. Since

Oregon was sparsely populated in the 1800s, the detection of pre-instrumental earthquakes is quite difficult. Populations in some regions in or near the Willamette Valley and along the Columbia River began distribution of newspapers as early as the 1850s. Newspapers from these towns provide a good source of historical documentation of earthquakes of a magnitude five or greater since about 1850. The seismic damage potential is more severe today than in the past because the population is increasing.

History of Earthquake Events in Douglas County

Dating back to 1841, there have been more than 6,000-recorded earthquakes in Oregon, most with a magnitude below three. Coastal Oregon, including the Douglas County Coastline is the most seismically active in the State.

Table 5-1. Historical Earthquake Events

There have been no recorded earthquakes in Douglas County. The following lists earthquakes that have occurred near Douglas County.

January 26, 1700

A magnitude of about 9 Earthquake was centered off the Northwest Coast. Buried forests have been discovered along the entire Oregon Coast as a result of this event. Native American villages along the coast were destroyed and Japanese temple records from that time described a Tsunami generated from the event.

November 3, 1981

Magnitude 6.2 earthquake off the Oregon Coast

March 13, 1985

Magnitude 6.1 earthquake located in the Pacific Ocean 140 miles west of Coos Bay

November 8, 1990

Magnitude 7.0 earthquake off the Oregon Coast

September 20, 1993

Magnitude 5.9 and 6.0 earthquakes struck 15 miles northeast of Klamath Falls, causing two deaths and $10 million in damages.

December 4, 1993

Magnitude 5.1 earthquake occurred, centered 10 miles northwest of Klamath Falls. Light damages to buildings.

Source: Oregon Department of Geology and Mineral Industries, Earthquake Education- Historic Earthquakes In The Pacific Northwest. http://www.oregon geology.com/earthquakes/historiceqs.htm

Causes and Characteristics of Potential Earthquakes in Douglas County

Crustal Fault Earthquakes

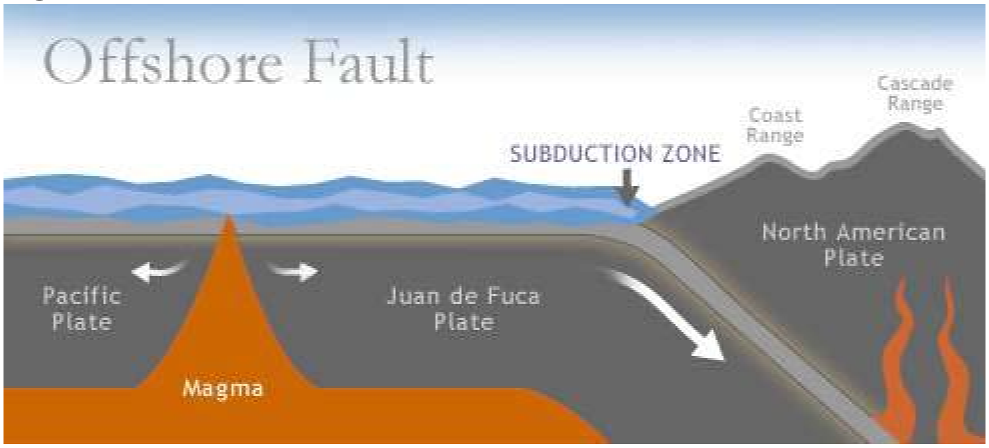
Crustal fault earthquakes are the most common earthquakes and occur at relatively shallow depths of 6-12 miles below the surface. While most crustal fault earthquakes are smaller than magnitude 4 and generally create little or no damage, they can produce earthquakes of magnitudes up to 7, which cause extensive damage.

Deep Intraplate Earthquakes
Occurring at depths from 25 to 40 miles below the earth's surface in the subducting oceanic crust, deep intraplate earthquakes can reach up to magnitude 7.5. The February 28, 2001 earthquake in Washington State was a deep intraplate earthquake. It produced a rolling motion that was felt from Vancouver, British Columbia to Coos Bay, Oregon and east to Salt Lake City, Utah. A 1965 magnitude 6.5 intraplate earthquake centered south of Seattle-Tacoma International Airport caused seven deaths.

Subduction Zone Earthquakes
The Pacific Northwest is located at a convergent plate boundary, where the Juan de Fuca and North American tectonic plates meet. The two plates are converging at a rate of about 1-2 inches per year. This boundary is called the Cascadia Subduction Zone. It extends from British Columbia to northern California. Subduction zone earthquakes are caused by the abrupt release of slowly accumulated stress. Subduction zones similar to the Cascadia Subduction Zone have produced earthquakes with magnitudes of 8 or larger. Historic subduction zone earthquakes include the 1960 Chile (magnitude 9.5) and 1964 southern Alaska (magnitude 9.2) earthquakes.

Geologic evidence shows that the Cascadia Subduction Zone has generated great earthquakes, most recently about 300 years ago. It is generally accepted to have been magnitude 9 or greater. The average recurrence interval of these great Cascadia earthquakes is approximately 500 years, with gaps between events as small as 200 years and as large as 1,000 years. Such earthquakes may cause great damage to the coastal area of Oregon as well as inland areas in western Oregon. Shaking from a large Subduction zone earthquake could last up to five minutes. A Cascadia Subduction Zone Earthquake is the most likely to occur, and the most damaging to Douglas County of the three types of Earthquakes discussed.

Figure 5-1. Cascadia Subduction Zone



Source: *Off Shore Fault Zone: Washington State Department of Ecology*
http://www.ecy.wa.gov/programs/sea/coast/waves/fault.html

Earthquake Related Hazards

Ground shaking, landslides, liquefaction, and amplification are the specific hazards associated with earthquakes. The severity of these hazards depends on several factors, including soil and slope conditions, proximity to the fault, earthquake magnitude, and the type of earthquake.

Ground Shaking

Ground shaking is the motion felt on the earth's surface caused by seismic waves generated by the earthquake. It is the primary cause of earthquake damage. The strength of ground shaking depends on the magnitude of the earthquake, the type of fault, and distance from the epicenter (where the earthquake originates). Buildings on poorly consolidated and thick soils will typically see more damage than buildings on consolidated soils and bedrock.

Earthquake-Induced Landslides

Earthquake-induced landslides are secondary earthquake hazards that occur from ground shaking. They can destroy the roads, buildings, utilities, and other critical facilities necessary to respond and recover from an earthquake. Many communities in Oregon have a high likelihood of encountering such risks, especially in areas with steep slopes.

Liquefaction

Liquefaction occurs when ground shaking causes wet granular soils to change from a solid state to a liquid state. This results in the loss of soil strength and the soil's ability to support weight. Buildings and their occupants are at risk when the ground can no longer support these buildings and structures.

Amplification

Soils and soft sedimentary rocks near the earth's surface can modify ground shaking caused by earthquakes. One of these modifications is amplification. Amplification increases the magnitude of the seismic waves generated by the earthquake. The amount of amplification is influenced by the thickness of geologic materials and their physical properties. Buildings and structures built on soft and unconsolidated soils can face greater risk. Amplification can also occur in areas with deep sediment filled basins and on ridge tops.

Un-reinforced Brick or Masonry Buildings (URMs)
Most injuries in an earthquake are from building failures. The most potentially dangerous buildings are constructed of un-reinforced brick masonry. URMs are typically older brick buildings, often concentrated in an urban setting.

Fire
A serious hazard following an earthquake is fire, often caused by damage to utility lines.

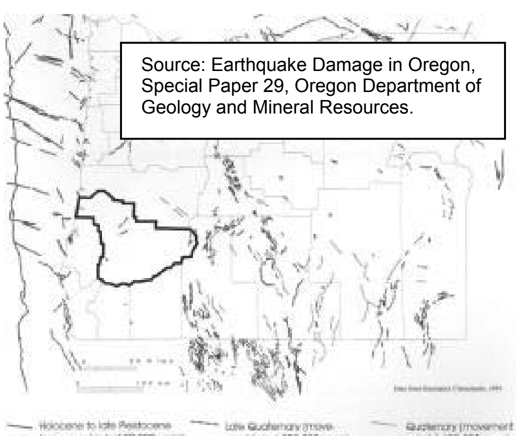
Tsunami
A tsunami is a series of sea waves generated by an earthquake. Damage as a result of Tsunami are discussed more thoroughly in Section 6 of the Douglas County Natural Hazard Mitigation Plan.

Earthquake Hazard Assessment

Hazard Identification

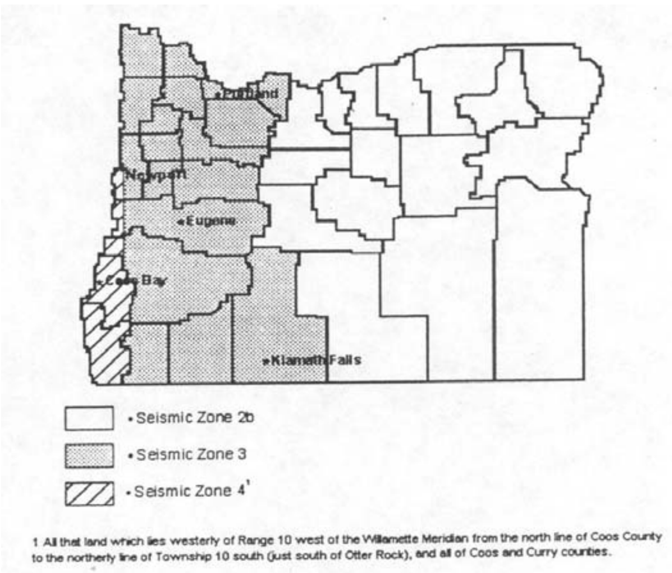
The Department of Geologic and Mineral Industries (DOGAMI), in partnership with other state and federal agencies, has undertaken a rigorous program in Oregon to identify seismic hazards and risks, including active fault identification, bedrock shaking, tsunami inundation zones, ground motion amplification, liquefaction, and earthquake induced landslides. Seismic hazard maps have been published and are available for many communities in Oregon through DOGAMI.

Map 5-1. Fault Locations in Douglas County



The Oregon Building Codes Division revised and upgraded its construction standards for new buildings to make them resistant to seismic events. The State Building Codes reflect three seismic zones. An increase in zone number reflects increased seismic activity. The *Current Seismic Zones* map below shows that Douglas County east of Range 10 West is within Zone 3, while west of Range 10 West is within Seismic Zone 4. Many buildings in Douglas County were built prior to the Zone 3 and Zone 4 code requirements, established in 1993.

Figure 5-2. Seismic Zones in Oregon



Vulnerability Assessment

The effects of earthquakes span a large area, and an earthquake occurring in Douglas County would probably be felt throughout the county. However, the degree to which the earthquakes are felt, and the damages associated with them may vary. At risk from earthquake damage are large stocks of old buildings and bridges, hazardous materials facilities, extensive sewer, water, and natural gas pipelines, dams, a petroleum pipeline, and other critical facilities and private property located in the county. The areas that are particularly vulnerable to potential earthquakes in the county have been identified as the coastal area of the county, as reflected in the increased seismic zone rating of the areas west of Range 10W. The relative or secondary earthquake hazards, which are liquefaction, ground shaking, amplification, and earthquake-induced landslides, can be just as devastating as the earthquake. DOGAMI is currently conducting research regarding the location and potential damage associated with secondary earthquake hazards. Liquefaction occurs when ground shaking causes wet granular soils to change from a solid state to a liquid state. This results in the loss of soil strength and the soil's ability to support weight. Buildings and their occupants are at risk when the ground can no longer support these buildings and structures.

Risk Analysis

Risk analysis is the third phase of a hazard assessment. Risk analysis involves estimating the damage and costs likely to be experienced in a geographic area over a period of time. Factors included in assessing earthquake risk include population and property distribution in the hazard area, the frequency of earthquake events, landslide susceptibility, buildings, infrastructure, and disaster preparedness of the region. This type of analysis can generate estimates of the damages to the county due to an earthquake event in a specific location.

- Due to the high risk, but low probability of earthquakes in Douglas County, widespread mitigation of seismic hazards is probably not called for in the case of most typical buildings. New buildings will be built in accordance with current Seismic Zone 3 requirements from Range 10W and East, and Seismic Zone 4 requirements in areas west of Range 10W. Thus, the seismic capacity of the Douglas County building stock will improve over time as the existing stock is gradually replaced and/or upgraded.

- Structural retrofit of buildings and infrastructure should focus on buildings that are most vulnerable to seismic damage, and are most important to the community, such as schools, hospitals, and other critical facilities. Priorities should include buildings on soft soil sites subject to amplification of ground motion and/or liquefaction.
- Non-structural bracing of equipment and contents is often the most cost-effective type of seismic mitigation. Inexpensive bracing and anchoring may protect expensive equipment whose function is critical in hospitals or power companies.

Table 5-2. Cascadia Subduction Zone Earthquake (Magnitude 8.5) and 500 year return Interval Damage Estimate Model for Douglas County by Oregon Department of Geology and Mineral Resources

Based on computer modeling and research, DOGAMI estimates future earthquake damage in a number of categories based on a magnitude 8.5 Subduction Zone earthquake off the Oregon Coast, and statewide earthquakes within a 500 year return interval.

Cascadia Subduction Zone Magnitude 8.5 and 500 year Model for Douglas County

	8.5 Subduction Zone Event	500-Year Model
Injuries	151	294
Deaths	2	4
Displaced Households	255	534
Short Term Shelter Needs	193	410
Economic Loss for Buildings	$275 Million	$546 Million
Operating the Day After The Earthquake		
Fire Stations	66%	NA
Police Stations	57%	NA
Schools	44%	NA
Bridges	74%	NA
Economic Losses to:		
Highways	$43 Million	$69 Million
Airports	$5 Million	$9 Million
Communication Systems	$7 Million	$12 Million
	(61% operating the day of The Quake)	NA
Debris Generated (thousands of tons)	222	411

Percentage of Buildings in Damage Categories

8.5 Cascadia Event

Building Type	None	Slight	Moderate	Extensive	Complete
Agricultural	19	10	12	9	6

Commercial	12	9	16	12	7
Education	25	8	10	7	4
Government	20	8	13	10	6
Industrial	19	8	13	10	7
Residential	36	10	6	3	2

500 Year Model

Building Type	None	Slight	Moderate	Extensive	Complete
Agricultural	19	10	12	9	6
Commercial	12	9	16	12	7
Education	17	9	13	10	6
Government	12	8	15	13	8
Industrial	11	8	16	13	9
Residential	27	14	9	4	2

Source: Wang, Yumei and Clark, J.L. *Earthquake damage in Oregon: Preliminary Estimates of Future Earthquake Losses* (1999), DOGAMI, Special Paper 29 with the following notation: **"These figures have a high degree of uncertainty and should be used only for general planning purposes. Because of Rounding, numbers may not add up to 100%." "Because the 500-year model includes several earthquakes, the number of facilities operational the "day after" cannot be calculated."**

Community Earthquake Issues

What is Susceptible to Earthquakes?

Earthquake damage occurs because humans have built structures that cannot withstand severe shaking. Buildings, airports, schools, and lifelines (highways and utility lines) suffer damage in earthquakes and can cause death or injury to humans. The welfare of homes, major businesses, and public infrastructure is very important. Addressing the reliability of buildings, critical facilities, and infrastructure, and understanding the potential costs to government, businesses, and individuals as a result of an earthquake, are challenges faced by the county.

Dams

Douglas County dams hold millions of gallons of water in reservoirs. Releases of water from the major reservoirs are designed to protect Douglas County from high floodwaters. Seismic activity can compromise the dam structures, and the resultant downstream flooding would cause catastrophic flooding.

Buildings

The built environment is susceptible to damage from earthquakes. Buildings that collapse can trap and bury people. Lives are at risk and the cost to clean up the damages is great. In most Oregon communities, including Douglas County, many buildings were built before 1993 when building codes were not as strict. In addition, retrofitting is not required except under certain conditions and can be expensive. Therefore, the number of buildings at risk remains high. The Oregon Building Codes Division revised its construction standards for new buildings to make them more resistant to seismic events. Central Douglas County, east of Range 10 west, is within Zone 3, while Douglas County West of Range 10 is within Seismic Zone 4. The Douglas County Building Department has an archive of building permits.

Infrastructure and Communication
Residents in Douglas County commute almost exclusively by automobile c An earthquake can greatly damage bridges and roads, hampering the movement of people and goods. Damaged infrastructure strongly affects the economy of the community because it disconnects people from work, school, food, and leisure, and separates businesses from their customers and suppliers.

Bridge Damage
Even modern bridges can sustain damage during earthquakes, leaving them unsafe for use. Some bridges have failed completely due to strong ground motion. Bridges are a vital transportation link – with even minor damages making some areas inaccessible. Because bridges vary in size, materials, siting, and design, any given earthquake will affect them differently. Bridges built before the mid-1970's have a significantly higher risk of suffering structural damage during a moderate to large earthquake compared with those built after 1980 when design improvements were made.

Much of the interstate highway system was built in the mid to late 1960's. Bridges in Douglas County are state, county, city, or privately owned. A state-designated inspector must inspect all state, county, and city bridges every two years, and the inspections are rigorous, looking at everything from seismic capability to erosion and scour. However, private bridges are not inspected, and can be very dangerous.

Upon inspection, the bridges are subject to a sufficiency score. This score uses a scale of 1 to 100 with 1 being the worst rating. The bridges are ranked throughout the state according to their score. The state then prioritizes the bridge repair according to each score. If the bridge receives a sufficiency score of less that 50, it is on the list for upgrading and rehabilitation. If it scores over 50, it is not included on the list.

Small repairs to county bridges may be done entirely by Douglas County, while the larger projects require funding through the Highway Bridge Replacement and Rehabilitation program (HBRR). HBRR provides 80% of funding, and the county is responsible for 20%.

Damage to Lifelines
Lifelines are the connections between communities and outside services. They include water and gas lines, transportation systems, electricity, and communication networks. Ground shaking and amplification can cause pipes to break open, power lines to fall, roads and railways to crack or move, and radio and telephone communication to cease. Disruption to transportation makes it especially difficult to bring in supplies or services. Lifelines need to

be usable after an earthquake to allow for rescue, recovery, and rebuilding efforts and to relay important information to the public.

Disruption of Critical Services

Critical facilities include police stations, fire stations, hospitals, shelters, and other facilities that provide important services to the community. These facilities and their services need to be functional after an earthquake event. Many critical facilities are housed in older buildings that are not up to current seismic codes.

Businesses

Seismic activity can cause great loss to businesses; both large-scale corporations and small retail shops. When a company is forced to stop production for just a day, the economic loss can be tremendous, especially when its market is at a national or global level. Seismic activity can create economic loss that presents a burden to large and small shop owners who may have difficulty recovering from their losses.

Individual Preparedness

A 1999 DOGAMI survey shows that about 39% of respondents think an earthquake will occur in Oregon within the next 10 years. Only 28% of Oregon residents say they are prepared for an earthquake, and 22% have earthquake insurance. In addition, only 24% correctly identified what to do during an earthquake.

Because the potential for earthquake occurrences and earthquake-related property damage is relatively high, increasing individual preparedness is a significant need. Strapping down heavy furniture, water heaters, and expensive personal property, as well as being earthquake insured, and anchoring buildings to foundations are just a few steps individuals can take to prepare for an earthquake.

Death and Injury

Death and injury can occur both inside and outside of buildings due to collapsed buildings falling equipment, furniture, debris, and structural materials. Downed power lines and broken water and gas lines can also endanger human life.

Fire

Downed power lines or broken gas mains can trigger fires. When fire stations suffer building or lifeline damage, quick response to extinguish fires is less likely.

Debris

After damage to a variety of structures, much time is spent cleaning up brick, glass, wood, steel or concrete building elements, office and home contents, and other materials. Developing strong debris management strategies can assist in post-disaster recovery.

Existing Mitigation Activities

Existing mitigation activities include current mitigation programs and activities that are being implemented by county, regional, state, or federal agencies or organizations.

Douglas County Code

Implementation of earthquake mitigation policy takes place at the local government level. Codes pertaining to earthquake hazards are managed through the Planning and Building Codes Departments. Developers in potential hazard-prone areas are required to retain a professional engineer to evaluate level of risk onsite and recommend mitigation measures.

Coordination Among County Building Officials

The Oregon State Building Code Division (BCD) sets the minimum design and construction standards for new buildings. In 1993, BCD upgraded the Oregon Specialty Code (OSSC) seismic zone rating, which requires that new buildings be built at a higher seismic standard. Since 1993, BCD also requires that site-specific seismic hazard investigations be performed for new essential facilities, major structures, hazardous facilities, and special occupancy structures such as schools, hospitals, and emergency response facilities.

The county enforces the Unified Building Code (UBC), as adopted by the BCD to insure building code standards in new construction. Codes related to Natural Hazard Mitigation are Chapter 16 of the UBC. It introduces seismic zones, which are rated from 1-4 depending on risk. Each zone has different standards that are specific to the level of risk. The following sections of the UBC address the earthquake hazard: 1605.2.1 (Distribution of Horizontal Sheer); 1605.2.2 (Stability against Overturning); 1626 (Seismic); 1605.2.3 (Anchorage); and 1632, 1633.2.8, 1633.2.9 deal with specific earthquake hazards.

Businesses/Private Sector

Natural Hazards can have a devastating impact on businesses. The Institute of Business and Home Safety has developed "Open for Business", which is a disaster planning toolkit to help guide businesses in preparing for and dealing with the adverse affects of natural hazards. The kit integrates protection from natural disasters into the company's risk reduction measures to safeguard employees, customers, and the investment itself. The guide helps businesses secure human and physical resources during disasters, and helps to develop strategies to maintain business continuity before, during, and after a disaster occurs.

Senate Bill 13: Seismic Event Preparation

Senate Bill 13, signed on June 14, 2001, requires each state and local agency and persons employing 250 or more full-time employees to develop seismic preparation procedures and inform their employees about the procedures. Further, the bill requires agencies to conduct drills in accordance with Office of Emergency Management guidelines. These drills must include "familiarization with routes and methods of exiting the building and methods of duck, cover and hold during an earthquake." Each state and local agency and employer with 250 or more full-time employees shall maintain a file that documents the date the earthquake drill was conducted. Oregon Emergency Management (OEM) was tasked to write the Oregon Administrative Rule (OAR) for this bill. The draft rule went out for public comment in February 2002, and was revised based on public comment. The final rule (OAR 104-020-000-040) went into effect April 1, 2002.

Senate Bill 14: Seismic Surveys For School Buildings
The Governor signed Senate Bill 14 on July 19, 2001, which requires the State Board of Higher Education to provide for seismic safety surveys of buildings that have a capacity of 250 or more persons and are routinely used for student activities by public institutions or departments under the control of the board.

Senate Bill 15: Seismic Surveys For Hospital Buildings
The Governor signed Senate Bill 15 on July 19, 2001, which requires the Health Division to provide for seismic safety surveys of hospital buildings that contain an acute in-patient care facility. Seismic surveys shall also be conducted on fire stations, police stations, sheriffs' offices, and similar facilities subject to available funding. The surveys should be completed by January 1, 2007.

Earthquake Education
All three of the state's major public universities (University of Oregon, Oregon State University, and Portland State University) are involved with earthquake education in some capacity. At these institutions, the federally funded work conducted tends to be oriented towards basic research, whereas state funded work typically has more practical application.

The Department of Education is generally concerned with seismic safety in schools. It supports the required monthly earthquake drills mandated in Oregon Revised Statutes (ORS 336.072). The Department is not authorized to mandate seismic safety efforts in schools but can make recommendations to local school districts on such issues. It encourages the use of a curriculum produced by FEMA that focuses on mitigating non-structural hazards in schools and assists schools in obtaining funds for these purposes. Each year, Oregon Emergency Management provides information to facilitate school earthquake drills statewide. Currently, all thirteen Douglas County School Districts have committed to performing earthquake drills.

Earthquake Mitigation Action Items

The earthquake mitigation action items provide guidance on suggesting specific activities that agencies, organizations, and residents in Douglas County can undertake to reduce risk and prevent loss from earthquake events. Each action item is followed by ideas for implementation, which can be used by the steering committee and local decision makers in pursuing strategies for implementation.

Earthquake Mitigation Goals

GOAL A
Prevent Loss of Life from Earthquakes

GOAL B
Reduce Property Damages

GOAL C
Enhance Education and Public Awareness of Earthquake Danger

GOAL D
Increase Preparedness of Communities and Agencies To Deal With Earthquakes

Earthquake Mitigation Action Items

ACTION ITEM 1 – Promote and continue building code standards
Ideas for Implementation:
Continue building code education, promotion, and utilization to ensure earthquake resistant new construction.

Coordinating Organization: County and City Planning Departments and Douglas County Building Department
Timeline: Continue
Plan Goals Addressed: A, B, C, D

ACTION ITEM 2 – ID and strengthen weak existing buildings to mitigate for damage; especially: Schools, fire/police stations/hospitals, historic buildings, un-reinforced masonry buildings that could risk lives in a quake due to falling bricks
Ideas for Implementation:
Refit older public buildings to bring them up to current earthquake standards.

Coordinating Organization: County and City Planning Departments and Douglas County Building Department
Timeline: Continue
Plan Goals Addressed: A, B, C, D

ACTION ITEM 3 – Identify and enhance water, sewer, electric, gas and other utilities to improve their survivability in an earthquake.

Ideas for Implementation:
Coordinate utility improvements with companies, cities and Douglas County.

Coordinating Organization: County and City Planning Departments, Douglas County Emergency Management, Douglas County Building Department, Douglas County Public Works
Timeline: Continue
Plan Goals Addressed: A, B, C, D

ACTION ITEM 4 – Encourage Earthquake safety promotion and drills to schoolchildren and community groups

Ideas for Implementation:
Conduct safety seminars with community groups to describe earthquake dangers, and steps that can be taken to reduce their impact. Encourage Douglas County Schools to promote earthquake safety education.

Coordinating Organization: County and City Planning Departments, Douglas County Emergency Management, Douglas County Schools, Community Organizations
Timeline: Continue
Plan Goals Addressed: A, B, C, D

ACTION ITEM 5 – Continue and improve tsunami education for residents and tourists on the coast

Ideas for Implementation:
Work with Coastal Communities and agencies dealing with tsunami dangers to continue education and enhancement of tsunami evacuation routes.

Coordinating Organization: County and City Planning Departments, Douglas County Emergency Management
Timeline: Continue
Plan Goals Addressed: A, B, C, D

Earthquake Endnotes

1 Wang, Yumei and Clark, J.L. *Earthquake damage in Oregon: Preliminary estimates of future earthquake losses* (1999), DOGAMI, Special Paper 29.

2 Preparing for Earthquakes in Oregon. Oregon Geology, Vol. 59. No. 2, March/April 1997.

Institute for Business and Home Safety Resources
http://www.ibhs.net/ibhsdocuments/pdf/earthquake.pdf.

Section 6:
Tsunami

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Why are Tsunamis a Threat to Douglas County?

Oregon coastal communities, including the Douglas County Coastline are threatened by tsunamis that are generated by both local earthquakes and distant earthquakes. Local tsunamis give residents only a few minutes to seek safety. Tsunamis of distant origins give residents more time to evacuate threatened coastal areas but increase the need for timely and accurate assessment of the tsunami hazard to avoid costly false alarms. Thus, Alaska or Hawaii can experience a local earthquake and tsunami while residents Douglas County may experience this disaster as a distant tsunami. Similarly, a local tsunami may also have an impact on the distant states of Alaska, Hawaii or even across the Pacific. Of the two, local tsunamis are more devastating.

In Oregon, prehistoric runups (i.e., how high a tsunami wave reaches above mean sea level) can be deduced with numerical methods. From such models, it was concluded that a tsunami that struck Salishan Spit in Lincoln County between 300 and 800 years ago had a runup of up to 40 feet above sea level. It is likely that the same wave probably overtopped a 16-foot-high barrier ridge at Cannon Beach and breached a 20-foot ridge at Seaside.

One of the largest subduction zone earthquakes ever recorded was the M 9.2 quake on March 27, 1964. A tsunami generated by the same 1964 Alaska earthquake also struck the Oregon coastline, killing four people and causing nearly $1 million damage (in 1964 dollars). **The highest officially measured tsunami wave in Oregon in 1964 was 14.2 feet at the mouth of the Umpqua River** [1]. When the same tsunami struck Crescent City, California, the maximum wave height was 14 feet, 11 people were killed, and approximately $8 million of damage was done. Heights of tsunami waves generated by nearby earthquakes could be much higher.

There has been no significant damage in Douglas County from tsunamis. However, given the damages caused to Oregon coastal towns, and the historical evidence of tsunami impacts through the Pacific Ocean, a tsunami affecting vulnerable locations on the Douglas County Coast is a real issue.

History of Tsunamis along the Oregon Coast and Douglas County

As stated previously, there is no recorded tsunami damage other than minor flooding "Run Up" as a result of the 1964 Tsunami, in Douglas County.

Tsunamis have historically been rare in Oregon. Since 1812, Oregon has experienced about a dozen tsunamis with wave heights greater than 3 feet; some of these were destructive. Ten of these were generated by distant earthquakes near Alaska, Chile or Japan. The worst damage and loss of life resulted from the 1964 Alaskan earthquake.

1964 Alaskan Earthquake and Tsunami

The 1964 earthquake caused 115 deaths in Alaska alone, with 106 of these due to tsunamis, which were generated by tectonic uplift of the sea floor, and by localized subareal and submarine landslides. The earthquake shaking caused at least 5 local slide generated tsunamis within minutes after the shaking began. (In general, slide/slump induced tsunamis are generated within a few minutes after an earthquake starts.) This created a local tsunami causing much damage and the spreading of oil, which was on fire and floating on the water. About 20 minutes after this occurred, the first wave of the main tsunami arrived. The 11-13 fatalities in Seward were due to the local and the main tsunami.

Tsunamis generated by the 1964 earthquake (and their subsequent damage, loss of life, etc.) were recorded throughout the Pacific. This was the most disastrous tsunami to hit the U.S. West Coast and British Columbia in Canada. The largest wave height for this tsunami was reported at Shoup Bay, Valdez Inlet Alaska (67 meters). Summary of lives lost and damage for Alaska, Canada, Washington, Oregon and California are: Alaska- 106 deaths and $84 million; British Columbia- $10 million; Washington- minor damage throughout the coast; In Oregon, 4 deaths and $0.7 million, with much of the damage away from the coast where rivers overflowed.

Characteristics of Tsunamis

A tsunami, also called a seismic sea wave, or incorrectly called a tidal wave, travels across the deep ocean at speeds up to 500 miles per hour. A tsunami generated offshore from Japan or Alaska might not hit the Oregon coast for several hours. A tsunami following a Cascadia earthquake may hit in less than 30 minutes.

On the open ocean, a fast moving tsunami might be a wave only three to four feet high, with 100 miles separating wave crests. Approaching the coast, however, the tsunami begins to slow in shallow water, and successive waves bunch up, increasing in height. As the ocean bottom shallows even more, the wave rapidly rises and may break several tens of feet high with incredible destructive power. It has been conjectured that the configuration of the Oregon and Washington continental shelf could produce tsunami waves that would appear to rise slowly out of the ocean but build up to 30 feet or more in height as water is cast shoreward.

If you throw a pebble into standing water, a succession of ripples or waves moves across the water. Similarly, tsunamis almost never come as single waves but arrive as multiple crests that are sometimes hours apart. Often the first tsunami is not even the largest or most destructive, and wave four or five may be the largest of all.

Tsunamis are caused by undersea volcanic eruptions, landslides, or faulting as slabs of the sea floor are displaced vertically. Most commonly, rapid uplift or subsidence of the sea floor along faults is transmitted to the surface of the ocean, forming unusually large waves. Coastal slides from land under the water, also triggered by earth movement, can intensify the effects of tsunamis.

The undersea subduction zone, paralleling the Oregon coast at a distance of about 75 miles, is the junction between the Juan de Fuca and the North American tectonic plates. The two plates lock together, but periodically the stress is released suddenly with a snapping motion, and the resulting shock may trigger a tsunami. Distinctive, thin deposits of shallow marine sands along the coast are physical evidence of these ancient waves.

Some Tsunami Facts:

1. Tsunamis are caused by an underwater disturbance — usually an undersea earthquake. Landslides, volcanic eruptions, and even meteorites can also generate a tsunami.
2. Tsunamis can originate hundreds or even thousands of miles away from coastal areas. Local geography may intensify the effect of a tsunami. Areas at greatest risk are less than 50 feet above sea level and within one mile of the shoreline.
3. People who are near the seashore during a strong earthquake should listen to a radio for a tsunami warning and be ready to evacuate at once to higher ground.
4. Rapid changes in the water level are an indication of an approaching tsunami.
5. Tsunamis arrive as a series of successive “crests” (high water levels) and “troughs” (low water levels). These successive crests and troughs can occur anywhere from 5 to 90 minutes apart. They usually occur 10 to 45 minutes apart.

Two kinds of tsunamis could affect the Douglas County coast:

- Tsunamis generated by undersea earthquakes just off the Oregon coast can strike the coast within five to thirty minutes, possibly disrupting power lines and communications and leaving little time for an official warning. The actual ground shaking of the earthquake may be the only warning received.
- Tsunamis generated by earthquakes occurring thousands of miles away will take several hours to reach the coast. There would be time for official warning, no earthquake would be felt, and the only warning may be a sudden unexpected change in sea level.

A tsunami is not a single wave but a series of long period waves that can cause havoc along the coastline, in harbors and bays, and move up coastal rivers. The unusual, wild oscillations of sea level caused by the tsunami can last for hours following arrival of the first wave. In 1964, many people in Crescent City, California, thought it was safe to return to the harbor area only to be killed by later arriving tsunami waves. The same happened in Hilo, Hawaii, in 1960.

Hazard Assessment

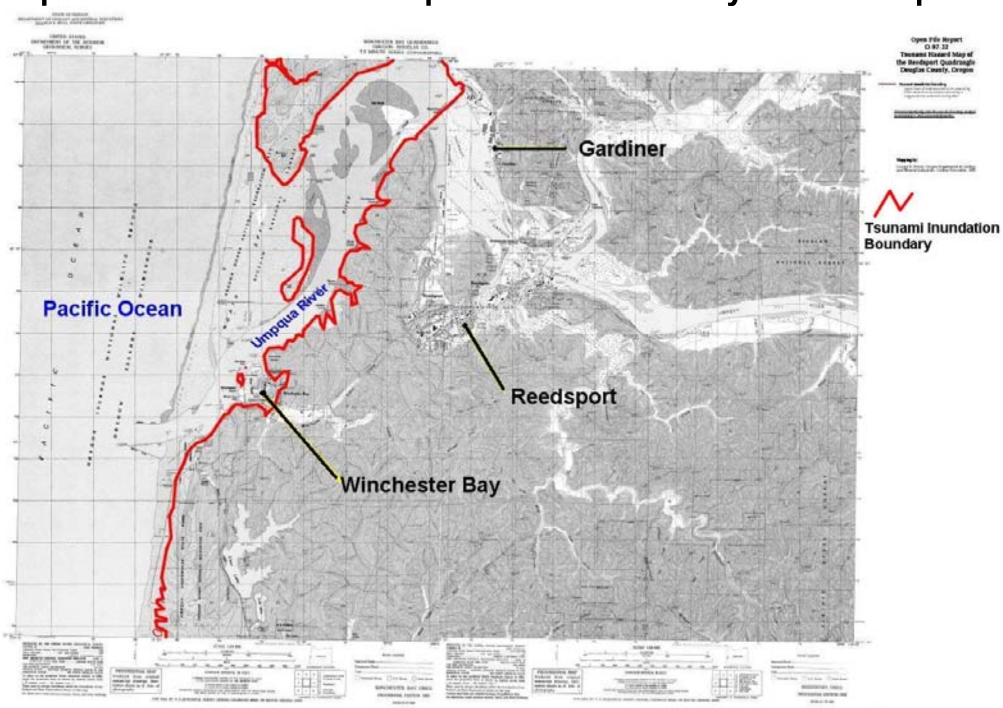
Hazard Identification

DOGAMI Tsunami Hazard Maps

The tsunami hazard maps were produced to help implement Senate Bill 379 (SB 379), which was passed by the 1995 regular session of the Oregon Legislature.

SB 379, implemented as Oregon Revised Statutes (ORS) 455.446 and 455.447, and Oregon Administrative Rules (OAR) 632-005 limits construction of new essential facilities and special occupancy structures in tsunami flooding zones. The focus of the maps is therefore on implementation of this public safety bill and has minor impacts on land use or emergency planning.

Map 6-1 Tsunami Hazard Map for Winchester Bay and Reedsport



Source: Oregon Department of Geology and Mineral Resources – Enhanced for readability in this document

As part of an international cooperative effort to save lives and protect property, the National Oceanic & Atmospheric Administration's (NOAA) National Weather Service operates two tsunami warning centers. The West Coast & Alaska Tsunami Warning Center (WCATWC) in Palmer, Alaska, serves as the regional Tsunami Warning Center for Alaska, British Columbia, Washington, Oregon and California.

The Pacific Tsunami Warning Center (PTWC) in Ewa Beach, Hawaii, serves as the regional Tsunami Warning Center for Hawaii and as a national/international warning center for tsunamis that pose a Pacific-wide threat. This international warning effort became a formal arrangement in 1965 when PTWC assumed the international warning responsibilities of the Pacific Tsunami Warning System (PTWS). The PTWS is comprised of 26 international Member States that are organized as the International Coordination Group for the Tsunami Warning System in the Pacific. The PTWS operate national tsunami warning centers, providing warning services for their local area.

The objective of the PTWS is to detect, locate and determine the magnitude of potential tsunami generating earthquakes occurring in the Pacific Basin or its immediate margins. Earthquake information is provided by seismic stations operated by PTWC, WCATWC, the U.S. Geological Survey's National Earthquake Information Center and international sources. If the location and magnitude of an earthquake meet the known criteria for generation of a tsunami, a tsunami warning is issued to warn of an imminent tsunami hazard.

The warning includes predicted tsunami arrival times at selected coastal communities within the geographic area defined by the maximum distance the tsunami could travel in a few hours. A tsunami watch with additional predicted tsunami arrival times is issued for a geographic area defined by the distance the tsunami could travel in a subsequent time period.

If a significant tsunami is detected by sea-level monitoring instrumentation, the tsunami warning is extended to the entire Pacific Basin. The International Tsunami Information Center, part of the Intergovernmental Oceanographic Commission, monitors and evaluates the performance and effectiveness of the Pacific Tsunami Warning System. This effort encourages the most effective data collection, data analysis, tsunami impact assessment and warning dissemination to all TWS participants.

Tsunami watches, warning, and information bulletins are disseminated to appropriate emergency officials and the general public by a variety of communication methods. [2]

The WC/ATWC and PTWC may issue the following bulletins:

- <u>WARNING</u>: A tsunami was or may have been generated, which could cause damage; therefore, people in the warned area are strongly advised to evacuate.

- <u>WATCH</u>: A tsunami was or may have been generated, but is at least two hours travel time to the area in watch status. Local officials should prepare for possible evacuation if their area is upgraded to a warning.

- <u>ADVISORY</u>: An earthquake has occurred in the Pacific basin, which might generate a tsunami. WC/ATWC and PTWC will issue hourly bulletins advising of the situation.

- <u>INFORMATION</u>: A message with information about an earthquake that is not expected to generate a tsunami. Usually only one bulletin is issued.

Vulnerability Assessment

A vulnerability assessment that describes the number of lives or amount of property exposed to tsunami threat has not yet been conducted for Douglas County. However, tsunamis can cause property damage, transportation and economic disruptions, and pose a high risk for injuries and loss of life. The tsunami event may also require needed shelter and care for adversely impacted individuals. The county has not experienced a serious damaging Tsunami event in the past, however the potential threat is one to be concerned about as the Douglas County Coastline is threatened by tsunamis that are generated by both local earthquakes and distant earthquakes. In general, the community of Winchester Bay is vulnerable, however topography and distance limit vulnerability of other areas outside of the immediate Douglas County coastline. However, communities in Oregon and other states along the Pacific Coast have experienced serious tsunami damage, and loss of life, therefore preparedness is needed.

Factors included in assessing tsunami risk include population and property distribution in the hazard area, tsunami warnings, and information on utilities, and infrastructure that may be impacted by a tsunami. When sufficient data is collected for hazard identification and vulnerability assessment, a risk analysis can be completed. Insufficient data currently exists to complete a risk analysis.

Community Tsunami Issues

What is Susceptible to Damage During a Tsunami Event?

People and properties located in low-lying areas near the ocean are at greatest risk from tsunami flooding.

Boats and ships in harbor are also at great risk from the wild changes in sea level. The water level can change so fast that lines holding ships to the pier will break like string. Navigating in these conditions will be treacherous as unpredictable, dangerous currents can continue for hours while the water in the harbor shifts back and forth.

The rapidly increasing sea level caused by the tsunami picks up debris, rocks, logs and other materials that act as projectiles causing additional damage and dangers.

Existing Tsunami Mitigation Activities

Douglas County Codes

SECTION 3.35.960 of the Douglas County Land Use and Development Ordinance, Tsunami Inundation Overlay (TIO)

The purpose of the Tsunami Inundation Overlay is to implement state legislation and agency rules adopted by the Governing Board of the Oregon Department of Geology and Mineral Industries (DOGAMI). The TIO Overlay is intended to reduce the risk of loss of life in the event of a Tsunami inundation. Inundation risks can be reduced by the provision of information and assistance from DOGAMI to developers, and by limiting where certain types of essential facilities or special occupancy structures may be located. This overlay also requires that, after land use approval, developers subject to overlay requirements shall submit building plans or proposals to DOGAMI for their review and response prior to receiving a development permit. The Overlay shall be applied to the Tsunami Inundation Zone, as defined in this Section, and as depicted in the Comprehensive Plan.

1. Definitions: For the purpose of this section only, the following definitions are established:

ESSENTIAL FACILITY: Hospitals and other medical facilities having surgery and emergency treatment areas; fire and police stations; structures and equipment in emergency-preparedness centers; and structures and equipment in government communication centers and other facilities required for emergency response.

HAZARDOUS FACILITY: Structures housing, supporting or containing sufficient quantities of toxic or explosive substance to be of danger to the safety of the public if released.

MAJOR STRUCTURE: A building over six stories in height with an aggregate floor area of 60,000 square feet or more; every building over ten stories in height; and parking structures as determined by Department of Consumer and Business Services rule.

SPECIAL OCCUPANCY STRUCTURE: Covered structures whose primary occupancy is public assembly with a capacity greater than 300 persons; buildings with a capacity greater than 50 individuals for every public or private school through secondary level or day care centers; buildings for colleges or adult education schools with a capacity greater than 500 persons; medical facilities with 50 or more residents, incapacitated patients already included in this definition; jails and detention facilities; and all structures and occupancies with a capacity greater than 5,000 persons.

TSUNAMI INUNDATION ZONE: A Tsunami is a series of ocean waves caused by an undersea earthquake. The Tsunami Inundation Zone was scientifically modeled by DOGAMI and estimates how far upland the tsunami wave will run.

2. Permitted Uses: Uses and activities permitted by the underlying zoning district shall be allowed unless specifically prohibited by Subsection 3 of this section. Water-dependent and water-related facilities and structures in the tsunami inundation zone are exempt from Tsunami Inundation Overlay restrictions.

3. Buildings Prohibited: The construction of, conversion to, or replacement of the following essential facilities or special occupancy structures shall not be allowed in the tsunami inundation zone:

a. Hospitals and other medical facilities having surgery and emergency treatment areas;
b. Fire and Police station unless there is a need for a strategic location;
c. Government communication centers and other emergency response centers.
d. Private or public elementary and/or secondary school, or day care center, with a capacity greater than 50 individuals unless there is a need for the school to be within the boundaries of a school district and no other sites are available;
e. Colleges or adult education schools with a capacity greater than 500 persons; and
f. Jails and detention facilities

4. DOGAMI Review: After planning approval, or prior to issuance of a development permit for construction of, conversion to, or replacement of any development on the following list, the owner or developer shall consult with the local building official to determine whether ORS 455 applies (in this subsection, ORS 455 shall specifically refer to those sections of the statute dealing with tsunami inundation zones, specifically the "prohibition of construction for certain facilities and structures" and, the "regulation of certain vulnerable structures", identified in the 2001 Edition of the statutes as ORS 455.446 and ORS 455.447):
1) Emergency preparedness center
2) Hazardous Facilities
3) Covered structures used primarily for public assembly with capacity over 300 people
4) Medical facilities with over 50 patients
5) Structures with capacity over 5,000 persons

a. If the building official determines that ORS 455 is not applicable, then the owner or developer may proceed through the development permit process without further review under this Section.
b. If the building official determines that ORS 455 is applicable, then the owner or developer shall consult with DOGAMI and submit a copy of building plans or proposals to that agency for their review. In cases where ORS 455 is applicable, a local development permit shall not be issued until a written response is received from DOGAMI.

Tsunami Mitigation Goals

GOAL A
Protect Lives of Residents and Visitors in Tsunami Prone Areas

GOAL B
Reduce Property Damages and Loss in Tsunami Prone Areas

GOAL C
Enhance Education and Public Awareness of Tsunami Dangers

GOAL D
Increase Preparedness of Communities and Agencies To Deal With Tsunami Threat

Tsunami Mitigation Action Items

ACTION ITEM 1 – Identify vulnerable assets (fire stations, equipment, utilities) likely to be impacted by tsunami and determine ways of mitigating the vulnerability.
Ideas for Implementation
Coordinate emergency response to disaster, enhance local mapping capabilities and forecasting, encourage tsunami evacuation training for emergency responders.

Coordinating Organization: Douglas County Emergency Management
Timeline: continue
Plan Goals Addressed: B, C, D

ACTION ITEM 2 –Work with coastal communities, citizen groups, property owners, recreation areas, emergency responders, schools and businesses in promoting tsunami awareness and evacuation
Ideas for Implementation:
Distribution of Tsunami information describing dangers and evacuation routes for visitors at the coast and continued educational outreach for residents and business owners.

Coordinating Organization: County and City Planning Departments
Timeline: Continue
Plan Goals Addressed: A, B, C, D

ACTION ITEM 3 – Improve technology capacity of communities, agencies and responders needed to adequately map hazard areas, broadcast warnings, inform, and educate residents and visitors of tsunami dangers
Ideas for Implementation
Improve and utilize tsunami information, utilize technology to assist in determining evacuation needs and concerns.

Coordinating Organization: Douglas County and City of Reedsport Planning Departments
Timeline: Continue
Plan Goals Addressed: A,B,C,D

ACTION ITEM 4 – Develop, coordinate with state and surrounding counties, the development and installation of a coastal tsunami warning system.
Ideas for Implementation
Develop a system to track and warn the Douglas County Coastline in coordination with the State, Federal and other Oregon County Emergency Planners.

Coordinating Organization: Douglas County Emergency Management, City of Reedsport, Salmon Harbor, Coastal Fire Agencies, ODOT, Douglas County Public

Works.
Timeline: Continue
Plan Goals Addressed: A,C,D

ACTION ITEM 5 –Enhance tsunami evacuation route capacity and visibility
Ideas for Implementation
Improve evacuation route road conditions, expand use and visibility of Tsunami Evacuation Route signs around hazard areas.

Coordinating Organization: Douglas County Emergency Management, Douglas County Public Works, City of Reedsport, Oregon Department of Transportation
Timeline: Continue
Plan Goals Addressed: A, C, D

ACTION ITEM 6 –Control evacuation of hazard areas by ensuring capacity of evacuation routes
Ideas for Implementation
Prevent "onlookers" from becoming an obstacle to the evacuation of affected areas.

Coordinating Organization: Douglas County Emergency Management
Timeline: Continue
Plan Goals Addressed: A, C, D