9.4 Planning Process

9.4.6 State IHMT Meeting: July 2014

State Interagency Hazard Mitigation Team
DRAFT Meeting Agenda

Meeting Date & Time: Thursday, July 17, 2014, 9:00 to 11:30 a.m.

Meeting Location: Maj. Gen. Donald N. Anderson Readiness Center
3225 State Street[1] Salem 97301
Room #115, State ECC[2]

Call-In Number: telephone number; 1-888-363-4734, participant code; 152191

1) Introductions [5 minutes]
Dennis Sigrist, OEM

2) Action on minutes of April 17 meeting (distributed by email on June 18) [5 minutes]
Dennis

3) Grant updates [25 minutes]
Dennis
   a) Roll-out of HMGP for FEMA-4169-DR-OR
   b) HMGP "1733" and FMA 2009 project close-out by the end of this year
   c) PDM13
   d) PDM14 and FMA14

4) Improper Payments Elimination and Recovery Act (IPERA) [10 minutes]
Dennis

5) Oregon NHMP, 2015 preliminary draft [45 minutes]
Marian Lahav, DLCD

6) Other business [15 minutes]
Dennis, facilitating

7) Discuss/develop possible agenda items for October meeting [10 minutes]
Dennis, facilitating

8) Public comment [Each public speaker is limited to three minutes, unless the time is extended by the Chair.]
Dennis, facilitating

9) Adjourn

The next three meetings of the State IHMT are scheduled for October 16, January 15, and April 16.

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[1] Access to the Donald N. Anderson Readiness Center is via a controlled gate on Geer Drive NE, which is west of the building. A guard will ask for identification when you reach the entrance to the parking lot. Once inside the fence, standard entry to OEM's facility is through the double doors (use the portico walkway) on the east end of the building (Hawthorne Avenue side). Please do not park inside the chain-link fenced area on the east end. You may park anywhere outside of the chain-link fenced area.

[2] The meeting location is accessible to persons with disabilities. A request for an interpreter for the hearing impaired or for other accommodations for persons with disabilities should be made at least 48 hours before the meeting to Cherie Cline at 503-378-2911, ext. 22221 or TDD/TTY 503-373-7857. Questions about the agenda should be addressed to Joseph Murray via email joseph.murray@state.or.us or ext. 22240 or TDD/TTY as noted above.

REVISED DRAFT – revisions are in **bold text**

Minutes of the
July 17, 2014 meeting of the
State Interagency Hazard Mitigation Team

Meeting location: This meeting was held in the State Emergency Coordination Center (ECC) within the Donald N. Anderson Readiness Center in Salem.

The following people participated in the meeting:

Oregon Partnership for Disaster Resilience (OPDR)	Josh Bruce
	Michael Howard
	Sarah Allison (student)
	Emily Kettell (student)
	Elizabeth Miller (student)
Department of Administrative Services (DAS)	Darrin Brightman
	Daniel Christensen (on telephone)
Oregon Department of Agriculture (ODA)	Ryan Scholz
	Madeline Benoit (intern)
DCBS, Insurance Division	Kevin Jeffries
Department of Environmental Quality (DEQ)	Don Pettit (on telephone)
Office of State Fire Marshal (OSFM)	Claire McGrew
Dept. of Geology and Mineral Industries (DOGAMI)	Rachel Smith
OHA – Oregon Public Health Division	Jere High
Dept. of Land Conservation and Development (DLCD)	Matt Crall
	Marian Lahav
	Chris Shirley
Department of State Lands	Bill Ryan
OMD, Office of Emergency Management (OEM)	Sean McCormick
	Joseph Murray
	Dennis Sigrist
Oregon Department of Transportation (ODOT)	Greg Ek-Collins
Public Utility Commission (PUC)	Rick Carter
Water Resources Department (WRD)	Alyssa Mucken
Benton County Emergency Management	Eric Rau
	Krystle Garcia (intern)
U.S. Army Corps of Engineers (USACE)	D. Leslie (Les) Miller
Federal Emergency Management Agency (FEMA)	Brett Holt (on telephone)

The following were distributed during or prior to the meeting:

- *Meeting agenda*
- *Revised minutes of the April 17, 2014 meeting* (agenda item #2)
- Oregon NHMP handout with a first page titled *Table of Contents* (agenda item #3)

[Email joseph.murray@state.or.us for a copy of one or more meeting handouts.]

1) Introductions

   Dennis opened the meeting at 9:03 a.m. with telephone and microphone instructions, followed by introductions.

2) Action on revised minutes of April 17 meeting

   A revised draft had been distributed by email on June 18. The minutes were considered acceptable as revised.

3) Oregon NHMP, 2015 preliminary draft

Marian led off by thanking the many people who have been helping with the Oregon NHMP update. She noted that is DLCD doing this plan update "in half the time with one-quarter of the budget of the previous update." She provided an Oregon NHMP handout with pages titled: *Table of Contents* and *NEXT STEPS.* She also displayed on the screen a document entitled *2015 Oregon Natural Hazard Mitigation Plan Risk Assessment DRAFT v.02*.

Marian went through the *Table of Contents* handout (red, yellow, and green text shows things that are, respectively: not yet available; in process; and included in the current draft). She noted that there is a parallel process occurring to update the "enhanced" portions of the plan. Dennis later noted that this part of the plan also comes with a "FEMA report card" on the state's program management capability. This includes both financial grants management, and environmental and historic preservation (EHP) provisions. We have made good progress on the former and are working on the latter. Dennis notes that a big piece of this is the need to be adequately staffed. He said that Matt and Sean plan to work on this challenge during the Oregon Legislature's 2015 Session. Matt and Sean confirmed this, and Sean noted that it will be hard to regain enhanced status without additional staff.

Josh noted that local governments also are greatly lacking in mitigation staff resources and wonders if OEM or DLCD plan to take this up with the Oregon Legislature? Sean noted that this is not in our Legislative Concepts (LCs), but will likely become part of testimony if/when the LCs come before committees in the Oregon Legislature. Matt noted that DLCD plans to ask for additional money to help local communities, especially rural local communities to better implement their overall comprehensive plans.

Marian explained that the material that had been in the hazard chapters has been moved to other portions of the plan. "We plan to drop-in the THIRA[1] like we have done in the recent past." There will be a changes document that shows how the plan has changed since 2012.

She then highlighted new information on climate change. Brett noted that FEMA is developing guidance on how to address this, and that there will be an opportunity for comment, probably sometime within the next six months. Dennis asked, "Will this affect the current update?" Brett said, "No – there will be a long time period before it becomes effective."

Marian noted that DLCD is working with OPRD and OEM on new material on cultural resources, and also noted new work being led by ODOT on lifelines that will be included.

She then showed an example of how the regional profiles and "success stories" will look. Marian further indicated that she will provide a template for new success stories to be developed by State IHMT agencies for things that should be highlighted since 2012. She then showed an example of how information on local NHMP status will be included in the state plan. She emphasized work needed from State IHMT members on the mitigation action table.

She noted that the DLCD staff are having trouble with images, and are likely to ask State IHMT members for the original image files.

Marian said that DLCD wants to make the plan more Internet friendly, more of a living document on the Internet. There will be an outward facing public version and inward facing State IHMT version that our players can go in and edit and add to as things happen and change. She said that the current plan is about 1,200 pages. One of DLCD' goals for the 2015 version of the plan was to streamline it, but with all the material being added, that may not work-out.

Dennis noted that FEMA has changed the state NHMP update cycle from three to five years, so we automatically gained two years. At the very least, we have gained some wiggle room. Marian noted that we do have contractual obligations tied to the grant funding source. Dennis indicates that this likely could be extended for up to one year.

Dennis noted how **fortunate** Oregon is to have the State IHMT; many other states are not so fortunate to have a standing body like the State IHMT.

[1] THIRA is Threat and Hazard Identification and Risk Assessment.

4) Grant updates

   a) Roll-out of HMGP[2] for FEMA-4169-DR-OR[3]

      Dennis gave a brief update on his work with consumer owned utilities in the five declared counties to develop good applications for this HMGP offering.

   b) HMGP "1733" and FMA[4] 2009 project close-out by the end of this year

      Likewise, Dennis gave a very brief update on efforts underway to "close-out" grants provided on HMGP for FEMA-1733-DR-OR and FMA 2009.

   c) PDM[5]13

      Dennis noted complications the FEMA delay in funding of this grant has caused, especially in Lincoln County where the plan may expire before a project gets funded.

   d) PDM14 and FMA14

      Dennis talked about FMA work with Linn County on an severe repetitive loss (SRL) property (a grant application resubmission); and about the six counties with which OPDR plans to work under a PDM14 grant, to include cities within Deschutes County which have not previously had FEMA-approved plans. Chris talked about mitigation planning work DLCD is to facilitate with PDM14 grant funding with Tillamook County and its cities; as well as the cities of Albany and Medford.

      The non-participation of the City of Tualatin was noted; this has occurred despite considerable outreach by OEM and DLCD. Josh came back to lack of capacity at the local government level, but also noted that we end-up helping these communities all the same if there is an event. Josh noted that the challenge with McMinnville has long been capacity. Les indicated that local communities are looking for templates or examples. Dennis noted that both FEMA and OPDR provide great guidance and tools. Dennis then said that local communities really need to buy into the process of mitigation planning. Josh added that OPDR has a solid template and the holes that need to be filled require a good public process. Les noted that an education process with the local planning departments might help. Chris said that Central Point also declined state help, but because they felt they can do what needs to be done in the area of mitigation without being tied to the constraints of the federal funding.

      Dennis noted that OSU has also come on-board with a very strong PDM application for their main campus and satellite campuses. He then mentioned a project proposed by Portland and DOGAMI that includes better LIDAR characterization of risks.

5) Improper Payments Elimination and Recovery Act (IPERA)

   Dennis said if you haven't been touched by this yet, you likely will be. That was the extent of this agenda item.

6) Other business

   Matt noted that Chris has been appointed to the FEMA Technical Mapping Advisory Committee. Chris said she does not intend to do this alone and generally asked for help.

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[2] HMGP is Hazard Mitigation Grant Program.
[3] This and other entries like it are Presidential major disaster declaration numbers.
[4] FMA is Flood Mitigation Assistance.
[5] PDM is Pre-Disaster Mitigation, a FEMA grant program.

Les expressed his appreciation for being able to be involved in the State IHMT meeting today. He noted that when he works with local **communities** on their flood hazard, he always points **them** to their mitigation plans first. Les also noted the good work being done by "Silver Jackets" [the State IHMT's Flood Mitigation Subcommittee]. Les also noted the whole community approach.

Dennis mentioned one billion dollars in HUD money that he has been tracking for a couple of weeks now that is likely to turn into a resiliency grant program. Yesterday Dennis learned that this is to be a two-phase process with the first phase involving essentially a risk assessment. Dennis says we will work with Business Oregon, and that Reedsport is a possible candidate for this funding. Josh noted that the White House made an announcement yesterday about a new climate based resilience initiative that includes, but is not limited to, this HUD money. It includes a mitigation task force at the federal level. It also includes new NOAA money ($1.5 million competitive), and EPA and CDC money.

Dennis noted that OEM has two projects going in Benton County, one of which involved moving a big home on its property from an area inside the floodplain to an area well outside of the floodplain.

Chris talked about a Silver Jackets project just funded to do a specific building risk assessment project in the Lents Neighborhood in Portland's (Johnson Creek) Foster Road area.

Brett noted that FEMA plans to have a booth this weekend at an event in Portland.

Dennis gave a brief update on the fire situation around the state and noted that as soon as this meeting ends, OEM is going to move toward setting-up the ECC for a possible activation.

7) Discuss/develop possible agenda items for October meeting

Joseph noted that there are already four agenda commitments for the October 16 meeting:

- Our standing agenda item on the Oregon NHMP;
- DLCD (Marian and Lisa) want to revisit the topic of prioritizing our hazards;
- DOGAMI (Yumei) wants to talk about the Top-10 priority needs on liquefaction and lateral spreading; and
- OEM (Sean) wants DLCD to do an update on the proposed new Oregon Risk Assessment Model.

Josh noted that the October meeting would be prime time to look at the *Oregon Resiliency Plan* recommendations to the 2015 Oregon Legislative Session because those are due in the same timeframe. Dennis encouraged State IHMT members to email Joseph with additional agenda requests.

8) Public comment

No members of the general public were present, so there was no public comment.

9) Adjourn

The meeting was adjourned at 10:29 a.m.

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KEY

Red – not yet available

Yellow – in process

Green – included in the current draft

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  - **b. Information on 1931 Dust Storm**
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NEXT STEPS

Mitigation Action Tables: Review, Revise, Supplement — August 1

Mitigation Action Successes — September 1

- Use MA Tables for Thought Triggers
- Use Template

Specific Questions and Assistance

- Data
- Specific Information
- Processes and Procedures
- Original Image Files

DOGAMI's Publications Expert will format, construct, and edit

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FINAL DRAFT SEPTEMBER 30, 2014!!

2015 Oregon Natural Hazard Mitigation Plan

Risk Assessment

* DRAFT *

v.02, 07/17/2014

Chapter 2
RISK ASSESSMENT

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            ii. State
        d. Vulnerability
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In This Chapter

The Oregon NHMP Risk Assessment is divided into four sections: 1) introduction, 2) executive summary, 3) state risk assessment and 4) regional risk assessment. Following is a description of each section.

1. **Introduction:** *States the purpose of the risk assessment and understanding risk.*
2. **Executive Summary:** *Summarizes the analysis and findings in the State and Regional Profiles.*
3. **State Risk Assessment:** *Includes the following components:*
   - Oregon Hazards: *Profiles each of Oregon's hazards by identifying each hazard, its generalized location and presidentially declared disasters; introduces how the state is impacted by climate change; characterizing each hazard that impacts Oregon; listing historic events; identifying the probability of future events; and introducing how climate change is predicted to impact each hazard statewide.*
   - Oregon Vulnerabilities: *Includes an overview and analysis of the State's vulnerability to each hazard by identifying which communities are most vulnerable to each hazard based on local and state vulnerability assessments; providing loss estimates for State owned or leased facilities and critical or essential facilities located in hazard areas; and identifying seismic lifeline vulnerabilities.*
   - Future Enhancements: *Describes ways in which Oregon is planning to improve future state risk assessments.*
4. **Regional Risk Assessment:** *Includes the following components:*
   - Regional Summary: *Summarizes the OEM Natural Hazard Region's statistical profile, hazard and vulnerability analysis; and projected impacts of climate change on hazards in the region.*
   - Regional Profile: *Provides an overview of the region's unique characteristics, including a natural environment profile, social /demographic profile, economic profile, infrastructure profile, and built environment profile.*
   - Regional Hazards and Vulnerability: *Further describes the hazards in each region by charactering how each hazard presents itself in the region; listing historic hazard events in the region; and identifying probability of future events based on local and state analysis. Also includes an overview and analysis of the region's vulnerability to each hazard; identifies which communities in the region are most vulnerable to each hazard based on local and state analysis; provides loss estimates for State owned or leased facilities and critical or essential facilities located in hazard areas; and identifies the region's seismic lifeline vulnerabilities.*

Introduction

Requirement 44 CFR §201.4(c)(2), [The plan must include] risk assessments that provide the factual basis for activities proposed in the strategy portion of the mitigation plan. Statewide risk assessments must characterize and analyze natural hazards and risks to provide a statewide overview. This overview will allow the State to compare potential losses throughout the State and to determine their priorities for implementing mitigation measures under the strategy, and to prioritize jurisdictions for receiving technical and financial support in developing more detailed local risk and vulnerability assessments.

Purpose

The purpose of the Oregon NHMP Risk Assessment is to identify and characterize Oregon's natural hazards, determine which jurisdictions are most vulnerable to each hazard and estimate potential losses to vulnerable structures and infrastructure and to state facilities from those hazards.

It is impossible to predict exactly when natural hazards will occur, or the extent to which they will affect communities within the state. However, with careful planning and collaboration, it is possible to minimize the losses that can result from natural hazards. The identification of actions that reduce the state's sensitivity and increase its resilience assist in reducing overall risk – or the area of overlap in Figure 2-1 below. The Oregon NHMP Risk Assessment informs the State's mitigation strategy, as found in Chapter XX (pg.XX).

Figure 2-1: Understanding Risk

Assessing the state's level of risk involves three components: characterizing natural hazards, assessing vulnerabilities and analyzing risk. Characterizing natural hazards involves determining hazards' causes and characteristics, documenting historic impacts, and identifying future probabilities of hazards occurring throughout the State. The section in this risk assessment titled Oregon Hazards characterizes each of the state's natural hazards.

A vulnerability assessment combines information from the hazard characterization with an inventory of the existing (or planned) property and population exposed to a hazard, and attempts to predict how different types of property and population groups will be affected by each hazard. Vulnerability is determined by a community's exposure, sensitivity, and resilience to natural hazards, as well as its ability to mitigate, prepare for, respond to, and recover from a disaster. The section Oregon Vulnerabilities identifies and assesses the state's vulnerabilities to each hazard identified in the Oregon Hazards section of this risk assessment.

Finally, a risk analysis involves estimating the damages, injuries, and costs likely to be incurred in a geographic area over a period of time. Risk has two measurable components: (1) the magnitude of the harm that may result, defined through vulnerability assessments, and (2) the likelihood or probability of the harm occurring, defined in the hazard characterization. Together, the Oregon Hazards and Oregon Vulnerabilities sections form the state's risk analysis.

Executive Summary

< Placeholder for Executive Summary >

State Risk Assessment

Oregon Hazards

Overview

Requirement: 44 CFR §201.4(c)(2)(i): Th[e] risk assessment shall include… (i) (a)n overview of the type and location of all natural hazards that can affect the State…

The State of Oregon is subject to 11 primary hazards. Table 2-2 lists each hazard and describes in general terms where the hazard is located. Each hazard is described in greater detail later in State Risk Assessment, including an introduction, description, historical events and probability on pages 23-155. The state's vulnerability to each hazard is discussed in the Oregon Vulnerabilities section of the state risk assessment, beginning on page 156.

Table 2.2: Oregon Hazard Overview

Hazard	Generalized Locations
Coastal Hazards	West Oregon Coast
Drought	Generally east of the Cascades, with localized risks statewide
Dust Storm	Generally east of the Cascades
Earthquake	
Cascadia Subduction	Primarily Western Oregon
Other Active EQ Faults	Localized Risks Statewide
Flood	Localized risks statewide
Landslide/ Debris Flow	Localized risks statewide
Tsunami	West Oregon Coast*
Volcano	Central Oregon, Cascade Range and Southeast Oregon, High Lava Plains
Wildfire	Primarily Southwest, Central and Northeast Oregon, with localized risks statewide
Windstorm	Localized Risks Statewide
Winter Storm	Localized Risks Statewide

** Potential tsunami inundation for five levels of local Cascadia scenarios and two maximum-considered distant tsunami scenarios are available as published maps and geographic information (GIS) files through the Oregon Department of Geology and Mineral Industries (DOGAMI). GIS files were released in 2013 as Open-File Report O-13-19.*

Source: Oregon NHMP lead state agency(ies) for each hazard

Since 1955 (the year the U.S. began formally tracking natural disasters), Oregon has received 28 major disaster declarations, two emergency declarations and 49 fire management assistance declarations. Table 2.3 below lists each of the major disaster declarations, the hazard that the disaster is attributed to and counties impacted. Since 1955, Clatsop, Douglas, Lincoln, Tillamook and Yamhill Counties have each been impacted by ten or more federally declared non-fire related disasters. Of the 28 major disasters to impact Oregon, the vast majority have resulted from storm events; notably, flooding impacts from those events are reported in over two-thirds of the major disaster declarations.

The reported federal disaster declarations (including fire management assistance declarations) document that storm events, floods and wildfires have been the primary chronic hazards with major

disaster impacts in Oregon over the last half century. The data also show a trend geographically of a greater number of major federal disaster declarations in the northwest corner of the state. Anecdotally, this pattern plays out for non-federally declared hazard events in the state as well. The following subsections summarize type, location, history and probability information for each of the hazard types listed above.

Table 2.3: Presidential Major Disaster Declarations Since 1955

Disaster	Incident Period	Disaster Type	Baker	Benton	Clackamas	**Clatsop**	Columbia	Coos	Crook	Curry	Deschutes	**Douglas**	Gilliam	Grant	Harney	Hood River	Jackson	Jefferson	Josephine	Klamath	Lake	Lane	**Lincoln**	Linn	Malheur	Marion	Morrow	Multnomah	Polk	Sherman	Siletz IR	**Tillamook**	Umatilla	Union	Wallowa	Warm Springs IR	Wasco	Washington	Wheeler	**Yamhill**
DR-4055	1/17 - 1/21/2013	Severe winterstorm / flooding /landslides / mudslides		X			X	X		X		X				X						X	X	X		X			X			X								
DR-1964	3/11/2011	Tsunami						X		X													X																	
DR-1956	1/13-1/21/2011	Winter storms / flooding / mudslides / landslides / debris flows			X	X			X			X											X									X								
DR-1824	12/13-1/26/2008	Winter storms / flooding			X	X	X																			X		X	X			X						X		X
DR-1733	12/1-12/17/2007	Storms / flooding / landslides / mudslides				X	X																						X			X						X		X
DR-1683	12/14-12/15/2006	Winter storms / flooding		X		X	X																X						X		X	X					X		X	X
DR-1672	11/5-11/8/2006	Storms / flooding / landslides / mudslides				X										X							X									X								
DR-1632	12/18/2005-1/21/2006	Storms / flooding / landslides / mudslides		X	X	X	X	X	X	X		X	X				X	X	X				X	X					X	X		X				X			X	X
DR-1510	12/26/2003-1/14/2004	Winter storms	X	X	X	X	X		X		X	X	X	X	X	X		X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
DR-1405	2/7-2/8/2002	Wind storm						X		X		X										X		X																
DR-1221	5/28-6/3/1998	Flooding							X																															
DR-1160	12/25/1996-1/6/1997	Winter storm / flooding						X				X					X		X	X	X	X													X					
DR-1107	12/10-12/12/1995	Storms / high winds		X		X	X					X										X	X	X								X						X		X
DR-1099	2/4-2/21/1996	Storms / flooding		X	X	X	X	X			X	X	X			X		X	X			X	X	X		X	X	X	X	X		X	X	X	X		X	X		X
DR-1061	7/8-7/9/1995	Flash flooding																																			X			
DR-1036	5/1-10/31/1994	El Nino effects																																						
DR-1004	9/20/1993	Earthquakes																		X																				
DR-985	3/25/1993	Earthquake			X																					X												X		X
DR-853	1/6-1/9/1990	Storms / flooding				X																										X								
DR-413	1/25/1974	Storms / snow melt / flooding		X	X		X	X		X		X	X			X	X		X			X	X			X			X			X			X		X	X		X
DR-319	1/21/1972	Storms / flooding			X	X		X				X										X	X	X				X				X						X		
DR-301	2/13/1971	Storms / flooding				X																										X								
DR-184	12/24/1964	Heavy rains / flooding	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Total number of disasters by county / IR* post 1964			2	7	9	**13**	9	8	5	5	3	**10**	5	2	2	5	4	4	5	3	3	8	**11**	7	2	6	3	5	8	4	1	**14**	3	3	5	1	6	8	4	**10**
DR-144	2/25/1963	Flooding	No individual county impact data available																																					
DR-136	10/16/1962	Storms																																						
DR-69	3/1/1957	Flooding																																						
DR-60	7/20/1956	Storm/flooding																																						
DR-49	12/29/1955	Flooding																																						

* IR = Indian Reservation

Source: Oregon Emergency Management, 2013

Introduction to Climate Change

This section presents an overview of climate change in Oregon. Climate is an important element in certain natural hazards, even though in itself, climate is not a distinct natural hazard.

In broad terms, climate in the Pacific Northwest is characterized by variability, and that variability is largely dominated by the interaction between the atmosphere and ocean in the tropical Pacific Ocean that is responsible for El Niño and La Niña. Human activities are changing the climate, particularly temperature, beyond natural variability. Climate change is already affecting Oregon communities and resources, and needs to be recognized in various planning efforts as an important stressor that significantly influences the incidence—and in some cases the location—of natural hazards and hazard events. Climate change is anticipated to affect the frequency and/or magnitude of some kinds of natural hazards in Oregon. A brief review of some of the observed changes in Oregon or the Pacific Northwest will give some idea of the influence of climate on natural hazards. First, temperatures increased across the Pacific Northwest by 1.3˚F in the period from 1895-2011 (the observed record). In that same timeframe, Cascade Mountain snowpacks have declined, and higher temperatures are causing earlier spring snowmelt and spring peak streamflows. On the coast, increasing deep-water wave heights in recent decades are likely to have increased the frequency of coastal flooding and erosion. In Oregon's forested areas, large areas have been impacted by disturbances that include wildfire in recent years, and climate change is probably one major factor. Closer to home for some Oregonians, a three-fold increase in heat-related illness has been documented in Oregon with each 10 ˚F rise in daily maximum temperature. (Dalton et al 2013, OCCRI 2010).

Oregon Responses to Climate Change

The human influence on the climate is clear (IPCC 2013). Global greenhouse gas emissions will determine the amount of warming both globally and here in Oregon. On that basis, Oregon and other states and local communities have undertaken measures to reduce greenhouse gas emissions as a way to slow the warming trend. Similarly, states and local communities are beginning to implement measures to adapt to future climate conditions that cannot be avoided. The global climate has considerable inertia, so the changes that can be anticipated today are largely a result of conditions that occurred up to several decades, almost a century ago. Inertia in the global climate system cannot be immediately influenced, so states and communities are beginning to do 'climate adaptation planning' on local and regional scales. In many cases, planning for climate change—or adaptation planning—quickly comes down to improved planning for natural hazards, since many of the anticipated effects of climate change will be experienced in the form of natural hazard events. That said, planning to adapt to climate change and planning to mitigate natural hazards are not entirely the same thing, although there is considerable overlap. Planning for climate change also includes planning for public health and natural resource protection.

In 2010, the State of Oregon produced the Oregon Climate Adaptation Framework. This framework identifies 11 climate-related risks for which the state must plan for. Five of those eleven climate risks—drought, coastal erosion, fire, flood, and landslides— are directly identified in the Oregon NHMP. In addition, three other hazards in the Oregon NHMP —wind storms, winter storms, and dust storms—have an underlying climate component.

Oregon and the Pacific Northwest have been rich in climate impacts research over the last eighteen years. In 2007, the Oregon Legislature created the Oregon Climate Change Research Institute (OCCRI) under HB3543 (OCCRI). Much of the material in this section is drawn from two reports from OCCRI: the 2010 Oregon Climate Assessment Report (OCCRI 2010) and the 2013 Northwest Climate Assessment Report (Dalton *et al.* 2013), both found at http://occri.net/reports. This section is not meant to be a comprehensive assessment of climate change and impacts in Oregon or an all-encompassing overview of each hazard. Rather, it presents future projections of temperature and precipitation, and describes some of the effects of such future conditions based on the frequency and magnitude of natural hazards in Oregon.

Past and Future Climate in Oregon (Mote et al, 2013)

Historical (1895-present)

The impacts of climate change in Oregon are largely driven by temperature and precipitation. Temperatures in the Pacific Northwest increased 1.3 ˚F over the historical period (1895-2011 observed period). Over the last 30 years, temperatures in Oregon have generally been above the 20th century average (Figure 2-CC-1). The average annual temperatures in all but two years since 1998 have been above the average annual temperatures for the 20th century. Within the same historical time period, annual precipitation amounts fall within the normal range of natural annual variability.

Future climate

Climate modeling is mostly performed at global to regional scales because of the computational power required. The temperature and precipitation projections relied on for this summary use data from the grid cells covering the Pacific Northwest in Global Climate Models. Since the Pacific Northwest region is relatively homogenous in its climate, Global Climate Model projections for the Pacific Northwest are relevant for planning in Oregon.

A number of research centers around the world run computerized Global Climate Models (GCMs), which provide scientists and decision makers with simulations of future global climate for comparison purposes. One such project, the Coupled Model Intercomparison Project (CMIP), involves many of these modeling centers worldwide. CMIP offers many simulations for scientists to use to assess the range of future climate projections for the globe. The latest CMIP experiment is the 5th phase of the project and is thus referred to as the CMIP5. CMIP5 simulations of the 21st century climate are driven by what are called “representative concentration pathways” (RCPs). RCPs represent the total amount of extra energy (in watts/m^2) entering the climate system throughout the 21st century and beyond.

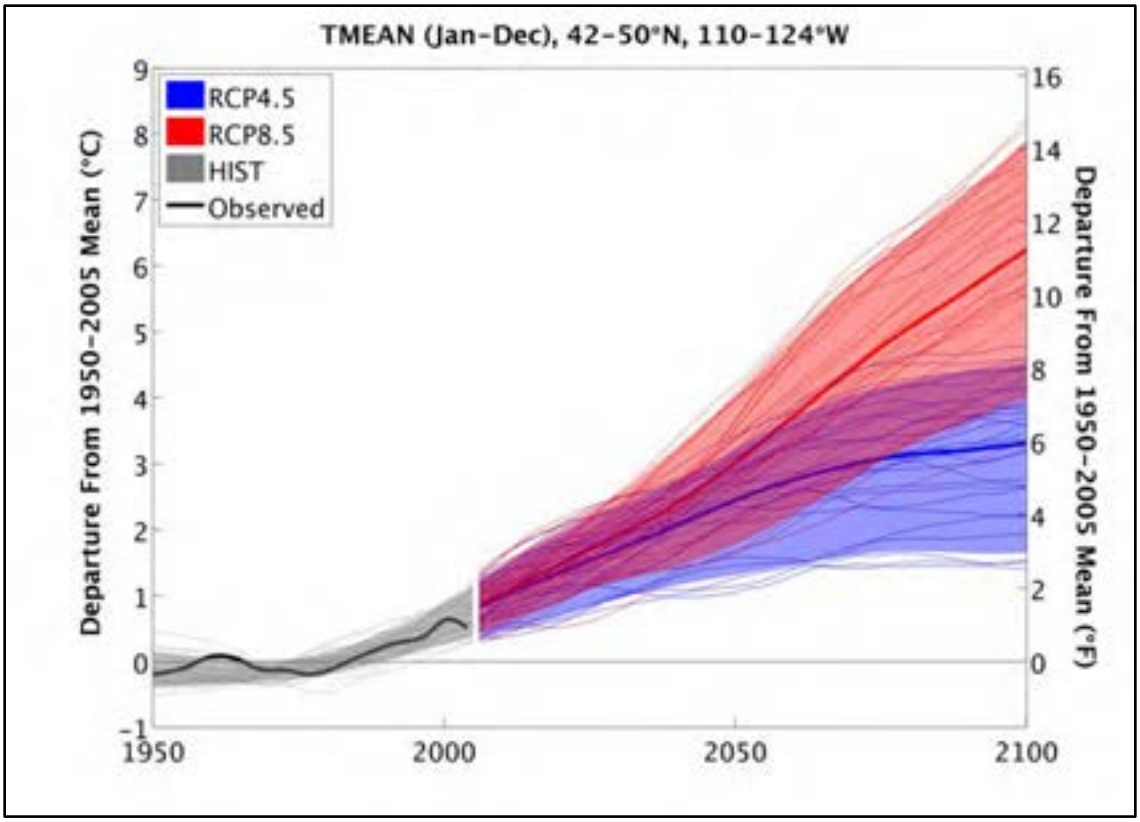

Figure 2-CC-1: Observed (1950-2011, black line) and simulated (1950-2100) regional mean annual temperature for selected GCMs for RCP 4.5 and 8.5 scenarios.

Source: Dalton et al., 2013

This summary and the Pacific Northwest section of the National Climate Assessment use scenarios RCP 4.5, which represents a significant reduction in global greenhouse gases; and RCP 8.5, which represents increasing greenhouse gases over time. Figure 2-CC-1 shows observed mean global temperatures from 1950 to 2011, and simulated mean temperatures under the two different RCPs from 2011 to 2100. Note that the projected temperature trends under different RCPs generally track closely until about 2030 or so, and they dramatically diverge after 2050.

Seasonality

Some of the most relevant climate data for planning purposes, and the most crucial to some of the hazards addressed in this plan, are seasonal projections of temperature, seasonal projections of precipitation, and change in extreme precipitation events (Tables 2-CC- 2, 3 and 4).

Tables 2-CC-2 and 3 below summarize a lot of information drawn from analyses of CMIP5 data[1]. Table 2-CC-2 contains the maximum, mean, and minimum projected changes in Pacific Northwest temperatures

[1] In this and the following discussions about Tables 1and 2, the maximum, mean, and minimum values represent the maximum model projection, the multi-model mean, and the minimum model projection.

from historical (1950-1999) to mid-21st century (2041-2070), using both RCP 4.5 and RCP 8.5 scenarios. Projected changes are shown annually and for each season.

Every climate model shows an increase in temperature for the Pacific Northwest, with the magnitude of the increase depending on rate or magnitude of global greenhouse gas emissions. *There is no plausible scenario in which the Pacific Northwest cools in the next century*. New models project an increase by mid-century (2041-2070) in annual temperatures in the PNW of 2.0°F to 8.5°F over the recent past (1970-1999). The lower projection is possible only if greenhouse gas emissions are significantly reduced (Figure 2-CC-2, RCP4.5 scenario). Both scenarios show a similar amount of warming through about 2040, meaning that temperatures beyond 2040 depend on global greenhouse emissions occurring now (Mote et al. 2013).

Of particular note in Table 2-CC-2 is that both scenarios (for RCP 4.5 and RCP 8.5) show increased average temperatures for the year *and for every season*. All models are in agreement that each season will be warmer in the future, and that the largest amount of warming will occur in the summer. Increased average winter temperatures will result in less snowpack in Oregon. Increased summer temperatures have the potential to increase the potential for wildfires and increase health-threats from poor air quality conditions and the potential for heat waves.

Table 2-CC-2: Projected change in average temperatures (maximum, mean, and minimum) for two scenarios, from last half of 20th to mid-21st centuries, in degrees Celsius

Time Period	Annual		Winter (J, F, M)		Spring (A, M, J)		Summer (J, A, S)		Fall (O, N, D)	
Scenario	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
Maximum change	3.7°	4.7°	4.0°	5.1°	4.1°	4.6°	4.1°	5.2°	3.2°	4.6°
Mean change	2.4°	3.2°	2.5°	3.2°	2.4°	3.0°	2.6°	3.6°	2.2°	3.1°
Minimum change	1.1°	1.7°	0.9°	1.3°	0.5°	1.0°	1.3°	1.9°	0.8°	1.6°

Source: Dalton et al. 2013

Table 2-CC-3 contains a summary of projected change, *in percent*, in average precipitation for the Pacific Northwest (maximum, mean, and minimum) from historical (1950-1999) to mid-21st century (2041-2070), under both RCP 4.5 and RCP 8.5 scenarios. Projected changes are shown annually and for each season.

Note in the "Annual" columns in Table 2-CC-3 that precipitation amounts are projected to remain within the range of current natural variability. However, Table 2-CC-3 also shows that there is some indication from climate models that summers will be drier in the future.

Table 2-CC-3: Projected changes in average precipitation (maximum, mean and minimum) for two scenarios, from last half of 20th to mid-21st centuries, in percent										
Time Period	**Annual**		**Winter (J, F, M)**		**Spring (A, M, J)**		**Summer (J, A, S)**		**Fall (O, N, D)**	
Scenario	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
Maximum change	10.1	13.4	16.3	19.8	18.8	26.6	18	12.4	13.1	12.3
Mean change	2.8	3.2	5.4	7.2	4.3	6.5	-5.6	-7.5	3.2	1.5
Minimum change	-4.3	-4.7	-5.6	-10.6	-6.8	-10.6	-33.6	-27.8	-8.5	-11

Source: Dalton et al. 2013

Extreme Precipitation

Natural hazards are often an expression of extreme conditions—wind storms, rain storms, floods, droughts, and so on. Extreme precipitation is perhaps the most common and widespread natural hazard in Oregon. Many people may associate extreme rainfall events almost exclusively with western Oregon, but in fact extreme precipitation events occur across the entire state.

Projected future changes in extreme precipitation are less ambiguous (Table 2-CC-4) than changes in total seasonal precipitation. The North American Regional Climate Change Assessment Program (NARCCAP) results indicate increases throughout the Northwest in the number of days above every threshold. Table 2-CC-4 shows the projected *percent change* in the number of days when rainfall will exceed thresholds of one, two, three, and four inches.[2] These projections (which are based on different models from those summarized in Tables 2-CC-2 and 3) show there will likely be an increase in extreme events of several different magnitudes. Note that the higher magnitude events show the largest overall increase. Note that although the frequency of extreme events rises in percentage with the magnitude of the extreme, the standard deviation rises faster. In other words, only modest events (>2.5 cm or 1 inch) increase by much more than one standard deviation (Mote et al 2013).

[2] Table 3 summarizes data from the North American regional Climate Change Assessment Program (NARCCAP). See http://www.narccap.ucar.edu/. NARCCAP is a multi-institution regional modeling effort with a coordinated approach similar to CMIP, described above.

Table 2-CC-4: Change in the number of days with extreme precipitation (from mid-century (2041-2070) minus historical (1971-2000)) over four thresholds, in percent[3]; and Standard Deviation		
	NARCCAP mean change	**NARCCAP standard deviation**
Change in the number of days with precipitation ***over one inch***	+13%	7%
Change in the number of days with precipitation ***over two inches***	+15%	14%
Change in the number of days with precipitation ***over three inches***	+22%	22%
Change in the number of days with precipitation ***over four inches***	+29%	40%

Source: Dalton et al. 2013

Effect of Oregon's Future Climate Conditions on Natural Hazards

In 2010, Oregon achieved a significant milestone in the release of two reports for two important initiatives that developed in parallel, and both addressed climate change across the state. In November 2010, OCCRI released the Oregon Climate Assessment Report (OCCRI, 2010), the first ever comprehensive scientific assessment of climate change in Oregon. At the same time, the state released the Oregon Climate Change Adaptation Framework, representing the efforts of over a dozen state agencies and institutes, including OCCRI, to begin to establish a rigorous framework for addressing the effects of climate change across the state. More recently, the 2010 Oregon Climate Assessment Report was updated by the 2013 Northwest Climate Assessment Report, also produced by OCCRI. The framework, however, has not been updated since its release in 2010.

Development of Oregon's Climate Change Adaptation Framework was significant in that the state began to address the need to plan for the effects of future climate conditions. Furthermore, Oregon's framework is the first state-level adaptation strategy based on *climate risks* as opposed to *affected sectors*. Oregon's framework lays out eleven climate risks that are of concern to the state. The risks provide a consistent basis for agencies and communities to review plans and decisions to identify measures to reduce those risks. Many of the risks in the Oregon Framework are natural hazards.

Following is a summary of the principal effects of changing climate conditions on the natural hazards addressed in the Oregon NHMP. Hazards are discussed together where the climate changes and drivers are essentially the same. How each hard (or group of hazards) affects each of the eight Oregon Office of Emergency Management (OEM) Hazard Mitigation Regions is then summarized. See Figure 2-CC-2 for the location of these regions.

[3] Values calculated at gridpoint, then averaged.

Relationship between Adaptation Framework *Risks* and *Hazards* in the Oregon NHMP

What is contained in Table 2-CC-5: The leftmost column contains the climate *risks* in the Oregon Climate Change Adaptation Framework. Column headings show natural hazards identified in the Oregon Natural Hazard Mitigation Plan.

How to read this table: Cells with an 'x' or 'X' show which *climate risks* will affect the frequency, intensity, magnitude or duration of which *natural hazards*. A big 'X 'shows a primary relationship between the risk and the hazard. A small 'x' shows a secondary relationship. The green cells in the body of the table show where an Adaptation Framework *risk* and a natural hazard in the Oregon NHMP are essentially the same thing.

Note that the first two risks—increased temperatures and changes in hydrology—are *the primary climate drivers* for natural hazards. The other climate risks represent known environmental or ecosystem responses to one or both of the primary drivers. Note also that a clear link has not been established between climate change and the frequency or intensity of wind storms.

Table 2-CC-5: Relationship between Adaptation Framework *Risks* and *Hazards* in the Oregon NHMP

	NHMP hazards								
Adaptation Framework climate risks	**Coastal erosion**	**Droughts**	**Dust storms**	**Fire**	**Flood/ CMZ**	**Landslides**	**Wind storms**	**Winter storms**	**Heat wave[4]**
Increased temperatures	x	X	x	X					X
Changes in hydrology		X	x		X	X			
Increased wildfires		x	x	X	x	x			
Increase in ocean temperatures and changes in ocean chemistry	X				x			X	
Increased drought		X		X					
Increased coastal erosion	X					x			
Changes in habitat									
Increase in invasive species and pests		x		X					
Loss of wetland ecosystems and services		X	X		X				
Increased frequency of extreme precipitation events and flooding					X	X		x	
Increased landslides						X			

[4] Heat waves are not identified as a natural hazard in the current natural hazard mitigation plan.

Figure 2-CC-2: OEM Hazard Mitigation Regions

Coastal Erosion and Coastal Flooding.

Regions affected: 1

Oregon's ocean shoreline is constantly subject to the dynamic and powerful forces of the Pacific Ocean, and it changes at timescales that vary from days to decades. Variable and changing ocean conditions continuously reshape the ocean shoreline, particularly where the shore is comprised primarily of sand. Sand levels on Oregon's beaches generally experience an annual cycle of erosion through winters and rebuilding in summer months. Over any extended time period, sandy beaches and shores will build out and retreat several times, due in part to the effects of winds, storms, tides, currents and waves. These cycles can occur over decades. In the annual cycle, beach profiles do not always recover to the heights and extent of previous years. In recent years, sand levels have remained fairly low at many locations on the Oregon coast.

The shape of Oregon's ocean shoreline is a function in part of ocean water levels and wave heights. Ocean water levels are also a primary factor in the frequency of flooding around the fringes of Oregon's estuaries. In other words, erosion of the ocean shore is directly affected by sea levels and wave heights. Flooding on the estuarine fringe is affected by ocean water levels—including tides and storm surges—in addition to freshwater inflow from the estuarine watershed. Other factors influence coastal erosion, but sea levels and wave heights are the primary climate-related drivers that influence rates of coastal erosion.

Recent studies make it clear that global ocean water levels are rising. Global sea levels are projected to rise 8-23 cm by 2030 and 18-48 cm by 2050 (NRC 2012). In Oregon (as elsewhere)

the rates of *relative* sea level rise are not the same as rates of change in global sea levels, because of a number of factors related to ocean conditions and vertical movement of the land. Oregon's western edge is rising, so the rates of sea level rise in Oregon are not as high as rates seen in other west coast locations. But even after factoring in local conditions, sea levels along Oregon's coast are rising. For more information on coastal erosion and see level rise, see the Coastal Hazards section of this Plan, beginning on page 24.

Recent research also indicates that significant wave heights off Oregon are increasing. Increasing significant wave heights may be a factor in the observed increase of coastal flooding events in Oregon. During El Niño events, sea levels can rise up to about 1.5 feet (0.5 meters) higher over extended periods (seasons).

Rising sea levels and increasing wave heights are both expected to increase coastal erosion and coastal flooding.

One of the climate risks discussed in the Oregon Climate Adaptation Framework is "Increased coastal erosion and risk of inundation from increasing wave heights and storm surges." The executive summary of the Adaptation Framework provides a summary of various challenges associated with increased coastal erosion:

> *Increased wave heights, storm surges, and sea levels can lead to loss of natural buffering functions of beaches, tidal wetlands, and dunes. Accelerating shoreline erosion has been documented, and is resulting in increased applications for shore protective structures. Shoreline alterations typically reduce the ability of beaches, tidal wetlands, and dunes to adjust to new conditions.*
>
> *Increasing sea levels, wave heights and storm surges will increase coastal erosion and likely increase damage to private property and infrastructure situated on coastal shorelands. Coastal erosion and the common response to reduce shoreland erosion can lead to long-term loss of natural buffering functions of beaches and dunes. Applications for shoreline alteration permits to protect property and infrastructure are increasing, but in the long term they reduce the ability of shore systems to adjust to new conditions.*

Drought, Wildfire, and Dust Storms.

Regions affected: 1-8

All eight regions in the Oregon NHMP are potentially affected by increasing incidence of drought and wildfire. Moreover, areas that have historically been both hotter and drier than the statewide average—southwest Oregon counties and central and eastern Oregon—are at somewhat higher risk of increased drought and wildfire than the state overall.
There is no current research available on the direct effects of future climate conditions on the incidence of dust storms. However, because drought conditions have the effect of reducing wetlands and drying soils, droughts can increase the amount of soil particulate matter available to be entrained in high winds, in particular where agriculture practices include tilling. This correlation between drought conditions and dust storms means that an increase in future

droughts could increase the incidence of dust storms, even though the drought is unrelated to the storm.

Droughts, fires, and dust storms are addressed as separate hazards in this plan. However, the underlying climate mechanism is similar for each. These hazards all occur in conjunction with warmer and drier conditions.

Virtually all climate models project warmer, drier summers for Oregon, with mean projected seasonal increases in summer temperatures of 2.6 to 3.6 ˚C by mid-century, and a decline in mean summer precipitation amounts of 5.6 to 7.5 percent by mid-century. These summer conditions will be coupled with by projected decreases in mountain snowpack due to warmer winter temperatures. Models project a mean increase in winter temperatures of 2.5 to 3.2 ˚C by mid-century. This combination of factors exacerbates the likelihood of drought, which in turn often leads to an increase in the incidence and likelihood of wildfires and dust storms.

Two climate risks that are somewhat prominent in the framework are "Increase in wildfire frequency and intensity" and "Increased incidence of drought." Dust storms were not addressed in the framework as a climate risk; at the time the framework was developed, research literature on the climatic conditions behind dust storms was scarce or nonexistent.
The executive summary of Oregon's Climate Change Adaptation Framework provides a summary of challenges associated with increased incidence of both wildfires and drought, as follows.

Wildfire
Increased temperatures, the potential for reduced precipitation in summer months, and accumulation of fuels in forests due to insect and disease damage (particularly in eastside forests[5]) present high risk for catastrophic fires. An increase in frequency and intensity of wildfire will damage larger areas, and likely cause greater ecosystem and habitat damage. Larger and more frequent wildfires will increase human health risks due to exposure to smoke.

Increased risk of wildfire will result in increased potential for economic damage at the urban-wildland interface. Wildfires destroy property, infrastructure, commercial timber, recreational opportunities, and ecosystem services. Some buildings and infrastructure subject to increased fire risk may not be adequately insured against losses due to fire. Increased fire danger will increase the cost to prevent, prepare for, and respond to wildfires.

Drought

Longer and drier growing seasons and drought will result in increased demand on ground water resources and increased consumption of water for irrigation, which will have potential consequences for natural systems. Droughts affect wetlands, stream systems, and aquatic habitats. Drought will result in drier forests and increase likelihood of wildfire.

[5] Forests east of the crest of the Cascade Range.

Droughts will cause significant economic damage to the agriculture industry through reduced yields and quality of some crops. Droughts can increase irrigation-related water consumption, and thus increase irrigation costs. Drought conditions can also have a significant effect on the supply of drinking water.

Winter Storms, Flooding, and Landslides

Regions affected: 1-4

Flooding and landslides are projected to occur more frequently throughout western Oregon, in Oregon NHMP Regions 1 through 4. While winter storms affect all areas of the state, there is no current research available indicating any change in the incidence of winter storms due to changing climate conditions.

The increase in extreme precipitation that is projected to occur at all thresholds from 1 to 4 inches per day (see Table 2-CC-4) is expected to result in a greater risk of flooding in certain basins. Changes in flood risk are strongly associated with the dominant form of precipitation in a basin, with mixed rain-snow basins in Washington and Oregon already seeing increases in flood risk. Generally, western Oregon basins are projected to experience increased flood risk in future decades. Increased flood risk involves both an increased incidence of flooding of a certain magnitude and an increase in the magnitude of floods of a certain return interval. In other areas of the state, flood risk may decrease in some basins and increase in others.

Landslides in Oregon are strongly correlated with rainfall, so increased rainfall— particularly in extreme events—will likely trigger increased landslides.

The executive summary of Oregon's Climate Change Adaptation Framework provides a summary of challenges associated with both flooding and landslides:

Floods:

Extreme precipitation events have the potential to cause localized flooding due partly to inadequate capacity of storm drain systems. Extreme events can damage or cause failure of dam spillways. Increased incidence and magnitude of flood events will increase damage to property and infrastructure, and will increase the vulnerability of areas that already experience repeated flooding. Areas thought to be outside the floodplain may begin to experience flooding. Many of these areas have improvements that are not built to floodplain management standards and are not insured against flood damage; therefore being more vulnerable to flood events. Finally, increased flooding will increase flood-related transportation system disruptions, thereby affecting the distribution of water, food, and essential services.

Landslides

Increased landslides will cause increased damage to property and infrastructure, and will disrupt transportation and the distribution of water, food, and essential services. Widespread damaging landslides that accompany intense rainstorms (such as

“pineapple express” winter storms) and related floods occur during most winters. Particularly high-consequence events occur about every decade; recent examples include those in February 1996, November 2006 and December 2007.

Windstorms

Regions affected: Unknown

There is little research on changing wind in the Pacific Northwest as a result of climate change.

IPCC 2013. Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

OCCRI 2010. The Oregon Climate Assessment Report, K.D. Dello and P.W. Mote (eds). College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis OR.

Dalton, M.M., P.W. Mote, A.K. Snover (eds.) 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters and Communities. Washington DC: Island Press.

Mote, P.W, J.T. Abatzoglou, K.E. Kunkel (2013). Variability and Change in the Past and Future. In Climate Change in the Northwest: Implications for Our Landscapes, Waters and Communities. Washington DC: Island Press.

Hazards

Requirement: 44 CFR §201.4(c)(2)(i): Th[e] risk assessment shall include… (i) (a)n overview of the type and location of all natural hazards that can affect the State, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate;

Coastal Hazards

Figure 2-CE-1: The Capes, a multi-million dollar condominium complex constructed on an old Holocene dune field adjacent to Oceanside. Due to erosion of the sand at the toe of the bluff during the 1997-98 El Nińo winter, the bluff face began to fail threatening several of the homes built nearest the bluff edge

Source: DOGAMI

The Pacific Northwest (PNW) coast of Oregon is without doubt one of the most dynamic coastal landscapes in North America, evident by its long sandy beaches, sheer coastal cliffs, dramatic headlands and vistas, and ultimately the power of the Pacific Ocean that serves to erode and change the shape of the coast. It is these qualities along with its various natural resources that have drawn people to live along its narrow shores. However, coastal communities are increasingly under threat from a variety of natural hazards, including coastal erosion (both short and long-term), landslides, earthquakes, and potentially catastrophic tsunamis generated by the Cascadia subduction zone (CSZ). Over time, these hazards are gradually being compounded, in part due to the degree of development that has evolved along the Oregon coast in recent decades (Figure 2- CE-1). A particular concern is that the local geology and geomorphology of the region have restricted development to low-lying areas, chiefly along dunes, barrier spits, or along coastal bluffs present along the open coast that are subject to varying rates of erosion, and to low-lying areas adjacent to the numerous estuaries that make up the coast. All of these sites are highly susceptible to increased impacts as erosion processes and flood hazards intensify, driven by rising sea level and increased storminess.

(Figure2- CE-2: A) Emergency riprap being placed in front of a home at Gleneden Beach, following a recent bluff failure (February 2013).

B) Homes being inundated with excess sand during a strong wind event in November 2001.

Source: DOGAMI

Beaches and coastal bluffs are some of the most dynamic landforms, responding to a myriad of variables. Both

landforms are constantly changing (at varying time scales) as they respond to changes in the ocean processes (waves, nearshore currents and tides) that affect the beach and toe of the bluff as well as those sub-aerial processes (rainfall, sun, wind) that directly affect coastal bluffs. There are many dangers inherent in living on the coast. While coastal bluffs gradually erode over the long-term, they can also respond very rapidly, at times sliding away (in a matter of minutes to a few hours) so that homes and sections of highways are damaged or destroyed (Figure2-CE-2A). Beaches are especially dynamic features, as sand is constantly shifted about. This is especially noticeable in major storms, with the shoreline retreating rapidly, periodically destroying homes built too close to the sea. At other times, large quantities of sand migrate back onto beaches, burying homes built atop coastal dunes (Figure 2-CE-2B). There is no location on the Oregon coast that is immune to coastal hazards.

Without question, the most important natural variables that influence changes to the shape and width of the beach and ultimately its stability are the beach sand budget (balance of sand entering and leaving the system) and the processes (waves, currents, tides, and wind) that drive the changes.

Human influences associated with jetty construction, dredging practices, coastal engineering, and the introduction of non-native dune grasses have all affected the shape and configuration of the beach, including the volume of sand on a number of Oregon's beaches, ultimately influencing the stability or instability of these beaches.

Analysis and Characterization

Geology and Geomorphology

The Oregon coast is 366 miles long from the Columbia River to the California border. The present coastline is the result of geologic processes that include a rise in sea level as Ice Age glaciers melted. The coastal geomorphology of this landscape reflects a myriad of geomorphic features (Figure 2-CE-3) that range from plunging cliffs (in regions 1, 4, & 5), rocky shorelines and shore platforms (regions 1, 3, 5, & 6), wide and narrow sandy beaches backed by both dunes (regions 2, 5 & 6) and cliffs (regions 3 & 4), gravel and cobble beaches backed by cliffs (regions 1, 5 & 6), barrier spits (regions 2, 4 & 5), and estuaries (regions 1-6). Cliffed or bluff-backed shorelines make up the bulk of the coast accounting for 58% of the coastline, the remainder being dune-backed. Geomorphically, the coast can be broken up into a series of "pocket beach" littoral cells (Figure 2-CE-3) that reflect resistant headlands (chiefly basalt) interspersed with short to long stretches of beaches backed by both less resistant cliffs and dunes (e.g. Lincoln and Tillamook Counties (regions 3 & 5 in Figure 2-CE-4). The headlands effectively prevent the exchange of sand between adjacent littoral cells. Some beaches form barrier spits, creating estuaries or bays behind them (e.g. Netarts, Nestucca and Siletz Spits). About 75.6% of the coastline consists of beaches comprised of sand or gravel backed by either dunes or bluffs, while the remaining 24.4% of the

Figure 2-CE-3: The coastal geomorphology of the Oregon coast, including a break-down of Oregon littoral cells. Bold black lines denote the locations of cliffs and rocky shores. Faint grey lines denote faulting. Numbers indicate regional coastal geomorphic features: plunging cliffs (1, 4 & 5), rocky shorelines and shore platforms (1, 3, 5 & 6), wide and narrow sandy beaches backed by both dunes (2, 5 & 6) and cliffs (3 & 4), gravel and cobble beaches backed by cliffs (1, 5 & 6), barrier spits (2 & 5), and estuaries (1-6)

Source: DOGAMI

coast is comprised of a mixture of rocky cliffs (including headlands) and shores. Of the 18 littoral cells on the Oregon coast, the largest is the Coos cell, which extends from Cape Arago in the south to Heceta Head in the north, some 62.6 miles in length.

Interspersed among the littoral cells are 21 estuaries that range in size from small, such as the Winchuck estuary (0.5 km^2) adjacent to the Oregon/California border, to large, such as the Columbia River (380 km^2), which separates the states of Oregon and Washington. The estuaries are all ecologically important to many fish and wildlife species and in many cases are the sites of important recreational and commercial enterprise. In general, Oregon estuaries can be divided into two broad groups based on physiographic differences between estuaries located on the north and south coast. On the northern Oregon coast, the prevalence of pocket beach littoral cells and weaker rock formations in the coast range has resulted in more rapid erosion of the region's rock formations. This produces ample material at the coast, and coupled with alongshore sediment transport, has aided the formation of barrier spits across drowned river valleys and hence estuaries. In contrast, sediment loads on the southern Oregon coast are comparatively lower due to there being more resistant rock formations. Furthermore, the region is generally much steeper, which essentially limits the landward extent of the tide in drowned rivers and hence, ultimately the size of the estuaries.

Figure 2-CE-4: A) Houses line the cliff at Fogarty Creek in Lincoln County. Note the proximity of the eroding cliff edge to the homes.

B) Extensive erosion along the dune-backed beaches in Neskowin have resulted in the construction of massive riprap structures (solid bold line), which now essentially protect the entire community from further erosion

Source: L. Stimely, DOGAMI.

Unlike much of the U.S. coast, population pressure on the Oregon coast is relatively low and is largely confined to small coastal towns separated by large tracts of coast with little to no development. The bulk of these developments are concentrated on the central to northern Oregon coast in Lincoln, Tillamook and Clatsop Counties. On the cliffed shores of the central Oregon coast (Figure 2-CE-4A), between Newport and Lincoln City, homes are perched precariously close to the edge of the cliffs and in some areas the erosion has become acute requiring various forms of coastal engineering (commonly riprap) in order to mitigate the problem (Figure 2-CE-4B), and in a few cases the landward removal of the homes. In other areas, critical infrastructure such as U.S. Highway 101 track close to the coast and in a few areas, erosion of the cliffs has resulted in expensive remediation (e.g. adjacent to Nesika Beach in

Curry County). While the processes driving coastal erosion on bluff-backed shores are entirely a function of the delicate balance between the assailing forces (waves, tides, and currents) and properties of the rock (rock type, bedding, strength, etc.), increasing development pressure, weak land-use regulations, a lack of quantitative information, and ignorance of the physical processes have certainly contributed to the need for remediation in many coastal areas.

Elsewhere, significant development is typically located along the seaward most dune (foredune) system (Figure 2-CE-2B and 5B), as developers seek to capitalize on ocean views and proximity to the beach. However, major storms, especially in the late 1990s have resulted in extensive erosion, with many communities (e.g. Neskowin and Rockaway Beach in Tillamook County) having to resort to major coastal engineering in order to safeguard individual properties. The magnitude and extent of these erosion events have now left entire communities entirely dependent on the integrity of the structures.

Sand Budget

The beach sand budget is the rate at which sand is brought into the coastal system versus the rate at which sand leaves the system. A negative balance means that more sand is leaving than is arriving and results in erosion of that segment of shoreline. A positive balance means that more sand is arriving than is leaving, enabling that segment of shoreline to gain sand and accrete and potentially advance seaward. Along the Oregon coast, potential sources of sand include rivers, bluffs, dunes, and the inner shelf. Potential sand sinks include, bays (estuaries), dunes, dredging around the mouths of estuaries, and mining of sand.

Attention is often focused on the effects of beach and dune erosion. Yet, there are segments of Oregon's coast where periodically the concern is excess sand build-up, as has occurred in places like Pacific City (Figure 2-CE-2B), Manzanita, Bayshore Spit, Nedonna and Cannon Beach.

Classifying Coastal Hazards

Natural hazards that affect coastal regions can be divided into two general classes, *chronic* and *catastrophic*:

> Chronic hazards are those we can see clear evidence of along the shore: beach, dune, and bluff erosion, landslides, slumps, and flooding of low-lying lands during major storms. The damage caused by chronic hazards is usually gradual and cumulative. However, storms that produce large winter waves, heavy rainfall and/or high winds may result in very rapid erosion or other damage that can affect properties and infrastructure over a matter of hours. The regional, oceanic, and climatic environments that result in intense winter storms determine the severity of chronic hazards along the Oregon coast. Chronic hazards are typically local in nature, and the threats to human life and property that arise from them are generally less severe than those associated with catastrophic hazards. However, the wide distribution and frequent occurrence of chronic hazards makes them a more immediate concern.
>
> Catastrophic hazards are regional in scale and scope. Cascadia Subduction Zone earthquakes, and the ground shaking, subsidence, landsliding, liquefaction, and tsunamis that accompany them are catastrophic hazards. Tsunamis generated from distant earthquakes can also cause substantial damage in some coastal areas. The processes associated with earthquakes, tsunamis, floods, and landslides are discussed later in this chapter.

Causes of Coastal Hazards

Chronic coastal hazards include periodic high rates of beach and dune erosion, sand inundation, "hotspot erosion" due to the occurrence of El Niños and from rip current embayments, intermittent coastal flooding as a result of El Niños, storm surges and high ocean waves, and the enduring recession of coastal bluffs due to long-term changes in mean sea level, variations in the magnitude and frequency of storm systems, and climate change. Other important hazards include mass wasting of sea cliffs such as slumping and landslides, which may be due to wave attack and geologic instability.

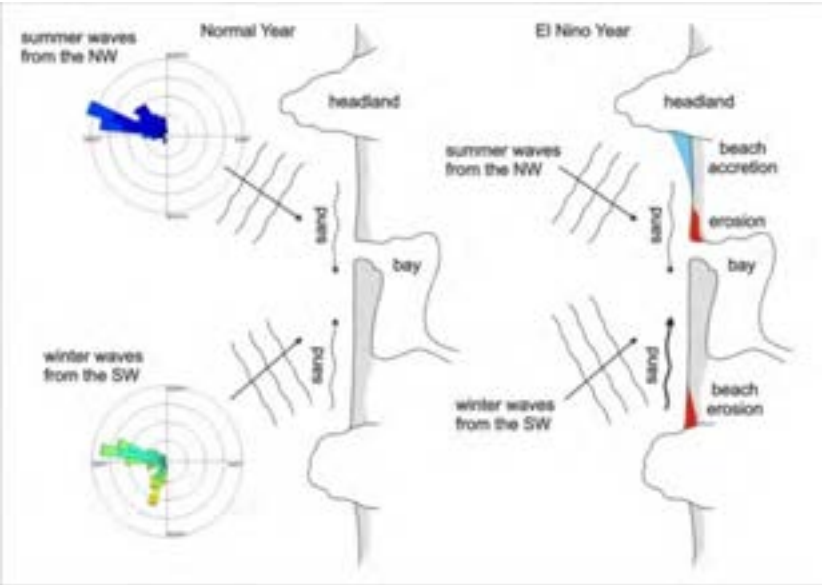

Figure CE-5: Patterns of sediment transport during "normal" and El Nino years

Source: Komar, 1986.

Most of these hazards are the product of the annual barrage of rain, wind, and waves that batter the Oregon coast, causing ever-increasing property damage and losses. A number of these hazards may be further exacerbated by climate cycles such as the El Niño Southern Oscillation, or longer-term climate cycles associated with the Pacific Decadal Oscillation. Other hazards, such as subduction zone earthquakes and resulting tsunamis, can have catastrophic impacts on coastal communities' residents and infrastructure, and in many areas these impacts will persist for many decades following the event due to adjustments in the coastal morphodynamics following subsidence or uplift of the coast. All of these processes can interact in complex ways, increasing the risk from natural hazards in coastal areas.

Waves

Along dune- and bluff-backed shorelines, waves are the major factor that affect the shape and composition of beaches. Waves transport sand onshore (towards the beach), offshore (seaward to form nearshore bars etc.), and along the beach (longshore transport). Short-term beach and shoreline variability (i.e. storm related changes) is directly dependent on the size of the waves that break along the coast, along with high ocean water levels, and cell circulation patterns associated with rip currents. In contrast, long-term shoreline changes is dependent on the balance of the beach sediment budget, changes in sea level over time, and patterns of storminess.

The Oregon coast is exposed to one of the most extreme ocean wave climates in the world, due to its long fetches and the strength of the extratropical storms that develop and track across the North Pacific. These storms exhibit a pronounced seasonal cycle producing the highest waves (mean = 12.8 ft) in the winter, with winter storms commonly generating deep-water wave heights greater than 33 ft, with the

largest storms in the region having generated waves in the range of 45 to 50 ft. In contrast, summer months are dominated by considerably smaller waves (mean = 5.3 ft), enabling beaches to rebuild and gain sand eroded by the preceding winter. When large waves are superimposed on high tides, they can reach much higher elevations at the back of the beach, contributing to significantly higher rates of coastal erosion and flood hazards. It is the combined effect of these processes that leads to the erosion of coastal dunes and bluffs, causing them to retreat landward.

Winds and waves tend to arrive from the southwest during the winter and from the northwest during the summer. Net sand transport tends to be offshore and to the north in winter and onshore and to the south during the summer (Figure 2-CE-5). El Niño events can exaggerate the characteristic seasonal pattern of erosion and accretion, and may result in an additional 60–80 feet of "hotspot" dune erosion along the southern ends of Oregon's littoral cells, particularly those beaches that are backed by dunes, and on the north side of estuary inlets, rivers and creeks.

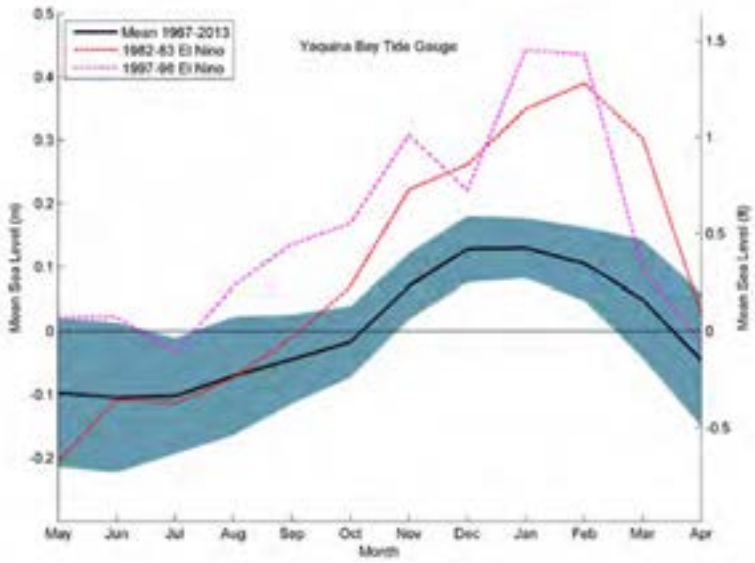

Figure 2-CE-6: Average monthly tides for the Yaquina Bay tide gage (± 1 standard deviation (shaded region) providing a measure of normal ranges) expressed as an average for the period 1967-2013, and as monthly averages for the 1982-83 and 1997-98 El Niños.

Source: DOGAMI

Ocean Water Levels

The elevation of the sea is controlled in part by the astronomical tide. High ocean water levels at the shoreline may be the product of combinations of high tides, storm surges, strong onshore-directed winds, El Niños and wave runup. As can be seen in Figure 2-CE-6, the Oregon coast experiences a seasonal cycle in its measured tides, with the tides tending to be highest in the winter and lowest in the summer. This seasonal variation is entirely a function of ocean upwelling during the summer months, which brings cold dense water to the surface and due to the Coriolis effect and ocean currents, this water is directed landward where it piles up along the coast depressing sea level. In the winter this process breaks down resulting in a warming of the ocean, which raises the mean sea level. The typical seasonal variability in water levels is ~0.8 ft, increasing to as much as 2 ft during an El Nińo (Figure 2-CE-6), essentially raising the mean shoreline elevation, enabling waves to break closer to dunes or along the base of coastal bluffs.

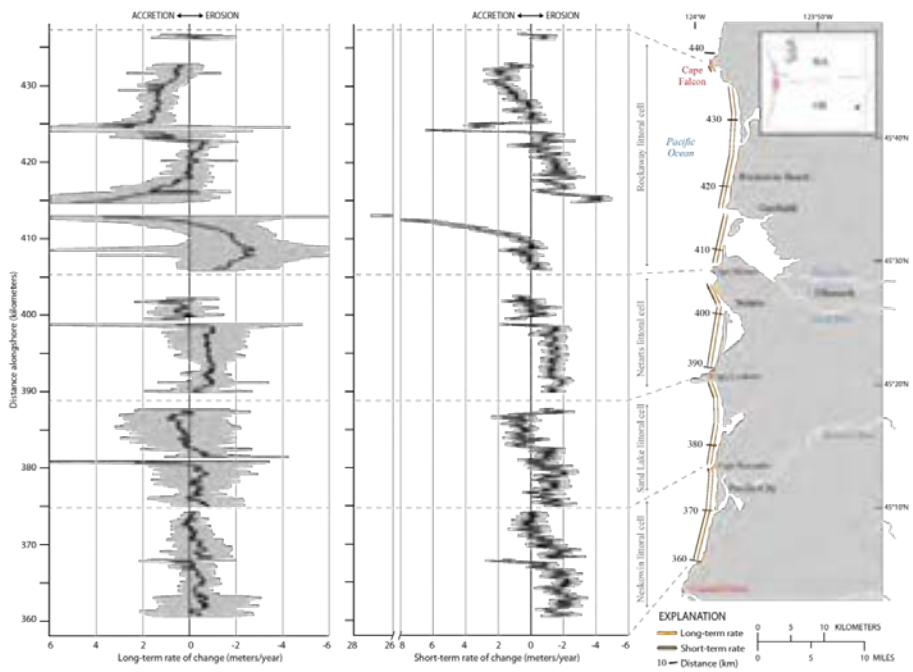

Figure 2-CE-7: Plots showing long- and short-term shoreline change rates calculated for the Tillamook County region.

Source: Ruggiero et al., in press

Shoreline Changes

Dune-backed beaches respond very quickly to storm wave erosion, sometimes receding tens of feet during a single storm and hundreds of feet in a single winter season. Beach monitoring studies undertaken by DOGAMI staff (http://nvs.nanoos.org/BeachMapping) have documented storm induced erosion of 30 – 60 ft from single storm events, while seasonal changes may reach as much as 90-130 ft on the dissipative, flat, sandy beaches of Oregon, and as much as 190 ft on the more reflective, steeper beaches of the south coast (e.g. adjacent to Garrison Lake, Port Orford). Furthermore, during the past 15 years a number of sites on the northern Oregon coast (e.g. Neskowin, Netarts Spit and Rockaway Beach) have experienced considerable erosion and shoreline retreat. For example, erosion of the beach in

Neskowin has resulted in the foredune having receded landward by as much as 150 ft since 1997. South of Twin Rocks near Rockaway, the dune has eroded ~140 ft over the same time period. Continued monitoring of these study sites are now beginning to yield enough data from which trends (erosion or accretion rates) may be extrapolated. These latter datasets are accessible via the web (http://nvs.nanoos.org/BeachMapping).

Recently, studies undertaken by the USGS provide additional insights into the spatial extent of erosion patterns on the Oregon coast. Figure 2-CE-7 provides analyses of both long-term (~1900s to 2002) and short-term (~1960s/80s to 2002) shoreline change patterns along the Tillamook County coast, confirming measured data reported by DOGAMI. As can be seen from the figure, long-term erosion rates (albeit low rates) dominate the bulk of Tillamook County (i.e. Bayocean Spit, Netarts, Sand Lake, and Neskowin littoral cells), while accretion prevailed in the north along Rockaway Beach and on Nehalem Spit. The significant rates of accretion identified adjacent to the mouth of Tillamook Bay are entirely due to construction of the Tillamook jetties, with the north jetty completed in 1917 and the south jetty in 1974. Short-term shoreline change patterns indicate that erosion has continued to dominate the bulk of the shoreline responses observed along the Tillamook County coast. Erosion is especially acute in the Neskowin, Sand Lake and Netarts littoral cells, and especially along Rockaway Beach. In many of these areas, the degree of erosion remains so significant, that were we to experience a major storm(s) in the ensuing winters, the risk of considerable damage to property and infrastructure in these areas would likely be high.

Figure 2-CE-8: Map showing Alsea Bay spit erosion as a result of the 1982-83 El Nińo (left), and state of the beach in 2009 (right). Yellow/black line delineates a riprap structure constructed to protect the properties from further erosion. Orange line defines the maximum extent of dune erosion due to wave attack as a result of the 1982-83 event. Note the northward migration of the estuary mouth compared to its position in 2009.

Source: DOGAMI

The processes of wave attack significantly affect shorelines characterized by indentations, known as inlets. Waves interact with ocean tides and river forces to control patterns of inlet migration. This is especially the case during El Niño's. During an El Niño, large storm waves tend to arrive out of the south, which causes the mouth of the estuary to migrate to the north, where it may abut against the shoreline, allowing large winter waves to break much closer to the shore. This can result in significant "hotspot" erosion" north of the estuary mouth. Recent examples of the importance of inlet dynamics during an El Niño are Alsea Spit near Waldport (Figure 2-CE-8), Netarts Spit near Oceanside, and at Hunter Creek on the southern Oregon coast at Gold Beach.

Floods

Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies (FISs)are also often used in characterizing and identifying flood-prone areas. FEMA conducted many FISs in the late 1970s and early 1980s. Included were "VE" zones, areas subject to wave action and ocean flooding during a "100-year" event that encompass the area extending from the surfzone to the inland limit of wave runup, and/or wave overtopping and inundation, and or the location of the primary frontal dune or any other area subject to high velocity wave action from coastal storms. Areas identified as VE zones are subject to more development standards than other flood zones. Currently, DOGAMI is working with FEMA to update and remap FEMA coastal flood zones established for coastal communities along the Oregon coast.

Landslides

Simple surface sloughing is the dominant process along bluff-backed shorelines. Other shorelines are backed by steep slopes, where deep-seated landslides and slumping are the dominant processes (Figure 2-CE-1). The geologic composition of the bluff is a primary control on slope stability.

Headlands, generally composed of basalt, are more resistant to erosion and do not readily give way. In contrast, soft bluff-forming sandstone and mudstone are highly susceptible to slope movement. Prolonged winter rains saturate these porous bluff materials, increasing the likelihood of landslides.

The geometry and structure of bluff materials also affect slope stability by defining lines of weakness and controlling surface and subsurface drainage. As waves remove sediment from the toe of the bluff, the bluffs become increasingly vulnerable to slope failure due to increased exposure to wave attack. The extent to which the beach fronting the bluff acts as a buffer is thus important in this regard. Thus a reduction in the sand beach volume in front of a bluff increases its susceptibility to wave erosion along its toe, which can eventually contribute to the failure of the bluff.

Figure 2-CE-9: Bluff failure due to toe erosion by ocean waves resulted in the top of the bluff eroding landward by ~30 ft over a 48 hour period in November 2006.

Photo source: OPDR

A recent example of such a process occurred at Gleneden Beach in Lincoln County in November 2006 (Figure 2-CE-9), when a large rip current embayment (an area of the beach that exhibits more erosion and beach narrowing due to removal of sand by rip currents) formed in front of a portion of the bluff, allowing waves to directly attack the base of the bluff. In a matter of two days, the bluff eroded back by up to 30 ft, undermining the foundation of two homes, almost resulting in to their destruction.

Similar processes occurred nearby during the 1972/73 winter, which led to one home having to be pulled off its foundation. Both examples provide a stark reminder of the danger of building too close to the beach and that these types of changes do occur relatively frequently.

Climate Change and Sea Level Rise

An understanding of the trends and variations in sea level on the Oregon coast provides important insights as to the spatial patterns of erosion and flood hazards. In general, tectonic uplift is occurring at a much faster rate (~2-4 mm/year) on the south coast (south of about Coos Bay), while the uplift rates on the central to northern Oregon coast are much lower, averaging about 1 mm/year (Figure 2-CE-10, left). When combined with regional patterns of sea level change (Figure 2-CE-10, right), it is apparent that the southern Oregon coast is essentially an emergent coast, with the coast rising at a much faster rate when compared with sea level. In contrast, the central to northern Oregon coast is a submergent coast due to the fact that sea level is rising faster than the land. Not surprisingly, it is the north coast that exhibits the most pervasive erosion and flood hazards when compared with the south coast.

In 2012, the National Research Council completed a major synthesis of the relative risks of sea level rise on the US West Coast. The consensus from that report is that sea level has risen globally by on average 1.7 mm/year, while rates derived from satellite altimetry indicate an increase in the rate of sea level rise to 3.2 mm/year[6] since 1993. Combining our knowledge of glacial isostatic rebound (the rate at which the earth responds to the removal of ice from the last glaciations), regional tectonics, and future temperature patterns, the committee concluded that sea level on the Oregon coast would increase by approximately 2.1 ft by 2100.

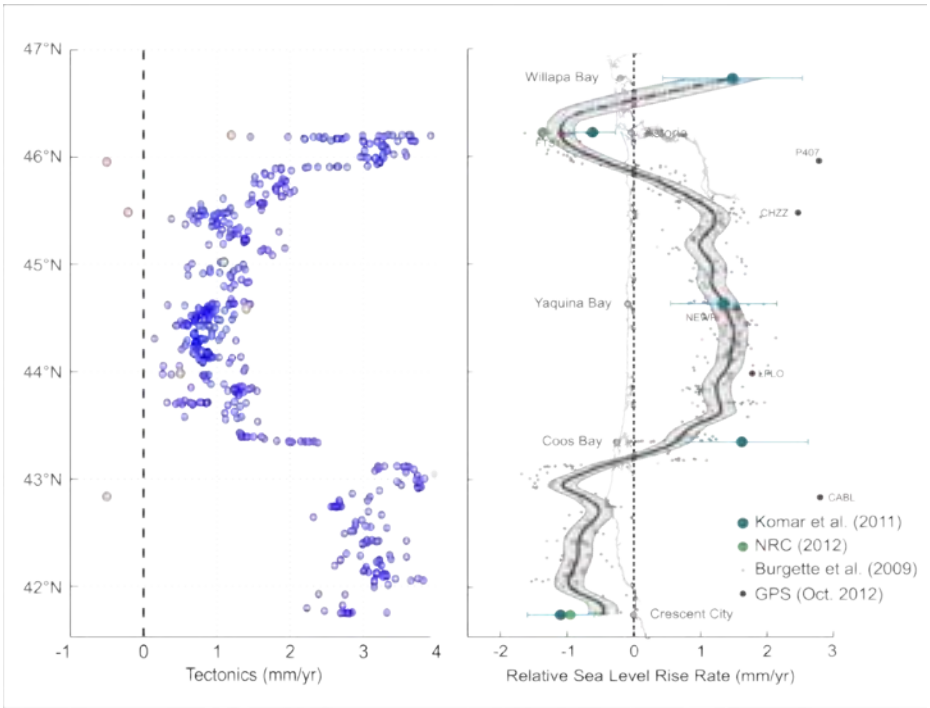

Figure 2- CE-10: (Left) Along coast variations in rates of tectonic uplift, and (Right) Relative sea level trends for the Oregon coast.

[6] Source: After Komar et al., 2011. Website: http://www.aviso.oceanobs.com/en/news/ocean-indicators/mean-sea-level/

2030 Projection	Range	2050 Projection	Range	2100 Projection	Range
0.2 ft	-0.1 – 0.7 ft	0.6 ft	-0.07 – 1.6 ft	2.1 ft	0.4 – 4.7 ft

Table 2-CE-1: Projected sea level rise for the central Oregon coast

Source: NRC, 2012.

Table 2-CE-1 presents the NRC (2012) projected sea level rise findings for the Central Oregon coast. The largest increase in regional sea level is estimated to be 4.7 ft by 2100. Of importance, these projections assume that sea level is uniform year round. However, as noted previously, sea level on the Oregon coast exhibits a pronounced seasonal cycle of about 0.8 ft between summer and winter, increasing to as much as 2 ft in response to the development of a strong El Nińo. Thus, when combined with projected future increases in regional sea level, it becomes apparent that the potential increase in mean sea level could be substantially greater depending on the time of year (Figure 2-CE-11). For example, by 2100, sea level during an El Nińo winter will have increased by a total of 6.6 ft, raising the mean shoreline position by that amount, which will have shifted upward and landward as beaches respond to the change in mean water levels. Based on these projections, it can be expected that areas presently classified as emergent (e.g. the southern Oregon coast), will become submergent over time as the rate of sea level rise surpasses tectonic uplift. Furthermore, erosion and flood hazards on the northern Oregon coast will almost certainly accelerate, increasing the risk to property.

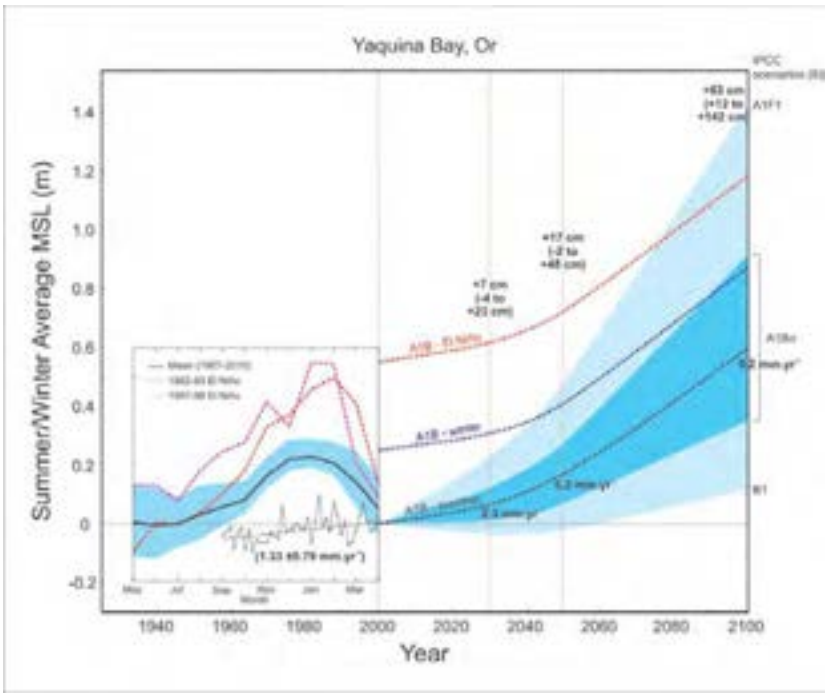

Figure 2-CE-11: Projected future changes in regional sea levels on the Oregon coast

Source: NRC, 2012.

Human Activities

Human activities affect the stability of all types of shoreline. Large-scale human activities such as jetty construction and maintenance dredging have a long-term effect on large geographic areas. This is particularly true along dune-backed and inlet-affected shorelines such as the Columbia River and Rockaway littoral cells (Figure 2-CE-3). The planting of European beachgrass (Ammophila arenaria) since the early 1900s, and more recently American beachgrass (Ammophila breviligulata) has locked up sand in the form of high dunes. Such a process can contribute to a net loss in the beach sand budget and may help drive coastal erosion.

Residential and commercial development can affect shoreline stability over shorter time periods and smaller geographic areas. Activities such as grading and excavation, surface and subsurface drainage alterations, vegetation removal, and vegetative as well as structural shoreline stabilization can all affect shoreline stability.

While site-specific coastal engineering efforts such as the construction of riprap revetments is less likely to cause direct adverse impacts to the beach, **the cumulative effect of constructing many of these structures along a particular shore** (e.g. as has occurred along the communities of Gleneden Beach, Siletz Spit, Lincoln City, Neskowin, Pacific City, and Rockaway) **will almost certainly decrease the volume of sediment being supplied to the beach system,** potentially affecting the beach sediment budget and hence the stability of beaches within those littoral cells.

Heavy recreational use in the form of pedestrian and vehicular traffic can affect shoreline stability over shorter time frames and smaller spaces. Because these activities may result in the loss of fragile vegetative cover, they are a particular concern along dune-backed shorelines. Graffiti carving along bluff-backed shorelines is another byproduct of recreational use that can damage fragile shoreline stability.

Historical Coastal Hazards in Oregon

Table 2- CE-2 lists historic coastal erosion and flood hazard events in Oregon.

Table 2-CE-2: Historic Coastal Hazard Events in Oregon

Date	Location	Description
January 1914	Newport	Damage (Nicolai Hotel).
1931	Rockaway	Coastal damage from December storm.
October- December 1934	Waldport and Rockaway	Flooding (Waldport). Coastal damage (Rockaway Beach).
December 1935	Cannon Beach and Rockaway Beach	Coastal damage.
January 1939	Coastwide	Severe gale. Damage: coastwide. Severe flooding (Seaside, and Ecola Creek near Cannon Beach): • Multiple spit breaches (southern portion of Netarts Spit) • Storm damage (along the shore of Lincoln City and at D River) • Flooding (Waldport) • Extensive damage (Sunset Bay Park) • Storm surge overtopped foredune (Garrison Lake plus Elk River lowland)
December 1940	Waldport	Flooding.
1948	Newport	Wave damage(Yaquina Arts Center)
January 1953	Rockaway	70 foot dune retreat. One home removed.
April 1958	Sunset Bay State Park Newport	Flooding (Sunset Bay); Wave damage (Yaquina Arts Center in Newport).
January- Februrary 1960	Sunset Bay State Park	Flooding.
1964	Cannon Beach	Storm damage.
December 1967	Netarts Spit Lincoln City Newport Waldport	Damage: coastwide. • State constructed wood bulkhead to protect foredune along 600 ft section (Cape Lookout State Park campground). • Flooding and logs (Lincoln City). • Wave damage (Yaquina Arts Center, Newport). • Flooding (Waldport). • Storm damage (Beachside State Park • Washed up driftwood (Bandon south jetty parking lot).

Date	Location	Description
1971-73	Siletz Spit	• High tide line eroded landward by 300 ft. • February 1973, one home completely destroyed. Spit almost breached. • Logs through Sea Gypsy Motel (Nov. 1973).
1982-83	Alsea Spit	Northward migration of Alsea Bay mouth. Severe erosion.
1997-98	Lincoln and Tillamook Counties	El Nino winter (second strongest on record). Erosion: considerable.
1999	Coastwide	Five storms between January and March. Coastal erosion: extensive, including: • Significant erosion (Neskowin, Netarts Spit, Oceanside, Rockaway beach); • Overtopping and flooding (Cape Meares) • Significant erosion along barrier beach (Garrison Lake); overtopping 27ft high barrier.
December 2007	Tillamook and Clatsop Counties	Wind storm.

Source: Schlicker et al. 1972; Schlicker et al. 1973; Stembridge 1975; Komar and McKinney 1977; Komar 1986, 1987, 1997, 1998; Allan et al. 2003; Allan et al. 2009, and many others.

Probability

Waves

Previous analyses of extreme waves for the Oregon coast estimated the "100-year" storm wave to be around 33 feet. In response to a series of large wave events that occurred during the latter half of the 1990s, the wave climate was subsequently re-examined and an updated projection of the 100-year storm wave height was determined, which is now estimated to reach approximately 47 to 52 feet (Table 2-CE-3), depending on which buoy is used. These estimates are of considerable importance to the design of coastal engineering structures and in terms of defining future coastal erosion hazard zones.

Recurrence Interval (*years*)	**Extreme Wave Heights** (*feet*)	
	NDBC buoy #46002* **(Oregon)**	**NDBC buoy #46005+ (Washington)**
10	42.5	41.7
25	46.2	44.0
50	48.8	-
75	50.1	45.7
100	51.2	47.1

Table 2-CE-3: Projection of extreme wave heights for various recurrence intervals: Each wave height is expected to occur on average once during the recurrence interval.

Source: *DOGAMI analyses; +Ruggiero et al. (2010).

Figure CE-11: Example map product showing erosion hazard zones developed for Rockaway Beach in Tillamook County. Note the erosion that has taken place since 1998 (red line) up through 2009 (black line)

Photo source: DOGAMI

Coastal Erosion Hazard Zones

For the purposes of providing erosion hazard information for the Oregon coast, DOGAMI has completed coastal erosion hazard maps for Lincoln, Tillamook and Clatsop Counties, as well in the Nesikka Beach area in Curry County. Maps were completed for these areas mainly because these areas contain the largest concentration of people living along the coastal strip, and in the case of Nesika Beach in response to a specific request by the Department of Land Conservation and Development agency. In all cases, the maps depict erosion hazard zones that fall into four categories (Figure CE-11):

1. Active Hazard Zone (AHZ): For dune-backed shorelines, the AHZ encompasses the active beach to the top of the first vegetated foredune, and includes those areas subject to large morphological changes adjacent to the mouths of the bays due to inlet *migration. On bluff-backed shorelines the AHZ includes actively eroding coastal bluff escarpments and active or potentially active coastal landslides.*

2. High Hazard Zones (HHZ): This scenario is based on a large storm wave event (wave heights ~47.6 ft high) occurring over the cycle of an above average high tide, coincident with a 3.3 ft storm surge. The wave heights associated with this scenario have an expected recurrence interval of 50-60 years or a 2% chance in any given year.

3. Moderate Hazard Zones (MHZ): This scenario is based on an extremely severe storm event (waves ~52.5 ft high) and may or may not encompass a long-term rise in sea level (depends on the coastal region). As with the HHZ, the wave event occurs over the cycle of an above average high tide, coincident with a 5.6 ft storm surge. The wave heights associated with this scenario have an expected recurrence interval of 100 years or a 1% chance in any given year.

4. Low Hazard Zones (LHZ): This scenario is analogous to the MHZ scenario described previously, with the addition of a 3.3 ft coseismic subsidence of the coast.

Drought

The state of Oregon is confronted with continuing challenges associated with drought and water scarcity. The challenges are "exacerbated" because of a rapidly growing population and the demands placed on a renewable, yet finite resource - water. The two terms, drought and water scarcity, are not necessarily synonymous; distinctly water scarcity implies that demand is exceeding the supply. The combined effects of drought and water scarcity are far-reaching and merit special consideration.

Drought is typically measured in terms of water availability in a defined geographical area. It is common to express drought with a numerical index that ranks severity. Most federal agencies use the Palmer Method which incorporates precipitation, runoff, evaporation, and soil moisture. However, the Palmer Method does not incorporate snowpack as a variable. Therefore, it is not believed to provide a very accurate indication of drought conditions in Oregon and the Pacific Northwest.

Oregon's Emergency Operations Plan includes a Drought Annex for the purposes of coordinating state and federal agency response to drought emergencies caused by water shortages and to provide emergency water supplies for human consumption under conditions of inadequate supply. The Annex outlines several steps and lists major responsibilities of various federal, state, and local jurisdictions. It also includes a description of federal drought assistance programs and guidelines for water curtailment planning and program development.

Analysis/Characterization

Drought can be defined several ways. The American Heritage Dictionary defines drought as "a long period with no rain, especially during a planting season." While straight forward, this definition falls far short of the benchmark needed to assess the extent or severity of the hazard and how it might be mitigated.

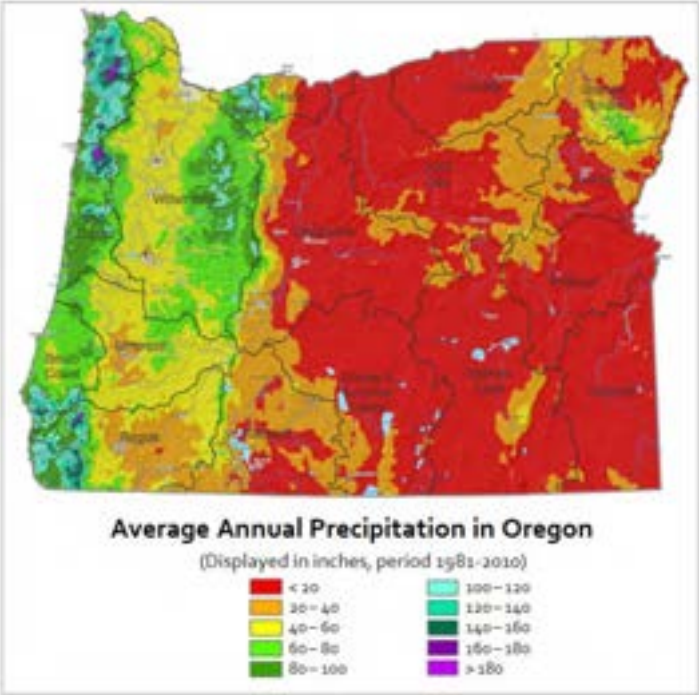

Figure 2-D-1: Oregon Average Annual Precipitation, 1981-2010

Source: PRISM Group, Oregon State University
Map: Oregon Water Resource Department
Website: http://www.prismoregonstate.edu and http://prism.oregonstate.edu/state_products/index.phtml

In the early 1980's, researchers with the National Drought Mitigation Center and the National Center for Atmospheric Research located more than 150 published definitions of drought. There clearly was a need to categorize the hazard by "type of drought." The following definitions are a response to that need:

Meteorological or climatological droughts usually are defined in terms of the departure from a normal precipitation pattern and the duration of the event. Drought is a slow-onset phenomenon that usually takes at least three months to develop and may last for several seasons or years.

Agricultural droughts link the various characteristics of meteorological drought to agricultural impacts. The focus is on precipitation shortages and soil-water deficits. Agricultural drought is largely the result of a deficit of soil moisture. A plant's demand for water is dependent on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil.

Hydrological droughts refer to deficiencies in surface water and sub-surface water supplies. It is measured as stream flow, and as lake, reservoir, and ground water levels. Hydrological measurements are not the earliest indicators of drought. When precipitation is reduced or deficient over an extended period of time, the shortage will be reflected in declining surface and sub-surface water levels.

Socioeconomic droughts occur when physical water shortage begins to affect people, individually and collectively. Most socioeconomic definitions of drought associate it with supply, demand, and economic good. One could argue that a physical water shortage with no socio-economic impacts is a policy success.

History of Droughts in Oregon

Oregon records, dating back to the late 1800s, clearly associate drought with a departure from expected rainfall. Concern for mountain snowpack, which feeds the streams and rivers, came later. Some Oregon droughts were especially significant during the period of 1928-1994.[2] The period from 1928 to 1941 was a prolonged drought that caused major problems for agriculture. The only area spared was the northern coast, which received abundant rains in 1930-33. The three Tillamook burns (1933, 1939, and 1945) were the most significant results of this very dry period. During 1959-1962 stream flows were low throughout eastern Oregon, but areas west of the Cascades had few problems. Ironically, the driest period in western Oregon was the summer following the benchmark 1964 flood. Low streamflows prevailed in western Oregon during the period from 1976-81, but the worst year, by far, was 1976-77, the single driest year of the century. The Portland Airport received only 7.19 inches of precipitation between October 1976 and February 1977, only 31 percent of the average 23.16 inches for that period.

The 1985-94 drought was not as severe as the 1976-77 drought in any single year, but the cumulative effect of ten consecutive years with mostly dry conditions caused statewide problems. The peak year of the drought was 1992, when a drought emergency was declared for all Oregon counties. Forests throughout the state suffered from a lack of moisture. Fires were common and insect pests, which attacked the trees, flourished.

In 2001 and 2002, Oregon experienced drought conditions, affecting 6 out of 8 regions. During the 2005 drought, the Governor issued declarations for thirteen counties, all east of the Cascades, and the USDA issued three drought declarations, overlapping two of the Governor's. State declarations were made for Baker, Wallowa, Wheeler, Crook, Deschutes, Klamath, Lake, Hood River, Wasco, Sherman, Gilliam, Morrow, and Umatilla counties. Federal declarations were made in Coos, Klamath, and Umatilla

counties. Federal drought declarations by the USDA provide accessibility to emergency loans for crop losses. Since 2001, the Governor has declared a drought every year, with the exception of 2006, 2009, and 2011, in at least one Oregon county. Most of these declarations have involved one or more counties in Regions 5-8.

Impacts

Droughts are not just a summer-time phenomenon; winter droughts can have a profound impact on the state's agricultural sector, particularly east of the Cascade Mountains. Also, below average snowfall in Oregon's higher elevations has a far-reaching effect on the entire state, especially in terms of hydroelectric power generation, irrigation, recreation, and industrial uses. In March of 2014, Mt. Ashland Ski Resort in Southern Oregon announced that it would be unable to open due to the lack of snow[7]. The lack of snow has affected other regions of the state. In the Klamath Basin, the Natural Resources Conservation Service reports that the mountains are generally snow-free below 5000 feet. The Taylor Butte SNOTEL site at elevation 5030 feet was snow-free on March 1, 2014 for the first time since it was installed in 1979. Five long-term snow measurement sites in the Klamath basin set new record lows for March 1 snowpack. The lack of snow and precipitation during the winter months led Governor Kitzhaber to declare a drought for 4 Oregon counties – Klamath, Lake, Harney, and Malheur – in February 2014. As of March 18, 2014, the U.S. Drought Monitor reports that nearly half of Oregon is experiencing a severe drought (Figure 2-D-2).

[7] http://www.oregonlive.com/travel/index.ssf/2014/03/mount_ashland_gearing_up_to_ce.html

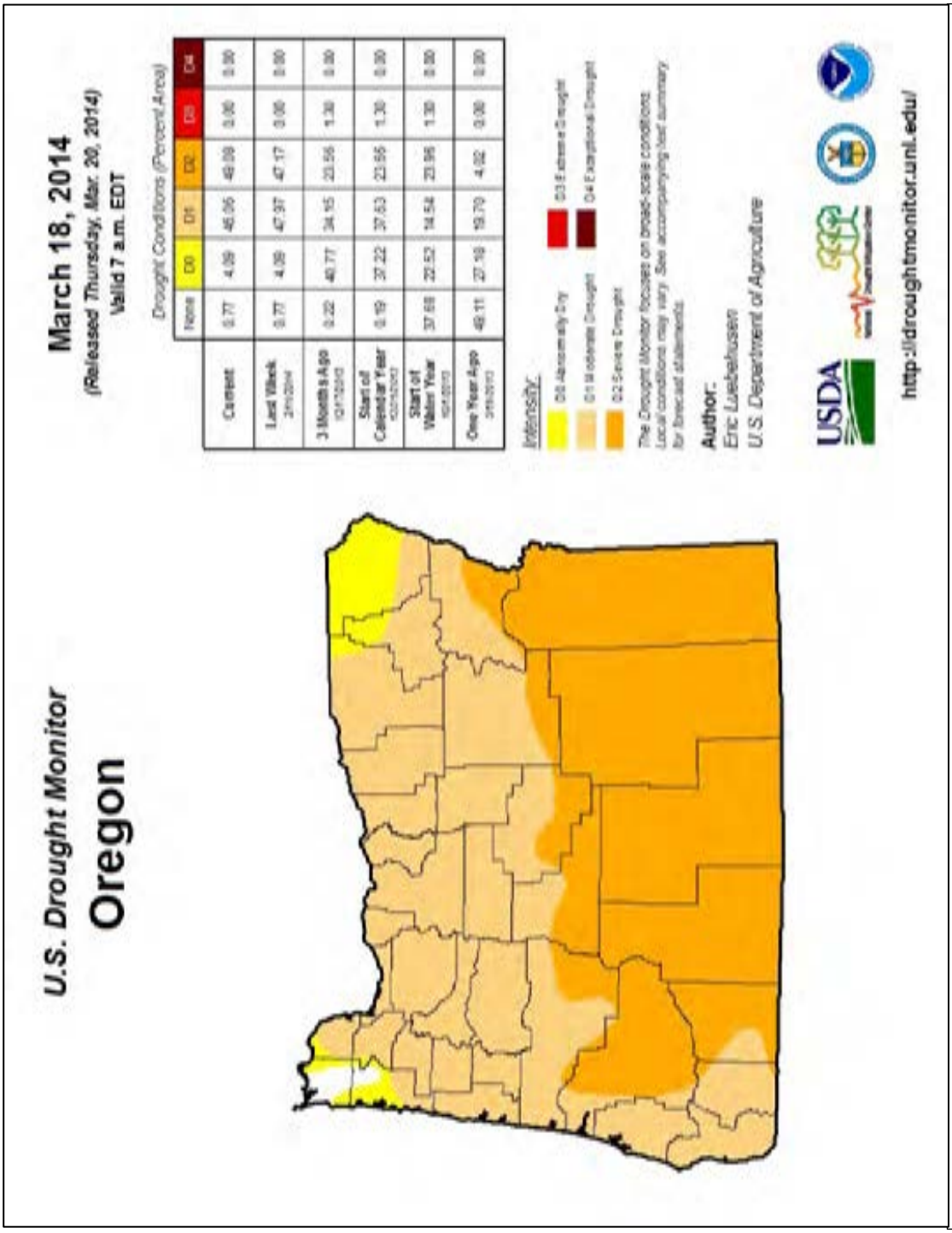

Figure 2-D-2: March 18, 2014 U.S. Drought Monitor Report for Oregon.

Source: U.S. Drought Monitor

There also are environmental consequences. A prolonged drought in Oregon's forests promotes an increase of insect pests, which in turn, damage trees already weakened by a lack of water. In the Willamette Valley, for example, there has been an unusual pattern of tree mortality involving Douglas-fir, grand fir, and western red cedar. Water stress brought on by drought and other factors is the central cause in these mortality events.

A moisture-deficient forest constitutes a significant fire hazard (see the Wildfire section of this Plan, pg. xx). In addition, drought and water scarcity add another dimension of stress to imperiled species. The following information addresses the impact of a severe or prolonged drought on the population, infrastructure, facilities, the economy, and environment of Oregon:

Population: Drought can affect all segments of Oregon's population, particularly those employed in water-dependent activities (e.g., agriculture, hydroelectric generation, recreation, etc.). Also, domestic water-users may be subject to stringent conservation measures (e.g., rationing) and could be faced with significant increases in electricity rates.

Infrastructure: Infrastructure such as highways, bridges, energy conveyance systems, etc., are typically unaffected by drought; however drought can cause structural damage. [5] An example would include areas of severe soil shrinkage. In these uncommon situations, soil shrinkage would affect the foundation upon which the infrastructure was built. In addition, water-borne transportation systems (e.g., ferries, barges, etc.) could be impacted by periods of low water.

Critical/Essential Facilities: Facilities affected by drought conditions include communications facilities, hospitals, and correctional facilities that are subject to power failures. Storage systems for potable water, sewage treatment facilities, water storage for firefighting, and hydroelectric generating plants also are vulnerable. Low water also means reduced hydroelectric production especially as the habitat benefits of water compete with other beneficial uses.

State Owned or Operated Facilities: There are a variety of state owned or operated facilities that could be affected by a prolonged drought. The most obvious include schools, universities, office buildings, health-care facilities, etc. Power outages always are a concern. Maintenance activities (e.g., grounds, parks, etc.) may be curtailed during periods of drought.

Economy: Drought has an impact on a variety of economic sectors. These include water-dependent activities and economic activities requiring significant amounts of hydroelectric power. The agricultural sector is especially vulnerable as are some recreation-based economies (e.g., boating, fishing, water or snow skiing). Whole communities can be affected. This was particularly evident during 2001 water year when many Oregon counties sought relief through state and federal drought assistance programs.

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[5] Some clay soils (e.g., containing bentonite) have significant shrink-swell properties. Prolonged drought can shrink these soils resulting in structural damage. Although these soils occur in Oregon, their geographical extent is limited.

The years 2000 and 2001 were the second driest years in Oregon's climate history. Marion County's recreation community of Detroit suffered economic hardships when adjacent reservoir levels became too low to support normal summer activities. In addition, the drought directly affected over 200,000 irrigated acres in the Klamath River Basin. Farmers were among the first to be affected, followed by local agricultural support industries (e.g., pesticides, fertilizer, farm equipment, etc.), as well as Native American Tribes which depend on local fisheries. There were also endangered species considerations.

Environment: Oregon has several fish species listed as threatened or endangered under the Endangered Species Act (ESA). Some of these species have habitat requirements that jeopardized by the needs or desires of the human environment. For example, in times of scarcity, the amount of water necessary to maintain certain fish species may conflict with the needs of consumptives uses of water. . The state of Oregon is committed to implementation of the ESA and the viability of a productive economic base. There are no easy solutions, only continuous work to resolve difficult drought situations.

Historic Droughts in Oregon

Historic drought events in Oregon are listed in Table 2-DR-1.

Table 2-DR-1: Historic Droughts in Oregon

Date	Location	Description
1928-41	Statewide	Prolonged statewide drought that caused major problems for agriculture. Statewide, the northern coast was the only area spared, with abundant rains in 1930-1933. The three Tillamook burns, the first in 1933, were the most significant impacts of this very dry period.
1959-1964	Eastern Oregon	Streamflows were low through eastern Oregon during this period.
1976-77	Western Oregon	Low streamflows prevailed during this period, the worst year during this period was 1976-77
1985-94	Statewide	Generally dry period, capped by statewide droughts in 1992 and 1994. Although not as severe the 1976-1977 drought, ten consecutive years of dry conditions caused problems throughout the state, such as fires and insect outbreaks.
2001-02	Affected all Regions, except Regions 2 & 3	The second most intense drought in Oregon's history. Eighteen counties with state drought declaration (2001).Twenty-three counties state-declared drought (2002). Some of the 2001 and 2002 drought declarations were in effect through June or December 2003.
2003	Regions 5, 6, 7, & 8	Governor-declared drought issued in 7 counties: Sherman, Wheeler, Crook, Baker, Wallowa, Malheur, & Harney
2004	Regions 5, 6, 7, & 8	Governor-declared drought issued in 4 counties: Morrow, Klamath, Baker, and Malheur
2005	Regions 5, 6, and 7	Affected area: thirteen of Oregon's thirty-six counties.
2007	Regions 6, 7, and 8	Governor-declared drought emergency in Lake, Grant, Baker, Union, Malheur, and Harney counties
2008	Region 5	Governor-declared drought emergency in Sherman and Gilliam counties
2010	Region 6	Governor-declared drought emergency for Klamath County and contiguous counties

2012	Region 6	Governor-declared drought emergency for the Lost River Basin, located in Klamath County and Lake County
2013	Regions 5, 6, 7, & 8	Governor-declared drought in Gilliam, Morrow, Klamath, Baker, and Malheur counties
2014	Regions 4, 6, 7, & 8	Governor-declared drought in 9 counties: Klamath, Lake, Malheur, Harney, Jackson, Josephine, Crook, Wheeler, and Grant. Oregon experienced its third driest November – January period since 1895.

Source:Taylor, George and Raymond R Hatton. (September 1999). The Oregon Weather Book: State of Extremes. Governor-declared drought declarations obtained from the Oregon State Archives division.

Probability

Drought is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event. It is a temporary condition and differs from aridity because the latter is restricted to low rainfall regions and is a permanent feature of climate. It is rare for drought not to occur somewhere in North America each year. Despite impressive achievements in the science of climatology, estimating drought probability and frequency continues to be difficult. This is because of the many variables that contribute to weather behavior, climate change, and the absence of historic information. Nevertheless, progress is being made, particularly in the area of cyclic climatic variations.

Cyclical Climatic Variations

There is a great deal of debate about cyclic climatic changes in Oregon and the Pacific Northwest. The dialogue seems to center on two Pacific weather systems, El Niño and La Niña, but there also is considerable interest in two much larger systems: the El Niño Southern Oscillation (ENSO) and its counterpart, the Pacific Decadal Oscillation (PDO). Simply stated, all of these systems involve the movement of abnormally warm or cool water into the eastern Pacific, dramatically affecting the weather in the Pacific Northwest.

An El Niño system moves heat, both in terms of water temperature and in atmospheric convection. The heat is transported toward North America, producing mild temperatures and dry conditions in Oregon. Its effects are most pronounced from December through March. It appears to occur in cycles of two to seven years and its effects have become fairly predictable.

La Niña conditions are more or less opposite those created by El Niño. It involves the movement of abnormally cool water into the eastern Pacific. This event produces cooler than normal temperatures in Oregon and increased precipitation. It also is most pronounced from December to March. Typically, El Niño events occur more frequently than La Niña events.

- Drought is often associated with water scarcity, which usually is perceived as a "human-caused" hazard, rather than a "natural" hazard.
- Drought is frequently an "incremental" hazard, the onset and end are often difficult to determine. Also, its effects may accumulate slowly over a considerable period of time and may linger for years after the termination of the event.
- Quantifying impacts and provisions for disaster relief is a less clear task than it is for other natural hazards.
- The lack of a precise and universally accepted definition adds to the confusion about whether or not a drought actually exists.
- Droughts are often defined by growing seasons, the water year, and livestock impacts.

Figure D-3: drought – the nebulous natural hazard

Predicting Droughts in Oregon

Predicting weather patterns is difficult at best, however the 1997-98 El Niño event marked the first time in history that climate scientists were able to predict abnormal flooding and droughts months in advance for various locations around the United States.3 The methodology consists of monitoring water temperatures, air temperatures, and relative humidity plus measuring sea-surface elevations. Once an El Niño or La Niña pattern is established, climatologists can project regional climatic behavior. Although the scientific community is enthusiastic about its recent successes, all droughts are not associated with El Niño / La Niña events.

[3] nationalgeographic.com, 1999

Dust Storms

A dust storm is a strong, violent wind that carries fine particles such as silt, sand, clay, and other materials, often for long distances. The fine particles swirl around in the air during the storm. A dust storm can spread over hundreds of miles and rise over 10,000 feet. They have wind speeds of at least 25 miles per hour.

> Think dusts storms aren't a serious natural hazard? Over the past 40 years in Oregon, more than ten people have been killed and more than 60 injured – some very seriously – due to automobile accidents caused by dust storms, often exacerbated by excessive speed.

Dust storms usually arrive with little warning and advance in the form of a big wall of dust and debris. The dust is blinding, making driving safely a challenge. A dust storm may last only a few minutes at any given location, but often leave serious car accidents in their wake, occasionally massive pileups.

Dust storms occur most frequently over deserts and regions of dry soil, where particles are loosely bound to the surface. Dust storms don't just happen in the middle of the desert, however. They happen in any dry area where loose dirt can easily be picked up by wind. Grains of sand, lofted into the air by the wind, fall back to the ground within a few hours, but smaller particles remain suspended in the air for a week or more and can be swept thousands of kilometers downwind. Dust from the Sahara desert regularly crosses the Atlantic, causing bright red sunrises and sunsets in Florida, traveling as far as the Caribbean and the Amazon Basin.[8]

Airborne dust particles, or dust aerosols, alter the climate by intercepting sunlight intended for the surface. By shading the earth from the sun's radiation, dust aerosols have the same effect as a rain cloud. While solar radiation is reduced beneath the dust cloud, the absorption of sunlight by dust particles heats the cloud itself.

Approximately half of the dust in today's atmosphere may result from changes to the environment caused by human activity, including agriculture, overgrazing, and the cutting of forests. Data from dust traps near urban areas like Las Vegas show that the spread of housing and other human construction across the desert directly causes increases in dust storms by destabilizing the surface and vegetation.

Analysis and Characterization

Intensive tillage of soils in agricultural uses is also a significant condition releasing soil to make it easily transportable by high winds. Depending on the crop and region involved, tillage may be occurring in the spring and/or in the autumn. Research in north-central Oregon and south-central Washington indicates that region's dust problem isn't simply a matter of soil being redistributed from one field to another by the wind. Fine particulate becomes suspended in the air and may travel thousands of miles. Scientists indicate that the region is truly losing soil.

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[8] Some of the preceding material is from http://www.kidzworld.com/site/p707.htm#

"In September of 1999, after a long dry summer, a farmer was plowing his wheat fields in Eastern Oregon on a blue-sky day. A freak wind whipped up and dust covered the roadway. Instantly, everything went black. Later, they found dead people in cars with the cruise controls still set as high as 75 miles an hour. One person involved in the accident tried to go back to warn others. He waved at them, but the passing drivers just waved back... The last sight the young man had of one trucker was the trucker driving full bore into the dust storm, both hands off the wheel as he waved at the young man."
(April Henry from *Learning to Fly*)

During this September 25, 1999 dust storm, high winds blowing dust set off a chain-reaction of crashes that killed eight people and injured more than twenty. In all, more than forty vehicles crashed in separate pileups in both freeway directions between Hermiston and Pendleton. Parts of Interstate 84 were blocked from mid-morning until nearly midnight.

Huge dust clouds set off by 50 mile per hour winds, dry soil, recent planting of nearby wheat fields and harvesting of potato fields created extremely hazardous driving conditions that fateful morning. However, an Oregon State Police (OSP) report on the dust storm didn't blame the weather. It reported that driving too fast for conditions was the primary cause of the pileups.

The report indicated that neither OSP nor ODOT had enough warning time to close the freeway before the chain reaction crashes started. Five minutes after OSP noticed that visibility on the freeway was rapidly getting worse, the accidents started.

Community Solutions Team meetings held in early 2000 determined that focusing on the Natural Resources Conservation Service, and Soil and Water Conservation District practices shown on pages xx will help reduce the volume of materials available to be whipped-up in dust storms.

These meetings also resulted in initiatives to increase detection and warning time. These allow OSP and ODOT to temporarily close certain highways, as well as better inform and advise the traveling public.

Several other ideas were examined for possible implementation along the I-84 corridor. Most were determined to be either ineffective or impractical for solving the problems of dust storms that occasionally occur in the area.

Derived from the reports developed by a Community Solutions Team and Oregon State Police after the September 25, 1999 Umatilla County dust storm

Air quality is adversely affected by windblown dust. Oregon's Department of Environmental Quality (DEQ) has developed a rule concerning air pollution caused by particulates from volcanic ashfall or windblown dust. Excerpts from that rule are shown in Appendix XX.

> "We called the weather service about 9:30 saying that visibility was getting bad… I could see the dust coming in a big cloud from the southwest. There's too much tillage to the west and southwest of us. You get a wind event like we had and that soil is loose, powdery and lifting, and I don't think you can stop it… Farming by its very nature, particularly in this country on these soils, at some time is going to involve tillage, and when it does… you're going to have exposure to winds… have wind and exposed soil, you're going to have dust."

Pendleton area farmer and member of the Oregon Wheat Growers League, talking about the September 25, 1999 event

Although many people are aware of the negative effects of dust storms such as vehicle crashes on highways, erosion of topsoil, dust in electronic equipment and aircraft engines, and poor air quality, a less obvious but important effect of dust storms and volcanic ashfall is not widely known: dust and ash deposited on the ground surface in new locations is eventually carried down into the soil by rain, providing important nutrients for plants in those locations.

> "(Farmers) say this is a problem the Columbia Basin, composed of mostly sandy soils, has experienced every spring before the rapid farm development that has followed circle irrigation… Luther Fitch, county extension agent in Hermiston… facetiously said Wednesday's winds 'probably sent a foot of topsoil back to Montana… undoubtedly there will be considerable need to replant spring wheat and potatoes. Fertilizer will have moved on and needs to be reapplied.' " *East Oregonian*, Steve Clark, Friday, March 26, 1976, p.1

> "…dust from freshly plowed fields hung heavy over much of Oregon last night as a windstorm of gale proportions continued unabated. One death and several injuries were attributed to the storm… Political storms abated for the moment, Salem lay yesterday under a pall of Eastern Oregon dust, which the oldest old-timers said was unique in the city's history. A swirling northeast wind drove tons of Eastern Oregon dust before it, down the Columbia Gorge and into Western Oregon. Diverting down the Willamette River at Portland, the dust clouds reached the valley early Wednesday morning and shrouded the entire country… Lights went on in schools, homes, and business houses as though the day was mid-winter… Old-timers in Salem scratched their heads yesterday and tried to recall a parallel in storm history for the dust invasion… but no precedent for the gale of dirt could be recalled. 'I recall a terrific storm in January 1880,' said A.N. Moores. 'However, it was a wind storm alone and there was no dirt accompanying it'… (Mill City) was surprised Tuesday evening when a heavy bank of clouds filled with dust began to work its way over the mountains and shut off the view of the surrounding hills by its denseness."
>
> *Oregon Statesman*, Thursday, April 23, 1931, pp.1-2

During June 2004, a group of residents of Summer Lake, known as Friends of Summer Lake, asked the state to divert to the lake a third of the water that currently feeds a wildlife sanctuary and irrigates pastures, contending that these uses make the lake dry-up sooner and more often. Another factor in the lake drying-up, however, is increased development in and around the basin, which has reduced the underground aquifer, decreasing the flow of springs.

Rainfall in the area, mostly during winter, averages 12 inches per year, but evaporation in the high desert - where summer temperatures can climb to 105 degrees - averages 40 to 50 inches per year.

Darrell Seven, who owns Summer Lake Inn with his wife, Jean Sage, said wind whipping over the dry lakebed causes alkali dust storms. "It's hard to breathe, it's irritating and it makes you sick," said Seven, who has been in the valley for 30 years. "I lose customers all the time who say they just can't handle it."

Alan Withers, president of the Summer Lake Irrigation District said, however, "This lake isn't very pretty, and we get a lot of dust down here. It's nature's way."

Based on an Associated Press article

Competition for scarce water can affect the location and frequency of dust storms.

Historic Dust Storms in Oregon

Table 2-DU-1 lists historic dust storms in Oregon.

Table 2-DU-1: Historic Dust Storms in Oregon

Date	Location	Description
May 1843[9]	Columbia Gorge	Rev. Gustavus Hines, who was traveling by canoe with a Dr. Davis in the Columbia Gorge, reported this storm
1906	Mid-Willamette Valley	News reports from the April 1931 event (see below) make historical reference to "the great sandstorm of 1906 that lasted two weeks."
April 1931[10]	Columbia Gorge, Central Oregon, north and mid-Willamette Valley, and Santiam Canyon	A swirling northeast wind drove tons of dust down the Columbia Gorge and into Portland and the north and mid-Willamette Valley; a heavy bank of clouds filled with dust also reportedly worked their way over mountain passes into the Santiam Canyon.
May 1975[11]	Near Echo Junction	Winds up to 45 mph blew dust from nearby plowed fields, resulting in a seven-car accident on a Friday afternoon in the eastbound lanes of Interstate 80 (now I-84); four injured.
March 1976[12]	Near Stanfield	Eighteen vehicles piled-up in two separate accidents on Interstate 80, now I-84; these accidents killed one and

[9] Diary of Rev. Gustavus Hines

[10] *Oregon Statesman*, "Dust, Wind, and Fire Cause Great Damage," April 23, 1931 and "Dust Storm Precedent on Record 88 Years Ago," April 26, 1931; information on this event, as well as the 1906 event, may also be found in the *Pacific Northwest Quarterly*, "The Pacific Northwest Dust Storm of 1931," Paul C. Pitzer, April 1988, pp. 50-55, as informed by the following sources used by Mr. Pitzer:

Albany *Democrat-Herald*, April 22, 1931
Astoria *Evening Budget*, April 24, 1931
Coos Bay *Times*, April 22, 23, 1931
Corvallis *Gazette-Times*, April 22, 24, 1931
Pendleton *East Oregonian*, April 22, 1931
Portland *Oregonian*, April 22, 25, 26 and May 1, 1931
Portland *Oregonian*, Lancaster Pollard, August 21, 1955 and November 25, 1962
Roseburg *News-Review*, April 22, 23, 1931
Salem *Oregon Journal*, April 22, 23, 24, 1931
San Francisco *Chronicle*, April 25, 1931
The Dalles *Optimist*, April 24, 1931
Wenatchee *Daily World*, April 22, 1931
Beef Cattle Industry in Oregon: 1890-1938, Dexter K. Strong, 1940
Wind Erosion and Dust Storms in Oregon, Arthur King, 1938.

[11] *East Oregonian*, May 24, 1975

[12] *East Oregonian*, March 24, 25, and 26, 1976, including articles titled "18 Vehicles Crash in Dust Storm; Woman Killed" and "Dust Problem Stymies Farmers"; *Oregon Statesman*, "Dust Storms Hit E. Oregon…", March 25, 1976

Date	Location	Description
		injured 20 people; they were caused by a dust storm (referred to in the press as a sand storm) that produced "near zero" visibility; one of the pile-ups was a fiery accident involving a loaded fuel tanker truck, two other trucks, and two cars; this dust storm also caused road closures both south and north of Hermiston, and caused other accidents on Highway 207 about nine miles south of I-80 (84).
July 1979[13]	Near Stanfield	This dust storm caused two deaths and six injuries in a freeway pile-up on I-80 (84) very close to the location of the previous event; winds near 60 mph; some of the injured were hit as pedestrians while trying to assist those already injured or pinned in automobiles.
Sept. 1999[14]	Morrow and Umatilla Counties	Blowing dust off wheat fields killed eight and injured more than twenty people in chain-reaction auto crashes.
April 2001[15]	Near Klamath Falls	Highway 97 about five miles north of Klamath Falls was closed for approximately six hours following three separate crashes; eleven cars were involved, sending nine people to the hospital; the accidents were due to severely limited visibility caused by high winds blowing dust from a recently plowed field across the highway.
June 2004[16]	Lake County	Blowing dust from a dry lake bed filled the sky in and near Summer Lake.
March 2005[17]	Near Boardman, and in Deschutes County	Weather stations at nineteen locations measured peak wind gusts from 45 to 64 mph. Visibility restrictions down to near zero due to blowing dust occurred along I-84 between Boardman and Pendleton. Extremely low visibilities led to road closures and multiple vehicle pileups. Vehicles pulled off the road to avoid collisions. Visibilities of a half mile or less due to flowing dust were also reported in Deschutes County.

[13] *Oregon Statesman*, "2 Dead, 6 Injured in Freeway Accident; Dust Storm Blamed," July 11, 1979

[14] *La Grande Observer*, "State Gives Dust Storm Driving Advice," October 1, 1999 and "Report Blames Speed," November 20, 1999; *Statesman Journal*, "Six Die in 50-car Pileup on I-84: Dust Blinds Drivers on the Interstate near Pendleton," September 26, 1999, "Dust Brownout Led to Fatal Wrecks: Dry Weather and High Winds Created the Deadly Eastern Oregon Storm," September 27, 1999, and "Road Warnings Needed: Motorists Can Learn from Last Week's Fatal Dust Storm Collisions," October 5, 1999; *Corvallis Gazette-Times*, "Corvallis Couple Recovering from Highway Crash," September 27, 1999; *Learning to Fly*, April Henry; *East Oregonian,* Mitchell Zach; Associated Press news story dated September 26, 1999; also post-event documents of the Community Solutions Team (meeting minutes) and Oregon State Police

[15] Weather Channel website, April 18, 2001

[16] Associated Press, TBD

[17] TBD

Date	Location	Description
Jan. 2008[18]	Baker, Morrow, Umatilla, and Union Counties	ODOT closed the freeway's westbound lanes between Baker City and La Grande about noon because of blowing snow, dust, and debris that created near-zero visibility in the Ladd Canyon area east of La Grande. The eastbound freeway lanes were closed between mile point 193 west of Pendleton and Baker City because of high winds, crashes, and visibility issues. Five patrol cars and two pickup trucks operated by troopers responding to overturned vehicles received windshield and body damage from wind-blown rocks. ODOT also closed Oregon 11 between Pendleton and Milton-Freewater. Police reported several accidents caused by low visibility, blowing dust and debris.
Nov. 2009[19]	Lake County	An alkaline dust storm blew into Lakeview.
Aug. 2012[20]	Harney and Malheur Counties	A massive dust storm due to 50 to 60 mph winds produced by thunderstorms eventually blew on into Idaho; some media reports indicate this event darkened the skies in some areas for more than two hours.
March 2013[21]	Malheur County	Dust from this storm is reported to have accelerated snowmelt in a Southwestern Idaho mountain range. 'nobody on our staff has ever witnessed anything similar,' said Adam Winstral, Research Hydrologist with the U.S. Depertment of Agriculture.
Sept. 2013[22]	Baker and Umatilla Counties	Dust storm occurs in and near Baker City; dust storms two weeks apart hit Weston.

Sources: Various sources, See footnotes

[18] TBD

[19] http://en.wikipedia.org/wiki/Goose_Lake_(Oregon-California)

[20] *Idaho Press Tribune* (Tom Dale), August 6, 2012; KTVB, August 5, 2012; KBOI, August 5, 2012; USGS, *Dust, an emerging problem in the Great Basin: insights from 2012,* January 23, 2013; YouTube, Brenda Burns, published August 6, 2012 and Zeronieo, published August 14, 2012; *Mother Recounts Her Encounter with an Oregon Dust Storm,* Yahoo Voices, August 8, 2012

[21] *The Oregonian* (oregonlive,com), March 29, 2013; *Idaho Statesman* (Rocky Barker), March 28, 2013

[22] *Daily Mail*, September 16, 2013; YouTube, Fredrik Anderson, September 12, 2013

Probability

Based on a literature search conducted by the Oregon Office of Emergency Management (OEM), thirteen significant dust storms have been recorded in Oregon over the past 40 years. Four of these were during 2012 and 2013, which suggests a bias in the research toward more recent events. Based strictly on the average, the recurrence interval is about once every three years for significant dust storms. However, the mid '70s, the millennium roll-over years, and other short time periods seem to have produced more storms. There may be a relationship with ENSO, droughts, or some other weather pattern. This would benefit by more research.

Earthquake

Oregon has experienced few damaging earthquakes during its recorded history, leading to complacency and lack of attention to earthquake-resistant design and construction. Since the mid-1980's, an increasing body of geologic and seismologic research has changed the scientific understanding of earthquake hazards in Oregon, and in recent years several large and destructive earthquakes around the world have heightened public awareness. Recognized hazards range from moderate sized crustal earthquakes in eastern Oregon to massive subduction zone megathrust events off the Oregon coast. All have the potential for significant damage as long as most of Oregon's buildings and infrastructure have inadequate seismic resistance. The scale of structural retrofit and replacement needed to make Oregon earthquake safe is huge, and beyond our capacity to implement in anything less than decades. To manage the human and economic impact of the next damaging earthquake will require thoughtful and comprehensive emergency response planning, based on realistic loss estimates driven by accurate and detailed geologic and seismologic, structural and cultural information. To minimize the human and economic impact of the next damaging earthquake will require a sustained program of public education, forward-thinking research, and structural replacement and retrofit, based on cost-effective earthquake resistant design and a combination of public funding and private sector incentives.

Analysis and Characterization

Earthquake sources

Earthquakes are a highly variable natural phenomenon. The vast majority occur when two masses of rock in the earth's crust abruptly move past each other along a large crack or fracture called a fault. The energy released as the two parts slide along the fault produces waves of shaking that we perceive as an earthquake. Faults typically build up stress over decades to millennia in response to large scale movement of the earth's tectonic plates. Even the most active faults only produce damaging earthquakes at intervals of a century or more, and for many the intervals are much longer. As a result, it is very difficult to forecast the likelihood of an earthquake on a particular fault because we rarely have a long enough record to determine a statistically meaningful return period (average time between earthquakes).

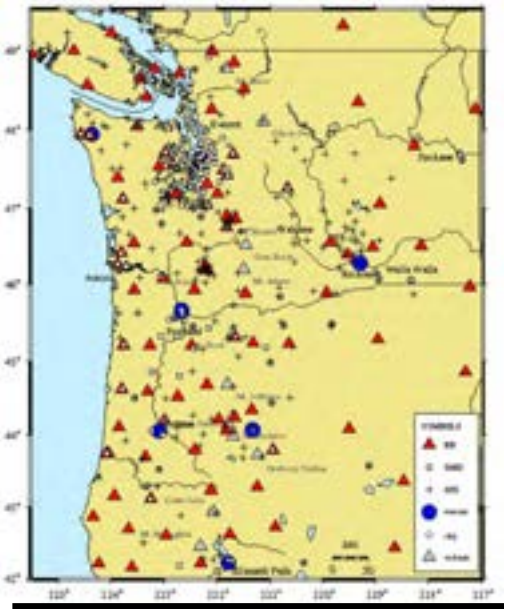


Figure 2-EQ-1: Current configuration of the network of earthquake monitoring stations in the Pacific Northwest, The system is operated out of the University of Washington by the Pacific Northwest Seismic Network.

Source: Pacific Northwest Seismic Network at website: http://www.pnsn.org/

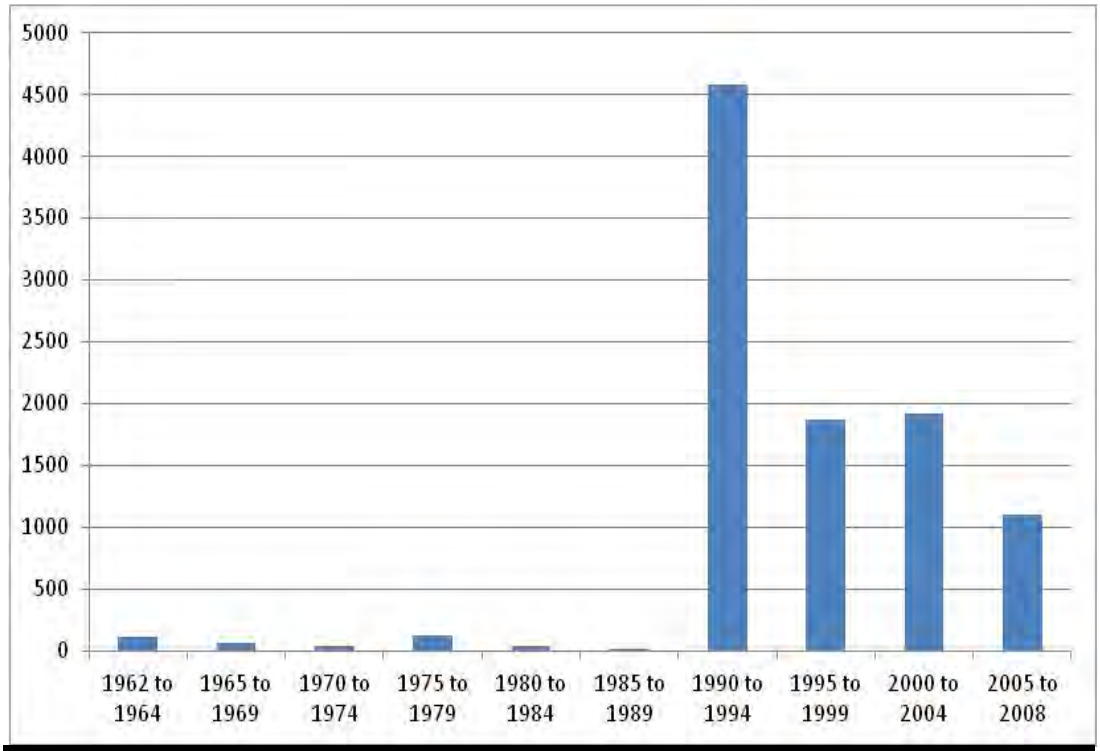


Figure 2-EQ-2: Annual rate of earthquake occurrence in Oregon, in 5-year increments. Seismic instruments began operation in 1970, but the network only became fully effective in 1990. Huge spikes in earthquake numbers in the early 1990s are aftershocks from the 1993 Scotts Mills and Klamath Falls earthquakes.

The history of earthquakes in a region comes from three types of information. Instrumental data comes from networks of seismic recording instruments (seismographs) that are widely deployed in the Pacific Northwest.

Seismic networks can detect very small earthquakes, locate them to within a few miles, and determine their magnitude accurately. Seismographs have only existed for about a century, and in Oregon, the instrumental record is really only complete and modern from about 1990 on. Historical felt location data comes from verbal and written reports of earthquake effects. The felt record extends back to the mid 1800's for Oregon, but only locates moderate to large earthquakes, and those only with an accuracy of tens or even hundreds of miles.

Paleoseismic data uses geologic records of earthquake effects to determine the approximate size and timing of earthquakes that happened in prehistoric times. The paleoseismic record can extend back for thousands or tens of thousands of years, but provides only approximate information about the size, time and place of past large earthquakes.

In Oregon, the combined earthquake history derived from these three sources clearly outlines two major types of earthquake hazard and two less significant sources. By far the greatest is the hazard posed by infrequent **megathrust earthquakes** on the Cascadia Subduction Zone. The second major hazard comes from smaller **crustal earthquakes** on faults in or near populated areas, which includes all of Oregon's damaging historic earthquakes. Intraplate eathquakes, which have been historically damaging in the Puget Sound area are possible in Oregon but no damaging prehistoric or historic events are known. Finally, earthquakes associated with Oregon's many young volcanoes may produce damaging shaking in communities close to the volcano.

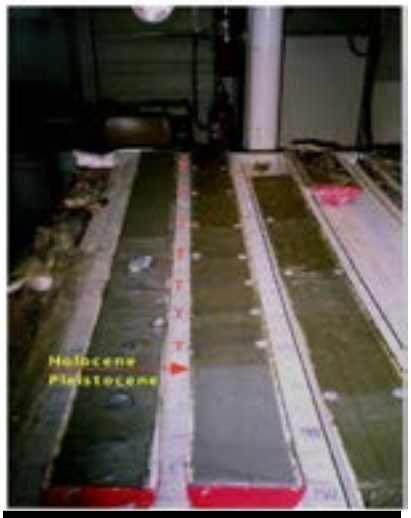


Figure 2-EQ-3: Deep sea sediment cores showing submarine landslide layers (turbidites) that record past megathrust earthquakes off the Oregon coast. Red T's mark the top of each layer.

Source: Goldfinger and others, 2011.

The Cascadia Subduction Zone is the boundary between two of the earth's crustal plates. These continent-sized plates are in constant slow motion, and the boundaries between plates are the site of most earthquake activity around the globe. At the Cascadia Subduction Zone, the Juan De Fuca plate, located offshore of Oregon and Washington, slides to the northeast and under the North American plate, which extends from the Oregon coast clear to the middle of the Atlantic Ocean. The Juan de Fuca plate slides beneath the continent (subducts) at about 1.5 inches per year, a speed which has been directly measured using high accuracy GPS. The fault that separates the plates extends from Cape Mendocino in Northern California to Vancouver Island in British Columbia, and slopes down to the east from the sea floor. The fault is usually locked, so that rather than sliding slowly and continuously, the 1.5 inches per year of subduction motion builds tremendous stress along the fault. This stress is periodically released in a megathrust earthquake, which can have a magnitude anywhere from 8.3 to 9.3.

Figure 2- EQ-4: Schematic 3-D map showing the general source areas for subduction zone, crustal earthquakes and intraplate earthquakes

Source: DOGAMI

Figure 2-EQ-4 (left) is a schematic three dimensional diagram with the generalized locations of the three types of earthquake sources found in Oregon: subduction zone, crustal and intraplate earthquakes.

The Cascadia Subduction Zone closely mirrors the subduction zone in northern Japan that produced the 2011 Tohoku earthquake (Figure EQ-5) . This magnitude 9 megathrust event and its associated tsunami captured the world's attention with unforgettable images of destruction on a massive scale. Oregon should regard this as a window into our future, as this is the very type of earthquake that our best science tells us is likely on the Cascadia Subduction Zone. Particular attention must be paid to the incredibly destructive tsunami that accompanied the Tohoku earthquake, and we must plan for a similar tsunami in Oregon (see the Tsunami section of this Plan, beginning on page 99, for more information about tsunamis in Oregon).

Figure EQ-5: Comparison of the subduction zone in northern Japan that was the setting for the 2011 Tohoku M 9.0 earthquake and the Cascadia subduction zone. Yellow patches are the measured earthquake rupture zone in Japan, modeled earthquake rupture zone in Oregon.

Source: DOGAMI

- ~16,000 dead
- ~4,000 missing (as of 10/12/2011)
- ~6,000 injuries
- ~300,000 homes destroyed
- ~600,000 homes damaged
- 92% of deaths due to tsunami (drowning)
- Fatality rate within the tsunami inundation zone ~16%
- Population within 40 km of coastline ~3,000,000

Figure 2-EQ-6: 2011 Tohoku earthquake numbers

Crustal earthquakes occur for the most part on shore on much smaller faults located in the North American plate,. These are the more familiar "California-style" earthquakes with magnitudes in the 5 to 7 range. Although much smaller than the megathrust earthquakes, crustal earthquakes may occur much closer to population centers, and are capable of producing severe shaking and damage in localized areas. For many parts of eastern Oregon, crustal faults dominate the hazard, and they may also have a significant impact in the Portland region and Willamette Valley.

Intraplate earthquakes are a third type that is common in the Puget Sound, where they represent most of the historical record of damaging events. In Oregon, these earthquakes occur at much lower rates, and none have ever been close to a damaging magnitude. They contribute little to the aggregate hazard in most of Oregon.

Earthquake Effects

Earthquake damage is largely controlled by the strength of shaking at a given site. The strength of shaking at any point is a complex function of many factors, but magnitude of the earthquake (which defines the amount of energy released) and distance from the epicenter or fault rupture, are the most important. The ripples in a pond that form around a dropped pebble spread out and get smaller as they move away from the source. Earthquake shaking behaves in the same way, and you can experience the same strength of shaking 10 miles from a magnitude 6 earthquake as you would feel 100 miles from a magnitude 9 earthquake.

Two measurement scales are used to describe the magnitude and intensity of earthquakes. To measure the magnitude the "Moment Magnitude" (M_w) scale uses the Arabic numbering scale. It provides clues to the physical size of an earthquake (NOAA-OAR-CPO-2014-2003692) and is more accurate than the previously used Richter scale for larger earthquakes. The second scale, the "Modified Mercalli," measures the shaking intensity and is based on felt observations and is therefore more subjective than the mathematically derived Moment Magnitude. It uses Roman numerals to indicate the severity of shaking. It is important to understand the relationship between the intensity of shaking the amount of damage expected from a given earthquake scenario.

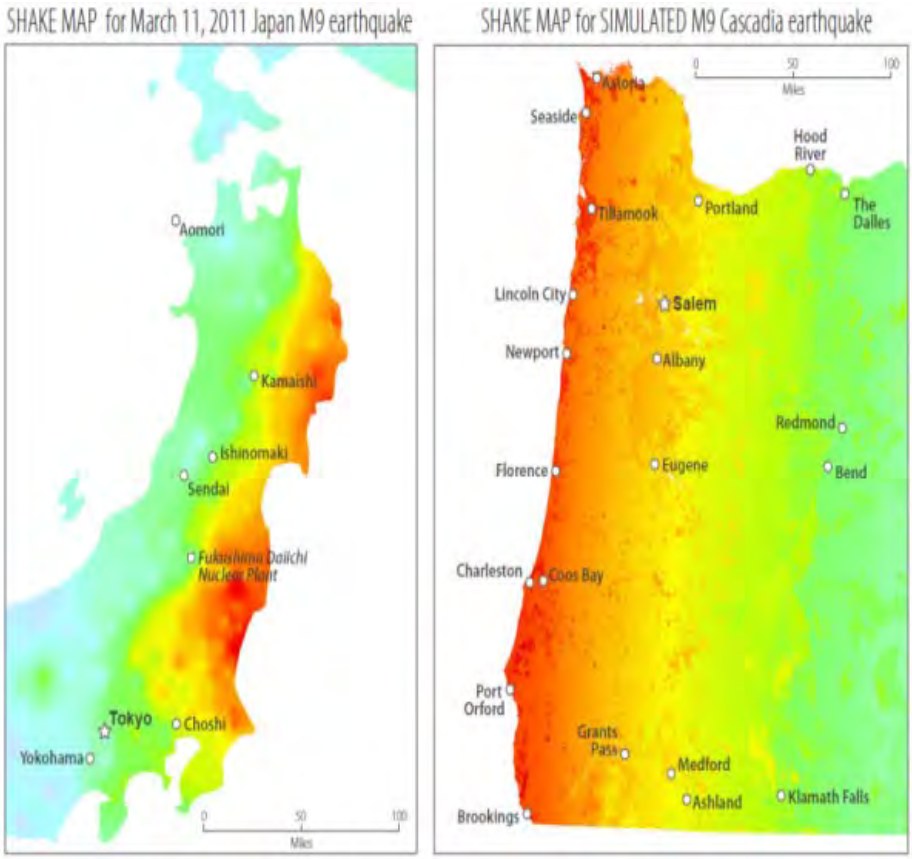
Table 2-EQ-1 gives an abbreviated description of the 12 levels of Modified Mercalli intensity.

Table 2-EQ-1: 12 levels of Modified Mercalli intensity

I.	Not felt except by a very few under especially favorable conditions.
II.	Felt only by a few persons at rest, especially on upper floors of buildings.
III.	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV.	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V.	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI.	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII.	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII.	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX.	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X.	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI.	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII.	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Source: Abridged from The Severity of an Earthquake, a U. S. Geological Survey General Interest Publication. U.S. GOVERNMENT PRINTING OFFICE: 1989-288-913

Future megathrust earthquakes on the Cascadia Subduction Zone (CSZ) will occur off the coast, and the strength of shaking will decrease inland. Oregon coastal communities will experience severe shaking, but the Portland area and Willamette Valley communities are far enough inland that they will feel much less shaking. Because of the size of the megathrust fault, the shaking will impact all of Oregon west of the Cascades, and will still be felt to the east of the Cascades, and will extend to northern California and British Columbia. The other unique characteristic of megathrust earthquakes is that the strong shaking will last for several minutes, in contrast to a large crustal earthquake, which might shake for only 30 seconds. The long duration of shaking contributes greatly to damage, as structures go through repeated cycles of shaking. Figure 2-EQ-7 shows a side-by-side comparison of ShakMaps for 1) the 2011 M9 Earthquake in Japan, and 2) a simulated M9 CSZ event in Oregon.

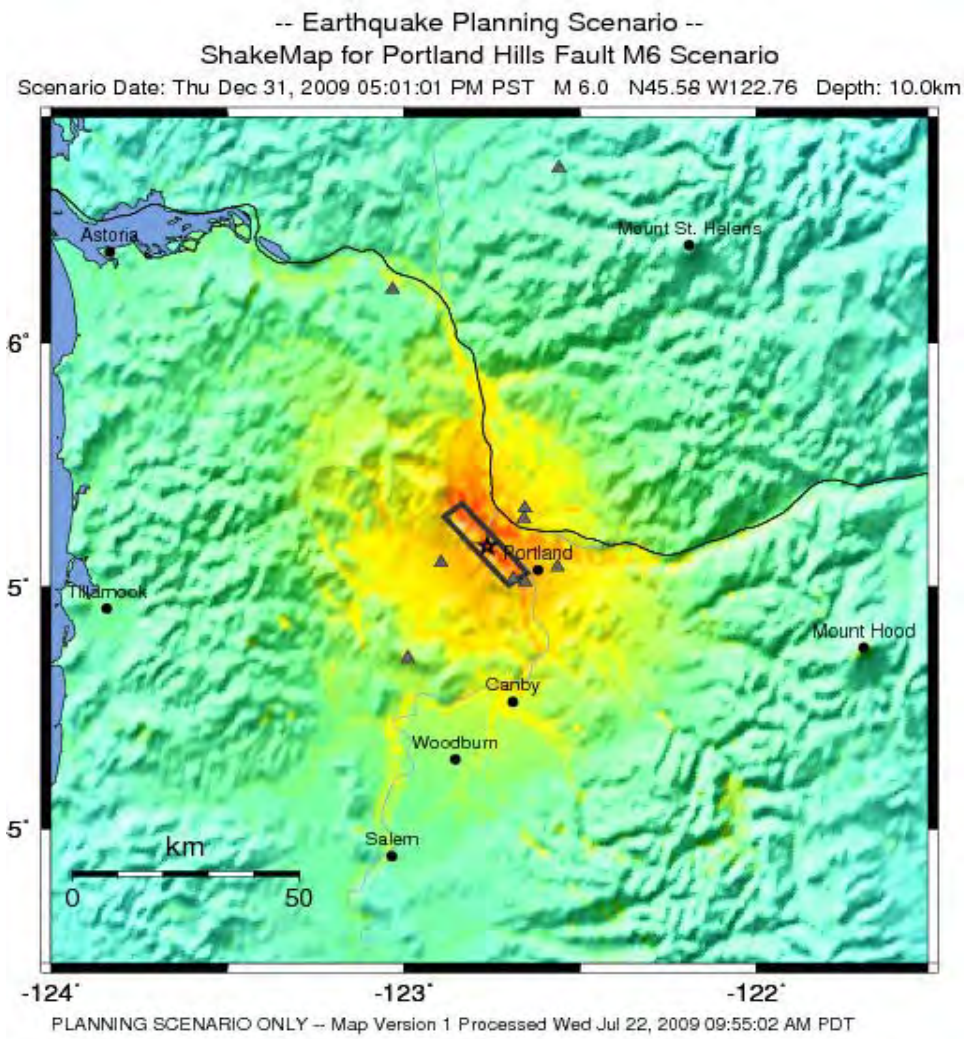


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 2-EQ-7: Comparison of measured shaking from Tohoku earthquake and simulated shaking from M 9 Cascadia megathrust earthquake.

Source: USGS

Future crustal earthquakes will occur along one of many Oregon fault lines, and the shaking will be strongest near the epicenter, and will decrease fairly quickly as you move away. So a magnitude 6 earthquake in Klamath Falls may cause significant damage near the epicenter, but will be only weakly felt in Medford or Eugene. Figure EQ-8 shows a M6 crustal fault ShakeMap scenario along the Portland Hills fault.



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+

Figure 2-EQ-8: Simulated shaking from M 6.0 crustal earthquake on the Portland Hills Fault.

Source: USGS

The other important factor in controlling earthquake damage is the contribution of local geology. Soft soils can strongly amplify shaking, loose saturated sand or silt can liquefy, causing dramatic damage, and new landslides can occur on steep slopes while existing landslide deposits may start to move again (Figure 2-EQ-9). These effects can occur regardless of the earthquake source, and the geologic factors that cause them can be identified in advance by geologic and geotechnical studies. Liquefaction and earthquake induced landslides are both more likely to occur during the several minutes of shaking produced by a megathrust earthquake, and these effects are expected to be widespread during the next event (Figures 2-EQ-10, 11 and 12). In 2013, DOGAMI published a suite of statewide earthquake hazard maps with GIS files in Open File Report O-13-06, including: GROUND MOTION, GROUND DEFORMATION, TSUNAMI INUNDATION, COSEISMIC SUBSIDENCE, AND DAMAGE POTENTIAL MAPS FOR THE 2012 OREGON RESILIENCE PLAN FOR CASCADIA SUBDUCTION ZONE EARTHQUAKES. (2013, Madin and W. Burns). (This report and maps are available at website: http://www.oregongeology.org/pubs/ofr/p-O-13-06.htm.)

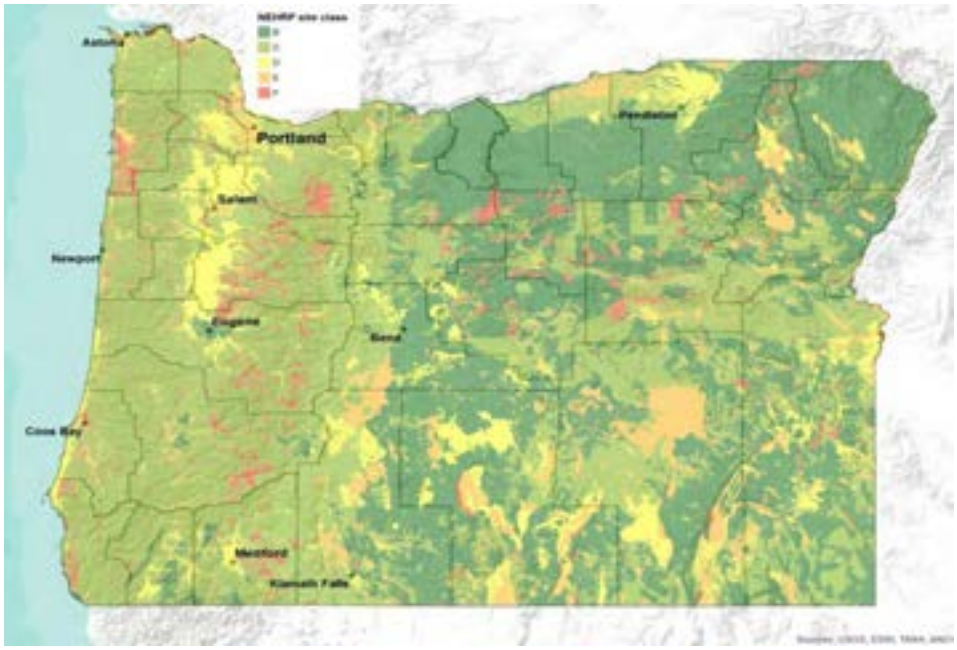


Figure 2-EQ-9: This NEHRP soils map shows areas where soils can amplify the earthquake ground shaking. NEHRP site class F soils are prone to produce the greatest amplification

Source: Madin and Burns, 2013

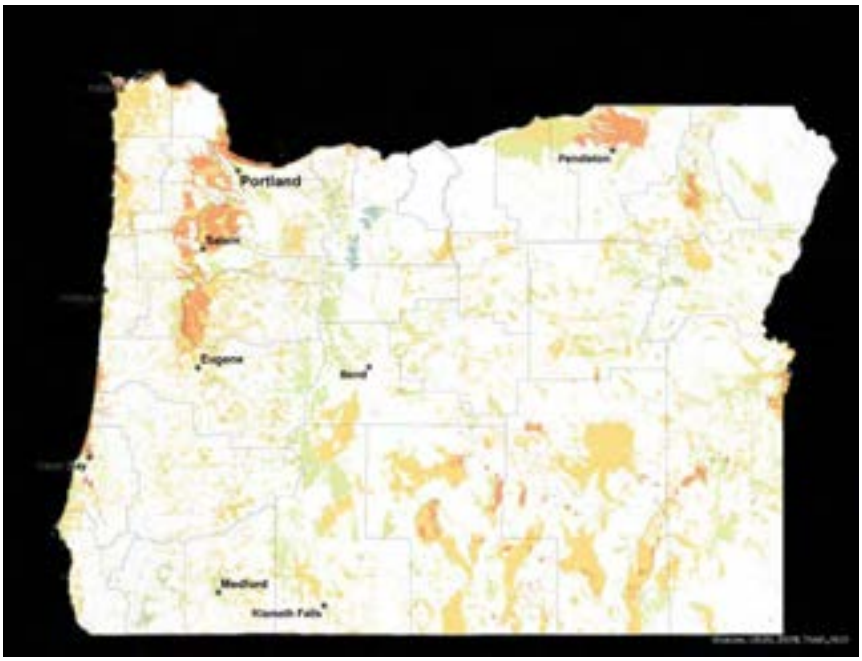


Figure 2-EQ-10: This liquefaction susceptibility map shows areas where soils can liquefy due to the earthquake ground shaking. Areas in red are most prone to liquefy.

Source: Madin and Burns, 2013

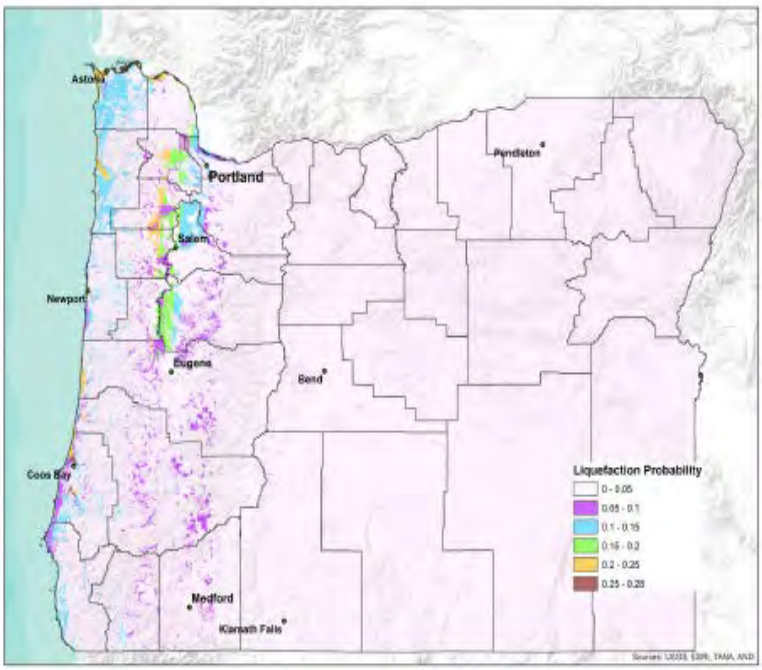


Figure 2-EQ-11: This liquefaction probability map shows the probability of soil liquefaction due to a magnitude 9 Cascadia earthquake. Areas in brown have the highest probability.

Source: Madin and Burns, 2013

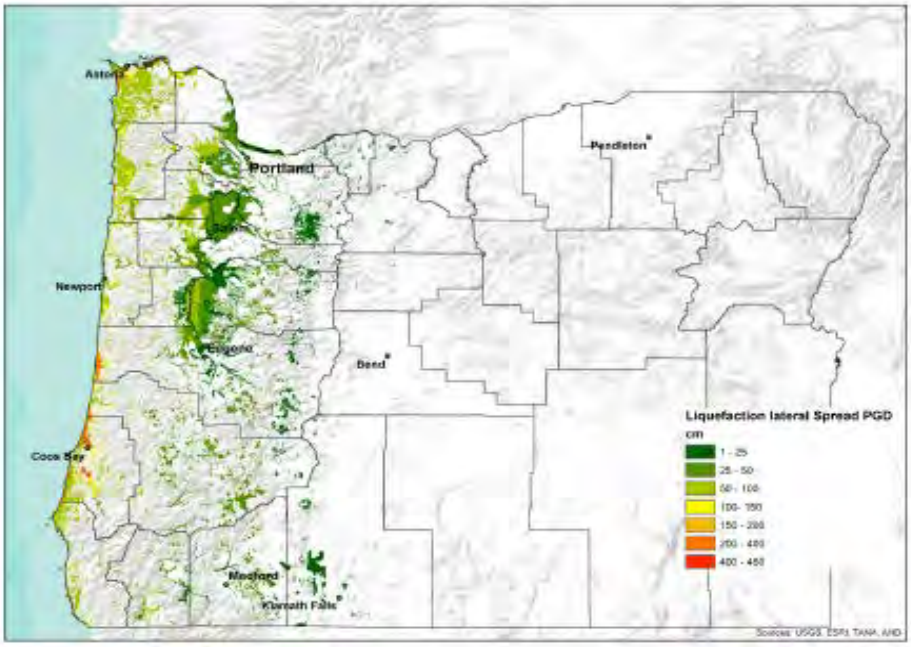


Figure 2-EQ-12: This lateral spreading map shows areas of lateral spreading hazard due to a magnitude 9 Cascadia earthquake. Areas in red have the highest displacement.

Source: Madin and Burns, 2013

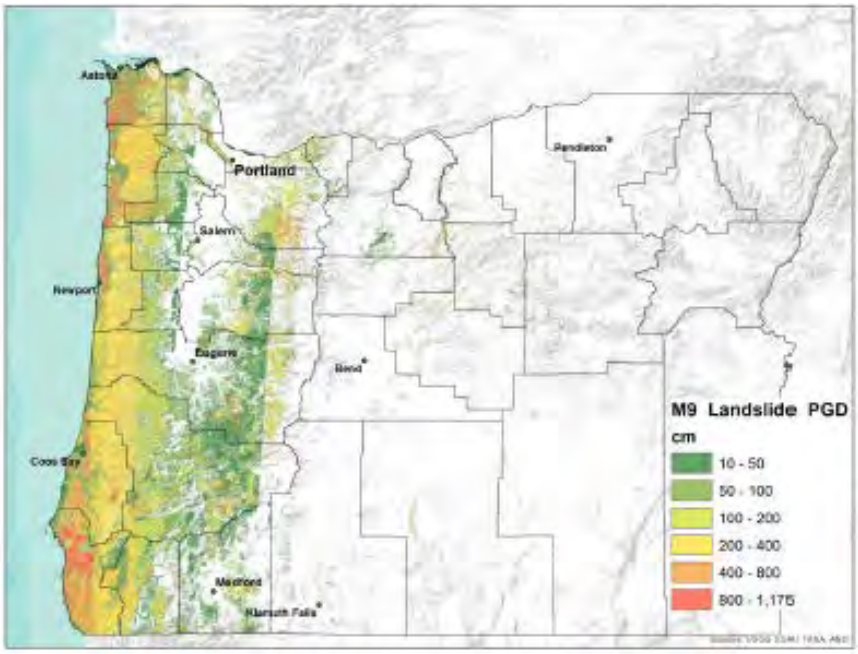


Figure 2-EQ-13: This landslide hazard map shows areas and amount of expected displacement due to a magnitude 9 Cascadia earthquake. Areas in red have the highest displacement.

Source: Madin and Burns, 2013

Historic Earthquakes in Oregon

Figure 2-EQ-14 shows the history of the CSZ megathrust activity in the Pacific Northwest over the past 10,000 years. Table XX lists historic earthquakes in Oregon from both CSZ events and combined crustal events.

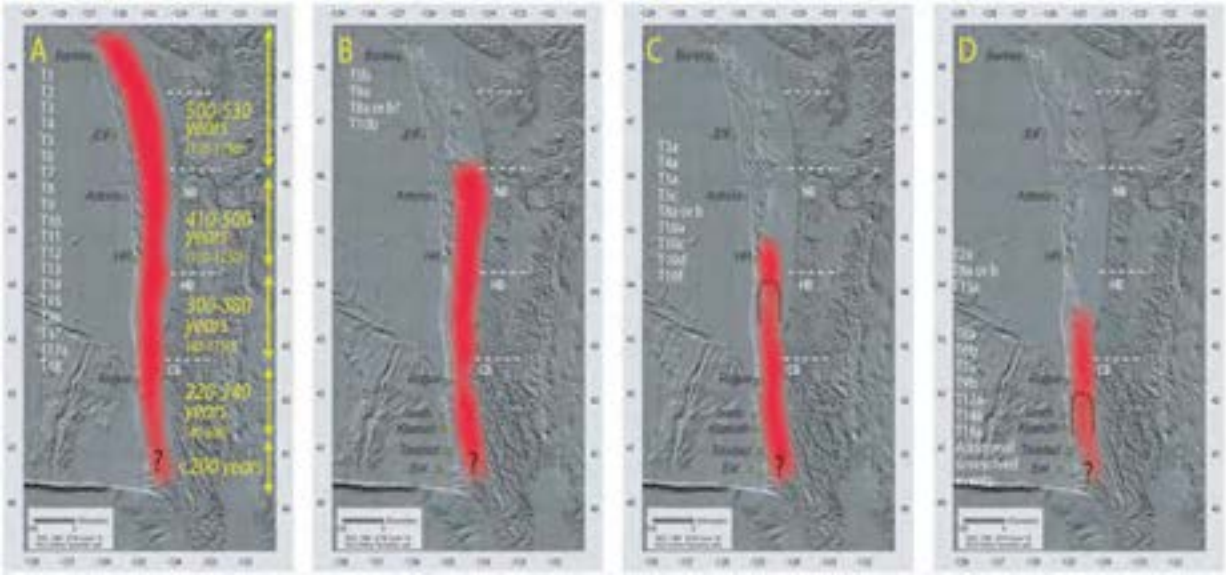


Figure 2-EQ-14: Summary diagram showing Cascadia megathrust earthquake history over the last 10,000 years, "T" numbers identify individual earthquakes. Four distinct modes are seen, ranging from the 19 full-length ruptures in panel A (~M 9) to the 10 smaller ruptures in panel D.

Source: Goldfinger and others, 2011.

Table 2-EQ-2: Historic Earthquakes in Oregon

Date	Location	Description
1873*	Del Norte County, CA	Felt in Portland. Localized chimney damage as far north as Port Orford, Oregon.
1877*	Portland, OR	Intensity Vii. Chimney damage
1892*	Portland, OR	Intensity VI. Affected area: 26,000 square. Buildings swayed, people terrified and rushed into the street. Felt in Astoria and Salem.
1893*	Umatilla, OR	Intensity VI-VII. Damage to buildings in Umatilla.
1896*	McMinneville, OR	Intensity VI. Three shocks in succession in McMinnville . Main shock felt at Portland and Salem.
1906*	Paisley, OR	Intensity V. Three additional shocks followed within 1 1/2 hours.
1913*	Seven Devil's Mountains of western Idaho	Intensity V. Broke windows and dishes.
1915*	Portland, OR	Intensity V. Three shocks reported. Rattled dishes, rocked chairs, and caused fright at Portland.
1923*	Southern Oregon	Intensity V. Plaster fell at Alturas, California. Tremor felt at Lakeview, Oregon
April 8, 1927*	Eastern Baker County, OR	Maximum intensity V (Halfway and Richland). Center: eastern Baker County. Felt widely over eastern Oregon.
July 15 – November , 1936*	Milton-Freewater, OR	Intensity VII. Magnitude 5.75. Center: near the State line between Milton-Freewater, Oregon, and Walla Walla, Washington. Affected area: 272,000 square kilometers in the two States, and Idaho. Ground cracking observed 6.5 kilometers west of Freewater. Marked changes in flow of well water (). Chimneys damaged, plaster broken and walls cracked in Freewaterand Umapine. Total damage : $100,000. Numerous aftershocks up to November 17 (more than 20 moderate shocks during the night, and stronger ones (V) on July 18 and August 4 and 27.
Dec,ber 29, 1941*	Portland, OR	Intensity VI. Affected area: 13,000 square kilometers (Portland). Felt at Hillsboro, Sherwood, Yamhill,and into Washington (Vancouver and Woodland). Windows broken.
April 13, 1941*	Olympia, WA	Magnitude 7.0. At Olympia, Washington, and a broad area around the capital city. Fatalities: 8. Damage: $25 million . Affected area: 388,000 square kilometers. Damage: widespread (Oregon); injuries: several (Astoria and Portland). Maximum intensity: VIII (Clatskanie and Rainier); chimneys twisted and fell;damage to brick and masonry.
December 15, 1953*	Portland, OR	Intensity: VI. Minor damage (Portland area). Affected area: 7,700 square kilometers . One cracked chimney and slight damage to fireplace tile. Plaster cracking (Portland and Roy, OR and Vancouver, WA).
November 16, 1957*	Salem, OR	Intensity VI. Affected area: 11,600 square kilometers (northwestern Oregon). Frightened all in the city and cracked plaster (West Salem).
August 18, 1961*	Albany/Lebanon, OR	Intensity VI. Magnitude 4.5 . Affected area: 18,000 square kilometers. Felt region extended into Cowlitz County, Washington. Damage: minor (Albany and Lebanon, south of the 1957 center Felt in both cities. Two house chimneys toppled, and plaster cracked.
November 6, 1961*	Portland, OR	Intensity VI. Affected area: 23,000 square kilometers (northwestern Oregon and southwestern Washington). Principle damage: plaster

		cracking. Part of a chimney fell, and windows and lights broke.
May 26 – June 11, 1968*	Oregon/California border	Intensity: VI. Magnitude: 4.7. Affected area: 18,000 square kilometers (in the two states).A series of earthquakes near the Oregon-California border. Chimneys fell or cracked, and part of an old rock cellar wall fell. Ground fissures in Bidwell Creek Canyon, near Fort Bidwell, California.
1993**	Scott's Mills, OR	5.7 Mw. Largest earthquake since 1981. Felt from Puget Sound to Roseburg, OR, †,
1993***	Klamath Falls, OR	5.9 Mw & 6.0 Mw. ***Affected area: 130,000 sq km (southwestern Oregon and northern California). Losses: concentrated in downtown area. Intensity VII in downtown Klamath Falls and immediate vicinity and to the Oregon Institute of Technology, but surrounding experienced intensity VI. ††, Fatalities: Two.
2001**	Nisqually, WA	Felt as far south as central Oregon

Sources: * USGS. *Oregon Earthquake History*. Retrieved October 28, 2013, http://earthquake.usgs.gov/earthquakes/states/oregon/history.php
USGS. *Earthquake Archive*. Retrieved October 28, 2013, http://earthquake.usgs.gov/earthquakes/search/

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† - Thomas, G. C., Crosson, R. S., Carver, D. L., and Yelin, T. S. (1996). The 25 March 1993 Scotts Mills, Oregon, Earthquake and Aftershock Sequence: Spatial Distribution, Focal Mechanisms, and the Mount Angel Fault. Bulletin of the Seismological Society of America, 86(4). 925-935.

†† - Dewey, J. W. (1993). Damages from the 20 September Earthquakes Near Klamath Falls, Oregon. Earthquakes & Volcanoes, 24(3), 121.

††† - Bott, J. D., & Wong, I. G. (1993). Historical earthquakes in and around Portland, Oregon. *Oregon Geology*, *55*(5), 116-122.

Probability

The probability of damaging earthquakes varies widely across the state. In Coastal and Western Oregon, the hazard is dominated by Cascadia subduction earthquakes originating from a single fault with a well understood recurrence history. For eastern Oregon the hazard is dominated by numerous crustal faults and background seismicity, with poorly understood probability that varies from region to region. The probability of earthquake hazards occurring in Oregon is defined in two ways. Figure 2-EQ-15 shows the probabilistic hazard for the entire state. This map shows the expected level of earthquake damage that has a 2 percent chance of occurring in the next 50 years. The map is based on the 2008 USGS National Seismic Hazard Map, and has been adjusted to account for the effects of soils following the methods of Madin and Burns, 2013. In this case, the strength of shaking, calculated as peak ground acceleration and peak ground velocity, have been expressed as Mercalli intensity, which describes the effects of shaking on people and structures, and is more readily understandable for a general audience. These maps incorporate all that is known about the probabilities of earthquake on all Oregon faults, including the Cascadia Subduction Zone.

For Oregon west of the crest of the Cascades, the Cascadia subduction zone is responsible for most of the hazard, as shown in Figure 2-EQ-15. The paleoseismic record includes 18 M_W 8.8-M 9.1 megathrust earthquakes in the last 10,000 years that affected the entire subduction zone. The return period for the largest earthquakes is 530 years, and the probability of the next such event occurring in the next 50 years ranges from 7-12%. An additional 10-20 smaller M_W 8.3-8.5 earthquakes only affected the southern half of Oregon and northern California. The average return period for these is about 240 years, and the probability of a small or large subduction earthquake occurring in the next 50 years is 37-43%.

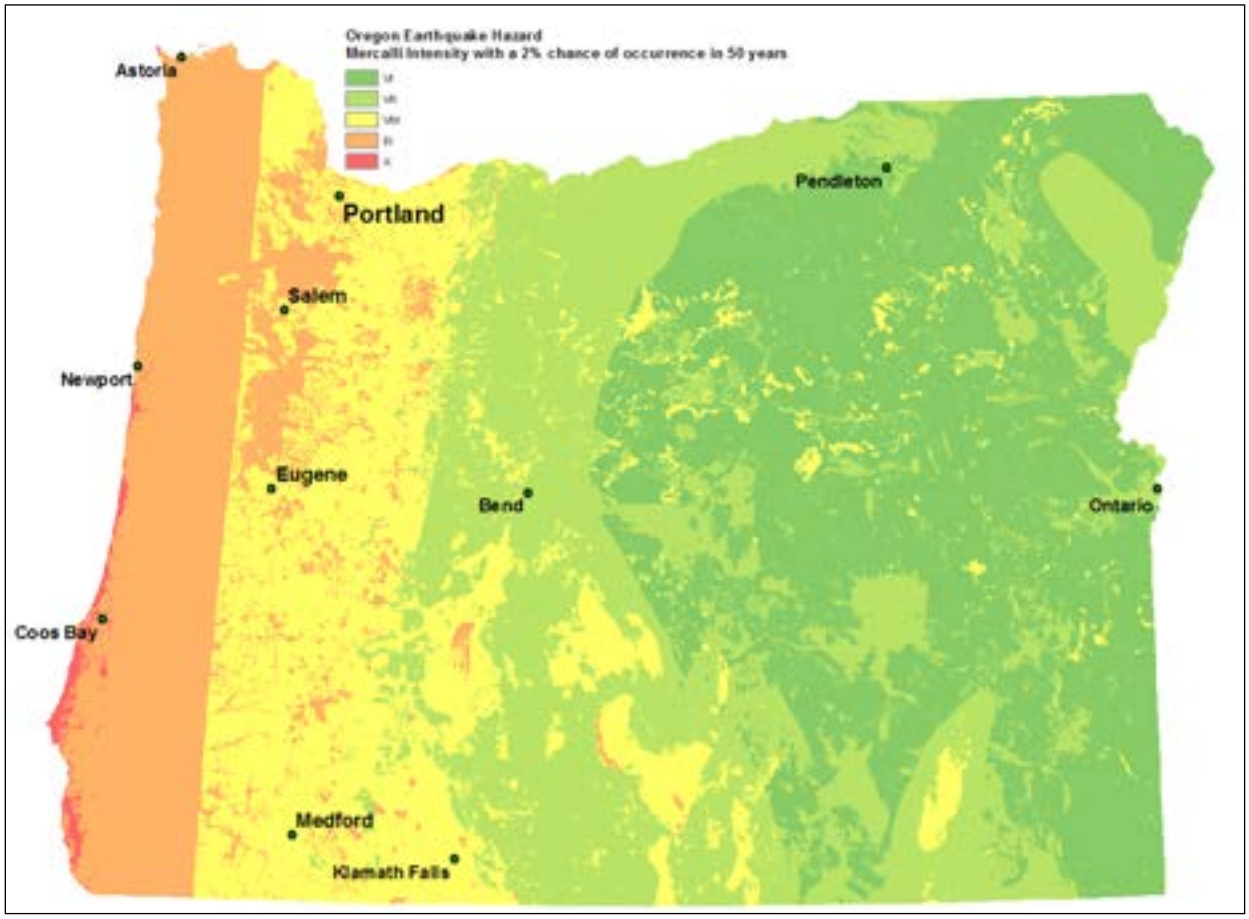

Figure 2-EQ-15: Statewide Probabilistic Earthquake Hazard. Color zones show the maximum level of earthquake shaking and damage (Mercalli Intensity Scale) expected with a 2% chance of occurrence in the next 50 years. A simplified explanation of the Mercalli levels is:

- VI Felt by all, weak buildings cracked
- VII Chimneys break, weak buildings damaged, better buildings cracked
- VIII Partial collapse of weak buildings, unsecured wood frame houses move
- IX Collapse and severe damage to weak buildings, damage to wood-frame structures
- X Poorly built structures destroyed, heavy damage in well-built structures

Source: DOGAMI

Flood

Floods are a common and widespread natural hazard in Oregon; the state has an extensive history of flooding (Figure 2-FL-1).

{figure xx placeholder – extent of SFHA and number of NFIP losses by county}

Flooding typically results from large-scale weather systems that generate prolonged rainfall or rain on snow events that result in large amounts of runoff. Other sources of flooding include flash floods associated with locally intense thunderstorms, channel migration, ice or debris jams, and much less frequently dam failures.

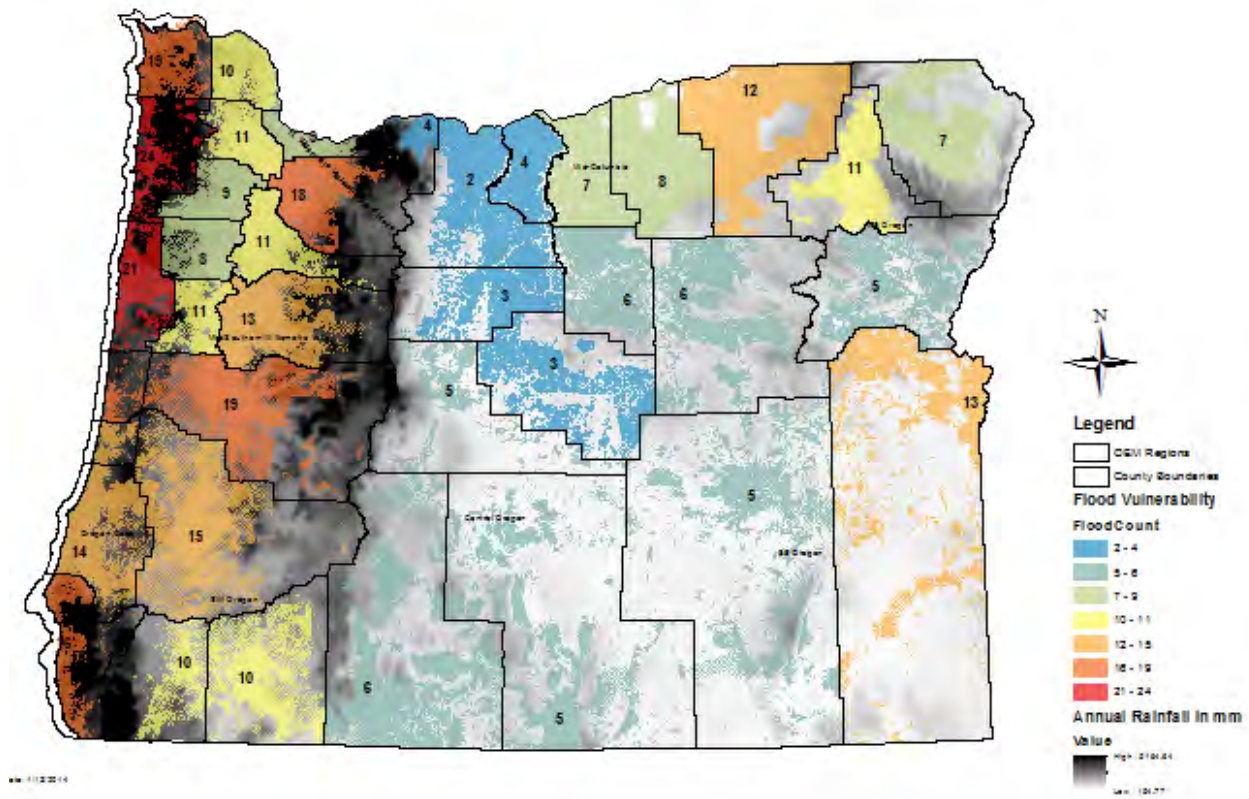

Figure 2-FL-1: Number of damaging flood events by County since 1978. The frequency of damaging floods overlaid upon annual precipitation (mm). Damaging floods only depicted on lands in private ownership.

Source: DLCD

The National Flood Insurance Program (NFIP) identifies 251 communities in Oregon as flood-prone including locations in all 36 counties, 212 cities, and 3 tribal nations. Every county and all but two of these flood-prone cities belong to the NFIP, allowing residents to purchase flood insurance. Nine additional cities for which FEMA has not mapped Special Flood Hazard Areas also belong to the NFIP, indicating that they believe a flood hazard exists within their jurisdiction.

Hazard Analysis and Characterization

History of Flooding in Oregon

Oregon has an extensive history of flooding. Tables FL-1 and FL-2 summarize major floods within the state. Oregon's deadliest recorded flood occurred in Heppner in 1903 when a June 14th storm dropped 1.5 inches of rain within a twenty-minute period. The storm was centered in the headwaters area of Willow Creek above Heppner in Northeastern Oregon. Within minutes, a five-foot wall of water and debris poured through Heppner with enough velocity to rip homes off foundations. These floodwaters claimed 247 lives.

Another late spring flood in 1948 is best remembered for destroying the entire city of Vanport (now Delta Park). Record flow levels on the Columbia River caused the structural failure of a dike. Much of Vanport was destroyed in minutes and was never rebuilt. Nineteen thousand people lost their homes and eighteen people lost their lives.

Many of Oregon's floods of records occurred in December 1964 and January 1965 during the "Christmas Flood." Damage from these floods totaled over $157 million dollars and twenty Oregonians lost their lives. From December 20 through 24, 1964, the most severe rainstorm to occur in Central Oregon and one of the most severe west of the Cascades left many areas with two-thirds their normal annual rainfall in five days. The ensuing floods destroyed hundreds of homes and businesses, forced the evacuation of thousands of people, destroyed at least thirty bridges and washed out hundreds of miles of roads and highways.

A similar flood event occurred in February 1996. Following an extended period of unseasonably cold weather and heavy snowfall in the Pacific Northwest, warming temperatures and rain began thawing the snowpack and frozen rivers throughout Oregon. On February 6, a strong subtropical jet stream or "pineapple express" reached Oregon. This warm, humid air mass brought record rainfall amounts, quickly melting the snowpack. At least twenty-five rivers reached flood stage. Many reached flood levels comparable to those reached in the 1964 flood. Twenty-seven of Oregon's thirty-six counties were eventually covered by a Presidential major disaster declaration due to this event. Statewide, damages totaled over $280 million.

A series of powerful wind and rain storms caused extensive flooding in northwestern in December of 2007. Three people were killed as a result of these storms. The City of Vernonia was hard hit with over 200 buildings substantially damaged and subsequently elevated or bought-out by FEMA.

Types of Flooding

Riverine – Riverine flooding is the most common flood hazard in Oregon. It is caused by the passage of a larger quantity of water than can be contained within the normal stream channel. The increased stream flow is usually caused by extensive rainfall over a period of several days. The most severe flooding conditions generally occur when rainfall is augmented by snowmelt. If the ground is saturated or frozen, stream flow can be increased even more by the inability of the soil to absorb additional precipitation. Examples of riverine events are the flooding in December 2007, February 1996, and December 1964 to January 1965.

Flash Floods – Flash flooding is caused by extremely intense rainfall over a short period of time, commonly within a single drainage. Flash floods usually occur in the summer during the thunderstorm season. The two key contributors to flash flooding are rainfall intensity and duration. Topography, soil conditions and ground cover also impact flooding. Flash floods, because of their intensity, often pick up large loads of sediment and other solid materials. In these situations, a flash flood may arrive as a fast moving wall of debris, mud, and water.

Occasionally, floating debris or ice accumulates at a natural or man-made obstruction and restrict the flow of water. Water held back by the ice jam or debris dam can cause flooding upstream. Subsequent flash flooding can occur downstream if the obstruction suddenly releases. Areas subject to flash floods are not as obvious as a typical riverine floodplain. However, flash floods may be associated with recognizable locations such as canyons or arroyos. There is also always some potential for flash floods associated with dam failure.

The most notorious flash flood in Oregon was the June 14, 1903 event in Heppner summarized previously. More recent flash floods have occurred in Wallowa Co. (July 2002) and the City of Rufus (August 2003).

Coastal Floods – Coastal areas have additional flood hazards. Winds generated by tropical storms or intense off shore low-pressure systems can drive ocean water inland and cause significant flooding. The height of storm surge is dependent on the wind velocity, water depth and the length of open water (the fetch) over which the wind is flowing. Storm surges are also affected by the shape of the coastline and by the height of tides.

Coastal flooding also may result from tsunamis. A tsunami is a series of traveling ocean waves generated by an earthquake or landslide that occurs below or on the ocean floor. Oregon's seven coastal counties and many coastal cities are susceptible to flood damage associated with tsunamis. Both "distant" tsunamis generated from seismic events in the Pacific basin and "near shore" tsunamis generated from activity associated with the Cascadia Subduction Zone can impact Oregon's coast. For more information, see the Tsunami Chapter of this plan.

Shallow Area Flooding – Some areas are characterized by FEMA as being subject to shallow flooding. These are areas that are predicted to be inundated by the 100-year flood with flood depths of one to

three feet. Flooding events are expected to be low velocity events characterized by "sheet flows" of water.

Urban Flooding – As land is converted from fields or woodlands to roads, roofs, and parking lots, it loses its ability to absorb rainfall. This transition from pervious surfaces to impervious surfaces results in more and faster runoff of water. During periods of urban flooding, streets can become swift moving rivers, and basements can fill with water. Storm drains may back-up with yard waste causing additional nuisance flooding.

Playa Flooding – Playa flooding results from greater than normal runoff into a closed basin. Closed basin systems are those areas that have one or more rivers emptying into one or more lakes that have no outlet. In these situations, water can only leave the system through evaporation. Thus, if annual precipitation in the basin increases significantly, evaporation is not enough to reduce water levels. Lake levels rise and inundate the surrounding properties.

The best-known example of playa basin flooding in Oregon occurs at Malheur and Harney lakes in Harney County. In higher than average precipitation years, the lakes flood adjacent ranches and public roads. Malheur and Harney lakes flooded during the years 1979 to 1986, and then gradually receded. During the wetter years of 1997 to 1999, these lakes again flooded. By 2005, following a number of dry years, they had receded significantly. In spring 2011, as a result of a heavy snowpack and persistent rainfall, Harney Lake's water level increased significantly with flooding observed in low-lying areas.

Ice Jams – Ice jams happen in colder regions of the State during winter and early spring while rivers are frozen. Sudden warming at higher altitudes melts snow resulting in increased runoff which breaks the ice from reaches of frozen river below. On the way downstream, the floating ice can "jam" in a narrow reach of the drainage or against a road crossing which then dams melting water. As the ice weakens, water breaches the dam releasing a torrent of water.

Dam Failure – Dam failures and accidents, though rare, can result in extreme flooding downstream of the dam. Catastrophic dam failures have occurred in other parts of the country and around the world. The South Fork Dam failure (1889 Johnstown flood) resulted in over 2000 fatalities in western Pennsylvania. The Saint Francis Dam in southern California failed in 1928 with a loss of an estimated 600 people. Oregon's dam safety statutes (ORS 540.350 through 400) came into effect shortly after the Saint Francis disaster. Many historical dam failures were triggered by flood events, others by poor dam construction, and some have been triggered by earthquakes.

Dam Safety is one of the Oregon Water Resources Department's roles. The dam safety program reviews designs for dam construction or modification and approves designs when they are shown to be safe; conducts routine inspections; determines hazard rating and condition; encourages emergency action plans for high hazard dams; and takes enforcement on unsafe dams. The dam safety program also coordinates with federal agencies that are responsible for their dams, and is the Oregon Emergency Response System contact in the event of a major emergency for any dam in the State.

Without safety standards for design, construction, maintenance, operations and inspections there is an increased risk of dam safety problems. Oregon has a very good dam safety record, with no fatalities from dam failures. The vast majority of Oregon's approximately 55 recorded dam failures occurred

before 1987. About 1/3 of these 55 dam failures resulted in significant property damage. Much of Oregon's dam infrastructure is aging, and many dams were designed prior to the current understanding of earthquake hazard and especially the risk associated with the Cascadia subduction zone. Primary dam safety program goals are: conducting timely inspections; reducing the number of dams in poor or unsatisfactory condition; having emergency action plans for most high hazard dams; and responding to events that might trigger dam failures. Additional information on dams and dam safety in Oregon is found at: http://www.oregon.gov/owrd/pages/SW/dams_in_oregon.aspx

The dam safety program has been ensuring the over 900 dams under its jurisdiction are inspected on schedule, with recommendations sent to dam owners. At times this requires urgent dam safety notices and/or enforcement action. Other high priority functions include determining dam hazard to people and changing hazard ratings based on hydraulic analyses, and development of emergency action plans for high hazard dams. The dam safety program also coordinates with the National Weather Service and OEM on severe flood potential that could affect dams and other infrastructure. The program exceeds FEMA guidance for dam safety inspections on schedule and for condition classification, and should be at the FEMA standard for Emergency Action Plans shortly.

Channel Migration in Association with Flooding

Channel migration is the process by which streams move laterally over time. It is typically a gradual phenomenon that takes place over many years due to natural processes of erosion and deposition. In some cases, usually associated with flood events, significant channel migration can happen rapidly. In high flood flow events stream channels can "avulse" and shift to occupy a completely new channel.

Areas most susceptible to channel migration are transitional zones where steep channels flow from foothills into broad, flat floodplains. The most common physiographic characteristics of a landscape prone to channel migration include moderate channel steepness, moderate to low channel confinement (i.e. valley broadness), and erodible geology.

Channel migration can and has created hazardous conditions within Oregon's developed riparian areas. Rapid migration can undercut structure foundations and damage infrastructure. The upper Sandy River in eastern Clackamas County is an example of where channel migration and development intersect. A recent January 2011 flood resulted in temporary avulsion that washed out section of Lolo Pass Road and also bank erosion that damaged and destroyed several homes.

Channel migration is not a standard consideration of the NFIP and has not been mapped systematically in Oregon. The Oregon Department of Geology and Mineral Industries (DOGAMI) recently started mapping channel migration zones for areas with known susceptibility on an ad hoc basis. DOGAMI is mapping channel migration zones using procedures developed by the Washington Department of Ecology for administration of its regulatory Shoreline Master Program[23]. In Oregon more work is required to identify susceptible areas where detailed channel migration zone mapping is needed.

El Niño[24] and La Niña Events in Oregon and Relationship to Flooding[25]

One of the most prominent aspects of Oregon's weather and climate is its variability. This variability ranges over many time and space scales, from small-scale phenomena such as wind gusts and localized thunderstorms, to larger-scale features like fronts and storms, to even more prolonged features such as droughts and periods of flooding. Fluctuations occur on multi-seasonal, multi-year, multi-decade and even multi-century time scales. Examples of these longer time-scale fluctuations include an abnormally hot and dry summer, an abnormally cold and snowy winter, a consecutive series of abnormally mild or exceptionally severe winters, and even a mild winter followed by a severe winter. Human inputs into our geophysical environment are also imposing cumulative impacts with measurable changes to global climate, sea-level and even localized weather. These human inputs along with the normal climate cycles may be working together in unpredictable ways and lead to future climate scenarios that do not resemble past, historic cycles. For example, recent research suggests that a warming climate reinforces the possibility that El Niño events could be stronger and more frequent while La Niña episodes may be weaker and less frequent.

The terms El Niño and La Niña represent opposite extremes of the ENSO cycle in an otherwise continuum of global climate events, with "average" conditions generally prevailing between those extremes. In the past three decades there have been several El Niños, with the 1982 to 1983 and 1997 to 1998 events having been the strongest on record, while the period between 1990 and 1995 was characterized by persistent El Niño conditions, the longest on record. (Trenberth, 1999)

In general, the longer time-scale phenomena are associated with changes in oceanic and atmospheric circulation that encompass areas far larger than a particular affected region. At times, these persistent features occur simultaneously over vast, and seemingly unrelated, parts of the hemisphere, or even the globe, resulting in abnormal weather, temperature and rainfall patterns throughout the world. During the past several decades, scientists have discovered that important aspects of this interannual variability in global weather patterns are linked to a global-scale, naturally occurring phenomenon known as the El Niño Southern Oscillation (ENSO) cycle. A measure of this cycle is the Southern Oscillation Index (SOI), which is "calculated from the monthly or seasonal fluctuations in the air pressure difference between Tahiti and Darwin, Australia."

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[23] The State of Washington has included channel migration as a consideration in its regulatory Shoreline Master Programs (http://www.ecy.wa.gov/programs/sea/sma/st_guide/jurisdiction/cmz.html).

[24] The cyclical warming of east Pacific Ocean seawater temperatures off the western coast of South America that can result in significant changes in weather patterns in the United States and elsewhere.

[25] In large part from Impacts of the El Niño/Southern Oscillation on the Pacific Northwest, George Taylor, OCS, March 1998, http://www.ocs.orst.edu/reports/enso_pnw.html

The ENSO cycle is caused by periodic changes in atmospheric pressure differences in the South Pacific Ocean. These changes then cause a periodic rise or fall in Pacific Ocean equatorial sea surface temperatures. The abnormal temperatures affect atmospheric conditions impacting the weather of a large portion of the world, including Oregon. The interaction of the abnormal sea surface temperatures and the atmosphere affect the position and intensity of the polar and sub-tropical jet streams, which in turn determine the intensity and track of storms.

Historical El Niño and La Niña Events In Oregon

The earliest systematic study of ENSO in the Northwest was Redmond and Koch (1991). The results were sufficiently strong that the authors suggested a cause-effect relationship between the SOI and Oregon weather. They determined that the Southern Oscillation Index (SOI) can be used as a predictor for weather, especially for winter weather. Greatest correlations between SOI and winter weather patterns occur with about a four-month time lag with summer average SOI correlating well with weather in the Northwest during the following winter. SOI values less than zero represent El Niño conditions, near zero values are average, and positive values represent La Niña conditions.

El Niño Events	La Niña Events
1982-1983	1988-1989
1994-1995	1995-1996
1997-1998	1999-2000
2002-2003	
2004-2005	
2006-2007	2007-2009
2009-2010	2010-2012

Table 2-FL-1:
Recent ENSO events in Oregon

Source: http://www.esrl.noaa.gov/psd/enso/mei/

In Oregon El Niño impacts associated with these climate features generally include warmer winter temperatures and reduced precipitation with drought conditions in extreme events.

What Oregonians should especially plan for and monitor, however, is La Niña. Severe flooding during the winters of 1995-96, 1998-99, and 2007-08 are attributable largely to the combination of heavy snows and warm, intense tropical rain. During La Niña events, heavy rain arrives in Oregon from the western tropical Pacific, where ocean temperatures are well above normal, causing greater evaporation, more extensive clouds, and a greater push of clouds across the Pacific toward Oregon. During February 1996, for example, severe flooding – the worst in the state since 1964 – killed several people and caused widespread property damage. Nearly every river in Oregon reached or exceeded flood stage, some setting all-time records. Debris flows[26] and landslides were also numerous.

El Niño Events	La Niña Events
1982-1983	1988-1989
1994-1995	1995-1996
1997-1998	1999-2000
2002-2003	
2004-2005	
2006-2007	2007-2009
2009-2010	2010-2012

Table FL-3:
Recent ENSO events in Oregon
Source: http://www.esrl.noaa.gov/psd/enso/mei/

[26] These events are typically associated with periods of heavy rainfall or rapid snowmelt on steeply sloping ground. The term "mudslide" is often used interchangeably but is poorly defined as a natural hazard. FEMA uses the terms "mudslide" and "mudflow" in the context of the National Flood Insurance Program, e.g., 44 CFR 59.1 and 206.2(a)(17).

Historic Flood Events in Oregon

Table 2-FL-2 lists historic damaging floods in Oregon.

Table 2-FL-2: Historic Damaging Floods in Oregon

Date	Location	Notes
September 1861	Klamath, Willamette, and Umpqua	
June 1880	Columbia	
January 1881	Willamette Basin	
December 1882	Umatilla	
June 1884	John Day	
May - June 1894	Columbia River Basin	Rain on snowpack; highest flood stage ever recorded at Vancouver, WA (33.6 feet)
June 1903	Willow Creek	Flash flood in Heppner; 247 people killed
April 1904	Silvies and Klamath	
February 1907	Western Oregon and John Day	
November 1909	Deschutes, Willamette, Santiam, Umpqua, Coquille, and Rogue	
March 1910	Powder and Malheur	
June 1913	Columbia	
January 1923	Clackamas, Santiam, Sandy, Deschutes, Hood, and McKenzie	Record flood levels
February 1925	Malheur	
February 1927	Klamath, Willamette, Umpqua, Rogue, and Illinois	Major flooding
May 1928	Columbia	
March 1931	Umatilla, Sandy, Clackamas, and Santiam	
March 1932	Malheur, Grande Ronde, John Day, and Umpqua	
January 1933	Coquille	
November - December 1942	Willamette Basin	10 deaths; $34 million damage
December 1945	Coquille, Santiam, Rogue, and McKenzie	9 deaths and homes destroyed in Eugene area
December 1946	Willamette, Clackamas, Luckiamute, and Santiam	
May - June 1948	Columbia River	Rain on snow; destruction of the City of Vanport

Date	Location	Notes
March 1952	Malheur, Grand Ronde, and John Day	Highest flood stages on these rivers in 40 years
December 1955	Rogue, Umpqua, Coquille	11 deaths; major property damage
July 1956	Central Oregon	Flash floods
February 1957	Southeastern Oregon	$3.2 million in flood damages
December 1961	Willamette Basin	$3.8 million in flood damages
December 1964 - January 1965	Pacific Northwest	Rain on snow; record flood on many rivers
December 1967	Central Oregon Coast	Storm surge
January 1972	Western Oregon	Record flows on coastal rivers
January 1974	Western Oregon	$65 million in damages
November - December 1977	Western Oregon	Rain on snow event; $16.5 million in damages
1979 to present	Harney County	Cyclical playa flooding on Harney & Malheur lakes
December 1981	Umpqua and Coquille	
January 1982	Tillamook County	
February 1982	Malheur and Owyhee Basins	
January 1990	Clatsop and Tillamook counties	
July 1995	Fifteenmile Creek	Flash flood in Wasco County (DR-1061)
February 1996	Nearly statewide	Damages totaling over $280 million (DR-1099)
November 1996	Southwest Oregon	Flooding, landslides, and debris flows; eight deaths in Douglas County (DR-1149)
January 1997	Southwest and Northeast Oregon	(DR-1160)
May - June 1998	Crook County and Prineville	Ochoco River (DR-1221)
December 1998	Lincoln and Tillamook counties	
November 1999	Coastal rivers in Lincoln and Tillamook counties	Heavy rainfall and high tides
July 2002	Wallowa County	Flash flood above Wallowa Lake damaged Boy Scout Camp facility
August 2003	City of Rufus	Flash flood (Gerking Canyon)
December 2005 - January 2006	Western and Central Oregon, Malheur County	Multiple heavy precipitation events on snow and/or saturated or frozen ground (DR-1672)
November 2006	Clatsop, Hood River, Lincoln, and Tillamook Counties	Heavy precipitation and wind resulted in flooding, landslides, and mudslides (DR-1672)
February 2007	Western and Central Oregon, and the Confederated Tribes of	Severe winter storm and flooding (DR-1683)

Date	Location	Notes
	the Siletz Indians	
December 2007	Northwestern Oregon, Southern Coast	Heavy precipitation and wind resulted in flooding, landslides, mudslides, and tree blow down. (DR-1733)
December 2008	Tillamook County	Flooding caused by convergence of heavy precipitation and high tides
January 2009	Tillamook and Washington Counties	Severe winter storm/snow event which included snow, high winds, freezing rain, ice, blizzard conditions, mudslides, and landslide (flooding, post DR-1824)
January 2011	Clackamas, Clatsop, Crook, Douglas, Lincoln, and Tillamook Counties	Severe winter storm, flooding, mudslides, landslides, and debris flows (DR-1956)
April 2011	Harney County	Widespread basin flooding. Oregon DOT closed and breached U.S. 20 at milepost 132.6 on April 8, 2011, for flood relief. The breach was done at the request of Harney County Emergency Operations Center to avoid damage to nearby residences. Larger culverts were later installed.
May – June 2011	Union and Grant Counties	Melting heavy snowpack caused riverine and playa flooding
June 2011	Heppner	Persistent showers with heavy rainfall of 1 to 2 inches produced flooding on Willow and Hinton Creeks. Flash flooding on Hinton and Willow Creeks damaged roads, bridges, and the Morrow County Fairgrounds. The Heppner elementary school was evacuated as a precaution.
January 2012	Columbia, Hood River, Tillamook, Polk, Marion, Yamhill, Lincoln, Benton, Linn, Lane, Douglas, Coos, Curry	Heavy rain and wind; ice (DR-4055). Flooding in the Willamette Valley. 130 homes and seven businesses were damaged in the City of Turner. Twenty-nine streets were closed in the City of Salem. The state Motor Pool lost 150 vehicles and thousands of gallons of fuel. Thomas Creek in the City of Scio overtopped, damaging several buildings.
November 2012	Curry , Josephine, and Lane Counties	Heavy precipitation. The Curry Coastal Pilot reported over 2

Date	Location	Notes
		million dollars in infrastructure damage in Brookings and another 2 million in Curry County due to recent heavy rains. Sinkholes and overflowing sewage facilities were also reported. According to KVAL news, Eugene Public Works has opened its emergency command center to deal with numerous flooding incidents, including two flooded intersections.
September 2013	Multnomah and Tillamook Counties	Heavy rain resulted in flooding of the Wilson River near Tillamook as well as urban flooding in the Portland metro area. KPTV-KPDX Broadcasting reported that heavy rain resulted in flooding and damage to the Legacy Good Samaritan Medical Center and several businesses in Northwest Portland. Besides damage to the hospital's emergency and operating room, some elective surgeries were cancelled.

Source: FEMA and NOAA Storm Events Database (http://www.ncdc.noaa.gov/stormevents/)

Probability

Flood risk or probability is generally expressed by frequency of occurrence. Since 1960 one or more damaging floods have occurred somewhere in Oregon in 42 of 52 years reported by NOAA[27]. Probability of flooding is measured as the average recurrence interval of a flood of a given size and place. It is stated as the percent chance that a flood of a certain magnitude or greater will occur at a particular location in any given year.

FEMA's NFIP extends regulation to an area covered by the "base flood" (see Figure FL-2), a flood that has a 1% chance of occurring in any year. Flood Insurance Rate Maps depict the inundation area of the 1% annual flood. It is important to recognize, however, that floods occur more frequently near the flooding source. Information regarding the probability of flooding at a given location in the regulated flood zones is provided by Flood Insurance Studies (FIS) for large watersheds. FEMA does not provide

[27] NOAA Storm Events Database

information about floods emanating from small watersheds (less than one square mile), or for floods caused by local drainage issues. Probabilities for these types of flood are, as a result, difficult to obtain.

The majority of flood studies in Oregon were conducted in the late 1970s and early 1980s. These studies represent flood risk at a point in time and don't reflect changing conditions in the watershed. Many of Oregon's metropolitan areas have significantly developed during the past twenty years resulting in increased impervious surface which causes higher velocities and increased volume of water. While FEMA's Map Modernization Program did result in updated FIRMs for 14 Counties, many of these maps were produced using models from old flood insurance studies. Whether or by how much these old models underestimate current flood potential is unknown.

Despite the shortcomings of NFIP Flood Insurance Rate Maps, most Oregon communities exclusively rely on them to characterize the risk of flooding. Some jurisdictions use their own flood hazard maps derived from aerial photos of past flood events in conjunction with FEMA FIRMs to better reflect their communities' flood risks. Others have implemented a higher regulatory standard to address changing conditions; for example Metro's balanced cut and fill requirements, and Tillamook County's and the City of Vernonia's requirement that new homes and substantial improvements to existing homes be elevated at least three feet above base flood elevation (BFE).[28] (See inset for a definition of substantial improvement.)

Channel migration associated with flooding also can be identified with respect to a probability of migration over a period of 100 years. Historic aerial photos are catalogued to calculate past rates of migration which are then projected out to define a channel migration zone. Avulsion (i.e. channel shifting) zones, which are a component of the larger channel migration zone, are an exception to the migration rate approach. Areas of likely avulsion are identified by professional judgment of a fluvial geomorphologist, using high-resolution topographic data, aerial photos, and field observation.

Identification of channel migration susceptibility at the regional level is described in terms of low, moderate, and high relative probabilities. Probability is determined by assessing physiographic parameters of channel gradient, confinement, and pattern.

[28] BFE is the projected depth of floodwater at the peak of a base flood, generally measured as feet above sea level.

Landslides

Landslides can be found throughout the state of Oregon, as seen in the current statewide landslide inventory database, SLIDO-2, in Figure 2-LS-1 and Table 2-LS-1 below (Burns and others, 2011). Systematic statewide landslide mapping has not been performed, however in general the areas of the state with more relief and steeper slopes, such as the Coast Range Mountains and the Cascade Mountains, tend to have more landslides. In general counties in Oregon have hundreds to thousands of existing landslides as shown in the table below derived from the SLIDO-2 database.

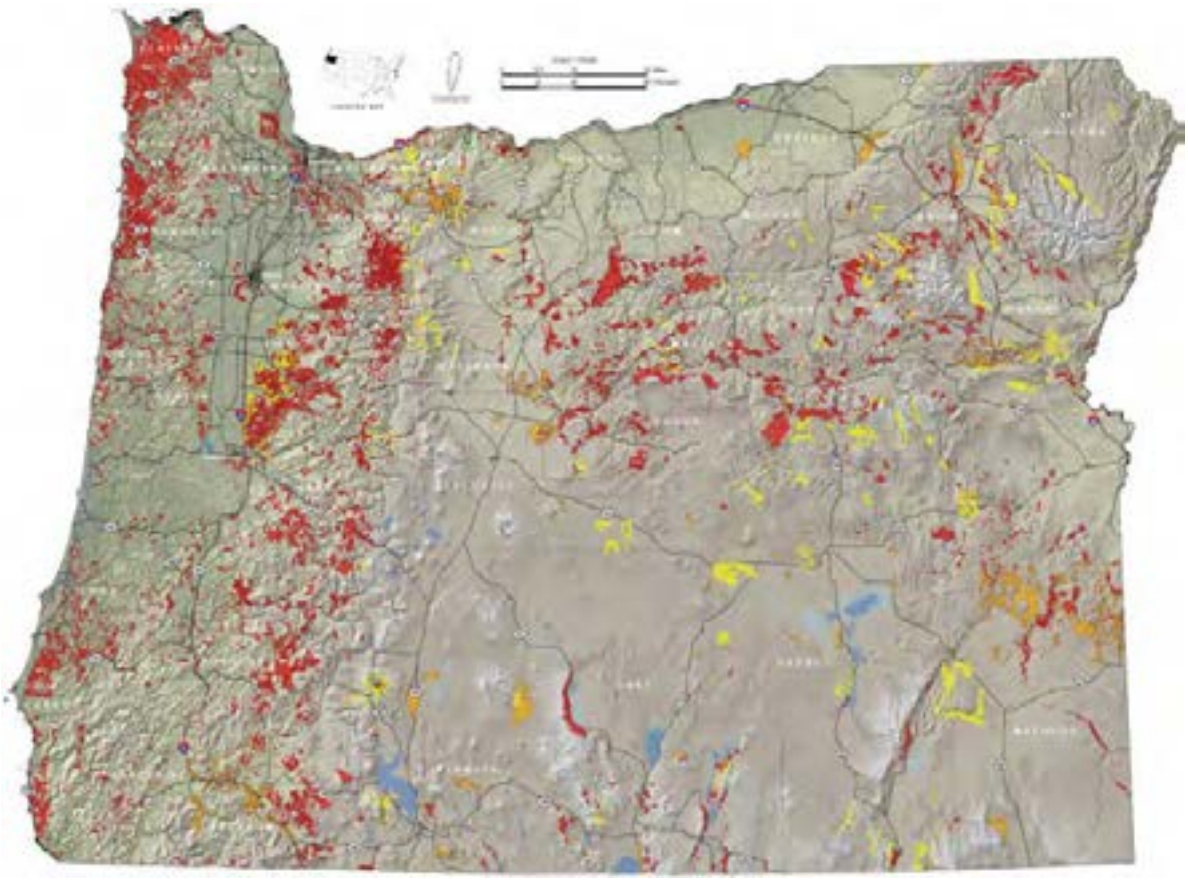

Figure 2-LS-1: Statewide Landslide Inventory

Source: DOGAMI

Burns, W.J., Mickelson, K.A., Saint-Pierre, E.C., 2011. Statewide Landslide Information Database of Oregon Release-2, Oregon Department of Geology and Mineral Industries, SLIDO-2

Note: Clackamas County has many more landslides than most other counties, which is partially because new very detailed lidar based mapping was completed in the NW portion of this county.

County	Number of landslides within and/or touching
Baker County	499
Benton County	885
Clackamas County	3013
Clatsop County	774
Columbia County	212
Coos County	1524
Crook County	397
Curry County	384
Deschutes County	83
Douglas County	1526
Gilliam County	35
Grant County	477
Harney County	435
Hood River County	178
Jackson County	809
Jefferson County	274
Josephine County	380
Klamath County	582
Lake County	204
Lane County	1353
Lincoln County	773
Linn County	1528
Malheur County	737
Marion County	622
Morrow County	56
Multnomah County	1330
Polk County	52
Sherman County	18
Tillamook County	1332
Umatilla County	151
Union County	483
Wallowa County	62
Wasco County	237
Washington County	538
Wheeler County	413
Yamhill County	187

Table 2-LS-1: Number of Landslide Within or Touching Each County in Oregon

Source: Source: Burns and others, 2011

DOGAMI found that in order to truly understand the landslide hazard in Oregon, lidar (light detection and ranging) topographic data must be collected and used during the mapping of existing landslides and modeling of future susceptibility. In fact, DOGAMI estimates that SLIDO-2 is between 0% and 25% capturing the existing landslides in Oregon. This variance in landslide detail can be seen when examining the small NW portion of Clackamas County which has been recently mapped.

One of the most common and devastating geologic hazards in Oregon is landslides. Average annual repair costs for landslides in Oregon exceed $10 million and individual severe winter storm losses can exceed $100 million (Wang and others, 2002). As population growth continues to expand and development into landslide susceptible terrain occurs, greater losses are likely to result.

Landslides in Oregon are typically triggered by periods of heavy rainfall and/or rapid snowmelt. Earthquakes, volcanoes, and human activities also trigger landslides.

There are 3 main factors that influence an area's susceptibility to landslides: geometry of the slope, geologic material, and water. Certain geologic formations are more susceptible to landslides than others. In general, locations with steep slopes are most susceptible to landslides, and the landslides occurring on steep slopes tend to move more rapidly and therefore may pose life safety risks.

Wang, Y., Summers, R.D., and Hofmeister, R.J., 2002, Landslide loss estimation pilot project in Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-02-05, 23 p.

Analysis and Characterization

The term landslide encompasses a wide range of geologic processes and a variety of nomenclatures that can lend itself to confusion. The general term landslide refers to a range of mass movement including rock falls, debris flows, earth slides, and other mass movements. One very important thing to understand is the fact that all landslides have different frequencies of movements, triggering conditions, and very different resulting hazards.

All landslides can be classified into one the following six types of movements: 1) slides, 2) flows, 3) spreads, 4) topples, 5) falls, 6) complex. Most slope failures are complex combinations of these distinct types, but the generalized groupings provide a useful means for framing discussion of the type of hazard associated with the landslide, the landslide characteristics, identification methods, and potential mitigation alternatives.

El Nino Southern Oscillation and Effects on Landslides

The strongest impacts of intra-seasonal variability on the U.S. occur during the winter months over the western U.S. During the winter this region receives the bulk of its annual precipitation. Storms in this region can last for several days or more and are often accompanied by persistent atmospheric circulation features. Of particular concern are the extreme precipitation events which are linked to flooding and landslide. There is strong evidence for a linkage between weather and climate in this region from studies that have related the El Niño-Southern Oscillation (ENSO) to regional precipitation variability. From these studies it is known that extreme precipitation events can occur at all phases of the El Niño-Southern Oscillation (ENSO) cycle, but the largest fraction of these events occur during La Niña episodes and during ENSO-neutral winters. During La Niña episodes much of the Pacific Northwest experiences increased storminess, increased precipitation and more overall days with measurable precipitation. The risk of flooding and rain-induced landslides (and debris flows) in this region can be related to La Niña episodes.

Source: NOAA/Climate Prediction Center
http://www.cpc.noaa.gov/products/intraseasonal/intraseasonal_faq.html#usimpacts

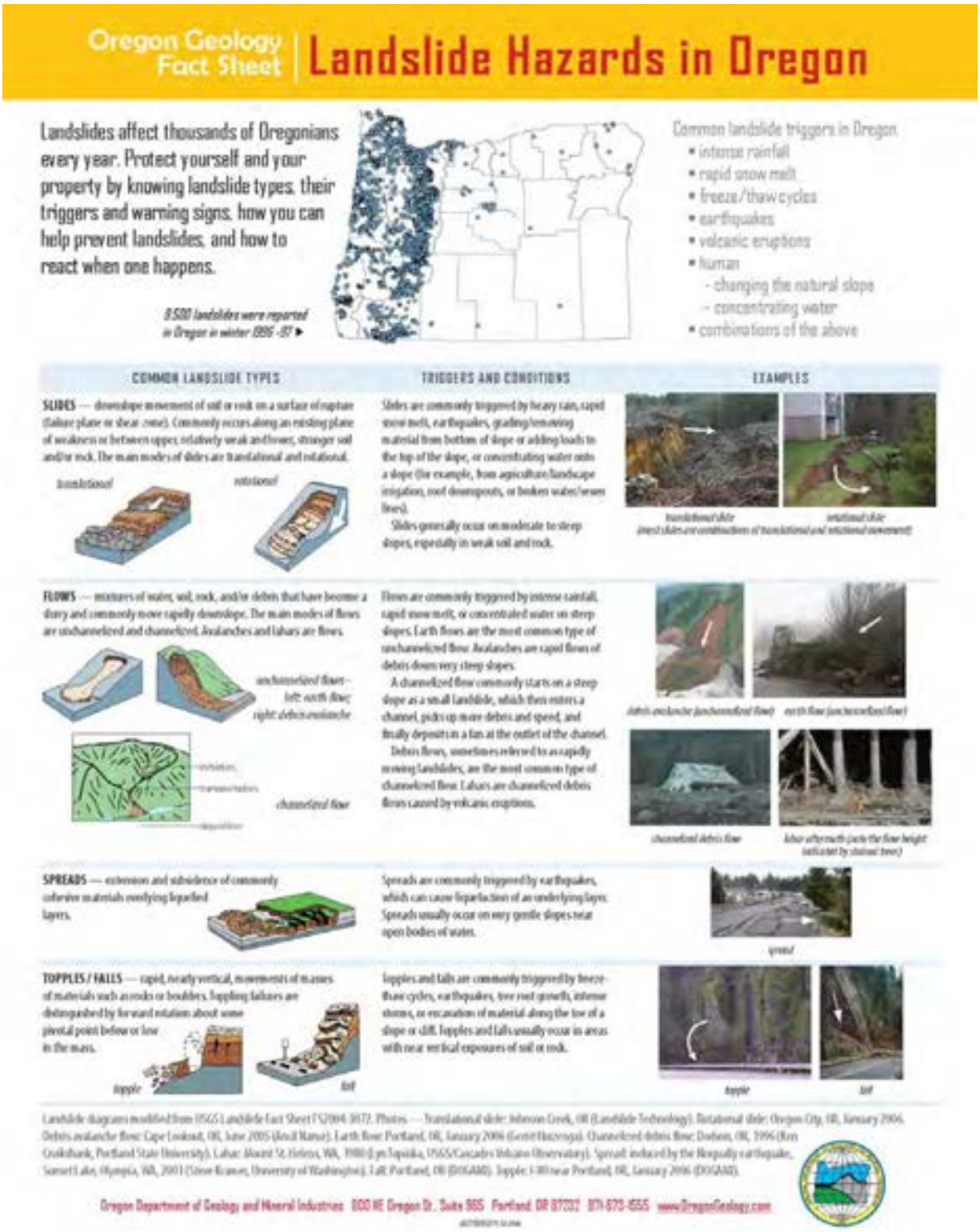

Figure 2-LS-2: Common types of landslides in Oregon.

Source: DOGMI. Website: http://www.oregongeology.org/sub/Landslide/Landslidehome.htm

These types of movements can be combined with other aspects of the landslide such as type of material, rate of movement, depth of failure, and water content for a better understanding of the type of landslide.

One potentially life threatening type of landslide is the channelized debris flow or "rapidly moving landslide" which are flows that initiate upslope, move into or transport down a steep channel (or drainage) and deposit material, usually at the mouth of the channel. Debris flows are also commonly initiated by other types of landslides that occur on slopes near a channel. They can also initiate within the channel in areas of accelerated erosion during heavy rainfall or snowmelt. Rapidly moving landslides have caused most of the recent landslide related injuries and deaths in Oregon. Debris flows or rapidly moving landslides caused eight deaths in Oregon in 1996 following La Niña storms.

Areas that have failed in the past often remain in a weakened state, and many of these areas tend to fail repeatedly over time. This commonly leads to distinctive geomorphology that can be used to identify landslide areas, although over time the geomorphic expression may become subtle, making the landslide difficult to identify. Other types of landslides tend to occur in the same locations and produce distinctive geomorphology, such as channelized debris flows, which form a fan at the mouth of the channel after repeated events. This is also true for the talus slopes, which form after repeated rock fall has taken place in an area.

Previously impacted areas are particularly important to identify, as they may pose a substantial hazard for future instability and help identify areas that are susceptible to future events. Large, slow moving landslides frequently cause significant property damage, but are far less likely to result in serious injuries. Several examples are the subdivision landslide in Kelso, Washington, the slide at The Capes development in Tillamook County, and the apartment complex in Oregon City.

The velocity of landslides varies from imperceptible to over 35 miles per hour. Some volcanic induced landslides have been known to travel between 50 to 150 miles per hour. On less steep slopes, landslides tend to move slowly and cause damage gradually. Debris flows typically start on steep hillsides as shallow landslides, enter a channel, then liquefy and accelerate. Canyon bottoms, stream channels, and outlets of canyons can be particularly hazardous. Landslides can move long distances, sometimes as much as several miles. The Dodson debris flows in 1996 started high on Columbia River Gorge cliffs, and traveled down steep canyons to form debris fans in the Dodson-Warrendale area.

Landslide recurrence interval is highly variable. Some large landslides move continuously at very slow rates. Others move periodically during wet periods. Very steeply sloped areas can have relatively high landslide recurrence intervals (10 to 500 years on an initiation site basis).

Since debris flows can be initiated at many sites over a watershed, in some cases recurrence intervals can be less than ten years. Slope alterations can greatly affect recurrence intervals for all types of landslides, and also cause landslides in areas otherwise not susceptible. Most slopes in Western Oregon steeper than 30 degrees (~60%) have a risk of rapidly moving landslide activity regardless of geologic unit. Areas directly below these slopes in the paths of potential landslides are at risk as well.

Based on the Oregon Department of Forestry Storm Impacts Study, the highest debris flow hazard occurs in Western Lane County, Western Douglas County, and Coos County. The combination of steep slopes and geologic formation (sedimentary rock units) contributes to the increased hazard. The debris flow hazard is also high in much of the Coast Range and Cascade Mountains and in the Columbia River Gorge.

Deep landslides are generally defined as having a failure plane within the regional bedrock unit (generally greater than 15 feet deep), whereas the failure plane of shallow landslides is commonly between the thin soil mantle and the top of the bedrock. Deep landslide hazard is high in parts of the Coast Range. Deep landslides are fairly common in pyroclastic rock units of the Western Cascade Mountains, and in fine-grained sedimentary rock units of the Coast Range. Deep landslides also occur in semi-consolidated sedimentary rocks at or near the Oregon coast particularly around Newport, Lincoln County and Tillamook County, and in the Troutdale Formation around the Portland area.

Infrequent very large landslides and debris flows may occur in any of the larger mountain ranges or in deep gorges throughout Oregon.

During 1996 and 1997, heavier than normal rains caused over 700 landslides within the Portland Metropolitan region, which totaled over $40 million for mitigation (Burns et al., 1998). In the City of Portland, 17 homes were completely destroyed and 64 were badly damaged. There were no serious injuries associated with the landslides in Portland or in other urban areas within Oregon during the 1996 storms.

The Oregon Department of Forestry Storm Impacts Study estimated that tens of thousands of landslides occurred on steep slopes in the forests of Western Oregon during 1996. The Oregon Department of Geology and Mineral Industries Slope Failures in Oregon inventoried thousands of reports of landslides across the state resulting from the 1996-1997 storms. There are a significant number of locations in Oregon that are impacted frequently (every 10 to 100 years) by dangerous landslides. The number of injuries and deaths in the future will be directly related to vulnerability: the more people in these areas, the greater the risk of injury or death.

Burns, S.F., Burns, W.J., James, D.H., and Hinkle, J.C., 1998. Landslides in Portland, Oregon: Metropolitan Area Resulting from the Storm of February 1996: Inventory Map, Database, and Evaluation. METRO Natural Hazards Publication 905828, p.1-65.

Historic Landslides in Oregon

Oregon has declared 28 major disaster declarations from 1955-2012. Most of these are related to storm events causing flooding and landslides. One of the most significant of these disasters is the 1996 and 1997 storms which caused thousands of landslides in Oregon.

Table 2-LS-2: Historic Landslides in Oregon from SLIDO-2

Date	Count	Comments
1931-1935	2	
1946-1950	1	
1951-1955	2	
1956-1960	1	
1961-1965	14	Presidential DR184
1966-1970	1	
1971-1975	11	
1976-1980	24	
1981-1985	9	
1986-1990	8	
1991-195	42	
1996-2000	7,903	Presidential DR1099
2001-2005	648	Presidential DR1510
2006-2010	1,960	Presidential DR1824 & DR1956
Total	**10,626**	

Source: Burns, W.J., Mickelson, K.A., Saint-Pierre, E.C., 2011. Statewide Landslide Information Database of Oregon Release-2, Oregon Department of Geology and Mineral Industries, SLIDO-2

Burns, W.J., Mickelson, K.A., Jones, C.B., Pickner, S.G., Hughes, K.L., Sleeter, R., 2013. Landslide hazard and risk study of northwestern Clackamas County, Oregon: Oregon Department of Geology and Mineral Industries, Open-File Report O-13-08, 74 map plates

Probability

Landslides are found in every county in Oregon as shown in the Table 2-LS-1. There is a 100% probability of landslides occurring in Oregon in the future. Although we do not know exactly where and when they will occur, they are more likly to happen in the general areas where landslides have occurred in the past. Also, they will likely occur during heavy rainfall events or during a future earthquake.

In order to reduce losses from landslides, areas of landslide hazard must first be identified. The first step in landslide hazard identification is to create an inventory of past (historic and prehistoric) landslides. Once this inventory is created, it can be used to create susceptibility maps which display areas that are likely to have landslides in the future. Once the landslide hazards are identified on inventory and susceptibility maps, the risk can be quantified, mitigation projects prioritized and implemented.

In 2005, DOGAMI began a collaborative landslide research program with the U.S. Geological Survey (USGS) Landslide Hazards Program to identify and understand landslides in Oregon. In order to begin the extensive undertaking of mapping existing landslides throughout Oregon, a pilot project area was selected to compare remote sensing data/images for effectiveness. The remote sensing data sets compared included (Burns, 2007): (Figure 2-LS-3)

1. 30 m (98 ft) Digital elevation model (DEM) from the Shuttle Radar Topography Mission
2. 10 m (33 ft) DEM derived from the USGS topographic quadrangles
3. Photogrammatic and ground based 1.5 m (5 ft) interval contour data
4. Stereo aerial photographs from 1936 to 2000
5. Lidar imagery with an average of 1 data point per m^2 (3.2 ft) and with a vertical accuracy of about 5 cm (6 in)

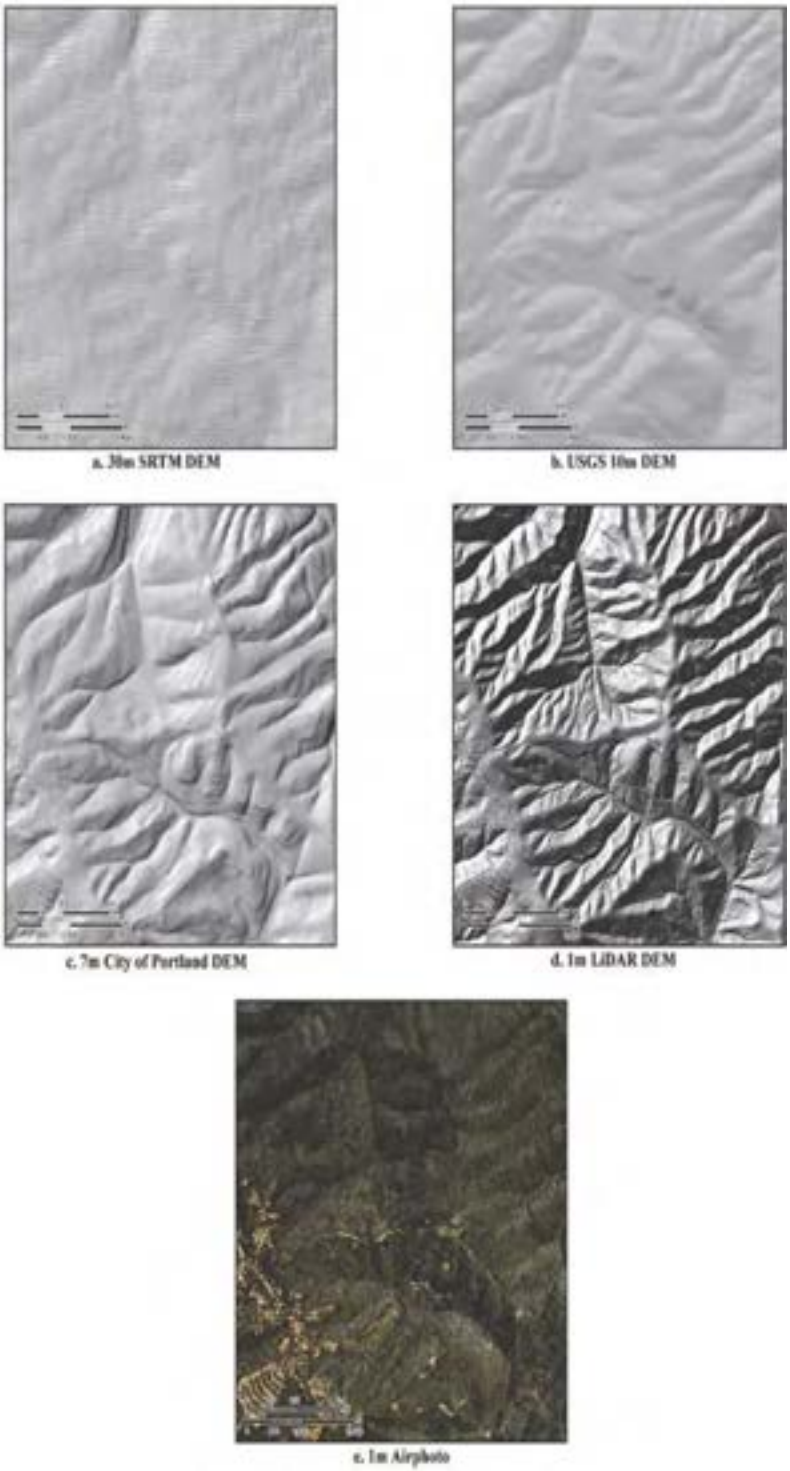

Figure 2-LS-3: Visual comparison of the five (a, b, c, d, e) remote sensing data sets. The air photo is draped over a DEM so that it appears to have the 3-dimensional view provided by a stereo-pair.

Two key findings of the pilot project were: 1) the use of the LIDAR data resulted in the identification of between 3 to 200 times the number of landslides identified using the other data sets and 2) the ease and accuracy of mapping the spatial extent of the landslides identified from lidar data were greatly improved compared to other mapping methods.

When examining the results of the comparison of remote sensing data, several debris flow fans at the mouths of channels or potential channelized debris flow deposits, were identified with serial stereo-pair aerial photos, which did not get identified on the lidar derived DEMs. Dense development has taken place in Oregon in the last 40 years, which can mask landslide features, especially if major earthwork has taken place. In most of the populated areas of Oregon, if historic air photos are available, at least one review of (greater than 40 years old) photos should be performed (Burns, 2007).

In order to develop accurate large scale landslide inventory maps, DOGAMI recommends the following minimal requirements:

1. All previously identified landslides from geologic maps, previous landslide studies, and other local sources should be compiled.

2. The mapper should have experience identifying all types and ages of landslides within the area being studied.

3. Lidar data should be used to identify landslides and accurately locate the extents of previously mapped landslides (from step 1).

4. An orthophoto of similar age to the LIDAR data should be used to minimize the misidentification of man-made cuts and fills as landslides.

5. The mapper should use at least one set of historical stereo-pair aerial photography to locate landslides in the area being studied.

6. Non-spatial data should also be collected at the time of the mapping so that a comprehensive database can be formed. Non-spatial data should generally include confidence of interpretation, movement class, direction of movement, etc. and are described in detail in section 6.0 of this paper.A comprehensive check of spatial (map) and non-spatial data should be developed and implemented including technical review of mapped landslides and field checks where possible.

Step one was accomplished in 2008 with the publication of SLIDO-1. This publication has been updated and again published as SLIDO-2 (Figure 2-LS-4).

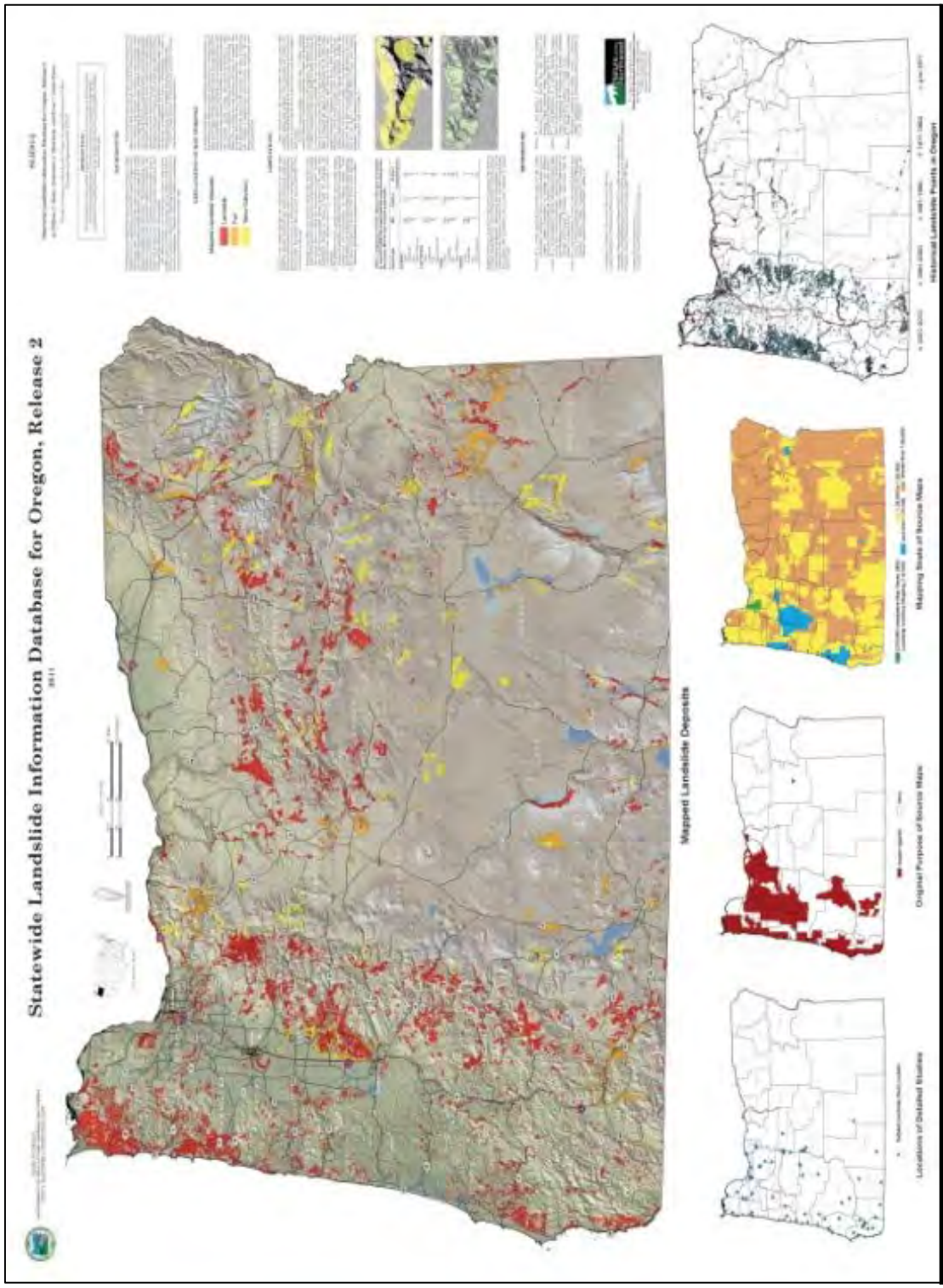

Figure 2-LS-4: Statewide Landslide Information Database for Oregon, Release 2. The resulting SLIDO-2 geodatabase includes 22,542 landslide deposit polygons and landslide-related features from 313 published and unpublished studies, 10,636 historical landslide point locations (including all points from the 1996-97 events), and 72 locations of detailed studies on individual landslides, a significant increase over SLIDO-1.

Source: DOGAMI

A protocol was developed by DOGAMI so that we can produce consistent lidar-based landslide inventory maps at an accelerated rate without having to describe how the mapping was done every time a new area is mapped (Burns and Madin, 2009). The results of following this protocol in any particular area include a very detailed database and map of the landslide inventory (Figure 2-LS-5).

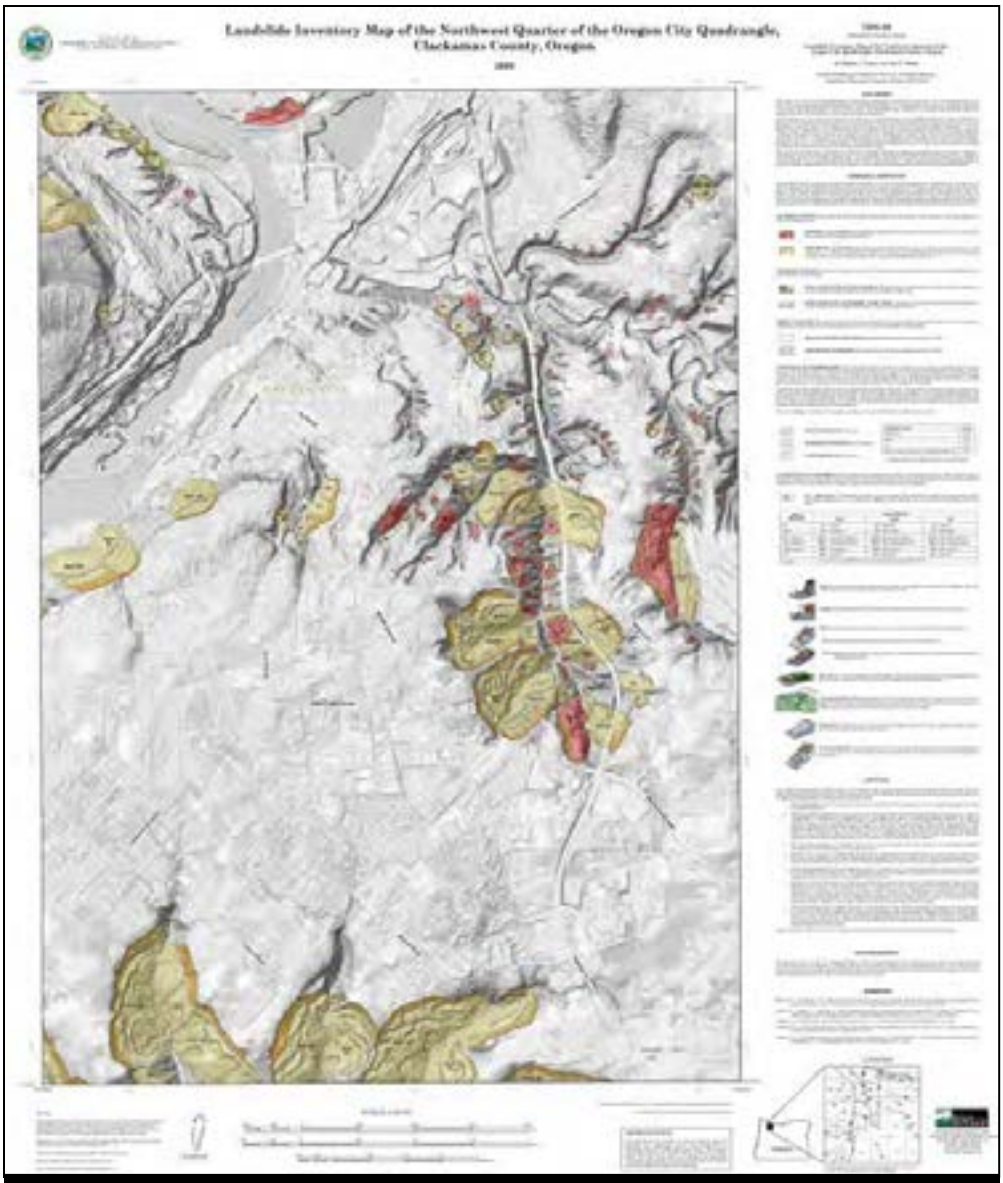

Figure 2-LS-5: Example of a new Lidar-based landslide inventory (Oregon City,OR)

Source: DOGAMI

Burns, W. J., 2007, Comparison of remote sensing datasets for the establishment of a landslide mapping protocol in Oregon. AEG Special Publication 23: Vail, Colo., Conference Presentations, 1st North American Landslide Conference.

Burns, W.J., Madin, I.P., 2009. Protocol for Inventory Mapping of Landslide Deposits from Light Detection and Ranging (lidar) Imagery, Oregon Department of Geology and Mineral Industries, Special Paper 42

With an accurate landslide inventory in hand, the next step in a complete landslide hazard mapping program is to develop susceptibility maps for common types of landslides. DOGAMI has just finished a shallow landslide susceptibility method and is in progress of completing deep landslide and channelized debris flow susceptibility mapping protocols.

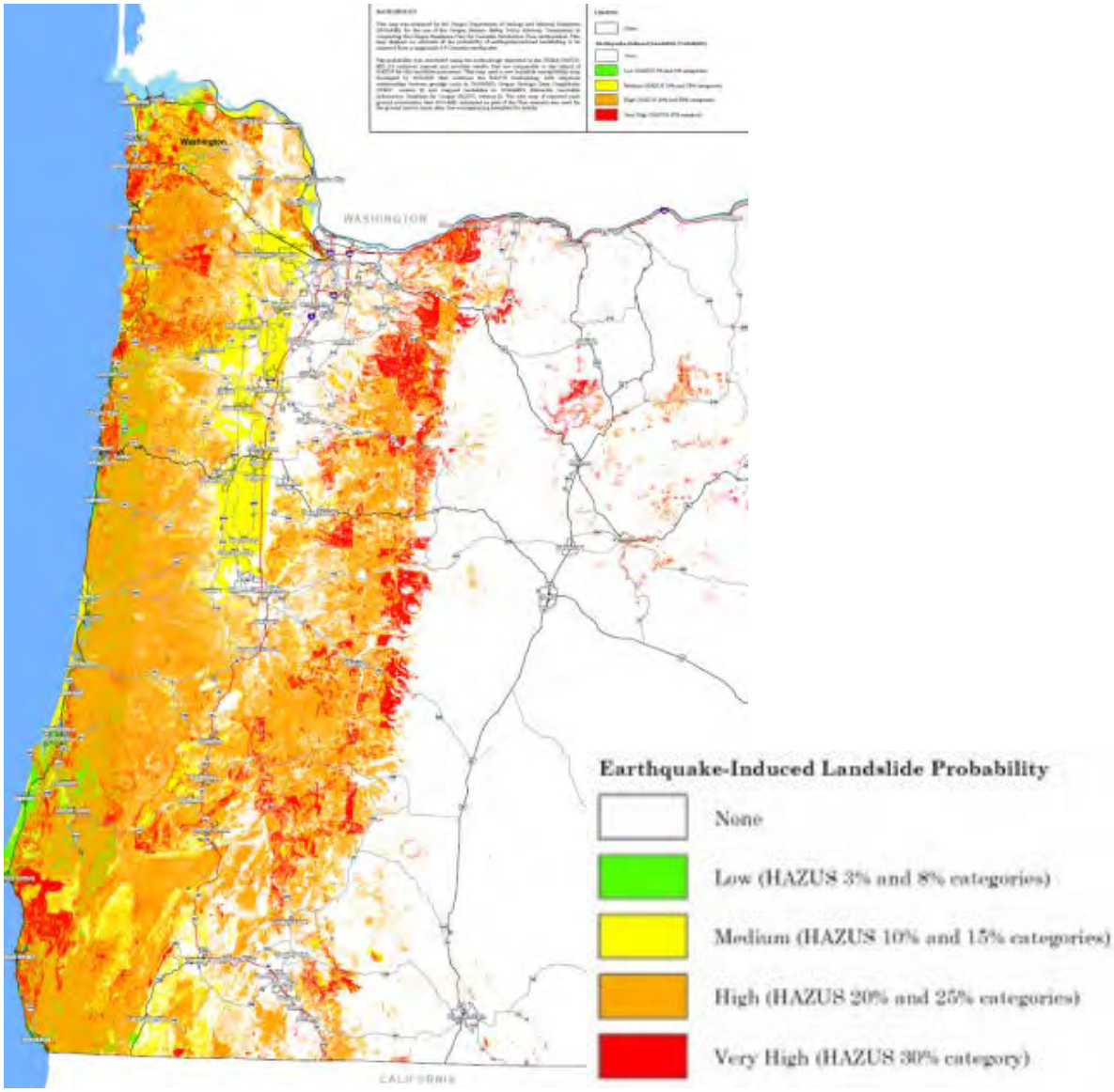

Figure 2-LS-6: Earthquake-Induced Landslide Probability

Source: Madin and Burns, 2013

Madin, I.P. and Burns, W.J., 2013. Ground motion, ground deformation, tsunami inundation, coseismic subsidence, and damage potential maps for the 2012 Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes: Oregon Department of Geology and Mineral Industries, Open-File Report O-13-06.

Tsunami

What is a tsunami?

Tsunamis are a low frequency natural hazard in Oregon and are restricted almost exclusively to coastal areas. Tsunamis are most often caused by the abrupt change in the seafloor accompanying an earthquake (Figure 2-TS-1).The most common sources of the largest tsunamis are earthquakes that occur at subduction zones like the Cascadia Subduction Zone (CSZ), where an oceanic plate descends beneath a continental plate (Figure 2- TS-2). Other important processes that may trigger a tsunami include underwater volcanic eruptions and landslides (includes landslides that start below the water surface and landslides that enter a deep body of water from above the water surface). Tsunamis can travel thousands of miles across ocean basins, so that a particular coastal area may be susceptible to two different types of tsunami hazard caused by:

1) Distant sources across the ocean basin, and

2) Local sources that occur immediately adjacent to a coast.

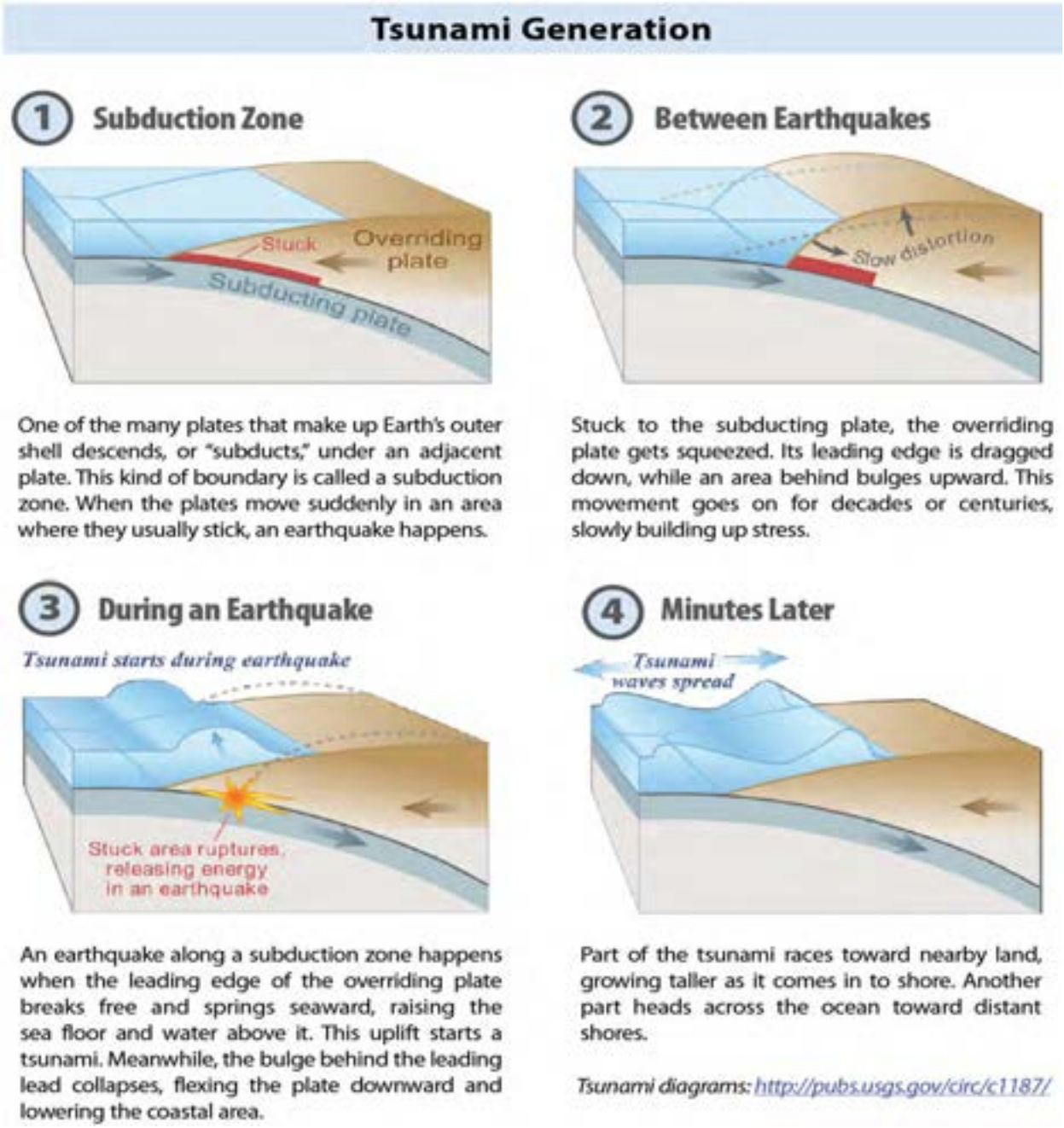

Figure 2-TS-1: Generation of a Tsunami by Subduction Zone Earthquakes

Source: DOGAMI Cascadia Winter 2012.

Figure 2-TS-2: Map of the surface trace of the Cascadia Subduction Zone (CSZ) active fault (triangles). The fault is the contact where the Juan de Fuca Plate plunges beneath the North American continental plate.

Source: DOGAMI

Distant tsunamis that may threaten the Oregon Coast are usually generated by a subduction zone earthquake elsewhere in the Pacific and would take at least 4 hours to reach the Oregon coastline from the closest source, the subduction zone in the Gulf of Alaska. For example, the 1964 Alaska tsunami reached the Oregon Coast in four to five hours after the magnitude 9.2 earthquake that generated it. In contrast, a local tsunami generated by a CSZ earthquake, would take about 15-20 minutes to reach most of the coast.

Most locally-generated tsunamis will be higher and travel farther inland (overland and up river) than distant tsunamis. By the time the tsunami wave hits the coastline, it may be traveling at 30 mph and have heights of 20 to ~100 feet, depending on the local coastal bathymetry (water depths), shape of the shore, and the amount of fault movement on the subduction zone. The tsunami wave will break up into a series of waves that will continue to strike the coast for a day or more, with the most destructive waves arriving in the first 4-5 hours after the local earthquake. As was seen in the 2004 Sumatra tsunami, the first wave to strike the coast is not always the most destructive. This was again the case during the 2011 Japan tsunami.

The coasts of Washington, Oregon, and northern California are particularly vulnerable to tsunamis from magnitude 9+ earthquakes that occur about every 500 years on the CSZ (Figure 2-TS-2). Additional, smaller tsunamis and earthquakes occur in the subduction zone south of Waldport. The combined recurrence for both types of Cascadia earthquake can be as low as ~230 years in Curry County.

The initial tsunami wave mimics the shape and size of the sea floor movement that causes it, but quickly evolves into a series of waves that travel away from the source of disturbance, reflect off of coastlines, and then return again and again over many hours. The tsunami is thus “trapped” owing to the processes of reflection and refraction. In the deep ocean, tsunami waves may be only a few feet high and can travel at wave speeds of 300 - 600 mph. As a tsunami approaches land where the water depth

decreases, the forward speed of the wave will slow as wave height increases dramatically. When the wave makes landfall, the water is mobilized into a surging mass that floods inland until it runs out of mass and energy. The wave then retreats, carrying all sorts of debris. Successive waves then batter the coast with this debris. Swimming through such turbulent debris-laden water is next to impossible.

Tsunamis are potentially more destructive than the earthquake that caused them. Loss of lives from the tsunami can often be many times the loss from the earthquake ground shaking. This was highlighted by the December 26, 2004 tsunami, associated with a magnitude 9.3 earthquake, which occurred offshore from the Indonesian island of Sumatra. The tsunami impacted almost every county located around the Indian Ocean rim and claimed the lives of approximately 350,000 people. The greatest loss of life occurred along the coast of Sumatra, close to the earthquake epicenter. The event displaced some 2 to 3 million people and its economic impact continues to be felt to the present. The Sumatra event is a direct analogue for what can be expected to occur along the Oregon Coast due to its close proximity to the Cascadia Subduction Zone.

In addition, fires started by the preceding earthquake are often spread by the tsunami waves, if there is a gasoline or oil spill. As was seen in the Sumatra 2004 tsunami, flood inundation from a tsunami may be extensive, as tsunamis can travel up rivers and streams that lead to the ocean. Delineating the inland extent of flooding, or inundation, is the first step in preparing for tsunamis.

Analysis and Characterization

The entire coastal zone is highly vulnerable to tsunami impact. Distant tsunamis caused by earthquakes on Pacific Rim strike the Oregon coast frequently but only a few of them have caused significant damage or loss of life. Local tsunamis caused by earthquakes on the Cascadia Subduction Zone (CSZ) happen much less frequently but will cause catastrophic damage and, without effective mitigation actions, great loss of life.

Figure 2-TS- 3: Tsunami damage on the Chetco River, Oregon from March 11, 2011 tsunami.

Source: USGC

On March 11, 2011, a magnitude (M_w) 9.0 earthquake struck off the east coast of Japan. This caused a massive tsunami that inundated much of the eastern coastline of Japan, and reached the west coast of the U.S. many hours later. There was one death and millions of dollars of damage to ports and harbors in Oregon and California (Figure 2-TS-3). Japan suffered many thousands of dead and missing as well as a nuclear catastrophe which will continue to be a hazard far into the future. Oregon received a Presidential Declaration of Disaster (DR-1964) which brought millions of dollars of financial aid to repair and mitigate future tsunami damage. Debris from tsunami-damaged buildings in Japan floated across the Pacific Ocean and began arriving on the Canadian and US West Coast in December 2011 and is expected to continue to arrive for years.

In March 1964, a tsunami struck southeastern Alaska following an earthquake beneath Prince William Sound and arrived along the Alaska coastline between 20 and 30 minutes after the quake, devastating villages. Damages were estimated to be over $100 million (1964 dollars). Approximately 120 people drowned. The tsunami spread across the Pacific Ocean and caused damage and fatalities in other coastal areas, including Oregon. The tsunami killed five people in Oregon and caused an estimated $750,000 to $1 million in damage. In Crescent City, California, there were 10 fatalities, while damage to property and infrastructure was estimated to range from $11 to 16 million.

Going still further back in time, there is scientific consensus that the Pacific Northwest experienced a subduction zone earthquake estimated at magnitude 9 on January 26, 1700. The earthquake generated a tsunami that caused death and damage as far away as Japan, where it was well-documented in the literature of the time. The earthquake and tsunami left behind geologic “footprints” in the form of (1) tsunami sand sheets in marshes, (2) layers of marsh vegetation covered by tide-borne mud when the coast abruptly subsided, and (3) submarine sand and silt slurries shaken off the continental shelf by the earthquake (turbidites). The widespread and large body of oral traditional history of the Thunderbird and Whale stories passed down by First Nations people depict both strong ground shaking and marine flooding that may have been inspired by this event. Although this earthquake undoubtedly produced tsunamis that reached on the order of 30-40 feet at the coast, geologic evidence from study of 10,000 years of turbidite deposits suggests that the 1700 earthquake was just an average event. Some Cascadia earthquakes have been many times larger, so, while devastating, the earthquake and tsunami were far from the worst case.

In 2010 the Oregon Department of Geology and Mineral Industries (DOGAMI) completed an analysis of the full range of Cascadia tsunamis and earthquakes, separating the results into 5 size classes with "T-shirt" names, S, M, L, XL, and XXL. The XL or XXL events probably only happened once or twice in the last 10,000 years, but estimated tsunami heights were comparable to those of the 2011 Japan and 2004 Sumatra tsunamis, the largest known.

The tsunami wave tends to arrive at the coast as a fast moving surge of rising water. As the tsunami enters coastal bays and rivers, it may move as a high velocity current or a breaking wave that travels up an estuary as a bore (wall of turbulent water like the waves at the coast after they break). This inland wave of water can often cause most or all of the damage, and the current may be just as destructive when it is retreating from the land as when it is advancing. For example, in Seaside the damage from the 1964 Alaskan tsunami occurred along the Necanicum River and Neawanna Creek, well inland from the coast. In addition, storm waves and wind waves may ride on top of the tsunami waves, further compounding the level of destruction.

During Cascadia earthquakes there is also the added effect of coastal subsidence, or the downward movement of the land relative to the sea level, during the earthquake. This is due to the release of the accumulated strain that caused the western edge of the North American Plate to bend and bulge. The new earthquake models used for the local tsunami scenarios indicate that portions of the Oregon coast could drop by a few to several feet.

Seven tsunami flooding (inundation) zones are mapped by DOGAMI: five Cascadia tsunami scenarios, S, M, L, XL, XXL, and two maximum-considered distant tsunami scenarios (the 1964 Alaska tsunami and a larger hypothetical maximum Alaska tsunami, AKmax). All 7 are depicted on DOGAMI tsunami inundation maps (TIM's, Figure T-4) plus digital files for use in geographic information systems (GIS). The 5 local CSZ-sourced inundation scenarios involve greater and greater amounts of movement on the subduction zone fault, ranging from 30 feet (S scenario) to 144 feet (XXL scenario).The 7 inundation lines are reduced to 2 for evacuation planning: AKmax inundation is the distant tsunami evacuation zone, and XXL is the local tsunami evacuation zone (Figure 2-TS-4). Brochures illustrating these zones and evacuation routes are available for all population centers, but both zones can also be viewed for any part of the coast using an interactive map portal and mobile phone apps at www.oregontsunami.org. The evacuation zones are critical for life safety planning and preparation. All seven scenarios assumed a maximum high tide (MHHW) tide and include the effects of subsidence from the earthquake fault process (release of strain on the North American Plate).

Figure 2-TS-4. Examples from North Bend (Coos Bay area) of DOGAMI tsunami inundation maps (TIM's in top two maps) and an evacuation map (bottom map). The top map illustrates inundation for five "T-shirt" size CSZ scenarios (S, M, L, XL, and XXL); the middle map shows inundation from two maximum considered distant tsunamis from subduction zone earthquakes in the Gulf of Alaska, a hypothetical maximum (termed Alaska Maximum or AKmax in DOGAMI databases), and the largest historical event that struck the Oregon coast in 1964 . Note the close similarity of Alaska Maximum to the Small CSZ inundation.

Source: DOGAMI. Visit: www.oregontsunami.org

Historical Tsunami Events in Oregon

Table 2-TS-1 lists historic tsunami events in Oregon.

Table 2-TS-1: Historic Tsunamis in Oregon

Date	Origin of Event	Affected Oregon Community	Damage	Remarks
04/1868	Hawaii	Astoria		Observed
08/1868	N. Chile	Astoria		Observed
08/1872	Aleutian Is	Astoria		Observed
11/1873	N. California	Port Orford		Debris at high tide line
04/1946	Aleutian Is	Bandon		Barely perceptible
04/1946		Clatsop Spit		Water 3.7m above MLLW
04/1946		Depoe Bay		Bay drained. Water returned as a wall
04/1946		Seaside		Wall of water swept up Necanicum River
11/1952	Kamchatka	Astoria		Observed
11/1952		Bandon	Log decks broke loose	
05/1960	S. Cent. Chile	Astoria		Observed
05/1960		Seaside	Bore on Necanicum River damaged boat docks	
05/1960		Gold Beach		Observed
05/1960		Newport		Observed for about four hours
05/1960		Netarts	Some damage observed	
03/1964	Gulf of Alaska	Cannon Beach	Bridge and motel unit moved inland. $230,000 damage	
03/1964		Coos Bay	$20,000 damage	
03/1964		Depoe Bay	$5,000 damage; 4 children drowned at Beverly Beach	
03/1964		Florence	$50,000 damage	
03/1964		Gold Beach	$30,000 damage	
03/1964		Seaside	1 fatality (heart attack); Damage to city: $41,000; Private: $235,000; Four trailers, 10-12 houses, two bridges damaged	
05/1968	Japan	Newport		Observed
04/1992	N. California	Port Orford		Observed
10/1994	Japan	Coast		Tsunami warning issued, but no tsunami observed
3/2011	Japan	Coast	$6.7 million. Extensive damage to the Port of Brookings.	Tsunami warning issued, observed ocean waves. and

Source: NOAA, 1993, Tsunamis Affecting the West Coast of the United States: 1806-1992.
FEMA, 2011, Federal Disaster Declaration

In addition to the historical distant tsunamis of Table 2-TS-1, the last CSZ tsunami struck at 9 PM on January 26, 1700. This may be considered a historical event, because the tsunami was recorded in historical port records in Japan. The date and time of occurrence here in Oregon were inferred by Japenese and USGS researchers from a tsunami and earthquake model.

Probability

While large (~magnitude 9) CSZ earthquakes and associated tsunamis have occurred on average every ~500 years over the last 10,000 years, the time interval between events has been as short as decades and as long as 1150 years. Smaller earthquakes on the southern part of the CSZ have occurred about as often as larger earthquakes, making CSZ events in southernmost Oregon about twice as likely as in northern Oregon. The size and frequency of the 19 large earthquakes on the CSZ are inferred from offshore turbidite deposits and are shown in Figure 2-TS-5. All 19 of these large CSZ events were likely magnitude 8.7 to 9.2 earthquakes.

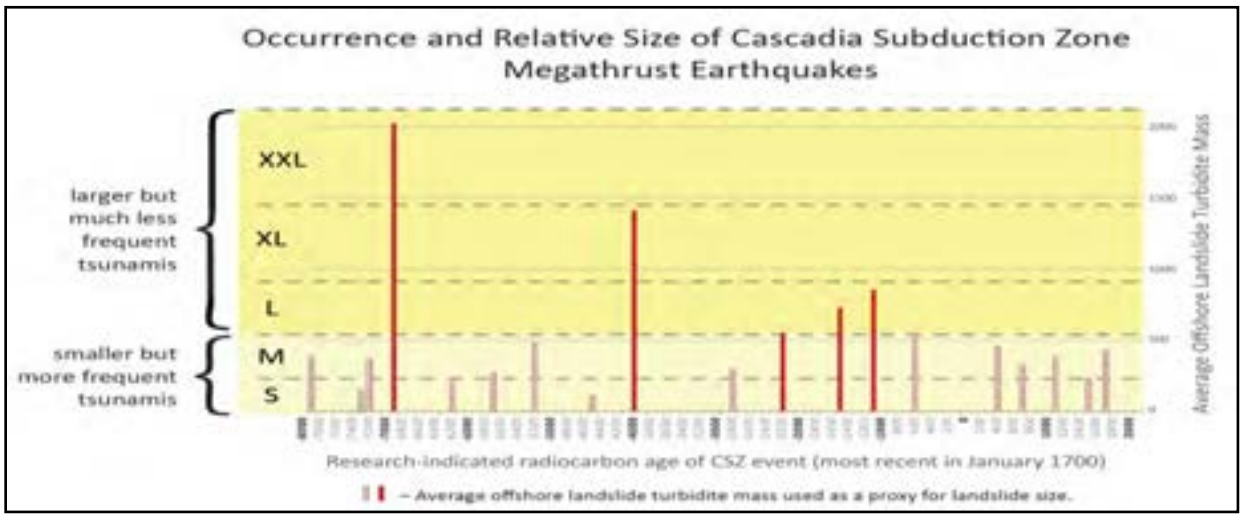

Figure 2-TS-5: Occurrence and Relative Size of Cascadia Subduction Zone Megathrust Earthquakes

Source: DOGAMI Cascadia, Winter 2012

In April 2008 the USGS wrote that for the next 30 years there is a 10% probability of a magnitude 8 to 9 quake somewhere along the 750-mile-long Cascadia Subduction Zone. In 2012 USGS Professional Paper 1661-F (http://pubs.usgs.gov/pp/pp1661f/) showed that the southern part of the CSZ also ruptures in segments, so probabilities some type of CSZ earthquake increase from north to south, as illustrated in Figure 2-TS-6. Segment earthquakes and tsunamis will generally be smaller than full-margin events. Segment tsunamis, by the time they travel more than ~43 miles north of a segment, are similar in size to distant tsunamis with the largest waves striking 2 hours or more after the earthquake (Priest et al., 2014; http://link.springer.com/article/10.1007/s11069-014-1041-7). New tsunami inundation maps from DOGAMI illustrate the range of inundation from all full-margin and significant segment ruptures on the CSZ.

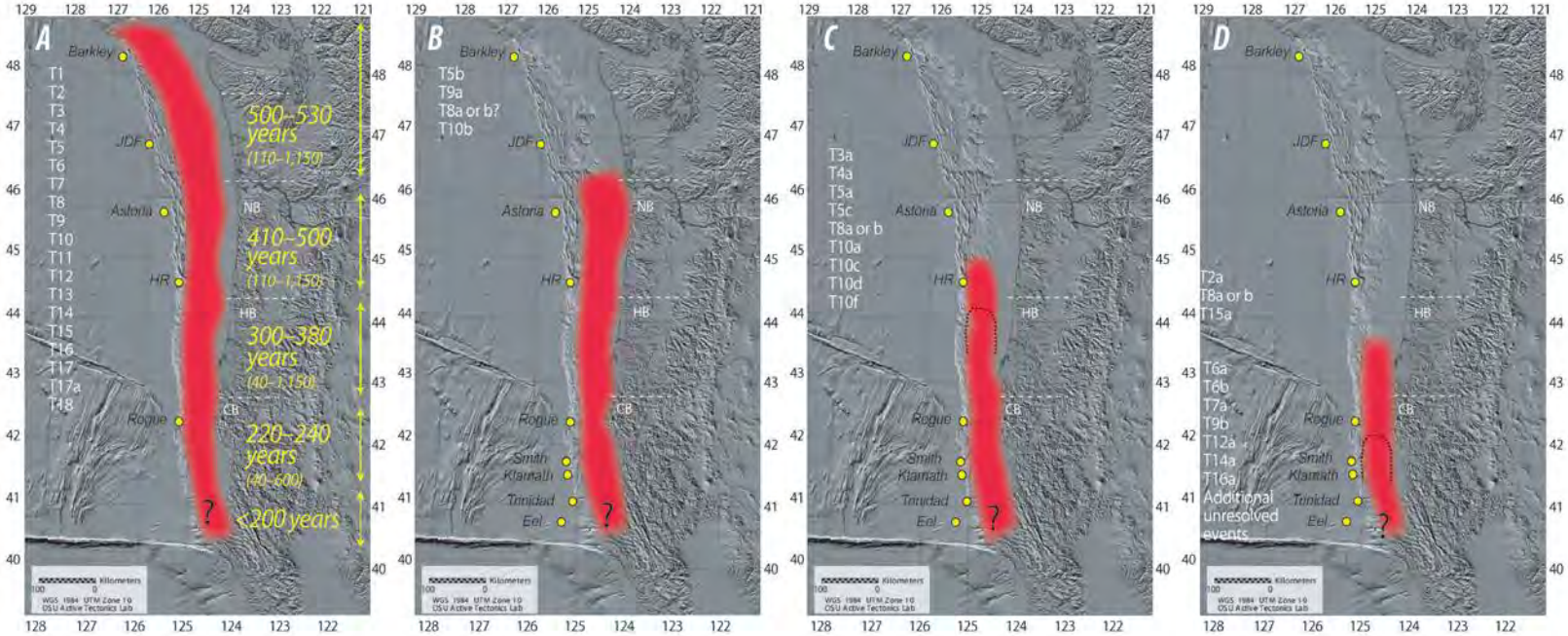

Figure 2-TS-6. Red areas depict hypothetical rupture patches of Cascadia subduction zone (CSZ) earthquakes over the last ~10,000 years inferred by Goldfinger et al. (2012) from marine and onshore paleoseismic data plus geological and geophysical data. White line with triangles marks the CSZ deformation front also visible as boundary between smooth to rough terrain. Numbers with "T" prefixes are offshore turbidite layers correlated with each rupture patch and arranged with youngest at the top. The white dashed lines are inferred segment boundaries of CSZ ruptures designated segments A (full-margin rupture), B (rupture north to Nehalem Bank (NB)), C (rupture north to Heceta Bank (HB)), and D (rupture north to Coquille Bank (CB)). Northern extents of segment D events break into two groups, one terminating south of the Rogue submarine canyon, indicated by dashed line. The second group extends north of Rogue but is not observed at Hydrate Ridge (HR). Although presumed to extend no further south than the southern terminous of the CSZ at Cape Mendocino, southern rupture limits are poorly known for all events indicated by query, limited by temporal coverage of turbidites and probable non-seismic turbidites in the early Holocene. Uncertainty in the northern extent of segments C and D are shown as the difference between the red patches and the black dashed lines. In the map of segment A, mean return in years of CSZ earthquakes is listed at each latitude and is calculated by dividing the number of turbidite layers into 10,000 years; minimum and maximum time intervals between turbidites at each latitude is given in parentheses. See Priest et al. (2014; http://link.springer.com/article/10.1007/s11069-014-1041-7) for estimates of height and arrival times of Segment C and D tsunamis.

Source: Goldfinger et al. (2012).[1]

Volcano

Volcanoes are potentially destructive natural phenomena, constructed as magma ascends and then erupts onto the earth's surface. Volcanic eruptions are typically focused around a single vent area, but vary widely in explosivity. Therefore volcanic hazards can have far reaching consequences. Volcanic hazards may occur during eruptive episodes or in the periods between eruptions. Eruptive events may include hazards such as, pyroclastic surges and flows, ash fall, lava flows, or slurries of muddy debris and water known as lahars. Eruptions may last days to weeks or years, and have the potential to dramatically alter the landscape for decades. Unlike other geologic hazards (e.g., earthquakes, tsunamis), impending eruptions are often foreshadowed by a number of precursors including ground movements, earthquakes, and changes in heat output and volcanic gases. Scientists use these clues to recognize a restless volcano and to prepare for events that may follow. Hazards occurring between eruptive periods are typically related to earthquakes or natural erosion, which may trigger debris avalanches or debris flows on the flanks of the volcano. Such events often occur without warning.

Potentially hazardous volcanoes in Oregon are present along the crest of the Cascade Range and to a much lesser extent in the High Lava Plains. The volcanoes within these regions provide some of Oregon's most spectacular scenery and popular recreational areas, yet the processes that led to their formation also present significant challenges and hazard to communities within the region. The catastrophic eruption of Washington's Mount St. Helens in 1980 and subsequent activity demonstrate both the power and detrimental consequences that Cascade-type volcanoes can have on the region. Lessons learned at Mount St. Helens, led the U.S. Geological Survey (USGS) to establish the Cascades Volcano Observatory (CVO) in Vancouver, Washington. Scientists at CVO continually monitor volcanic activity within the Cascade Range and in cooperation with the Oregon Department of Geology and Mineral Industries (DOGAMI), study the geology of volcanic terrains in Oregon.

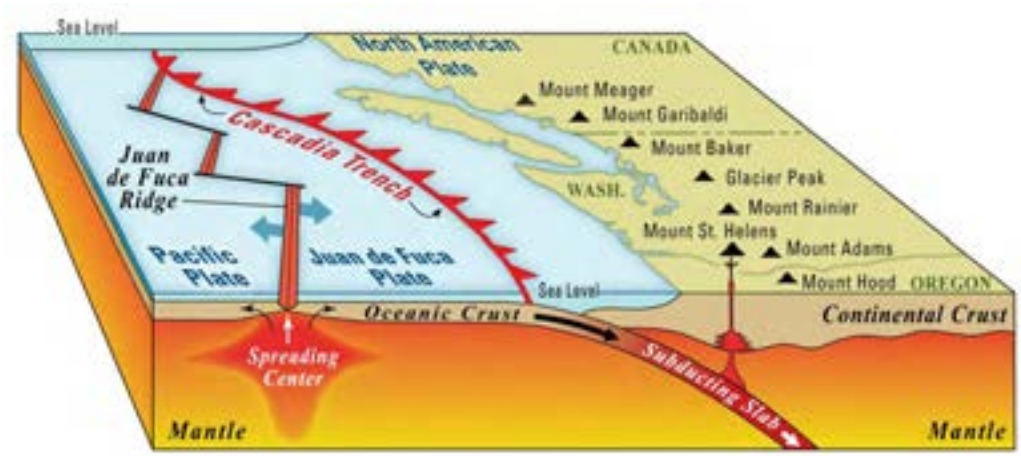

Figure 2-V-1: Cartoon diagram showing a generalized subduction zone setting.

Source: U.S. Geological Survey, Cascades Volcano Observatory
http://volcanoes.usgs.gov/vsc/multimedia/cvo_popular_graphics_gallery.html

Analysis and Characterization

The volcanic Cascade Range extends southward from British Columbia into northern California. The volcanoes are a result of the complex interaction of tectonic plates along the Cascadia Subduction Zone (CSZ). Subduction is the process that results in the Juan de Fuca plate (oceanic crust) subducting, or sinking, underneath the North American plate (continental crust) on which we live (Figure 2-V-1). As the subducted plate descends, it heats up and begins to melt. This provides the reservoir of heat and molten rock needed to create the magma chambers that lie kilometers deep, beneath the Cascades.

Stratovolcanoes like Mount Hood, also called composite volcanoes, are generally tall, steep, conical shaped features, built up through layering of volcanic debris, lava, and ash. Eruptions tend be explosive, for example, the violent 1980 eruption of Mount St. Helens, and they produce volcanic mudflows (lahars) that can travel far from the mountain. Future eruptions are likely to be similar and present a severe hazard to the surrounding area. Volcanoes also pose other hazards because of their geology and resulting geomorphology. The relatively high elevation of volcanoes usually results in the meteorological effect called orographic lifting, which causes high precipitation and snow on the mountains that can result in flooding. The geologic material tends to be relatively weak and, when combined with the steep slopes, can cause frequent and hazardous landslides. Cascade Mountain Range volcanoes are also located near the active CSZ and nearby potentially active crustal faults, which contribute to moderate seismic hazard in the area.

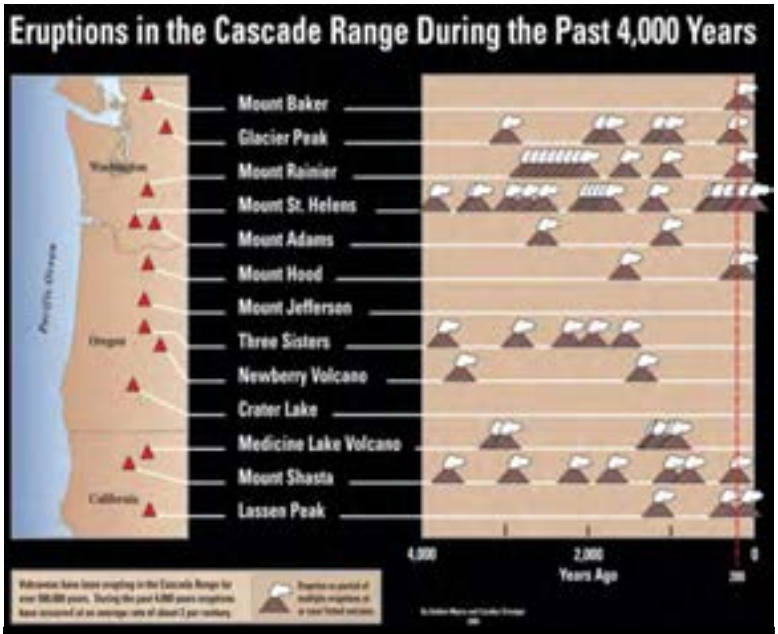

Figure 2-V-2: Eruptions in the Cascade Range during the Past 4,000 years.

Source: Myers and Driedger, (2008), USGS GIP-63

The volcanoes of the Cascade Range have a long history of eruption and intermittent quiescence. Note that in Figure 2-V-2, each volcano has a different frequency of eruption. Not all Cascade volcanoes have been active in the recent past. This is typical of a volcanic range and is one of the reasons forecasting eruptions can be difficult.

Several smaller volcanoes, including Diamond Craters and Jordan Craters, in the High Lava Plains of southeast Oregon have experienced eruptions in the last 6,000 years. Generally non-explosive eruptions at these sites have built complexes of lava flow fields and cinder cones. Unlike the far-reaching effects that may be generated by large, potentially explosive stratovolcanoes in the Cascade Range, hazards associated with future eruptions in sparsely populated southeast Oregon are most likely limited to localized lava flows.

Volcano-Associated Hazards

A number of hazards are associated with volcanoes (Figure V-3). In general, volcanic hazards are commonly divided into those that occur in proximal (near the volcano) and distal (far from the volcano) hazard zones. In the distal hazard zone, volcanic activity includes lahars (volcanic mudflows or debris flows) and fallout of ash; in the proximal hazard zone, activity can be much more devastating and includes rapidly moving pyroclastic flows (glowing avalanches), lava flows, and landslides. Each eruption is a unique combination of hazards. Not all hazards will be present in all eruptions, and the degree of damage will vary. It is important to know that during an active period for a volcano many individual eruptions may occur and each eruption can vary in intensity and length. For example, while Mount St. Helens is best known for its catastrophic May 1980 eruption, periodic eruptions of steam and ash and the growth of a central lava dome have continued to pose a hazard since that time.

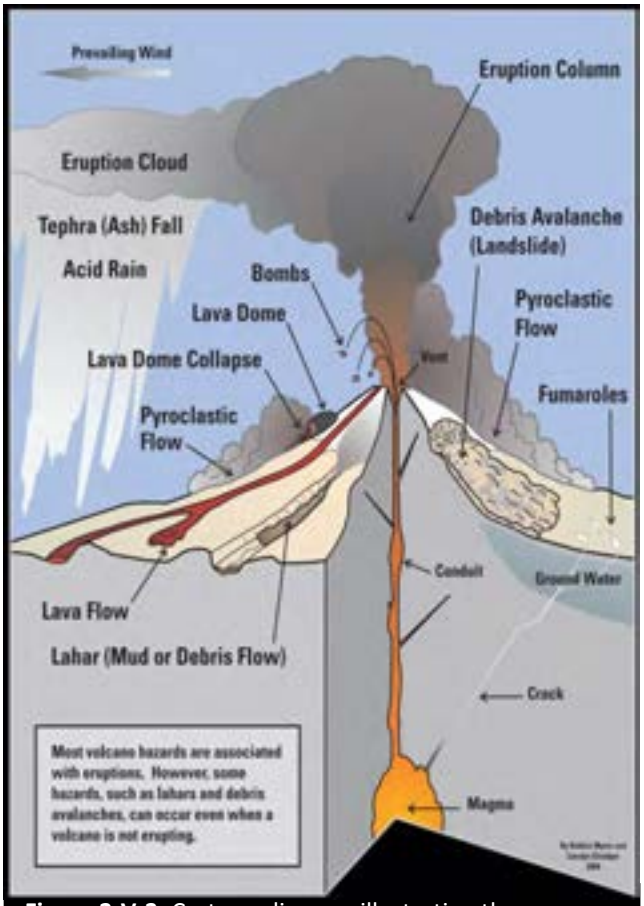

Figure 2-V-3: Cartoon diagram illustrating the potential hazards at a stratovolcanoe.

Source: Myers and Others 1997,

Eruptive hazard

Ash Fall

Dust-sized ash particles are the by-products of many volcanic eruptions. Ash, when blown into the air, can travel large distances causing significant problems for distal hazard zones. During ash-dominated eruptions, deposition is largely controlled by the prevailing wind direction. The predominant wind pattern over the Cascade Range is from the west to the east. Previous eruptions documented in the geologic record indicate most ash fall drifting to and settling in areas to the east of the Cascade volcanoes. The probable geographic extent of volcanic ash fall from select volcanic eruptions in the Pacific Northwest is depicted in the figure below (Figure 2-V-4).

Within a few miles of the vent, the main ash fall hazards to man-made structures and humans include high temperatures, being buried, and being hit by falling fragments. Within ten to twelve miles, hot ash fall may set fire to forests and flammable structures.

Structural damage can also result from the weight of ash, especially if it is wet. Four inches of wet ash may cause buildings to collapse. Accumulations of a half inch of ash can impede the movement of most vehicles, disrupt transportation, communication, and utility systems, and cause problems for human and animal respiratory systems. It is extremely dangerous for aircraft, particularly jet planes, as volcanic ash accelerates wear to critical engine components, can coat exposed electrical components, and erodes exposed structure. Ash fall may severely

decrease visibility, even cause darkness, which can further disrupt transportation and other systems. Recent work by the Volcano Hazards Group of the U.S. Geological Survey has attempted to rank the relative hazard of volcanoes in North America. According to this study, Oregon has four Very High Threat Volcanoes: Crater Lake, Mount Hood, Newberry Volcano, and South Sister (Ewert and others, 2005).

Ash fall can severely degrade air quality and trigger health problems. In areas with considerable ash fall, people with breathing problems might need additional services from doctors or emergency rooms. In severe events an air quality warning could be issued, informing people with breathing problems to remain inside

Ash fall can create serious traffic problems as well as road damage. Vehicles moving over even a thin coating of ash can cause clouds of ash to swell. This results in visibility problems for other drivers, and may force road closures. Extremely wet ash creates slippery and hazardous road conditions. Ash filling roadside ditches and culverts can prevent proper drainage and cause shoulder erosion and road damage. Blocked drainages can also trigger debris flows if the blockage causes water to pool on or above susceptible slopes. Removal of ash is extremely difficult as traditional methods, such as snow removal equipment, stir up ash and cause it to continually resettle on the roadway.

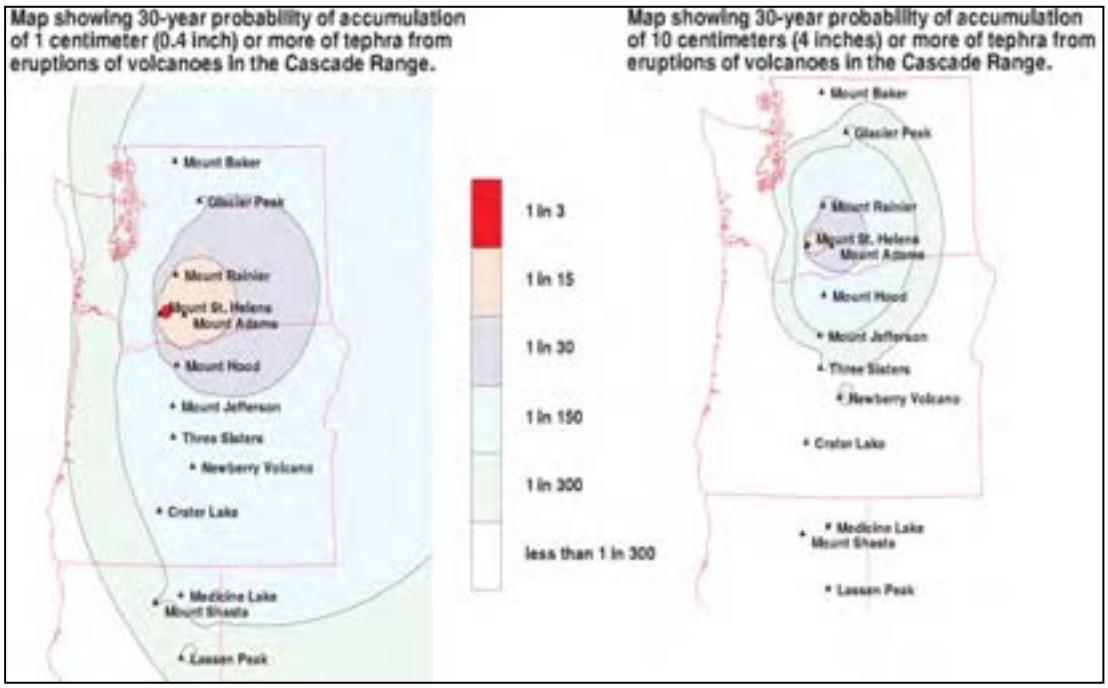

Figure 2-V-4: The probable geographic extent of volcanic ash fall from select volcanic eruptions in the Pacific Northwest.

Source: Scott and others, 1997.

Lahars

Cascade Range volcanoes and the floodplains that drain them contain abundant evidence for past lahar events. Lahars or volcanic debris flows are water-saturated mixtures of soil and rock fragments originating from a volcano. These sediment gravity flows can travel very long distances (over 62 mi) and travel as fast as 50 mi per hour in steep channels close to a volcano; further downstream, where they reach gently sloping valley flows speeds generally slow to 10 to 20 mi per hour. The largest of these flows are known to transport boulders exceeding 30 ft in diameter. Lahars are often associated with eruptions, but they can also be generated by rapid erosion of loose rock during heavy rains or by sudden outbursts of glacial water. Highly erodible, unconsolidated lahar deposits may be easily remobilized by normal rainfall, snowmelt, and streams for years after their deposition.

Figure 2-V-5: Trees buried in volcanic sediment, Sandy River, Oregon. Trunks of forest trees, initially growing on a terrace above the Sandy River (Oregon) at Oxbow Regional Park, were buried by rapid deposition of sediment following a dome-building eruption at Mount Hood in 1781. Erosion during a flood about a week before the photo was taken exposed this "ghost forest."

Photo Source: T.C. Pierson, USGS, 1/15/2009

Hazards associated with lahars include direct impact and burial by the advancing flow, burial of valuable infrastructure or agricultural land, and secondary flooding due to temporary damming and breakouts along tributary streams (Figure 2-V-5). Because of their relatively high viscosity, lahars can move, or even carry away, vehicles and other large objects such as bridges. Municipalities, industries, and individuals who take their water from streams affected by lahars may have water quality and/or quantity issues. Wildlife could be adversely affected by changes in streams, including the deposition of debris in streambeds and floodplains. For example, salmonids trying to spawn could find it impossible to swim upstream. Long-term drainage pattern alteration and increased sedimentation rates downstream may persist for decades following such an event.

Lava Flow

Lava flows are streams of molten rock that erupt relatively non-explosively from a volcano and move downslope. Hazards associated with lava flow events include ash falls proximal to vents, extensive damage or total destruction of objects in the lava flow path(s) by burning, crushing, or burial, and disruption of local stream drainages. Lava flows are generally not life threatening because people can usually out-walk or out-run them. The Parkdale Lava Flow, located along the north flank of Mount Hood, erupted from a small vent about 7,600 years ago (Figure V-6).

Figure 2-V-6: Oblique air-view of the Parkdale lava flow. The flow erupted around 7,600 years ago from a small vent located about 6 miles south of Parkdale, Oregon.

Photo source: Bill Burns, DOGAMI

Pyroclastic Flow and Surges

Pyroclastic flows are avalanches of rock and gas at temperatures of 600 to 1500 degrees Fahrenheit. They typically sweep down the flanks of volcanoes at speeds of up to 150 miles per hour. Pyroclastic surges are a more dilute mixture of gas and rock. They can move even more rapidly than a pyroclastic flow and are more mobile. Both generally follow valleys, but surges especially may have enough momentum to overtop hills or ridges in their paths. Because of their high speed, pyroclastic flows and surges are difficult or impossible to escape. If it is expected that they will occur, evacuation orders should be issued as soon as possible for the hazardous areas. Objects and structures in the path of a pyroclastic flow are generally destroyed or swept away by the impact of debris or by accompanying hurricane-force winds. Wood and other combustible materials are commonly burned. People and animals may also be burned or killed by inhaling hot ash and gases. The deposit that results from pyroclastic flows is composed of a combination of ash, pumice, and rock fragments. These deposits may accumulate to hundreds of feet thick and can harden to a resistant rock called tuff. Pyroclastic flows and surges are considered a proximal hazard, but in some instances may extend tens or even hundreds of miles from the volcanic vent.

Landslides

Because the stratovolcanoes that form the Cascade Mountains are composed of layers of weak fragmented rock and lava, they are prone to landslides. Landslides range in size from small to massive summit or flank failures like the one in May 1980 at Mount St Helens (Figure 2-V-7). They may be triggered by volcanic activity or during times of excessive rainfall or snowmelt. Speeds of movement range from slow creep to more catastrophic failure. If enough water is incorporated into the material, the failure will become a lahar.

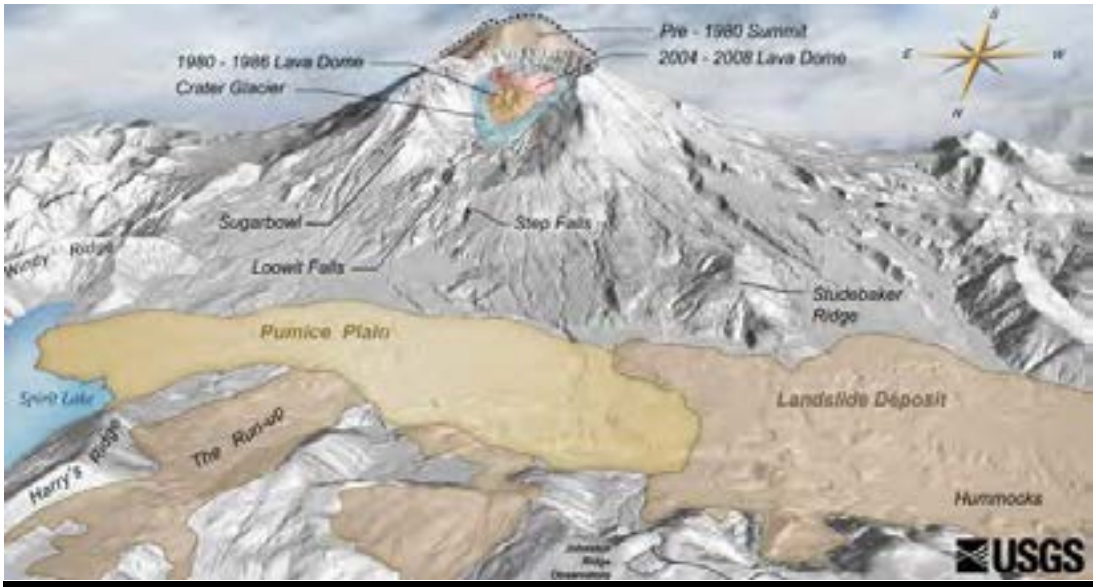

Figure 2-V-7: Mt. Saint Helens

Photo source: Bill Burns, DOGAMI

Non-Eruptive Hazards

Earthquake

Earthquake effects are a significant threat along the Cascade Mountains and come from three main sources: the CSZ, crustal faults, and volcanic activity. The CSZ is generally over 150 miles away, but it produces earthquakes as a large as M 9.0 every 240 to 500 years. Crustal earthquakes occur in the North American plate at relatively shallow depths of approximately 6 to12 miles below the surface. However, some can rupture through the surface. The distance from a potentially active fault is critical to the evaluation of the earthquake shaking hazard. Volcanic earthquakes are usually small and frequent, but they can be as large or larger than the M4.5 earthquake on Mount Hood in 2002. During 2002, a swarm of earthquakes ranging from M3.2 to M4.5 occurred on the southeast flank of Mount Hood. The damaging effects of all three kinds of earthquakes can be enhanced by amplification of shaking in soft soils, liquefaction, or induced landslides.

Flood and Channel Migration

The relatively high elevation of volcanoes usually results in the meteorological affect called orographic lifting, which causes high precipitation and snow on the mountains. The result can be very high levels of rainfall and/or rapid snowmelt that can result in flooding.

Floods cause damage to assets through inundation of water and by erosion and deposition of soil and/or large objects. Defining the hazard associated with inundation by flooding is done by calculating the area that is likely to be flooded during different levels of flooding. Larger floods are less frequent than smaller floods, so flood levels may be defined by their return period. The longer the return period, the deeper the flood waters, and hence the larger the area that is inundated. Some common return periods used in flood hazard mapping include 10-year, 25-year, 100-year, and 500-year floods. Most flooding on Cascade Range volcanoes occurs when heavy, warm rain during large winter or spring storms falls on accumulations of low-elevation snow. Channel migration hazards can occur slowly, for example, by continuous erosion along a cutbank meander and deposition onto a point bar during high flows, or very rapidly during storm events through avulsion or rapid abandonment of the current river channel for a new one. Such rapid migration can not only destroy structures but even remove the land beneath structures.

For more information on flooding and channel migration zones see the Flood section of this Plan, beginning on page 75.

Landslide

The general term landslide refers to a range of geologic events including rock falls, debris flows, earth slides, and other mass movements. Most landslides that occur on volcanoes are large deep-seated landslide complexes or debris flows. Deep-seated landslides have failure surfaces usually tens of feet below the surface and can cover large areas from acres to square miles. These types of landslides tend to move relatively slowly, but they can lurch forward if shaken by an earthquake or if disturbed by removal of material from the toe, by addition of material to the head, or by addition of water into the slide mass. Debris flows tend to initiate in the upper portions of a drainage, picking up water, sediment, and speed as they come down the drainage. As they reach the mouth of the confined/steep portion of the drainage, they tend to spread out and deposit the majority of the material, generally creating a fan. Debris flows are also commonly initiated by other types of landslides that occur on slopes near a channel. They can also initiate within the channel in areas of accelerated erosion during heavy rainfall or snowmelt.

Characterization of Individual Volcanoes

The history of volcanic activity in the Cascade Range is contained in its geologic record. The ages, eruptive history, and hazards associated with each volcano vary considerably. Cascade volcanoes may be characterized by intermittent periods of activity, followed by longer periods of relative quiescence. The incompleteness of eruptive records, even at relatively well-studied volcanoes, makes prediction of probability and recurrence intervals of future eruptions difficult to determine. Table 2-V-1 lists Cascade Volcanoes in southwest Washington and Oregon that can affect Oregon communities. The discussion that follows further details those volcanic centers from Table 2-V-1 for which the U.S. Geological Survey has developed hazard assessments and ranked as having a high to very high threat potential. Threat potential is described as very high, high, moderate, low, or very low based upon eruption history, distance to population centers, and potential impacts to aviation (Open-File Report 2005-1164, An Assessment of Volcanic Threat and Monitoring Capabilities in the United States: Framework for a National Volcano Early Warning System (NVEWS), John W. Ewert, Marianne Guffanti, and Thomas L. Murray, U.S. Geological Survey, April 2005). From north to south these high-threat volcanoes are: Mount St. Helens (Wolfe and Pierson, 1995), Mount Adams (Scott and others, 1995),Mount Hood (Scott and others, 1997; Burns and others, 2011), Mount Jefferson (Walder and others , 2000), the Three Sisters Region (Scott and others, 2001), Newberry Volcano (Sherrod and others, 1997), and Crater Lake (Bacon and others, 1997). Digital hazard data for some of these volcanoes has been produced by Schilling (1996); Schilling and others (1997), Schilling and others (2008a,b, c). For a detailed inventory of each volcano's history and hazards, please refer to the appropriate report referenced above, in Table V-1, and listed in Appendix X. Further information can also be obtained from the U.S. Geological Survey Cascade Volcano Observatory via the world-wide web at http://volcanoes.usgs.gov/observatories/cvo/.

Table 2-V-1: Prominent Volcanoes in the Cascade Range of Oregon and Southwest Washington

Volcano Name	Eleva-tion	Volcano Type	Most Recent Eruptions	USGS Threat Potential	Nearby Towns	Remarks/ Hazard Study
Mount St. Helens (WA)	8363 ft.	Stratovol-cano	1980-1986; 2004-2008	High to very high	Portland (OR); Castle Rock (WA); Olympia (WA); Vancouver (WA); Yakima (WA)	Major explosive eruption and debris avalanche in 1980. Widespread ash fall. Wolfe and Pierson (1995).
Mount Adams (WA)	12,277 ft.	Stratovol-cano	~520,000 to 1000 YBP;	High to very high	Portland (OR); Hood River (OR); Vancouver (WA); Yakima (WA)	Numerous eruptions in last 15,000 years. Major debris avalanches effecting White Salmon River at 6000 and 300 YBP. Scott and others (1995).

Volcano Name	Eleva-tion	Volcano Type	Most Recent Eruptions	USGS Threat Potential	Nearby Towns	Remarks/ Hazard Study
Mount Hood	11,240 ft.	Stratovol-cano	1760-1865	High to very high	Portland (OR); Sandy (OR); Welches(OR); Brightwood (OR); Parkdale (OR) Hood River (OR)	Pyroclastic flows in the Upper White River drainage; lahars in Old Maid Flat; lava dome at Crater Rock; steam explosions. Scott and others (1997); Schilling and others (2008a).
Mount Jefferson	10,495 ft.	Stratovol-cano	280,000 to 15,000 YBP	Low to very low	Idanha (OR); Detroit (OR); Warm Springs (OR); Madras (OR); Lake Billy Chinook	Potentially active and capable of large explosive eruptions. Recent history of lava domes, small shields, and lava aprons.Walder and others (1999); Schilling and others (2007).
Mount Washington	7,796 ft.	Mafic volcano		Low to very low		No hazard study.
North Sister	10,085 ft.	Mafic volcano	300,000-120,000 YBP	High to very high	Sisters (OR); Bend (OR); Redmond (OR); Sunriver (OR); La Pine (OR); Blue River (OR); McKenzie Bridge (OR); Vida (OR); Springfield (OR)	Deep glacial erosion; Ash fall, pyroclastic flows, lava flows and domes, and lahars. Scott and others (2001); Schilling and others (2008c).
Middle Sister	10,047 ft.	Stratovol-cano	~40,000 – 14,000 YBP	High to very high	Sisters (OR); Bend (OR); Redmond (OR); Sunriver (OR); La Pine (OR); Blue River (OR); McKenzie Bridge (OR); Vida (OR); Springfield (OR)	Potentially active, capable of large explosive eruptions, ash fall, pyroclastic flows, lava flows and domes, and lahars.Scott and others (2001); Schilling and others (2008c).

Volcano Name	Eleva-tion	Volcano Type	Most Recent Eruptions	USGS Threat Potential	Nearby Towns	Remarks/ Hazard Study
South Sister	10,358 ft.	Stratovol-cano	~50,000 – 2,000 YBP	High to very high	Sisters (OR); Bend (OR); Redmond (OR); Sunriver (OR); La Pine (OR); Blue River (OR); McKenzie Bridge (OR); Vida (OR); Springfield (OR)	Potentially active, capable of large explosive eruptions, ash fall, pyroclastic flows, lava flows and domes, and lahars. Most silicic of the cones in the Three Sisters complex. Phase of uplift started in 1997 within a broad area about 6 km west of South Sister. Scott and others (2001); Schilling and others (2008c).
Broken Top	9,152 ft.	Stratovol-cano	300,000 - 100,000 YBP	Low to very low	Bend (OR); Sunriver (OR); La Pine	Deep glacial erosion; Lava flows, pyroclastic flows, ash fall. No hazard study
Mount Bachelor	9,068 ft.	Mafic volcano	~18,000 – 7,700 YBP	Moderat e	Bend (OR); Sunriver (OR); La Pine (OR);	Lava flows and near vent cinder and ash falls. No hazard study.
Newberry Volcano	7,986 ft.	Shield volcano/ caldera	~400,000 – 1,300 YBP	High to very high	Bend (OR); Sunriver (OR); La Pine (OR);	Potentially active and capable of large explosive eruptions. Lava flows and near vent cinder and ash falls. Present day hot springs. Sherrod and others (1997); Schilling and others (2008b).
Mount Thielsen	9,187 ft.	Shield volcano	> 250,000	Low to very low	Chemult (OR);	Deep glacial erosion; Lava flows, pyroclastic eruptions. No hazard study.
Crater Lake Caldera	8,159 ft.	Caldera	~420,000 – 7,700 YBP	High to very high	Grants Pass (OR); Roseburg	Lava flows, pyroclastic flows,

Volcano Name	Eleva-tion	Volcano Type	Most Recent Eruptions	USGS Threat Potential	Nearby Towns	Remarks/ Hazard Study
(Mount Mazama)					(OR); Chemult (OR); La Pine (OR); Fort Klamath (OR); Chiloquin (OR); Klamath Falls (OR)	ash fall. Source of the widespread Mazama ash. Bacon and others (1997).
Mount McLaughlin	9,496 ft.	Stratovol-cano	>80,000 YBP	Low to very low	Medford (OR); Grants Pass (OR); Klamath Falls (OR)	Lava flows, pyroclastic flows. No hazard study.

Source: Source: U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/
Wolfe and Pierson (1995); Scott and others (1995); Sherrod and others (1997); Scott and others (1997); Bacon and others (1997); Walder and others (2000); Scott and others (2001).

Mount St. Helens (WA)

The May 18, 1980, eruption of Mount St. Helens is the best-known example of volcanism to most Oregonians. That eruption included a debris avalanche, as part of the volcanic edifice collapsed (Figure 2-V-7). This caused a lateral blast of rock, ash, and gas that devastated areas to the north of the volcano. Lahars rushed down the Toutle and Cowlitz River valleys, reaching the Columbia River and halting shipping for some time. All other river valleys on the volcano experienced smaller lahars. Pyroclastic flows devastated an area up to five miles north of the volcano. Ash fall deposits affected people as far away as Montana, and ash circled the earth in the upper atmosphere for over a year.

Except for the debris avalanche and lateral blast, the events of this eruptive period are typical of a Mount St. Helens eruption and can be expected to occur again (Table 2-V-1). The primary hazards that will affect Oregonians are ash fall and lahars that affect the Columbia River. Since the major eruptive activity in the early 1980s, Mount St. Helens has experienced two episodes of dome building activity. The latest activity lasted from 2004 until 2008. Another eruption from Mount Saint Helens is very likely in the near future.

Mount Adams (WA)

Mount Adams, located 35 miles north of Hood River, Oregon, is the largest active volcano in Washington State and among the largest in the Cascade Range (Table 2-V-1). The volcano was active from about 520,000 to about 1,000 years ago. Eruptions from Mount Adams within the last 500,000 years have mainly consisted of effusive lava flows; highly explosive events are rare in the geologic record of Mount Adams. Eruptions have also occurred from ten vents in the vicinity of Mount Adams since the last period of glaciation about 15,000 years ago. Approximately 6,000 and 300 years ago, debris avalanches from the southwest face of Mount Adams generated clay-rich lahars that traveled down the White Salmon River. The summit of Mount Adams contains a large section of unstable altered rock that can spawn future debris avalanches and lahars.

Potential hazards from Mount Adams include lava flows near the central vent area and lahars that could reach and disrupt the Columbia River channel. Such lahars may have little or no advanced warning.

Mount Hood

The last major eruption of Mount Hood occurred in approximately 1781 (232 years ago)(Tables 2- V-1 and 2). The Sandy River that drains the volcano's northwest side was originally named the Quicksand River by Lewis and Clark, who traversed the area only a couple of years after an eruption. Lahars had filled the river channel with debris, much of which has now been scoured away. There were two other minor periods of eruptions during the last 500 years, the last in the mid-1800s. Typically, these involved lava flows near the summit, pyroclastic flows, and lahars but little ash fall. From its recent eruptive history, the volcano is most likely to erupt from the south side, but planning should be done assuming eruptions could be centered anywhere on the mountain. A large eruption could generate pyroclastic flows and lahars that could inundate the entire length of the Sandy and White River Valleys. An eruption from the north flank could affect the Hood River Valley.

Due to its proximity to the Portland metropolitan area, major east-west highways, the Bull Run Reservoir (which supplies water to a majority of Portland area residents), and ski and summer recreation areas, Mount Hood poses the greatest potential volcanic hazard to Oregonians. In addition, a large volume of debris and sediment in lahars could affect shipping lanes in the Columbia River and operation of Bonneville and The Dalles dams.

In recent years, numerous debris flows caused by winter storms have flowed down river drainages. Highway 35 is periodically closed for repair work after these events damaged the bridge over the White River. If a volcanic event occurred, the same drainages would be affected.

Text Version

Mount Hood, Oregon
Notable Geologic Events Near Mount Hood, Oregon
-- In the Past 50,000 Years --

-- Excerpt from: Scott, Gardner, Sherrod, Tilling, Lanphere, and Conrey, 1997, Geologic History of Mount Hood Volcano, Oregon -- A Field-Trip Guidebook: U.S. Geological Survey Open-File Report 97-263, p.7.

Date or Age	Event	Deposits
A.D. 1859, 1865, 1907?	Minor explosive eruptions of Mount Hood	Scattered pumice
late 19th century	Late neoglacial advance	Prominent, sharp-crested moraines
late 18th century	Old Maid eruptive period	Lava dome, pyroclastic-flow and lahar deposits, tephra
about 500 years ago	Debris flows in Zigzag River	Debris-flow deposits
1,000 years ago	Debris flows in upper Sandy River	Debris-flow deposits
1,500 years ago	Timberline eruptive period	Lava dome, pyroclastic-flow and lahar deposits, tephra
7,700 years ago	Eruptions from vent near Parkdale; Mount Mazama ashfall	Basaltic andesite of Parkdale lava flow; about 5 centimeters of Mazama ash
11-20,000 years ago	Waning phases of Evans Creek glaciation	Moraines
13-20,000 years ago	Polallie eruptive period	Lava domes, pyroclastic-flow and lahar deposits, tephra
20-25,000 years ago	Maximum of Evans Creek glaciation	Belts of moraines in most valleys
20-30,000 years ago	Mount Hood dome eruptions	Lava domes, pyroclastic-flow and lahar deposits
30(?)-50,000(?) years ago	Mount Hood lava-flow eruptions	Andesite lava flows of Cathedral Ridge and Tamanawas Falls

Table 2-V-2: Notable Geologic Events Near Mt. Hood

Photo source: Bill Burns, DOGAMI

Mount Jefferson

Mount Jefferson is located in a relatively unpopulated part of the Cascade Range. The last eruptive episode at Mount Jefferson was about 15,000 years ago. Research at stratovolcanoes around the world indicates that Mount Jefferson should be regarded as dormant, not extinct.

The steep slopes of the volcano provide the setting for possible debris flows and lahars, even without an eruption. These would be confined to valleys, generally within 10 miles of the volcano.

A major eruption, however unlikely in the short term, could generate pyroclastic flows and lahars that would travel up to a few dozen miles down river valleys. Two reservoirs could be affected by pyroclastic flows from a major eruption: Detroit Lake and Lake Billy Chinook. An explosive eruption could spew ash for hundreds of miles in the downwind direction.

Many smaller volcanoes are located between Mount Jefferson and Mount Hood to the north and Three Sisters to the south. Eruptions from any of these would be primarily erupt *cinders* and ash to form cinder cones.

Three Sisters Region

North Sister has probably been inactive for at least 100,000 years (Table 2-V-1). Middle Sister last erupted between 25,000 and 15,000 years ago. South Sister had a very small ongoing uplift, which began in 1996 and became undetectable by 2003. The uplift was about one inch a year and likely indicated movement of a small amount of magma. At this writing, there is no indication that the uplift will ever develop into a volcanic eruption. However, that possibility cannot be ruled out. Hence, the Cascade Volcano Observatory has increased their monitoring of the area over the past several years.

Future eruptions at South Sister (and possibly Middle Sister) are likely to include lava flows, pyroclastic flows, and lahars. The possibility exists for lahars to travel many miles down valley floors, if an eruption melts a large amount of snow and ice. Ash fall would likely be contained within 20 miles of the vent.

Newberry Volcano

Newberry Volcano, unlike the stratovolcanoes of the Cascade Range, is a shield volcano with broad, relatively gently sloping flanks composed of stacked basaltic lavas flows (Table 2-V-1). The volcano is about 400,000 years old and has had thousands of eruptions both from the central vent area and along its flanks. The present 4 by 5 mi wide caldera at Newberry Volcano's summit formed about 75,000 years ago by a major explosive eruption and collapse event. This was the most recent of at least three caldera-forming eruptions that lofted pumice and ash high into the air and spread pyroclastic flows across the volcano's surface. The most recent eruption was 1,300 years ago when the “Big Obsidian Flow”, a glassy rhyolitic lava flow, erupted within the caldera. Future eruptions are likely to include lava flows, pyroclastic flows, lahars, and ash fall. Newberry Volcano has attracted interest for its geothermal potential. The heat under the volcano, with temperatures in some areas in excess of 509 degrees Fahrenheit, is evidence that it is only dormant.

Crater Lake Caldera

About 7,700 years ago, Mount Mazama erupted with great violence, leaving the caldera that Crater Lake now occupies (Table V-1). Layers of ash produced from that eruption have been found in eight western states and three Canadian provinces. The countryside surrounding Crater Lake was covered by

pyroclastic flows. Wizard Island is the result of much smaller eruptions since that cataclysm. The most recent eruption was about 5,000 years ago and occurred within the caldera. No eruptions have occurred outside the caldera since 10,000 years ago.

This potentially active volcanic center is contained within Crater Lake National Park. The western half of the caldera is considered the most likely site of future activity. Effects from volcanic activity (e.g., ash fall, lava flows) are likely to remain within the caldera. If an eruption occurs outside the caldera, pyroclastic flows and lahars could affect valleys up to a few dozen miles from the erupting vent. The probability of another caldera-forming eruption is very low, as is the probability of eruptions occurring outside the caldera.

Other Volcanic Areas of Oregon

On the scale of geologic time, volcanic eruptions may occur in other parts of Oregon. However, on a human time scale, the probability of an eruption outside the Cascades is so low as to be negligible.

Although the high, snow-topped mountains of the Cascades are Oregon's most visible volcanoes, other potential eruptive centers exist. These include smaller peaks, such as the Belknap shield volcano in central Oregon, which had a lava flow about 1,400 years ago. Several smaller volcanoes, including Diamond Craters and Jordan Craters, in the High Lava Plains of southeast Oregon have experienced recent eruptions in the last 7,000 years. Generally non-explosive eruptions at these sites have built complexes of lava flow fields and cinder cones. Hazards associated with future eruptions in sparsely populated southeast Oregon would most likely include lava flows covering many square miles; ash and volcanic gases derived from these eruptions may be regionally significant.

Historic Volcanic Events

Table 2-V-3 lists historic volcanic events in Oregon in the last 20,000 years.

Table 2-V-3: Historic Volcanic Events in Oregon

Date	Location	Description
~18,000 to 7700 YBP	Mount Bachelor, central Cascades	Cinder cones, lava flows
~20,000 -13,000 YBP	Polallie Eruptive episode, Mount Hood	Lava dome, pyroclastic flows, lahars, tephra
~13,000 YBP	Lava Mountain, south-central Oregon	Lava Mountain field, lava flows
~13,000 YBP	Devils Garden, south-central Oregon	Devils Garden field, lava flows
~13,000 YBP	Four Craters, south-central Oregon	Four Craters field, lava flows
~7,780 to 15,000 YBP	Cinnamon Butte, southern Cascades	Basaltic scoria cone and lava flows
~7700 YBP	Crater Lake Caldera	Formation of Crater Lake caldera, pyroclastic flows, widespread ash fall.
~7700 YBP	Parkdale, north-central Oregon	Eruption of Parkdale lava flow.
<7000 YBP	Diamond Craters, eastern Oregon	Lava flows and tephra in Diamond Craters field.
< 7700 YBP; 5300 – 5600 YBP	Davis Lake, southern Cascades	Lava flows and scoria cones in Davis Lake field.
~10,000 - <7,700 YBP	Cones south of Mount Jefferson; Forked Butte and South Cinder Peak	Lava flows
~4000 – 3000 YBP	Sand Mountain, central Cascades	Lava flows and cinder cones in Sand Mountain field.
< 3200 YBP	Jordan Craters, eastern Oregon	Lava flows and tephra in Jordan Craters field.
~3000 - 1500 YBP	Belknap Volcano, central Cascades	Lava flows, tephra
~ 2000 YBP	South Sister Volcano	Rhyolite lava flow.
~1500 YBP	Timberline eruptive period, Mount Hood	Lava dome, pyroclastic flows, lahars, tephra
~1300 YBP	Newberry Volcano, central Oregon	Eruption of Big Obsidian flow.
~1300 YBP	Blue Lake Crater, central Cascades	Spatter cones and tephra
1760-1810	Crater Rock/Old Maid Flat on Mount Hood	Pyroclastic Flows in upper White River; lahars in Old Maid Flat; dome building at Crater Rock
1859/1865	Crater Rock on Mount Hood	Steam explosions/tephra falls
1907 (?)	Crater Rock on Mount Hood	Steam explosions
1980	Mount St. Helens (WA)	Debris avalanche, ash fall, flooding

		on Columbia River
1981-1986	Mount St. Helens (WA)	Lava dome growth, steam, lahars
1989-2001	Mount St. Helens (WA)	Hydrothermal explosions
2004-2008	Mount St. Helens (WA)	Lava dome growth, steam, ash

Sources: Source: Source: U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/
Wolfe and Pierson (1995); Sherrod and others (1997); Scott and others (1997); Bacon and others (1997); Walder and others (2000); Scott and others (2001).

Probability

Geologists can make general forecasts of long-term volcanic activity from careful characterization of past activity, but they cannot supply a timeline. Several U.S. Geological Survey open-file reports provide the odds of certain events taking place at particular volcanoes. However, the U.S. Geological Survey stresses that government officials and the public must realize the limitations in forecasting eruptions and be prepared for such uncertainty.

Short-range forecasts, on the order of months or weeks, are often possible. There are usually several signs of impending volcanic activity that may lead up to eruptions. The upward movement of magma into a volcano prior to an eruption generally causes a significant increase in small, localized earthquakes and an increase in emission of carbon dioxide and compounds of sulfur and chlorine that can be measured in volcanic springs and the atmosphere above the volcano. Changes in the depth or location of magma beneath a volcano often cause changes in elevation. These changes can be detected through ground instrumentation or remote sensing (for example, this was how the South Sister Bulge uplift was discovered).

The Cascades Volcanic Observatory (CVO) employs scientists from a range of disciplines to continually assess and monitor volcanic activity in the Cascade Ranges. If anomalous patterns are detected (for example, an increase in earthquakes), CVO staff coordinate the resources necessary to study the volcano

Wildfire

Wildfire is a common and widespread natural hazard in Oregon; the state has a long and extensive history of wildfire. A significant portion of Oregon's forestland is dominated by ecosystems dependent upon fire for their health and survival. In addition to being a common, chronic occurrence, wildfires frequently threaten communities. These communities are often referred to as the "wildland-urban interface" (WUI), the area where structures and other human development meet or intermingle with natural vegetative fuels.

Oregon has in excess of 41 million acres (more than 64,000 square miles) of forest and rangeland that is susceptible to damage from wildfire. In addition, significant agricultural areas of the Willamette Valley, north central, and northeastern Oregon grow crops such as wheat that are also susceptible to damage by wildfire.

Wildfires occur throughout the state and may start at any time of the year when weather and fuel conditions combine to allow ignition and spread.

Figure 2-WF-1: OEM Hazard Mitigation Regions

Source: OEM

The majority of wildfires take place between June and October, and primarily occur in the Oregon Office of Emergency Management's (OEM's) Hazard Mitigation Regions 4, 5, 6 and 7 (Figure 2-WF-1). However, even areas classified as low or moderate are susceptible to wildfires if the right combination of fuels, weather, and ignition conditions exist. Historically, Oregon's largest wildfires have burned in the Coast Range (Regions 1 & 2) where the average rainfall is high, but heavy fuel loads created low frequency, high intensity fire environment during the dry periods.

According to OEM, extreme winds are experienced in all of Oregon's eight regions. The most persistent high winds occur along the Oregon Coast and the Columbia River Gorge. The Columbia Gorge is the most significant east-west gap in the mountains between California and Canada. It serves as a funnel for east and west winds, where direction depends solely on the pressure gradient. Once set in motion, the winds can attain speeds of 80 mph. Wind is a primary factor in fire spread, and can significantly impede fire suppression efforts.

Historically, seventy percent of the wildfires suppressed on lands protected by the Oregon Department of Forestry (ODF) result from human activity. The remaining thirty percent result from lightning. Typically, large wildfires result primarily from lightning in remote, inaccessible areas.

According to a University of Oregon Study (The Economic Impacts of Large Wildfires) conducted between 2004 and 2008, the the financial and social costs of wildfires impact lives and property, as well as the negative short and long-term economic and environmental consequences they cause.

El Niño winters can be warmer and drier than average in Oregon. This often leads to an increased threat for large wildfires the following summer and autumn.

ODF's analysis of large fire potential is nearly complete: 12 of 14 identified Fire Danger Rating Areas have completed their analysis. These analyses will be reevaluated annually based on each year's weather and fire occurrence data. State firefighting agencies will continue to monitor correlations between seasonal weather conditions and wildfire occurrences and severity to refine planning tools for fire seasons and to aid in the pre-positioning of firefighting resources to reduce the vulnerability posed by large wildfires to natural resources and structures.

Figure 2-WF-2: ENSO and Wildfire Hazards

Life safety enhancement and cost savings may be realized by appropriate mitigation measures, starting with coordinated fire protection planning by local, state, tribes, federal agencies, the private sector, and community organizations. Additionally, and often overlooked, is the role that individual WUI property owners should play in this coordinated effort.

Wildfire suppression costs escalate dramatically when agencies must adjust suppression tactics because of the presence of structures. Additionally, the associated costs of structural protection also rise significantly, especially when there is a need to mobilize personnel and equipment from across the state. Costs may also be incurred by non-fire agencies in order to provide or support evacuations, traffic control, security, public information, and other needed support services during WUI fire incidents. These other agency costs vary widely and have not been well documented.

The number of people living in Oregon's WUI areas is increasing. Where people move into these areas, the number of wildfires has escalated dramatically. Many people arriving from urban settings expect a level of fire protection similar to what they had prior to moving. The reality is many WUI homes are located in portions of the state with limited capacity structural protection and sometimes no fire protection whatsoever. Many Oregon communities (incorporated and unincorporated) are within or abut areas subject to serious wildfire hazards. In Oregon, there are about 240,000 homes worth around $6.5 billion within the WUI. Such development has greatly complicated firefighting efforts and significantly increased the cost of fire suppression. While Oregon's Emergency Conflagration Act helps protect WUI communities who've depleted their local resources when threatened by an advancing wildfire, the escalating number of fires has led to the recognition that citizens in high fire risk communities need to provide mitigation and an appropriate level of local fire protection. Oregon's seller

disclosure requires a statement of whether or not property is classified as forestland-urban interface. Collaboration and coordination is ongoing among several agencies to promote educational efforts through programs like Firewise, the Oregon Forestland Urban Interface Fire Protection Act, and Fire Adapted Communities from the National Cohesive Wildfire Strategy.

While many homes already exist in WUI areas, increasing construction in vulnerable areas also increases risk for vulnerable populations. The initial role of land use, such as Oregon's Goal 4 and Goal 7 play critical roles and guidance to development in these areas[29]. Life safety enhancement and cost saving mitigation measures include Community Wildfire Protection Plans (CWPP), coordinated fire protection planning and coordination by local, state, tribal, federal agencies, the private sector, and community organizations. Many local communities use their CWPP as their wildland fire chapter in their Local Natural Hazards Mitigation Plan (LNHMP).

Overabundant, dense forest fuels, particularly on public lands, are a focus of mitigation discussion. The Healthy Forest Restoration Act is focused on reducing overly dense vegetation and trees to create fuel breaks, provide funding and guidance to reduce or eliminate hazardous fuels in National Forests, improve forest fire fighting, and research new methods to reduce the impact of invasive insects. Oregon's efforts in and near WUI areas are a massive task, but are resulting in improvements. Not only does it take many years, sustaining the work requires a substantial, ongoing financial commitment. Progress is often challenging because fuel mitigation methods are not universally accepted and are often controversial. However, recurring WUI fires continue to bring the issue into public focus as well as unite communities and stakeholders in a common set of values.

Analysis and Characterization

History of Wildfire

Wildfires have been a feature of the Oregon landscape for thousands of years. Prehistoric fires resulted from lightning and from the practices of Native Americans. The Blue Mountains in northeastern Oregon were named by early immigrants, because of the existence of a perpetual, blue colored wildfire smoke haze that lingered over the region. Between 1840 and 1900, wildland fires burned at least two million acres of forestland in western Oregon. It is believed settlers caused many of these fires. Following the establishment of the U.S. Forest Service and Oregon Department of Forestry, in 1905 and 1911, respectively, an aggressive and coordinated system of fire prevention and suppression emerged. However, it took several decades before significant gains were made.

Major wildfires in 1933, 1939, 1945 and 1951 burned across more than 355,000 acres in the northern Coast Range and became known collectively as the "Tillamook Burn."

[29] Oregon's Statewide Planning Goals http://oregon.gov/LCD/goals.shtml#Statewide_Planning_Goals

Better suppression and more effective fire prevention campaigns combined to reduce large wildfire occurrences following World War II. Suppression improvements included the establishment of organized and highly trained crews, which replaced the previous system of hiring firefighters on an as-needed basis. Additional improvement resulted from construction of an extensive system of forest roads, lookouts and guard stations, the use of aircraft for the detection of fires and the delivery of fire suppression retardant, the invention and modification of modern and efficient fire suppression equipment, and refinements in weather forecasting and fire reporting. Prevention benefited from war-era campaigns, which united prevention activities with patriotism, and birthed movements such as the Smokey Bear campaign and the Keep Oregon Green Association.

Project Wildfire is the result of a Deschutes County effort to create long-term wildfire mitigation strategies and provide for a disaster-resistant community. Project Wildfire is the community organization that facilitates, educates, disseminates and maximizes community efforts toward effective fire planning and mitigation.

Project Wildfire achieves its mission by:

- Developing long-term wildfire prevention and education strategies designed to reach an ever-changing community.
- Creating disaster r130resistant communities through collaboration with community members and a network of specialized partners.
- Reducing the severity and amount of damage caused by wildfire in wildland urban interface (WUI) areas through hazardous fuels reduction programs.
- Reducing the impact of fuels reduction on the environment by recycling the woody biomass resulting from hazardous fuels reduction projects.

Figure WF-3: Project Wildfire

Source: ODF, website: http://www.projectwildfire.org

A pattern of frequent, large WUI fires emerged during the 1970s as people began flocking to more rural settings. Suburban growth increased and continued through the 1980s. This introduced substantially more structures into what had previously been wildland areas that historically depended on periodic fires to sustain a healthy forest ecosystem.

By the early 1990s, frequent, destructive WUI fires had become a major concern of the State Forester, the State Fire Marshal, and the Oregon Legislature. By the mid-1990s, over 100 structures had been destroyed by wildfires. Thousands more had been threatened and suppression costs were increasing sharply. The same trends were occurring in surrounding states, but at an even greater pace.

Oregon Forestland-Urban Interface Fire Protection Act

In 1988, following the very difficult and expensive fire season of 1987, Oregon developed An Action Plan for Protecting Rural/Forest Lands from Wildfire. The work was funded by the federal (FEMA) Fire Suppression Assistance (FSA) Program. The action plan was updated in 1991 with an Awbrey Hall Fire Appendix, in response to a fire which burned 22 structures on the western fringe of Bend. The 1988 action plan and the 1991 update led to the Legislature's attachment of a Budget Note to ODF's 1995-1997 budget, which required an examination of the WUI situation and the development of "*…recommendations which may include…statutory changes on how to minimize the costs and risks of fire in the interface*." Spurred by the loss of additional homes during the 1996 Skeleton Fire, these recommendations became the basis for passage of the *Oregon Forestland-Urban Interface Fire Protection Act of 1997*.

The Act recognized that "…*forestland-urban interface property owners have a basic responsibility to share in a complete and coordinated protection system*..." In addition, during the 1990s, prevention and mitigation of WUI fires included enactment of the Wildfire Hazard Zone process and the inclusion of defensible space requirements in the land use planning process. Significant efforts were made to increase voluntary landowner participation, through aggressive awareness campaigns, such as FireFree, Project Wildfire, Project Impact, Firewise, and other locally driven programs.

Through the years, Oregon's wildfire suppression system continued to improve. Firefighters benefited from improved training, coordination, and equipment. Better interagency initial attack cooperation, the growth of private crew and fire engine wildfire suppression resources, formation of structural incident management teams, and regional coordination of fire suppression are additional examples of these continued improvements. Technology has improved as well with the addition of lightning tracking software and fire detection cameras to support or replace deteriorating lookout towers.

Nevertheless, the frequency of wildfires threatening WUI communities continues to underscore the need for urgent action. The summer of 2002 included eleven Emergency Conflagration Act incidents, with as many as five running concurrently. More than 50 structures burned and, at one point, the entire Illinois Valley in Josephine County seemed under siege from the Biscuit Fire, Oregon's largest wildfire on record. This wildfire threatened the homes of approximately 17,000 people, with over 4,000 homes under imminent evacuation alert. At almost 500,000 acres, it was the nation's largest wildfire of the year. The summer of 2013 once again brought to bear one of the worst fire season's in Oregon. For the first time since 1951, more than 100,000 acres burned on lands protected by the Oregon Department of Forestry. Five incident management teams were deployed in a period of three days following a dry lightning thunderstorm event in late July that sparked nearly 100 fires in southern Oregon from more than 300 lightning strikes. Another storm that passed over central and eastern Oregon in mid-August produced significant fires that threatened the communities of John Day and The Dalles. Since 1996, Oregon has had 52 declared Conflagrations under the Act. Oregon's mitigation efforts since 2002 have influenced a dramatic decrease in these types of fires, resulting in none to three per year through 2011. (see Appendix X for more information on Conflagration Fires from 1996 to 2011)

Types of Wildfire

Wildfires burn primarily in vegetative fuels located outside highly urbanized areas. Wildfires may be broadly categorized as agricultural, forest, range, or WUI fires.

Agricultural - Fires burning in areas where the primary fuels are flammable cultivated crops, such as wheat. This type of fire tends to spread very rapidly, but is relatively easy to suppress if adequate resources are available. Structures threatened are usually few in number and generally belong to the property owner. There may be significant losses in terms of agricultural products from such fires.

Forest - The classic wildfire; these fires burn in fuels composed primarily of timber and associated fuels, such as brush, grass, and logging residue. Due to variations of fuel, weather, and topography, this type of fire may be extremely difficult and costly to suppress. In wilderness areas these types of fires are often monitored and allowed to burn for the benefits brought by the ecology of fire, but also pose a risk to private lands when these fires escape these wilderness areas.

Range - Fires that burn across lands typically open and lacking timber stands or large accumulations of fuel. Such lands are used predominately for grazing or wildlife management purposes. Juniper, bitter-brush, and sage are the common fuels involved. These fires tend to spread rapidly and vary from being easy to difficult to suppress. They often occur in areas lacking both wildland and structural fire protection services.

Wildland-Urban Interface (WUI) - These fires occur in portions of the state where urbanization and natural vegetation fuels are mixed together. This mixture may allow fires to spread rapidly from natural fuels to structures and vice versa. Such fires are known for the large number of structures simultaneously exposed to fire. Especially in the early stage of WUI fires, structural fire suppression resources may be quickly overwhelmed, which may lead to the destruction of a large number of structures. Nationally, wildland interface fires have frequently resulted in catastrophic structure losses.

Increased risk of landslides and erosion are secondary hazards associated with wildfires that occur on steep slopes. Wildfires tend to denude the vegetative cover and burn the soil layer creating a less permeable surface prone to sheetwash erosion. This - in turn - increases sediment load and the likelihood of downslope failure and impact.

Wildfires can also impact water quality (e.g., drinking water intakes). During fire suppression activities some areas may need coordinated efforts to protect water resource values from negative impact.

Wildfire smoke may also have adverse effects on air quality health standards and visibility, as well as creating nuisance situations. Strategies to limit smoke from active wildfires are limited, but interagency programs exist to alert the public of potential smoke impact areas where hazardous driving or health conditions may occur.

Figure 2-WF-4: Secondary hazards

Common Sources of Wildfire

For statistical tabulation purposes, wildland fires are grouped into nine categories. These categories relate to the historically common wildfire ignition sources. Graphical information that displays trends for some of these sources may be found in Appendix X.

Lightning – There are tens of thousands of lightning strikes in Oregon each year. Of the ten categories, lightning is the leading ignition source of wildfires. In addition, lightning is the primary cause of fires which require utilization of Oregon's *Conflagration Act*.

Equipment Use – This source ranges from small weed eaters to large logging equipment; many different types of equipment may readily ignite a wildfire, especially if used improperly or illegally. Although fire agencies commonly limit or ban certain uses of fire prone equipment, the frequency of fires caused by equipment has been trending upward in recent years. This increase may be related to the expansion of the wildland interface, which results in more people and equipment being in close proximity to forest fuels.

Railroad – Wildfires caused by railroad activity are relatively infrequent. In the early twentieth century, this had been a major cause of fires, but has been decreasing for many years. Over the past ten-year

period, the number of fires has leveled out. In the past few decades, Oregon has responded to railroad caused fires with aggressive fire investigation and cost recovery efforts. Oregon Department of Forestry works with the railroad on hazard abatement along tracks and requires water cars and chase vehicles during high fire danger. The resulting quick return to normal fire incidence showed that railroad fires are preventable.

Recreation – The trend in fires caused by people recreating in and near Oregon's forests has been rising over the past ten years. This trend may reflect the state's growing population and as well as a greater interest in outdoor recreation opportunities.

Debris Burning – Historically, fires resulting from debris burning activities has been a leading cause of human caused wildfires. Aggressive prevention activities, coupled with an increasing use of local burning bans during the wildfire season, has begun to show positive results. Many debris burning fires occur outside the confines of fire season, which has led to increased awareness during the spring and fall months leading into and out of fire season.

Juvenile – The trend in the incidence of juveniles starting wildland fires is downward in recent years. This is attributed to concerted effort by local fire prevention cooperatives to deliver fire prevention messages directly to school classrooms and the Office of the State Fire Marshall's (OSFM's) aggressive youth intervention program. In 1999, according to the ODF, juveniles were reported to have started 60 wildland fires. Conversely, juveniles accounted for just 17 fires in 2013 and, on average, have only accounted for 25 fires per year over the last 10 years. Additionally, parents or guardians, under Oregon Law, are responsible for damages done by fires started by their children. ORS 30.765 covers the liability of parents; ORS 163.577 holds parents or guardians accountable for child supervision; ORS 477.745 makes parents liable for wildfire suppression costs of a fire by a minor child; and ORS 480.158 holds a parent liable for fireworks caused fires. Additionally, parents may be assessed civil penalties.

Arson – Oregon experienced a rapid rise in the frequency of arson caused fires in the early '90s. 1992 was the worst fire season for arson with 96 fires attributed to the category. In response, the state instituted aggressive arson prevention activities with solid working relationships with local law enforcement and the arson division of the Oregon State Police. The result has seen the 10-year average slightly decline with just 41 fires occurring annually since 2004.

Smoking – Fires caused by smoking and improperly discarded cigarettes is down. It is not known if this is due to fewer people smoking, recent modifications producing self extinguishing cigarettes, or better investigation of fire causes.

Miscellaneous – Wildfires resulting from a wide array of causes: automobile accidents, burning homes, pest control measures, shooting tracer ammunition and exploding targets, and electric fence use are a few of the causes in this category. The frequency of such fires has been rising in recent years.

Historic Wildfires in Oregon

Table 2-WF-1 lists historic wildfire in Oregon.

Table 2-WF-1: Historic Wildfires in Oregon

Date	Location	Description
1933 1939 1945 1951	Tillamook County	The Tillamook Burn included four fires occurring every six years over an 18 year period that burned 355,000 acres and killed one person.
1936	Bandon	This fire destroyed the town of Bandon, burned 400 structures and killed 11 people.
1951	Douglas County	The Hubbard Creek Fire burned 15,774 acres and destroyed 18 homes. The Russell Creek Fire burned 350 acres and killed one person.
1966	Douglas County	The Oxbow Fire burned 43,368 acres and killed one person.
1987	Douglas County	The Bland Mountain Fire burned 10,300 acres and 14 homes and killed two people.
1990	Deschutes County	The Awbrey Hall Fire burned 3,353 acres and destroyed 22 homes.
1992	Klamath County	The Lone Pine Fire burned 30,320 acres and destroyed 3 structures.
1994	Jackson County	Hull Mountain Fire burned 8,000 acres, destroyed 44 structures and killed one person.
1996	Deschutes County	Skeleton Fire burned 17,776 acres and destroyed 19 homes.
2002	Coos, Josephine, Jefferson, Deschutes Counties	Biscuit Fire burned 500,000 acres and destroyed 13 structures. Eyerly Fire burned 23,573 acres and destroyed 37 structures. Cache Mountain Fire burned 4,200 acres and destroyed 2 structures.
2010	Jackson County	Oak Knoll Fire in Ashland destroyed 11 homes in less than 45 minutes.
2011	Wasco County	High Cascade Complex burned on the east side of Mount Hood into Warm Springs, consuming 101,292 acres.
2012	Malheur, Harney	The Long Draw Fire consumed 557,648 acres.
2013	Douglas, Josephine, Wasco, Grant Counties	The most acres burned in the last 50 plus years during 2013. More than 100,000 acres burned and destroyed four homes. Three firefighter deaths were also attributed to the fires.

Source: Oregon Department of Forestry, 2013

Probability

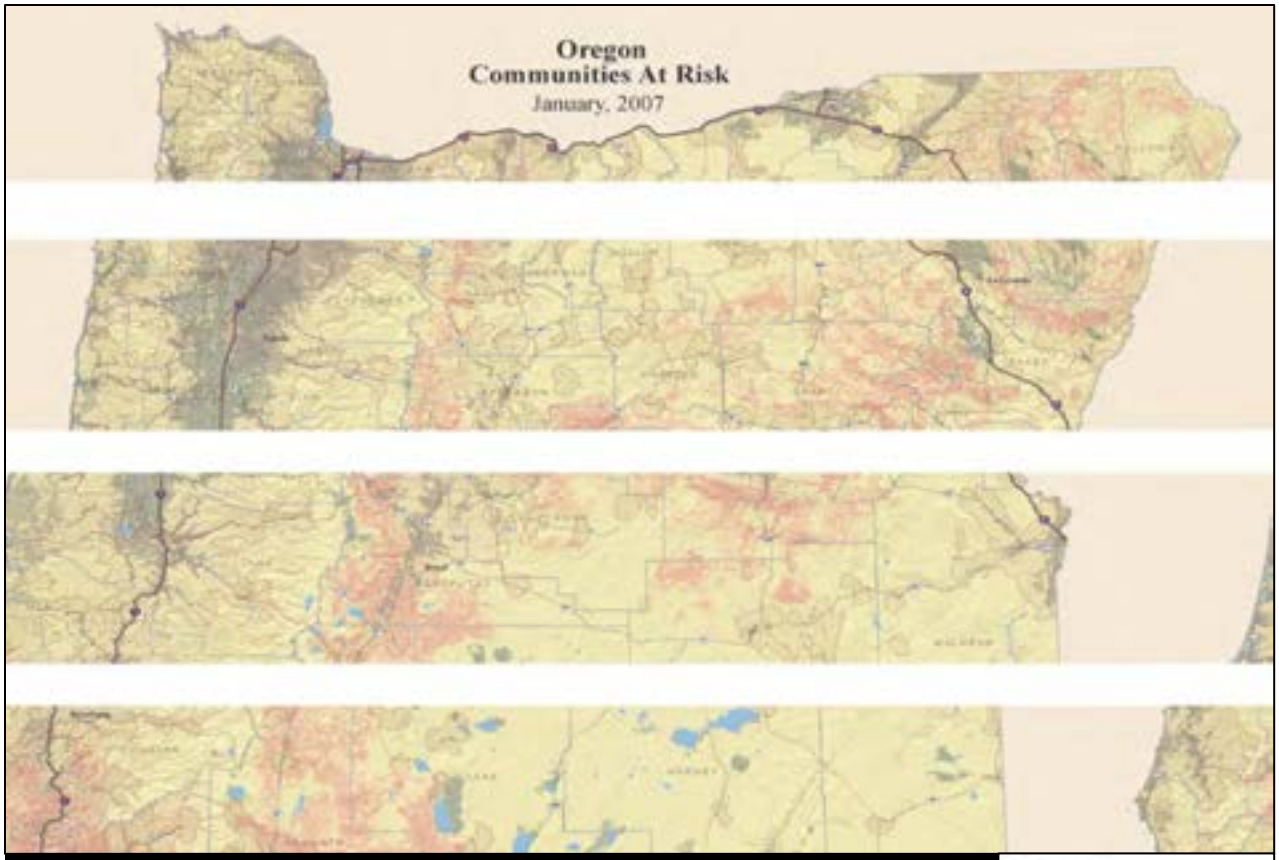

Figure 2-WF-5: Communities at Risk, Overall Rating Map

Source: Oregon Department of Forestry

Fire is a natural component of forest and rangeland ecosystems found in all portions of the state. Many of these ecosystems are dependent upon the existence of frequent fire, or on a viable substitute, for their continued existence. Even western Oregon forests, in the "wet" northwestern portion of the state, depend upon fire. It is a common myth that an unbroken carpet of old growth timber blanketed western Oregon prior to the beginning of European American settlement. In fact, fire and other natural forces had created a mosaic of different aged timber stands across the region. Factors now influencing the occurrence and severity of wildfires include poor forest health, invasive plant and tree species, high amounts of vegetation arising from long-term fire exclusion, changes in weather patterns, and the presence of humans and human development.

In Oregon, wildfires are inevitable. Figure 2-WF-5 shows areas of low, moderate, and high fire risk across the state based on data that while dated, is the best available at this time. The Westwide Regional Assessment for Wildfire contains new data that was being supplemented with local weather and fire history at the time of this update and was not available for the 2015 risk assessment.

Although usually thought of as being a summer occurrence, wildland fires can occur during any month of the year. The vast majority of wildfires burn during the June to October time period. Dry spells during the winter months, especially when combined with winds and dead fuels, may result in fires that burn with an intensity and a rate of spread that surprises many people.

During a typical year, in excess of 2,500 wildland fires are ignited on protected forestlands in Oregon. On lands protected by ODF, the ten-year trend in both the incidence of human caused fires and the acres they burn across is rising. When compared to Oregon's rapidly increasing population, the trend in the number of human caused wildland fires has also been trending upward.

Windstorm

This section covers most kinds of windstorm events in Oregon, including the wind aspects of Pacific storm events. The precipitation aspects of Pacific storm events are covered earlier in the Flood section of this Plan (page 75). Winds specifically associated with blizzards and ice storms are covered in the Winter Storms section of this Plan (pg. 144).

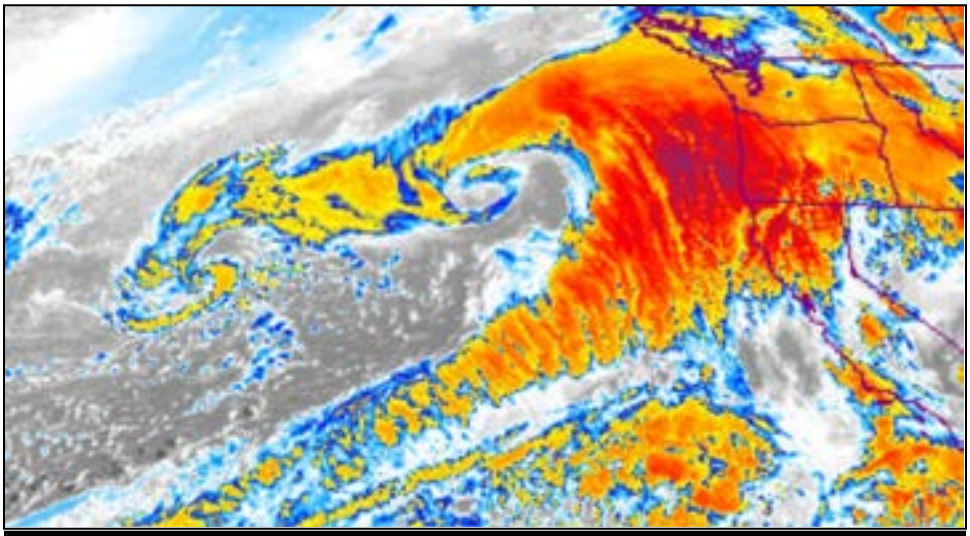

Figure 2-WI-1: Pacific Storms like this one not only bring heavy precipitation, but also often bring high winds to Western Oregon.

Source: NOAA

Analysis and Characterization

High winds can be among the most destructive weather events in Oregon; they are especially common in the exposed coastal regions and in the mountains of the Coast Range. Most official wind observations in Oregon are sparse, taken at low-elevation locations where both the surface friction and the blocking action of the mountain ranges substantially decrease the speed of surface winds. Furthermore, there are few long-term reliable records of wind available. Even the more exposed areas of the coast are lacking in any long-term set of wind records. From unofficial, but reliable observations, it is reasonable to assume that gusts well above 100 mph occur several times each year across the higher ridges of the Coast and Cascades Ranges. At the most exposed Coast Range ridges, it is estimated, that wind gusts of up to 150 mph and sustained speeds of 110 mph will occur every five to ten years.

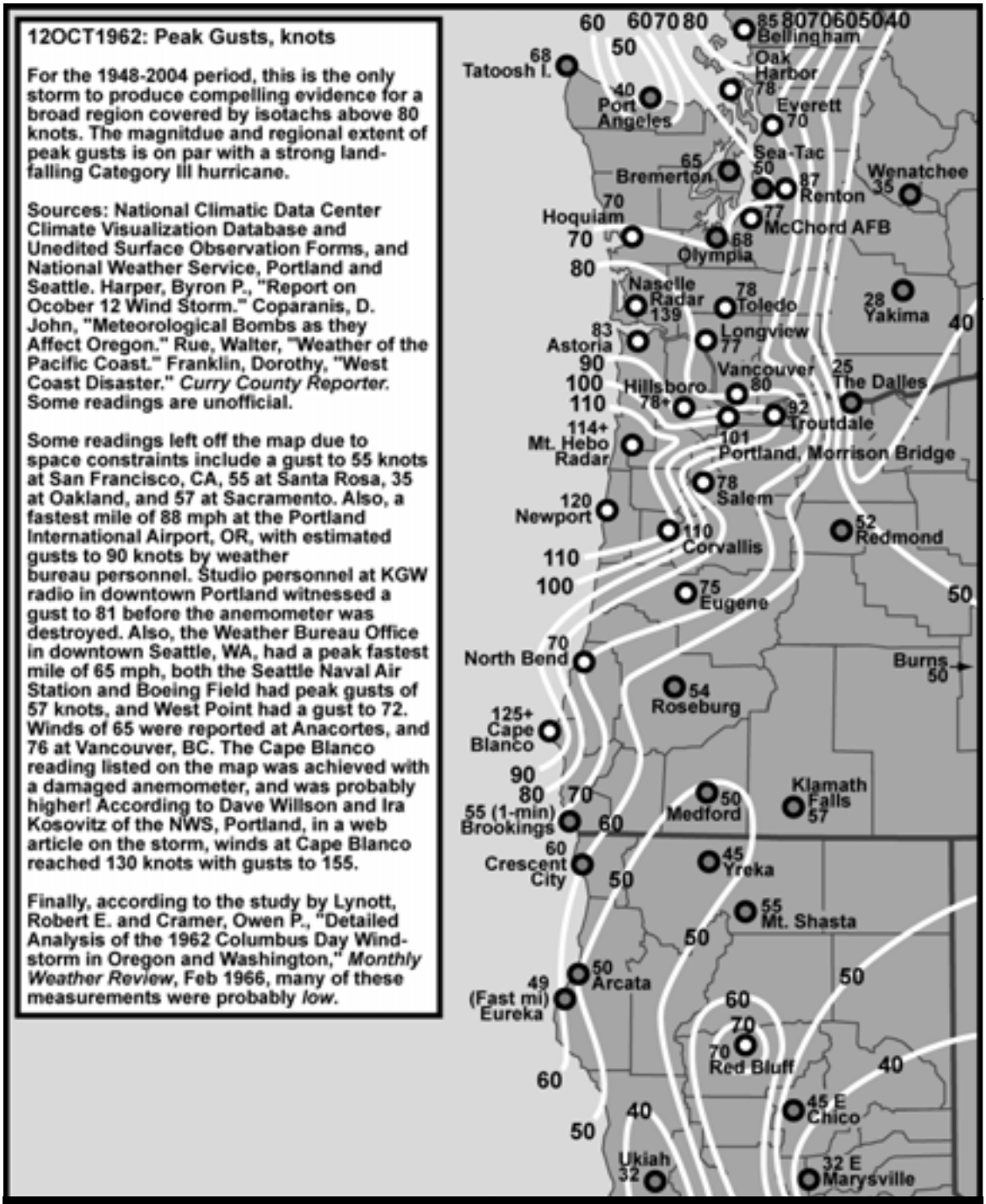

Figure 2-WI-2: Peak Gusts for windstorm on October 12, 1962

Source: Wolf Read, Climatologist, Oregon Climate Center at Oregon State University.

Figure 2-WI-3: Unstable trees left after a logging operation near electric lines pose a serious threat of personal injury, forest fire, and outages should high winds develop. Forest owners and workers need to coordinate their "leave trees" with electric utilities to prevent dangerous conditions as depicted here.

Photo source: Randy Miller, PacifiCorp.

Pacific storms can produce high winds, and often are accompanied by significant precipitation and low barometric pressure. These storms usually produce the highest winds in Western Oregon, especially in the coastal zone. These storms are most common from October through March. The impacts of these storms on the state are influenced by storm location, intensity, and local terrain.

The historian Lancaster Pollard documented exceptional storms that occurred in 1880, 1888, 1920, 1931, and 1962. On January 29, 1920 a hurricane off the mouth of the Columbia River had winds estimated at 160 miles per hour.[30]

One easterly windstorm that affected much of Oregon, particularly northern Oregon, was the northeasterly gale of April 21-22, 1931. This storm proved to be very destructive. Dust was reported by ships 600 miles out to sea. "While officially recorded wind speeds were not extreme, sustained wind speeds observed were 36 mph at Medford, 32 mph at Portland, 28 mph at Baker, and 27 mph at Roseburg. Unofficial wind measuring equipment reported winds of up to 78 mph. Damage was heavy to standing timber and fruit orchards." [31]

[30] *Pacific Northwest Quarterly,* "The Pacific Northwest Dust Storm of 1931," Paul C. Pitzer, April 1988, p. 50

[31] http://www.wrh.noaa.gov/Portland/windstorm.html - For more information on this 1931 storm, see Appendix XX.

Effects

The damaging effects of windstorms may extend for distances of 100 to 300 miles from the center of storm activity. Isolated wind phenomena in the mountainous regions have more localized effects. Near-surface winds and associated pressure effects exert loads on walls, doors, windows, and roofs, sometimes causing structural components to fail.

> Positive wind pressure is a direct and frontal assault on a structure, pushing walls, doors, and windows inward. Negative pressure also affects the sides and roof: passing currents create lift and suction forces that act to pull building components and surfaces outward. The effects of high velocity winds are magnified in the upper levels of multi-story structures. As positive and negative forces impact and remove the building protective envelope (doors, windows, and walls), internal pressures rise and result in roof or leeward building component failures and considerable structural damage.

Debris carried along by extreme winds can directly contribute to loss of life and indirectly to the failure of protective building envelope components. Upon impact, wind-driven debris can rupture a building, allowing more significant positive and internal pressures. When severe windstorms strike a community, downed trees, powerlines, and damaged property are major hindrances to response and recovery.

The most destructive winds are those which blow from the south, parallel to the major mountain ranges. The Columbus Day Storm of 1962 was a classic example of a south windstorm. The storm developed from Tyhoon Freda remnants in the Gulf of Alaska, deepened off the coast of California and moved from the southwest, then turned, coming into Oregon directly from the south. This was the most damaging windstorm in Oregon of the last century. Winds in the Willamette Valley topped 100 mph, while in the Coast Range they exceeded 140 mph. The Columbus Day Storm was the equivalent of a Category IV hurricane in terms of central pressure and wind speeds.

In terms of damage, "throughout the Willamette Valley, undamaged homes were the exception, not the rule. In 1962 dollars, the Columbus Day Storm caused an estimated $230-280 million in damage to property in California, Oregon, Washington and British Columbia combined, with $170-200 million happening in Oregon alone. This damage figure is comparable to eastern hurricanes that made landfall in the 1957-1961 time period...The (Columbus Day Storm) was declared the worst natural disaster of 1962 by the Metropolitan Life Insurance Company. In terms of timber loss, about 11.2 billion board feet was felled... in Oregon and Washington combined."[32] "The storm claimed 46 lives, injured hundreds more, and knocked power out for several million people.[33]

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[32] http://www.climate.washington.edu/stormking/

[33] http://www.wrh.noaa.gov/pqr/info/pdf/pacwindstorms.pdf

Other Issues

In the Hazard Mitigation Survey Team (HMST) Report developed in response to the February 7, 2002 windstorm the recommended observation issued that "differences in definitions of easements and allowable practices within them ('easement language') for private versus public, and urban forests vs. rural forests should be resolved." The State IHMT agencies agree that this issue continues to exist, but neither the resources nor the political will exist at this time to attempt to fix this complicated issue with many vested stakeholders.

Two other issues identified in that report also continue to exist, but cannot be solved at this time:

1. "Land use actions being proposed by agencies with non-utility interests, which would affect land for which utilities have an interest, should be coordinated and should address vegetation management as it affects utility system operations", and

2. "Agencies and organizations should be identified to work with federal and state landowners to streamline processes by which electric utilities conduct hazard mitigation work on those lands..." Currently, ODOT issues permits for right-of-way work and ODF issues permits for the use of power equipment in forested areas.

Other areas of ongoing concern from this HMST Report are:

- Under Coordination - Utility providers should receive notification, from property owners, of planned tree-harvesting operations near utility lines.
- Under Vegetation Management - Diseased, damaged, and hazard trees near powerlines that could fall or hit utility lines should be removed. Some "leave trees" remaining after new building developments and tree harvesting operations pose a threat to utility line safety and reliability. See Appendix W-3 to this chapter, *How to Recognize and Prevent Tree Hazards*, for progress that has been made towards vegetation management issues.
- Under Engineering, Construction, and Compliance - *"During initial planning and design of utility lines, identify types of geographic areas already known to pose hazards during windstorms. Inventory and analyze areas of repetitive failures to determine alternate designs and construction methods that will mitigate future damages... Consider selective undergrounding of lines where repetitive tree damage occurs, keeping in mind excavations can undermine tree root zones and create new hazards."*

Historic Windstorm Events in Oregon

Table 2-WI-1 summarizes selected significant windstorms in Oregon.

Table 2-WI-1: Historic Windstorms in Oregon

Month - Year	Location	Comments
October 1962	Western Oregon and locations east of Cascades, OR	Columbus Day Storm. Oregon's most famous and most destructive windstorm. Barometric pressure low of 960 mb (*).
March 1963	Western Oregon	Second strongest windstorm in the Willamette Valley since 1950.
October 1967	Most of Western and Central Oregon	An intense 977 mb low produced a sudden, destructive blow (*)
November 1981	Oregon Coast and N. Willamette Valley, OR	Back-to-back storms on the 13th and 15th of November.
January 1993	North Coast Range, OR	Inauguration Day Storm. Major disaster declaration in Washington State.
December 1995	Northwest Oregon	FEMA-1107-DR-OR (*). Strongest windstorm since Nov. 1981. Barometric pressure of 966.1 mb (Astoria), and *Oregon record low 953 mb (*off the coast).
February 2002	South and Central Coast, Southern Willamette Valley, OR	FEMA-1405-DR-OR. Surprise windstorm.
February 2007	Northwest & Central Coast and North Central Oregon	FEMA-1683-DR-OR. Severe winter storm with a wind component.
December 2007	South, Central, North Coast and Willamette Valley, OR	FEMA-1733-DR-OR. Severe winter storm, including flood and landslide events.

(*) For the sake of comparison, surface barometric pressures associated with Atlantic hurricanes are often in the range of 910 to 960 mb. The all-time record low sea level barometric pressure recorded was associated with Typhoon Tip in the Northwest Pacific Ocean on October 12, 1979 at 870 mb.

Sources: Oregon Climate Service; Pitzer (1988)[1]; and WRH[2].

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[1] *Pacific Northwest Quarterly,* "The Pacific Northwest Dust Storm of 1931," Paul C. Pitzer, April 1988, p. 50

[2] http://www.wrh.noaa.gov/Portland/windstorm.html - For more information on this 1931 storm, see Appendix XX.

Probability

Extreme weather events are experienced in all regions of Oregon. Areas experiencing the highest wind speeds are the Central and North Coast under the influence of winter low-pressure systems in the Gulf of Alaska and North Pacific Ocean; and the Columbia River Gorge, when cold air masses funnel down through the canyon in an easterly direction. For example, at Crown Point, located about 20 miles east of Portland, easterly winds with a 24-hour average of more than 53 mph and gusts in excess of 120 mph were recorded.

Table 2-WI-2: Probability of Severe Wind Events by OEM Hazard Mitigation Region (one-minute average, 30 feet above the ground

Location	25-Year Event (4% annual probability)	50-Year Event (2% annual probability)	100-Year Event (1% annual probability)
Region 1 - Oregon Coast	75 mph	80 mph	90 mph
Region 2 - Northern Willamette Valley	65 mph	72 mph	80 mph
Region 3 - Mid/Southern Willamette Valley	60 mph	68 mph	75 mph
Region 4 - Southwest Oregon	60 mph	70 mph	80 mph
Region 5 - Mid-Columbia	75 mph	80 mph	90 mph
Region 6 - Central Oregon	60 mph	65 mph	75 mph
Region 7 - Northeast Oregon	70 mph	80 mph	90 mph
Region 8 - Southeast Oregon	55 mph	65 mph	75 mph

Source: PUC

Additional wind hazards occur on a very localized level, due to several down-slope windstorms along mountainous terrain. These regional phenomena known as foehn-type winds, result in winds exceeding 100 mph, but they are of short duration and affect relatively small geographic areas. A majority of the destructive surface winds in Oregon are from the southwest. Under certain conditions, very strong east winds may occur, but these are usually limited to small areas in the vicinity of the Columbia River Gorge or in mountain passes.

The much more frequent and widespread strong winds from the southwest are associated with storms moving onto the coast from the Pacific Ocean. If the winds are from the west, they are often stronger on the coast than in the interior valleys due to the north-south orientations of the Coast Range and Cascades. These mountain ranges obstruct and slow down the westerly surface winds.

High winds occur frequently in Oregon, and they are especially common in coastal regions and in the mountains of the Coast Range between October and March. From unofficial but reliable observations, it is reasonable to assume that gusts well above 100 mph occur several times each year across the higher ridges of the Coast and Cascades Ranges. At the most exposed Coast Range ridges, it is estimated that wind gusts of up to 150 mph and sustained speeds of 110 mph will occur every five to ten years. The Willamette Valley may face 40 to 60 mile per hour winds from a 100 mph+ storm on the coast. Also, the Columbia River Gorge funnels very strong winds, often from east to west.

Winter Storm

Winter storms are among nature's most impressive spectacles. Their combination of heavy snow, ice accumulation, and extreme cold can totally disrupt modern civilization, closing down roads and airports, creating power outages, and downing telephone lines. Winter storms remind us how vulnerable we are to nature's awesome powers.

For the most part, the wind aspects of winter storms are covered in the Windstorms section of this Plan (pg. 137). Heavy precipitation aspects associated with winter storms in some parts of the state, which sometimes lead to flooding, are covered in the Flood section of this Plan (pg. 75). This winter storms section instead generally addresses snow and ice hazards, and extreme cold.

Analysis and Characterization

Snowstorms need two ingredients: cold air and moisture. Rarely do the two ingredients occur at the same time over western Oregon, except in the higher elevations of the Coast Range and especially in the Cascades. But snowstorms do occur over eastern Oregon regularly during December through February. Cold arctic air sinks south along the Columbia River basin, filling the valleys with cold air. Storms moving across the area drop precipitation, and if conditions are right, snow will occur.

Figure 2-WS -1: Troutdale area – December 1996

Photo Source: National Weather Service

However, it is not that easy a recipe for western Oregon. Cold air rarely moves west of the Cascades Range. The Cascades act as a natural barrier, damming cold air east of the range. The major spigot is the Columbia River Gorge, which funnels cold air into the Portland area. Cold air then begins deepening in the Columbia River Gorge, eventually becoming deep enough to sink southward into the Willamette Valley. If the cold air east of the Cascades is deep, it will spill through the gaps of the Cascades and flow into western valleys via the many river drainage areas along the western slope. Cold air in western Oregon is now in place. Now, the mechanism is to get a storm to move near or over the cold air, which will use the cold air and produce freezing rain, sleet and/or snow. Sometimes, copious amounts of snow are produced. Nearly every year, minor snowfalls of up to six inches occur in the western interior valleys. However, it is a rare occurrence for snowfalls of over a foot in accumulation.[34]

[34] National Weather Service – Portland, Oregon Forecast Office, *Historical Storms and Data—Oregon's Notable Historical Snowstorms,* Nov. 2013

Snow is relatively rare along the coast in Oregon. There is, however, a noticeable relationship between latitude and snowfall. Appendix WS-1 shows average annual snowfall at various Oregon stations. Notice, in particular, Crater Lake, one of the snowiest measurement stations in the United States, which once reported nearly 900 inches of snow in one season.[35]

Figure 2-WS-2: Shielded snow gauge used in the Pacific Northwest to register snowfall, 1917.

Source: National Weather Service

Ice storms and freezing rain can cause severe problems when they occur. The most common freezing rain events occur in the proximity of the Columbia Gorge. The Gorge is the most significant east-west air passage through the Cascades. In winter, cold air from the interior commonly flows westward through the Gorge, bringing very cold air to the Portland area. Rain arriving from the west falls on frozen streets, cars, and other sub-freezing surfaces, creating severe problems. As one moves away from the Gorge, temperatures moderate as the marine influence becomes greater and cold interior air mixes with milder west-side air. Thus freezing rain is often confined to areas in the immediate vicinity of the Gorge: Corbett, Troutdale, perhaps as far west as Portland Airport. Downtown Portland and the western and southern suburbs often escape with no ice accumulation.[36]

Freezing rain (also known as an ice storm) is rain that falls onto a surface with a temperature below freezing. The cold surface causes the rain to freeze so the surfaces, such as trees, utilities, and roads, become glazed with ice. Even small accumulations of ice can cause a significant hazard to property, pedestrians, and motorists.

Sleet is rain that freezes into ice pellets before reaching the ground. Sleet usually bounces when hitting a surface and does not stick to objects; however, it can accumulate like snow and cause roads and walkways to become hazardous.
Black ice can fool drivers into thinking water is on the road. What they may not realize is that condensation, such as dew, freezes when temperatures reach 32 degrees Fahrenheit (F) or below, forming a thin layer of ice. This shiny ice surface is one of the most dangerous road conditions. Black ice is likely to form under bridges and overpasses, in shady spots and at intersections.

Meteorologists define *heavy snow* as six inches or more falling in less than twelve hours, or snowfall of eight inches or more in twenty-four hours. A *blizzard* is a severe winter weather condition characterized by low temperatures and strong winds blowing a great deal of snow. The National Weather Service

[35] Oregon Climate Service, The Climate of Oregon, From Rain Forest to Desert, Corvallis, Oregon 1999

[36] From *The Oregon Weather Book, A State of Extremes*, George Taylor and Raymond Hatton, OSU Press, 1999

defines a blizzard as having wind speeds of 35 mph or more, with a visibility of less than a quarter mile. Sometimes a condition known as a *whiteout* can occur during a blizzard. This is when the visibility drops to zero because of the amount of blowing snow.

Wind blowing across your body makes you feel colder. The *wind chill* factor is a measure of how cold the combination of temperature and wind makes you feel. Wind chill of 50 degrees or lower can be very dangerous: exposed skin can develop frostbite in less than a minute, and a person or animal could freeze to death after just 30 minutes of exposure.

A snow avalanche is a mass of snow falling down a mountain or incline. Three variables interact to determine whether an avalanche is possible:

1. Terrain: the slope must be steep enough to avalanche.
2. Snowpack: the snow must be unstable enough to avalanche.
3. Weather: changing weather can quickly increase instability.

According to the Northwest Weather and Avalanche Center, avalanches don't happen by accident and most human involvement is a matter of choice, not chance. Most avalanche accidents are caused by slab avalanches that are triggered by the victim or a member of the victim's party. However, any avalanche may cause injury or death and even small slides may be dangerous.

On average, about 30 people in the United States are killed in avalanches each year. For the 21 years between 1985 and 2006. Oregon ranks 10th among the states for avalanche fatalities with five fatalities. This is based on statistics from the Colorado Avalanche Information Center. Avalanche victims are almost exclusively backcountry recreationists—snowmobilers, climbers, snowboarders, snowshoers, skiers, and hikers. Nationally snowmobilers lead the list with twice as many fatalities as any other activity.

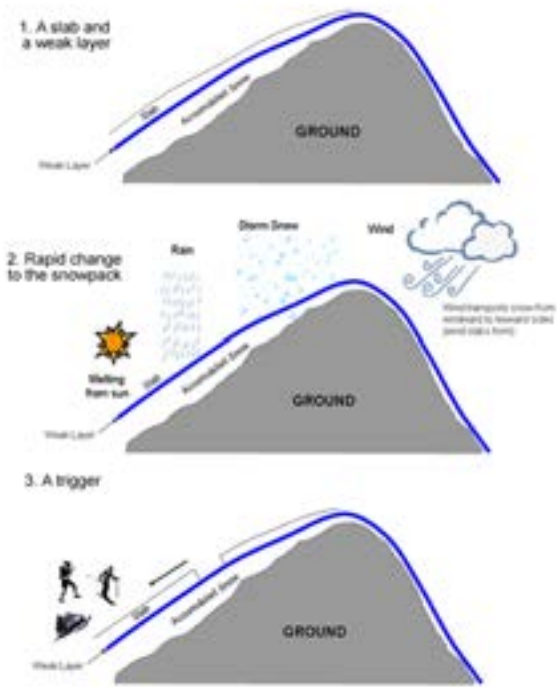


Figure 2-WS-3: Ingredients for a Slab Avalanche

Source: Northwest Weather and Avalanche Center

According to Portland Mountain Rescue, most avalanche victims triggered the very avalanche that caught them. The group advises people to be aware of the constantly changing conditions in the backcountry and take a certified avalanche class to increase their avalanche awareness.

Ski areas are different from the backcountry. It is very rare for someone to get caught in an avalanche within a ski area. Professional snow safety crews rely on explosives and ski compaction to stabilize ski area snowpack.

Historical Winter Storm Events in Oregon

Table 2-WS-1 lists historic winter storms in Oregon.

Table 2-WS-1: Historical Winter Storms in Oregon

Date	Location	Description
December 16 to 18, 1884	Linn, Marion, Washington, Multnomah, Hood River and Wasco counties	Heavy snow in the Columbia River Basin from Portland to The Dalles and along the Cascades foothills in the Willamette Valley. One-Day snow totals: Albany 16.0 inches, The Dalles 29.5 inches, Portland 12.4 inches
December 20 to 23, 1892	Linn, Marion, Washington, Multnomah, Umatilla counties	Substantial snow across most of northern Oregon. Greatest snowfall in the northwest part of the state, totals from (15 to 30 inches) with Albany 15.0 inches, Corvallis 14.0 inches, Portland 27.5 inches, Forest Grove 28.0 inches, Pendleton 8.0 inches
January 5 to 10, 1909	Josephine, Jackson, Douglas Lane, Linn, Marion, Clackamas, Hood River, Waco counties	Heavy snowfall in mountainous areas. 34.5 inches at Siskiyou Summit. Many locations, particularly in western Oregon, received more snow in this six-day period than they normally would receive in an entire year. Snow totals: Ashland 9.1 inches, Eugene 15.1 inches, Forest Grove 29.0 inches, Lakeview 17.0 inches, Portland 19.3 inches, The Dalles 14.5 inches
January 11 to 15, 1916	Josephine, Jackson, Douglas Lane, Linn, Marion, Clackamas, Hood River, Waco counties	5-8 inches of snow in western Oregon, except for the southwestern interior and the coastal areas, McMinnville. had the most snow in one day, with 11 inches falling on January 12. Another 24 inches at Siskiyou Summit, Higher elevations in the Cascades received very heavy snowfall
January 30 to February 3, 1916	Hood River, Clackamas, Marion, Wasco, Jefferson, Multnomah counties	Snow and Ice storm along the northern Oregon border. Heaviest snowfall in the Hood River Valley with 29.5 inches in one day at Parkdale, and81.5 inches total. Heavy snow especially in the higher Cascades with Government Camp 41.0 inches in a day and storm total of 87.5 inches. The ice inflicted severe damage to electric light, telephone and telegraph companies, fruits and ornamental trees. Many locations, earlier snow had not melted, resulting in substantial snow depths.
December 9 to 11, 1919	Statewide storm	One of three heaviest snowfall-producing storms to hit Oregon on record. Lowest statewide average temperature since record keeping began in 1890. The Columbia River froze over, closing the river to navigation from the confluence with the Willamette River upstream. Nearly every part of the state affected. Snow totals (inches): Albany 25.5, Bend 49.0, Cascade Locks 21.5,

		Eugene 8.5, Heppner 16.0, Parkdale 63.0, Pendleton 15.0, Siskiyou Summit 50.0
February 10, 1933	Statewide storm	Cold outbreak across state. The city of Seneca, in northeast Oregon, recorded the state's all-time record low temperature of -54 degrees F. The next day high was nearly 100 degrees warmer at 45 degrees).
January 31 to February 4, 1937	Statewide storm	. Heavy snowfalls in the western slopes of the Cascades and the Willamette Valley. Deep snowdrifts blocked major highways and most minor roads in northern Oregon and passes of the Cascade Mountains for several days.
Jan 5 - 7, 1942	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, Polk counties	Considerable sleet, followed by freezing rain in some areas. Freezing rain, resulting in heavy accumulations of ice in upper and middle Willamette Valley. Roads and streets dangerous for travel, orchard and shade trees damaged, and telephone, telegraph, and power wires and poles broken down.
Mid Jan – Feb, 1950	Statewide storm	Extremely low temperatures injured a large number of orchard and ornamental trees and shrubs, and harmed many power and telephone lines and outdoor structures. Severe blizzard conditions and a heavy sleet and ice storm together caused several hundred thousand dollars damage and virtually halted traffic for two to three days. Columbia River Highway closed between Troutdale and The Dalles leaving large numbers of motorists stranded, removed to safety only by railway. Damage to orchard crops, timber, and power services, costing thousands in damages.
January 9 to 20, 1950	Columbia, Washington, Multnomah, Hood River, Wasco, Clackamas, Yamhill, Marion, Polk, Linn, Benton, Lane, counties	Frequent snowstorms throughout January. Snow heavier during this January than ever before on record. Snow plus high winds created widespread blowing and drifting of snow. Deep snowdrifts closed all highways west of the Cascades and through the Columbia River Gorge. Sleet 4-5 inches in northwestern Oregon. Sleet turned to freezing rain, creating havoc on highways, trees, and power lines. Hundreds of motorists stranded in the Columbia River Gorge, only rescued by train. Hundreds of thousands of dollars of damage occurred. Winds reached 60 – 70 mph in gusts along the coast and excess of 40 mph in Portland and Grants Pass. Outdoor work and school halted due to impeded traffic, down power lines, and community isolation. In Portland 32.9 inches of snow fell (5.8 inches was the January average).

Dec 5 – 7, 1950	Washington, Multnomah, Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla counties	Severe ice storm with light freezing rain over the Columbia Basin east of the Cascades. Heavy ice accretions on trees, highways, power and telephone lines causing accidents due to broken limbs, slippery pavements, and down power lines. Heavy snowfall across Oregon. Crater Lake reported 93 inches of snow for December.
Jan. 18, 1956	Washington, Multnomah, Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla counties	Freezing rain mixed with snow. Ice coated trees, highways and utility lines. Traffic accidents due to slick surfaces. Trees heavy with ice broke, sometimes on top of houses.
Jan 11 – 12, 1960	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, Polk counties	Light to moderate snows and freezing rain produced dangerous highway conditions. Automobile accidents, but no known fatalities. Accidents blocked arterial highways creating serious traffic jams.
Jan 30 – 31, 1963	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, Polk, Hood River, Waco, Jefferson, Deschutes counties	Substantial snowfall amplified by moderate to severe icing created hazardous conditions on highways. Power lines downed due to ice or felled trees. Injuries,1 reported death, and statewide school closures due to the icy streets and highways.
January 25 to 31, 1969	Douglas, Coos, Josephine, Jackson, Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, Polk counties	Snowfall records throughout Lane, Douglas, and Coos counties were surpassed by incredible numbers. 2-3 feet on the valley floors. Heavier amounts at higher elevations. At Eugene, a snow depth of 34 inches. Total January snowfall was 47 inches, nearly seven times the normal monthly snowfall. Roseburg reported 27 inches and monthly snowfall of 35.2 inches. Along the coast, where the average snowfall is generally less than two inches, January snowfall totals ranged2-3 feet, with snow depths of 10-20 inches reported. Hundreds of farm buildings and several large industrial buildings collapsed under the weight of the heavy wet snow. Heavy losses in livestock. Entire communities completely isolated for nearly a week. Traffic on major highways west of the Cascades and central Oregon halted. Total losses estimated $3 to $4 million.
Jan 17 – 19, 1970	Washington, Multnomah, Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla counties	Columbia River Basin area for a week. Ice accumulation up to 1.5 inches on tree branches. Property damages due to destroyed orchards and utilities.

Nov 22-23, 1970	Columbia, Washington, Multnomah, Hood River, Wasco, Clackamas, Yamhill, Marion, Polk, Linn, Benton, Lane, counties	Freezing rain across Western Oregon, especially in Corvallis, Albany, Salem, Independence, and Dallas. Ice accumulations up to .5 inches broke thousands of tree limbs and telephone lines. Hazardous traffic conditions, power and phone outages, and felled trees.
Feb 4 – 6, 1972	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, Polk counties	Several days of sub-freezing temperatures across Oregon followed by warm moist air across northwestern Oregon. Glazed roads were hazardous. 140 persons in Portland treated for sprains, fractures or head injuries. Some ambulance services doing twice their normal business.
Jan 11 – 12, 1973	Columbia, Clackamas, Multnomah, Washington, Marion, Linn, Yamhill, Polk counties	Rains beginning in the Willamette Valley glazed streets and highways in the Portland area and into the Gorge. Auto, bus and truck accidents and persons injured in falls. Hospitals reported "full house" conditions. Glaze of .25 - .75 inches in the Portland area.
Jan. 1978	Columbia Gorge, Willamette Valley, Portland, OR and Vancouver, WA	Over an inch of rain froze, covering everything with ice. Power outages (some for more than 10 days). Areas east of Portland hit hardest.
Jan 9 – 10, 1979	Portland, Multnomah County, OR	Severe ice storm in Portland area as a Pacific storm moved across the state. Temperatures ranged from low teens to 33 degrees F. Half inch of rain turned to ice.
Jan. 5, 1986	Multnomah, Hood River, Waco counties	Roads covered with ice and caused power outages to several thousand houses.
February 1 to 8, 1989	Statewide storm	Heavy snow across state. Up to 6-12 inches of snow at the coast, 9 inches in Salem, more than a foot over the state. Numerous record temperatures set. Wind chill temperatures 30 - 60 degrees below zero F. Power failures throughout state, with home and business damage resulting from frozen plumbing. Several moored boats sank on the Columbia River because of ice accumulation. Five weather-related deaths (three auto accidents caused by ice and snow, and two women froze to death). Damage estimates exceeded one million dollars.
February 14 to 16, 1990	Columbia, Clackamas, Multnomah, Washington, Hood River, Wasco, Marion, Linn, Yamhill, Polk counties	24 to 35 inches of snow in Cascade Locks and Hood River. Up to 28 inches in the North Coast Range, 16 inches at Timberline Lodge. The Willamette Valley had 2-4 inches with up to 1 foot in higher hills around Portland. 10-15 inches of snow in the North Coast Range, 20-35 inches in the North Cascades,1-2 feet in the South Cascades. Snow in South-central areas included 9 inches at Chemult, 6-8 in Klamath Falls and Lakeview. 6 inches at Tipton Summit in the northeast mountains and Juntura in the southeast.

Jan. 6-7, 1991	All of Eastern Oregon	Constant precipitation all over Oregon. Freezing rain in Willamette Valley made transportation difficult. Two auto fatalities. 1-6 inches of new snow in high ground of eastern Oregon. 12 inches of snow in the Columbia Gorge.
Jan. 16-18, 1996	Columbia Gorge, Willamette Valley, Portland, OR Columbia, Clackamas, Multnomah, Washington, Hood River, Wasco, Marion, Linn, Yamhill, Polk counties	Freezing rain with heavy accumulations of glaze ice in the Gorge, Northern Cascades and extreme eastern Portland metropolitan area. Numerous minor traffic accidents due to power outages . Freezing rain in the Willamette Valley as far south as Eugene.
Feb. 2-4, 1996	Columbia Gorge, Willamette Valley, Portland, OR Columbia, Clackamas, Multnomah, Washington, Hood River, Wasco, Marion, Linn, Yamhill, Polk counties	Ice storm caused disruption of traffic and power outages in the Willamette Valley and Coast Range valleys. Freezing rain in the Willamette Valley. Traffic accidents, including a 100 car pileup near Salem. One traffic fatality near Lincoln City.
Dec. 26-30, 1996	Columbia Gorge, Willamette Valley, Portland, OR Columbia, Clackamas, Multnomah, Washington, Hood River, Wasco, Marion, Linn, Yamhill, Polk counties	Ice storm paralyzed the Portland metropolitan area and the Columbia Gorge. Ice accumulations of 4 - 5 inches in the Columbia Gorge. Interstate 84 through the Gorge closed for 4 days. Widespread electricity outages and hundreds of downed trees and power lines in the Portland area.
Dec.28, 2003-Jan. 9, 2004	Statewide storm	The most significant winter storm in several y ears brought snowfall to most of Oregon. The largest snowstorm to hit the Siskiyou Pass in Jackson County in a quarter century. Interstate 5 shut down for nearly a day as ODOT maintenance crews and Oregon State Police troopers dug stranded motorists out of snowdrifts reaching five to six feet. Two feet of snow in the Blue Mountains in eastern Oregon. Roadside snow levels exceeded six feet along the Tollgate Highway, Oregon 204. The eastbound lanes of Interstate 84 closed at Ladd Canyon east of La Grande. Additional segments of I-84 eastbound at Pendleton closed as stranded motorists filled truck stops, motels and restaurants in the La Grande area. Wet snow on highways in the Willamette Valley, toppled power lines and trees. Oregon 34 east of Philomath

		closed for 30 hours while crews removed trees. Snow on the Siskiyou Pass made national news and was a top story on the CNN website. 150 miles of I-5 from Ashland to south of Redding, California closed, leaving 100 to 200 vehicles stranded on the Siskiyou Pass overnight. The American Red Cross opened a shelter on the Southern Oregon University campus, and reports out of cities from Redding to Medford confirmed that all motels were full. Emergency service delivered gasoline, food, and water to stranded motorists and hard-to-reach areas. One fatality related to the storm. (Heart attack after helping a stranded motorist). I-5 North on the Siskiyou Pass closed for 19-hours. The snow event turned into a major ice storm. Icy roads made driving hazardous. Trees damaged or destroyed by ice adhering to the branches. Downed power lines, often due to falling trees, caused power outages. Businesses, school districts, and government offices closed or hours shortened. Several hundred flights cancelled at the Portland International Airport. Thousands of passengers stranded at the airport. The MAX light rail system also was shut down by the storm. ODOT closed Interstate 84 through the Columbia Gorge twice, for almost 70 hours total. Freight trucks and passenger cars had to detour over Mount Hood where, ironically, road conditions were better than they were in downtown Portland where all vehicles were required to chain up. ODOT closed US 101 over the Astoria Megler Bridge for about 14 hours as large chunks of ice fell off the bridge's superstructure. Many other highways in the state were closed. Freezing rain also in eastern Oregon. Minus thirty degrees reported in Meacham. 60 mph wind gusts in Union County created whiteout conditions, prompting the closure of I-84 between La Grande and Baker City. 2 fatalities. President Bush issued a major disaster declaration for 26 Oregon counties affected by the winter storm, later extended to 30 of Oregon's 36 counties. Estimated the cost of damages to public property at $16 million. A frigid arctic air mass, heavy snow, sleet and freezing rain, strong east winds and blizzard conditions through and near the Columbia River Gorge snarled travel, forced school and business closures, and resulted in widespread power outages and properly damage in

		Northwestern Oregon. 2-6 inches of snow along the North Oregon Coast, 2-8 inches in the Willamette Valley,5–8 inches in the Portland metro area, and up to 27 inches in the Cascade Mountains. Up to 2 inches of sleet and freezing rain followed the snowfall. In Portland this winter storm: limited or halted most forms of travel resulted in the cancellation of over 1300 flights at Portland International Airport, stranding 90,000 passengers. Shut down Portland's light rail train system. Closed most businesses and schools Blizzard conditions in the Columbia River Gorge: Closured Interstate 84 between Troutdale and Hood River. Closed Washington State Route 14 between Washougal, and White Salmon , Washington. Halted east-west travel through the Gorge and stranding hundreds of trucks at both ends of the Gorge. Weight from snow and ice buildup: Downed trees and power lines, leaving 46,000 customers without power, and collapsed roofs at Portland's Gunderson Steel and Rail, Fred Meyer stores in Gateway and Clackamas, and a barn in Forest Grove that killed 4 horses. Collapsed a Scappoose marina roof, sinking 4 boats and damaging many others. Snowfall in the Cascades ranged from 8 inches at Blue Box Pass and Bennett Pass to 27 inches at Timberline Lodge and White River.
March 8-10, 2006	Lane, Linn, Benton, Marion, Jefferson, Polk, Yamhill, Clackamas counties	Snow fell up to a few inches at the coast and through the Willamette Valley; 2 - 4 feet in the Coast Range, Cascades, and Cascade Foothills. Many school closures.
January 2 – February 9, 2008	Hood River, Waco, Sherman, Gilliam, Morrow, Umatilla, Union, Grant, Baker, Wheeler, Jefferson Deschutes, Crook	Heavy snow and freezing rain across eastern Oregon. 5-13 inches of snow. A multi-vehicle accident closed Interstate 84, 15 miles west of Arlington, for 5 hours. 36 Oregon National Guard personnel helped with snow removal in Detroit and Idanha with over 12 feet of record snow. Inmate crews removed snow that cracked walls

	counties	and collapsed roofs
December 9-11, 2009	Marion, Linn, Lane counties	Freezing rain covered the central valley with a coating of ice. South of Salem, numerous road closures due to accidents caused by icy roadways. Interstate 84 from Troutdale to Hood River closed for 22 hours.
November 29-30, 2010	Hood River, Multnomah, Wasco counties	4-5 inches of snow reported in Cascade Locks and Hood River. 1/2 inch of ice in Corbett.
January 12-18, 2012	Hood River, Wasco counties	4.5 inches of new snow reported in Hood River. Interstate 84 closed due to ice and snow east of Troutdale.

Source: The National Weather Service

Figure 2-WS-4: Rescuing snow bound vehicles, Old Oregon Trail Highway between Kamela and Meacham, 1923.

Source: ODOT

Figure 2-WS-5: Stranded motorists on Interstate 5 southbound at Siskiyou Pass, late December 2003; note vehicles being towed out the "wrong way".

Source: ODOT

Figure WS-7: Trees collapse from weight of the snow on Oregon 62 near Prospect, February 2, 2008.

Source: ODOT

Figure 2-WS-6:Detroit, February 2, 2008, buried from the 12 feet of snow.

Source: ODOT

Probability

Winter storms occur annually in Oregon bringing snow to Oregon's mountains and much of Eastern Oregon. These winter storms are welcomed by Oregon's skiers and the ski industry and are tolerated by people traveling the numerous mountain passes and Eastern Oregon highways kept open during the winter by the Oregon Department of Transportation. Approximately every four years, winter storms bring extreme cold temperatures, snow, sleet and ice to Oregon's western valley floors. Because these storms are infrequent and tend to last only a few days, residents in Western Oregon are often unprepared for such events.

One issue concerns the fact that there is not a statewide effort regarding Winter Storm impacts, either historical or for future planning. There are only limited snow fall sensors distributed mainly through the mountain ranges of the state and there is not an annual tracking system in place for snow fall statewide. A program of statewide snow fall sensors would allow us to better understand the impact of Winter Storms on Oregon and have a better means of predicting potential impacts in the future.

The American Society of Civil Engineers has developed a 50-year recurrence interval map of Oregon showing probabilities for ice thickness caused by freezing rain (ASCE-7-02, 2003a), found at website: http://www.americanlifelinesalliance.com/pdf/PipecommFinalPosted061705.pdf

According to the Northwest Weather and Avalanche Center (NWAC), experts on the subject aren't able to predict, nor do they completely understand each and every avalanche occurrence. Regional avalanche centers across the country do have the technology to forecast avalanche danger. These forecasts are valuable tools in reducing danger to people. However, no matter what forecasts indicate even the smallest avalanche can be injurious or life threatening!

Avalanche danger ratings levels have been adopted within North America (with slight changes in Canada) and are generally accepted internationally. These levels are:

Low Avalanche Danger (green)—Natural avalanches very unlikely. Human triggered avalanches unlikely. Generally stable snow. Isolated areas of instability. Travel is generally safe. Normal caution advised.

Moderate Avalanche Danger (yellow)—Natural avalanches unlikely. Human triggered avalanches possible. Unstable slabs possible on steep terrain. Use caution in steeper terrain on certain aspects.

Considerable Avalanche Danger (orange)—Natural avalanches possible. Human triggered avalanches probable. Unstable slabs probable on steep terrain. Be increasingly cautious in steeper terrain.

High Avalanche Danger (red)—Natural and human triggered avalanches likely. Unstable slabs likely on a variety of aspects and slope angles. Travel in avalanche terrain is not recommended. Safest travel on windward ridges of lower angle slopes without steeper terrain above.

Extreme Avalanche Danger (red with black border)—Widespread natural or human triggered avalanches certain. Extremely unstable slabs certain on most aspects and slope angles. Large destructive avalanches possible. Travel in avalanche terrain should be avoided and travel confined to low angle terrain well away from avalanche path run outs.

Oregon Vulnerabilities

Overview

Requirement: 44 CFR §201.4(c)(2)(ii): Th[e] risk assessment shall include… (ii) (a)n overview and analysis of the State's vulnerability to the hazards described . . . based on estimates provided in local risk assessments as well as the State risk assessment. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…

The vulnerability assessment provides an overview and analysis of the state's vulnerabilities to each of Oregon's 11 hazards addressed in this Plan. Both local and state risk assessments are referenced to identify vulnerabilities, most vulnerable jurisdictions and potential impacts from each hazard. In addition, a side-by-side comparison of local and state vulnerability "rankings" for each county show similarities and differences that the state will be addressing over the course of the next Plan update cycle.

Requirement: 44 CFR §201.4(c)(2)(ii): Th[e] risk assessment shall include… (ii) (s)tate owned or operated critical facilities located in the identified hazard areas shall also be addressed.

Requirement: 44 CFR §201.4(c)(2)(iii): Th[e] risk assessment shall include… (iii) (a)n overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

The exposure analysis and estimate of potential losses to state owned and leased facilities and critical and essential facilities (both state owned/leased and non-state owned/leased) located within hazard zones performed by the Department of Geology and Mineral Industries (DOGAMI) for the 2012 Oregon NHMP was updated by DOGAMI in 2014. Loss data is not available in local plans. Therefore, this Plan only includes the most recent estimates provided by DOGAMI.

In addition, an overview of seismic lifeline vulnerabilities is a new addition to the 2015 Oregon NHMP. This includes a summary of the Oregon Department of Transportation's (ODOT's) 2012 Oregon Seismic Lifeline Report (OSLR) findings, including identification of system vulnerabilities, loss estimates and recommended next steps. Both the facilities and lifeline report findings are further discussed in the Regional Risk Assessment later in this Plan (pg.xx-xx).

Local Vulnerability Assessments

Requirement: 44 CFR §201.4(c)(2)(ii): Th[e] risk assessment shall include… (ii) (a)n overview and analysis of the State's vulnerability to the hazards described . . . based on estimates provided in local risk assessments …. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…

The Oregon Military Department, Office of Emergency Management (OEM) periodically collects hazard vulnerability information from each of the 36 counties in the state. The information is generated at the local government level to meet OEM required activities under the State's Emergency Management Grant Program (EMPG) and in many cases to inform Local NHMPs.

The OEM Hazard Analysis Methodology was first developed by FEMA in 1983, and has been gradually refined by OEM over the years. There are two key components to this methodology: vulnerability and probability. Vulnerability examines both typical and maximum credible events, and probability reflects how physical changes in the jurisdiction and scientific research modify the historical record for each hazard.

This analysis is conducted by county or city emergency program managers, usually with the assistance of a team of local public safety officials. The assessment team initially identifies which hazards are relevant in that community. Then, the team scores each hazard in four categories: history, probability, vulnerability, and maximum treat. Following is the definition and ranking method for each category:

- History= the record of previous occurrences
  - Low 0 - 1 event past 100 years
  - Moderate 2 - 3 events past100 years
  - High 4 + events past100 years
- Probability= the likelihood of future occurrence within a specified period of time
  - Low one incident likely within 75 to 100 years
  - Moderate one incident likely within 35 to 75 years
  - High one incident likely within 10 to 35 years
- Vulnerability= the percentage of population and property likely to be affected under an "average" occurrence of the hazard
  - Low < 1% affected
  - Moderate 1 - 10% affected
  - High > 10% affected
- Maximum Threat= the highest percentage of population and property that could be impacted under a worst-case scenario
  - Low < 5% affected
  - Moderate 5 - 25% affected
  - High > 25% affected

Each county in Oregon is required to periodically update their Hazard Analysis. As part of this analysis,

each county develops risk scores for the natural hazards that affect their communities. These scores range from 24 (low) to 240 (high), and reflect risk for each particular hazard, as determined by a team process facilitated by the emergency manager. This method provides local jurisdictions with a sense of hazard priorities, or relative risk. It doesn't predict the occurrence of a particular hazard in a community, but it does "quantify" the risk of one hazard compared with another. By doing this analysis, local planning can first be focused where the risk is greatest. This analysis is also intended to provide comparison of the same hazard across various local jurisdictions.

Among other things, the hazard analysis can:

- Help establish priorities for planning, capability development, and hazard mitigation;
- Serve as a tool in the identification of hazard mitigation measures;
- Be one tool in conducting a hazard-based needs analysis;
- Serve to educate the public and public officials about hazards and vulnerabilities; and
- Help communities make objective judgments about acceptable risk.

Although this methodology is consistent statewide, the reported raw scores for each county are based on partially subjective rankings for each hazard. Because the rankings are used to describe the 'relative risk' of a hazard within a county, and because each county conducted the analysis with a different team of people working with slightly different assumptions, comparing scores between counties must therefore be treated with caution.

For the purposes of the Oregon NHMP, the State Vulnerability Assessment focuses only on county vulnerability rankings (H, M, L) taken from LNHMP Hazard Analysis scores. These rankings provide the state an understanding of local hazard concerns and priorities. Table 2-V-1 presents the local vulnerability rankings for each of Oregon's 11 primary hazards by county. In the Regional Risk Assessment, found later in this Plan (beginning on pg. x), both county vulnerability and probability rankings are identified for each OEM Natural Mitigation Region.

Source: Oregon Emergency Management (OEM) Hazard Analysis Methodology, OEM, May 2008

Table 2-V-1: Local Vulnerability Rankings by County

Local Vulnerability Rankings by County											
County	Coastal Erosion	Tsunami	Drought	Dust Storm	Earthquake	Volcanic	Landslide	Wildfire	Flood	Wind Storm	Winter Storm
Baker			H	M	M	L	M	H	M	H	H
Benton			L		H	L	L	M	M	M	M
Clackamas			L		H	H	L	M	M	L	M
Clatsop	H	H	M		H	M	H	H	H	H	H
Columbia			M		H	H	M	M	M	H	H
Coos	M	H	M		H	M	M	M	H	H	H
Crook			H	L	L	H	L	M	H	M	M
Curry		H			H	H	L	H	H	H	
Deschutes			L		M	H		M	L	L	H
Douglas - Central					M		M	H	H	M	H
Douglas - Coastal	L	H			H		M	M	M	M	M
Gilliam			H		M	M	M	M	M	L	H
Grant			H		M	L	M	H	H		H
Harney			M					M	M	L	M
Hood River			H		M	L	M	M	M	H	H
Jackson			M		H	L	L	M	M	H	H
Jefferson			H		L	H	L	H	M		H
Josephine					H			M	M	H	H
Klamath			M		M	L		L	M		M
Lake			H		H	H	L	M	M	M	H
Lane - Central			M		M	M	L	M	H	M	H
Lane - Coastal		H			H		M	L	H	H	L
Lincoln		M	L		M	L		M	L	H	
Linn					H	H		M	H	M	H
Malheur			H	L	M	M	M	M	H	M	M
Marion					H	M		M	M	H	H
Morrow				M	H		M	M	H	M	H
Multnomah					H	H	M	M	H	H	H
Polk					H	M		M	H	H	
Sherman			M		L	L	M	M	M	M	M
Tillamook		H	L	L	H	M	H	H	H	H	H
Umatilla					M			M	M	H	H
Union			M	M	M		M	M	M	H	H
Wallowa			H		M	L	M	H	H	H	H
Wasco			H		M	L	M	M	L	H	H
Washington			M		H	H	L	M	H	H	H
Wheeler					M			H	M		H
Yamhill			H		H		M	L	H	M	H

Vulnerability Scores:
H= high
M= moderate
L= low

Source: OEM, November 2013

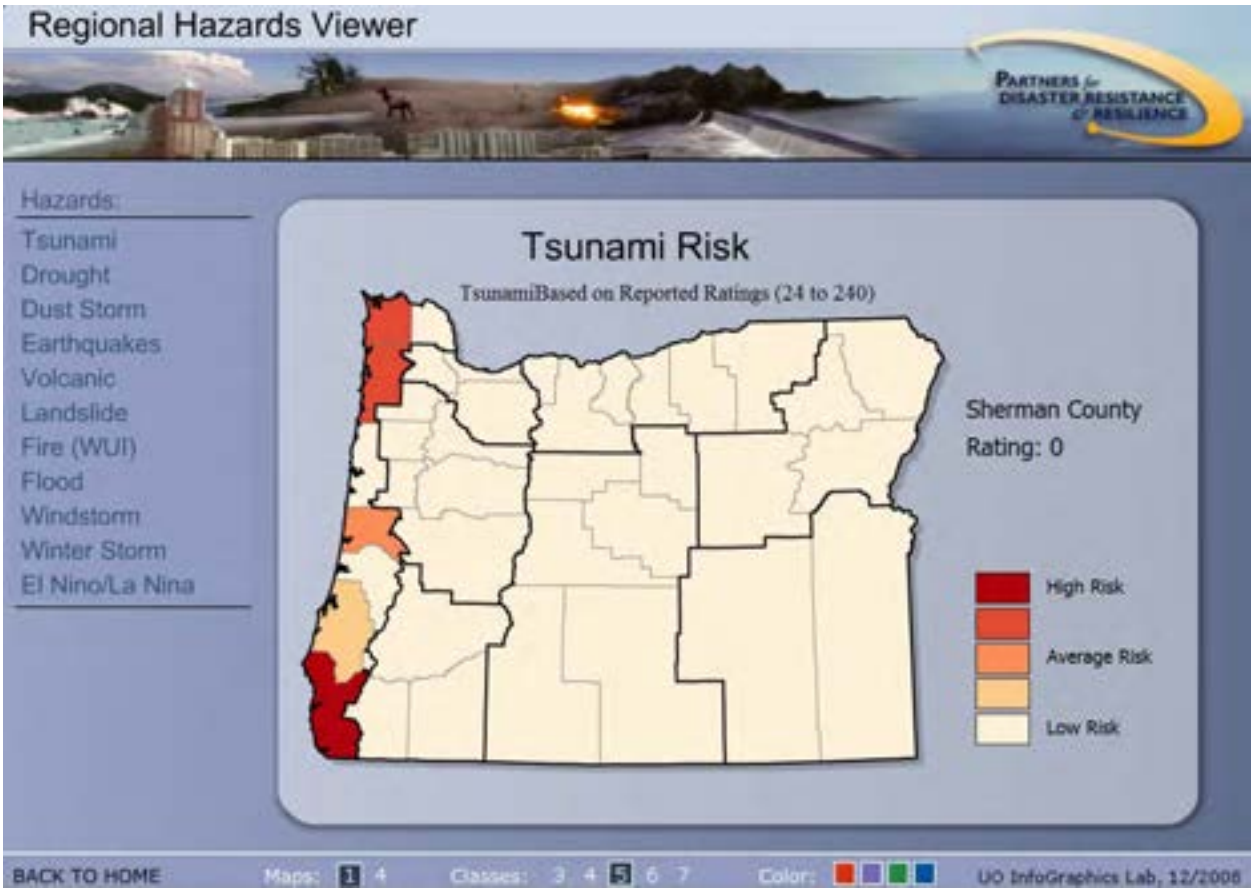
State's Natural Hazards Viewer

The State's Natural Hazards Viewer is an online interface that visually describes natural hazard risk throughout the State of Oregon. Information displayed in the Viewer is taken from the OEM Hazard Analysis Methodology findings. Figure 2-V-1 shows an example of the visual display available for each hazard. By moving the cursor over each county, individual hazard scores are displayed on the right-hand side of the screen. Up to four hazard maps can be displayed at one time. The Natural Hazard Viewer can be found at the following web link: http://infographics.uoregon.edu/hazardmaps/webapp/beta.html

Data in the Natural Hazards Viewer is current through December 2008. However, OEM is requiring counties to update their analyses for the local fiscal year that ends on June 30, 2016. Therefore, the Hazards Viewer will be updated to reflect these county updates during the summer of 2016.

Note: the Natural Hazards Viewer addresses all hazards in the plan except Coastal Erosion.

Figure 2-V-1: The State's Natural Hazard Viewer



Source: UO InfoGraphics Lab, website: http://infographics.uoregon.edu/hazardmaps/webapp/beta.html

State Vulnerability Assessment

Requirement: 44 CFR §201.4(c)(2)(ii): Th[e] risk assessment shall include… (ii) (a)n overview and analysis of the State's vulnerability to the hazards described . . . based on estimates provided in … the State risk assessment. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events…

Oregon does not have one standard method to assess risk across all hazards statewide. For each of the 11 hazards addressed in this Plan, a state agency has been identified as the lead over that hazard (Table 2-V-2). All hazards have at least one lead and one support hazard expert who have compiled and analyzed respective hazard data for this state risk assessment. In some instances both experts are from the same agency. For other hazards two agencies worked together to perform the analysis. Due to the wide range of data available for each hazard, the method used to assess risk varies from hazard to hazard. For example, there is a wealth of data available to assess risk to earthquakes, but data on dust is difficult to locate. In response, the state relies on hazard lead and support experts to determine the best method, or combination of methods, to identify vulnerability and potential impacts for this Plan. In general, each hazard is assessed using a combination of exposure, historical, and scenario analyses. Hazards for which more data exists have undergone a more robust analysis, including earthquake, flood, tsunami, and wildfire; and to a lesser degree Volcanic events (primarily related to Mt. Hood).

Table 2-V-2: Oregon NHMP Hazard Lead Agencies

Hazard	Lead Agency	Support Agency
Coastal Hazards	Department of Geology and Mineral Industries	
Drought	Oregon Water Resources Department	
Dust	Oregon Office of Emergency Management	Oregon Department of Transportation
Earthquake	Oregon Office of Emergency Management	Department of Geology and Mineral Industries
Flood	Department of Land Conservation and Development	
Landslide	Department of Geology and Mineral Industries	Department of Geology and Mineral Industries
Tsunami	Department of Geology and Mineral Industries	
Volcano	Department of Geology and Mineral Industries	
Wildfire	Oregon Department of Forestry	
Windstorm	Oregon Public Utility Commission	Oregon Climate Change Resource Institute
Winter Storm	Oregon Department of Transportation	Oregon Public Utility Commission

Coastal Hazards

Chronic hazards are clearly evident along Oregon's shores, including beach, dune, and bluff erosion, landslides, slumps, gradual weathering of sea cliffs, and flooding of low-lying coastal lands during major storms. The damage caused by chronic hazards is usually gradual and cumulative. The regional, oceanic, and climatic environments that result in intense winter storms determine the severity of chronic hazards along the coast. These hazards threaten property in its path and, in extreme events, can threaten human life as well.

Most Vulnerable Communities

The Department of Geology and Mineral Industries is the agency with primary oversight of the coastal erosion hazard. Based on agency staff review of the available hazard data, DOGAMI ranks Tillamook, Lincoln, Clatsop and Curry Counties one through four respectively as the counties most vulnerable to coastal erosion in the state.

Coastal hazards in Coos, Lane and Douglas counties are considered to be generally negligible. This is because the bulk of these coastlines have little population base and hence are largely unmodified. In Coos County, coastal hazards can be found in a few discrete communities such as adjacent to the Coquille jetty in Bandon and along Lighthouse Beach near Cape Arago. Similarly, coastal hazards in Lane County are confined almost entirely to the Heceta Beach community and adjacent to the Siuslaw River mouth, particularly within the lower estuary mouth where development lines coastal bluffs that is gradually being eroded by riverine processes.

The most vulnerable counties and communities on the Oregon coast include:

Tillamook County (ranked #1)
- Neskowin (erosion and flooding)
- Pacific City (erosion)
- Tierra del Mar (erosion and flooding)
- Cape Meares (flooding)
- Twin Rocks (erosion and flooding)
- Rockaway Beach(erosion and flooding)

Lincoln County (ranked #2)
- Yachats to Alsea Spit (erosion)
- Waldport (erosion and flooding)
- Alsea Spit (erosion)
- Seal Rock (erosion and landsliding)
- Ona Beach to Southbeach (erosion and landsliding)
- Newport (landsliding)
- Beverly Beach (erosion and landsliding)
- Gleneden Beach to Siletz Spit (erosion, landsliding, and flooding)
- Lincoln City (erosion and landsliding)

Clatsop County (ranked #3)

- Falcon Cove (erosion and landsliding)
- Arch Cape (erosion and flooding)
- Tolovana to Cannon Beach (erosion and flooding)
- Seaside (Flooding)

Curry County (ranked #4)

- Nesika Beach (erosion and landsliding)
- Port Orford (flooding at Garrison Lake)

Coos County (ranked #5)

- North Coos Spit (erosion)
- Lighthouse Beach (bluff erosion)
- Bandon (erosion and flooding, particularly adjacent to the south Coquille jetty)

Lane County (ranked #6)

- Heceta Beach (erosion and flooding)

Intellectual knowledge derived from field experience, discussions with scientists, scientific publications, agency reports, and thesis dissertations were used to determine which communities are the most vulnerable to coastal hazards within Oregon.

Drought

There is a tendency to associate drought conditions with the arid sections of the state, principally east of the Cascade Mountains. However, this perception is not entirely accurate. During the winter of 2002-03, Coos and Curry counties on the south coast experienced drought conditions for some time.

When a drought occurs, it may affect all regions of the state. However, most of Oregon's urban areas usually fare much better during a drought than rural, less populated regions of the state. By encouraging or invoking water conservation measures during a drought, municipalities can reduce residential and industrial demand for water.

Rural areas are much more dependent on water for irrigation for agricultural production. Several regions of the state, dependent on an agricultural economy, are more vulnerable to drought conditions. Generally, counties west of the Cascades and in the southern portions of the state are more prone to drought-related impacts.

Most Vulnerable Communities

The Water Resources Department (WRD) is the state agency with primary oversight of drought conditions and mitigation activities. Based on the frequency of drought declarations issued by the Governor issued since 1995, Klamath and Baker Counties are the most vulnerable to drought, followed by Sherman, Gilliam, Morrow, and Malheur Counties. Both Klamath and Baker Counties have experienced 7 drought declarations out of the last 13 years.

The above communities were identified as most vulnerable based on the frequency of drought declarations issued by the Governor issued since 1995.

Dust Storms

Dust storms primarily occur in the arid regions of Central and Eastern Oregon They are generally produced by the interaction of strong winds, fine-grained surface material, and landscapes with little vegetation. The winds involved can be as small as "dust devils" or as large as fast moving regional air masses.

Most Vulnerable Communities

Based on research conducted by OEM, the counties in Oregon most vulnerable to dust storms are Morrow and Umatilla. These two counties are most vulnerable because historically in locations close to their county lines, a combination of soil types, past agricultural practices, and high winds have led to motor vehicle accidents that have resulted in many deaths and injuries. The following counties are also vulnerable: Baker, Deschutes, Harney, Jefferson, Klamath, Lake, Malheur, Union, and Wasco.

Poor visibility leading to motor vehicle crashes is the worst potential impact of these storms; often these crashes result in fatalities and major injuries. Other impacts include poor air quality, including dust infiltration of equipment and engines, loss of productive soil, and an increase in fine sediment loading of creeks and rivers.

Communities most vulnerable to dust storms have been identified on the basis of historic occurrence, including the impacts of those occurrences.

Earthquake

Oregon has a long history of earthquakes (and tsunamis, which often accompany major off-shore seismic events) because of the state's proximity to the Cascadia Subduction Zone (CSZ) just off the Pacific Coast, and also from crustal faults that run under or near populated areas. Oregon is vulnerable to damage because of its topography and geology; many of its local soil profiles are prone to liquefaction during the shaking that would occur during a Cascadia event. Depending on the size of the fault rupture, areas receiving major damage from an magnitude 8.0 – 9.0 earthquake would include most of the counties in Western Oregon; the heavily populated metropolitan areas of Portland, Salem, and Eugene would certainly experience major damage.

A major Cascadia earthquake (>M_W8.5) or a local crustal earthquake (>M_W5.0) would be devastating to the Portland metropolitan area. The Northern Willamette Valley/Portland Metro Region is the most densely populated region with a total population of almost 1.5 million people. A major earthquake would likely do extensive damage to many of the region's 1382 bridges and overpasses as few bridges have been retrofitted to withstand this type of event. In addition, many structures are located on soils likely to experience liquefaction from the shaking that would occur. Most of the state's major critical infrastructure such as energy sector lifelines, transportation hubs, and medical facilities are particularly vulnerable to damage from liquefaction and long periods of shaking. The Northern Willamette Valley/Portland Metro Region also has 49 dams that could be affected by a major earthquake.

Depending on the size of the fault rupture, this magnitude of earthquake would likely cause extensive damage to structures and infrastructure in the Mid/Southern Willamette Valley Region as well. The city of Salem, Oregon's state capital, is only 46 miles south of Portland. To gain a perspective of the potential damage from a major earthquake, 169 of the state's facilities are located in or near Salem. To replace these state facilities would cost over $850 million dollars. Marion County, where Salem is located, has over 20 dams and 400 bridges that could also be affected. For more information on state facilities located in earthquake hazard zones, see pg. X of this Plan.

The long-term effects from a major earthquake would be felt for years. Major damage would likely occur to most of western Oregon's public and private buildings, its vast road network, to its rail lines and power transmission lines, and to the state's most important employment centers.

A major earthquake that occurs in the southern, central, or eastern areas of Oregon would be catastrophic to that region. It may also be catastrophic to the state economically if key facilities and infrastructure (i.e., highways, bridges, rail lines, power transmission lines, and dams) are damaged to the degree that links with the Portland metropolitan region and the rest of the state could not quickly be repaired. However, the length of time for the state to recover from such a disaster occurring in an area away from the Portland metropolitan area should be much shorter than if the same event occurred near Portland. For more information about the seismic vulnerability lifelines, see pages X-X summarizing the Oregon Department of Transportation's Seismic Lifeline Report.

In the late 1990s, DOGAMI developed two earthquake loss models for Oregon: (1) a magnitude 8.5 Cascadia Subduction Zone (CSZ), and (2) a 500-yr probabilistic ground motion model, which combines CSZ, intraplate and crustal events. Both models are based on HAZUS, a computer program developed by the Federal Emergency Management Agency (FEMA) as a means of determining potential losses from earthquakes. The CSZ event is based on a potential 8.5 earthquake generated off the Oregon

coast. The 500-yr model incorporates earthquake ground motions with 10% chance of exceedence in the next 50 years, which was used by the building code. It does not look at a single earthquake (as in the CSZ model) but encompasses many faults.

Neither model takes into account damage and losses from unreinforced masonry buildings or tsunamis. Due to the limitations of HAZUS with respect to modeling damage from unreinforced masonry buildings and tsunamis at that time, DOGAMI estimated fatalities outside of the HAZUS model. DOGAMI developed lower bound estimates on the order of 5,000 fatalities.

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning and policy purposes. Despite the model limitations, valuable estimates of damage, functionality and relationships between county estimates are made available for each region within Oregon. Results for each OEM Hazard Mitigation Region are found in the Regional Risk Assessment section of this plan (beginning on page xx).

In 2000, DOGAMI co-organized an important conference convening scientists to discuss the Cascadia fault. At this Geological Society of America Penrose conference, which was held in Seaside, Oregon, there was scientific consensus that the most recent Cascadia earthquake occurred in 1700, that it was a magnitude 9 earthquake, and the Cascadia fault would produce future magnitude 9 earthquakes and damaging tsunamis (DOGAMI Special Paper 33, found at website: http://www.naturenw.org/qs3/products.php?sku=001227).

Also in 2000, the Oregon Seismic Safety Policy Advisory Commission (OSSPAC) developed a report called "Oregon At Risk" which address the many cross-cutting effects that earthquakes have on our communities, including the basic services provided by infrastructure. Five objectives were outlined: 1) earthquake awareness and education, 2) earthquake risk information, 3) earthquake safety of buildings and lifelines, 4) geoscience and technical information, and 5) emergency pre-disaster planning, response and recovery. The report is available on the following Oregon Emergency Management webpage: http://www.oregon.gov/omd/oem/pages/osspac/osspac.aspx.

In 2007, DOGAMI completed a rapid visual screening (RVS) of educational and emergency facilities in communities across Oregon, as directed by the Oregon Legislature in Senate Bill 2 (2005). RVS is a technique developed by the Federal Emergency Management Agency (FEMA), known as FEMA 154, to identify, inventory, and rank buildings that are potentially vulnerable to seismic events. DOGAMI surveyed a total of 3,349 buildings, giving each a 'low,' 'moderate,' 'high,' or 'very high' potential of collapse in the event of an earthquake. It is important to note that these rankings represent a probability of collapse based on limited observed and analytical data and are therefore *approximate* rankings.[1] The RVS study can help to prioritize which buildings require additional studies and which do not. To fully assess a building's potential of collapse, a more detailed engineering study completed by a qualified professional is required. In the Regional Assessments section of this Plan, details of this study for each OEM Hazard Mitigation Region can be found (pages xx-yy).

[1] State of Oregon Department of Geologic and Mineral Industries, Implementation of 2005 Senate Bill 2 Relating to Public Safety, Seismic Safety and Seismic Rehabilitation of Public Building, May 22, 2007, iv.

In 2012 the USGS published Professional Paper 1661-F, by Goldfinger and others[2], "Turbidite Event History Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone" which provides the most comprehensive catalog of prehisotirc Cascadia Subduction earthquakes to date, including a 10,000 year chronology (Table 2-V-EQ-1) of as many as 40 subduction earthquakes ranging from ~M8.1 to ~M9.3. This study forms the basis for efforts to evaluate the consequences and likelihood of future Cascadia earthquakes, and has been particularly useful in DOGAMI's program to map tsunami inundation zones along the Oregon coast.

Turbidite number	Mean age	Northern margin following interval, in years	Northern margin slip from following time, in meters	Southern margin interval, in years	Southern margin slip from time, in meters	Average northern and southern slip, in meters	Segment name	Rupture length, in kilometers	Rupture width, in kilometers	Mw	Seismic moment
1	250					16.0	A	1,000	83	9.00	398.4E+27
2	482	232	8.9	232	8.3	8.4	A	1,000	55	8.70	138.3E+27
2a	550			57	2.1	2.1	D	222	40	8.19	23.8E+27
3	798	305	11.2	248	8.9	10.0	A	1,000	83	8.87	250.2E+27
3a	1,077			279	10.0	10.0	C	444	50	8.34	40.1E+27
4	1,243	446	16.3	167	6.0	11.2	A	1,000	83	8.90	277.9E+27
4a	1,429			186	6.7	6.7	C	444	50	8.25	29.9E+27
5	1,554	311	11.4	125	4.5	7.9	A	1,000	83	8.80	197.4E+27
5a	1,820			266	9.6	9.6	C	444	50	8.41	51.9E+27
5b	2,036			216	7.8	7.8	B	660	60	8.66	122.5E+27
5c	2,323			286	10.3	10.3	C	444	50	8.41	51.1E+27
6	2,536	982	35.9	213	7.7	21.8	A	1,000	83	9.09	542.7E+27
6a	2,730			194	7.0	7.0	D	222	40	8.24	28.7E+27
7	3,028	492	18.0	298	10.7	14.4	A	1,000	83	8.97	358.2E+27
7a	3,157			129	4.6	4.6	D	222	40	8.23	27.5E+27
8	3,443	415	15.2	286	10.3	12.7	A	1,000	83	8.94	317.2E+27
8a	3,599			442	5.6	0.0	B	660	60	8.67	124.4E+27
8b	3,890			447	10.5	10.5	D	222	40	8.15	21.0E+27
9	4,108	665	24.4	218	7.9	16.1	A	1,000	83	9.01	401.1E+27
9a	4,438			548	11.9	0.0	B	660	60	8.35	41.4E+27
9b	4,535			426	3.5	3.5	D	222	40	8.17	22.5E+27
10	4,770	661	24.2	235	8.5	16.3	A	1,000	83	9.01	406.6E+27
10a	5,062			292	10.5	10.5	C	444	50	8.39	47.6E+27
10b	5,260			198	7.1	7.1	B	660	60	8.43	55.7E+27
10c	5,390			130	4.7	4.7	C	444	50	8.55	82.7E+27
10d	5,735			344	12.4	12.4	C	444	50	7.90	9.0E+27
10f	5,772			37	1.3	1.3	C	444	50	8.37	44.8E+27
11	5,959	1189	43.5	187	6.7	25.1	A	1,000	83	9.13	625.5E+27
12	6,466	508	18.6	508	18.3	18.4	A	1,000	55	8.93	304.0E+27
12a	6,903			437	15.7	15.7	D	222	40	8.22	26.7E+27
13	7,182	715	26.2	278	10.0	18.1	A	1,000	83	9.04	450.7E+27
14*	7,625	443	16.2	443	16.0	16.1	A	1,000	83	9.01	400.7E+27
14a	7,943			318	11.4	11.4	D	222	40	8.17	22.1E+27
15	8,173	548	20.1	230	8.3	14.2	A	1,000	83	8.97	353.0E+27
15a	8,459			286	10.3	10.3	D	222	40	8.36	42.9E+27
16	8,906	733	26.8	447	16.1	21.4	A	1,000	83	9.09	534.1E+27
16a	9,074			169	6.1	6.1	D	222	40	7.54	2.6E+27
17	9,101	195	7.2	27	1.0	4.1	A	1,000	55	8.49	67.0E+27
17a	9,218	117	4.3	117	4.2	4.2	A	1,000	55	8.50	70.1E+27
18	9,795	577	21.1	577	20.8	20.9	A	1,000	83	9.08	521.2E+27

Table 2-V-EQ-1: Turbidite Event History Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone

Source: Goldfinger and others, 2012

[2] Goldfinger, C. , Nelson, C.H., Morey, A.E., Johnson, J.E., Patton, J.R., Karabanov, E., Gutierrez-Pastor, J., Eriksson, A.T., Gracia, E., Dunhill, G., Enkin, R.J., Dallimore, A., and Vallier, T., 2012. Turbidite Event History__Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone; USGS Professional Paper 1661-F

In 2013, DOGAMI published Open-File Report O-13-09, by Wang and others[3], "Earthquake Risk Study for Oregon's Critical Energy Infrastructure Hub**".** This report highlights the concentration of critical energy facilities in the Portland Harbor area of the lower Willamette River, and the seismic risk posed by a combination of liquefiable soils and the age and poor condition of many facilities in the area. The report also points out how dependent Oregon is on this concentration of facilities for virtually all petroleum products used in the State, and the potential impacts on post earthquake recovery if these facilities are damaged.

Also in 2013, the Cascadia Region Earthquake Workgroup (CREW) issued a Cascadia magnitude 9 scenario, which provides a narrative on the expected effects throughout the region including northern California, Oregon, Washington and British Columbia (www.crew.org). Some of the CREW scenario was obtained from the 2011 Federal Emergency Management Agency (FEMA) regional planning scenario for the Pacific Northwest (Draft Analytical Baseline Study for the Cascadia Earthquake and Tsunami, September 12, 2011) based on a magnitude 9 megathrust earthquake. Using the most current version of HAZUS, FEMA's disaster loss modeling software, they have prepared the most comprehensive and realistic Cascadia scenario to date). In addition to HAZUS analysis, FEMA evaluated likely tsunami effects for several Oregon coastal communities. Data like this provides a critical tool for planning emergency response and for designing a resiliency plan, as it highlights areas of infrastructure damage that affect the entire system. State and local government agencies have been working with FEMA to provide local knowledge to inform the scenario, and the final document and associated databases should be adopted as the basis for planning. In general the scenario results predict severe damage in coastal areas, particularly in tsunami inundation zones with widespread but moderate damage along the I-5 corridor (Figure 2-V-EQ-1). For more information about tsunamis in Oregon, see pages 102 and X. For more information about seismic lifeline vulnerability see page xx.

[3] Wang, Y., Bartlett, S.F., and Miles, S.B., 2013, Earthquake Risk Study for Oregon's Critical Energy Infrastructure Hub; Oregon Department of Geology and Mineral Industries Open-File Report, O-13-09

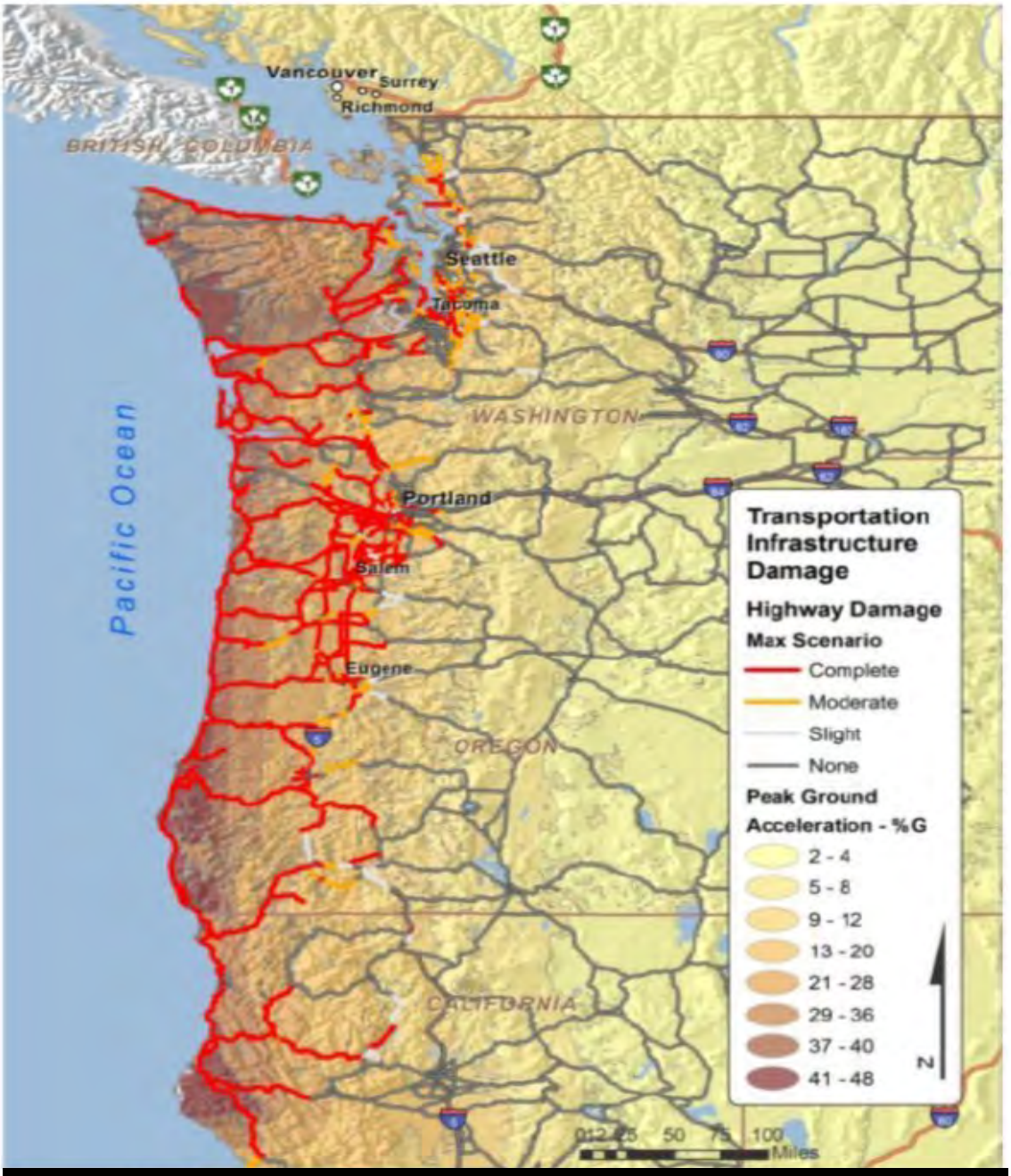


Figure 2-V-EQ-1: Draft HAZUS results from the 2011 FEMA Analytical Baseline Study for the Cascadia Earthquake and Tsunami

Source: FEMA

The Oregon Seismic Safety Policy Advisory Commission (OSSPAC) developed a report in 2013 entitled "The Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami". The report, which was commissioned by a legislative resolution, estimated the impacts of an M 9.0 Cascadia subduction earthquake on the State's population, buildings and infrastructure with a focus on 7 sectors:

- Businesses
- Coastal Communities
- Energy
- Transportation
- Communication
- Critical Buildings
- Water and wastewater

For each of these sectors the Plan sets a desired level of performance (time to recover a given level of service) and estimates preformance under current conditions in each of four earthquake impact zones:

- Tsunami, where damage will be complete and saving lives through evacuation is the main focus
- Coastal, where damage will be severe and the focus will be on managing a displaced population with little functioning infrastructure,
- Valley, where moderate damage will be widespread, and the focus will be on restoring services quickly to re-start the economy,
- Eastern, where damage will be light, and the focus will be on staging recovery efforts for the rest of the state.

For the first three zones, times for restoration of services(Table 2-V-EQ-2) are typically several months, and in some cases several years, a clearly unacceptable level of performance, and far short of the general performance goal of two weeks to restore most services to functional, if not original conditions. These results are particularly sobering in the face of the report's finding that where services are not restored within 2 to 4 weeks, businesses will either fail or leave.

The report includes extensive recommendations for actions that if implemented over the next 50 years, should greatly improve the performance of Oregon's buildigns and infrastructure in the next great earthquake. These include:

- Undertaking comprehensive assessments of key structures and systems
- Launching a sustained program of investment in retrofit of Oregon's public buildings
- Creating a package of incentives to help Oregon's private sector improve its resieinece
- Updating public policies to streamline recovery and to increase public preparedness.

Upon consideration of the Plan, the 2013 Oregon Legislature passed Senate Bill 33 establishing an Oregon Resilience Task Force to facilitate a comprehensive and robust plan to implement the Oregon Resilience Plan. The Task Force will report to the Oregon Legislature during the 2015 session.

The report and an executive summary are available at:

- http://www.oregon.gov/OMD/OEM/osspac/docs/Oregon_Resilience_Plan_Final.pdf
- http://www.oregon.gov/OMD/OEM/osspac/docs/Oregon_Resilience_Plan_Executive_Summary_Final.pdf

Table 2-V-EQ-2: Estimated Times for Restoration Services post CSZ and tsunami event

Critical Service	Zone	Estimated Time to Restore Service
Electricity	Valley	1 to 3 months
Electricity	Coast	3 to 6 months
Police and fire stations	Valley	2 to 4 months
Drinking water and sewer	Valley	1 month to 1 year
Drinking water and sewer	Coast	1 to 3 years
Top-priority highways (partial restoration)	Valley	6 to 12 months
Healthcare facilities	Valley	18 months
Healthcare facilities	Coast	3 years

Source: Oregon Resilience Plan, OSSPAC, 2013.

Most Vulnerable Communities

The Department of Geology and Mineral Industries (DOGAMI) is the agency with primary oversight of the earthquake hazard identification and risk evaluation, and also has responsibilities on earthquake risk mitigation. DOGAMI has developed two earthquake loss models for Oregon based on the two most likely sources of seismic events: (1) the Cascadia Subduction Zone (CSZ), and (2) combined crustal events (500-year Model). Both models are based on HAZUS, a computerized program, currently used by the FEMA as a means of determining potential losses from earthquakes.

The CSZ event is based on a potential 8.5 earthquake generated off the Oregon coast. The model does not take into account a tsunami, which probably would develop from the event. The 500-Year crustal model does not look at a single earthquake (as in the CSZ model); it encompasses many faults, each with a 10% chance of producing an earthquake in the next 50 years. The model assumes that each fault will produce a single "average" earthquake during this time. Neither model takes unreinforced masonry buildings into consideration

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning purposes. Despite their limitations, the models do provide some approximate estimates of damage.

Below DOGAMI lists all counties in the state in the order of projected losses and damages (highest to lowest) based on the two models mentioned above. See Special Paper 29 for more information on these earthquake loss models, found at website:
http://www.naturenw.org/qs3/products.php?sku=001223.

Counties listed from highest to lowest based on projected losses and damages from a Cascadia Subduction Zone (CSZ) earthquake:

1. Multnomah
2. Lane
3. Coos
4. Washington
5. Marion
6. Benton
7. Lincoln
8. Josephine
9. Clatsop
10. Jackson
11. Linn
12. Curry
13. Clackamas
14. Douglas
15. Yamhill
16. Polk
17. Tillamook
18. Columbia

19. Klamath
20. Deschutes
21. Hood River
22. Jefferson
23. Grant
24. Gilliam
25. Harney
26. Lake
27. Umatilla
28. Baker
29. Crook
30. Malheur
31. Morrow
32. Sherman
33. Union
34. Wallowa
35. Wasco
36. Wheeler

Counties listed from highest to lowest based on projected losses and damages due to combined crustal events using a 500-year model:

1. Multnomah
2. Washington
3. Lane
4. Marion
5. Clackamas
6. Coos
7. Jackson
8. Benton
9. Linn
10. Klamath
11. Josephine
12. Lincoln
13. Clatsop
14. Yamhill
15. Douglas
16. Polk
17. Curry
18. Tillamook
19. Columbia
20. Deschutes

21. Umatilla
22. Hood River
23. Malheur
24. Lake
25. Wasco
26. Jefferson
27. Baker
28. Morrow
29. Union
30. Wallowa
31. Crook
32. Grant
33. Harney
34. Sherman
35. Wheeler
36. Gilliam

It should be emphasized that in the original 1999 DOGAMI study, the estimated statewide losses did not include tsunami-related losses. In the future, an updated HAZUS study should include the current population and infrastructure as well as losses from a tsunami. If the tsunami losses were included, the above 15 counties may be shifted to include coastal counties, such as Lincoln County.

Flood

Flooding is a natural phenomenon. Damage and loss of life occur when flood waters come into contact with the built environment or where people congregate. Flood can have secondary effects of causing streambank erosion and channel migration, or precipitating landslides.

Every Oregon County has suffered flood losses at one time or another. Some counties are more susceptible to both flood events and damages. To capture these differences in susceptibility DLCD created a countywide flood vulnerability index by compiling data from NOAA's Storm Events Database and from FEMA National Flood Insurance Program. Data were calculated statewide for the period 1978 through 2013 for five input datasets: number of events, structure and crop damage estimates in dollars and NFIP claims number and dollar amounts. The mean and standard deviation were calculated for each input. Then, each county was assigned a score ranging from 0 to 3 for each of these inputs according to Table xx.

Table XX: Scoring for vulnerability index

Score	Description
3	County data point is greater than 2.5 times standard deviation for the input dataset
2	County data point is greater than 1.5 times standard deviation for the input dataset
1	County data point is within standard deviation
0	No data reported

DLCD summed the scores for each of the five inputs to create a county-by-county vulnerability index. Since there were five input datasets, with a maximum score of 3 each, the maximum countywide score could be 15. The theoretical minimum score could be 0, but in fact all but one county had complete datasets, so the actual minimum score was 4.

A vulnerability index value over 5 indicates that one or more input variables exceeded 1.5 times the confidence limit for that input, meaning that the value exceeds the average value for that input. A score over 6 indicates that at least one variable significantly exceeds average values. Tillamook, Clackamas, and Columbia Counties received flood vulnerability scores of 11, 9 and 8 respectively indicating that two or more input variables in those counties significantly exceeded average values for the State, making these the most vulnerable to flood losses. Figure xx shows results overlaid onto annual rainfall amounts to convey the relationship between rainfall amounts and flood vulnerability. Public land areas were removed to show distribution of potential damage to the built environment, although analyses were conducted countywide. Not surprisingly, areas of, or downstream from, areas of high annual rainfall tend to be most vulnerable to flood damage. This appears to more true in the northern rather than southern Oregon coast, possibly because of higher intensity land use in the north.

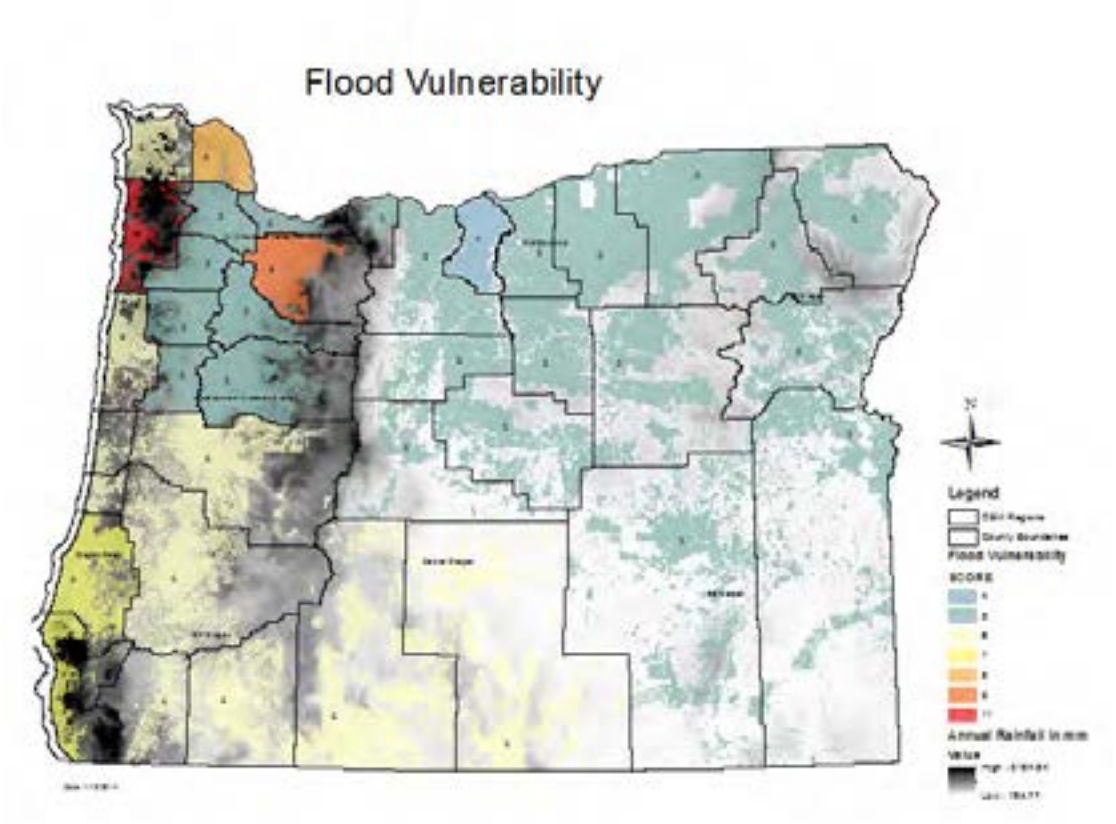


Figure 2-V-FL-1: Annual Rainfall Relationship to Flood Vulnerability

Source: DLCD

Most Vulnerable Communities

DLCD supplemented the countywide assessment of vulnerability by looking at cities that received the most NFIP claims by dollar amount and count. We also identified cities with a large proportion of their land area identified as Special Flood Hazard Area. Eight of the 10 cities with highest NFIP paid claims and number of claims are within the three most vulnerable counties (Clackamas, Columbia, and Tillamook). These three counties also have received the lion's share of mitigation grant funding since 19xx.

Table XX Top 10 vulnerable Counties as measured by NFIP claims

County	NFIP Claims Paid ($)	Population (2011)	Claim $ Per Capita	Unmitigated Repetitive Loss Buildings	Vulnerability Score
Clackamas	23282552	378,480	62	86	9
Columbia	19925386	49,625	402	17	8
Tillamook	12989179	25,255	514	163	11
Marion	5664119	318,150	18	25	5
Lincoln	5439319	46,155	118	108	6
Lane	3736028	353,155	11	71	6
Washington	3305600	536,370	6	12	5
Coos	2408653	62,960	38	28	7
Jackson	2334687	203,950	11	16	6
Clatsop	1824264	37,145	49	16	6

The top 10 vulnerable cities, as measured by amount paid on NFIP flood insurance claims, are shown on Table 2.x.xx. The Most Vulnerable Counties and cities within them are shown in bold type.

City	County	NFIP Claims Paid ($)	Population	$ Per Capita	Unmitigated Repetitive Loss Buildings
VERNONIA	**Columbia**	$13,733,794	2080	6603	2
TILLAMOOK	**Tillamook**	$7,551,192	4880	1547	17
LAKE OSWEGO	Multnomah/ **Clackamas**	$3,583,026	36760	97	0
SALEM	Marion	$3,390,250	156455	22	3
PORTLAND	Multnomah/ **Clackamas**	$2,581,748	586307	4	9
MILWAUKIE	**Clackamas**	$1,904,200	20435	93	6
WEST LINN	**Clackamas**	$1,886,683	25370	74	1
OREGON CITY	**Clackamas**	$1,467,600	32500	45	1
TUALATIN	Washington/ Clackamas	$1,390,381	26120	53	5
COOS BAY	Coos	$1,355,071	16060	84	6

The top 10 vulnerable cities, as measured by number of paid NFIP flood insurance claims, are shown on table 2.x The Most Vulnerable Counties and cities within them are shown in bold type.

City	County	Number of NFIP Paid Claims	Population	Per Capita	Unmitigated Repetitive Loss Buildings
VERNONIA	**Columbia**	223	2080	11%	2
PORTLAND	Multnomah/ **Clackamas**	198	586307	<1%	9
SALEM	Marion	190	156455	<1%	3
TILLAMOOK	**Tillamook**	180	4880	1%	17
LAKE OSWEGO	**Clackamas**	64	36760	<1%	0
MILWAUKIE	**Clackamas**	57	20435	<1%	6
SHERIDAN	Yamhill	57	6180	<1%	1
COOS BAY	Coos	56	16060	<1%	6
LINCOLN CITY	Lincoln	53	7965	1%	5
WEST LINN	**Clackamas**	52	25370	<1%	1

Cities with a high proportion of FEMA-defined Special Flood Hazard area within their city boundaries are shown in Table 2.x. The area of Special Flood Hazard Area within city limits for each NFIP city was estimated by calculating the area of the Special Flood Hazard Area minus bodies of water to estimate normally dry Special Flood Hazard Area within city limits. We assumed that highest population densities are in cities due to Oregon's requirement to site most residential development inside Urban Growth Boundaries. All of the cities identified in this analysis have small populations, however, and therefore don't help to identify a significant proportion of the population at risk from flooding. Only one of these cities is located in one of the three most vulnerable counties.

Table 2.7: Top 10 Cities by Percent Land Area in 1% Annual Flood Zone

City	County	Percent Normally Dry Land Area Within 1% Flood Zone	Population Portland State University, 2012 Annual Population Report Tables
Helix	Umatilla	70	190
Scio	Linn	62	830
Burns	Harney	52	2835
Warrenton	Clatsop	47	5090
Seaside	Clatsop	38	6550
Vernonia	Columbia	36	2080
Sheridan	Yamhill	36	6180
Ione	Morrow	34	330
Adams	Umatilla	33	365
Athena	Umatilla	33	1125

Source: DLCD (2014)

Estimated using area of Special Flood Hazard Area, excluding area below ordinary high water divided by area within city limits.

Severe Repetitive Losses

FEMA has identified 296 buildings in Oregon as repetitive loss (RL) properties.

The NFIP defines a repetitive loss property as any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period since 1978. At least two of the claims must be more than 10 days apart but within 10 years of each other. A repetitive loss property may or may not be currently insured by the NFIP.

In Oregon, RL properties represent about 1% of all insured properties, and account for about 14% of all claims paid (19% of the dollar amount paid). Most (80%) of Oregon's repetitive loss properties pre-date the FIRMs. [4] These properties are referred to as "pre-FIRM"; they were built in floodplains before FEMA FIRMs became available. Because of this, the property owners do not pay the true, actuarial cost of flood insurance. The RL lists provided by FEMA can have value for hazard mitigation planning because their locations may be indicative of persistent flood or drainage problems that may or may not be reflected on a FIRM.

RL properties in Oregon have suffered on average less than 3 losses each. FEMA reports counts for unincorporated Clackamas (26), Lane (22), Lincoln (37), Tillamook (37), and Washington (25) in the double digits[5]. Each of these counties also shows at least one severe repetitive loss (defined below). Of the cities, only the City of Tillamook shows RL buildings in the double digits. Together these counties and the one city account for over half of Oregon's repetitive losses. All of these counties and the one city are located all or part in Oregon's coastal region, suggesting where the State should focus future mitigation planning and project development. Any mitigation of repetitive loss buildings along the coast also should address exposure to tsunami hazards. Where both flood and tsunami are factors, buy-outs would seem to be an appropriate mitigation strategy.

Severe Repetitive Losses

A subset of repetitive loss properties, a severe repetitive loss property is a structure that:

(a) Is covered under a contract for flood insurance made available under the NFIP; and
(b) Has incurred flood related damage –

> (i) For which 4 or more separate claims payments have been made under flood insurance coverage with the amount of each such claim exceeding $5,000, and with the cumulative amount of such claims payments exceeding $20,000; or
> (ii) For which at least 2 separate claims payments have been made under such coverage, with the cumulative amount of such claims exceeding the market value of the insured structure.

[4] BureauNet, accessed 7/11/2014

[5] Ibid.

Oregon is fortunate to have few severe repetitive loss properties (Table 2.6). Four of the 11 buildings FEMA identified as Severe Repetitive Loss (SRL) properties are located in one the counties with identified as most vulnerable to flood damages.

The State's strategy for selecting properties for flood hazard mitigation projects is four-fold. It prioritizes projects that 1) are geographically balanced 2) are in communities with a FEMA-approved local hazard mitigation plan, 3) address properties with sustained substantial damages or repetitive losses, 4) provide communities with information and/or tools to evaluate properties suitable for mitigation, and to develop mitigation projects.

In 2013, the Oregon Department of Land Conservation and Development visited each of the FEMA-identified severe repetitive loss properties and assessed their mitigation potential. Contact has been made contact with the owners of homes located in Lane, Linn and Marion Counties, and one in Clackamas County. The Linn County home is expected to be acquired in 2014. Two properties in Tillamook County are pending SRL status.[6]

Table 2.6: Distribution of Severe Repetitive Flood Loss Properties by County

County	Number of Severe RFL Properties
Clackamas	3
Clatsop	1
Lane	1
Lincoln	2
Linn	1
Marion	2
Washington	1

Source: FEMA, June 2014

The majority of Oregon's 296 repetitive loss buildings appear to be residential structures, but DLCD has yet to examine assessor data for all of the repetitive loss buildings. Building type will be assigned to each RL property as part of the annual review described below.

The state, working with local jurisdictions, will verify the FEMA-provided repetitive flood loss information at least once during this plan's term and establish a priority ranking for properties that would benefit most from hazard mitigation by means of acquisition, relocation, elevation, or demolition. The state will maintain and review this list annually as a basis for selecting and funding hazard mitigation projects that directly benefit homeowners and businesses. The State has found that the RL list published by FEMA contains many geolocation errors, and in some cases the building has already been mitigated. Review of the repetitive lost list will be tied to the Flood Mitigation Assistance grant program guidance, updated annually. In addition, following a major disaster declaration, these properties could be pre-approved by FEMA for hazard mitigation using post-disaster mitigation funding from the Hazard Mitigation Grant Program.

[6] FEMA, June 2014

Once the repetitive loss list is verified, DLCD and OEM will analyze and summarize the information in a geographical information system to discover spatial patterns associated with repetitive losses. Results will be shared with jurisdictions in which repetitive loss structures are located, with the recommendation that the loss areas be addressed in local hazard mitigation plans as potential mitigation action items (in concept but not by specific property address). DLCD will provide NFIP communities that contain RL properties with the information necessary for them to identify and pre-qualify potential mitigation project opportunities that are cost-effective, environmentally sound and technically feasible. OEM will work with these communities in turning qualified potential projects into sub-grant applications.

In addition, Notice of Funding Availability letters will be sent directly to jurisdictions with validated RL and SRL properties when funding opportunities become available. Local jurisdictions are required to have a current FEMA-approved local hazard mitigation plan in order to be eligible to receive any FEMA funding.

Channel Migration

Channel migration vulnerability is not well understood at the state or regional level because no systematic identification of the hazard has been performed in Oregon.

Landslide

Landslides occur statewide in Oregon, although areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. In general, the coast and Coast Range Mountains and the Cascade Mountains have the most landslides. On occasion, major landslides occur on US or State Highways that sever these major transportation routes (including rail lines) causing temporary but significant economic damage to the state. Although less frequent, landslides and debris flows do occur that result in the death of people located in their paths.

Most Vulnerable Communities

The Department of Geology and Mineral Industries is the agency with primary oversight of the landslide hazard. Based on agency staff review of available hazard data, DOGAMI lists Clackamas, Linn, Douglas, Coos, Lane, Tillamook, Multnomah, Benton, Jackson, Clatsop, Lincoln, Marion, Washington, Curry, Columbia, Hood River, and Yamhill Counties as having the highest hazard and risk to landslide in the state. Because of their importance to the state's economy, landslides occurring in Multnomah, Clackamas, and Washington Counties present the greatest danger from this type of disaster. Landslides that close US Highway 101 or any of the many highways connecting the I-5 corridor to the coast have a significant effect on commerce in the Oregon Coast Region.

Currently, there is no method to evaluate statewide vulnerability to landslides. The communities listed above are primarily based on existing landslide inventory data in SLIDO-2. DOGAMI has performed landslide risk analysis of some individual communities in Oregon including Astoria, part of the HWY 30 transportation corridor, the Mt. Hood region, and parts of the Portland metro. The Mt Hood multi-hazard risk study provides details on the methods used to evaluate landslide and other hazard risk.

Burns, W.J., Hughes, K. B., Olson, K. V., McClaughry, J. D., Mickelson, K. A., Coe, D. E., English, J.T., Roberts, J. T., Lyles Smith, R. R., Madin, I.P., 2012. Multi-Hazard and Risk Study for the Mount Hood Region, Multnomah, Clackamas, and Hood River Counties, Oregon, Oregon Department of Geology and Mineral Industries, Open-File Report O-11-16

Tsunami

The entire coastal zone is highly vulnerable to tsunami impact. Distant tsunamis caused by earthquakes on the Pacific Rim strike the Oregon coast frequently but only a few of them have caused significant damage or loss of life. Local tsunamis caused by earthquakes on the Cascadia Subduction Zone (CSZ) happen much less frequently but will cause catastrophic damage and, without effective mitigation actions, great loss of life.

Because tsunamis in Oregon typically occur as a result of earthquakes, the unknown time and magnitude of such events adds to the difficulty in adequately preparing for such disasters. If a major earthquake occurs along the CSZ, a local tsunami could follow within 5 to 30 minutes. Although tsunami evacuation routes have been posted all along the Oregon Coast, damage to bridges and roadways from an earthquake could make evacuation quite difficult even if a tsunami warning were given. In addition, if a major earthquake and tsunami occur during the "tourist season," causalities and fatalities from these disasters would be far greater than if the same events occurred during the winter months.

It is also important to consider where the impact of a tsunami would be the greatest. Owing to relatively large resident and visitor populations located at very low elevations, cities facing the Pacific Ocean on the northern Oregon Coast are more vulnerable to inundation and have the greater potential for loss of life than coastal cities in central and southern Oregon. USGS estimated vulnerable populations using a tsunami inundation zone similar to the Medium CSZ event, which is the most likely event to occur. That study found that:

> (1) 22,201 residents and 10,201 households are in the zone, with the largest numbers in the northern coast;
>
> (2) the City of Seaside had the highest number of residents in the zone (4,790), (3) 7,912 residents (36% of all residents in the zone) are in unincorporated communities, the balance in 26 incorporated communities.[7]

Similar inventories are not yet available for the currently mapped DOGAMI tsunami inundaton zones, but the lower probability L, XL, and XXL CSZ inundation zones will impact more residents. Distant tsunamis, except for the most extreme events, will not affect significant numbers of residents, since they flood principally beaches and immediate waterfront areas. Loss of life from distant tsunamis will also be far less than for local tsunamis, because there will be at least four hours to evacuate prior to wave arrival rather than 15-20 minutes.

That said, visitors are more vulnerable than residents to both distant and locally generated tsunamis, because they are more likely to be at beaches and shoreline parks and are generally less aware of hazard response and preparedness. During the summer and holidays, visitors can greatly outnumber residents in the small coastal towns. While intensive education and outreach programs led by DOGAMI and OEM have greatly increased awareness and preparedness, residents are much more likely to have received this education than visitors.

[7] US Geological Survey Scientific Investigations Report 2007-5283.

The Oregon Resilience Plan (ORP) uses the impact of a "Medium" or "M" CSZ earthquake and tsunami for planning purposes, because this was judged the most likely CSZ event (see DOGAMI Special Paper 43 for explanation). The current regulatory tsunami inundation utilized by the Oregon Building Code to limit new construction of critical, essential, large occupancy, and hazardous facilities also uses a scenario similar to the "Medium" case. The ORP describes the "M" impact as follows:

> *Following the Cascadia event, the coastal communities will be cut off from the rest of the state and from each other. The coastal area's transportation system, electrical power transmission and distribution grid, and natural gas service will be fragmented and offline, with long-term setbacks to water and wastewater services. Reliable communications will be similarly affected. Because so many of these connecting systems are single lines with little or no redundancy, any break or damage requiring repair or replacement will compromise the service capacity of the entire line.*
>
> *The loss of roads and bridges that run north and south will make travel up and down the coast and into the valley difficult, if not impossible, due to the lack of alternate routes in many areas. Reestablishing the roads and utility infrastructure will be a challenge, and the difficulties will be exacerbated in the tsunami inundation area by its more complete destruction. Even businesses outside of the tsunami inundation may not recover from the likely collapse of a tourist-based economy during the phased and complicated recovery and reconstruction period.*
>
> *Based on the resilience targets provided by the Transportation, Energy, Communications, and Water/Wastewater task groups, current timelines for the restoration of services up to 90-percen toperational levels will take a minimum of one to three years, and often over three years in the earthquake-only zone. Restoration in the tsunami zone will take even longer than that... The most critical infrastructure is the road and highway system. Without functioning road systems, none of the infrastructure can be accessed to begin repairs.*
>
> *The tsunami will also create an enormous amount of debris that needs to be gathered, sorted, and managed. The recent experience of Japan, with a similar mountainous coastline, has shown that debris management competes with shelter and reconstruction needs for the same flat land that is often in the inundation zone.*

The ORP estimates that times for recovery of the coastal infrastructure for a Medium CSZ event will be as follows: Electricity and natural gas – 3-6 months, drinking water and sewer systems –1-3 years, and Healthcare facilities – 3 years. The ORP gives no estimate for times to recover police and fire stations or the coastal transportation system, but times for the latter would no doubt be measured in years. Economic recovery would also be many years, since much of the coast is dependent on tourism that is directly dependent on the transportation system. According to the ORP:

> *Even if a business had sufficient capital to relocate, it is unlikely that the tourist industry will recover rapidly enough to support business start-up. Local authorities may need to keep tourists out of the inundation zones, for safety reasons, for months or years after a tsunami.*

Most Vulnerable Communities

The entire coastal region is highly vulnerable to tsunamis, but some areas are more vulnerable owing to geographic and demographic factors. Oregon Emergency Management (OEM) is the agency with primary oversight of emergency response to the tsunami hazard. A 1990 revision of DOGAMI's enabling statutes added geologic hazard mitigation to its responsibilities, but other state agencies such as OEM and local governments share this responsibility. Based on agency staff review of the available hazard data, particularly estimates of Wood (2007) [5], OEM lists, Clatsop and Tillamook counties as having the highest hazard to tsunami in the state. As previously mentioned, Seaside is the most vulnerable town to tsunamis on the coast, but Gearhart, Cannon Beach, Rockaway Beach, Pacific City, Neskowin, Salishan Spit, Cutler City in Lincoln City, South Beach in Newport, and downtown Waldport are all extremely difficult to evacuate owing to local geographic factors (marshes or lakes limiting evacuation, long distances to evacuation routes, and limited high ground for evacuees) and significant percentages of retirees with limited mobility.

Vulnerability of communities is based primarily on difficulty of evacuation in the 15-20 minutes between a CSZ earthquake and arrival of the tsunami. A community is considered highly vulnerable if the population is large with high ground located a long distance away accessible by only a few routes that could be compromised by earthquake damage.

Volcano

Oregon's vulnerability to volcanic events varies statewide. The Cascade Mountains, which separate Western Oregon from Central Oregon, poses the greatest threat for volcanic activity. OEM Hazard Mitigation Regions that include the Cascade Mountains are most vulnerable to the effects of a volcanic event. Within the State of Oregon, there are several volcanoes that may pose a threat of future eruption. These include Mount Hood, which most recently erupted about 200 years ago, Newberry Volcano with recent eruptions about 1300 years ago, and the Three Sisters and Mount Jefferson with eruptions about 15,000 years ago. Eruptions from volcanoes in Washington State, like the Mount St. Helens eruption in 1980, can also significantly impact Oregon.

Most Vulnerable Communities

The Oregon Department of Geology and Mineral Industries (DOGAMI) is the agency with primary oversight of the Volcano hazard. Based on agency staff review of the available hazard data, DOGAMI lists Clackamas, Douglas, Deschutes, Hood River, Jackson, Jefferson, Klamath, Lane, Linn, Marion, Multnomah and Wasco counties as having the highest volcanic hazard in the state. Deschutes County is most vulnerable in the Central Oregon Region because the region's most populous city, Bend, is located here and the greatest numbers of "composite" volcanic mountains are located near the county's population centers. Klamath and Jefferson counties are also vulnerable within this region. Other regions are also vulnerable to damage from volcanic eruptions. If Mount Hood erupted, the Northern Willamette Valley/Portland Metro Region and the Mid-Columbia Region would both be impacted. Because of Mount Hood's proximity to Portland, the Columbia River, the I-84 freeway, and major dams on the Columbia River, the potential for a large disaster exists.

Little has been done to evaluate risk to volcanoes. One of the first studies to evaluate risk for the Mount Hood region was by Burns and others (2011)(Figures 2-V-V-1 and 2-V-V-2; and Table 2-V-V-3). The main purpose of this study was to help communities on or near Mount Hood become more resilient to geologic hazards by providing accurate, detailed, and up-to-date information about the hazards and the community assets at risk. A second purpose was to explore hazard and risk analysis methodologies that would be applicable to other volcanic areas. The study examined volcano, landslide, flood, channel migration, and earthquake hazards on Mount Hood, along Highway 26 and the Sandy River Corridor, and along Highway 35 and the Hood River Corridor (Figure 2-V-V-1). Two types of risk analysis were performed: 1) hazard and asset exposure, and 2) HAZUS-MH (FEMA, 2005). The figure and table below are a summary of volcano and community asset exposure for the study area.

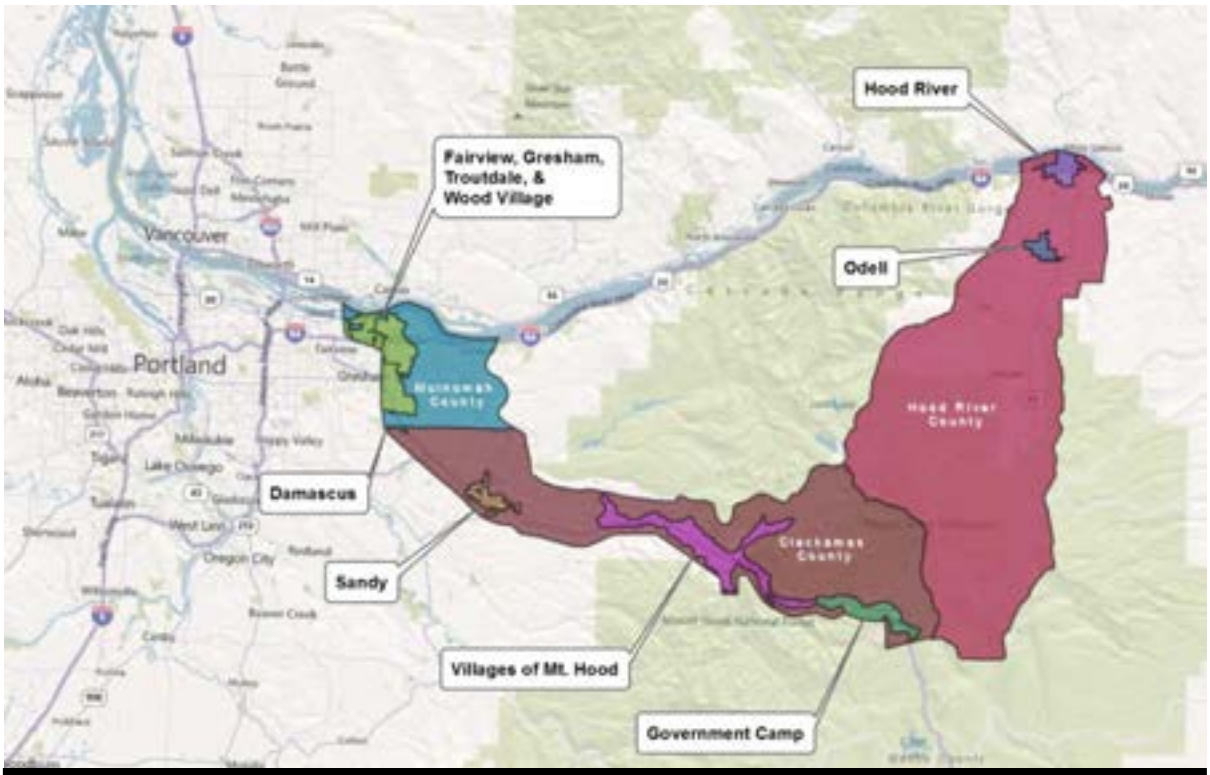


Figure 2-V-V-1: Mount Hood risk study project area.

Source: DOGAMI

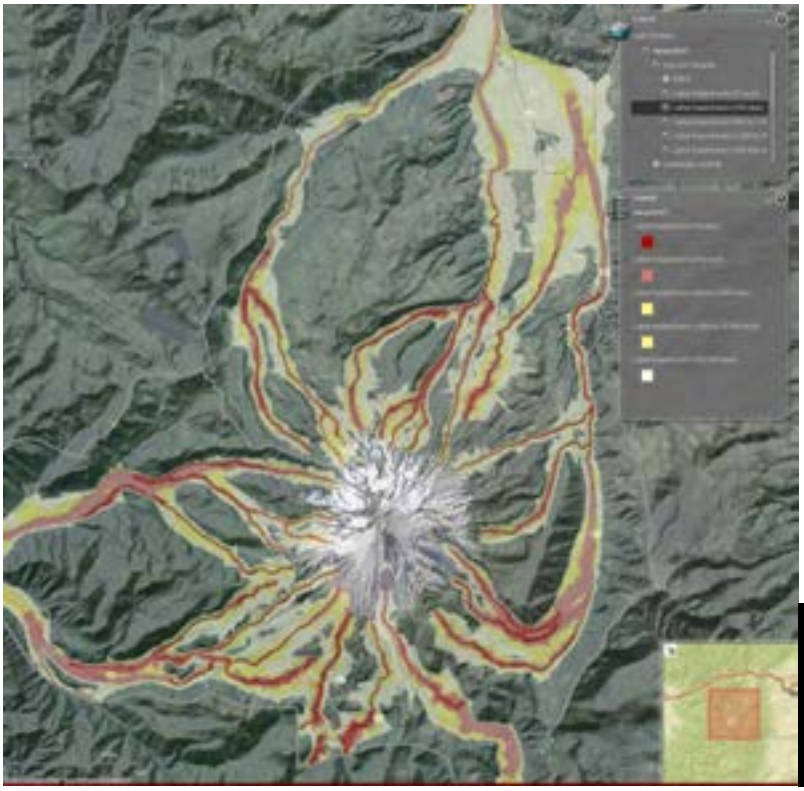


Figure 2-V-V-2: Interactive web map for Mount Hood risk study.

Source: DOGAMI. Map found at website: http://www.regongeology.org/MtHood/

This study also found approximately 5,000 people are located in the 500-year volcano hazard zones, which is a large amount of people to evacuate in an event. Although the report estimated 6% to 22% of the total study area community assets will be damaged or lost, this percentage is significantly more within some individual communities, especially The Villages at Mt Hood. Both risk methods resulted in ranges of percent damage and losses that appear reasonable. For example, we found 11% to 34% loss ratios for the volcano exposure method and 5% to 35% loss ratios for the HAZUS-MH volcano analyses are all in the same approximate range of 10% to 35%. The report estimates the loss ratio for the 500-year volcano hazard to be approximately 18% for the study area from these ranges of percent loss from the various portions of the two risk analyses.

Table 2-V-V-1: Summary of Community Asset Exposure to Volcano Hazards for Mount Hood

	Population	Buildings (Building Count/$Value)	Generalized Land Use/ Zoning Parcels (Count/$Value)	Critical Facilities	Primary Infrastructure – Roads (miles)
Proximal	2129	1,604 / $242 million	2,995 / $208 million	8	287
Lahar 10-year	163	120 / $32 million	520 / $19 million	0	22
Lahar 100-year	473	531 / $92 million	1,633 / $71 million	0	91
Lahar 500- to 10,000-year	3,843	3,731 / $663 million	7,120 / $402 million	7	271
Lahar 100,000-year	14,635	9,897 / $1,510 million	13,082 / $1,364 million	21	525

Source: DOGAMI, Burns and others, 2011

Wildfire

Wildfires are a common and widespread natural hazard in Oregon. Fire is a critical component of the forest and rangeland ecosystems found in all portions of the state. Over 41 million acres of forest and rangeland in Oregon are susceptible to wildfire, which may occur during any month of the year, but usually occur between July and October. In addition to wildland-urban interface(WUI) fires, Oregon experiences wildland fires that do not threaten structures, and also occasionally has prescribed fires. The principal type of wildfire affecting Oregon communities is the interface fire, which occurs where wildland and developed areas intermingle with both vegetation and structures combining to provide fuel. As more people have moved into WUI areas, the number of large wildfires impacting homes has escalated dramatically.

Most Vulnerable Communities

In 2006, the Oregon Department of Forestry conducted a Statewide Forest Assessment of the communities at risk to wildfire to determine priorities for delivering landowner assistance. The parameters of this assessment included high priority fish and wildlife habitat, potential for forest conversion, and communities at risk to wildfire. The communities at risk to wildfire component will be used to characterize the wildfire hazard in this Plan.

A community was defined as a geographic area within and surrounding permanent dwellings with basic infrastructure and services, under a common fire protection jurisdiction, government, or tribal trust or allotment, for which there is a significant threat due to wildfire. The 2006 communities at risk assessment first evaluated landscape wildfire risk based on ignition risk, fuel loading and hazard, suppression capability, and values at risk (population, municipal watersheds, commercial timber); and then evaluated community risk as a function of the surrounding landscape risk ratings.

Of the 595 identified community areas in Oregon, 159 (27%) face a HIGH risk from wildfire and 331 (56%) faced a moderate threat. Although the majority of OEM Hazard Mitigation Regions in Oregon have at least one high risk community, the majority are concentrated in Regions 4 and 6. In Region 4, Douglas County had the highest *absolute* number of high risk communities with 33, and Jackson County had the highest percent of communities facing high risk (all 22 identified communities). In Region 6, Deschutes County recorded the second highest percentage with 10 out of 12 identified communities facing high risk of wildfire.

An update to the 2006 statewide wildfire assessment is currently underway. The update is a part of a regional wildfire assessment referred to as the West Wide Risk Assessment (WWRA) to assess wildfire risk in 17 western states. The WWRA uses indices (Fire Risk, Fire Threat, Fire Effects) as well as Ratings (Values Impacted, Suppression Difficulty) to generate a composite assessment of wildfire vulnerability and risk. Although the WWRA is complete, Oregon is in the process of scaling the assessment to the state level, so the complete data set for Oregon is not available at this time. A complete wildfire hazard and vulnerability analysis using the WWRA will be available for the next Oregon NHMP update.

Preliminary maps from the WWRA were used in the critical and essential infrastructure analysis. In addition, preliminary hazard and exposure summary statistics from the WWRA for the state of Oregon are as follows:

- 22% of burnable acres in the state have a Moderate-to-High wildfire risk
- 56 million burnable acres across the state (90% of all lands)
- 751,672 people are living at risk to wildfire within Wildland Development Areas
- 27.6 million acres of forest assets are at risk to wildfire

With respect to structures and population density, communities that were evaluated for wildfire risk were either rural (consisting of 1 to 3.9 dwellings per 40 acres and a population density of 28 to 111 people per square mile), suburban (consisting of 4 to 19.9 dwellings per 40 acres and a population density of 112 to 559 people per square mile) or urban (consisting of 20 to 99 dwellings per 40 acres and 560 to 1,371 people per square mile). Highly urbanized areas (100 or more dwellings per square mile and 1,372 or more people per square mile) were excluded.

Factors that contributed to a community being rated as at high risk from wildfire were as follows:

Ignition Risk – A high risk rating was given when fire occurrence exceeded 1 fire per 1,000 acres over 10 years.

Fuel Loading and Hazard – A high risk rating was based on a composite rating based on the following (percents indicate weight each factor is given to the composite rating):

Weather (25%) – The weather risk rating is based on the number of days per season that forest fuels were capable of producing a significant wildfire event as determined by an analysis of daily fire danger rating indices for regulated use areas across Oregon. All of eastern Oregon and interior southwest Oregon are high weather risk.

Slope, Aspect and Elevation (12%) – Slopes greater than 40 percent with south facing aspects at elevations at or below 3,500 feet all contribute to high risk.

Fuels (30%) – Forest fuels that result in fire behaviors of flame lengths exceeding 8 feet; frequent spotting, torching, or crowning such that fire severity is stand replacing. Example fuel conditions include flammable grasses, heavy/flammable brush, and mature timber with slash.

Insect and Disease Damage (20%) – A high risk rating was given for forested areas exhibiting at least 3 dead trees per acre from insect and disease; or at least 3 consecutive years of defoliation from the spruce budworm, as determined by the statewide aerial insect and disease survey.

Fire Regime Condition Class (13%) – Fire regime condition class is a measure of forest conditions that are outside the range of natural variability in fuel conditions as result from increased tree stocking and fuel build-up resulting from fire suppression. Lodgepole pine forests are the exception as they can exhibit a high Fire Regime Condition Class rating even though the conditions are within their range of natural variability. Forests with the high risk Fire Regime Condition Class rating exhibit

excessive surface fuels, brush, live and dead mid-canopy or ladder fuels as well as canopy fuels in standing dead and overstocked mature trees. Wildfire under these forest conditions are likely to develop in severe crown fires.

Suppression Capability – Areas at high risk have no organized fire suppression response capability. Areas at moderate risk have wildland forest suppression response, but structural response within 10 minutes is limited.

Values at Risk – High values at risk were defined by population and dwelling densities (urban and highly urbanized), forests containing municipal watersheds and forests managed for wood production.

In summary, the perfect storm for a community at the highest risk of wildfire would be an urban community within interior southwestern or eastern Oregon surrounded by forests of low elevation on south facing slopes exceeding 40 percent in slope; containing high amounts of surface and ladder fuels arising from insect and disease mortality as well as the exclusion of fire due to fire suppression efforts; with little or no organized wildfire suppression capability. On average, 96% of the fires are suppressed at 10 acres or less. Unfortunately, the remaining 4% of the fires tend to be damaging and very difficult to suppress.

Windstorm

The damaging effects of windstorms may extend for distances of 100 to 300 miles from the center of storm activity. Isolated wind phenomena in the mountainous regions have more localized effects. Near-surface winds and associated pressure effects exert loads on walls, doors, windows, and roofs, sometimes causing considerable damage. When severe windstorms strike a community, downed trees, power lines, and damaged property are major hindrances to response and recovery.

Most Vulnerable Communities

The Oregon Coast has several relatively harsh storms during the winter months. Although major damage from these storms is infrequent, the Oregon Coast Region of the state is the most vulnerable to windstorms. The seven coastal counties in the Oregon Coast Region often face 60 to 100 mile an hour winds sometime during the year. While the coast is experiencing severe winds, the Willamette Valley may also face 40 to 60 mile per hour winds from the same storm. Also, the Columbia River Gorge funnels very strong winds, often from east to west. The Northern Willamette Valley/Portland Metro and Mid-Columbia Regions are most vulnerable to this type of wind event.

Major windstorms that can impact large areas of the state, like the Columbus Day windstorm of 1962, are relatively rare. These storms can cause major damage to many areas of the state with the Oregon coastal counties typically suffering the most damage from this type of hazardous event.

The PUC is the entity with primary oversight over the windstorm hazard. PUC lists Benton, Clatsop, Coos, Columbia, Curry, Douglas, Gilliam, Hood River, Lane, Lincoln, Linn, Marion, Morrow, Multnomah, Polk, Sherman, Tillamook, and Washington as the most vulnerable to damage and loss associated with windstorms. The Oregon Climate Service (OCS) and Oregon Climate Change Research Institute (OCCRI) provides weather and climate support.

The identification of communities most vulnerable to windstorms is based on PUC agency staff and OCCRI/OCS staff review.

Winter Storm

A major winter storm can last for days and can include high winds, freezing rain or sleet, heavy snowfall, and cold temperatures. People can become marooned at home without utilities or other services. Severe cold can cause much harm. It can damage crops and other vegetation and freeze pipes, causing them to burst. Unusually cold temperatures are especially dangerous in areas not accustomed to them because residents are generally unprepared and may not realize the dangers severe cold presents.

Figure WS-8: Trucks wait at a truck stop in Troutdale after ice, wind, and snow caused ODOT to close Interstate 84 through the Columbia River Gorge – January 2004
Photo source: William Hamilton, The Oregonian

Heavy snowfall and blizzards can trap motorists in their vehicles and make walking to find help a deadly mistake. Heavy snow can immobilize a region and paralyze a city, stranding commuters, closing airports, stopping the flow of supplies, and disrupting emergency and medical services. Accumulations of snow can cause roofs to collapse and knock down trees and power lines. Homes and farms may be isolated for days. In rural areas, unprotected livestock can be lost. In urban areas, the cost of snow removal, damage repair, and lost business can have severe economic impacts.

When an ice storm strikes, some landscape trees seem to be able to come through with only minor damage, while others suffer the loss of large limbs or sizable parts of their branching structure. In the worst cases, trees may be completely split in two or may have nothing left standing but a trunk. If a tree has been weakened by disease, there may be little that can be done to prevent major breakage or loss when the stresses of a storm occur. However, there are preventive measures that cities and property owners can take to help their trees be stronger and more resistant to storm damage. For more information, see Appendix X: Reducing Ice Storm Damage to Trees.

Heavy accumulations of ice can bring down trees and topple utility poles and communication towers. Ice can disrupt power and communication for days while utility companies repair extensive damage. Even small accumulations of ice can be dangerous to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces.

Exposure to cold can cause frostbite and life-threatening hypothermia. Frostbite is the freezing of body tissue. It most frequently affects fingers, toes, earlobes, and the tip of the nose. Hypothermia begins to occur when a person's body temperature drops three degrees below normal temperature. On average, a person begins to suffer hypothermia if his or her temperature drops to 96 degrees F (35.6 degrees Celsius). Cold temperatures can cause hypothermia in anyone who is not adequately clothed or sheltered in a place with adequate heat. Hypothermia can kill people, and those who survive hypothermia are likely to suffer lasting ill effects. Infants and elderly people are the most susceptible. Elderly people account for the largest percentage of hypothermia victims, many of whom freeze to death in their own homes. Most of these victims are alone and their heating systems are working

improperly or not at all. People who take certain medications, who have certain medical conditions, or who have been drinking alcohol also are at increased risk for hypothermia.

Driving can be tricky in the snow, but once a storm has passed, there is another danger: flying snow from trucks and cars. When snow is warmed by the vehicle, it will begin to melt. Wind and motion cause sections to break off and hit other vehicles. The snow can also fall on the road, melt, and later turn into ice.

Winter storms are considered deceptive killers because most winter storm deaths are related only indirectly to the storms. Overall, most winter storm deaths result from vehicle or other transportation accidents caused by ice and snow. Exhaustion and heart attacks brought on by overexertion are two other common causes of deaths related to winter storms. Tasks such as shoveling snow, pushing a vehicle, or even walking in heavy snow can cause a heart attack, particularly in people who are older or who are not used to high levels of physical activity. Home fires occur more frequently in the winter because people do not take the proper safety precautions when using alternative heat sources. Fires during winter storms present a great danger because water supplies may freeze and it may be difficult for firefighting equipment to get to the fire. In addition, people can be killed by carbon monoxide emitted by fuels such as charcoal briquettes improperly used to heat homes.[8]

One issue concerns the fact that there is not a statewide effort regarding Winter Storm impacts, either historical or for future planning. There are only limited snow fall sensors distributed mainly through the mountain ranges of the state and there is not an annual tracking system in place for snow fall statewide. A program of statewide snow fall sensors would allow us to better understand the impact of Winter Storms on Oregon and have a better means of predicting potential impacts in the future.

Most Vulnerable Communities

The Oregon Department of Transportation (ODOT) is the agency with primary oversight of the Winter Storm hazard. Based on agency staff review of the available hazard data, ODOT lists the Northern Willamette Valley (Linn, Benton, Marion, Polk and Yamhill Counties); the Portland Metro Region (Columbia, Washington, Multnomah and Clackamas Counties); and the Mid/Southern Willamette Region (Lane, Douglas, Josephine and Jackson Counties) as the most vulnerable to damage and loss associated with winter storms because Oregon's most densely populated cities are located within these regions.

The Portland metropolitan area is the most vulnerable not only because it is the most densely populated but also because of its proximity to the Columbia River Gorge. It is not uncommon to have severe ice and sleet storms occurring as cold artic winds blow down the Gorge over east Multnomah County and Portland. These storms have delayed air traffic and even closed the Portland International Airport in the past, thus negatively affecting Oregon's economy. Winter storms often bring ice and sleet that makes driving extremely dangerous. Ice and sleet storms can cripple the movement of goods and services, thus negatively impacting Oregon's economy.

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[8] From *Talking About Disaster: Guide for Standard Messages*, produced by the National Disaster Education Coalition, Washington, D.C., 2004

National Weather Service Winter Storm reports were used as the basis for determining community vulnerabilities. Unfortunately there is only the NWS storm information available for analysis. There is no statewide Winter Storm program to study the impacts of these storms statewide. There is no program to identify annual average snow falls across the state either historical or for planning purposes. Hydrological precipitation information is available but not winter storm and snow fall information.

Local and State Vulnerability Assessment Comparison

Past iterations of the Oregon NHMP stated local and state vulnerability "rankings" separately. No comparison or analysis of similarities and differences among the methods was conducted. For this update, the state placed local and state vulnerability "rankings" side-by-side to identify if and where similarities and differences occur. Following is a summary of basic similarities and differences in these methods as well as in the vulnerability "rankings".

While local risk assessments are standardized and state risk assessments vary from hazard to hazard, there are similarities among these methods. First, in all of these assessments historical events are identified and are the basis upon which probability of future hazard events occurring is determined. Second, based on best available data, vulnerability to each hazard is identified at the local or state scale respectively.

On the other hand, *how* local and state assessments identify vulnerability varies greatly from local to state, as well as across all hazards at the state level. As described on pg XX, local assessments use the OEM Hazard Analysis Methodology that ranks vulnerability to each hazard based on the estimated the percentage of population and property likely to be affected. The "ranking" of vulnerability is based on local knowledge, and is therefore somewhat subjective. This methodology identifies which hazards are priorities at the local level.

As described in the preceding section of this Plan, for the state assessment, each hazard lead assesses vulnerability based on best available data. For some hazards– such as flood, earthquake and tsunami – a significant amount of data is available and supports detailed damage and loss estimates. Projected damages and losses help the state identify which communities are most vulnerable to each hazard. Hazards for which there is limited data available undergo a less rigorous assessment, and identifying which communities are most vulnerable may be more challenging. Each hazard lead is an expert on that particular hazard. Hazard lead knowledge with some combination of research, literature and agency knowledge form the factual basis for each state hazard risk assessment accompanied by some level of subjectivity.

While local and state risk assessment methods are inherently different, there is added value in comparing findings from both. All methods identify hazard priorities. Local assessments identify the hazards to which each community believes they are most vulnerable. State hazard leads identify which communities are most vulnerable to each hazard compared to other communities. These assessment rankings are intended to guide local and state mitigation goals and actions which inform mitigation priorities for local and state NHMPs.

Table 2-V-3 shows a side-by-side comparison of local and state vulnerability rankings. Symbols in this table are defined as:

Local	**State**
H= High Vulnerability	MV= Most Vulnerable Community (as identified by all hazard leads)
M= Moderate Vulnerability	V= Vulnerable Community (as identified by *some* hazard leads)
L= Low Vulnerability	

This side-by-side comparison indicates similarities and differences between local and state vulnerability rankings. For some counties, local and state assessments agree there is a high level of vulnerability to a

hazard, as indicated by both an “H” (high vulnerability) and a “MV” (Most Vulnerable) rankings by local and state assessments respectively. In other instances, local and state rankings are not in sync. For example, a county that did not score itself for a hazard (indicating it is not at risk to that hazard), or scored itself “L” (as having low vulnerability) to a hazard; and the state ranked that county as one of the “MV” (most vulnerable) counties to that hazard.

Time did not permit for an analysis of this table to be conducted during this Plan update cycle. For the purposes of this update, a side-by-side comparison is the extent to which the state is able to address these inconsistencies. However, the state is in the process of exploring what these findings mean and how Oregon can better align local and state risk assessments to identify its most vulnerable communities.

In April 3014, The Department of Land Conservation and Development (DLCD) presented a version of this table at the Oregon Prepared Conference to emergency managers and others involved with LNHMP updates. This presentation initiated a local-state discussion about risk assessments in Oregon; how to enhance the Plan update process at the local level; and how state hazard experts can better inform local jurisdictions on statewide hazard data.

This table will also be presented to the State Interagency Hazard Mitigation Team (IHMT) for feedback on how to best initiate a two-way information sharing dialogue between local and state entities that perform risk assessment updates for NHMPs. Between the 2015 and the next Oregon NHMP update the state will facilitate these discussions. The state is also identifying ways to incorporate this discussion into statewide conferences and trainings.

Table 2-V-3: Local and State Vulnerability Rankings by County

	Coastal Erosion		Tsunami		Drought		Dust Storm		Earthquake		Volcanic		Landslide		Wildfire		Flood		Wind Storm		Winter Storm	
County	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*	*Local*	*State*
Baker					H	MV	M	V	M	V	L		M	MV	H		M		H	V	H	
Benton					L				H	MV	L		L	MV	M		M		M	MV	M	MV
Clackamas					L				H	MV	H	MV	L	MV	M		M	MV	L	V	M	MV
Clatsop	H	MV	H	MV	M				H	MV	M		H	MV	H		H	V	H	MV	H	
Columbia					M				H	V	H		M	MV	M		M	MV	H	MV	H	MV
Coos	M	V	H	MV	M				H	MV	M		M	MV	M		H	V	H	MV	H	
Crook					H		L		L	V	H		L	MV	M	V	H		M	V	M	
Curry		MV	H	MV					H	MV	H		L	MV	H		H	V	H	MV		
Deschutes					L			V	M	V	H	MV			M	MV	L		L	V	H	
Douglas - Central									M	MV		MV	M	MV	H	MV	H		M	MV	H	MV
Douglas - Coastal	L		H	MV					H	MV			M	MV	M		M		M	V	M	
Gilliam					H	MV			M	V	M		M		M		M		L	MV	H	
Grant					H				M	V	L		M	MV	H		H			V	H	
Harney					M			V		V				MV	M		M	V	L	V	M	
Hood River					H				M	V	L	MV	M	MV	M		M		H	MV	H	
Jackson					M				H	MV	L	MV	L	MV	M	MV	M		H	V	H	MV
Jefferson					H			V	L	V	H	MV	L		H	V	M			V	H	
Josephine									H	MV				MV	M	V	M		H	V	H	MV
Klamath					M	MV		V	M	MV	L	MV		MV	L	V	M			V	M	
Lake					H			V	H	V	H		L		M	V	M		M	V	H	
Lane - Central					M				M	MV	M	MV	L	MV	M		H		M	MV	H	MV
Lane - Coastal		V	H	MV					H	MV			M	MV	L		H		H	V	L	
Lincoln		MV	M	MV	L				M	MV	L			MV	M		L	V	H	MV		
Linn									H	MV	H	MV		MV	M		H	V	M	MV	H	MV
Malheur					H	MV	L	V	M	V	M		M	MV	M		H		M	V	M	
Marion									H	MV	M	MV		MV	M		M	V	H	MV	H	MV
Morrow						MV	M	MV	H	V			M		M		H	V	M	MV	H	
Multnomah									H	MV	H	MV	M	MV	M		H	V	H	MV	H	MV
Polk									H	V	M				M		H		H	MV		MV
Sherman					M	MV			L	V	L		M		M		M		M	MV	M	
Tillamook		MV	H	MV	L		L		H	V	M		H	MV	H		H	MV	H	MV	H	
Umatilla								MV	M	V					M		M	V	H	V	H	
Union					M		M	V	M	V			M	MV	M		M		H	V	H	
Wallowa					H				M	V	L		M		H		H		H	V	H	
Wasco					H			V	M	V	L	MV	M	MV	M		L		H	V	H	
Washington					M				H	MV	H		L	MV	M		H	V	H	MV	H	MV
Wheeler									M	V				MV	H	V	M			V	H	
Yamhill					H				H	MV			M	MV	L		H	V	M	V	H	MV

Source: DLCD and OEM

State-Owned and Leased Facilities and Critical and Essential Facilities Exposure Assessment

Requirement: 44 CFR §201.4(c)(2)(ii): Th[e] risk assessment shall include… (ii) (s)tate owned or operated critical facilities located in the identified hazard areas shall also be addressed.

Requirement: 44 CFR §201.4(c)(2)(iii): Th[e] risk assessment shall include… (iii) (a)n overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

According to the Oregon Department of Administrative Services (DAS), the State of Oregon owns or leases buildings having a total value of over $7.3 billion. Because of this investment it is important the State assess the vulnerability of these structures to Oregon's natural hazards, including landslides, floods, volcanic hazards, tsunamis, earthquakes, wildfires, and coastal erosion. The Oregon Department of Geology and Mineral Industries (DOGAMI) assembled the best-available statewide natural hazard data and assessed which state-owned/leased buildings are exposed to each hazard. Data to support this level of analysis was available for the follow hazards: coastal erosion, earthquake, flood, landslide, tsunami, volcano, and wildfire.

Most building data were carried forward from the 2012 Oregon NHMP assessment of state-owned/leased buildings. For the 2015 assessment, this building data (originally digitized by DOGAMI from DAS-supplied spreadsheets) was updated with DAS deletions and additions current as of 2013. Because of imprecise, incomplete, or ambiguous addresses, 205 lower-value entries in the "additions" spreadsheets were not digitized in this study. This amounts to nearly $28 million worth of property, though only about $17 million is within Oregon state boundaries; at least $11 million of that total is located in Utah, Texas, or Washington and therefore outside the bounds of this analysis.

Notably, the DAS building data does not identify "critical and essential" facilities. So, DOGAMI identified indicative descriptors found within building names and usage descriptions (e.g. armory, haz-mat storage, hospital, communication tower, etc.) and identified those facilities critical/essential . It is also important to note this assessment is based on limited data. The DAS buildings list is of variable quality and completeness. Facilities for which there were missing or incomplete address/location information, uncertain matches to older building data, missing or vague names, or locations outside of the State of Oregon were not used in this update.

The DAS database lists 5,693 state facilities owned or leased by 122 state agencies. DOGAMI used the DAS list to locate facilities using Geographic Information Systems (GIS). Figure FAC-V-1 shows the distribution of these 5,693 state-owned/leased facilities within Oregon Emergency Management (OEM) Natural Hazard Mitigation Regions.

Critical and essential facilities not owned or leased by the state are in each map developed for this analysis. These facilities were carried forward from an earlier DOGAMI project to locate critical and essential facilities such as military facilities, schools, communication towers, police and fire stations,

hospitals, etc. These facilities were located and digitized by DOGAMI. Critical and/or essential facilities were defined using criteria developed by FEMA and the International Building Council. Facilities were located and digitized from a variety of sources including FEMA, the US Department of Transportation, DAS, the Oregon Office of Emergency Management, the Oregon Department of Transportation, and others. However, since no property values are included in this data, and they are not owned or leased by the state, they are not included in property value.

Hazard Data Limitations

This assessment evaluates each hazard individually; there are no comprehensive or multi-hazard assessments. In order to prioritize facilities most vulnerable facilities to natural hazards, DOGAMI categorized most hazards with simple classification schemes (most commonly “High”, “Moderate”, “Low”, or “Other”). For each hazard “Other” is used to describe very low hazard areas, unmapped and/or unstudied areas, or zero hazard zones (this is further defined in each of the hazard descriptions below).

Statewide natural hazard data are generalized in several ways and provide a gross view of their distribution and magnitude across the state. They are often combined or derived from other data sources that themselves can have widely different quality, accuracy, attribution, or currency. Future investigations or actual hazard events may substantially modify our understanding of where and when natural hazards might occur.

Last, it is worth noting that building-specific information can make an enormous difference when evaluating the actual damaging effects of natural hazards. For example, a modern seismically-reinforced building may receive far less or no earthquake damage relative to older un-reinforced buildings next door. This study evaluates which facilities are *exposed* to certain natural hazards and, due to data and time limitations, makes no attempt to account for site-specific characteristics.

Oregon Emergency Management Hazard Mitigation Regions

State Owned/Leased Facilities
Critical/Essential Facilities

Property Value Statistics within All Hazard Areas				
Region	# of state owned/leased critical/essential facilities (☆)	# of non-state owned/leased critical/essential facilities (★)	# of state owned/leased non-critical/essential facilities (▪)	Total property value of state owned/leased facilities (☆ , ▪)
1	33	1082	1084	$336,073,104
2	36	696	2806	$1,002,513,064
3	67	1608	2838	$4,277,693,803
4	20	380	1091	$164,409,632
5	29	485	1623	$744,388,079
6	46	844	805	$371,339,811
7	26	335	288	$139,508,917
8	19	183	236	$302,954,349
Grand Total	276	5413	10771	$7,338,880,759

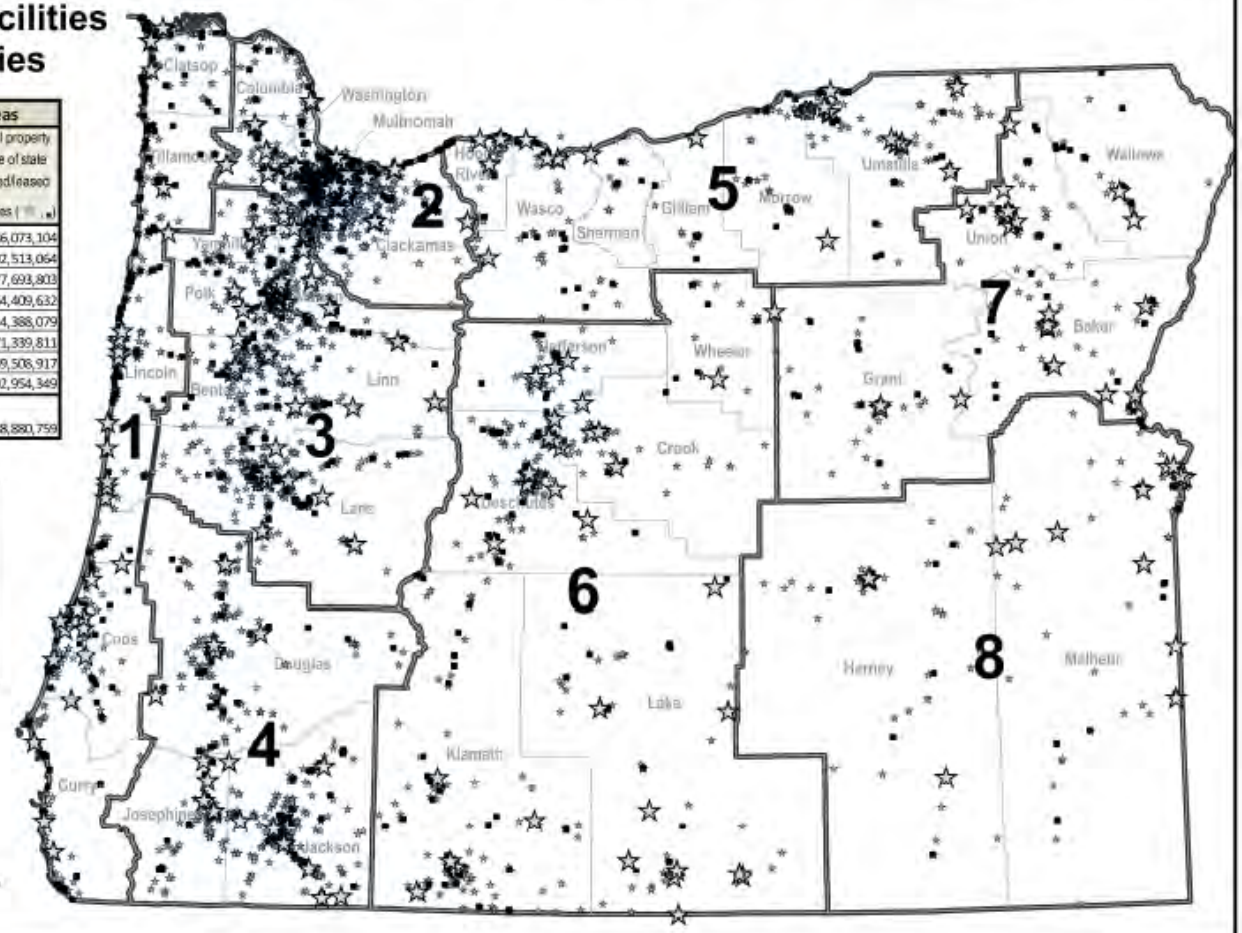


Figure 2-V-FAC-1: Statewide Distribution of State Owned/Leased Facilities and Critical/Essential Facilities

Source: DOGAMI

State Owned/Leased Facilities and Critical/Essential Facilities Within Hazard Areas

The spatial distribution of the facilities in this analysis is not easily viewed on a statewide map. Therefore, maps depicting hazard zones and facilities within those zones have only been created at the regional scale. Those maps can be found later in this Plan, in the Regional Risk Assessment, beginning on page XX.

Coastal Erosion

DOGAMI used the results from several of their coastal erosion studies to develop a coastal erosion hazard zone for this analysis. However, this data does not cover the entire Oregon coastline: coastal erosion hazard zones have not been created for Lane, Douglas, and Coos Counties, and only partial data coverage exists for Curry County. To address these data gaps, DOGAMI excluded those portions of the coast from the analysis, using a 0.5km buffer of the coastline to delineate an "other" value. In areas where mapping exists, the hazard is mapped as Active, High, Moderate, or Low Hazard Zones which, for the purposes of this analysis, were simplified to "High" (encompassing Active and High), "Moderate", and "Other" (encompassing Low hazards and unmapped areas). The Low hazard zones incorporate hypothetical landslide block failures assumed to fail in the event of a M9 Cascadia earthquake and were placed under "Other" due to their very low probability. All other areas of the state received a None attribute.

Coastal Erosion Hazard Facility Summary

Of the 5,693 facilities evaluated, 33 are currently located within a coastal erosion zone representing a value of approximately $7 million. Table 2-V-FAC-1 shows all 33 state owned facilities located within a coastal erosion hazard zone. One of the 33 (ODOT Cape Perpetua Radio building) is identified as a critical or essential facility.

Coastal Erosion Data Limitations

1. Erosion rates used to estimate widths of hazard zones are based on interpretation of a relatively short historical series of aerial photography (1939 to present) and very limited lidar data acquired before 2008. Photos were georeferenced but not necessarily orthorectified and spatial locations may have considerable error.
2. Coastal erosion hazard zones have not been created for Lane, Douglas, and Coos Counties, and only partial data coverage exists for Curry County. Therefore, state owned facilities along the coastline in these areas are not accounted for in this study.

Recommended Data Improvements

As previously stated, the coastal erosion hazard dataset used the best available data from detailed studies conducted by DOGAMI. However, this data does not cover the entire coastline and outside of very small, specific areas, the overall coastal erosion hazard in Lane, Douglas, Coos and Curry counties is undetermined. Therefore, DOGAMI recommends conducting detailed coastal erosion studies on a case-by-case basis within these counties. This recommendation should be included as a specific action item in this Plan.

Table: 2-V-FAC-1: State Owned/Leased facilities and Critical/Essential Facilities in a Coastal Erosion Hazard Zone

Region	# of State Owned/ Leased Critical/ Essential Facilities	# of Non-State Owned /Leased Critical/ Essential Facilities	# of State Owned/ Leased Non-Critical/ Essential Facilities	Total Property Value of State Facilities
1	1	5	27	$7,020,077
2	0	0	0	$0
3	0	0	0	$0
4	0	0	0	$0
5	0	0	0	$0
6	0	0	0	$0
7	0	0	0	$0
8	0	0	0	$0
Totals	1	5	27	$7,020,077

Source: DOGAMI

Earthquake

The state facility vulnerability assessment used a combination of datasets that represent key geologic factors that contribute to earthquake hazard damage. This assessment utilizes two statewide earthquake hazard datasets created by DOGAMI to assess the exposure of state owned facilities to these hazards: liquefaction susceptibility and ground shaking intensity (estimated peak ground motions over a 2500 year forecast period). Where they overlapped, ground shaking and liquefaction were combined. The greater hazard of the two at any given location was determined and the higher hazard category assigned.

Ground Shaking

Earthquakes produce various types of seismic waves which can be felt as ground shaking. Ground shaking is stronger close to earthquake sources and weakens with distance. Stronger earthquakes result in more ground shaking, though how it is felt partly depends on the underlying geology at any location. For example, some geologic units can amplify ground shaking while others can lessen it. One simple way to classify ground shaking is to use the Modified Mercalli Index (MMI), which ties how an earthquake is measured to how it is felt as ground shaking.

INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
Shaking	Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
Damage	None	None	None	Very slight	Light	Moderate	Moderate/ heavy	Heavy	Very heavy
Peak Acc	<0.17	0.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
Peak Vel	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116

Peak Acc = Peak ground acceleration (g), Peak Vel = Peak ground velocity (cm/s)

Table 2-V-FAC-2: Modified Mercalli Index

Source: DOGAMI

For the purposes this analysis, DOGAMI created data layers representing the likelihood of maximum ground acceleration and velocity for all earthquake scenarios (crustal and subduction zone) over a 2500 year forecast period. This forecast period was used since it follows the standard used in building codes for the state of Oregon. A Modified Mercalli Index was created from this data and anything receiving a MMI value of VII or greater was divided in to "Low" (VII), "Moderate" (VIII), or "High" (IX and above) earthquake hazard zones. Areas with modeled MMI values less than VII were given an attribute of "Other". It is important to note that these areas can still sustain damage from earthquakes, particularly if buildings are poorly built.

Liquefaction Susceptibility

Deposits of loose sand or silt that are saturated with water commonly liquefy when shaken strongly or repeatedly by an earthquake. The liquefied materials lose most of their ability to support overlying soil layers and structures: buildings and bridges can sink and tilt, while riverbanks may slump and flow into a river channel. In many large earthquakes, liquefaction results in considerable damage. However, it only occurs in certain types of geologic settings and soil types. As part of the Oregon Resilience Plan, DOGAMI created a data layer depicting liquefaction susceptibility that generally represents where certain geologic formations may liquefy in earthquakes. These liquefiable geologic units are derived from the geologic units within the Oregon Geologic Data Compilation (OGDC v5). The liquefaction data layer from the Oregon Resilience Plan was categorized as Very Low, Low, Moderate, High, and Very High. For the purposes of this analysis, Very Low and Low were combined into " Low"; "Moderate" remained the same; and High and Very High were combined into the "High" category. Areas with no known liquefiable geology were given the attribute "Other". Future geologic mapping, particularly maps that emphasize shallow geology, may change our understanding of where liquefiable deposits occur in Oregon.

Earthquake Hazard Facility Summary

Of 5,693 state facilities evaluated, 5,360 totaling over $7 billion worth of property fall into one of the earthquake hazard zones. Among the 1,141 critical and essential state facilities, 1,069 are in earthquake hazard zones (Table 2-V-FAC-3).

Data Limitations

It is important to note that the methodology used for this vulnerability study is a very broad-scaled approach and does not assess the ability of a building to withstand the earthquake hazard. For a given amount of ground motion, two buildings with different construction types may receive very different

types and amounts of damage. The data provided by DAS does not have adequate structure information within its inventory of state owned facilities to conduct a more accurate earthquake vulnerability assessment. All state-owned facilities should have a site-specific study performed in order to more accurately assess hazard vulnerability. Last, future geologic mapping will likely further define liquefiable soils and geologic units as well as faulting style and rates. These could change our understanding of the earthquake hazard in Oregon.

Table: 2-V-FAC-3: State Owned/Leased facilities and Critical/Essential Facilities in an Earthquake Hazard Zone

Region	# of State Owned/ Leased Critical/ Essential Facilities	# of Non-State Owned /Leased Critical/ Essential Facilities	# of State Owned/ Leased Non-Critical/ Essential Facilities	Total Property Value of State Facilities
1	186	913	1114	$336,012,474
2	120	2675	729	$1,002,278,664
3	455	2413	1679	$4,277,900,069
4	34	1069	400	$164,409,632
5	76	1446	335	$527,780,360
6	100	721	60	$365,685,290
7	47	168	297	$130,162,468
8	53	153	158	$284,568,313
Totals	1071	9558	4772	$7,088,797,270

Source: DOGAMI

Flood

DOGAMI used a combination of Federal Emergency Management Agency (FEMA) effective and preliminary flood zone data, state digitized flood zone data, and FEMA Q3 data to develop a statewide flood hazard zone for this analysis. DOGAMI indicated a flood hazard if a building fell within floodways, 100 year floodplains, or 500 year floodplains. The flood hazard was not divided in to High, Moderate, or Low categories due to the wide variety of flood data, its variable absolute and relative accuracy, and its variable geographic coverage and completeness. In particular, rural or sparsely-populated areas tend to have poorly-mapped or nonexistent flood hazard data. For these reasons, buildings were simply classified as “Hazard Zone” or “Other”. “Hazard Zone” indicates a building falls within one of the floodway, 100 year, or 500 year flood hazard zones. “Other” indicates there is insufficient information to determine whether a flood hazard exists for a given site. Buildings with “Other” designations could conceivably face relatively high flood hazards or no flood hazard at all.

Flood Hazard Facility Summary

Of the 5,693 state facilities evaluated, 889 are currently located within a flood hazard zone and have an estimated total value of nearly $900 million. Of these, 143 are identified as a critical or essential facility. See Table 2-V-FAC-4 for a summary of facilities located in the flood hazard zone, by county and OEM Region.

Recommended Data Improvements
The flood hazard dataset used multiple data layers in order to fully cover the state of Oregon. FEMA is currently updating flood data for several counties. The effective FEMA data is the most recently updated data for the state. Both the state digitized flood data and the FEMA Q3 data layers need revision and update because of inaccuracy (created on poor topography source data) and the overall age of the data. These findings demonstrate the need for enhanced flood data in certain areas of the state. Therefore, DOGAMI recommends including flood data enhancement as an action in this Plan.

Table: 2-V-FAC-4: State Owned/Leased facilities and Critical/Essential Facilities in a Flood Hazard Zone

Region	# of State Owned/ Leased Critical/ Essential Facilities	# of Non-State Owned /Leased Critical/ Essential Facilities	# of State Owned/ Leased Non-Critical/ Essential Facilities	Total Property Value of State Facilities
1	5	85	146	$22,823,803
2	2	56	49	$25,422,551
3	1	90	27	$13,110,987
4	4	80	98	$45,443,883
5	3	35	262	$6,205,342
6	6	71	60	$9,103,740
7	14	28	75	$40,965,936
8	6	48	30	$14,656,711
Totals	41	493	747	$177,732,953

Source: DOGAMI

Landslides and Debris Flow

DOGAMI used their recent landslide inventory publication entitled SLIDO-3 (Statewide Landslide Information Database for Oregon, release 3) and a statewide landslide susceptibility model from the Oregon Resilience Plan to determine which state owned facilities are vulnerable to the landslide hazard. The statewide landslide susceptibility model was originally published with susceptibility values of 1 through 10 using FEMA HAZUS-MH classifications; for this analysis these were reclassified into "Low" (values 1-3), "Moderate" (values 4-6), and "High" (values 7 -10). Atop this, existing landslide outlines from SLIDO-3 were overlain as High hazards to emphasize that pre-existing landslides are relatively more likely to reactivate in rainstorms or during earthquake shaking.

Landslide Hazard Facility Summary
Of the 5,693 facilities evaluated, 5,146 (amounting to nearly $7 billion) are located within High and Moderate landslide hazard areas; this includes 1,038 critical or essential facilities (Table 2-V-FAC-5).

Data Limitations and Recommended Improvements
The statewide landslide susceptibility map generalizes geology and topography at a statewide level using FEMA HAZUS guidelines and indicates large portions of the state are susceptible to landslides. Future geologic mapping may change our understanding of which geologic units are more or less prone to landslides and where they occur. Additionally, site-specific information, if available, would likely supersede the statewide susceptibility data and accurately portray the actual risk to buildings posed by

landslides. Additionally, although DOGAMI used the most data available in SLIDO, the database is combination of landslide inventories of varying scale, coverage, and quality. Future studies will likely change the extent and quality of data in SLIDO.

Table: 2-V-FAC-5: State Owned/Leased facilities and Critical/Essential Facilities in a Landslide Hazard Zone

Region	# of State Owned/ Leased Critical/ Essential Facilities	# of Non-State Owned /Leased Critical/ Essential Facilities	# of State Owned/ Leased Non-Critical/ Essential Facilities	Total Property Value of State Facilities
1	186	913	1114	$336,012,474
2	120	2675	728	$1,002,258,406
3	455	2413	1679	$4,277,900,069
4	34	1069	400	$164,409,632
5	121	1541	510	$744,312,579
6	103	744	682	$370,945,511
7	58	237	361	$139,508,917
8	64	192	202	$302,954,349
Totals	1141	9784	5676	$7,338,301,937

Source: DOGAMI

Tsunami

DOGAMI used recently-published tsunami inundation model results for the entire coast to determine the tsunami hazard zone for this analysis. The coast-wide inundation models divide tsunami scenarios by whether an earthquake source is local or distant; these in turn are graded in to various inundation zones depending on the size of the earthquake. For the purposes of this exposure analysis, all of these zones are described as the “Tsunami Hazard Zone”, with the remainder of the state receiving an “Other” designation to encompass very-low probability events or no tsunami hazard.

Tsunami Hazard Facility Summary

Of the state 5,693 facilities evaluated, 571 are currently located within the tsunami hazard zone and have an estimated total value of $134 million. These facilities are shown on Table 2-V-FAC-6. Of the 690 state buildings, 105 are identified as critical or essential facilities.

Data

Detailed tsunami modeling for the entire Oregon coastline was completed in 2013.

Table: 2-V-FAC-6: State Owned/Leased facilities and Critical/Essential Facilities in a Tsunami Hazard Zone

Region	# of State Owned/ Leased Critical/ Essential Facilities	# of Non-State Owned /Leased Critical/ Essential Facilities	# of State Owned/ Leased Non-Critical/ Essential Facilities	Total Property Value of State Facilities
1	105	243	571	$134,347,494
2	0	0	0	$0
3	0	0	0	$0
4	0	0	0	$0
5	0	0	0	$0
6	0	0	0	$0
7	0	0	0	$0
8	0	0	0	$0
Totals	105	243	571	$134,347,494

Source: DOGAMI

Volcanic Hazards

DOGAMI utilized data from the U.S. Geological Survey (USGS) Cascades Volcano Observatory (CVO) to develop the statewide volcanic hazard layer for this analysis. CVO maintains hazard zone data for five volcanic areas in the Cascade Mountains of Oregon: Mt Hood, Crater Lake, Newberry Crater, Mount Jefferson, and the Three Sisters. This assessment scores each facility based on whether it is located within a proximal hazard zone (translating to “High”) or distal hazard zone (translating to “Moderate” or “Low”). The maximum credible lahar scenario for each volcano was put in “Low” because it has a very low probability of occurring, while the others were placed in to “Moderate”. DOGAMI added its own unpublished lahar data for Mt Hood which resulted in a slight expansion of “Low” hazard areas for the maximum credible lahar scenario. Additionally, DOGAMI included an airfall ash hazard area in the “Low” category to capture USGS depictions of areas with a 1 in 2500 to 1 in 5000 annual chance of receiving 4 inches or more of volcanic ash. Any facility located within these hazard zones is considered vulnerable to volcanic hazards. Outside these hazard zones, the volcanic hazard is undetermined and therefore categorized as “Other.”

Volcanic Hazard Facility Summary

Of the 5,693 state facilities evaluated, 537 are located within a volcanic hazard area representing an approximate value of $355 million (Table 2-V-FAC-7). Of those, 55 are located in the “Moderate” or “High” hazard zones. One critical/essential facility falls in a High hazard zone, while the remaining 76 critical/essential facilities fall in to Low volcanic hazard zone.

Table: 2-V-FAC-7: State Owned/Leased facilities and Critical/Essential Facilities in a Volcano Hazard Zone

Region	# of State Owned/ Leased Critical/ Essential Facilities	# of Non-State Owned /Leased Critical/ Essential Facilities	# of State Owned/ Leased Non-Critical/ Essential Facilities	Total Property Value of State Facilities
1	0	0	0	$0
2	17	601	203	$73,677,661
3	1	90	27	$13,110,987
4	0	0	0	$0
5	59	1377	262	$259,126,313
6	0	22	32	$11,593,171
7	0	0	0	$0
8	0	0	0	$0
Totals	77	2090	524	$357,508,132

Source: DOGAMI

Wildfire

The Oregon Department of Forestry (ODF) participated in a statewide fire hazard and risk assessment in 2012 and 2013 as part of the West Wide Wildfire Risk Assessment for states in the western United States. Following ODF guidance, DOGAMI evaluated building exposure to wildfire using the Fire Risk Index which was classified by ODF in “High”, “Moderate”, and “Low” categories. Urban areas, lake surfaces, and areas bare of vegetation do not have fire risk classifications in the data and are represented here as “other”. For more detailed information regarding this dataset, refer to the West Wide Wildfire Risk Assessment or contact an ODF representative.

Fire Hazard Facility Summary

Of the 5,693 state facilities evaluated, 2,597 are within the overall wildfire hazard zone and total about $1.05 billion in value. Of these, 1372 have a High or Moderate wildfire hazard. Among state critical/essential facilities, 330 have a wildfire hazard in any category (Table 2-V-FAC-8).

Data Limitations

As with several other natural hazards described here, it is important to note that the type of vulnerability study performed for the wildfire hazard is very broad-scaled analysis. All state facilities should have a site-specific study performed because structure risk for fire hazard can be better determined by analyzing the ignition zone surrounding the specific structure and identifying details of the structure type (roof type, construction materials, etc.). Building data provided by DAS does not have adequate structure information within its inventory of state owned facilities to conduct a more accurate fire hazard vulnerability assessment.

Table: 2-V-FAC-8: State Owned/Leased facilities and Critical/Essential Facilities in a Wildfire Hazard Zone

Region	# of State Owned/ Leased Critical/ Essential Facilities	# of Non-State Owned /Leased Critical/ Essential Facilities	# of State Owned/ Leased Non-Critical/ Essential Facilities	Total Property Value of State Facilities
1	98	408	698	$186,184,049
2	18	380	216	$114,809,329
3	70	587	540	$314,818,225
4	11	450	187	$44,078,123
5	23	1072	216	$81,561,189
6	59	350	445	$187,857,811
7	32	141	197	$84,199,026
8	19	135	98	$41,075,335
Totals	330	3523	2597	$1,054,583,087

Source: DOGAMI

Seismic Transportation Lifeline Vulnerabilities

Requirement: 44 CFR §201.4(c)(2)(iii): Th[e] risk assessment shall include… (iii) …The State shall estimate the potential dollar losses to … infrastructure…located in the identified hazard areas.

In 2012 the Oregon Department of Transportation (ODOT) conducted the Oregon Seismic Lifeline Routes (OSLR) identification project. The purpose of the OSLR project was to support emergency response and recovery efforts by providing the best connecting highways practicable between service providers, incident areas and essential supply lines to allow emergency service providers to do their jobs with minimum disruption. It is also intended to support community and regional economic recovery after a disaster event. While the focus of the OSLR project is entirely on state highway right of way, there was an assumption that other transportation modes and facilities are part of an integrated lifelines system. The Oregon Seismic Resilience Plan furthers the discussion of the roles of the different modes and facilities in the aftermath of a CSZ event.

Prior to the OSLR project, most seismic resiliency planning and analysis at ODOT focused on bridges. Recognizing that fully resilient bridges alone would not ensure resilient highways, the ODOT Bridge Section and Transportation Development Division Planning Unit worked together to develop a method for evaluating seismic vulnerability of highways at a corridor level. The methodology included factors related to both the physical characteristics of the highway and a range of trip-ends served that are critical to emergency response and recovery. The result is a backbone system of state highways to connect the areas of the state most vulnerable to a major CSZ event with areas best suited for staging relief efforts and keeping the state economy going, to be prioritized for appropriate retrofit and improvement as funds are made available.

A Cascadia Subduction Zone event has the potential to simultaneously affect all of western Oregon, potentially crippling the statewide transportation network.

The OSLR project study concludes with recommendations for designation of a Seismic Lifelines System. The OSLR project implements Oregon Highway Plan Policy 1E: Lifeline Routes, by recommending a specific list of highways and bridges that comprise the seismic lifeline network. Further, it establishes a three-tiered system of seismic lifelines to help prioritize investment in seismic retrofits on state-owned highways and bridges. The OSLR project was conducted by the ODOT Transportation Development Division (TDD) from September 2011 through April 2012, in coordination and consultation with Bridge, Maintenance, Geotechnical, and other impacted divisions within the agency, as well as with other state agencies including the Oregon Department of Geological and Mineral Industries (DOGAMI) and the Public Utility Commission (PUC) through a Project Management Team (PMT) and Steering Committee (SC). The full report can be found at
website: https://services.oregon.gov/ODOT/TD/TP/Reports/Seismic%20Lifelines%20Evaluation%20Vulnerability%20Synthese%20and%20Identification.pdf

Methodology

The OSLR project management team used the following 5-step process to conduct the OSLR analysis.

Step 1: Identify study corridors

State highways west of US 97 were selected as study corridors that met one or more of the following characteristics (Figure 2-V-LL-1):

- Likely ability to promote safety and survival through connections to major population centers with survival resources
- Current use as a strategic freight and commerce route
- Connection to one or more of the following key destinations of statewide significance:
    - Interstate (I)-84 east of Biggs Junction
    - US 20 east of Bend
    - The California border on I-5
    - The California border on US 97
    - A crossing of the Columbia River into southwest Washington
    - A port on the Columbia or Willamette River
    - A port on the coast
    - Portland International Airport
    - Redmond Municipal Airport

The study corridors were grouped geographically into the following six distinct zones within the western half of the state (Figure 2-V-LL-2):

- Coast (US 101 and connections to US 101 from the I-5 corridor)
- Portland Metro (highways within the Portland metro region)
- Valley (circulation between the Portland metro area and other major population centers in the Willamette Valley)
- South I-5 (the section of I-5 south of Eugene/Springfield)
- Cascades (highways crossing the Cascades mountain range)
- Central (the US 97/US 197 corridor from Washington to California)

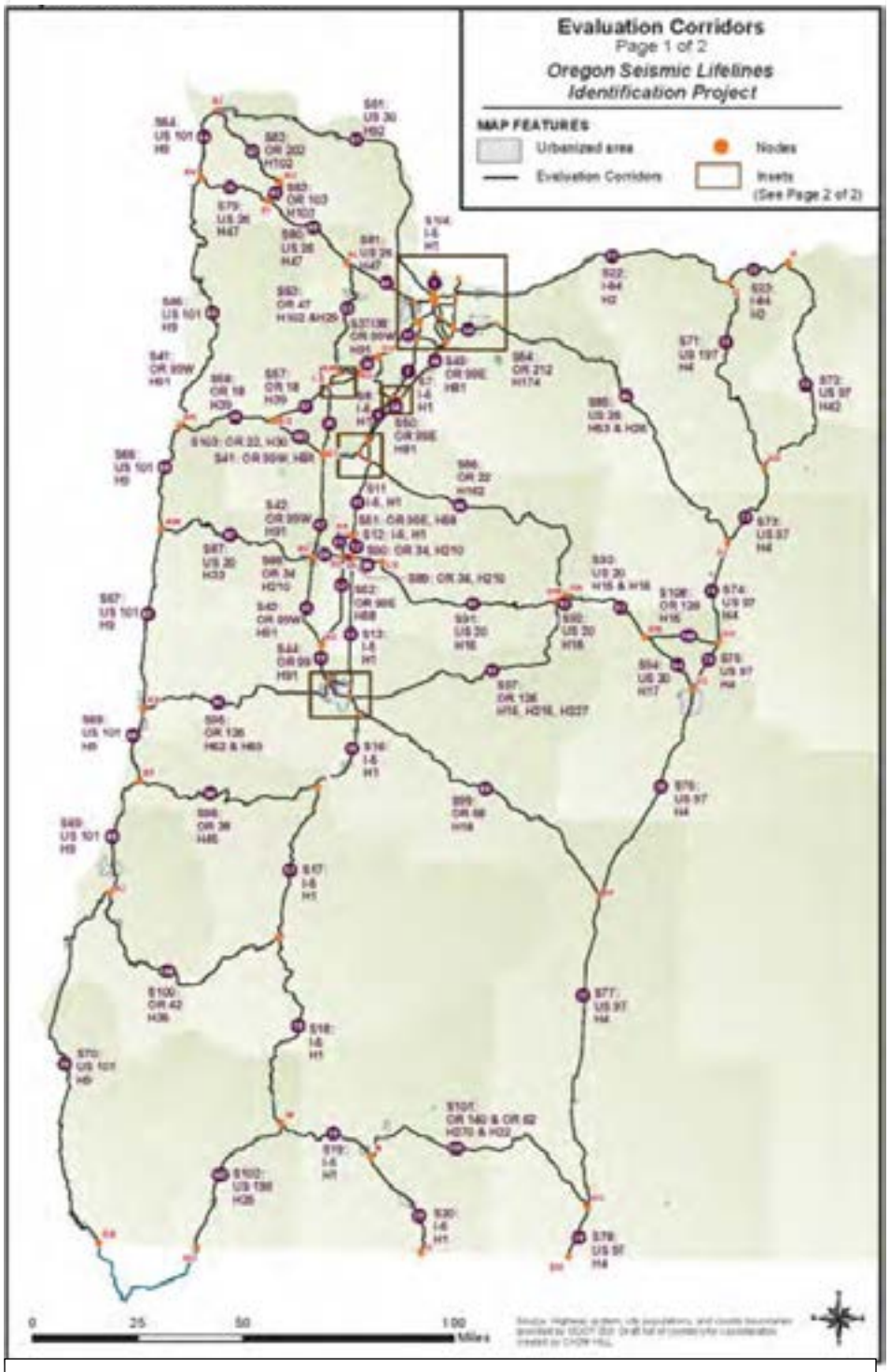


Figure 2-V-LL-1: OSLR Evaluation Corridors.

Source: ODOT

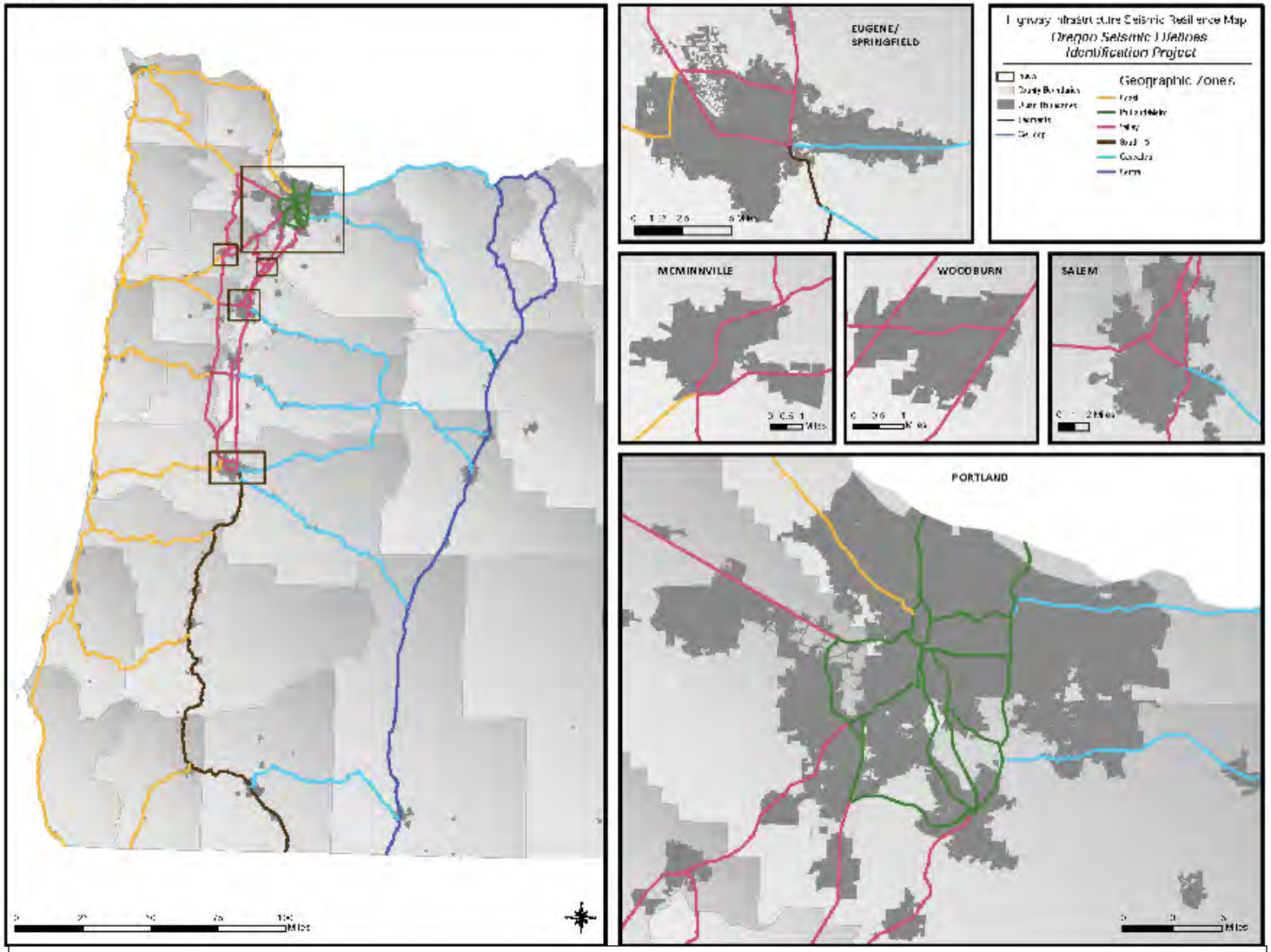


Figure 2-V-LL-2: OSLR Geographic Zones

Source: ODOT

Step 2: Develop Evaluation Framework

The PMT established an evaluation framework that consists of the following four main elements: goals, objectives, criteria, and parameters (Table 2-V-LL-1).

Table 2-V-LL-1: OSLR Evaluation Framework

Goals	Objectives	Criteria
1. Support survivability and emergency response efforts immediately following the event *(immediate and short-term needs)*	1A: Retain routes necessary to bring emergency responders to emergency locations	• Bridge seismic resilience • Roadway seismic resilience • Dam safety • Roadway width • Route provides critical non-redundant access to a major area • Access to fire stations • Access to hospitals • Access to ports and airports • Access to population centers • Access to ODOT maintenance facilities • Ability to control use of the highway
	1B: Retain routes necessary to (a) transport injured people from the damaged area to hospitals and other critical care facilities and (b) transport emergency response personnel (police, firefighters, and medical responders), equipment, and materials to damaged areas	• Route provides critical non-redundant access to a major area • Bridge seismic resilience • Dam safety • Roadway seismic resilience • Access to hospitals • Access to emergency response staging areas
2. Provide transportation facilities critical to life support for an interim period following the event *(midterm needs)*	2A: Retain the routes critical to bring life support resources (food, water, sanitation, communications, energy, and personnel) to the emergency location	• Access to ports and airports • Bridge seismic resilience after short term repair • Dam safety • Roadway seismic resilience • Access to critical utility components (such as fuel depots and critical communication facilities) • Access to ODOT maintenance facilities • Freight access
	2B: Retain regional routes to hospitals	• Access to hospitals
	2C: Retain evacuation routes out of the affected region	• Access to central Oregon • Access to ports and airports • Importance of route to freight movement

Evaluation Framework

Goals	Objectives	Criteria
3. Support statewide economic recovery *(long-term needs)*	3A: Retain designated critical freight corridors	• Freight access • Bridge seismic resilience after short-term repair • Roadway seismic resilience after short-term repair • Route provides critical non-redundant access to a major area • Access to ports and airports • Access to railroads
	3B: Support statewide mobility for connections outside of the affected region	• Access to central Oregon • Access to ports and airports • Access to railroads
	3C: Retain transportation facilities that allow travel between large metro areas	• Route provides critical non-redundant access to a major area • Connection to centers of commerce

Source: ODOT

The criteria in the evaluation framework fell into three categories—connections, capacity, and resilience. Criteria within each category are listed in Table 2-V-LL-2. All criteria are formulated so that a favorable performance is rated “high” and an unfavorable performance is rated “low;” “moderate” indicates a middle rating.

The “Connections” category of criteria includes all criteria relating to proximity to key resources and geographic areas likely to be essential after a seismic event.

The criteria listed under the “Capacity” category measure the characteristics of the roadway itself. These criteria may be important in the case of a seismic event because they can help determine how usable the actual roadway will be for large volumes of traffic, quick evacuation, or moving freight to and from populated areas.

The “Resilience” criteria assess the likely capability that a corridor will function in the aftermath of a major seismic event, with or without a short term repair.

Table 2-V-LL-2: OLSR Evaluation Criteria by Group

Connections	Capacity	Resilience
• Access to fire stations • Access to hospitals • Access to ports and airports • Access to railroads • Access to ODOT maintenance facilities • Access to population centers • Access to emergency response staging areas • Access to critical utilities • Access to central Oregon	• Width of roadway • Ability to control use of the highway • Freight access	• Bridge seismic resilience • Roadway seismic resilience • Bridge seismic resilience after short-term repair • Roadway seismic resilience after short-term repair

Source: ODOT

Step 3: Analyze Selected Highways

Each of the criteria were weighted and ranked for each study segment.

Step 4: Solicit Feedback from Steering Committee

The OSLR project team used the results of the evaluation to identify a three-tiered seismic lifeline system—Tier 1 being the highest priority roadway segment, Tier 2 being the next highest, and Tier 3 being the third highest priority grouping to functions as follows:

- **Tier 1**: A system that provides access to and through the study area from Central Oregon, Washington, and California, and provides access to each region within the study area
- **Tier 2:** Additional roadway segments that extend the reach of the Tier 1 system throughout seismically vulnerable areas of the state and that provide lifeline route redundancy in the Portland Metro Area and Willamette Valley
- **Tier 3:** Roadway segments that, together with Tier 1 and Tier 2, provide an interconnected network (with redundant paths) to serve all of the study area

Step 5: Propose a System of Lifeline Routes

The proposed Tier 1 lifeline network shown provides roadway access to within about 50 air miles of all locations in western Oregon. Total roadway miles for each tier are as follows:

- Tier 1: 1,146 miles
- Tier 2: 705 miles
- Tier 3: 422 miles

This provides a total of 2,273 miles of designated lifeline route. Study routes not identified as seismic lifelines total 298 miles. Figure 2-V-LL-3 shows the proposed seismic lifeline routes with tier designations.

Table 2-V-LL-3 contains a tabulation of lifeline roadway miles within three classifications (high, moderate, low) of peak ground acceleration (PGA) coefficients, by tier for the CSZ seismic event. These CSZ PGA zones generally correlate to geographic areas with the high acceleration zone being the coast and Coast Range Mountains, the moderate acceleration zone the inland valleys, and low acceleration zone the Cascades and Central Oregon.

Table 2-V-LL-3: Lifeline Roadway Length by CSZ Seismic Acceleration Zone and Tier, in Miles

CSZ PGA Zone	Approximate PGA (g)	Tier 1	Tier 2	Tier 3	Total
High	0.56 – 0.96	217	211	236	664
Moderate	0.24 – 0.48	540	313	127	979
Low	0.08 – 0.16	389	181	59	630
Total		1,146	705	422	2,273

Source: ODOT

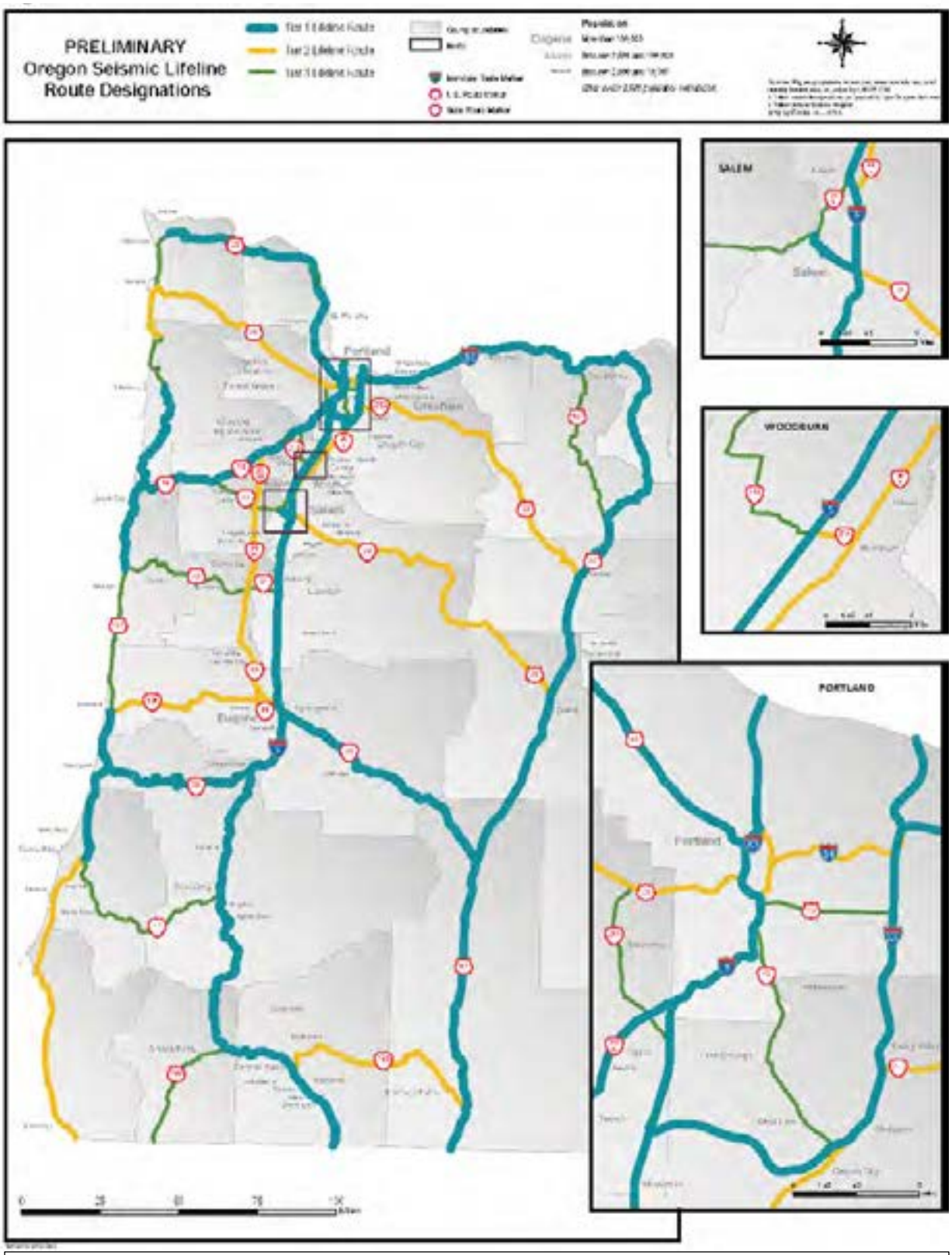


Figure 2-V-LL-3: Preliminary Oregon Seismic Lifeline Routes, by Tier

Source: ODOT

Seismic Hazards Affecting Lifeline Routes

The following seismic hazards have the potential to affect the seismic vulnerability of structures (such as bridges, retaining walls, culverts, and tunnels) and roadway grades along the lifeline routes:

Ground Shaking. Ground shaking is a function of the distance to the earthquake epicenter, the magnitude of the earthquake, regional bedrock properties, and the stiffness of the site-specific soils. It includes the potential for ground amplification because of soft soil deposits. The effects of ground shaking, including the intensity, frequency content, and duration of the shaking, can physically damage structures (such as bridges, culverts, retaining walls, and tunnels), as well as trigger other seismic hazards (such as liquefaction and landslides).

Coseismic Deformation. During a subduction zone earthquake, the tectonic plates undergo elastic deformation on a regional scale, resulting in the potential for several meters of permanent uplift or subsidence that could occur along the entire rupture zone, as expected along the entire Oregon Coast for the CSZ magnitude 9.0 event. Coseismic subsidence can affect tsunami wave heights and run-up. If the ground subsides during the seismic event, the effective tsunami wave and associated run-up are increased by the amount of subsidence. In addition, coseismic deformation can reduce ground elevations along low-elevation roadway grades to the extent that the elevations end up below design sea level following coseismic subsidence.

Liquefaction. Soil liquefaction is a phenomenon by which loose, saturated, and sandy/silty soils undergo almost a complete loss of strength and stiffness because of seismic shaking. Its occurrence along highway corridors is likely most significant at bridge sites (which are often near bodies of water) or along roadways that are adjacent to bodies of water (such as estuaries, rivers, and lakes). Liquefaction may cause failure of retaining walls from excessive earth pressure, movement of abutments and slopes caused by lateral spreading (liquefaction-induced slope instability), and loss of bearing or pile capacity for bridge abutments and pile caps.

Cyclic Degradation of Clays. The cyclic degradation of clays is a process by which clayey soils may lose the majority of their strength and stiffness because of cyclic shaking. Cyclic degradation of clays is typically associated with sensitive and soft clays. As with liquefaction, these susceptible soils are typically located at or adjacent to bodies of water.

Landslides. Landslide hazards are most likely to occur at locations of steeply sloping ground within the Coast Range and Cascade Mountains, or near alluvial channels. Landslides located above a roadway may lead to the blockage of a road from debris buildup. Landslides located below a roadway may cause undermining and loss of road grade. Landslides can occur at locations with recognized slope instabilities, but they can also occur in areas without a historic record of landslide activity.

Fault Rupture. During shallow crustal earthquakes, the rupture of a fault may propagate to the ground surface and lead to horizontal and/or vertical displacements of the ground. These displacements may be on the order of several meters and will depend on the size of the earthquake and the proximity of the fault plane to the ground surface. The effect of fault rupture is much more devastating for structures, such as bridges, than it is for roadways.

However, the thoroughness of current mapping of faults for the State of Oregon is uncertain and very few of the observed earthquakes in Oregon are associated with mapped crustal faults. It is anticipated that, given the heavy vegetative cover for a lot of Oregon and the short period of time for which records have been kept, not all active faults have been identified.

Tsunamis. Tsunamis may affect lifeline routes near and adjacent to the coastline. The resulting water forces can damage structures within the tsunami run-up zone, and can also cause debris buildup or inundation and the washing away of roadway grades.

Seiche Waves. Seiche waves are resonance waves that are caused by seismic shaking of enclosed bodies of water, and often occur at distances far from the earthquake epicenter.

The hazards listed previously all have relevance to seismic lifeline routes. However, fault rupture, cyclic degradation of clayey soils, and seiche wave hazards were not further evaluated because a CSZ event is not a fault rupture event, there is limited information on clay deformation and the affected areas are likely to also be subject to liquefaction which is considered and seiche waves are limited in height so not expected to have destructive effects on the studied highways. (See Figures 4-1, 4-4 and 4-5)

State Vulnerability

Given the current conditions of the state highway system, the western half of Oregon will be profoundly impacted by a Cascadia Subduction Zone that will fragment major highways by damaging and destroying bridges, triggering landslides that obstruct and/or undermine roadways, other geological hazards such as soil liquefaction and the potential for tsunami that could overwhelm low-lying transportation facilities.

Significant loss of life is likely in tsunami prone areas. Additional loss of life from untreated injuries and disease due to a fragmented response network could also be significant. Loss of life due to structural collapse could be widespread, exacerbated by the duration of ground shaking and the size of the event at the coast, in the Coast Range, along the Lower Columbia, in the Metro area and in the central valleys.

The long term economic impacts would be profound. Many buildings – residential, commercial, and industrial – would collapse or suffer significant damage. Supply lines for reconstruction materials would be disrupted and the transportation system capacity to move goods is likely to be usurped for a period of weeks for response/survival supplies and materials and personnel needed to re-establish essential services. The ability of employees and customers to get to businesses could be disrupted for weeks if not longer. Smaller and locally based businesses cannot typically survive long periods of closure.

A program to immediately (within the next few years) retrofit all seismic lifeline routes in western Oregon to current design standards is not possible with current budget limitations. Even if the State were able to embark on a program of rapid seismic strengthening of the entire highway system, let alone other regional and private transportation assets, it would be prudent to begin where the most benefit is accomplished in the least time for the least cost. That is a key premise of the development of the OSLR project and the Seismic Options Report that was, in part, based upon it.

Statewide Loss Estimates

The OSLR project includes consideration of the costs of retrofitting bridges and other highway facilities to support the tiering decisions and a preliminary work for revenue requests for implementation. Cost estimates were made for construction projects to mitigate or correct vulnerabilities on the recommended Seismic Lifelines system. Details can be found in Appendix E of the Seismic Options Report developed by ODOT staff to brief executive staff and OTC.

Appendix F of that report considers the **Estimated Economic Impact Due to Failure of Transportation Infrastructure.** This analysis was done to answer a slightly different question: what is the value of making the recommended improvements to the identified lifeline routes?

> *"This analysis evaluated four alternative scenarios in order to gain a sense of the potential loss in production activity we could expect due to the damage to the transportation system after a major seismic event. Four scenarios representing seismic preparation and repair demonstrate the value added (impacts avoided) to the Oregon economy. Significant economic losses in production activity can be avoided by preparing for a major earthquake ahead of time. With no preparation ahead of time, Oregon could lose up to $355 billion in gross state product in the 8 to 10 year period after the event. Proactive investment in bridge strengthening and landslide mitigation reduces this loss between 10% and 24% over the course of the eight years simulated for this analysis."*

It is important to note that the losses considered in the economic analysis only considered impacts directly related to transportation system failures. It did not account for impacts outside of the transportation economic impacts such as the collapse of industrial or commercial buildings or basic service failures. Even so, the benefit to cost ratio of making needed improvements to the Seismic Lifelines system is 46:1.

Figure 2-V-LL-4 shows seismic vulnerability of proposed lifeline routes relative to projected ground shaking form a CSZ event. Figure 2-V-LL-5 shows bridges in tsunami zones. These are the most significant vulnerabilities of the state highway system.

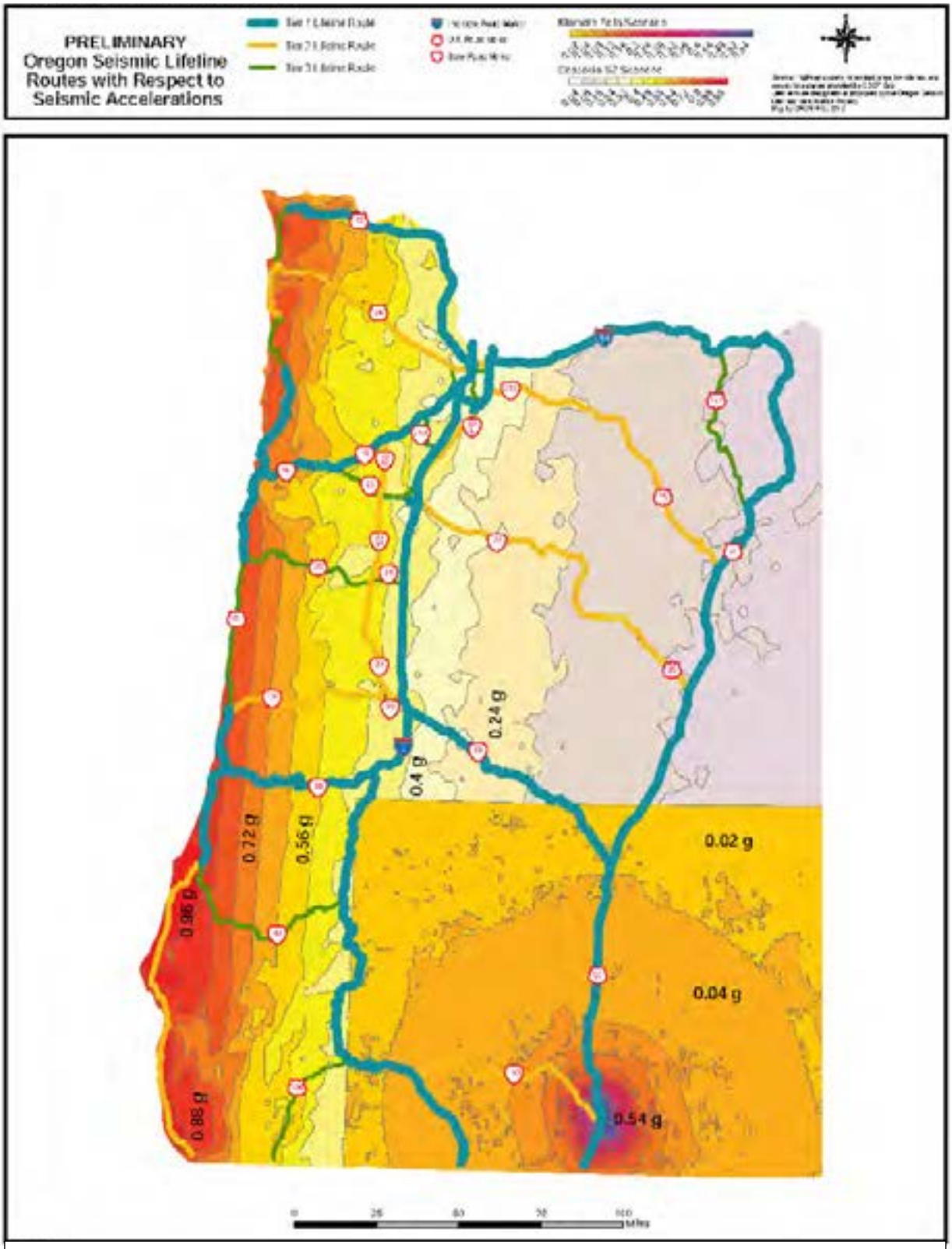


Figure 2-V-LL-4: Preliminary Seismic Lifeline Routes and Seismic Acceleration

Source: ODOT

Most Vulnerable Jurisdictions

The OSLR analysis did not focus at a jurisdictional level. The "planning area" was essentially state right-of-way connecting to population centers and critical resources. The locale referents were large geographic areas with similar risk situations.

The design events considered in the OSLR project are:

- CSZ moment magnitude (Mw) 9.0 earthquake scenario, which has the potential to affect all of western Oregon (as well as northern California, western Washington, and southwestern British Columbia)
- A design-level Klamath Falls crustal earthquake scenario, Mw 6.5, which is limited to the Klamath Falls region because Klamath Falls area is the only region of the state with known significant seismic hazard that is not at a significant level of risk from the CSZ event.

The most vulnerable jurisdictions for a CSZ event are all of the coastal ports, cities, towns and counties. The impacts to the east are less predictable, but expensive losses are also expected in river-dependent areas in the Portland area and at Columbia River ports. The extent of the damage in most of the state will vary with the current conditions including the time of day (extent that highways and public and business buildings are occupied), soil saturation conditions and the size of the earthquake.

<u>Coastal Counties</u>: Most vulnerable to ground shaking, tsunami, landslide and rockfall causing likely long-term impacts on all structures and utilities: Curry, Coos, coastal Douglas, Lane, Lincoln, Tillamook and Clatsop Counties

<u>Lower Columbia River Area</u>: Vulnerable to ground shaking, port and navigation hazards, liquefaction: Columbia, Multnomah, Hood River Counties and river ports

<u>Portland Metro Area</u>: Ground shaking, extensive liquefaction damages to industry, fuel storage, and major bridges in addition to widespread ground shaking damage

<u>Coast Range, I-5 Corridor Valleys</u>: Fragmented surface transportation infrastructure depending upon the extent of ground shaking, likely disruptions of most utilities

<u>Cascade Mountains and Central Oregon</u>: Redmond Airport is the FEMA staging area for federal emergency operations in a major catastrophic event. Connecting the central valleys to US 97 east of the Cascades is important strategically for response efforts and long-term economic recovery. Though the damage to highways is anticipated to be relatively minor, making vulnerable facilities resilient is a high priority to ensure statewide resilience.

Bridges: Bridges are the most significant vulnerabilities of the state highway system. They are primarily vulnerable to the following seismic hazards:

- Ground shaking, which can results in structural damage of the bridge elements
- Liquefaction, which can result in movement or failure of the abutments and/or the bridge piers
- Tsunamis that can scour or result in large loads on bridge piers and abutments and, if high enough, can damage the bridge superstructure
- Landslides that can undermine a bridge

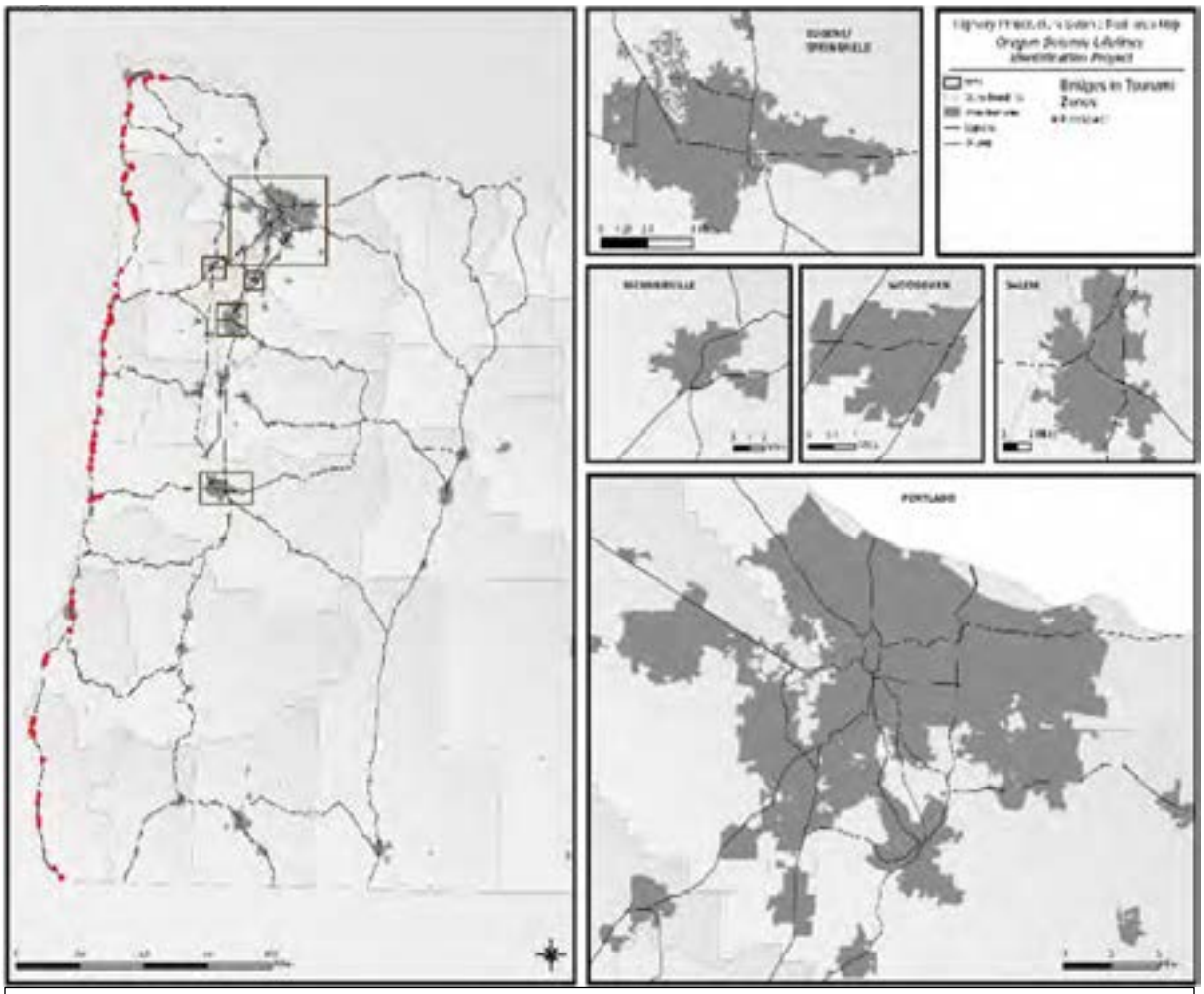


Figure 2-V-LL-5: Bridges in Tsunami Zones

Source: ODOT

Road Grade Vulnerabilities: Roadway grades are vulnerable to the following seismic hazards:

- Ground shaking, which can result in structural damage of roadway elements, including culverts, retaining walls, and abutments
- Liquefaction, which can result in movement or failure of the slopes and ground under and adjacent to the roadway
- Landslides, which can results in failure of the slope above the roadway (which may lead to the blockage of a road from debris buildup) and/or failure of the slope below the roadway (which may result in loss or complete failure of road grade). Landslides may be known, new or ancient slides reactivated by ground shaking. Landslide potential is most prominent in the Coast Range and Cascade Mountains.
- Tsunamis, which can scour or deposit debris on the roadways making them inaccessible
- Coseismic deformation, which can result in the roadway grade being below design sea level

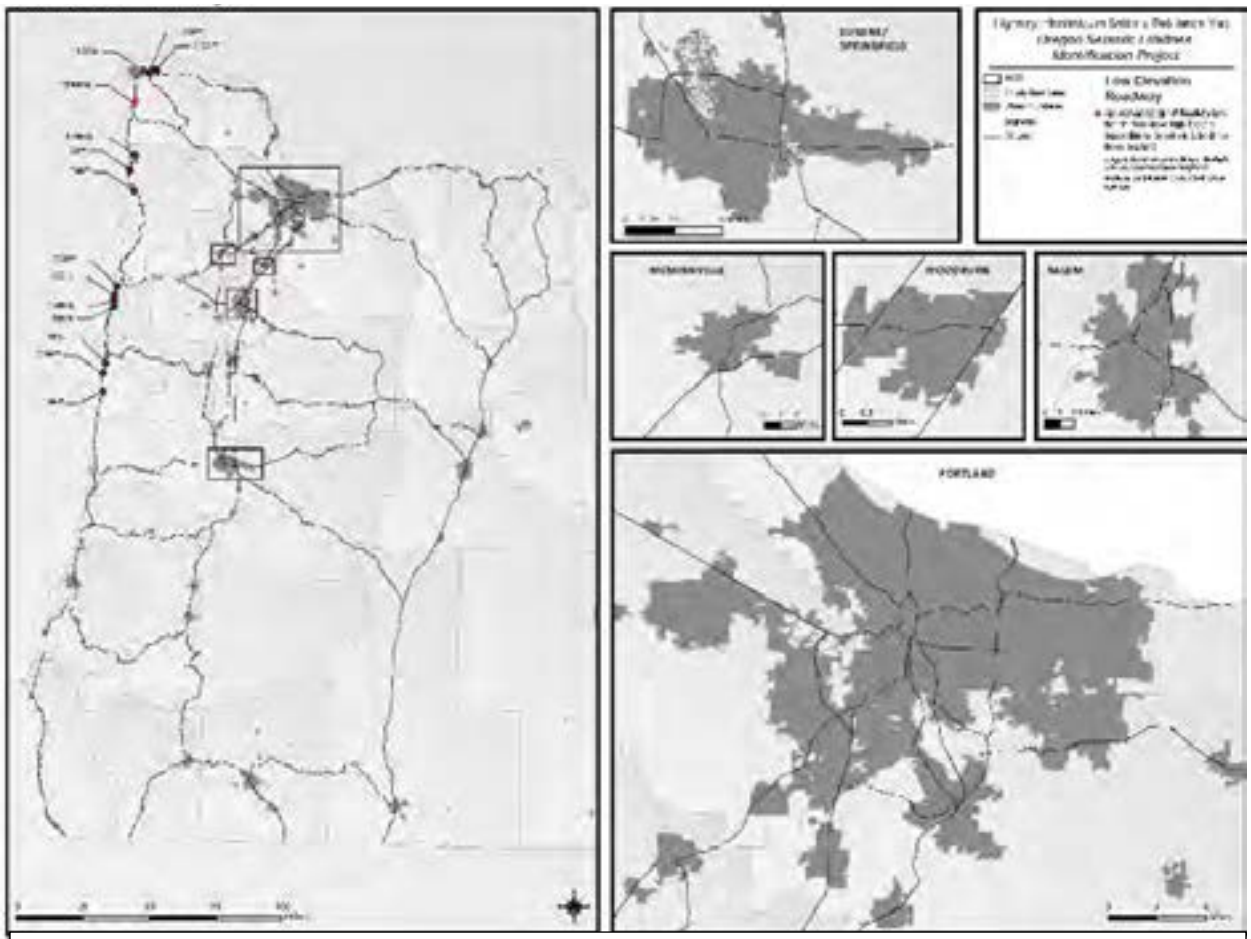


Figure 2-V-LL-6: Low Elevation Roadways

Source: ODOT

Tunnels: Tunnels generally perform well in seismic events; however, some amount of rock fall and structural damage is likely, particularly at portals. The length of tunnels along each segment was tabulated.

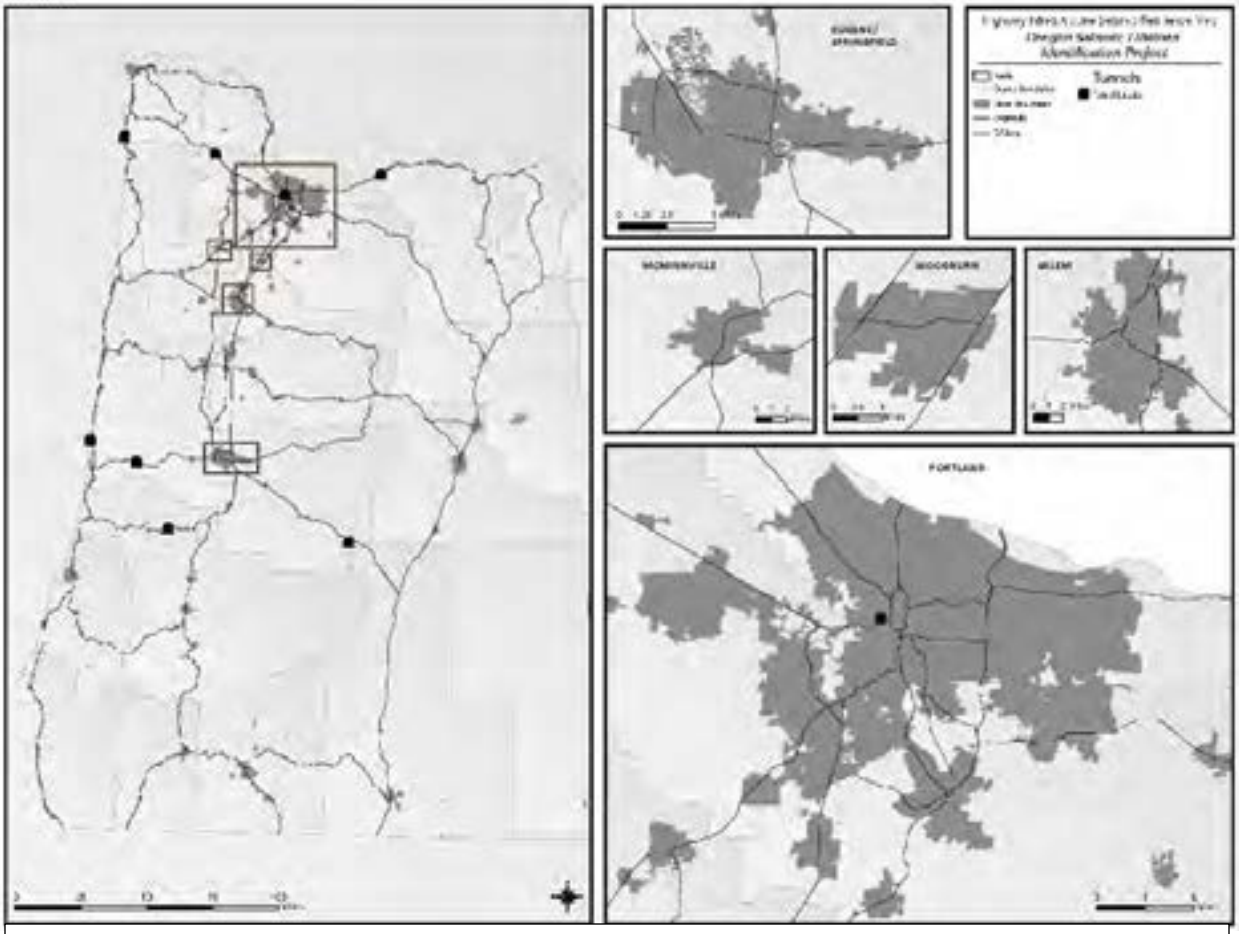


Figure 2-V-LL-7: Tunnels

Source: ODOT

Dams: Dams can pose significant risk to roadways because of releases of large volumes of water that can wash out roadway grades and scour out bridge foundations. This sudden release of water could be due to a dam failure, intentional rapid drawdown in response to structural damage, or overtopping due to a landslide into the upstream pool. Furthermore, rapid drawdown of water levels can also cause slope failures upstream of the dam along the edge of the reservoir. The dams identified in this study are those that have a potential to pose a risk to a state highway. Only one segment was noted to be at risk per dam, in spite of the fact that a dam failure may cause damage on multiple downstream segments. In general, segments farther downstream are at lower risk due to attenuation of the flood wave and the fact that further downstream waterways and crossings generally have a larger capacity.

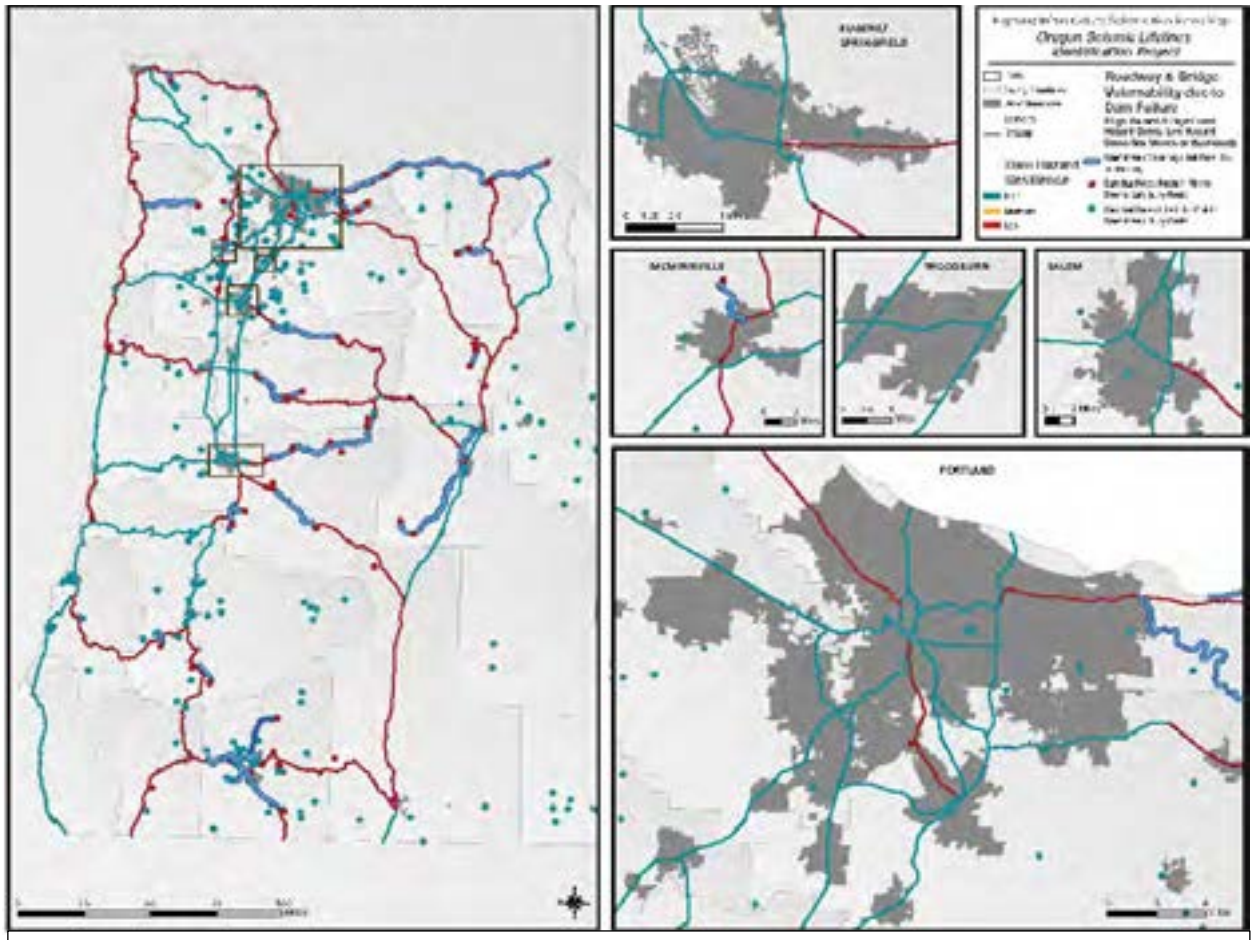


Figure 2-V-LL-8: Roadway and Bridge Vulnerability to Dam Failure

Source: ODOT

Data

The main sources of data used to analyze the seismic vulnerability of each highway segment include:

- ODOT GIS Database.
- DOGAMI References.
- U.S. Geological Survey (USGS) Seismic Hazard References.
- Risks from Earthquake Damage to Roadway Systems (REDARS2) Data.
- DOGAMI and the Federal Emergency Management Agency evaluations of the potential impacts of a major seismic event in Oregon,
- Local knowledge of CH2M HILL staff who have lived and worked in these regions
- Interviews with key maintenance and technical staff at ODOT
- Interviews of technical and field staff at DOGAMI
- Public mapping databases, including aerial photographs, digital terrain models (DTMs), and transportation GIS databases

Data Limitations

The goal of the seismic vulnerability assessment was to use the best available data to make informed and rational seismic lifelines route decisions at the current time. A complete and thorough engineering evaluation would require a much larger project and longer timeframe than is currently prudent. However, the available data is believed to have been judiciously used to enable the development of reasonable criteria and procedures for selecting a backbone system of seismic lifeline routes that will meet ODOT's needs.

During the last 15 years ODOT Bridge Section has compiled statewide hazard and vulnerability data including data on bridge seismic vulnerabilities and existing landslides, while other state and federal agencies have compiled geographic and other data defining seismic risks including predicted tsunami inundation zones. That work is the foundation of this study. Most of the earlier studies have been either comprehensive (statewide) but imprecise, or precise but not comprehensive.

Some statewide information used in the OSLR analysis (for example, the landslide data) was compiled from various sources and is based on varied data-gathering technologies and data-evaluation methods. Therefore, the data are highly variable and are not precise or consistent as a whole. Some older statewide or region-wide data were used in this project in place of more recent site-specific information to provide a platform to make relative comparisons (rather than absolute measures) of seismic risks along various candidate lifeline routes.

Recommended Next Steps

This report provides ODOT with guidance about which roadways are most important for response and recovery following a major earthquake and which roadways are most easily prepared for, and repaired after, a major seismic event. Tier 1 lifeline routes are the most critical highways identified to provide statewide coverage; Tiers 2 and 3 lifeline routes would increase the usability of the system and add access to other areas. The Tier 1 routes have been divided into two phases for planning purposes. Phase one engineering and site evaluations are under way.

The next steps in the process of planning for a seismic event are to do engineering and site evaluations of the recommended routes to inform prioritizing specific mitigation and retrofit projects on these lifelines. Although this study has provided comparative results for seismic vulnerability on roadways, it does not provide sufficient detail to actually prioritize bridge and roadway seismic retrofits on a given highway facility. The engineering and site evaluations will determine the actual needs for and costs of bridge and roadway seismic retrofit projects.

Identifying funding and implementing seismic lifelines priorities will be an ongoing part of the Highway Division's work for many years to come. The OSLR enables an approach that can be expedited or done incrementally over time. The Seismic Options Report addresses general questions about the kinds of work that need to be done and the economic value of doing that work. It is the intent of this combined effort to position the state to develop an increasingly resilient highway system in an efficient and strategic manner.

Future Enhancements to the State Risk Assessment

Climate Change

<Place holder for Climate Change Enhancements in next Plan update>

New Risk Assessment Methodology

During the 2012 Oregon NHMP update process it was realized by the state that no standardized statewide risk assessment methodology is being used across all hazards— each hazard lead uses a different method to assess risk. This is due in part to the fact that "many state agencies do not have the tools and/or resources to conduct a full risk assessment. Likewise, most agencies do not maintain existing statewide risk assessment data" as identified in Task 5 of the Mid-Planning Alterations to the 2012 work plan. In response, the state allocated remaining federal funds from DR-1733 to support initial stages of the development of a standardized risk assessment model.

Beginning in March 2013, Oregon's Interagency Hazard Mitigation Team (IHMT) established a Risk Assessment Sub-Committee (RAS-C) that worked in partnership with faculty and staff from the University of Oregon's Department of Geography, InfoGraphics's Lab and Oregon Partnership for Disaster Resilience (OPDR) to develop a new risk assessment model concept. When fully developed and implemented, the model will provide a standardized way to assess vulnerability to natural hazards in Oregon thereby allowing the state to better identify where to strategically target mitigation resources. This initiative was facilitated by the Department of Land Conservation and Development (DLCD).

The RAS-C convened a total of five times from March to August to develop a risk assessment methodology that 1) meets federal requirements, 2) draws from the strengths of existing methods and 3) addresses Oregon's unique priorities. The committee took a four-pronged approach to developing a new risk assessment model. Phase One involved the review of natural hazard risk assessment methodologies found in academic literature and in other SNHMPs. In Phase Two, the UO team developed a proposed risk assessment model concept drawing from the strongest elements of the literature review and other research. While this phase focused heavily on adapting Susan Cutter's Social Vulnerability Index (SoVI), a key driver was the development of a framework tailored toward Oregon that could address key shortcomings identified in Cutter and other models. In addition, the model incorporates state priorities identified by the RAS-C. Phase Three involved testing the feasibility of the proposed model. Finally, in Phase Four, the UO team developed a timeline, work plan and budget in an effort to identify the resources needed to fully develop the risk assessment model and interface. The proposed three-year budget is roughly $600,000, which includes UO staff and resources.

This budget does not consider state time and resource needs, including, but not limited to, a high level of interagency collaboration to identify and classify hazard and vulnerability data, testing, and implementing the model. Notably, state resource needs will ultimately have to be identified and supported through funding and technical support to fully realize this model.

At this time, further development of the new model is pending funding. The RAS-C continues to meet to discuss potential funding opportunities. Due to the considerable amount of funding and other resources needed to fully develop and implement the new risk assessment methodology, it is likely that its development will take place in phases over the course of the next few iterations of the Oregon NHMP. At the time this Plan was written, the following grant proposal that would support the development and testing of the social vulnerability and flood hazard elements of the new model has been submitted and is awaiting funding announcements.

Oregon's Social Vulnerability to Climate-driven Hazards

One step toward developing the new risk assessment model would be the implementation of the Oregon Social Vulnerability to Climate-driven Hazards Project. Three state agencies – the Oregon Health Authority (OHA), the Department of Geology and Mineral Industries (DOGAMI), and the Department of Land Conservation and Development (DLCD) – and the University of Oregon will collaborate to complete this work.

This project will combine social vulnerability data, climate data, and natural hazard data to produce a decision support tool identifying risks to vulnerable populations and future flooding hazards. This partnership will 1) develop and refine an index of social vulnerability to climate change at the census-tract level, 2) develop a new climate-induced flood hazard data layer for one pilot watershed, and 3) combine the two data sets to analyze vulnerability to flooding. The information developed in this project will be used to inform the update of a Local Natural Hazard Mitigation Plan (LNHMP) in the pilot watershed.

Furthermore, the Oregon refined index of social vulnerability (at the census tract level) developed in this project will be used to further develop and test the social vulnerability element of the state's new risk assessment model. Testing the new risk assessment model will provide the state with a better understanding of the inter-agency data sharing and collaboration resources needed to fully realize the new model.

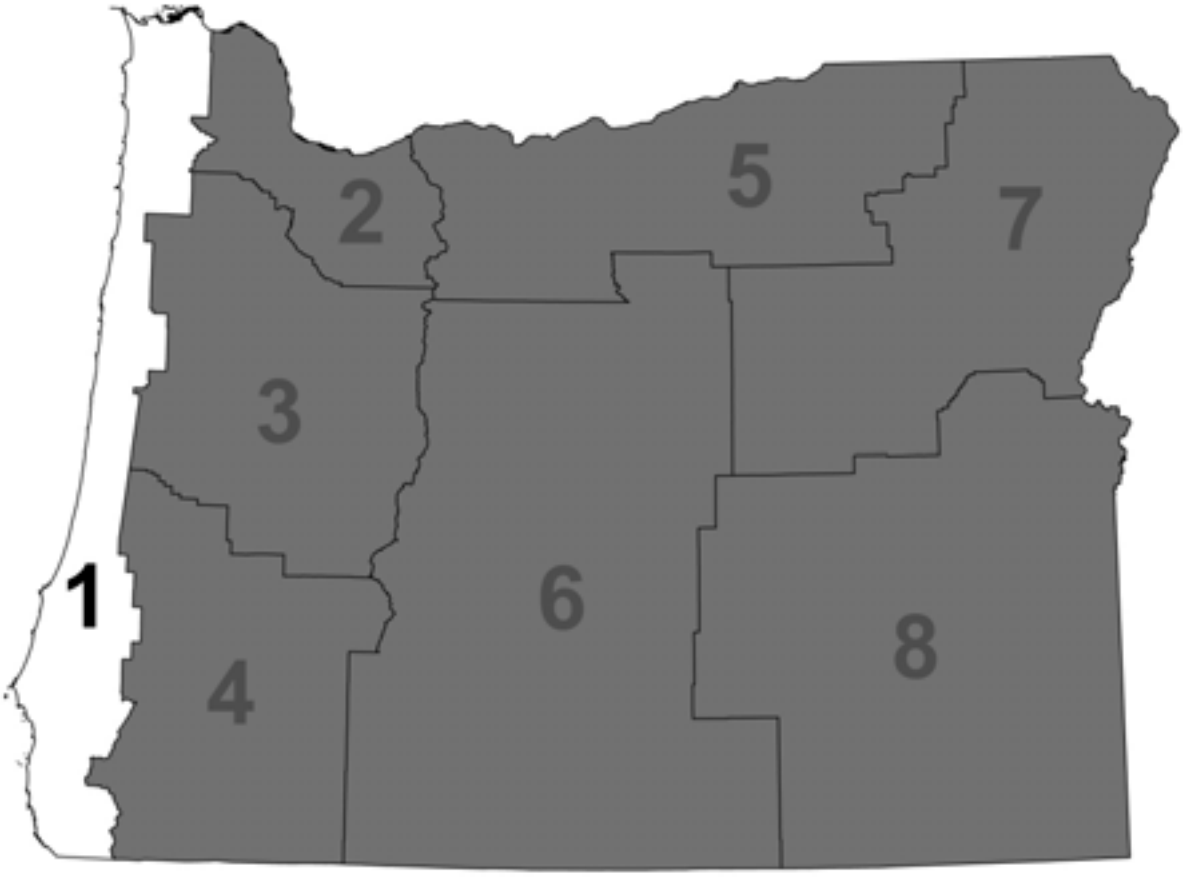
This project is pending funding from a National Oceanic and Atmospheric Administration (NOAA) - Climate Program Office (CPO) - Climate and Societal Interactions (CSI) - Sectoral Applications Research Program (SARP): Climate Extreme Event Preparedness, Planning, and Adaptation grant. Grantee announcement are scheduled for Spring 2014. Pending NOAA funding, this project is projected to be implemented August 1st, 2014 - July 31, 2016.

Cultural Resources

<Place holder for Cultural Resources Enhancements in next Plan update>

Region 1: Oregon Coast

Clatsop, Coos, Curry, Douglas (coastal section), Lane (coastal section), Lincoln, and Tillamook Counties.



Region 1: Regional Summary

<Placeholder for Regional Summary from OPDR >

Climate Change

Hazards projected to be impacted by climate change in Region 1 include coastal hazards, drought, wildfire, flooding and landslides. Research shows that sea levels and wave heights along the Oregon Coast are rising and are expected to increase coastal erosion and coastal flooding. In addition, virtually all climate models project warmer drier summers and a decline in mean summer precipitation for Oregon. Coupled with projected decreases in mountain snowpack due to warmer winter temperatures, all eight regions are expected to be affected by an increased incidence of drought and wildfire. Furthermore, flooding and landslides are projected to occur more frequently throughout western Oregon. An increase in extreme precipitation — from 1 to 4 inches per day — is projected for some areas in Region 1 and can result in a greater risk of flooding in certain basins; including an increased incidence of magnitude and return intervals. Landslides in Oregon are strongly correlated with rainfall, so increased rainfall — in particular in extreme events — will likely trigger increased landslides in the region. While winter storms and windstorms affect Region 1, there is no current research available indicating any change in the incidence of either in Oregon due to changing climate conditions. For more information on climate drivers and the projected impacts of climate change statewide, see the section Climate Change Introduction in this Plan, pg.X.

Region 1: Regional Profile

Introduction

The Region 1 Profile includes Natural Environment, Social/Demographic, Economic, Infrastructure, and Built Environment sections. Using the best available data, the regional profile describes each section's characteristics, vulnerability to hazards as supported by literature (when available), and trends and issues. Major data sources for the regional profile include the Oregon Employment Department (OED), U.S. Census Bureau and the U.S. Environmental Protection Agency (EPA). Susan Cutter's article entitled "Social Vulnerability to Environmental Hazards" (2003) provides the framework for discussion of vulnerability.[1] Cutter's framework helps to illustrate the geographic variability of vulnerability and allows policy makers to better understand how to prepare for, mitigate and reduce the vulnerability. This profile concludes with a Synthesis section– a summary of the region's social, economic, infrastructure and built environment vulnerabilities.

Region 1, also known as the Oregon Coast, is approximately 17,063 square miles in size, and includes Clatsop, Coos, Curry, Lincoln and Tillamook counties as well as the coastal areas of Douglas and Lane counties. For this regional profile, where data is available for the coastal areas of Douglas and Lane counties it will be used, where data is available only at the county level it will be reported within the Region 3 (Lane) and Region 4 (Douglas) profiles.

Natural Environment

The Natural Environment section describes the geographic and climatic characteristics of the region.

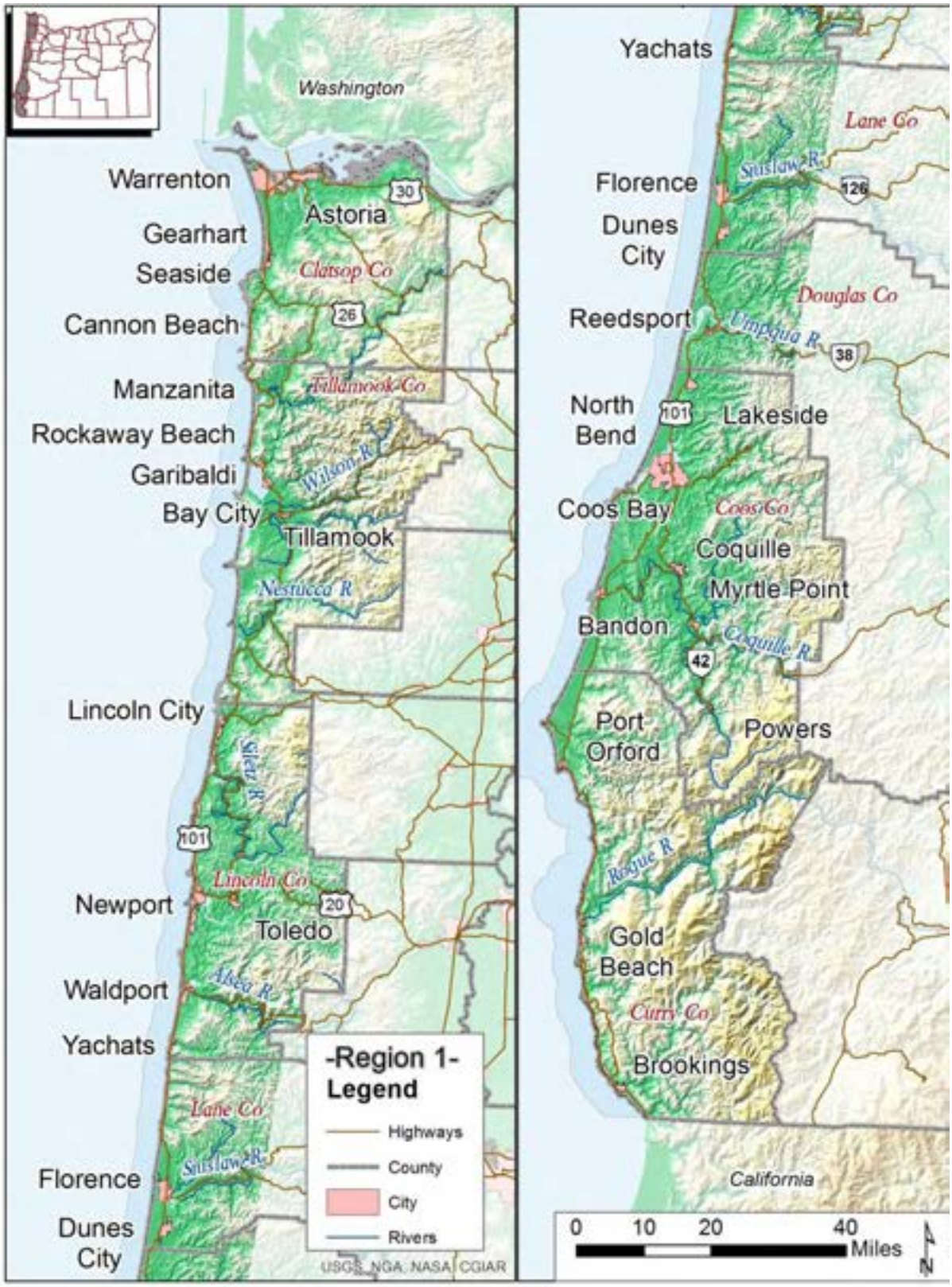
Geography

Geography describes the region's physical features including elements such as ecosystems, mountain ranges, major watersheds, and soils.

The Coast Range's mountains and waterways shape Region 1's topography. The region begins at the Pacific Ocean on the west side and continues through to where the Coast Range meets the major valleys in the east. It extends from Washington State in the North to the California border in the south. Major rivers in the region include the Siuslaw, Umpqua, Nehalem, Rogue, Yaquina, Siletz, Nestucca, Trask, Wilson, Coos, and Coquille. Figure 2-R1-RP-1 shows the dominant mountain ranges, major watersheds, and political boundaries of Region 1.

[1] Cutter, Susan L., Bryan Boruff, W. Lynn Shirley. Social Vulnerability to Environmental Hazards. Social Science Quarterly. Volume 84, Number 2, June 2003.

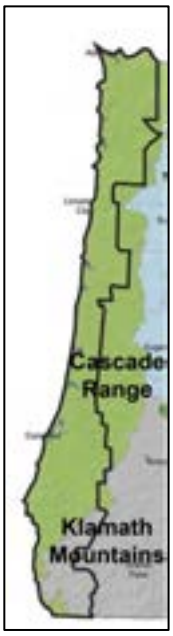
1. **Figure 2-R1-RP-1: County Boundaries, and Major Geographic Features in Region 1**



Source: USGS, NGA, NASA, CGIAR

The U.S. EPA's ecoregions are used to describe areas of ecosystem similarity. Region 1 is comprised of two ecoregions, as defined by the U.S. EPA: the Coast Range and a smaller area of the Klamath Mountains (Figure 2-R1-RP-2).

2. Figure 2-R1-RP-2: Ecoregions in Region 1



Source: Integrated Water Resources Strategy Map Gallery, State of Oregon, 2010

Coast Range: The Coast Range is Region 1's dominant ecoregion. Mountains in the Coast Range are low in elevation and high in precipitation, creating lush evergreen forests. The Coast Range's naturally occurring diverse forests have given way to monocrop plantings for timber harvest. Sedimentary soils are prone more to failure following clear cuts and road building than areas with volcanic soils, which may be of concern as the commercial Douglas Fir forests located here are highly productive commercial logging areas. Landslides can impact the safety of nearby infrastructure and health of the region's waterways. The ecoregion's sedimentary soils can create more concerns for stream sedimentation than areas with volcanic soils. The Coast Range's low lands include beaches, dunes, forests, lakes, marshes, and streams. Many wetlands in the ecoregion have been converted to dairy pastures.[2]

Klamath Mountains: The majority of the Klamath Mountains found in Region 1 are classified as the Coastal Siskiyous. This area has a wet, mild maritime climate. Land cover is a mix of hard- and soft- wood forests, which is far more diverse than the predominantly coniferous forests of the Coast Range. Logging, recreation, rural residential development, and mining activities are common in this ecoregion.[3]

Climate

Climate refers to the temperatures, weather patterns, and precipitation in the region. This section covers historic climate information. For estimated future climate conditions and possible impacts refer

[2] Ecoregions of Oregon. (n.d.). EPA. Retrieved March 8, 2014, from http://www.epa.gov/wed

[3] Ibid.

to the State Risk Assessment (pg. X) for statewide projections and the Region 1 Summary for projections in this region (pg.X).

Region 1 has a predominantly mild climate with localized variation in precipitation levels. Precipitation occurs predominantly in the winter months, mostly in the form of rain due to the region's low elevation. Wet winters and dry summers impact risk to drought, floods, landslides, and wildfires. Winter storms are often accompanied by high winds, which present a hazard for the region. Table 2-R1-RP-1 shows mean annual precipitation and temperatures for the three ecoregions in Region 1.[4] Variations in temperature and precipitation vary widely by subecoregion and microclimates. For more detailed and locally relevant climate data refer to the Oregon Climate Service.

3. Table 2-R1-RP-1: Average Rainfall and Temperatures in Region 1 Ecoregions

Ecoregion	Mean Annual Rainfall Range (inches)	Mean Temperature Range (°F) January min/max	Mean Temperature Range (°F) July min/max
Klamath Mountains*	35-130	29.5	49/88
Coast Range*	50-140	30/52	48/78

4.

Source: Thorson, Thor D. "Ecoregions of Oregon." Map. *Ecoregions of Oregon*. Reston, VA: U.S. Dept. of the Interior, U.S. Geological Survey, 2004. 1-2. Print. Note: *Data has been aggregated from all sub-regions present in the ecoregion

Social and Demographic

This section describes the characteristics of Region 1's population, tourism, income, housing tenure, gender, age, language, family structure, education level, persons with disabilities, and unhoused and transient populations. Data is followed by a discussion of characteristics that may indicate community vulnerability to natural hazards. Susan Cutter's research provides the basis by which the above demographic data sets were chosen for this analysis.

Population

Table 2-R1-RP-2 shows recent population estimates and the annual percent change for Region 1. Overall, from 2000-2013 Region 1's growth rate is 11.3% less than the state's average growth. The region has grown by just under 6,100 people (3.2%) during this period; the majority of growth has been in the northern three counties. While growth in Coos County (0.1%), the region's largest county, has been flat, Curry County has grown by over 1,100 (5.5%). The table also shows projected population for 2020. The data shows that counties in Region 1 are projected to grow at a slower rate than the state overall; with Lincoln County expected to experience the highest growth rate (6.4%) and Coos County to experience the lowest growth rate (2.0%).

[4] Ibid.

5. **Table 2-R1-RP-2: Population Estimate and Forecast for Region 1**

	2000	2013	Percent Change (2000 to 2013)	2020 Projected	Percent Change (2013 to 2020)
Oregon	3,421,399	3,919,020	14.5%	4,252,100	8.5%
Region 1	188,287	194,365	3.2%	201,941	3.9%
Clatsop	35,630	37,270	4.6%	38,461	3.2%
Coos	62,779	62,860	0.1%	64,098	2.0%
Curry	21,137	22,300	5.5%	23,087	3.5%
Lincoln	44,479	46,560	4.7%	49,535	6.4%
Tillamook	24,262	25,375	4.6%	26,760	5.5%

6.

Source: Population Research Center, Portland State University, 2013; U.S. Census Bureau, 2010 Decennial Census. Table DP-1; Office of Economic Analysis, Long-Term Oregon State's County Population Forecast, 2010-2050, 2013

Population forecasts are an indicator of future development needs and trends. Based on Cutter's research, community demographics may indicate where specific vulnerabilities may be present in the aftermath of a natural hazard. If a population is forecasted to increase substantially, a community's capacity to provide adequate housing stock, services, or resources for all populations post disaster may be stressed or compromised.[5]

Tourists

Tourists are not counted in population statistics; and are therefore considered separately in this analysis. Tourism activities in Region 1[6] are largely centered on outdoors activities, touring (traveling to experience scenic beauty, history and culture), special events, and resort stays.[7] The average travel party contains 3.2 persons and 82% of these trips originate from Oregon or California. In this region, the average trip length is 3.4 nights.[8] Table 2-R1-RP-3 shows the estimated number of person nights in private homes, hotels and motels, and other types of accommodations. The table provides information for coastal regions and for each county (except Central Coast counties Douglas and Lane). The data shows that the North and Central coast regions attract more tourists than the South Coast and that Lincoln County receives the largest single county share of tourists.

This table also shows that, as of 2013, visitors in Region 1 largely lodging in hotels and motels or within campgrounds or vacation homes (included within the "other" category). Tourists lodging in hotels, motels, vacation homes or campgrounds suggests that targeted outreach to these establishments could be useful in preparing tourists for hazards. It is important to note that a significant number of tourists also lodge in private homes (especially within Coos County).

[5] Cutter, Susan L., Bryan Boruff, W. Lynn Shirley. Social Vulnerability to Environmental Hazards. Social Science Quarterly. Volume 84, Number 2, June 2003.

[6] Note: "The Coast" includes coastal areas of Douglas and Lane Counties

[7] Longwoods Travel USA.(2011) *Regional Visitor Report 2011, The Coast.* Retrieved May 2, 2014 from http://industry.traveloregon.com/wp-content/uploads/2013/04/OR-Coast-Region-2011-Final-Report-rev-4_10_13.pdf

[8] Ibid.

7. Table 2-R1-RP-3: Annual Visitor Estimates in Person Nights in Region 1

	2011		2012		2013	
	Number	Percent	Number	Percent	Number	Percent
Region 1	14,368	-	14,669	-	15,388	-
North Coast	5,362	100%	5,537	100%	5,857	100%
Hotel/Motel	2,278	42.5%	2,394	43.2%	2,686	45.9%
Private Home	714	13.3%	738	13.3%	746	12.7%
Other	2,370	44.2%	2,405	43.4%	2,425	41.4%
Clatsop	3,082	100%	3,180	100%	3,410	100%
Hotel/Motel	1,671	54.2%	1,742	54.8%	1,954	57.3%
Private Home	467	15.2%	481	15.1%	487	14.3%
Other	944	30.6%	957	30.1%	969	28.4%
Tillamook	2,280	100%	2,357	100%	2,448	100%
Hotel/Motel	607	26.6%	652	27.7%	733	29.9%
Private Home	247	10.8%	257	10.9%	259	10.6%
Other	1,426	62.5%	1,448	61.4%	1,456	59.5%
Central Coast*	5,350	100%	5,392	100%	5,626	100%
Hotel/Motel	2,146	40.1%	2,134	39.6%	2,315	41.1%
Private Home	761	14.2%	780	14.5%	801	14.2%
Other	2,443	45.7%	2,478	46.0%	2,510	44.6%
Lincoln	4,004	100%	4,045	100%	4,233	100%
Hotel/Motel	1,857	46.4%	1,853	45.8%	2,004	47.3%
Private Home	573	14.3%	589	14.6%	604	14.3%
Other	1,574	39.3%	1,604	39.7%	1,626	38.4%
South Coast	3,656	100%	3,740	100%	3,905	100%
Hotel/Motel	1,230	33.6%	1,261	33.7%	1,389	35.6%
Private Home	1,015	27.8%	1,028	27.5%	1,042	26.7%
Other	1,411	38.6%	1,451	38.8%	1,474	37.7%
Coos	2,235	100%	2,296	100%	2,406	100%
Hotel/Motel	843	37.7%	875	38.1%	970	40.3%
Private Home	796	35.6%	806	35.1%	815	33.9%
Other	596	26.7%	615	26.8%	621	25.8%
Curry	1,421	100%	1,444	100%	1,500	100%
Hotel/Motel	387	27.2%	386	26.7%	420	28.0%
Private Home	219	15.4%	222	15.4%	227	15.1%
Other	815	57.4%	836	57.9%	853	56.9%

Source: Oregon Travel Impacts: 1991-2013, April 2014. Dean Runyan Associates, http://www.deanrunyan.com/doc_library/ORImp.pdf

* Central Coast also includes the coastal portions of Douglas and Lane counties; data is not aggregated for coastal portions of these counties within the report. See Region 3 (Lane) and Region 4 (Douglas) profiles for the entire county tourism data.

Tourists are specifically vulnerable due to the difficulty of locating or accounting for travelers within the region. Tourists are often at greater risk during a natural disaster because of unfamiliarity with

evacuation routes, communication outlets, or even the type of hazard that may occur.[9] Knowing whether the region's visitors are staying in friends/relatives homes in hotels/motels, or elsewhere (campgrounds, vacation homes, etc.) can be instructive when developing outreach efforts.

Income

Income describes the amount of monetary compensation a household receives for work, from government programs, or from other sources to pay for expenses such as food, housing, transportation, and to contribute to savings. The recent Great Recession impacted Region 1 unevenly, the greatest impacts occurred in the south coast counties (Coos, Curry and Douglas) which were already affected by increased levels of joblessness and less diverse economies. Table 2-R1-RP-4 shows slight increases in real incomes in Clatsop, Lincoln and Tillamook counties and shows decreases in real incomes for Coos and Curry counties. Median household incomes in the region are $6,000 - $12,000 below the state level, with the lowest median household incomes in Coos and Curry counties.

8. Table 2-R1-RP-4: Median Household Income in Region 1

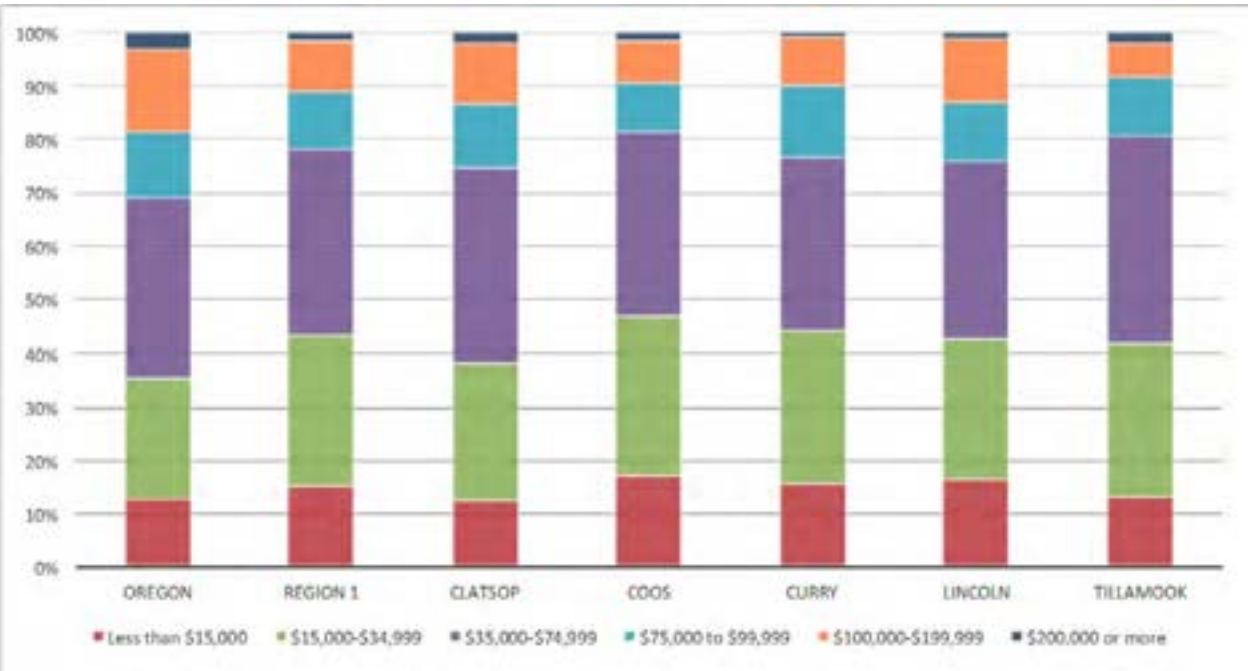
	2009	2012	Percent Change
Oregon	$52,474	$50,036	-4.6%
Region 1	n/a	n/a	n/a
Clatsop	$43,263	$44,330	2.5%
Coos	$39,334	$37,853	-3.8%
Curry	$38,714	$38,401	-0.8%
Lincoln	$40,849	$41,996	2.8%
Tillamook	$41,578	$41,869	0.7%

Source: U.S. Census Bureau. 2005-2009 and 2008-2012. American Community Survey – 5-Year Estimates. Table DP03.
Note: 2009 dollars are adjusted for 2012 using Bureau of Labor Statistics' Consumer Price Index Inflation Calculator.
n/a = data not aggregated at the regional level.

Figure 2-R1-RP-3 illustrates that the region has a larger percentage (43.2%) of its households making less than $35,000 per year than the state as a whole (35.2%). Conversely, the region has approximately 9% of its households making $75,000 or more per year than the state (21.9% and 31.0% respectively). Within the region, Clatsop and Lincoln counties have the largest percentage of their households making more than $75,000 per year, 25.2% and 24.0% respectively.

[9] MDC Consultants (n.d.). *When Disaster Strikes – Promising Practices*. Retrieved March 18, 2014, from http://www.mdcinc.org/sites/default/files/resources/When%20Disaster%20Strikes%20-%20Promising%20Practices%20-%20Tourists.pdf

9. Figure 2-R1-RP-3: Median Household Income Distribution in Region 1, 2012



Source: U.S. Census Bureau; 2008-2012 American Community Survey 5-Year Estimates, Table DP03

Table 2-R1-RP-5 shows poverty rates, and percent change, from 2009 to 2012. The rates are shown for the total population that is in poverty (including children) and for the subset of children under 18. The region has more individuals (16.3%) and children (22.6%) living in poverty than the state averages (15.5% and 20.6% respectively); however, the growth rate of individuals (5.5%) and children (4.5%) living in poverty is less than the state averages (17.7% and 17.6% respectively). Coos County has the highest percent (17.3%0 and number (10,661) of individuals living in poverty. Tillamook County has the highest percent of children (26.7%) living in poverty, while Coos County has the largest number of children (2,659) living in poverty. Clatsop County has the highest percent change in total population in poverty, 27.1%. Lincoln County's has experienced a 6.9% decrease in individuals in poverty and a 14.8% decrease in children under 18 in poverty.

10. Table 2-R1-RP-5: Poverty Rates in Region 1, 2012

	Total Population in Poverty			Children Under 18 in Poverty		
	Number	Percent	Percent Change*	Number	Percent	Percent Change*
Oregon	584,059	15.5%	17.7%	175,303	20.6%	17.6%
Region 1	30,893	16.3%	5.5%	7,958	22.6%	4.5%
Clatsop	5,725	15.8%	27.1%	1,829	25.0%	37.3%
Coos	10,661	17.3%	3.6%	2,659	23.1%	0.3%
Curry	3,048	13.7%	3.9%	531	14.8%	-8.4%
Lincoln	7,262	16.0%	-6.9%	1,618	20.5%	-14.8%
Tillamook	4,197	17.2%	12.2%	1,321	26.7%	14.9%

Source: U.S. Census Bureau. 2005-2009 and 2008-2012. American Community Survey – 5-Year Estimates, Table S1701
Note: *Percent change since 2009

Cutter's research suggests that lack of wealth contributes to social vulnerability because individual and community resources are not as readily available. Affluent communities are more likely to have both the collective and individual capacity to more quickly rebound from a hazard event, while impoverished communities and individuals may not have this capacity –leading to increased vulnerability. Wealth can help those affected by hazard incidents to absorb the impacts of a disaster more easily. Conversely, poverty, at both an individual and community level, can drastically alter recovery time and quality.[10]

Federal assistance programs such as food stamps are another indicator of poverty or lack of resource access. Statewide social assistance programs like the Supplemental Nutritional Assistance Program (SNAP) and Temporary Assistance for Needy Families (TANF) provide assistance to individuals and families. In Region 1, TANF reaches approximately 1,800 families per month and SNAP helps to feed just over 48,000 people (28,500 households) per month (about 23% of the region's population).[11] Those reliant on federal assistance are more vulnerable in the wake of disaster because of a lack of personal financial resources and reliance on government support.

Housing Tenure

Housing tenure describes whether residents rent or own the housing units they occupy. Homeowners are typically more financially stable but are at risk of greater property loss in a post-disaster situation. People may rent because they choose not to own, do not have the financial resources for home ownership, or are transient.

Collectively, counties in Region 1 have a 4.0% greater home-ownership rate compared to the state overall. Tillamook County has the highest percentage of owned occupied households in the region– 3.6% more than the region's average. Clatsop County has a 4.2% higher rate of renter occupied units than the other counties in the region. Region 1 has a housing unit vacancy rate (7.3%) that is higher than the state average (6.3%); Coos (9.0%) and Curry (12.1%) have the highest vacancy rates. Seasonal, or recreational use, homes account for 18.2% of the regions housing units, compared to the state as a whole (3.3%). Lincoln County has the largest number of housing units (7,739) that are seasonal or recreational, while Tillamook County has the highest percentage (37.1%) in this category; the region as a whole has over 20,600 units.

[10] Cutter, S. L. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly*.

[11] Sabatino, J. (2014). *Oregon TANF Caseload, "One and Two Parent Families Combined",* Districts 1, 4, 5 6, and 7; May 2014 data, and Sabatino, J. (2014). *Oregon SNAP Program Activity, "SSP, APD and AAA Combined",* Districts 1, 4, 5, 6 and 7; May 2014 data. Retrieved from State of Oregon Office of Business Intelligence website: http://www.oregon.gov/dhs/assistance/Pages/data/main.aspx, June 2014. Note: Only coastal field offices reported for Districts 1, 4, 5, 6 and 7.

Table 2-R1-RP-6: Housing Tenure in Region 1, 2012

	Occupied Units	Owner-occupied		Renter-occupied		Vacant^	
		Estimate	Percent	Estimate	Percent	Estimate	Percent
Oregon	1,512,718	945,824	62.5%	566,894	37.5%	105,417	6.3%
Region 1	84,526	56,191	66.5%	28,335	33.5%	8,346	7.3%
Clatsop	15,757	9,814	62.3%	5,943	37.7%	1,647	7.6%
Coos	26,567	17,672	66.5%	8,895	33.5%	2,750	9.0%
Curry	10,320	7,162	69.4%	3,158	30.6%	1,517	12.1%
Lincoln	21,039	13,945	66.3%	7,094	33.7%	1,738	5.7%
Tillamook	10,843	7,598	70.1%	3,245	29.9%	694	3.8%

Source: U.S. Census Bureau, 2008-2012 American Community Survey 5-Year Estimates, Table DP04 and Table B25004.
^ = Functional vacant units, computed after removing seasonal, recreational, or occasional housing units from vacant housing units.

According to Cutter, wealth increases resiliency and recovery from disasters. Renters often do not have personal financial resources or insurance to assist them post-disaster. On the other hand, renters tend to be more mobile and have fewer assets at risk of natural hazards.[12] In the most extreme cases, renters lack sufficient shelter options when lodging becomes uninhabitable or unaffordable post-disaster.

Gender

The gender breakdown in Region 1 (Male: 49.4%, Female 50.6%) is similar to that of the state.[13] It is important to recognize that women tend to have more institutionalized obstacles than men during recovery due to sector-specific employment, lower wages, and family care responsibilities.[14]

Age

Age can impact health, physical ability, experience and skill sets. Table 2-R1-RP-7 shows Region 1 has a 7.4% greater share of seniors than the state average. The percentage of children, under age 18, in Region 1 is 3.8% lower than the statewide percentage.

[12] Cutter, S. L. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly*.

[13] U.S. Census Bureau; American Community Survey, 2010 Demographic Profile Data, Table DP-1; using American FactFinder (2 May 2014).

[14] Ibid.

'Table 2-R1-RP-7: Population by Vulnerable Age Groups, in Region 1, 2012

	Total Population	Under 18 years old		65 years and older	
	Estimate	Estimate	Percent	Estimate	Percent
Oregon	3,836,628	864,243	22.5%	540,527	14.1%
Region 1	193,595	36,181	18.7%	41,648	21.5%
Clatsop	37,068	7,583	20.5%	6,368	17.2%
Coos	62,937	11,932	19.0%	13,674	21.7%
Curry	22,344	3,592	16.1%	6,240	27.9%
Lincoln	45,992	8,040	17.5%	10,090	21.9%
Tillamook	25,254	5,034	19.9%	5,276	20.9%

Source: U.S. Census Bureau; 2008-2012 American Community Survey 5-Year Estimates, Table DP05

Studies show that children and seniors are particularly vulnerable populations. Cutter reiterates this point saying, "Extremes of age spectrum affect the movement out of harm's way." According to Cutter's research children and the elderly may need greater assistance during and after a natural hazard. Additionally, parents may lose time and money when their children's childcare facilities and schools are impacted by disasters.[15]

In addition, literature suggests the elderly may be reluctant to leave their homes in a disaster event. This implies the need for targeted preparatory programming that includes evacuation procedures and shelter locations accessible to the elderly populations[16].

Language

Table 2-R1-RP- 8 shows a majority (97.7%) of the region's population speaks English very well; this rate is higher than the state average of 93.8%. Conversely, the percentage of people who do not speak English very well, 2.3% (3.4% within Tillamook County) is lower than the state average of 6.2%.

Table 2-R1-RP- 8: English Usage in Region 1, 2012

	Speak English "Very Well"		Speak English less than "very well"	
	Estimate	Percent	Estimate	Percent
Oregon	3,376,744	93.8%	224,905	6.2%
Region 1	179,730	97.7%	4,281	2.3%
Clatsop	34,027	97.0%	1,070	3.0%
Coos	58,969	98.7%	798	1.3%
Curry	21,227	98.9%	230	1.1%
Lincoln	42,374	96.9%	1,365	3.1%
Tillamook	23,133	96.6%	818	3.4%

Source: U.S. Census Bureau; 2008-2012 American Community Survey 5-Year Estimates, Table DP02

[15] Cutter, S. L. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly*.

[16] Morrow, B. H. (1999). Identifying and Mapping Community Vulnerability. *Disasters*. doi:10.1111/1467-7717.00102

Outreach materials used to communicate with, plan for, and respond to non-English speaking populations, and those who do not speak English very well, should take into consideration the language needs of these populations.

Families and Living Arrangements

Two ways the census defines households are by type of living arrangement and family structure. A householder may live in a "family household" (a group related to one another by birth, marriage or adoption living together); in a "nonfamily household" (a group of unrelated people living together); or alone. Region 1 is predominately comprised of family households (61.5%), a rate that is slightly lower than the state average (63.7%). Of the non-family households (households that include people who are not related by birth or marriage), 31.3% are one-person households, a rate that is 3.4% higher than the state average (Table 2-R1-RP- 9).

Table 2-R1-RP- 9: Family vs. Non-family Households in Region 1, 2012

	Total Households	Family Households		Nonfamily Households		Householder Living Alone	
	Estimate	Estimate	Percent	Estimate	Percent	Estimate	Percent
Oregon	1,512,718	964,274	63.7%	548,444	36.3%	421,620	27.9%
Region 1	84,526	52,009	61.5%	32,517	38.5%	26,443	31.3%
Clatsop	15,757	9,825	62.4%	5,932	37.6%	4,893	31.1%
Coos	26,567	16,171	60.9%	10,396	39.1%	8,215	30.9%
Curry	10,320	6,298	61.0%	4,022	39.0%	3,317	32.1%
Lincoln	21,039	12,725	60.5%	8,314	39.5%	6,802	32.3%
Tillamook	10,843	6,990	64.5%	3,853	35.5%	3,216	29.7%

Source: U.S. Census Bureau, 2008-2012 American Community Survey 5-Year Estimates, Table DP04

Table 2-R1-RP-10 shows household structures for families with children within Region 1. In total the region has fewer families with children (20.5%) than the state as a whole (27.5%). The region also has a smaller percent of single parent families with children (male parent 2.3%, female parent 4.9%) than the state as a whole (male parent 2.4%, female parent 6.2%). Coos County has the largest number of households with children (5,205) followed by Lincoln (3,969) and Clatsop (3,873) counties. The region combined has a lower rate of married couple households with children (13.3%) than does the state as a whole (18.9%).

Table 2-R1-RP-10: Family Households with Children by Head of Household in Region 1, 2012

	Family Households with Children		Single Parent (male)		Single Parent (female)		Married Couple with Childern	
	Estimate	Percent	Estimate	Percent	Estimate	Percent	Estimate	Percent
Oregon	415,538	27.5%	35,855	2.4%	93,575	6.2%	286,108	18.9%
Region 1	17,303	20.5%	1,914	2.3%	4,124	4.9%	11,265	13.3%
Clatsop	3,873	24.6%	393	2.5%	1,035	6.6%	2,445	15.5%
Coos	5,205	19.6%	543	2.0%	1,230	4.6%	3,432	12.9%
Curry	1,763	17.1%	271	2.6%	331	3.2%	1,161	11.3%
Lincoln	3,969	18.9%	381	1.8%	947	4.5%	2,641	12.6%
Tillamook	2,493	23.0%	326	3.0%	581	5.4%	1,586	14.6%

Source: U.S. Census Bureau; 2008-2012 American Community Survey 5-Year Estimates, Table DP04
Note: The table shows the percent of total households represented by each family household structure category.

Literature indicates that households with children and those headed by single parents are at greater risk because they often have limited resources. Family care and obligations can create additional hardship during recovery. Generally, the juggling of work responsibilities and family care affect the resilience to and recovery from natural disasters.[17]

Education Level

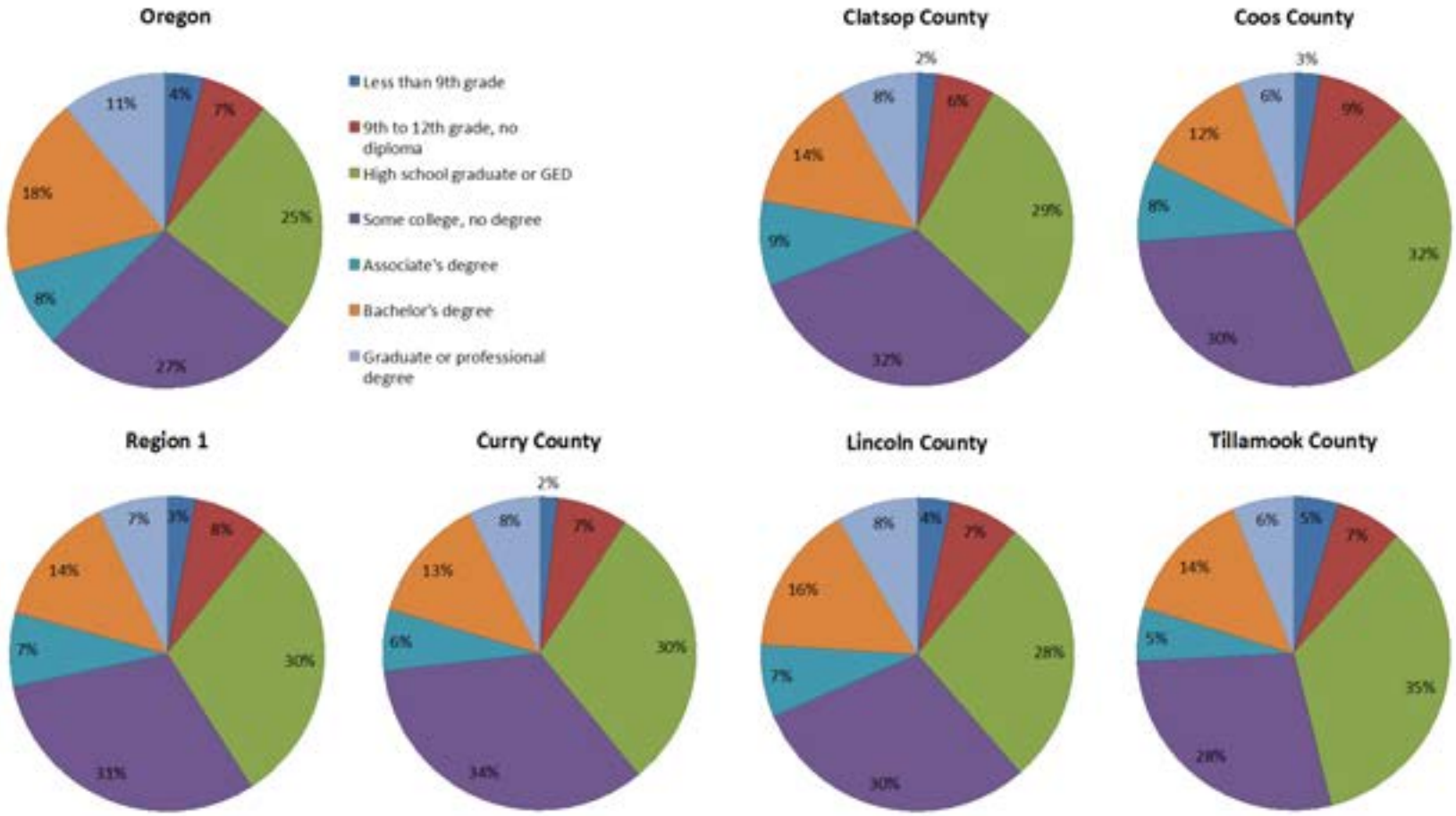
Studies show, education and socioeconomic status are deeply intertwined, with higher educational attainment correlating to increased lifetime earnings. The region has a 5% higher rate of persons with a high school degree or GED and a 4% higher rate with some college, compared to state percentages. The percentage of those with less than a high school education is proportional to state numbers. The percentage of individuals with some college, but no degree, is 4% greater in the region than state the state average. In contrast those with a bachelor's or master's degree is 8% less than the state average. Coos (44%) and Tillamook (47%) have the greatest proportion of their population with a high school degree or less (state average is 36%); while Clatsop (31%) and Lincoln (31%) have the greatest proportion of their populations with an associate's degree or more (state average is 37%).

Education can influence the ability to access resources, while lack of resources may constrain the ability to understand warning information.[18] Therefore, levels of education within the region should be considered when designing hazard outreach materials to local communities.

[17] Cutter, S. L. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly*.

[18] Ibid.

11. Figure 2-R1-RP-4: Educational Attainment in Region 1, 2012



Source: U.S. Census Bureau; 2008-2012 American Community Survey 5-Year Estimates, Table DP02

Persons with Disabilities

Disabilities appear in many different forms. While some disabilities may be easily identified, others may be less perceptible. Some common disabilities include autism, diabetes, sensory impairments, spinal injuries, post-traumatic stress syndrome and mental disabilities.[19] Table 2-R1-RP-11 shows greater percentage of the population in Region 1 (20.1%) identify themselves as having a disability than the state average (13.5%). In Curry County 25.0% of the population has a mental or physical disability (or both). The rate of children (under 18) with a disability is 1.5% greater than the state average. Additionally, about 40% of the elderly populations in the region have mental and/ or physical disabilities, which is comparable to the state average; Coos (43.9%) and Curry (42.5%) counties have the highest rate of seniors with a disability.

12. Table 2-R1-RP-11 People with a Disability by Age Groups in Region 1, 2012

	Total Population*	With a disability (Total Population)		Under 18 years with a disability		65 years and over with a disability	
	Estimate	Estimate	Percent	Estimate	Percent**	Estimate	Percent**
Oregon	3,796,881	511,297	13.5%	39,439	4.6%	200,374	37.8%
Region 1	190,678	38,347	20.1%	2,200	6.1%	16,126	39.2%
Clatsop	36,381	6,447	17.7%	540	7.1%	2,335	37.3%
Coos	62,026	14,000	22.6%	824	6.9%	5,911	43.9%
Curry	22,180	5,547	25.0%	221	6.2%	2,629	42.5%
Lincoln	45,632	8,746	19.2%	409	5.1%	3,679	36.8%
Tillamook	24,459	3,607	14.7%	206	4.1%	1,572	30.4%

Source: U.S. Census Bureau, 2008-2012 American Community Survey 5-Year Estimates, Table DP02
Note: *Total population does not include institutionalized population
Note: **Percent of age group

According to Cutter, "Special needs populations (infirm, institutionalized, transient, homeless), while difficult to identify and measure, are disproportionately affected during disasters and, because of their invisibility in communities, mostly ignored during recovery."[20] Because Region 1 has a higher number of persons with disabilities, plans should be made to identify those populations pre-disaster and to specifically target hazard preparedness outreach programs to them to help better prepare for and recover from hazard events.

Homeless Population

Population estimates of the homeless (those seeking emergency shelter, voucher, transitional housing, unsheltered or turned away) are performed once each year (in January) across Oregon. These are rough estimates and can fluctuate with many factors, including the economy or season. The overwhelming majority of homeless are either single adult males or families with children. Communities located along major transportation corridors tend to have higher concentrations of transient populations.[21] The homeless

[19] Kirshman, N. H., & Grandgenett II, R. L. (1997). *ADA: The 10 Most Common Disabilities and How to Accommodate | LegalBrief.com*. Retrieved March 2014, from http://www.LegalBrief.com/kirshman.html

[20] Cutter, S. L. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly*.

[21] Thomas, Y. F., Richardson, D., Cheung, I., & Association of American Geographers, N. (2008). *Geography and drug addiction*.Dordrecht: Springer.

population has increased over the three-year period with about 696 persons in 2009 to 1,892 persons in 2011. Coos County has more than double the number of homeless persons than any other county in the region.

Table 2-R1-RP-12: Homeless Population Estimate for Region 1

	2009	2010	2011	Three Year Average
Oregon	17,122	19,208	22,116	19,482
Region 1	696	1,504	1,892	1,364
Clatsop	137	184	407	243
Coos	390	821	991	734
Curry	105	133	93	110
Lincoln	48	82	41	57
Tillamook	16	284	360	220

Source: Oregon Point in Time Homeless Count, Oregon Housing and Community Services.
http://www.oregon.gov/ohcs/pages/ra_point_in_time_homeless_count.aspx

Extra attention is needed to care for and serve homeless communities. Many unhoused or transient people choose to remain hidden or anonymous, while others are simply unnoticed. To serve these communities post-disaster, it is important to provide easy and accessible shelter and social services.

Social and Demographic Trends

The Social and Demographic analysis shows that Region 1 is particularly vulnerable during a hazard event in the following categories:

Population growth is one-fifth the rate of the states and is projected to grow at half the rate of the state;
Tourists lodging in hotels, motels and other non-private home locations, especially within the central and north coast;
Household with a median income below the state average (Coos and Curry counties);
Households living in poverty is increasing dramatically within Clatsop County;
People over the age of 65 (Curry County);
There are lower percentages of people with college and/ or advanced degrees;
People with disabilities higher than the state average (Coos and Curry counties);
Coos County includes approximately half of all homeless persons within the region.
Local plans should recognize these vulnerabilities as well as potential combined vulnerabilities within social groups; for example, a child with a disability living in poverty in a single-parent household. LNHMPs should identify mitigation efforts that can effectively deal with the populations who lack adequate social, physical, and educations resources to assist with post-disaster recovery.

Economic

Economic characteristics include the financial resources present and revenue generated in the community to achieve a higher quality of life. Employment characteristics, income equality, employment and industry

sectors are measures of economic capacity. However, economic resilience to natural disasters is far more complex than merely restoring employment or income in the local community. Building a resilient economy requires an understanding of how the component parts of employment sectors, workforce, resources and infrastructure are interconnected in the existing economic picture. Once any inherent strengths or systematic vulnerabilities become apparent, both the public and private sectors can take action to increase the resilience of the local economy. Data in this section is followed by a discussion of characteristics that may indicate community vulnerability to natural hazards.

Employment

Regional unemployment rates are declining steadily since 2009 but remain 0.8% higher than the statewide rate (Table 2-R1-RP-13). The region's unemployment rate has changed less (-2.5%) than the state as a whole (-3.4%).

13. Table 2-R1-RP-13: Unemployment Rates in Region 1, 2009-2013

	2009	2010	2011	2012	2013	Change (2009-2013)
Oregon	11.1%	10.8%	9.7%	8.8%	7.7%	-3.4%
Region 1	11.0%	11.1%	10.3%	9.6%	8.5%	-2.5%
Clatsop	9.0%	9.3%	8.7%	7.8%	6.8%	-2.2%
Coos	12.8%	12.6%	11.5%	10.8%	9.9%	-3.0%
Curry	13.0%	12.8%	12.2%	11.7%	10.6%	-2.4%
Lincoln	10.5%	10.7%	10.1%	9.4%	8.2%	-2.3%
Tillamook	9.4%	9.7%	9.1%	8.6%	7.2%	-2.2%

Source: Oregon Employment Department, 2014.

Table 2-R1-RP-14 shows that regional employment, as of 2013, is slightly lower than the state as a whole. Coos County has the largest labor force in the region and the second highest unemployment rate; Curry County has the highest unemployment rate in the region (10.6%). Spring and summer bring the highest employment rates to the region, as the weather improves and tourism, construction, fishing, and retail trade increase.[22]

[22] Knoder, E. A. (2014, April 1). *OLMIS – Recent Trends: Region 1*. Retrieved from http://www.qualityinfo.org/olmisj/Regions?page=2&area=000001 and Tauer, G. (2014, April 1). *OLMIS - Recent Trends: Region 7*. Retrieved from http://www.qualityinfo.org/olmisj/ArticleReader?print=1&itemid=00002492

Table 2-R1-RP-14: Employment and Unemployment Rates in Region 1, 2013

	Civilian Labor Force	Employed Workers		Unemployed	
	Total	Total	Percent	Total	Percent
Oregon	1,924,604	1,775,890	92.3%	148,714	7.7%
Region 1	90,368	82,699	91.5%	7,669	8.5%
Clatsop	19,984	18,621	93.2%	1,363	6.8%
Coos	27,479	24,772	90.1%	2,707	9.9%
Curry	8,689	7,770	89.4%	919	10.6%
Lincoln	21,916	20,121	91.8%	1,795	8.2%
Tillamook	12,300	11,415	92.8%	885	7.2%

Source: Oregon Employment Department, 2014.

According to Cutter, "The potential loss of employment following a disaster exacerbates the number of unemployed workers in a community, contributing to a slower recovery from the disaster." Lower employment rates during winter months could be further exacerbated by a hazard event.

Table 2-R1-RP-15 shows average earnings of the labor force. The majority of the region's employees are within Clatsop (16,888), Coos (21,579), and Lincoln (17,329) counties. Average salaries are 25.2% to 29.3% lower than the statewide average ($45,010).[23]

14. Table 2-R1-RP-15: Employment and Payroll in Region 1, 2013

	Employees	Average Pay	Percent State Average
Oregon	1,679,364	$45,010	100%
Region 1	70,445	–	–
Clatsop	16,888	$33,680	74.8%
Coos	21,579	$33,332	74.1%
Curry	6,180	$31,801	70.7%
Lincoln	17,329	$32,387	72.0%
Tillamook	8,469	$32,685	72.6%

Source: Oregon Employment Department, 2014.

According to Cutter (2003), employment status and salary level may impact the resilience of individuals and families in the face of disasters as well as their ability to mitigate against natural hazards. Since the end of the Great Recession in June 2009 job recovery in Region 1 has lagged behind statewide numbers. However, the region's economy has seen a high level of job growth since 2012, with an over-the year gain of 950 jobs in 2012.[24]

[23] Data is for "Covered Employment", workers covered by state Unemployment Insurance (UI) laws and for civilian workers covered by the program of Unemployment Compensation for Federal Employees

[24] Knoder, E. A. (2014, March 28). *OLMIS - The Oregon Coast Economy in 2013*. Retrieved from http://www.olmis.org/olmisj/ArticleReader?itemid=00007480

Employment Sectors and Key Industries

In 2012, the five major employment sectors in Region 1 are: Government (21.3%), Trade Transportation and Utilities (18.2%), Leisure and Hospitality (18.0%), Education and Health Services (10.2%), and Manufacturing (9.3%). Tables 2-R1-RP-16a and 16b show the distribution of total employment across all sectors. Natural-resource industries (wood products, fishing, etc.) are historic key industries of Region 1 and remain important. However, of growing importance are industries that rely upon the emerging retirement and seasonal tourist populations (leisure and hospitality).[25]

15. Table 2-R1-RP-16a: Covered Employment by Sector in Region 1, 2013

		Clatsop County		Coos County		Curry County	
Industry	Region 1	Employment	Percent	Employment	Percent	Employment	Percent
Total All Ownerships	70,445	16,888	100%	21,579	100%	6,180	100%
Total Private Coverage	78.7%	14,241	84.3%	16,017	74.2%	5,031	81.4%
Natural Resources & Mining	3.8%	441	2.6%	979	4.5%	298	4.8%
Construction	3.7%	658	3.9%	674	3.1%	332	5.4%
Manufacturing	9.3%	2,149	12.7%	1,657	7.7%	564	9.1%
Trade, Transportation & Utilities	18.2%	2,925	17.3%	4,085	18.9%	1,187	19.2%
Information	0.9%	151	0.9%	187	0.9%	65	1.1%
Financial Activities	3.2%	526	3.1%	669	3.1%	238	3.9%
Professional & Business Services	6.8%	711	4.2%	2,266	10.5%	428	6.9%
Education & Health Services	11.1%	2,116	12.5%	2,502	11.6%	671	10.9%
Leisure & Hospitality	18.0%	3,915	23.2%	2,352	10.9%	1,028	16.6%
Other Services	3.6%	651	3.9%	646	3.0%	218	3.5%
Private Non-Classified	0.0%	(c)	–	(c)	–	(c)	–
Total All Government	21.3%	2,647	15.7%	5,562	25.8%	1,150	18.6%
Federal Government	1.5%	206	1.2%	323	1.5%	84	1.4%
State Government	3.8%	450	2.7%	963	4.5%	174	2.8%
Local Government	16.0%	1,990	11.8%	4,276	19.8%	892	14.4%

Source: Oregon Employment Department, 2013

Note: (c) = confidential, information not provided by Oregon Employment Department to prevent identifying specific businesses.

[25] "Regions 1, 4, 5, 6 and 7: Overviews." *OLMIS*. N.p., n.d. Web. May 7. 2014. <http://www.qualityinfo.org/olmisj/Regions?area=000008&page=2>.

Table 2-R1-RP-16b: Covered Employment by Sector in Region 1, 2013

Industry	Region 1	Lincoln County		Tillamook County	
		Employment	Percent	Employment	Percent
Total All Ownerships	70,445	17,329	100%	8,469	100%
Total Private Coverage	78.7%	13,497	77.9%	6,684	78.9%
Natural Resources & Mining	3.8%	310	1.8%	661	7.8%
Construction	3.7%	652	3.8%	300	3.5%
Manufacturing	9.3%	1,080	6.2%	1,133	13.4%
Trade, Transportation & Utilities	18.2%	3,332	19.2%	1,289	15.2%
Information	0.9%	174	1.0%	43	0.5%
Financial Activities	3.2%	561	3.2%	257	3.0%
Professional & Business Services	6.8%	989	5.7%	405	4.8%
Education & Health Services	11.1%	1,667	9.6%	898	10.6%
Leisure & Hospitality	18.0%	4,096	23.6%	1,315	15.5%
Other Services	3.6%	631	3.6%	381	4.5%
Private Non-Classified	0.0%	6	0.0%	(c)	–
Total All Government	21.3%	3,833	22.1%	1,785	21.1%
Federal Government	1.5%	352	2.0%	107	1.3%
State Government	3.8%	694	4.0%	386	4.6%
Local Government	16.0%	2,788	16.1%	1,292	15.3%

Source: Oregon Employment Department, 2013
Note: (c) = confidential, information not provided by Oregon Employment Department to prevent identifying specific businesses.

Each of the primary private employment sectors has sensitivity to natural hazards, as follows.

The ***Government*** sector is comprised of federal, state and local employees. Following a disaster event it is likely that agencies will be understaffed. It is important to have established clear lines of authority and to develop productive intergovernmental relations to develop additional capacity. In addition, all level of governments should have established funding sources decision-making processes.

Trade, Transportation and Utilities: *Retail Trade* is the largest employment subsector within the Trade, Transportation and Utilities sector. Retail Trade is vulnerable to disruptions in the disposable income of regional residents and to disruptions in the transportation system. Residents' discretionary spending diminishes after natural disasters as spending priorities tend to focus on essential items. Disruption of the transportation system could sever connectivity of people and retail hubs. Retail businesses are concentrated in the larger cities of the region.

The ***Leisure and Hospitality*** sector primarily serves regional residents with disposable income and tourists. The behavior of both of these social groups would be disrupted by a natural disaster. Regional residents may have less disposable income and tourists may choose not to visit a region with unstable infrastructure.

Education and Health Services: The *Health and Social Assistance* industries play important roles in emergency response in the event of a disaster. The importance of the health care and social assistance sector is underscored in Region 1 because of the region's increasing numbers of retirees and individuals with a disability. Health care is a relatively stable revenue sector regionally with an abundant distribution of businesses primarily serving a local population.

Manufacturing is highly dependent upon transportation networks in order to access supplies and send finished products to outside markets. For these reasons the manufacturing sector may be susceptible to

disruptions in transportation infrastructure. However, manufacturers are not dependent on local markets for sales, which may contribute to the economic resilience of this sector. Within the region, manufacturers are primarily based in Clatsop and Tillamook counties.

Revenue by Sector

In 2007 Manufacturing, Trade (Retail and Wholesale), and Healthcare and Social Assistance were the highest revenue grossing industries in Region 1.[26] Combined, these three industries generated nearly $5.9 billion (84% of $7 billion total) in revenue for the region (Table 2-R1-RP-17). Manufacturing represented nearly 60% of revenue within Tillamook County, whereas it accounted for only 15.0% of Coos County's revenue. Conversely, Health Care and Social Assistance accounted for 17.7% of Coos County's revenue and only 6.9% of Tillamook County's. Trade (Retail and Wholesale) accounted for approximately 40% of all revenue within the region, but only 24.0% within Tillamook County.

16. Table 2-R1-RP-17: Revenue of Top Industries (in Thousands of Dollars) in Region 1, 2007

	Total Revenue (in Thousands)	Trade (Retail & Wholesale)	Manufacturing	Health Care and Social Assistance
Oregon	$277,017,733	44.4%	24.1%	7.3%
Region 1	$6,987,691	39.3%	33.9%	11.0%
Clatsop	$1,800,769	37.8%	38.0%	8.0%
Coos	$1,859,888	52.5%	15.0%	17.7%
Curry	$586,151	38.7%	32.5%	10.5%
Lincoln	$1,675,051	36.3%	34.8%	9.3%
Tillamook	$1,065,832	24.0%	59.5%	6.9%

Source: U.S. Census, Economic Census. 2007, Table ECO700A1

Sectors that are anticipated to be major employers in the future warrant special attention, especially in the hazard mitigation planning process so workforces and employers can be more prepared to respond and adapt to needs that arise after a natural hazard event. According to the Oregon Employment Department, between 2012 and 2022, the largest job growth in Region 1 is expected to occur in the following sectors: education and health services; government; trade, transportation and utilities (including retail trade); leisure and hospitality; and professional and business services sectors.[27]

Identifying sectors with a large number of businesses, and targeting mitigation strategies to support those sectors, can help the region's resiliency. The Trade, Transportation and Utilities sector includes the most businesses in Region 1 with 1,344 units, 19.4% of all businesses. Retail Trade is the largest sub-category within this sector with 965 business units, 13.9% of all businesses. The Leisure and Hospitality sector has the second largest number of business units (1,053 units, or 15.2%). The Other Services sector is the third most abundant with 889 business units, 12.8%. Professional and Business Services is next with 677 business units (9.8%). Construction rounds off the top five with 638 business units (9.2%).[28] While many of these are small businesses, employing fewer than 20 employees, collectively they represent two-thirds of

[26] Revenue data from the 2012 Economic Census will not be released prior to the publication of this SNHMP.

[27] Oregon Employment Department (2014), *Employment Projections by Industry and Occupation: 2012-2022 Oregon and Regional Summary* Retrieved May 9, 2014, from http://www.qualityinfo.org/olmisj/PubReader?itemid=00005720

[28] Oregon Employment Department, 2013.

the business units in the region. Due to their small size and large collective share of the economy, these businesses are particularly sensitive to temporary decreases in demand, such as may occur following a natural hazard event.

Economic Trends and Issues

Current and anticipated financial conditions of a community are strong determinants of community resilience, since a strong and diverse economic base increases the ability of individuals, families and communities to absorb impacts of a disaster and recover more quickly. The Economic analysis shows that Region 1 is particularly vulnerable during a hazard event due to the following characteristics:

- High regional unemployment (Coos and Curry counties);
- Lower regional wages – 71% to 75% of state average pay;
- An economy heavily dependent on a seasonal employment (tourism based) and a few key industries.

Supporting the growth of dominant industries and employment sectors, as well as emerging sectors identified in this analysis, can help the region become more resilient to economic downturns that often follow a hazard event.[29]

Infrastructure Profile

Infrastructure analyzed in this Plan include, transportation networks, power transmission systems, telecommunications, and water systems.

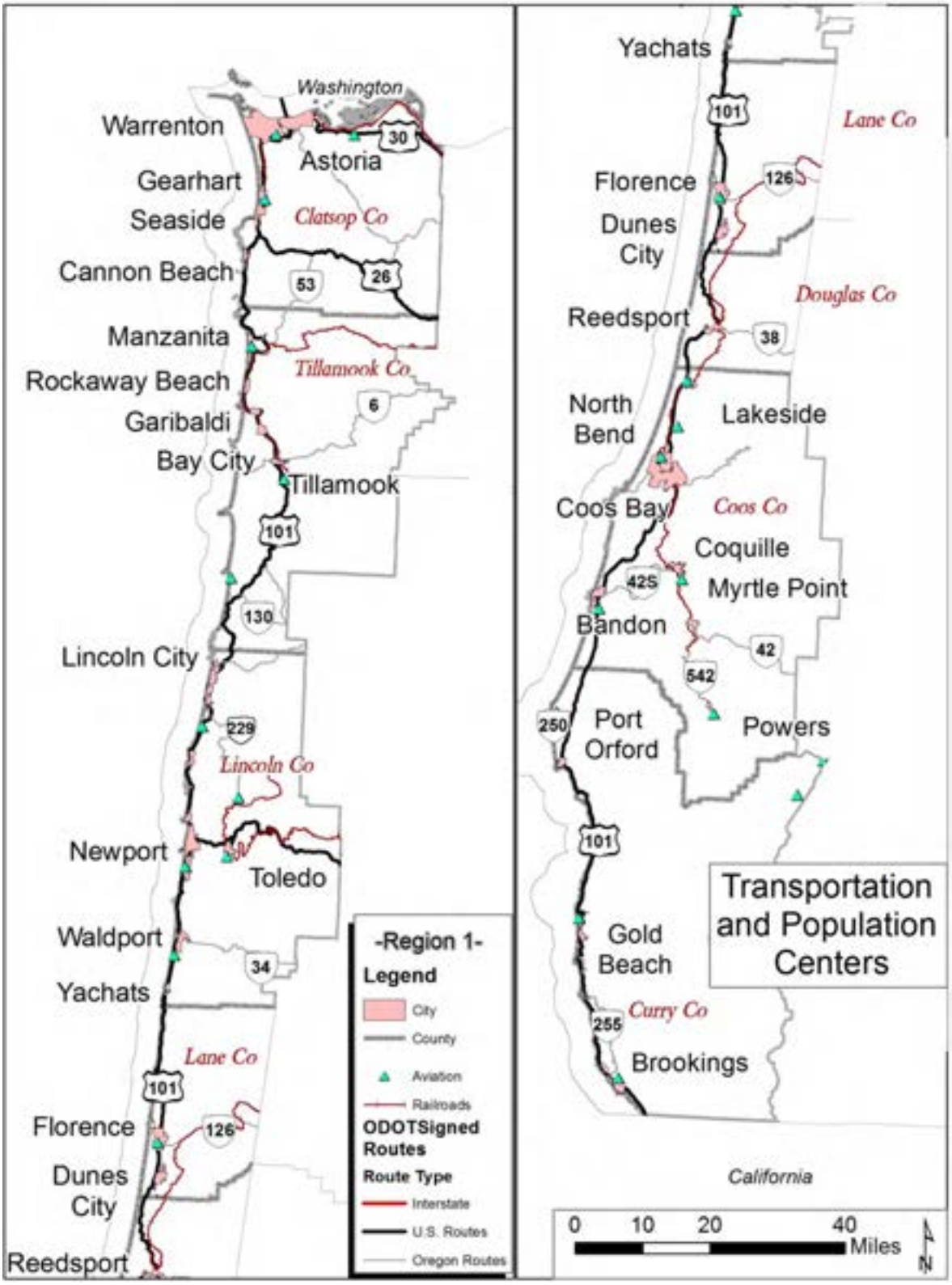
Transportation

Roads

Most of the population bases in Region 1 are located along the region's major freeway, Highway 101. Highway 101 runs north/south through Region 1 and is the only continuous passage for automobiles and trucks traveling along the Oregon Coast. Figure 2-R1-RP-5 shows Region 1's highways and population centers. Region 1 is connected to the interior via a variety of routes including (from south to north): Highway 199 (via California, Curry), Highway 42 (Douglas), Highway 38 (Douglas), Highway 126 (Lane), Highways 34 and 20 (Lincoln), Highway 18 (Lincoln), Highway 6 (Tillamook), Highway 26 (Clatsop, Tillamook) and Highway 30 (Clatsop).

[29] Hazards Workshop Session Summary #16, Disasters, Diversity, and Equity. (July 2000). University of Colorado, Boulder.

Figure 2-R1-RP-5: Highways and Population Centers in Region 1



Source: Department of Land Conservation and Development

Region 1's growing population brings more workers, automobiles and trucks onto roads. Collectively, these create additional stresses on transportation systems through added maintenance, congestion, and

oversized loads. Furthermore, a high percentage of workers driving alone to work can cause added traffic congestion and accidents.

Natural hazards and emergency events can further disrupt automobile traffic, create gridlock, and shut down local transit systems, making evacuations and other emergency operations difficult. Hazards such as localized flooding can render roads unusable. Likewise, a severe winter storm has the potential to disrupt the daily driving routine of thousands of people.

Bridges

Because of earthquake risk in Region 1, the seismic vulnerability of the region's bridges is an important issue. Non-functional bridges can disrupt emergency operations, sever lifelines, and disrupt local and freight traffic. These disruptions may exacerbate local economic losses if industries are unable to transport goods. The region's bridges are part of the state and interstate highway system that is maintained by the Oregon Department of Transportation (ODOT) or that are part of regional and local systems that are maintained by the region's counties and cities.

Table 2-R1-RP-18 shows the structural condition of bridges in the region. A distressed bridge (Di) is a condition rating used by the Oregon Department of Transportation (ODOT) indicating that a bridge has been identified as having a structural or other deficiency, while a deficient bridge (De) is a federal performance measure used for non-ODOT bridges; the ratings do not imply that a bridge is unsafe.[30] The table shows that the region has a higher percentage of bridges that are distressed and/ or deficient (29%) than the state (21%). About 42% of the region's ODOT bridges are distressed, compared to 22% for the state.

17. Table 2-R1-RP-18: Bridge Inventory for Region 1

	State Owned			County Owned			City Owned			Other Owned			Area Total			Historic
	Di	ST	%D*	De	ST	%D	De	ST	%D	De	ST	%D	D	T	%D	Covered
Oregon	610	2,718	22%	633	3,420	19%	160	614	26%	40	115	35%	1,443	6,769	21%	334
Region 1	125	299	42%	64	361	18%	16	24	67%	11	37	30%	216	749	29%	57
Clatsop	27	68	38%	9	51	18%	13	19	68%	2	8	25%	51	150	34%	19
Coos	18	58	30%	10	113	9%	1	2	50%	3	11	27%	32	186	17%	6
Curry	14	29	41%	6	31	19%	0	0	-	0	0	-	20	65	31%	7
Lincoln	21	68	31%	20	85	24%	2	2	100%	2	3	67%	45	158	28%	10
Tillamook	45	76	48%	19	81	23%	0	1	0%	4	15	27%	68	190	36%	15

Source: Oregon Department of Transportation, 2014; Oregon Department of Transportation (2013), Oregon's Historic Bridge Field Guide

Note: Di = ODOT bridges Identified as distressed with structural or other deficiencies; De = Non-ODOT bridge Identified with a structural deficiency or as functionally obsolete; D = Total od Di and De bridges; ST = Jurisdictional Subtotal; %D = Percent distressed (ODOT) and/or deficient bridges; * = ODOT bridge classifications overlap and total (ST) is not used to calculate percent distressed, calculation for ODOT distressed bridges accounts for this overlap.

There are 57 historic and/ or covered bridges included within the total bridge counts (additionally, the coastal portions of Douglas (2) and Lane (7) counties have an additional nine historic and/ or covered bridges). For more information on seismic lifeline vulnerability in Region 1, see page XX.

[30] Oregon. Bridge Engineering Section (2012). 2012 Bridge Condition Report. Salem, Oregon: Bridge Section, Oregon Department. of Transportation.

Railroads

Railroads that run throughout Region 1 support cargo and trade flows. All of the region's rail lines are short line freight routes, connecting the coast to larger rail lines and inland metropolitan areas; Curry County is the only coastal community without rail service. The region's rail providers are the Portland & Western Railroad (PNWR), Port of Tillamook Bay Railroad (POTB), and the Coos Bay Rail Link (CBRL). There is no passenger rail line through the region, however several passenger bus providers serve to connect the region's cities. The PNWR lines in Clatsop County connect Astoria and the Portland Metro Area. The POTB line connects Tillamook to inland railways operated by PNWR. Oregon's rail system is critical to the state's economy, energy, and food systems. Rail systems export lumber and wood products, pulp and paper, and other goods produced in Oregon and products from other states that are shipped to and through Oregon by rail.[31]

Rails are sensitive to storms that can occur in Region 1. Disruptions in the rail system can result economic losses for the region. The potential for harm from rail accidents can also have serious implications for local communities, particularly if hazardous materials are involved.

Airports

Southwest Oregon Regional Airport is the only commercial airport in the region and is the fifth busiest airport in Oregon.[32]. The airport is owned, operated and administered by Coos County Airport District. It serves two hubs and two air carriers.[33] Table 2-R1-RP-19 shows the number and designation of all airports in Region 1.

18. Table 2-R1-RP-19: Public and Private Airports in Region 1

	Number of Airports by FAA Designation				
	Public Airport	Private Airport	Public Heliport	Private Heliport	Total
Region 1	16	6	0	10	32
Clatsop	2	1	0	4	7
Coos	4	2	0	2	8
Curry	3	2	0	1	6
Lincoln	4	1	0	2	7
Tillamook	3	0	0	1	4

Source: FAA Airport Master Record (Form 5010), 2014

In the event of a natural disaster, public and private airports are important staging areas for emergency response activities. Public airport closures will impact the region's tourism industries, as well as the ability for people to leave the region by air. Businesses relying on airfreight may also be impacted by airport closures.

[31] Oregon Department of Transportation (2014). DRAFT Oregon State Rail Plan: Freight and Passenger Rail Inventory. Salem, Orregon. Oregon Department of Transportation.

[32] Federal Aviation Administration (2012) *CY 2012 Passenger Boarding and All-Cargo Data.* Retrieved March 5, 2014, http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/media/cy11_primary_enplanements.pdf

[33] *Southwest Oregon Regional Airport > Master Plan Documents*. (n.d.). Retrieved from http://www.flyoth.com/mp_documents.php

Ports

Oregon's ports have historically been used for timber transport, and, commercial and recreational fishing. With the decline in the timber industry ports have evolved to embrace economic development and tourism by offering industrial land and infrastructure (river, rail, road, and air) and, often on the coast, by promoting fresh seafood, fishing trips, and ecotourism. Oregon's coastal ports are divided by region north, central and south.[34] The North Coast ports include: Astoria, Nehalem, and Garibaldi (including Tillamook Bay). The Astoria Port includes facilities for cruise ships while the Port of Garibaldi/ Tillamook Bay includes more than 1,600 acres of industrial zoned land. The central coast ports include: Newport, Toledo, Alsea, and Siuslaw. The Newport and Siuslaw ports are active fishing ports that also provide a diverse array of businesses catering to tourists. South coast ports include: Umpqua, Coos Bay, Bandon, Port Orford, Gold Beach, and Brookings-Harbor. The Port of Coos Bay is Oregon's largest coastal deep-draft harbor and supports cargo ships that link to the Coos Bay Rail Link.[35] The Port of Brooking Harbor is the busiest recreational port in Oregon with more than 31,000 visitor trips for more than 95,000 recreational boaters.[36]

Energy

Electricity

There are no power plants in Region 1. The region is served by several investor-owned, public, cooperative and municipal utilities. The Bonneville Power Administration is the areas wholesale electricity distributor. Pacific Power and Light (Pacific Power) is the largest investor-owned utility company serving the region (primarily Clatsop, northern Lincoln, and Coos counties). The Blachly-Lane Electric Cooperative (Lane), Coos-Curry Electric Cooperative (Coos, Curry), and Western Oregon Electric Cooperative (Clatsop) serve portions of Region 1. The Bandon municipal utility district serves an area around the city in Coos County. In addition, the Tillamook People's Utility District (Tillamook, Clatsop), Central Lincoln People's Utility District (Lincoln, Lane, Douglas), and Consumer's Power, Inc. (Lane, Lincoln) serve the region.

Oregon has a diverse energy portfolio (Figure 2-R3-RP-6)[37]. Pacific Power provides 28% of the states electricity needs, and Consumer Owned Utilities provide for approximately 30% of the states electricity consumption (largely through Bonneville Power Administrations electric generation facilities) while Portland General Electric provides about 39% of the states electricity need (largely in the Portland area) another 3% is generated from suppliers that do not report to the State of Oregon.

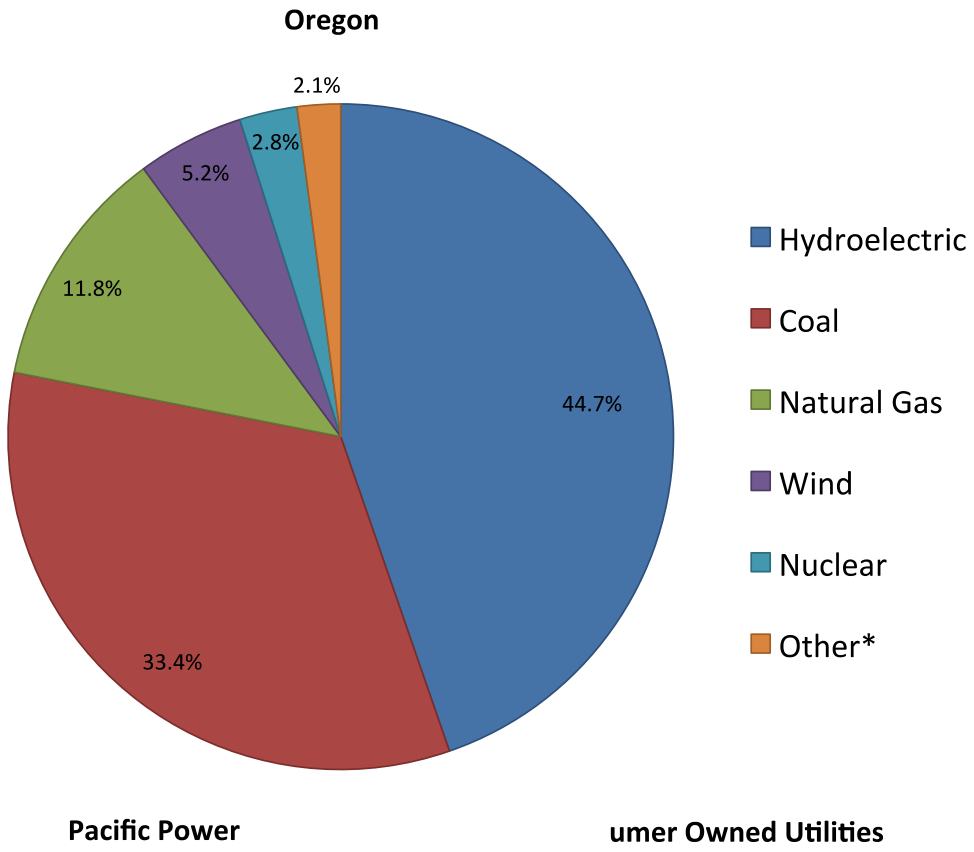
[34] Central Oregon Marine Experiment Station, About Our Ports, retrieved from http://marineresearch.oregonstate.edu/about-our-ports

[35] Ibid.

[36] Port of Brookings Harbor, information retrieved from http://www.port-brookings-harbor.com/

[37] Oregon Department of Energy. *Oregon's Power Mix*. Retrieved May 5, 2014, from http://www.oregon.gov/energy/pages/oregons_electric_power_mix.aspx

19. Figure 2-R3-RP-6: Oregon Energy Portfolio, in Region 1



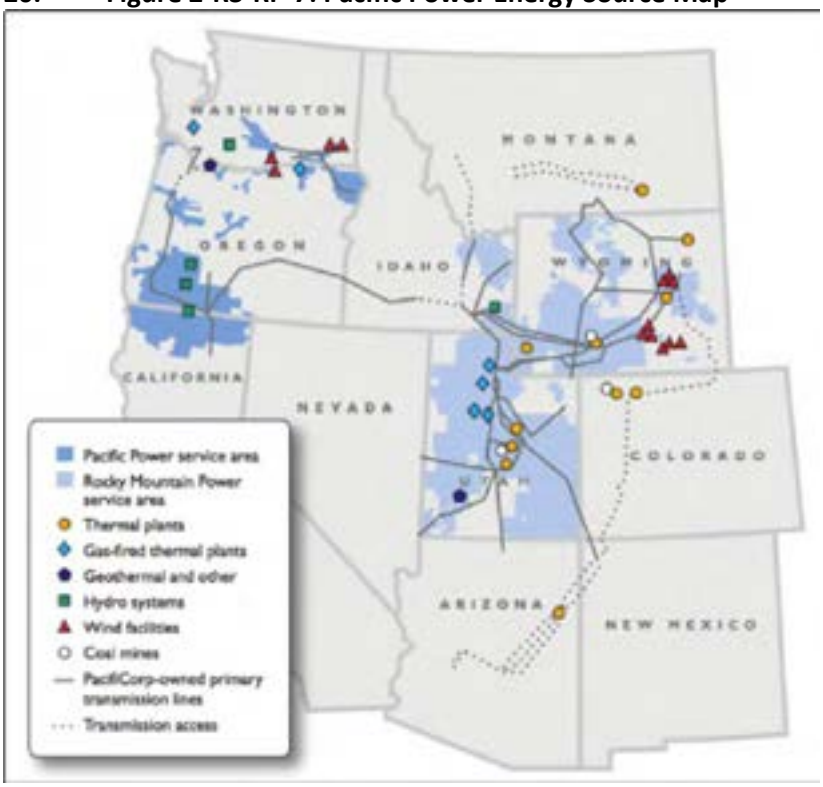
Source: Oregon Department of Energy, 2014.
Note: 3.9% of Oregon's electricity needs are met through Electric Service Suppliers that are not required to provide descriptions of their power sources to the State of Oregon.
* = Other includes biomass, geothermal, landfill gas, solar, petroleum, and waste.

Transmission lines from the Rocky Mountain Region provide additional energy sources (Figure 2-R3-RP-7). The redundancies and diversity in Pacific Power's energy generation portfolio and pipeline systems may

create added resilience to the region's power system in the face of failures to the system, i.e. due to additional stresses created by hazard events.

Pacific Power generates its power supply from a variety of sources including sites in Oregon and other western states. Figure 2-R3-RP-7 shows the various energy sources, service areas and distribution lines for Pacific Power for the western portion of the United States.

20. Figure 2-R3-RP-7: Pacific Power Energy Source Map



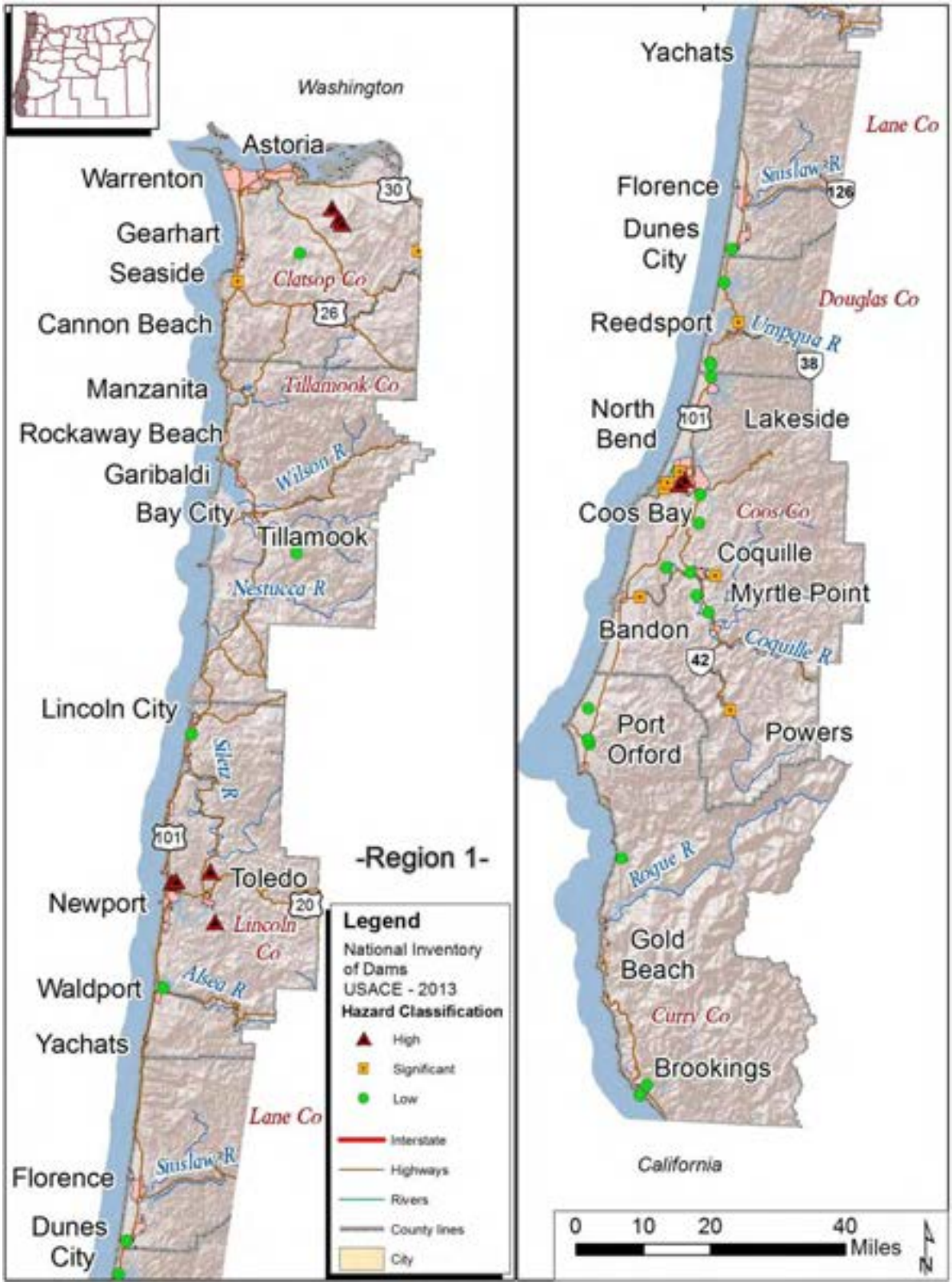
Source: Pacific Power, 2014

Hydropower

There are no major dams in the Oregon Coast region, but just east of the region (in the Cascades), there are several major dams: Bonneville, Round Butte, Lookout Point, Carmen- Smith, Detroit, and Pelton dams all have maximum generating capacities of over 100 megawatts (mw's) of electricity.[38] Figure 2-R3-RP-8 shows the major dams, and transmission lines, operated by the Bonneville Power Administration (BPA), which provides hydro-generated electricity to the states consumer owned utilities.

[38] Loy, W.G., ed. 2001. *Atlas of Oregon*, 2nd Edition. Eugene: University of Oregon Press.

Figure 2-R3-RP-8: Dams in Region 1.



Source: National Inventory of Dams, 2013

Minor dam failures can occur at any time. Most dam failures result in minor damage to structures and pose little or not risk to life safety. However, the potential for severe damage and fatalities does exist (major dam failures have occurred most recently near Hermiston, 2005, and Klamath Lake, 2006).[39] The Oregon Water Resources Department maintains an inventory of all large dams located in Oregon (using the National Inventory of Dams (NID) threat potential methodology). The table below lists the number of dams included in the inventory. The majority of dams in the region are located in Coos County (26). There are 11 High Threat Potential dams and 9 Significant Threat Potential dams in the region.

Table 2-R1-RP-20: Threat Potential of Dams in Region 1

	Threat Potential			Total
	High	Significant	Low	Dams
Region 1	11	9	35	55
Clatsop	4	1	1	6
Coos	2	8	16	26
Curry	0	0	8	8
Lincoln	5	0	2	7
Tillamook	0	0	8	8

Source: Oregon Water Resources Department, Dam Inventory Query, 2014

Natural Gas

Although natural gas does not provide the most energy to the region, it does contribute energy to the Region's portfolio. Liquefied Natural Gas (LNG) is transported via pipelines throughout the United States. Figure 2-R1-RP-9 shows existing LNG pipelines (in blue) and the proposed Pacific Connector Gas Pipeline (in red).[40] At the time of this writing no LNG pipelines exist in Region 1. LNG pipelines, like other buried pipe infrastructure are vulnerable to earthquakes and can cause danger to human life, safety, and environmental impacts in the case of a spill.

[39] Association of Dam Safety Officials. Dam Failures, Dam Incidents. Retrieved April 10, 2014, from http://www.damsafety.org/media/Documents/PDF/US_FailuresIncidents.pdf.

[40] Oregon Department of Environmental Quality (2014). *Jordan Cove Energy Project*. Retrieved February 19, 2014, from http://www.deq.state.or.us/wr/localprojects/jordancove/index.htm

Figure 2-R1-RP-9: Liquefied Natural Gas Pipelines in Region 1

Source: Retrieved from http://gs-press.com.au/images/news_articles/cache/Pacific_Connector_Gas_Pipeline_Route-0x600.jpg

A proposed LNG storage facility and power plant, the Jordan Cove Energy Project, is proposed within the Port of Coos Bay. The proposed facility will provide LNG storage (320,000 cubic meters), liquefaction capacity (6 million metric tons per year), sendout capacity (1,000,000 dth/ day) via the Pacific Connector Gas Pipeline (shown in red within the map above) and will include marine facilities (a single LNG marine berth and a dedicated tractor tug dock) and an associated power generation plant (South Dunes Power plant) capable of providing energy for the facility and the local grid (peak capacity of 420 Megawatts).[41] If developed the pipeline will extend 235 miles through both public and private lands.

Utility Lifelines

Utility lifelines are the resources that the public relies on daily, (i.e., electricity, fuel and communication lines). If these lines fail or are disrupted, the essential functions of the community can become severely impaired. Utility lifelines are closely related to physical infrastructure, (i.e., dams and power plants) as they transmit the power generated from these facilities.

The electric, oil, and gas lines that run through the Oregon Coast region are privately owned. A network of electricity transmission lines, owned by Bonneville Power Administration and Pacific Power run through the Oregon Coast region. Most of the natural gas Oregon uses originates in Alberta, Canada. Northwest Natural Gas serves the central region of the Oregon Coast.[42] These electric, oil, and gas lines may be vulnerable to severe, but infrequent natural hazards, such as earthquakes.

[41] Jordan Cove Energy Project, L.P., retrieved from http://www.jordancoveenergy.com/

[42] Loy, W.G., ed. 2001. *Atlas of Oregon*, 2nd Edition. Eugene: University of Oregon Press.

Telecommunications

Telecommunications infrastructure includes television, telephone, broadband internet, radio, and amateur radio (Ham radio). Parts of Region 1 are included in the Southern Oregon, the South Valley, and the North Coast Operational Areas under The Oregon State Emergency Alert System Plan[43], which also includes parts Jackson, Josephine and Klamath counties. There is a memorandum of understanding between these counties that facilitates the launching of emergency messages for counties by Jackson County. Counties in this area can launch emergency messages by contacting the Oregon Emergency Response System (OERS) that in turn creates emergency messages to communities statewide.

Beyond day to day operations, maintaining communications capabilities during disaster events and other emergency situations helps to keep citizens safe by keeping them informed of the situation's status, areas to avoid, and other procedural information. Additionally, responders depend on telecommunications infrastructure to be routed to sites where they are needed.

Television

Television serves as a major provider for local, regional, and national news and weather information and can play a vital role in emergency communications. The local primary stations identified as emergency messengers by The Oregon State Emergency Alert System Plan include:

- KOBI-TV Channel 36, Coos Bay
- KOBI-TV Channel 8, Coos Bay
- KOBI-TV Channel 25, Coos Bay
- KOBI-TV Channel 7, Coos Bay

Telephone and Broadband

Landline telephone, mobile wireless telephone and broadband service providers serve Region 1. Broadband technology (including mobile wireless) is provided in the region via five primary technologies: cable, digital subscriber line (DSL), fiber, fixed wireless and mobile wireless. Internet service is becoming more readily available in the region with a greater number of providers and service types available within major communities and along major transportation corridors (Interstate 5, Highway 199, etc.).[44] Landline telephones are common throughout the region; however, residents in rural areas rely more heavily upon the service since they may not have cellular reception outside of major transportation corridors.

Wireless providers sometimes offer free emergency mobile phones to those impacted by disasters, which can aid in communication when landlines and broadband service are unavailable.

Radio

Radio is readily available to those who live within Region 1 and can be accessed through car radios, emergency radios, and home sound systems. Radio is a major communication tool for weather and emergency messages. Radio transmitters for Region 1:

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[43] Oregon Military Department's Office of Emergency Management (2013). *The 2013 Oregon State Emergency Alert System Plan* (12.0). Retrieved from State of Oregon website: http://www.oregon.gov/OMD/OEM/tech_resp/EAS/EAS_Plan.pdf

[44] Oregon Broadband Mapping Project. Interactive Map. Accessed May 10, 2014. https://broadband.oregon.gov/StateMap/

- KIX-37, 162.550 MHZ, Brookings
- WIX-32, 162.400 MHZ, Coos Bay
- WNG-596, 162.425 MHZ, Port Orford
- WNG-674, 162.525 Florence
- WZ-2509, 162.525 Reedsport
- KIH-33 162.550 MHZ., Newport
- WWF-95 162.475 Tillamook
- KOGL, 89.3 Gleneden Beach
- KTMK, 91.1 Tillamook
- KWAX-FM 91.3 Toledo[45]

Ham Radio

Amateur Radio, or Ham Radio, is a service provided by licensed Amateur Radio operators (hams) and is considered to be an alternate means of communicating when normal systems are down or at capacity. Emergency communications is a priority for the Amateur Radio Relay League (ARRL). Region 1 is served by ARES District 5. Radio Amateur Civil Emergency Services (RACES) is a special phase of amateur radio recognized by FEMA that provides radio communications for civil preparedness purposes including natural disasters[46]. The official Ham emergency station calls for Region 1 include[47]:

- Clatsop County: WA7FIV, KD7IBA
- Tillamook County: KF7ARK
- Lincoln County: none available at this time
- West Lane County: K7BHB
- Douglas County: K7AZW
- Coos County: KE7EIB
- Curry County: W7VN

Water

Water infrastructure includes drinking water, stormwater, and wastewater systems. All of these systems possess some level of vulnerability to natural hazards that can have repercussions on human health, ecosystems, and industry.

Drinking Water

In Region 1 the majority of the municipal drinking water supply is primarily obtained from surface water. Each county's water is drawn from several water sources including the major waterways (Youngs, Nehalem, Wilson, Nestucca, Siletz, Yaquina, Alsea, Siuslaw, Umpqua, Coos, Coquille, and Rogue rivers). Most urbanized areas also have infrastructure for ground-water wells in place in case of a surface water shortage. Because of high levels of turbidity in streams during heavy rain events many communities are investing in new well fields. However, groundwater drawn within the flood plain is often heavy in iron causing

[45] Oregon Military Department's Office of Emergency Management (2013). *The 2013 Oregon State Emergency Alert System Plan* (12.0). Retrieved from State of Oregon website: http://www.oregon.gov/OMD/OEM/tech_resp/EAS/EAS_Plan.pdf

[46] Oregon Office of Emergency Management (n.d.). *Amateur Radio Unit - W7OEM*. Retrieved March 15, 2014, from http://www.oregon.gov/OMD/OEM/Pages/tech_resp/amateur_radio.aspx

[47] The American Relay Radio League: Oregon Chapter. Retrieved June 6, 2014, from www.arrloregon.org/

undesirable odor and taste although no health risks have been associated with heavy iron levels. Earthquakes pose a major threat to region's water supply because of the risk of dam failure at the region's reservoirs.

Rural residences may get water primarily from groundwater wells. Groundwater wells in the region generally have low flow levels due to the region's predominantly volcanic soils. Areas with sedimentary and volcanic soils may be subject to high levels of arsenic, hydrogen sulfide and fecal coliform bacteria, which can impact the safety of groundwater sources, although the coast is less subject to concerns about arsenic than inland areas of Oregon.

Water rights for rivers and streams in the region have reached a tipping point due to low summer water flows. No new water rights can be purchased in Region 1, however conservation approaches now allow landowners to share or sell a portion of their water rights to other users downstream from their properties. Many farmers in the region are turning to above ground water storage gathered from streams in the winter to aid with summer irrigation.

Non-point source pollution is a major threat to surface water quality, and may include stormwater runoff from roadways, agricultural operations, timber harvest, erosion and sedimentation. Landslides, flood events, and earthquakes and resulting liquefaction can cause increased erosion, and sedimentation in waterways.

Municipal water supplies buried underground and aging or outdated infrastructure can be severed during a seismic event. Rigid materials such as cast iron may snap under the pressure of liquefaction; and more flexible materials such as polyvinal chloride (PVC) and ductile iron may pull apart at joints under the same stresses. These types of infrastructure damages could result in a loss of water pressure in municipal water supply systems–potentially causing lack of access to potable water, which can lead to unsanitary conditions that may threaten human health. Lack of water can also impact industry, i.e. the manufacturing sector. Furthermore, a seismic event could damage older reservoirs, treatment facilities, and pump stations. Damage or failure of these systems could result in a reduction of accessibility and quality of water supplies. Moreover, if transportation infrastructure is impacted by disaster, the timing of repairs to water infrastructure will be delayed.

Stormwater and Wastewater

Stormwater is the result of precipitation events. It becomes surface runoff when it is unable to percolate into the ground because of impermeable surfaces. In urbanized areas severe precipitation events may cause urban flooding, leading to stormwater runoff– and this can become a serious issue. Stormwater is one non-point source of water pollution and may impact drinking water quality downstream. Other environmental impacts of stormwater runoff may include increased temperatures in surface water quality, adversely affecting habitat health, flooding, and erosion due to the fast moving large volumes of water entering surface waterways from storm sewer systems.

Storm sewer and wastewater systems are generally networks of underground pipes with inflows from streets gutters, directly from the roofs of buildings, and from interior building plumbing. When exterior intake areas and pipes become clogged with leaves and other debris, stormwater systems can cause urban flooding, which can present health and economic risks to residents. In areas where stormwater systems are combined with wastewater systems (combined sewers), combined sewer overflows (CSOs) present a heightened health threat as sewage may flood urban areas and waterways. Underground pipes for stormwater and wastewater are subject to similar threats during seismic events. Disruptions in transportation infrastructure would delay the repair of stormwater and wastewater infrastructure, which could lead to increased flood damage and health risks from standing water and sewage in waterways.

In Region 1, most municipal building codes and stormwater management plans (city and county) emphasize use of centralized storm sewer systems to manage stormwater. Low impact development (LID) mitigation strategies can alleviate or lighten the burden to a jurisdiction's storm sewer system by allowing water to percolate through soil onsite or detaining water so water enters the storm sewer system at lower volumes, at lower speed, and at lower temperatures. No jurisdictions in Region 1 refer to LID techniques in their stormwater management plans. Requiring decentralized LID stormwater management strategies could help reduce the burden of new development on stormsewer systems, and increase a community's resilience to many types of hazard events

Infrastructure Trends and Issues

Physical infrastructure is critical for every day operations and is essential following a disaster. Lack, or poor condition, of infrastructure can negatively affect a community's ability to cope, respond and recover from a hazard event

Diversity, redundancy and consistent maintenance in infrastructure systems help to create system resiliency.[48] Older and structurally unsound bridges in Region 1 compromise transportation systems. The effects of bridge and road failures on the economy and health of the Region's residents could be devastating (of special concern is the impact to transportation routes, Highway 101 bridges, following a Cascadia earthquake event and resulting tsunami, which are at risk of collapse and/ or blockage by landslides).

A varied portfolio of energy systems that support the region may help increase the area's ability to communicate and transport goods and emergency services after a hazard event. However, because electricity, petroleum and LNG are transmitted long distances from out of state to reach Region 1, there may be added vulnerability in the transportation networks of these energy sources. Building capacity for local, decentralized systems such as wind and solar energy may help to increase the resilience of the region's, and the state's, energy systems. The proposed Jordan Cove LNG facility will provide redundant energy supply and generation; however, proposed LNG pipeline constitutes a new vulnerability.

Decentralization and redundancy in the region's telecommunication systems can help boost the area's ability to communicate before, during, and after a disaster event. It is important to note that broadband and mobile telephone services do not cover many rural areas of the region that are distant from major transportation corridors (Highway 101). This may present a communication challenge in the wake of a hazard event. Encouraging residents to keep AM/FM radios available for emergency situations could help increase the capacity for communicating important messages throughout the region.

Water systems in the region are particularly vulnerable to hazard events because they tend to be centralized and lacking in system redundancies. Furthermore, because most drinking water is sourced from surface water, the region is at risk in case of high levels of pollutants entering waterways- such as through CSO's during high water events. Older, centralized infrastructure in storm and wastewater infrastructure creates vulnerability in the system during flood events. The implementation of decentralized LID stormwater systems can increase the region's capacity to better manage high precipitation events.

[48] Meadows, D. H. (2008). *Thinking in Systems: A Primer*. White River Junction, VT: Chelsea Green Publishing.

Built Environment

Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

The built environment refers to development patterns and building stock within the region. Understanding where development occurs and the vulnerabilities of the building stock is key to developing mitigation efforts that move people and property out of harms way. Eliminating or limiting development in hazard prone areas, can reduce exposure to hazards, and potential losses and damages. Therefore, balancing growth with hazard mitigation is key to planning resilient communities.

Development Patterns

Since 1973, Oregon has maintained a strong statewide program for land use planning. The foundation of Oregon's program are 19 land use goals that "help communities and citizens plan for, protect and improve the built and natural systems." These goals are achieved through local comprehensive planning. The intent of Goal 7, Areas Subject to Natural Hazards, is to protect people and property from natural hazards.[49]

Population and Settlement Patterns

Table 2-R1-RP-21 shows the percent growth of population in urban areas between 2000 and 2010. Urban development in Region 1 has increased by 15.2% while rural development has decreased by 3.1%. Curry and Tillamook Counties are experiencing the most urban growth in the region (36.6% and 30.3%, respectively) while Lincoln County is experiencing the most rural growth at 2.8%.

Table 2-R1-RP-21: Urban and Rural Populations in Region 1

	Urban			Rural		
	2000	2010	Percent Change	2000	2010	Percent Change
Oregon	2,694,144	3,104,382	15.2%	727,255	726,692	-0.1%
Region 1	103,534	111,575	7.8%	84,753	82,155	-3.1%
Clatsop	20,976	22,604	7.8%	14,654	14,435	-1.5%
Coos	38,999	38,864	-0.3%	23,780	24,179	1.7%
Curry	10,030	13,702	36.6%	11,107	8,662	-22.0%
Lincoln	27,640	28,730	3.9%	16,839	17,304	2.8%
Tillamook	5,889	7,675	30.3%	18,373	17,575	-4.3%

Source: U.S. Census Bureau. 2000 Decennial Census, Table P002, and 2010 Decennial Census, Table P2

Table 2-R1-RP-22 shows the percent growth of housing units in urban areas between 2000 and 2010 (13.4%) is twice the percent growth in rural areas (6.7%). Curry and Tillamook counties are experiencing more urban growth than the region's other counties. Lincoln and Tillamook Counties have experienced the most growth in rural housing units.

[49] Department of Land Conservation and Development, website: http://www.oregon.gov/

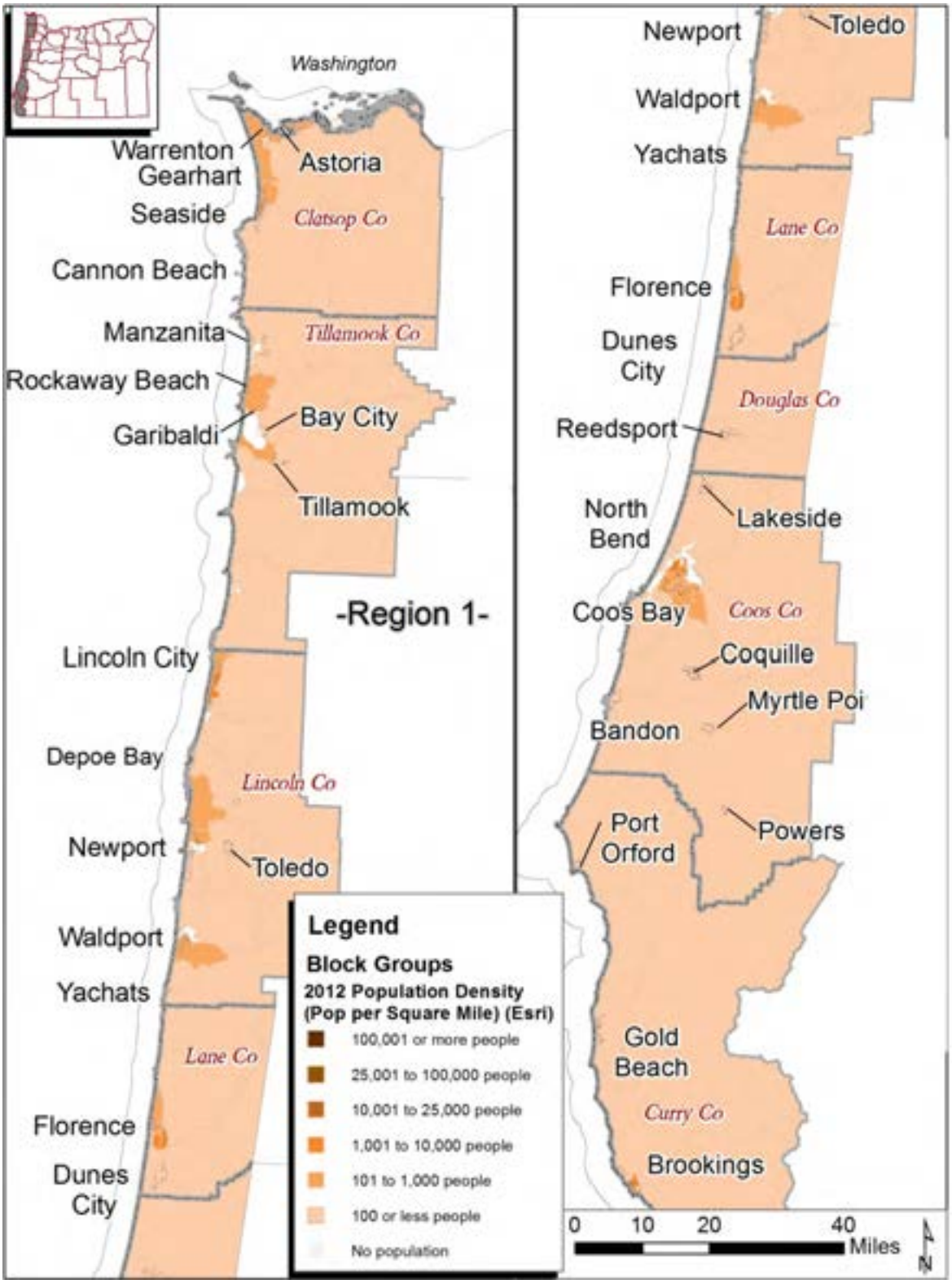
Table 2-R1-RP-22: Urban and Rural Housing Units in Region 1

	Urban			Rural		
	2000	2010	Percent Change	2000	2010	Percent Change
Oregon	1,131,574	1,328,268	17.4%	321,135	347,294	8.1%
Region 1	54,599	61,938	13.4%	48,534	51,783	6.7%
Clatsop	11,639	12,866	10.5%	8,046	8,680	7.9%
Coos	17,957	18,578	3.5%	11,290	12,015	6.4%
Curry	5,331	7,428	39.3%	6,075	5,185	-14.7%
Lincoln	17,152	19,534	13.9%	9,737	11,076	13.8%
Tillamook	2,520	3,532	40.2%	13,386	14,827	10.8%

Source: U.S. Census Bureau. 2000 Decennial Census, Table H002, and 2010 Decennial Census, Table H2

Figure 2-R1-RP-10 shows population density in Region 1 (each red dot represents 50 residents). The region's population is clustered around major population centers (Astoria, Tillamook, Newport, Florence, Coos Bay, Brookings, etc). Unsurprisingly, populations tend to cluster around major road corridors and waterways.

21. Figure 2-R1-RP-10: Population Density in Region 1



Source: US Census, 2012

Land Use and Development Patterns[50]

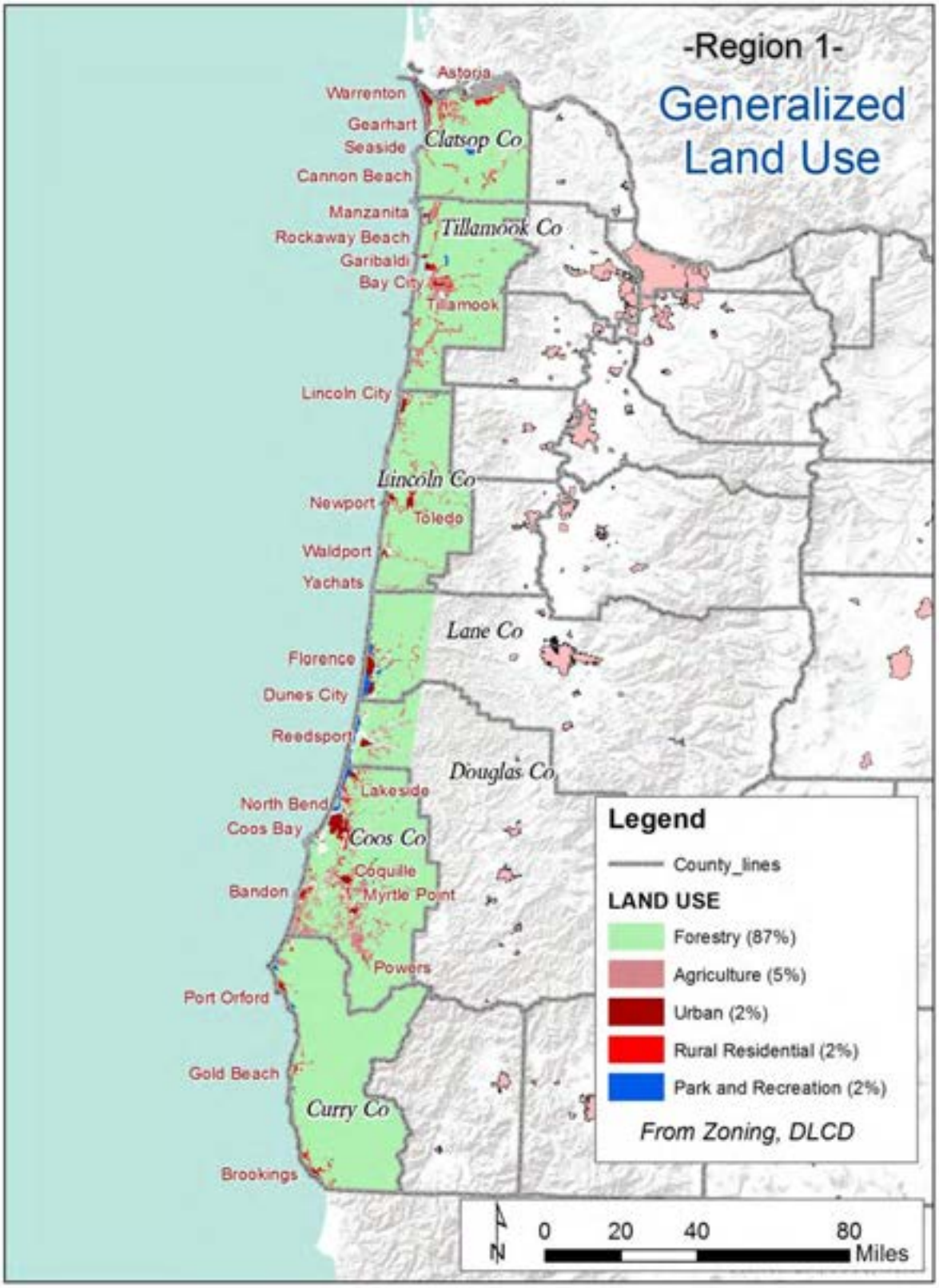
Just over half of the land ownership (51%) of the Coast Region is private, with an additional 35% in federally ownership. The vast majority of this land is dedicated to forestry. From the period of 1974 to 2009 the north coast area has had the lowest rate in the state of conversion of private land from resource land uses to low-density residential and urban uses. Figure 2-R1-RP-11 illustrates the change in land uses on non-Federal lands during the 25-year period between 1984 and 2009. Overall the Coastal Region has experienced little development in the past five years, although recently (2013-1014) building permitting has increased, mostly for infill of existing subdivisions (DLCD).

The first liquefied natural gas export terminals on the Oregon Coast are proposed in Warrenton and Coos Bay. The Coos Bay project would also sport the first power generation plant on the Coast. These projects are the focus of several state, federal, and local permitting issues, including whether they are consistent with the Coastal Zone Management Act.

During 2012-2013, the Department of Geology and Mineral Industries released new tsunami inundation maps displaying five scenarios of a potential impact of a Cascadia Subduction Zone tsunami, reflecting the full range of what was experienced in the past and will be encountered in the future. Then in January, 2014, the Department of Land Conservation and Development distributed "Preparing for a Cascadia Subduction Zone Tsunami: A Land Use Guide for Oregon Coastal Communities." This guide is intended to help communities develop land use planning strategies to reduce tsunami hazard risk.

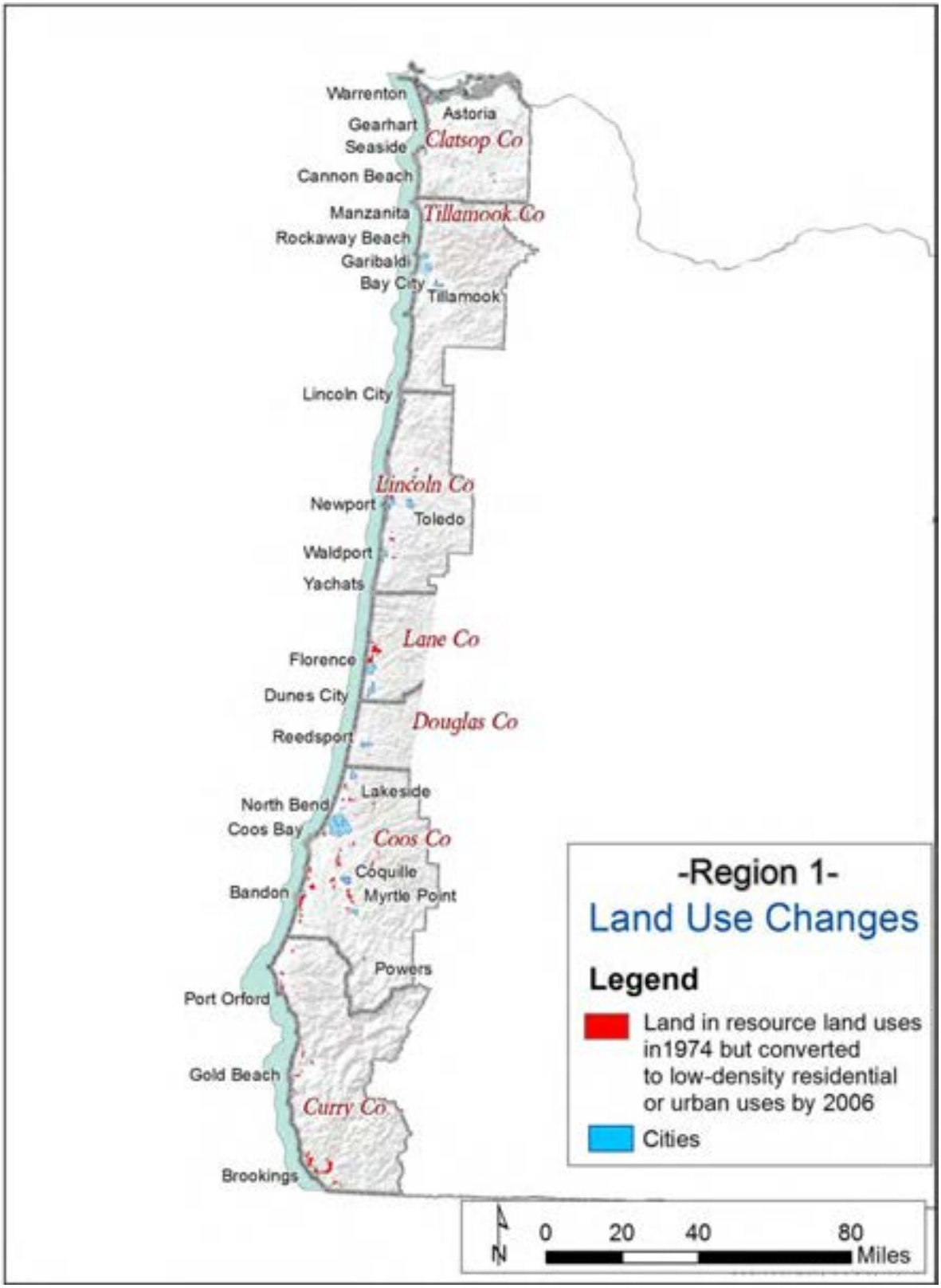
[50] Land Use Change on Non-Federal Land in Oregon and Washington, September, 2013, USFS, ODF

Figure 2-R1-RP-11: Generalized Land Use



Source: Department of Land Conservation and Development, 2014

Figure 2-R1-RP-11: Changes in Land Use, 1974-2009, in Region 1



Source: Land Use Change on Non-Federal Land in Oregon and Washington, September, 2013, USFS, ODF

Housing

In addition to location, the character of the housing stock can also affect the level of risk a community faces from natural hazards. Table 2-R1-RP-23 provides a breakdown by county of housing types (single, multi-family and mobile homes[51]).

The data show that the majority (71.5%) of the region's housing stock is single-family homes. Multi-family housing represents a smaller portion (14.4%) of housing within the region; Clatsop and Lincoln counties have higher percentages of multifamily homes than the regional average, 21.3% and 15.7% respectively. Mobile residences make up 13.6% of Region 1's housing (Curry County has the highest regional percentage of mobile homes, 25.1% and Clatsop the lowest, 5.9%). In natural hazard events, such as earthquakes and floods, moveable structures like mobile homes are more likely to shift on their foundations and create hazardous conditions for occupants.[52]

22. Table 2-R1-RP-23: Housing Profile for Region 1, 2012

	Total Housing Units	Single Family		Multi-Family		Mobile Homes	
		Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Oregon	1,673,593	1,140,319	68.1%	460,852	27.5%	139,768	8.4%
Region 1	113,554	81,174	71.5%	16,310	14.4%	15,440	13.6%
Clatsop	21,563	15,669	72.7%	4,586	21.3%	1,282	5.9%
Coos	30,569	22,105	72.3%	3,867	12.7%	4,468	14.6%
Curry	12,569	7,980	63.5%	1,439	11.4%	2,971	23.6%
Lincoln	30,516	20,998	68.8%	4,777	15.7%	4,490	14.7%
Tillamook	18,337	14,422	78.6%	1,641	8.9%	2,229	12.2%

Source: U.S. Census Bureau. 2008-2012. American Community Survey 5-Year Estimates, Table B25024

Aside from location and type of housing, the year structures were built has implications. Seismic building standards were codified in Oregon building code starting in 1974; more rigorous building code standards were passed in 1993 that accounted for the Cascadia earthquake fault.[53] Therefore, homes built before 1993 are more vulnerable to seismic events. Also in the 1970's,FEMA began assisting communities with floodplain mapping as a response to administer the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Upon receipt of floodplain maps, communities started to develop floodplain management ordinances to protect people and property from flood loss and damage (see tables below for more information on floodplain maps). Table 2-R1-RP-24 illustrates the number and percent of homes built between 1970 and 2012. Regionally 39.2% of the housing stock was built prior to 1970, before the implementation of floodplain management ordinances (47.5% in Clatsop and 47.3% in Coos Counties). Less than one-third of the region's housing stock was built after 1990 and the codification of seismic building standards. Tillamook, 33.8%, Curry, 31.2% and Lincoln, 30.6%, have more of their housing built

[51] The total housing units includes boats, RVs, vans, etc. that are used as a residence. These homes are not included in the table as a separate category since they represent a small percentage of the overall housing profile.

[52] Governor's Office of Emergency Services, California (1997) *Emergency Plans for Mobile Home Parks.* Retrieved March 10, 2014 from http://www.oes.ca.gov/Operational/OESHome.nsf/PDF/Emergency%20Plans%20for%20Mobilehome%20Parks/$file/Feat5.pdf

[53] State of Oregon Building Codes Division. *Earthquake Design History: A summary of Requirements in the State of Oregon*, February 7, 2012. http://www.oregon.gov/OMD/OEM/osspac/docs/history_seismic_codes_or.pdf

after 1990 than do Clatsop and Coos Counties (27.1% and 21.5% respectively). (Note: the percentages listed above do not reflect the number of structures that are built within special flood hazard areas, or that are at risk of seismic damage).

Table 2-R1-RP-24: Age of Housing Stock in Region 1, 2012

	Total Housing Units	Pre 1970		1970 to 1989		1990 or later	
		Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Oregon	1,673,593	609,062	36.4%	518,569	31.0%	545,962	32.6%
Region 1	113,554	44,465	39.2%	37,214	32.8%	31,875	28.1%
Clatsop	21,563	10,236	47.5%	5,474	25.4%	5,853	27.1%
Coos	30,569	14,448	47.3%	9,547	31.2%	6,574	21.5%
Curry	12,569	3,423	27.2%	5,228	41.6%	3,918	31.2%
Lincoln	30,516	10,072	33.0%	11,106	36.4%	9,338	30.6%
Tillamook	18,337	6,286	34.3%	5,859	32.0%	6,192	33.8%

Source: U.S. Census Bureau. 2008-2012. American Community Survey 5-Year Estimates, Table B25034

The National Flood Insurance Program's (NFIP's) Flood Insurance Rate Maps (FIRMs) delineate flood-prone areas. They are used to assess flood insurance premiums and to regulate construction so that in the event of a flood, damage minimized. Table 2-R1-RP-25 shows the initial and current FIRM effective dates for Region 1 communities. For more information about the flood hazard, NFIP, and FIRMs, please refer to pages YY and ZZ.

Table 2-R1-RP-25: Community Flood Map History in Region 1

	Initial FIRM	Current FIRM
Clatsop	July 3, 1978	September 17, 2010
Astoria	August 1, 1978	September 17, 2010
Cannon Beach	September 1, 1978	September 17, 2010
Gearhart	May 15, 1978	September 17, 2010
Seaside	September 5, 1979	September 17, 2010
Warrenton	May 15, 1978	September 17, 2010
Coos	November 15, 1984	March 17, 2014
Bandon	August 15, 1984	March 17, 2014
Coos Bay	August 1, 1984	March 17, 2014
Coquille	September 28, 1984	March 17, 2014
Lakeside	August 1, 1984	March 17, 2014
Myrtle Point	July 16, 1984	March 17, 2014
North Bend	August 1, 1984	March 17, 2014
Curry	April 3, 1978	September 25, 2009
Brookings	September 18, 1985	September 25, 2009
Gold Beach	November 15, 1985	September 25, 2009
Port Orford	January 29, 1980	September 25, 2009
Douglas	December 15, 1978	February 17, 2010
Reedsport	April 3, 1984	February 17, 2010
Lane	December 18, 1985	June 2, 1999
Dunes City	March 24, 1981	6/2/1999 (M)
Florence	May 17, 1982	June 2, 1999
Lincoln	September 30, 1980	December 18, 2009
Depoe Bay	October 15, 1980	December 18, 2009
Lincoln City	April 17, 1978	December 18, 2009
Newport	April 15, 1980	December 18, 2009
Siletz	March 1, 1979	December 18, 2009
Toledo	March 1, 1979	December 18, 2009
Waldport	March 15, 1979	December 18, 2009
Yachats	March 1, 1979	December 18, 2009
Tillamook	August 1, 1978	August 20, 2002
Bay City	August 1, 1978	August 1, 1978
Garibaldi	April 17, 1978	April 17, 1978
Manzanita	May 1, 1978	January 12, 1982
Nehalem	April 3, 1978	December 7, 1982
Rockaway	September 29, 1978	October 12, 1982
Tillamook, City	May 1, 1978	April 16, 2004
Wheeler	November 16, 1977	November 16, 1977

Source: Federal Emergency Management Agency, Community Status Book Report;
(M) – No elevation determined, All Zone A, C and X

State-Owned/Leased and Critical and Essential Facilities

In 2014 the Department of Geology and Mineral Industries updated the 2012 Oregon SNHMP inventory and analysis of state owned and leased facilities and critical and essential facilities. Results from this report relative to Region 1 can be found in Table 2-R1-RP-26. The region contains 4.6% of the total value of state-owned or leased critical and essential facilities.

Table 2-R1-RP-26: Value of State-Owned/ Leased Critical and Essential Facilities

	Total Property Value (state facilities)	Percent State Total
Oregon	$7,339,087,023	100%
Region 1	$336,073,104	4.6%
Clatsop	$116,767,199	1.6%
Coos	$59,977,786	0.8%
Curry	$13,782,834	0.2%
Douglas	$3,063,701	0.0%
Lane	$43,742,674	0.6%
Lincoln	$38,634,005	0.5%
Tillamook	$60,104,905	0.8%

Source: The Department of Geology and Mineral Industries

Built Environment Trends and Issues

The trends within the built environment are critical to understanding the degree to which urban form affects disaster risk. Region 1 is largely a rural county with urban development focused along Highway 101 and around the major population centers. The region's urban areas are growing about half as fast as the state's urban growth rate. Curry and Tillamook counties have the fastest urban growth rates (at about twice the state's urban growth rate). The region's housing stock is largely that of single-family homes, however, the region has nearly double the state's percentage of mobile homes; Curry County has the region's highest percentage of mobile homes. The regions housing age profile matches that of the state; however, Clatsop and Curry counties have almost half of their housing stock built prior to 1970. With the exception of Tillamook county cities all of the region's FIRMs have been modernized or updated. The cities in Tillamook County have maps that are not as up-to-date as other areas of the state and therefore may not accurately represent flood risk.

Regional Profile Synthesis

Information presented in the Natural Environment, Social/Demographic, Economic, Infrastructure, and Built Environment Profiles can be used to help communities identify areas of vulnerability to natural hazards. Understanding the interconnectivity of these systems can inform local decision makers as they identify local mitigation strategies and priorities.

Ecosystems in the region are exposed to all hazards in the area. Vulnerabilities to these natural systems are increased by human development. Therefore, understanding where people and improvements are located in proximity to sensitive ecosystems and hazard areas can help identify potential environmental vulnerabilities.

The region's social vulnerability is driven by lower median household incomes; more people living in poverty (particularly on the south coast); and a greater percentage of disabled and elderly populations than the state average, driven in part by an increasing population of retirees. Conversely, Region 1 has a higher level of homeownership relative to the state average. Research suggests homeownership may be an indicator of resiliency post natural disaster.

Having relatively few key industries and employment sectors and lower wages than the state average drives Region 1's economic vulnerability. The region's economy is becoming more reliant upon tourism, which peaks in the spring and summer. As such, the region's economy is particularly vulnerable during winter months when there are fewer employment opportunities. Region 1 was hit particularly hard by the Great Recession and continues to suffer from significantly low job recovery rates; especially along the south coast. The region's fishing industry may be particularly vulnerable to an earthquake/ tsunami event, particularly in areas where harbors are not fortified.

The region's infrastructure is comprised of transportation, energy, telecommunications and water systems. Like many regions in the state, the transportation network is vulnerable to seismic events, especially bridges along Highway 101. Older centralized water infrastructure is vulnerable to pollution and flooding, which can have implications on human health and water quality. The region will have limited access along Highway 101 following a Cascadia earthquake and may also have limited access via roads that lead east.

The regions energy systems are largely reliant upon long distance transmission lines. Liquid natural gas may be particularly vulnerable, as it relies on long distance pipelines that may be inherently more susceptible to damage due to their length.

Region 1 is growing at a much slower pace than the rest of the state. Where growth is occurring it is largely urban, increased growth may signal pressure to develop in areas within hazard areas. All counties across the state have seen increased protections of farm and forestlands.

Region 1: Regional Hazards and Vulnerability

Coastal Hazards

Characteristics

The Pacific Northwest (PNW) coast of Oregon is without doubt one of the most dynamic coastal landscapes in North America, evident by its long sandy beaches, sheer coastal cliffs, dramatic headlands and vistas, and ultimately the power of the Pacific Ocean that serves to erode and change the shape of the coast. Coastal communities in Oregon are increasingly under threat from a variety of natural hazards, including coastal erosion (both short and long-term), landslides, earthquakes, and potentially catastrophic tsunamis generated by the Cascadia Subduction Zone (CSZ). Over time, these hazards are gradually being compounded, in part due to the degree of development that has evolved along the Oregon coast in recent decades. A particular concern is that the local geology and geomorphology of the region have restricted development to low-lying areas, chiefly along dunes, barrier spits, or along coastal bluffs present along the open coast that are subject to varying rates of erosion, and to low-lying areas adjacent to the numerous estuaries that make up the coast. All of these sites are highly susceptible to increased impacts as erosion processes and flood hazards intensify, driven by rising sea level and increased storminess.

Historic Coastal Hazards Events

Table 2-R1-CE-1: Historic Coastal Erosion and Flood Hazard Events

Date	Location	Description
January 1914	Newport	Damage (Nicolai Hotel).
1931	Rockaway	Coastal damage from December storm.
October- Decer 1934	Waldport and Rockaway	Flooding (Waldport). Coastal damage (Rockaway Beach).
December 1935	Cannon Beach & Rockaway Beach,	Coastal damage.
January 1939	Coastwide	Severe gale. Damage: coastwide. • Severe flooding (Seaside, and Ecola Creek near Cannon Beach): • Multiple spit breaches (southern portion of Netarts Spit) • Storm damage (along the shore of Lincoln City and at D River) • Flooding (Waldport) • Extensive damage (Sunset Bay Park) • Storm surge overtopped foredune (Garrison Lake plus Elk River lowland)
December 1940	Waldport	Flooding.
1948	Newport	Wave damage(Yaquina Arts Center)
January 1953	Rockaway	70 foot dune retreat. One home removed.
April 1958	Sunset Bay State Park, Newport	Flooding (Sunset Bay); Wave damage (Yaquina Arts Center in Newport).
January-February 1960	Sunset Bay State Par	Flooding.
1964	Cannon Beach	Storm damage.
December 1967	Netarts Spit, Lincoln City, Newport, Waldport	Damage: coastwide. • State constructed wood bulkhead to protect foredune along 600 ft section (Cape Lookout State Park campground). • Flooding and logs (Lincoln City).

		• Wave damage (Yaquina Arts Center, Newport). • Flooding (Waldport). • Storm damage (Beachside State Park • Washed up driftwood (Bandon south jetty parking lot).
1971-73	Siletz Spit	• High tide line eroded landward by 300 ft. • February 1973, one home completely destroyed. Spit almost breached. • Logs through Sea Gypsy Motel (Nov. 1973).
1982-83	Alsea Spit	Northward migration of Alsea Bay mouth. Severe erosion.
1997-98	Lincoln and Tillamook Counties	El Nino winter (second strongest on record). Erosion: considerable.
January - March 1999	Coastwide	Five storms. Coastal erosion: extensive, including: • Significant erosion (Neskowin, Netarts Spit, Oceanside, Rockaway beach); • Overtopping and flooding (Cape Meares) • Significant erosion along barrier beach (Garrison Lake); overtopping 27ft high barrier.
December 2007	Tillamook and Clatsop Counties	Wind storm.

Source: Schlicker et al. 1972; Schlicker et al. 1973; Stembridge 1975; Komar and McKinney 1977; Komar 1986, 1987, 1997, 1998; Allan et al. 2003; Allan et al. 2009, and many others.

The table below lists historic landslides at the Oregon Coast. Landsliding in these areas will almost certainly continue due to the combination of steep terrain, local geology (seaward dipping tertiary sediments), and high precipitation.

Table 2-R1-CH-3: Historic Coastal Landslide Hazards

Date	Location	Description
Ongoing	Clatsop County (Cannon Beach)	Several large landslides exist along the Clatsop County coastline, particularly in the vicinity of Cannon Beach. These include: • Large landslide block failure at Ecola State Park occurred in 1961 • Silver Point landslide in 1974 damaged several homes and affected Highway 101 • Slow moving S-Curves landslide (1995) • Landslide/rockfall at the south end of Falcon Cove ~2003
Ongoing	Tillamook County	Several large landslides exist along the Tillamook County coastline. These include: • The Capes development on the north side of Netarts Bay and south of Oceanside; • A large active landslide exists on the north side of Cape Meares and affects the southern portion of the community of Cape Meares; • The Three Capes landslide, located to the south of Tierra del Mar, occurred during the 1997-98 El Nińo and affected the Three Capes Scenic byway road. This landslide has been remediated. • A small landslide failure developed on 21 August 2011 above Happy Camp in Netarts. This landslide has been remediated.
Ongoing	Lincoln County (Newport area)	Several large translational landslide blocks exist throughout Lincoln County. The majority of these are in the Newport/Beverly Beach area and include: • Cape Foulweather landslide failed in December 1999 (now since remediated) • Johnson Creek • Carmel Knoll • Moolack Shores • NW 73rd St Landslide • Schooner Creek • Landslide block failed immediately adjacent to the Jump-Off Joe headland destroying multiple homes over a period in 1942-1943. • Mark St
January 2000	Lane County	Cape Cove landslide (immediately adjacent to the tunnel located between the Heceta Head lighthouse and the Sea Lion caves)
Ongoing	Curry County	Multiple large active landslide block failures exist along Highway 101 along the Curry County coastline. These include: • Gregory Point landslide 2.2 miles south of Port Orford occurred in January 2006 • Multiple landslides between Gregory Point and Humbug Mountain • Arizona landslide south of Humbug Mountain, north of Ophir

Source: Schlicker et al. 1961; Schlicker et al. 1972; Schlicker et al. 1973; Komar 1997; Allan and Hart, 2009; Witter et al. 2009; SLIDO web database (http://www.oregongeology.org/slido/index.html).

Probability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the probability (High, Moderate, Low) that Region 1 will experience coastal erosion is depicted in Table 2-R1-CH-4 below. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration. These cases are noted with a dash (-) in the table below. (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx)

Table 2-R1-CH-4: Local Probability Assessment of Coastal Erosion

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	H	H	-	H	-	-	-

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

Add coastal erosion probability, per FEMA's request (need from J. Allan)

Although some coastal landslide failures have been remediated, the majority are considered active and hence will continue to move and fail. Without detailed knowledge of every slide, it is impossible to assign probabilities of failure. However, it is a high probability that all of these existing landslide sites would be activated following a Cascadia earthquake, and more new landslides would occur.

Previous analyses of extreme waves for the Oregon coast estimated the "100-year" storm wave to be around 33 feet. In response to a series of large wave events that occurred during the latter half of the 1990s, the wave climate was subsequently re-examined and an updated projection of the 100-year storm wave height was determined, which is now estimated to reach approximately 47 to 52 feet (Table 2-R1-CE-2), depending on which buoy is used. These estimates are of considerable importance to the design of coastal engineering structures and in terms of defining future coastal erosion hazard zones.

Recurrence Interval (*yrs.*)	**Extreme Wave Heights** (*ft.*)	
	NDBC buoy #46002*(Oregon)	**NDBC buoy #46005+(Washington)**
10	42.5	41.7
25	46.2	44.0
50	48.8	-
75	50.1	45.7
100	51.2	47.1

Table 2-R1-CE-2: Projection of extreme wave heights for various recurrence intervals: Each wave height is expected to occur on average once during the recurrence interval.

Source: *DOGAMI analyses; +Ruggiero et al. (2010)

Vulnerability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the region's vulnerability (High, Moderate, Low) to coastal erosion is depicted in Table 2-R1-CH5 below. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (-) in the table below. (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx.)

Table 2-R1-CH-5: Local Vulnerability Assessment of Coastal Erosion

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	H	M	-	L	-	-	-

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

The Department of Geology and Mineral Industries is the agency with primary oversight of coastal hazards. Based on agency staff review of the available hazard data, DOGAMI ranks Tillamook, Lincoln, Clatsop and Curry Counties one through four respectively as the counties most vulnerable to coastal hazards in the state.

Coastal hazards in Coos, Lane and Douglas counties are considered to be generally negligible. This is because the bulk of these coastlines have little population base and hence are largely unmodified. In Coos County, coastal hazards can be found in a few discrete communities such as adjacent to the Coquille jetty in Bandon and along Lighthouse Beach near Cape Arago. Similarly, coastal hazards in Lane County are confined almost entirely to the Heceta Beach community and adjacent to the Siuslaw River mouth, particularly within the lower estuary mouth where development lines coastal bluffs that is gradually being eroded by riverine processes.

The most vulnerable counties and communities to coastal hazards on the Oregon Coast include:

Tillamook County (ranked #1)

- Neskowin (erosion and flooding)
- Pacific City (erosion)
- Tierra del Mar (erosion and flooding)
- Cape Meares (flooding)
- Twin Rocks (erosion and flooding)
- Rockaway Beach(erosion and flooding)

Lincoln County (ranked #2)

- Yachats to Alsea Spit (erosion)
- Waldport (erosion and flooding)
- Alsea Spit (erosion)
- Seal Rock (erosion and landsliding)
- Ona Beach to Southbeach (erosion and landsliding)
- Newport (landsliding)
- Beverly Beach (erosion and landsliding)
- Gleneden Beach to Siletz Spit (erosion, landsliding, and flooding)
- Lincoln City (erosion and landsliding)

Clatsop County (ranked #3)

- Falcon Cove (erosion and landsliding)
- Arch Cape (erosion and flooding)
- Tolovana to Cannon Beach (erosion and flooding)
- Seaside (Flooding)

Curry County (ranked #4)

- Nesika Beach (erosion and landsliding)
- Port Orford (flooding at Garrison Lake)

Coastal hazards in Lane and Douglas counties are considered to be negligible.

State Owned/Leased Facilities and Critical and Essential Facilities

The following information is based on a state facility and critical and essential facility vulnerability assessment update completed by DOGAMI in 2014. (See the State Risk Assessment, Oregon Vulnerabilities for more information, pg xx-xx.)

Of the 5,693 state facilities evaluated, 28 are currently located within a coastal erosion zone in Region 1, representing a value of approximately $7 million in property value (Figure 2-R1-CE-1). One of these (ODOT Cape Perpetua Radio building) is identified as a critical or essential facility. Five additional critical/essential facilities, not state owned/leased, are also located in a Region 1 coastal erosion zone.

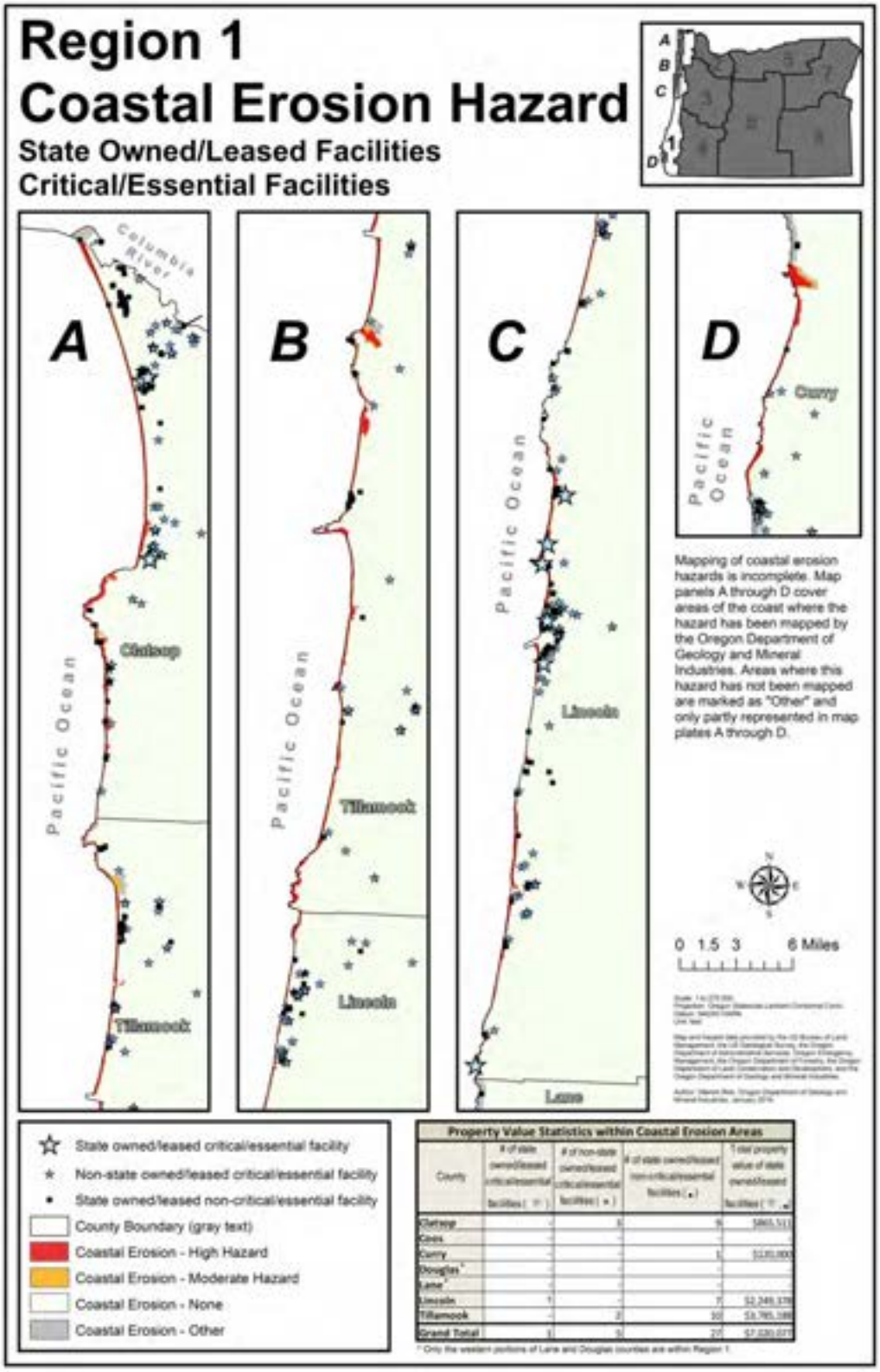


Figure 2-R1-CH-1: State Owned/ Leased Facilities and Critical/ Essential Facilities in a Coastal Erosion Zone in Region 1

Source: DOGAMI

Drought

Characteristics

Drought is not a common occurrence in Region 1. Since 1995, the Governor has declared drought only once, in Coos and Curry Counties during 2002 when much of the state was facing drought conditions. Although Region 1 is less vulnerable to drought impacts than most of Oregon, droughts can still be problematic, especially given that they often precede major wildfires. Severe drought conditions resulted in the four disastrous Tillamook fires (1933, 1939, 1945, 1951), collectively known as the Tillamook Burn.

Historic Drought Events
History table may be updated by Alyssa

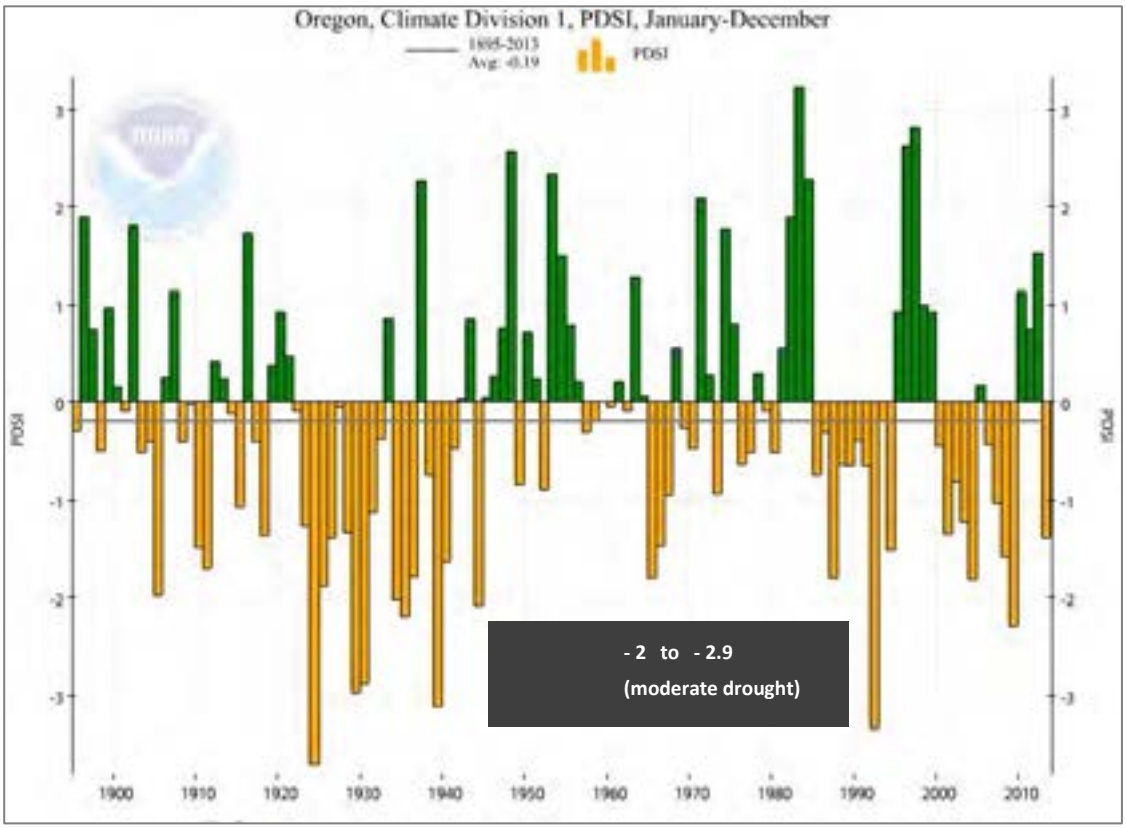
Table 2-R1-DR-1: Historic Droughts

Date	Location	Description
1928-41	Statewide	Prolonged statewide drought that caused major problems for agriculture. Statewide, the northern coast was the only area spared, with abundant rains in 1930-1933. The three Tillamook burns, the first in 1933, were the most significant impacts of this very dry period.
1976-81	Western Oregon	Low streamflows prevailed during this period, the worst year during this period was 1976-77
1985-94	Statewide	Generally dry period, capped by statewide droughts in 1992 and 1994. Although not as severe the 1976-1977 drought, ten consecutive years of dry conditions caused problems throughout the state, such as fires and insect outbreaks.
2001-02	Affected all Regions, except Regions 2 & 3	The second most intense drought in Oregon's history. Eighteen counties with state drought declaration (2001).Twenty-three counties state-declared drought (2002). Some of the 2001 and 2002 drought declarations were in effect through June or December 2003.

Source: Taylor, George and Raymond R Hatton. (September 1999). The Oregon Weather Book: State of Extremes, and the Oregon Secretary of State's Archives Division.

Historic drought information can also be obtained from the National Climatic Data Center, which provides climate data showing wet and dry conditions, using the Palmer Drought Severity Index (PDSI) that dates back to 1895. The Palmer Index is not the best indicator of water availability for Oregon as it does not account for snow or ice (delayed runoff), but it has the advantage of providing the most complete, long-term record. The following PDSI graph shows years where drought or dry conditions affected the coastal areas of Oregon (Climate Division 1). Based on this index, 1924, 1929, 1939, and 1992 were severe drought years for this region.

U.S Climate Divisions



Source: Taylor, George and Raymond R Hatton. (September 1999). The Oregon Weather Book: State of Extremes.

Probability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the probability (High, Moderate, Low) that Region 1 will experience drought is depicted in Table 2- R1-DR-2 below. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (-). (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx)

Table 2-R1-DR-2: Local Probability Assessment of Drought

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	M	H	-	-	-	H	L

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

Despite impressive achievements in the science of climatology, estimating drought probability and frequency continues to be difficult. This is because of the many variables that contribute to weather behavior, climate change and the absence of long historic databases. A comprehensive risk analysis is needed to fully assess the probability and impact of drought to Oregon communities. Such an analysis should be completed statewide in order to analyze and compare the risk of drought across the state.

Based on limited data, there is a low probability of drought occurring in this region.

Vulnerability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the region's vulnerability (High, Moderate, Low) to drought is depicted in Table 2-R1-DR-2 below. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (-). (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx)

Table 2-R1-DR-2: Local Vulnerability Assessment of Drought

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	M	M	-	-	-	L	L

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

Oregon has yet to undertake a comprehensive, statewide analysis to identify which communities are most vulnerable to drought. However, based on a review of Governor drought declarations since 1992, Region 1 could be considered less vulnerable to drought impacts than many other parts of the state. Regardless, even short term droughts can be problematic. Potential impacts to community water supplies are the greatest threat. Long-term drought periods of more than a year can impact forest conditions and set the stage for potentially devastating wildfires.

Earthquake

Characteristics

The geographical position of Region 1 makes it susceptible to earthquakes from three sources: (1) the off-shore Cascadia Fault Zone, (2) deep intra-plate events within the subducting Juan de Fuca plate, and (3) shallow crustal events within the North America Plate. All have some tie to the subducting or diving of the dense, oceanic Juan de Fuca Plate under the lighter, continental North America Plate. Stresses occur because of this movement.

There is no historic record of major damaging crustal earthquakes centered in this region in the past 156 years, although Region 1 has experienced small crustal earthquakes and crustal earthquakes that originated outside the region. The geologic record shows that movement has occurred along numerous offshore faults as well as a few onshore faults in Coos and Tillamook counties. The faulting has occurred over the last 20,000 years. Intraplate earthquakes are very rare in Oregon, although such earthquakes originating outside of the state have been felt in this region. It is believed that the M7.3 near Brookings in 1873 was an intraplate quake.

In Region 1, geologic earthquake hazards include severe ground shaking, liquefaction of fine-grained soils, landslides and flooding from local and distant tsunamis. The severity of these effects depend on several factors, including the distance from the earthquake source, the ability of soil and rock to conduct seismic energy composition of materials, and the ground and ground water conditions.

Historical Earthquake Events

Table 2-R1-EQ-1: Historic Earthquakes

Date	Location	Magnitude (M)	Comments
Approximate Years 1400 BCE* 1050 BCE 600 BCE 400 750 900	Offshore, Cascadia Subduction Zone	Probably 8-9	These are the mid-points of the age ranges for these six events.
January, 1700	Offshore, Cascadia Subduction Zone	Approximately 9.0	Generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast
November, 1873	Brookings area, OR	7.3	Intraplate event. Origin: probably Gorda block of the Juan de Fuca plate. Chimneys fell (Port Orford, Grants Pass, and Jacksonville). No aftershocks.
November, 1962	Portland, OR	5.2 to 5.5	Crustal event. Damage: to many homes (chimneys, windows, etc.).
March, 1993	Scotts Mills, OR	5.6	Crustal Event. FEMA-985-DR-OR. Damage: $28 million. (homes, schools, businesses, state buildings (Salem)).
September, 1993	Klamath Falls, OR	5.9 to 6.0	Crustal event. FEMA-1004-DR-OR. Two earthquakes. Fatalities: ctwo. Damage $7.5 million (homes, commercial, and government buildings).

Source: Wong, Ivan and Bolt, Jacqueline, November 1995, A Look Back at Oregon's Earthquake History, 1841-1994, *Oregon Geology,* p.125-139.

Notes: *BCE: Before the Common Era

Probability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the probability (High, Moderate, Low) that Region 1 will experience earthquakes is depicted in Table 2-R1-EQ-1 below. (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx.)

Table 2-R1-EQ-1: Local Probability Assessment of Earthquake

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	H	H	M	M	M	H	H

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

The probability of damaging earthquakes varies widely across the state. In Region 1, the hazard is dominated by Cascadia Subduction Zone (CSZ) earthquakes originating from a single fault with a well understood recurrence history. The probability of earthquake hazards occurring in Oregon is defined in the following two ways.

Figure 2-R1-EQ-1 shows the expected level of earthquake damage that has a 2 percent chance of occurring in the next 50 years. The map is based on the 2008 USGS National Seismic Hazard Map, and has been adjusted to account for the effects of soils following the methods of Madin and Burns, 2013. In this case, the strength of shaking, calculated as peak ground acceleration and peak ground velocity, have been expressed as Mercalli intensity, which describes the effects of shaking on people and structures, and is more readily understandable for a general audience. These maps incorporate all that is known about the probabilities of earthquake on all Oregon faults, including the Cascadia Subduction Zone.

For Oregon west of the crest of the Cascades, the CSZ is responsible for most of the hazard shown in Figure 2-R1-EQ-1. The paleoseismic record includes 18 M_W 8.8-M 9.1 megathrust earthquakes in the last 10,000 years that affected the entire subduction zone. The return period for the largest earthquakes is 530 years, and the probability of the next such event occurring in the next 50 years ranges from 7-12%.

An additional 10-20 smaller M_W 8.3-8.5 earthquakes only affected the southern half of Oregon and northern California. The average return period for these is about 240 years, and the probability of a small or large subduction earthquake occurring in the next 50 years is 37-43%.

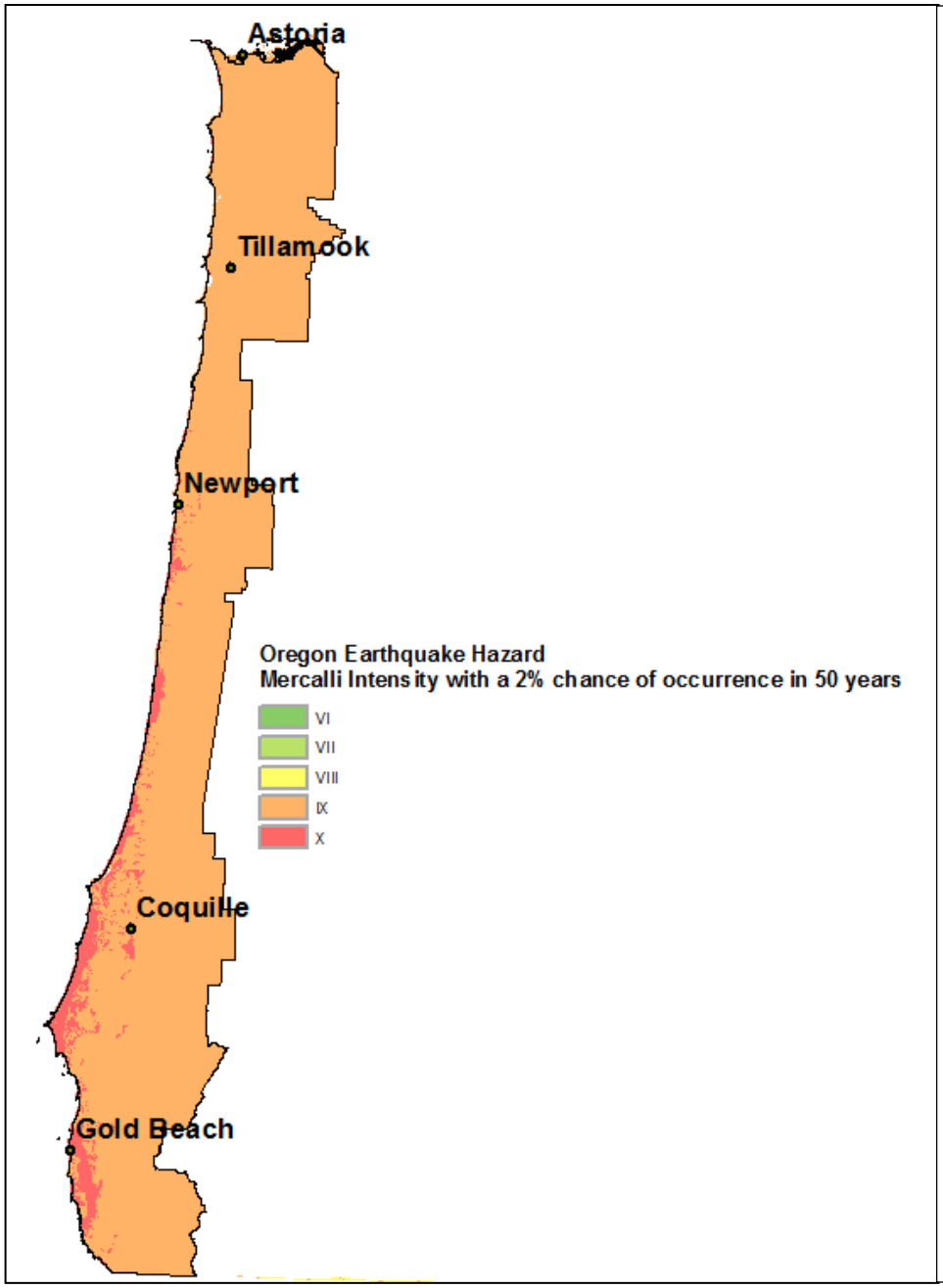


Figure 2-R1-EQ-1: Region 1 Probabilistic Earthquake Hazard. Color zones show the maximum level of earthquake shaking and damage (Mercalli Intensity Scale) expected with a 2% chance of occurrence in the next 50 years. A simplified explanation of the Mercalli levels is:

- VI Felt by all, weak buildings cracked
- VII Chimneys break, weak buildings damaged, better buildings cracked
- VIII Partial collapse of weak buildings, unsecured wood frame houses move
- IX Collapse and severe damage to weak buildings, damage to wood-frame structures
- X Poorly built structures destroyed, heavy damage in well-built structures.

Source: DOGAMI, Madin and Burns, 2013

Vulnerability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the region's vulnerability (High, Moderate, Low) to earthquakes is depicted in Table 2-R1-EQ-2 below. (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx.)

Table 2-R1-EQ-2: Local Vulnerability Assessment of Earthquakes

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	H	H	H	H	H	M	H

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

Of the 15 counties in Oregon with the highest expected damages and losses, based on the 500-year model CSZ earthquake, the following counties reside in Region 1:

- Lane
- Coos
- Lincoln
- Clatsop
- Douglas

Region 1 is especially vulnerable to earthquake hazards. This is because of the built environment's proximity to the CSZ, regional seismicity, topography, bedrock geology and local soil profiles. For example, a large number of buildings are constructed of unreinforced masonry (URM) or are constructed on soils that are subject to liquefaction during severe ground shaking. Also, some principal roads and highways are susceptible to earthquake-induced landslides. Bridges and tunnels need to be retrofitted to withstand ground shaking and the dams should be able to withstand earthquake forces to prevent uncontrolled releases. This is especially important as 12 dams in Region 1 have been designated as "high hazard." Problem areas within the region are readily identifiable online at Oregon's hazard viewer at http://www.oregongeology.org/sub/hazvu/index.htm and on earthquake hazard maps prepared by DOGAMI (available at website: http://www.oregongeology.org/pubs/ofr/p-O-13-06.htm).

Table 2-R1-EQ-3 shows the number of school and emergency response buildings surveyed in each county with their respective rankings.

Table 2-R1-EQ-3: School and Emergency Response Building Collapse

County	Level of Collapse Potential			
	Low (< 1%)	Moderate (>1%)	High (>10%)	Very High (100 %)
Clatsop	24	19	20	1
Tillamook	19	9	23	5
Lincoln	30	18	12	3
Lane*	8	4	5	-
Douglas**	3	2	10	-
Coos	41	11	48	7
Curry	15	10	10	2

Source: DOGAMI Seismic Needs Assessment, available at http://www.oregongeology.org/sub/projects/rvs/default.htm

* Includes only the Lane County coastal communities of Deadwood, Florence, Mapleton, and Swisshome

**Includes only the Douglas County coastal communities of Gardiner, Reedsport, and Winchester Bay

Other useful resources for planning for earthquakes include the following:

- **Maps of earthquake hazard areas:** DOGAMI has mapped all of the Region 1 counties, and has statewide GIS earthquake hazard layers available through the Nature of the NW.
- **Map of coastal critical facilities vulnerable to hazards:** DOGAMI has developed these maps for all Region 1 counties. (Also see pg. XX for more information about critical facilities in Region 1)
- **Environmental Geology of Land Use Geology maps:** DOGAMI has developed these maps for all Region 1 counties. DOGAMI maps can be obtained from the Nature of the Northwest at: http://www.naturenw.org/
- **Nuclear energy/hazardous waste sites inventories**: No Region 1 counties have nuclear facilities

DOGAMI also developed two earthquake loss models for Oregon based on the two most likely sources of seismic events: (1) the Cascadia Subduction Zone (CSZ), and (2) combined crustal events (500-year model). Both models utilize HAZUS, a software program developed by the Federal Emergency Management Agency (FEMA) as a means of determining potential losses from earthquakes. The CSZ event is based on a potential M8.5 earthquake generated off the Oregon coast. The model does not take into account a tsunami, which probably would develop from such an event. The 500-year crustal model does not look at a single earthquake (as in the CSZ model); it encompasses many faults. Neither model takes unreinforced masonry buildings into consideration.

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning and policy making purposes. Despite their limitations, the models do provide some approximate estimates of damage and are useful to understand the relative relationships between the counties.

Table 2-R1-EQ-4 shows the projected dollar losses based on both models. Please note that the losses are in 1999 dollars. Since that time, additional growth and inflation has occurred, thus the values are too low. However, the relative rankings are between the counties likely remains the

same. For example, the economic base (column 2) for Clatsop County remains lower than Coos County, and the expected losses from a magnitude 8.5 Cascadia earthquake (column 3) in Clatsop County remain lower than Coos County.

Table 2-R1-EQ-4: Projected Dollar Losses Region 1, Based on a M8.5 Subduction Event and a 500-Year Model

Region 1 Counties	Economic Base in Thousands (1999)	Greatest Absolute Loss in Thousands (1999) From an M8.5 CSZ Eevent[1]	Greatest Absolute Loss in Thousands (1999) From a 500-Year Model[2]
Clatsop	$2,198,000	$549,000	$760,000
Coos	$3,263,000	$1,339,000	$1,429,000
Curry	$1,093,000	$371,000	$388,000
Douglas[3]	$4,631,000	$275,000	$546,000
Lane[3]	$15,418,000	$1,614,000	$3,044,000
Lincoln	$2,668,000	$624,000	$793,000
Tillamook	$1,539,000	$226,000	$364,000

Source: DOGAMI, 1999, Special Paper 29: Earthquake Damage in Oregon.

Notes:
[1] "…there are numerous un-reinforced masonry structures (URMs) in Oregon, the currently available default building data does not include any URMs. Thus, the reported damage and loss estimates may seriously under-represent the actual threat" (page 126 – 1998, DOGAMI)
[2]Every part of Oregon is subject to earthquakes. The 500-year model is an attempt to quantify the risk across the state. The estimate does not represent a single earthquake. Instead, the 500-year model includes many faultsMore and higher magnitude earthquakes than used in this model may occur (DOGAMI, 1999).
[3]Entire county

Table 2-R1-EQ-5 below shows the projected dollar losses associated with the magnitude 8.5 Cascadia model

Table 2-R1-EQ-5: Estimated Losses in Region 1, Associated with a M8.5 Subduction Zone Event

	Region 1 Counties							
	Clatsop	**Coos**	**Curry**	**Douglas[1]**	**Lane[1]**	**Lincoln**	**Tillamook**	**Remarks**
INJURIES	298	854	221	151	1,036	358	132	Cascadia Subduction Zone (CSZ) is the most dangerous fault in Oregon. The entire coastline is essentially the epicenter. The earthquake could have a magnitude 8.5 (or M9.0). The event might last as long as four minutes. Within a few minutes, a tsunami would follow. (Tsunami damages are not included in the estimates for this earthquake, and would dramatically increase losses for coastal counties). A CSZ earthquake could affect a very large area. If the entire fault ruptures, destruction could occur from northern California to Canada. The number of deaths and injuries depends on the time of day, building type, occupancy class, and traffic pattern. (DOGAMI, Special Paper 29, 1999, p.4).
DEATHS	6	16	3	2	19	7	3	
DISPLACED HOUSEHOLDS	788	2,069	430	255	2,345	592	158	
OPERATIONAL THE DAY AFTER THE QUAKE[2]:	16%	10%	9%	66%	49%	26%	31%	
Fire stations	15%	6%	5%	57%	42%	22%	44%	
Police stations	16%	8%	6%	44%	46%	19%	32%	
Schools	58%	44%	34%	74%	76%	51%	58%	
Bridges								
ECONOMIC LOSSES TO[2]:	$18 mil	$44 mil	$48 mil	$43 mil	$39 mil	$16 mil	$25 mil	
Highways	$5 mil			$5 mil		$9 mil	$7 mil	
Airports	$6 mil	$20 mil	$11 mil	$7 mil	$11 mil	$9 mil	$5 mil	
Communications		$25 mil	$18 mil		$11 mil			
DEBRIS GENERATED (thousands of tons)	383	853	267	222	1,341	446	158	

Source: DOGAMI, 1999, Special Paper 29: Earthquake Damage in Oregon.

Notes:
[1]Entire county
[2]"…there are numerous un-reinforced masonry structures (URMs) in Oregon, the currently available default building data does not include any URMs. Thus, the reported damage and loss estimates may seriously under-represent the actual threat" (page 126 – 1998, DOGAMI).

Table 2-R1-EQ-6 shows the estimated losses associated with the 500-year model.

Table 2-R1-EQ-6: Estimated Losses in Region 1, Associated with a 500-Year Model [1]

	Clatsop	Coos	Curry	Douglas[2]	Lane[2]	Lincoln	Tillamook
INJURIES	397	845	212	294	2,254	436	181
DEATHS	8	16	3	4	45	9	4
DISPLACED HOUSEHOLDS	1,182	2,521	486	534	4,543	847	275
ECONOMIC LOSSES FOR BUILDINGS[3]	$760 mil	$1.4 bil	$328 mil	$546 mil	$3 bil	$792 mil	$364 mil
OPERATIONAL THE DAY AFTER THE QUAKE							
Fire stations	N/A[4]	N/A	N/A	N/A	N/A	N/A	N/A
Police Stations	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Schools	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bridges	N/A	N/A	N/A	N/A	N/a	N/A	N/A
ECONOMIC LOSSES TO:[3]	$33 mil	$49 mil	$44 mil	$69 mil	$74 mil	$22 mil	$39 mil
Highways	$7 mil	$20 mil	$12 mil	$9 mil	$20 mil	$12 mil	$8 mil
Airports	$8 mil	$2 mil	$15 mil	$12 mil	$20 mil	$10 mil	$6 mil
Communications							
DEBRIS GENERATED (thousands of tons)	474	864	261	411	2,424	525	224

Source: DOGAMI, 1999, Special Paper 29: Earthquake Damage in Oregon.

Notes:
[1]Every part of Oregon is subject to earthquakes. The 500-year model is an attempt to quantify the risk across the state. The estimate does not represent a single earthquake. Instead, the 500-year model includes many faults. More and higher magnitude earthquakes than used in this model may occur. (DOGAMI, 1999)
[2]Entire county
[3] "…there are numerous un-reinforced masonry structures (URMs) in Oregon, the currently available default building data does not include any URMs. Thus, the reported damage and loss estimates may seriously under-represent the actual threat" (page 126 – 1998, DOGAMI)
[4]NA - Because the 500-year model includes several earthquakes, the number of facilities operational the "day after" cannot be calculated

State Owned/Leased Facilities and Critical and Essential Facilities

The following information is based on a state facility and critical and essential facility vulnerability assessment update completed by DOGAMI in 2014. (See the State Risk Assessment, Oregon Vulnerabilities for more information, pg xx-xx.)

Of 5,693 state facilities evaluated, 1,300 totaling over $336 million worth of property are located in an earthquake hazard zone in Region 1 (Figure 2-R1-EQ-1). Among the 1,141 critical and essential state facilities, 186 are in an earthquake hazard zone in Region 1. Additionally, 913 non-state critical/essential facilities in Region 1 are located in an earthquake hazard zone.

Region 1 Earthquake Hazard

State Owned/Leased Facilities Critical/Essential Facilities

Property Value Statistics within Earthquake Hazard Areas				
County	# of state owned/leased critical/essential facilities (★)	# of non-state owned/leased critical/essential facilities (★)	# of state owned/leased non-critical/essential facilities (▪)	Total property value of state owned/leased facilities (★ , ▪)
Clatsop	86	151	236	$116,767,199
Coos	41	276	261	$59,977,786
Curry	4	102	104	$13,782,834
Douglas*	1	40	44	$3,063,701
Lane*	7	64	92	$43,742,674
Lincoln	21	172	220	$38,573,375
Tillamook	26	108	157	$60,104,905
Grand Total	186	913	1114	$336,012,474

* Only the western portions of Lane and Douglas counties are within Region 1.

- State owned/leased critical/essential facility
- Non-state owned/leased critical/essential facility
- State owned/leased non-critical/essential facility
- County Boundary (gray text)
- Region Boundary (black numbers)
- Earthquake - High Hazard
- Earthquake - Moderate Hazard
- Earthquake - Low Hazard
- Earthquake - Other

N W E S

0 20 40 80 Miles

Scale: 1 to 1,160,000
Projection: Oregon Statewide Lambert Conformal Conic
Datum: NAD83 HARN
Unit: feet

Map and hazard data provided by the US Bureau of Land Management, the US Geological Survey, the Oregon Department of Administrative Services, Oregon Emergency Management, the Oregon Department of Forestry, the Oregon Department of Land Conservation and Development, and the Oregon Department of Geology and Mineral Industries.

Author: Warren Ren, Oregon Department of Geology and Mineral Industries, January 2014

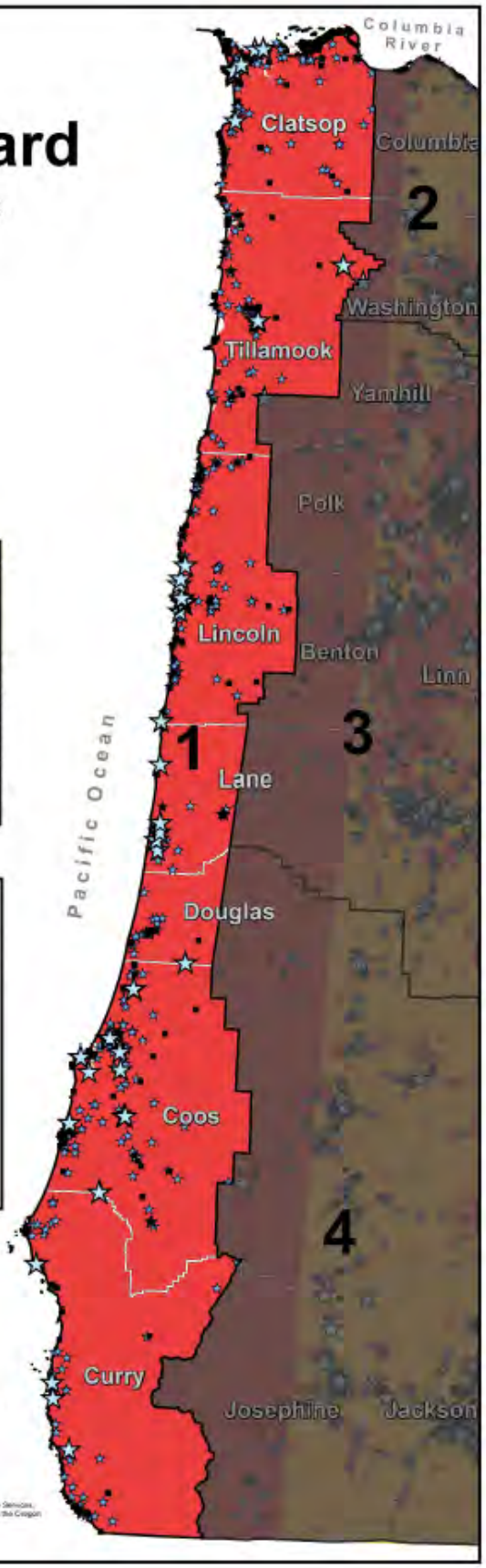


Figure 2-R1-EQ-1: State Owned/ Leased Facilities and Critical/ Essential Facilities in an Earthquake Zone in Region 1

Source: DOGAMI

Seismic Lifelines

According to the Oregon Department of Transportation's (ODOT) Oregon Seismic Lifeline Report (OSLR), Region 1 has the most seismically vulnerable highway system of all the geographic zones and is the most difficult to access due to multiple geographic constraints. While it could be argued that the region's critical post-earthquake needs should dictate that all coastal area routes be Tier 1 (first priority roadways), the reality is that-- to make the entire lifeline system resilient-- the vulnerabilities in Region 1 are so extensive that the majority of the cost would be incurred for repairs done within this region. Furthermore, because of the high vulnerability of the region, it is paramount that emergency services and recovery resources are able to reach this region from other regions. Consequently, all needs are best served with a conservative Tier 1 backbone system, selected according to the criteria described earlier in this Plan. For a detailed description of the OSLR report and findings see pages xx-xx in the State Risk Assessment, Oregon Vulnerabilities section of this Plan.

The Tier 1 (first roadway priority) system in Region 1 consists of three access corridors:

- OR 30 from Portland to Astoria
- OR 18 from the Willamette Valley to US 101 and north and south on US 101 between Tillamook and Newport
- OR 38 from I-5 to US 101 and north and south on US 101 from Florence to Coos Bay

The Tier 2 (second roadway priority)system in Region 1 consists of three access corridors:

- US 26 from OR-217 in Portland to US 101 and north and south on US 101 from Seaside to Nehalem
- OR 126 from the Valley to US 101 at Florence
- US 101 from Coos Bay to the California border

The Tier 3 (third roadway priority)system in Region 1 would complete an integrated coastal lifeline system and consists of the following corridors:

- US 101 from Astoria to Seaside
- US 101 from Nehalem to Tillamook
- OR 22 from its junction with OR 18 to the Valley
- OR 20 from Corvallis to Newport
- OR 42 from I-5 to US 101
- US 199 from I-5 to the California border

Regional Impact

Coastal highways, most importantly US 101, will be fragmented in many areas. In some areas there are possible detours inland from US 101 but many of those routes are also vulnerable to ground shaking, landslides and other hazards.

Ground Shaking: In Region 1 ground shaking will be intense and prolonged. Most unreinforced structures and many unreinforced roadbeds and bridges will be damaged to varying extents, and it is likely that many damaged areas will become impassable without major repairs.

Landslides and Rockfall: Many areas along the coast highway, US 101, are cut into or along landslide prone features. Removal of slide and rockfall material is an ongoing

responsibility of ODOT Maintenance crews on long stretches of the highway. A major seismic event will increase landslide and rockfall activities and may reactivate ancient slides that are currently inactive.

Tsunami: Some reaches of US 101 and connecting and parallel routes will be inundated by tsunami. Tsunami debris may block large areas of the street and highway network.

Liquefaction: Structures in wetland, estuarine, alluvial and other saturated areas will be subject to liquefaction damage; the total area of such impacts will vary with the extent of saturated soils at the time of the event.

Regional Loss Estimates.
Highway related losses include disconnection from supplies and replacement inventory, and the loss of tourists and other customers who must travel to do business with affected businesses.

Most Vulnerable Jurisdictions.
The vulnerabilities studied in the OSLR project are geographic rather than jurisdictional. Other research suggests that the risks of a subduction zone seismic event are somewhat higher along the Southern Oregon Coast, but the risks assessed in this study pertain to the vulnerability of highway facilities in the case of a CSZ event and the higher vulnerabilities are generally low lying areas, active and ancient landslide and rockfall areas, and where critical bridges may not be easily repaired or detoured around. Vulnerability also relates to a current conditions context – high groundwater and saturated soils, high tides and time of day as it relates to where people are relative to the highway system and other vulnerable facilities. Coos, Curry, Douglas, Lane, Lincoln, Tillamook and Clatsop Counties are all highly vulnerable to a CSZ event.

Flood

Characteristics

In general, three types of flooding occur in this region: (1) riverine, (2) ocean flooding from high tides and wind-driven waves, and (3) flooding associated with a tsunami event. Tsunami flooding is not addressed in this section. There are two distinct periods of riverine flooding in this region, winter and late spring. The most serious flooding occurs during December, January, and February. The situation is especially severe when riverine flooding, caused by prolonged rain and melting snow, coincides with high tides and coastal storm surges. In short, the rivers back up and flood the lowlands. This type of flooding is especially troublesome in the Tillamook Bay area where homes and livestock can be isolated for several days. Several northern coastal rivers carry heavy silt loads that originated in areas burned during the "Tillamook Burn" fires (1933 to 1951) or from areas covered with volcanic ash during the Mt. St. Helens eruption (1980). Consequently, some rivers actually may be elevated above local floodplains, which increases flood hazards.

Riverine

There are two distinct periods of riverine flooding in this region— winter and late spring —with the most serious occurring December through February. The situation is especially severe when riverine flooding, caused by prolonged rain and melting snow, coincides with high tides and coastal storm surges. This type of flooding is especially troublesome in the Tillamook Bay area where homes and livestock can be isolated for several days. Several northern coastal rivers carry heavy silt loads that originated in areas burned during the "Tillamook Burn" fires (1933 to 1951) or from areas covered with volcanic ash during the Mt. St. Helens eruption (1980). Consequently, some rivers actually may be elevated above local floodplains, which increases flood hazards. The costs and long-term benefits of dredging these rivers have not been determined. Table 2-R1-FL-1 lists the principal riverine flood sources in Region 1.

Ocean Flooding / Wave Action

Flooding from wind-driven waves is common during the winter, during El Niño events, and when spring and perigean tides occur. The Federal Emergency Management Agency has identified and mapped coastal areas subject to direct wave action (V zones) and sand dune over-topping (AH and AO zones). Direct wave action was especially severe during the winter storm events of 1972 (Siletz Spit), 1978 (Nestucca Spit), and the El Niño events of 1982-83 and 1997-98. Significant beach and cliff erosion occurred during these periods and a number of homes were destroyed. The following lessons were learned (and oftentimes forgotten between damaging events):

- Oregon coastal processes are complex and dynamic, sometimes eroding, sometimes aggrading;
- Some sections of the Oregon coast are rising in relation to ocean levels, others remain fairly constant or are becoming lower (Komar 1992, 40-41);
- Primary frontal dunes provide protection from ocean storms;
- Sand spits are not permanent features;
- Erosion rates vary and are dependent on several factors including storm duration and intensity, composition of sea cliff, time of year, and impact of human activities (e.g., altering the base of sea cliffs, interfering with the natural movement of beach sand).

Table 2-R1-FL-2: Historic Floods

DATE	LOCATION	DESCRIPTION	TYPE OF FLOOD
1813	NW Oregon	Said to exceed "Great Flood" of 1861 (Source: Native Americans)	unknown
12/1861	Coastal rivers	The "Great Flood"; largest flood of known magnitude on the Rogue	Rain on snow
02/1890	Coastal rivers	Widespread flooding; Siuslaw River dammed by a large debris flow	Rain on snow
01/1923	Lower Columbia	Mild temperatures; large amount of rain. Flooded roads / railroads	Rain on snow
03/1931	Western Oregon	Extremely wet and mild; saturated ground	Rain on snow
12/1933	Northern Oregon	Intense warm rains; Clatskanie River set record	Rain on snow
12/1937	Western Oregon	Heavy coastal rain; large number of debris flows	Rain on snow
10/1950	SW Oregon coast	Heavy October rain	Rain on snow
12/1953	Western Oregon	Heavy rain accompanied major windstorm; serious log hazards on Columbia	Rain on snow
12/1955	Columbia & coastal streams	Series of storms; heavy, wet snow; many homes and roads damaged	Rain on snow
12/1962	SW Oregon	Severe flooding, especially the Rogue River	Rain on snow
03/1964	Coast & Columbia River estuary	Ocean flooding	Tsunami
12/1964	Entire state	Two storms; intense rain on frozen ground	Rain on snow
01/1972	Northern coast	Severe flooding and mudslides; 104 evacuated from Tillamook	Rain on snow
01/1974	Western Oregon	Series of storms with mild temperatures; large snowmelt; rapid runoff	Rain on snow
12/1978	Coastal streams	Intense warm rain; two fatalities on Yaquina River; widespread flooding	Rain on snow
02/1986	Entire state	Warm rain and melting snow; numerous homes evacuated	Rain on snow
02/1987	Western Oregon	Heavy rain; mudslides; flooded highways; damaged homes	Rain on snow
12/1989	Clatsop, Tillamook &	Warm Pacific storm system. High winds. Fatalities. Mudslides	Rain on snow

DATE	LOCATION	DESCRIPTION	TYPE OF FLOOD
	Lincoln		
01/1990	W. Oregon	Significant damage in Tillamook Co. Many streams had all-time records	Rain on snow
04/1991	Tillamook County	48-hour rainstorm. Wilson River 5 ft. above flood stage. Businesses closed	Rain on snow
02/1996	NW Oregon	Deep snow pack. Warm temperatures. Record-breaking rains.	Rain on snow
11/1996	W. Oregon	Record-breaking precipitation. Flooding. Landslides. (FEMA-1149-DR-OR)	Rain on snow
12/2005	Coos County Curry County Douglas County	$2,840,000.00 in property damage *figure also includes Jackson and Josephine Counties	Riverine
11/2006	Tillamook County	Heavy rains caused major flooding in Nehalem and Tillamook, causing $1 million in damage in Nehalem and $15 million in Tillamook	Riverine
11/2006	Lincoln County	Siletz River crested at 7 feet above flood stage	Riverine
12/2006	Coos County	Two floods in Coos County on the Coquille River inundated several roads, including Highways 42 and 42S.	Riverine
12/2007	Clatsop County	Storm total of 7.3 inches of rain, causing many rivers to overflow their banks. $9.15 million in damages	Riverine
12/2007	Columbia County	Nehalem (Vernonia)	Riverine
12/2007	Tillamook County	Heavy rains led to flooding in Tillamook along the Wilson River damaging businesses, homes, the railroad to the Port. County-wide damages total 26 million.	Riverine
12/2007	Lincoln County	Siletz River had moderate flooding, causing flood damage near Siletz and Lincoln City. Total county-wide damages include $124,000 in damages inland, and $31,000 damages for coastal property.	Riverine
12/2007	Lane County	Flooding along coast, $31,000 in property damage.	Riverine
12/2007	Curry County	Rogue river exceeds flood stage, but no known damages.	Riverine
12/2008	Tillamook County	Heavy rainfall caused flooding in downtown Tillamook. Estimate of $3.8 million in damages throughout Tillamook County.	Riverine
1/2012	Coos Curry	A severe winter storm including flooding, landslides, and mudslides affected mostly the southern Oregon	Riverine

DATE	LOCATION	DESCRIPTION	TYPE OF FLOOD
	Lincoln Tillamook Counties	coastal counties.	
11/2012	Curry Josephine Counties	Heavy precipitation caused over $4 million in damages to public infrastructure	Riverine, Sheet flow
9/2013	Tillamook County	Heavy rain caused flooding at the Wilson River	Riverine

Source: Taylor and Hannon, 1999, *The Oregon Weather Book*, pp.96-103 Source: Hazards & Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org; National Climatic Data Center, Storm Events, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms.

TABLE 16. PRINCIPAL RIVERINE FLOOD SOURCES

CLATSOP	COOS	CURRY	DOUGLAS	LANE	LINCOLN	TILLAMOOK
Lewis & Clark R Little Walluski R Necanicum R Nehalem R Bear Cr Beerman Cr Big Cr Cow Cr Fishhawk Cr Humbug Cr Little Cr Neacoxi Cr Neawanna Cr Northrup Cr Plymton Cr	Coquille R Willicoma R Ten Mile Cr Palouse Cr Larson Cr Kentuck Sl Willanch Sl Pony Cr	Chetco R Elk R Pistol R Rogue R Sixes R Winchuck R Hunter Cr	Umpqua R Smith R Scholfield Cr	Siuslaw R Munsel Cr	Alsea R Salmon R Siletz R Yachats R Yaquina R Drift Cr Depot Cr Ollala Cr Schooner Cr	Kilchis R Miami R Nehalem R Nestucca R Three Rivers Tillamook R Trask R Wilson R Dogherty Sl Hoquarten Sl

Sources: Federal Emergency Management Agency (FEMA), Clatsop County Flood Insurance Study (FIS), 7/17/01, FEMA, Coos County FIS, 5/15/84, FEMA, Curry County FIS, 2/04/98, FEMA, Douglas County FIS, 4/21/99, FEMA, Lane County FIS, 06/02/99, FEMA, Lincoln County FIS, 3/01/80, FEMA, Tillamook County FIS, 8/20/02.

Probability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the probability (High, Moderate, Low) that Region 1 will experience flooding is depicted in Table R1-FL-1 below. (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx.)

Table 2-R1-FL-3: Local Probability Assessment of Flood

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	H	H	H	H	H	H	H

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

Riverine

FEMA has mapped the streams listed in Table 16 for 10, 50, 100, and 500-year flood events, with the probability of flooding in a year being 10%, 2%, 1%, and 0.2%, respectively. Areas subject to the 1% annual flood are depicted on FEMA Flood Insurance Rate Maps (FIRMs). Recurrence intervals can differ between reaches of the same stream during the same flood event. For example, certain reaches of the Wilson River may experience a 100-year (1%) flood while other sections of the river may be having a 50-year (2%) or perhaps a 500-year (0.2%) flood event.

Flood Insurance Rate Maps (FIRM) depict flood conditions; however, many maps are based on old flood models. The following is a list of Region 1 counties and the date of their most recent FIRM:

- Clatsop, 9/17/2010
- Coos, 9/25/2009
- Curry, 9/25/2009
- Douglas, 2/17/2010
- Lane, 6/02/1999
- Lincoln, 12/18/2009
- Tillamook, 8/20/2002

Communities can reduce the likelihood of damaging floods by employing sound floodplain management practices. DLCD encourages communities to participate in FEMA's Community Rating System, which rewards jurisdictions that adopt practices higher than NFIP minimum standards. Douglas and Lane Counties participate in this program, as do the cities of Cannon Beach, Nehalem, and Tillamook. Clatsop County and Lincoln City have expressed interest in the CRS program.

Ocean Flooding / Wave Action

Ocean storms can be expected every year. El Niño effects, which tend to raise ocean levels, occur about every three to five years (Taylor and Hannan, 1999). V (wave velocity) zones, depicted on FEMA's Flood Insurance Rate Maps, are areas subject to 100-year events (i.e., 1% chance in any given year). The Flood Insurance Rate Maps show areas vulnerable to wave action (V zones), ponding and sheet-flow from waves over-topping dunes (AO and AH zones). All of the counties in Region 1 have hazardous areas identified on the maps. DOGAMI and FEMA also provide information about wave action.

Vulnerability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the region's vulnerability (High, Moderate, Low) to flooding is depicted in Table R1-FL-2 below. (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx)

Table 2-R1-FL-4: Local Vulnerability Assessment of Flood

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	H	H	H	M	H	L	H

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

Low-lying coastal areas in Region 1 are particularly vulnerable to flood hazards that can be exacerbated by high tides. Region 1 received the highest flood vulnerability index score (83) partly because seven counties (all or partial) are included in this region, but also because four of the highest scoring counties are located in Region 1. The lower Siletz and Siuslaw rivers in Lincoln and Lane Counties respectively and the rivers that feed Tillamook Bay in Tillamook County have all experienced significant flood losses. In fact, the meaning of the term "100-year flood" was lost when repetitive flood events impacting the City of Tillamook and adjacent portions of Tillamook County exceeded the base flood elevation numerous times, including major flood events in 1996, 1998 and 1999, 2007, and 2011. Many pre- and post-FIRM buildings experienced repetitive flood losses along Highway 101 in north of the City of Tillamook, many of which have been mitigated using HMGP grants.

In general, the northern half of Region 1 is more vulnerable to riverine flood damage than the southern half because it is more densely populated and consequently contains much of the region's infrastructure. Physical location also makes a difference. For example, five rivers empty into Tillamook Bay, thereby increasing risk from riverine flooding on the relatively flat valley floor.

Fortunately, unlike the East and Gulf coasts, only a few of Oregon's coastal developments are within FEMA-designated Velocity (V) zones. Region 1 counties have not inventoried all buildings that are vulnerable to wave action (i.e., in V zones); however pertinent information from the National Flood Insurance Program (NFIP) indicates that Lincoln and Tillamook Counties and their coastal cities account for nearly all of the V-zone flood policies (275 of 277) and losses (18 out of 20) in Region 1 .

While the exact number of buildings, parks, infrastructure, and critical facilities in Region 1 vulnerable to ocean storms is unknown, the low-lying areas adjacent to bays or the ocean are known to be at risk. Bayocean, Salishan Spit, Jumpoff Joe, Rogue Shores, and The Capes are examples of development in such areas whose buildings and infrastructure have been destroyed by wave attack. A number of local governments in Region 1 have initiated and accomplished building elevation and /or buy-out programs. Also, dairy farmers and other businesses have made considerable progress in protecting their investments.

Coastal highways have always been problematic. In Region 1, much of the problem is linked to the local geology. Bedrock conditions change abruptly within very short distances resulting in inconsistent highway foundation; some sections are more susceptible to wave action than

others and require continuous maintenance. There is no practical solution outside of relocation of the highway; this option is not financially feasible at this point in time.Flood vulnerability scores for Region 1 are listed below (Table 2-R1-FL-5).

Table 2-R1-FL-5: Flood Vulnerability Scores, by County

County	Flood Vulnerability Score
Clatsop	6
Coos	7
Curry	7
Douglas *	6
Lane *	6
Lincoln	6
Tillamook	11

*Only coastal sections of Douglas and Lane Counties

Source: DLCD

State Owned/Leased Facilities and Critical and Essential Facilities

The following information is based on a state facility and critical and essential facility vulnerability assessment update completed by DOGAMI in 2014. (See the State Risk Assessment, Oregon Vulnerabilities for more information, pg xx-xx.)

Of the 5,693 state facilities evaluated, 151 are currently located within a flood hazard zone in Region 1 and have an estimated total value of nearly $23 million (Figure R1-FL-1). Of these, 5 are identified as a critical or essential facility. An additional 146 non-state owned/leased critical/essential facilities are located in a flood hazard zone in Region 1.

Region 1
Flood Hazard

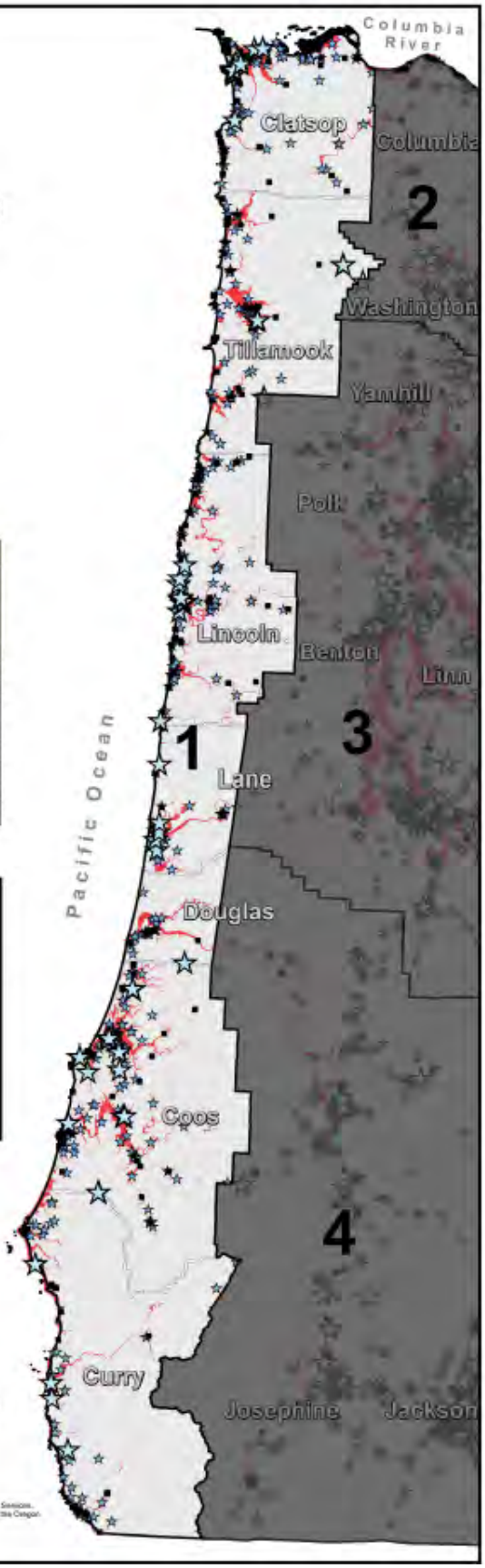
State Owned/Leased Facilities
Critical/Essential Facilities

Property Value Statistics within Flood Hazard Areas

County	# of state owned/leased critical/essential facilities (☆)	# of non-state owned/leased critical/essential facilities (★)	# of state owned/leased non-critical/essential facilities (▪)	Total property value of state owned/leased facilities (☆, ▪)
Clatsop	1	25	41	$4,490,585
Coos	2	13	35	$8,550,106
Curry	-	6	15	$1,939,199
Douglas*	-	4	1	$30,000
Lane*	-	3	1	$13,400
Lincoln	2	18	46	$6,728,808
Tillamook	-	16	7	$1,071,705
Grand Total	5	85	146	$22,823,803

* Only the western portions of Lane and Douglas counties are within Region 1.

- ☆ State owned/leased critical/essential facility
- ★ Non-state owned/leased critical/essential facility
- ▪ State owned/leased non-critical/essential facility
- County Boundary (gray text)
- Region Boundary (black numbers)
- Flood - Hazard Zone
- Flood - Other



N W E S

0 20 40 80 Miles

Scale: 1 to 1,150,000
Projection: Oregon Statewide Lambert Conformal Conic
Datum: NAD83 HARN
Unit: feet

Map and hazard data provided by the US Bureau of Land Management, the US Geological Survey, the Oregon Department of Administrative Services, Oregon Emergency Management, the Oregon Department of Forestry, the Oregon Department of Land Conservation and Development, and the Oregon Department of Geology and Mineral Industries.

Author: Warren Roe, Oregon Department of Geology and Mineral Industries, January 2014.

Figure 2-R1-FL-1: State Owned/ Leased Facilities and Critical/ Essential Facilities in a Flood Zone in Region 1

Source: DOGAMI

Landslide

Characteristics

Landslides occur throughout this region of the state, although areas with steeper slopes, weaker geology, and higher annual precipitation tend to have more landslides. In general, the coast and Coast Range Mountains have a very high incidence of landslides. On occasion, major landslides occur on US or State Highways and sever these major transportation routes (including rail lines) causing temporary but significant economic damage to the state. Although less frequent, landslides and debris flows do occur that result in the death of people located in their paths.

Historic Landslide Events

Table 2-R1-LS-1: Historic Landslides

Date	Location	Description
February 1926	Between Coos Bay and Coquille, OR	Damages: $25,000. Closed Roosevelt Highway.
February1961		Large section of Ecola State Park slid into the Pacific Ocean.
February1996		FEMA-1099-DR-OR. Heavy rains and rapidly melting snow contributed to hundreds of landslides/debris flows across the state. Many on clear cuts that damaged logging roads.
November 1996	Lane and Douglas Counties, OR	FEMA-1149-DR-OR . Heavy rain triggered mudslides (Lane and Douglas Counties). Fatalities: five fatalities. Injuries: several (Douglas County).
February 1999	South of Florence, OR	Two timber workers killed in a mud and rockslide (south of Florence).
January 2000	North of Florence, OR	A landslide (north of Florence) closed Highway 101 for 3 months, resulting in major social and economic disruption to nearby communities.
December 2004	Lane, Polk, and Lincoln Counties, OR	Property damage: $12,500.
December 2007	Clatsop and Tillamook Counties, OR	Property damage: $300,000.

Sources:

Taylor and Hatton, 1999, *The Oregon Weather Book;* and FEMA After-Action Report, 1996 events; and interviews, Oregon Department of Transportation representatives.

Hazards & Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from: http://www.sheldus.org.

Probability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the probability (High, Moderate, Low) that Region 1 will experience landslides is depicted in Table 2-R1-LS-2 below. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (-). (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx.)

Table 2-R1-LS-2: Local Probability Assessment of Landslides

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	H	H	H	H	H	-	H

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

Landslides are found in every county in Oregon. There is a 100% probability of landslides occurring in Oregon in the future. Although we do not know exactly where and when they will occur, they are more likely to happen in the general areas where landslides have occurred in the past. Also, they will likely occur during heavy rainfall events or during a future earthquake.

Vulnerability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the region's vulnerability (High, Moderate, Low) to landslides is depicted in Table 2-R1-LS-3 below. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (-). (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx.)

Table 2-R1-LS-3: Local Vulnerability Assessment of Landslides

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	H	M	L	M	M	-	H

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

Rain-induced landslides and debris flows can potentially occur during any winter in this region. This area is also subject to future very large earthquakes, which will trigger landslides. Many of the communities in this region have a high exposure to the landslide hazard, for example Astoria. A new study of the landslide hazard and risk of Astoria found 121 landslides within the city limits and losses in a major earthquake are likely to be 50% greater than somewhere with low or no landslide hazards (Burns and Mickelson, 2013).

Some of the greatest exposure in this region is the east-west roadways that carry traffic to and from the coast, with the potential for injuries and loss of life from rapidly moving landslide events.

Burns, W.J. and Mickelson, K.A., 2013. Landslide Inventory, Susceptibility Maps, and Risk Analysis for the City of Astoria, Clatsop County, Oregon: Oregon Department of Geology and Mineral Industries, Open-File Report O-13-05.

State Owned/Leased Facilities and Critical and Essential Facilities

The following information is based on a state facility and critical and essential facility vulnerability assessment update completed by DOGAMI in 2014. (See the State Risk Assessment, Oregon Vulnerabilities for more information, pg xx-xx.)

Of the 5,693 state facilities evaluated, 1,300 are located within landslide hazard areas in Region 1, totaling roughly $336 million (Figure 2-R1-LS-1). This includes 186 critical or essential facilities. 913 additional critical/essential facilities, not owned/leased by the state, also reside within a landslide hazard zone in Region 1.

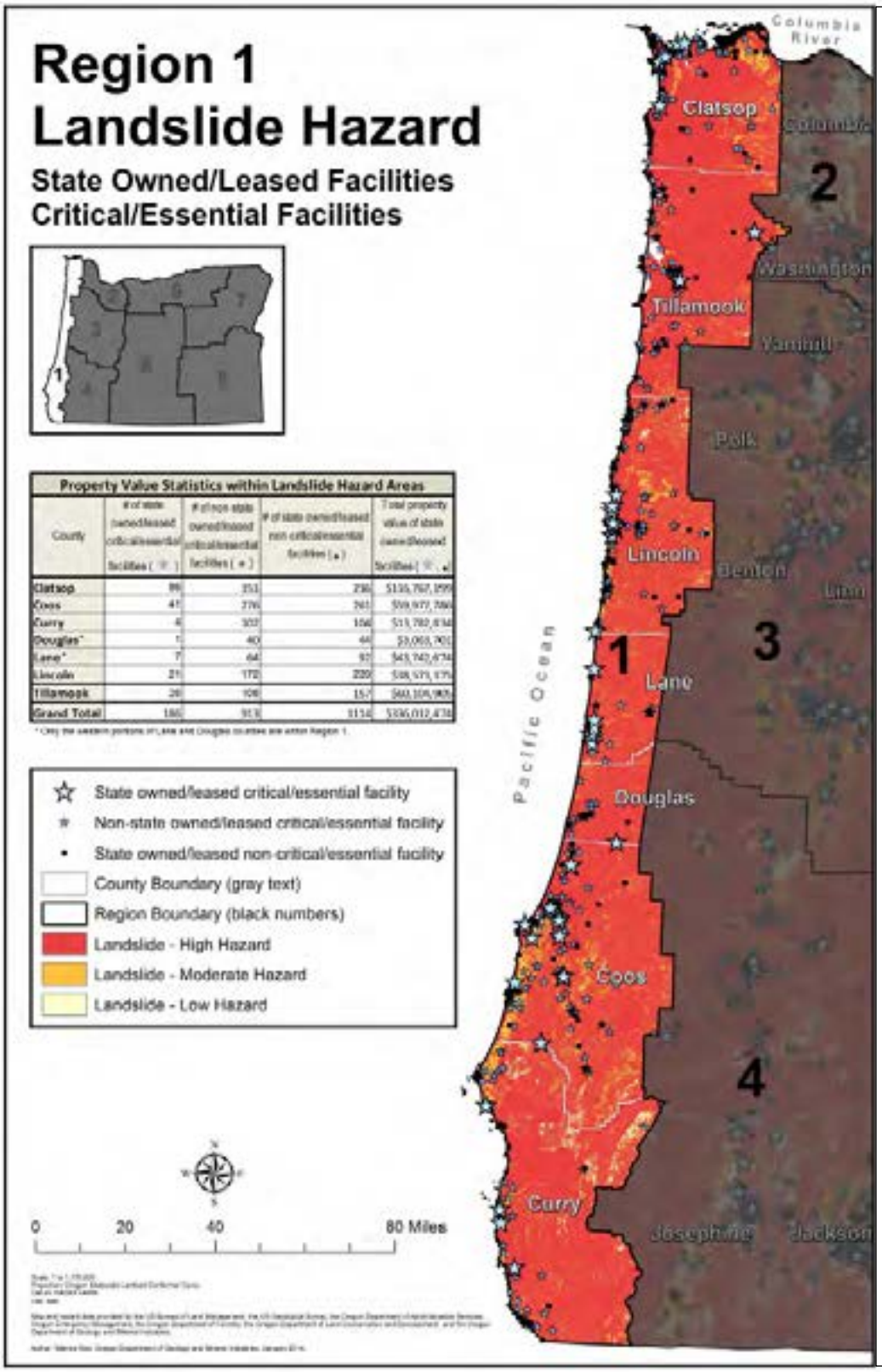


Figure 2-R1-LS-1: State Owned/ Leased Facilities and Critical/ Essential Facilities in a Landslide Hazard Zone in Region 1

Source: DOGAMI

Tsunami

Characteristics and Brief History

Tsunami waves are infrequent events, but can be extremely destructive. They may be generated by earthquakes, submarine volcanoes, or landslides, and travel hundreds of miles before striking land. Hardly discernible at sea, tsunami waves travel as fast as 500 mph across open water until, at landfall, they slow-down significantly and can reach heights up to 20 to ~100 feet. Seward, Alaska, experienced tsunami waves as high as 25 feet during the 1964 earthquake-tsunami event.

Most tsunami waves have been described as an onrushing, rapidly rising tide, which can be seen in the few motion pictures that have captured the tsunami phenomenon. The size and behavior of tsunamis depend on a number of factors, including distance traveled, submarine topography and the shape and orientation of the coastline. Much of the damage results from water-borne debris, which can act as battering rams against on-shore development. Wave-borne fuel drums are especially hazardous because of their propensity to cause or exacerbate fires.

All Region 1 counties are susceptible to tsunami hazards. Oregon's coastal communities have experienced, to various degrees, tsunamis that have originated in the oceanic regions near Russia's Kamchatka Peninsula, Japan, Chile, Hawaii, the Gulf of Alaska and northern California. Additionally, the geologic record implies that over the last 10,000 years ~42 tsunamis have been generated locally off the Oregon Coast along the Cascadia Subduction Zone (CSZ). Nineteen of these tsunamis were from full-margin ruptures of the CSZ and arrived in all parts of the coast ~15-20 minutes after the earthquake; the others arrived this quickly on parts of the south coast adjacent to each of the segment ruptures. All 42 tsunamis would create significant damage to coastal ports and pose a threat to those near waterfront areas. This is the region's greatest concern (see Earthquake section, Pg. X).

Table 2-R1-TS-1 describes some of the tsunami history of Region 1.

Historic Tsunami Events

Table 2-R1-TS-1: Historic Tsunamis

Date	Origin of Event	Affected Community	Damage	Remarks
04/1868	Hawaii	Astoria, OR		Observed
08/1868	N. Chile	Astoria, OR		Observed
08/1872	Aleutian Is	Astoria, OR		Observed
11/1873	N. California	Port Orford, OR		Debris at high tide line
04/1946	Aleutian Is	Bandon, OR		Barely perceptible
04/1946		Clatsop Spit, OR		Water 3.7m above MLLW
04/1946		Depoe Bay, OR		Bay drained. Water returned as a wall
04/1946		Seaside, OR		Wall of water swept up Necanicum River
11/1952	Kamchatka	Astoria, OR		Observed
11/1952		Bandon, OR	Log decks broke loose	
05/1960	S. Cent. Chile	Astoria, OR		Observed
05/1960		Seaside, OR	Bore on Necanicum River damaged boat docks	
05/1960		Gold Beach, OR		Observed
05/1960		Newport, OR		Observed for about four hours
05/1960		Netarts, OR	Some damage observed	
03/1964	Gulf of Alaska	Cannon Beach, OR	Bridge and motel unit moved inland. $230,000 damage	
03/1964		Coos Bay, OR	$20,000 damage	
03/1964		Depoe Bay, OR	$5,000 damage; 4 children drowned at Beverly Beach	
03/1964		Florence, OR	$50,000 damage	
03/1964		Gold Beach, OR	$30,000 damage	
03/1964		Seaside, OR	1 fatality (heart attack); Damage to city: $41,000; Private: $235,000; Four trailers, 10-12 houses, two bridges damaged	
05/1968	Japan	Newport, OR		Observed
04/1992	N. California	Port Orford, OR		Observed
10/1994	Japan	Oregon Coast		Tsunami warning issued, but no tsunami observed
3/2011	Japan	Oregon Coast	$6.7 million. Extensive damage to the Port of Brookings.	Tsunami warning issued, observed ocean waves. and

Sources:
NOAA, 1993, Tsunamis Affecting the West Coast of the United States: 1806-1992.
FEMA, 2011, Federal Disaster Declaration

Probability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the probability (High, Moderate, Low) that Region 1 will experience a tsunami is depicted in Table 2-R1-TS-2 below. (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx)

Table 2-R1-TS-2: Local Probability Assessment of Tsunami

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	H	H	H	H	M	H	M

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

The entire coastal zone is highly vulnerable to tsunami impact. Distant tsunamis caused by earthquakes on the Pacific Rim strike the Oregon coast frequently but only a few of them have caused significant damage or loss of life. Local tsunamis caused by earthquakes on the CSZ happen much less frequently but will cause catastrophic damage and, without effective mitigation actions, great loss of life.

With respect to distant sources, Oregon has experienced 25 tsunamis in the last 145 years with only 3 causing measurable damage. Thus, the average recurrence interval for tsunamis on the Oregon coast from distant sources would be about 6 years. However, the time interval between events has been as little as one year and as much as 73 years. The two most destructive tsunamis occurred only four years apart (1960 and 1964) and originated from two different source areas (south central Chile and the Gulf of Alaska). Since only a few tsunamis caused measurable damage, a recurrence interval for distant tsunamis does not have much meaning for this region with respect to losses. However, every time the coast is put into a distant tsunami warning by NOAA, evacuation plans are triggered at significant cost to local government and business.

Geologists predict a 10 percent chance that a CSZ tsunami will be triggered by a shallow, undersea earthquake offshore Oregon in the next 30 years, causing a tsunami that will strike all parts of the Oregon coast ~15-20 minutes after the earthquake. This forecast comes from the 10,000-year geologic record of 19 CSZ fault ruptures extending the entire length of the Oregon coast (i.e., recurrence of ~500 years).[54] As previously mentioned, the southern Oregon coast has a higher chance of experiencing a local tsunami and earthquake, the probability increasing progressively southward. The last CSZ event occurred approximately 300 years ago.[55]

Owing to much faster arrival and generally larger size, tsunamis originating from the CSZ will cause much larger life and property losses than most distant tsunamis and are at least as frequent as the largest distant tsunamis. Inundation from the largest distant tsunamis

[54] Department of Geologic and Mineral Industries. *Oregon Geology Factsheet: Tsunami Hazards in Oregon*. http://www.oregongeology.org/pubs/fs/tsunami-factsheet_onscreen.pdf.

[55] Satake K, Shimazaki K, Tsuji Y, Ueda K (1996) Time and size of a giant earthquake in Cascadia inferred from Japanese tsunami records of January 1700. Nature 379:246–249.

approximates inundation from the "Small" Cascadia tsunami on Oregon Tsunami Inundation zone Maps (TIMs).

Vulnerability

Local Assessment

Based on an OEM Hazard Analysis conducted by county emergency program managers, the region's vulnerability (High, Moderate, Low) to tsunami is depicted in Table 2-R1-TS-3 below. (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx.)

Table 2-R1-TS-3: Local Vulnerability Assessment of Tsunami

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	H	H	H	H	H	M	H

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

The entire coastal zone is highly vulnerable to tsunami impact. Distant tsunamis caused by earthquakes on Pacific Rim strike the Oregon coast frequently but only a few of them have caused significant damage or loss of life. Local tsunamis caused by earthquakes on the Cascadia Subduction Zone (CSZ) happen much less frequently but will cause catastrophic damage and, without effective mitigation actions, great loss of life.

All communities in low-lying coastal areas in Region 1 are especially vulnerable to tsunamis because of its coastal setting and the location of many of its communities in low-lying areas. Seaside is the most vulnerable city due to its low elevation and high numbers of residents and tourist population and its county, Clatsop, is the most vulnerable county, having the largest population exposed (Figure 2-R1-TS-1). [56] Although many communities have evacuation maps and evacuation plans, many casualties are expected. The built environment in the inundation zone will be especially hard hit.

In 2008, the United States Geological Survey (USGS) completed a comprehensive study of coastal cities' exposure and sensitivity to a CSZ tsunami similar to the most likely, "Medium" scenario depicted on 2010-2013DOGAMI tsunami inundation maps.[6] The tsunami zone of the USGS study is the 1995 regulatory inundation zone used by the Oregon Building Code to limit new construction of critical and essential, hazardous, and high occupancy facilities. Results indicate that the regulatory inundation zone contains approximately 22,201 residents (four percent of the total population in the seven coastal counties), 14,857 employees (six percent of the total labor force), and 53,714 day-use visitors on average every day to coastal Oregon State Parks within the tsunami-inundation zone. The zone also contains 1,829 businesses that generate approximately $1.9 billion in annual sales volume (seven and five percent of study-area totals, respectively) and tax parcels with a combined total value of $8.2 billion (12 percent of the study-area total). Although occupancy values are not known for each facility, the tsunami-inundation zone also contains numerous dependent-population facilities (for example, adult-

[56] Wood, N. 2007. *Variations in City Exposure and Sensitivity to Tsunami Hazards in Oregon.* US Geological Survey. Scientific Investigations Report 2007-5283.

residential-care facilities, child-day-care facilities, and schools), public venues (for example, religious organizations and libraries), and critical facilities (for example, police stations).

Additionally, results indicate that vulnerability, described in the study by exposure (the amount of assets in tsunami-prone areas) and sensitivity (the relative percentage of assets in tsunami-prone areas) varies considerably among 26 incorporated cities in Oregon. City exposure and sensitivity to tsunami hazards is highest in the northern portion of the coast. The City of Seaside in Clatsop County has the highest exposure, the highest sensitivity, and the highest combined relative exposure and sensitivity to tsunamis. Results also indicate that the amount of city assets in tsunami-prone areas is weakly related to the amount of a community's land in this zone; the percentage of a city's assets, however, is strongly related to the percentage of its land that is in the tsunami-prone areas.

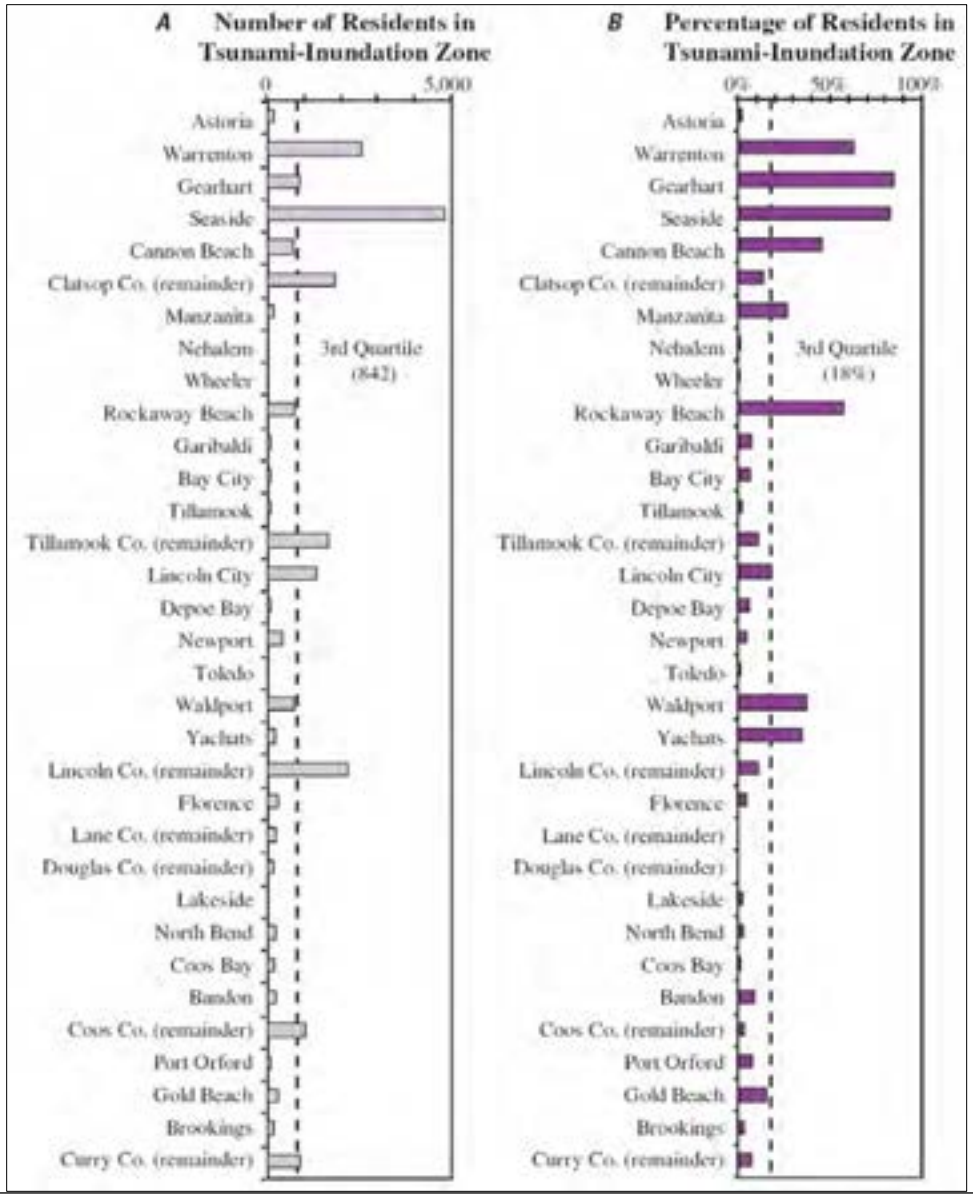


Figure 2-R1-TS-1: Number (A) and percentage (B) of residents in the Oregon regulatory tsunami inundation zone.

Source: Wood (2007).[5]

State Owned/Leased Facilities and Critical and Essential Facilities

The following information is based on a state facility and critical and essential facility vulnerability assessment update completed by DOGAMI in 2014. (See the State Risk Assessment, Oregon Vulnerabilities for more information, pg xx-xx.)

Of the state 5,693 facilities evaluated, 676 are currently located within the tsunami hazard zone and have an estimated total value of $134 million (Figure 2-R1-TS-1). Of these, 105 are identified as state owned or leased critical or essential facilities. An additional 243 non-state critical/essential facilities are also located with a tsunami hazard zone in Region 1.

Region 1
Tsunami Hazard

State Owned/Leased Facilities
Critical/Essential Facilities

Property Value Statistics within Tsunami Hazard Areas

County	# of state owned/leased critical/essential facilities (★)	# of non-state owned/leased critical/essential facilities (★)	# of state owned/leased non-critical/essential facilities (▪)	Total property value of state owned/leased facilities (★ , ▪)
Clatsop	80	84	160	$83,665,885
Coos	5	47	109	$16,111,686
Curry	3	31	33	$8,226,016
Douglas*	-	10	7	$1,307,978
Lane*	1	1	17	$1,903,595
Lincoln	16	39	152	$16,008,435
Tillamook	-	31	93	$7,123,900
Grand Total	105	243	571	$134,347,494

* Only the western portions of Lane and Douglas counties are within Region 1.

- ☆ State owned/leased critical/essential facility
- ★ Non-state owned/leased critical/essential facility
- ▪ State owned/leased non-critical/essential facility
- County Boundary (gray text)
- Region Boundary (black numbers)
- Tsunami - Hazard Zone
- Tsunami - Other

N W E S

0 20 40 80 Miles

Scale: 1 to 1,150,000
Projection: Oregon Statewide Lambert Conformal Conic
Datum: NAD83 HARN
Unit: feet

Map and hazard data provided by the US Bureau of Land Management, the US Geological Survey, the Oregon Department of Administrative Services, Oregon Emergency Management, the Oregon Department of Forestry, the Oregon Department of Land Conservation and Development, and the Oregon Department of Geology and Mineral Industries.

Author: Wenlei Hao, Oregon Department of Geology and Mineral Industries, January 2014.

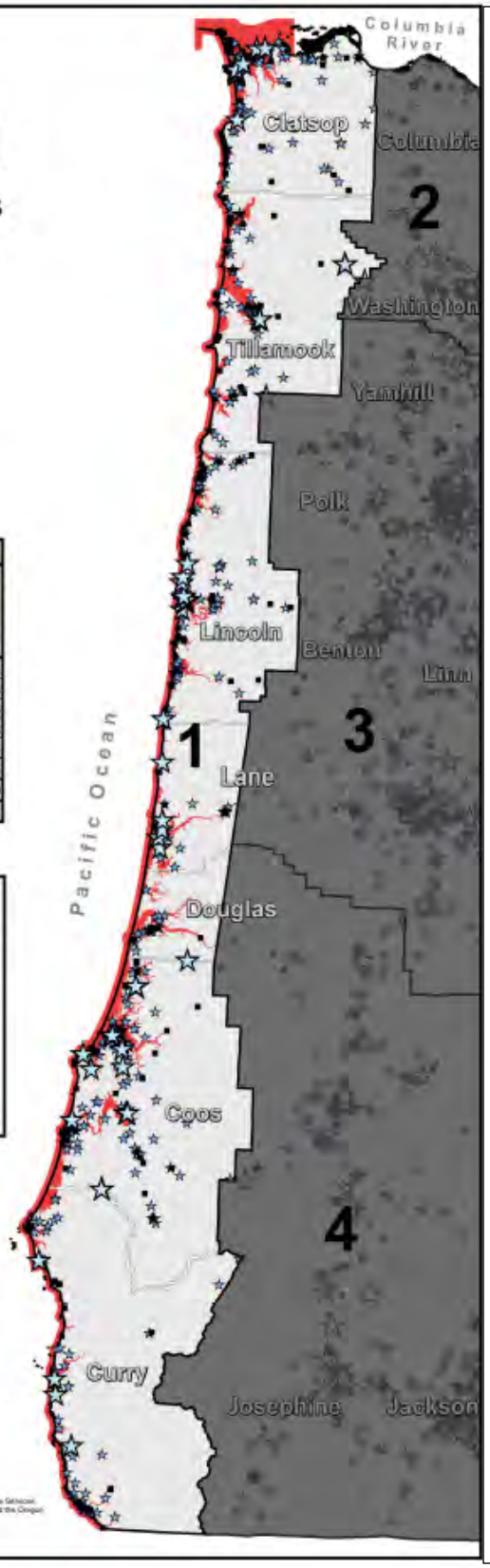


Figure 2-R1-TS-1: State Owned/ Leased Facilities and Critical/ Essential Facilities in a Tsunami Hazard Zone in Region 1

Source: DOGAMI

Volcano

Characteristics

The volcanic Cascade Mountain Range is not within Region 1 counties; consequently, the risk from local volcano-associated hazards (e.g., lahars, pyroclastic flows, lava flows, etc.) is not a priority consideration to Coastal Oregon. However, there is some risk from volcanic ash fall. This fine-grained material, blown aloft during a volcanic eruption, can travel many miles from its source. For example, the cities of Yakima (80 miles) and Spokane (150 miles), Washington, were inundated with ash during the May 1980, Mount St. Helens eruption. Ash fall can reduce visibility to zero, and bring street, highway, and air traffic to an abrupt halt. The material is noted for its abrasive properties and is especially damaging to machinery. It would be prudent for vulnerable communities to identify disposal areas for large quantities of ash.
Part of Clatsop County borders the Columbia River -- which in theory makes it vulnerable to lahars or mudflows carried by the river. Although remote, such an event cannot be dismissed out of hand. A lahar or mudflow that traveled down Washington's Cowlitz River following the eruption of Mount St. Helens, filled the Columbia River channel overnight from its previous 40-foot depth to a mere 14 feet. This delayed ship movements in the vicinity of the Cowlitz for months (Wolfe and Pierson, 1995).

Historic Volcanic Events

There are no significant volcanoes within Region 1; and there are have been no historic volcano-related events.

Probability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the probability (High, Moderate, Low) that Region 1 will experience volcanic hazards is depicted in Table 2-R1-V-1 below. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (-). (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx.)

Table 2-R1-V-1: Local Probability Assessment of Volcanic Hazards

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	M	M	L	-	-	L	M

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

Mount St. Helens is a probable source of ash fall and lahars that can reach the Columbia River. The probability of coastal counties receiving ash fall is about 1 in 10,000-- with a large portion of Curry County being even less (Sherrod and others, 1997). A lahar mudflow that traveled down Washington's Cowlitz River following the 1980 eruption of Mount St. Helens filled the Columbia River channel overnight from its previous 40-foot depth to a mere 14 feet. This delayed ship movements for months.

Vulnerability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the region's vulnerability (High, Moderate, Low) to volcanic hazards is depicted in Table 2-R1-V-2 below. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (-). (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx.)

Table 2-R1-V-2: Local Vulnerability Assessment of Volcanic Hazards

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	M	M	H	-	-	L	M

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

Of the communities identified by DOGAMI as being most vulnerable to volcano hazards, none of these communities reside in Region 1. However, as noted earlier, there is some risk of ash fall that can be especially damaging to machinery. Although remote, the threat of lahars or volcanic related mudflows could impact the shipping industry on the Columbia River in Region 1.

Wildfire

Characteristics

Existing development near wildland areas combined with the spread of gorse and other flammable plant species throughout the region is increasing the level of wildfire risk. Wildfires in the wildland-urban interface (WUI) pose serious threats to life and endanger property, critical infrastructure, water resources, and valued commercial and ecological forest resources. While the region is characterized as moist and regarded as lower than normal fire danger, some the largest fire events have occurred in this area. The historic Tillamook Burn, comprised of devastating wildfire every six years between 1933 and 1951, burned a total of 355,000 acres. Much of the burn was attributed to powerful east wind events and heavy fuels.

Historically, lighting has been the primary ignition source of wildfires in the region. Weather patterns from May through October are characterized by periods of drought separated by storms that produce dry forest fuels followed by frequent lightning strikes, a common source of ignitions. During the past two decades, fires caused by human activities were more frequent than those ignited by natural processes.

Long periods of drought are common during the summer and electrical storms are a common cause of wildfire. These types of storms are most frequent from May through October. Long periods of drought during the summer months also create challenges for wildfire responders. Many small rural communities lack the type of water systems that make water accessible for fire suppression. Instead fire fighters in these areas are often dependent on water from ponds, creeks and rivers. Often in the mid to late summer months, these sources are low or completely dry.

Wind direction changes to an easterly flow in early fall when landscapes are at their driest. These “east wind events” resemble the well-known Santa Anna winds of southern California that produce large, destructive wildfires.

Wildfires have played a significant role in shaping the species composition and forest structure in the region. Intensive fire suppression has resulted in forest fuel buildup and changes in species composition and structure in the past 60 years.

Coastal and Lower Columbia River counties are heavily timbered and have a long history of devastating forest fires. Some of the history is derived from Native Americans who recall extensive forest fires before the arrival of Euro-Americans. Fires involving the wildland interface occur in portions of the state where urbanization and natural vegetation fuels allow a fire to spread rapidly from natural fuels to structures and vice versa. Especially in the early stage of such fires, structural fire suppression resources can be quickly overwhelmed increasing the number of structures destroyed. Such fires are known for the large number of structures that are simultaneously exposed to fire, increasing the total losses per structure ignited. Nationally, wildland interface fires commonly produce widespread, extreme losses. Thus far, Oregon has escaped the level of property losses experienced by neighboring states.

Gorse, a spiny evergreen shrub, was introduced in south coastal Oregon from Europe. It has become an established invasive weed that displaces native vegetation, significantly altering the native vegetation patterns. Because Gorse is highly flammable, it increases wildfire risk wherever it spreads. Infestations of Gorse are particularly common along the coastal area; these areas are a

major concern for wildfire managers.

Wildfire managers are also concerned with the spread of Port-Orford-Cedar root disease and Sudden Oak Death. Trees infected by these pathogens are at increased risk to wildfire and vegetation management activities need to be conducted in a way that minimizes the spread of disease pathogens. The Rogue River-Siskiyou National Forest, Bureau of Land Management, Oregon Department of Forestry and Oregon State Parks have implemented actions to manage the spread of these pathogens.

Historic Wildfire Events

Table 2-R1-WF-1: Historic Wildfires

Date	Name of Fire	Location	Characteristics	Remarks
1846	Yaquina	Lincoln & Lane Counties	Over 450,000 acres.	Event related by Native American hunters
1853	Nestucca		Over 320,000 acres	
1868	Coos Bay	Coos	296,000 acres	
1922	Astoria	Downtown City of Astoria	Many Buildings (32 city blocks burned!)	Early December structural fire most likely not related to wildfire
1933	Tillamook		240,000 acres	The Tillamook Forest burned every six years between 1933 and 1951. Total acreage burned was over 350,000 acres. Together, the four events are called the Tillamook Burn. Dry forest conditions seems to have been a major factor (Taylor)
1936	Bandon		143,000 acres	
1939	Saddle Mountain	Clatsop County	207,000 acres	
1945	Wilson River / Salmon-berry	Tillamook County	173,000 acres	
1951	North Fork / Elkhorn	Tillamook County	33,000 acres	
2002	Florence/Biscuit	Curry County	Almost 500,000 acres (perimeter)	Largest forest fire in Oregon since arrival of Euro-Americans (FEMA Fire Suppression Authorization on 7/29/02). The perimeter contained many unburned islands within the overall acreage.

Source: Brian Ballou, 2002, A Short History of Oregon Wildfires, Oregon Department of Forestry, unpublished; and unknown sources

Probability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the probability (High, Moderate, Low) that Region 1 will experience wildfire is depicted in Table 2-R1-WF-2 below. (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx)

Table 2-R1-WF-2: Local Probability Assessment of Wildfire in Region 1

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	H	M	H	M	L	H	M

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

The potential that wildland fires, both small and large, will threaten life, property and natural resources is a reality. Fire statistics show that fire incident rates, and therefore risks, are prevalent in the WUI areas. Population growth and development continue to encroach into and fragment forests. The natural ignition of forest fires is largely a function of weather and fuel; human-caused fires add another dimension to the probability. Dry and diseased forests can be mapped accurately and some statement can be made about the probability of lightning strikes. Each forest is different and consequently has different probability/recurrence estimates.

The probability of significant fire activity occurring in Region 1 is most likely during the late summer and early fall months when temperatures remain high, vegetation has had the entire summer to dry out and east winds are more prevalent coming out of the Columbia Gorge in the north and Chetco drainages in the south portions of the region.

Vulnerability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the region's vulnerability (High, Moderate, Low) to wildfire is depicted in Table 2-R1-WF-3 below. (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx)

Table 2-R1-WF-3: Local Vulnerability Assessment of Wildfire

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	H	M	H	M	L	M	H

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

Most counties within Region 1 have low to moderate risk from wildfire based primarily on cool, moist weather conditions. However, this region has had some of the largest wildfires that posed threats to communities when they occurred. The 1936 Bandon Fire is a prime example of a fire that, when combined with heavy fuels (gorse) and powerful dry east winds, an entire city was destroyed killing 13 people.

Gorse, brush and timber still make up much of the landscape in Region 1. Given the right conditions, this region's vulnerability to wildfire exists. However, due to infrequent fire activity, the level of vulnerability can be categorized as moderate. A large wildfire in this region would affect local economies that rely on tourism and recreation dollars.

The economic stability of the region is dependent on a major state highway (HWY 101) that runs along the Oregon Coast. Should a major wildfire or other natural event (such as a tsunami) threaten or impact this major thoroughfare, coastal tourism and recreational economies would come to a halt.

Each year a significant number of people build homes within or on the edge of the forest (urban-wildland interface), thereby increasing wildfire hazards. These communities have been designated "Interface Communities" and include the table below.

Table 2-R1-WF-4: Wildland-Urban Interface Communities

Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook	
Arch Cape	Bandon	Agness	Gardiner	Dunes City	Depoe Bay	Bay City	Oceanside
Astoria	Charleston	Brookings	Reedsport	Florence	E. Lincoln Co.	Beaver	Oretown
Brownsmead	Coos Bay	Gold Beach	Winchester Bay	Mapleton	Elk City	Blaine	Pacific City
Cannon Beach	Coquille	Langlois		Swisshorne	Lincoln City	Cape Meares	Pleasant Valley
Coastal Strip	Dora	Nesika Beach		Triangle Lake	Newport	Cloverdale	Rockaway
Elsie-Vinemaple	Fairview	Port Orford			Otter Rock	Foley Creek	Sandlake
Fern Hill	Green Acres				Rose Lodge	Garibaldi	Siskeyville
Ft. Clatsop	Lakeside				Seal Rock	Hebo	Tierra del Mar
Hamlet	Millington				Siletz	Hemlock	Tillamook
Hewell	Myrtle Point				Tidewater	Jordan Creek	Winema Beach
Knappa-Svensen	North Bend				Toledo	Lees Camp	Woods
Lewis & Clark	Powers				Waldport	Nehalem Bay	
Necanicum	Saunders Lake				Yachats	Neskowin	
Olney	Sumner					Netarts	
West Port							

Source: Oregon Dept. of Forestry Statewide Forest Assessment September, 2006

State Owned/Leased Facilities and Critical and Essential Facilities

The following information is based on a state facility and critical and essential facility vulnerability assessment update completed by DOGAMI in 2014. (See the State Risk Assessment, Oregon Vulnerabilities for more information, pg xx-xx.)

Of the 5,693 state facilities evaluated, 796 are within a wildfire hazard zone in Region 1 and total about $186 million in value (Figure 2-R1-WF-1). Among those, 98 are state critical/essential facilities. An additional 408 non-state critical/essential facilities are located in a wildfire hazard zone in Region 1.

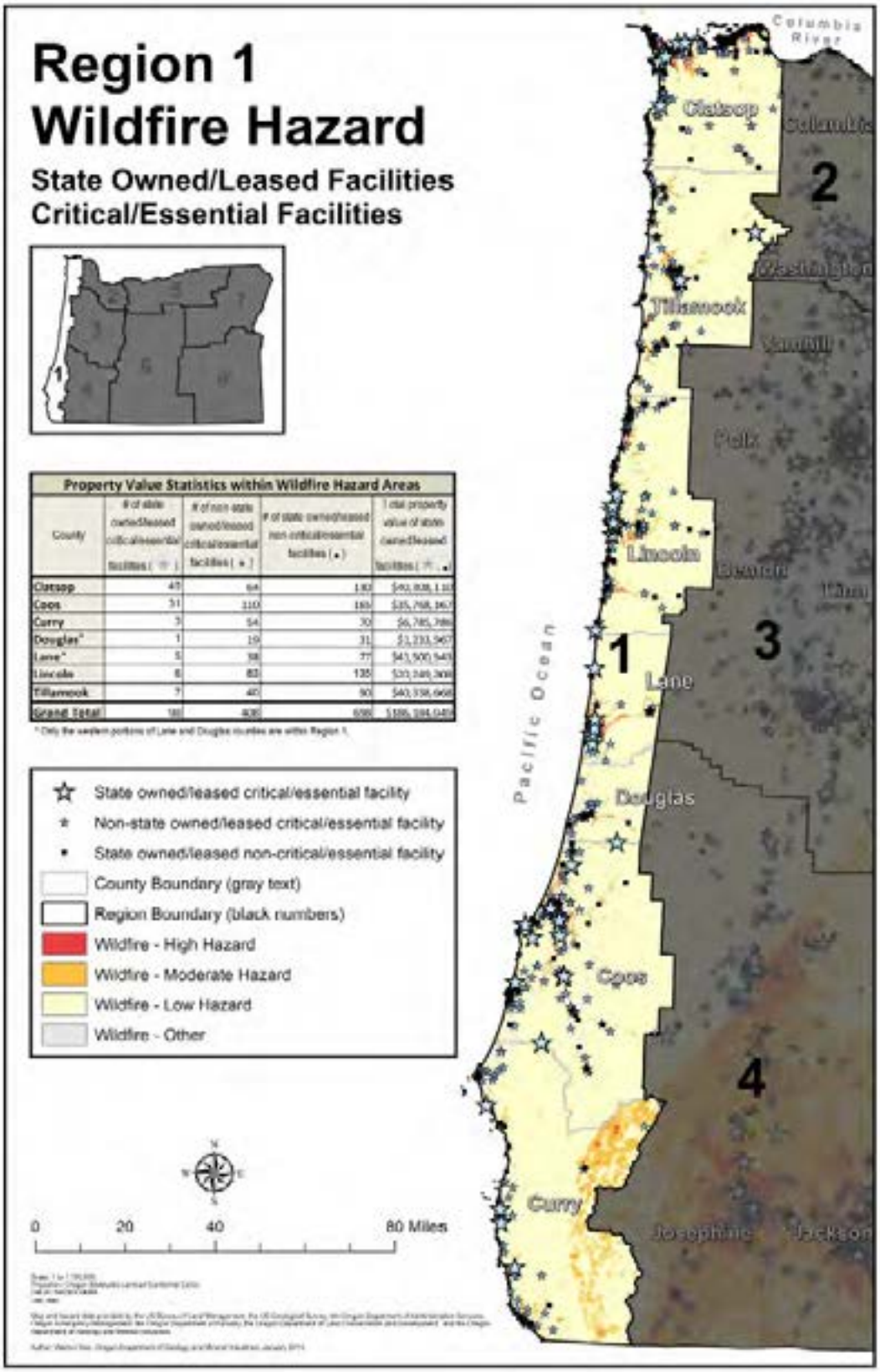


Figure 2-R1-WF-1: State Owned/ Leased Facilities and Critical/ Essential Facilities in a Wildfire Zone in Region 1

Source: DOGAMI

Windstorm

Characteristics

High winds can be expected throughout Region 1, due to their coastal location. Destructive wind storms are less frequent, and their pattern is fairly well known. They form over the North Pacific during the cool months (October through March), move along the coast and swing inland in a northeasterly direction. Wind speeds vary with the storms. Gusts exceeding 100 miles per hour have been recorded at several coastal locations (Table 2-R1-WI-1), but lessen as the storm moves inland. These storms can be very destructive as documented in the Columbus Day Storm of October, 1962. Less destructive storms usually topple trees, power lines, and cause building damage. Flooding can be an additional problem. A large percentage of Oregon's annual precipitation comes from these events.[57]

Tornadoes

Most people do not associate tornadoes with the State of Oregon, and certainly not in coastal areas. Nevertheless, they have occurred in Region 1, the first of which was recorded in 1897. They are characteristically brief and small, but also damaging.

Historic Windstorm Events

Table 2-R1-WI-1: Historic Windstorms

Date	Location	Description	Remarks
01/1880	Western Oregon	Very high winds. 65-80 mph near Portland	Flying debris; fallen trees
01/1921	Oregon coast / Lower Columbia	Winds 113 mph at mouth of Columbia. Gusts at Astoria, 130 mph	Widespread damage
04/1931	Western Oregon	Unofficial reports of wind speeds up to 78 mph	Widespread damage
11/1951	Most of Oregon	Winds 40-60 mph with 75-80 mph gusts	Widespread damage, especially to transmission lines
12/1951	Most of Oregon	Winds, 60-100 mph, strongest along coast	Many damaged buildings. Telephone / power lines down
12/1955	Western Oregon	Wind gusts at North Bend 90 mph	Significant damage to buildings and farms
01/1956	Western Oregon	Heavy rains, high winds, mud slides	Estimated damage: $95,000 (1956 dollars)
11/1958	Most of Oregon	Wind gusts to 75 mph at Astoria. Gusts to 131 mph at Hebo	Damage to buildings and utility lines
11/1962	Statewide	Wind speeds of 131 mph on the Oregon coast (Columbus Day Windstorm Event)	Oregon's most destructive storm. 23 fatalities. Damage at $170 million
03/1963	Coast and N.W. Oregon	100 mph gusts (unofficial)	Widespread damage
10/1967	Western and N. Oregon	Winds on Oregon Coast 100-115 mph	Significant damage to buildings, agriculture, and timber

[57] Taylor and Hatton, 1999, *The Oregon Weather Book*, p. 139; and FEMA-1405-DR-OR, YEAR, Reducing Windstorm Damage to Property and Electrical Utilities.

Date	Location	Description	Remarks
03/1971	Most of Oregon	Notable damage in Newport	Falling trees took out power lines. Building damage
01/1986	N and Cent. Oregon Coast	75 mph winds	Damaged trees, buildings, power lines
01/1987	Oregon Coast	Wind gusts to 96 mph at Cape Blanco	Significant erosion (highways and beaches). Several injuries
12/1987	Oregon Coast / N.W. Oregon	Winds on coast 60 mph	Saturated ground enabled winds to uproot trees
03/1988	N. and Central Coast	Wind gusts 55-75 mph	One fatality near Ecola State Park. Uprooted trees
01/1990	All of Oregon	100 mph winds in Netarts and Oceanside	One fatality. Damaged buildings. Falling trees (FEMA-853-DR-OR)
02/1990	Oregon Coast	Wind gusts of 53 mph at Netarts	Damage to docks, piers, boats
01/1991	Most of Oregon	Winds of 63 mph at Netarts. 57 at Seaside	75 foot trawler sank NW of Astoria
11/1991	Oregon Coast	Slow-moving storm. 25- foot waves off shore	Buildings, boats, damaged. Transmission lines down.
01/1992	Southwest Oregon	Wind gusts of 110 mph at Brookings	Widespread damage
01/1993	Oregon coast / N. Oregon	Tillamook wind gusts at 98 mph	Widespread damage, esp. Nehalem Valley
12/1995	Statewide	Wind gusts over 100 mph. Sea Lion Caves: 119 mph. Followed path of Columbus Day Storm (12/1962)	Four fatalities; many injuries. Widespread damage (FEMA-1107-DR-OR)
11/1997	Western Oregon	Winds of 89 mph at Florence. 80 mph at Netarts and Newport	Severe beach erosion. Trees toppled
2/2002	SW Oregon	75-100 mph on the SW Coast (Douglas, Coos and Curry counties)	Widespread loss of electricity and damage to public utility infrastructure (FEMA-1405-DR-OR)
4/2004	Lane County, OR		$5,000 in property damage *figure includes damages outside of Lane County
12/2004	Lane County, OR		$6,250 in property damage *figure includes damages outside of Lane County
12/2004	Lincoln County, OR		$6,250 in property damage *figure includes damages outside of Lincoln County
12/2004	Tillamook County, OR		$6,250 in property damage *figure includes damages outside of Tillamook County
12/2004	Clatsop County, OR		$6,250 in property damage *figure includes damages outside of Clatsop County
1/2006	Clatsop, Tillamook, Lincoln, Lane Counties, OR	Two storm events with high winds of 86 mph and 103 mph.	$244,444 and $144,444 in estimated property damage among all four coastal counties. The storm also impacted 5 other counties outside Region 1. Total damages equal $300,000 and $200,000 respectively.

Date	Location	Description	Remarks
2/2006	Clatsop, Tillamook, Lincoln, Lane Counties, OR	Wind storm event with winds measured at 77 mph	$150,000 and $91,600 in estimated property damage among all four coastal counties. The storm also impacted nine other counties outside of Region 1. Total damages equal $300,000 and $275,000
3/2006	Clatsop, Tillamook, Lincoln, Lane Counties, OR	Two wind storm events with winds measured at 60 mph and 75 mph	$75,000 and $211,000 in estimated property damage among all four coastal counties. The storms also impacted ten other counties outside of Region 1. Total damages equal $75,000 and $475,000
11/2006	Coos, Curry, Douglas Counties, OR	Storm with winds measured at 70 mph.	Total of $10,000 in damages.
12/2006	Coos, Curry, Douglas Counties, OR	Storm with winds measured at 90 mph.	Total of $225,000 in estimated damages for Coos, Curry, and Douglas Counties. The storm also impacted Josephine County, leading to a total storm damage of $300,000.
12/2006	Clatsop, Tillamook Counties, OR	Storm with high winds	Total of $10,000 in damages.
11/2007	Clatsop, Tillamook Counties, OR	Storm with high winds	Total of $10,000 in damages.
12/2007	Clatsop, Tillamook Counties, OR	Series of powerful Pacific storms	Resulted in Presidential Disaster Declaration. $180 million in damage in the State, power outages for several days, and 5 deaths were attributed to the storm.
12/2008	Clatsop, Lane, Tillamook, Lincoln Counties, OR	Intense wind and rain events	Resulted in nearly $8 million in estimated property and crop damages for Clatsop, Lane, Tillamook, and Lincoln Counties.

Sources:

Taylor and Hatton, 1999, *The Oregon Weather Book*, p.151-157.

Hazards & Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org

Table 2-R1-WI-2: Tornadoes Recorded

Date	Location	Remarks
June, 1897	Bay City, OR	Observed, but no damage recorded
October, 1934	Clatskanie, OR	Observed. No damage
April, 1960	Coquille, OR	Accompanied by heavy rain. No damage
November, 1965	Rainier, OR	Crossed Columbia River. Two buildings damaged
October, 1966	Seaside, OR	Windows broken, telephone lines down, outdoor signs destroyed
October, 1967	Near Astoria, OR airport	Began over ocean and moved inland. Several homes and commercial buildings damaged
December, 1973	Newport, OR	Some roof damage
December, 1975	Tillamook, OR	90 mph wind speed. Damage to several buildings
August, 1978	Scappoose, OR	Manufactured home destroyed; Other damage
March, 1983	Brookings, OR	Minor damage
November, 1984	Waldport, OR	Damage to automobiles and roofs
February, 1994	Near Warrenton, OR	Damage in local park
November, 2002	Curry County, OR	$500,000.00 in property damage
November, 2009	Lincoln County, OR	$35,000 in property damage, damage to homes and automobiles

Sources:

National Weather Service, Portland. Taylor and Hatton, 1999, The Oregon Weather Book, pp. 130-137, National Climatic Data Center (2013) Storm Events Database http://www.ncdc.noaa.gov/stormevents/;

Hazards & Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available frm http://www.sheldus.org , National Climatic Data Center (2013). US Tornado Climatology. http://www.ncdc.noaa.gov/oa/climate/severeweather/tornadoes.html

Probability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the probability (High, Moderate, Low) that Region 1 will experience windstorms is depicted in Table 2-R1-WI-3 below. (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx)

Table 2-R1-WI-3: Local Probability Assessment of Windstorm

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	H	H	H	H	H	H	H

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

High winds occur yearly in Region 1. The 100-year event is considered to be a storm with 1 minute average winds of 90mph. A 50-year event has average winds of 80mph and a 25-year event has winds of 75 mph.

Vulnerability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the region's vulnerability (High, Moderate, Low) to windstorm is depicted in Table 2-R1-WI-4 below. (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx)

Table 2-R1-WI-4: Local Vulnerability Assessment of Windstorm

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	H	H	H	M	H	H	H

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

Many buildings, utilities, and transportation systems within Region 1 are vulnerable to wind damage. This is especially true in open areas, such as along the Oregon Coast, natural grasslands, or farmland. It also is true in forested areas, along tree-lined roads and electrical transmission lines, and on residential parcels --- where trees have been planted or left for aesthetic purposes. Clatsop, Coos, Curry, Douglas, Lane, Lincoln, and Tillamook are all coastal counties and most vulnerable to windstorm damage.

Oregon's history of wind damage underscores the need for a comprehensive wind-hazard mitigation program. The necessity of such an action is partly supported in an after-action report focusing on western Oregon's high wind event of February 7, 2002 (Hazard Mitigation Survey Team Report, FEMA-1405-DR-OR). Other historic events (e.g., 1962 Columbus Day Storm) provide additional insights.

Structures most vulnerable to high winds in Region 1 include insufficiently-anchored manufactured homes and older buildings in need of roof repair. Section 307 of the Oregon Building Code identifies high wind areas along the Oregon Coast and sets anchoring standards for manufactured homes located in those areas. It is essential that coastal counties ensure that the standards are enforced. The Oregon Department of Administrative Service's inventory of state-owned and operated buildings includes an assessment of roof conditions as well as the overall condition of the structure.

Fallen trees are especially troublesome. They can block roads and rails for long periods, which can affect emergency operations. In addition, uprooted or shattered trees can down power and/or utility lines, effectively bringing local economic activity and other essential activities to a standstill. Much of the problem may be attributed to a shallow or weakened root system in saturated ground. Many roofs have been destroyed by uprooted ancient trees growing next to a house. In some situations, strategic pruning may be the answer. Prudent counties will work with utility companies in identifying problem areas and establishing a tree maintenance / removal program.

Tree-lined coastal roads and highways present a special problem. This is because much of the traveling public enjoys the beauty of forested corridors and most certainly would be concerned with any sort of tree removal program. In short, any "safety" program involving tree removal must be convincing, minimal, and involve a variety of stakeholders.

Wind-driven waves are common along the Oregon coast and are responsible for road and highway wash-outs and the erosion of beaches and headlands. These problems are addressed in the Flood section of this regional analysis (pg. X). Unlike Oregon's Willamette Valley (Regions 2 and 3), there are no water-borne ferry systems in Region 1 whose operations would be affected by high winds. Bridges spanning bays or the lower Columbia River would be closed during high wind periods.

Winter Storm

Characteristics

Severe winter weather in Region 1 is characterized by extreme cold, snow, ice, and sleet. Snow and ice are less common in the coastal regions, but often bring flooding after snow melts. Flooding is where the problem begins. See the Flood section in this regional analysis for more about flooding along the Oregon Coast (pg. X).

Historic Winter Storm Events

Table 2-R1:WS-1: Historic Winter Storms

Date	Location	Description
Jan. 1998	Clatsop County, OR	Trees and large tree limbs were knocked down causing widespread power outages. Citizens urged to stay home. Three known fatalities..
Jan. 2002	Statewide	Strong winter storm with high winds at coast and heavy snows to the inland areas of Northwest Oregon. Florence had 46 mph sustained winds and 36 mph gusts to 63 mph, Newport Jetty 39 mph with gusts to 53 mph, and Garibaldi 42 mph. 32 inches of snow at Timberline Lodge on Mt Hood and30 inches at Santiam Pass.
Jan. 2004	Statewide	Frigid arctic air mass, heavy snow, sleet and freezing rain. Weight from the snow and ice buildup resulted in widespread downed trees and power lines, leaving 46,000 customers without power, and collapsed roofs. Oregon Governor Kulongoski estimated cost of damages to public property at $16 million.
Dec. 2008	Northern Oregon Coast	Third unusually cold storm system that season with heavy snow in northwest Oregon. Heavy snowfall across northwest Oregon. 11 -24 inches of snow in the north Oregon Coast Range.

Source: National Weather Service

Probability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the probability (High, Moderate, Low) that Region 1 will experience winter storms is depicted in Table WS-V-1 below. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration, noted with a dash (-). (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx)

Table WS-V-1: Local Probability Assessment of Winter Storm

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Probability	H	H	-	H	L	-	H

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

Based on historical data, severe winter storms could occur about every four years in this region. We can expect to have continued annual storm events in this region however there is no statistical data available other than the historical events that have occurred upon which to base these judgments. There is no statewide program to study the past, present and potential future impacts of winter storms in the state of Oregon at this time.

Vulnerability

Local Assessment

Based on the OEM Hazard Analysis conducted by county emergency program managers, the region's vulnerability (High, Moderate, Low) to winter storms is depicted in Table WS-V-2 below. In some cases, counties either did not rank a particular hazard or did not find it to be a significant consideration. These cases are noted with a dash (-) in the table below. (See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology, pg. xx-xx)

Table WS-V-2: Local Vulnerability Assessment of Winter Storms

	Clatsop	Coos	Curry	Douglas	Lane	Lincoln	Tillamook
Vulnerability	H	H	-	M	L	-	H

Source: Oregon Emergency Management, November 2013, County Hazard Analysis Scores.

State Assessment

Severe winter weather in Region 1 is characterized by extreme cold, snow, ice, and sleet. These conditions bring widespread power outages and road closures due to down trees from the heavy ice. These events close roads and isolate communities. Due to the logistics of the coastal regions many of the communities may become isolated due to winter storms. Countywide road closures can cause considerable travel delays. Communities in Region 1 that may be impacted by severe winter storms include Astoria, Cannon Beach, Rockaway Beach, Oceanside, Lincoln City, Depot Bay and Newport.

Chapter 2
MITIGATION STRATEGY

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In This Chapter

The Oregon NHMP Mitigation Strategy is divided into 5 sections: 1) Introduction, 2) Goals, 3) Mitigation Actions, 4) Capability Assessment, and 5) Coordinating State and Local Mitigation Planning. Following is a description of each section.

1. **Introduction:** *States the purpose of the mitigation strategy.*
2. **Mission, Vision, and Goals:** *Presents Oregon's natural hazard mitigation mission and vision, and describes the goals that guide the selection of mitigation actions.*
3. **Mitigation Actions:** *Includes the following components:*
   - Mitigation Actions: *Describes the process for identifying, evaluating, and prioritizing cost-effective, environmentally sound, and technically feasible mitigation actions and activities the state is considering implementing over the next five years (Priority); that the state does implement (Ongoing) as part of its agencies' regular work programs; and that the state has implemented or will not be implementing (Removed). Also describes the organization of the mitigation actions in tables throughout the process and points to their location in Appendix XX.*
   - Mitigation Successes: *Describes successful mitigation actions throughout Oregon from 2012 through 2014. Previous mitigation successes are archived in Appendix XX.*
   - Funding Sources: *Identifies current and potential federal, state, local, and private sources of funding for mitigation actions.*
4. **Capability Assessment:** *Assesses the state's capability to carry out the mitigation strategy through its pre- and post-disaster hazard management policies, programs, and funding capabilities as well as policies related to development in hazard-prone areas. Discusses changes in these capabilities since approval of the 2012 Oregon NHMP. Generally describes and analyzes in table format the effectiveness of local mitigation policies, programs, and capabilities. Also in table format, indicates status of local jurisdictions' hazard mitigation plans and participation in the National Flood Insurance and CRS Programs.*
5. **Coordinating State and Local Mitigation Planning:** *Describes the state's support of local mitigation planning through funding and technical assistance, as well as the way the state prioritizes funding for local mitigation planning and projects. Describes the processes the state uses to review local NHMPs, and to coordinate and link local NHMPs to the Oregon NHMP.*

Introduction

Purpose

The purpose of this section is to establish Oregon's mission and vision for mitigation planning, and to present the State's strategy for achieving that vision. The mission, vision, and goals are purposefully aspirational, providing the foundation for the state's overall mitigation strategy. The culture of our state is influenced by its rich natural resources and pioneering spirit. Oregon has often taken a leading role in the development of innovative and progressive strategies to address issues that impact our residents, our economy and our natural and built environment. The Oregon Beach Bill (1967), the Oregon Bottle Bill (1971) and the Oregon Land Use Program (1973) are but three historical examples of Oregon's visionary spirit.

As it relates to natural hazard mitigation, Oregon is no less visionary. The state adopted its first natural hazard mitigation plan in 1992 with subsequent updates occurring in 2000, 2004, 2006, 2009, and 2012. In addition, Oregon's Clackamas County adopted the nation's first FEMA approved Natural Hazard Mitigation Plan under DMA2000 in 2002. Hazard mitigation planning as a foundation for plan implementation through hazard risk reduction project activities is a top priority in Oregon when using available state funding, post-disaster FEMA mitigation grants and non-disaster FEMA grant funding.

Given the current economic climate, it is important to acknowledge that state resources are limited. Oregon is not unique in that regard. Even so, Oregon is committed to remaining at the forefront of mitigation planning and will continue to innovate and leverage limited resources to reduce losses resulting from natural hazards in our state. The mitigation strategy presented herein reflects that commitment.

Mission, Vision, and Goals

Requirement 44 CFR §201.4(c), *To be effective the plan must include the following elements:*

(3) A Mitigation Strategy that provides the State's blueprint for reducing the losses identified in the risk assessment. This section shall include:

(i) A description of State goals to guide the selection of activities to mitigate and reduce potential losses.

MISSION Create a disaster-resilient state of Oregon.

VISION Natural hazard events result in no loss of life, minimal property damage, and limited long-term impacts to the economy.

GOALS

1. Protect life and reduce injuries resulting from natural hazards.
2. Minimize public and private property damages and the disruption of essential infrastructure and services from natural hazards.
3. Increase the resilience of local, regional, and statewide economies.
4. Minimize the impact of natural hazards while protecting, restoring, and sustaining environmental processes.
5. Enhance and maintain state capability to implement a comprehensive statewide hazard loss reduction strategy.
6. Document and evaluate Oregon's progress in achieving hazard mitigation.
7. Motivate the public, private sector, and government agencies to mitigate against the effects of natural hazards through information and education.
8. Eliminate development within mapped hazardous areas where the risks to people and property cannot be mitigated.
9. Minimize damage to historic and cultural resources.
10. Increase communication, collaboration, and coordination among agencies at all levels of government and the private sector to mitigate natural hazards.
11. Integrate local NHMPs with comprehensive plans and implementing measures.

Goals: Linking the Risk Assessment and Mitigation Actions

Natural hazard mitigation plan goals link the risk assessment and mitigation actions, guiding the direction of future natural hazard risk reduction and loss prevention activities.

The risk assessment speaks directly to protection of life and property, infrastructure and services, and local, regional, and state economic resilience, the topics of Goals 1, 2, and 3. The vulnerability assessments for each hazard and the potential loss estimates highlight the importance of informing and educating citizens about the risks and what they can do to reduce potential losses, including eliminating development where risks cannot be mitigated, the topics of Goals 7 and 8. Environmental stewardship, the topic of Goal 4, plays a role in mitigating some hazards, and must be considered in designing mitigation projects. These are clear connections between the information in the risk assessment and the existing goals.

Goals 5 and 6 are more administrative in nature. Goal 5 focuses on the state's ability to implement the Plan, the subject of the *Capability Assessment* element of the *Mitigation Strategy*. Goal 6 focuses on documenting and evaluating progress in achieving mitigation, elements of the *Mitigation Strategy* and the *Planning Process*.

A review of county-level natural hazard mitigation goals brought to light some topics addressed local NHMP goals but not by Oregon's. At its April 2014 meeting, the IHMT reviewed the eight 2012 Oregon NHMP goal statements (Goals 1-8) and the local NHMP goal topics not reflected in the state's goals. The IHMT revised existing Goal 4 to reflect the state's focus not only on protecting and restoring the environment, but also on sustaining environmental processes. To better align the state and local NHMPs, the IHMT adopted three new goals (Goals 9-11) that address cultural and historic resource protection; better collaboration and coordination between all levels of government and the private sector; and integration of NHMPs with local comprehensive plans.

The information in the risk assessment also supports these statements:

A. Much more data is available for some hazards than others, resulting in a more robust risk analysis for the more data-rich hazards.

B. There is a clear need to develop a statewide standardized risk assessment methodology across all hazards.

C. Similarities and differences between state and local level vulnerability assessments have not been analyzed. Some state and local vulnerability assessments are quite consistent, while others are starkly inconsistent. Communication and education among state and local staff responsible for assessing vulnerability would improve understanding and consistency.

D. Several hazards are related to one another through cause and effect (e.g., earthquakes and tsunamis, floods and landslides, drought and wildfires) or through shared drivers (e.g., El Nino Southern Oscillation (ENSO)), indicating opportunity for increasing interagency collaboration and efficiencies in research and mitigation activities.

E. Some state-owned or –leased buildings or critical/essential facilities and their contents cannot be accurately identified using available state data. Property values are not available for critical and essential facilities that are not state-owned or –leased. Local knowledge could be helpful in improving the state data by more accurately identifying buildings and their contents and determining which buildings and critical/essential facilities should be prioritized for mitigation. The state data could be useful at the local level as well. This opportunity for state and local collaboration could improve risk assessments and loss estimates at both levels.

These statements address issues covered by a Goals 1, 2, 3, 7, 8. In particular, they raise an important question concerning Goal 5, the state's capability to implement a comprehensive

statewide hazard loss reduction strategy. The State currently recognizes eleven hazards, obligating it to address each one, and strives to do so as fully and equitably as possible. Due to staffing, funding, data availability, access to expertise, or other reasons, some hazards cannot be addressed to the same extent as others. Prioritizing hazards would allow resources to be strategically targeted. At the same meeting, the IHMT decided to consider prioritizing hazards for the next Plan update.

These statements also suggest a few new mitigation actions:

1. Analyze the similarities and differences between state and local vulnerability assessments.
2. Schedule three opportunities for state/local dialogue on local vulnerability assessments in the next year to improve consistency and mutual understanding.
3. Collaborate with local governments to improve the accuracy of potential loss totals by more accurately identifying critical/essential facilities, and determining their property values.
4. Improve state agency procedures for tracking data on state-owned and -leased buildings and critical/essential facilities.
5. Develop an improved methodology for gathering data and identifying the communities most vulnerable to drought.
6. Establish a program for studying winter storms and their impacts statewide. Install snowfall sensors throughout the state to develop annual snowfall data.

The IHMT decided further to include these mitigation actions with a few revisions as follow in the 2015 Plan:

1. Analyze the similarities and differences between state and local vulnerability assessments. (Same)
2. Schedule three opportunities *over the life of this plan* for state/local dialogue on vulnerability assessments to improve consistency and mutual understanding. *(Revised)*
3. Collaborate with local governments *to develop a database of non-state-owned critical/essential facilities and their property values. (Revised)*
4. Improve state agency procedures for tracking data on state-owned and -leased buildings and critical/essential facilities. (Same)
5. Develop an improved methodology for gathering data and identifying the communities most vulnerable to drought *and related impacts*. *(Revised)*
6. Establish a program for studying winter storms and their impacts statewide. *As a part of that program, develop a system for gathering snowfall data statewide. (Revised)*

The mitigation action tables (Priority, Ongoing, and Removed) demonstrate the link between the goals and mitigation actions by noting the goal(s) that each mitigation action addresses.

Mitigation Actions

Requirement 44 CFR §201.4(c), *To be effective the plan must include the following elements:*

(3) A Mitigation Strategy that provides the State's blueprint for reducing the losses identified in the risk assessment. This section shall include:

(iii) An identification, evaluation, and prioritization of cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering and an explanation of how each activity contributes to the overall mitigation strategy. This section should be linked to local plans, where specific local actions and projects are identified.

(iv) Identification of current and potential sources of Federal, State, local, or private funding to implement mitigation activities.

Mitigation actions are detailed recommendations for activities that the state is considering implementing to reduce risk and prevent loss from natural hazards.

The 2015 Oregon NHMP mitigation actions were developed through a process that began with reviewing the 2012 Plan mitigation actions to establish their implementation status (not started, progressing, completed, not being pursued) and evaluate them against several criteria:

1. Statutory (cost-effective, technically feasible, environmentally sound);
2. SMART (specific, measurable, achievable, realistic, time-oriented); and
3. Whether they were integrated with related state initiatives (e.g., Oregon Resilience Plan, Oregon Climate Change Adaptation Framework, Oregon Plan for Salmon and Watersheds, etc.).

As a result of this evaluation process, the mitigation actions were placed into one of three categories: priority, ongoing, or removed. Priority actions are those the state aspires to begin or complete; ongoing actions are those the state is doing in the normal course of business; and removed actions are those that have been completed or will not be completed for various reasons. A table has been created for each category.

Also as a result of this evaluation, many actions were broken into their component parts and placed on the appropriate tables. For example, LP-5, *Establish a system of special zones, procedures, restrictions, and conditions to limit development in tsunami inundation zones* was broken into four component parts:

1. *Develop* land use guidance and best practices for local governments for reducing risk within tsunami inundation zones.
2. *Provide* land use guidance and best practices for reducing risk within tsunami inundation zones to local governments.
3. *Assist* local governments in implementing the land use guidance and best practices for reducing risk within tsunami inundation zones.
4. *Monitor* the effectiveness of the land use guidance and best practices for reducing risk within tsunami inundation zones provided to local governments.

The first two parts – develop guidance and provide it to local governments – have been done, and they are entered on the *Removed* table. The last two – assist local governments in using it and monitor its effectiveness – have not, and will continue to be implemented for many years to come. They have been

entered on the *Ongoing* table. While this approach results in more actions, it facilitates tracking, reporting, and highlighting achievements.

The next step was to prioritize the actions on the *Priority* table. This was done in two basic steps. First, each action was scored according to the statutory criteria (cost-effective, technically feasible, and environmentally sound) and STAPLEE (social, technical, administrative, political, legal, economic, and environmental). A score sheet was developed that weighted all the criteria except cost-effectiveness and political support. Not having the time or funding to develop a detailed cost/benefit analysis for each of the actions, the score totals were considered to be an indication of cost-effectiveness – the higher the score the more cost-effective the action.

The political criterion was covered in the second step. State agency managers who would be responsible for implementing the actions were asked to provide their level of support for their actions. A rating of *1* indicated that the action was likely to be funded and undertaken during the life of the 2015 Plan. A rating of *3* indicated that the action was unlikely to be funded or undertaken during the life of the 2015 Plan. A rating of *2* indicated a lack of certainty about the likelihood of funding or achievement.

Each priority action was then ranked according to its political rating first and then its score.

Mitigation Action Tables: Priority, Ongoing, Removed

The 2015 Oregon NHMP mitigation actions are arranged in a series of three tables. On each table, mitigation actions are numbered and presented as a brief statement with a longer description that explains its contribution to the overall mitigation strategy of the 2015 Plan. The goal(s) and hazards each action addresses are identified. On the *Priority* and *Ongoing* tables, any other state initiative(s) with which an action is integrated is identified. Current or potential funding sources are also identified. On the *Removed* table, funding sources for actions that have been completed are identified. The Priority table includes the individual action item scores, ratings, and final ranking.

A crosswalk has been developed to aid in determining how 2012 Plan mitigation actions are represented in the 2015 plan.

Due to their length, the 2015 Mitigation Action Priority, Ongoing, and Removed Tables and crosswalk are presented in Appendix XXX. Also presented in Appendix XXX are the Initial Evaluation, Prioritization, and Level of Support tables illustrating key points in the development of the final 2015 Plan Mitigation Action Tables.

Funding Sources for Mitigation Actions

Oregon's mitigation activities are funded directly and most visibly through sources such as FEMA's Pre-Disaster Mitigation Grant, Flood Mitigation Assistance, Public Assistance, and Hazard Mitigation Grant Programs, with state general funds usually providing the state's cost share. The State's Seismic Rehabilitation Grant Program is a direct funding source for earthquake mitigation projects. The Oregon Disaster Assistance Loan and Grant account provides post-disaster mitigation funds to local governments and school districts. More indirect and less visible funding sources include state general funds and other sources that fund state agency activities. More detailed information about mitigation funding sources is in the State Capability Assessment (pages XX-XX).

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Disaster Mitigation Working in Oregon

Mitigation Brings Enhanced Safety and Reduced Losses

Oregon individuals, businesses and government agencies work together to promote safety and to invest in hazard mitigation actions that save lives and reduce or eliminate damage. As a result, a severe winter storm may become an emergency, but not necessarily a disaster.

Oregon — A severe winter storm may bring extreme cold, wind, snow, ice, falling trees, or all of these and more. The result, at the very least, is major inconvenience. Emergency managers and others work throughout the year to limit the impacts of these storms.

During the hazardous event, transportation woes can be kept to a minimum when public warning systems and years of outreach education convince most people to stay off the roads. Schools may be closed and other activities canceled or postponed. With reduced traffic, emergency services crews are better able to respond quickly and efficiently.

There may or may not be electrical power outages associated with a storm. Electric utility officials work throughout the year to improve the reliability of their power distribution systems. They make ongoing investments in tree pruning, pole replacement and maintenance of equipment, as well as investing in strong, flexible and more durable insulators and other components. The experts must analyze and prioritize the investments to address the most trouble-prone sections of the distribution systems. In some instances these may be rerouted to safer areas or placed underground in buried conduit and waterproof vaults.

Additionally, electric utilities undertake projects that provide redundant power sources to critical facilities such as emergency services buildings, medical centers, communications towers, sewage treatment plants, water systems and so on. The investments often include automated power transfer switches, sensors, monitors and other sophisticated equipment.

The wide variety of mitigation investments that promote safety and prevent damage are funded, in part, through state and federal grant programs. Others are paid for by local governments, utilities, businesses and individuals.

The work and expense pay big dividends when a storm arrives and departs without generating a disaster. No news can really be very good news!

Hazard mitigation is about taking action before the next disaster to reduce human and financial consequences later.

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Disaster Mitigation Working in Oregon

Mitigation Investments Bring Safety and Reliable Power

Effective mitigation can break the cycle of disaster damage, reconstruction and repeated damage. It lessens the financial impact on individuals, communities and society as a whole.

A recent study by the Multi-hazard Mitigation Council shows that each dollar spent on mitigation saves society an average of four dollars.

Wind, snow, and ice cause damage to power systems

Benton County, Oregon— Electrical power outages are a familiar experience when winter storms bring high wind, heavy snow, ice and falling trees. All of these can cause severe damage to transmission lines, poles and transformers.

Consumers Power Inc. (CPI) is a consumer-owned electric power cooperative that serves parts of Benton and five other Oregon counties. Director of Operations & Engineering Greg Pierce said he knows that prevention of storm damage and resulting service disruption requires continuous maintenance and investment in upgrades to the utility's electrical distribution system.

Pruning and removing "hazard trees" is part of the solution. Permanent system improvements can also be cost effective.

"These can sometimes include adding more poles to reduce spans and reduce stress on poles and arms," said Pierce. "Using new technology such as more flexible and durable insulators and fiberglass cross arms is another way to reduce storm damage."

Relocating the power lines to underground conduit, while expensive, can also sometimes be an excellent alternative. This approach has helped CPI to improve the reliability of power from its Corvallis substation to a major hospital and surrounding campus of 13 other buildings on Medical Hill just north of the city. The mitigation project was developed in partnership with Good Samaritan Hospital, Corvallis Clinic, and the Benton County Emergency Management Council.

As a consumer-owned utility, CPI was eligible to apply for financial assistance from the Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant Program (HMGP) to replace a troublesome section of its

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Good Samaritan Hospital

12,470-volt feeder line that serves the health care complex. The project was approved and completed in 2003. Moving the wires underground has significantly reduced power outages caused by winter storms.

HMGP funding is administered by the Oregon Office of Emergency Management FEMA. FEMA provides 75 percent of the eligible costs of approved projects.

CPI is now in the pre-application process for HMGP funding to begin a similar project to further improve the reliability of electrical service to the hospital campus and surrounding area. A nearby section of the main overhead feeder line passes through a 4,330-foot right-of-way corridor that has no road access. Part of the densely wooded area is very wet and muddy, making it difficult during most of the year to make repairs, replace poles or prune trees. The CPI proposal is to move the transmission lines underground by digging a trench in part of the problem area, and to use horizontal boring equipment to install the line beneath the ground. This type of work requires "best management practices" to minimize disturbance of wildlife and other natural resources.

Approval of grant-funded hazard mitigation projects requires proof of a clear benefit to the community. An obvious fact is that critical medical facilities depend on reliable sources of electricity.

The grant application will include a benefit-versus-cost analysis that includes the history of power outages from this section of line along with associated repair expenses. Approximate costs to utility customers who lose power will also be considered. The proposal must also describe and analyze alternative solutions. An example would be rerouting the power around the entire problem area by using an existing road right of way. Detailed cost estimates of the proposed new work are another critical part of a successful grant application.

The safety of utility workers is another important factor to be considered. Emergency repair work during bad weather is dangerous!

New insulator technology

"The cost of power failures and emergency repairs is just too much for our customers and our utility" said Pierce. "We've found that continuous improvements can bring safety, reliability and savings year after year."

Underground power conduit

Project site visit

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Disaster Mitigation Working in Oregon

Protecting Critical Power and Communications Facilities

Hazard mitigation benefits society by:

- **Creatinig safer communities by reducing loss of life and property;**
- **Enabling individuals to recover more rapidly from floods and other disasters, and;**
- **Lessening the financial impact on the Federal Treasury, States, Tribes and communities.**

EPUD is in the preliminary stages of requesting Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant Program (HMGP) cost-share-funding to replace the 2.3 mile overhead line with an underground power line along existing roads. This is expected to eliminate the outages caused by falling limbs, trees and lightning. It will also reduce fire danger by eliminating risk of dry weather tree contact with energized power lines.

Previous and highly successful Harness Mountain project

Lane County, Oregon — The Emerald People's Utility District (EPUD) provides electrical power to a remote mountaintop communications site on Badger Mountain, west of Veneta, Oregon. Over the years, the 12,000-volt overhead power line has been consistently subjected to prolonged outages during storm seasons while serving AT&T Cellular, Verizon, Nextel, Blachly Lane Electric Cooperative, and the Bonneville Power Administration communication tower. All are critical links to the cellular phone service and power transmission in the Lane County area.

Buried power line vault

The consumer-owned utility district made a similar investment in 2002 that was also partially funded with HMGP funds. A 5.5-mile overhead line to Harness Mountain communications facilities was plagued with repetitive outages. Repair work sometimes took many hours- and even days- to restore because of deep snow, impassible roads and fallen trees. EPUD leaders have stated the project is a huge success.

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Disaster Mitigation Working in Oregon

Electric Power Loss Mitigation: Invest in the Weak Links

Hazard mitigation is about taking action before the next disaster to reduce human and financial consequences later.

Overhead to underground power transmission project

Springfield, Oregon - The Emerald Circuit is a vital part of an electrical power transmission system that connects three Springfield-area substations to hundreds of homes, businesses, a shopping center, schools, a fire station, traffic signals and two water reservoirs.

Sections of the overhead line run through an area with numerous trees, making damage to the system almost inevitable when severe storms bring high wind, wet snow or freezing rain. A mitigation measure for one segment of circuit was implemented in 2002, when a particularly damage-prone 2,700-foot section of the overhead system was removed and replaced with wires installed in underground conduit and waterproof vaults.

The Springfield Utility Board worked closely with the Oregon Office of Emergency Management and the Federal Emergency Management Agency (FEMA) to secure Hazard Mitigation Grant Program (HMGP) funding to enable the $163,642 investment in greater system reliability.

The HMGP funding required that costs, benefits and alternatives were carefully analyzed to ensure the project was cost-effective and appropriate. The area's rugged and steeply sloping landscape meant that the estimated cost of replacing damaged poles and lines for the section was to be $144,000 to $180,000. Access issues added additional expenses and delay when past repairs were needed. Potential threats to public health and safety from a power outage, along with extremely high costs to utility customers, were also significant factors in the calculation of project benefits and losses that could be avoided.

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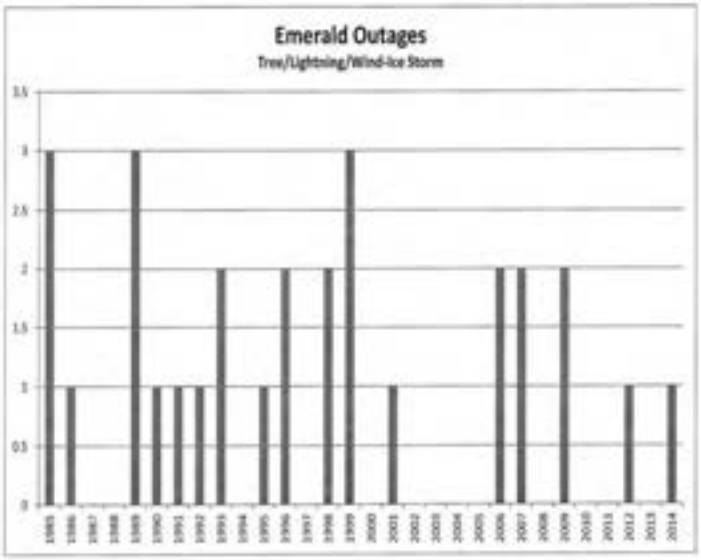
The 12 years since project completion have brought significant reduction of documented damage to the Emerald Circuit *(see chart on right)*. During this period, the Springfield Utility Board made various investments in equipment upgrades as well as two additional "undergrounding" projects.

Severe winter storms still cause occasional power outages along another section of the Emerald line. This residual "weak link" in the system is a vulnerable 1,450-foot stretch of overhead transmission line adjacent to the earlier project and similarly accessible only on foot or with track equipment. A pre-application for HMGP funding to help pay for the undergrounding of this troublesome section is currently under review.



Power transmission easement bordered by 40-to 80-foot trees

The Federal Emergency Management Agency (FEMA), along with its state partners, administers the Hazard Mitigation Grant Program (HMGP) to assist states and local communities in implementing long-term hazard mitigation measures following a major disaster declaration.

Following 2012's Hurricane Sandy, the *Sandy Recovery Improvement Act* helped bring about a more streamlined HMGP process with an emphasis on more timely selection and implementation of projects.

State and local Hazard Mitigation Plans that are up to date and approved are critical to establishing eligibility and priorities in the selection of projects.

Best Practices Federal Emergency Management Agency / Region 10 2014

FEMA

Best practices

Disaster Mitigation Working in Oregon

Vernonia's Whole Community Working for a Resilient Future

Vernonia, Oregon — This remote community of about 2,150 people is celebrating the relocation and replacement of its three school facilities. The success of the enormous project came after years of struggling to recover from the 2007 "flood of record," the worst of 27 flood events that are part of the town's history.

Among the many challenges that followed the flood was the need to replace the heart of their community, the elementary, middle and high schools that served more than 700 students. After an impressive investment of resources, and intense effort by the local communities, Vernonia now has a far brighter outlook. Its beautiful new school buildings are finally relocated out of the flood-plain and in full use.

New school and community center facilities

A history of disaster damage: The city of Vernonia has been plagued with severe, repetitive, highly damaging floods, typically from rain falling on snow in the Nehalem River and Rock Creek watersheds. A major event in 1996 was about three feet higher than the 1972 and 1974 floods. Residents and business owners cleaned up and made major efforts to rebuild stronger and safer, elevating many buildings above the floodplain. But disaster struck again in December of 2007, with an even more catastrophic "flood of record."

This time, infrastructure and property, including electrical substations, health care buildings, the senior center and many other critical facilities, were severely damaged or destroyed. More than 1,000 homes sustained damage and at least 100 were found to be beyond repair.

A final blow came when the wastewater treatment facility was inundated and five feet of sewage-contaminated water poured into the elementary, middle and high school buildings.

Oregonians and the nation provided emergency assistance, including more than 1 million hours of volunteer aid, but the nearly complete loss of Vernonia's school system cast an enormous shadow over the future of the community.

continued on page 2

This publication was produced by FEMA Region 10 Mitigation Division and the Oregon Office of Emergency Management

The "Best Practices" story:
The story of recovery and triumph over this disaster involves intense determination and cooperative effort that began in the local community. The challenges were taken up by virtually all of the local leaders, local and regional business owners and countless volunteers.

Oregon's governor appointed an **Oregon Solutions Task Force** of 36 agencies and organizations, and more than 50 individuals, to identify funding sources for a renewed school system and to develop a plan. **Their charge was to involve the community through a fair, open and participatory process that would earn the support of the whole community.**

After researching a variety of alternatives, the community agreed to build an entirely new K-12 campus and community center. The discussions led to the decision to locate the new facilities on higher ground that was partly occupied by Spencer Park. After demolition of the old school buildings, the plan specified that the park would be re-established at the flood-prone school property.

A daunting challenge was the need to raise an estimated $40 million to accomplish the ambitious goals. The search for financial resources would include potential State of Oregon contributions. One of the many successes was an eventual $3.8 million Oregon Department of Transportation grant.

The largest sources of funding for the school project, and for many other elements of Vernonia's overall disaster recovery, were made possible by the coordination and collaboration of the Oregon Office of Emergency Management and the Federal Emergency Management Agency (FEMA). These agencies were able to provide approximately

2007 "flood of record" — hours before sewage-contaminated water rose two additional feet

$20 million in FEMA Flood Mitigation Assistance and Hazard Mitigation Grant Program funds, along with many additional millions through the Public Assistance infrastructure repair funding, and Individual Assistance programs.

Other federal agencies, including the Department of Energy, also helped make it possible to invest in Leadership in Energy and Environmental Design Platinum-rated "state of the art" buildings. The energy-efficient, durable and sustainable new facilities are now compatible with the ambitious educational program goals of the Vernonia school district.

A major foundation challenge grant was matched by corporate, small business, foundation and individual contributions from all over the state.

In a critical 2009 vote, despite severe blows to the local economy from the flood and a more general recession, voters in Columbia County and Washington County who live within the Vernonia School District voted to approve a $13 million school construction bond measure. In addition, the school district secured a $5.6 million long-term, low-interest loan.

At a recent celebration of the completed school replacement project, donors and supporters who were responsible for achieving the ambitious goals were honored for their dedication. The superintendent of Vernonia schools summarized the spirit and motivation that brought success: **"We came together for a common purpose: Not just to build a school, but to strengthen the community."**

Vernonia is an example of a resilient community, where people work together to anticipate and address future conditions and challenges. Investing in hazard mitigation can break the cycle of disaster damage, reconstruction and repeated damage.

Capability Assessment

Requirement 44 CFR §201.4(c), *To be effective the plan must include the following elements:*

(3) A Mitigation Strategy that provides the State's blueprint for reducing the losses identified in the risk assessment. This section shall include:

(ii) A discussion of the State's pre- and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the area, including: an evaluation of State laws, regulations, policies, and programs related to hazard mitigation as well as to development in hazard-prone areas; a discussion of State funding capabilities for hazard mitigation projects; and a general description and analysis of the effectiveness of local mitigation policies, programs, and capabilities.

State Capability Assessment

Pre-Disaster Hazard Mitigation Policy Framework

Oregon maintains a robust pre-disaster natural hazard mitigation policy framework. The foundation of this framework is rooted in the Oregon statewide land use planning requirements passed in 1972. Goal 7, the natural hazard planning component of a community's comprehensive land use plan, provided an incentive for all of Oregon's flood-prone communities to participate in the National Flood Insurance Program. A number of Oregon communities have chosen to participate in the Community Rating System as well. Oregon updated Goal 7 in 2002, largely driven by the flooding and landslides of the February 1996 major disaster declaration (DR-1099). In its current form, the goal directs communities regulate development in hazard prone areas through local comprehensive plans and implementing ordinances. At minimum, local comprehensive plans in Oregon must address floods (coastal and riverine), landslides, earthquakes and related hazards, tsunamis, coastal erosion, and wildfires where applicable. Thus, all of Oregon's cities and counties are required to plan for Oregon's major natural hazard events and to mitigate impacts through regulatory controls.

Mitigation for the earthquake hazard specifically has also been a top legislative priority for Oregon resulting in the passage into law of four senate bills during the 2005 legislative session. The legislation focused on: 1) Performing a statewide seismic needs assessment for all schools and emergency facilities, 2) Formation of a temporary committee to establish a new state grant program to distribute earthquake rehabilitation grants using state bond funds, and 3) Issuance of state bond funds through the newly established grant program to state and local communities for the rehabilitation (seismic retrofit) of fire stations, police stations, hospitals and high occupancy school buildings. DOGAMI completed the needs assessment in 2007 and OEM hired a Seismic Grants Coordinator to develop and implement the grant program for the state bond funds. Up to $100 million in state-bonded funding could become available to seismically retrofit facilities around the state.

Funding provided by a FEMA Pre-Disaster Mitigation competitive grant for the seismic retrofit of three university facilities (two dormitories at Portland State University and

operations/administration building at the Oregon Institute for Technology) helped lay the foundation for this successful legislative initiative. The PSU seismic retrofit projects showed that the state could successfully leverage funding, program management, technical assistance and university-managed implementation to complete the projects within the grant budget and on schedule.

After adoption of the 2012 Oregon NHMP, the Oregon Department of Transportation completed the *Oregon Seismic Lifeline Routes (OSLR) Identification* project. The OSLR project study recommends a specific list of highways and bridges that comprise the seismic lifeline network; and establishes a three-tiered system of seismic lifelines to help prioritize investment in seismic retrofits on state-owned highways and bridges.

In February 2013, the Oregon Seismic Safety Policy Advisory Commission (OSSPAC) published the Oregon Resilience Plan, highlighting the state's vulnerabilities in the event of a Cascadia earthquake and tsunami and identifying mitigation actions. Following publication, the Oregon legislature demonstrated its continuing strong policy focus on earthquake and tsunami mitigation by appointing a Resilience Task Force to suggest which mitigation actions should be undertaken first. The Task Force's report to the legislature is due October 1, 2014.

Since adoption of the 2012 Oregon NHMP, there have been no revisions in statewide planning policies related to development in hazard prone areas. However, Oregon is actively encouraging local governments to consider natural hazards in their land use planning processes. In January 2014, DLCD issued *Preparing for a Cascadia Subduction Zone Tsunami: A Land Use Guide for Oregon Coastal Communities* which provides information on planning techniques to mitigate loss from a Cascadia earthquake and tsunami event. The North Coast Resilience Project, a cooperative endeavor of DLCD, OPDR, and Oregon Sea Grant is engaging north coast communities in hazard mitigation and resilience planning as well. Further, DLCD is encouraging local governments to integrate NHMPs with comprehensive plans. With assistance from OPDR and DLCD acting in an advisory capacity, the City of Madras undertook a pilot project to update the Goal 7 section of its comprehensive plan and integrate it with its recently updated NHMP. Clatsop County is updating its NHMP and integrating it with its comprehensive plan on its own. With new landslide susceptibility maps issued by DOGAMI at the end of 2013, Clackamas County and most of its cities are positioned to do the same.

Table 4.1 provides an overview of the various policies and federal programs related to specific natural hazards in Oregon.

Table 4.1 Policies and Federal Programs Related to Specific Natural Hazards in Oregon

Hazard	Oregon Statewide Planning Goals & Policies	Federal Programs & National Resources
Multi-Hazard	Local Comprehensive Plans Goal 2: Land Use Planning Goal 7 Natural Hazards Oregon Building Codes	Pre-disaster mitigation planning grants (FEMA) American Planning Association (Resources on landslides, flooding, and post-disaster recovery)
Coastal Hazards	Goal 17: Coastal Shorelands Goal 18: Beaches and Dunes Ocean Shore Regulation Tsunamis – ORS 336.071, ORS 455.446, and ORS 455.448	National Flood Insurance Program (NFIP) NFIP V-Zone Construction Army Corps of Engineers Permit Program
Flood	Goal 5: Natural Resources, Scenic and Historic Areas, and Open Spaces Division of State Lands (DSL) Fill and Removal Permit Program The Oregon Plan for Salmon and Watersheds Oregon's Wetlands Protection Program	National Flood Insurance Program (NFIP) NFIP Community Rating System and Flood Mitigation Assistance Programs Severe Repetitive Loss Repetitive Flood Claims Program FEMA Region X's Policy on Fish Enhancement Structures in the Floodway Army Corps of Engineers Permit Program
Landslide	Goal 17: Coastal Shorelands The Oregon Plan for Salmon and Watersheds 1997 Senate Bill 12: Rapidly Moving Landslides	American Planning Association: Landslide Hazards and Planning
Seismic	2005 Senate Bill 2: Statewide seismic needs assessment for schools and emergency facilities 2005 Senate Bill 3: Seismic earthquake rehabilitation grant program 2005 Senate Bill 4 & 5: State bond authorization 2001 Senate Bill 13: Seismic Event Preparation 2001 Senate Bill 14: Seismic Surveys for School Buildings 2001 Senate Bill 15: Seismic Surveys for Hospital Buildings 1991 Senate Bill 96: Seismic Hazard Investigation Tsunamis – ORS 336.071, ORS 455.446, and ORS 455.448	USGS Earthquake Hazards Program
Fire – WUI	1997 Senate Bill 360: Wildland/ Urban Interface Additional Criteria for Forestland Dwellings – ORS 215.730 Urban Interface Fire Protection – ORS 477.015-061	National Fire Protection Agency Firewise Program

Source: OPDR

State Pre-Disaster Hazard Management Policies

Multi-Hazard

STATEWIDE LAND USE PLANNING GOALS RELATED TO NATURAL HAZARDS

Goal 2: Land Use Planning

Statewide Land Use Planning Goal 2 establishes a land use planning process and policy framework as a basis for decisions and actions related to use of land. It also assures that an adequate factual base exists for such decisions and actions.

In Oregon, every city and county has a comprehensive plan that includes inventories and implementation measures (e.g., laws and ordinances) to guide community land use decisions. Comprehensive plans are required to address local concerns and issues raised by each of the state's nineteen land use planning goals.

Goal 5: Natural Resources, Scenic and Historic Areas, and Open Spaces

Statewide Land Use Planning Goal 5 requires local governments to adopt programs that will protect natural resources and conserve scenic, historic, and open space resources for present and future generations. Conservation of resources promotes a healthy environment and natural landscape that contributes to Oregon's livability.

Goal 7: Areas Subject to Natural Hazards

Statewide Land Use Planning Goal 7 aims to protect people and property from natural hazards. Local governments are required to adopt comprehensive plans (inventories, policies and implementing measures) to reduce risk to people and property from natural hazards. Natural hazards for the purpose of this goal are: floods (coastal and riverine), landslides[1], earthquakes and related hazards, tsunamis, coastal erosion, and wildfires. Local governments may also identify and plan for other natural hazards.

OREGON BUILDING CODES

COASTAL AND FLOOD HAZARDS. The 2010 Oregon Structural Specialty Code and the 2011 Oregon Residential Specialty Code contain requirements for all new construction of buildings, structures, and portions of buildings and structures within flood hazard areas, including substantial improvement and restoration of substantial damage to buildings and structures. For example, the lowest floors of buildings and structures must be elevated at least one foot above the design flood elevation. Flood hazard areas are determined by flood hazard maps that include, at minimum, areas of special flood hazard as identified by the Federal Emergency Management Agency.

Coastal areas that are subject to wave heights in excess of three feet or subject to high-velocity wave action or wave-induced erosion are designated as high-hazard areas. Buildings and structures constructed in whole or in part in coastal high-hazard areas must be designated and constructed in accordance with building code requirements.

[1] For "rapidly moving landslides," the requirements of ORS 195.250-195.275 (1999 edition) apply.

SEISMIC HAZARDS. The 2011 Oregon Residential Specialty Code addresses seismic concerns by breaking the state up into the following zones. The code contains specific regulations for development within each zone.

Unlike the Oregon Residential Specialty Code which assigns seismic categories, the Structural Specialty Code relies on a "seismic design load." The seismic design load is determined in accordance with an engineering calculation factoring:

- Peak ground acceleration of the site;
- Use of the building; and
- Soil conditions.

LANDSLIDE HAZARDS. The 2010 Oregon Structural Specialty Code and the 2011 Oregon Residential Specialty Code contain provisions for lot grading and site preparation for the construction of building foundations. Both codes contain requirements for cut, fill and sloping of the lot in relationship to the location of the foundation. There are also building setback requirements from the top and bottom of slopes. The codes specify foundation design requirements to accommodate the type of soils, the soil bearing pressure, and compaction and lateral loads from soil and groundwater on sloped lots.

WILDFIRE HAZARDS. The 2011 Oregon Residential Specialty Code provides minimum standards for dwellings and their accessory structures located in or adjacent to vegetated areas subject to wildfires, to reduce or eliminate hazards presented by such wildfires. Wildfire zones are determined using criteria established by the Oregon Department of Forestry.

WINDSTORM HAZARDS. The 2011 Oregon Residential Specialty Code and the 2010 Oregon Structural Specialty Code provide design criteria for buildings and construction within 'exposure classification' areas of the state. Within Oregon, there are three exposure categories. All areas with full exposure to ocean winds, for example, must be designed to accommodate 110 mph winds. Design criteria include requirements related to protection of openings, and building height and wind load.

Coastal Hazards

STATEWIDE LAND USE PLANNING GOALS RELATED TO NATURAL HAZARDS

Goal 15: Willamette River Greenway

To protect, conserve, enhance and maintain the natural, scenic, historical, agricultural, economic and recreational qualities of lands along the Willamette River as the Willamette River Greenway.

Goal 16: Estuarine Resources

To recognize and protect the unique environmental, economic, and social values of each estuary and associated wetlands; and To protect, maintain, where appropriate develop, and where appropriate restore the long-term environmental, economic, and social values, diversity and benefits of Oregon's estuaries. Comprehensive management programs to achieve these objectives

shall be developed by appropriate local, state, and federal agencies for all estuaries.

Goal 17: Coastal Shorelands

Statewide Land Use Planning Goal 17 is concerned with conservation and protection, as well as appropriate development of Oregon's coastal shorelands. It aims to reduce the hazard to human life and property, and the adverse effects upon water quality and fish and wildlife habitat resulting from the use and enjoyment of Oregon's coastal shorelands.

Goal 18: Beaches and Dunes

The purpose of Statewide Land Use Planning Goal 18 is to conserve, protect, and where appropriate, to either develop on or restore resources and benefits of coastal beach and dune areas. It is also concerned with reducing the hazard to human life and property from natural or human-induced actions associated with these areas.

Ocean Shore Regulation

The Oregon Parks and Recreation Department (OPRD) is responsible for protecting the scenic, recreational, and natural resource values of the Oregon coast. OPRD accomplishes this through an extensive permitting program for shoreline protection under the authority of The Ocean Shore Law (ORS 390.605-390.770), also known as the "Beach Bill." While not responsible for activities above the statutory vegetation line, the survey line, or the line of established vegetation, OPRD is the permitting authority for actions affecting the ocean shorelands. This distinction can be seen visually at the line of established vegetation that backs the shoreline.

The Division of State Lands (DSL) has co-authority with the OPRD over rocky intertidal areas. The DSL manages the state-owned seabed within three nautical miles of low tide at the ocean shore. Specifically, the DSL regulates removal and filling of seabed and estuaries, including any dredged materials or seabed minerals. DSL may also issue leases for the harvest of Bull Kelp, alarge seaweed in rocky areas of Oregon's coast. The Beach Bill requires that a permit be obtained from the OPRD for all "beach improvements" west of a surveyed beach zone line. Communities can check their comprehensive plan or contact OPRD to obtain the location of this surveyed line.

Figure 4.D.1: Oregon's Seismic Design Regions

The Removal/Fill Law and implementing regulations (ORS 196.800–196.990) contain specific standards and requirements for riprap and other bank and shore stabilization projects in areas that extend from the Pacific Ocean shore to the line of established upland vegetation or the highest measured tide, whichever is greater. OPRD administers the removal/fill

regulations jointly with the Ocean Shore Permit Authority. Activities permitted under these regulations are required to comply with the Statewide Planning Goals and be compatible with corresponding provisions of local comprehensive plans. Permits for shoreline protective structures may be issued only when development existed prior to January 1, 1977, as required under Goal 18. Foredune management plans, often implemented as hazard mitigation strategies, require a permit from OPRD because these strategies affect the structure of the shoreline. Other hazard mitigation strategies that require OPRD approval include: natural product (dirt) removal, re-sloping of a vertical bank below the statutory line of vegetation, and mitigating for erosion by altering the course of a stream that flows into the ocean.

Earthquake / Tsunamis

TSUNAMIS – ORS 336.071, ORS 455.446, AND ORS 455.448

Fourteen earthquake-related bills were introduced during the 1995 session. Several passed, including a new requirement for earthquake education and tsunami drills to be conducted in public schools (ORS 336.071), a requirement for essential and special-occupancy structures to be built outside of tsunami inundation zones (ORS 455.446), provisions for the inspection and entrance of buildings damaged by earthquakes (ORS 455.448) and specific provisions for the abatement of buildings damaged by earthquakes. Senate Bill 1057 created a task force to evaluate the risks impacting existing buildings and make recommendations to the 1997 legislature.

SENATE BILL 96 (1991): SEISMIC HAZARD INVESTIGATION

The legislature passed Senate Bill 96 in 1991. This law requires site-specific seismic hazard investigations before the construction of essential facilities, hazardous facilities, major structures, and special-occupancy structures (e.g., hospitals, schools, utilities and public works, police and fire stations). These requirements are adopted into the State Building Code. The law also provides for the installation of strong-motion sensors in selected major buildings and mandates that school officials in all public schools lead students and staff in earthquake drills.

SENATE BILL 13 (2001): SEISMIC EVENT PREPARATION

Senate Bill 13, signed by the Governor 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 Oregon 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."

SENATE BILL 14 (2001): SEISMIC SURVEYS FOR SCHOOL BUILDINGS

The Governor signed Senate Bill 14 on July 19, 2001. The bill required the State Board of Higher Education to conduct 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. A seismic safety survey was not required for buildings that had previously undergone seismic safety surveys, or that had been constructed to meet state building code standards. For buildings that were found to pose an undue risk to life and safety during a seismic event, the bill required the State Board of Higher Education to develop plans for seismic rehabilitation or seismic risk reduction. Subject to available funding, all seismic rehabilitation or risk reduction activities must be completed before January 1, 2032.

Senate Bill 15 (2001): Seismic Surveys for Hospital Buildings

The Governor signed Senate Bill 15 on July 19, 2001. The bill required the Health Division to conduct seismic safety surveys of hospital buildings that contain acute inpatient care facilities. Subject to available funding, seismic surveys must also be conducted on fire stations, police stations, sheriffs' offices, and similar facilities. The surveys were completed in January, 2007.

A seismic survey was not required for buildings that had previously undergone seismic safety surveys, or that had been constructed to meet state building code standards. For buildings that were found to pose an undue risk to life and safety during a seismic event, the bill required building occupants to develop plans for seismic rehabilitation or seismic risk reduction. Subject to available funding, all seismic rehabilitation or risk reduction activities must be completed before January 1, 2022.

Oregon Seismic Safety Policy Advisory Commission (OSSPAC) – ORS 401.337 to 401.353

The Oregon Seismic Safety Policy Advisory Commission (OSSPAC), otherwise known as the Earthquake Commission, is a state advisory commission that was created in February 1990 through an executive order from Governor Neil Goldschmidt. The group is comprised of 18 individuals who represent a variety of interests concerned with the formulation of public policy regarding earthquakes. It is made up of six representatives of government, six representatives of the public interest, and six representatives of industries and stakeholders. This variety of interests helps direct the goals of the Commission for the benefit of all Oregon citizens.

The Earthquake Commission has the unique task of promoting earthquake awareness and preparedness through education, research, and legislation. OSSPAC seeks to positively influence decisions and policies regarding pre-disaster mitigation of earthquake and tsunami hazards, and to increase public understanding of hazards, risk, exposure, and vulnerability. In order to fulfill the goals of the commission, OSSPAC members have developed five primary objectives. These objectives are to increase or improve:

- Earthquake awareness, education, and preparedness;
- Earthquake risk information;
- The earthquake safety of buildings and lifelines;
- Geoscience and technical information; and
- Emergency pre-disaster planning, response and recovery efforts.

For information on OSSPAC, contact Oregon Emergency Management.

Senate Bill 2 (2005): Statewide Seismic Needs Assessment Using Rapid Visual Screening

Oregon Senate Bill 2 directed DOGAMI, in consultation with project partners, to develop a statewide seismic needs assessment that includes seismic safety surveys of K-12 public school buildings and community college buildings that have a capacity of 250 or more persons, hospital buildings with acute inpatient care facilities, fire stations, police stations, sheriffs' offices and other law enforcement agency buildings.

The statewide needs assessment consisted of rapid visual screenings (RVS) of these buildings; information gathering to supplement RVS; and ranking of RVS results into risk categories. The results are posted on DOGAMI's website.

Senate Bill 2 (2005) provided the first step in a pre-disaster mitigation strategy that is further defined in Senate Bills 3-5 (2005).

Senate Bill 3 (2005): Statewide Earthquake Rehabilitation Grant Program

Administration of the Seismic Rehabilitation Grant Program (SRGP) was transferred from the Oregon Office of Emergency Management (OEM) to the Oregon Infrastructure Finance Authority (OIFA) on January 1, 2014. The SRGP is a competitive grant program that provides state funds on a reimbursable basis for seismic rehabilitation of critical public buildings:

- Hospital buildings with acute inpatient care facilities;
- Fire stations;
- Police stations;
- Sheriffs' offices; and
- Other facilities used by state, county, or district municipal law enforcement agencies.

In addition, eligible school buildings must (a) have a capacity of 250 or more persons; (b) be routinely used for student activities by K-12 public schools, community colleges, education service districts (ESDs), and higher education institutions; and (c) be owned by the State Board of Higher Education, a school district, an education service district, a community college district, or a community college service district.

The SRGP program is subject to the availability of funding, as well as any directive or restriction made with respect to such funds. SRGP grants are awarded on a competitive basis, and the maximum grant award is $1.5 million.

Table 4.D.1: SRGP Awarded Projects, 2009-2010

School District/Entity	Project	Award Amount	Project Status
Linn Benton Community College	Science Technology Building	$565,016	Complete
Three Rivers School District	Applegate School	$826,018	Complete
Beaverton School District	Elmonica Elementary School	$200,200	Complete
Beaverton School District	Cooper Mountain Elementary School	$162,640	Complete
Beaverton School District	McKay Elementary School	$320,035	Complete
Beaverton School District	Oak Hills Elementary School	$120,600	Complete
Western Oregon University	Todd Hall	$1,190,895	Complete
Lake County School District	Lakeview High School	$589,700	Complete
Lake County School District	Fremont Elementary School	$398,100	Complete
Medford School District	Washington Elementary School	$271,000	Complete
Medford School District	Medford Opportunity High School	$200,926	Complete
David Douglas School District	Floyd Light Middle School	$1,489,766	Complete
Yamhill Carlton School District	Yamhill Carlton Intermediate School	$76,500	Complete
North Clackamas School District	Milwaukie Elementary School	$1,088,604	Complete
2009-2010 Schools SRGP Sub-Total		***$7,500,000***	
Emergency Services	**Project**	**Amount Awarded**	**Project Status**
Tuality Healthcare	Tuality Hospital, Building A	$1,380,480	Complete
City of Dallas Fire Department	Dallas Fire Station	$887,725	Complete
City of Albany Fire Department	Station 12	$280,023	Complete
City of Gresham Fire & Emergency Services	Stations 71 (Public Safety Bldg) & 72	$273,866	Complete
Netarts Oceanside Fire District	Station 61	$170,000	Complete
City of St. Helens Police Department	St. Helens Police Station	$20,000	Complete
Klamath County Fire District No. 1	Station 6	$1,311,704	Complete
City of Eugene	Danebo Fire Station Number 8	$66,739	Complete
Silverton Fire District	Scotts Mills Station	$131,207	Complete
Oregon Health & Science University	University Hospital South	$1,478,256	Complete
City of Coos Bay	Coos Bay City Hall	$1,500,000	Complete
2009-2010 Emergency Services SRGP Sub-Total		***$7,500,000***	
2009-2010 SRGP AWARDS GRAND TOTAL		**$15,000,000**	

Source: Business Oregon, Infrastructure Finance Authority

Table 4.D.2: SRGP Awarded Projects, 2010-2011

School District/Entity	Project	Award Amount	Project Status
Greater Albany Public Schools	Central Elementary School	$1,500,000	Open
Klamath Falls City Schools	Mills Elementary School Auditorium	$1,495,212	Complete
Tigard-Tualatin School District	Twality Middle School	$835,750	Complete
2010-2011 Schools SRGP Sub-Total		***$3,830,962***	
Emergency Services	**Project**	**Award Amount**	**Project Status**
Langlois RFPD	Langlois Fire Station	$249,894	Complete
City of Garibaldi	Garibaldi Fire Station	$270,000	Complete
City of Grants Pass	Hillcrest Public Safety Building	$477,024	Complete
City of Astoria	Public Safety Building	$1,500,000	Complete
Santa Clara Fire District	Station 1	$570,000	Complete
City of Hood River	Hood River Fire Department	$291,225	Complete
Woodburn RFPD	Station 22	$310,895	Complete
2010-2011 Emergency Services SRGP Sub-Total		***$3,669,038***	
2010-2011 SRGP AWARDS GRAND TOTAL		**$7,500,000**	

Source: Business Oregon, Infrastructure Finance Authority

Table 4.D.3: SRGP Awarded Projects, 2011-2012

School District/Entity	Project	Amount Awarded	Project Status
Portland Public Schools	Alameda Elementary School	$1,500,000	Complete
Lake County School District	Daly Middle School	$1,186,251	Complete
Rogue River School District	Rogue River Elementary School	$1,500,000	Complete
Lane Community College	Building 11	$708,718	Open
Myrtle Point School District	Myrtle Point High School	$1,470,939	Complete
Philomath School District	Philomath Middle School	$284,920	Complete
Hillsboro School District	North Plains Elementary School	$593,623	Complete
Springfield Public Schools	Walterville Elementary School	$255,549	Complete
2011-2012 Schools SRGP Sub-Total		$7,500,000	
2011-2012 SRGP GRAND TOTAL		**$7,500,000**	

Source: Business Oregon, Infrastructure Finance Authority

Two projects remain open. No new SRGP projects have been awarded at this time.

Senate Bills 4 and 5 (2005): State Bond Authorization

Senate Bills 4 (2005) and 5 (2005) direct the state treasurer to issue voter approved bonds for the seismic rehabilitation of public education buildings and emergency service buildings. The 2013-2015 state budget includes $30 million for these bonds. No new SRGP projects were funded in 2013. The 2014 project application window was July 1 through September 30, 2014. SRGP project funds will be made available following bond sales expected in spring of 2015.

Funding provided by a FEMA Pre-Disaster Mitigation competitive grant for the seismic rehabilitation of three university facilities (two dormitories at Portland State University and operations/administration building at the Oregon Institute for Technology) helped lay the foundation for this successful legislative action. The PSU seismic rehabilitation projects showed that the state could successfully leverage funding, program management, technical assistance and university-managed implementation to complete the projects within the grant budget and on schedule.

Fire (Wildfire and Wildland-Urban Interface)

Oregon Forestland-Urban Interface Fire Protection Act (SB 360)

The Oregon Forestland-Urban Interface Fire Protection Act, often referred to as Senate Bill 360, enlists the aid of property owners toward the goal of turning fire-vulnerable urban and suburban properties into less-volatile zones where firefighters may more safely and effectively defend homes from wildfires. Senate Bill 360 established Oregon's first comprehensive statewide policy regarding mitigation in wildland-urban interface areas. It broadly defined the WUI and set in place a process to identify and classify these areas. The legislation also required the development of standards, which WUI owners are to apply in order to manage and minimize wildfire hazards on their property. When work to implement Senate Bill 360 begins in a county, a committee of local representatives formally identifies and classifies WUI areas. Individual property owners in these areas are then contacted and informed of the standards they are required to meet. They have up to two years to bring their property into compliance with the standards and then to certify that they have done so. Owners who fail to certify become subject to a potential liability of up to $100,000 for certain costs of suppressing fires which start on their property.

The Oregon Forestland-Urban Interface Fire Protection Act is fully described in Oregon Revised Statutes 477.015 through 477.061, and Oregon Administrative Rules 629-044-1000 through 629-044-1110.

Oregon Revised Statute 215.730: Additional Criteria for Forestland Dwellings

ORS 215.730 (County Planning; Zoning, Housing Codes) pro-vides additional criteria for approving dwellings located on lands zoned for forest and mixed agriculture/forest use. Under its provisions, county governments must require, as a condition of approval, that single-family dwellings on lands zoned forestland meet the following requirements:

1. Dwelling has a fire retardant roof;
2. Dwelling will not be sited on a slope of greater than 40 percent;
3. Evidence is provided that the domestic water supply is from a source authorized by the Water Resources Department and not from a Class II stream as designated by the State Board of Forestry;
4. Dwelling is located upon a parcel within a fire protection district or is provided with residential fire protection by contract;
5. If dwelling is not within a fire protection district, the applicant provides evidence that the applicant has asked to be included in the nearest such district;
6. If dwelling has a chimney or chimneys, each chimney has a spark arrester; and
7. Dwelling owner provides and maintains a primary fuel-free break and secondary break areas on land surrounding the dwelling that is owned or controlled by the owner. If a governing body determines that meeting the fourth requirement is impractical, local officials can approve an alter-native means for protecting the dwelling from fire hazards.

This can include a fire sprinkling system, on-site equipment and water storage, or other methods that are reasonable, given the site conditions. If a water supply is required under this subsection, it must be a swimming pool, pond, lake or similar body of water that at all times contains at least 4,000 gallons or a stream that has a minimum flow of at least one cubic foot per second. Road access must be provided to within 15 feet of the water's edge for fire-fighting pumping units, and the road access must accommodate a turnaround for fire-fighting equipment.

Oregon Revised Statute 477.015-061 Urban Interface Fire Protection

These provisions were established through efforts of the Oregon Department of Forestry, the Office of the State Fire Marshal, fire service agencies from across the state, and the Commissioners of Deschutes, Jefferson, and Jackson Counties. It is innovative legislation designed to address the expanding interface wildfire problem within Oregon Department of Forestry Fire Protection Districts. Full implementation of the statute will occur on or after January 1, 2002. The statute does the following:

1. Directs the State Forester to establish a system of classifying forestland-urban interface areas;
2. Defines forestland-urban interface areas;
3. Provides education to property owners about fire hazards in forestland-urban interface areas. Allows for a forestland-urban interface county committee to establish classification standards;
4. Requires maps identifying classified areas to be made public;
5. Requires public hearings and mailings to affected property owners on proposed classifications;
6. Allows property owners appeal rights;
7. Directs the Board of Forestry to promulgate rules that set minimum acceptable standards to minimize and mitigate fire hazards within forestland-urban interface areas; and
8. Creates a certification system for property owners meeting acceptable standards. Establishes a $100,000 liability limit for cost of suppressing fires, if certification requirements are not met.

Oregon Revised Statute Chapter 478: Rural Fire Protection Districts

ORS 478, Rural Fire Protection Districts, includes the following provisions, among others, related to wildfire hazard mitigation:

478.120 Inclusion of forestland in district. The authority to include forestland within a rural fire protection district pursuant to ORS 478.010 (2)(c) applies to forestland within the exterior boundaries of an existing district and to forestland on which structures subject to damage by fire have been added after July 20, 1973.

478.140 Procedure for adding land to district by consent of owner. Any owner consenting to add the forestland of the owner to the district under ORS 478.010 (2)(c) shall do so on forms supplied by the Department of Revenue. The owner shall file the original with the district. The district shall forward a copy to the assessor of each county in which the land is located, within 20 days of receipt.

478.910 Adoption of fire prevention code. A district board may, in accordance with ORS 198.510 to 198.600, adopt a fire prevention code.

478.920 Scope of fire prevention code. The fire prevention code may provide reasonable regulations relating to:

1. Prevention and suppression of fires.
2. Mobile fire apparatus means of approach to buildings and structures.
3. Providing fire-fighting water supplies and fire detection and suppression apparatus adequate for the protection of buildings and structures.
4. Storage and use of combustibles and explosives.
5. Construction, maintenance and regulation of fire escapes.
6. Means and adequacy of exit in case of fires and the regulation and maintenance of fire and life safety features in factories, asylums, hospitals, churches, schools, halls, theaters, amphitheaters, all buildings, except private residences, which are occupied for sleeping purposes, and all other places where large numbers of persons work, live, or congregate from time to time for any purpose.
7. Requiring the issuance of permits by the fire chief of the district before burning trash or waste materials.
8. Providing for the inspection of premises by officers designated by the board of directors, and requiring the removal of fire hazards found on premises at such inspections.

478.927 Building permit review for fire prevention code. A district adopting a fire prevention code shall provide plan review at the agency of the city or county responsible for the issuance of building permits for the orderly administration of that portion of the fire prevention code that requires approval prior to the issuance of building permits.

Additional Criteria for Forestland Dwellings

ORS 215.730 (County Planning; Zoning, Housing Codes) provides additional criteria for approved dwellings located on lands zoned for forest and mixed agriculture/forest use. Under its provisions, county governments must require, as a condition of approval, that single-family dwellings on lands zoned forestland meet the following requirements:

1. Dwelling has a fire retardant roof;
2. Dwelling will not be sited on a slope of greater than 40 percent;
3. Evidence is provided that the domestic water supply is from a source authorized by the Water Resources Department and not from a Class II stream as designated by the State Board of Forestry;
4. Dwelling is located upon a parcel within a fire protection district or is provided with residential fire protection by contract;
5. If dwelling is not within a fire protection district, the applicant provides evidence that the applicant has asked to be included in the nearest such district;
6. If dwelling has a chimney or chimneys, each chimney has a spark arrester; and

7. Dwelling owner provides and maintains a primary fuel-free break and secondary break areas on land surrounding the dwelling that is owned or controlled by the owner. If a governing body determines that meeting the fourth requirement is impractical, local officials can approve an alternative means for protecting the dwelling from fire hazards.

This can include a fire sprinkling system, on-site equipment and water storage, or other methods that are reasonable, given the site conditions. If a water supply is required under this subsection, it must be a swimming pool, pond, lake or similar body of water that at all times contains at least 4,000 gallons or a stream that has a minimum flow of at least one cubic foot per second. Road access must be provided to within 15 feet of the water's edge for fire-fighting pumping units, and the road access must accommodate a turnaround for fire-fighting equipment.

Flood

Statewide Land Use Planning Goals Related to Natural Hazards

Goal 15: Willamette River Greenway

To protect, conserve, enhance and maintain the natural, scenic, historical, agricultural, economic and recreational qualities of lands along the Willamette River as the Willamette River Greenway.

Oregon's Wetlands Protection Program

Oregon's Wetlands Program was created in 1989 to integrate federal and state rules concerning wetlands protection with the Oregon Land Use Planning Program. The Wetlands Program has a mandate to work closely with local governments and the Division of State Lands (DSL) to improve land use planning approaches to wetlands conservation. A Local Wetlands Inventory (LWI) is one component of that program. DSL also develops technical manuals, conducts wetlands workshops for planners, provides grant funds for wetlands planning, and works directly with local governments on wetlands planning tasks.

The Oregon Plan for Salmon and Watersheds

"The Oregon Plan" is the state's program to restore native salmon and trout populations and to improve water quality. The overall goal of the Oregon Plan is to restore fish populations to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits.

Division of State Lands Fill and Removal Permit Program (ORS 196.800-990)

Statewide Land Use Planning Goal 5 requires local governments to adopt programs that will protect natural resources and conserve scenic, historic, and open space resources for present and future generations. In implementing this goal, Division of State Lands (DSL) Fill and Removal Permit Program (ORS 196.800-990) requires individuals who remove or fill 50 cubic yards or more in "waters of the state" to obtain a permit from the DSL. In State Scenic Waterways or areas designated by DSL as essential indigenous anadromous salmonid habitat, most removal-fill activities require a permit, regardless of the number of cubic yards affected. In addition, the Oregon Department of Environmental Quality is

responsible for water quality certification under section 401(a) of the Clear Water Act. This certification is required as part of the DSL permitting process.

Landslide

Senate Bill 12: Rapidly Moving Landslides

Following the flood and landslide events of 1996, legislation was drafted to reduce risk from future landslide hazards. The legislature passed Senate Bill 1211 in 1997, which dealt with rapidly moving landslide issues around steep forestlands, and not in typical urban or community settings. Senate Bill 1211 granted authority to the State Forester to prohibit forest operations in certain landslide-prone locations, and created the Interim Task Force on Landslides and Public Safety. SB 1211 charged the Interim Task Force with developing a comprehensive, practicable, and equitable solution to the problem of risks associated with landslides.

The Interim Task Force developed the legislative concept that resulted in Senate Bill 12 in the 1999 session (ORS 195.250 et seq.). Senate Bill 12 directs state and local governments to protect people from rapidly moving landslides. The bill has three major components affecting local governments: detailed mapping of areas potentially prone to debris flows (i.e., “further review area maps”); local government regulating authority; and funding for a model ordinance. The legislature allocated funding to the Department of Geology and Mineral Industries (DOGAMI) to prepare the “further review area maps,” and provided $50,000 for a grant to a local government to develop a model program to address rapidly moving landslides. Senate Bill 12 applies only to rapidly moving landslides, which are uncommon in many communities, but are very dangerous in areas where they do occur.

Post-Disaster Hazard Mitigation Policy Framework

Following the Presidential Disaster Declaration for the December 2007 winter storm event (DR-1683), the Governor signed Executive Order 08-20 establishing the Governor's Emergency Recovery Framework. The Order established a Recovery Planning Cell (RPC) comprised of emergency recovery advisors, state agency leadership, and others as the situation requires. The RPC directs emergency recovery in Oregon, providing leadership and coordinating private and government sector recovery efforts. It is charged with the development and initial execution of a “day after” plan for recovery efforts. The Order also established the Governor's Recovery Cabinet to coordinate ongoing recovery efforts following the initial emergency response.

State Post-Disaster Hazard Management Policies

Earthquake/Tsunami

More recently, the legislature passed House Resolution 3 following the 2011 Great Tohoku Earthquake in Japan and the resulting tsunami that impacted the Oregon coast (DR-1964). HR 3 recognizes risks and susceptibility of Oregon to catastrophic damage and loss of life resulting from megathrust earthquakes and

tsunamis associated with Cascadia fault. Furthermore, it directed the creation and legislative consideration of an "Oregon Resilience Plan." The Oregon Seismic Safety Policy Advisory Committee published that Plan in February 2013. The plan identifies the state's vulnerabilities in the event of a Cascadia earthquake and tsunami, and contains mitigation actions. Following publication, the legislature appointed the Resilience Task Force to recommend which mitigation actions to take first. The Resilience Task Force's report is due to the legislature on October 1, 2014.

Flood

For the purposes of determining substantial damage following a major hazard event, Oregon implements its substantial damage policy. A building is considered to be substantially damaged when the total cost of repair equals or exceeds 50% of the pre-damage market value of the structure. For flood hazard mitigation, a substantial damage determination provides opportunities for mitigation of buildings through acquisition (to include demolition), relocation out of the floodplain and, potentially, elevation. In fact, when a building is substantially damaged (whether by flooding or other disaster) or substantially improved and said building is in a Special Flood Hazard Area (SFHA), NFIP regulations require mitigation be applied to meet the local community's current floodplain development regulations. Immediately after a flood, local officials should tour the floodplain and note damaged areas on a community map and develop a database of properties that flooded. Where the flooding was deep and with potentially high velocity (the mapped floodway, for example) it will become evident that damages to buildings will reach and exceed the 50% threshold. For those properties that have NFIP flood insurance, timely determinations of substantial damage by flooding will assist property owners in considering mitigation alternatives so that they can apply for an Increased Costs of Compliance (ICC) mitigation claim. If approved for ICC, the ICC claim can be used to expedite mitigation implementation.

In the post-disaster environment, particularly when such events are declared major disasters, the state, local governments and FEMA work closely together during Joint Field Office Operations to facilitate substantial damage determinations and identify early mitigation opportunities for buildings. Structures that are substantially damaged in the SFHA have been given top priority in the past when considering what structures to acquire. In some instances, the benefit/cost analysis can be waived using Hazard Mitigation Grant Program funding when a building is substantially damaged by flood. Timely substantial damage determination is a standard protocol for all flood disaster declarations in Oregon.

Pre- and Post-Disaster Hazard Mitigation Programs and Capabilities Framework

Oregon facilitates the state's hazard mitigation programs and capabilities in a variety of ways. The State IHMT, convened by Governor Kitzhaber in 1996, oversees the state mitigation strategy and is the primary venue for all-hazards information and resource sharing among state agencies. Oregon Emergency Management (OEM) coordinates the group's activities and chairs its quarterly meetings.

Other primary state-level mitigation program and capability examples include:

- OREGON LIDAR CONSORTIUM

  Formed by the Department of Geology and Mineral Industries, the Oregon LiDAR Consortium (OLC) develops cooperative agreements for the collection of high-quality LiDAR that benefits the public at large, the business community, and agencies at all levels of government. The goal of the OLC is to provide high-quality LiDAR coverage for the entire state. The collection of LiDAR data can assist governments in better identifying hazardous areas.

- OREGON SEISMIC SAFETY POLICY ADVISORY COMMITTEE

  OSSPAC is a state advisory commission created in February 1990 through an executive order from Governor Neil Goldschmidt and established in statute by the 1991 Oregon Legislature (ORS 401.337). The purpose of the 18 member group is to reduce exposure to Oregon's earthquake hazards.

- HAZARD MITIGATION GRANT REVIEW BOARD

  The Hazard Mitigation Grant Review Board is an intergovernmental body which, when convened, reviews, discusses, ranks, and recommends project selections for funding under Section 404 of the Stafford Act (aka Hazard Mitigation Grant Program or HMGP).

- DROUGHT COUNCIL

  The Drought Council is responsible for assessing the impact of drought conditions and making recommendations to the Governor's senior advisors.

Numerous additional agency-specific hazard mitigation programs and capabilities also exist or are under development. For example, OPDR is a coalition of public, private, and professional organizations working collectively toward the mission of creating a disaster resilient and sustainable state. Developed and coordinated by the Community Service Center at the University of Oregon, OPDR employs a service learning model to increase community capacity and enhance disaster safety and resilience statewide. Similarly, DLCD is currently working to incorporate the principles of FEMA's Risk Map program into an Oregon-specific initiative called Risk Plan. The Risk Plan program is conceptual at this point, but when implemented will offer an integrated state-wide framework for delivering information, guidance, technical assistance and other resources to local governments.

Agencies/Organizations

STATE INTERAGENCY HAZARD MITIGATION TEAM

First convened by Governor Kitzhaber in 1996, the State Interagency Hazard Mitigation Team (IHMT) meets quarterly, and provides leadership in addressing natural hazards mitigation in Oregon. The State IHMT is an important state mechanism for interagency coordination. The team's focus is to understand losses arising from natural hazards, including secondary losses that occur when natural hazard events impact technological systems and critical infrastructure, and to

coordinate recommended strategies to mitigate loss of life, property, economic and natural resources by maintaining the FEMA-approved and Governor-adopted *Oregon Natural Hazards Mitigation Plan*.

The State IHMT's goals are:

1. Coordinate hazard mitigation programs and activities at all levels in the state of Oregon.
2. Describe and evaluate the natural hazards to which the state of Oregon is vulnerable.
3. Describe and evaluate state, local government, and private sector hazard mitigation policies, programs, and capabilities, consistent with federal codes and regulations.
4. Identify sources of hazard mitigation funding and the procedures that must be followed to obtain such funding; make this information widely available.
5. Identify and evaluate proposed hazard mitigation strategies, projects, and legislation to ensure consistency and to proactively integrate natural resource goals into mitigation activities.
6. Continue to develop, implement, monitor, evaluate, and update the Oregon Natural Hazards Mitigation Plan.
7. Provide education and information about natural hazards and steps which can be taken to mitigate against their effects.
8. Facilitate integration of hazard mitigation into the activities and programs of state and local government agencies, and to the extent practical, into the activities of private sector organizations.
9. Strive to integrate into natural hazard mitigation: natural resource protection and restoration, stormwater management, ecosystem concerns, floodplain management, and protection of water quality for public use.
10. Promote and facilitate the concept of a disaster resistant economy in Oregon.

OEM houses the State Hazard Mitigation Officer who also serves as Chair of the IHMT. In addition, OEM provides overall staff support through routine communication with the membership, agenda development, and meeting logistics. Members of the State IHMT are called upon to assist with various mitigation activities outside of the scheduled State IHMT meetings to include such things as updating the Oregon NHMP, project identification and review, particularly following major disaster declarations.

State IHMT meetings are open to the public. Liaison representatives from non-State IHMT agencies and organizations can be added as needed. Descriptions of the state IHMT agencies' hazard mitigation roles, responsibilities, and authorities are provided in Table 4.D.4.

Table 4.D.4. IHMT Agencies' Hazard Mitigation Roles, Responsibilities and Authorities

State IHMT Agency and Web Address	Hazard Mitigation Roles and Responsibilities	Natural Hazards Mitigation Legal Authority
Department of Administrative Services (DAS), Risk Management Division http://risk.das.state.or.us	Works to prepare state government offices for emergency evacuation planning using the State of Oregon's *Sound the Alarm RisKey* guide. DAS works to improve safety among the workplace by identifying risks and developing tools to manage risks. DAS provides central services when it makes sense or is mandated to do so. DAS also works to protect state owned property and buildings, and sets standards for leasing and constructing state buildings. DAS is not currently an active participant in the state IHMT.	No legal authority for natural hazards mitigation, except that which may arise from a claim under self-insurance property coverage.
Oregon Department of Agriculture (ODA) http://www.oregon.gov/ODA/	Works to exclude or eradicate certain insect pests from becoming established in the state. Using the insect Pest Prevention and Management program (IPPM), the ODA works to protect Oregon's agriculture, horticulture and timber resources from damaging insect pests, thus preventing the defoliation of vast acreage of trees and reducing fire and erosion hazards; works with soil and water conservation districts to help landowners implement best management practices to reduce erosion, thereby preventing slides, floods, and erosion-related problems; actively involved in watershed health and maintaining natural resources through education, technical assistance, and regulatory programs for landowners.	ORS, Chapter 568 provides authority for water quality and soil conservation measures, and Chapter 570 provides authority for pest and disease control programs.
Department of Consumer and Business Services (DCBS), Building Codes Division (BCD) www.cbs.state.or.us/external/bcd	Works to implement statewide building codes through a permitting program. BCD building codes have adopted construction standards that help create disaster resistant buildings. BCD administers the post-earthquake inspection program for damaged buildings and provides technical assistance and training for building inspectors, plans examiners, designers and contractors. A post-earthquake inspector carries out post-earthquake habitability assessments for all structures affected by an earthquake. BCD has compiled an active list of certified post-earthquake inspectors. BCD generally adopts nationally recognized model codes that include various standards to ensure building safety. Technical assistance is provided to designers, contractors, building officials, and the public through its code specialists, its web page, regular mailings to interested parties and local building officials, and its quarterly publication *Codelink*.	ORS, Chapter 455 provides legal authority for the Building Codes Division's (BCD) natural hazard mitigation activities including 455.020 (code adoption), .725 (training), .440 (site soil analysis), .446 (construction in tsunami zones), .447 (seismic site hazard analysis), and .448-.449 (entry and inspection of earthquake damaged buildings).
DCBS - Insurance Division www.cbs.state.or.us/external/ins	Works to perform a major balancing role, protecting the public's interests through ensuring the financial soundness of insurers, the availability and affordability of insurance and the fair treatment of policyholders and claimants while maintaining a positive business climate. The CDBS Insurance Division helps home and business owners prepare for natural hazards through the provision of insurance-related educational material. The BCDS Insurance Division also works to help ensure insurance compensation to insurance holders in the wake of a natural disaster.	ORS Chapter 731 provides authority to DCBS insurance division. House Bill 3605 allows the director of the Department of Consumer and Business Services (DCBS) to modify insurance policy terms in times of emergency.

State IHMT Agency and Web Address	Hazard Mitigation Roles and Responsibilities	Natural Hazards Mitigation Legal Authority
Oregon Business Development Department (OBDD) http://www.oregon.gov/OBDD/index.shtml	Works with the Governor and all state agencies to prioritize programs and modify services that help those affected by natural disasters. OBDD works with current loan customers to address needs during recovery from a natural disaster. OBDD works with communities to prioritize infrastructure needs resulting from a natural disaster, which is used to develop state and federal funding solutions for Oregon communities. OBDD offers Emergency Response Funding Programs. OBDD resources also support hazard mitigation by promoting development of new facilities and infrastructure in appropriate locations. OBDD is not currently an active participant in the state IHMT.	ORS Chapter 285A-C provides authority to the OECDD, including 285B.020 (infrastructure).
Department of Environmental Quality (DEQ) http://www.oregon.gov/DEQ/	Works to protect and maintain waters of the state for public health and safety as well as for all future beneficial uses under EPA delegated programs from the Clean Water Act and Safe Drinking Water Act. Emergency actions related to natural hazards must meet environmental protection requirements. If a natural hazard were to result in hazardous materials being released into the environment, DEQ's Emergency Response Program is designed to respond. DEQ's Environmental Cleanup Division takes action should a release occur or the threat of a release. DEQ assists OEM, DLCD, and FEMA in conducting environmental assessments related to watershed restoration, hazard mitigation projects, and provides matching grants for projects under the Clean Water Act. DEQ plays a central role in the disposal of disaster debris. DEQ also works with Oregon Natural Events Action Plan for Wildfire Smoke. DEQ offers the Wildfire Air Quality Rating to monitor air pollution throughout the state to ensure that air quality standards are being met.	ORS, Chapter 468, water pollution control, enables DEQ to protect all future beneficial uses of waters of the state (surface and groundwater), and allows DEQ to act should there be a threat of release or a spill. ORS, Chapter 468a, enables the DEQ to regulate and monitor air quality. ORS, Chapters 465 and 466 enables the DEQ to respond to hazardous waste and materials that have been released into the environment.
Oregon Department of Fish and Wildlife (ODFW) www.dfw.state.or.us	Has a primary role in determining the effects of potential hazard mitigation projects on fish and wildlife habitats and recommending measures that enhance or at least do not degrade such habitats; administers the state's Riparian Tax Incentive Program and Restoration and Enhancement Program, and can provide cost-share funding, grants and technical assistance.	ORS, Chapter 496 (application, administration and enforcement of wildlife laws), Chapter 497 (licenses and permits), Chapter 498 (hunting, angling and trapping) and Chapter 501 (refuges and closures).

State IHMT Agency and Web Address	Hazard Mitigation Roles and Responsibilities	Natural Hazards Mitigation Legal Authority
Oregon Department of Forestry (ODF) http://www.oregon.gov/ODF/	Works to protect communities from wildfires through the implementation of the Communities at Risk Assessment Program. ODF Identifies communities and assigns each a low, moderate, or high risk rating for the following categories: risk, hazard, protection, capability, value, and overall. ODF works with communities to create Community Wildfire Protection Plans (CWPP): a process involving collaboration between communities and agencies interested in reducing wildfire risk. ODF is responsible for all aspects of wildland fire protection on private, state and BLM forestlands. ODF administers regulations, including landslide mitigation, on non-federal lands. ODF does all of the following things which advance natural hazards mitigation: requiring landowners to control fires on their lands, controlling fires that other landowners cannot control, administering the industrial fire prevention program, investigating wildfires, administering the Forest Practices Act, coordinating with other agencies, maintaining technical expertise on wildfire sciences, geosciences, and hydrology, completing debris flow hazard mapping for Western Oregon, and leading many aspects of the *Oregon Plan for Salmon and Watersheds.*	ORS, Chapter 477 addresses the fire protection of forests and vegetation, including sections on urban interface fire protection, hazard abatement, fire abatement, fire prevention, and related sections. Chapter 527 contains provisions which pertain to timber harvest and road construction regulations in landslide areas.
Department of Geology and Mineral Industries (DOGAMI) http://www.oregongeology.com/sub/default.htm	Works to develop geologic maps and data to enable Oregonians to understand geology and to mitigate the hazards resulting from earthquakes, tsunamis, landslides, and other hazards; works with project partners, to develop a statewide seismic needs assessment; focuses much effort on risk reduction, often in partnership with other federal, state, and local agencies, and the private sector; provides information which leads to the construction of safer buildings; works on sighting of natural gas cogeneration power plants, correctional facilities, gas pipelines using policy decisions related to geologic, seismic and coastal hazards; also works with local partners to develop systematic evaluations of risk to people and property so mitigation efforts can be prioritized.	ORS, Chapter 516 creates and defines the duties; Section 516.030(3) directs DOGAMI to administer on a cooperative basis studies and programs that will reduce the loss of life and property by understanding and mitigating geological hazards.
Department of Land Conservation and Development (DLCD) www.lcd.state.or.us	Manages the statewide land use planning program; Goal 7 of which addresses development in places subject to natural hazards, requiring that jurisdictions apply "appropriate safeguards" when planning for development there. The goal requires local comprehensive plans to include inventories, policies, and ordinances which will reduce losses. DLCD supports local government efforts to address natural hazards through technical assistance during periodic plan review; provides workshops and responds to local government requests for information. DLCD manages the National Flood Insurance Program (NFIP) in the State of Oregon through an agreement with FEMA. As part of the NFIP the DLCD manages the Map Modernization Program and the Cooperating Technical Partners Program. DLCD also manages the Oregon Coastal Management Program, which implements a coastal hazards and assessment program.	ORS, Chapter 197 provides the basis for comprehensive land use planning in the State of Oregon, including provisions governing development in floodplains and in other areas subject to natural hazards, which are intended to mitigate the effects of such hazards. ORS, Chapter 476 provides the basis for the Conflagration Act.

State IHMT Agency and Web Address	Hazard Mitigation Roles and Responsibilities	Natural Hazards Mitigation Legal Authority
Department of State Lands (DSL) http://statelands.dsl.state.or.us	Responsible for a variety of service-related functions relating to land management and implementation of state removal-fill law. DSL's role in hazard mitigation is in the issuing of removal and fill permits or enforcement actions on wetlands waters of the state.	ORS, Chapters 196 and 390 address wetlands, issue of removal and fill permits or enforcement actions on the the beds and banks of the waters of this state. Many of these provisions have a tangential effect on floodplain management and flood hazard mitigation.
Oregon Military Department, Oregon Emergency Management (OEM) http://www.oregon.gov/OMD/index.shtml	Convenes the IHMT and provides overall coordination of natural hazards mitigation in the State of Oregon. The State Hazard Mitigation Officer (SHMO) is on the staff of the Office of Emergency Management. Among OEM's related responsibilities are chairing the Oregon Emergency Response System (OERS) Council, staffing the Oregon Seismic Safety Policy Advisory Commission (OSSPAC), developing and maintaining the state *Emergency Management Plan* and related documents, managing the Chemical Stockpile Emergency Preparedness Program and providing training and other assistance which help to mitigate hazards.	ORS, Chapter 401 Includes many of the state's emergency management statutes one section of which states that the general purpose of the law is to reduce the vulnerability of the State of Oregon to loss of life, injury to persons or property, human suffering, and financial loss resulting from emergencies.
Oregon State Police, Office of State Fire Marshal (OSFM) http://www.oregon.gov/OSP/SFM/	Develop, promote, and maintain protection of life, property, and the environment from fire and other perils through leadership, direct action, and coordination of public safety resources; provides hazard mitigation through programs to educate, inspect, survey, investigate, respond to emergency incidents, and communicate with the public and emergency responders. The Conflagration Act and the State Fire Services Mobilization Plan are coordinated at all levels of state, county, and city government and they foster cooperation in responding to fires and emergency incidents. OSFM employs Regional HazMat Emergency Response Teams to help ensure public safety regarding hazardous materials incidents occurring throughout the state. OSFM provides education and programs, inspections, information, reports, data and brochures, training programs, and emergency responses to incidents for the schools, governments, and the public.	ORS, Chapters 453 and 476-480 authorize the State Fire Marshal to perform a wide variety of education and training programs, inspections, investigative and information reports and other activities related to fire prevention, safety, and management.

State IHMT Agency and Web Address	Hazard Mitigation Roles and Responsibilities	Natural Hazards Mitigation Legal Authority
Public Utility Commission (PUC) www.puc.state.or.us	A regulatory agency for certain electric, gas, telecommunication, and water utility companies; enforces the National Electrical Safety Code and the Federal Gas Pipeline Safety Regulations, which address utility operations under both normal and emergency conditions; monitors utilities' actions and infrastructure under a wide variety of conditions, including natural hazards, to ensure code compliance and prudent practices. Promotes effective vegetation management practices to improve safety and reliability by its ongoing enforcement of statutes and rules via OAR 860-024 rules and FERC/. NERC Rules for transmission lines.	ORS, Chapters 756-759, 772 and 774 authorize the PUC to carry out its purpose.
Oregon Department of Transportation (ODOT) http://www.oregon.gov/ODOT/	Is the road authority for all state highways in Oregon, including interstate highways; works to maintain drainage, open culverts, clean ditches, and perform hydraulic studies; helps prevent or reduce damage to the state highway system caused by floods or landslides. ODOT invites and works with local public works agencies to become participating parties in the Oregon Public Works Emergency Response Cooperative Assistance Agreement. ODOT and local agencies completed a seismic retrofit prioritization study of Oregon's bridges in 1997. As of January 1999, ODOT completed seismic retrofit projects on 124 state bridges.	ORS, Chapter 810 designates ODOT as the road authority for all state highways and specifies a wide range of maintenance, operations, and analysis activities related to hazard mitigation, for example: drainage maintenance, culvert inventory, and the bridge seismic retrofit program.
Water Resources Department (WRD) www.wrd.state.or.us	Responsible for allocation of the water that is produced by watersheds each year; quantifies and provides public notification of flows throughout the state, and insures safe operation of certain dams and other hydraulic structures.	ORS Chapter 540 provides WRD statutory authorities for dam safety and a statewide hydrographic program for measuring river and stream flows.
Oregon Parks & Recreation Department www.oregon.gov/OPRD/index.shtml	Works to provide and protect outstanding natural, scenic, cultural, historic and recreational sites for the enjoyment and education of present and future generations. OPRD is responsible for land stewardship, marine conservation / rocky shores, several permit programs, department-wide resource policies, and park plants and animals. OPRD strives to provide a safe environment while maintaining the natural beauty and historic importance of our parks. In certain areas providing a safe environment for park users involves planning for natural disasters.	ORS Chapter 390 provides deals with the role of OPRD in dealing with state and local parks, recreation programs, scenic waterways and recreation trails

State IHMT Agency and Web Address	Hazard Mitigation Roles and Responsibilities	Natural Hazards Mitigation Legal Authority
Oregon Partnership for Disaster Resilience (OPDR) http://csc.uoregon.edu/opdr	OPDR is a coalition of public, private, and professional organizations working collectively toward the mission of creating a disaster resilient and sustainable state. Developed and coordinated by the Community Service Center at the University of Oregon, OPDR employs a service learning model to increase community capacity and enhance disaster safety and resilience statewide. Primary activities include community plan and project development support; applied research and technical resource development; training programs and capacity building, and the development of strategic alliances.	N/A

Cascadia Regional Earthquake Workgroup

The Cascadia Region Earthquake Workgroup (CREW) is a coalition of private and public representatives working together to improve the ability of Cascadia Region communities to reduce the effects of earthquake events.

CREW's goals include the following:

- Promote efforts to reduce the loss of life and property damage from earthquakes.
- Educate and motivate decision makers, managers, and the general public to reduce risks associated with earthquakes.
- Foster productive linkages between scientists, critical infrastructure providers, businesses and governmental agencies in order to improve the viability of communities after an earthquake event.

"Experience in Oregon tells us that the most effective measures for mitigation and response include a good program for monitoring statewide conditions, close coordination among state 'experts' who are involved in reporting statewide conditions, and a good public information program. While these activities do not actually provide direct mitigation, they promote public awareness and allow individuals and organizations to make preparations.
A second important factor in drought response and mitigation is to approach special water management practices with caution. It is easy for regulation activities to fall into a trap of invoking special use permits in a manner that will actually encourage more than normal use in some areas.

- *From the beginning of our effort in developing a state drought plan it was evident that we needed to concentrate on three things:*
- *Close coordination among state and federal agencies*
- *Procedures for obtaining the best data available on statewide conditions*
- *Establish a strong network and public information program to make data on existing conditions available"*

Source: Barry Norris, Administrator, Technical Services Division, Oregon Water Resources Department, *Planning for Drought*, 2001

Figure 4-D-2: Planning for Drought

Drought Council

The Drought Council is responsible for assessing the impact of drought conditions and making recommendations to the Governor's senior advisors. The Drought Council is, in turn, advised by a subcommittee of technical people who monitor conditions throughout the state and report these conditions monthly. It is known as the Water Availability Committee. In this manner the Drought Council keeps up-to-date on water conditions. Members combine this knowledge with information they bring from their organizations and differing geographic areas of the state in order to make recommendations for policy, response, and mitigation.

The Drought Council is chaired and facilitated by Oregon Emergency Management. Members of the Council include state and federal agencies, and private organizations involved in drought forecasting, assessment, response, or recovery. The goal of the Drought Council is to "strive to reduce the effects of an impending drought through a coordinated federal, state, local, and voluntary effort, consisting of the development of drought plans, policies, and procedures, and through coordinated state response."[6]

"The heart of the matter is the process of determining a menu of mitigation options that is fair, equitable, economically realistic, and environmentally responsible. As an example, when surface water is in short supply, irrigators turn to groundwater. The added stress to groundwater aquifers may be environmentally feasible in some instances, and not in others. The argument can be made that even in groundwater aquifers that are already stressed, short-term use is feasible. However, groundwater pumping installations are expensive to

[6] Drought Annex to the State Emergency Operations Plan, September 2002

develop and, once installed, they are not easily abandoned. Short-term use easily becomes long-term use, considering it is more reliable, and environmental problems grow.

Recommendations by the Drought Council include public information and proposals for reallocation of existing resources to be considered by the Governor. When a statewide emergency is declared by the Governor, existing resources are not normally reallocated for mitigation purposes. The Governor simply stresses the need for state agencies to perform as best they can in mitigation activities already included in existing programs." [7]

Specific tasks of the Drought Council include:

- Monitoring meteorologic and hydrologic conditions to determine the current and future severity of a drought;
- Estimating the severity of a drought and its impact on electric power consumption and generation, agricultural production, essential human needs, industrial output, fish and wildlife, state forests, and other areas as appropriate;
- Developing an inventory of physical, economic, or other resources available for responding to anticipated drought impacts;
- Determining potential conflicts between water users and electric power users, and initiating actions to minimize these conflicts;
- Coordinating drought response and recovery efforts;
- Acting as a clearinghouse for questions and requests for state and federal drought declarations;
- Assisting the Governor and Oregon Emergency Management in determining the need for various federal disaster declarations and other federal assistance;
- Reporting to the Governor's Natural Resource Advisor;
- Facilitating and coordinating development of water and power conservation plans; and
- Facilitating and coordinating public information processes that encourage voluntary conservation measures.

Energy Facility Siting Council

The Energy Facility Siting Council reviews proposed energy facilities for seismic vulnerability through its structural standard, Oregon Administrative Rule (OAR) 345-022-0020. This standard is a safety standard rather than a reliability standard. It ensures that structural failure at an energy facility will not endanger workers or the public. It does not require that energy facilities be proven to remain operable in a seismic event because the Council assumes that key safety facilities such as hospitals will have backup electricity.

The standard requires that:

- The applicant, through appropriate site-specific study, has adequately characterized the site as to appropriate seismic design category and expected ground motion and ground failure, taking into account amplification during the maximum credible and maximum probable seismic events;
- The applicant can design, engineer, and construct the facility to avoid dangers to human safety presented by seismic hazards affecting the site that are expected to

[7] Barry Norris, Administrator, Technical Services Division, Water Resources Department, *Planning for Drought*, 2001

result from all maximum probable seismic events (as used in the rule, "seismic hazard" includes ground shaking, landslide, liquefaction, lateral spreading, tsunami inundation, fault displacement, and subsidence);

- The applicant, through appropriate site-specific study, has adequately characterized the potential geological and soils hazards of the site and its vicinity that could, in the absence of a seismic event, adversely affect, or be aggravated by, the construction and operation of the proposed facility; and
- The applicant can design, engineer and construct the facility to avoid dangers to human safety presented by the hazards identified.

The Council reviews proposed energy facilities such as power plants, major electric transmission lines, major gas pipelines (greater than 16 inch diameter) for compliance with this standard. They do so in consultation with Oregon Department of Geology and Mineral Industries under an interagency agreement.

In response to an electricity shortage, the 2001 Oregon Legislature created an expedited review process for certain qualifying power plants. These power plants are generally not required to meet the structural standard; however, the Oregon Office of Energy, in consultation with Oregon Department of Geology and Mineral Industries, can still impose conditions on these plants related to the structural standard.

Hazard Mitigation Grant Review Board

The Hazard Mitigation Grant Review Board is an intergovernmental body which when convened reviews, discusses, ranks, and recommends project selections for funding under Section 404 of the Stafford Act (aka Hazard Mitigation Grant Program – HMGP).

With requirements for FEMA-compliant (201.6) local mitigation plans to be eligible for Section 404 grants, the need to convene the Hazard Mitigation Grant Review Board has been largely replaced by project actions and priorities identified in those local mitigation plans. In order to expedite the Section 404 grant offering early in the post-disaster recovery process, HMGP project funding is first prioritized to the disaster-declared counties (and all eligible applicant entities therein) on a pro rata share basis of their Public Assistance and Individual Assistance eligible costs as initially determined during the Preliminary Damage Assessment. The pro rata applicant share can be further refined at either the 12-month or 18-month HMGP lock-in. HMGP planning grant funding is available statewide from the onset of the program's availability.

During the PA and HMGP Applicant Briefing, the state promulgates broad priorities and project categories for Section 404 project pre-applications that tend to focus on the nature of the disaster and related mitigation opportunities. Representatives from the Hazard Mitigation Grant Review Board and the State IHMT are encouraged to provide their input into establishing the broad priorities and project categories for Section 404 project pre-applications early in the process. The Hazard Mitigation Grant Review Board plays a key role in selecting state 5% initiative projects as there are oftentimes many more "5%" projects than available funding.

Board Membership

- Director of the Office of Emergency Management or designee (most usually the Section Director, Financial and Recovery Services who is also the State Coordinating Officer for major disaster declarations), who chairs the Board;
- State Floodplain Program Coordinator (Natural Hazards Program Coordinator) of the Department of Land Conservation and Development or designee;
- President of the Oregon Emergency Management Association (OEMA) or designee;
- A representative of the Association of Oregon Counties (AOC) and/or the League of Oregon Cities (LOC); and
- For flood disasters and related projects, Chief of the Emergency Management Branch, Portland District, U.S. Army Corps of Engineers (USACE) or designee.

The State Hazard Mitigation Officer (SHMO) of the Office of Emergency Management provides staff and technical assistance, and presents hazard mitigation projects to the Board, but is not a voting member.

Oregon Board of Geologist Examiners

In 1990 the Oregon Board of Geologist Examiners adopted guidelines to assist professionals in preparing engineering geologic reports in the state. Then in 1996, the Board adopted additional guidelines for site-specific seismic hazard reports for essential and hazardous facilities, major structures and special occupancy structures as provided in ORS 455.447. A complete listing of all report elements is included in Section 1802.6.1 of the *Oregon Structural Specialty Code.* In 2001, the Board established a Memorandum of Understanding with the Engineering & Land Surveying Examiners Board to clarify the roles of Certified Engineering Geologists and Geotechnical Engineers.

Oregon Emergency Management Association

Oregon Emergency Management Association (OEMA) is the association for Oregon's emergency management professionals. OEMA provides over 200 public, private, and non-profit members with the following:

- A network for training, education, and preparedness information and professional development;
- A forum for the sharing of knowledge, ideas, processes and building partnerships; and
- A collective and unified voice for emergency management issues in Oregon.

OEMA promotes the efforts of Oregon's communities to plan for all natural and human caused hazards through improved mitigation, preparedness, response, and recovery capabilities.

Oregon LiDAR Consortium

Formed by the Department of Geology and Mineral Industries, the Oregon LiDAR Consortium (OLC) develops cooperative agreements for the collection of high-quality LiDAR that benefits the public at large, the business community, and agencies at all levels of government. The goal of the OLC is to provide high-quality LiDAR coverage for the entire state. The collection of LiDAR data can assist governments in better identifying hazardous areas.

Oregon Seismic Safety Policy Advisory Committee

OSSPAC is a state advisory commission created in February 1990 through an executive order from Governor Neil Goldschmidt and established in statute by the 1991 Oregon Legislature (ORS 401.337).

It is made up of 18 members with interests in earthquake safety: Building Codes Division, Oregon Emergency Management, Department of Geology and Mineral Industries, Department of Land Conservation and Development, Oregon Department of Transportation, two representatives from the Oregon Legislature, one local government representative, one member from education, three from the general public and six members from affected industries, such as homebuilders and banking industries.

The purpose of the work of OSSPAC is to reduce exposure to Oregon's earthquake hazards by:

- Developing and influencing policy at the federal, state, and local government levels;
- Facilitating improved public understanding and encouraging identification of earthquake risk; and
- Supporting research and special studies, appropriate mitigation and response and recovery.

The Commission has proposed concepts to the Oregon Legislature on improving seismic safety in Oregon. They have prepared a document entitled *Oregon at Risk,* which outlines seismic hazards in the state. In 2004 the Commission provided a venue to the General Obligation (GO) Bond Task Force to develop policy recommendations for implementation of SB 14 & 15 (2001). These bills and general obligation bonds for funding of the grant program would improve the earthquake safety of public schools and emergency response facilities across the state.

Oregon Sea Grant Extension

The Oregon State University Extension Service conveys research-based knowledge to a variety of businesses owners, growers, foresters, youth and community leaders in an effort to improve their lives, their homes, their businesses and their communities. The Oregon Sea Grant program provides education regarding watershed health and creating hazard resilient coastal communities with particular attention placed to earthquake and tsunami hazards.

Pacific Northwest Seismograph Network

The Pacific Northwest Seismograph Network operates seismograph stations and locates earthquakes in Oregon and Washington. They are funded by the US Geologic Survey, the Department of Energy and the State of Washington. Their website provides information on Pacific Northwest earthquake activity and hazards.

Pacific Northwest Wildfire Coordinating Group

The Pacific Northwest Wildfire Coordinating Group provides leadership in interface and wildland fire management for local, tribal, state and federal agencies. The PNWCG is comprised of USDA-Forest Service, USDI-Bureau of Land Management, Bureau of Indian Affairs, National Park Service, Fish and Wildlife Service, Oregon Department of Forestry, washing Department of Natural Resources, Washington Association of Fire Chiefs, The Oregon Fire Chiefs Association, The Oregon State Fire Marshall and the Washington State Fire Marshall.

Water Availability Committee

The Water Availability Committee is a subcommittee of the Drought Council. The committee is chaired by the Oregon Water Resources Department. Committee members include representatives from the National Weather Service, NW River Forecast Center, Natural Resources Conservation Service, U.S. Geological Survey, Oregon Climate Service,[2] and Oregon Department of Forestry. The primary responsibility of the Water Availability Committee is to determine the appropriate Oregon Drought Severity Index for locations throughout the state.

State Pre-Disaster Hazard Mitigation Programs

Conservation Reserve Program

CRP retires eligible cropland from agricultural production and plants the land to permanent grass cover that reduces erosion and benefits wildlife populations. CRP does a very good job of providing cover that reduces windblown dust and has been effective in reducing soil erosion in the areas most prone to wind erosion. However, silt soils easily stay suspended for long periods of time and thus can move great distances affecting visibility on roads away from the protected fields. The strategy to encourage a strip of CRP along the freeway has been determined to probably be ineffective at reducing dust storm intensity. Also, the fire hazard could be worse than the dust hazard. In Umatilla County, NRCS has designated an area near I-84 as a wind erosion priority area to influence enrollment into the Conservation Reserve Program.

Oregon Coastal Management Program

The Oregon Coastal Management Program (OCMP) is the combined effort of 32 cities, seven counties, and a host of state agencies to carry out the statewide lad use program on the Oregon Coast. OCMP's mission is to work in partnership with coastal local governments, state and federal agencies, and other stakeholders to ensure that Oregon's coastal and ocean resources are managed, conserved, and developed consistent with statewide planning goals.

To accomplish this mission OCMP provides substantial financial and technical assistance to coastal local governments for planning, capacity building, and special projects. OCMP also coordinates and integrates programs of local, state, and federal agencies to support local planning and to protect and restore coastal natural resources, and reviews state and federal permits to ensure compliance with local, state, and federal program requirements. OCMP also utilizes the Internet to provide coastal data and information to a wide public through the Oregon Coastal Atlas.

URL: http://www.oregon.gov/LCD/OCMP/about_us.shtml

DOGAMI Partnership with U.S. Geological Survey National Landslide Hazard Program

DOGAMI has entered into a collaborative partnership with this program, centered on three targeted goals for Western Oregon: 1) develop inventory maps and digital databases of existing deep-seated landslides, 2) develop predictive hazard maps of areas prone to rapidly moving landslides, and 3) develop susceptibility maps of deep-seated landslides for targeted developable areas. The second of these incorporates the mandates of Oregon Revised Statutes 195.260 (2003) to produce *further review areas* of rapidly moving landslide hazard. This will be conducted in cooperation with local governments and will provide some technical assistance

[2] The Oregon Climate Service and Oregon Climate Change Research Institute are based at Oregon State University.

to local governments to facilitate the use and application of this information. A Landslide Advisory Committee consisting of local government stakeholders and state and federal agencies will aid the agency in prioritizing projects.

DOGAMI Earthquake Hazard Mitigation Program

DOGAMI's organic statute gives the agency broad responsibility and authority for evaluating all geologic hazards statewide, including earthquake hazards. DOGAMI has published numerous maps and reports on the earthquake hazards of the state. The agency, in partnership with other state and federal agencies, has undertaken a wide-ranging program in Oregon to identify seismic hazards, including active fault identification, bedrock shaking, tsunami inundation zones, ground motion amplification, liquefaction, and earthquake induced landslides.

DOGAMI Tsunami Hazard Mitigation Program

The primary goal of the Oregon Tsunami Hazard Mitigation Program is to reduce loss of life and property damage from tsunamis. Additionally, the program aims to promote community preparedness through development of mitigation products and the implementation of a coast-wide, volunteer driven education and outreach initiation to support the National Weather Service's *TsunamiReady*™ progam. Funding granted from the National Tsunami Hazards Mitigation Program is being used to complete the next generation of tsunami inundation maps along Oregon's 43 *TsunamiReady*™ communities.

ODF National Fire Plan Implementation in Oregon

Under the National Fire Plan (NFP), funding opportunities for local WUI planning, prevention and mitigation projects first became available in 2000. Since that time, Oregon has aggressively sought funding for a wide variety of projects, including fuels reduction work, education and prevention projects, community planning, and alternative uses of fuels. The majority of these monies have been used to fund fuels reduction projects on individual properties and to establish community fuel breaks in the most wildfire prone portions of the state. NFP funds have also been used to expand fire prevention efforts, to educate local officials about how they may help address the WUI situation, to implement Senate Bill 360, to improve public awareness about the wildfire problem, and to better identify areas especially exposed to wildland fire.

ODFW Habitat Resources Program – Riparian Lands Tax Incentive

The Riparian Tax Incentive Program, authorized by ORS 308A.350—308A.383, offers a property tax incentive to property owners for improving or maintaining qualifying riparian lands. Under this program, property owners receive complete property tax exemption for their riparian property. This can include land up to 100 feet from a stream.

When the Riparian Tax Incentive law was passed in 1981, the Oregon Legislative Assembly declared that "it is in the best interest of the state to maintain, preserve, conserve and rehabilitate riparian lands to assure the protection of the soil, water, fish and wildlife resources of the state for the economic and social well-being of the state and its citizens." Healthy riparian zones are important to the resource by providing: cooler water due to shading resulting in better habitat for salmon, trout and steelhead; more and better varieties of habitat for wildlife; increased water during summer low flow periods; erosion control by stabilizing streambanks with protective vegetation; and flood control.

ODFW Fisheries Restoration and Enhancement Program

The Fisheries Restoration and Enhancement Program is a comprehensive program to restore state-owned hatcheries, enhance natural fish production, expand hatchery production and provide additional public access to fishing waters. The R&E Program provides increased sport fishing opportunities, and also supports and improves the commercial salmon fishery.

The program was authorized by the Oregon Fisheries and Enhancement Act of 1989 and was renewed in 2009. The program focuses on projects that increase fish production (either hatchery or natural production), increase recreational or commercial opportunities or access to the fish resources, or improve fish management capabilities. Restoration projects that facilitate fish passage may also provide flood-control benefits.

OEM Pre-Disaster Mitigation Planning and Project Activities

State pre-disaster mitigation planning and project activities are an integral component of OEM's mission. OEM's Financial and Recovery Services Section provides oversight and administration of financial services and related funding that is passed-through to local governments. Specifically, the Section Director, SHMO, Alternate SHMO, Facilities Engineer (Public Assistance Officer), Seismic Grants Coordinator, and financial support staff work together closely on pre-disaster mitigation grant programs and project activities. Although OEM has limited staff support available for mitigation planning and project implementation activities, the state is able to effectively secure and manage FEMA's PDM and FMA grants.

The success of mitigation planning activities state-wide combines Oregon's past history of land use planning and goals with the integration of resources from FEMA's mitigation grants leveraged through the Oregon Partnership for Disaster Resilience. The concept of aggregating regional, jurisdictional mitigation planning needs that leverage and target financial and technical resources to geographic areas around the state has proven to be successful in securing funding and completing local mitigation plans.

OPDR Pre-Disaster Mitigation Planning Program

Despite the growing recognition of the need for long-term coordination to reduce risk from natural disasters, many communities in Oregon continue to experience difficulty in developing and implementing natural hazard risk reduction plans, policies and activities. Communities regularly suffer from a lack of technical and funding assistance, as well as insufficient coordination among public, private, and non-profit sectors at the local, regional, and statewide levels. OPDR works to address these challenges and offers a model of how increased communication, coordination and collaboration between diverse partners can assist communities in reducing their risk from natural hazards. The Pre-Disaster Mitigation (PDM) program is completely funded by nationally competitive federal grants with in-kind match coming from local communities and the University of Oregon. Mitigation planning occurs in partnership with Oregon Emergency Management, the Department of Land Conservation and Development, Department of Geology and Mineral Industries, FEMA Region X, and local governments throughout Oregon.

OPDR Disaster Resilient University Initiative

The Oregon Disaster Resilient University (Oregon-DRU) is a new initiative between University of Oregon Emergency Management, Oregon Partnership for Disaster Resilience and Oregon's

post-secondary institutions. The concept is to build a collaborative service center model between campuses in Oregon to link the skills, expertise, resources, and innovation of post-secondary education, federal agencies, professional and trade organizations, and state agencies to reduce risk on Oregon campuses. The Oregon-DRU has five specific service areas geared to enhance and support emergency management and risk reduction efforts within post-secondary institutions in Oregon.

ODF Community Wildfire Protection Plans

A Community Wildfire Protection Plan (CWPP) is developed by a community in an area at-risk from wildfire. CWPs have three primary requirements: they must be developed collaboratively between local and state government representatives in consultation with federal agencies and other interested parties, they must identify and prioritize areas for hazardous fuels reduction treatments while also recommending methods for treatments that will protect at-risk communities and essential infrastructure, and lastly the must recommend measures that homeowners and communities can take to reduce ignitability of structure throughout the plan area. The statutory definition of a CWPP appears in Title I of the Healthy Forest Restoration Act of 2003. Oregon has 35 County CWPPs and 26 additional community CWPPs.

Oregon Plan for Salmon and Watersheds – Covered in Policies

"The Oregon Plan" is the state's program to restore native salmon and trout populations and to improve water quality. The overall goal of the Oregon Plan is to restore fish populations to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits.

Statewide Land Use Planning Program

Since 1973, Oregon has maintained a strong statewide program for land use planning. The foundation of that program is a set of 19 statewide planning goals. The goals express the State's policies on land use and related topics, such as citizen involvement, housing and natural resources. Oregon Statewide Planning Goal 7- *Areas Subject to Natural Hazards* was developed to protect people and property from natural hazards in Oregon. Goal 7 provides guidelines for local government planning officials to follow that can reduce their vulnerability to natural hazards. These guidelines include what factors local governments can consider in adopting policies and measures to protect people and property from natural hazards, and several ways in which local governments can implement mitigation measures more effectively.

NFIP, Map Mod, Risk MAP, and cooperating technical partners

NFIP – The Oregon Department of Land Conservation and Development serves as the state NFIP coordinating agency, partnering with BCD and OEM. These agencies are responsible for existing flood mitigation strategies and programs. In addition to state programs, the NFIP of the FEMA is designed to help minimize flood losses through local floodplain management. The NFIP relies on flood hazard mapping, flood insurance, and floodplain development standards implemented at the local level to reduce flood losses. In Oregon, 259 cities and counties and two tribal nations participate in the NFIP (total of 259 "NFIP" communities) and thus play a key role in flood mitigation.

Map Mod – Map Modernization is responding to National Flood Insurance requirements and feedback provided by Federal, State, and Local Program stakeholders. Flood hazard conditions are dynamic, and many NFIP maps may not reflect recent development and/or natural

changes in the environment. Map modernization is the cornerstone for helping community officials and citizens be better prepared for flood related disasters. In 2014, the Map Mod is almost complete with two communities' maps under appeal. The Map Mod program has progressed into the Risk MAP program.

Risk Map - Risk Mapping, Assessment, and Planning (Risk MAP) is the Federal Emergency Management Agency (FEMA) Program that provides communities with flood information and tools they can use to enhance their mitigation plans and take action to better protect their citizens. Through more precise flood mapping products, risk assessment tools, and planning and outreach support, Risk MAP strengthens local ability to assess risks and identify actions to reduce vulnerability to those risks, enabling communities to enhance their mitigation plans and actions. In 2014 more than a dozen Risk MAP projects were active in Oregon.

Cooperating Technical Partners- The MMMS partnership mechanism provides the opportunity to pool resources and extend the productivity of limited public funds. MMMS partners include State or regional agencies and federally recognized tribes that serve communities participating in the National Flood Insurance Program (NFIP). MMMS partner activities include, but are not limited to, assessing mapping needs, reviewing hydrologic and hydraulic studies prepared for flood map revisions, and providing an inventory of base maps.

FEMA partners with State and regional organizations in the management of Map Mod activities for the following reasons:

- Management participation will help to ensure that the products resulting from Map Mod do not conflict and are complementary, not duplicative.
- MMMS provides a means to interject a tailored, local focus into a national program. Where unique conditions may exist, special approaches to communication, coordination, and compliance that may be necessary can be taken.
- The MMMS partnership mechanism provides the opportunity to combine resources and extend the productivity of limited public funds.

Oregon Coastal Management Program

Oregon's Coastal Management Program (OCMP) is the combined effort of 32 cities, seven counties, and a host of state agencies to carry out the statewide land use program on the Oregon coast. All statewide planning goals apply to the coast, but the OCMP emphasizes four coastal-related goals: Goal 16, Estuarine Resources; Goal 17, Coastal Shorelands; Goal 18, Beaches and Dunes; and Goal 19, Ocean Resources. The Department of Land Conservation and Development is the state's Coastal Management Agency and provides overall program administration and coordination. The OCMP assists coastal planners to identify and plan for costal hazards to prevent property damage and avoid loss of life. The OCMP also works with the Oregon Department of Geology and Mineral Industries and Oregon Sea Grant to identify and communicate natural hazards such as shoreline erosion and tsunami inundation.

Oregon Emergency Response System

Oregon's Emergency Response System coordinates and manages state resources in response to natural and technological emergencies and civil unrest involving multijurisdictional cooperation between all levels of government and the private sector. Established in 1972, OERS was the first state plan of its kind, it serves as the primary point of contact by which any

public agency reports the state with notice of an emergency or disaster or from which they can request access to state or federal resources.

Oregon's Wetlands Protection Program

Oregon's Wetlands Program was created in 1989 to integrate federal and state rules concerning wetlands protection with the Oregon Land Use Planning Program. The Wetlands Program has a mandate to work closely with local governments and the Division of State Lands (DSL) to improve land use planning approaches to wetlands conservation. A Local Wetlands Inventory (LWI) is one component of that program. DSL also develops technical manuals, conducts wetlands workshops for planners, provides grant funds for wetlands planning, and works directly with local governments on wetlands planning tasks.

National Tsunami Hazard Mitigation Program

The National Tsunami Hazard Mitigation Program (NTHMP) is a state/federal partnership. The program's Coordinating Committee includes emergency management and geoscience representatives from the original five Pacific states (Alaska, California, Hawaii, Oregon, and Washington), emergency management representatives from the Atlantic and Gulf Coast states, the United States Geological Survey (USGS), the Federal Emergency Management Agency (FEMA), National Oceanographic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF). Funds to administer the program are provided by NOAA and have been available every fiscal year since federal FY 1997.

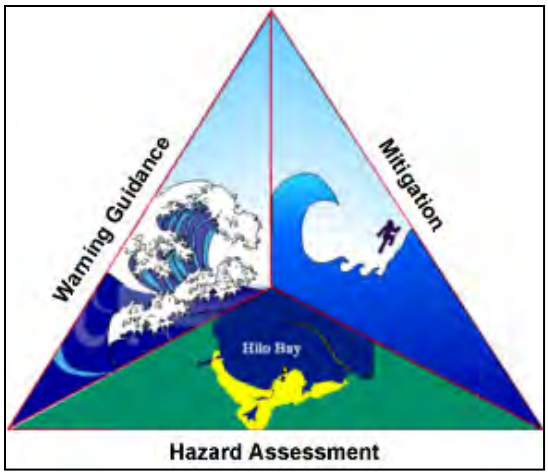


Figure 4.D.3: Tsunami Hazard Mitigation Program

The 2006 *Tsunami Warning and Education Act* (PL 109-424) called for a Forecasting and Warning Program, a Tsunami Hazard Mitigation Program, and a Tsunami Research Program. These programs include the upgrade of seismic networks and installation of open ocean tsunami detection equipment designed to reduce the number of false alarms; development of tsunami inundation models and maps; and education, preparedness and mitigation work, including an implementation plan to insure that the goals of the program were met.

Water Resources Department Dam Safety Program

The Water Resources Department Dam Safety Program reviews design plans, reports and specifications and approves for construction, modification or enlargement all hydraulic structures greater than or equal to 10 feet height and 3,000,000 gallons reservoir capacity (ORS 540.350). Design approval for High Hazard hydraulic structures typically includes a satisfactory review of Emergency Action Plans and inundation maps.

The Dam Safety Program maintains for the National Inventory of Dams, a database of all Oregon dams and reservoirs that exceed statutory size criteria regardless of ownership. The program also performs regular inspections of all existing non-federal dams statewide. The

WRD dam safety program participates cooperatively with existing established federal dam safety programs such as U.S. Army Corps Engineers, U.S. Bureau Reclamation, Federal Energy Regulatory Commission and others in their design review and inspection of federal project dams, reservoirs and appurtenant works.

WRD is the designated state agency and the Hydroelectric Licensing Program is the lead for review and license permitting for new and existing hydroelectric projects. WRD's licensing program collects data and requests from other state agencies, negotiates settlements and assembles the state's criteria for power development and operation. When the process is completed, the conditions and requirements are incorporated into and apply concurrently with issuance of the federal license for all regulated hydroelectric projects statewide (ORS 543, ORS 543A).

Wildfire Awareness Week

Since 2001, when Governor John Kitzhaber proclaimed Oregon's first Wildfire Awareness Week, this interagency effort has grown with each passing year. That year, a coalition led by the Office of State Fire Marshal, and including the Department of Forestry, structural fire agencies, insurance industry representatives, and others developed and distributed a campaign tool kit with model proclamations and recorded pubic service announcements designed for distribution to media outlets. In 2008, the Keep Oregon Green Association became the caretaker of the annual campaign.

OEM Statewide Earthquake & Tsunami Drills

Earthquake and tsunami drills are conducted annually by OEM. On January 25, 2011 the first annual Great Oregon Shake Out occurred throughout Oregon with over 39,000 participants. In partnership with DOGAMI, OEM also conducts voluntary tsunami evacuation drills. The community-wide drills incorporate aircraft public address systems, in addition to the tsunami warning issued by the National Weather Service, in areas where sirens have limited coverage.

ODOT Winter Maintenance Practices

ODOT's winter maintenance practices include plowing, sanding and applying anti-icing liquids in order to increase efficiency of snow removal and to reduce motor vehicle crashes. To increase motorist safety in collaboration with local media, ODOT Region 5, publishes a special multi-page flyer known as the Winter Roadway Guide as an annual newspaper insert. Additionally, ODOT publishes winter driving tips and information on its website geared to motorists and bicyclists.

Public Health Mitigation Planning

The Oregon Public Health Emergency Preparedness Program is an effort to anticipate, detect, assess and understand health risks associated with an emergency. The mitigation aspect focuses on long-term measures for reducing or eliminating risk including technological and policy changes. The department promotes guidance from the National Health Security Strategy, Interim Implementation Guides, and Community Mitigation Strategies.

Oregon Seismic Safety Policy Advisory Commission

The Oregon Seismic Safety Policy Advisory Commission has the unique task of promoting earthquake awareness and preparedness through education, research, and legislation. The mission of OSSPAC positively influence decisions and policies regarding pre-disaster mitigation

of earthquake and tsunami hazards, increase public understanding of hazard, risk, exposure, and vulnerability through education seminars, etc., and be responsive to the new studies and/or issues raised around earthquakes and tsunamis.

As a result of the Loma Prieta Earthquake in the Bay Area of California in 1989,Oregon residents wanted the State government to address the earthquake hazard and preparedness of the State. As a result, the Interagency Seismic Task Force recommended that a new state commission be formed in response to this need. OSSPAC was formed as a result of Senate Bill 96 in 1991. Since this time, OSSPAC has continued to increase Oregon 's awareness to earthquake hazards by supporting earthquake education, research, and legislation. Every two years, OSSPAC provides a summary report to the Governor of the Commission's activities. OSSPAC has also formed relationships with the Western States Seismic Policy Council (WSSPC) and the California Seismic Safety Commission which provides a persuasive advantage to affect federal policy for the West Coast.

National Programs & Organizations

American Planning Association (APA)

The APA's Hazards Planning Research Center brings together solutions from multiple disciplines into a single source. The center provides original and applied research to identify best practices that that protect communities from natural and man-made hazards. APAs efforts are accomplished through research, outreach, education, policy and resource guides and other publications. The APA is currently in the midst of an update of its 1998 PAS report, *Planning for Post-Disaster Recovery and Reconstruction* (No. 483/ 484). Updates on the project status and other news is provided on the websites blog, *Recovery News*.

Firewise

Firewise is a program developed within the National Wildland/Urban Interface Fire Protection Program, and it is the primary federal program addressing interface fire. It is administered through the National Wildfire Coordinating Group whose extensive list of participants includes a wide range of federal agencies. The program is intended to empower planners and decision makers at the local level. Through conferences and information dissemination, Firewise increases support for interface wildfire mitigation by educating professionals and the general public about hazard evaluation and policy implementation techniques. Firewise offers online wildfire protection information and checklists, as well as listings of other publications, videos, and conferences. www.firewise.org

FireFree Program – Bend, Oregon

FireFree is a unique private/public program for interface wildfire mitigation involving partnerships between an insurance company and local government agencies. It is an example of an effective non-regulatory approach to hazard mitigation. Originating in Bend, the program was developed in response to the city's "Skeleton Fire" of 1996, which burned over 17,000 acres and damaged or destroyed 30 homes and structures. Bend sought to create a new kind of public education initiative that emphasized local involvement. SAFECO Insurance Corporation was a willing collaborator in this effort. Bend's pilot program included:

- A short video production featuring local citizens as actors, made available at local video stores, libraries, and fire stations;
- Two city-wide yard debris removal events;

- A 30-minute program on a model FireFree home, aired on a local cable television station; and
- Distribution of brochures, featuring a property owner's evaluation checklist and a listing of fire-resistant indigenous plants.

The program continues to provide educational materials on fire risk reduction strategies and fire resistant plants.

National Flood Insurance Program (NFIP)

The function of the NFIP is to provide flood insurance to homes and businesses located in floodplains at a reasonable cost, and to encourage the location of new development away from the floodplain. The program is based upon mapping areas of flood risk, and requiring local implementation to reduce that risk, primarily through restrictions on new development in floodplains. Elevation Certificates are forms published by FEMA required to be maintained by communities participating in the NFIP. New development is required to be elevated or otherwise designed to protect against flooding. The NFIP requires local governments to obtain certificates for all new construction in floodplains and to keep the certificates on file. Local governments must insure that elevation certificates are filled out correctly for structures built in floodplains.

V-Zone Construction

In many of Oregon's coastal communities, FEMA has mapped "V zones" (velocity zones), areas of special flood hazard that are subject to high velocity wave action from storm surges or seismic events. Because of the potential force associated with this wave action, special regulations apply for new construction and substantial improvements in "V zones."

Community Rating System (CRS)

Community Rating System (CRS) is a program operated by the NFIP that recognizes communities who go beyond the minimum requirements of the NFIP. CRS offers reduced flood insurance premiums for communities who adopt higher standards and encourages community activities that reduce flood losses, facilitate accurate insurance rating, and promote flood insurance awareness.

FEMA Region 10 Policy on Fish Enhancement Structures in the Floodway

FEMA regulates development in the floodway. The regulations require that a community prohibit encroachments (including fill, new construction, and other development) within the floodway unless it is demonstrated by engineering analysis that the proposed encroachment will not result in any increase in flood levels during the occurrence of a 100-year flood event. The recent designation of several northwest salmon and steelhead runs as threatened or endangered has resulted in an increased effort to restore fish habitat. Restoring habitat often involves placing structures in stream.

Army Corps of Engineers Permit Program

The U.S. Army Corps of Engineers is responsible for the protection and development of the nation's water resources, including navigation, flood control, energy production through hydropower management, water supply storage and recreation. The Corps administers a permit program to ensure that the nation's waters are used in the public interest, and requires any person, firm, or agency planning work in the waters of the United States to first obtain a

permit from the Corps. Permits are required even when land next to or under the water is privately owned. It is a violation of federal law to begin work before a permit is obtained and penalties of fines and/or imprisonment may apply. Examples of activities in waters that may require a permit include: construction of a pier, placement of intake and outfall pipes, dredging, excavation and depositing of fill. Permits are generally issued only if the activity is found to be in the public interest. In Oregon, the Division of State Lands (DSL) and the U.S. Army Corps of Engineers jointly issue permits for development of these activities. As mentioned in the discussion of DSL permits, local planning agencies are required to sign off on any permits issued by DSL and the U.S. Army Corps of Engineers and water quality certification is required by the Department of Environmental Quality.

Pre-Disaster Hazard Mitigation Projects

Tsunami Evacuation Signs

Figure 4.D.4: Tsunami Hazard Zone

The Oregon Department of Transportation (ODOT) collaborated with DOGAMI, OEM, and coastal counties to develop signs denoting tsunami hazard zones, evacuation routes, and evacuation sites. ODOT manufactures the signs and makes them available to local governments at cost. The signs also have been used in California, Washington, Alaska, the Philippines, and Japan.

A project started in 2003 with OEM, DOGAMI, and coastal counties involved the development of signs that tell motorists when they are entering or leaving a tsunami hazard zone. The new signs have been placed on U.S. 101, the Pacific Coast Highway, when local communities establish the locations of their tsunami evacuation routes.

As local tsunami evacuation plans are developed, ODOT will work with communities to develop corresponding alternate route plans for U.S. 101 and other state highways.

Wind Erosion Control Practices

The Natural Resources Conservation Service (NRCS) and local soil and water conservation districts (SWCD) have long sought to reduce wind erosion of cropland. Farming practices commonly used in dryland cropping areas, such as reduced tillage and residue management, reflect this interest. However, occasionally after long periods with little or no precipitation any activities that disturb soil or reduce vegetation can lead to conditions conducive to dust storms.

Nationally, NRCS has developed quality criteria for wind erosion control practices and use a wind erosion equation model for predicting potential wind erosion under various farming systems.

Since 1985, to maintain eligibility for USDA Farm Program benefits, landowners have been required to meet minimum standards for control of erosion, both from water and wind. Participating farmers have developed and are responsible for implementing conservation plans for all farmland designated as highly erodible. Plans address practices such as residue management, tillage methods, and irrigation management.

At this time, wind erosion control is a requirement under the Federal Farm Bill for certain commodities such as wheat and corn, but depending on the rotation, may not be a

requirement for other commodities such as potatoes or vegetables. USDA-NRCS is generally responsible for these programs.

Wind erosion is ranked high among concerns for funding under the Environmental Quality Incentive Program, the current USDA cost-share program available to landowners.

No Till Cropping

SWCDs have been actively promoting, through education and incentives, direct seeding methods. Direct seeding or no-till cropping systems utilize technology that places seed and fertilizer into undisturbed soil and residue from the previous crop. This results in minimal soil disturbance and reduced potential for wind and water erosion.

Cooperative State Research, Education, and Extension Service (CSREES) funded research on the Columbia Plateau has demonstrated that no-till cropping can significantly reduce predicted dust emissions during severe winds:
http://www.csrees.usda.gov/nea/nre/sri/air_sri_dust.html

The research shows that no-till cropping can reduce predicted dust emissions by 94% during severe wind events, compared to conventional wheat-fallow. Research continues on measuring dust emissions from fields on the Columbia Plateau, a 50,000 square-mile region in Washington, Oregon, and Idaho containing one of the driest, yet most productive, rain-fed wheat regions in the world. No-till only works for some crops under certain conditions, however, and even in situations where it does work, some farmers find that they need to till the soil periodically to reduce diseases and redistribute soil moisture.

National Fire Plan

Under the National Fire Plan (NFP), funding opportunities for local WUI planning, prevention and mitigation projects first became available in 2000. Since that time, Oregon has aggressively sought funding for a wide variety of projects, including fuels reduction work, education and prevention projects, community planning, and alternative uses of fuels. As of early 2007 the ODF had received approximately $25 million. The majority of these monies have been used to fund fuels reduction projects on individual properties and to establish community fuel breaks in the most wildfire prone portions of the state. NFP funds have also been used to expand fire prevention efforts, to educate local officials about how they may help address the WUI situation, to implement Senate Bill 360, to improve public awareness about the wildfire problem, and to better identify areas especially exposed to wildland fire.

Trip Check

TripCheck is an online travel planning resource, developed by the Oregon Department of Transportation (ODOT) to provide travelers with the latest travel conditions and information via road cameras, continuous winter travel updates, year-round highway construction details, and other valuable tips. Several projects were included in providing the public with this resource, including installation of closed circuit television cameras on remote state highways, installation of Road Weather Information Systems (RWIS) on state highways. The RWIS's are used to make winter road maintenance decisions, and data is shared with the public. Installation of Wind Warning Systems on state highways to alert drivers to hazardous wind conditions at bridge crossings and along coastal highways.

Highway Advisory Radio

ODOT has coordinated the installation of Highway Advisor Radio transmitters for Highway Advisory Radio in select travel corridors. Locations include; installation of radio transmitters along Interstate 84 in Morrow and Umatilla counties for, and along the full length of US 101.

When an emergency occurs, the ODOT District 12 office selects the appropriate pre-recorded message on the system and transmits it via radio. At the same time, ODOT activates yellow flashing beacons. Motorists seeing the signs and flashing lights should tune to 1610 AM and comply with any messages. In the case of a dust storm, motorists are advised to slow down and exit the freeway as soon as possible. ODOT worked with OEM's Chemical Stockpile Emergency Preparedness Program office in Pendleton and local emergency management personnel on this project.

Also installed in the system is the ability to re-broadcast National Weather Service (NWS) weather information. NOAA Weather Radio is re-broadcast on a continuous basis unless there is an emergency. An emergency broadcast then overrides the NOAA Weather Radio service

ODOT Mitigation Efforts

ODOT has several implemented several hazard mitigation measures and increase motorists' safety, including:

- Installation of Debris Flow Warning Signs at designated locations on three at-risk highways: Oregon 38, Oregon 6, and I-84
- Installation of automated Flood Warning systems on some state highways - used to monitor water levels and to notify maintenance crews and the public of potentially hazardous conditions
- Installation of Snow Zone signs on state highways notifying motorists of chain and traction tire requirements ahead.
- Installation of Tsunami Zone signs on state highways.
- Installation of 511 statewide toll free telephone number - allows drivers to hear road and weather information by phone.

Publications / Studies

Energy Assurance Plan

As the designated State Energy Office, the Oregon Department of Energy (ODOE) is responsible for developing and maintaining the State Energy Emergency Plan under the State Energy Program. ODOE was required to review and update the State Energy Emergency Plan annually for submission to USDOE as the state energy Plan of Record.

The September 2009 Oregon Energy Emergency Response Plan was revised and renamed theOregon State Energy Assurance Plan as a result of a grant awarded to ODOE by the USDOE's Office of Electricity Delivery and Energy Reliability (DOE/OE) to enhance state government energy assurance resiliency. As a result, new information was added to the state's 2009 plan.

This includes information on seismic vulnerabilities and earthquake impacts on the critical energy infrastructure in Oregon from a magnitude 9 Cascadia Subduction Zone earthquake. Furthermore, the state is considering the integration of new energy portfolios like alternative

fuels as well as smart grid technologies into Oregon's response strategies to energy emergencies to improve energy assurance resiliency.

"Resiliency" is defined as the ability of a critical infrastructure to absorb, adapt to, and/or rapidly recover from a potentially severe and disruptive event. "Critical infrastructure" involve energy lifelines that, if disrupted, could significantly impact public health and safety, the economy, and/or national security. Any prolonged interruption of the supply of basic energy whether it is petroleum products, electricity, or natural gas - could do considerable harm. As a result, improving energy assurance and resiliency in Oregon's energy infrastructure is intended to help mitigate the impacts of an energy supply interruption and help the state return to normal conditions as quickly as possible, regardless of the cause of the interruption. Oregon's energy assurance and resiliency planning takes into account four key components. This includes: 1) understanding the energy infrastructure, Oregon's Energy Profile, and system interdependencies, 2) assessing potential risks and hazards threatening the state's critical energy infrastructure and considering short and long-term mitigation measures to reduce risk and vulnerability, 3) developing effective plans and procedures to help minimize the impacts of an energy supply interruption and rapidly restore the energy infrastructure should an emergency occur, and 4) increase public awareness. The Oregon State Energy Assurance Plan is designed to provide an overview of the first three components to help achieve the fourth component, which is to increase general awareness of the energy infrastructure, risks to the state energy lifelines, and the state's approach to restore fuel, power, and natural gas should an emergency occur.

The Oregon State Energy Assurance Plan is an introduction to how Oregon prepares for, responds to, and recovers from energy emergencies. The Oregon State Energy Assurance Plan complies with the National Association of State Energy Officials (NASEO) guidelines, the NASEO Energy Assurance Planning Framework, the National Response Framework, the National Infrastructure Protection Plan, and the National Incident Management System. The Oregon Energy Assurance Plan is also consistent with the Oregon Emergency Management Plan and Oregon Revised Statute (ORS) 401 to "coordinate the activities of all public and private organizations providing emergency services within this state." ODOE will review and update the Oregon State Energy Assurance Plan annually or as needed to reflect changing response trends and strategies and to incorporate

Oregon Climate Change Adaptation Framework (2010)

The plan would provide a framework for state agencies to identify authorities, actions, research, and resources needed to increase Oregon's capacity to address the likely effects of a changing climate.

Given the broad range of expected changes to Oregon's climate in the coming decades, the breadth of state-level responsibilities, authorities, and programs that will likely need to respond to the effects of future climate conditions, and limited time, it has only been possible to begin the development of a climate change adaptation strategy for Oregon. This report constitutes a *framework* for the continued development of strategies and plans to address future climate conditions. This Climate Change Adaptation Framework provides context, identifies risks, lays out short-term priorities, and provides momentum and direction for Oregon to prepare for future climate change. The framework has been developed in parallel with the Oregon Climate Assessment Report (OCAR) by the Oregon Climate Change Research Institute (OCCRI). The OCAR and this framework are intended to complement each other. The

OCAR identifies the most likely impacts from climate change, which will help the state prioritize resources to prepare for and adapt to a changing and variable climate. The OCCRI assisted in the development of this Framework.

This Framework lays out expected climate-related risks, the basic adaptive capacity to deal with those risks, short-term priority actions, and several steps that will evolve into a long-term process to improve Oregon's capacity to adapt to variable and changing climate conditions.

Oregon Climate Assessment Report (2010)

In 2007, the Oregon State Legislature charged the Oregon Climate Change Research Institute, via HB 3543, with assessing the state of climate change science including biological, physical and social science as it relates to Oregon and the likely effects of climate change on the state. This inaugural assessment report is meant to act as a compendium of the relevant research on climate change and its impacts on the state of Oregon. This report, published December 2010, draws on a large body of work on climate change impacts in the western US from the Climate Impacts Group at the University of Washington and the California Climate Action Team.

State Emergency Management Plan

This Natural Hazards Mitigation Plan is a document within Volume I, Preparedness and Mitigation, of the state Emergency Management Plan, administered by Oregon Emergency Management. The other volumes of the Emergency Management Plan are: Volume II, Emergency Operations Plan, and Volume III, Relief and Recovery.

Volume I: "Preparedness and Mitigation" includes the plans and guidance necessary for the state to prepare and mitigate the effects of a disaster. It includes the state disaster hazard assessment, exercise and training programs, and plans to lessen the physical effects of a disaster to citizens, the environment, and property. Volume I also includes this natural hazards mitigation plan.

Volume II: "Emergency Operations Plan," which is also referred to as the Basic Plan, describes in broad terms the organization used by the state to respond to emergencies and disasters. The EOP is supplemented by emergency Support Function Annexes, Support Annexes and Incident Annexes. It describes common management functions including areas common to most major emergencies or disasters such as communications, public information, and others.

Volume III: "Relief and Recovery" gives guidance, process and rules for assisting Oregonians with recovering from the effects of a disaster. It includes procedures to be used by government, business, and citizens.

State Fire Services Mobilization Plan

The State Fire Services Mobilization Plan is an all-hazard based plan used to mobilize fire resources to any incident beyond local fire service capabilities that are necessary to protect life, property, and the environment. It assumes the prior existence of mutual aid agreements that organize district and regional firefighting forces to cope with local emergencies.

The primary purpose of mutual aid is to supplement resources of a fire agency during a time of critical need. Mutual aid is based on reciprocal, non-reimbursed contributions for services rendered and is contingent upon a responding fire chief's approval. Mutual aid is given only when equipment and resources are available and dispatch will not jeopardize local firefighting capabilities.

Under the Emergency Conflagration Act, local firefighting forces will be mobilized when the state fire marshal believes that a fire or emergency is causing, or may cause, undue jeopardy to life and/or property and the Act is invoked by the governor.

For purposes of this plan, Oregon has been divided into fire defense districts. The Emergency Conflagration Act fire suppression resources of each fire defense district include the county, city and rural fire protection departments and districts, as well as any other resources available through mutual aid agreements.

The Mobilization Plan may be used separately from the Conflagration Act to mobilize local structural fire agencies for any emergency situation exceeding local mutual aid resources. However, reimbursement for responding resources is assured only when the governor invokes the Conflagration Act. Federal or state disaster assistance reimbursement may or may not apply to emergency services mobilizations.

The objectives of the Oregon Fire Service Mobilization Plan are:

- To provide organizational structure and operating guidelines for the expeditious mobilization and direction of Oregon fire service forces;
- To promote effective communication among agencies during the preparation for, progress of, and demobilization from a fire suppression operation or other emergency response activity;
- To effectively cooperate and coordinate the efforts of various participating agencies through the use of a common command structure and terminology;
- To ensure prompt, accurate and equitable apportionment of fiscal responsibility for fire suppression or other emergency response activity;
- To provide an OSFM Incident Management Team for effective support to local agencies and fire defense districts during major operations

Oregon's Communities at Risk Assessment

A statewide task force was formed in February 2004 as part of the Oregon Department of Forestry's Fire Program Review to develop a statewide assessment of *Communities at Risk*. The assessment was used to develop a statewide fuels strategy, and to help set large-scale priorities across geographic areas. A *Community at* Risk is a "geographic area within and surrounding permanent dwellings with basic infrastructure and services, under a common fire protection jurisdiction, government, or tribal trust or allotment, for which there is significant threat due to wildfire." The assessment identifies communities and assigns each a *low, moderate,* or *high* risk rating for *Risk, Hazard, Protection, Capability, Value,* and *Overall*.

The Water Quality Model Code and Guidebook is a companion to the Model Development Code and User's Guide for Small Cities. These documents were developed by the Department of Land Conservation and Development and the Department of Transportation under the Transportation and Growth Management Program (TGM). This guidebook integrates many of the "smart development" inspired code recommendations of the TGM project with recommended code language to achieve water quality objectives. The goal of this guidebook is to provide local communities, both small cities and counties, with a practical guide to protecting and enhancing water quality through improved land use regulations. The guidebook includes both model zoning code ordinances and comprehensive plan policies that are ready

for implementation. It also provides references to other publications and resources which provide background information on the link between development activity and water quality.

While Goal 7 does not point specifically towards the issue of water quality, Goal 7 compliance entails measures that will help improve water quality. This goal notes that comprehensive plans "should consider as a major detriment, the carrying capacity of the air, land and water resources… (and) should not exceed the carrying capacity of such resources." In protecting against floods and other natural disasters, local governments may jointly address issues of water quality, such as limiting development within floodways and reducing impervious surfaces that increase runoff and flooding.

DOGAMI Tsunami Evacuation Maps

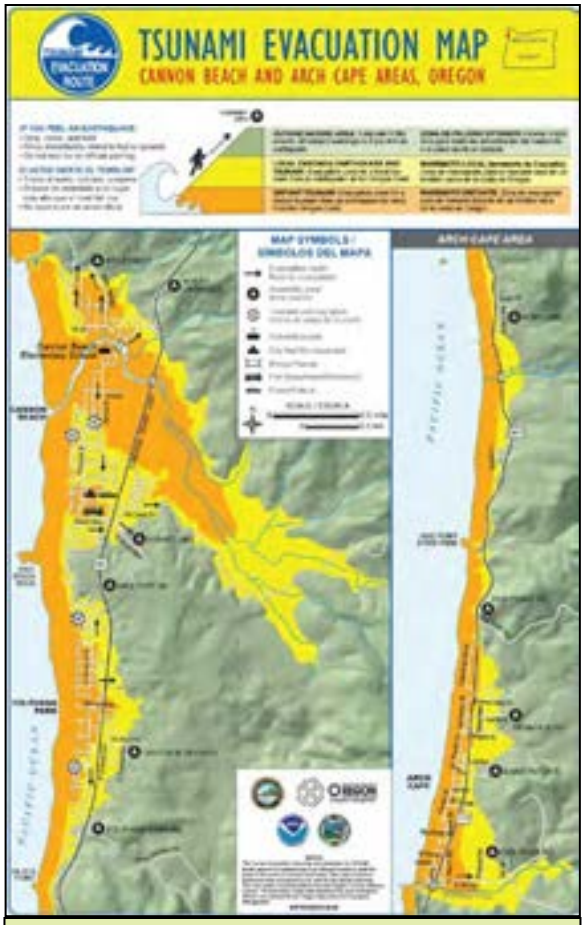


Figure 4.D.5. Cannon Beach-Arch Cape tsunami evacuation map, 2008, from DOGAMI web site, http://www.oregongeology.com/sub/earthquakes/Coastal/Tsubrochures.htm

The Department of Geology and Mineral Industries has statutory authority to take a lead role in the mitigation of geologic hazards statewide and assists the BCD in administering ORS 455.446 and .447. Tsunamis can potentially cause the most loss of life of any geologic hazard in the state, so mitigation and assessment of these hazards has a high priority in the agency

DOGAMI's Newport Coastal Field Office, in collaboration with OEM and DLCD is developing tsunami evacuation maps for every coastal population center. These maps and evacuation routes are also being compiled into an online Geographic Information System that is being developed for the coast by DLCD. Figure T-4 illustrates the 2008 format for evacuation maps in Oregon. The format prior to 2008 depicted only an evacuation zone based on a locally generated Cascadia tsunami. The 2008 map shows an additional, smaller evacuation zone appropriate for distant tsunamis. Strong ground shaking at the coast should trigger evacuation of the Cascadia zone, whereas the NOAA warning system will trigger evacuation of the distant tsunami zone.

DOGAMI, in collaboration with the Oregon Health and Science University and NOAA, has developed detailed tsunami inundation maps for several areas on the coast, including Gold Beach, Coos Bay, Siletz Bay (southern Lincoln City), Alsea Bay (Waldport), Yaquina Bay (Newport), Cannon Beach, Seaside-Gearhart, and Warrenton/Astoria.

The Cascadia Subduction Zone earthquake sources developed for maps produced prior to 2008 were also used as standards for similar mapping in Washington State. These sources for the northern Oregon coast and Washington were updated in a 2008 pilot study of Cannon Beach by DOGAMI (Figure 4.D.5).

These more detailed maps are used as guides for emergency response planning. DOGAMI plans to develop detailed inundation maps for other areas according to a priority list. Local steering groups established for each map project ensure that maps meet local needs. Local emergency officials review inundation and evacuation maps in the field to ensure that the boundaries are accurate and meet the practical necessities of local government.

DOGAMI also administers, in collaboration with local building codes officials, ORS 455.446 and ORS 455.447 that limit construction of critical and essential facilities in an official tsunami inundation zone. This regulatory zone was mapped along the entire coastline by DOGAMI in 1995. This zone is not appropriate for evacuation planning, but still gives some indication of the potential severity of tsunami flooding from a local earthquake on the Cascadia Subduction Zone.

The Public Education Team at DOGAMI develops and distributes numerous educational materials aimed at tsunami hazard mitigation. These materials can be obtained from them by contacting DOGAMI's retail outlet, the Nature of the Northwest Information Center (503-872-2750 or http://www.naturenw.org).

DLCD Tsunami Land Use Guide

DLCD released "Preparing for a Cascadia Subduction Zone Tsunami: A Land Use Guide for Oregon Coastal Communities" on January 15, 2014. Its purpose is to assist vulnerable communities as they incorporate tsunami resilience measures into their local land use programs. The guide can be tailored by communities for their individual risk and location. It includes information on map amendments, sample tsunami related comprehensive plan text and policies, a model tsunami hazard overlay zone, financing and incentive concepts, evacuation route planning assistance, and web links to other helpful information. The guide is designed to be used with the Department of Geology and Mineral Industries' Tsunami Inundation Maps (TIMs).

DLCD Water Quality Model Code and Guidebook

In Oregon it is no longer possible to ignore the connection between urban development and degraded water quality. Extensive findings demonstrate that our urban streams do not meet state water quality standards, and do not adequately support native salmon populations. The best way to reverse these trends is to think differently about land use planning at the local level. Local governments are already rethinking the connection between land use and transportation as it relates to air quality. The new challenge is to amend local plans and codes to protect water quality.

Mount Hood Coordination Plan

The Mount Hood Coordination Plan provides vital Mount Hood volcanic event response information for the areas that will be most affected by a volcanic event. The purpose of the Mount Hood Coordination Plan is to coordinate the actions that various agencies must take to minimize the loss of life and damage to property before, during, and after hazardous geologic events at Mount Hood volcano. The plan strives to ensure timely and accurate dissemination of warnings and public information.

Planning for Natural Hazards: Oregon Technical Resource Guide, 2000

Developed for DLCD by the Community Service Center's Oregon Natural Hazards Workgroup at the University of Oregon, the Technical Resource Guide (TRG) provides contacts, documents,

and internet resources to assist planners, emergency managers, and citizens in mitigating earthquake hazards along with several other hazards.

Natural Hazards Mitigation in Oregon: an Evaluation of Natural Hazards Mitigation Planning and Implementation in Oregon

In January 2010, the Oregon Partnership for Disaster Resilience (OPDR) at the University of Oregon's Community Service Center received a grant from the Hazard Mitigation Grant Program (HMGP) to facilitate and document the State's Enhanced Natural Hazards Mitigation Plan update process. As part of the plan update process, OPDR and the Department of Land Conservation and Development (DLCD) were tasked with conducting a survey of natural hazards mitigation planning in Oregon. This report is a summary of the findings of the natural hazards mitigation planning survey.

The survey assessed: 1) the extent to which natural hazards mitigation strategies were being implemented at the local level; and 2) the availability and applicability of technical resources designed to assist jurisdictions in planning for or mitigating the effects of natural hazards. Additionally, the survey asked for suggestions on how to make hazards planning and mitigation more effective at both the state and local levels.

Where applicable, results are compared to a similar survey that was conducted by DLCD and the University of Oregon's Community Planning Workshop (CPW) in 1998. Survey results will be used to inform content within the State's Enhanced Natural Hazards Mitigation Plan and to develop more effective long-term statewide mitigation efforts.

Seismic Vulnerability of Oregon State Highway Bridges, Mitigation Strategies to Reduce Major Mobility Risks, *Oregon Department of Transportation, November 2009*

This report describes potential damage to state highway bridges from six representative earthquake scenarios that are thought most likely to occur in Oregon. The study found that highway mobility would be severely reduced after a major Cascadia Subduction Zone event, as well as after a significant crustal earthquake. The report also considers possible mitigation, including bridge retrofit and strengthening to withstand seismic damage.

Figure 4.D.6. Seismic Vulnerability Report (ODOT,

Oregon Transportation Plan

A sound transportation network is what enables Oregonians to reach jobs and recreation access goods and services, and meet daily needs. Due to the extent of the existing transportation infrastructure, and the importance of sustaining that infrastructure, there are numerous ways in which Oregon's transportation system could be adversely affected by any of Oregon's natural hazards. Just as other critical infrastructure can be vulnerable to natural hazards, so too can Oregon's transportation system. The Oregon Transportation Plan addresses the risk and vulnerability to natural hazards by outlining strategies for reducing risk, such as "Evaluate the impacts of geological hazards and natural disasters including earthquakes, floods, landslides and rockfalls, on the efficiency and sustainability of the location and design of new or improved transportation facilities as appropriate."

Oregon Highway Plan

Oregon's state highways are a critical component of the state's transportation network. Oregonians rely on highways to go between the state's widespread cities, towns, parks, forests, and businesses. Oregon's industries, including agriculture, timber, tourism, and technology, all depend on highways.

The Oregon Department of Transportation owns, operates, and maintains 7,483 miles (12,040 kilometers) of roads in every corner of Oregon. The state highway system is as diverse as Oregon itself–ranging from six-lane, limited access freeways with metered ramp entrances in the Portland area to the gravel road from Prineville to Brothers. The challenge facing Oregon is to efficiently and effectively guide this diverse highway system into the next millennium. Oregon will continue to grow. Forecasts predict that the state will have 1.2 million new residents by 2020. With limited funding, intelligent investment strategies must be devised to help Oregon meet its long-term goals. Intelligent investments include planning for, and reduce vulnerability to natural hazards. The Oregon Highway Plan addresses this issue by recommending actions and policy elements that include identifying hazards, and improving the safety of potentially hazardous sites and corridors. Mitigation measures listed within the recommended actions include advance maintenance, structural reinforcement, flood proofing, emergency response planning, and development of emergency alternative routes. These risk reduction efforts can also bolster the State of Oregon's emergency response and post-disaster recovery efforts.

Drought Annex to the State Emergency Operations Plan

Droughts occur within drainage basins (watersheds) that usually involve more than one city or county. Some cities and counties benefit by planning on a regional level. The state Drought Annex provides information to facilitate regional planning efforts, model water curtailment measures for water utilities, and other strategies. It describes the state system for addressing drought emergencies, but it does not carry the force of law. Its purpose is to coordinate local, state, and federal agency response to drought emergencies and to provide water supplies for human consumption and use under conditions of inadequate supply.

Post-Disaster Hazard Mitigation Programs & Capabilities

Hazard Mitigation Grant Program

The state and local communities integrate mitigation into post-disaster recovery operations by taking advantage of Hazard Mitigation Grant Program (HMGP) dollars that become available after presidentially declared disasters.

OEM Disaster Recovery and Post-Disaster Mitigation

State post-disaster mitigation planning and project activities following disasters are an integral component of OEM's mission. OEM's Financial and Recovery Services Section provides oversight and administration of financial services and related funding that is passed through to local governments. Additionally, the Financial and Recovery Services Section manages disaster recovery activities for state and local governments in the event of a devastating emergency or disaster. Specifically, the Section Director, SHMO, Alternate SHMO, Facilities Engineer (Public Assistance Officer), Seismic Grants Coordinator, and financial support staff work together closely post-disaster mitigation grant programs and project activities. Although OEM has limited staff support available for post-disaster mitigation planning and project

implementation activities, the state is able to effectively secure and manage FEMA's HMGP grants.

OEM also staffs county liaisons that are assigned specific counties to support operations both during and after disasters. By working closely with the state's Public Assistance Officer, the state is able to identify early mitigation opportunities immediately following a disaster declaration that can frequently be implemented quickly as a component of Section 406 disaster assistance.

BCD Post-Earthquake Inspection Program

BCD supports training to inspectors, architects, engineers, contractors and post-earthquake inspectors by providing funding to agencies that provide training. Various classes in seismic design and construction techniques have been sponsored by the division during the last several years Other classes covering subjects such as soils classification, excavation and grading and landslides, which are often related to earthquakes, have also been sponsored.

BCD maintains a roster of persons qualified to inspect buildings following an earthquake. As part of this program, the division adopted rules establishing qualifications and training required to be registered as a post-earthquake damage inspector.

DEQ Emergency Response Program

DEQ's Emergency Response Program is designed to carry out legislative direction to work with other agencies and industry to prevent and respond to spills of oil and hazardous materials. Oil and hazardous material spills pose a major potential threat to Oregon's waters, air, land, and wildlife. Large volumes of oil move along the Columbia River and along the coast. Hazardous materials are shipped along the highways and by rail. DEQ works with other agencies and industry to prevent and respond to spills of these materials. The program also coordinates removal of drug lab materials which would otherwise present a risk to the public.

Office of State Fire Marshal – Conflagration Act

OSFM works in a collaborative role in helping to respond to WUI fire issues. As part of its fire prevention program, OSFM provides statewide standardization and technical assistance to local fire agencies and to communities with no structural fire protection. Coordination of structural firefighting resources occurs pursuant to the *Conflagration Act.* When directed by the Governor, the Act allows the State Fire Marshal to mobilize structural firefighting personnel and equipment, when a significant number of structures or lives are threatened by fire, and the local capacity to provide structural protection has been exhausted.

The *Conflagration Act* was established as a civil defense measure to provide a mechanism to mobilize structural fire suppression resources for massive urban fires. It was first used in 1959 to coordinate aid resulting from the explosion of a dynamite filled truck in downtown Roseburg. The Act was not invoked again until 1972, when a wildland fire in Yamhill County exceeded the capacity of local structural agencies to protect isolated structures and agricultural lands. Since then, the Act has been invoked more and more frequently – and nearly always for lightning caused wildfires threatening structures in the WUI. In the decade after 1977, the average number of declared conflagrations was about one per year. In the decade after 1987 (a record year) the average number of declarations per year more than doubled. Since 1998, the average has doubled again.

Under this law, only the Governor may invoke the Act to mobilize fire suppression resources from the across the state, but only if local resources, including what is available under mutual aid agreements, has first been fully committed. The increasing frequency of *Conflagration Act* utilization has caused funding concerns and challenges because no dedicated funds are set aside for this purpose. Especially troubling is the increasing frequency and public expectation to use the Act to protect structures in communities having minimal or nonexistent structural protection. Since 2002, with onset of stronger mitigation efforts, *Community Wildfire Protection Plans* along with ODF's surge in initial attacks on wildfires threatening structures, the use of the Act has dropped significantly.

OPDR Post-Disaster Recovery Planning for Catastrophic Disasters

In collaboration with the Cascadia Region Earthquake Workgroup (CREW), the United States Geological Survey (USGS), the City of Cannon Beach, and Oregon Emergency Management, OPDR developed a pilot long-term catastrophic post-disaster recovery planning process in the City of Cannon Beach. [2006]

OPDR developed a Post-Disaster Recovery Planning Forum: How-To Guide for communities desiring a framework to identify redevelopment issues they will face after a disaster. [2007]

OPDR assisted Douglas County in obtaining over $250,000 in grant funding from the Federal Emergency Management Agency to develop long-term, catastrophic post-disaster recovery plans for Coos, Curry, Douglas, and Lane Counties. [2009 – 2011]

Funding Sources

Funding Overview

Oregon utilizes a number of local, state and federal funding sources to support natural hazard mitigation projects and planning. In general, FEMA Hazard Mitigation Assistance (HMA) grants figure prominently in the state's funding strategy. Several of the grant programs are available "pre-disaster" while others are available only after a federally declared disaster has occurred.

State funding to support hazard mitigation and risk reduction remains limited. However, Oregon has an excellent track record of leveraging limited local resources to successfully complete mitigation planning and projects throughout the state. State funding often consists of "General Fund" money that pays for the labor costs of state officials who are working to support local and statewide hazard mitigation activities. These labor costs are often used as non-federal cost-share for projects that are otherwise federally funded. For example, all of OEM's mitigation staff are funded in part by state dollars that are used to match other federal, homeland security based funding sources. Notably, the majority of state-level staff positions dedicated to hazard mitigation planning and implementation (and a growing number of those at the local level) are funded through federal programs or grants.

Chief among the federal funding sources used to support local mitigation planning in Oregon is FEMA's Pre-Disaster Mitigation Grant Program (PDM). PDM funds generally support one or more local mitigation projects each year as well. The Flood Mitigation Assistance Program (FMA) provides federal funds for flood hazard planning, flood mitigation projects or both. FMA priorities for funding are (1) mitigation plans, (2) projects that mitigate Severe Repetitive Loss

(SRL) properties and (3) projects that mitigate Repetitive Loss (RL) properties. Because Oregon is so successful at developing and updating mitigation plans through the PDM program, FMA funds are used exclusively for SRL and RL flood mitigation project grants.[3] FEMA's Risk MAP program also provides funding for hazard studies, flood mapping products, risk assessment tools, mitigation, and planning and outreach support

Post-disaster, the Hazard Mitigation Grant Program (HMGP), Public Assistance (PA) Program, and Small Business Association's (SBA) Physical Disaster Loan Program each support varying levels and types of mitigation planning and projects. Oregon has experienced ten presidentially declared disasters over the past 10-years. Each of these disaster declarations has opened up funds through HMGP that Oregon has used to support local and statewide hazard mitigation planning as well as numerous local mitigation projects.

In addition, cities, counties and special districts utilize a variety of funding mechanisms to support local mitigation projects. Capital improvement funds, service fees, general funds, levies and local grants are used to support mitigation projects across Oregon. For example, Lincoln County voters have approved several bond measures that specifically supported the relocation of schools outside the tsunami inundation zone. In one case, local bond funds leveraged the first FEMA supported (PDM) tsunami school buy-out in the nation. These examples reflect the creative, innovative and pro-active methods communities in Oregon are using to support risk reduction.

Given the annual uncertainty regarding the availability of HMA Grants[4], Oregon is actively pursuing opportunities to expand funding for local mitigation planning and projects. In 2013, the state augmented its technical assistance capability by hiring two full-time staff in DLCD focused exclusively on natural hazard mitigation, with implementation of Goal 7 as one of their core activities. In 2014, several state agencies are working on significantly increasing current funding levels and establishing stable funding for hazard mitigation beginning with the 2015-2017 budget cycle. These efforts include requests for additional staff; state funds to provide local governments with at least a portion of the non-federal cost-share required to obtain and use federal hazard mitigation grants; and funding hazard identification studies, improvements to the current risk assessment methodologies, and enhanced risk communication technology. As with federal funding, appropriation of funds depends on budget priorities and politics, so the level of funding to support local hazard mitigation planning and projects will always fluctuate. The state may need to explore private foundations and public-private partnerships to expand its funding capacity.

Federal Funding Sources Pre-Disaster

UNIFIED HAZARD MITIGATION ASSISTANCE (HMA)

According to the 2013 HMA Program Guidance, U.S. Department of Homeland Security (DHS) Federal Emergency Management Agency (FEMA) HMA programs present a, ". . .critical opportunity to reduce the risk to individuals and property from natural hazards while simultaneously reducing reliance on Federal disaster funds.". HMA programs provide funding

[3] Because FMA funds can only be used to update the flood hazard chapter of a local mitigation plan, Oregon has not historically pursued mitigation planning grants through FMA.

[4] The PDM Grant program has been zeroed out in each of the past two Presidential Budgets. Congress has subsequently directed funds to be put back in to PDM. This illustrates the uncertain nature federal funding.

for eligible mitigation planning and project activities. HMA programs are intended to reduce community vulnerability to disasters. Specific information about each HMA grant program is presented below.

Pre-Disaster Mitigation Grant Program

The Pre-Disaster Mitigation (PDM) Program is funded annually. Each state receives a set amount. Additional funds are available on a competitive basis. The program supports mitigation planning as well as cost-effective hazard mitigation (risk reduction) projects. To be eligible for PDM funds, states and tribes are required to have an approved local mitigation plan prior to the approval of PDM project grant. Similarly, local jurisdictions must also have an approved NHMP in place in order to receive funds. These requirements demonstrate why the development of state and local natural hazard mitigation plans is a high priority in Oregon. PDM grants are offered on a 75% federal share with a required 25% non-federal match.

Flood Mitigation Assistance Program

The Flood Mitigation Assistance (FMA) Program was authorized by the National Flood Insurance Reform Act of 1994 and amended by the Biggert-Waters Flood Insurance Reform Act of 2012.[5] The FMA Program provides Federal grant funds to pay for up to 100% of the cost of eligible mitigation activities, such as elevating SRL structures. In addition, mitigated properties may qualify for reduced flood insurance rates.

The overall goal of the Flood Mitigation Assistance (FMA) Program is to fund cost-effective measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other National Flood Insurance Program (NFIP) insurable structures. FMA prioritizes mitigation of SRL and RL properties. Example projects include:

- Acquisition or relocation of at-risk structures and conversion of the property to open space;
- Elevation of existing structures; or
- Dry floodproofing of historic properties.

There are three types of FMA Program grants:

- Planning Grants - to prepare flood mitigation plans;
- Project Grants - to implement measures to reduce flood losses, such as elevation, acquisition or relocation of NFIP-insured structures; and
- Management Cost Grants - for the grantee to help administer the FMA program and activities.

The Oregon Military Department's Office of Emergency Management is the grantee for FMA Program grants; cities and counties are eligible sub-applicants. As of this writing, FEMA is selecting eligible planning and project sub-applications in accordance with the applicant's priorities for the grant year. Currently, funding is only available for flood mitigation planning or SRL/RL mitigation projects.

[5] The Biggert-Waters Flood Insurance Reform Act of 2012 eliminated the Severe Repetitive Loss (SRL) and Repetitive Flood Claims (RFC) Programs.

Federal Funding Sources Post-Disaster

HAZARD MITIGATION GRANT PROGRAM

FEMA's Hazard Mitigation Grant Program (HMGP) was created in November 1988 under the authority of the Stafford Act, Section 404. The HMGP assists states and local governments to implement long-term hazard mitigation measures following a Presidential major disaster declaration. Initially, the federal cost-share for projects was established at 50%; however, in 1993 that portion was increased to 75% of a project's total eligible costs. Objectives of HMGP include:

- preventing loss of lives and property due to disasters;
- implementing state and local hazard mitigation plans;
- enabling mitigation measures to be implemented during immediate recovery from a disaster; and
- providing funding for previously identified mitigation measures that benefit the disaster area.

Effective November 2004, the state and its applicants must minimally have a FEMA-approved natural hazards mitigation plan (44 CFR Section 201) to qualify for HMGP funding. Eligible applicants for the HMGP are the same as for the Public Assistance Program (Stafford Act, Section 406):

- state and local governments (including special districts);
- certain private nonprofit organizations or institutions; and
- Native American nations and authorized organizations (in Oregon these entities have a direct relationship with FEMA and do not apply through the state).
- Homeowners and businesses, whose properties can benefit from hazard mitigation measures, cannot apply directly for HMGP funding, but rather must be represented by an eligible applicant, such as the city or county where their project is located.

HMGP activities are managed by the Office of Emergency Management as grantee. The state develops a program administrative plan, solicits applicant interest and project applications, establishes priorities and selection criteria, reviews and selects projects. FEMA reviews all projects submitted by the state, conducts the required environmental reviews and benefit/cost analyses, and approves projects for funding.

The amount of HMGP funding available to the state is calculated at 15% of the federal funds spent on FEMA Public Assistance and Human Services Programs (minus administrative expenses) for each disaster. When a state has a FEMA-approved *enhanced* state hazard mitigation plan (Section 201.5), the calculated amount of HMGP funding increases to 20% of the federal funds spent on FEMA Public Assistance and Human Services Programs.

HMGP allows the state to set-aside up to 5% of the total obligation for projects that are not specifically hazard mitigation, such as warning systems. Another set-aside of 7% of the total HMGP obligation can be earmarked to state and local naturals hazards mitigation planning.

Although HMGP project funding is intended for use in the disaster-declared counties, it can be, at the state's request, used in non-declared counties for eligible hazard mitigation projects.

Public Assistance Program

The FEMA Public Assistance (PA) Program (Stafford Act, Section 406) provides disaster response and recovery assistance to communities following a Presidential Disaster Declaration. PA primarily supports debris removal, emergency protective measures, and the repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain Private Non-Profit (PNP) organizations. However, PA also encourages protection of these damaged facilities from future events by providing assistance for hazard mitigation measures during the recovery process. Federal assistance is provided at 75% or more of the eligible costs with the balance of funds provided by the grantee/sub-grantee.

Physical Disaster Loan Program

When Physical Disaster Loans are made to homeowners and businesses by the U.S. Small Business Administration (SBA) following disaster declarations, up to 20% of the loan amount can go toward specific measures taken to protect against recurring damage in similar future disasters.

Increased Cost of Compliance (ICC)

The Standard Flood Insurance Policy has a provision that will pay the policy holder to comply with a state or local floodplain management law or ordinance regulating repair or reconstruction of a structure that has suffered flood damage and meets other eligibility criteria, such as receiving a substantial damage or repetitive loss determination from a local official. Mitigation activities eligible for payment are: elevation, floodproofing, relocation, or demolition (or any combination of these activities) of the structure. The private-party premium payments are considered non-federal cost share as long as the claim is made within the timeframes allowed by the NFIP. In addition, if the ICC payment is being used as a sub-applicant's non-Federal cost share, the NFIP policy holder must assign the claim to the subapplicant (city or county).Policyholders may receive up to $30,000 under this coverage.

General Fund

State general fund" money pays for the labor costs of state officials who are working on mitigation projects for their agencies; these labor costs can be used as non-federal cost-share for projects that are otherwise federally funded. The state also occasionally contributes cash match through one of several funding mechanisms, such as portions of state agency budgets that are funded by a state source of revenue.

Seismic Rehabilitation Grant Program

The Seismic Rehabilitation Grant Program (SRGP) provides state funds to strengthen public schools and emergency services buildings so they will be less damaged during an earthquake. For more information on the SRGP see *Senate Bill 3 (2005): Statewide Earthquake Rehabilitation Grant Program* (pages XX-XX).

Community Development Block Grant

Community Development Block Grants (CDBG) are made available to communities in the State of Oregon, usually via the Infrastructure Finance Authority with funding provided by the U.S. Department of Housing and Urban Development (HUD). While these grants originate with a

federal agency, the funding is usually considered non-federal for matching grant purposes (i.e., CDBG can usually be utilized as non-federal match to other federal funding sources).

In 1981 Congress amended the Housing and Community Development Act of 1974 (HCD Act) to give each state the opportunity to administer CDBG funds for non-entitlement areas. These areas include those local governments that do not receive CDBG funds directly from HUD as part of the entitlement program (entitlement cities and urban counties). Non-entitlement areas are cities with populations of less than 50,000, and counties with populations of less than 200,000 although some entitlement cities have a population of less than 50,000 (cities that are designated central cities of metropolitan statistical areas).

The primary statutory objective of the CDBG Program is to develop viable communities by revitalizing neighborhoods, expanding affordable housing and economic opportunities, and improving community facilities and services, principally for persons of low and moderate income. The state must ensure that a specified percent of its CDBG grant funds are used for activities that benefit low and moderate-income persons over a three-year time period.

However, states may also use their funds to meet other urgent community development needs. A need is considered urgent if it poses a serious and immediate threat to the health or welfare of the community, has arisen in the past 18 months, and the project serves primarily low to moderate-income residents. For example, funds can be used as the non-federal match for eligible HMGP, PDM, and FMA Program projects.

Community Development Block Grant – Disaster Recovery

In addition to CDBG funds made available to the state on an annual basis, special HUD funding can become available to the state as a result of natural disasters. This HUD assistance supplements assistance from FEMA and other federal agencies. Traditionally, funds provided via HUD disaster recovery initiatives can be used for long-term recovery efforts, property acquisitions, relocations, and other efforts to reduce future damage. The program is intended to give communities flexibility in meeting local needs quickly. Unless restricted by regulation, these funds can also be used as non-federal, local match for eligible HMGP, PDM, and FMA Program projects.

Congressional supplemental appropriations provide HUD disaster funds. For example, in late 1998, funds were provided to address unmet disaster-related needs in communities affected by recent Presidentially declared disasters. Unmet needs were those that were not addressed by federal disaster relief and recovery programs following these declared disasters. OECDD (now IFA) was directed to administer these supplemental funds in Oregon for the Crook County and Prineville floods of May and June 1998. These particular HUD funds carried a requirement for other non-federal match.

Oregon Watershed Enhancement Board

Previously known as the Governor's Watershed Enhancement Board (GWEB), the Oregon Watershed Enhancement Board (OWEB) was created by the 1987 Oregon Legislature. OWEB is charged with supporting implementation of *The Oregon Plan for Salmon and Watersheds*, which includes the Oregon Coastal Salmon Restoration Initiative (OCSRI) and the Healthy Streams Partnership.

In 1995 the Legislature directed OWEB to provide support to watershed councils. OWEB directs a grant program through the Natural Resources Division of the Oregon Department of

Agriculture by which each of the state's 45 soil and water conservation districts may apply for funds for watershed enhancement projects.

While OWEB's primary responsibilities are implementing projects addressing coastal salmon restoration and improving water quality statewide, these projects can sometimes also benefit efforts to reduce flood and landslide hazards. For example, XXX In addition, OWEB conducts watershed workshops for landowners, watershed councils, educators, and others, and conducts a biennial conference highlighting watershed efforts statewide.

Funding for OWEB programs comes from the general fund, state lottery, timber tax revenues, license plate revenues, angling license fees, and other sources. OWEB awards approximately $20 million in funding annually.

Table XXX. Potential Hazard Mitigation Funding Programs

Program Activity	Type of Assistance	Agency & Contact
Basic & Applied Research/Development		
Community Resilience to Coastal Hazards & Climate Change	Physical and social science research aimed at better understanding ocean and coastal processes and the socio-economic barriers to hazard and climate change preparation.	Oregon State University – Oregon Sea Grant http://seagrant.oregonstate.edu/coastal-hazards-and-climate-change
Decision, Risk, and Management Science (DRMS) Program	**Funding** for research and related educational activities on risk, perception, communication, and management (primarily technological hazards)	**NSF** – Directorate for Social, Behavioral and Economic Science, Division of Social Behavioral and Economic Research, Decision, Risk, and Management Science Program (DRMS). http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5423
Disaster Resilience for Rural Communities	Basic **research** in engineering and in the social, behavioral, and economic sciences on enhancing disaster resilience in rural communities.	**USDA** – National Institute of Food and Agriculture http://www.csrees.usda.gov/fo/disasterresilienceforruralcommunities.cfm
Disaster Resilient Oregon	Coalition of public, private, and professional organizations working collectively with graduate students and University of Oregon faculty toward the mission of creating a disaster resilient and sustainable state.	University of Oregon – Oregon Partnership for Disaster Resilience http://csc.uoregon.edu/opdr/
Hazard Mitigation and Structural Engineering (HMSE)	Supports fundamental **research** to mitigate impacts of natural and anthropogenic hazards on civil infrastructure and to advance the reliability, resiliency, and sustainability of buildings and other structures.	National Science Foundation (NSF), Directorate for Engineering, Division of Civil, Mechanical and Manufacturing Innovation. www.nsf.gov/funding/pgm_summ.jsp?pims_id=13358&org=CMM
National Earthquake Hazard Reduction Program (NEHRP) in Earth Sciences	**Research** into basic and applied earth and building sciences.	**NSF** – Directorate for Geosciences, Division of Earth Sciences: (703) 306-1550 http://www.nehrp.gov/index.htm
Natural Hazards Gateway	**Research** into the natural hazards facing the nation. Additionally, provides education and real - time data on natural hazards.	**DOI –** US Geological Survey (USGS) www.usgs.gov/hazards
Societal Dimensions of Engineering, Science, and Technology Program	**Funding** for **research** and related educational activities on topics such as ethics, values, and the assessment, communication, management and perception of risk	**NSF** – Directorate for Social, Behavioral and Economic Science, Division of Social, Behavioral and Economic Research, Societal Dimensions of Engineering, Science and Technology Program. http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5323&org=NSF

Program Activity	Type of Assistance	Agency & Contact
Science, Technology and Society (STS) Program	Funding for research into the historical, philosophical, and sociological questions that arise in connection with science, engineering, and technology, and their respective interactions with society.	
Technical and Planning Related Assistance		
Coastal Management Training	Program provides **training** on subjects ranging from coastal hazards to climate adaptation. User selects training format (in-person, on-line, etc.)	NOAA Coastal Services Center (CSC) http://www.csc.noaa.gov/training/
Community Assistance Grants	Grants to communities in Oregon and Washington for **planning** and projects related to wildfire.	Oregon Department of Forestry (via National Forest Service and the Pacific Northwest Wildfire Coordinating Group). http://www.fs.fed.us/r6/fire/fireplan/apply/
Disaster Mitigation Planning and Technical Assistance	**Technical and planning assistance** grants for capacity building and mitigation project activities focusing on creating disaster resistant jobs, workplaces and economies.	Department of Commerce (**DOC**), US Economic Development Administration (EDA) http://www.eda.gov/funding-opportunities/ http://csc.uoregon.edu/eda/
Emergency Management / Mitigation Training	**Training** in disaster mitigation, preparedness, planning.	Federal Emergency Management Agency (FEMA) Emergency Management Institute (EMI) http://www.training.fema.gov/
Environmental Quality Incentives Program (EQIP)	**Technical**, educational, and limited **financial assistance** to encourage environmental enhancement.	**USDA-NRCS** www.nrcs.usda.gov
National Dam Safety Program	**Technical assistance,** training, and grants to help improve State dam safety programs.	Federal Emergency Management Agency (FEMA) http://www.fema.gov/about-national-dam-safety-program
National Earthquake Hazard Reduction Program	**Technical and planning assistance** for activities associated with earthquake hazards mitigation.	**FEMA, DOI-USGS** Earthquake Program Coordinator: http://www.nehrp.gov/
National Flood Insurance Program	**Formula grants to States** to assist communities to comply with NFIP floodplain management requirements (Community Assistance Program).	FEMA http://www.fema.gov/business/nfip/
Risk Mapping, Assessment, and Planning (Risk MAP) Program	Risk MAP provides technical assistance aimed at delivering quality data that increases public awareness and leads to action that reduces risk to life and property.	Federal Emergency Management Agency (FEMA) http://www.fema.gov/risk-mapping-assessment-planning Department of Land Conservation and Development http://www.oregonriskmap.com/

Program Activity	Type of Assistance	Agency & Contact
Silver Jackets (Oregon)	Interagency team dedicated to establish and strengthen **intergovernmental partnerships** at the state level as a catalyst in developing comprehensive and sustainable solutions to state flood hazard challenges	US Army Corps of Engineers; Federal Emergency Management Agency; Oregon Interagency Hazard Mitigation Team. http://www.nfrmp.us/state/factOregon.cfm
Volcano Hazards Program	**Technical assistance**: Volcano hazard warnings and operation of four volcano observatories to monitor and assess volcano hazard risk.	**DOI-USGS** Volcanic Hazards http://volcanoes.usgs.gov/
Watershed Protection and Flood Prevention Program	Watershed and Flood Prevention Operations provides **technical and financial assistance** in authorized watershed projects which have public sponsors.	USDA-NRCS http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wfpo/
Hazard ID & Mapping		
Climate Data, Products and Services	Provides science and information for a climate-smart nation.	NOAA http://www.climate.gov/maps-data
Conservation Gateway	The Gateway provides information on conservation planning and adaptive management, conservation topics and geographic implications. Includes the West Wide Wildfire Risk Assessment in addition to many other tools.	The Nature Conservancy https://www.conservationgateway.org/Pages/default.aspx https://www.conservationgateway.org/Files/Pages/west-wide-wildfire-risk-a.aspx
National Flood Insurance Program: Flood Mapping	**Flood insurance rate maps** and flood plain management maps for all NFIP communities;	FEMA https://msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1
National Flood Insurance Program: Technical Mapping Advisory Council	**Technical guidance and advice** to coordinate FEMA's map modernization efforts for the National Flood Insurance Program.	DOI-**USGS** – National Mapping Division:
National Digital Orthophoto Program	Develops **topographic quadrangles** for use in mapping of flood and other hazards.	DOI-USGS – National Mapping Division: http://www.ndop.gov/
National Earthquake Hazards Program	Seismic mapping for U.S.	DOI-USGS http://www.nehrp.gov/ http://earthquake.usgs.gov/ http://earthquake.usgs.gov/earthquakes/map/
National Geophysical Data Center (NGDC)	NGDC provides stewardship, products, and services for geophysical data from our Sun to Earth and Earth's sea floor and solid earth environment, including Earth observations from space.	http://maps.ngdc.noaa.gov/index.html http://maps.ngdc.noaa.gov/viewers/hazards/

Program Activity	Type of Assistance	Agency & Contact
Oregon Hazard Mapping	Results of geologic studies presented in a variety of formats including CD-ROM disks, computer files, and publications such as maps, books, open-file reports, special papers and brochures. Includes the Oregon Lidar Consortium, Oregon HazView and other mapping resources.	Oregon Department of Geology and Mineral Industries http://www.oregongeology.org/sub/pub%26data/pub%26data.htm http://www.oregongeology.org/sub/hazvu/index.htm http://www.oregongeology.org/sub/projects/olc/
Oregon Explorer	Information to help citizens, planners, and policymakers make more informed decisions about Oregon's natural resources and communities.	Oregon State University – Institute for Natural Resources http://oregonexplorer.info/northcoast/NaturalHazards
Risk Mapping, Assessment, and Planning (Risk MAP) Program	Risk MAP provides technical assistance aimed at delivering quality data that increases public awareness and leads to action that reduces risk to life and property.	Federal Emergency Management Agency (FEMA) http://www.fema.gov/risk-mapping-assessment-planning Department of Land Conservation and Development http://www.oregonriskmap.com/
Sea Level Rise and Coastal Flooding Impacts Viewer	Tool visualizes potential impacts from sea level rise.	NOAA Digital Coast http://www.csc.noaa.gov/digitalcoast/tools/slrviewer
Soil Survey	**Maintains soil surveys** of counties or other areas to assist with farming, conservation, mitigation or related purposes.	USDA-NRCS http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
Stream gauging and Flood Monitoring Network	Operation of a **network of over 7,000 stream gaging stations** that provide data on the flood characteristics of rivers.	DOE-USGS http://water.usgs.gov/wid/FS_209-95/mason-weiger.html
US Drought Monitor	Maintains up to dare national and regional drought map resources.	Partnership between the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. http://droughtmonitor.unl.edu/
Project Support		
The Agricultural Conservation Easement Program (ACEP)	Provides **financial and technical assistance** to help conserve agricultural lands and wetlands and their related benefits.	USDA Natural Resources Conservation Service http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/easements/acep/?cid=stelprdb1242695
Aquatic Ecosystem Restoration	**Direct support** for carrying out aquatic ecosystem restoration projects that will improve the quality of the environment.	DOD-USACE http://www.aquatics.org/

Program Activity	Type of Assistance	Agency & Contact
Association of State Floodplain Managers	Promotes education, policies, and activities **(information)** that mitigate current and future losses, costs, and human suffering caused by flooding, and to protect the natural and beneficial functions of floodplains - all without causing adverse impacts.	ASFPM http://www.floods.org/
Beneficial Uses of Dredged Materials	**Direct assistance** for projects that protect, restore, and create aquatic and ecologically-related habitats, including wetlands, in connection with dredging an authorized Federal navigation project.	DOD-USACE http://el.erdc.usace.army.mil/dots/budm/budm.cfm
Clean Water Act Section 319 Grants	**Grants to States** to implement nonpoint source programs, including support for non-structural watershed resource restoration activities.	Environmental Protection Agency http://water.epa.gov/polwaste/nps/cwact.cfm
Coastal Zone Management Program	**Grants** for planning and implementation of non-structural coastal flood and hurricane hazard mitigation projects and coastal wetlands restoration.	Department of Commerce **DOC** National Oceanic and Atmospheric Administration (**NOAA**) http://coastalmanagement.noaa.gov/funding/welcome.html
Coastal Services Center Grant Opportunities	**Formula and program enhancement grants** for implementing and enhancing Coastal Zone Management programs that have been approved by the Secretary of Commerce.	National Oceanic and Atmospheric Administration (NOAA) http://www.csc.noaa.gov/funding/
Coastal Wetlands Conservation Grant Program	Matching **grants to states** for acquisition, restoration, management or enhancement of coastal wetlands.	US Fish and Wildlife Service http://www.fws.gov/Coastal/CoastalGrants/index.html
Community Assistance and Protection Program	Mitigation/prevention experts offer mitigation/prevention **support, education, and outreach** that addresses reduction of wildland fire threats and losses to communities and natural resources by taking actions before a fire starts.	Bureau of Land Management (BLM), Fire and Aviation http://www.blm.gov/nifc/st/en/prog/fire/community_assistance.html

Program Activity	Type of Assistance	Agency & Contact
Community Development Block Grant (CDBG) State Administered Program	**Grants to States** to develop viable communities (e.g., housing, a suitable living environment, expanded economic opportunities) in non-entitled areas, for low- and moderate income persons. Includes suite of relevant programs including Entitlement Communities, Section 108 Loan Guarantee Program, and Disaster Recovery Assistance.	US Department of Housing and Urban Development **(HUD)** http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs
Community Development Block Grant (CDBG) Disaster Recovery Assistance	Provides **flexible grants** to help cities, counties, and States recover from Presidentially declared disasters, especially in low-income areas, subject to availability of supplemental appropriations	US Department of Housing and Urban Development http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs/drsi
Disaster Assistance for State Units on Aging (SUAs)	Provide disaster relief **funds** to those SUAs and tribal organizations who are currently receiving a grant under Title VI of the Older Americans Act.	Administration on Aging. http://www.aoa.gov/
Economic Administration Grants	EDA provides support and funds post disaster (pending congressional approval) to support economic recovery and mitigation in disaster areas.	Economic Development Administration http://www.eda.gov/about/disaster-recovery.htm
Emergency Watershed Protection Support Services	**Funds** for public and private landowners to implement emergency measures in watersheds to relieve imminent hazards to life and property created by a natural disaster.	**USDA Natural Resources Conservation Service.** http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/ewp/
Farm Service Agency Conservation Programs	Transfers title of certain inventory farm properties owned by FSA to Federal and State agencies for **conservation** purposes (including the restoration of wetlands and floodplain areas to reduce future flood potential)	US Department of Agriculture (**USDA**) –Farm Service Agency (**FSA**) http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=landing
Federal Land to Parks Program	Identifies, assesses, and transfers available Federal real property for acquisition for State and local parks and recreation, such as open space.	DOI-National Park Service http://www.nps.gov/ncrc/programs/flp/index.htm
Firewise Communities Program	To save lives and property from wildfire, NFPA's Firewise Communities program **teaches** people how to adapt to living with wildfire and encourages neighbors to work together and take action now to prevent losses.	Firewise Communities http://www.firewise.org/

Program Activity	Type of Assistance	Agency & Contact
Forest Stewardship Program	Helps family forestland owners with hazard reduction **training and funding** to assist with thinning and other actions to reduce wildfire hazard.	**USDA – US Forest Service** http://www.fs.fed.us/spf/coop/programs/loa/fsp.shtml
Hazard Mitigation Assistance	Grant programs designed to provide **funding** to protect life and property from future natural disasters.	Federal Emergency Management Agency (FEMA) http://www.fema.gov/hazard-mitigation-assistance
Highway Bridge Replacement and Rehabilitation	Deficient highway bridges on all public roads may be eligible for replacement or rehabilitation.	USDOT – Federal Highway Adminstration https://www.fhwa.dot.gov/bridge/hbrrp.cfm
HOME Investment Partnerships Program	Provides **formula grants to States** and localities to fund a wide range of activities including building, buying, and/or rehabilitating affordable housing for rent or homeownership.	US Department of Housing and Urban Development http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/affordablehousing/programs/home/
Indian Housing Assistance (Housing Improvement Program)	**Project grants and technical assistance** to substantially eliminate sub-standard Indian housing.	HUD Office of Public and Indian Housing http://portal.hud.gov/hudportal/HUD?src=/program_offices/public_indian_housing
Land Trusts	Land trusts assist with the **preservation** of open spaces, scenic vistas, working landscapes and natural areas.	Coalition of Oregon Land Trusts (for more information) http://oregonlandtrusts.org/
National Database of State and Local Wildfire Hazard Mitigation Programs	**Information clearinghouse** related to nonfederal policies and programs that seek to reduce the risk of loss of life and property through the reduction of hazardous fuels on private lands.	USDA – US Forest Service http://www.wildfireprograms.usda.gov/
National Flood Insurance Program (NFIP)	Makes available **flood insurance** to residents of communities that adopt and enforce minimum floodplain management requirements.	FEMA http://www.fema.gov/business/nfip/
National Tsunami Hazard Mitigation Program	Program provides a coordinated, national effort to assess tsunami threat, prepare community response, issue timely and effective warnings, and mitigate damage.	Coordinated by **NOAA**, **USGS,** and **FEMA**. http://nws.weather.gov/nthmp/
Partners for Fish & Wildlife Program	Provides **financial and technical assistance** to **private landowners** interested in restoring degraded wildlife habitat.	US Fish and Wildlife Service http://www.fws.gov/partners/

Program Activity	Type of Assistance	Agency & Contact
Public Assistance Program (Infrastructure)	**Grants to States and communities** to repair damaged infrastructure and public facilities, and help restore government or government-related services. Mitigation funding is available for work related to damaged components of the eligible building or structure.	Federal Emergency Management Agency (FEMA) http://www.fema.gov/public-assistance-local-state-tribal-and-non-profit
Public Housing Modernization Reserve for Disasters and Emergencies	**Funding** to public housing agencies for modernization needs resulting from natural disasters (including elevation, floodproofing, and retrofit). (24 CFR 968.104)	Housing and Urban Development http://www.hud.gov/ http://www.gpo.gov/fdsys/granule/CFR-2011-title24-vol4/CFR-2011-title24-vol4-sec968-104
Rural Fire Assistance and Volunteer Fire Assistance Grants	**Grants** to fund to improve firefighter skills and to purchase needed equipment; priority areas are located in or adjacent to WUI areas.	Oregon Department of Forestry http://www.oregon.gov/odf/pages/fire/grantopps.aspx
Rural Development Assistance --Utilities	USDA Rural Development provides **funding opportunities** in the form of payments, grants, loans, and loan guarantees, for the development and commercialization of vital utility services.	**USDA**-Rural Development http://www.rurdev.usda.gov/Utilities_Assistance.html
Rural Development Assistance –Housing	USDA Rural Development provides **funding** for single family homes, apartments for low-income persons or the elderly, housing for farm laborers, childcare centers, fire and police stations, hospitals, libraries, nursing homes, schools, and much more.	**USDA**-Rural Development http://www.rurdev.usda.gov/LP_Subject_HousingAndCommunityAssistance.html
Title III Funds	The Self-Determination Act (SRS Act) has recently been reauthorized and now includes specific language regarding the Firewise Communities program. Counties seeking funding under Title III must use the **funds** to perform work under the Firewise Communities program.	USDA Forest Service http://www.fs.usda.gov/wps/portal/fsinternet/!ut/p/c4/04_SB8K8xLLM9MSSzPy8xBz9CP0os3gjAwhwtDDw9_AI8zPwhQoY6BdkOyoCAPkATlA!/?ss=119985&navtype=BROWSEBYSUBJECT&cid=FSE_003853&navid=091000000000000&pnavid=null&position=BROWSEBYSUBJECT&ttype=main&pname=Secure%20Rural%20Schools-%20Home
Watershed Protection and Flood Prevention Program	**Funds** for soil conservation; flood prevention; conservation, development, utilization and disposal of water; and conservation and proper utilization of land.	USDA Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wfpo/

Program Activity	Type of Assistance	Agency & Contact
Wetlands Protection – Development Grants	**Grants** support the development and enhancement of State and tribal wetlands protection programs.	US Environmental Protection Agency (**EPA**) http://www.epa.gov/owow/wetlands/initiative/#financial
Watershed Protection and Flood Prevention Program	Funds for soil conservation; flood prevention; conservation, development, utilization and disposal of water; and conservation and proper utilization of land.	USDA Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wfpo/
Financing and Loan Guarantees		
Physical Disaster Loans and Economic Injury Disaster Loans	**Disaster loans** to non-farm, private sector owners of disaster damaged property for uninsured losses. Loans can be increased by up to 20 percent for mitigation purposes.	Small Business Administration (**SBA**) http://www.sba.gov/services/disasterassistance/
Conservation Contracts	**Debt reduction** for delinquent and non-delinquent borrowers in exchange for conservation contracts placed on environmentally sensitive real property that secures FSA loans.	USDA-FSA http://www.fsa.usda.gov/FSA/webapp?area=home&subject=fmlp&topic=landing
Clean Water State Revolving Funds	**Loans** at actual or below-market interest rates to help build, repair, relocate, or replace wastewater treatment plants.	EPA Office of Water State Revolving http://water.epa.gov/grants_funding/cwsrf/cwsrf_index.cfm
Section 108 Loan Guarantee Program	**Loan guarantees** to public entities for community and economic development (including mitigation measures).	HUD http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs/108
Section 504 Loans for Housing	**Repair loans, grants and technical assistance** to very low-income homeowners to repair, improve, or modernize their dwellings or to remove health and safety hazards.	US Department of Agriculture (**USDA**) – Rural Housing Service (**RHS**) http://www.rurdev.usda.gov/had-rr_loans_grants.html
Single Family Housing Loans and Grants	Provides **loans, loan guarantees, and technical assistance** to low- and moderate-income rural Americans through **several loan, grant, and loan guarantee** programs. The programs also make funding available to individuals to finance vital improvements necessary to make their homes decent, safe, and sanitary.	USDA-Rural Development http://www.rurdev.usda.gov/hsf_sfh.html

Program Activity	Type of Assistance	Agency & Contact
Community Facilities Direct Loan Program, Guaranteed Loan Program, and Grant Program	**Provide loans, grant and loan guarantee**s for essential community facilities in rural areas. Priority is given to health care, education and public safety projects. Typical projects are hospitals, health clinics, schools, fire houses, community centers and many other community based initiatives.	USDA – Rural Development http://www.rurdev.usda.gov/hcf_cf.html
Rural Development Assistance –Utilities	Provides funding opportunities in the form of **payments, grants, loans, and loan guarantee**s, for the development and commercialization of vital utility services.	**USDA**-Rural Development http://www.rurdev.usda.gov/utilities_assistance.html
Farm Service Agency Disaster Assistance Programs	**Provides assistance for natural disaster losses**, resulting from drought, flood, fire, freeze, tornadoes, pest infestation, and other calamities	USDA-Farm Service Agency http://www.fsa.usda.gov/FSA/webapp?area=home&subject=diap&topic=landing
Farm Ownership Loans	**Direct loans, guaranteed / insured loans, and technical assistance** to farmers so that they may develop, construct, improve, or repair farm homes, farms, and service buildings, and to make other necessary improvements.	USDA-Farm Service Agency http://www.fsa.usda.gov/FSA/webapp?area=home&subject=fmlp&topic=dflon

Source: OPDR

Local Capability Assessment

Local Policies, Programs and Capabilities & Their Effectiveness			
Policy/Program/Capability[6]	General Description	Applicability	Effectiveness
Comprehensive Land Use Planning (ORS 197; OAR 660-003, OAR 660-018) Statewide Land Use Planning Goals (ORS 197.225; OAR 660-015, OAR 660-025) Goal 7, Areas Subject to Natural Hazards (RE: Landslides – ORS195.250-195-275; OAR 629-623	In Oregon, comprehensive planning is directed through 19 statewide land use planning goals. Goal 7 is entitled *Areas Subject to Natural Hazards.* Its stated goal is "To protect people and property from natural hazards." Goal 7 requires local governments to adopt inventories, policies, and implementing measures to reduce risk to people and property from floods, landslides, wildfires, earthquakes and related hazards, tsunamis, and coastal erosion, and allows communities to plan for protection from other natural hazards as well. It encourages local governments to use both regulatory and non-regulatory strategies to achieve risk reduction.	All cities and counties in Oregon must have a comprehensive plan acknowledged by the state as compliant.	Land use plans can be used to guide new development to a community's less hazardous areas. Additionally, they can identify opportunities for redevelopment projects that will improve hazard mitigation by adjusting current land uses, and by requiring up-to-date building codes and standards for rehabilitation of existing structures. Compliance with Goal 7 is dependent on the availability of hazard inventory information. Many jurisdictions have not updated the Goal 7 section of their comprehensive plans in many years. Recently, there has been increased interest in addressing landslide hazards and the much anticipated Cascadia earthquake event and resulting tsunami. Landslide susceptibility maps based on LiDAR have been produced for a few areas of the state, and funding is being pursued to do additional studies, eventually covering the entire state. As these studies are completed, DLCD will be working with local governments to incorporate the new information into their comprehensive plans, development regulations, and other programs to improve loss reduction. Several communities are updating the Goal 7 section of their comprehensive plans on their own initiative. The City of Madras is undertaking a pilot project to integrate its comprehensive plan and NHMP by update its comprehensive plan Goal 7 section and incorporating within it elements of its NHMP. The City of Eugene is undertaking another pilot project to explicitly align and integrate climate change considerations into its comprehensive plan, NHMP, and Climate & Energy Action Plan.

[6] Note regarding Statutory and Administrative Rule references: There are numerous laws and rules governing the use and management of land in Oregon. The referenced statutes and administrative rules include sections of Oregon law with a direct connection to the identified policy or program.

Local Policies, Programs and Capabilities & Their Effectiveness			
Policy/Program/Capability[6]	General Description	Applicability	Effectiveness
Zoning (ORS 215, ORS 227)	Zoning consists of a map and text that outlines where and how development is to occur within a jurisdiction. Definitions, general provisions, zoning district regulations, special development standards and administration and enforcement are typical elements of a zoning ordinance.	All cities and counties in Oregon must have a zoning ordinance that implements provisions of the comprehensive plan.	Zoning is used to specify the type and location of development within a jurisdiction. In this respect, zoning is a very effective tool to reduce hazard risk in a community. Hazard overlay zones can prohibit or restrict certain types of development within areas known to contain hazards. Hillside development, flood, tsunami and wildland urban interface zones are some examples of zoning regulations that can be used to control development on lands subject to natural hazards. Flood zones, which can be found in all of Oregon's NFIP participating jurisdictions, are the most commonly utilized hazard zone. Other types of local hazard zones found in Oregon include geologic hazard (e.g. Marion County), landslide (e.g. City of Salem), tsunami inundation (e.g. Douglas County), and wildfire safety (e.g. Jackson County) overlay zones.
Land Division Ordinances (ORS 92)	Land division ordinances (including partitions and subdivisions) govern the division of land into two or more parcels. Land development ordinances include both standards and procedures that must be followed in order to legally divide land.	All cities and counties in Oregon must have a land division ordinance that implements provisions of the zoning ordinance and comprehensive plan.	Land division ordinances are used to ensure that land is made ready for development in an orderly manner. In addition, the land division process ensures that public improvements are available to serve the area when development occurs. For example, subdivision regulations ensure that emergency service personnel have adequate access and infrastructure in place in order to respond to hazard events or other emergencies. Land division ordinances also provide jurisdictions with the opportunity to require site specific evaluations of potentially hazardous areas to ensure the area is suitable and safe to build on. All jurisdictions in Oregon have adopted land division regulations.

Local Policies, Programs and Capabilities & Their Effectiveness			
Policy/Program/Capability[6]	General Description	Applicability	Effectiveness
Building Codes (ORS 445; OAR 918)	Oregon building codes establish uniform standards for all residential and commercial buildings in Oregon. The codes prohibit local governments from enacting conflicting regulations. The Oregon Building Codes Division (BCD) provides code development, administration, inspection, plan review, licensing, and permit services to ensure the safe and effective construction of structures in Oregon.	Building codes govern the construction, reconstruction, alteration and repair of buildings and other structures throughout Oregon.	The mission of the Building Codes Division is to work with Oregonians to ensure safe building construction while promoting a positive business climate. This mission is accomplished through: (1) adopting and administering uniform statewide building codes, (2) providing code and rule interpretation, (3) assisting local government building departments and facilitating dispute resolution, (4) enforcing license, code, and permit requirements, (5) certifying inspectors and licensing trade professionals, (6) facilitating economic development efforts around the state, and (7) conducting inspections where local entities do not. At the local level, all jurisdictions have building codes. This allows cities and counties in Oregon to ensure that new construction is built to minimum standards. Certain provisions of the building code apply to the design and construction of buildings located in areas prone to natural hazards. For example, buildings in the Special Flood Hazard area are required to be constructed with a first floor elevation one-foot above the Base Flood Elevation (BFE). Several cities have taken this one step further by adopting regulations that supplement the building code and require first floor elevations two to three feet above the BFE or the flood of record, whichever is higher.
Tsunami Inundation Zone (ORS 455.446 and 455.447; OAR 632-005)	Senate Bill 379 restricts the construction of certain essential facilities, hazardous facilities, major structures and special occupancy structures in the tsunami inundation zone.	All incorporated and unincorporated land in Oregon westward of the statutorily identified building line.	ORS 455.446 and 455.447 restrict the construction of certain essential facilities, hazardous facilities, major structures and special occupancy structures in the tsunami inundation zone, with some exemptions. The zone is enforced through local building codes at the time of development. Certain structure types require additional review by and consultation with DOGAMI before development can proceed to the development phase. Provisions of the zone are enforced at the local level. Some coastal communities have proactively relocated critical facilities such as schools (e.g. City of Waldport) and fire stations (e.g. city of Cannon Beach) east of the statutory line.

Local Policies, Programs and Capabilities & Their Effectiveness			
Policy/Program/Capability[6]	General Description	Applicability	Effectiveness
Open Space Preservation (ORS 197; OAR 660-16, 660-023, OAR 660-017, OAR 660-020; OAR 660-034)	In Oregon, comprehensive planning is directed through 19 statewide land use planning goals. Goal 5 is entitled Natural Resources, Scenic and Historic Areas and Open Space. Its stated goal is "To protect natural resources and conserve scenic and historic areas and open spaces." Goal 5 requires local governments to adopt inventories, policies, and implementing measures to protect natural resources and conserve scenic, historic, and open space resources for present and future generations.	All cities and counties in Oregon must have a comprehensive plan acknowledged by the state as compliant.	Land use plans can be used to ensure communities have adequate supply of and access to resources that promote healthy and safe environments. Resource areas and open spaces offer natural mitigation opportunities by buffering development from or absorbing the impacts of natural hazards. For example, riparian buffers along streams serve multiple functions from flood control and storage to habitat preservation and stormwater filtration. Compliance with Goal 5 requires that communities: (1) Inventory local occurrences of resources listed in Goal 5 and decide which ones are important; (2) Identify potential land uses on or near each resource site and any conflicts that might result; (3) Analyze economic, social, environmental, and energy, (ESEE) consequences of such conflicts; (4) Decide whether the resource should be fully or partially protected and justify the decision; and (5) Adopt measures such as zoning to put that decision into effect. Resources inventoried under Goal 5 number more than a dozen resources, including threatened and endangered species, critical habitats, scenic and historic places and aggregate. Emphasis is placed on wetlands, riparian zones and wildlife habitats. Jurisdictions are required to update Goal 5 under Oregon Administrative Rule 660 during their next "periodic review" of the goal or "when they amend their current land-use plan or ordinances."

Local Policies, Programs and Capabilities & Their Effectiveness			
Policy/Program/Capability[6]	General Description	Applicability	Effectiveness
Local Natural Hazards Mitigation Plans	Many Oregon cities and counties have prepared local NHMPs, in great measure through the state's Pre-Disaster Mitigation (PDM) program. The primary aim of the program is to help communities develop or update local natural hazards mitigation plans. It systematically provides funding and technical assistance targeted annually to local governments in specific planning regions identified by OEM for the purpose of developing or updating existing local natural hazards mitigation plans. The PDM planning program was established by OPDR and OEM in 2004 and is carried out in partnership with DLCD, DOGAMI, FEMA Region X, and local governments with FEMA funding.	Oregon cities and counties	Historically, OPDR has offered grant writing support, technical assistance, and human resource capacity to jurisdictions across the state. Recent administrative changes at the University of Oregon, where OPDR is housed, have made it more challenging for OPDR to maintain its current operational structure. It is unclear if or how these changes may impact OPDR's role in local natural hazard mitigation planning in the future. While OPDR has provided the majority of this assistance to local governments, private consulting firms have also assisted local communities. As Clatsop County is currently doing, some jurisdictions undertake development or updates of NHMPs on their own. Until 2013, jurisdictions in the Portland Metro Region received varying degrees of Urban Area Security Initiative (UASI) support for mitigation planning. Plans are tracked and inventoried at the county level (36 Oregon counties). Table XX shows the status of local NHMPs in Oregon.

Local Policies, Programs and Capabilities & Their Effectiveness			
Policy/Program/Capability[6]	General Description	Applicability	Effectiveness
Capital Improvement Plans (ORS Chapter 223; OAR 660-011-0000, OAR 660—12-0000, OAR 660-013-0010)	Local jurisdictions maintain capital improvement plans/programs to ensure that infrastructure is developed and maintained at an adequate level to serve the needs of the community.	Oregon Cities, Counties and Special Districts	Many communities are directly or indirectly addressing hazard mitigation through their capital improvement plans. Such plans are generally maintained on a five to six-year basis. CIPs distribute the expense of major capital construction projects over time. Long-range infrastructure improvement projects are implemented annually through the jurisdictions standard budget process. In many cases, bonds are used to finance projects. In recent years, state and federal grants have been used to offset the costs of local infrastructure improvements. The primary opportunity to mitigate projects comes when old infrastructure is improved in ways that eliminate or reduce hazard impacts. For example, bridges can be retrofitted to address seismic impacts; culverts can be upsized to reduce localized flood impacts; electrical lines can be buried to avoid impacts associated with snow, ice and wind storms. These efforts may not be seen by the community as mitigation, but by bringing the infrastructure/facilities up to code, they are reducing the vulnerability of those systems. For example, the Harney Electric Cooperative in south-central Oregon has planned or completed three power line undergrounding projects to offset impacts from winter storm events in that region.
Erosion Control Management Plans (ORS Chapter 568; OAR 340-041, OAR 603-095)	Erosion control aims to reduce soil loss from wind and water through a variety of control techniques including vegetative cover, buffer strips, contour plowing, riparian enhancements and windbreaks.	Erosion control plans can apply to any lands where erosion is a concern; wind erosion control is a requirement under the Federal Farm Bill for certain commodities such as wheat and corn, but depending on the rotation, may not be a requirement for other commodities such as potatoes or vegetables.	The Natural Resources Conservation Service (NRCS) and local soil and water conservation districts (SWCD) have long sought to reduce wind erosion of cropland. Specific requirements for erosion control plans apply to certain agricultural lands. Nationally, NRCS has developed quality criteria for wind erosion control practices and use a wind erosion equation model for predicting potential wind erosion under various farming systems. Since 1985, USDA-NRCS has been responsible for agriculture programs that require wind and water erosion control as a requirement under the Federal Farm Bill for certain commodities such as wheat and corn. Participating farmers develop and implement conservation plans for all farmland designated as highly erodible. Plans address practices such as residue management, tillage methods, and irrigation management. The Environmental Quality Incentive Program provides funds and technical assistance to agricultural producers and owners of non-industrial forest lands. Eligibility requires that applicants, “be in compliance with the highly erodible land and wetland conservation requirements.”

Local Policies, Programs and Capabilities & Their Effectiveness			
Policy/Program/Capability[6]	General Description	Applicability	Effectiveness
Floodplain Management (ORS Chapter 536, ORS Chapter 549)	Floodplain management aims to reduce losses associated with flood events and encourage restoration and protection of natural floodplain function.	Oregon has 258 cities and counties that are subject to flooding, and all participate in the National Flood Insurance Program (NFIP) thereby making flood insurance available to their residents and businesses.	The NFIP has three basic components: - flood hazard mapping, floodplain insurance, and floodplain regulations. Does the combination of mapping, regulations, and insurance work to reduce flood damages? Yes! According to FEMA, flood insurance provides an alternative to publicly funded disaster assistance that reduces the ever escalating costs of repairing damage to buildings and their contents caused by floods. FEMA further reports that flood damages are reduced by nearly $1 billion a year nationally through communities implementing sound floodplain management requirements and property owners purchasing flood insurance. Newer buildings constructed in compliance with floodplain regulations suffer approximately 80 percent less damage annually than those not built to current standards. Oregonians make use of floodplains for a variety of purposes. Floodplain management involves recognition that our use of floodplains can negatively impact floodplain functions and that communities will be faced with making choices about land uses in the floodplain. Water quality and endangered species benefits also result from proactive floodplain management. Development within floodplains is generally not prohibited. Rather, floodplain management involves regulatory, construction, and public education measures designed to avoid and minimize potential risk to development from flood hazards. Floodplain management also entails implementation of specific actions intended to prevent future damages and threats to human life and public health. Local floodplain programs are built upon statewide requirements for land use planning and implementation of building codes. Local governments implement flood damage prevention ordinances through floodplain development permits, and the state building codes via local building permits. Many local governments in Oregon adopt higher regulatory standards into their flood damage prevention ordinances. For example, some jurisdictions require two or three feet of freeboard (e.g. City of Scio), regulate an area larger than the floodplain shown on FEMA FIRMs, require balanced cut/fill in the floodplain, etc. Table XX shows the status of local jurisdiction participation in the NFIP in Oregon.

Local Policies, Programs and Capabilities & Their Effectiveness			
Policy/Program/Capability[6]	General Description	Applicability	Effectiveness
Community Rating System	The National Flood Insurance Program's (NFIP) Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements.	All NFIP Communities in Oregon are eligible to participate.	The National Flood Insurance Program's (NFIP) Community Rating System (CRS) effectively addresses the flood hazard by discounting flood insurance premium rates. CRS participating communities (1) reduce flood damage to insurable property; (2) strengthen and support the insurance aspects of the NFIP, and (3) encourage a comprehensive approach to floodplain management. Local governments in Oregon are encouraged to join CRS. The CRS provides an important avenue for Oregon's NFIP communities to obtain recognition for their local floodplain programs. With recent NFIP reforms (i.e. Biggert Waters), many communities in Oregon are interested in joining or enhancing their current participation in the CRS program. As of December 2013l, 26 cities and eight counties participate in the CRS program. The City of Portland has the highest rating in the state at five; 18 other cities have ratings of six or 7 with the remainder falling at eight or above. Table XX shows the status of local jurisdiction participation in the CRS program in Oregon.

Local Policies, Programs and Capabilities & Their Effectiveness			
Policy/Program/Capability[6]	General Description	Applicability	Effectiveness
Community Wildfire Protection Planning (Related Statute: ORS 477; OAR 629-042, OAR 629-043; OAR 629-044; OAR 629-048	A Community Wildfire Protection Plan (CWPP) is developed by a community in an area at-risk from wildfire. The CWPP establishes strategies aimed at reducing wildfire risk.	Primarily counties; plan boundaries may include sub-county regions (e.g. Fire Protection District, unincorporated communities, watersheds, etc.) as well as multi-jurisdictional plans. Certain types of federal funding require the adoption of a CWPP under the provision of the Healthy Forest Restoration Act.	The purpose of a CWPP is to establish a strategic vision (normally five-years in duration) for long-term wildfire risk reduction activities and public outreach. CWPPs outline wildfire mitigation goals, strategies, and activities and highlight other relevant plans and partnerships, including: land use, natural resource, capital improvement, and emergency operation plans. All 36 counties in Oregon have adopted a CWPP; the Oregon Department of Forestry identifies 28 additional sub-county CWPPs. The statutory definition of a CWPP appears in Title I of the Healthy Forest Restoration Act of 2003 (HFRA). The HRFA decrees that communities which have a CWPP in place will be a priority for receiving hazardous fuels reduction funding administrated by the US Forest Service and Bureau of Land Management. Plans developed to address the requirements of the 2003 Healthy Forests Restoration Act (HFRA) must meet three minimum requirements: • Collaboration: Local and state government representatives, in consultation with federal agencies and other interested parties, must collaboratively develop a CWPP. • Prioritized Fuel Reduction: A CWPP must identify and prioritize areas for hazardous fuel reduction treatments and recommend the types and methods of treatment that will protect at-risk communities and essential infrastructure. • Treatment of Structural Ignitability: A CWPP must recommend measures that homeowners and communities can take to reduce the ignitability of structures. The Healthy Forest Restoration Act (HFRA) requires that three decision-makers mutually agree to the final contents of the CWPP. The three are the applicable local government (i.e. counties or cities), the local fire department(s) and the state entity responsible for forest management (ODF). These three are directed to consult with and involve local representatives of the USFS and BLM and other interested parties or persons in the development of the CWPP.

Local Policies, Programs and Capabilities & Their Effectiveness			
Policy/Program/Capability[6]	General Description	Applicability	Effectiveness
Local Emergency Planning Committees (OAR 104-040; OAR 837-085, OAR 837-120)	Under the Emergency Planning and Community Right-to-Know Act (EPCRA), Local Emergency Planning Committees (LEPCs) must develop an emergency response plan, review the plan at least annually, and provide information about chemicals in the community to citizens.	All designated emergency planning districts established under 42 U.S.C. 116§11001(c).	In 1986, the federal government established the Emergency Planning and Community Right to Know Act (EPCRA). The intent of this law was to give citizens the right to know what types of hazardous materials were in their communities, so they could be prepared to respond if a release occurred. Part of this law provided states with the opportunity to create Local Emergency Planning Committees (LEPCs). LEPCs work to understand chemical hazards in the community, develop emergency plans in case of an accidental release, and look for ways to prevent chemical accidents. The Office of State Fire Marshal (OSFM) has created a State Emergency Response Commission Advisory Board, to help Oregon communities establish LEPCs and support them in their activities. OSFM currently recognizes 11 LEPCs in the state. In addition, OSFM is actively supporting Community Capability Assessments (a planning approach that, "aids emergency responders in evaluating, coordinating and enhancing the cohesiveness of their emergency response plans") in communities with active LEPCs. LEPC members include people from emergency management, police, fire, emergency medical services, transportation, health, broadcast and print media, industry, community groups, colleges, and the public. Notably, many of these organizations are also typically involved in the development of local natural hazards mitigation plans.

Local Policies, Programs and Capabilities & Their Effectiveness			
Policy/Program/Capability[6]	General Description	Applicability	Effectiveness
Local Fire Prevention Cooperatives (ORS 447)	Fire prevention cooperatives are nonprofit interagency fire service groups engaged in fire prevention and public education within their communities. They promote an exchange of ideas, programs and resources in both wildland and structural fire prevention and public education. They also promote, coordinate, and actively support interagency participation in fire prevention activities.	Any collective group of agencies interested and engaged in fire prevention and education can form an LFPC.	A wide range of community-based fire prevention efforts exist across Oregon. Many of these efforts are developed and implemented by local fire prevention cooperatives. Since the mid-1970s, fire prevention cooperatives have been highly successful at the creation and delivery of cost effective fire prevention programs, developed to address specific local situations. Cooperatives multiply the effectiveness of community fire prevention efforts by identifying common needs among neighboring agencies, then developing a single, joint approach to addressing those needs. The cooperative concept recognizes that no single agency usually has the personnel, expertise, community recognition, or financial resources to develop, implement and deliver a comprehensive package of fire awareness, education and public safety needs for a local area. In addition to identifying, designing and implementing unique local programs, fire prevention cooperatives serve as highly effective distributors of materials and programs developed by others. One example is their increasing involvement in Wildfire Awareness Week programs. ODF lists the following communities on the current LFPC roster: Baker County Interagency Fire Prevention Team Central Oregon Fire Prevention Cooperative Clackamas County Fire Prevention Cooperative Clatsop County Fire Fighter's Association Columbia County Fire Prevention Cooperative Douglas County Fire Prevention Cooperative Grant-Harney County Fire Prevention Cooperative Klamath Fire Prevention Cooperative Lane Fire Prevention Cooperative Northwest Passage Fire Prevention Cooperative Rogue Valley Fire Prevention Cooperative Southwest Oregon Public Safety Association Wallowa County Fire Prevention Cooperative

Local Policies, Programs and Capabilities & Their Effectiveness			
Policy/Program/Capability[6]	General Description	Applicability	Effectiveness
Local Fire Departments and Fire Protection Districts (ORS 476)	City fire departments, rural fire protection districts, county special service districts, and commercial subscription based entities provide both structural and non-structural fire protection.	Authority to establish and maintain LFDs and FPDs is granted in ORS 476.060.	Most structural fire protection in Oregon is provided by city fire departments, rural fire protection districts, county special service districts, and commercial subscription based entities. Specialized agencies also provide structural protection, such as the Portland Airport Fire Department and the National Park Service. A variety of volunteer organizations also exist. In some locations, such as the area immediately west of Portland, structural fire agencies have complete responsibility for the prevention and suppression of all fires, both wildland and structural. Across much of the state, structural fire agencies and the ODF share jurisdiction in Wildland Urban Interface areas. In some parts of Oregon, property owners may be subject to the protection, assessment and taxation of both a local structural fire agency and ODF. In such areas, the structural fire department and ODF jointly protect properties, with the fire departments focused on protecting improvements and ODF focused on protecting the forest resources. To facilitate this joint responsibility, mutual aid agreements signed by both the structural district/department and ODF typically provide up to 24 hours of non-reimbursed firefighting assistance for fires that threaten each other's protected property and resources. The Oregon State Fire Marshal's office currently lists 301 distinct local fire departments in Oregon.

Local Policies, Programs and Capabilities & Their Effectiveness			
Policy/Program/Capability[6]	General Description	Applicability	Effectiveness
Rangeland Fire Protection Associations (ORS 477)	Formed under ORS 477.315, RFPAs are nonprofit, locally governed and operated landowner associations organized to provide fire protection on rangeland areas of eastern Oregon which lack both structural and wildland fire protection.	RFPA membership is voluntary.	State law provides for the formation of these RFPAs under the authority of the Oregon Board of Forestry, with assistance from ODF. There are currently 14 RFPAs that collectively protect over 3.2 million acres of private land in Eastern Oregon. The RFPA's also protect approximately a half-million acres of State lands. These lands are primarily Department of State Lands, with lesser amounts of Department of Fish & Wildlife, and Parks & Recreation Department. In 2005, the state established a Rangeland Fire Protection Coordinator position. Since that time, federal grants have supported state program administration. In addition, ODF contributes approximately $30,000 per biennium to support associations and reimburse, primarily to reimburse insurance and administration costs. ORS 477.317(2) limits state funding support for the program to, "50 percent of the total of budgeted operating costs and the cash equivalent of in-kind supplies and services of the association in any fiscal year." RFPAs also rely on a variety of additional federal grants for funding support.

Local Hazard Mitigation Planning

Table XX shows the status of local NHMPs, NFIP and CRS Participation in Oregon.

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
1	**Baker**	**Baker County**	NE Oregon - Region 7 HMP	**Jun-19**		**Yes**		
2	Baker	Baker City	NE Oregon - Region 7 HMP	**Jun-19**		**Yes**		
3	Baker	Greenhorn			No Plan	**No**		**Never mapped**
4	Baker	Haines			No Plan	**Yes**		
5	Baker	Halfway	NE Oregon - Region 7 HMP	**Jun-19**		**Yes**		
6	Baker	Huntington			No Plan	**Yes**		
7	Baker	Richland			No Plan	**No**		**Never mapped**
8	Baker	Sumpter			No Plan	**Yes**		
9	Baker	Unity			No Plan	**No**		**Never mapped**
10	Benton	Benton County	Benton County Hazard Mitigation Plan	Feb-16	Stand-alone County NHMP	Yes		
11	Benton	Adair Village			No Plan	No		Has FIRM
12	Benton	Corvallis	Corvallis HMP	**Jan-13**	Stand-alone City NHMP	**Yes**		
13	Benton	Monroe			No Plan	**Yes**		
14	Benton	Philomath			No Plan	**Yes**		
15	**Clackamas**	**Clackamas County**	Clackamas County HMP	**Apr-18**		**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
16	Clackamas	Barlow			No Plan	**Yes**		
17	Clackamas	Canby	Clackamas County HMP	**Apr-18**		**Yes**		
18	Clackamas	Damascus	Clackamas County HMP	**Apr-18**		**Yes**		
19	Clackamas	Estacada	Clackamas County HMP	**Apr-18**		**Yes**		
20	Clackamas	Gladstone	Clackamas County HMP	**Apr-18**		**Yes**		
21	Clackamas	Happy Valley	Clackamas County HMP	**Apr-18**		**Yes**		
22	Clackamas	Johnson City	Clackamas County HMP	**Apr-18**		**No**		**All X zone**
23	Clackamas	Lake Oswego	Clackamas County HMP	**Apr-18**		**Yes**		
24	Clackamas	Milwaukie	Clackamas County HMP	**Apr-18**		**Yes**		
25	Clackamas	Molalla	Clackamas County HMP		Approved Pending Adoption	**Yes**		
26	Clackamas	Oregon City	Clackamas County HMP	**Apr-18**		**Yes**		
27	Clackamas	Rivergrove			No Plan	**Yes**		
28	Clackamas	Sandy	Clackamas County HMP	**Apr-18**		**Yes**		
29	Clackamas	West Linn	Clackamas County HMP	**Apr-18**		**Yes**		
30	Clackamas	Wilsonville	Clackamas County HMP	**Apr-18**		**Yes**		
31	**Clatsop**	**Clatsop County**	Clatsop County HMP	**Nov-13**		**Yes**		
32	Clatsop	Astoria	Clatsop County HMP	**Nov-13**		**Yes**		
33	Clatsop	Cannon Beach	Clatsop County HMP	**Nov-13**		**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
34	Clatsop	Gearhart	Clatsop County HMP	**Nov-13**		**Yes**		
35	Clatsop	Seaside			No Plan. Working on addendum to County Plan.	**Yes**		
36	Clatsop	Warrenton	Clatsop County HMP	**Nov-13**		**Yes**		
37	**Columbia**	**Columbia County**	Columbia County HMP	**Jul-14**		**Yes**		
38	Columbia	Clatskanie	Columbia County HMP	**Jul-14**		**Yes**		
39	Columbia	Columbia City	Columbia County HMP	**Jul-14**		**Yes**		
40	Columbia	Prescott			No Plan	**Yes**		
41	Columbia	Rainier	Columbia County HMP	**Jul-14**		**Yes**		
42	Columbia	Scappoose	Columbia County HMP	**Jul-14**		**Yes**		
43	Columbia	St Helens	Columbia County HMP	**Jul-14**		**Yes**		
44	Columbia	Vernonia	Columbia County HMP	**Jul-14**		**Yes**		
45	**Coos**	**Coos County**	Coos County Multi-Jurisdictional NHMP 2010	**Aug-15**		**Yes**		
46	Coos	Bandon	Coos County 2005 HM Plan	**Jul-10**		**Yes**		
47	Coos	Coos Bay	Coos County Multi-Jurisdictional NHMP 2010	**Aug-15**		**Yes**		
48	Coos	Coquille	Coos County 2005 HM Plan	**Jul-10**		**Yes**		
49	Coos	Lakeside	Coos County 2005 HM Plan	**Jul-10**		**Yes**		
50	Coos	Myrtle Point	Coos County Multi-Jurisdictional NHMP 2010	**Aug-15**		**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
51	Coos	North Bend	Coos County Multi-Jurisdictional NHMP 2010	**Aug-15**		**Yes**		
52	Coos	Powers	Coos County 2005 HM Plan	**Jul-10**		**Yes**		
53	**Crook**	**Crook County**	Crook County NHMP	**Mar-16**		**Yes**		
54	Crook	Prineville	Crook County NHMP	**Mar-16**		**Yes**		
55	**Curry**	**Curry County**	Curry County HM Plan 2010	**Sep-15**		**Yes**		
56	Curry	Brookings	Curry County HM Plan 2010	**Sep-15**		**Yes**		
57	Curry	Gold Beach	Curry County HM Plan 2010	**Sep-15**		**Yes**		
58	Curry	Port Orford	Curry County HM Plan 2010	**Sep-15**		**Yes**		
59	**Deschutes**	**Deschutes County**	Deschutes County HMP	**May-15**	Stand-alone County NHMP	**Yes**		
60	Deschutes	Bend			No Plan	**Yes**		
61	Deschutes	La Pine			No Plan	**Yes**		
62	Deschutes	Redmond			No Plan	**Yes**		
63	Deschutes	Sisters			No Plan	**Yes**		
64	**Douglas**	**Douglas County (Inland)**	Douglas County 2010 HM Plan	**Apr-15**		**Yes**		
65	**Douglas**	**Douglas County (Coastal)**			Not Applicable	**Yes**		
66	Douglas	Canyonville	Douglas County 2003 HM Plan	**Dec-08**		**Yes**		
67	Douglas	Drain	Douglas County 2003 HM Plan	**Dec-08**		**Yes**		
68	Douglas	Elkton	Douglas County 2003 HM Plan	**Dec-08**		**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
69	Douglas	Glendale	Douglas County 2003 HM Plan	**Dec-08**		**Yes**		
70	Douglas	Myrtle Creek	Douglas County 2003 HM Plan	**Dec-08**		**Yes**		
71	Douglas	Oakland	Douglas County 2003 HM Plan	**Dec-08**		**Yes**		
72	Douglas	Reedsport	Douglas County 2010 HM Plan	**Apr-15**		**Yes**		
73	Douglas	Riddle	Douglas County 2003 HM Plan	**Dec-08**		**Yes**		
74	Douglas	Roseburg	Douglas County 2003 HM Plan	**Dec-08**		**Yes**		
75	Douglas	Sutherlin	Douglas County 2003 HM Plan	**Dec-08**		**Yes**		
76	Douglas	Winston			No Plan	**Yes**		
77	Douglas	Yoncalla	Douglas County 2003 HM Plan	**Dec-08**		**Yes**		
78	**Gilliam**	**Gilliam County**	Gilliam County HMP	**Apr-18**		**Yes**		
79	Gilliam	Arlington	Gilliam County HMP	**Apr-18**		**Yes**		
80	Gilliam	Condon	Gilliam County HMP	**Apr-18**		**Yes**		
81	Gilliam	Lonerock	Gilliam County HMP	**Apr-18**		**No**		**Never mapped**
82	**Grant**	**Grant County**	NE Oregon - Region 7 HMP	**Jun-19**		**Yes**		
83	Grant	Canyon City			No Plan	**Yes**		
84	Grant	Dayville			No Plan	**Yes**		
85	Grant	Granite			No Plan	**No**		**Never mapped**
86	Grant	John Day	NE Oregon - Region 7 HMP	**Jun-19**		**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
87	Grant	Long Creek			No Plan	**Yes**		
88	Grant	Monument			No Plan	**Yes**		
89	Grant	Mt Vernon			No Plan	**Yes**		
90	Grant	Prairie City			No Plan	**Yes**		
91	Grant	Seneca			No Plan	**Yes**		
92	**Harney**	**Harney County**	Harney County HMP	**Jun-18**		**Yes**		
93	Harney	Burns	Harney County HMP	**Jun-18**		**Yes**		
94	Harney	Hines	Harney County HMP	**Jun-18**		**Yes**		
95	Harney	*Harney Electric Co-op Special District*	Harney County HMP	**Jun-18**		**N/A**		
96	**Hood River**	**Hood River County**	Hood River County HMP	**Dec-17**		**Yes**		
97	Hood River	Cascade Locks	Hood River County HMP	**Jan-12**		**Yes**		
98	Hood River	Hood River (City)	Hood River County HMP	**Jan-12**		**Yes**		
99	**Jackson**	**Jackson County**	Jackson County HMP	**Feb-18**		**Yes**		
100	Jackson	Ashland	Jackson County HMP	**Feb-18**		**Yes**		
101	Jackson	Butte Falls			No Plan	**Yes**		
102	Jackson	Central Point	Central Point HMP	**Dec-16**	Stand-alone City NHMP	**Yes**		
103	Jackson	Eagle Point	Jackson County HMP	**Feb-18**		**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
104	Jackson	Gold Hill			No Plan	**Yes**		
105	Jackson	Jacksonville			No Plan	**Yes**		
106	Jackson	Medford	Medford HMP	**Oct-15**	Stand-alone City NHMP	**Yes**		
107	Jackson	Phoenix			No Plan	**Yes**		
108	Jackson	Rogue River	Jackson County HMP	**Feb-18**		**Yes**		
109	Jackson	Shady Cove	Jackson County HMP	**Feb-18**		**Yes**		
110	Jackson	*Southern Oregon University Special District*	Southern Oregon University	**Jul-17**	Stand-alone Special District Plan	**N/A**		
111	Jackson	Talent			No Plan	**Yes**		
112	**Jefferson**	**Jefferson County**	Jefferson County HMP	**Feb-19**		**Yes**		
113	Jefferson	Culver	Jefferson County HMP	**Dec-13**	Expired. Declined participation in update.	**Yes**		
114	Jefferson	Madras	Jefferson County HMP	**Feb-19**		**Yes**		
115	Jefferson	Metolius	Jefferson County HMP	**Feb-19**		**No**		**Never applied**
116	**Josephine**	**Josephine County**	Josephine County HMP	**Jan-17**		**Yes**		
117	Josephine	Cave Junction		**Oct-09**	After partial participation in the 2011-12 process, decided not to finish.	**Yes**		
118	Josephine	Grants Pass	Josephine County HMP	**Jan-17**		**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
119	**Klamath**	**Klamath County**	Klamath County HMP	**Nov-16**		**Yes**		
120	Klamath	Bonanza			No Plan	**Yes**		
121	Klamath	Chiloquin			No Plan	**Yes**		
122	Klamath	Klamath Falls	Klamath County HMP	**Nov-16**		**Yes**		
123	Klamath	Malin			No Plan	**No**		**No FIRM**
124	Klamath	Merrill			No Plan	**No**		**No FIRM**
125	Klamath	*Oregon Tech Special District*	Oregon Tech	**Mar-18**	Stand-alone Special District Plan	**N/A**		
126	**Lake**	**Lake County**	Lake County HMP	**Sep-18**		**Yes**		
127	Lake	Lakeview	Lake County HMP	**Sep-18**		**Yes**		
128	Lake	Paisley	Lake County HMP	**Sep-18**		**Yes**		
129	**Lane**	**Lane County (Inland)**	Lane County HMP	**Mar-17**	Stand-alone County NHMP	**Yes**		
130	Lane	**Lane County (Coastal)**			Not Applicable	**Yes**		
131	Lane	Coburg			No Plan	**Yes**		
132	Lane	Cottage Grove	Cottage Grove HMP	**May-17**	Stand-alone City NHMP	**Yes**		
133	Lane	Creswell			No Plan	**Yes**		
134	Lane	Dunes City	Dunes City Addendum to the City of Florence NHMP	**Feb-14**	Stand-alone City NHMP - Addendum to City of Florence NHMP	**Yes**		
135	Lane	Eugene	Eugene-Springfield Multi-Juridictional NHMP	**Feb-15**	Stand-alone joint City NHMP -	**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
					Eugene/Springfield NHMP			
136	Lane	Eugene/Springfield Metro			Not Applicable	**N/A**		
137	Lane	Florence	City of Florence NHMP	**Feb-14**	Stand-alone City NHMP	**Yes**		
138	Lane	Junction City			No Plan	**Yes**		
139	Lane	Lowell			No Plan	**Yes**		
140	Lane	Oakridge			No Plan	**Yes**		
141	Lane	Springfield	Eugene-Springfield Multi-Juridictional NHMP	**Feb-15**	Stand-alone joint City NHMP - Eugene/Springfield NHMP	**Yes**		
142	Lane	*University of Oregon Special District*	University of Oregon HMP 2011	**Sep-16**	Stand-alone Special District Plan	**N/A**		
143	Lane	Veneta			No Plan	**Yes**		
144	Lane	Westfir			No Plan	**Yes**		
145	**Lincoln**	**Lincoln County**	Lincoln County HMP	**Jul-14**		**Yes**		
146	Lincoln	Depoe Bay	Lincoln County HMP	**Jul-14**		**Yes**		
147	Lincoln	Lincoln City	Lincoln County HMP	**Jul-14**		**Yes**		
148	Lincoln	Newport	Lincoln County HMP	**Jul-14**		**Yes**		
149	Lincoln	Siletz	Lincoln County HMP	**Jul-14**		**Yes**		
150	Lincoln	Toledo	Lincoln County HMP	**Jul-14**		**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
151	Lincoln	Waldport	Lincoln County HMP	**Jul-14**		**Yes**		
152	Lincoln	Yachats	Lincoln County HMP	**Jul-14**		**Yes**		
153	**Linn**	**Linn County**	Linn County HMP 2010	**Dec-15**		**Yes**		
154	Linn	Albany	Albany HMP	**Feb-16**	Stand-alone City NHMP	**Yes**		
155	Linn	Brownsville			No Plan	**Yes**		
156	Linn	Halsey			No Plan	**Yes**		
157	Linn	Harrisburg			No Plan	**Yes**		
158	Linn	Lebanon			No Plan	**Yes**		
159	Linn	*Linn-Benton Community College Special District*	Linn-Benton Community College	**May-18**	Stand-alone Special District Plan	**N/A**		
160	Linn	Lyons	Linn County HMP 2010	**Dec-15**		**Yes**		
161	Linn	Mill City			No Plan	**Yes**		
162	Linn	Millersburg			No Plan	**Yes**		
163	Linn	Scio	Linn County HMP 2010	**Dec-15**		**Yes**		
164	Linn	Sodaville	Linn County HMP 2010	**Dec-15**		**No**		**Has FIRM**
165	Linn	Sweet Home	Sweet Home HMP	**Aug-14**	Stand-alone City NHMP	**Yes**		
166	Linn	Tangent	Linn County HMP 2010	**Dec-15**		**Yes**		
167	Linn	Waterloo			No Plan	**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
168	**Malheur**	**Malheur County**	Malheur County HMP	**May-19**		**Yes**		
169	Malheur	Adrian	Malheur County HMP	**Sep-13**	Did not participate in update	**Yes**		
170	Malheur	Jordan Valley	Malheur County HMP	**Sep-13**	Did not participate in update	**Yes**		
171	Malheur	Nyssa	Malheur County HMP	**May-19**		**Yes**		
172	Malheur	Ontario	Malheur County HMP	**May-19**		**Yes**		
173	Malheur	Vale	Malheur County HMP	**May-19**		**Yes**		
174	**Marion**	**Marion County**	Marion County HMP	**Jul-16**		**Yes**		
175	Marion	Aumsville			No Plan	**Yes**		
176	Marion	Aurora	Marion County HMP	**Jul-16**		**Yes**		
177	Marion	Detroit			No Plan	**Yes**		
178	Marion	Donald			No Plan	**No**		**All X zone**
179	Marion	Gates			No Plan	**Yes**		
180	Marion	Gervais			No Plan	**Yes**		
181	Marion	Hubbard			No Plan	**Yes**		
182	Marion	Idanha			No Plan	**Yes**		
183	Marion	Jefferson (City)			No Plan	**Yes**		
184	Marion	Keizer	Marion County HMP	**Jul-16**		**Yes**		
185	Marion	Mt Angel			No Plan	**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
186	Marion	Salem	Salem HMP	**Dec-17**	Stand-alone City NHMP	**Yes**		
187	Marion	Scotts Mills			No Plan	**Yes**		
188	Marion	Silverton	Marion County HMP	**Jul-16**		**Yes**		
189	Marion	St Paul			No Plan	**Yes**		
190	Marion	Stayton			No Plan	**Yes**		
191	Marion	Sublimity			No Plan	**Yes**		
192	Marion	Turner	City of Turner	**Mar-18**	Stand-alone City NHMP	**Yes**		
193	Marion	Woodburn	Marion County HMP	**Jul-16**		**Yes**		
194	**Morrow**	**Morrow County**	Morrow County HMP	**Dec-11**		**Yes**		
195	Morrow	Boardman	Morrow County HMP	**Dec-11**		**Yes**		
196	Morrow	Heppner	Morrow County HMP	**Dec-11**		**Yes**		
197	Morrow	Ione	Morrow County HMP	**Dec-11**		**Yes**		
198	Morrow	Irrigon	Morrow County HMP	**Dec-11**		**Yes**		
199	Morrow	Lexington	Morrow County HMP	**Dec-11**		**Yes**		
200	**Multnomah**	**Multnomah County**	Multnomah County HMP	**Jul-17**	Stand-alone County NHMP	**Yes**		
201	Multnomah	Fairview	Fairview HMP	**Jan-16**	Stand-alone City NHMP	**Yes**		
202	Multnomah	Gresham	Gresham HMP	**Jan-12**	APA 08/02/13	**Yes**		
203	Multnomah	Maywood Park			No Plan	**N/A**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
204	Clackamas, Multnomah, Washington	Metro Region			Not Applicable	**N/A**		
205	Clackamas, Multnomah, Washington	Metro Region			Not Applicable	**N/A**		
206	Multnomah	Mt Hood Community College Special District	Mt. Hood Community College NHMP	**May-17**	Stand-alone Special District Plan	**N/A**		
207	Multnomah	Portland	Portland Hazard Mitigation Plan	**Feb-16**	Stand-alone City NHMP	**Yes**		
208	Multnomah	Troutdale	Troutdale HMP	**Jan-16**	Stand-alone City NHMP	**Yes**		
209	Multnomah	Wood Village	Wood Village HMP	**Jan-16**	Stand-alone City NHMP	**Yes**		
210	**Polk**	**Polk County**	Polk County HMP	**Oct-14**		**Yes**		
211	Polk	Dallas	Polk County HMP	**Oct-14**		**Yes**		
212	Polk	Falls City	Polk County HMP	**Oct-14**		**Yes**		
213	Polk	Independence	Polk County HMP	**Oct-14**		**Yes**		
214	Polk	Monmouth	Polk County HMP	**Oct-14**		**Yes**		
215	**Sherman**	**Sherman County**	Sherman County HMP	**Feb-19**		**Yes**		
216	Sherman	Grass valley	Sherman County HMP	**Feb-19**		**Yes**		
217	Sherman	Moro	Sherman County HMP	**Feb-19**		**No**		**Never mapped**
218	Sherman	Rufus	Sherman County HMP	**Feb-19**		**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
219	Sherman	Wasco (City)	Sherman County HMP	**Feb-19**		**Yes**		
220	**Tillamook**	**Tillamook County**	Tillamook County HMP	**Apr-17**		**Yes**		
221	Tillamook	Bay City	Tillamook County HMP	**Apr-17**		**Yes**		
222	Tillamook	Garibaldi	Tillamook County HMP	**Apr-17**		**Yes**		
223	Tillamook	Manzanita	Tillamook County HMP	**Apr-17**		**Yes**		
224	Tillamook	Nehalem	Tillamook County HMP	**Apr-17**		**Yes**		
225	Tillamook	Rockaway Beach	Tillamook County HMP	**Apr-17**		**Yes**		
226	Tillamook	Tillamook (City)	Tillamook County HMP	**Apr-17**		**Yes**		
227	Tillamook	Wheeler (City)	Tillamook County HMP	**Apr-17**		**Yes**		
228	**Umatilla**	**Umatilla County**	Umatilla County HMP	**Jul-14**	APA 03/17/14	**Yes**		
229	Umatilla	Adams	Umatilla County HMP	**Jul-14**		**Yes**		
230	Umatilla	Athena	Athena Addendum to Umatilla County Plan	**Jul-14**		**Yes**		
231	Umatilla	Echo			No Plan	**Yes**		
232	Umatilla	Helix			No Plan	**Yes**		
233	Umatilla	Hermiston			No Plan	**Yes**		
234	Umatilla	Milton-Freewater			No Plan	**Yes**		
235	Umatilla	Pendleton			No Plan	**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
236	Umatilla	Pilot Rock	Umatilla County HMP	**Jul-14**		**Yes**		
237	Umatilla	Stanfield			No Plan	**Yes**		
238	Umatilla	Ukiah			No Plan	**Yes**		
239	Umatilla	Umatilla (City)	Umatilla County HMP	**Jul-14**		**Yes**		
240	Umatilla	Weston	Weston Addendum to Umatilla County Plan	**Jul-14**		**Yes**		
241	**Union**	**Union County**	NE Oregon - Region 7 HMP	**May-13**	APA 04/01/14	**Yes**		
242	Union	Cove			No Plan	**No**		**Never mapped**
243	Union	*Eastern Oregon University Special District*	Eastern Oregon University	**May-18**	Stand-alone Special District Plan	**N/A**		
244	Union	Elgin			No Plan	**Yes**		
245	Union	Imbler			No Plan	**No**		
246	Union	Island City			No Plan	**Yes**		
247	Union	La Grande	NE Oregon - Region 7 HMP	**May-13**	APA 04/01/14	**Yes**		
248	Union	North Powder			No Plan	**Yes**		
249	Union	Summerville			No Plan	**Yes**		
250	Union	Union (City)			No Plan	**Yes**		
251	**Wallowa**	**Wallowa County**	NE Oregon - Region 7 HMP	**May-13**	APA 04/01/14	**Yes**		
252	Wallowa	Enterprise	NE Oregon - Region 7 HMP		APA 04/01/14 1st Plan	**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
253	Wallowa	Joseph			No Plan	**Yes**		
254	Wallowa	Lostine			No Plan	**Yes**		
255	Wallowa	Wallowa (City)			No Plan	**Yes**		
256	**Wasco**	**Wasco County**	Wasco County HMP	**Jan-18**		**Yes**		
257	Wasco	Antelope			No Plan	**No**		**Never mapped**
258	Wasco	Dufur			No Plan	**Yes**		
259	Wasco	Maupin			No Plan	**Yes**		
260	Wasco	Mosier			No Plan	**Yes**		
261	Wasco	Shaniko			No Plan	**No**		**Never mapped**
262	Wasco	The Dalles	Wasco County HMP	**Jan-18**		**Yes**		
263	**Washington**	**Washington County**	Washington County Hazard Mitigation Plan	**Feb-16**		**Yes**		
264	Washington	Banks			No Plan	**No**		**Never mapped**
265	Washington	Beaverton	Beaverton HMP	**Mar-16**	Stand-alone City NHMP	**Yes**		
266	Washington	Cornelius	Washington County Hazard Mitigation Plan	**Feb-16**		**Yes**		
267	Washington	Durham			No Plan	**Yes**		
268	Washington	Forest Grove	Washington County Hazard Mitigation Plan	**Feb-16**		**Yes**		
269	Washington	Gaston			No Plan	**Yes**		
270	Washington	Hillsboro	Hillsboro HMP	**Apr-13**	Stand-alone City NHMP. Update	**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
					underway.			
271	Washington	King City			No Plan	**Yes**		
272	Washington	North Plains			No Plan	**Yes**		
273	Washington	Sherwood			No Plan	**Yes**		
274	Washington	Tigard	Washington County Hazard Mitigation Plan	**Dec-09**	Tigard did not participate in Washington County's HMP update so its plan is expired.	**Yes**		
275	Washington	Tualatin			No Plan	**Yes**		
276	**Wheeler**	**Wheeler County**	Wheeler County HMP	**May-19**		**Yes**		
277	Wheeler	Fossil	Wheeler County HMP	**Apr-13**		**No**		
278	Wheeler	Mitchell	Wheeler County HMP	**Apr-13**		**Yes**		
279	Wheeler	Spray	Wheeler County HMP	**Apr-13**		**No**		
280	**Yamhill**	**Yamhill County**	Yamhill County HMP	**Jul-14**		**Yes**		
281	Yamhill	Amity	Yamhill County HMP	**Jul-14**		**Yes**		
282	Yamhill	Carlton	Yamhill County HMP	**Jul-14**		**Yes**		
283	Yamhill	Dayton	Yamhill County HMP	**Jul-14**		**Yes**		
284	Yamhill	Dundee	Yamhill County HMP	**Jul-14**		**Yes**		
285	Yamhill	Lafayette	Yamhill County HMP	**Jul-14**		**Yes**		

LOCAL JURISDICTION NHMP, NFIP, AND CRS STATUS								
#	COUNTY	JURISDICTION	PLAN TITLE	**EXPIRATION DATE**	LNHMP COMMENTS	**NFIP?**	**CRS Level**	NFIP COMMENTS
286	Yamhill	McMinnville			No Plan	**Yes**		
287	Yamhill	Newberg	Yamhill County HMP	**Jul-14**		**Yes**		
288	Yamhill	Sheridan	Yamhill County HMP	**Jul-14**		**Yes**		
289	Yamhill	Willamina	Yamhill County HMP	**Jul-14**		**Yes**		
290	Yamhill	Yamhill (City)	Yamhill County HMP	**Jul-14**		**Yes**		

Coordinating State and Local Mitigation Planning

(4) A section on the Coordination of Local Mitigation Planning that includes the following:

(i) A description of the State process to support, through funding and technical assistance, the development of local mitigation plans.

(ii) A description of the State process and timeframe by which the local plans will be reviewed, coordinated, and linked to the State Mitigation Plan.

(iii) Criteria for prioritizing communities and local jurisdictions that would receive planning and project grants under available funding programs, which should include consideration for communities with the highest risks, repetitive loss properties, and most intense development pressures. Further, that for non-planning grants, a principal criterion for prioritizing grants shall be the extent to which benefits are maximized according to a cost benefit review of proposed projects and their associated costs.

Funding and Technical Assistance

< Placeholder for Funding and Technical Assistance >

Prioritizing Local Jurisdictions for Mitigation Funding

< Placeholder for Prioritizing Local Jurisdictions for Mitigation Funding >

Local Plan Integration

State Review of Local Mitigation Plans

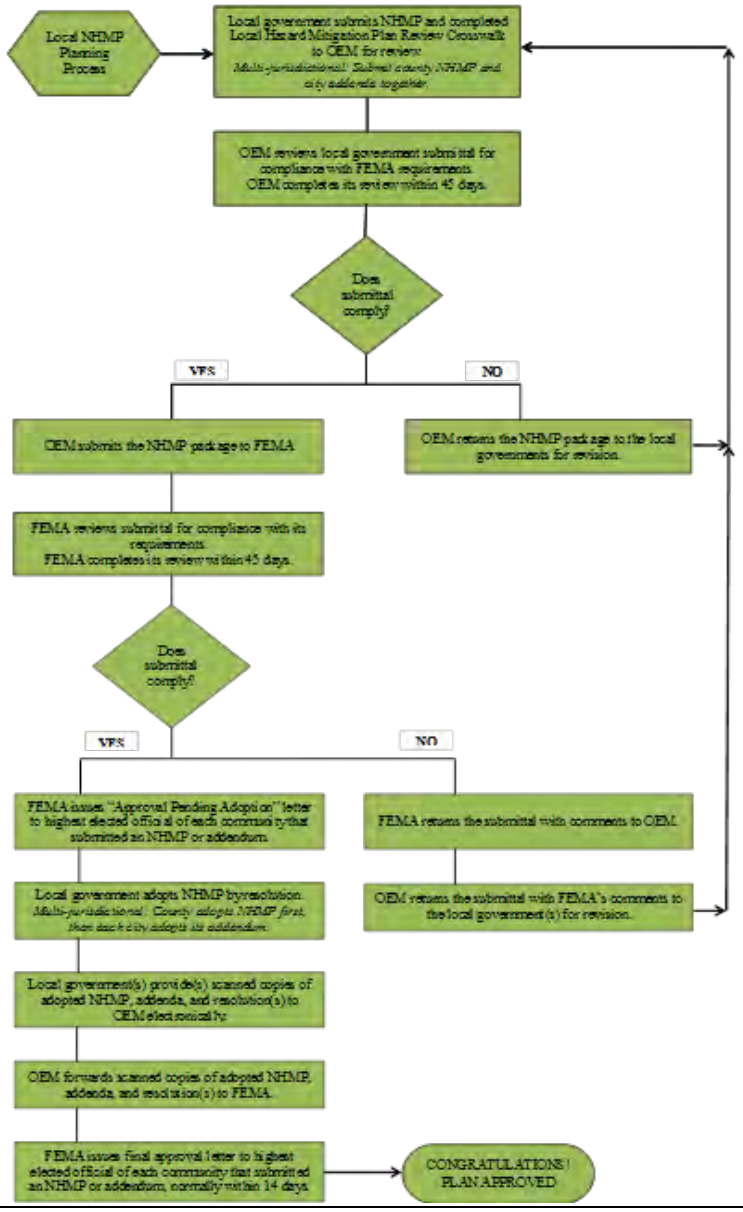
Oregon is responsible for reviewing local jurisdictions' NHMPs prior to submittal to FEMA for review and approval (Figure XXX (flowchart)). Once a local jurisdiction has completed a draft plan, it submits the plan to the Oregon Military Department, Office of Emergency Management (OEM) for review. If OEM finds that the draft plan does not meet all FEMA requirements, it returns the draft to the local jurisdiction for revision. Once OEM is satisfied that the draft plan is approvable, it forwards the draft to FEMA for review. Because of OPDR's extensive experience assisting local jurisdictions with developing NHMPs, the state delegates its review function to OPDR for those plans with which it assisted, and OPDR forwards approvable plans directly to FEMA for review.

If FEMA finds deficiencies, it returns the draft to OEM/OPDR which in turn returns it to the jurisdiction for revision. Once OEM/OPDR and FEMA are satisfied that the draft is approvable, FEMA issues *Approved Pending Adoption* (APA) status by letter to the highest elected official of the local jurisdiction. At this point, the local jurisdiction adopts its NHMP, usually by resolution, and sends a copy of the resolution and adopted NHMP to OEM/OPDR. OEM/OPDR verifies that the NHMP has not changed substantively since APA status was conferred, and forwards the adopted NHMP and resolution to FEMA.

Upon receipt and verification that the NHMP has not changed substantively, FEMA issues final approval, again by letter to the highest elected official of the local jurisdiction.

In many cases, two or more local jurisdictions collaborate to develop a multi-jurisdictional NHMP. Often this collaboration is among a county and some or all of its cities. In these cases, the county plan is primary, and the cities' plans are addenda to the county plan. The same process is followed, but the county adopts and receives final approval from FEMA first, then the cities follow suit. All jurisdictions that are parties to the plan receive the same effective date as the county.

Figure XX, State Process for Reviewing Local Mitigation Plans



Linking State and Local Plans

Mitigation Action Tracker

Prior to 2012, OPDR hosted a searchable action item database on its website. The purpose of the database was to provide a central, searchable, online location for mitigation actions found within Oregon's local natural hazards mitigation plans. OPDR supported the development, maintenance and update of the database through FEMA Hazard Mitigation Grant Program grants that supported update of the Oregon Natural Hazards Mitigation Plan.

At the local level, communities used the database to gather ideas for actions, or to identify areas for potential intergovernmental partnerships. Engaged state agencies used the database to gain a better understanding of local mitigation needs and implement more effective mitigation actions on a statewide level.

In early 2012, FEMA developed and released a new *Mitigation Action Tracker* in conjunction with the FEMA Risk MAP program. The FEMA tool offers a web-based interface, custom reports and technical support from FEMA through a contractor. Also in 2012, the Oregon Department of Land Conservation and Development agreed to assume responsibility and the requisite grant funding needed to update the Oregon NHMP. The availability of FEMA's *Mitigation Action Tracker* and loss of grant funding led OPDR to discontinue support for the native database in late 2012.

Following conversations with FEMA Region X and state mitigation representatives, OPDR agreed to beta-test FEMA's *Mitigation Action Tracker* in the summer of 2012. OPDR uploaded one city and two county NHMP action sets into FEMA's *Mitigation Action Tracker* and provided FEMA Region X with recommendations for how to improve the tool. In its memo to FEMA Region X, OPDR concluded that *data entry will be more efficient and less subject to varying interpretations of data* using the FEMA database. The memo went on to state, *With the ability to edit and run reports in the FEMA database the database will be more user-friendly and more effective as a data storage and data reporting tool*.

When it becomes fully functional, the expectation is that all local and state NHMP actions will be uploaded into FEMA's *Mitigation Action Tracker*. This approach will ensure that both local and state mitigation planning partners will have a central place to gather ideas for mitigation actions and coordinate local and state mitigation priorities. FEMA's *Mitigation Action Tracker* provides the added benefit of being connected directly to FEMA with access to mitigation actions from communities across the nation.

State and Local Natural Hazard Mitigation Plan Goals

As in 2009, state and local NHMP goals were reviewed and the 2015 Oregon NHMP goals revised to improve the linkage between state and local NHMPs.

Oregon's 36 county-level NHMPs were reviewed to:

- Discern, if possible, whether the state NHMP goals were considered in developing local NHMP goals;
- Determine to what extent local and state NHMP goals are correlated; and
- Identify county-level goals that are not reflected in the Oregon NHMP.

At the local level, counties review the state's goals to inform their local goal identification. If a state goal is determined to be applicable it may be adopted into the local NHMP (often the wording of a goal is changed to account for local circumstances and needs). However, county NHMPs do not consistently explicitly reference their review of the state goals. Table XX shows which local NHMPs contain a direct textual reference to the state goals. Only 10 of 36 or 28% do make a direct reference.

Table XX also shows the linkage between state and local goals for all 36 counties. In some circumstances state goals are combined into a single goal at the local level (e.g., state Goals 1 and 2 are often combined at the local level.) When that is the case, both goals are shown in Table XX as appearing in the local plan.

Goal 1 appears in all 36 county NHMPs; Goal 2 in 35 (97%) and Goal 7 in 34 (94%). Goal 4 appears in 83% and Goal 3 in 56%. Goals 5, 6, and 8 appear in very few local NHMPs. Goal 5 has to do with the capability of the jurisdiction to carry out its Plan; Goal 6 concerns documenting and evaluating progress in achieving natural hazard mitigation; and Goal 8 promotes eliminating development in hazard areas where risk cannot be mitigated. A goal similar to Goal 8 was found in only one local NHMP.

There are several goals that appear at in local NHMPs that were not reflected in the 2012 Oregon NHMP. The most relevant statewide are those with themes of protecting and mitigating risk to cultural and historic resources; enhancing partnerships and coordination among agencies at all levels of government; and integrating NHMPs with other plans. In its April 2014 meeting, the IHMT decided to include three new goals addressing these themes to better coordinate state and local NHMPs. Counties and cities should continue to be encouraged to review the Oregon NHMP goals when developing their NHMPs and to explicitly state their decisions to include or exclude state goal themes.

Figure XX, Correlation of State and County NHMP Goals

		Baker (NE Oregon)	Benton	Clackamas	Clatsop	Columbia	Coos	Crook	Curry	Deschutes	Douglas	Gilliam	Grant (NE Oregon)	Harney	Hood River	Jackson	Jefferson	Josephine	Klamath	Lake	Lane	Lincoln	Linn	Malheur	Marion	Morrow	Multnomah	Polk	Sherman	Tillamook	Umatilla	Union (NE Oregon)	Wallowa (NE Oregon)	Wasco	Washington	Wheeler	Yamhill	Percent Included
Plan Date		2014	2011	2013	2014*	2009	2010	2011	2010	2010	2010	2013	2014	2013	2012	2013	2014	2011	2012	2013	2012	2009	2011	2014	2011	Expired	2012	2009	2014	2012	2014	2014	2014	2012	2011	2014	2014*	-
Plan Goals	OR NHMP: Goal Statement	4	5	5	7	5	6	5	6	5	8	3	4	6	7	7	6	6	6	4	6	5	3	5	7	7	5	6	4	4	6	4	4	7	3	3	6	-
Goal 1	Protect life and reduce injuries resulting from natural hazards.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100%
Goal 2	Minimize public and private property damages and the disruption of essential infrastructure and services from natural hazards.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	97%
Goal 3	Increase the resilience of local, regional, and statewide economies.	X	X		X	X	X		X				X	X	X			X	X	X	X			X	X					X		X	X	X	X			56%
Goal 4	Minimize the impact of natural hazards while protecting and restoring the environment.	X		X	X		X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X		X	83%
Goal 5	Enhance and maintain state capability to implement a comprehensive statewide hazard loss reduction strategy.										X				X				X	X							X									X			17%
Goal 6	Document and evaluate Oregon's progress in achieving hazard mitigation.																		X																		X	6%
Goal 7	Motivate the public, private sector, and government agencies to mitigate against the effects of natural hazards through information and education.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	94%
Goal 8	Eliminate development within mapped hazardous areas where the risks to people and property cannot be mitigated.																									X												3%
Link	Are the local NHMP goals specifically linked with the Oregon NHMP goals?	N	Y	N	N	N	Y	N	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	Y	Y	N	Y	N	N	N	N	N	Y	N	Y	28%
Notes:	Clatsop and Yamhill county plans are not yet adopted. They are expected to be adopted and approved before the 2015 Oregon NHMP is approved.																																					
	Klamath County is the only county in the state that directly copies Goals 1 - 6 of the 2012 Oregon NHMP.																																					

Chapter 3
ENHANCED PLAN

< Placeholder for Enhanced Plan:>

A. In this Chapter
B. Introduction
C. Executive Summary
D. Compliance with Standard Plan
E. Integration with Other Planning Initiatives
F. Capability Assessment
    1. Project Implementation
    2. Program Management
G. Mitigation Action Assessment
H. Effective Use of Available Mitigation Funding
I. Commitment to a Comprehensive Mitigation Program

Chapter 4
Planning Process

Table of Contents

A. In this Chapter
B. Introduction
C. Updating the Plan
    1. Revisions
D. Maintaining the Plan
    1. Future Enhancements to the Planning Process *(?)*
        a. "Living Document"
        b. Outreach and Input

In This Chapter

The Oregon NHMP Planning Process is divided into three sections: 1) Introduction, 2) Updating the 2012 Plan, and 3) Maintaining the 2015 Plan. Following is a description of each section.

1. **Introduction:** *States the purpose of the natural hazard mitigation planning process, both updating the 2012 Plan and maintaining the 2015 Plan.*
2. **Updating the 2012 Plan:** *Describes the planning environment and details the plan update process. Includes a table indicating whether or not each section of the 2012 plan was revised.*
3. **Maintaining the 2015 Plan:** *Includes the following components:*
   - Monitoring the Plan: *Analyzes the efficacy of the method and schedule for monitoring, evaluating, and updating the 2012 Oregon NHMP and establishes a method and schedule for monitoring, evaluating, and updating the 2015 Oregon NHMP.*
   - Monitoring Goals, Activities, and Projects: *Analyzes the efficacy of the 2012 Oregon NHMP system for reviewing progress on mitigation activities; discusses whether mitigation actions were implemented as planned; and establishes a system for reviewing progress on implementing mitigation activities and projects and achieving 2015 Oregon NHMP goals.*

Introduction

44 CFR §201.4(b), Planning process. *An effective planning process is essential in developing and maintaining a good plan. The mitigation planning process should include coordination with other State agencies, appropriate Federal agencies, interested groups, and be integrated to the extent possible with other ongoing State planning efforts as well as other FEMA mitigation programs and initiatives.*

The Disaster Mitigation Act of 2000 (44 CFR 201.4) had required that states update their multi-hazard mitigation plans every three years to maintain eligibility for federal disaster assistance. In April 2014, FEMA changed the state mitigation planning update cycle from three to five years. Oregon chose to complete the three-year update already in progress. Oregon first completed a Natural Hazards Mitigation Plan (Oregon NHMP or Plan) in 1992 with subsequent updates occurring in 2000, 2004, 2006, 2009, and 2012.

The purpose of this chapter is three-fold:

- To describe the process used to develop the 2015 Oregon NHMP;
- To describe the process to be used for tracking progress on mitigation activity and goal achievement during the life of the 2015 Plan; and
- To describe the method and schedule for monitoring, evaluating, and updating the 2015 Plan.

Updating the 2012 Plan

Requirement 44 CFR §201.4(c), Plan content. *To be effective the plan must include the following elements:*

Requirement 44 CFR §201.4(c)(1) *Description of the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how other agencies participated.*

The purpose of this section is to describe the process used to develop the 2015 Oregon NHMP. Key meetings, participants, decision points, interagency coordination and public outreach efforts are described. In addition, other state and federal planning efforts with which the 2015 Plan is integrated are identified, as are the sections of the 2012 Plan that were revised.

DLCD managed and facilitated the update process with oversight and direction from the IHMT, guidance from FEMA, and in close cooperation with OEM and the State Hazard Mitigation Officer, DOGAMI, and OPDR. Other state and federal agencies also contributed substantively and substantially to the update.

The IHMT

The hazard characterizations, probability, and vulnerability assessments were reviewed and revised by subject matter experts from IHMT agencies, the Oregon Climate Change Research Institute and Oregon Climate Service. The Regional Profiles, Local Capability Assessment, Coordination of Local Mitigation Planning, and Funding sections were reviewed and revised by OPDR and DLCD. Information about state-owned and leased buildings and critical and essential facilities was provided by DOGAMI, and about seismic lifelines by ODOT. Mitigation actions were reviewed, evaluated, revised, and prioritized by IHMT agency representatives and approved by the IHMT. Goals were reviewed and revised by the IHMT.

The IHMT's Risk Assessment Sub-Committee, comprised of personnel from OEM, DLCD, DOGAMI, DEQ, Business Oregon, UO, and FEMA developed a new concept methodology for a risk assessment that could, if fully developed, be used to assess risk for all hazards at both the state and local levels.

The Silver Jackets, a US Army Corps of Engineers program, is implemented in Oregon as another sub-committee of the IHMT. It brings together a number of federal and state agencies and has been instrumental in moving flood hazard mitigation forward during this update cycle.

Maintaining the 2015 Plan

Requirement 44 CFR §201.4(c)(5)(i-iii), *A Plan Maintenance Process that includes: (i) An established method and schedule for monitoring, evaluating, and updating the plan; (ii) A system for monitoring implementation of mitigation measures and project closeouts; and (iii) A system for reviewing progress on achieving goals as well as activities and projects identified in the Mitigation Strategy.*

The purpose of this section is to describe procedures for maintaining the Oregon NHMP which involves monitoring progress in achieving mitigation actions and Plan goals as well as monitoring, evaluating and updating the Oregon NHMP itself.

The procedures described within this section are informed by analyses of previous plan maintenance methods and schedules and the state's current and projected capabilities. Because this plan and the state's capabilities are ever-evolving, the systems and processes described herein are subject to change. The information collected and documented through the plan maintenance process will serve as the basis for the next plan update. The process of updating the plan provides the state with an opportunity to review its progress in achieving mitigation goals and chart its course for the next mitigation planning cycle.

Analysis of the 2012 Plan Maintenance Process

The Oregon NHMP was last updated and formally adopted by Governor Kitzhaber on March 5, 2012. As described earlier in this chapter, DLCD first took on responsibility for updating the Plan during 2012 and hired two positions to manage the effort in 2013. The process of transferring responsibility and gearing up to execute consumed the first 14 months of the update cycle. Subsequently and necessarily, all available resources were allocated to the update; therefore, the detailed plan maintenance and monitoring process for the plan and mitigation actions set forth in the 2012 Plan was not able to be followed. FEMA acknowledged this situation through the 2015 Plan update funding negotiation. Nevertheless, a thorough review and evaluation of the entire 2012 Plan was undertaken through the plan update process – including Plan goals and mitigation actions – substituting effectively for the Plan maintenance and monitoring process envisioned in the 2012 Plan. All the sections of the 2012 Plan that were revised are identified on page XXX.

In 2012, Oregon lost enhanced plan status due to project implementation and program management issues. Much effort has been expended during this update cycle on making the changes necessary to regain enhanced plan status. OEM and the State Hazard Mitigation Officer have been leading the charge, working closely with FEMA and making substantial progress. In anticipation of regaining enhanced plan status, the 2012 Enhanced Plan was also thoroughly reviewed, evaluated, and updated during this cycle.

Monitoring, Evaluating, and Updating the 2015 Plan

Monitoring the 2015 Plan

DLCD, with input and involvement from State IHMT agency representatives will prepare an annual mitigation planning progress report. While it is anticipated that the report will be prepared during the first quarter of the calendar year to be delivered to the IHMT at its regularly scheduled April meeting, this schedule may be amended as circumstances dictate (e.g., a disaster declaration might require an adjustment). The first annual report for this planning cycle will be prepared in 2016 for 2015. Annual reports will be suspended for the last two years of the planning cycle (2019 report on 2018, and 2020 report on 2019) to conserve scarce resources by avoiding duplication of effort, as the information developed during that period will be developed as part of the plan update.

The annual report will document any disaster events (declared or not) that have occurred in the previous year and milestones in plan implementation, including key meetings, participants, decision points, interagency coordination, public outreach efforts, mitigation action status, other mitigation project status, and mitigation success stories. The report will also document progress toward achieving Plan goals by correlating mitigation action status and successes with the goals and other state mitigation-related activities and initiatives. The information in the annual reports will be included in the Plan update.

Further, at a regular quarterly meeting as soon as feasible following a disaster event in Oregon (whether declared or not), the State IHMT will discuss the event in the context of the Oregon NHMP and provide any necessary direction for updating the Plan. This discussion will be documented and any directed plan revisions will be included in the annual report or Plan update depending on when the disaster event occurred.

Monitoring Mitigation Actions and Project Closeouts

Progress on state mitigation actions, including projects that may be listed as mitigation actions will be monitored through the annual reporting process. Progress of “Priority” mitigation actions will be noted; completed actions or those that will not be completed will be deleted from the “Priority” list and entered on the “Removed” list with a brief explanation. Progress of “Ongoing” mitigation actions will be noted.

In addition, OEM systematically monitors the implementation of FEMA-funded mitigation actions and projects for which it is the grantee at both state and local levels using: required sub-grantee quarterly reporting; telephone and e-mail communications; and project site visits as required. Successful project implementation requires open communication between the grantee and sub-grantee to ensure schedules, budget, and scope-of-work deliverable requirements are met. Project closeouts are always conducted on site allowing the grantee and sub-grantee to certify completion of the project activity (performance component) and that all eligible expenses have been submitted, reviewed for eligibility and reimbursed (financial component). OEM documents project closeout by summary performance and financial reports making sure the sub-grantee is aware of documentation retention requirements, audit requirements and maintenance schedule (if so required) to ensure the performance of the mitigation over the life of the project. The State Hazard Mitigation Officer is responsible for reporting this information to the state IHMT for projects funded by the Hazard Mitigation Grant, Pre-Disaster Mitigation and Flood Mitigation Assistance programs.

Outside of the traditional FEMA mitigation grant programs, state and local governments identify and oftentimes implement mitigation actions and projects using their own capabilities and resources. At the local level, this may include the development and adoption of local ordinances and regulations that have

a hazard mitigation component; mitigation codes and standards as part of ongoing transportation and public works programs; hazard-related components of local comprehensive land use plans; and so forth. While it may not be possible to track and report on every mitigation accomplishment in local mitigation plans, communities will see the positive cumulative impacts of these efforts in reduced disaster losses. The state encourages the seamless integration of mitigation activities into the day-to-day operations of state and local government programs.

Evaluating and Updating the 2015 Plan

DLCD will manage and facilitate the plan update process, beginning with review and evaluation of the 2015 Oregon NHMP. The criteria to be used for evaluation of the 2015 Plan are:

- Compliance with FEMA crosswalk requirements.
- Corroboration or invalidation of risk assessment in the context of any disaster events (declared or not) during the update cycle.
- Progress toward completion of mitigation actions.
- Progress toward completion of other mitigation projects.
- Progress toward completion of any other Plan commitments.
- Progress toward achieving Plan goals.

Results of the evaluation will be documented and serve as the basis for updating the Plan.

Living Document

REFERENCES

< Placeholder for References:>

GLOSSARY

< Placeholder for Glossary:>

APPENDICES

< Placeholder for Appendices:>

SUBJECT TO CHANGE

A. Risk Assessment
    1. Dust Storms
        a. DEQ Air Pollution Rule
        b. Information on 1931 Dust Storm
    2. Volcanic Hazards
        a. Detailed inventory of history and hazards for Mount St. Helens, Mount Adams, Mount Hood, Mount Jefferson, the Three Sisters Region, Newberry Volcano, and Crater Lake
    3. Wildfire
        a. Conflagration Fires 1996-2011
        b. Graphical information displaying trends for some wildfire ignition sources
    4. Windstorm
        a. How to Recognize and Prevent Tree Hazards
    5. Winter Storm
        a. Average Annual Snowfall at Various Oregon Stations
        b. Reducing Ice Storm Damage to Trees
    6. Statewide Loss Estimates
        a. Complete State-Owned Facilities/Critical and Essential Facilities Loss Estimates Table
        b. ODOT Seismic Options Report, Appendices E and F
    7. THIRA
B. Mitigation Strategy
    1. Mitigation Action Tables
        a. Initial Evaluation
        b. Prioritization Score Sheet
        c. Prioritization
        d. Level of Support
        e. 2015 Mitigation Actions: Priority, Ongoing, Removed
        f. Crosswalk: 2012 to 2015 Mitigation Actions
    2. Archive of Mitigation Successes
C. Planning Process
    1. Planning Process Documentation
        g. Letter to Directors, 4/2013

h. Meetings
i. Website screenshots
j. Emails to subscribers
k. Info to Regional Reps
l. Emails to Regional Reps' contacts
m. Plan Updates

D. Enhanced Plan