Chapter 2 RISK ASSESSMENT

In This Chapter

The Oregon NHMP Risk Assessment chapter is divided into three sections: (a) Introduction, (b) State Risk Assessment, and (c) Regional Risk Assessment. Following is a description of each section.

1. **Introduction:** States the purpose of the risk assessment and explains risk.
2. **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; characterizes each hazard that impacts Oregon; lists historic events; identifies the probability of future events; and introduces 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/leased facilities and critical/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.
3. **Regional Risk Assessment:** Includes the following components for each of the eight Oregon NHMP Natural Hazard Regions:
   - Summary: Summarizes the region's statistical profile and hazard and vulnerability analysis and generally describes projected impacts of climate change on hazards in the region.
   - 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.
   - Hazards and Vulnerability: Further describes the hazards in each region by characterizing how each hazard presents itself in the region; listing historic hazard events; 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 are most vulnerable to each hazard based on local and state analysis; provides loss estimates for state-owned/leased facilities and critical/essential facilities located in hazard areas; and identifies the region's seismic lifeline vulnerabilities.

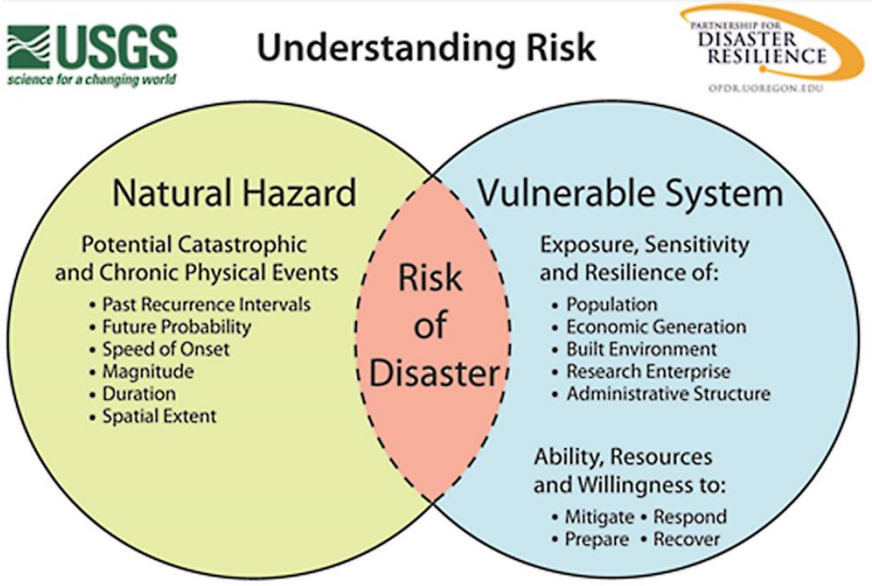
2.1 Introduction

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.

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 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 — the area of overlap in **Figure 2-1**. The Oregon NHMP Risk Assessment informs the State's mitigation strategy, found in **Chapter 3**.

Figure 2-1. Understanding Risk



Source: Wood (2007)

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.

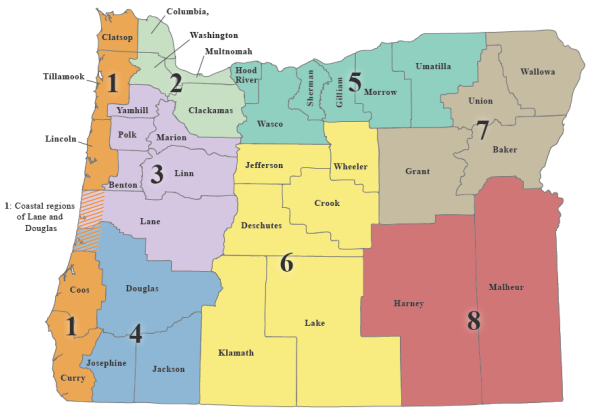
A vulnerability assessment combines information from the hazard characterization with an inventory of the existing (or planned) property and population exposed to a hazard and attempts to predict how different types of property and population groups will be affected by each hazard. Vulnerability is determined by a community's exposure, sensitivity, and resilience to natural hazards as well as by 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.

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

This Plan also analyzes risk at the regional level. Regional risk assessments begin with a description of the region's assets in the Regional Profile section. The Profile is followed by a characterization of each hazard and identification of the vulnerabilities and potential impacts of each hazard. Regions are defined in the Oregon NHMP Natural Hazards Regions map (**Figure 2-2**):

- **Region 1 – Coast:** Clatsop, Tillamook, Lincoln, coastal Lane, coastal Douglas, Coos, and Curry Counties;
- **Region 2 – Northern Willamette Valley/Portland Metro:** Colombia, Clackamas, Multnomah, and Washington Counties;
- **Region 3 – Mid/Southern Willamette Valley:** Benton, Lane, Linn, Marion, Polk, and Yamhill Counties;
- **Region 4 – Southwest:** Douglas (non-coastal), Jackson, and Josephine Counties;
- **Region 5 – Mid-Columbia:** Gilliam, Hood River, Morrow, Sherman, Umatilla, and Wasco Counties;
- **Region 6 – Central:** Crook, Deschutes, Jefferson, Klamath, Lake, and Wheeler Counties;
- **Region 7 – Northeast:** Baker, Grant, Wallowa, and Union Counties; and
- **Region 8 – Southeast:** Harney and Malheur Counties.

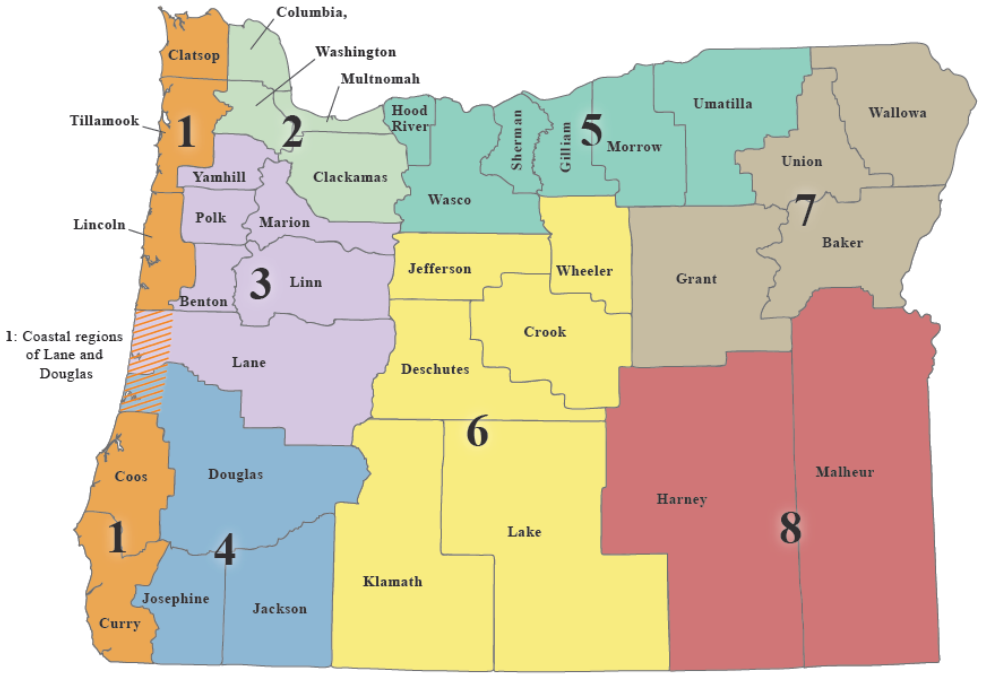
Figure 2-2. Oregon NHMP Natural Hazards Regions



2.3 Regional Risk Assessments

The purpose of the Regional Risk Assessment is to assess risks at a regional scale by profiling the characteristics, natural hazards, and vulnerabilities within the eight Oregon NHMP Natural Hazard Regions (Figure 2-81). Each region has its own Risk Assessment. Together, the eight Regional Risk Assessments combine to describe the State's overall risk to natural hazards.

Figure 2-81. Oregon NHMP Natural Hazards Regions



Each Regional Risk Assessment includes three sections:

1. The **Summary** provides a general overview of (a) the Regional Profile, (b) the Regional Hazards and Vulnerability, and (c) how climate change models predict hazards in the region will be impacted based on statewide data.
2. The **Profile** section provides an overview of the region's unique characteristics including profiles of the natural environment, social and demographic situation, economic environment, infrastructure, and built environment.

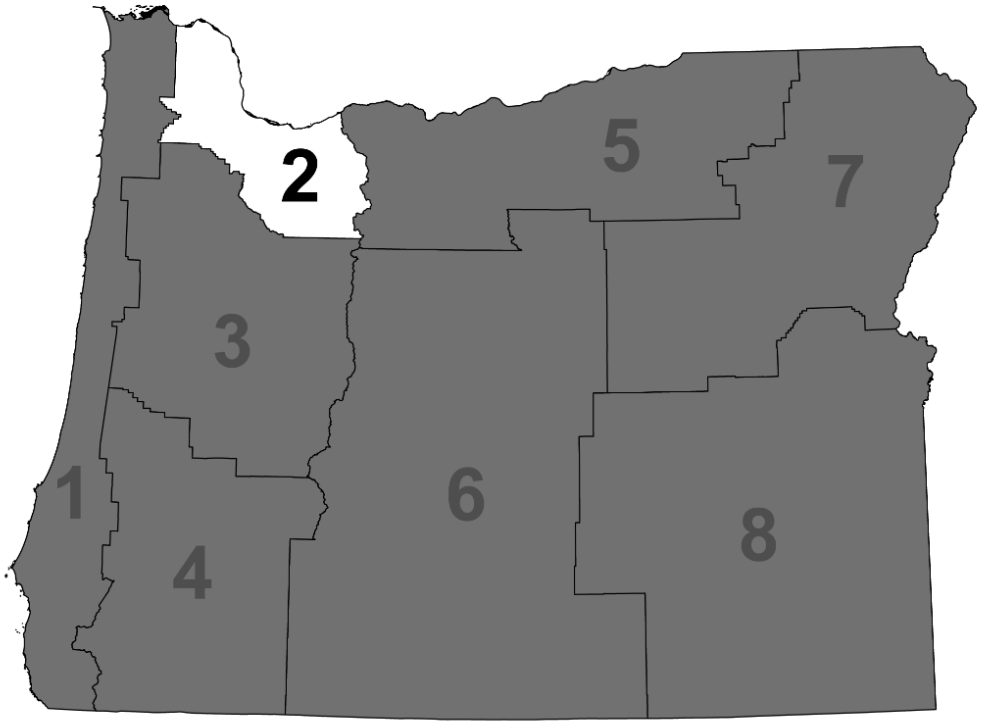
   The research of Susan Cutter, Professor of Geography at the University of South Carolina, Columbia, on vulnerability and environmental hazards provides the framework for discussion of vulnerability in the Regional Profile section. Cutter's framework helps to illustrate the geographic variability of vulnerability and allows policy makers to better understand how to prepare for, mitigate, and reduce vulnerability (Cutter et al., 2003; Cutter, 2006).

3. The **Hazards and Vulnerability** section first identifies each hazard and its characteristics in the region. Then, the historical events that have impacted the region are listed. Lastly, probabilities and vulnerabilities are discussed as identified by local and state risk assessments. Vulnerabilities to and potential impacts from each hazard in the region are described including the identification and analysis of the region's State owned/leased facilities and critical/essential facilities located within hazard zones and seismic lifeline vulnerabilities.

Regional Risk Assessments add to the current body of literature and technical resource guides available to Oregon communities. The three levels of government — federal, state, and local — will find the Regional Risk Assessments useful when assessing natural hazards and vulnerabilities and when planning mitigation activities. Local governments can use the Regional Risk Assessments in the development of their jurisdiction's natural hazards mitigation plan. Information from these assessments is intended to be used as a springboard for more detailed community profiles. Likewise, information from local plans helps to inform the Oregon NHMP risk assessment overall.

2.3.2 Region 2: Northern Willamette Valley / Portland Metro

Clackamas, Columbia, Multnomah, and Washington Counties



2.3.2.1 Summary

Profile

The region's demographic, economic, infrastructure, and development patterns indicate that some populations, structures, and places may be more vulnerable to certain natural hazards than others. Mitigation efforts directed at these vulnerabilities may help boost the area's ability to bounce back after a natural disaster.

Regionally, social vulnerability is driven by a high number of tourists who are likely not familiar with the hazard types and level of risk in the region. At the county level, high numbers of disabled persons in Multnomah County; a dramatic increase in the homeless population in Clackamas County; and higher numbers of renters and of persons who do not speak English "very well" in Multnomah and Washington Counties increase the level of risk to these populations. Columbia County's low incomes and high poverty rates make it especially vulnerable to heightened economic hardship that often follows a hazard event.

Compared to other areas of the state, communities around the Portland Metro area weathered the financial crisis that began in 2007 due to the diversity of key industries, employment sectors, and higher wages than the state average. The region's resilience is bolstered by strong Professional and Business Services, Health and Social Assistance, and Government sectors, which have low vulnerability to natural disasters and are key to post-disaster recovery efforts. Columbia County's economy is struggling the most, with higher unemployment and lower wages.

Transportation networks across the state are vulnerable to natural hazard events, especially seismic events. Following a Cascadia earthquake event, access across the Willamette River and along I-5 may be limited due to bridge collapse. The region has two ports with facilities, including the Portland International Airport, that are key to the statewide economy and are vulnerable to disruptions in service that can impact the transport of people, goods, and emergency services.

Older centralized water infrastructure is vulnerable to flooding and pollution. Upstream pollution in the Willamette and Columbia Rivers threaten ecosystems and public health.

Eight power-generating facilities and many dams — including Bonneville Power Administration's main dam, the Bonneville Dam — are in this region. Additionally, the site of Oregon's Critical Energy Infrastructure Hub, located in Portland, is subject to seismically induced liquefaction, making it exceptionally vulnerable to a Cascadia earthquake. Disruption or failure to these systems could be devastating to the region and state.

Region 2 is developing at a slightly faster pace than the rest of the state. The majority of growth is occurring in urban areas surrounding Portland. Over half the homes in Multnomah County were built prior to current seismic and floodplain management standards, making them particularly vulnerable to seismic and flood events.

Hazards and Vulnerability

Region 2 is affected by eight of the 11 natural hazards that affect Oregon communities. Coastal hazards, dust storms, and tsunami do not directly impact this region.

Droughts: The region is affected by droughts to a lesser extent than other areas in the state. Moderate-type drought years have occurred in Region 2 more than a dozen times between 1939 and 2001.

Earthquakes: Four types of earthquakes affect Region 2 (a) shallow crustal events, (b) deep intra-plate events within the subducting Juan de Fuca plate, (c) the offshore Cascadia Subduction Zone (CSZ) Fault, and (d) earthquakes associated with renewed volcanic activity. The CSZ is the chief earthquake hazard for the Northern Willamette Valley. The region is particularly vulnerable to earthquakes due to the amount of area that is susceptible to earthquake-induced landslide, liquefaction, and ground shaking. Region 2 is home to the majority of the state's population, employment, and built environment. A CSZ event will dramatically impact the region's critical infrastructure, including seismic lifelines along Interstate-5 and Oregon's Critical Energy Hub in North Portland. There are 849 state-owned/leased facilities, valued at over $1 billion, in Region 2's earthquake hazard zone. Of these, 120 are critical/essential facilities. An additional 2,675 non-state-owned/leased critical/essential facilities are also located within this hazard zone.

Floods: All counties in the Northern Willamette Valley are affected by riverine flooding. Rain-on-snow events and heavy rain events leading to tributary backups are common in this region. Clackamas and Columbia Counties are most vulnerable to flooding events. Region 2 has the second highest number of repetitive flood losses in the state (which is one third of all losses statewide), of which four are severe repetitive losses. Many of these are along the Columbia River where high rainfall impacts high population density. Following floods in 1996 and 2007, elevation and acquisition projects initiated by the City of Vernonia helped reduce flood risk in Columbia County. There are 51 state-owned/leased facilities, valued at approximately $25.4 million, located in the region's flood hazard zone. Of these, two are considered critical/essential facilities. In addition, 56 non-state-owned/leased critical/essential facilities are located in this hazard zone.

Landslides: Landslides can occur throughout the region, though more tend to occur in areas with steeper slopes, weaker geology, and higher annual precipitation. Rain-induced landslides can occur during winter months, and earthquakes can trigger landslides. Vulnerability is increased in populated areas such as the Portland Metro Area and in the Coast and Cascade Mountain Ranges. In general, the counties of Washington, Multnomah, and Clackamas have relatively high vulnerability. There are 848 state-owned/leased facilities, valued at over $1 billion, in Region 2's earthquake hazard zone. Of these, 120 are critical/essential facilities. An additional 2,675 non-state-owned/leased critical/essential facilities are also located within this hazard zone.

Volcanoes: The region can be impacted by volcanic activity, particularly within parts of eastern Clackamas and Multnomah Counties (including Portland) that coincide with the crest of the Cascade Mountain Range. Most volcanic activity is considered local. However, some activity, such as lahars and ashfall, can travel many miles and could impact the communities of Government Camp, Rhododendron, and Welches. There are 220 state-owned/leased facilities,

valued at approximately $73.7 million, located in a volcanic hazard zone. Of these, 17 are identified as critical/essential facilities. In addition, 601 non-state-owned/leased critical/essential facilities are also located in this hazard zone.

Wildfires: The region's vulnerability to wildfire is moderate at best. Wildfires are most common during the late summer. The areas of greatest vulnerability are within the wildland-urban interface communities. Much of the risk to wildfire in Region 2 is mitigated by large expanses of urban development and quick response times. There are 234 state-owned/leased facilities, valued at approximately $115 million, located in a wildfire hazard zone. Of these, 18 are identified as critical/essential facilities. In addition, 380 non-state-owned/leased critical/essential facilities are also located in this hazard zone.

Windstorms: Windstorms affect the region annually. The most frequent and strongest originate in the Pacific Ocean and travel southwest. Columbia, Multnomah, and Washington Counties are most vulnerable to these types of storms. To a lesser degree, eastern winds traveling through the Columbia River Gorge also affect Region 2 communities. Windstorms can impact the region's buildings, utilities, tree-lined roads, transmission lines, residential parcels, and transportation systems along open areas such as grasslands and farmland.

Winter Storms: Winter storms occur annually. The Columbia River Gorge can bring colder weather, higher precipitation, and high westerly winds to the region causing severe weather for short periods of time. Because these storms are infrequent and short lived, communities including the Portland Metro Area are often unprepared for them.

Climate Change

The most reliable information on climate change to date is at the state level. The state information indicates that hazards projected to be impacted by climate change in Region 2 include drought, wildfire, flooding, and landslides. 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. In addition, flooding and landslides are projected to occur more frequently throughout western Oregon. An increase in extreme precipitation is projected for some areas of Region 2 and can result in a greater risk of flooding in certain basins, including an increased incidence of magnitude and return interval. Landslides in Oregon are strongly correlated with rainfall, so increased rainfall — particularly extreme events — will likely trigger increased landslides. While winter storms and windstorms affect Region 2, there is little research on how climate change influences these hazards in the Pacific Northwest. For more information on climate drivers and the projected impacts of climate change in Oregon, see the section **Introduction to Climate Change**.

2.3.2.2 Profile

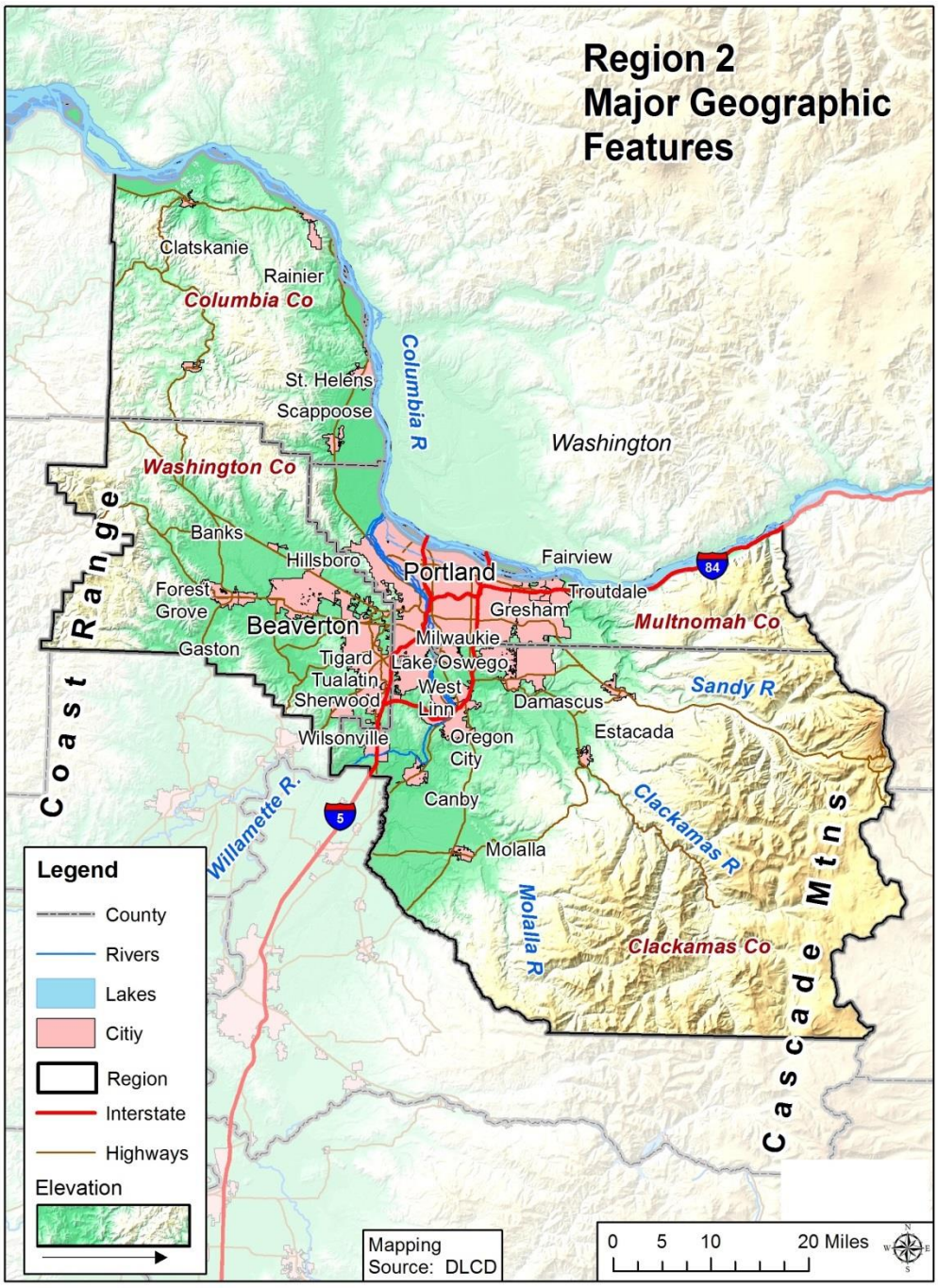
Requirement: 44 CFR §201.4(d): The Plan must be reviewed and revised to reflect changes in development…

Natural Environment

Geography

The Northern Willamette Valley and Portland Metro Area is approximately 3,758 square miles in size, and includes Clackamas, Columbia, Multnomah, and Washington Counties. Mountain ranges and watersheds shape the region's topography. Region 2 begins at the Cascade Mountain Range in the east and extends westward through the Willamette Valley and into the Coast Range and southward from the Columbia River in the North to the Mid-Willamette Valley. Two rivers shape the region's main watersheds, the Columbia River and the Willamette River. **Figure 2-101** shows the dominant mountain ranges, major watersheds, and political boundaries of Region 2.

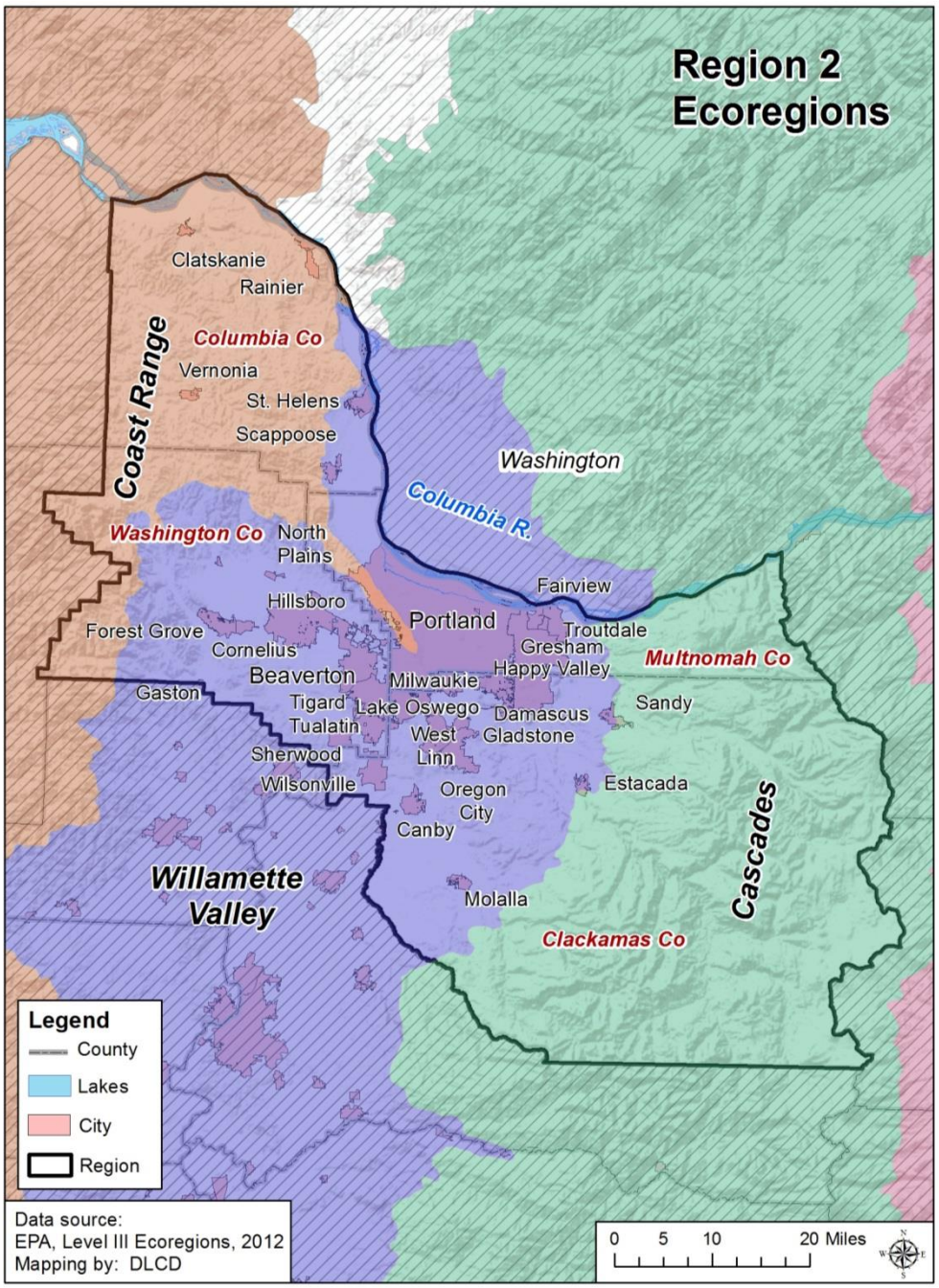
Figure 2-101. Region 2 Major Geographic Features



Source: Department of Land Conservation and Development, 2014

The U.S. EPA's ecoregions are used to describe areas of ecosystem similarity. Region 2 is composed of three ecoregions: the Coast Range, the Willamette Valley, and the Cascades (**Figure 2-102**).

Figure 2-102. Region 2 Ecoregions



Cascades: Soil in this ecoregion is volcanic. Mixed conifer forests have given way to predominantly Douglas fir forests that are managed for commercial logging. Logging activities have put a strain on the ecological health of streams in the area (Thorson et al., 2003). Waterways in the steeper valleys support threatened cold-water salmonids including Chinook salmon, steelhead, and bull trout. Streams, lakes, reservoirs, rivers, and glacial lakes at higher elevations are key sources of water (Thorson et al., 2003).

Willamette Valley: Terraces and floodplains dominate the nearly flat central Willamette Valley. The valley floor is dotted with scattered hills, buttes, and bordered by the adjacent foothills. Historically, valley waterways meandered throughout floodplains on the nearly flat valley floor, contributing to the valley's highly fertile soil and supporting the dominance of oak savannah and prairie ecosystems. Today the Willamette River and its tributaries are highly channelized, restricting the flow of these waterways, helping protect property but also threatening stream health. The productive soils and temperate climate make this ecoregion one of the most important agricultural areas in Oregon. The valley's flat terraces have made urban and suburban development possible in the valley (Thorson et al., 2003).

Coast Range: The east slope of the Coast Range is located within Region 2. Soils are a mix of sedimentary and volcanic composition. Sedimentary soils can create more concerns for stream sedimentation than areas with volcanic soils (Thorson et al., 2003). Volcanic soils are underlain by basaltic rocks resulting in more consistent summer stream flows. This soil composition supports runs of spring Chinook salmon and summer steelhead. On the other hand, sedimentary soils are prone to failure following clear cuts. This may be of concern as the commercial Douglas fir forests are highly productive commercial logging areas.

Climate

This section covers historic climate information only. For estimated future climate conditions and possible impacts refer to the **State Risk Assessment**.

Variations in temperature and precipitation vary widely by sub-ecoregion and microclimate. Precipitation generally occurs in the winter months. Wet winters and dry summers increase risk to droughts, floods, landslides, wildfires, and winter storms. For more detailed and locally relevant climate data refer to the Oregon Climate Service.

Table 2-118. Average Precipitation and Temperature Ranges in Region 2 Ecoregions

Ecoregion	Mean Annual Precipitation Range (inches)	Mean Temperature Range (°F) January min/max	Mean Temperature Range (°F) July min/max
Cascades*	55–140	16/41	38/78
Willamette Valley*	37–60	32/46	50/85
Coast Range*	50–200	30/46	50/76

*Data have been generalized from all the sub-ecoregions of the ecoregion in Region 2.

Source: Thorson et al. (2003)

Demography

Population

Population forecasts are an indicator of future development needs and trends. Community demographics may indicate where specific vulnerabilities may be present in the aftermath of a natural hazard (Cutter et al., 2003). If a population is forecast 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.

Overall, from 2000 to 2013, Region 2 grew at about the same rate as the state. The exception is Washington County, which grew almost most 10% more than the rest of the region. By 2020, all counties in Region 2 except Multnomah are projected to grow at a rate greater than the state.

Table 2-119. Population Estimate and Forecast for Region 2

	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 2	1,487,779	1,743,450	17.2%	1,906,659	9.4%
Clackamas	338,391	386,080	14.1%	422,576	9.5%
Columbia	43,560	49,850	14.4%	54,517	9.4%
Multnomah	660,486	756,530	14.5%	807,198	6.7%
Washington	445,342	550,990	23.7%	622,368	13.0%

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

Tourists

Tourists are not counted in population statistics and are therefore considered separately in this analysis. Tourism activities in Region 2 are largely centered on special events (such as fairs, festivals or sporting events), city trips, and touring (traveling to experience scenic beauty, history and culture) (Longwoods International, 2011). Thirty percent of all overnight trips in Oregon included time in the Northern Willamette Valley/Portland Metro area. The average travel party contains 3.4 persons and 68% of these trips originate from Oregon or California. The average trip length is 3.5 nights (Longwoods International, 2011). In 2013, over 70% of visitors in Clackamas, Columbia, and Washington Counties lodged in private homes.

Difficulty locating or accounting for travelers increases their vulnerability in the event of a natural disaster. Furthermore, tourists are often unfamiliar with evacuation routes, communication outlets, or even the type of hazard that may occur (MDC Consultants, n.d.). Targeting natural hazard mitigation outreach efforts to places where tourists lodge can help increase awareness and minimize the vulnerability of this population.

Table 2-120. Annual Visitor Estimates in Person Nights in Region 2

	2011		2012		2013	
	Number	Percent	Number	Percent	Number	Percent
Region 2	25,731	—	26,367	—	26,780	—
Clackamas	6,626	100%	6,832	100%	6,828	100%
Hotel/Motel	1,205	18.2%	1,279	18.7%	1,292	18.9%
Private Home	4,849	73.2%	4,974	72.8%	4,948	72.5%
Other	572	8.6%	579	8.5%	588	8.6%
Columbia	627	100%	622	100%	622	100%
Hotel/Motel	51	8.1%	43	6.9%	38	6.1%
Private Home	496	79.1%	493	79.3%	493	79.3%
Other	80	12.8%	86	13.8%	91	14.6%
Multnomah	10,996	100%	11,475	100%	11,686	100%
Hotel/Motel	5,440	49.5%	5,785	50.4%	5,979	51.2%
Private Home	5,127	46.6%	5,251	45.8%	5,262	45.0%
Other	429	3.9%	439	3.8%	445	3.8%
Washington	7,482	100%	7,438	100%	7,644	100%
Hotel/Motel	1,693	22.6%	1,682	22.6%	1,769	23.1%
Private Home	5,640	75.4%	5,604	75.3%	5,721	74.8%
Other	149	2.0%	152	2.0%	154	2.0%

Source: Oregon Travel Impacts: 1991–2013, April 2014. Dean Runyan Associates, http://www.deanrunyan.com/doc_library/ORImp.pdf

Persons with Disabilities

Disabilities appear in many forms. While some disabilities may be easily identified, others may be less perceptible. Disabled populations, while difficult to identify and measure, are disproportionately affected during disasters (Cutter et al., 2003). While somewhat fewer people in Region 2 identify as having a disability than do people throughout the state, 46% of those who consider themselves to have a disability live in Multnomah County. Local natural hazard mitigation plans should specifically target outreach programs toward helping disabled residents better prepare for and recover from hazard events.

Table 2-121. People with a Disability by Age Group in Region 2, 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 2	1,683,829	184,388	11.0%	15,218	3.9%	68,586	36.4%
Clackamas	375,412	42,579	11.3%	3,849	4.3%	17,787	34.6%
Columbia	49,072	6,968	14.2%	546	4.7%	2,600	38.1%
Multnomah	730,762	85,534	11.7%	6222	4.1%	29,888	39.1%
Washington	528,583	49,307	9.3%	4,601	3.4%	18,311	34.3%

*Total population does not include institutionalized population.

**Percent of age group.

Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP02

Homeless Population

Population estimates of the homeless in Oregon are performed each January. These are rough estimates and can fluctuate with many factors, including the economy or season. The overwhelming majority of homeless people are either single adult males or families with children. Communities located along major transportation corridors, such as I-5, tend to have higher concentrations of homeless people (Thomas et al., 2008). This population has increased in the region by roughly 30% from 2009 to 2011. The greatest increase, roughly 163%, in homeless populations in the Northern Willamette Valley and Portland Metro Area has taken place in Clackamas County.

Extra attention is needed to care for and serve homeless communities**.** Some homeless people choose to remain hidden or anonymous, making it especially difficult to mitigate harm to them from natural hazard events. Accessible shelter and social services are key emergency considerations for the homeless community.

Table 2-122. Homeless Population Estimate for Region 2

	2009	2010	2011	3-Year Average
Oregon	17,122	19,208	22,116	19,482
Region 2	6,440	5,132	9,439	7,004
Clackamas	168	208	2,741	1,039
Columbia	256	342	285	294
Multnomah	4,808	3,199	5,059	4,355
Washington	1,208	1,383	1,354	1,315

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

Gender

The gender breakdown in Region 2 is similar to that of the state, roughly 50:50 (U.S. Census Bureau, 2010, American Community Survey, Table DP-1). 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 (Cutter et al., 2003).

Age

The region's percentage of seniors is slightly lower than the state. Senior citizens may require special consideration due to sensitivity to heat and cold, reliance upon transportation to obtain medication, and comparative difficulty in making home modifications that reduce risk to hazards. In addition, the elderly may be reluctant to leave home in a disaster event. This implies the need for targeted preparatory programming that includes evacuation procedures and shelter locations accessible to elderly (Morrow, 1999).

The region's percentage of children is similar to the statewide percentage. Special consideration should be given to young children, schools, and parents during the natural hazard mitigation process. Young children are more vulnerable to heat and cold, have fewer transportation

options, and require assistance to access medical facilities. Parents may lose time and money when their children's childcare facilities and schools are impacted by disasters.

Table 2-123. Population by Vulnerable Age Groups in Region 2, 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 2	1,695,451	386,620	22.8%	191,947	11.3%
Clackamas	377,206	88,732	23.5%	52,187	13.8%
Columbia	49,317	11,704	23.7%	6,926	14.0%
Multnomah	737,110	150,824	20.5%	78,778	10.7%
Washington	531,818	135,360	25.5%	54,056	10.2%

Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP05, http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

Language

Special consideration in hazard mitigation should be given to populations who do not speak English as their primary language. These populations can be harder to reach with outreach materials. They are less likely to be prepared if special attention is not given to language and culturally appropriate outreach techniques. In the region, Multnomah and Washington Counties have the highest percentages of residents who do not speak English very well. Outreach materials used to communicate with and plan for this community should take into consideration their language needs.

Table 2-124. English Usage in Region 2, 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 2	1,458,376	91.9%	128,981	8.1%
Clackamas	339,863	95.5%	16,163	4.5%
Columbia	46,006	98.9%	528	1.1%
Multnomah	626,678	90.7%	64,290	9.3%
Washington	445,829	90.3%	48,000	9.7%

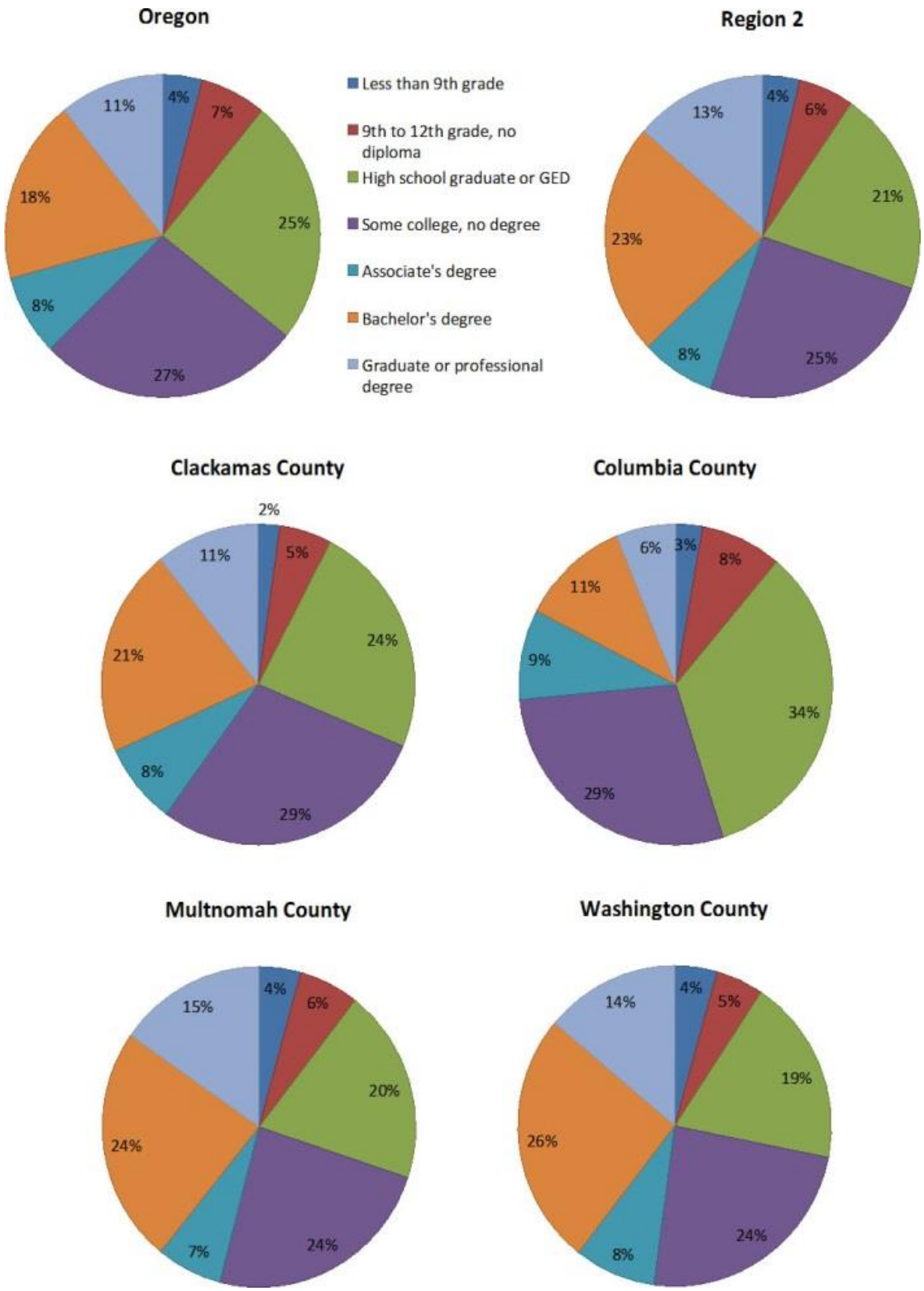
Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP02, http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

Education Level

Studies (Cutter et al., 2003) show that education and socioeconomic status are deeply intertwined, with higher educational attainment correlating to increased lifetime earnings. Furthermore, education can influence the ability to understand warning information (Cutter et al., 2003) and to access hazard resources.

There is a higher percentage of bachelor's and graduate or professional degrees in the Northern Willamette Valley and Portland Metro Area compared to statewide numbers (**Figure 2-103**). There is a lower percentage of people with only a high school degree or GED.

Figure 2-103. Educational Attainment in Region 2, 2012



Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP02

Income

The impact of a disaster in terms of loss and the ability to recover varies among population groups. "The causes of social vulnerability are explained by the underlying social conditions that are often quite remote from the initiating hazard or disaster event" (Cutter, 2006, p. 76). Historically, 80% of the disaster burden falls on the public. Of this number, a disproportionate burden is placed upon those living in poverty. People living in poverty are more likely to be isolated, are less likely to have the savings to rebuild after a disaster, and less likely to have access to transportation and medical care.

The recent financial crisis that began in 2007 moderately affected Region 2. Overall, median household incomes in the region are between $5,000 and $14,000 above those for the state, except in Multnomah County where they are only about $1,000 more than statewide numbers. Between 2009 and 2012, the greatest percent decrease in median household incomes occurred in Columbia County, falling by 9% — dropping by roughly 2 times median household incomes statewide.

Table 2-125. Median Household Income in Region 2

	2009	2012	Percent Change
Oregon	$52,474	$50,036	-4.6%
Region 2	N/A	N/A	N/A
Clackamas	$66,383	$63,951	-3.7%
Columbia	$60,897	$55,358	-9.1%
Multnomah	$52,622	$51,582	-2.0%
Washington	$66,585	$64,375	-3.3%

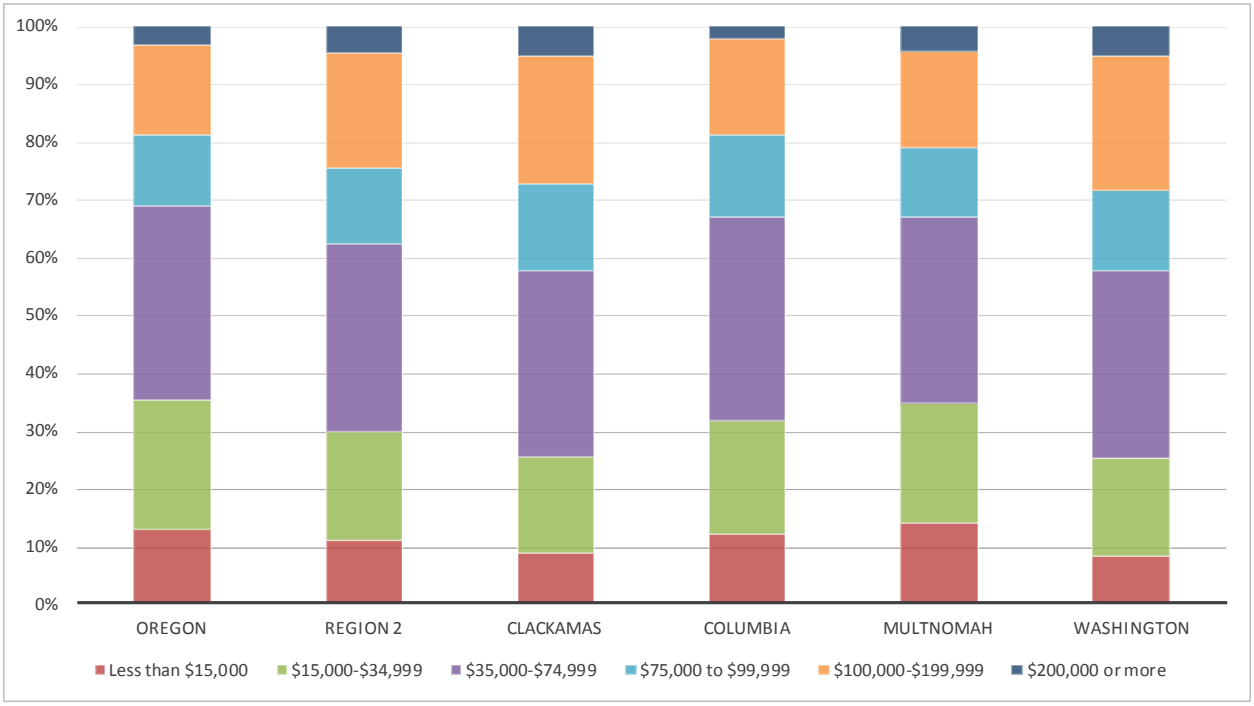
Note: 2009 dollars are adjusted for 2012 using Bureau of Labor Statistics' Consumer Price Index Inflation Calculator.

N/A = data not aggregated at the regional level.

Source: U.S. Census Bureau, 2005–2009 and 2008–2012 American Community Survey – 5-Year Estimates, Table DP03

The region has a smaller percentage of households earning less than $35,000 per year than the state as a whole. Clackamas and Washington Counties have the largest percentages of households earning more than $75,000 per year.

Figure 2-104. Median Household Income Distribution in Region 2, 2012



Source: U.S. Census Bureau; 2008–2012 American Community Survey 5-Year Estimates, Table DP03

The region has 2% fewer individuals and 3% fewer children living in poverty than the statewide average. Multnomah County has the highest percentage of its population living in poverty. However, the most dramatic increase in poverty rates has been in Columbia County with an almost 59% increase in overall poverty, including an 86% increase in child poverty.

Table 2-126. Poverty Rates in Region 2, 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 2	223,962	13.4%	15.6%	66,738	17.5%	14.4%
Clackamas	36,265	9.7%	9.2%	11,161	12.7%	9.0%
Columbia	6,797	13.9%	58.7%	2,257	19.6%	86.2%
Multnomah	123,434	17.1%	16.3%	34,231	23.1%	13.5%
Washington	57,466	10.9%	14.7%	19,089	14.3%	14.2%

*Percent change since 2009

Source: U.S. Census Bureau, 2005–2009 and 2008–2012 American Community Survey – 5-Year Estimates, Table S1701

Low-income populations require special consideration when mitigating loss to a natural hazard. Often, those who earn less have little to no savings and other assets to withstand economic setbacks. When a natural disaster interrupts work, the ability to provide housing, food, and basic necessities becomes increasingly difficult. In addition, low-income populations are hit especially

hard as public transportation, public food assistance, public housing, and other public programs upon which they rely for day-to-day activities are often impacted in the aftermath of the natural disaster. To reduce the compounded loss incurred by low-income populations post-disaster, mitigation actions need to be specially tailored to ensure safety nets are in place to provide further support to those with fewer personal resources.

Housing Tenure

Wealth can increase the ability to recover from a natural disaster (Cutter et al., 2003), and homeownership, versus renting, is often linked to having more wealth. Renters often do not have personal financial resources or insurance to help recover post-disaster. Further, renters are typically not in a position to be able to decide to and make substantive improvements such as seismic retrofits to their residences. On the other hand, renters tend to be more mobile and have fewer assets at risk. In the most extreme cases, renters lack sufficient shelter options when lodging becomes uninhabitable or unaffordable due to natural disaster events.

Compared to the state overall, Multnomah and Washington Counties have a higher share of rental units. Almost half of the units in Multnomah County are rented. Columbia County has the highest percentage of owner occupied households — nearly 15% more than the region's average.

Table 2-127. Housing Tenure in Region 2

	Total 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 2	667,878	404,784	60.6%	263,094	39.4%	39,156	5.5%
Clackamas	145,004	100,759	69.5%	44,245	30.5%	9,203	5.9%
Columbia	19,060	14,383	75.5%	4,677	24.5%	1,436	7.0%
Multnomah	303,654	166,200	54.7%	137,454	45.3%	17,496	5.4%
Washington	200,160	123,442	61.7%	76,718	38.3%	11,021	5.2%

*Functional vacant units, computed after removing seasonal, recreational, or occasional housing units from vacant housing units.

Source: U.S. Census Bureau, 2008–2012 American Community Survey, Table DP04

Families and Living Arrangements

Family care and obligations can create additional hardship during post-disaster recovery, especially for single-parent households (Cutter et al., 2003). Every county in the region except Multnomah has a slightly higher share of family households with children when compared to statewide numbers. Multnomah County's share is slightly less.

Table 2-128. Family vs. Non-family Households in Region 2, 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 2	667,878	413,103	61.9%	254,775	38.1%	191,979	28.7%
Clackamas	145,004	100,694	69.4%	44,310	30.6%	35,549	24.5%
Columbia	19,060	13,440	70.5%	5,620	29.5%	4,499	23.6%
Multnomah	303,654	164,793	54.3%	138,861	45.7%	101,623	33.5%
Washington	200,160	134,176	67.0%	65,984	33.0%	50,308	25.1%

Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP04

Table 2-129. Family Households with Children by Head of Household in Region 2, 2012

	Family Households with Children		Single Parent (Male)		Single Parent (Female)		Married Couple with Children	
	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 2	192,041	28.8%	13,723	2.1%	40,615	6.1%	137,703	20.6%
Clackamas	43,804	30.2%	3,346	2.3%	8,026	5.5%	32,432	22.4%
Columbia	5,328	28.0%	424	2.2%	1,226	6.4%	3,678	19.3%
Multnomah	75,794	25.0%	5,957	2.0%	19,076	6.3%	50,761	16.7%
Washington	67,115	33.5%	3,996	2.0%	12,287	6.1%	50,832	25.4%

Note: The table shows the percent of total households represented by each family household structure category.

Source: U.S. Census Bureau, 2008–2012 American Community Survey 5-Year Estimates, Table DP04

Social and Demographic Trends

The social and demographic analysis shows that Region 1 is particularly vulnerable during a hazard event in the following categories:

- Thirty percent of all tourists in the state visited this region.
- Columbia County has a greater percentage of disabled citizens than the region overall and the state overall.
- Clackamas County has seen a drastic increase in its homeless population.
- Multnomah and Washington Counties have the greatest proportion of residents who do not speak English well.
- Columbia County has seen a drop in median household income and dramatic increase in poverty.
- The percentage of renters in Multnomah County significantly exceeds that of the region and the state overall.

Economy

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 employment sectors, workforce, resources, and infrastructure are interconnected in the existing economic picture.

Employment

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 (Cutter et al., 2003). Since the end of the financial crisis that began in 2007 job recovery in Region 2 has outpaced the state's as a whole. Most major private sector industries are at or above pre-recession employment levels. Portland has regained about 90% of jobs lost, and half of these new jobs pay more than $50,000 annually.

Regional unemployment rates have been declining steadily since 2009. Unemployment rates in all counties except Columbia are generally 1% lower than the state. Columbia County has the smallest labor force in the region, the highest unemployment rate, and the lowest average salary. The majority of the region's employees are within Multnomah County. Washington County has the highest average wage, $59,481 (132% of the state average).

Winter months tend to have the lowest employment rates due to less tourism and fewer employment opportunities in outdoor industries such as construction and agriculture (Tauer, 2014). "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" (Cutter et al., 2003). Lower employment rates during winter months could be further exacerbated by a hazard event.

Table 2-130. Employment and Unemployment Rates in Region 2, 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 2	910,110	848,951	93.3%	61,159	6.7%
Clackamas	196,081	182,673	93.2%	13,408	6.8%
Columbia	23,449	21,516	91.8%	1,933	8.2%
Multnomah	400,250	372,664	93.1%	27,586	6.9%
Washington	290,330	272,098	93.7%	18,232	6.3%

Source: Oregon Employment Department, 2014

Table 2-131. Unemployment Rates in Region 2, 2009–2013

	2009	2010	2011	2012	2013	Change (2009–2013)
Oregon	11.1%	10.8%	9.7%	8.8%	7.7%	-3.4%
Region 2	10.1%	9.7%	8.5%	7.7%	6.7%	-3.4%
Clackamas	10.2%	10.1%	8.9%	8.0%	6.8%	-3.4%
Columbia	13.2%	12.1%	10.7%	9.7%	8.2%	-4.9%
Multnomah	10.4%	9.9%	8.7%	7.8%	6.9%	-3.5%
Washington	9.4%	9.0%	7.8%	7.1%	6.3%	-3.1%

Source: Oregon Employment Department, 2014

Table 2-132. Employment and Payroll in Region 2, 2013

	Employees	Average Pay	Percent State Average
Oregon	1,679,364	$45,010	100%
Region 2	861,474	$52,136	116%
Clackamas	143,101	$45,274	100.6%
Columbia	9,797	$34,558	76.8%
Multnomah	452,060	$50,521	112.2%
Washington	256,516	$59,481	132.2%

Source: Oregon Employment Department, 2014

Employment Sectors and Key Industries

In 2013 the five major employment sectors in Region 2 were: (a) Trade, Transportation, and Utilities; (b) Professional and Business Services; (c) Education and Health Services; (d) Government; and (e) Manufacturing. The following information is from the State of Oregon Employment Department (https://www.qualityinfo.org): Columbia County is within the Portland Metro area but remains a strong natural resource based economy that also has an increasing number of residents commuting to jobs in Portland and Cowlitz County, Washington. Multnomah and Washington Counties have a diverse economic base that has seen the most recovery in the state since the financial crisis that began in 2007. Industries in these counties include manufacturing, trade, and services. The high-tech industry is of particular importance to the region. Clackamas County has some of the state's most fertile farmland and is known for a strong agriculture based economy.

Table 2-133. Covered Employment by Sector in Region 2, 2013

		Clackamas		Columbia	
Industry	**Region 2**	**Employment**	**Percent**	**Employment**	**Percent**
Total All Ownerships	861,474	143,101	100%	9,797	100%
Total Private Coverage	87.3%	127,251	88.9%	7,886	80.5%
Natural Resources & Mining	1.1%	4,527	3.2%	311	3.2%
Construction	4.7%	8,806	6.2%	517	5.3%
Manufacturing	11.1%	17,657	12.3%	1,336	13.6%
Trade, Transportation & Utilities	18.8%	31,903	22.3%	1,941	19.8%
Information	2.3%	1,963	1.4%	53	0.5%
Financial Activities	5.8%	7,260	5.1%	368	3.8%
Professional & Business Services	15.6%	15,952	11.1%	638	6.5%
Education & Health Services	13.7%	19,382	13.5%	1,110	11.3%
Leisure & Hospitality	10.1%	13,790	9.6%	1,075	11.0%
Other Services	3.9%	5,970	4.2%	535	5.5%
Private Non-Classified	0.0%	42	0.0%	(c)	-
Total All Government	12.7%	15,850	11.1%	1,911	19.5%
Federal Government	1.6%	1,062	0.7%	67	0.7%
State Government	1.9%	2,322	1.6%	256	2.6%
Local Government	9.2%	12,466	8.7%	1,588	16.2%

		Multnomah		Washington	
Industry	**Region 2**	**Employment**	**Percent**	**Employment**	**Percent**
Total All Ownerships	861,474	452,060	100%	256,516	100%
Total Private Coverage	87.3%	381,281	84.3%	235,231	91.7%
Natural Resources & Mining	1.1%	1,760	0.4%	3,228	1.3%
Construction	4.7%	18,809	4.2%	12,546	4.9%
Manufacturing	11.1%	32,874	7.3%	44,128	17.2%
Trade, Transportation & Utilities	18.8%	83,202	18.4%	45,297	17.7%
Information	2.3%	10,504	2.3%	7,307	2.8%
Financial Activities	5.8%	27,481	6.1%	14,644	5.7%
Professional & Business Services	15.6%	69,947	15.5%	47,522	18.5%
Education & Health Services	13.7%	66,568	14.7%	30,830	12.0%
Leisure & Hospitality	10.1%	51,072	11.3%	21,298	8.3%
Other Services	3.9%	19,036	4.2%	8,345	3.3%
Private Non-Classified	0.0%	30	0.0%	85	0.0%
Total All Government	12.7%	70,779	15.7%	21,286	8.3%
Federal Government	1.6%	12,271	2.7%	705	0.3%
State Government	1.9%	11,063	2.4%	2,763	1.1%
Local Government	9.2%	47,444	10.5%	17,818	6.9%

Note: (c) = confidential, information not provided by Oregon Employment Department to prevent identifying specific businesses.

Source: Oregon Employment Department, 2013

Each industry faces distinct vulnerabilities to natural hazards. Identifying key industries in the region enables communities to target mitigation activities toward those industries' specific sensitivities. Each of the primary private employment sectors has sensitivity to natural hazards, as follows.

Trade, Transportation, and Utilities: Retail Trade is the largest employment subsector within this 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 and are most numerous in the Portland Metro area.

Professional and Business Services: This sector is composed of professional service providing industries including scientific and technical, management professionals and administrative and support services (e.g., engineering, law, headquarters, temp help, etc.). In general, this sector has low vulnerability to natural disasters. Vulnerability is increased if suppliers are affected or physical infrastructure such as buildings, roads, telecommunications, or water systems is damaged. Mitigation efforts for this sector should include preparing business continuity and recovery plans.

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 2 because the region serves as a hub for health care. Health care is a relatively stable revenue sector with an abundant distribution of businesses primarily serving a local population.

Manufacturing: This sector 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 Multnomah and Washington Counties.

Revenue by Sector

Region 2 accounts for almost half of all revenue generated in Oregon. In 2007 Trade (Retail and Wholesale), Manufacturing, and Healthcare and Social Assistance were the highest revenue grossing industries in the region. (Revenue data from the 2012 Economic Census will not be released prior to the publication of this Plan.) Combined, these three industries generated over $114 billion (86%) in revenue. Trade (Retail and Wholesale) is the largest grossing sector in Clackamas and Multnomah Counties. Manufacturing is the highest grossing sector in Columbia and Washington Counties.

Table 2-134. Revenue of Top Industries (in Thousands of Dollars) in Region 2, 2007

	Total Revenue (in Thousands)	Trade (Retail and Wholesale)	Manufacturing	Health Care and Social Assistance
Oregon	$277,017,733	44.4%	24.1%	7.3%
Region 2	$132,790,589	47.1%	30.9%	7.9%
Clackamas	$19,898,459	52.2%	28.5%	8.6%
Columbia	$1,423,749	31.9%	58.0%	3.8%
Multnomah	$61,238,728	52.1%	17.2%	10.0%
Washington	$50,229,653	39.4%	47.9%	5.1%

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 the workforce 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 2010 and 2020, the largest job growth in Region 2 is expected to occur in the following sectors: (a) Education and Health services; (b) Trade, Transportation, and Utilities (including retail trade); (c) Professional and Business Services; (d) Leisure and Hospitality; and (e) Manufacturing (Oregon Employment Department, 2012; Employment Projections by Industry and Occupation: 2010–2020 Oregon and Regional Summary Retrieved April 10, 2014, from http://www.qualityinfo.org/olmisj/PubReader?itemid=00005720).

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 (19.2%). The Other Services sector is the second most abundant and Education and Health Services sector ranks third. Leisure and Hospitality and Construction round out the top five sectors (Oregon Employment Department, 2012). While many of these are small businesses, employing fewer than 20 employees, collectively they represent 40% of 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

Because a strong and diverse economic base increases the ability of individuals, families, and communities to absorb impacts of a disaster and recover more quickly, current and anticipated financial conditions of a community are strong determinants of community resilience. This analysis shows that the economy in Region 2 is particularly strong in the following areas:

- The Portland Metro area has rebounded from the financial crisis that began in 2007 more strongly than any other area in the state and is near pre-recession employment levels.
- Much of the growth in employment within the region is spurred by the high-tech industry, which grew by 70% over the last decade (Oregon Employment Department, n.d., Region 2 data).
- Regionally, Columbia County is still struggling the most after the financial crisis that began in 2007. The unemployment rate is higher, overall educational attainment is lower, and the average salary is only 77% of state average.

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 (Stahl et al., 2000).

Infrastructure

Transportation

Roads

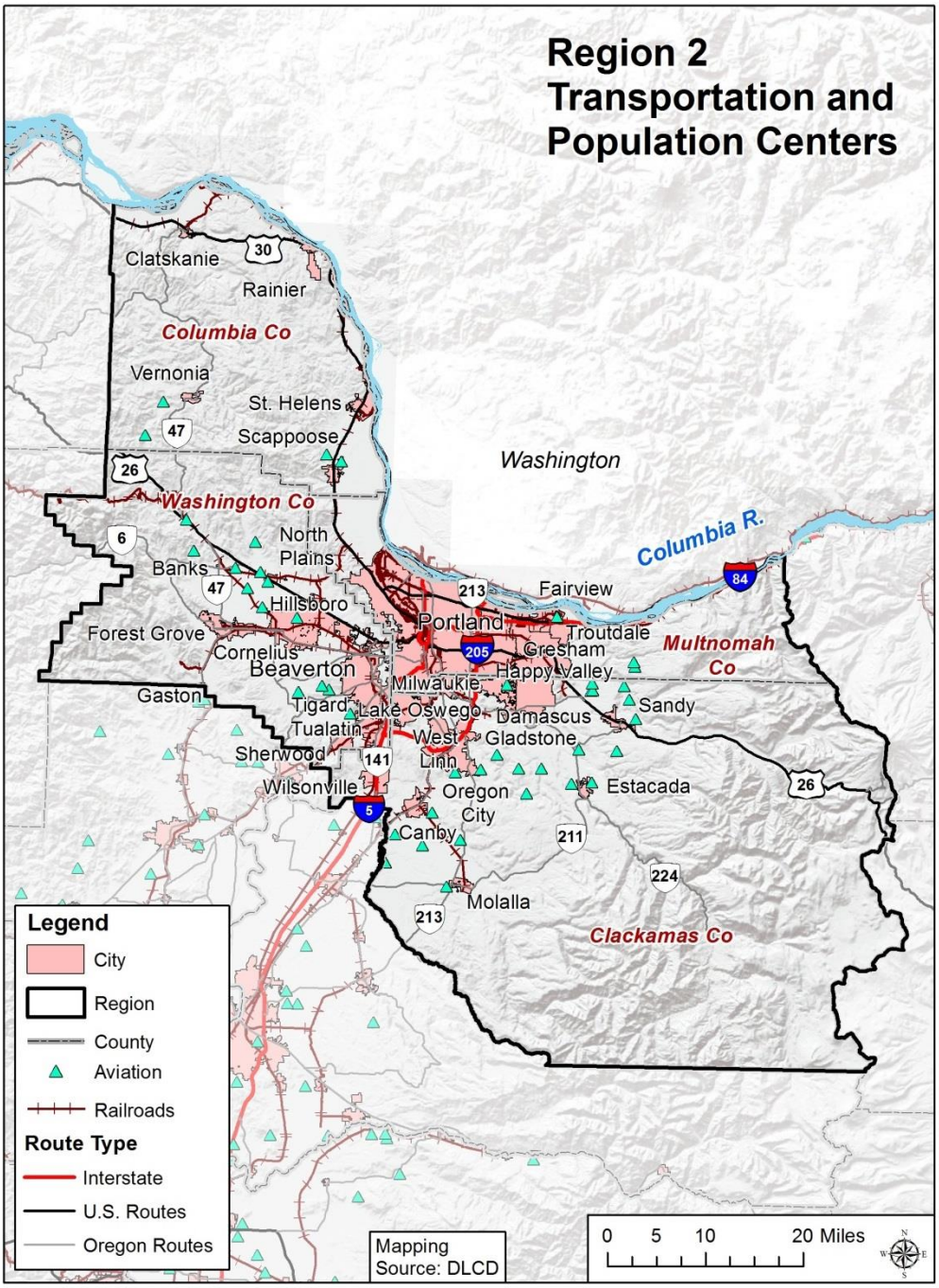
The largest population bases in Region 2 are located along the region's major freeways: I-5, I-205, and I-84. I-5 runs north-south through Region 2 and is the main passage for automobiles and trucks traveling along the West Coast. I-205 is a loop route that serves Portland and Vancouver and provides access through the eastern edge of the Portland area. I-84 runs east-west and is the main passage for automobiles and trucks traveling between Oregon and central and eastern states.

Region 2's growing population centers bring 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, coupled with interstate and international freight movement on the interstate corridors, 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.

The region has high exposure to earthquakes, especially a Cascadia Subduction Zone event. Therefore, the seismic vulnerability of the region's lifelines, including roadways and bridges, is an important issue. For information on ODOT's Seismic Lifeline Report findings for Region 2, see **Seismic Lifelines**.

Figure 2-105. Region 2 Transportation and Population Centers



Source: Oregon Department of Land Conservation and Development, 2014

Bridges

As mentioned, the region's bridges are highly vulnerable to seismic activity. 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 2-135 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. A deficient bridge (De) is a federal performance measure used for non-ODOT bridges. These ratings do not imply that a bridge is unsafe (ODOT, 2012, 2013). 30% of region's bridges are distressed or deficient. About 28% of the region's ODOT bridges are distressed; 51% of those are in Multnomah County. Five bridges within the Portland Metro area are part of an I-5 seismic retrofit project scheduled to begin in the summer of 2014.

Table 2-135. Bridge Inventory for Region 2

	State Owned			County Owned			City Owned			Other Owned			Area Total			Historic
	Di	ST	%D*	De	ST	%D	De	ST	%D	De	ST	%D	D	ST	%D	Covered
Oregon	610	2,718	22%	633	3,420	19%	160	614	26%	40	115	35%	1,443	6,769	21%	334
Region 2	154	549	28%	117	429	27%	64	182	35%	11	23	48%	346	1137	30%	76
Clackamas	22	114	20%	36	154	23%	5	17	29%	1	1	100%	64	283	23%	16
Columbia	10	33	32%	14	81	17%	2	9	22%	0	2	0%	26	123	21%	8
Multnomah	95	282	38%	23	45	51%	52	122	43%	5	13	38%	175	429	41%	50
Washington	27	120	24%	44	149	30%	5	34	15%	5	7	71%	81	302	27%	2

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.

Source: ODOT (2012, 2013)

Railroads

Railroads that run through Region 2 support cargo and trade flows. The region's major (Class I) freight rail providers are the Union Pacific (UP) and the Burlington Northern-Santa Fe (BNSF) railroads. The Port of Portland is a major marine gateway for rail freight. There are six major rail yards and terminals in the region — all of which are in Portland — operated by UP or BNSF. Oregon's freight 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 the state, as well as products from other states that are shipped to and through Oregon by rail.

Amtrak provides passenger rail service throughout the region. In addition, the Portland Westside Express Service provides passenger rail options for commuters in Washington County. The area is also serviced by a regional transit system (TriMet) that provides both bus and light rail service through the greater Portland Metropolitan area.

Rails are sensitive to icing from winter storms that can occur in Region 2. Disruptions in the rail system can result in economic losses for the region. The potential for harm from rail accidents can also have serious implications for local communities, especially if hazardous materials are involved.

Airports

The Portland International Airport is the only primary commercial airport in the region and is the busiest airport in Oregon (Federal Aviation Administration, 2012). The airport is owned, operated, and administered by the Port of Portland. It serves 17 passenger air carriers and seven cargo carriers with approximately 183,000 annual commercial flights, 20,300 cargo flights, and 21,000 military and general aviation annual flights (Portland International Airport, 2014). The Port of Portland also operates two relief airports, Portland-Hillsboro and Portland-Troutdale, that serve the region.

Table 2-136. Public and Private Airports in Region 2

	Number of Airports by FAA Designation				
	Public Airport	**Private Airport**	**Public Heliport**	**Private Heliport**	**Total**
Region 2	12	33	1	24	70
Clackamas	5	19	0	6	30
Columbia	2	2	0	0	4
Multnomah	2	1	1	10	14
Washington	3	11	0	8	22

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 air freight may also be impacted by airport closures.

Ports

Oregon's ports have historically been used for timber transport and for 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 river, rail, road, and air infrastructure. There are two ports within Region 2, the Port of St. Helens and the Port of Portland. The Port of St. Helens includes 93 acres of light industrial and is approximately 30 miles from Portland (Port of St. Helens, http://www.portsh.org/index.php). The Port of Portland is responsible for overseeing the Portland International Airport and other aviation and marine activities in the Portland Metro area. The Port of Portland includes four marine terminals, five industrial parks, and three airports (Port of Portland, http://www.portofportland.com).

Energy

Electricity

The region is served by several investor-owned, public, cooperative, and municipal utilities. Portland General Electric (PGE) is the largest investor-owned utility in the region, serving large areas of Clackamas, Multnomah, and Washington Counties. Pacific Power and Light (Pacific Power) is another investor-owned utility company serving a small portion of Multnomah County. Additionally, the Western Oregon Electric Cooperative, Inc. provides electricity for portions of Region 2. Three municipal utility districts support the region: City of Cascade Locks, City of Forest Grove, and City of Canby. In addition, the Clatskanie People's Utility District and the Columbia River PUD serve portions of the region.

The Northern Willamette Valley / Portland Metro area has eight power-generating facilities: six generate hydroelectric and two generate natural gas. In total, these facilities have the ability to produce up to 1,121 megawatts (MW) of electricity.

Table 2-137. Power Plants in Region 2

	Hydro-electric	Natural Gas	Wind	Coal	Other*	Total
Region 2	6	2	0	0	0	8
Clackamas	6	0	0	0	0	6
Columbia	0	2	0	0	0	2
Multnomah	0	0	0	0	0	0
Washington	0	0	0	0	0	0
Energy Production (MW)	203	918	0	0	0	1,121

*Other includes biomass, geothermal, landfill gas, solar, petroleum, and waste.

Source: Army Corps of Engineers; Biomass Power Association; Calpine Corporation; Eugene Water and Electric Board; Iberdola Renewables; Idaho Power Company; Klamath Energy LLC; Oregon Department of Energy; Owyhee Irrigation District; Form 10K Annual Report (2013), PacifiCorp; Form 10K Annual Report (2013), Portland General Electric; U.S. Geothermal, Inc.

Hydropower

Bonneville Power Administration (BPA) provides hydro-generated electricity to the state's consumer owned utilities. The Bonneville Dam is BPA's major dam in the region, located on the Columbia River. Other dams in the region are located on the Willamette, Clackamas, and Sandy Rivers.

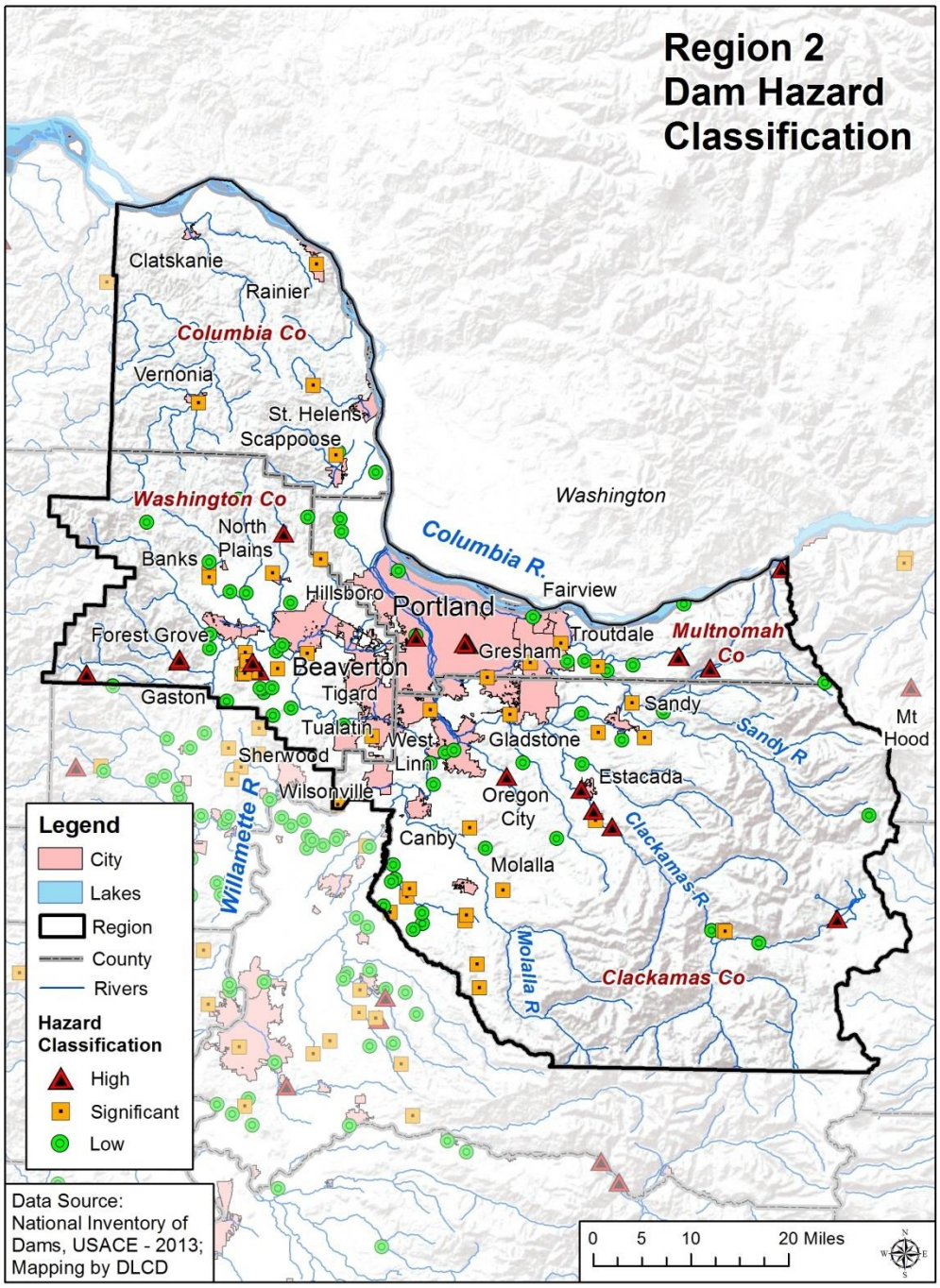
Minor dam failures can occur at any time. Most dam failures result in minor damage to structures and pose little or no risk to life safety. However, the potential for severe damage and fatalities does exist. For example, major dam failures occurred near Hermiston in 2005, and in Klamath Lake in 2006 (Association of Dam Safety Officials, n.d.). The Oregon Water Resources Department uses the National Inventory of Dams (NID) threat potential methodology and maintains an inventory of all large dams in Oregon. **Table 2-138** lists the number of dams included in the inventory. The majority of dams in the region are located in Clackamas and Washington Counties. There are 17 High Threat Potential dams and 42 Significant Threat Potential dams in the region.

Table 2-138. Threat Potential of Dams in Region 2

	Threat Potential			Total Dams
	High	Significant	Low	
Region 2	17	42	144	203
Clackamas	7	20	44	71
Columbia	0	3	9	12
Multnomah	7	5	14	26
Washington	3	14	77	94

Source: Oregon Water Resources Department, Dam Inventory Query, 2014

Figure 2-106. Region 2 Dam Hazard Classification

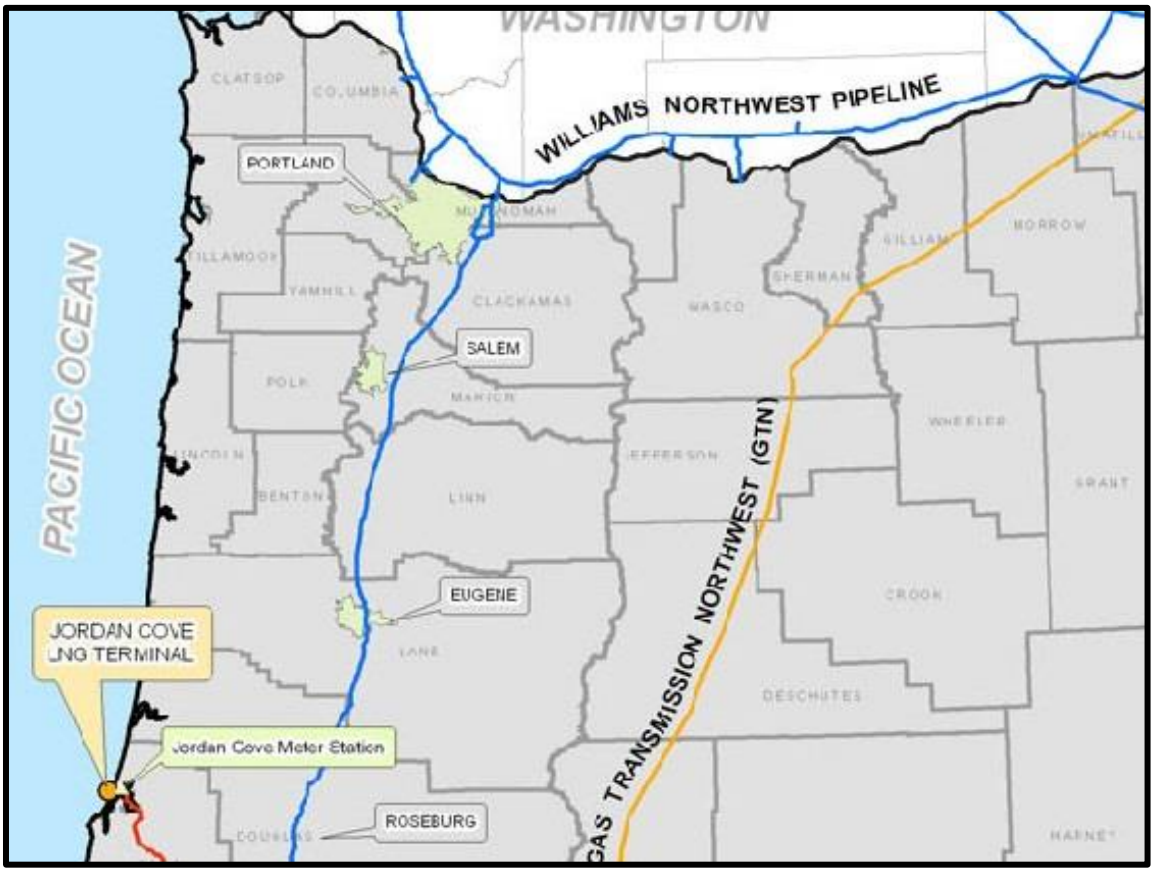


Source: USACE National Inventory of Dams, 2013

Natural Gas

Although natural gas does not provide the most energy to the region, it does contribute a significant amount of energy to the region's energy portfolio. Liquefied natural gas (LNG) is transported via pipelines throughout the United States. **Figure 2-107** shows the Williams Northwest Pipeline, which runs through Clackamas and Multnomah Counties (in blue) (Pipelines International, 2009). LNG pipelines, like other buried pipe infrastructure are vulnerable to earthquakes and can cause danger to human life and safety, as well as environmental impacts in the case of a spill.

Figure 2-107. Liquefied Natural Gas Pipelines in Region 2



Source: Retrieved from http://gs-press.com.au/images/news_articles/cache/Pacific_Connector_Gas_Pipeline_Route-0x600.jpg

Oregon's Critical Energy Infrastructure Hub

Oregon's critical energy infrastructure hub (CEI Hub) is located in north Portland on the lower Willamette River between the south tip of Sauvie Island and the Fremont Bridge along US-30. Over 90% of Oregon's refined petroleum is imported to Oregon via the Puget Sound and arrives to Oregon CEI Hub via pipeline or marine vessels (Wang et al., 2013). In addition, much of Oregon's natural gas passes through the CEI Hub and a high voltage electrical transmission corridor crosses, and supplies distribution for, the area. The CEI Hub includes the following energy sector facilities (Pipelines International, 2009):

- All of Oregon's major liquid fuel port terminals,
- Liquid fuel transmission pipelines and transfer stations,
- Natural gas transmission pipelines,
- A liquefied natural gas storage facility,
- High-voltage electric substations and transmission lines, and
- Electrical substations for local distribution.

In 2013, the Oregon Department of Geology and Mineral Industries (DOGAMI) conducted a study of the CEI Hub's earthquake risk entitled Earthquake Risk Study for Oregon's Critical Energy Infrastructure Hub (DOGAMI Open-File Report O-13-09). The study determined (a) the vast majority of facilities are constructed on soils susceptible to liquefaction and (b) significant seismic risk exists within the various energy sector facilities. The CEI Hub was identified as being highly vulnerable to a Cascadia Subduction Zone (CSZ) event: "western Oregon is likely to face an electrical blackout, extended natural gas service outages, liquid fuel shortage, as well as damage and losses in the tens of billions of dollars" (Pipelines International, 2009). Significant pro-active seismic mitigation projects are recommended to be integrated into the affected energy sector companies' business practices in order to allow Oregon to adequately recover from a CSZ event within a reasonable period of time. For more information see the full report.

Utility Lifelines

The Northern Willamette Valley / Portland Metro region is an important thoroughfare for oil and gas pipelines and electrical transmission lines, connecting Oregon to California and Canada. The infrastructure associated with power generation and transmission plays a critical role in supporting the regional economy. These lines may be vulnerable to severe, but infrequent natural hazards, such as earthquakes. If these lines fail or are disrupted essential functions of the community can become severely impaired.

Region 2 primarily receives oil and gas from Alaska by way of the Puget Sound through pipelines and tankers. Oil and gas are supplied by Northern California from a separate network. The electric, oil, and gas lifelines that run through the region are municipally and privately owned (Loy et al., 1976).

Portland General Electric and Bonneville Power Administration primarily operate the electrical transmission lines running through Region 2, and these lines produce and distribute power locally (Loy et al., 1976). Most of the natural gas Oregon uses originates in Alberta, Canada. Avista Utilities owns the main natural gas transmission pipeline (Loy et al., 1976).

Telecommunications

Telecommunications infrastructure includes television, telephone, broadband internet, radio, and amateur radio (ham radio). Region 2 is part of the Portland Operational Area under The Oregon State Emergency Alert System Plan (Oregon Office of Emergency Management, 2013), which also includes Clark County, Washington. There is a memorandum of understanding between these counties that facilitates the launching of emergency messages. Counties in this area can launch emergency messages by contacting the Oregon Emergency Response System (OERS), which in turn creates emergency messages to communities statewide.

Beyond day-to-day operations, maintaining communications capabilities during disaster events and other emergency situations helps 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 Oregon State Emergency Alert System Plan does not identify a local primary station for emergency messages.

Telephone and Broadband

Landline telephone, mobile wireless telephone, and broadband service providers serve Region 2. 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 readily available throughout most parts the region with a smaller number of providers and service types available in eastern Multnomah County and a small area of central Columbia County (NTIA, n.d.). 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 2 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 the Portland Operational Area are (Oregon Office of Emergency Management, 2013):

- KXL-FM, 10.1 MHZ, Portland;
- KGON-FM, 92.3 MHZ, Portland; and
- KOPB-FM, 91.5 MHZ, Portland.

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 communication is a priority for the Amateur Radio Relay League (ARRL). Region 2 is served by ARES District 1. 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 (Oregon Office of Emergency Management, n.d.). The official ham emergency station calls for Region 2 include (American Relay Radio League Oregon Chapter, http://www.arrloregon.org):

- Clackamas County: KA7OZO;
- Columbia County: W7OR;
- Multnomah County: N9VCU; and
- Washington County: KE7WKM.

Water

Drinking water, stormwater, and wastewater systems all possess some level of vulnerability to natural hazards that can have repercussions on human health, ecosystems, and industry.

Drinking Water

In Region 2 the majority of the municipal drinking water supply is obtained primarily from surface water sources such as rivers. These surface water sources are often backed up by groundwater that is drawn from an aquifer when surface water levels get low, especially in summer months. For many communities in Regions 2 and 3, the Willamette River is both a source of potable water and a discharge location for wastewater treatment facilities. Cities that draw water from the Willamette River face water rights disputes and issues related to water quality. The Bull Run watershed is the primary drinking source for the City of Portland and its 19 wholesale customers and does not face the same water quality issues as the Willamette River. However, Portland residents have expressed concerns about the well field that is the City's backup water source. Portlanders have complained of the water's unpleasant taste and expressed concern that water quality may be compromised due to the well field's close proximity to industrial facilities.

Rural residents in the region draw water from surface water, groundwater wells, or springs. 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. In areas where no new live-flow water rights are available, farmers and ranchers are turning to above-ground storage to help supply water for crop irrigation during dry seasons. At times, urban water districts with an abundant supply have sold water to rural areas. The City of Portland has a long history of these transactions and in recent years has faced competition from other sellers.

Surface sources for drinking water are vulnerable to pollutants caused by non-point sources and natural hazards. 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

Underground water supplies and aging or outdated infrastructure such as reservoirs, treatment facilities, and pump stations can be severed during a seismic event. Rigid materials such as cast iron may snap under the pressure of liquefaction. More flexible materials such as polyvinyl 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, thus limiting access to potable water. This can lead to unsanitary conditions that may threaten human health. Lack of water can also impact industry, such as the manufacturing sector. Moreover, if transportation infrastructure is impacted by a disaster event, repairs to water infrastructure will be delayed.

Stormwater and Wastewater

In urbanized areas severe precipitation events may cause flooding that leads to stormwater runoff. A non-point source of water pollution, stormwater runoff can adversely impact drinking water quality. It can also lead to environmental issues such as increasing surface water temperatures that can adversely affect habitat health. Furthermore, large volumes of fast-moving stormwater that enter surface waterways can cause erosion issues.

Stormwater can also impact water infrastructure. Leaves and other debris can be carried into storm drains and pipes, which can clog stormwater systems. In areas where stormwater systems are combined with wastewater systems (combined sewers), flooding events can lead to combined sewer overflows (CSOs). CSOs present a heightened health threat as sewage can flood urban areas and waterways. Underground stormwater and wastewater pipes are also vulnerable to damage by seismic events.

In Region 2, most local building codes and stormwater management plans emphasize the use of centralized storm sewer systems to manage stormwater. Requirements for stormwater mitigation vary in Region 2. 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, lower speeds, and lower temperatures. The City of Portland has been recognized as a national innovator in stormwater management and code because of its progressive LID stormwater mitigation strategies in the City's building code. However, the majority of jurisdictions in the region do not require LID strategies in their building code. Promoting and requiring decentralized LID stormwater management strategies could help reduce the burden of new development on storm sewer systems and increase a community's resilience to many types of hazard events.

Infrastructure Trends and Issues

Physical infrastructure is critical for everyday operations and is essential following a disaster. Lack or poor condition of infrastructure can negatively affect a community's ability to cope with, respond to, and recover from a hazard event. Diversity, redundancy, and consistent maintenance of infrastructure systems help create system resiliency (Meadows, 2008).

Roads, bridges, and rail systems in the region support Oregon's largest population centers and freight moving through the Pacific Northwest. These transportation systems and are vulnerable to a variety of natural hazards that could disrupt transportation of goods, block evacuation routes and sever lifelines. The effects of road, bridge, and rail failures on the economy and health of the region's residents could be devastating. ODOT understands this risk and began seismically upgrading five of the areas key bridges within the Portland Metro area in summer 2014.

In addition, the region has two ports with marine terminals, industrial parks and aviation facilities. The Portland International Airport is the busiest in the state, moving the majority of

passengers and freight. These ports, including airports, face potential disruptions in services due to natural hazard events.

The region is an energy hub for the state. There are multiple dams and eight power-generating facilities. The Bonneville Power Administration (BPA) provides hydro-generated electricity to the state's consumer owned utilities. BPA's main dam, the Bonneville Dam, is located on this region on the Columbia River. Liquid Natural Gas is transported through the region via the Williams Northwest Pipeline that runs through Clackamas and Multnomah Counties. Of particular concern is Oregon's critical energy infrastructure hub, located in north Portland, which is highly vulnerable to a Cascadia event.

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 may not cover rural areas of the region that are distant from Portland, especially central Columbia and eastern Multnomah Counties. 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 vulnerable to high levels of pollutants entering waterways during high-water events. The City of Portland has been recognized as a leader in stormwater management best practices because of its decentralized Low Impact Development (LID) stormwater systems.

Built Environment

Development Patterns

Balancing growth with hazard mitigation is key to planning resilient communities. Therefore, understanding where development occurs and the vulnerabilities of the region's building stock is integral to developing mitigation efforts that move people and property out of harm's way. Eliminating or limiting development in hazard prone areas can reduce exposure to hazards, and potential losses and damages.

Since 1973, Oregon has maintained a strong statewide program for land use planning. The foundation of Oregon's land use program is 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 (DLCD, http://www.oregon.gov/).

Settlement Patterns

The U.S. Census Bureau defines "urban" as either an "urbanized area" of 50,000 or more people or an "urban cluster" of at least 2,500 people (but less than 50,000). Wheeler County does not meet either definition; therefore all of its population is considered rural even though the county has incorporated cities.

Washington and Columbia Counties have experienced the region's greatest percent urban growth during the decade from 2000 to 2010, roughly 5% and 7% more than the state average

respectively. Similar to the state, the region is becoming less rural. However, Columbia County, the least populated county along the coast, is the only county in the region to increase its rural population.

The region's urban housing units grew eight times those in rural areas. Multnomah County was the only county to decrease its share of rural residences, notably by 11%. Columbia County had the largest percent growth in in both urban and rural units 24.1% and 10.8% respectively.

Not surprisingly, populations tend to cluster around major road corridors and waterways. The region's largest population is clustered around the Portland Metro area.

Table 2-139. Urban and Rural Populations in Region 2

	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 2	1,352,896	1,561,409	15.4%	134,883	128,978	-4.4%
Clackamas	266,367	308,018	15.6%	72,024	67,974	-5.6%
Columbia	22,769	27,828	22.2%	20,791	21,523	3.5%
Multnomah	649,010	725,464	11.8%	11,476	9,870	-14.0%
Washington	414,750	500,099	20.6%	30,592	29,611	-3.2%

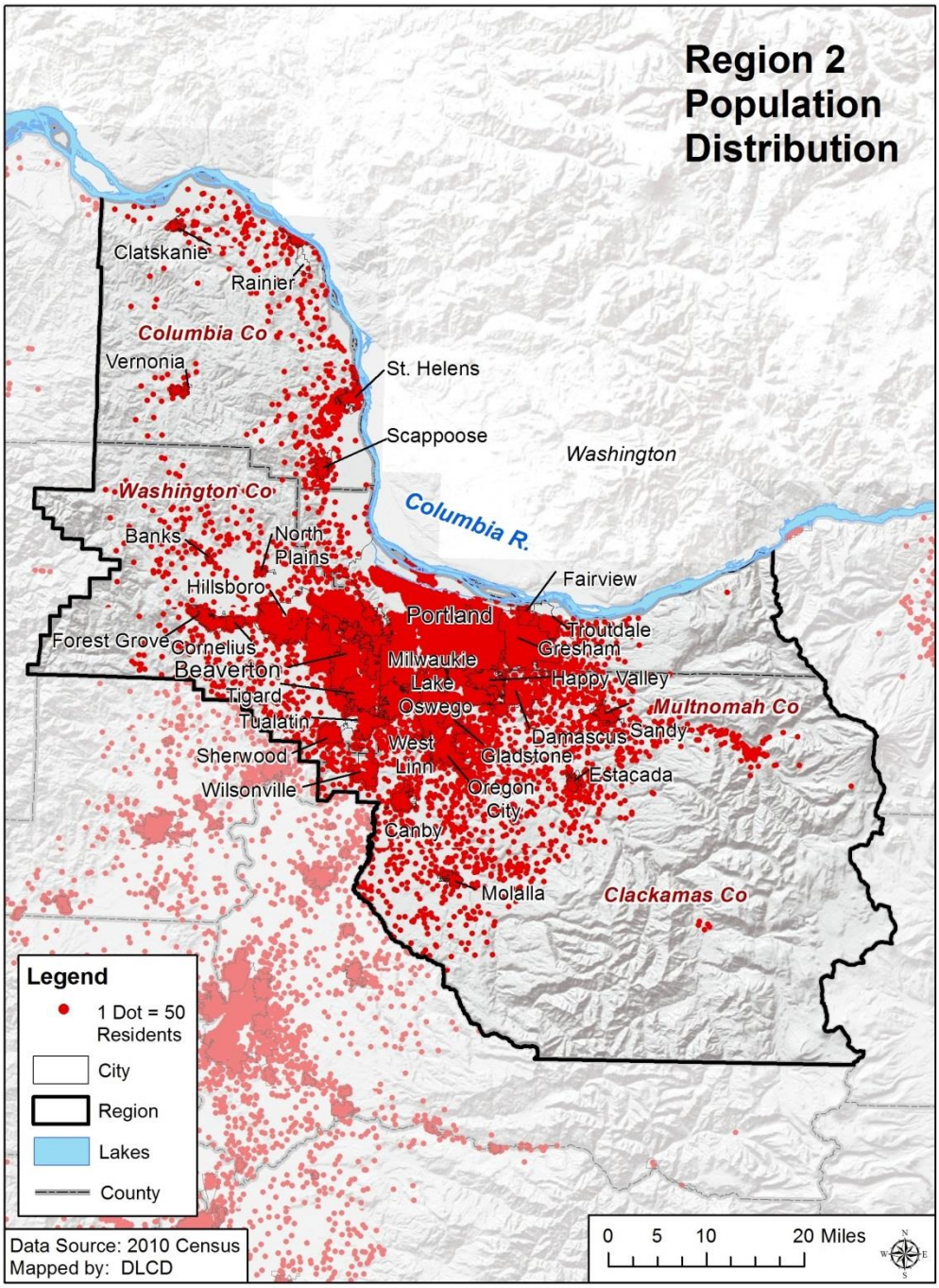
Source: U.S. Census Bureau. 2000 Decennial Census, Table P002 and 2010 Decennial Census, Table P2

Table 2-140. Urban and Rural Housing Units in Region 2

	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 2	569,834	661,845	16.1%	52,166	53,080	1.8%
Clackamas	109,047	128,740	18.1%	27,907	28,205	1.1%
Columbia	9,247	11,474	24.1%	8,325	9,224	10.8%
Multnomah	283,957	320,735	13.0%	4,604	4,097	-11.0%
Washington	167,583	200,896	19.9%	11,330	11,554	2.0%

Source: U.S. Census Bureau. 2000 Decennial Census, Table H002 and 2010 Decennial Census, Table H2

Figure 2-108. Region 2 Population Distribution



Source: U.S. Census, 2012

Land Use

Approximately 65% of the land in Region 2 is in private ownership, followed by federal (31%), state (3%), and local government (1%). Subtracting the Cascade Mountain area leaves nearly the entire Region 2 in private holdings.

Not surprisingly, between 1974 and 2009, the Portland area, followed by the North Willamette Valley area, demonstrated the greatest rates of change in the state in the conversion of private land in resource land uses to low-density residential and urban uses. Within the Portland area, the highest rate of increase took place in Washington County, followed by Clackamas County. Both counties experienced much higher rates of conversion to low-density residential and urban uses than was the case in highly urbanized Multnomah County (Lettman, 2011).

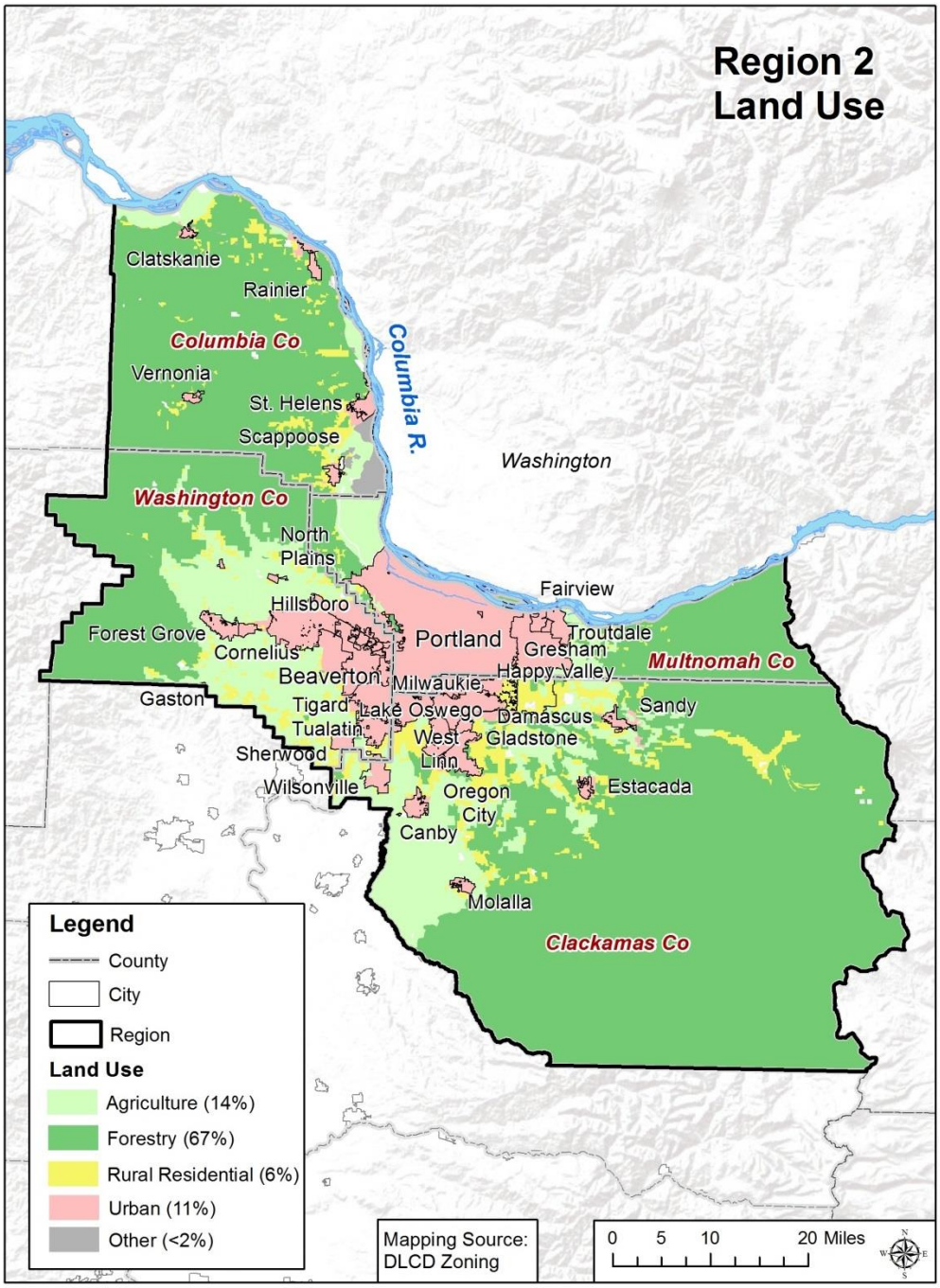
In the past few years, along with most of Western Oregon, Region 2 has experienced an upswing in residential building permits as the local and national economies rebounded. For example, in the first four months of 2014 the region saw a surge in these types of residential building permits. The City of Portland dominated the residential permit numbers, up 16% from the same period in 2013 (State of Oregon Employment Department, May 2014, Portland Economic Indicators). Since 2007, 58% of the new residential growth in the Portland area has been either infill or redevelopment. The rest of the residential construction in that time, about 42%, has been on vacant land (Lettman, 2011).

Overall, 2013 saw the strongest surge of new residents in 5 years for Region 2. According to the most recent estimates from the regional government Metro, by 2035 the Portland-Beaverton-Vancouver area (including Multnomah, Clackamas, Washington, Yamhill, Columbia, Clark, and Skamania Counties) might grow by up to 725,000 people, topping the 3 million population mark.

Under Oregon law, each of the state's cities and metropolitan areas has created around its perimeter an urban growth boundary (UGB), which is a land use planning line to control urban expansion onto farm and forest lands. The UGB is assessed every 6 years, in a process that involves various levels of government and the public. In 2013-2014 Metro will revise its UGB. Most notable will be changes in the urban and rural reserves of Washington County.

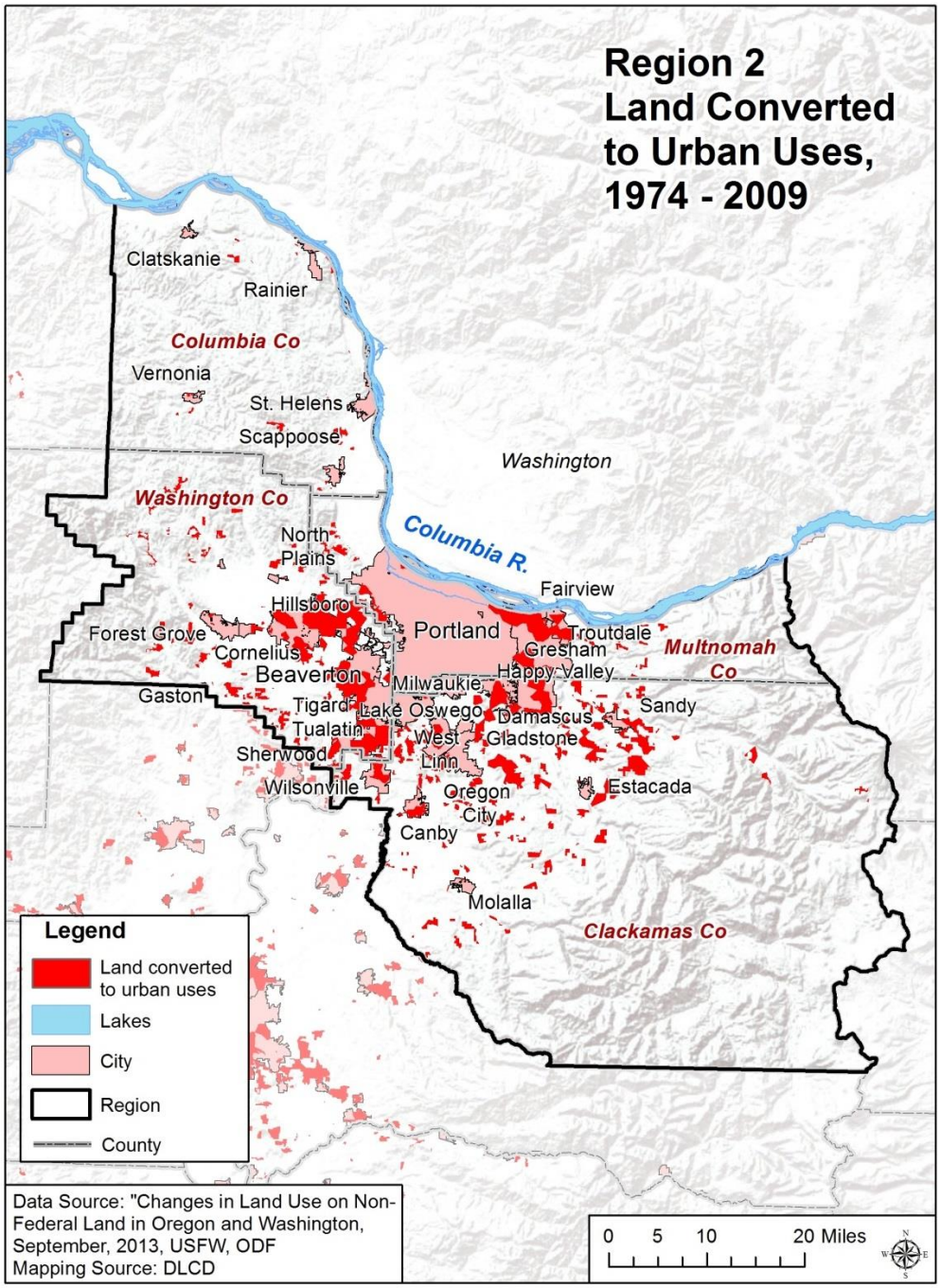
Potential upgrades to the 28 miles of levees that protect the north Portland area from the Columbia River remain a continuing land use issue for the region. As of July 2014, potential costs to the four drainage districts involved were estimated at $100 million dollars. Failure to maintain certification and FEMA accreditation may result in thousands of property owners and businesses subject to federal flood insurance regulations (DLCD, internal communication, 2014).

Figure 2-109. Region 2 Land Use



Source: DLCD, Statewide Zoning

Figure 2-110. Region 2 Land Converted to Urban Uses, 1974–2009



Source: “Changes in Land Use 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. The majority of the region's housing stock is single-family homes. Nearly half of the region's multi-family units are located in Multnomah County, in the Portland area in particular. Mobile residences make up only 3.5% of all housing in the region. Columbia County has the highest percentage of mobile homes (12.6%), and Clackamas County has the highest number of units (9,752). In natural hazard events such as earthquakes and floods, mobile homes are more likely to shift on their foundations and create hazardous conditions for occupants and their neighbors (California Governor's Office of OES, 1997).

Table 2-141. Housing Profile for Region 2

	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 2	714,150	469,018	65.7%	219,384	30.7%	24,748	3.5%
Clackamas	156,933	114,764	73.1%	32,160	20.5%	9,752	6.2%
Columbia	20,639	15,577	75.5%	2,334	11.3%	2,599	12.6%
Multnomah	324,192	196,592	60.6%	120,404	37.1%	6,657	2.1%
Washington	212,386	142,085	43.8%	64,486	19.9%	5,740	1.8%

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

Source: U.S. Census Bureau. 2008–2012, American Community Survey 5-Year Estimates, B25024

Aside from location and type of housing, the year a structure was built (**Table 2-142**) has implications for level of vulnerability to natural hazards. Seismic building standards were codified in Oregon building code starting in 1974. More rigorous building code standards passed in 1993 accounted for the Cascadia earthquake fault (Judson, 2012). Therefore, homes built before 1994 are more vulnerable to seismic events.

Also in the 1970s, FEMA began assisting communities with floodplain mapping as part of administering 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. Regionally, 38.7% of the housing stock was built prior to 1970, before the implementation of floodplain management ordinances. Notably, over 55% of homes in Multnomah County were constructed before 1970. Regionally, approximately two thirds of the housing stock was built before 1990 and the codification of seismic building standards. Washington County has the highest percentage (43.5%) and largest number (92,732) of units built after 1990.

Table 2-142. Age of Housing Stock in Region 2

	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 2	714,150	276,458	38.7%	208,448	29.2%	229,244	32.1%
Clackamas	156,933	45,462	29.0%	56,471	36.0%	55,000	35.0%
Columbia	20,639	7,324	35.5%	6,115	29.6%	7,200	34.9%
Multnomah	324,192	180,658	55.7%	68,862	21.2%	74,672	23.0%
Washington	212,386	43,014	20.3%	77,000	36.3%	92,372	43.5%

Source: U.S. Census Bureau. 2008–2012, American Community Survey 5-Year Estimates, 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 is minimized. **Table 2-143** shows the initial and current FIRM effective dates for Region 2 communities. For more information about the flood hazard, NFIP, and FIRMs, please refer to the State Risk Assessment, **Flood** section.

Table 2-143. Community Flood Map History in Region 2

	Initial FIRM	Current FIRM
Clackamas County	March 1, 1978	June 17, 2008
Barlow	May 5, 1981	June 17, 2008
Canby	June 15, 1984	June 17, 2008
Damascus	July 19, 2000	June 17, 2008
Estacada	June 17, 2008	June 17, 2008
Gladstone	March 15, 1977	June 17, 2008
Happy Valley	December 4, 1979	June 17, 2008
Lake Oswego	August 4, 1987	June 17, 2008
Milwaukie	June 18, 1980	June 17, 2008
Molalla	June 17, 2008	June 17, 2008
Oregon City	December 15, 1980	June 17, 2008
Portland	see Multnomah County	see Multnomah County
Rivergrove	August 4, 1987	June 17, 2008
Sandy	December 11, 1979	June 17, 2008
Tualatin	see Washington County	see Washington County
West Linn	March 15, 1977	June 17, 2008
Wilsonville	January 6, 1982	June 17, 2008
Columbia County	August 16, 1986	November 26, 2010
Clatskanie	September 29, 1986	November 26, 2010
Columbia, City	June 5, 1985	November 26, 2010
Prescott	August 16, 1988	November 26, 2010
Rainier	August 16, 1988	November 26, 2010
St. Helens	September 29, 1986	November 26, 2010
Scappoose	December 19, 1975	November 26, 2010
Vernonia	August 16, 1988	November 26, 2010
Multnomah County	June 15, 1982	December 18, 2009
Fairview	March 18, 1986	December 18, 2009
Gresham	July 16, 1979	December 18, 2009
Lake Oswego	see Clackamas County	see Clackamas County
Milwaukie	see Clackamas County	see Clackamas County
Portland	October 15, 1980	November 26, 2010
Troutdale	September 30, 1988	December 18, 2009
Wood Village	December 18, 2009	December 18, 2009
Washington County	September 30, 1982	February 18, 2005
Beaverton	September 28, 1984	February 18, 2005
Cornelius	January 6, 1982	January 6, 1982
Durham	January 6, 1982	February 18, 2005
Forest Grove	March 15, 1982	March 15, 1982
Gaston	July 5, 1982	July 5, 1982
Hillsboro	May 17, 1982	May 17, 1982
King City	February 18, 2005	February 18, 2005
Lake Oswego	see Clackamas County	see Clackamas County
North Plains	April 1, 1982	March 16, 1989
Portland	see Multnomah County	see Multnomah County
Rivergrove	see Clackamas County	see Clackamas County
Sherwood	January 6, 1982	January 6, 1982
Tigard	March 1, 1982	February 18, 2005
Tualatin	May 2, 1978	February 19, 1987
Wilsonville	see Clackamas County	see Clackamas County

Source: Federal Emergency Management Agency, Community Status Book Report

State-Owned/Leased and Critical/Essential Facilities

In 2014 the Department of Geology and Mineral Industries updated the 2012 Oregon NHMP inventory and analysis of state-owned/leased facilities and critical/essential facilities. Results from this report relative to Region 2 can be found in **Table 2-144**. The region contains 13.7% of the total value of state-owned/leased critical/essential facilities, valued at over $1 billion.

Table 2-144. Value of State-Owned/Leased Critical and Essential Facilities in Region 2

	Total Property Value (State Facilities)	Percent State Total
Oregon	$7,339,087,023	100%
Region 2	$1,002,513,064	13.7%
Clackamas	$233,143,765	3.2%
Columbia	$9,287,172	0.1%
Multnomah	$300,609,402	4.1%
Washington	$459,472,725	6.3%

Source: DOGAMI

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 2 is largely an urban county with urban development focused around the Portland Metropolitan area. The region's urban areas are growing at about the same rate as the state's. Columbia and Washington Counties have the fastest urban growth rates within the region. The region's housing stock is largely single-family homes. However, the region has a slightly higher percentage of multi-family units than the state as a whole; Multnomah County has the highest percentage (37%). Conversely, the region has a lower percentage of mobile homes than the state, with the exception of Columbia County. About 55% of housing in Multnomah was built prior to 1970, prior to current seismic and floodplain management standards. In contrast, over 44% of housing in Washington County was built after 1990. With the exception of some cities within Washington County all of the region's FIRMs have been modernized or updated. The cities in Washington County may have maps that are not as up-to-date as other areas of the state and therefore may not accurately represent flood risk.

2.3.2.3 Hazards and Vulnerability

Droughts

Characteristics

Droughts are uncommon in Region 2. In 1992, the Governor declared a drought for all 36 counties in Oregon. Since 1992, no Governor-declared droughts have occurred in this region.

Historic Drought Events

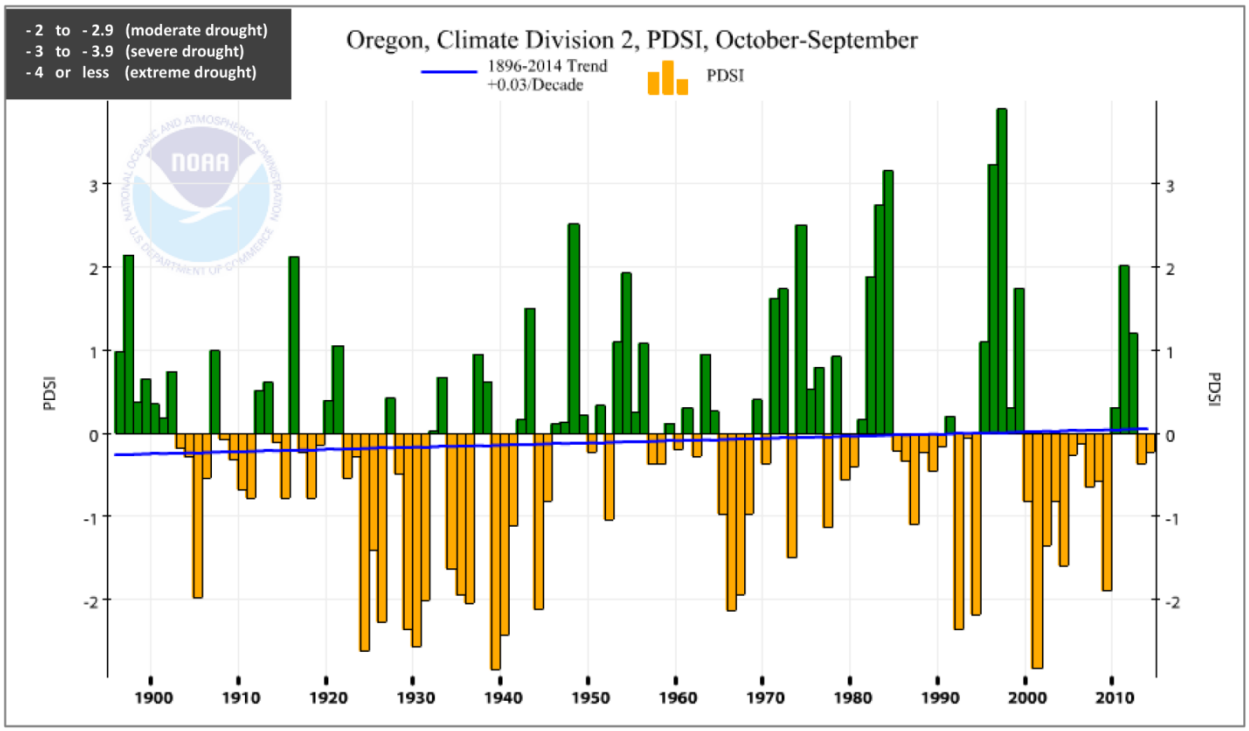
Table 2-145. Historic Droughts in Region 2

Date	Location	Description
1924	statewide	prolonged statewide drought that caused major problems for agriculture
1930	Regions 1–3, 5–7	moderate to severe drought affected much of the state; the worst years in Region 2 were 1928–1930, which kicked off an era of many drier than normal years
1939	statewide	the 1920s and 1930s, known more commonly as the Dust Bowl, were a period of prolonged mostly drier than normal conditions across much of the state and country
1992	statewide, especially Regions 1–4, 8	1992 fell toward the end of a generally dry period, which caused problems throughout the state; the 1992 drought was most intense in eastern Oregon, with severe drought occurring in Region 1
2001	Regions 2–4, 6, 7	the driest water year on record in the Willamette Valley (NOAA Climate Division 2); warmer than normal temperatures combined with dry conditions

Sources: Taylor and Hatton (1999); Oregon Secretary of State's Archives Division; NOAA's Climate at a Glance; Western Regional Climate Center's Westwide Drought Tracker http://www.wrcc.dri.edu/wwdt; personal Communication, Kathie Dello, Oregon Climate Service, Oregon State University

Historical drought information can also be obtained from the National Climatic Data Center, which provides historical 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. **Figure 2-111** shows years where drought or dry conditions affected the Willamette Valley (Climate Division 2). Based on this index, Water Years 1939 and 2001 were the driest years with values of -2.84 and -2.83 respectively. These moderate-type drought years have occurred more than a dozen times during this record.

Figure 2-111. Palmer Drought Severity Index for Region 2



Source: National Climatic Data Center, http://www.ncdc.noaa.gov/cag/

Although not shown here, drought data from Climate Division 4, "the High Cascades," could also be analyzed to show a broader picture of drought impacts in Hazard Regions 2 and 3.

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the probability that Region 2 will experience drought is shown in **Table 2-146**. 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.

Table 2-146. Local Probability Assessment of Drought in Region 2

	Columbia	Clackamas	Multnomah	Washington
Probability	M	M	—	L

Source: Oregon Office of Emergency Management, 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 could be completed statewide 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. There has only been one drought declaration in this region, which occurred in 1992 when all 36 counties were affected by a drought.

Vulnerability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the region's vulnerability to drought is shown in **Table 2-147**. 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.

Table 2-147. Local Vulnerability Assessment of Drought in Region 2

	Columbia	Clackamas	Multnomah	Washington
Vulnerability	L	L	—	M

Source: Oregon Office of Emergency Management, 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 2 could be considered less vulnerable to drought impacts than many other parts of the state.

Earthquakes

Characteristics

The geographic position of Region 2 makes it susceptible to earthquakes from four sources: (a) the off-shore Cascadia Fault Zone, (b) deep intraplate events within the subducting Juan de Fuca plate, (c) shallow crustal events within the North America Plate, and (d) earthquakes associated with renewed volcanic activity. 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 and there appears to be a link between the subducting plate and the formation of volcanoes some distance inland from the off-shore fault zone.

Region 2 has had at least seven crustal earthquakes of magnitude 4 or greater since 1877. The region's largest earthquakes were the 1877 M5.3 and the 1962 M5.2. In addition, the region has been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside the area. There is good reason to believe that the most devastating future earthquakes would probably originate along shallow crustal faults in the region and along the Cascadia Fault Zone. Deep-seated intraplate events, as occurred near Olympia, Washington in 1949 and 2001, could generate magnitudes as large as M7.5, but none have been identified in the region's historical or prehistoric records.

Earthquakes produced through volcanic activity could possibly reach magnitudes of 5.5. The 1980 Mount St. Helens eruption was preceded by a magnitude 5.1 earthquake. Despite the fact that Cascade volcanoes are some distance away from the major population centers in Region 2, earthquake shaking and secondary earthquake-related hazards such as lahars could cause major damage to these centers.

The City of Portland has been built on three identified crustal faults that stretch the length of Portland: the Oatfield Fault west of the northwest hills; the East Bank Fault, traversing the Willamette into Oregon City and the Portland Hills Fault which runs parallel to Forest Park into downtown Portland. Each of these crustal faults is capable of generating large earthquakes of M6.0–6.8.

Historic Earthquake Events

Table 2-148. Significant Earthquakes Affecting Region 2

Date	Location	Magnitude (M)	Description
Approximate Years: 1400 BCE*, 1050 BCE, 600 BCE, 400, 750, 900	Offshore, Cascadia Subduction Zone (CSZ)	probably 8.0–9.0	these are the mid-points of the age ranges for these six events
Jan. 1700	CSZ	about 9.0	generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast
Oct, 1877	Portland area, Oregon	5.2	two events in one day; affected area: 41,000 sq km; damage: chimney damage
Feb. 1892	Portland area, Oregon	5.0	no major damage occurred
Dec. 1941	Portland area, Oregon	4.5	felt by most Portland residents; damage: shattered windows and cracked plaster (Hillsboro and Sherwood)
Apr. 1949	Olympia, Washington	7.1	damage: in Washington and NW Oregon
Dec. 1953	Portland area, Oregon	4.5	cracked plaster and caused objects to fall (Portland)
Nov. 1961	Portland area, Oregon	5.0	principal damage: from cracked plaster
Nov. 1962	Portland area, Oregon	5.5	shaking: up to 30 seconds; damage: chimneys cracked, windows broken, furniture moved
Dec. 1963	Portland area, Oregon	4.5	damage: books and pictures fell (Plains)
Mar. 25, 1993	Scotts Mills, Oregon	5.6	FEMA-985-DR-Oregon; center: Mt. Angel-Gales Creek fault; damage: $30 million (including Oregon Capitol Building in Salem)
Feb. 2001	Nisqually, Washington	6.8	felt in the region, no damage reported

*BCE: Before Common Area.

Source: Wong and Bolt (1995)

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local

probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the probability that Region 2 will experience an earthquake is shown in **Table 2-149**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-149. Local Probability Assessment of Earthquakes in Region 2

	Columbia	Clackamas	Multnomah	Washington
Vulnerability	L	M	H	M

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

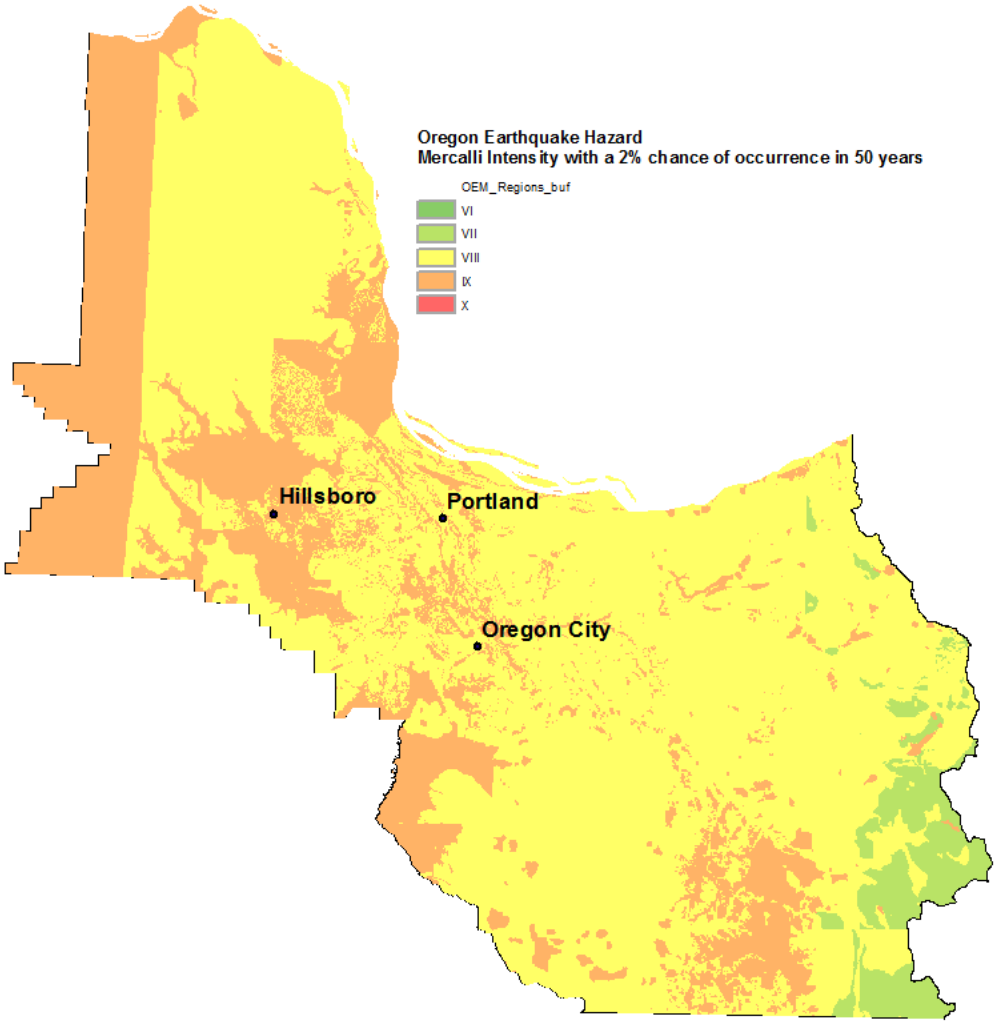
State Assessments

The probability of damaging earthquakes varies widely across the state. In Region 2 the hazard is dominated by Cascadia subduction earthquakes originating from a single fault with a well-understood recurrence history.

The probabilistic earthquake hazard for Region 2 is depicted in **Figure 2-112**. This map shows the expected level of earthquake damage that has a 2% 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 is expressed as Mercalli intensity, which describes the effects of shaking on people and structures. This map incorporates all that is known about the probabilities of earthquake on all Oregon faults, including the Cascadia Subduction Zone (CSZ).

For Oregon west of the crest of the Cascades, the CSZ is responsible for most of the hazard shown in **Figure 2-112**. The paleoseismic record includes 18 magnitude 8.8–9.1 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 to 12%. An additional 10 to 20 smaller, magnitude 8.3–8.5, earthquakes affected only 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 2-112. Probabilistic Earthquake Hazard in Region 2



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; and
X	Poorly built structures destroyed, heavy damage in well-built structures.

Source: Madin and Burns (2013)

Vulnerability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the region's vulnerability to earthquakes is shown in **Table 2-150**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-150. Local Vulnerability Assessment of Earthquakes in Region 2

	Columbia	Clackamas	Multnomah	Washington
Vulnerability	M	H	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

All of Region 2 is especially vulnerable to earthquake hazards for two reasons: (a) much of the area is susceptible to earthquake-induced landslides, liquefaction, and severe ground shaking; and (b) the region contains the bulk of Oregon's population and built environment.

Of the 15 counties in the state with the highest expected damages and losses, based on a 500-year model, the following counties are located in Region 2:

- Multnomah,
- Washington, and
- Clackamas.

Table 2-151 shows the number of school and emergency response buildings surveyed in each county with their respective rankings.

Table 2-151. School and Emergency Response Building Collapse Potential in Region 2

	Level of Collapse Potential			
County	**Low (< 1%)**	**Moderate (>1%)**	**High (>10%)**	**Very High (100%)**
Clackamas	123	48	40	6
Columbia	19	13	15	3
Multnomah	68	118	116	29
Washington	81	69	80	6

Source: Lewis (2007), available at http://www.oregongeology.org/sub/projects/rvs/default.htm.

The Oregon Department of Geology and Mineral Industries (DOGAMI) has also developed two earthquake loss models for Oregon based on the two most likely sources of seismic events: (a) the Cascadia Subduction Zone (CSZ), and (b) combined crustal events (500-year model). Both models use 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. Results are found in **Table 2-152**.

Metro (the elected regional government that serves more than 1.3 million residents in Clackamas, Multnomah, and Washington Counties and the 24 cities in the Portland Metro area) has likewise evaluated earthquake potential and losses for its three-county area. The analysis included an inventory of over 50,000 commercial and multi-family dwellings at risk. Single-family dwellings within the Metro boundary were not evaluated because their structural similarity (Metro, 1998).

Other useful resources for planning for earthquakes include the following:

Maps of earthquake hazard areas: DOGAMI has mapped all of the Region 2 counties and has statewide GIS earthquake hazard layers available (Madin & Burns, 2013).

Map of critical facilities vulnerable to hazards: DOGAMI has developed these maps for all Region 2 counties.

Environmental geology maps: DOGAMI has developed these maps for all Region 2 counties.

Nuclear energy/hazardous waste sites inventories: No Region 2 counties have nuclear facilities.

Table 2-152. Projected Dollar Losses in Region 2, Based on an M8.5 Subduction Event and a 500-Year Model

M8.5 CSZ Event						500-Year Model[1]			
COUNTIES	Multnomah	Washington	Columbia	Clackamas		Multnomah	Washington	Columbia	Clackamas
Injuries	1,521	555	36	128		8,659	2,910	150	1,402
Deaths	28	10	0	2		186	62	3	29
Displaced households	2,803	2,062	94	426		13,777	7,666	326	2,525
Economic losses for buildings[2]	$1.9 b	$931 m	N/A	$316 m		$9.2 b	$3.8 b	$267 m	$2.1 b
Operational "day after" the quake									
Fire Stations	78%	66%	unknown	84%		N/A[3]	*	*	*
Police Stations	76%	64%	45%	84%		N/A	*	*	*
Schools	81%	64%	63%	84%		*	*	*	*
Bridges	94%	79%	82%	90%		*	*	*	*
Economic losses to									
Highways	$21 m	$15 m	$2 m	$6 m		$437 m	$61 m	$10 m	$74 m
Airports	$2 m	$5 m	$2 m	$3 m		$12 m	$23 m	$8 m	$32 m
Communications	$3 m	$752,000	$97,000	$232,000		$31 m	$4 m	$950,000	$4 m
Debris generated (thousands of tons)	1,598	763	57	237		6,745	2,817	184	1,588

[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]"…there are "numerous unreinforced 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" (Wang, 1998, p. 5).

[3]Because the 500-year model includes several earthquakes, the number of facilities operational the "day after" cannot be calculated.

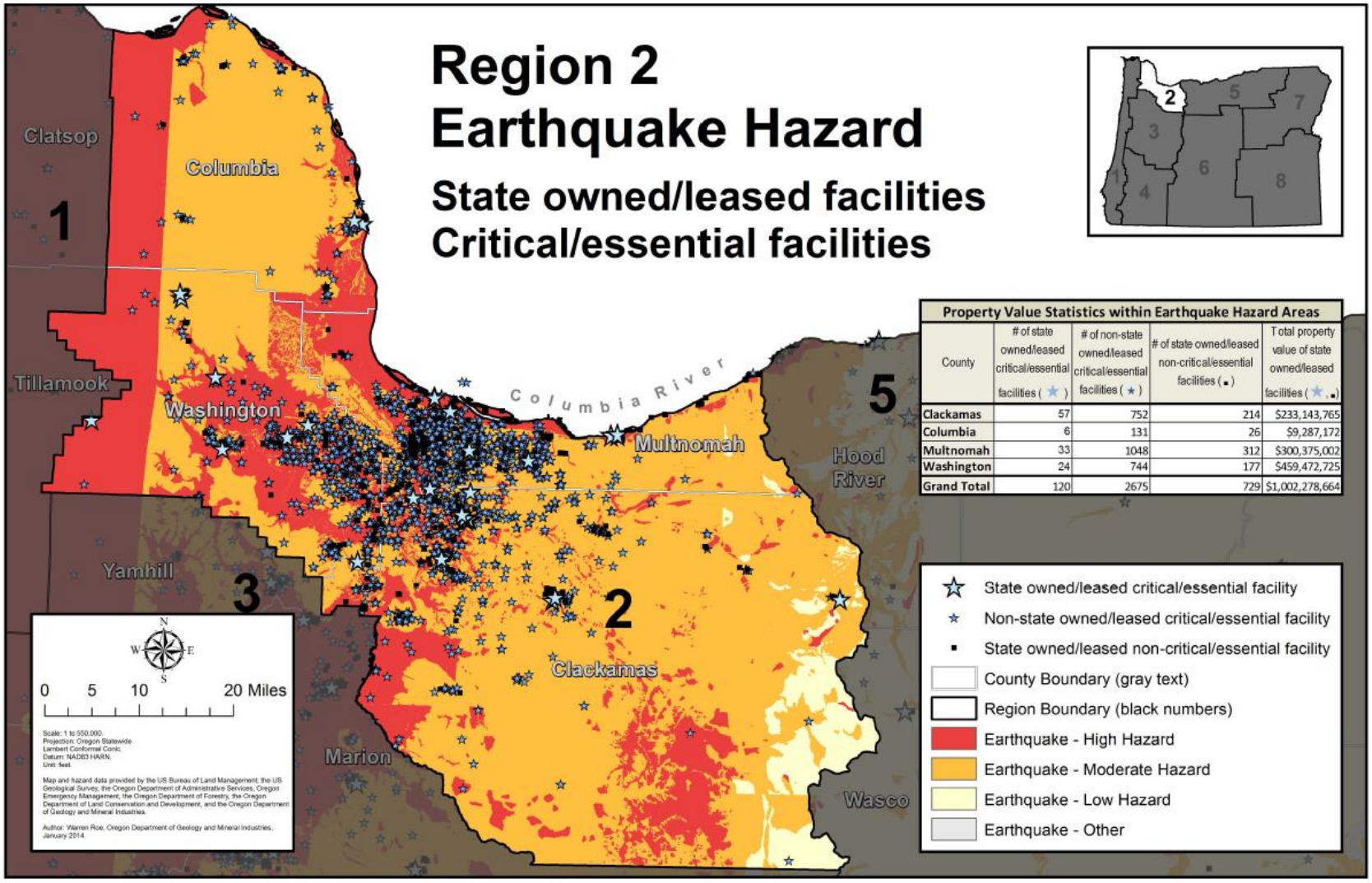
Source: Wang and Clark (1999)

State-Owned/Leased Facilities and Critical/Essential Facilities

The following information is based on a State facility and critical/essential facility vulnerability assessment update completed by DOGAMI in 2014. (See the State Risk Assessment, **Oregon Vulnerabilities** section for more information.)

Of 5,693 state facilities evaluated, 849 totaling over $1 billion worth of property are located in an earthquake hazard zone in Region 2 (**Figure 2-113**). Among the 1,141 State critical/essential facilities, 120 are in an earthquake hazard zone in Region 2. Additionally, 2675 non-state critical/essential facilities in Region 2 are located in an earthquake hazard zone.

Figure 2-113. State-Owned/Leased Facilities and Critical/Essential Facilities in an Earthquake Zone in Region 2



Source: DOGAMI

SEISMIC LIFELINES

"Seismic lifelines" are the state highways ODOT has identified as most able to serve response and rescue operations, reaching the most people and best supporting economic recovery. The process, methodology, and criteria used to identify them are described in **Section 2.2.2.6, Seismic Transportation Lifeline Vulnerabilities**, and the full report can be accessed at **Appendix 9.1.13**, *Statewide Loss Estimates: Seismic Lifelines Evaluation, Vulnerability Synthesis, and Identification* (OSLR). According to that report, seismic lifelines in Region 2 have the following vulnerabilities.

The following geographic zones identified in the OSLR are located within Region 2:

- *Portland Metro Geographic Zone:* In addition to encompassing the largest population concentration in the state, this zone contains extensive facilities (such as transportation, communication, and fuel depots) that are critical to statewide earthquake response and recovery. For these reasons, it has a higher concentration of lifeline routes than the other geographic zones and redundant Tier 1 crossings of the Willamette River.

  The Tier 1 system (highest priority roadway) in the Portland Metro Geographic Zone consists of the following corridors:

  - I-5, excluding the section between the northern and southern I-405 interchanges,
  - I-405,
  - I-205, and
  - OR-99 W from I-5 to OR-217.

  The Tier 2 system (second highest priority roadway) in the Portland Metro Geographic Zone consists of three access corridors:

  - I-84,
  - I-5 between the northern and southern I-405 interchanges, and
  - US-26 from OR-217 to I-405.

  The Tier 3 system in the Portland Metro Geographic Zone consists of the following corridors:

  - OR-217,
  - US-26 from I-5 to I-205, and
  - OR-43.

- *Cascades Geographic Zone:* This region also includes part of the OSLR Cascades Zone. The recommended seismic lifelines for this region include three crossings of the Cascades from western to central Oregon that have areas vulnerable to landslides and may be subject to damage from ground shaking. These routes connect the highly seismically impacted western portion of the state to the less seismically impacted central portion of the state. The Tier 1 system in the Cascades Geographic Zone that serves this region is I-84. The Tier two routes in the Cascades Geographic Zone that serve this region are OR-212 and US-26. There are no corridors designated as Tier 3 in the Cascades Geographic Zone.

REGIONAL IMPACT.

- Ground shaking: In the Northern Willamette Valley / Portland Metro Region, the level of damage from ground shaking levels depends upon its intensity and duration. Unreinforced structures, roadbeds, and bridges will be damaged to varying extents, and it is expected that river crossings and areas with limited surface transportation alternatives will isolate some neighborhoods hindering rescue and recovery activities. There are also several localized faults in the region about which not much is known; it is possible that a major CSZ event could activate local faults.
- Landslides and rockfall: Many roadways in the area are cut into or along landslide prone features. Removal of slide and rockfall material is an ongoing responsibility of ODOT Maintenance crews in hilly areas and the parts of the Cascades and Coast Regions that fall within Region 2. A major CSZ event may increase landslide and rockfall activities in this region and may reactivate ancient slides that are currently inactive. In the Lower Columbia River basin, ground shaking may change the shipping channel and other features.
- Tsunamis: There may be tsunami impacts in the Lower Columbia area, with variables including the size and force of the tsunami, whether jetties hold up to the tsunami and water levels in the river. Damage to ports, shipping channels, water-dependent uses, and other low lying areas is possible.
- Liquefaction: Structures in wetland, estuarine, alluvial, and other saturated areas may 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. Bridge approaches, low lying roadways, and transportation fuel supplies are all at risk in this region.

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. Columbia and Multnomah Counties are the most vulnerable to water related effects, particularly liquefaction. The whole region, including Clackamas and Washington Counties, is likely to have significant impacts related to ground shaking. Landslides are likely in some hilly areas. Vulnerabilities with both regional and statewide transportation impacts in Multnomah County, Portland, and the Portland Metro area include potential loss of stored fuels and distribution infrastructure; interruption of services at Portland International Airport; interruption of intermodal freight capacity due to river channel changes; damage to onshore facilities and surface transportation facilities; and bridge or bridge approach failures across both the Willamette and Columbia Rivers.

Floods

Characteristics

The northern Willamette Valley (including the Portland Metro area) has a lengthy flood history with significant floods occurring about every 5–7 years (**Table 2-153**). The Willamette and Columbia Rivers have produced numerous floods, some of which are shown in **Table 2-153**. Most Willamette River flooding is a winter phenomenon. The common pattern includes the accumulation of heavy wet snow in higher elevations followed by a mild, rainy, weather system. The resulting snowmelt on saturated or frozen ground sometimes produces devastating flood conditions. These conditions would be worse were it not for many dams (used for, among other purposes, flood control) on the upper reaches of the Willamette and some of its tributaries.

Clackamas County is the third most populated county in the state, with nearly all development concentrated in the western half of the county, downstream from significant sources of mountain runoff.

Columbia County, smaller in area and less populated than Clackamas County, receives more annual rainfall and, as a result, has a denser stream network. The City of Vernonia (see **3.3.5.5, Mitigation Success — City of Vernonia, 2014**), suffered extensive flooding in 2007 resulting in damage to over 300 buildings. Mitigation activities in Vernonia, including relocation of the K–12 school buildings, following the 2007 flood event have significantly reduced damage potential in this small city.

The Columbia River Estuary is the second largest river in the United States and the largest river to flow into the eastern North Pacific. Columbia River floods usually occur in the early summer and are associated with seasonal runoff from melting snow. Although unusually extreme, the Vanport Flood (1948) provides an example of such an event. The 20-day flood was the greatest single disaster in the recorded history of the Columbia River Basin. The toll was 32 dead and 7 missing in the Portland area. Flooding occurred when the Columbia River broke through a dike surrounding the community of Vanport and forced 50,000 people to evacuate their homes. Economic losses reportedly exceeded $100 million. Vanport, a Vancouver-Portland suburban community and the largest public housing project ever built in the United States, was not rebuilt. Prolonged winter rain, debris dams, and breeched dikes have produced flood conditions at several Columbia County locations. Tidal influences are observed on the Columbia River inland to the Bonneville Dam and on the Willamette in Portland.

A common Willamette Valley phenomenon involves tributary stream backup during periods of high water. When tributary streams cannot enter swollen main stem rivers during periods of high water, tributary streams are forced out of their banks. During the February 1996 flood, dams controlled Columbia River flows. This allowed the Willamette River to enter the Columbia, averting flooding in downtown Portland, but other streams produced widespread flooding throughout the region. **Table 2-154** summarizes the sources of flooding for each of the major rivers in the region.

Historic Flood Events

Table 2-153. Significant Historic Floods in Region 2

Date	Location	Description	Type of Flood
Dec. 1861	coastal rivers	the "Great Flood;" largest flood of known magnitude on the Willamette River; every town on the river was flooded or washed away; widespread damage	rain on snow and snow melt
Dec. 1862	Willamette River Basin	widespread flooding	rain on snow
Feb. 1890	Willamette Basin	second largest flood of known magnitude; water levels in Portland: 22.3 ft	rain on snow
June 1894	main stem Columbia	largest flood ever observed on the river; current small in Portland; little damage	snow melt
Jan. 1923	Willamette and Columbia Rivers	rain and mild weather; widespread damage to roads and railroads	rain on snow
Dec. 1937	Willamette Basin	considerable flooding; landslides	rain on snow
Dec. 1945	Willamette Basin / NW Oregon	very warm temperatures; considerable flood damage	rain on snow
June 1948	main stem of the Columbia	Vanport near Portland completely destroyed	snow melt
Dec. 1955	Columbia River and Willamette Basin	strong winds/flooding; five fatalities	rain on snow
Dec. 1964	entire state	record-breaking December rainfall; widespread damage; warm temperatures	rain on snow
Jan. 1972	Willamette and Sandy Rivers	widespread damage; many fish buildings, etc. destroyed; five fatalities	rain on snow
Jan. 1974	western Oregon	mild storms followed heavy snow and freezing rain; nine counties declared disasters	rain on snow
Jan. 1978	Willamette River and NW Oregon	intense rain/snowmelt; widespread flooding	rain on snow
Feb. 1986	entire state	numerous homes evacuated; intense rain and melting snow	snow melt
Feb. 1987	western Oregon	Willamette and tributaries; mud slides, flooded highways, damaged homes	rain on snow
Jan. 1990	western Oregon	10 rivers in eight counties flooded; many bridges washed away	rain on snow
Feb. 1996	NW Oregon	warm temperatures / record breaking rains; widespread flooding (FEMA-1099-DR-OR. 1996)	rain on snow
Dec. 1996	western Oregon	mild subtropical moisture led to extensive flooding. 14 county disaster	rain on snow
Jan. 2006	Washington County	Tualatin River in Dilley and Farmington reached above flood stages	riverine
Nov. 2006	Clackamas County	heavy rain caused the Sandy River and Clackamas River to flood, causing damage in Estacada and Oregon City. Total county-wide damages of $3 million	riverine
Dec. 2007	Washington County	flooding of the Tualatin River following heavy rainfall from a tropical storm; old OR-47 and OR-47 closed temporarily; total of $2.3 million in damages	riverine
Dec. 2007	Columbia County	flooding of the Nehalem River caused widespread damage in Vernonia, flooding numerous homes and causing a total of $36 million in damages for Columbia County	riverine
Jan. 2009	Washington County	severe winter storm/snow event that included snow, high winds, freezing rain, ice, blizzard conditions, mudslides, and landslides	
Jan. 2011	Clackamas County	severe winter storm, flooding, mudslides, landslides, and debris flows	
Sep. 2013	Multnomah County	heavy rain resulted in damage to the Legacy Good Samaritan Medical Center and several businesses in northwest Portland	riverine

Sources: Taylor and Hatton (1999); National Climatic Data Center; KPTV_KPDX (2013)

Table 2-154. Principal Riverine Flood Sources in Region 2

Clackamas	Columbia	Multnomah	Washington
Willamette River and tributaries:	Clatskanie River	Columbia and Willamette Rivers and tributaries:	Willamette River and tributaries:
Abernethy Creek	Columbia River	Sandy River	Tualatin River
Clackamas River	Conyers Creek	Multnomah Channel	Fanno Creek
Clear Creek	McNulty Creek	Johnson Creek	Summer Creek
Dear Creek	Milton Creek	Fairview Creek	Ash Creek
Eagle Creek	Multnomah Channel	Columbia Slough	Rock Creek
Johnson Creek	Nehalem Creek	Ponding within Drainage Dist. #1	Cedar Creek
Kellogg Creek	Rock Creek	Beaver Creek	Butternut Creek
Milk Creek	Scappoose Creek	Fairview Creek	Dawson Creek
Molalla River		Kelley Creek	Beaverton Creek
Mt. Scott Creek		Mitchell Creek	Bronson Creek
Nyberg Slough			Willow Creek
Oswego Channel			Cedar Mill Creek
Phillips Creek			Johnson Creek
Pudding River			Dairy Creek
Salmon River			McKay Creek
Sandy River			Council Creek
Still Creek			Gales Creek
Tualatin River			Wapato Creek
Zig Zag River			Nyberg Slough
Tickle Creek			

Sources: FEMA, Clackamas County Flood Insurance Study (FIS), Aug. 15, 1996, FEMA, Lane County FIS, June 2, 1999, FEMA, Linn County FIS, Sept. 29, 1986, FEMA, Marion County FIS, July 13, 2001, FEMA, Polk County FIS, Dec. 19, 1995, FEMA, Yamhill County FIS, Sept. 30, 1983

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the probability that Region 2 will experience flooding is shown in **Table 2-155**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-155. Local Probability Assessment of Flood in Region 2

	Columbia	Clackamas	Multnomah	Washington
Probability	H	H	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

All Region 2 counties have Flood Insurance Rate Maps (FIRM) depicting the extent of the 1% flood (100 year). Most of the flood zones shown on these maps are based on old modeling and could be outdated. The FIRM maps were issued at the following times:

- Clackamas County, June 2008;
- Multnomah County, December 2009;
- Washington County, September 1982 (rural areas) and February 2005 (urban areas); and
- Columbia County, November 2010.

Vulnerability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the region's vulnerability to flooding is shown in **Table 2-156**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-156. Local Vulnerability Assessment of Flood in Region 2

	Columbia	Clackamas	Multnomah	Washington
Vulnerability	H	M	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

The Oregon Department of Land Conservation and Development (DLCD) created a countywide flood vulnerability index by compiling data from NOAA's Storm Events Database and from FEMA's 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 2-157**.

Table 2-157. Scoring for Vulnerability Index

Score	Description
3	county data point is greater than 2.5 times standard deviation for the input data set
2	county data point is greater than 1.5 times standard deviation for the input data set
1	county data point is within standard deviation
0	no data reported

Source: DLCD

DLCD summed the scores for each of the five inputs to create a county-by-county vulnerability index. The maximum possible score is 15. A score over 6 indicates that at least one variable significantly exceeds average values.

The four counties in Region 2 received flood vulnerability scores ranging from 5 to 9: Clackamas (9), Columbia (8), Multnomah (5), and Washington (5). Clackamas County has the most repetitive losses of the group, which supports that county's higher than average vulnerability score. Washington County, on the other hand, reports a similar number of repetitive losses, but its vulnerability score is below average. The reasons for this difference have not been quantified; however, it is likely due to the very damaging flood and channel migration incidents that occurred in eastern Clackamas County on the flanks of Mount Hood. More research is needed to articulate the exact reasons why Clackamas County is the most vulnerable in the region to damaging floods. Columbia County's score is likely due to the very damaging floods in the City of Vernonia and Nehalem Valley in 1996 and 2007. After the 2007 floods, the city and county completed many mitigation projects (elevations and buy-outs) with the likely outcome

that this region is actually less vulnerable now than reported here because past losses were used to calculate vulnerability scores.

FEMA has identified 98 Repetitive Loss properties in Region 2, four of which are Severe Repetitive Loss properties. This region has the second most repetitive flood losses of the Oregon NHMP Natural Hazard Regions, reflecting high rainfall amounts near the Columbia River and a high population density.

Communities can reduce the likelihood of damaging floods by employing floodplain management practices that exceed NFIP minimum standards. DLCD encourages communities that adopt such standards to participate in FEMA's Community Rating System (CRS), which results in reduced flood insurance costs. Clackamas County participates in CRS, as do the cities of Oregon City, Portland, Scappoose, and Troutdale.

Table 2-158. Severe/Repetitive Flood Losses and Community Rating System Communities by County in Region 2

County	RL	SRL	# of CRS Communities per County
Clackamas	53	3	2
Columbia	6		1
Multnomah	4		2
Washington	35	1	0
Totals:	**98**	**4**	**5**

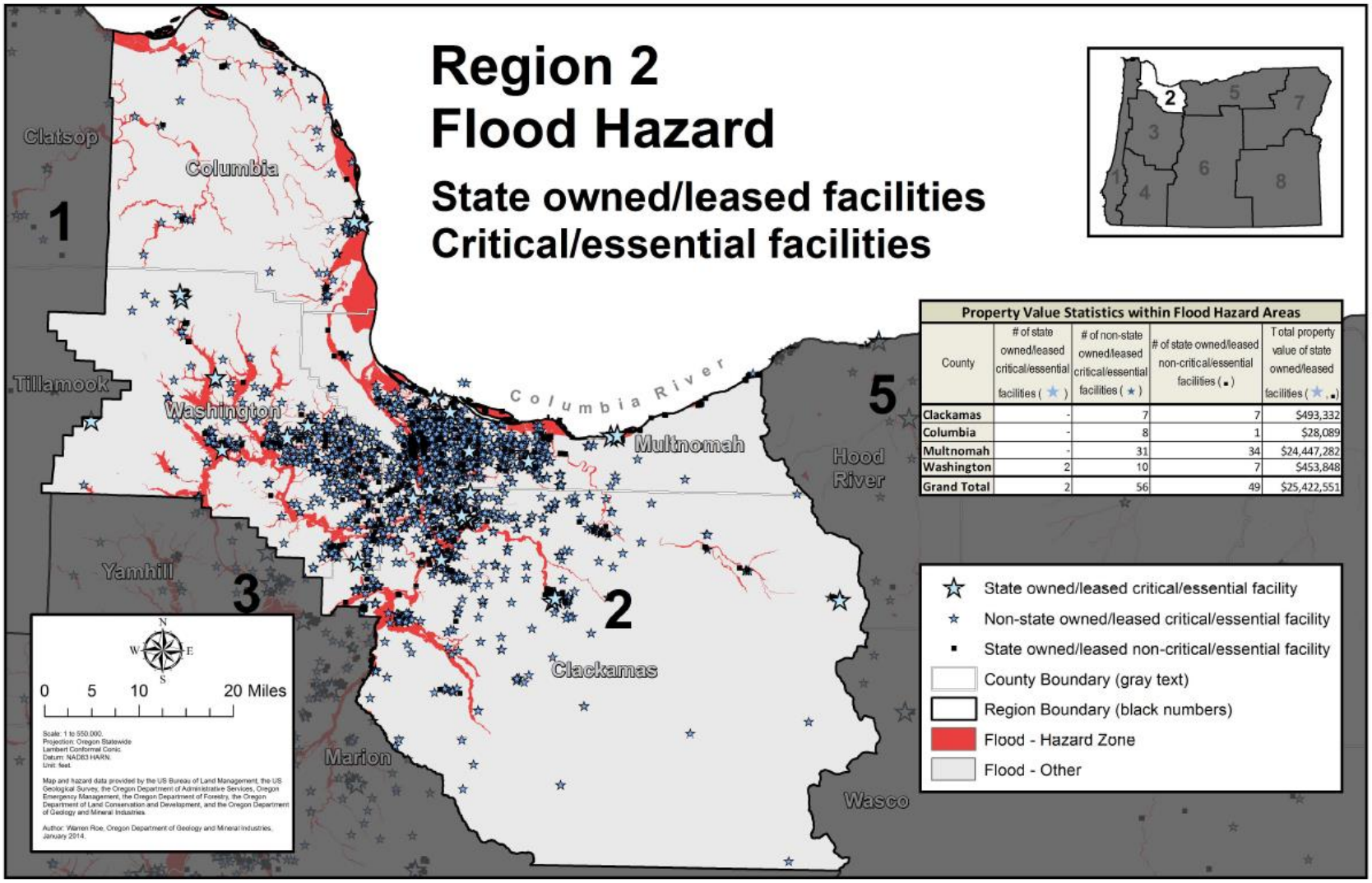
Source: FEMA NFIP BureauNet, http://bsa.nfipstat.fema.gov/, accessed 12/1/2014

State-Owned/Leased Facilities and Critical/Essential Facilities

The following information is based on a state-owned/leased facility and critical/essential facility vulnerability assessment update completed by DOGAMI in 2014. See the State Risk Assessment, **Oregon Vulnerabilities** section for more information.

Of the 5,693 state facilities evaluated, 51 are currently located within a flood hazard zone in Region 2 and have an estimated total value of $25.4 million (**Figure 2-114**). Of these, two are identified as a critical or essential facility. An additional 56 non-state-owned/leased critical/essential facilities are located in a flood hazard zone in Region 2.

Figure 2-114. State-Owned/Leased Facilities and Critical/Essential Facilities in a Flood Zone in Region 2



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
Clackamas	-	7	7	$493,332
Columbia	-	8	1	$28,089
Multnomah	-	31	34	$24,447,282
Washington	2	10	7	$453,848
Grand Total	2	56	49	$25,422,551

Source: DOGAMI

Landslides

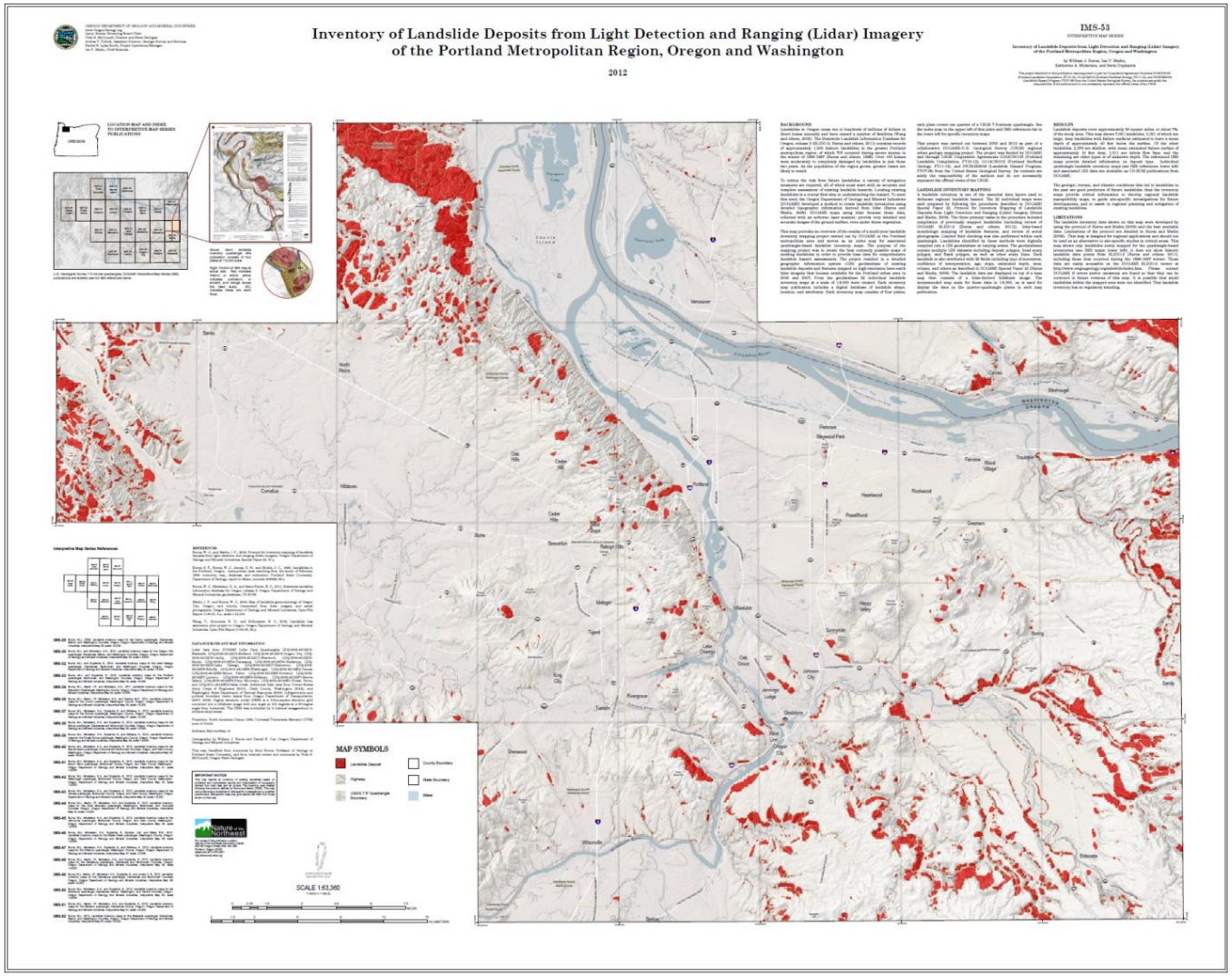
Characteristics

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 Range and Cascade Mountains have a very high incidence of landslides. On occasion, major landslides sever major transportation routes such as U.S. or state highways and rail lines, causing temporary but significant economic damage to the state.

In Multnomah County (including the city of Portland) landslide activity has been a recurring problem for many years. In February 1996, landslide activity that occurred in Portland and the Dodson-Warrendale area (east Multnomah County) was notable and severely impacted homeowners and transportation routes. In fact, I-84 in the Columbia River Gorge was closed for a number of days by fast moving debris flows that covered the roadway and the east-west railroad tracks.

New lidar-based landslide inventory mapping was just completed for most of the Portland Metro area (Burns et al., 2012b). Landslide deposits cover approximately 83 square miles, or about 7%, of the study area. This map shows 7,081 landslides, 3,321 of which are large, deep landslides with failure surfaces estimated to have a mean depth of approximately 40 feet below the surface. Of the other landslides, 2,376 are shallow, with mean estimated failure surface of approximately 10 feet deep; 1,311 are debris flow fans; and the remaining are other types or of unknown depth. The geologic, terrain, and climatic conditions that led to landslides in the past are good predictors of future landslides; thus the inventory maps provide critical information to develop regional landslide susceptibility maps, to guide site-specific investigations for future developments, and to assist in regional planning and mitigation of existing landslides.

Figure 2-115. Inventory of Landslide Deposits from Lidar Imagery of the Portland Metro region, Oregon and Washington



Source: Burns et al. (2012b)

Historic Landslides

In 1996-1997, 700 landslides occurred in the Portland Metro area. Over 100 homes were moderately to completely damaged by landslides in just those two years (Burns et al., 1998). As the population of the region grows, greater losses are likely to result.

Table 2-159. Historic Landslides in Region 2

Date	Location	Description
Mar. 1972	near Portland, Oregon	mud and rock slide on I-5; injured: three motorists
Oct. 1984	I-84 near Cascade Locks, Oregon	rockslide; fatalities: two children; cost of stabilizing the slide area: $4 million
Sep. 1990	near Troutdale, Oregon	landslide; injuries: four highway workers
Feb. 1996	Dodson-Warrendale, Portland Metro area, Oregon	FEMA-1099-DR-Oregon; heavy rains and rapidly melting snow contributed to thousands of landslides and debris flows across the state; many occurred on clear cuts that damaged logging roads; I-84 closed at Dodson-Warrendale (700 in the Portland Metro area)
Dec. 2007	Clatsop, Columbia, Tillamook, Washington, and Yamhill Counties, Oregon	landslide due to heavy rains from a strong winter storm; damages: $1.5 million total (Clatsop, Columbia, Tillamook, Washington, and Yamhill Counties); $300,000 (to Columbia County alone)

Sources: ODOT Emergency Operations Plan, May, 2002; Interagency Hazard Mitigation Team Report, FEMA-1099-DR-OR, June, 1997; Interagency Hazard Mitigation Team Report, FEMA-1149-DR-OR, March, 1997; Taylor and Hatton, 1999; Hazards and 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.

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the probability that Region 2 will experience landslides is shown in **Table 2-160**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-160. Local Probability Assessment of Landslides in Region 2

	Columbia	Clackamas	Multnomah	Washington
Probability	M	H	H	L

Source: Oregon Office of Emergency Management, 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 an analysis of risk conducted by county emergency program managers, the region's vulnerability to landslides is shown in **Table 2-161**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-161. Local Vulnerability Assessment of Landslides in Region 2

	Columbia	Clackamas	Multnomah	Washington
Vulnerability	M	L	M	L

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

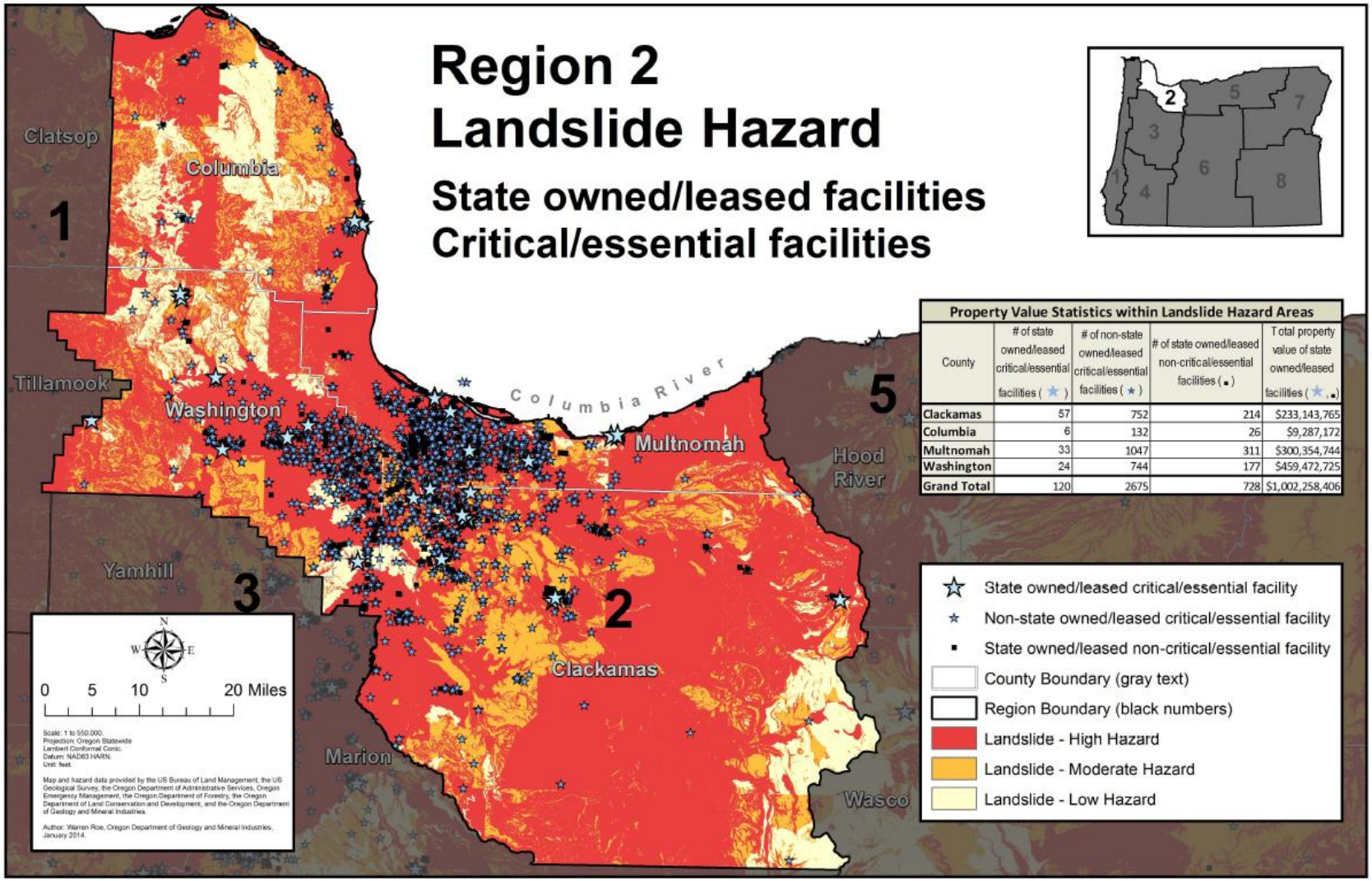
Many communities in this region are vulnerable to landslides; for example, the Portland Hills and the Oregon City area both have high exposure to landslides. In general, Washington, Multnomah, and Clackamas Counties have relatively high vulnerability.

STATE-OWNED/LEASED FACILITIES AND CRITICAL/ESSENTIAL FACILITIES

The following information is based on a state facility and critical/essential facility vulnerability assessment update completed by DOGAMI in 2014. (See the State Risk Assessment, **Oregon Vulnerabilities** section for more information.)

Of the 5,693 state facilities evaluated, 848 are located within landslide hazard areas in Region 2, totaling roughly $1 billion (**Figure 2-116**). This includes 120 state critical or essential facilities. An additional 2,675 critical/essential facilities, not owned/leased by the state, are also located within a landslide hazard zone in Region 2.

Figure 2-116. State-Owned/Leased Facilities and Critical/Essential Facilities in a Landslide Zone in Region 2



Source: DOGAMI

Volcanoes

Characteristics

The eastern boundaries of Clackamas and Multnomah Counties coincide with the crest of the Cascade Mountains. Volcanic activity in the Cascades will continue, but questions regarding how, to what extent, and when remain. Most volcano-associated hazards are local (e.g., explosions, debris, lava, and pyroclastic flows). However, lahars can travel considerable distances through stream valleys, and ashfall can blanket areas many miles from the source.

Historic Volcanic Events

Table 2-162. Historic Volcanic Events in Region 2

Date	Location	Description
about 20,000 to 13,000 YBP	Polallie eruptive episode, Mount Hood	lava dome, pyroclastic flows, lahars, tephra
about 1,500 YBP	Timberline eruptive period, Mount Hood	lava dome, pyroclastic flows, lahars, 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 (Washington)	debris avalanche, ashfall, flooding on Columbia River

Note: YBP is years before present.

Sources: U.S. Geological Survey, Cascades Volcano Observatory: http://volcanoes.usgs.gov/observatories/cvo/; Wolfe and Pierson (1995); Scott et al. (1997)

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the probability that Region 2 will experience volcanic activity is shown in **Table 2-163**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-163. Local Probability Assessment of Volcanic Activity in Region 2

	Columbia	Clackamas	Multnomah	Washington
Probability	L	L	H	L

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

Region 2 communities are closest to Mount Hood (Clackamas County), a stratovolcano. Stratovolcanoes have wide ranging modes of eruption, making future volcanic activity difficult to predict definitively. Mount Hood's eruptive history can be traced to late Pleistocene times (15,000–30,000 years ago) and will no doubt continue. However, the central question remains: When?

The most recent series of events (1760–1907) consisted of small lahars, debris avalanches, steam explosions, and minor ashfalls. Mount Hood's recent history also includes ashfalls, dome building, lahars, pyroclastic flows, and steam explosions. These occurred approximately 200 years ago. Geoscientists have provided estimates of future activity in the vicinity of Crater Rock, a well-known feature on Mount Hood. They estimate a 1 in 300 chance that some dome activity will take place in a 30-year period (1996–2026). For comparison, the 30-year probability of a house being damaged by fire in the United States is about 1 in 90 (Scott et al., 1997).

The probability of 1 cm or more of ashfall from eruptions throughout the Cascade Range include (Sherrod et al., 1997):

- Clackamas County: between 1 in 500 and 1 in 1000;
- Multnomah County: between 1 in 500 and 1 in 1,000;
- Washington County: between 1 in 1,000 and 1 in 5,000; and
- Columbia County: between 1 in 5,000 to 1 in 10,000.

Mount St. Helens is less than 50 air miles from some Columbia County communities and is still active. Prevailing wind direction is of paramount importance. Because the prevailing winds are westerly in Columbia County, the risk of ashfall is considerably reduced.

Table 2-164 summarizes the probability of volcano-related hazards for each county. Debris from the 1980 eruption of Mount St. Helens impacted the shipping channel on the Columbia River by reducing water depth to such an extent that dredging was required.

Table 2-164. Probability of Volcano-Related Hazards in Region 2

Volcano Related Hazards	Washington	Multnomah	Clackamas	Columbia	Remarks
Volcanic ash (annual probability of 1cm or more accumulation from eruptions throughout the Cascade Range)	1 in 5,000 to 1 in 10,000	1 in 1,000 to 1 in 5,000	1 in 1,000 to 1 in 5,000	1 in 5,000 to 1 in 10,000	Sherrod et al. (1997)
Lahar	no risk	Source: Mount Hood	Source: Mount Hood	no risk	Scott et al. (1997)
Lava flow	no risk	no risk	Source: Mount Hood	no risk	Scott et al. (1997)
Debris flow / avalanche	no risk	Source: Mount Hood	Source: Mount Hood	Mount St. Helens	Scott et al. (1997)
Pyroclastic flow	no risk	no risk	Source: Mount Hood	no risk	Scott et al. (1997)

Vulnerability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the region's vulnerability to volcanic activity is shown in Table 2-165. See the State Risk Assessment for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-165. Local Vulnerability Assessment of Volcanic Activity in Region 2

	Columbia	Clackamas	Multnomah	Washington
Vulnerability	M	H	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

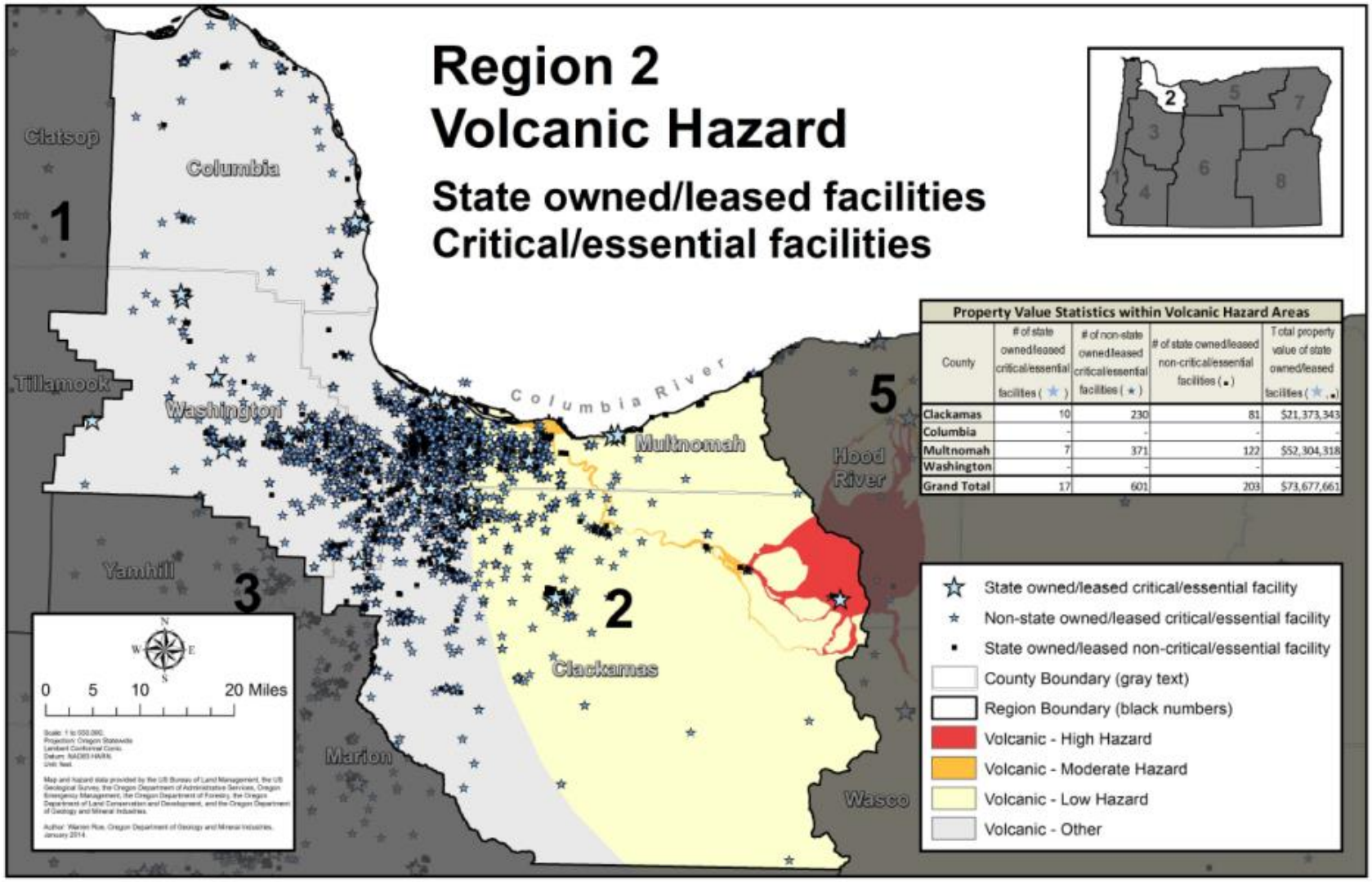
The U.S. Geological Survey has addressed volcanic hazards at Mount Hood (Scott et al., 1997) and Mount St. Helens (Wolfe and Pierson, 1995). These reports include maps depicting the areas at greatest risk. Clackamas and Multnomah Counties, including the Portland Metro area, are at risk and should consider the impact of volcano-related activity on small mountain communities, dams, reservoirs, energy-generating facilities, and highways. These counties also should consider probable impacts on the local economy (e.g., wood products and recreation). The communities of Government Camp, Rhododendron, and Welches merit special attention. There is virtually no risk from volcanoes in Washington County, although normal prevailing winds could shift and carry ash into that area. Debris entering the Columbia River from eruptions at Mount St. Helens or Mount Hood may disrupt shipping operations based in Columbia and Multnomah Counties.

STATE-OWNED/LEASED FACILITIES AND CRITICAL/ESSENTIAL FACILITIES

The following information is based on a state facility and critical/essential facility vulnerability assessment update completed by DOGAMI in 2014. (See the State Risk Assessment, **Oregon Vulnerabilities** for more information.)

Of the 5,693 state facilities evaluated, are 220 located within a volcanic hazard in Region 2; and total roughly $73.7 million in value. Of those facilities, 17 are critical or essential facilities. In addition, there are 601 non-state-owned/leased critical or essential facilities located within a volcanic hazard zone in Region 2 (**Figure 2-117**).

Figure 2-117. State-Owned/Leased Facilities and Critical/Essential Facilities in a Volcanic Hazard Zone in Region 2



Property Value Statistics within Volcanic 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 (★ , ▪)
Clackamas	10	230	81	$21,373,343
Columbia	-	-	-	-
Multnomah	7	371	122	$52,304,318
Washington	-	-	-	-
Grand Total	17	601	203	$73,677,661

Source: DOGAMI

Wildfires

Characteristics

There is extensive forested land in Columbia, Clackamas, Multnomah, and Washington Counties, both in undeveloped National Forest land and developing wildland-urban interface areas. All of it is at risk, but especially within the interface areas. In recent years, the cost of fire suppression has risen dramatically. A large number of homes have been threatened or burned, more firefighters have been placed at risk, and fire protection in wildland areas has been reduced. These factors have prompted communities and protection agencies to come together and use or create extensive fire prevention/mitigation programs. Community Wildfire Protection Plans lead the way for the development of Firewise Communities and fuel reduction projects throughout the region.

Residents have a high risk of experiencing a wildland fire due to the extensive forestland present in the communities and the current trend toward rural home site development. The age of the surrounding timber stands can be a factor in determining whether a non-threatening ground fire will spread to the canopy and become a dangerous crown fire. Clearings and fuel breaks will disrupt a slow moving wildfire enabling successful suppression. Agricultural and ranching activities throughout the area increase the risk of a human-caused wildfire spreading to forested areas. Large expanses of fallow fields or non-annual cash crops provide areas of continuous fuels that have potential to threaten several homes and farmsteads. Under extreme weather conditions, escaped agricultural fires could threaten individual homes or a town site; however, this type of fire is usually quickly controlled. High winds increase the rate of fire spread and intensity of fires.

Table 2-166 shows the single significant fire affecting Region 2.

Historic Wildfire Events

Table 2-166. Historic Wildfires in Region 2

Year	Name of Fire	Counties	Acres Burned	Remarks
1902	Columbia	Clackamas/Multnomah	170,000	—

Source: Brian Ballou, 2002, A Short History of Oregon Wildfires, Oregon Department of Forestry, unpublished

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next

plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the probability that Region 2 will experience wildfire is shown in **Table 2-167**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-167. Local Probability Assessment of Wildfire in Region 2

	Columbia	Clackamas	Multnomah	Washington
Probability	M	M	H	M

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

This document defines wildfire as an uncontrolled burning of forest, brush, or grassland. Wildfires have always been a part of these ecosystems, sometimes with devastating effects. Wildfire may result from natural causes (e.g., lightning strikes), a mechanical failure (Oxbow Fire), or human causes (unattended campfire, debris burning, or arson). Most wildfires can be linked to human carelessness.

Vulnerability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the region's vulnerability to wildfire is shown in **Table 2-168**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-168. Local Vulnerability Assessment of Wildfire in Region 2

	Columbia	Clackamas	Multnomah	Washington
Vulnerability	M	M	M	M

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

The vulnerability in this region is mild at best. The Northern Willamette Valley / Portland Metro area is dominated by highly populated rural interface as well as metropolitan areas. Timber and agriculture land line suburban areas. A cooler climate and reduced fire danger results in fewer wildfires. In addition, response times are typically much quicker in this region due to large populations and several fire agencies nearby.

Each year a significant number of people build homes within or on the edge of the forest (wildland-urban interface), thereby increasing wildfire hazards. These communities have been designated "Wildland-Urban Interface Communities" and include those in **Table 2-169**.

Table 2-169. Wildland-Urban Interface Communities in Region 2

Clackamas	Columbia	Multnomah	Washington
Beaver Creek	Alston	Bonneville	Buxton
Bull Run	Clatskanie	Burlington	Cherry Grove
Cedarhurst Park	Columbia City	East Metro	Gales Creek
Colton	Deer Island	Holbrook	Gaston
Dickey Prairie	Goble	Lower Columbia Gorge	Glenwood
Eagle Creek	Mist Birkenfeld	Portland Metro	Stimson Mill
Estacada	Pittsburg	Shelternoon	Timber
Fallsview	Prescott	Skyline	Tualatin Valley
Firgrove	Quincy	Warrendale	
Government Camp	Rainier		
Hoodland Corridor	St. Helens		
Maple Grove	Scappoose		
Molalla	Spitzenburg		
Molino	Swedetown		
Redland	Vernonia		
Sandy	Warren		
Springwater	Yankton		
Timber Grove			

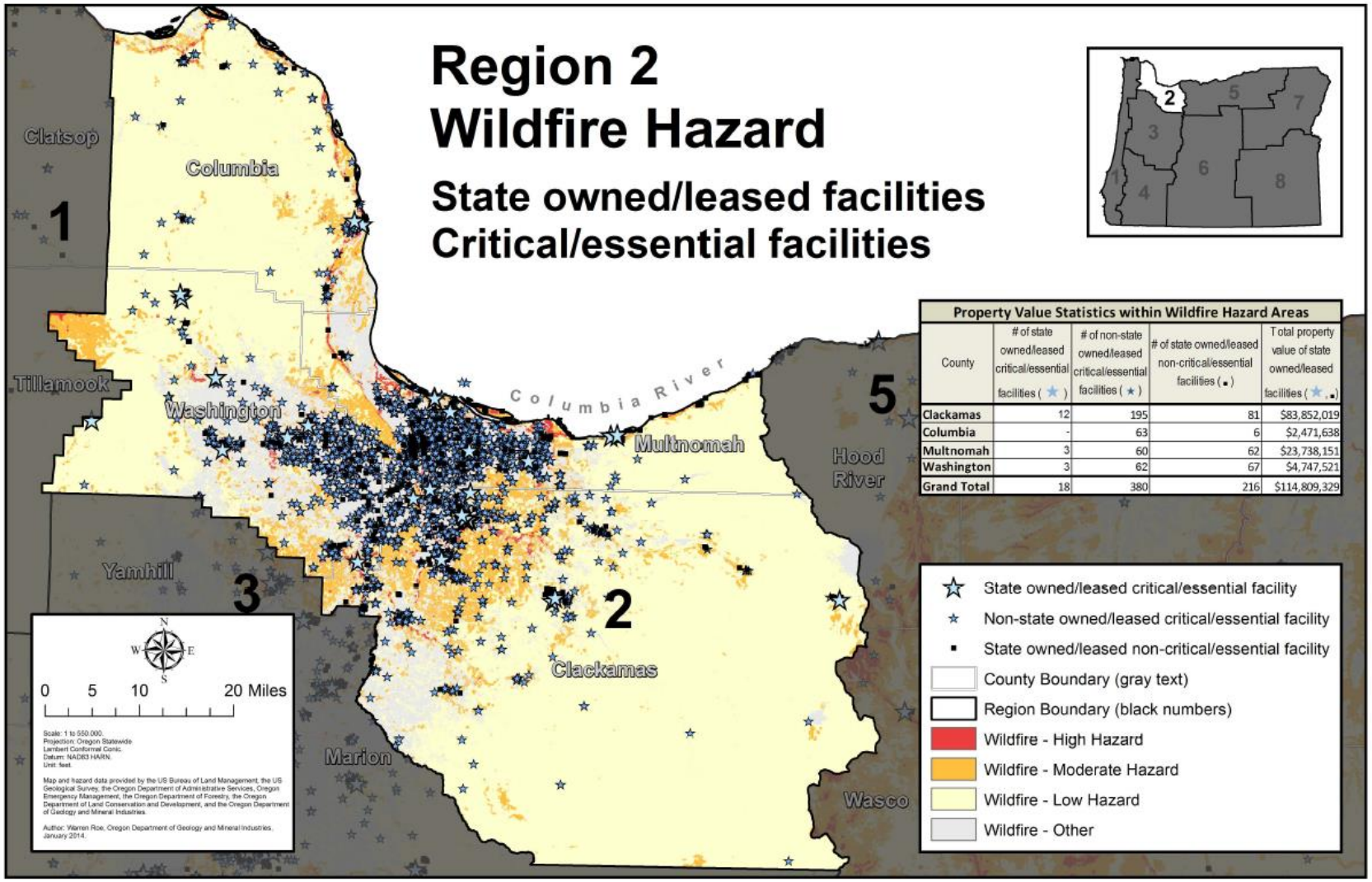
Oregon Dept. of Forestry Statewide Forest Assessment September, 2006

STATE-OWNED/LEASED FACILITIES AND CRITICAL/ESSENTIAL FACILITIES

The following information is based on a state facility and critical/essential facility vulnerability assessment update completed by DOGAMI in 2014. See the State Risk Assessment, **Oregon Vulnerabilities** for more information.

Of the 5,693 state facilities evaluated, 234 are within a wildfire hazard zone in Region 2 and total about $ 115 million in value (**Figure 2-118**). Eighteen of these facilities are state critical/essential facilities. An additional 380 non-state critical/essential facilities are also located in a wildfire hazard zone in Region 2.

Figure 2-118. State-Owned/Leased Facilities and Critical/Essential Facilities in a Wildfire Hazard Zone in Region 2



Source: DOGAMI

Windstorms

Characteristics

Extreme winds (other than tornadoes) are experienced in all of Oregon's eight regions. The most persistent high winds occur along the Oregon Coast and the Columbia River Gorge; these areas have special building code standards. A majority of the destructive surface winds in Region 2 are from the southwest. Under certain conditions, very strong east winds may occur, but these usually are limited to small areas in the vicinity of the Columbia River Gorge or other low 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 may be stronger on the coast than in the interior valleys because of the north-south orientation of the Coast Range and Cascades. These mountain ranges obstruct and slow down the westerly surface winds. 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 such a storm, and its effects were so devastating that it has become the benchmark from which other windstorms in Oregon are measured. The storm caused significant damage in Region 2.

Historic Windstorm Events

Table 2-170. Historic Windstorms in Region 2

Date	Location	Description
Apr. 1931	western Oregon	unofficial wind speeds reported at 78 mph; damage to fruit orchards and timber
Nov. 10-11, 1951	statewide	widespread damage; transmission and utility lines; wind speed 40-60 mph; gusts 75–80 mph
Dec. 1951	statewide	wind speed 60 mph in Willamette Valley; 75-mph gusts; damage to buildings and utility lines
Dec.1955	statewide	wind speeds 55–65 mph with 69-mph gusts; considerable damage to buildings and utility lines
Nov. 1958	statewide	wind speeds at 51 mph with 71-mph gusts; every major highway blocked by fallen trees
Oct. 1962	statewide	Columbus Day Storm; Oregon's most destructive storm to date; 116-mph winds in Willamette Valley; estimated 84 houses destroyed, with 5,000 severely damaged; total damage estimated at $170 million
Mar. 1971	most of Oregon	greatest damage in Willamette Valley; homes and power lines destroyed by falling trees; destruction to timber in Lane County
Nov. 1981	most of Oregon	highest winds since Oct. 1962; wind speed 71 mph in Salem; marinas, airports, and bridges severely damaged
Jan. 1990	statewide	heavy rain with winds exceeding 75 mph; significant damage; one fatality
Dec. 1995	statewide	followed path of Columbus Day Storm; wind speeds 62 mph in Willamette Valley; damage to trees (saturated soil a factor) and homes (FEMA-1107-DR-Oregon)
Nov. 1997	western Oregon	wind speed 52 mph in Willamette Valley; trees uprooted; considerable damage to small airports
Feb. 2002	western Oregon	strongest storm to strike western Oregon in several years; many downed power lines (trees); damage to buildings; water supply problems (lack of power); estimated damage costs: $6.14 million (FEMA-1405-DR-Oregon)
June 2004	Washington Count	$100 in property damage from a tornado
Dec. 2004	Clackamas County	$6,250 in property damage *damage estimate includes areas outside of Region 2
June 2005	Multnomah County	lightning causes $50,000 in damage
Dec. 2005	Clackamas, Multnomah, and Washington Counties	$9,000 in property damage
Jan. 2006	Clackamas, Columbia, Washington, and Multnomah Counties	wind storm with winds up to 58 mph caused a total of $500,000 in damages spread out over all four counties and included Yamhill, Marion, and Polk Counties as well
Feb. 2006	Columbia, Multnomah, Clackamas, Washington Counties	strong wind storm caused $167,000 in damage for all four counties; storm also impacted counties in Regions 3 and 1 for a total storm damage of $575,000
May 2007	Clackamas County	windstorm brought wind gusts up to 50 mph and produced extensive hail, causing $5000 in damages
July 2007	Multnomah and Washington Counties	heavy windstorm with 58-mph winds downed several trees, caused $5000 in damage/$1000 in damage in Beaverton
Sep. 2007	Multnomah County	severe storm that produced hail and a tornado, caused $5000 in damages
June 2008	Clackamas County	severe storms produced heavy winds and hail near the Cascades, caused $5000 in damages
Mar. 2009	Columbia County	72-mph winds caused $20,000 in property damage
Nov. 2012	Lincoln County	97-mph winds at Newport cost $1 million in property damage

Sources: Taylor and Hatton (1999; and FEMA-1405-DR-OR: February 7, 2002, Hazard Mitigation Team Survey Report, Severe Windstorm in Western Oregon; Hazards and 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, Database http://www.ncdc.noaa.gov/stormevents/

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the probability that Region 2 will experience windstorms is shown in **Table 2-171**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-171. Local Probability Assessment of Windstorms in Region 2

	Columbia	Clackamas	Multnomah	Washington
Probability	M	M	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

The 100-year storm in Region 2 is considered to be one-minute average winds of 80mph. A 50-year storm is 72 mph. And a 25-year storm is 65 mph in this region.

Vulnerability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the region's vulnerability to windstorms is shown in **Table 2-172**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-172. Local Vulnerability Assessment of Windstorms in Region 2

	Columbia	Clackamas	Multnomah	Washington
Vulnerability	H	L	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

Columbia, Multnomah, and Washington Counties are listed as most vulnerable to windstorms, as determined by the staff of the Oregon Public Utilities Commission and OCCRI.

Many buildings, utilities, and transportation systems within Region 2 are vulnerable to wind damage. This is especially true in open areas, such as natural grasslands or farmlands. 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. Structures most vulnerable to high winds include insufficiently anchored manufactured homes and older buildings in need of roof repair.

Fallen trees are especially troublesome. They can block roads and rails for long periods and affect emergency operations. In addition, uprooted or shattered trees can down power and other utility lines and effectively bring local economic activity and other essential facilities 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 to identify problem areas and establish a tree maintenance and removal program.

Additional considerations include ferry systems and bridges, which may be closed during high-wind periods.

Winter Storms

Characteristics

Winter storm events occur annually in Region 2, sometimes becoming severe. Severe winter weather in this region is characterized by extreme cold, snow, ice, and sleet. While most communities are prepared for severe winter weather, some are unprepared financially and otherwise. This is particularly true in the vicinity of Portland, where frigid air sometimes moves westward through the Columbia River Gorge. During these periods, it is not unusual for northern Willamette Valley communities to receive snow or ice storms known as “silver thaws.” Severe weather conditions do not last long in Region 2. Consequently, winter preparedness is a moderate priority.

Historic Winter Storms

Table 2-173. Historic Winter Storms in Region 2

Date	Location	Description
Dec. 1861	statewide	snowfall 1-3 ft; snow in Willamette Valley until late Feb.
1862, 1866, 1884, 1885, 1890, 1892, 1895	Portland area / Northern Willamette Valley	severe winter conditions, especially in the Portland area; record-breaking snowfalls
Jan. 1916	statewide	two snow storms, each totaling 5 inches or more
Dec. 1919	Portland area	third heaviest snowfall on record; Columbia River froze, closing navigation
1927, 1936, 1937, 1943, 1949	Portland area, Western Oregon	heavy snowfalls recorded
Jan. 1950	statewide	heaviest snowfall since 1890; many highway closures; considerable property damage
1956, 1960, 1962	western Oregon	packed snow became ice; automobile accidents throughout the region
Mar. 1960	statewide	snowfall: 3-12 inches, depending on location
Jan. 1969	statewide	record-breaking snowfalls; $3 to $4 million in property damage
Jan. 1980	statewide	a series of storms bringing snow, ice, wind, and freezing rain; six fatalities
Feb. 1985	statewide	western valleys received between 2-4 inches of snow; massive power failures (tree limbs broke power lines)
Dec. 1985	Willamette Valley	heavy snowfall throughout valley
Mar. 1988	statewide	strong winds and heavy snow
Feb. 1989	statewide	heavy snowfall and record low temperatures
Feb. 1990	statewide	average snowfall from one storm about 4 inches (Willamette Valley)
Dec. 1992	western Oregon	heavy snow; interstate highway closed
Feb. 1993	western Oregon	record snowfalls
Winter 1998-1999	statewide	series of storms; one of the snowiest winters in Oregon history
Dec. 2007	Columbia County	resulted in Presidential Disaster Declaration; $180 million in damage in the state; severe flooding in Vernonia; power outages for several days; five fatalities
Dec. 2008	Columbia County	snow and freezing rain in the Portland Metro area; $300,000 in property damage
Dec. 2009	statewide	snow and freezing rain in Salem, and Portland to Hood River; I-84 closed for 22 hours
Nov. 2010	statewide	snow, freezing rain, and ice accumulation in Portland to Hood River
Jan. 2012	Multnomah County	snow and ice east of Troutdale; I- 84 closed for 9 hours

Source: Taylor and Hatton (1999)

Probability and Vulnerability

As stated in the State Risk Assessment, **Section 2.2.2.4, Local and State Vulnerability Assessment Comparison**, different methods are used to assess risk at local and state levels. All methods employ history, probability, and vulnerability data to determine probability and vulnerability scores for each hazard. These scores identify high-priority areas to which local and state governments can target mitigation actions. The challenge with these varied methodologies is that access to, interpretation of, and scale of the data are not necessarily the same at local and state levels. As a result, local and state probability and vulnerability scores for a specific

hazard in a specific community are not always the same. In some instances, probability and vulnerability scores are even quite different. The state recognizes these inconsistencies and has prioritized the analysis of local and state probability and vulnerability scores during the next plan update. A description of how the High (H), Moderate (M), and Low (L) scores in the local probability and vulnerability tables in this section were determined is provided in the State Risk Assessment **Section 2.2.2.2, Local Vulnerability Assessments**. The complete "OEM Hazard Analysis Methodology" is located in **Appendix 9.1.16**.

Probability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the probability that Region 2 will experience winter storms is shown in **Table 2-174**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-174. Local Probability Assessment of Winters Storms in Region 2

	Columbia	Clackamas	Multnomah	Washington
Probability	H	H	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

Winter storms occur annually in Region 2. On the basis of historical data, severe winter storms could occur about every 4 years in this region. We can expect to have continued annual storm events in this region. However, there are no solid statistical data available upon which to base these judgments. There is no statewide program to study the past, present, and potential impacts of winter storms in the state of Oregon at this time.

Vulnerability

Local Assessment

Based on an analysis of risk conducted by county emergency program managers, the region's vulnerability to winter storms is shown in **Table 2-175**. See the **State Risk Assessment** for background information on the OEM Hazard Analysis and scoring methodology.

Table 2-175. Local Vulnerability Assessment of Winter Storms in Region 2

	Columbia	Clackamas	Multnomah	Washington
Vulnerability	H	M	H	H

Source: Oregon Office of Emergency Management, 2013 County Hazard Analysis Scores

State Assessment

Due to the large population and large truck commodity transport through this region, it is extremely costly when the roads are closed due to severe winter storms.