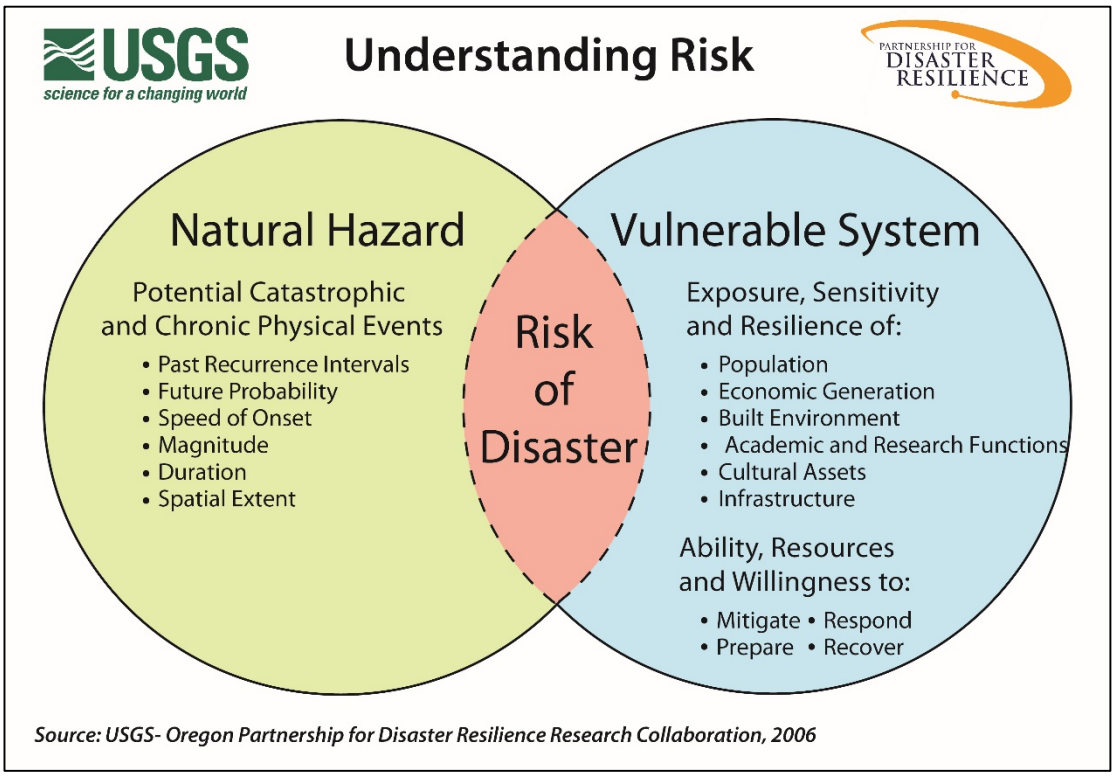
SECTION 2:
RISK ASSESSMENT

This section of the NHMP addresses 44 CFR 201.6(b)(2) - Risk Assessment. The Risk Assessment applies to Polk County and the Cities of Dallas, Falls City, Independence, and Monmouth. City specific information is called out where relevant. In addition, this chapter can assist with addressing Oregon Statewide Planning Goal 7 – Areas Subject to Natural Hazards.

The information presented below, along with hazard specific information presented in the Hazard Annexes and community characteristics presented in the Community Profile Appendix, is used to inform the risk reduction actions identified in Section 3 – Mitigation Strategy. The risk assessment process is graphically depicted in Figure 2-1 below. Ultimately, the goal of hazard mitigation is to reduce the area where hazards and vulnerable systems overlap.

Figure 2-1 Understanding Risk



Source: Oregon Partnership for Disaster Resilience.

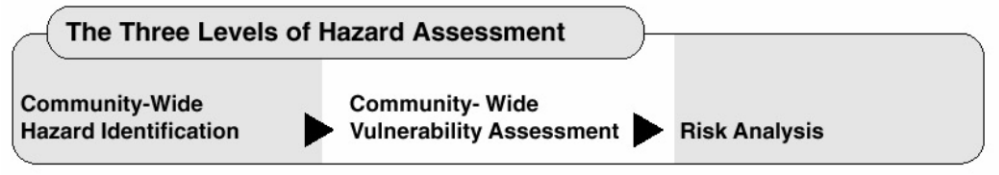
What is a Risk Assessment?

A risk assessment consists of three phases: hazard identification, vulnerability assessment, and risk analysis.

- **Phase 1:** Identify hazards that can impact the jurisdiction. This includes an evaluation of potential hazard impacts – type, location, extent, etc.
- **Phase 2:** Identify important community assets and system vulnerabilities. Example vulnerabilities include people, businesses, homes, roads, historic places and drinking water sources.
- **Phase 3:** Evaluate the extent to which the identified hazards overlap with, or have an impact on, the important assets identified by the community.

The following figure illustrates the three-phase risk assessment process:

Figure 2-2 Three Phases of a Risk Assessment



Source: Planning for Natural Hazards: Oregon Technical Resource Guide, 1998

This three-phase approach to developing a risk assessment should be conducted sequentially because each phase builds upon data from prior phases. However, gathering data for a risk assessment need not occur sequentially.

Hazard Identification

Polk County identifies eight natural hazards that could have an impact on the county and each of the participating jurisdictions. Summary information for each hazard is presented below; additional information pertaining to the types and characteristics of each hazard is available in the State of Oregon Natural Hazards Mitigation Plan Region 3 (Mid/ Southern Willamette Valley), Risk Assessment. Table 2-1 lists the hazards identified in the county in comparison to the hazards identified in the State of Oregon NHMP for Region 3, which includes Polk County.

The previous Polk County NHMP profiled riverine erosion and expansive soils as unique hazards. This update of the NHMP aligns each jurisdiction's hazard profiles with the hazards profiled in the State NHMP. Therefore, the riverine erosion hazard is profiled as a characteristic of the flood hazard and the expansive soils hazard is profiled as a characteristic of the flood and drought hazards. Additionally, the drought hazard was profiled as a characteristic of winter storm hazard in the previous NHMP, with this update the drought hazard receives a unique hazard profile.

Table 2-1 Polk County Hazard Identification

Polk County	State of Oregon NHMP Region 3: Mid/ Southern Willamette Valley
Drought	Drought
Earthquake	Earthquake
Flood	Flood
Landslide	Landslide
Volcano	Volcano
Wildfire	Wildfire
Windstorm	Windstorm
Winter Storm	Winter Storm

Source: Polk County NHMP Steering Committee (2016) and
State of Oregon NHMP, Region 3: Mid/ Southern Willamette Valley (2015)

The following subsections briefly describe relevant information for each hazard. For additional background on the hazards, vulnerabilities and general risk assessment information for hazards in the Mid/ Southern Willamette Valley (Region 3) refer to the State of Oregon NHMP, Region 3: Mid/ Southern Willamette Valley Risk Assessment (2015).

Drought

Significant Changes Since Previous Plan:

The Drought hazard was not profiled in the 2009 Plan as a unique hazard (it was previously incorporated within the Winter Storm hazard profile), therefore, this section provides a reorganization and new content. A description of expansive soils is included in this profile.

Characteristics

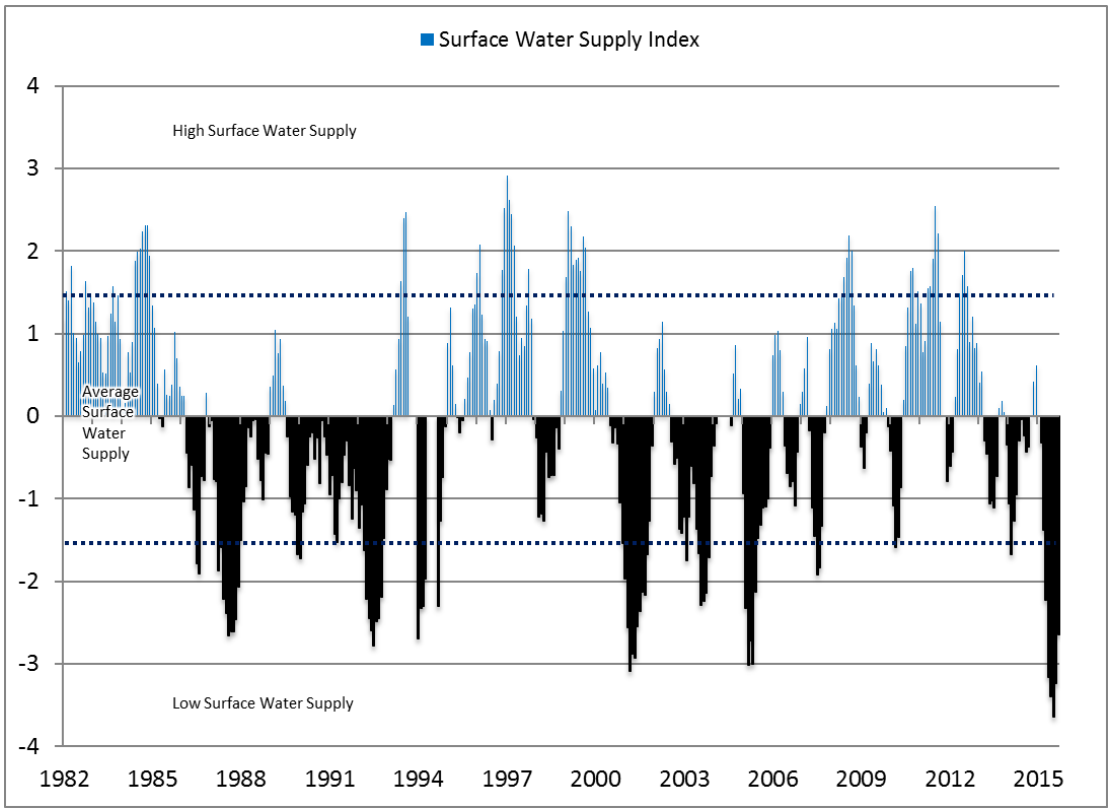
A drought is a period of drier than normal conditions. Drought occurs in virtually every climatic zone, but its characteristics vary significantly from one region to another. Drought is a temporary condition; it differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate. The extent of drought events depends upon the degree of moisture deficiency, and the duration and size of the affected area. Typically, droughts occur as regional events and often affect more than one city and county.

Location and Extent

Droughts occur in every climate zone, and can vary from region to region. Drought may occur throughout Polk County and may have profound effects on the economy, particularly the agricultural and hydro-power sectors. Drought is typically measured in terms of water availability in a defined geographical area. It is common to express drought with a numerical index that ranks severity. Most federal agencies use the Palmer Method which incorporates precipitation, runoff, evaporation and soil moisture. However, the Palmer Method does not incorporate snowpack as a variable. Therefore, it is not believed to provide a very accurate indication of drought conditions in Oregon and the Pacific Northwest.

The Surface Water Supply Index (SWSI) from the Natural Resources Conservation Service is an index of current water conditions throughout the state. The index utilizes parameters derived from snow, precipitation, reservoir and stream flow data. The data is gathered each month from key stations in each basin. The lowest SWSI value, -4.2, indicates extreme drought conditions (Low Surface Water Supply ranges from -1.6 to -4.2). The highest SWSI value, +4.2, indicates extreme wet conditions (High Surface Water Supply ranges from +1.6 to +4.2). The mid-point is 0.0, which indicates an average water supply (Average Water Supply ranges from +1.5 to -1.5). Figure 2-3 below shows the monthly history of SWSI values from February 1982 to October 2015 for the Willamette Basin which includes Polk County. Research shows that the periods of drought have fluctuated; recent drought periods occurred in 1987, 1992, 1994, 2001, 2003, 2005, and 2015.

Figure 2-3 SWSI Values for the Willamette Basin (1982-2015)



Source: Department of Agriculture-Natural Resources Conservation Service, "Surface Water Supply Index, Upper Deschutes Basin" www.or.nrcs.usda.gov. Accessed February 2016.

History

Drought conditions are not uncommon in Polk County. One recent drought event, and one previously omitted drought event, have been added to the hazard history since the previous plan (as shown in *italics* below):

- 1904-1905: A statewide drought period of about 18 months
- 1917-1931: A very dry period throughout Oregon, punctuated by brief wet spells in 1920-21 and 1927
- 1928-1941: Statewide prolonged drought caused major agricultural problems.
- 1939-1941: A three-year intense drought in Oregon
- 1976-1981: Intense drought in western Oregon; 1976-1977 single driest year of century (eclipsed only by 2015 water-year). During this period Polk County used dry ice seeding to enhance winter precipitation for agriculture use.
- 1985- 1994: Ten consecutive years of drought cause problems statewide; fires were common and insects attacked trees; a drought emergency was declared in 1992. As a result, Polk County adopted a water curtailment plan. Crop damage was documented and water systems were affected. However, no Polk County residents submitted claims for losses. Governor declared drought.
- 2000-2001: Severe drought conditions; October 2000 to February 2001 was the second driest period of record in Washington and Oregon.

- 2005: February 2005 was the driest since 1977.
- *August 2015: Federal Drought Declaration due low snow pack levels, and low water conditions. Governor and federal declarations of drought.*

El Niño

El Niño Southern Oscillation (ENSO) weather patterns can increase the frequency and severity of drought. During El Niño periods, alterations in atmospheric pressure in equatorial regions yield an increase in the surface temperature off the west coast of North America. This gradual warming sets off a chain reaction affecting major air and water currents throughout the Pacific Ocean; La Niña periods are the reverse with sustained cooling of these same areas. In the North Pacific, the Jet Stream is pushed north, carrying moisture laden air up and away from its normal landfall along the Pacific Northwest coast. In Oregon, this shift results in reduced precipitation and warmer temperatures, normally experienced several months after the initial onset of the El Niño. These periods tend to last nine to twelve months, after which surface temperatures begin to trend back towards the long-term average. El Niño periods tend to develop between March and June, and peak from December to April. ENSO generally follows a two to seven-year cycle, with El Niño or La Niña periods occurring every three to five years. However, the cycle is highly irregular, and no set pattern exists. The last major El Niño was during 1997-1998, and in 2015-2016 Oregon experience a "super" El Niño (the strongest in 15 years, the two previous events occurred in 1982-1983 and 1997-1998) that included record rainfall and snowpack in areas of the state.[1]

Future Climate Variability[2]

Climate models for Oregon suggest, future regional climate changes include increases in temperature around 0.2-1°F per decade in the 21st Century, along with warmer and drier summers, and some evidence that extreme precipitation will increase in the future. Increased droughts may occur in the Willamette Valley under various climate change scenarios as a result of various factors, including reduced snowpack, rising temperatures, and likely reductions in summer precipitation. Climate models suggest that as the region warms, winter snow precipitation will likely shift to higher elevations and snowpack will be diminished as more precipitation falls as rain altering surface flows.

Expansive Soils

The addition of moisture to any type of soil will cause a change in volume, which is referred to as a shrink-swell characteristic.[3] Expansive soils are typically comprised of clay minerals that under some conditions are capable of significantly increasing in volume when moisture is added. Clay soils consist of mineral particles that are less than 0.002 millimeters in diameter.

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[1] Cho, Renne. "El Nino and global warming – what's the connection." Phys.org, February 3, 2016. https://phys.org/news/2016-02-el-nino-global-warmingwhat.html

[2] Oregon Climate Change Research Institute (OCCRI), Oregon Climate Assessment Report (2010) and Northwest Climate Assessment Report (2013). http://occri.net/reports

[3] US Department of Agriculture, Natural Resources Conservation Service (USDA NRCS). 2008. National Cooperative Soil Survey, Physical Soil Properties–Polk County, Oregon.

Linear extensibility is used to determine the shrink-swell potential of soils. Linear extensibility refers to the change in soil volume as the moisture content is decreased from a moist to a dry state. The amount and type of clay minerals in the soil influence volume change. The volume change is described as a percentage value change for the soil being tested. A low shrink-swell potential is considered less than a 3% change in soil volume; whereas a high shrink- swell potential is greater than 6% change in soil volume.[4]

Soil expansion may be caused by changes in soil moisture, variations in thickness and composition of the expansive foundation soil, non-uniform structural loads, and the geometry of the structure. Potential sources of moisture changes are variation in precipitation, poor gutter or water drainage, vegetation changes over time (such as root growth of nearby trees), and plumbing leaks. By affecting the relative moisture of soils underlying foundations, uneven movement such as localized heave can occur, causing shifting and non- uniform foundation movements, thus impacting the structures above.

Many sources of soil moisture change can be avoided, minimized, or mitigated through planning and structure maintenance. Some signs of possible soil expansion include: separation of joints and trim; cracks in walls, floors, or concrete; and bowed or non-vertical walls. Some possible mitigation measures are maintaining separation between structures and runoff, using compact fill to shed water, not absorb it, and planting trees a distance equal to their mature height away from buildings to reduce root interference.

Several different types of soil expansion related to structures and infrastructure exist, which can include but are not limited to:

- Doming heave - upward, long-term, dome-shaped foundation movement that develops over many years
- Cyclic heave - shrink and swell associated with seasonal or water leak events
- Edge heave - damaging edge or dish-shaped heaving
- Lateral movement – lateral thrust of expansive soils

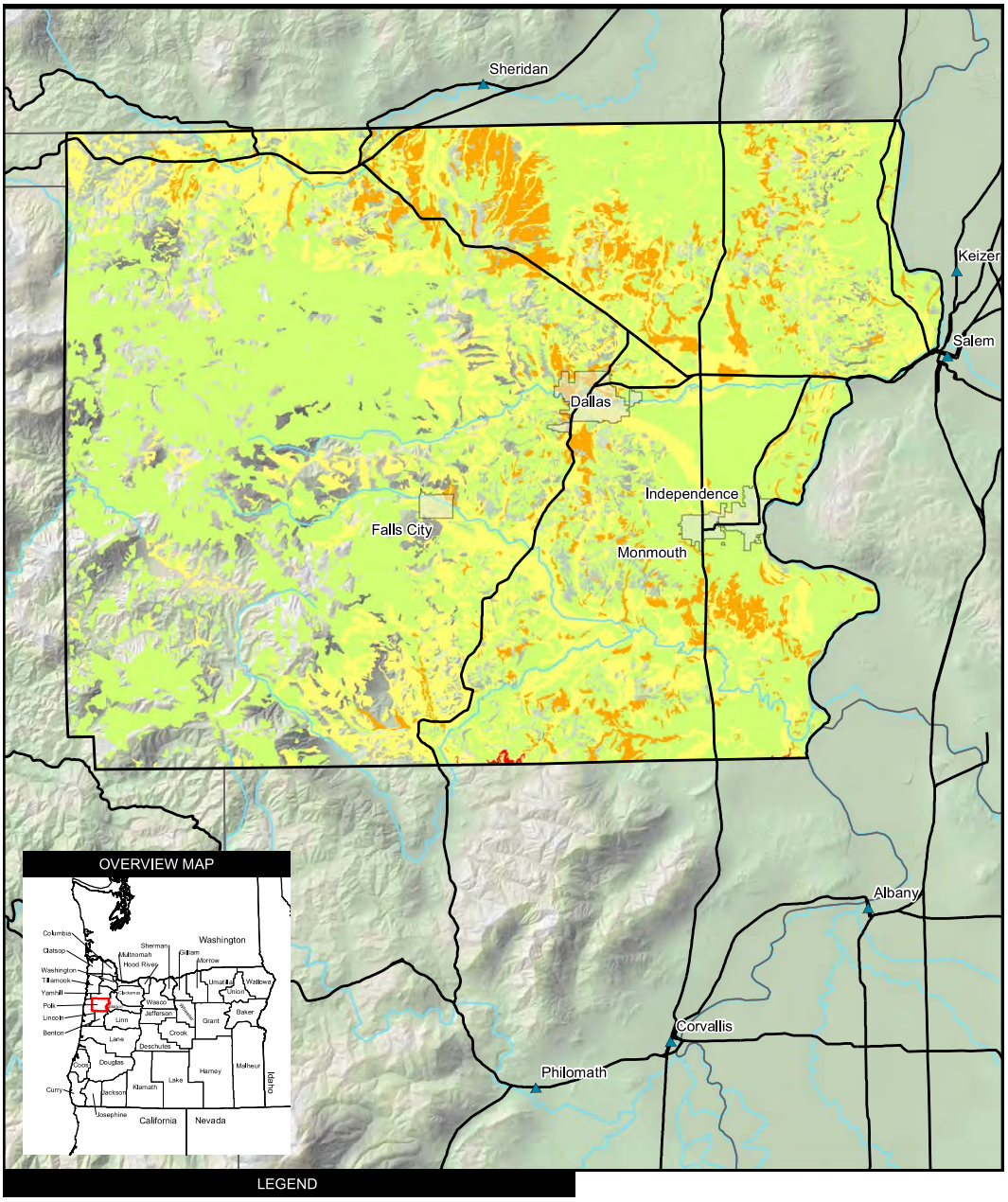
More than 162,000 acres in Polk County contain soils with “moderate” to “severe” shrink-swell potential. These areas are primarily located in the northern and eastern parts of the county. The City of Dallas has large areas of moderate to severe shrink-swell potential.

The geographic extent of expansive soil events are directly dependent on the extent of clay-based expansive soil types and the size and type of moisture event that triggers the soil expansion.

Another dependent factor contributing to risk is the amount and type of infrastructure that exists at the expansive soil location and near proximity, as well as the percentage volume change of the swelling or shrinking soil. The vulnerability of critical infrastructure could be assessed by the location of expansive soil types. The extent of expansive soil effects could be very local and limited to a single structure (i.e. resulting from a plumbing leak), or more landscape in nature due to a large area of soil moisture change (i.e. resulting from a large flood or storm event).

[4] Ibid.

Map 2-1 Expansive Soils Hazard Area



Source: Polk County NHMP (2009).

Probability Assessment

Droughts are not uncommon in the State of Oregon, nor are they just an "east of the mountains" phenomenon. They occur in all parts of the state, in both summer and winter. Oregon's drought history reveals many short-term and a few long-term events. The average recurrence interval for severe droughts in Oregon is somewhere between 8 and 12 years. Based on the available data and research for Polk County the NHMP Steering Committee assessed the **probability of experiencing a locally severe drought as "moderate,"** meaning one incident is likely within the next 75-year period.

Expansive soil events are difficult to predict since the location and time when water is available to the soil varies throughout the lifespan of a structure. Most soil expansion and associated structural damage has been shown to occur within five to eight years following construction. However, the effects of heave may also not be observed for many years until some change occurs in the foundation conditions to disrupt the moisture regime. The probability of damages increases for structures on expansive soils when the climate (increased rain), structure construction (type of foundation used), or occupancy habits (e.g., gardening, water diversion, etc.), increases the amount of moisture in the soil.

Vulnerability Assessment

Drought is commonly referenced in terms of its effects on agriculture, with crop damage or failure used to measure its effects. Other direct environmental effects of drought include livestock death or decreased production, wildland fire, impaired productivity of forest land, damage to fish habitat, loss of wetlands, and decreased air quality. Drought is also associated with insect infestation, disease, and wind erosion. Indirect effects to society are measured by the economic and physical hardships brought on by drought and by the increased stress on residents of a drought-stricken area. The economic impact of drought is estimated between $6 and $8 billion annually in the United States. These costs primarily affect agricultural, forestry, fisheries, recreation and tourism, transportation and energy sectors.

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

All parts of Polk County are susceptible to drought, however, the following areas and issues are of particular concern:

- Agriculture
- Drinking water system
- Power and water enterprises
- Residential and community wells in rural areas
- Fire response capabilities
- Fish and wildlife

Potential impacts to community water supplies and farming are the greatest threats. Additionally, long-term drought periods of more than a year can impact forest conditions

and set the stage for potentially destructive wildfires. The NHMP Steering Committee rated the county as having **a "moderate" vulnerability to drought hazards**, meaning that between 1-10% of the region's population or assets would be affected by a major drought emergency or disaster.

Potential damages to structures from expansive soils in Polk County include: cracks in grade beams, walls, and drilled shafts; distortion and cracking of pavements and on-grade floor slabs; failure of steel or concrete blocks supporting grade beams; jammed or misaligned doors and windows; and buckling of basement and retaining walls due to lateral forces. Extensive damage can potentially result in the condemnation of structures.

Per the previous version of this plan the County has critical facilities and infrastructure located within areas of low, moderate and high risk; see Map 2-1.

Low risk areas contain 19,057 residential structures (value $2.7B) and 67 non- residential structures (value unknown).

Moderate risk areas contain 15,578 residential structures (value $2.2B), 73 non-residential structures (value unknown), 11 government facilities (value $3.1M), four emergency response facilities (value $6.3M), nine educational facilities (value $9.1M), six care facilities (value unknown), and five utilities (value unknown).

High risk areas contain 8,774 residential structures (value 1.3B), 32 non-residential structures (value unknown), five government facilities (value unknown), four educational facilities (value $18.3M), one utility facility (value unknown) and one dam (value $25M).

Very high expansive soils areas contain 37 residential structures (worth $5.3M). [5]

A comprehensive risk and vulnerability assessment is not available for the drought hazard. Statewide droughts have historically occurred in Oregon, and as it is a region-wide phenomenon, all residents are equally at risk. Structural damage from drought is not expected; rather the risks are present to humans and resources. Agriculture, fishing, and timber have historically been impacted, as well as local and regional economies.

In Polk County, there are several roads that show signs of pavement heaving due to underlying expansive soils: James Howe Road, Crowley Road, Perrydale Road, and Grand Ronde Road appear to be underlain with expansive soils. At the north end of Perrydale road, there are obvious horizontal cracks indicative of pavement heaving.

More information on this hazard can be found in the Risk Assessment for Region 3, Mid-Willamette Valley, of the Oregon NHMP (2015).

[5] URS, 2009 Polk County Natural Hazards Mitigation Plan; values are in 2009 dollars.

Earthquake

Significant Changes Since Previous Plan:

The Earthquake Hazard section was reformatted since the 2009 Plan. There has not been any new history. However, the Oregon Resilience Plan (2013) has been cited and incorporated where applicable. The probability and vulnerability ratings were updated to distinguish between a Cascadia Subduction Zone event and a crustal event. Large areas of Polk County fall within two of the zones identified in the Oregon Resilience Plan as having significantly different probabilities and vulnerabilities in a Cascadia Subduction Zone event (Coastal and Valley regions). These differences have been incorporated throughout this section.

Characteristics

The Pacific Northwest in general is susceptible to earthquakes from four sources: 1) the offshore Cascadia Subduction Zone; 2) deep intraplate events within the subducting Juan de Fuca Plate; 3) shallow crustal events within the North American Plate, and 4) earthquakes associated with volcanic activity.

All types of earthquakes in the region have some tie to the subducting, or diving, of the dense, oceanic Juan de Fuca Plate under the lighter continental North American Plate. There is also a link between the subducting plate and the formation of volcanoes some distance inland from the offshore subduction zone.

Location and Extent

Polk County is located within the geographical area bordering the Cascadia Subduction Zone. This zone is comprised of an 800-mile sloping fault and several smaller inland and offshore faults extending from British Columbia to the north and Northern California to the south. The fault system separates the Juan de Fuca and North American plates.

The USGS Quaternary Fault and Fold Databases contain two inland fault databases covering Polk County; the Salem and Vancouver 1° x 2° Sheets. The Salem Sheet (44°- 45° by 124° - 122°) delineates nine (9) faults and the Vancouver Sheet (45°-46° by 124°-122°) delineates 15 faults. Those closest to Polk County are the Mount Angel Fault, the Canby-Molalla, and Newberg faults.

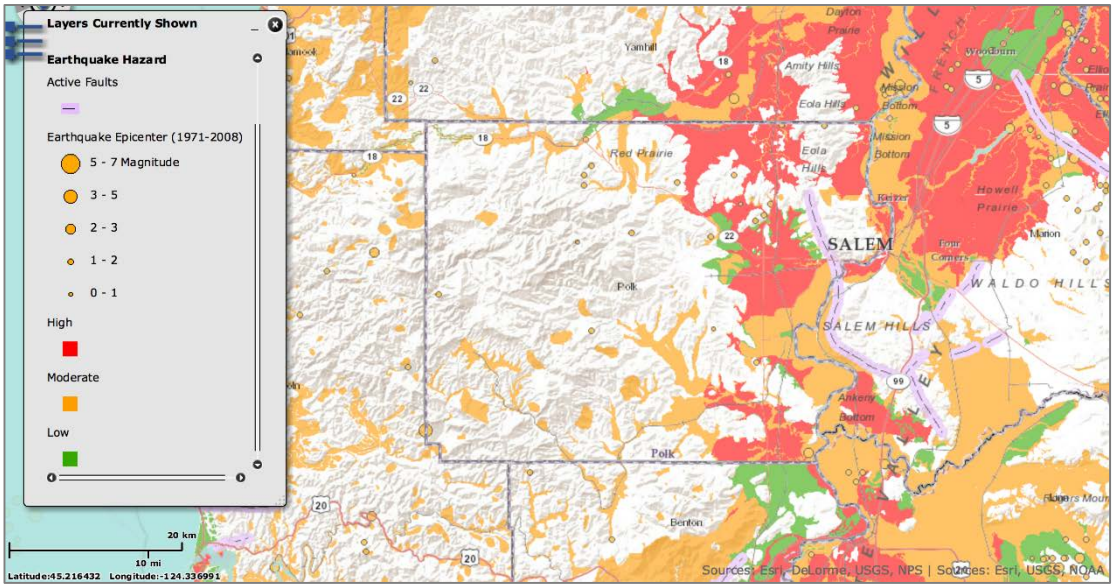
There have been several significant recent earthquakes in the region; however, all significant events have been located in Klamath and Lake Counties in southern Oregon. The region has also been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside Central Oregon. All considered, there is good reason to believe that the most devastating future earthquakes would probably originate along shallow crustal faults in the region, or along the offshore Cascadia Subduction Zone (see publications listed below for more information).

Hazard Shake Maps produced by the United States Geological Survey (USGS) consider two alternative scenarios for damaging earthquakes (M 8.3 or M 9.0) along the subduction zone.

The shake maps show the ground motion level that has 1 chance in 475 of being exceeded each year, which is equal to a 10 percent probability of being exceeded in 50 years. Polk County falls within the strong to very strong shaking range (15-25 percent of acceleration of gravity). All of Polk County is subject to earthquakes. However, the western portion of Polk County is more likely to be affected by a major quake, because of its closer proximity to the Cascadia Subduction Zone.

Figure 2-4 shows earthquake epicenters, active faults, and soft soils of Polk County. The earthquakes shown in the figure below are relatively insignificant events below M 2.0. The larger events may have been felt slightly, but little to no structural/property damage resulted. Thus, the seismic hazard for Polk County arises predominantly from major earthquakes on the Cascadia Subduction Zone. Smaller, crustal earthquakes in or near Polk County could be locally damaging, but would not be expected to produce widespread or major damage.

Figure 2-4 Earthquake Epicenters (1971-2008), Active Faults, and Soft Soils



Source: [Oregon HazVu: Statewide Geohazards Viewer (HazVu)]

The Oregon Department of Geology and Mineral Industries (DOGAMI), in partnership with other state and federal agencies, has undertaken a rigorous program in Oregon to identify seismic hazards, including active fault identification, bedrock shaking, tsunami inundation zones, ground motion amplification, liquefaction, and earthquake induced landslides. DOGAMI has published a number of seismic hazard maps that are available for communities to use. The maps show liquefaction, ground motion amplification, landslide susceptibility, and relative earthquake hazards. OPDR used the DOGAMI Statewide Geohazards Viewer to present a visual map of recent earthquake activity, active faults, and liquefaction; ground shaking is generally expected to be higher in the areas marked by soft soils in the map above. The severity of an earthquake is dependent upon a number of factors including: 1) the distance from the earthquake's source (or epicenter); 2) the ability of the soil and rock to conduct the earthquake's seismic energy; 3) the degree (i.e., angle) of slope materials; 4) the composition of slope materials; 5) the magnitude of the earthquake; and 6) the type of earthquake.

For more information, see the following reports:

Open-File-Report: O-2003-02 – Map of Selected earthquakes for Oregon (1841-2002), 2003

Open-File-Report: O-2007-02 - Statewide seismic needs assessment: Implementation of Oregon 2005 Senate Bill 2 relating to public safety, earthquakes, and seismic rehabilitation of public buildings, 2007

Interpretive Map Series: IMS-024 - Geologic hazards, earthquake and landslide hazard maps, and future earthquake damage estimates for six counties in the Mid/Southern Willamette Valley including Yamhill, Marion, Polk, Benton, Linn, and Lane Counties, and the City of Albany, Oregon, 2008

Open-File-Report: O-2013-22 - Cascadia Subduction Zone earthquakes: A magnitude 9.0 earthquake scenario, 2013

Special Papers: SP-29, Earthquake damage in Oregon Preliminary estimates of future earthquake losses (1999)

Additional reports are available via DOGAMI's Publications Search website: http://www.oregongeology.org/pubs/search.php

Oregon Seismic Safety Policy Advisory Commission Reports:

Oregon Resilience Plan (2013)

History

Polk County has not experienced any major earthquake events in recent history. Seismic events do, however, pose a significant threat. In particular, a Cascadia Subduction Zone (CSZ) event could produce catastrophic damage and loss of life in Polk County. For more information see Figure 2-4 and Map 2-4.

While Polk County has not experienced any significant earthquakes in recent history, earthquakes in Oregon that have affected the county are listed below[6] (there have not been any significant earthquake events since the previous plan):

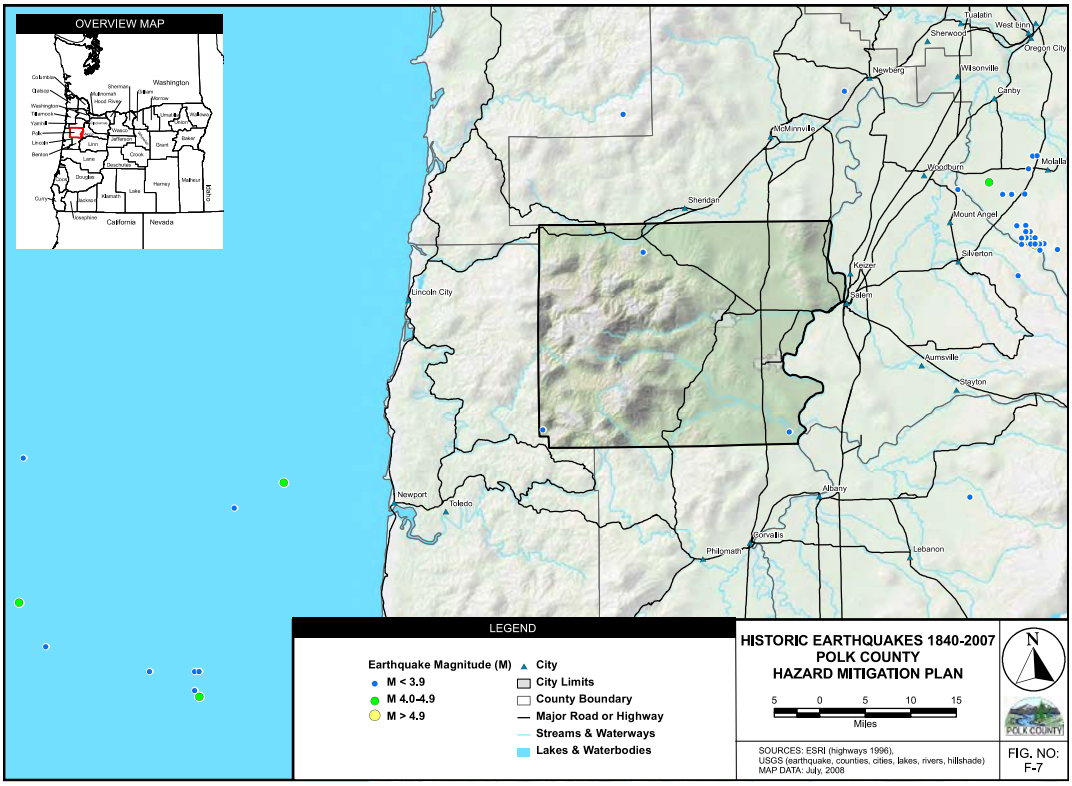
- January 1700: Offshore, Cascadia Subduction Zone (CSZ)- Approximate 9.0 magnitude earthquake generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast (additional CSZ events occurred approximately in 1400 BCE, 1050 BCE, 600 BCE, 400, 750, and 900)
- April 1949: Olympia, 7.1 magnitude, felt in Polk County.
- April 1961: Albany, 4.5 magnitude, minor damage in Albany
- November 1962: Portland- A 5.2-5.5 magnitude earthquake caused damage to many homes (chimneys, windows, etc); the earthquake was a crustal event
- March 1963: Salem, 4.6 magnitude, minor damage in Salem

[6] Ivan Wong and Jacqueline D.J. Bolt, 1995, "A Look Back at Oregon's Earthquake History, 1841-1994", Oregon Geology, pp. 125-139.

The Pacific Northwest Seismic Network: Notable Pacific Northwest Earthquakes since 1993

- March 1993: Scotts Mills- A 5.6 magnitude earthquake caused $27-$30 million in damages to homes, schools, businesses, state buildings (Salem). Crustal Event (FEMA-985-DR-OR)

Map 2-2 Earthquake History



Source: Polk County NHMP (2009).

Probability Assessment

Polk County is susceptible to deep intraplate events within the Cascadia Subduction Zone (CSZ), where the Juan de Fuca Plate is converging beneath the North American Plate, and shallow crustal events within the North American Plate.

Based on the available data and research (see below) for Polk County the NHMP Steering Committee determined the **probability of experiencing a Cascadia Subduction Zone (CSZ) or a crustal earthquake is "moderate",** meaning one incident could be expected within the next 75-year period.

Cascadia Subduction Zone

According to the Oregon NHMP, the return period for the largest of the CSZ earthquakes (Magnitude 9.0+) is 530 years with the last CSZ event occurring 314 years ago in January of 1700. The probability of a 9.0+ CSZ event occurring in the next 50 years ranges from 7 - 12%. Notably, 10 - 20 "smaller" Magnitude 8.3 - 8.5 earthquakes occurred over the past 10,000 years that primarily affected the southern half of Oregon and northern California. The average return period for these events is roughly 240 years. The combined probability of any CSZ earthquake occurring in the next 50 years is 37 - 43%.

New research from Oregon State University suggests that the CSZ has at least four segments that sometimes rupture independently of one another. Magnitude-9 ruptures affecting the entire subduction zone have occurred 19 times in the past 10,000 years. Over that time, shorter segments have ruptured farther south in Oregon and Northern California, producing magnitude-8 quakes. As such, the risks of a subduction zone quake may differ from north to south. Quakes originating in the northern portion of the CSZ tend to rupture the full length of the subduction zone. In southern Oregon and Northern California, quakes along the subduction zone appear to strike more frequently.

Benioff (Deep) Zone

Deep intraplate earthquakes may have magnitudes up to 7.5, with probable recurrence intervals of about 500 to 100 years (recurrence intervals are poorly determined by current geologic data).

Crustal Zone

Establishing a probability for crustal earthquakes is difficult given the small number of historic events in the region. Based on the historical seismicity in Western Oregon and on analogies to other geologically similar areas, small to moderate earthquakes up to M5 or M5.5 are possible almost anywhere in Western Oregon, including Polk County. Although the possibility of larger crustal earthquakes in the M6+ range cannot be ruled out, the probability of such events is likely to be very low. Earthquakes generated by volcanic activity in Oregon's Cascade Range are possible, but likewise unpredictable. For more information, see DOGAMI reports linked above.

Vulnerability Assessment

The local faults, the county's proximity to the Cascadia Subduction Zone, potential slope instability, and the prevalence of certain soils subject to liquefaction and amplification combine give the county a high-risk profile. Due to the expected pattern of damage resulting from a CSZ event, the Oregon Resilience Plan divides the State into four distinct zones and places Polk County predominately within the "Willamette Valley Zone" (Valley Zone, from the summit of the Coast Range to the summit of the Cascades), however, portions of the county are within the "Coastal Zone" (the area outside of the tsunami zone, from the Oregon coastline to the summit of the Coast Range)[7]. Within the Valley Zone damage and shaking is expected to be widespread but moderate, an event may be disruptive to daily life and commerce, and the main priority is expected to be restoring services to business and residents.[8] Within the Coastal Zone, damage and shaking is expected to be severe and communities may be isolated, the main priority after an event would be to keep the population sheltered, fed, and healthy.[9]

Figure 2-5 below shows the expected shaking/ damage potential for Polk County as a result of a Cascadia Subduction Zone (CSZ) earthquake event. The figure shows that the county

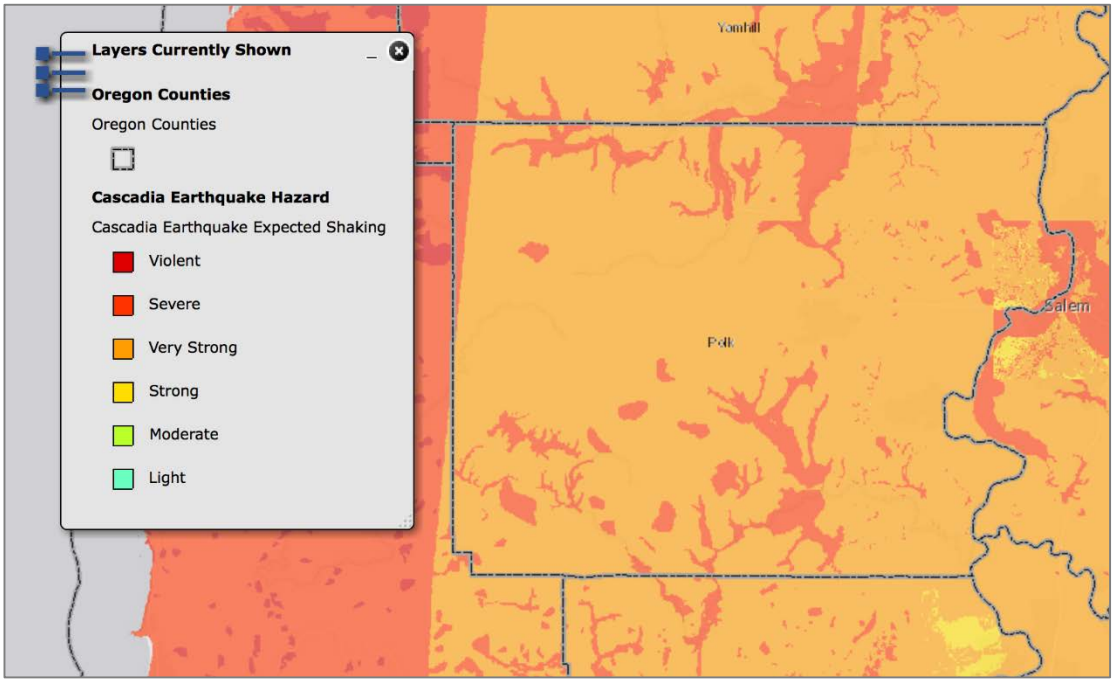
[7] Oregon Seismic Safety Policy Advisory Commission, *Oregon Resilience Plan* (2013)

[8] Ibid.

[9] Ibid.

may experience “very strong” to “severe shaking” that may last two to four minutes. The strong shaking may be extremely damaging to lifeline transportation routes including Highway 22 and Highway 99W. For more information on expected losses due to a CSZ event see the Oregon Resilience Plan.

Figure 2-5 Cascadia Subduction Zone Expected Shaking



Source: Oregon HazVu: Statewide Geohazards Viewer (HazVu)

A comprehensive risk and vulnerability assessment is not available. As of the publication of this NHMP FEMA is providing an opportunity for the county and cities to participate in a Risk Mapping, Assessment, and Planning (Risk MAP) process that would generate additional data on risks and vulnerabilities. The Risk Report would provide a quantitative risk assessment that informs communities of their risks related to certain natural hazards (including earthquake). If pursued, once complete the county can incorporate the risk assessment into this plan to provide greater detail to sensitivity and exposure to the earthquake hazard.

According to the previous version of this plan Polk County has approximately 21,405 residential structures (worth $3.5B), 104 non-residential structures (value unknown), 18 government facilities (worth $5.9M), six emergency response facilities (worth $9.9M), 20 educational facilities (worth $45.8M), nine care facilities (value unknown), ten utilities (worth $1.5M) and one dam (worth $25M) which would be impacted by strong shaking events.

There are 171 residential structures (worth $24.5M) located in very strong shaking areas with no residential structures or critical facilities located in locations which could experience severe ground shaking.[10]

[10] URS, 2009 Polk County Natural Hazards Mitigation Plan; values are in 2009 dollars.

The NHMP Steering Committee rated the county as having a **"moderate" vulnerability to the Cascadia Subduction Zone (CSZ) earthquake or crustal earthquake hazards**, meaning that between 1-10% of the region's population or assets would be affected by a major crustal earthquake emergency or disaster. All of Polk County is subject to earthquakes, however, the western portion of the county is more susceptible to damages because of its proximity to the Cascadia Subduction Zone.

1999 Assessment

Factors included in an assessment of earthquake risk include population and property distribution in the hazard area, the frequency of earthquake events, landslide susceptibility, buildings, infrastructure, and disaster preparedness of the region. This type of analysis can generate estimates of the damages to the county due to an earthquake event in a specific location.

Seismic activity can cause great loss to businesses, either a large-scale corporation or a small retail shop. Losses not only result in rebuilding cost, but fragile inventory and equipment can be destroyed. When a company is forced to stop production for just a day, business loss can be tremendous. Residents, workers, businesses, and industry all suffer temporary loss of income when their source of finances is damaged or disrupted.

The potential losses from an earthquake in Polk County extend beyond those to human life, homes, property and the landscape. A recent earthquake damage model has not been conducted for Polk County, however, based upon data from a 1999 DOGAMI report rough loss estimates are available. The economic base in Polk County is estimated at $2.33 billion in 1999 dollars ($3.31 billion in 2016 dollars), ranking it 17 of 36 Oregon counties in 1999). It is expected that the county will incur total direct losses valuing $249 million in 1999 dollars ($354 million in 2016 dollars) for the Cascadia model and $529 million in 1999 dollars ($752 million in 2016 dollars) for the 500-year model. The CSZ event direct losses amount to a loss ratio of 6-percent, while the 500-year model event direct losses amount to a loss ratio of 14-percent.[11] Table 2-2(a) and (b) adjusts the economic loss estimates from DOGAMI's 1999 report to account for inflation and reflect potential economic loss in 2016 dollars.

While the expected losses have increased due to increased development and population in the county, as well as inflation, the loss ratio and relative damage for the county is expected to be similar. See table on the following page for more information on expected losses. Local business economies are at substantial risk if an earthquake damages or otherwise necessitates the closure of any of the major transportation routes.

For more information, see: Special Papers: SP-29, Earthquake damage in Oregon Preliminary estimates of future earthquake losses (1999)

[11] DOGAMI, Special Papers: SP-29, Earthquake Damage in Oregon Preliminary Estimates of Future Earthquake Losses (1999). The loss ratio is determined as a percentage of the expected losses to the county's economic base.

Table 2-2(a) Polk County Earthquake Damage Summary

Polk County	8.5 Cascadia Subduction Zone Event	500-year model
Injuries	124	266
Death	2	6
Displaced households	538	1,064
Short-term shelter needs	419	825
Economic losses for buildings	249 million ($354 million*)	$529 million ($752 million*)
Operational the day after the quake		
Fires Stations	55%	n/a
Police Stations	46%	n/a
Schools	45%	n/a
Bridges	72%	n/a
Economic losses to		
Highways	$28 million ($40 million*)	$72 million ($102 million*)
Airports	$6 million ($8.5 million*)	$13 million ($18.5 million*)
Communication Systems		
Economic losses	$688,000 ($978,000*)	$2 million ($2.8 million*)
Operating the day of the quake	55%	n/a
Debris generated *(thousands of tons)*	219	378

These figures have a high degree of uncertainty and should be used only for general planning purposes. Beause of rounding, numbers may not add up to 100%.

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

Source: Y. Wang & J.L. Clark, Special Paper 29, Earthquake Damage in Oregon: Preliminary Estimates of Future Earthquake Losses. 1999. DOGAMI.
Note: * - 1999 dollars were adjusted for inflation to represent estimated economic loss in 2016 dollars using the State of Oregon Employment Department Inflation Calculator.

Table 2-2(b) Polk County Earthquake Damage Summary

8.5 Cascadia event	Percentage of buildings in damage categories				
Building type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Agriculture	37	15	17	18	14
Commercial	19	12	26	25	18
Education	30	13	20	21	16
Government	18	11	25	27	20
Industrial	17	11	25	27	21
Residential	60	22	10	5	3

500 year model	Percentage of buildings in damage categories				
Building type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Agriculture	18	17	21	20	24
Commercial	9	9	24	28	31
Education	15	14	22	24	27
Government	8	8	22	28	34
Industrial	7	8	22	28	33
Residential	31	31	24	9	6

Source: Y. Wang & J.L. Clark, Special Paper 29, Earthquake Damage in Oregon: Preliminary Estimates of Future Earthquake Losses. 1999. DOGAMI.

2007 Rapid Visual Survey

In 2007, DOGAMI completed a rapid visual screening (RVS) of educational and emergency facilities in communities across Oregon, as directed by the Oregon Legislature in Senate Bill 2 (2005). RVS is a technique used by the Federal Emergency Management Agency (FEMA), known as FEMA 154, to identify, inventory, and rank buildings that are potentially vulnerable to seismic events. DOGAMI ranked each building surveyed with a 'low,' 'moderate,' 'high,' or 'very high' potential for collapse in the event of an earthquake. It is important to note that these rankings represent a probability of collapse based on limited observed and analytical data and are therefore approximate rankings. To fully assess a building's potential for collapse, a more detailed engineering study completed by a qualified professional is required, but the RVS study can help to prioritize which buildings to survey.

DOGAMI surveyed 23 buildings in Polk County (not including facilities located in Salem). Buildings with a 'high' or 'very high' potential for collapse are listed below. Additional information can be found within the RVS study on DOGAMI's website (www.oregongeology.org).

'Very High' Collapse Potential

- Dallas Police Department (Dallas)
- Henry Hill Elementary School (Independence)
- Independence Elementary School (Independence)

'High' Collapse Potential

- Dallas High School (Dallas)
- LaCreole Middle School (Dallas)
- Lyle Elementary School (Dallas)
- Whitworth Elementary School (Dallas)
- Dallas Academy (Dallas)
- Dallas Fire Station (Dallas)
- Willamina Middle School at Grand Ronde (Grand Ronde)
- Central High School (Independence)
- Henry Hill Elementary School (Independence)
- Talmadge Middle School (Independence)
- Independence Police Department (Independence)
- Polk County Fire District 1 (Independence)

Mitigation Successes

Seismic retrofit grant awards per the Seismic Rehabilitation Grant Program[12] have been funded to retrofit Dallas Fire Department/ Station (2009-2010 grant award, $887,725), Whitworth Elementary School (Dallas; Phase One of 2015-2016 grant award, $1,492,900)[13].

In addition, the following structures have also had some structural and/ or non-structural seismic retrofitting:

- *Whitworth Elementary School (Dallas School District 2), brick flue was removed and a stainless steel flue was installed, funded per 2009 local school bond (completed in August 2010).*
- *Lyle Elementary School (Dallas School District 2), brick flue was removed and a stainless steel flue was installed, funded per 2009 local school bond (completed in August 2010).*
- *Dallas High School (Dallas School District 2), brick flue was removed and a stainless steel flue was installed, funded per 2009 local school bond (completed in August 2010).*
- *Morrison Campus Alternative School (1251 Main St., Dallas School District 2), brick flue was removed and a stainless steel flue was installed, stadium concrete foundation was installed, dry rot removed and structural upgrades to columns, press box support was engineered and upgraded; funded per2009 local school bond (completed in August 2010, stadium upgrades in September 2011).*
- *Independence Elementary School remodeled.*[14]
- *Central High School* significant upgrade.[15]

For more information, see: Open-File-Report: O-2007-02 - Statewide seismic needs assessment: Implementation of Oregon 2005 Senate Bill 2 relating to public safety, earthquakes, and seismic rehabilitation of public buildings, 2007, and

DOGAMI Statewide Seismic Needs Assessment Using Rapid Visual Screening (RVS)

[12] The Seismic Rehabilitation Grant Program (SRGP) is a state of Oregon competitive grant program that provides funding for the seismic rehabilitation of critical public buildings, particularly public schools and emergency services facilities.

[13] Additional information on seismic retrofits on the Whitworth School is found on the DOGAMI RVS webpage: http://www.oregongeology.org/sub/projects/rvs/activity-updates/2016/Dallas_SD2_SB1566Form2016.pdf

[14] Polk County Itemizer-Observer, *Will they Stand or Fall: Are Polk County governments ready for the 'big one'?,* September 9, 2015, http://www.polkio.com/news/2015/sep/09/will-they-stand-or-fall/

[15] Ibid.

2008 Assessment

In 2008, the Oregon Department of Geology and Mineral Industries (DOGAMI) developed regional earthquake hazard information to assess potential damages and losses for various earthquake scenarios in the Mid-Willamette Valley[16]. More specifically, DOGAMI:

- Identified the primary geologic hazards of Yamhill, Marion, Polk, Benton, Linn, and Lane Counties and the City of Albany;
- Developed countywide earthquake and landslide hazard maps for each county; and
- Developed future earthquake damage estimates for each community.

Damage and loss estimates for each community were analyzed for two earthquake scenarios:

- A magnitude ~6.7 crustal fault earthquake (Mill Creek)
- A magnitude 8.5 Cascadia Subduction Zone earthquake

Information was consolidated into the Hazards U.S. Multi-Hazard methodology and computer application (HAZUS – MH), which is a federally developed program used to model various earthquake scenarios and estimate associated damage and loss. The following is a brief summary of damage and loss estimates for Polk County in a magnitude 8.5 Cascadia Subduction Zone earthquake scenario:

- Estimated fatalities during late afternoon business hours: 49
- Injuries from minor to life threatening: 720
- Households displaced: 1,822
- People needing shelter: 464
- Injuries requiring hospitalization: 186
- Approximately 29% of buildings would be at least moderately damaged.

Note: Polk County has one hospital with 6 beds (up to 15). The hospital is expected to incur moderate damage due to earthquake impacts in the HAZUS M8.5 CSZ scenario

For more information, see: Interpretive Map Series: IMS-024 - Geologic hazards, earthquake and landslide hazard maps, and future earthquake damage estimates for six counties in the Mid/Southern Willamette Valley including Yamhill, Marion, Polk, Benton, Linn, and Lane Counties, and the City of Albany, Oregon, 2008

More information on this hazard can be found in the Risk Assessment for Region 3, Mid-Willamette Valley, of the Oregon NHMP (2015).

[16] Burns, William J., R. Jon Hofmeister, and Yumei Wang. Geologic Hazards, Earthquake and Landslide Hazard Maps, and Future Earthquake Damage Estimates for Six Counties in the Mid/Southern Willamette Valley including Yamhill, Marion, Polk, Benton, Linn, and Lane Counties, and the City of Albany, Oregon. Oregon Department of Geology and Mineral Industries Interpretive Map Series IMS-24. 2008.

Flood

Significant Changes Since Previous Plan:

The Flood hazard profile has been edited to reference new history since the 2009 Plan. This section has also been reformatted. A description of erosion is included in this profile.

Characteristics

Flooding results when rain and snowmelt creates water flow that exceed the carrying capacity of rivers, streams, channels, ditches, and other watercourses. In Oregon, flooding is most common from October through April when storms from the Pacific Ocean bring intense rainfall. Most of Oregon's destructive natural disasters have been floods.[17] The principal types of flood that occur in Polk County include: riverine floods and urban floods.

Riverine or overbank flooding of rivers and streams is the most common type of flood hazard. Riverine flooding most frequently occurs in winter and late spring. Air rises and cools over the Coast Range and its foothills and heavy rainfall develops over high-elevation streams, as storms move from the Pacific across the Oregon Coast. In this region, as much as four to six inches of rain can fall over a 24-hour period. Severe and prolonged storms can raise rivers and streams to their flood stages for three to four days or longer.

Urban flooding occurs in developed areas where the amount of water generated from rainfall and runoff exceeds the stormwater systems' capacity. As land is converted from agricultural and forest uses to urban uses, it often loses its ability to adsorb rainfall. Rain flows over impervious surfaces such as concrete and asphalt and into nearby storm sewers and streams. This runoff can result in the rapid rise of floodwaters. During urban floods, streets can become inundated, and basements can fill with water. Storm drains often back up because of the volume of water and become blocked by vegetative debris like yard waste, which can cause additional flooding. Development in the floodplain can raise the base flood elevation and cause floodwaters to expand past their historic floodplains.

Location and Extent

Polk County lies within the Mid-Willamette Valley between the Coastal Range and the Cascade Range, striated with rivers and tributaries. Melting snow and heavy winter rains combine to produce devastating flood events because of the County's alluvial floodplain topography on the main valley floor. These waterways easily exceed their banks because of the relatively flat terrain.

Floods frequently occur in Polk County during periods of heavy rainfall. The primary sources of riverine flooding include: the Willamette, Luckiamute, Little Luckiamute, and Yamhill rivers, in addition the North and South Ash, Berry, Gold, Gooseneck, Maxfield, Mill, Pedee, Rickreall, Ritner, Rowell, Salt, Soap, and Teal creeks along with many lesser creeks and

[17] Taylor, George H. and Chris Hannan. *The Oregon Weather Book*. Falls City, OR: Oregon State University Press. 1999

tributaries. Communities near these waterways are all susceptible to flood damage during a flood event. A common thread from these water courses is their potential to disrupt infrastructure by causing landslides, inundating roads, and eroding river banks and bridge abutments.

Floods are described in terms of their extent (including the horizontal area affected and the vertical depth of floodwaters) and the related probability of occurrence. Flood studies often use historical records, such as stream-flow gauges, to determine the probability of occurrence for floods of different magnitudes. The probability of occurrence is expressed in percentages as the chance of a flood of a specific extent occurring in any given year.

The magnitude of flood used as the standard for floodplain management in the United States is a flood having a one percent probability of occurrence in any given year. This flood is also known as the 100-year flood or base flood. The most readily available source of information regarding the 100-year flood is the system of Flood Insurance Rate Maps (FIRMs) prepared by FEMA. These maps are used to support the National Flood Insurance Program (NFIP). The FIRMs show 100-year floodplain boundaries for identified flood hazards. These areas are also referred to as Special Flood Hazard Areas (SFHAs) and are the basis for flood insurance and floodplain management requirements.

FEMA released the current Digital Flood Insurance Rate Map (DFIRM) for Polk County on December 19, 2006 which included data from city and unincorporated communities. This map delineates the flood extent within the County.

Areas with significant development in the mapped floodplains include North Dallas, East of West Salem along the Willamette River, Northwest of Independence along the North fork of Ash Creek, South of Monmouth along the South fork of Ash Creek, and Southeast of Falls City along the Little Luckiamute River. Portions of the following smaller communities are also within FEMA-mapped floodplains: Rickreall, Pedee, Willamina, Grand Ronde, and McCoy. For more information, refer to Table 2-3 and the following Flood Insurance Study (FIS) and associated Flood Insurance Rate Maps (FIRM):

- Polk County Flood Insurance Study (December 19, 2006)

Table 2-3 Flood Insurance Rate Maps (FIRMs)

Flood Source	Flood Insurance Rate Map (FIRM)	Notes
Willamette River	41053C0575F, 41053C0425F, 41053C0450F, 41053C0410F, 41053C0270F, 41053C0286F, 41053C0287F, 41053C0279F, 41053C0283F, 41053C0281F, 41053C0277F, 41053C0150F	Drainage area of 7,270 square miles 100-year peak discharge of 506,000 cubic feet per second (cfs) 500-year peak discharge of 675,000 cfs
Little Luckiamute River	41053C0355F, 41053C0360F, 41053C0400F	Drainage area of 22.4 square miles 100-year peak discharge of 5,390 cfs 500-year peak discharge of 7,070 cfs Peak discharge had a 5 percent chance of occurrence.
Lukiamute River	41053C0350F, 41053C0500F, 41053C0525F, 41053C0375F, 41053C0400F, 41053C0425F, 41053C0575F	Drainage area of 116 square miles 100-year peak discharge of 15,800 cfs 500-year peak discharge of 20,200 cfs
Yamhill River	41053C0040F, 41053C0030F, 41053C0035F, 41053C0045F, 41053C0065F, 41053C0055F	Drainage area of 129 square miles 100-year peak discharge of 18,600 cfs 500-year peak discharge of 21,800 cfs Peak flow of 19,000 cfs at the USGS stream gage near Wallace Bridge, about two miles upstream from Willamina.
North Ash Creek	41053C0236F, 41053C0238F, 41053C0239F, 41053C0237F, 41053C0241F, 41053C0242F, 41053C0245F, 41053C0265F, 41053C0401F, 41053C0402F	
South Ash Creek	41053C0245F, 41053C0400F, 41053C0403F, 41053C0404F, 41053C0402F	
Berry Creek	41053C0550F, 41053C0575F	
Gold Creek	41053C0200F, 41053C0045F	
Gooseneck Creek	41053C0200F, 41053C0045F, 41053C0065F, 41053C0075F	
Mill Creek	41053C0200F, 41053C0225F, 41053C0075F, 41053C0065F	Drainage area of 27.5 square miles 100-year peak discharge of 6,640 cfs 500-year peak discharge of 7,890 cfs
Pedee Creek	41053C0375F, 41053C0525F	
Rickreall Creek	41053C0200F, 41053C0225F, 41053C0217F, 41053C0236F, 41053C0237F, 41053C0241F, 41053C0242F, 41053C0265F, 41053C0270F, 41053C0286F	Drainage area of 46 square miles 100-year peak discharge of 13,300 cfs 500-year peak discharge of 17,200 cfs
Rowell Creek	41053C0200F, 41053C0040F	
Salt Creek	41053C0225F, 41053C0250F, 41053C0100F	
Soap Creek	41053C0575F	
Teal Creek	41053C0355F, 41053C0360F	

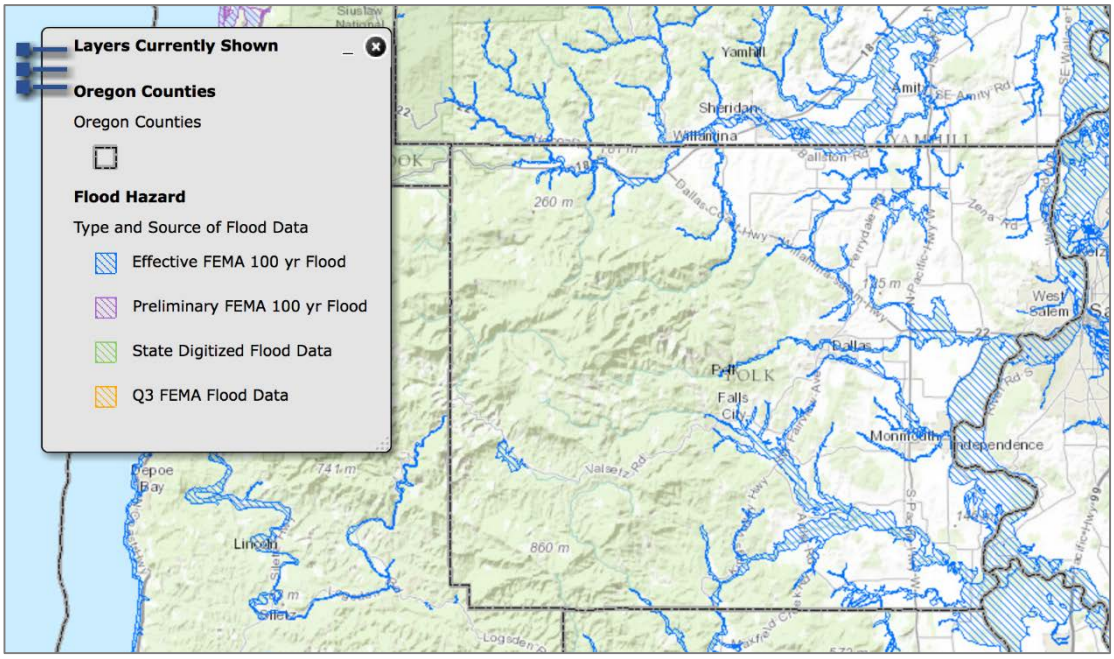
Source: Polk County Flood Insurance Study (December 19, 2006)

The FEMA-mapped floodplains in Polk County include, for the most part, only areas along the larger rivers and creeks which also have significant population and/or development. However, many agricultural fields are mapped floodplains (generally A zone). Many other areas in the county have significant flood risk, but are not included in the FIRMs because of small stream size or low population in the area. Flood hazard evaluation for Polk County must also take into account these localized high flood risk or repetitive flooding areas which lie outside mapped floodplains.

Additional reports may be available via DOGAMI's Publications Search website: http://www.oregongeology.org/pubs/search.php

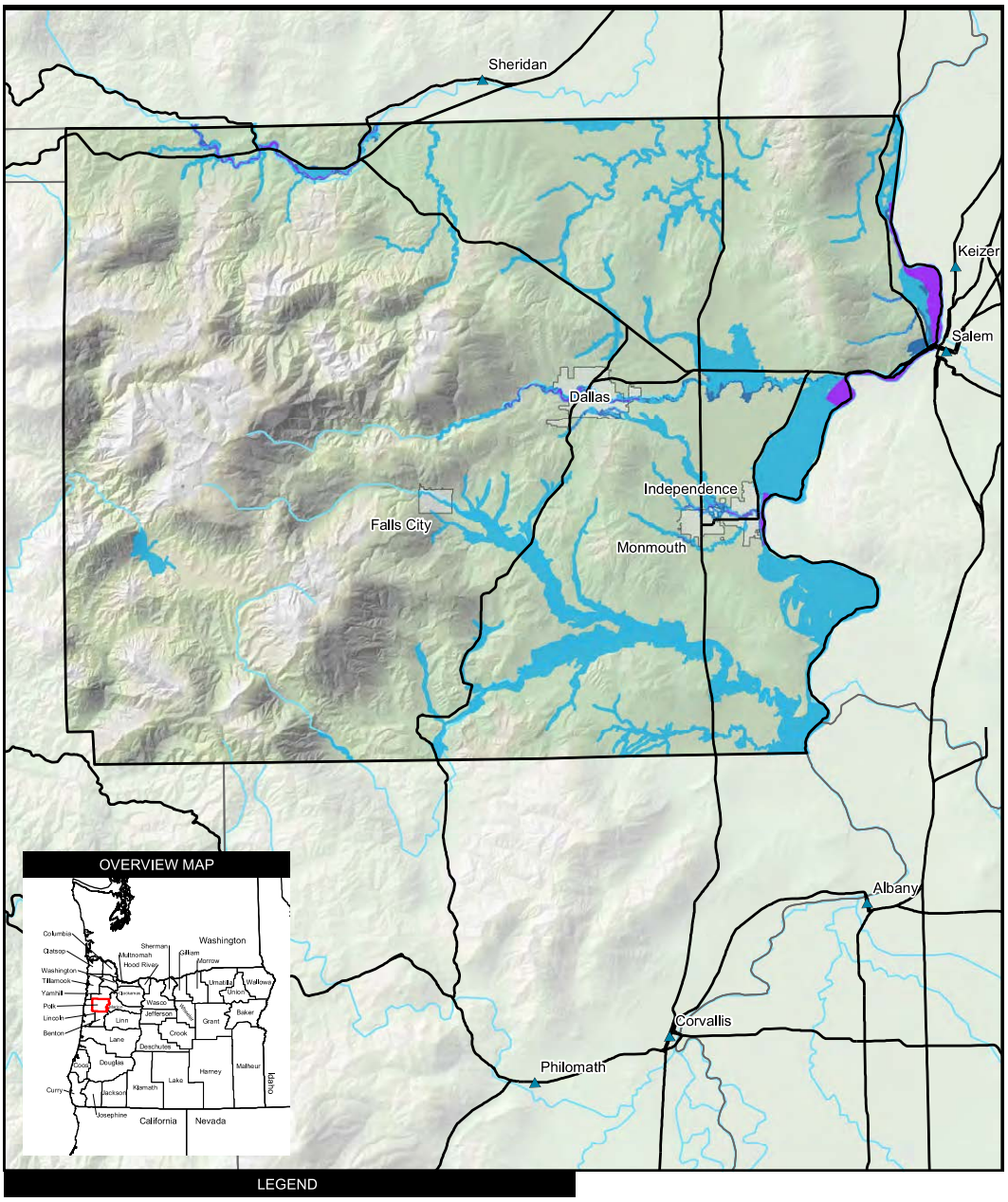
The special flood hazard that identifies the location and extent of the flood hazard is included as Figure 2-6 and Map 2-3, for more detailed mapping see the 2006 FIS or the community profile for Polk County located on the Oregon Risk MAP website. The Polk County Website also has information on flood hazards.

Figure 2-6 Special Flood Hazard Area



Source: Oregon HazVu: Statewide Geohazards Viewer (HazVu)

Map 2-3 Flood Hazard Area



Source: Polk County NHMP (2009).

History

Polk County, as well as much of western Oregon, has recorded several very destructive floods throughout the years. Listed below are historical flooding events that affected Polk County. The majority of flood events can be attributed to the Luckiamute and Willamette Rivers and Rickreall Creek.

Three significant flood events have been added since the previous plan (shown in *italics below*): [18]

- December 1964: Nearly every river in the state of Oregon exceeded its flood stages as weather stations set new precipitation records. This "Christmas Flood" event triggered debris flows, bridge failures and flooding that caused thousands to evacuate and closed airports, railways, and hundreds of miles of roads across the state. The event ultimately killed 20 people and caused more than $157 million in damages.
- January 1965: Residents were still recovering from the Christmas Flood when they were hit again by the January 31, 1965 flood. What made these back-to-back floods so disastrous was the heavy rainfall onto near-record early snow depths. The resulting water could not soak into frozen ground.
- February 1987: Rains caused the Willamette and Luckiamute rivers and Rockreall Creek to overtop their banks, inundate homes, and create highway problems from extensive mudslides.
- February 1996: Virtually every county in the state received a disaster declaration due to a combination of warm temperatures, heavy snow pack, and four days of record-breaking rain. Many areas had already received above-average rainfall. Rivers were at or reaching their capacities and flood stages. Increased runoff and atypical sediment and debris from recent logging activities contributed to conditions ripe for flooding and landslides. Hundreds of homes were destroyed, power outages were widespread, thousands were evacuated to public shelters, and five people died. Flood-related damage estimates exceeded $1 billion.
- November 1996-January 1997: A tropical air mass swept across the state, once again bringing record-breaking precipitation. The stormy weather continued into December and early January 1997, as 26 major rivers reached flood stage. Snow melt and intense rain caused extensive flooding that led to widespread landslides, erosion, power outages, damaged homes and businesses, closed roads, and eventually resulted in a Presidential Disaster Declaration.
    - Polk County's Luckiamute and Willamette Rivers experienced extreme high water flooding along with the rest of the State. Laurel Mountain, west of the City of Dallas, far exceeded any Oregon location's record rainfall receiving 204.12 inches of rain (17 feet) which ultimately flowed into the Luckiamute River and Rockreall Creek. The Willamette River's rapid water rise forced many residents along its course to evacuate. Telecommunications, including some emergency communications, were disrupted. FEMA disbursed repair

[18] Polk County Flood Insurance Study (2011); Taylor, George and Raymond Hatton, 1999, The Oregon Weather Book; National Climatic Data Center Storm Events, Polk County Community Development Department.

and response assistance totaling more than $3,000,000 to the State's public entities.

- December 2007: Severe storms, winds, mudslides, landslides, and flooding occurred between December 1 and 17, 2007 shutting down roads and highways including Interstate 5. Public infrastructure, homes, and personal property were damaged. In Oregon, 73,000 residents were without power, and wastewater treatment plants were overwhelmed. A major disaster was declared for the State of Oregon on December 8, 2007 with Polk County included in the declaration.
  Estimated losses within Polk County are $1,043,278.87.
- *Jan 15-18, 2011: Flooding of Luckiamute River results in the closing of Sarah Helmick State Park and covers Maple Grove Road near Monmouth. No reported injuries or damages.*
- *Jan 18, 2012: Independence OR – flooding of Ash Creek trapped a driver at car-door water level. No reported injuries or damages.*
- *Dec 8, 2015: Flooding of the Luckiamute River prompting the closing of Sarah Helmick State Recreation Area and Luckiamute Landing State Natural Area. 2,000 utilities customers in Salem and Keizer areas went without power as a result. No reported injuries or damages.*

Note: Other notable flooding events occurred in January 1972, November 1973, January 1974, December 1995, December 2003- January 2004, March 2006, and December 2006.

Erosion

Erosion is a process that involves the wearing away, transport, and movement of land. Erosion is typically a gradual process; however, it can also occur quickly as the result of a flash flood, coastal storm, or other event. Most of the geomorphic change that occurs in a river system is in response to a peak flow event. It is a natural process but its effects can be exacerbated by human activity.

Generally, erosion occurs when the flow of the river changes and is directed towards the banks or mid-channel islands. These changes can be caused by surface wind stress and gravity waves that occur during storm events (primarily severe winter storms), transporting sediment by bottom currents.

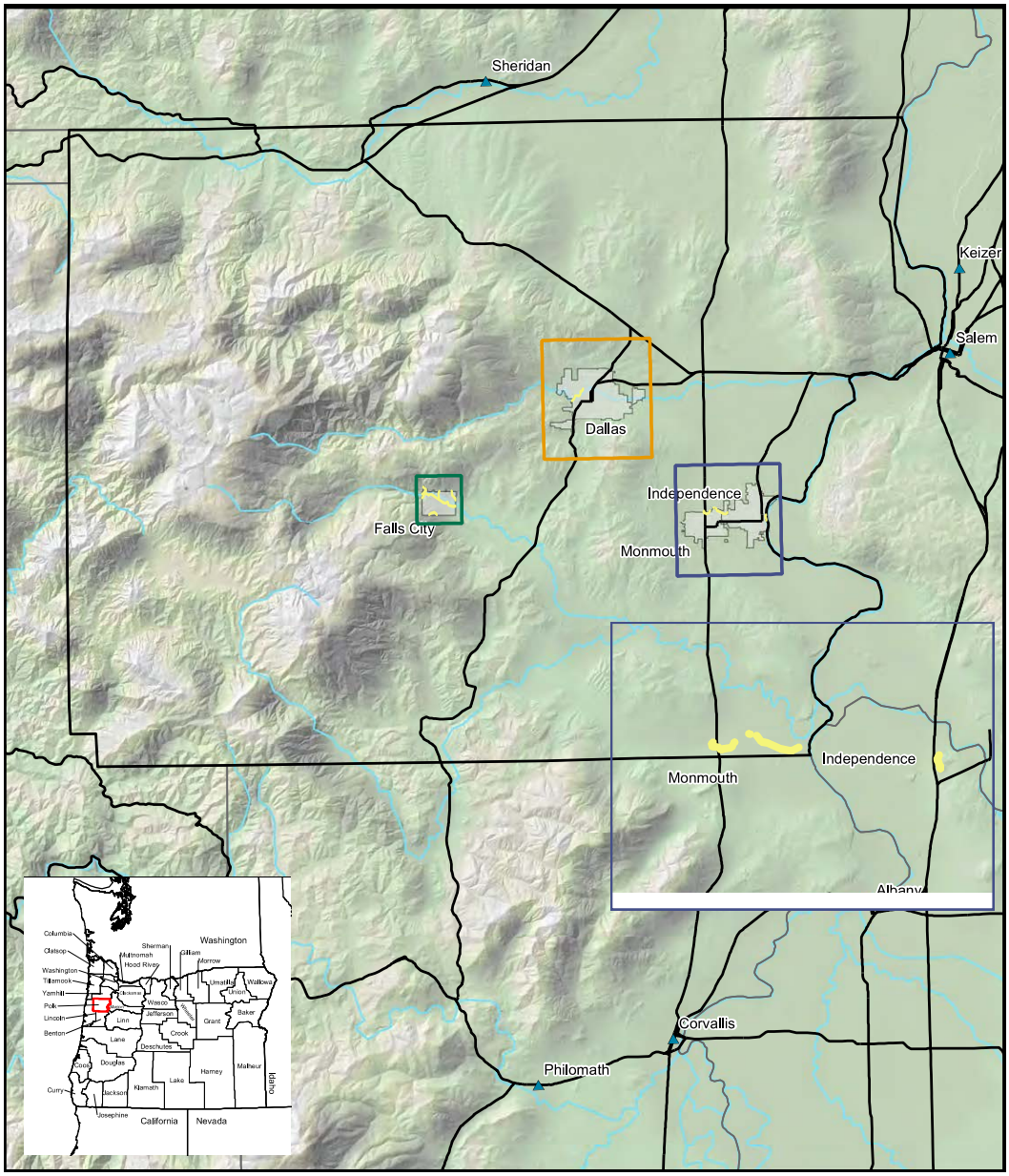
As shown in Map 2-4, several areas along the rivers and creeks in Polk County have been identified as vulnerable to riverine erosion. Riverine erosion in local creeks was a particular concern during the 1964 flood event.

Erosion loss has historically occurred in Polk County. Rivers and creeks that have been identified to be subject to the effects of erosion include the Willamette, Luckiamute, Little Luckiamute, and South Yamhill Rivers, and Rickreall, Ash, Boughey, Glenn, Gibson, Berry, Dutch, Everz, and Teal Creeks. The annual amounts of rain and wind that assail the bank combined with debris flows within the watersheds and loss of plant cover in riparian areas induce erosion; particularly during severe storm events.

Erosion is considered a particular concern in the following locations:

- Falls City: affecting Little Luckiamute River and Berry, Dutch, Everz, and Teal creeks.
- Independence: affecting the Willamette River to the east of Riverview Park.

Map 2-4 Erosion Hazard Area



Source: Polk County NHMP (2009).While erosion has been identified as occurring within the county, only one event was reported to result in damage. Based on past events and the lack of development in proximity to erosion hazard areas, the magnitude and severity of erosion impacts in Polk County are considered negligible, with the potential for critical facilities to

be shut down for 24 hours or less, and less than 10% of property or critical infrastructure being severely damaged.

Probability Assessment

Polk County and the incorporated Cities of Dallas, Falls City, Independence, and Monmouth, participate in the National Flood Insurance Program (NFIP) and are required to regulate floodplain development. Any structure built in the floodplain after 1974 must meet NFIP requirements for elevation and flood proofing. Polk County and the incorporated jurisdictions use FEMA developed floodplain maps as the basis for implementing floodplain regulations. FEMA has mapped the 10, 50, 100, and 500-year floodplains in portions of Polk County (see Figure 2-6 and referenced FIS for more information). This corresponds to a 10%, 2%, 1% and 0.2% chance of a certain magnitude flood in any given year. The 100-year flood is the benchmark upon which the NFIP is based.

Flooding in western Oregon generally occurs when storms from the Pacific Ocean bring intense or prolonged rainfall to the west coast. Polk County typically experiences the most severe floods from winter rainfall floods in December, January, and February. These floods are occasionally exacerbated by frozen snow packs where rain and snowmelt combine while the ground is frozen, preventing ground seepage capability. The county is also subject to flooding from river overflows, as well as flooding from local stormwater drainage. The county is susceptible to winter rain flooding from October through April; while the months between May and July bring snowmelt and runoff floods.

Based on the available data and research for Polk County the NHMP Steering Committee determined the **probability of experiencing a flood is "high",** meaning at least one incident could be expected within the next 35-year period.

Vulnerability Assessment

Flooding can occur every year depending on rainfall, snowmelt, or how runoff from development impacts streams and rivers. Surveys by the Department of Geology & Mineral Industries (DOGAMI), the county, and FEMA have established the 100-year floodplain.

Changes to development patterns since 2009 have the potential to incur increased risk of flooding. However, County development regulations restrict, but do not prohibit, new development in areas identified as floodplain. This reduces the impact of flooding on future buildings.

The floodplains in Polk County are generally located along the Willamette, Luckiamute, and Little Luckiamute river basins and their tributaries.

Damage estimates have been completed for Polk County in the past, but are no longer accurate. Consequently, estimations of potential dollar losses to vulnerable structures are not currently available. FEMA recommends that communities use HAZUS software (HAZUS = Hazards United States; a geographic information system-based natural hazard loss estimation software package) to produce loss estimates that accurately reflect local conditions. The HAZUS-MH Flood Model allows planners and other practitioners to carry out a wide range of flood hazard analyses, including:

- Studies of specific return intervals of floods (e.g., 100-year return interval)
- Studies of discharge frequencies, including analysis of discharges from specific streams and the exposure to buildings and population from the resultant flooding.
- Studies of annualized losses from flooding.
- 'Quick look' assessments, which allow the user to quickly evaluate potential flooding from specific flood depths at specific locations.
- 'What if' scenarios, which allow users to evaluate the consequences of specific actions, such as the introduction of flow regulation devices, acquisition of flood-prone properties, and other mitigation measures.

The flood loss estimation methodology consists of two modules that carry out basic analytical processes: flood hazard analysis and flood loss estimation analysis. The flood hazard analysis module uses characteristics, such as frequency, discharge, and ground elevation to estimate flood depth, flood elevation, and flow velocity. The flood loss estimation module calculates physical damage and economic loss from the results of the hazard analysis.

A comprehensive risk and vulnerability assessment is not available. As of the publication of this NHMP FEMA is providing an opportunity for the county and cities to participate in a Risk Mapping, Assessment, and Planning (Risk MAP) process that would generate additional data on risks and vulnerabilities. The Risk Report would provide a quantitative risk assessment that informs communities of their risks related to certain natural hazards (including flood). If pursued, once complete the county can incorporate the risk assessment into this plan to provide greater detail to sensitivity and exposure to the earthquake hazard.

Per the previous version of this plan approximately 8,288 residential structures (value $1.2B), 25 non-residential structures (value unknown), three government facilities (value unknown), two educational facilities (value $7M), one care facility (value unknown), three utility facilities (value unknown), and one dam (value $25M).

Within the 500-year floodplain, Polk County has 9,422 residential structures (worth $1.3B), 50 non-residential structures (value unknown), one government facility (value unknown), and one educational facility (value unknown).

In Polk County, 101 residential structures (worth $14.5M), one government facility (value unknown), one emergency response facility (worth $3M), and one utility facility (value unknown) are considered at risk of riverine erosion. [19]

As such, the NHMP Steering Committee rated the county as having a **"moderate" vulnerability to flood hazards**, meaning that between 1-10% of the region's population or assets would be affected by a major flood event.

More information on this hazard can be found in the Risk Assessment for Region 3, Mid-Willamette Valley, of the Oregon NHMP (2015).

[19] URS, 2009 Polk County Natural Hazards Mitigation Plan; values are in 2009 dollars.

Landslide

Significant Changes Since Previous Plan:

The Landslide hazard profile has been edited to reference new history since the 2009 Plan. New landslide susceptibility information based on updated Lidar data provided by DOGAMI (O-16-02) has also been included This section has also been reformatted.

Characteristics

A landslide is any detached mass of soil, rock, or debris that falls, slides or flows down a slope or a stream channel. Landslides are classified according to the type and rate of movement and the type of materials that are transported. In a landslide, two forces are at work: 1) the driving forces that cause the material to move down slope, and 2) the friction forces and strength of materials that act to retard the movement and stabilize the slope. When the driving forces exceed the resisting forces, a landslide occurs.

Polk County is subject to landslides or debris flows (mudslides), especially in the Coast Range, which may affect buildings, roads, and utilities.

Additionally, landslides often occur together with other natural hazards, thereby exacerbating conditions, as described below:

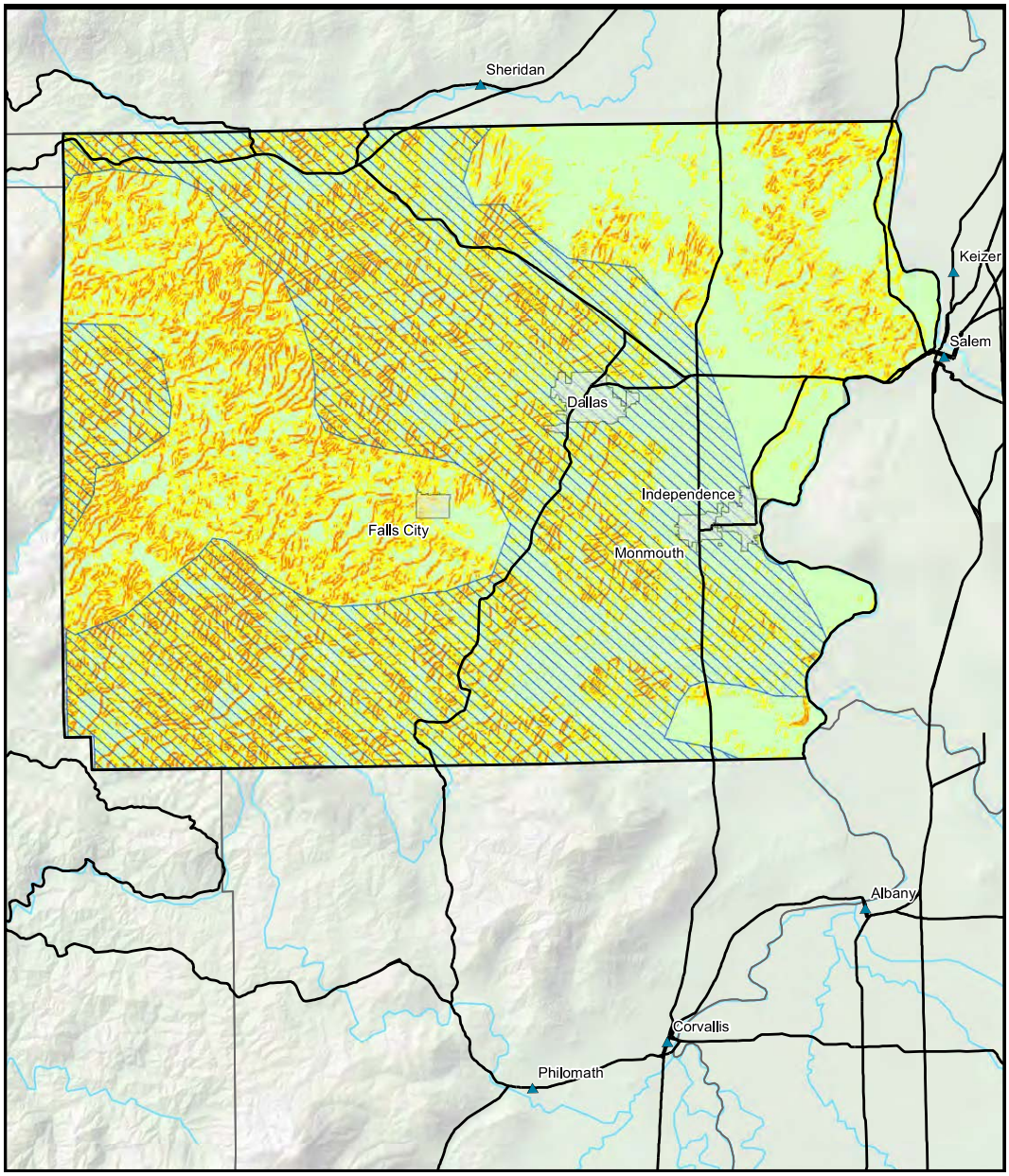
- Shaking due to earthquakes can trigger events ranging from rockfalls and topples to massive slides.
- Intense or prolonged precipitation that causes flooding can also saturate slopes and cause failures leading to landslides.
- Landslides into a reservoir can indirectly compromise dam safety, and a landslide can even affect the dam itself.
- Wildfires can remove vegetation from hillsides, significantly increasing runoff and landslide potential.

Location and Extent

The characteristics of the minerals and soils present in Polk County indicate the potential types of hazards that may occur. Rock hardness and soil characteristics can determine whether or not an area will be prone to geologic hazards such as landslides.

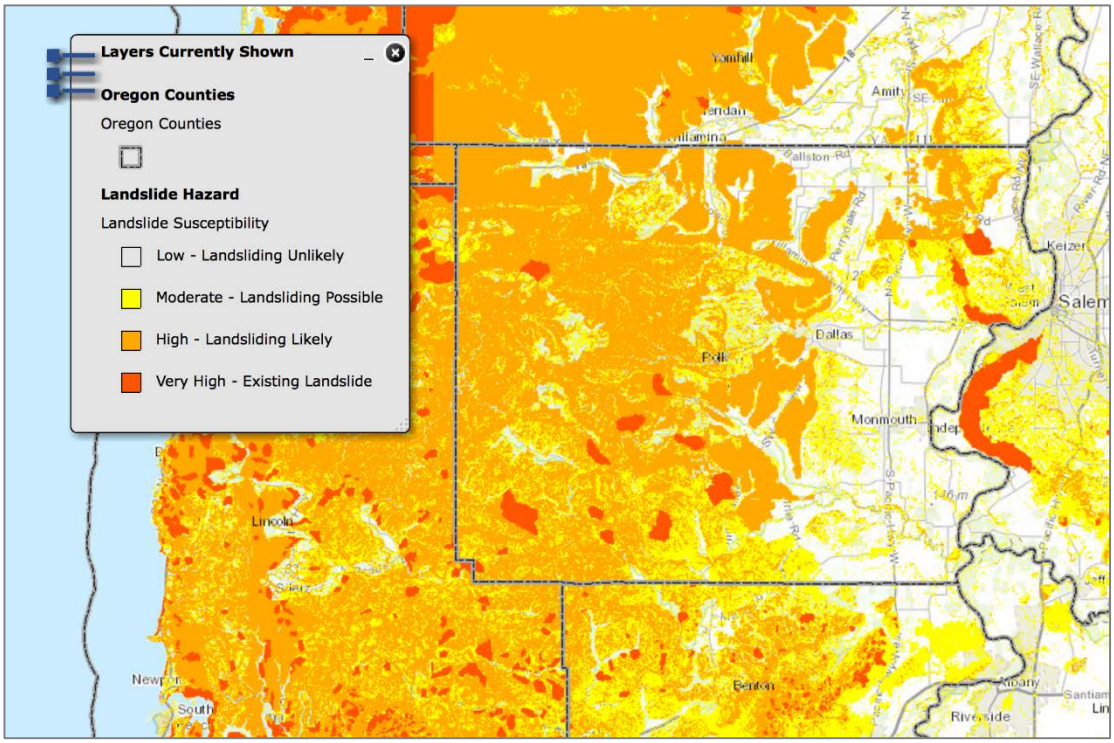
Landslides and debris flows are possible in any of the higher slope portions of Polk County, including much of the western portion of the county. Landslide prone areas also include portions of the hilly areas west of Falls City (see Map 2-5 and Figure 2-7).

Map 2-5 Landslide Hazard Area



Source: Polk County NHMP (2009).

Figure 2-7 Landslide Susceptibility Exposure



Source: [DOGAMI Statewide Landslide Information Layer for Oregon (SLIDO)]

For Polk County, many high landslide potential areas are in the hilly-forested areas western portion of the county. The western region of the county is hilly, primarily managed for timberland, and is sparsely populated. Landslides in these areas may damage or destroy some timber and impact logging roads. Many of the major highways in Polk County are at risk for landslides at one or more locations with a high potential for road closures and damage to utility lines. Especially in the western portions of the county, with a limited redundancy of the road network, such road closures may isolate some communities. In addition to direct landslide damages to roads and highways, affected communities are also subject to the economic impacts of road closures due to landslides, which may disrupt access to/egress from communities.

Table 2-4 shows landslide susceptibility exposure for Polk County and the incorporated cities. Approximately 46% of the county land has High landslide susceptibility exposure and just over 2% has Very High landslide susceptibility. While the cities generally have less exposure, nearly 60% of Falls City is within the High landslide susceptibility area. Note that even if a county or city has a high percentage of area in a high or very high landslide exposure susceptibility zone, this does not mean there is a high risk, because risk is the intersection of hazard and assets.

More detailed landslide hazard assessment at specific locations requires a site-specific analysis of the slope, soil/rock and groundwater characteristics at a specific site. Such assessments are often conducted prior to major development projects in areas with moderate to high landslide potential, to evaluate the specific hazard at the development site.

Table 2-4 Landslide Susceptibility Exposure

Jurisdiction	Area, ft^2	Low	Moderate	High	Very High
Polk County	20,738,900,872	31.2%	20.5%	46.0%	2.3%
Dallas	135,561,360	67.3%	13.4%	19.3%	0.0%
Falls City	33,481,019	24.6%	16.1%	59.3%	0.0%
Independence	82,442,831	88.4%	9.8%	1.8%	0.0%
Monmouth	58,577,531	91.1%	8.7%	0.2%	0.0%

Source: DOGAMI Open-File Report, O-16-02, Landslide Susceptibility Overview Map of Oregon (2016)

The severity or extent of landslides is typically a function of geology and the landslide triggering mechanism. Rainfall initiated landslides tend to be smaller, and earthquake induced landslides may be very large. Even small slides can cause property damage, result in injuries, or take lives.

For more information, refer to the following report and maps provided by DOGAMI:

- Open File Report: O-16-02, Landslide Susceptibility Overview Map of Oregon
- Open File Report: O-15-01, Landslide Susceptibility analysis of lifeline routes in the Oregon Coast Range (2015)
- Open-File Report: O-10-03, Digital geologic map of the southern Willamette Valley, Benton, Lane, Linn, Marion, and Polk Counties, Oregon
- Special Paper 34: Slope failures in Oregon: GIS inventory for three 1996/97 storm events, 2000

Additional reports are available via DOGAMI's Publications Search website: http://www.oregongeology.org/pubs/search.php

History

Landslides are not common in Polk County. Much of the terrain is relatively flat with few hills. However, landslides have occurred in Polk County potentially threatening infrastructure. Many slides take place in undeveloped areas and are unreported or even unnoticed. Figure 2-7 shows that landslide prone landscape is generally in the western portion of the county which is remote and primarily managed for timberland. A statewide survey of winter storm landslides during 1996 and 1997, conducted by the Oregon Department of Geology and Mineral Industries (DOGAMI), reported 9,582 documented slides.[20] The actual number occurring was estimated to be many times the documented number.

Landslides in Polk County are often associated with heavy rain events and landslides were reported during rain events in October 1950, November 1951, December 1951, December 1955, November 1958, March 1963, October 1967, March 1971, November 1981, December 1995, February 2002, December 2006. Below, the most severe landslide events are listed. Two (2) landslide event/s have been added since the previous plan (as shown in *italics* below):

[20] DOGAMI, Special Paper 34: Slope Failures in Oregon: GIS Inventory for three 1996/97 storm events (2000)

- October 1962, wind/ rain event; flood, landslides, tree toppling, utility disruption (Columbus Day Storm)
- December 1964, rain event, most severe flooding since 1870
- Feb. 1996: Entire State - Deep snow pack, warm temperatures, record-breaking rains. Flooding, landslides, power-outages. (FEMA-1099-DR-OR); $478,472 - Road damage, homes damaged from floodwater undercutting.
- Nov. – Dec. 1996: Entire State - Record-breaking precipitation; local flooding / landslides (FEMA-1107-DR-OR and FEMA-1149-DR-OR, *did not include Polk County*).
- *December 2005-January 2006: severe storms, flooding, landslides, and mudslides (FEMA-1632-DR-OR).*
- December 2007, snow and rain event; Heavy snowfall, rains, rapid temperature warming created widespread flooding, tree blockages, landslides, transportation and utility disruptions, and five deaths in Oregon. Statewide wind 50-100 mph - $180M damages.
- December 2008: snow, mudslide, and landslide event; A severe storm, record and near-record snow, mudslides, and landslides occurred between December 20 through 26, 2008.
- J*anuary, 2012: Heavy rain, landslides, downed trees, 24-hour rainfall of over 4-inches (FEMA-4055-DR-OR).*
- *December 2015: Severe Winter Storms, Straight-line Winds, Flooding, Landslides, and Mudslides (FEMA-4258-DR-OR)*

For additional history see flood section above for events that included landslides.

Probability Assessment

The probability of rapidly moving landslides occurring depends on a number of factors; these include steepness of slope, slope materials, local geology, vegetative cover, human activity, and water (surface and ground). There is a strong correlation between intensive winter rainstorms and the occurrence of rapidly moving landslides (debris flows). Given the correlation between precipitation / snow melt and rapidly moving landslides, it would be feasible to construct a probability curve. Many slower moving slides present in developed areas have been identified and mapped; however, the probability and timing of their movement is difficult to quantify. The installation of slope indicators or the use of more advanced measuring techniques could provide information on these slower moving slides.

Based on the available data and research for Polk County the NHMP Steering Committee determined the **probability of experiencing a landslide is "high",** meaning at least one incident is likely within the next 35-year period.

Vulnerability Assessment

Landslides can affect structures (residential, commercial, industrial), utility services, transportation systems, and critical lifelines among others. Communities may suffer immediate damages and loss of service. Disruption of infrastructure, roads, and critical facilities may also have a long-term effect on the economy. Utilities, including potable water, wastewater, telecommunications, natural gas, and electric power are all essential to service community needs. Loss of electricity has the most widespread impact on other

utilities and on the whole community. Natural gas pipes may also be at risk of breakage from slight landslide movements as small as an inch or two.

Roads and bridges are subject to closure during landslide events. Because many Polk County residents are dependent on roads and bridges for travel to work, delays and detours are likely to have an economic impact on county residents and businesses. To evaluate landslide mitigation for roads, the community can assess the number of vehicle trips per day, detour time around a road closure, and roads used for commercial traffic or emergency access. Particular vulnerabilities include major routes including Highway 51, 99, 223, and 22. In addition, the following roads within Polk County are susceptible to slides:

- High Frequency: Black Rock, Mill Creek, James Howe, and Liberty
- Lower Frequency: Buena Vista, Pioneer, and Pedee

Lifelines and critical facilities should remain accessible if possible during a natural hazard event. The impact of closed transportation arteries may be increased if the closed road or bridge is a critical lifeline to hospitals or other emergency facilities. Therefore, inspection and repair of critical transportation facilities and routes is essential and should receive high priority. Losses of power and phone service are also potential consequences of landslide events. Due to heavy rains, soil erosion in hillside areas can be accelerated, resulting in loss of soil support beneath high voltage transmission towers in hillsides and remote areas. Flood events can also cause landslides, which can have serious impacts on gas lines. Water and waste-water utilities may need treatment to quickly improve water quality by reducing excessive water turbidity and reestablishing wastewater disposal capability.

Mercer Reservoir is the drinking water source for Dallas and its spillway is vulnerable to impacts from landslide/debris flows. Falls City has experienced landslide debris flows from supersaturated soils.

A quantitative landslide hazard assessment requires overlay of landslide hazards (frequency and severity of landslides) with the inventory exposed to the hazard (value and vulnerability) by considering:

1. Extent of landslide susceptible areas;
2. Inventory of buildings and infrastructure in landslide susceptible areas;
3. Severity of earthquakes or winter storm event (inches of rainfall in 24 hours);
4. Percentage of landslide susceptible areas that will move and the range of movements (displacements) likely; and
5. Vulnerability (amount of damage for various ranges of movement).

A comprehensive risk and vulnerability assessment is not available. As of the publication of this NHMP FEMA is providing an opportunity for the county and cities to participate in a Risk Mapping, Assessment, and Planning (Risk MAP) process that would generate additional data on risks and vulnerabilities. The Risk Report would provide a quantitative risk assessment that informs communities of their risks related to certain natural hazards (including landslide). If pursued, once complete the county can incorporate the risk assessment into this addendum to provide greater detail to sensitivity and exposure to the landslide hazard.

According to the previous version of this plan approximately 14,232 residential structures (value $2B), 60 non-residential structures (value unknown), two government facilities (value

unknown), two emergency response facilities (value $3M), eight educational facilities (value $13.1M), five care facilities (value unknown) and six utility facilities (value $1.7M) are located within areas of moderate landslide risk.

Additionally, 8,850 residential structures (value $1.3B), 19 non-residential structures (value unknown), and two educational facilities (value unknown) are located within areas of high landslide risk.[21]

Since a recent comprehensive risk assessment is not available, current data does not allow for specific estimates of life and property losses during a given scenario. In addition, most of the area that is susceptible to landslides is remote and does not have a lot of development. As such, the NHMP Steering Committee rated the county as having a **"low" vulnerability to landslide hazards**, meaning that less than 1% of the region's population or assets would be affected by a major disaster.

More information on this hazard can be found in the Risk Assessment for Region 3, Mid-Willamette Valley, of the Oregon NHMP (2015).

[21] URS, 2009 Polk County Natural Hazards Mitigation Plan; values are in 2009 dollars.

Volcano

Significant Changes Since Previous Plan:

There has been no new history applicable to the Volcano hazard since the 2009 Plan. This section has been reformatted.

Characteristics

The Pacific Northwest, lies within the "ring of fire," an area of very active volcanic activity surrounding the Pacific Basin. Volcanic eruptions occur regularly along the ring of fire, in part because of the movement of the Earth's tectonic plates. The Earth's outermost shell, the lithosphere, is broken into a series of slabs known as tectonic plates. These plates are rigid, but they float on a hotter, softer layer in the Earth's mantle. As the plates move about on the layer beneath them, they spread apart, collide, or slide past each other. Volcanoes occur most frequently at the boundaries of these plates and volcanic eruptions occur when molten material, or magma, rises to the surface.

The primary threat to lives and property from active volcanoes is from violent eruptions that unleash tremendous blast forces, generate mud and debris flows, or produce flying debris and ash clouds. The immediate danger area in a volcanic eruption generally lies within a 20-mile radius of the blast site.

Location and Extent

Volcanic eruption is not an immediate threat to the residents of Polk County, as there are no active volcanoes within the county. Nevertheless, the secondary threats caused by volcanoes in the Cascade region must be considered. Volcanic ash can contaminate water supplies, cause electrical storms, create health problems, collapse roofs, and impact agricultural crops.

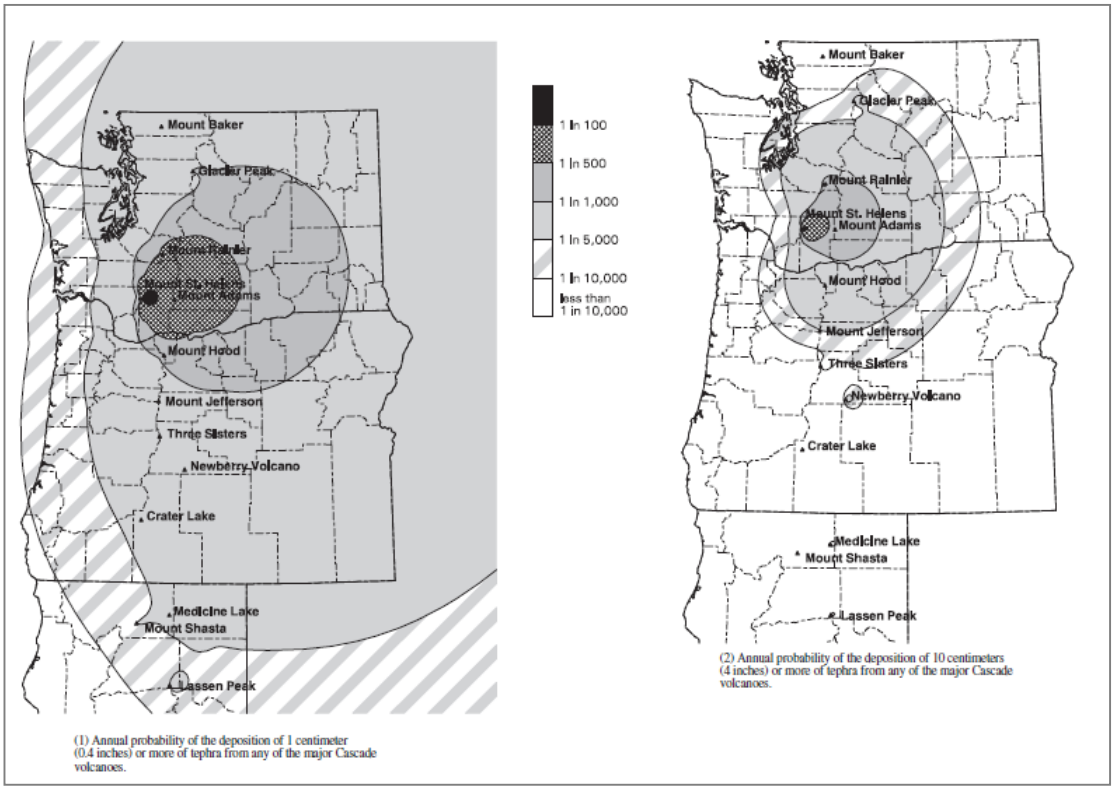
Polk County is located on the Pacific Rim. Tectonic movement within the earth's crust can renew nearby dormant volcanoes resulting in ash fallout in Polk County. Volcanic activity is possible from Mount Jefferson, Mount Hood and Mount Saint Helens, Three Sisters, Mount Bachelor, and the Newberry Crater areas. Because the distance to these potentially active volcanic areas is so great, the only adverse effect that would impact areas of Polk County is ash fallout, with perhaps some impact on water supplies. The area affected by ash fallout depends upon the height attained by the eruption column and the atmospheric conditions at the time of the eruption.

Geologic hazard maps have been created for most of the volcanoes in the Cascade Range by the USGS Volcano Program at the Cascade Volcano Observatory in Vancouver, WA and are available at http://vulcan.wr.usgs.gov/Publications/hazards_reports.html.

Scientists use wind direction to predict areas that might be affected by volcanic ash; during an eruption that emits ash, the ash fall deposition is controlled by the prevailing wind direction. The predominant wind pattern over the Cascades originates from the west, and previous eruptions seen in the geologic record have resulted in most ash fall drifting to the east of the volcanoes. Regional tephra fall shows the annual probability of ten centimeters

or more of ash accumulation from Pacific Northwest volcanoes. Figure 2-8 depicts the potential and geographical extent of volcanic ash fall in excess of ten centimeters from a large eruption of Mt. St. Helens.

Figure 2-8 Regional Tephra-fall Maps



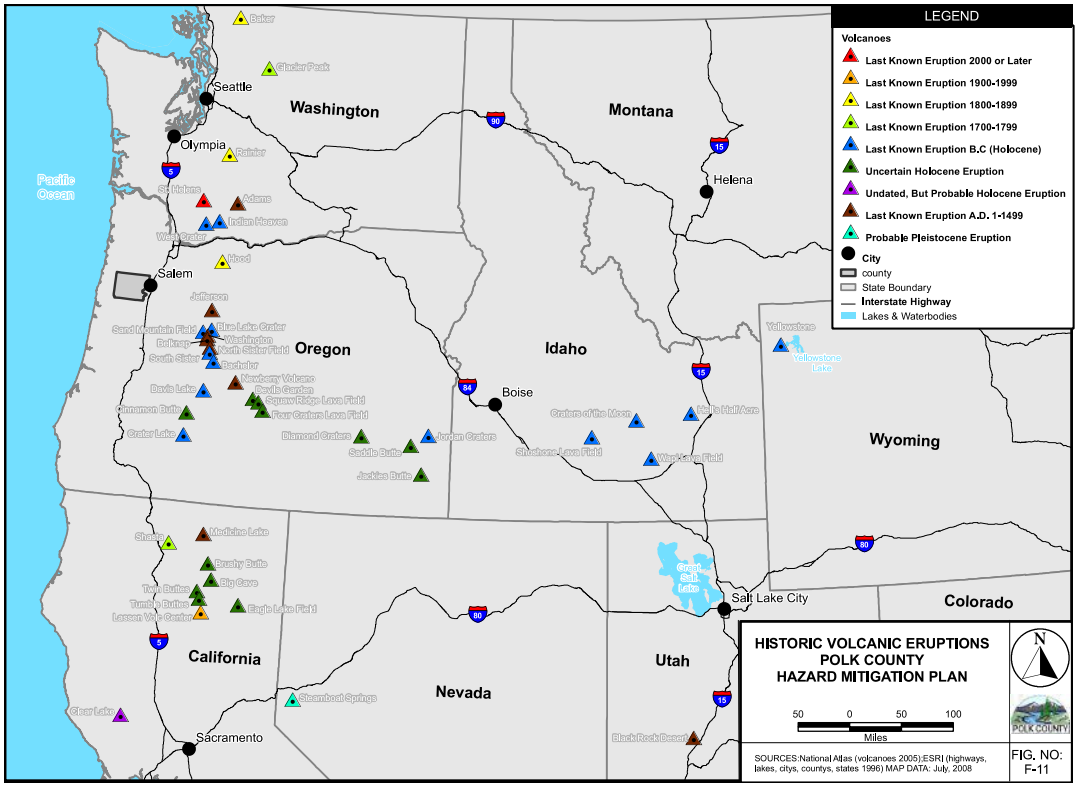
Source: USGS "Volcano Hazards in the Mount Jefferson Region, Oregon"

History

Mount Hood and Mount St. Helens are two active volcanoes in the vicinity of Polk County. Mount Hood is northeast of the county and is more than 500,000 years old. It has had two significant eruptive periods, one about 1,500 years ago and another about 200 years ago. Mount St. Helens is located in southern Washington State and has been active throughout its 50,000-year lifetime. Additionally, in the past 200 years, seven of the Cascade volcanoes have erupted, including (from north to south): Mt. Baker, Glacier Peak, Mt. Rainier, Mount St. Helens (Washington); Mt. Hood (Oregon); Mt. Shasta, and Mt. Lassen (California).

There has been no recent volcanic activity in close proximity to the county. The 1980 explosion of Mount Saint Helens in southern Washington State is the latest on record; both Mount St. Helens and Mount Hood remain listed as active volcanoes.

Map 2-6 Historic Volcanic Eruptions



Source: Polk County NHMP (2009).

Probability Assessment

The United States Geological Survey-Cascades Volcano Observatory (CVO) produced volcanic hazard zonation reports for Mount St. Helens and Mount Hood in 1995 and 1997. The reports include a description of potential hazards that may occur to immediate communities. The CVO created an updated annual probability of tephra (ash) fall map for the Cascade region in 2001, which could be a rough guide for Polk County in forecasting potential tephra hazard problems. The map identifies the location and extent of the hazard.

The CVO Volcanic tephra fall map is based on the combined likelihood of tephra-producing eruptions occurring at Cascade volcanoes. Probability zones extend farther east of the range because winds blow from westerly directions most of the time. The map shows annual probabilities for a fall of one centimeter (about 0.4 inch). The patterns on the map show the dominating influence of Mount St. Helens as a tephra producer. Because small eruptions are more numerous than large eruptions, the probability of a thick tephra fall at a given locality is lower than that of a thin tephra fall. The annual probability of a fall of one centimeter or more of tephra is about 1 in 10,000 for Polk County. This is small when compared to other risks faced by the county. The USGS map on the previous page illustrates potential tephra fall in the region.

Based on the available data and research for Polk County the NHMP Steering Committee determined the **probability of experiencing volcanic activity is "low",** meaning one incident (or less) is likely within the next 100-year period.

Vulnerabilities

Risks for Polk County associated with regional volcanic activity would be ash fall, air quality, water quality, impacts to agricultural crops, and possible economic or social disruption due to air traffic issues due to the ash cloud.

At the time of this update, sufficient data was not available to determine volcanic eruption vulnerability in terms of explicit types and numbers of existing and future buildings, infrastructure, or critical infrastructure. Due to the nature of the hazard, it is impossible to predict the location or extent of future events with any probability, although it can be assumed that all residential and critical facilities and infrastructure within the County are at risk.

Though unlikely, the impacts of a significant ash fall are substantial. Persons with respiratory problems are endangered, transportation, communications, and other lifeline services are interrupted, drainage systems become overloaded/ clogged, buildings can become structurally threatened, and the economy takes a major hit. Any future eruption of a nearby volcano (e.g., Hood, St. Helens, or Adams) occurring during a period of easterly winds would likely have adverse consequences for the county.

As such, the NHMP Steering Committee rated the county as having a **"moderate" vulnerability to volcanic activity**, meaning that between 1-10% of the region's population or assets would be affected by a major disaster (volcanic ash).

More information on this hazard can be found in the Risk Assessment for Region 3, Mid-Willamette Valley, of the Oregon NHMP (2015).

Wildfire

Significant Changes Since Previous Plan:

The Wildfire hazard has been edited to reference new history since the 2009 Plan. This section has also been reformatted.

Characteristics

Wildfires occur in areas with large amounts of flammable vegetation that require a suppression response due to uncontrolled burning. Fire is an essential part of Oregon's ecosystem, but can also pose a serious threat to life and property particularly in the state's growing rural communities. Wildfire can be divided into three categories: interface, wildland, and firestorms. The increase in residential development in interface areas has resulted in greater wildfire risk. Fire has historically been a natural wildland element and can sweep through vegetation that is adjacent to a combustible home. New residents in remote locations are often surprised to learn that in moving away from built-up urban areas, they have also left behind readily available fire services providing structural protection.

The following three factors contribute significantly to Wildfire behavior and can be used to identify Wildfire hazard areas.

Topography: As slope increases, the rate of Wildfire spread increases. South-facing slopes are also subject to more solar radiation, making them drier and thereby intensifying Wildfire behavior. However, ridgetops may mark the end of Wildfire spread, since fire spreads more slowly or may even be unable to spread downhill.

Fuel: The type and condition of vegetation plays a significant role in the occurrence and spread of Wildfires. Certain types of plants are more susceptible to burning or will burn with greater intensity. Dense or overgrown vegetation increases the amount of combustible material available to fuel the fire (referred to as the "fuel load"). The ratio of living to dead plant matter is also important. The risk of fire is increased significantly during periods of prolonged drought as the moisture content of both living and dead plant matter decreases. The fuel's continuity, both horizontally and vertically, is also an important factor which contributes to the wildfire's rate of spread and crown fires.

Weather: The most variable factor affecting Wildfire behavior is weather. Temperature, humidity, wind, and lightning can affect chances for ignition and spread of fire. Extreme weather, such as high temperatures, low humidity, and high wind speeds, can lead to extreme Wildfire activity. By contrast, cooling, higher humidity, and little to no wind often signals reduced Wildfire occurrence and easier containment.

The frequency and severity of Wildfires is also dependent upon other hazards, such as lightning, drought, equipment use, railroads, recreation use, arson, and infestations. If not promptly controlled, Wildfires may grow into an emergency or disaster. Even small fires can threaten lives and resources, and destroy improved properties. In addition to affecting people, Wildfires may severely affect livestock and pets. Such events may require emergency watering/feeding, evacuation, and shelter.

The indirect effects of Wildfires can be catastrophic. In addition to stripping the land of vegetation and destroying forest resources, large, intense fires can harm the soil, waterways, and the land itself. Soil exposed to intense heat may lose its capability to absorb moisture and support life, and can burn seed sources within the topsoil layer. Exposed soils erode quickly and enhance siltation of rivers and streams, thereby enhancing flood potential, harming aquatic life, and degrading water quality. Lands stripped of vegetation are also subject to increased debris flow hazards, as described above.

Location and Extent

Wildfire hazard areas are commonly identified in regions of the Wildland Urban Interface (WUI). The interface is the urban-rural fringe where homes and other structures are built into a densely forested or natural landscape or adjacent to non-irrigated farmland. The interface area in Polk County is generally considered to be east of the coastal mountain range due to the combination of fuel conditions and residential development. If left unchecked, it is likely that fires in these areas will threaten lives and property. One challenge Polk County faces is from the increasing number of houses being built in the urban/rural fringe as compared to twenty years ago. The “interface” between urban or suburban areas and the resource lands has significantly increased the threat to life and property from fires. Responding to fires in the expanding Wildland Urban Interface area may tax existing fire protection systems beyond original design or current capability.

Ranges of the wildfire hazard are further determined by the ease of fire ignition due to natural or human conditions and the difficulty of fire suppression. The wildfire hazard is also magnified by several factors related to fire suppression/control, such as the surrounding fuel load, weather, topography, and property characteristics.

Fire susceptibility throughout the county dramatically increases in late summer and early autumn as summer thunderstorms with lightning strikes increases and vegetation dries out, decreasing plant moisture content and increasing the ratio of dead fuel to living fuel. However, various other factors, including humidity, wind speed and direction, fuel load and fuel type, and topography can contribute to the intensity and spread of wildland. In addition, common ignition sources of Wildfires include arson and negligence from industrial and recreational activities.

Polk County is approximately 90% forested with Douglas fir, spruce, and hemlock dominating the western half of the county; oak dominating the eastern half. The non-forested areas, east of the coast range, comprise either agricultural crop lands or urban development.

The actual fire hazard in these areas may be lower than expected because a high percentage of forest lands in Polk County are actively managed for timber. Harvested areas typically have lower fire risk because they are relatively free of dead and downed material that would contribute to the fuel load. In addition, forests within Polk County are relatively free of major insect and disease problems which often plague other forests in Oregon. Finally, typical rainfall amounts for Polk County are rated as either “moderately high” or “high”, averaging 40 to 80 inches per year. High rainfall also reduces the threat of wildfires.

Table 2-5 shows the following areas of special concern for WUI fires that were identified by each committee:

Table 2-5 Wildfire-Urban Interface

Community	Areas of Special Concern
Dallas	Populated areas of the interface adjoining natural cover and wildland areas. Can occur in hilly area around Bridlewood Water Treatment Plant, Mercer Reservoir, Watershed Infrastructure, and homes in SE portion of the community.
Falls City	Populated areas of the interface adjoining natural cover and wildland areas. Fire in the hills bordering the town could propagate into the City. Prior fire events have had favorable wind keeping the fire confined to the hills.
Independence	Populated areas of the interface adjoining natural cover and wildland areas. No damages occurred to date.
Monmouth	Populated areas of the interface adjoining natural cover and wildland areas. Droughts for last decade have increased elements compatible for wildfires; growing rural population leads to more accidental fires. Willamette Valley contains wheat crops, which are very prone to fire.

Source: 2009 Steering Committee (Updated in 2017)

History

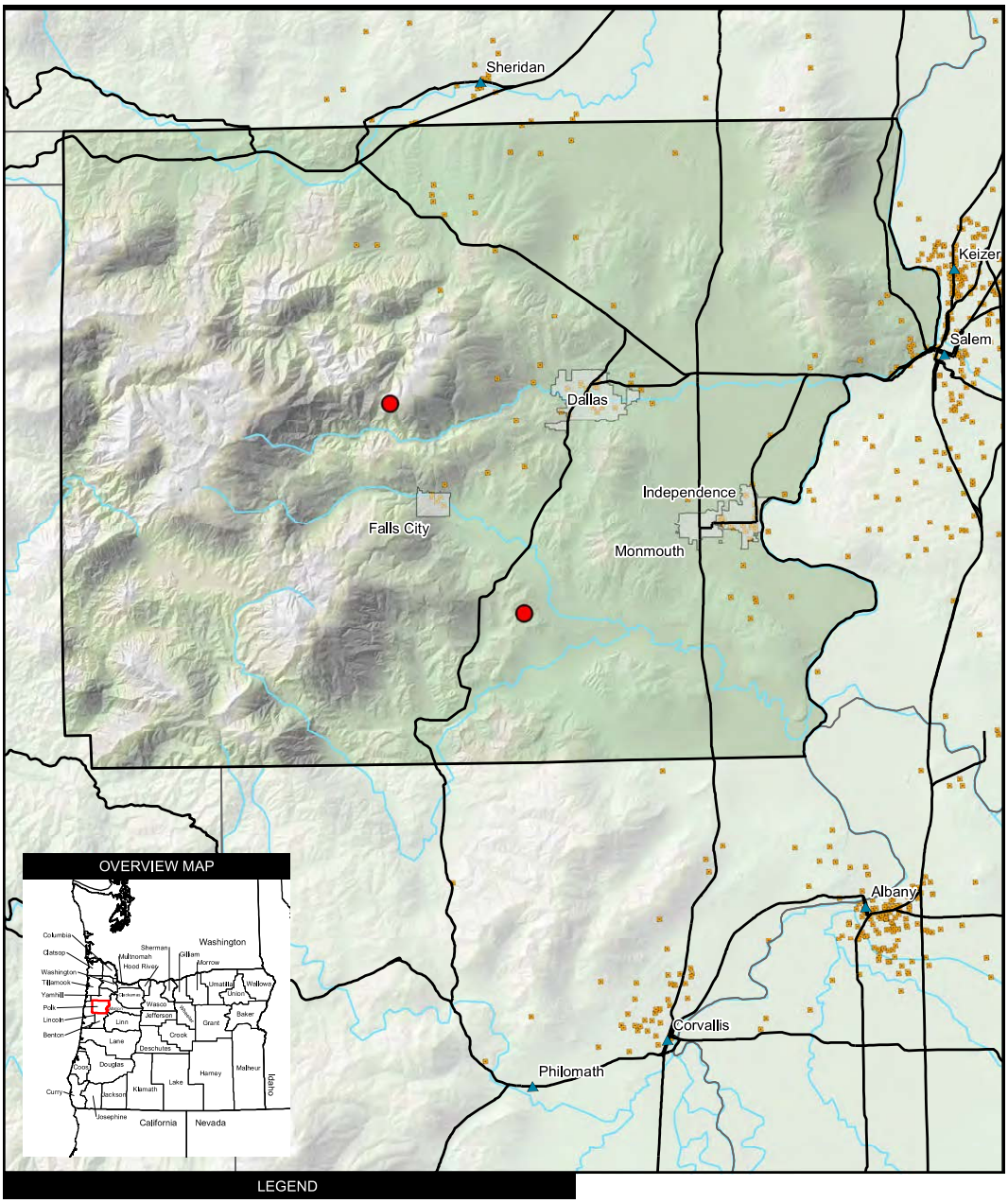
ODF records of historical fires show that minor wildland fires occur regularly in Polk County. Fire protection services have generally been able to contain these fires before they exceed 10 acres. The county's success in controlling wildland fires is likely due to a combination of well- run fire protection services, moderately high to high levels of rainfall, and the fact that most of the county's forests are disease-free and actively managed for timber.

Due to successful fire control, the minor wildland fires which have occurred in Polk County have damaged relatively few residential areas, scattered buildings, and natural resources in the affected forests. However, if a major wildland fire were to occur in the county, it would have the potential to severely impact residential structures, roads, power lines, and other critical infrastructure.

Significant conflagration fires have taken place in Polk County; such as the 1849 Siletz fire that burned at least two million acres of forestland (including 800,000 acres in portions of Lincoln and Polk counties), an unnamed fire in 1945 (12,785-acres), and the Rockhouse fire (5,000 acres), and Shady Lane fire (1,100 acres) in 1987. The Shady Lane fire, affecting the Rickreall Watershed, was declared a State Conflagration and received FEMA Fire Suppression Assistance and caused sediment damage to the Mercer Reservoir the sources of the City of Dallas' water supply.[22] Recent wildfires (1962-2004) are shown in Map 2-7.

[22] Polk County Community Wildfire Protection Plan (2009)

Map 2-7 Wildfire History (1962-2004)



Source: Polk County NHMP (2009).

There have been two significant wildfire events since the previous plan (as shown in *italics* below):

- *August 17, 2013. 200-acre wildfire along Highway 22 burned near a winery close to Dallas. Firefighters from Dallas, Yamhill, Polk County, Sheridan, Willamina, McMinnville and Depoe Bay were dispatched.*
- *July 24, 2015. 250- to 300-acre wildfire West of Monmouth – contained after several hours. No injuries or reported damages to property.*

Probability Assessment

Certain conditions must be present for significant interface fires to occur. The most common are hot, dry, and windy weather; the inability of fire protection forces to contain or suppress the fire; the occurrence of multiple fires that overwhelm committed resources; and a large fuel load (dense vegetation). Once a fire has started, several conditions influence its behavior, including fuel, topography, weather, drought, and development.

Based on the available data and research for Polk County the NHMP Steering Committee determined the **probability of experiencing a Wildfire is "moderate",** meaning one incident is likely within the next 75-year period.

Vulnerability Assessment

The 2009 Polk County Community Wildfire Protection Plan (CWPP) profiles two strategic planning areas: Zone 1 is the forested, mountainous area in the western portion of the county, and Zone 2 is the primarily agricultural areas to the east. Each zone is distinguished based on similar fuel conditions that would require similar initial attack techniques.

The risk rating presented below, and summarized in Table 2-6 and displayed in Map 2-8, is from the Polk County CWPP (2009) and serves to identify where certain constant variables are present.

Ignition Risk: *Most wildfires in Polk County are human-caused and the risk for wildfire ignition becomes greater as the density of homes increases. There are only a few homes in Zone 1, these being located on the eastern edge of the zone. The density of homes outside the incorporated cities is fairly uniform in Zone 2. However, there is a concentration of homes in the suburbs of West Salem and Dallas. Not surprisingly, the number of fire starts in these areas is higher than in most areas.*

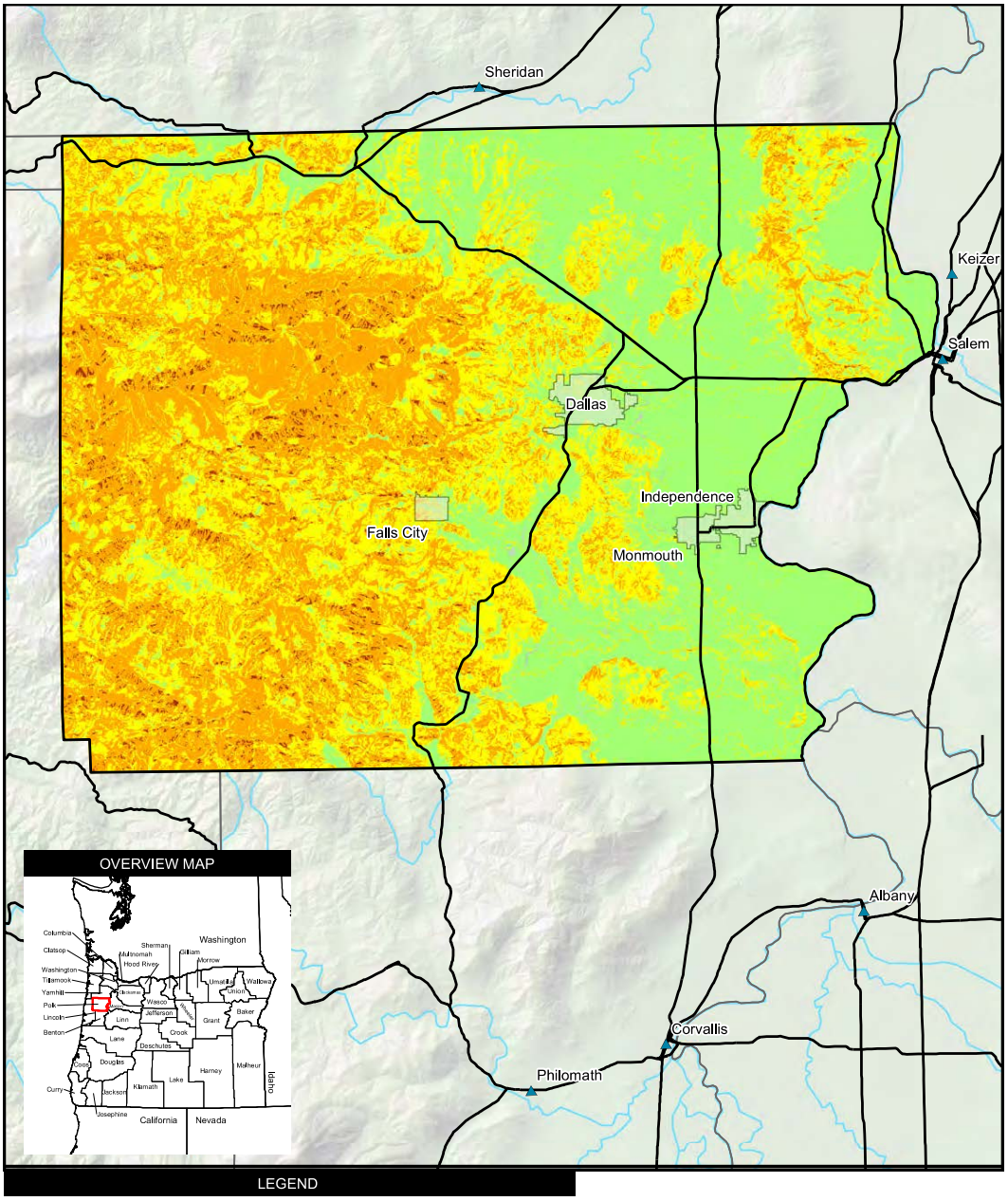
Hazard: *The high scores for this factor are primarily due to heavy fuel loads throughout both zones. Zone 1 does have heavier fuel loads overall, but the fuels in Zone 2 are considered flashy (easy to ignite and fast moving) which balances the heavier loads in Zone 1.*

Values: *Zone 1 has important natural resource values while Zone 2 has agricultural products and homes at risk from wildfire. Both have important infrastructure to be considered.*

Protection Capability: *While Zone 1 is vulnerable because response time from organized fire departments is high, it has proven mitigation efforts in place with loggers who are often on-site and have equipment for firefighting. Zone 2 lacks in community preparedness but response time from fire protection districts is good. Response capability for the Salem and Dallas Fire Departments is very strong.*

Overall Wildfire Risk Rating: *Both Zones 1 and 2 are considered a High Risk based on the combined scores of the four factors. Total scores that are more than 119 are considered in the High Risk category.*

Map 2-8 Wildfire Hazard Area



Source: Polk County NHMP (2009).

Table 2-6 Wildfire Risk Assessment Summary

Factor	Criteria	Possible Score	Zone 1 Score	Zone 2 Score
Ignition Risk	Wildfire History	5-20	10	20
	Home Density	0-10	0	2
	Other Wildfire Risk	0-10	5	10
Ignition Rating			*Moderate*	*High*
Hazard	Weather	20	20	20
	Slope	0-3	2	1
	Aspect	0-5	3	5
	Elevation	0-2	2	2
	Vegetation	0-20	20	20
	Crown Fire	0-10	10	5
Hazard Rating			*High*	*High*
Values	Natural Resources	0-15	15	8
	Home Density	0-30	0	7
	Infrastructure	0-20	20	20
Values Rating			*Moderate*	*Moderate*
Protection	Response Capability	0-36	36	8
	Community Preparedness	0-4	0	4
Protection Rating			*High*	*Moderate*
Total		0-195	**143**	**132**
Overall Risk Rating			**High**	**High**

Source: Polk County CWPP (2009)

A comprehensive risk and vulnerability assessment is not available. The Polk County CWPP provides some risk and vulnerability information related to Independence that has been incorporated into this plan as applicable.

Per the previous version of this plan the County has critical facilities and infrastructure located within areas of moderate, high, and very high risk.[23]

Moderate risk areas contain 21,451 residential structures (value $3.07B), 104 non-residential structures (value unknown), 18 government facilities (value $5.9M), six

[23] URS, 2009 Polk County Natural Hazards Mitigation Plan; values are in 2009 dollars.

emergency response facilities (value $9.9M), 20 educational facilities (value $45.8M), eight care facilities (value unknown), ten utilities (value $1.5M) and one dam (value $25M).

High risk areas contain 16,614 residential structures (value $2.4B), 58 non-residential structures (value unknown), four government facilities (value $851K), three emergency response facilities (value $3.6M), nine educational facilities (value $13.1M), four care facilities (value unknown), and six utility facilities (value $1.7M).

Very high risk areas contain 7,707 residential structures (value $1.1B), 13 non-residential structures (value unknown), three educational facilities (value unknown), and one utility facility (value unknown) with 2,664 residential structures (value $3.07) and eight non-residential structures (value unknown) in extreme fire risk areas.

As such, the NHMP Steering Committee rated the county as having a **"moderate" vulnerability to Wildfire hazards**, meaning that between 1-10% of the region's population or assets would be affected by a major disaster.

More information on this hazard can be found in the Risk Assessment for Region 3, Mid-Willamette Valley, of the Oregon NHMP (2015).

Windstorm

Significant Changes Since Previous Plan:

The Windstorm Hazard has been edited to reference new history since the 2009 Plan. This section has also been reformatted.

Characteristics

A windstorm is generally a short duration event involving straight-line winds and/or gusts in excess of 50 mph. The most persistent high winds take place along the Oregon Coast and in the Columbia River Gorge. High winds in the Columbia Gorge are well documented. The Gorge is the most significant east-west gap in the Cascade Mountains between California and Canada. Wind conditions in central Oregon are not as dramatic as those along the coast or in the Gorge, yet can cause dust storms or be associated with severe winter conditions such as blizzards. A majority of the destructive surface winds striking Oregon are from the southwest. Some winds blow from the east but most often do not carry the same destructive force as those from the Pacific Ocean.

Though tornadoes are not common in Oregon, these events do occasionally occur and sometime produce significant property damage and even injury. Tornadoes are the most concentrated and violent storms produced by earth's atmosphere, and can produce winds in excess of 300 mph. They have been reported in most of the regions throughout the state since 1887. Most of them are caused by intense local thunderstorms, common between April and October.

Location and Extent

The most common type of wind pattern affecting Polk County is straight-line winds, which originate as a downdraft of rain-cooled air, and spread out rapidly when they reach. Straight-line winds can produce gusts of up to 100 mph. For Polk County, the wind hazard levels are generally highest near the Willamette River and then fairly uniform across most of the rest of the county. In the mountainous areas, however, the level of wind hazard is strongly determined by local specific conditions of topography and vegetation cover. Mountainous terrain slows down wind movement, which is why Oregon's sheltered valley areas have the slowest wind speed in the state. However, in the foothills, the wind speeds may increase due to down-sloping winds from the mountains.

Although windstorms can affect the entire county, they are especially dangerous in developed areas with significant tree stands and major infrastructure, especially above ground utility lines. A windstorm will frequently knock down trees and power lines, damage homes, businesses, public facilities, and create a significant amount of storm related debris.

History

Windstorms with various intensity occur yearly. More destructive storms occur once or twice per decade, most recently in December 2015. One damaging windstorm (tornado) occurred north of Independence in Polk County, November 11, 1925. The tornado damaged

only a few structurally weak buildings and trees. Another tornado was documented in February, 1926 that damaged homes and trees in Polk County.

The following windstorms have occurred within, and/or near Polk County. Four (4) windstorm events were added to this hazard history section since the previous plan (shown in *italics* below):[24]

- November 10-11, 1951 (Statewide): Extensive timber, building, and utility losses and disruption. Damage was experienced statewide with wind speeds ranging from 40-80 mph.
- December 1951 (Statewide): Serious damage to buildings and utility system disruption. Statewide wind speeds ranging from 40-100 mph.
- December 1955 (Statewide): In addition to extensive damage to buildings, power and telephone lines throughout the state, heavy destruction occurred in the Willamette Valley orchards. Statewide wind speeds ranging from 55-70 mph.
- November 1958 (Statewide): Extensive timber, building, and utility losses and disruption. All highways closed at one or more points from fallen trees. Statewide wind speeds ranging from 50-75 mph.
- October 1962 (Columbus Day Storm, Statewide): Downed trees and power lines, utility disruption, the Columbus Day storm was the equivalent of a Category IV hurricane in terms of central pressures and wind speeds. The storm, which started east of the Philippines as Typhoon Freda, measured 1,000 miles long as it hit the West Coast. There were a total of 38 fatalities, 84 houses destroyed, 5,000 houses severely damaged, and $200M damages statewide. Statewide wind speeds ranging from 29-138. Wind speeds in Portland hit 116 mph.
- March 1963 (Statewide): Widespread destruction with wind speeds ranging from 39-100 mph.
- October 1967 (Statewide): Extensive agricultural, timber, power and telephone utilities, and home loses. There was one fatality and 15 injuries with wind speeds ranging from 70- 115 mph,
- March 1971 (Most of Oregon): Damages included extensive roof damage, toppled trees, power line breakages, and extensive utility disruption. Statewide wind speeds ranging from 40-71 mph.
- November 1981 (Most of Oregon): Most destructive windstorm since the 1962 Columbus Day storm. There were 11 fatalities and $50M damages statewide. Average sustained wind speeds of 57 mph, with wind speeds ranging from 75-92 mph along coast, gusts.

[24] Taylor, George H., and Ray Hatton, 1999, The Oregon Weather Book; The Spatial Hazard Events and Losses Database for the United States, [Online Database]. Columbia, SC: University of South Carolina. Available at http://www.sheldus.org; U.S. Department of Commerce. National Climatic Data Center. Available at https://www.ncdc.noaa.gov/; National Weather Service Forecast Office. Available at http://www.wrh.noaa.gov/pqr/paststorms/wind.php; FEMA Disaster Declarations for Oregon. Available at https://www.fema.gov/disasters/grid/state-tribal-government/88?field_disaster_type_term_tid_1=All#

- February 1989 (Statewide): Together with below-freezing temperatures (-40°F) and stiff winds, more than one foot of snow fell on some areas. Damages included burst pipes, flooding and water damage, Icy roads caused numerous accidents and injuries, several fires were also reported.
- December 1995 (Statewide): Very wet soil from an unusually rainy fall resulted in the toppling of many trees in the Willamette Valley. 100-119 mph coastal area winds creating extensive tree damage to forests, structures, autos, and utilities. (FEMA-1107-DR-OR)
- November 1997 (Western Oregon): Wind speed hit 52 mph in Willamette Valley. Trees were uprooted and considerable damage to small airports was reported.
- February 2002 (Western Oregon): Strongest storm to strike western Oregon in several years. Included downed power lines (due to tree fall), damage to buildings, and water supply problems (lack of power). Resulted in a Presidential declaration for coastal counties who experienced 70 mph winds, south of Polk County. Estimated damage costs $6.14 million. (FEMA-1405-DR-OR)
- January 2006 (Western Oregon): Wind speeds up to 58 mph caused a total of $500K in damages within Yamhill, Polk, Marion, Clackamas, Columbia, Washington, and Multnomah Counties.
- February 2006 (Western Oregon): Wind speeds up to 77 mph caused a total of $277K in damages within Linn, Lane, Marion, Benton, Polk, and Yamhill Counties.
- December 2007 (Most of Oregon): Heavy snowfall, rains, rapid temperature warming created widespread flooding, tree blockages, landslides, transportation and utility disruptions, and 5 deaths in Oregon. Statewide wind speeds ranging from 50-100 mph and damages totaled $180M.
- *January 17–21, 2012 (Willamette Valley): A severe winter storm that included high wind speeds, flooding, landslides, and mudslides.* (FEMA-4055-DR-OR)
- *March 11, 2012 (Western Oregon): Executive Order No. 12-06: State of Emergency declared in Polk County due to damaging winds, heavy rains, flooding, mudslides, and landslides impacting Federal highways. Damages are estimated at $5,856,881 of damage to federal-aid highways in the region.*
- *February 6–14, 2014 (Western Oregon): A strong winter storm system affected the Pacific Northwest February 6–10, 2014. The storm brought a mixture of arctic air, strong east winds, significant snowfall and freezing rain to several counties in northwest Oregon.* (FEMA-4169-DR-OR, Polk not included in declaration)
- *December 6-23, 2015 (Western Oregon): A severe winter storm, including straight-line winds, flooding, and landslides and mudslides occurring Dec. 6-23, 2015.Total estimated damages amounted to $2.6M of individual assistance and $24.4M of public assistance, 894 residences were impacted (11 destroyed, 75 major damage). Per capita damage estimate within Polk County of $5.24.* (FEMA-4258-DR-OR)

Several additional, small windstorm events have occurred since the previous plan, see the Storm Events Database provided by the National Oceanic and Atmospheric Administration for more information.

Probability Assessment

Windstorms in the county usually occur in the winter from October to March, and their extent is determined by their track, intensity (the air pressure gradient they generate), and local terrain. Summer thunderstorms may also bring high winds along with heavy rain and/or hail. The National Weather Service uses weather forecast models to predict oncoming windstorms, while monitoring storms with weather stations in protected valley locations throughout Oregon.

Table 2-7 below shows the wind speed probability intervals that structures 33 feet above the ground would expect to be exposed to within a 25, 50 and 100-year period. The table shows that structures in Region 3, which includes Polk County, can expect to be exposed to 60 mph winds in a 25-year recurrence interval (4% annual probability).

Table 2-7 Probability of Severe Wind Events (Region 3)

	25-Year Event (4% annual probability)	50-Year Event (2% annual probability)	100-Year Event (1% annual probability)
Region 3: Mid/Southern Willamette Valley	60 mph	68 mph	75 mph

Source: Oregon State Natural Hazard Mitigation Plan, 2009

Based on the available data and research for Polk County, the NHMP Steering Committee determined the **probability of experiencing a windstorm is "high",** meaning one incident is likely within the next 35-year period.

Vulnerabilities

Many buildings, utilities, and transportation systems within Polk County are vulnerable to wind damage. This is especially true in open areas, such as natural grasslands or farmlands. It is also 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 of time, impacting emergency operations. In addition, up-rooted or shattered trees can down power and/or 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. In Polk County, trees are more likely to blow over during the winter (wet season).

A comprehensive risk and vulnerability assessment is not available for the windstorm hazard. Due to the nature of the hazard, it is impossible to predict the location or extent of future events with any probability, although it can be assumed that all residential and critical facilities and infrastructure within the County are at risk.

As such, the NHMP Steering Committee rated the county as having a **"high" vulnerability to windstorm hazards**, meaning that more than 10% of the region's population or assets would be affected by a major disaster.

More information on this hazard can be found in the Risk Assessment for Region 3, Mid-Willamette Valley, of the Oregon NHMP (2015).

Winter Storm

Significant Changes Since Previous Plan:

The Winter Storm hazard has been edited to reference new history since the 2009 Plan. This section has also been reformatted.

Characteristics

Winter storms affecting Polk County are generally characterized by a combination of heavy rains and high winds throughout the county, sometimes with snowfall, especially at higher elevations. Heavy rains can result in localized or widespread flooding, as well as debris slides and landslides. High winds commonly result in tree falls which primarily affect the electric power system, but which may also affect roads, buildings and vehicles. This chapter deals primarily with the snow and ice effects of winter storms.

The winter storms that affect Polk County typically are not local events affecting only small geographic areas. Rather, winter storms are usually large cyclonic low-pressure systems that move in from the Pacific Ocean and affect large areas of Oregon and/or the whole Pacific Northwest. These storms are most common from October through March.

Ice storms are comprised of cold temperatures and moisture, but subtle changes can result in varying types of ice formation which may include freezing rain, sleet and hail. Of these, freezing rain can be the most damaging of ice formations.

Outside of mountainous areas, significant snow accumulations are much less likely in western Oregon than on the east side of the Cascades. However, if a cold air mass moves northwest through the Columbia Gorge and collides with a wet Pacific storm, then a larger than average snow fall may result.

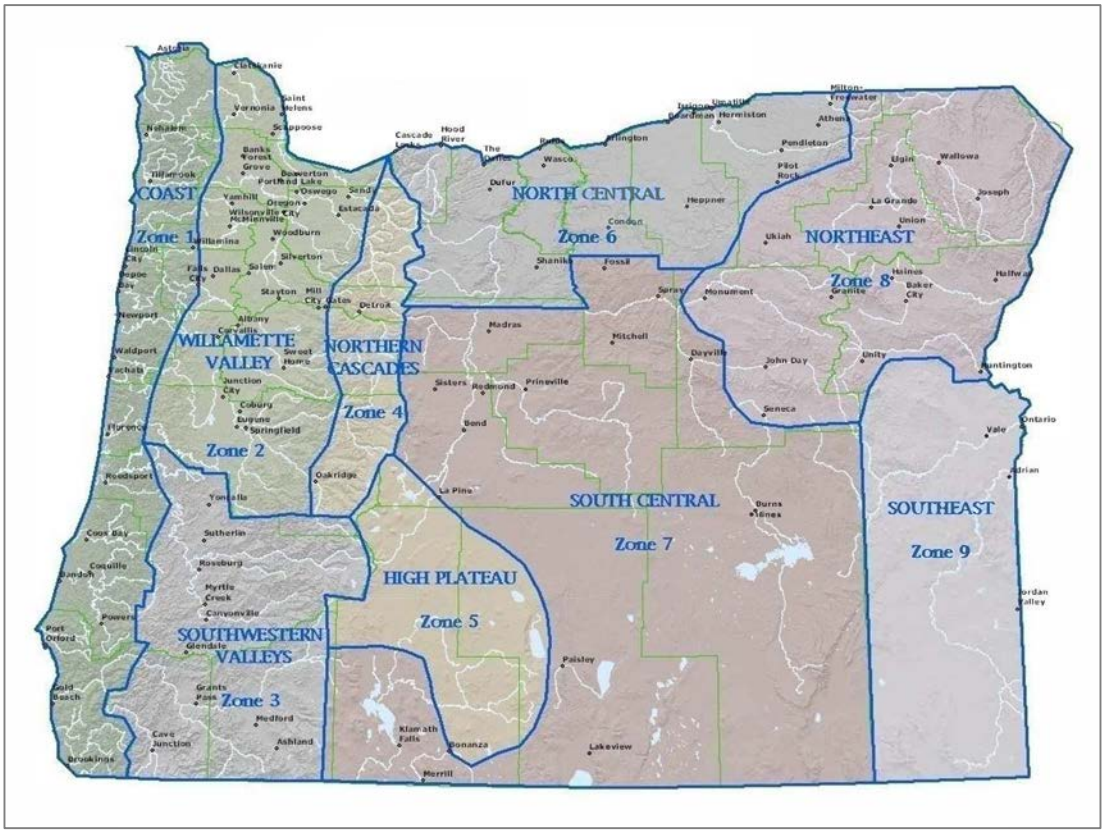
Location and Extent

Ice storms occasionally occur in northern areas of Oregon, resulting from cold air flowing westward through the Columbia Gorge. Sleet and hail can create hazards for motorists when it accumulates, but freezing rain can cause the most dangerous conditions within a community. Ice buildup can bring down trees, communication towers, and wires creating hazards for property owners, motorists, and pedestrians alike. The most common freezing rain problems occur near the Columbia Gorge. The Gorge is the most significant east-west air passage through the Cascades. Rain arriving from the west can fall on frozen streets, cars, and other sub-freezing surfaces, creating dangerous conditions.

The National Climatic Data Center has established climate zones in the United States for areas that have similar temperature and precipitation characteristics. Oregon's latitude,

topography, and proximity to the Pacific Ocean give the state diversified climates. Polk County is located within Zone 1: Coast and Zone 2: Willamette Valley. The climate in Zone 1 and Zone 2 generally consists of cool, wet winters and warm, dry summers; the coastal area of Polk County (Zone 1) maintains cooler temperatures during the summer.[25] The wet winters result in potentially destructive winter storms that produce heavy snow, ice, rain and freezing rain, and high winds generally within the Zone 2 portion of the county.

Figure 2-9 Oregon Climate Divisions



Source: Oregon Climate Service,

The principal types of winter storms that occur include:

- **Snowstorms:** require three variables: cold air, moisture, and air disturbance. In Oregon, the further inland and north one moves, the more snowfall can be expected. Blizzards are included in this category.
- **Ice storms:** are a type of winter storm that forms when a layer of warm air is trapped between two layers of cold air. Frozen precipitation melts when it hits the warm air layer, and refreezes when hitting the cold air layer below the inversion. Ice storms can include sleet (when the rain freezes before hitting the ground) or freezing rain (when the rain freezes once hitting the ground).

[25] Oregon Climate Service, "Climate of Polk County,"

- **Extreme Cold:** Often times low temperatures accompany winter storms. Low temperatures can become dangerous because snow and ice storms can cause power outages, leaving many people without adequate heating.

Unlike most other hazards, it is not simple to systematically map winter storm hazard zones. The entire County is susceptible to damaging severe weather. Winter storms that bring snow and ice can impact infrastructure, business, and individuals. Resources that exist at higher elevations have an increased risk of snow and ice, however, the entire County is susceptible to dangerous winter storm conditions.

History

Winter storms with various intensities occur yearly. However, more destructive winter storms occur once or twice per decade, most recently in December/ January 2016. The following winter storms have occurred within, or near Polk County. Seven (7) winter storm events were added to this hazard history section since the previous Plan (shown in *italics* below).[26]

- January 1950 (Willamette Valley): Winter storm event with the heaviest snowfall since 1890. Many highway closures occurred with considerable property damage. A total of 68 inches of snow fell in Polk County. Damages included floods caused by melting snow, collapsed buildings, fallen trees, utility disruption, and sub-freezing temperatures that caused frozen pipes.
- January 1956 (Western Oregon): The snowstorm began with 3.5 inches of snowfall which was followed by sub-freezing temperatures. Freezing temperatures and heavy fog disrupted transportation and caused school closures.
- March 1960 (Statewide): Large snowstorm with the heaviest snowfall accumulation since 1950, 11-inches, resulted in numerous accidents, several with serious injuries throughout Polk County.
- January 1963 (Willamette Valley): Four inches of snowfall and large amounts of ice caused transportation and utility disruption.
- January 1969 (Statewide): Ten inches of snowfall was reported in Dallas leading to school and business closures, transportation and utility disruption. Sub-freezing temperatures caused burst pipes.
- November 1970 (County): An ice event caused electrical, heat, transportation and utility systems disruption, small fires, and school closures.
- January 1978 (Willamette Valley): A freezing rain event led to transportation disruption with eight deaths and numerous accidents.

[26] Taylor, George H., and Ray Hatton, 1999, The Oregon Weather Book; The Spatial Hazard Events and Losses Database for the United States, [Online Database]. Columbia, SC: University of South Carolina. Available at http://www.sheldus.org; U.S. Department of Commerce. National Climatic Data Center. Available at https://www.ncdc.noaa.gov/; National Weather Service Forecast Office. Available at http://www.wrh.noaa.gov/pqr/paststorms/wind.php; FEMA Disaster Declarations for Oregon. Available at https://www.fema.gov/disasters/grid/state-tribal-government/88?field_disaster_type_term_tid_1=All#

- January 1980 (Statewide): A series of storms brought snow, ice, wind, and freezing rain and caused six fatalities.
- February 1985 (Statewide): Western valleys received between 2-4 inches of snow which led to massive power failures (tree limbs broke power lines).
- December 1985 (Willamette Valley): Heavy snowfall was reported throughout the region.
- March 1988 (Statewide): Strong winds associated with heavy snow were reported throughout the state.
- February 1989 (Statewide): Together with below-freezing temperatures (-40°F) and stiff winds, more than one foot of snow fell on some areas. Damages included burst pipes, flooding and water damage, Icy roads caused numerous accidents and injuries, several fires were also reported.
- February 1990 (Statewide): The Willamette Valley was coated with 2 to 4 inches of snowfall, while the higher hills around Portland received up to 1 foot.
- December 1992 (Western Oregon): Heavy snow fell throughout western Oregon causing a temporary closure of Interstate-5.
- February 1993 (Western Oregon): About one foot of heavy snow fell within a 24-hour period. The wet snow load broke tree limbs and powerlines which caused utility disruption.
- February 1996 (portions of Willamette Valley): Freezing rain fell for two days leading to the disruption of transportation, one death, and numerous accidents.
- Winter 1998-1999 (Statewide): Series of storms led to one of the snowiest winters in Oregon history.
- December 2003 – January 2004 (Statewide): Wet snow blanketed highways in the Willamette Valley, causing power lines and trees to topple. Most airports experienced closures and delays. (FEMA-1510-DR-OR).
- December 2006 (Most of Oregon): Polk County federally declared disaster due to damages from freezing rain. (FEMA-1632-DR-OR)
- December 2007 (Most of Oregon): Heavy snowfall, rains, rapid temperature warming created widespread flooding, tree blockages, landslides, transportation and utility disruptions, and 5 deaths in Oregon. Statewide wind speeds ranging from 50-100 mph and damages totaled $180M.
- December 2008 (Willamette Valley): A series of storms dropped feet of snow over portions of the Willamette Valley. The onset of cold air moved in around December 14 and lingered through Christmas morning (FEMA-1824-DR-OR)
- *November 2011 (Polk County): Heavy snowfall occurred with accumulations between 5 and 7 inches.*
- *January 17–21, 2012 (Willamette Valley): A severe winter storm that included high wind speeds, flooding, landslides, and mudslides.* (FEMA-4055-DR-OR)
- *March 2012 (Western Oregon): A mixture of snow, rain, and wind occurred throughout much of the coast and Willamette Valley. Storm included snowfall*

accumulations of up to 7-inches and included damages due to downed trees and closed roads.

- *December 2013 (Willamette Valley): Region experienced heavy snowfall with accumulations up to 9-inches.*
- *February 6–14, 2014 (Western Oregon): A strong winter storm system affected the Pacific Northwest February 6–10, 2014. The storm brought a mixture of arctic air, strong east winds, significant snowfall and freezing rain to several counties in northwest Oregon. (FEMA-4169-DR-OR, Polk County was not included in declaration)*
- *December 6-23, 2015 (Western Oregon): A severe winter storm, including straight-line winds, flooding, and landslides and mudslides occurring Dec. 6-23, 2015.Total estimated damages amounted to $2.6M of individual assistance and $24.4M of public assistance, 894 residences were impacted (11 destroyed, 75 major damage). Per capita damage estimate within Polk County of $5.24. (FEMA-4258-DR-OR)*
- *December 2016 (Western Oregon): A winter storm event affected the region bringing snow, high winds, freezing rain, and flooding. (FEMA-4296-DR-OR, Polk County was not included in declaration)*

Probability Assessment

The recurrence interval for a severe winter storm is about every 13 years. However, there can be many localized storms between these periods from November through February. Polk County experiences minor winter storms a couple times every year, to every other year and more severe winter storms once or twice per decade.

Based on the available data and research for Polk County the NHMP Steering Committee determined the **probability of experiencing a winter storm is "high",** meaning one incident is likely within the next 35-year period.

Vulnerabilities

Given current available data, no quantitative assessment of the risk of winter storm was possible at the time of this NHMP update. However, assessing the risk to the county from winter storms should remain an ongoing process determined by community characteristics and physical vulnerabilities. Weather forecasting can give County resources (emergency vehicles, warming shelters) time to prepare for an impending storm, but the changing character of the county population and resources will determine the impact of winter storms on life and property in Polk County.

The most likely impact of snow and ice events on Polk County are road closures limiting access/egress to/from some locations, especially roads to higher elevations. Winter storms with heavy wet snow or high winds and ice storms may also result in power outages from downed transmission lines and/or poles.

Winter storms which bring snow, ice and high winds can cause significant impacts on life and property (for more information on windstorms see the previous section). Deaths related to winter storms can occur as a result of traffic accidents on icy roads, and hypothermia from prolonged exposure to the cold. Low temperatures and temporary loss of home

heating can be particularly hard on the elderly, young children and other vulnerable individuals.

Property is at risk due to flooding and landslides that may result if there is a heavy snowmelt. Additionally, ice, wind and snow can affect the stability of trees, power and telephone lines and TV and radio antennas. Down trees and limbs can become major hazards for houses, cars, utilities and other property. Such damage in turn can become major obstacles to providing critical emergency response, police, fire and other disaster recovery services.

Severe winter weather also can cause the temporary closure of key roads and highways, air and train operations, businesses, schools, government offices and other important community services. Below freezing temperatures can also lead to breaks in un-insulated water lines serving schools, businesses, industries, and individual homes. All of these effects, if lasting more than several days, can create significant economic impacts for the affected communities, surrounding region, and region. In the rural areas of Oregon severe winter storms can isolate small communities, farms, and ranches.

A comprehensive risk and vulnerability assessment is not available for the winter storm hazard. Due to the nature of the hazard, it is impossible to predict the location or extent of future events with any probability, although it can be assumed that all residential and critical facilities and infrastructure within the County are at risk.

As such, the NHMP Steering Committee rated the county as having a **"high" vulnerability to winter storm hazards**, meaning that more than 10% of the region's population or assets would be affected by a major winter storm disaster.

More information on this hazard can be found in the Risk Assessment for Region 3, Mid-Willamette Valley, of the Oregon NHMP (2015).

Federal Disaster and Emergency Declarations

Reviewing past events can provide a general sense of the hazards that have caused significant damage in the county. Where trends emerge, disaster declarations can help determine priority hazard mitigation projects.

President Dwight D. Eisenhower approved the first federal disaster declaration in May 1953 following a tornado in Georgia. Since then, federally declared disasters have been approved within every state as a result of natural hazard related events. As of June 2017, FEMA has approved a total of 32 major disaster declarations, 65 fire management assistance declarations, and two (2) emergency declarations in Oregon.[27] When governors ask for presidential declarations of major disaster or emergency, they stipulate which counties in their state they want included in the declaration. Table 2-8 summarizes the major disasters declared in Oregon that affected Polk County, since 1953. The table shows that there have been ten (10) major disaster declarations for the county (two since the previous plan). All of which were related to weather events resulting primarily in flooding, landslides, and wind related damage.

Fire Management Assistance may be provided after a State submits a request for assistance to the FEMA Regional Director at the time a "threat of major disaster" exists. There has been one fire management assistance declaration on record for the county.

An Emergency Declaration is more limited in scope and without the long-term federal recovery programs of a Major Disaster Declaration. Generally, federal assistance and funding are provided to meet a specific emergency need or to help prevent a major disaster from occurring. Polk County has only one recorded Emergency Declaration related to the 2005 Hurricane Katrina evacuation.

[27] FEMA, *Declared Disasters by Year or State*, http://www.fema.gov/news/disaster_totals_annual.fema#markS. Accessed December, 2016.

Table 2-8 FEMA Major Disaster (DR), and Emergency (EM), and Fire Management Assistance (FMA) Declarations for Polk County

Declaration Number	Declaration Date	Incident Period		Incident	Individual Assistance	Public Assistance Categories
		From	To			
DR-184	12/24/1964	12/24/1964	12/24/1964	Heavy rains and flooding	Yes	A, B, C, D, E, F, G
DR-413	1/25/1974	1/25/1974	1/25/1974	Severe Storms, Snowmelt, Flooding	Yes	A, B, C, D, E, F, G
DR-1099	2/9/1996	2/4/1996	2/21/1996	Severe Storms/Flooding	Yes	A, B, C, D, E, F, G
DR-1510	2/19/2004	12/26/2003	1/14/2004	Severe Winter Storm	None	A, B, C, D, E, F, G
DR-1632	3/20/2006	12/18/2005	1/21/2006	Severe Storms, Flooding, Landslides, and Mudslides	None	A, B, C, D, E, F, G
DR-1683	2/22/2007	12/14/2006	12/15/2006	Severe Winter Storm and Flooding	None	A, B, C, D, E, F, G
DR-1733	12/8/2007	12/1/2007	12/17/2007	Severe Storms, Flooding, Landslides, and Mudslides	None	A, B, C, D, E, F, G
DR-1824	3/2/2009	12/13/2008	12/26/2008	Severe Winter Storm, Record and Near Record Snow, Landslides, and Mudslides	None	A, B, C, D, E, F, G
DR-4055	3/2/2012	1/17/2012	1/21/2012	Severe Winter Storm, Flooding, Landslides, and Mudslides	None	A, B, C, D, E, F, G
DR-4258	2/17/2016	12/6/2015	12/23/2015	Oregon Severe Winter Storms, Straight-line Winds, Flooding, Landslides, and Mudslides	None	A, B, C, D, E, F, G
FM-2066	10/10/1987	10/9/1987	-	Shady Lane Fire	None	-
EM-3228	9/7/2005	8/29/2005	10/1/2005	Hurricane Katrina Evacuation	None	B

Source: FEMA, Oregon Disaster History. Major Disaster Declarations.

Vulnerability Summary

Community vulnerabilities are an important component of the NHMP risk assessment. For more in-depth information regarding specific community vulnerabilities, reference Volume II, Jurisdictional Addenda and Appendix B: Community Profile. Changes to population, economy, built environment, critical facilities, and infrastructure have not significantly influenced vulnerability. New development has complied with the standards of the Oregon

Building Code and the county's development code including their floodplain ordinance. Data sources for the following community vulnerability information can be found in Appendix B – *Community Profile*, unless otherwise noted below.

Population

The socio-demographic qualities of the community population such as language, race and ethnicity, age, income, and educational attainment are significant factors that can influence the community's ability to cope, adapt to and recover from natural disasters. Historically, 80 percent of the disaster burden falls on the public.[28] Of this number, a disproportionate burden is placed upon special needs groups, particularly children, the elderly, the disabled, minorities, and low-income persons. Population vulnerabilities can be reduced or eliminated with proper outreach and community mitigation planning.

Population Vulnerabilities

- As of 2015, approximately 17% of Polk County's population is over the age of 64; that number is projected to rise to about 19% (or roughly 22,000 individuals) by 2035.
- The Polk County age dependency ratio[29] is 58.3, which is higher than that of the State of Oregon (52.3); the age dependency figure for the county is expected to increase to 60.6 by the year 2035.
- Polk County's real median income is decreasing, with the largest decreases in Independence and Monmouth.
- Approximately 17% of the total Polk County population lived at or below the poverty line in 2014, with 7.3% in "deep poverty" (earning less than half the federal poverty level).
- Approximately 11.7% of families are below the poverty line (9% for families with children).
- While over 90% of the population over the age of 25 has graduated high school or higher and about 29% have a bachelor's degree or higher, the cities of Falls City and Independence have about 20% of their population without a high school diploma (or equivalent).
- Approximately 10% of the population between the ages of 18-64 are without health insurance.
- Approximately 15% of the Polk County population is estimated to have a disability. Of that, approximately 4,600 individuals over 64 (38%) are disabled.
- Approximately 52% of Polk County renters spend more than 30% of their income on housing.

Economy

Economic diversification, employment and industry are measures of economic capacity. However, economic resilience to natural disasters is far more complex than merely restoring

[28] Hazards Workshop Session Summary #16, *Disasters, Diversity, and Equity*, University of Colorado, Boulder (2000).
[29] Age Dependency Ratio: the ratio of population typically not in the work force (less than 15, greater than 64)

employment or income in the local community. Building a resilient economy requires an understanding of how the component parts of employment sectors, workforce, resources and infrastructure are interconnected in the existing economic picture. The current and anticipated financial conditions of a community are strong determinants of community resilience, as a strong and diverse economic base increases the ability of individuals, families and the community to absorb disaster impacts for a quick recovery.

Economic Vulnerabilities

- According to the Oregon Employment Department, Polk County unemployment has decreased from 10.6% in 2010 to less than 5.7% in 2016.
- The largest sectors of employment in Polk County are Local Government (18.6%), Manufacturing (11.8%), Trade, Transportation, and Utilities (11.3%), Natural Resources and Mining (9.4%), and Leisure and Hospitality (8.3%).
- The Professional and Business Services sector is expected to have the most growth from 2015 to 2024 at 28%. Education and Health Services (17%) and Construction (17%) are the next closest growth sectors.

Environment

The capacity of the natural environment is essential in sustaining all forms of life including human life, yet it often plays an underrepresented role in community resiliency to natural hazards. The natural environment includes land, air, water and other natural resources that support and provide space to live, work and recreate.[30] Natural capital such as wetlands and forested hill slopes play significant roles in protecting communities and the environment from weather-related hazards, such as flooding and landslides. When natural systems are impacted or depleted by human activities, those activities can adversely affect community resilience to natural hazard events.

Environmental Vulnerabilities

- Forest, wetland, and riparian ecosystems are particularly vulnerable to drought, wildfire, and severe storm impacts.

Built Environment, Critical Facilities, and Infrastructure

Critical facilities (i.e. police, fire, and government facilities), housing supply and physical infrastructure are vital during a disaster and are essential for proper functioning and response. The lack or poor condition of infrastructure can negatively affect a community's ability to cope, respond and recover from a natural disaster. Following a disaster, communities may experience isolation from surrounding cities and counties due to infrastructure failure. These conditions force communities to rely on local and immediately available resources.

[30] Mayunga, J. "Understanding and Applying the Concept of Community Disaster Resilience: A capital-based approach. Summer Academy for Social Vulnerability and Resilience Building," (2007).

Housing Vulnerabilities

- Manufactured dwellings and other non-permanent residential structures account for *7.5%* of the housing in Polk County. Manufactured dwellings account for 27.2% of the housing in Falls City. These structures are particularly vulnerable to certain natural hazards, such as earthquake, windstorms, and heavy flooding events.
- Based on U.S. Census data, approximately 60% of the residential housing in Polk County was built before the current seismic building standards of 1993 (around 75% in Falls City).[31]
- Approximately 30% of residential structures were constructed prior to the local implementation of the flood elevation requirements of the 1970's (county Flood Insurance Rate Maps –FIRMs- were not completed until the late 1970s and early 1980s).
- The housing vacancy rate in Polk County was estimated at just under 7% in 2014 (around 12% in Falls City).

Critical Facilities and Infrastructure Vulnerabilities

- Virtually all state and county roads and bridges in Polk County are vulnerable to multiple hazards such as flooding, landslides, and earthquakes. Impacts to the transportation system can result in the isolation of vulnerable populations, limit access to critical facilities, such as hospitals, and adversely impact local commerce, employment and economic activity.
- There is one general hospital in the county located in Dallas.
- All of Polk County's power is generated outside the region; there is no redundancy in power transmission and only limited redundancy in the power distribution network.
- Polk County contains two (2) "high threat potential" dams (Croft and Mercer reservoirs) and seven (7) "significant threat potential" dams.

National Flood Insurance Program (NFIP) Vulnerability

FEMA modernized the Polk County Flood Insurance Rate Maps (FIRMs) in December 2006. The table below shows that as of December 2016, Polk County (including NFIP participating incorporated cities except for Salem) has 428 National Flood Insurance Program (NFIP) policies in force. Of those, 183 are for properties that were developed before development of the initial FIRM. The last Community Assistance Visit (CAV) for Polk County was on August 22, 2000 (the most recent CAV was for Dallas was June 2004). The county is a member of the Community Rating System (CRS) and has a Class 8 rating; none of the incorporated cities are current CRS members. The table shows that the majority of flood insurance policies are for residential structures, primarily single-family homes.

There have been 40 paid claims in the county totaling just over $682,000 (33 Pre-FIRM claims paid and zero (0) substantial damage claims paid to date). In addition, there is one (1)

[31] Ibid.

Repetitive Loss (RL) Property[32] located in Polk County and no Severe Repetitive Loss Properties.[33]

Table 2-9 Flood Insurance Detail

Jurisdiction	Effective FIRM and FIS	Initial FIRM Date	Total Policies	Pre-FIRM Policies	Policies by Building Type: Single Family	2 to 4 Family	Other Residential	Non-Residential	Minus Rated A Zone
Polk County	-	-	428	183	334	27	25	42	28
Unincorporated	12/19/2006	2/15/1978	189	95	150	6	0	33	17
Dallas	12/19/2006	4/5/1988	156	68	131	14	6	5	8
Falls City	12/19/2006	7/7/1981	0	0	0	0	0	0	0
Independence	12/19/2006	4/5/1988	61	16	38	0	19	4	3
Monmouth	12/19/2006	4/5/1988	22	4	15	7	0	0	0

Jurisdiction	Insurance in Force	Total Paid Claims	Pre-FIRM Claims Paid	Substantial Damage Claims	Total Paid Amount	Repetitive Loss Properties	Severe Repetitive Loss Properties	CRS Class Rating	Last CAV
Polk County	$ 93,520,500	40	33	0	$ 682,241	1	0	-	-
Unincorporated	$ 37,538,000	31	25	0	$ 578,415	1	0	8	8/22/2000
Dallas	$ 33,852,300	9	8	0	$ 103,826	0	0		6/3/2004
Falls City	$ -	0	0	0	$ -	0	0		none
Independence	$ 16,665,200	0	0	0	$ -	0	0		4/20/2004
Monmouth	$ 5,465,000	0	0	0	$ -	0	0		4/20/2004

Source: Information compiled by Department of Land Conservation and Development, September 2016.
Note 1: The data in this table differs from the data in Figure 2-12 due to the date of the underlying data.
Note 2: NFIP Information for the cities of Salem and Willamina is not provided in this NHMP. See Salem's Stand-alone NHMP and Yamhill County's NHMP for information for those cities.

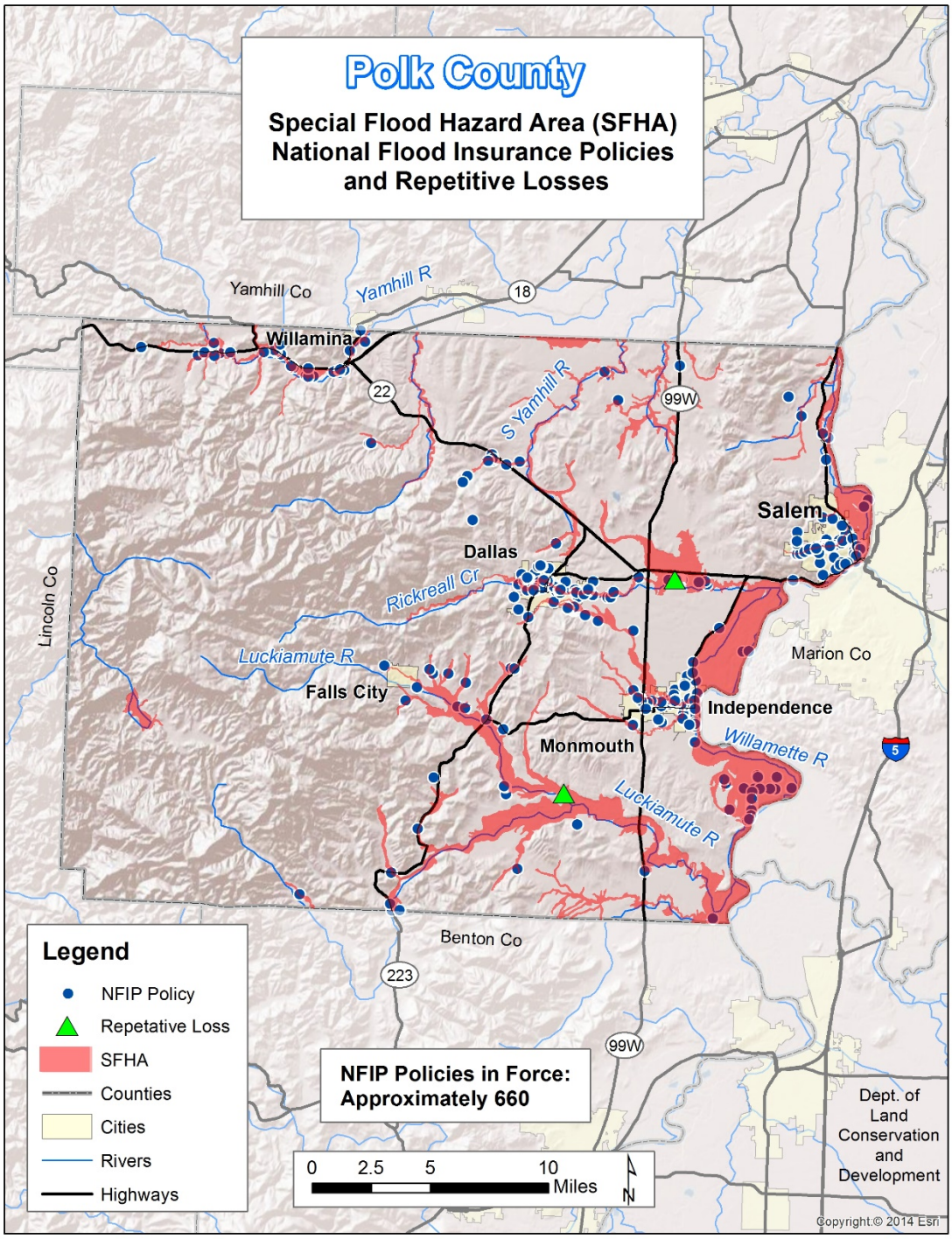
Mitigation Successes

A dwelling on Elkins Road, southwest of Monmouth in unincorporated Polk County was mitigated in 2015. The dwelling now has its lowest floor one foot higher than the design flood elevation (DFE) established for the project.

[32] A Repetitive Loss (RL) property is any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period, since 1978. A RL property may or may not be currently insured by the NFIP.

[33] A Severe Repetitive Loss (SRL) property is a single family property (consisting of 1 to 4 residences) that is covered under flood insurance by the NFIP and has incurred flood-related damage for which 4 or more separate claims payments have been paid under flood insurance coverage, with the amount of each claim payment exceeding $5,000 and with cumulative amount of such claims payments exceeding $20,000; or for which at least 2 separate claims payments have been made with the cumulative amount of such claims exceeding the reported value of the property.

Figure 2-12 NFIP Policies, Repetitive Loss, & Severe Repetitive Loss Properties



Source: Department of Land Conservation and Development, data circa 2014, October 2016.

Risk Assessment

Multi-jurisdictional Risk Assessment - §201.6(c) (2) (iii): For multi-jurisdictional plans, the risk assessment must assess each jurisdiction's risks where they vary from the risks facing the entire planning area.

Dallas, Independence, Falls City, and Monmouth participated in County Steering Committee meetings and worked with OPDR to complete a jurisdiction specific hazard analysis; for more information on the process see Appendix A. City specific information is presented in Volume II, *Jurisdictional Addenda*.

Probability Summary

Table 2-10 below presents the probability scores for each of the natural hazards present in Polk County for which descriptions are provided herein, and in Volume II with detail for the participating cities. As shown in the table with **bold text**, several hazards are rated with high probabilities.

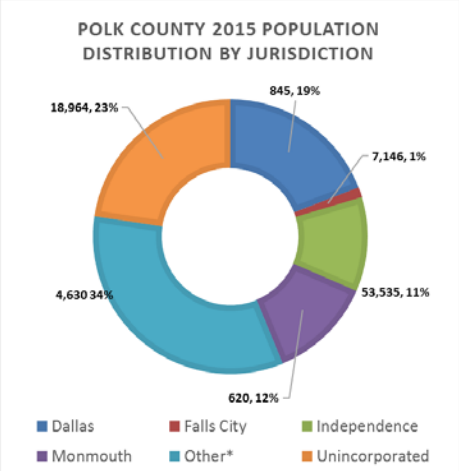
Table 2-10 Natural Hazard Probability Assessment Summary

Hazard	Polk County	Dallas	Falls City	Independence	Monmouth
Drought	Moderate	Moderate	Moderate	Moderate	Low
Earthquake (Cascadia)	Moderate	Low	Moderate	Moderate	Moderate
Earthquake (Crustal)	Moderate	Low	Low	Low	Low
Flood	**High**	**High**	**High**	Moderate	Moderate
Landslide	**High**	Low	**High**	Low	Low
Volcano	Low	Low	Low	Low	Low
Wildfire	Moderate	Low	**High**	Low	Low
Windstorm	**High**	Moderate	**High**	**High**	Moderate
Winter Storm	**High**	**High**	**High**	**High**	**High**

Source: Polk County and City NHMP Steering Committees 2016.

Vulnerability Summary

Vulnerability assesses the extent to which people are susceptible to injury or other impacts resulting from a hazard as well as the exposure of the built environment or other community assets (social, environmental, economic, etc.) to hazards. The exposure of community assets to hazards is critical in the assessment of the degree of risk a community has to each hazard. Identifying the populations, facilities and infrastructure at risk from various hazards can assist the county in prioritizing resources for mitigation, and can assist in directing damage assessment efforts after a hazard event has occurred. The exposure of county and city assets to each hazard and potential implications are explained in each hazard section.



Vulnerability includes the percentage of population and property likely to be affected under an "average" occurrence of the hazard. Polk County

evaluated the best available vulnerability data to develop the vulnerability scores presented below. For the purposes of this NHMP, the county and cities utilized the Oregon Military Department – Office of Emergency Management (OEM) Hazard Analysis methodology vulnerability definitions to determine hazard probability.

Table 2-11 below presents the vulnerability scores for each of the natural hazards present in Polk County and for participating cities. As shown in the table with **bold text**, the windstorm and winter storm hazards are the only hazards that are rated with a high vulnerability for the county.

Table 2-11 Community Vulnerability Assessment Summary

Hazard	Polk County	Dallas	Falls City	Independence	Monmouth
Drought	Moderate	Moderate	Moderate	Moderate	Low
Earthquake (Cascadia)	Moderate	**High**	**High**	**High**	**High**
Earthquake (Crustal)	Moderate	Moderate	Low	Moderate	Moderate
Flood	Moderate	Moderate	Moderate	Moderate	Moderate
Landslide	Low	Low	Moderate	Low	Low
Volcano	Moderate	Low	Moderate	Moderate	Low
Wildfire	Moderate	Low	**High**	Low	Low
Windstorm	**High**	Moderate	Moderate	Moderate	Moderate
Winter Storm	**High**	Moderate	Low	Moderate	Moderate

Source: Polk County and City NHMP Steering Committees 2016.

Hazard Analysis Matrix

The hazard analysis matrix involves estimating the damage, injuries, and costs likely to be incurred in a geographic area over a period of time. Risk has two measurable components: (1) the magnitude of the harm that may result, defined through the vulnerability assessment (assessed in the previous sections), and (2) the likelihood or probability of the harm occurring. The table below presents the entire updated hazard analysis matrix for Polk County. The hazards are listed in rank order from high to low. Table 2-12 below shows that hazard scores are influenced by each of the four categories combined. With considerations for past historical events, the probability or likelihood of a particular hazard event occurring, the vulnerability to the community, and the maximum threat or worst-case scenario, windstorm and winter storm events rank as the top hazard threats to the county (top tier). Floods, Cascadia Subduction Zone earthquake, crustal earthquake, and drought events rank in the middle (middle tier). Wildfire, Landslide, and Volcano (volcanic ash) comprise the lowest ranked hazards in the county (bottom tier).

Table 2-12 Hazard Analysis Matrix – Polk County

Hazard	History	Probability	Vulnerability	Maximum Threat	Total Threat Score	Hazard Rank	
Windstorm	20	70	40	100	230	# 1	*Top Tier*
Winter Storm	20	70	40	100	230	# 1	
Flood - Riverine	20	70	25	50	165	#3	*Middle Tier*
Earthquake - Cascadia	2	35	25	100	162	#4	
Earthquake - Crustal	2	35	25	100	162	#4	
Drought	10	35	25	90	160	#6	
Wildfire (WUI)	10	35	25	50	120	#7	*Bottom Tier*
Landslide	8	70	5	10	93	#8	
Volcano	2	7	25	50	84	#9	

Source: Polk County Steering Committee (2016)

For local governments, conducting the hazard analysis is a useful step in planning for hazard mitigation, response, and recovery. The method provides the jurisdiction with a sense of hazard priorities, but does not predict the occurrence of a particular hazard.

Hazard Analysis Methodology

The hazard analysis methodology in Oregon (primarily to inform Emergency Operations Planning) was first developed by FEMA circa 1983, and gradually refined by the Oregon Military Department's Office of Emergency Management over the years.

The methodology produces scores that range from 24 (lowest possible) to 240 (highest possible). Vulnerability and probability are the two key components of the methodology. Vulnerability examines both typical and maximum credible events, and probability endeavors to reflect how physical changes in the jurisdiction and scientific research modify the historical record for each hazard. Vulnerability accounts for approximately 60% of the total score, and probability approximately 40%. We include the hazard analysis summary here to ensure consistency between the EOP and NHMP.

The Oregon method provides the jurisdiction with a sense of hazard priorities, or relative risk. It doesn't predict the occurrence of a particular hazard, but it does "quantify" the risk of one hazard compared with another. By doing this analysis, planning can first be focused where the risk is greatest.

In this analysis, severity ratings, and weight factors, are applied to the four categories of history, vulnerability, maximum threat (worst-case scenario), and probability as demonstrated below.

History (Weight Factor = 2)

History is the record of previous occurrences. Events to include in assessing history of a hazard in different jurisdictions are events for which the following types of activities were required:

- The Emergency Operations Center (EOC) or alternate EOC was activated;
- Three or more Emergency Operations Planning (EOP) functions were implemented, e.g., alert & warning, evacuation, shelter, etc.;

- An extraordinary multi-jurisdictional response was required; and/or
- A "Local Emergency" was declared.

LOW = 0 to 1 event in the past 100 years, scores between 1 and 3 points
MODERATE = 2 to 3 event in the past 100 years, scores between 4 and 7 points
HIGH = 4+ events in the past 100 years, scores between 8 and 10 points

Probability (Weight Factor = 7)

Probability is the likelihood of future occurrence within a specified period of time.

LOW = one incident likely within 75 to 100 years, scores between 1 and 3 points
MODERATE = one incident likely within 35 to 75 years, scores between 4 and 7 points
HIGH = one incident likely within 10 to 35 years, scores between 8 and 10 points

Vulnerability (Weight Factor = 5)

Vulnerability is the percentage of population and property likely to be affected under an "average" occurrence of the hazard.

LOW = < 1% affected, scores between 1 and 3 points
MODERATE = 1 - 10% affected, scores between 4 and 7 points
HIGH = > 10% affected, scores between 8 and 10 points

Maximum Threat (Weight Factor =10)

Maximum threat is the highest percentage of population and property that could be impacted under a worst-case scenario.

LOW = < 5% affected, scores between 1 and 3 points
MODERATE = 5 - 25% affected, scores between 4 and 7 points
HIGH = > 25% affected, scores between 8 and 10 points

Jurisdiction Specific Risk Assessment

Multi-jurisdictional Risk Assessment - §201.6(c) (2) (iii): For multi-jurisdictional plans, the risk assessment must assess each jurisdiction's risks where they vary from the risks facing the entire planning area.

The four participating cities in Polk County: Dallas, Falls City, Independence, and Monmouth completed a jurisdiction specific hazard analysis. The multi-jurisdictional risk assessment information is located herein and within the Risk Assessment section of each jurisdiction's addendum, which is located in Volume II of this NHMP.

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