Section 12:
Earthquake

Why are Earthquakes a threat to Yamhill County?

Social and geological records show that Oregon has a history of seismic events. Oregon has experienced damaging earthquakes in the historic past, and geologic evidence indicates that because of our increasing population and development, we may expect earthquakes with even greater damage potential to occur in the future. The highest probabilities of experiencing an earthquake are in western Oregon, although the entire state is susceptible.

Recent research suggests that the Cascadia Subduction Zone is capable of producing magnitude 9 earthquakes. To put this in perspective, the 1906 San Francisco earthquake was about an 8.0.[1] South of McMinnville, near Dayton, there is a series of inferred faults, faults that extend underground from a visible fault, and concealed faults (completely underground faults).[2]

Earthquakes pose a serious threat to many Oregon communities. Local governments, planners, and engineers must consider the threat as they seek to balance development and risk. Identifying locations susceptible to seismic activity generated by local faults or the Cascadia Subduction Zone, adopting strong policies and implementing measures, and using other mitigation techniques are essential to reducing risk from seismic hazards in Yamhill County.[3]

The most recent significant earthquake event affecting Yamhill County was the February 28, 2001 Nisqually earthquake. The epicenter of the 6.8-magnitude earthquake was near Anderson Island in Pierce County, Washington, and shook western Washington and areas of western Oregon. Residents in the surrounding area, including Yamhill County felt the tremor. While the impacts of this quake were not severe in Oregon, the economic losses in Washington are estimated at $1 to $2 billion. Oregon ranks third in the nation for earthquake damage estimates in the future. Projected losses in the Cascadia region alone could exceed $12 billion, with over 30,000 destroyed buildings, and 8,000 lives lost in the event of a magnitude 8.5 Cascadia Subduction Zone earthquake.[4]

Most of the earthquake mapping and mitigation efforts made in Oregon have been accomplished in the past two decades, and public awareness has risen remarkably during this time. Major federal, state, and local government agencies and private organizations support earthquake risk reduction, and have made significant contributions in reducing the adverse impacts of earthquakes. Despite the progress, the majority of Oregon communities remain unprepared because there is a general lack of understanding regarding earthquake hazards among Oregonians.[5]

To better understand the earthquake hazard, the scientific community has looked at historical records and accelerated research on crustal faults, which are among the sources of the earthquakes occurring in the

Yamhill County region. Historical earthquake records can generally be divided into records of the pre-instrumental period and the instrumental period. In the absence of instrumentation, the detection of earthquakes is based on observations and felt reports, and is dependent upon population density and distribution. Since Oregon was sparsely populated in the 1800s, the detection of pre-instrumental earthquakes is quite difficult. Populations in some regions in or near the Willamette Valley and along the Columbia River began growing as early as the 1850s, including Portland (1840), Salem (1844), Hillsboro (1845), Forest Grove (1850), Eugene (1852), McMinnville (1853), and Tillamook (1866). Newspapers from these towns provide a good source of historical documentation of earthquakes of a magnitude five or greater since about 1850.[6] The seismic risk is more severe today than in the past because population is increasing.

It is imperative that residents of Yamhill County prepare for earthquakes. It is almost certain that significant loss of life, injuries and property damage will occur during a strong earthquake. The bases for this conclusion are:

- A significant portion of the population, and a large portion of the State government infrastructure is located within an area of greatest hazard; and
- Many of the older buildings as well as utility facilities in the western portions of the State have not been designed to resist earthquake damage.

Historical Earthquake Events

Dating back to 1841, there have been more than 6,000-recorded earthquakes in Oregon, most with a magnitude below three. The mid-Willamette Valley, including Yamhill County has experienced multiple earthquakes of an estimated magnitude of four and greater, with major earthquakes felt in 1941 (magnitude 7.1), 1962 (magnitude 5.2), and 2001 (magnitude 6.8). Figure 10-1 shows the location of selected Pacific Northwest earthquakes that have occurred since 1872.

Although seismograph stations were established as early as 1906 in Seattle and 1944 in Corvallis, improved seismograph coverage of the Yamhill County region did not begin until 1980, when the University of Washington expanded its regional network into northwestern Oregon.

February 28, 2001, Nisqually Earthquake- Magnitude 6.8

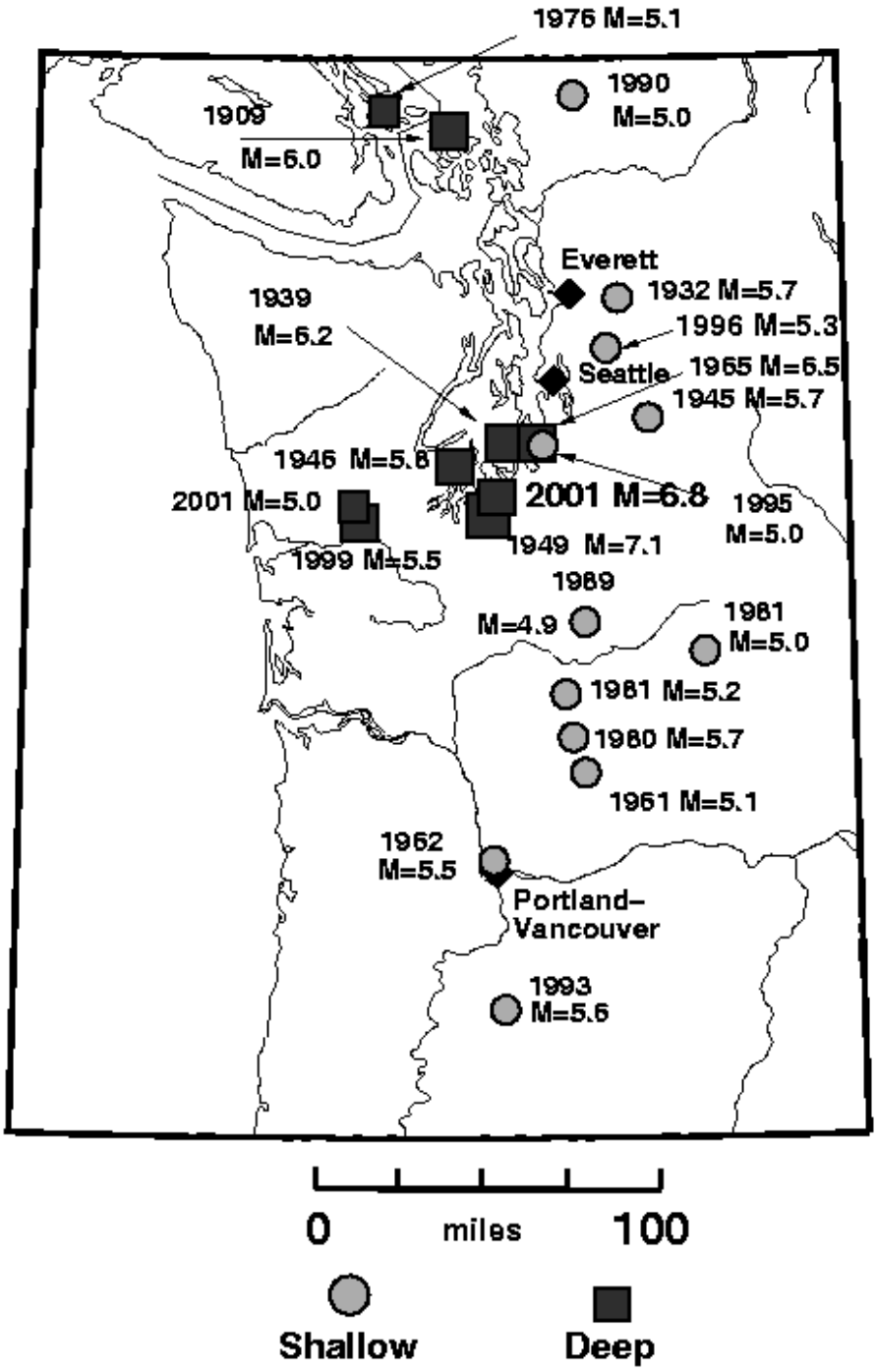
The most recent earthquake to be felt in Yamhill County was the Nisqually earthquake, on February 28, 2001. The earthquake hit at 10:54 a.m. and was centered 35 miles southwest of Seattle.[7] The quake registered 6.8 on the Richter Scale. In the Puget Sound area, this quake caused 400 injuries, one quake-related death, and about $2 billion dollars in damage.[8]

People evacuated buildings throughout the Willamette Valley, as well as places along the north Oregon coast.9 Although there was no danger of a tsunami, many residents on the coast acted responsibly in heading for high ground when they felt the earth shake.[10]

While the quake caused little damage in Yamhill County, it slowed businesses and schools as potential damage was assessed. At the Dundee Fire Hall, cracks developed in the walls, and Fire Chief John Stock moved the fire trucks and personnel outside until an engineer could inspect the building.[11] Tremors were also felt in the upper floors of the Oregon State Capitol, and legislators and staff said they could feel the building swaying.[12] Schools in Yamhill County also felt the Nisqually Earthquake, though little damage was found. The local schools that reported the strongest tremors were mostly in northern Marion County.[13] Saint Paul and North Marion high schools, both north of Woodburn, also briefly evacuated students.[14]

Even though the quake amounted to billions of dollars in damage in Washington, the cost there could have been much higher if not for retrofitting. Officials said millions of dollars spent to remodel buildings and highways to protect against earthquakes had paid off.[15]

Figure 12-1. Selected Pacific Northwest Earthquakes since 1872



Source: Pacific Northwest Seismograph Network.
www.geophys.washington.edu/SEIS/PNSN/INFO_GENERAL/hist.html

March 25, 1993, Scotts Mills Earthquake – Magnitude 5.6

The Scotts Mills Earthquake (also known as the "Spring Break Quake") was centered in Marion County, near the town of Woodburn and Scotts Mills. Most of the day's business had not begun when the 5:30 a.m.

quake hit. Schools were not in session; some brick buildings, including schoolhouses, suffered major damage. The earthquake originated on the Mt. Angel-Gales Creek fault, about two miles south of Scotts Mills and twelve to thirteen miles underground.[16]

Due to the earthquake's location in Marion County, there was more damage reported in Yamhill County than during the Nisqually quake in 2001. In Salem, approximately 20 miles southwest of the epicenter, the state Capitol rotunda cracked, and the Golden Pioneer statue nearly was rocked off its base.[17] The earthquake caused $30 million in damage in Oregon, but resulted in no deaths or serious injuries.[18] In the town of Mount Angel, authorities closed the historic St. Mary Catholic Church for fear its 200-foot bell tower could collapse.[19]

In Dayton, some bricks fell from an old, two-story un-reinforced masonry building (URM).[20] At least 90 buildings, which were generally URM construction, suffered some damage in Newberg, 28 miles from the epicenter.[21] This damage may have been due to local amplification of ground motion at this site.[22]

Approximately 23 miles northwest of the epicenter, the southwest deck of a six-span bridge on Highway 18 pulled away from the northeast deck at the separation joint and crushed bearings on the top of the middle pier.[23] Beams fell eight to nine inches, and a driver on the bridge had all four tires on his car flattened by the impact.[24] After assessing several bridges for structural damage in the state, ODOT closed the Dayton Bridge on Highway 18. This was the only bridge in the Mid-Willamette Valley that remained closed. Also, the north end of Highway 18 at Highway 99W was closed to southbound traffic, and Portland General Electric customers in the Dundee area experienced power failure.[25]

March 7, 1963, Salem, Oregon – Magnitude 4.6

On March 7, 1963, a quake measuring 4.6 on the Richter scale shook Yamhill County. Despite the low magnitude of the quake, damage still occurred – especially to older masonry buildings.

November 5, 1962, Vancouver, Washington – Magnitude 5.5

Three and a half weeks after the devastating Columbus Day Storm, an earthquake that measured approximately 5.5 on the Richter scale shook the Portland area. It was the largest recorded quake to be generated by a fault in the immediate Portland vicinity.[26] The shaking lasted up to 30 seconds. Chimneys cracked, windows were broken, and furniture moved. The *News Register* reported no damage in the county, although the County felt this quake, which occurred 364 days after the area's last quake.[27]

The quake was felt over a wide area of Oregon and Washington. Reports of the earthquake came from Eugene, 110 miles south of Portland, and from Seattle, 135 miles to the north.[28] The heaviest damage report came from Tillamook on the Oregon coast where the quake, lasting only a few seconds, cracked open barn walls and broke out windows at a local ranch.[29]

April 18, 1961, Albany, Oregon – Magnitude 4.5

A quake in April of 1961 caused little damage to the county, but startled many residents. The quake was centered just south of Salem, and registered 4.6 on the Richter scale. Described by most as a double shock, it shook houses, rattled dishes, woke the sleeping and startled the awake.[30] Damage was very limited – typical of an earthquake of lower magnitude. Albany reported some cracked plaster.[31]

April 13, 1949, Olympia, Washington- Magnitude 7.1

On April 13, 1949, Yamhill county residents felt an earthquake that was centered between Olympia and Tacoma, Washington. In Washington, this quake caused eight deaths. While Yamhill County was shaken by the quake, damage was minimal, and no deaths occurred.

The quake rocked northwestern Oregon, extending as far south as Eugene, Coos Bay, and Reedsport, and east as far as Prineville and La Grande.[32] In downtown Salem, West Salem and in outlying areas buildings trembled, light fixtures swayed, dishes rattle in cupboards. Most of those who were outside at the time reported no shock.[33]

Causes and Characteristics of Earthquake in Yamhill County

Most large earthquakes in the Pacific Northwest are shallow crustal, deep intraplate, or subduction zone earthquakes. These earthquakes can have great impact on Oregon communities. With its location in the Pacific Northwest, Yamhill County is susceptible to both intraplate and subduction zone earthquakes. In addition, the Mount Angel Fault, a crustal fault, is located less than fifteen miles east of Yamhill County. This fault was attributed with the "Spring Break Quake," and has the potential of producing more earthquakes.

Crustal Fault Earthquakes

Crustal fault earthquakes are the most common of earthquakes and occur at relatively shallow depths of six to twelve miles below the surface.[34] While most crustal fault earthquakes are smaller than magnitude 4.0 and generally create little or no damage, they can produce earthquakes of magnitudes 7.0 and higher and cause extensive damage. The Mount Angel Fault, a crustal fault located less than fifteen miles east of Yamhill County, produced a 5.7 magnitude quake in 1993.

Deep Interplate Earthquakes

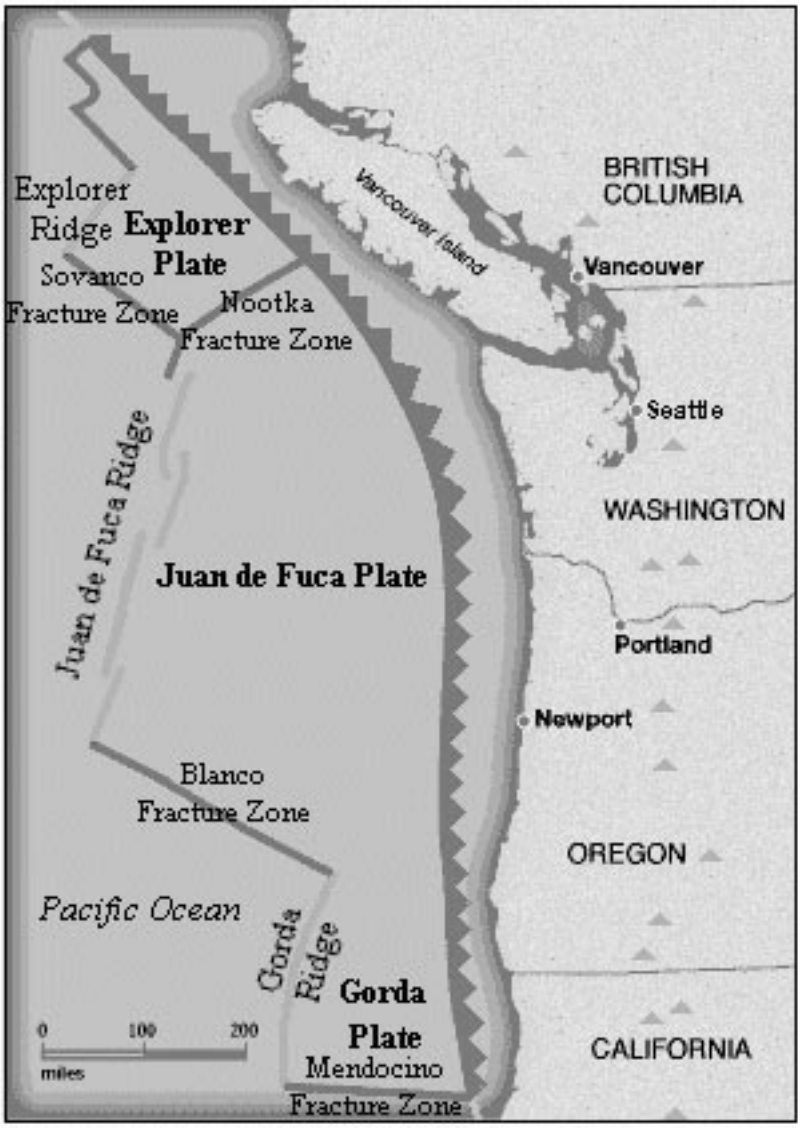
Occurring at depths from 25 to 40 miles below the earth's surface in the subducting oceanic crust, deep intraplate earthquakes can reach magnitude 7.5.[35] The February 28, 2001 earthquake in Washington State was a deep intraplate earthquake. It produced a rolling motion that was felt from Vancouver, British Columbia to Coos Bay, Oregon and east to Salt Lake City, Utah. A 1965 magnitude 6.5-intraplate

earthquake centered south of Seattle-Tacoma International Airport caused seven deaths.[36]

Subduction Zone Earthquakes

The Pacific Northwest is located at a convergent plate boundary, where the Juan de Fuca and North American tectonic plates meet. The two plates are converging at a rate of about one to two inches per year. This boundary is called the Cascadia Subduction Zone (see Figure 10-2). It extends from British Columbia to northern California. Subduction zone earthquakes are caused by the abrupt release of slowly accumulated stress. Subduction zones similar to the Cascadia Subduction Zone have produced earthquakes with magnitudes of 8.0 or larger. Historic subduction zone earthquakes include the 1960 Chile (magnitude 9.5) and the 1964 southern Alaska (magnitude 9.2) earthquakes. Geologic evidence shows that the Cascadia Subduction Zone has generated great earthquakes, most recently about 300 years ago. It is generally accepted to have been magnitude 9.0 or greater. The average recurrence interval of these great Cascadia earthquakes is approximately 500 years, with gaps between events as small as 200 years and as large as 1000 years. Such earthquakes may cause great damage to the coastal area of Oregon as well as inland areas in western Oregon including Yamhill County. It is estimated that shaking from a large subduction zone earthquake could last up to five minutes.[37]

Figure 12-2. Cascadia Subduction Zone



Source: Department of Land Conservation and Development.
www.lcd.state.or.us/coast/hazards/juandefucaplates.htm

Earthquake Related Hazards

Ground Shaking

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

Earthquake-Related Landslides

Earthquake-induced landslides are secondary earthquake hazards that occur from ground shaking. They can destroy roads, buildings, utilities, and other critical facilities necessary to respond to and recover from an earthquake. Many communities in Oregon, including those within Yamhill County, are likely to encounter such risks, especially in areas with steep slopes.

Liquefaction

Liquefaction occurs when ground shaking causes wet granular soils to change from a solid state to a liquid state. This results in the loss of soil strength and the soil's ability to support weight. Buildings and their occupants are at risk when the ground can no longer support these buildings and structures.[38] Areas of susceptibility to liquefaction include areas with groundwater tables and sandy soils.[39]

Amplification

Soils and soft sedimentary rocks near the earth's surface can modify ground shaking caused by earthquakes. One of these modifications is amplification. Amplification increases the magnitude of the seismic waves generated by the earthquake. Amplification depends on the thickness of geologic materials and their physical properties. Buildings and structures built on soft and unconsolidated soils can face greater risk.[40] Amplification can also occur in areas with deep sediment-filled basins.

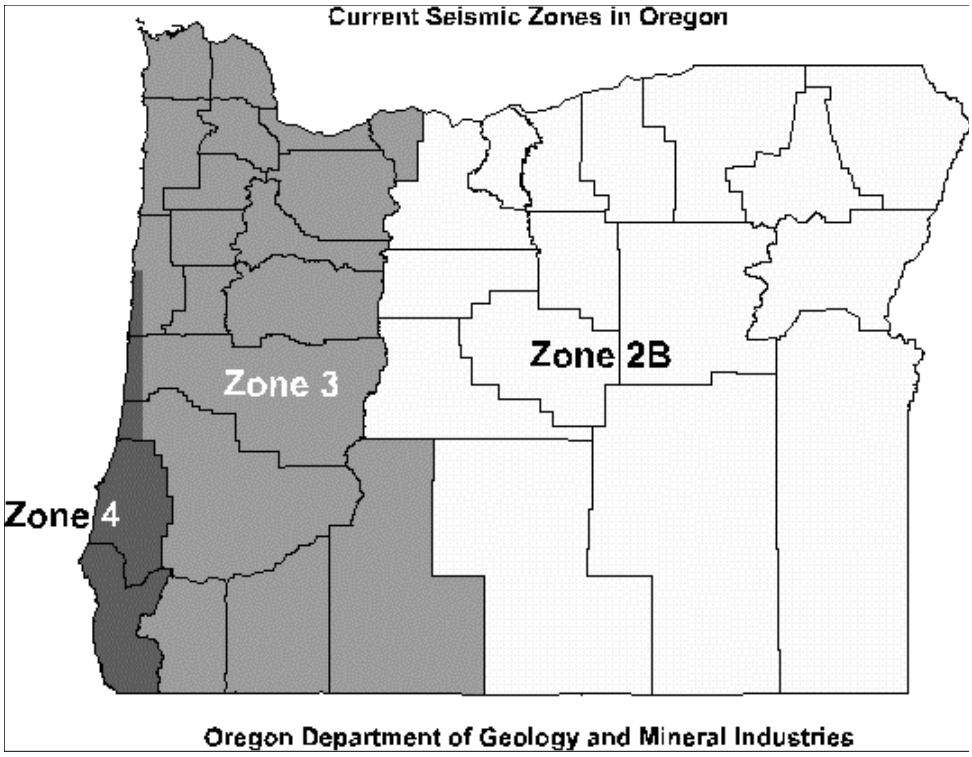
Earthquake Hazard Assessment

Hazard Identification

The 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 and risks, including active fault identification, bedrock shaking, tsunami inundation zones, ground motion amplification, liquefaction, and earthquake induced landslides. Seismic hazard maps have been published and are available for many communities in Oregon through DOGAMI.[41]

The Oregon Building Codes Division revised and upgraded its construction standards for new buildings to make them resistant to seismic events. The change in State Building Codes reflects updated seismic zones (see Figure 12-3). An increase in zone number reflects increased risk of seismic activity. Many buildings in Yamhill County were built prior to the imposition of the new seismic zone code requirements, established in 1993.

Figure 12-3. Seismic Zones in Oregon



Vulnerability Assessment

The effects of earthquakes span a large area. The degree to which earthquakes are felt, however, and the damages associated with them may vary. At risk from earthquake damage are large old buildings and bridges, many 'high tech' and hazardous material facilities, extensive sewer, water, and natural gas pipelines, petroleum pipelines, and other critical facilities and private property located within the county. The areas that are particularly vulnerable to potential earthquakes in the county have been identified as those areas near the crustal fault lines.

The relative or secondary earthquake hazards, which are liquefaction, ground shaking, amplification, and earthquake-induced landslides, can be just as devastating as the earthquake. DOGAMI is currently conducting research regarding the location and potential damage associated with secondary earthquake hazards.

Risk Analysis

Risk analysis is the third phase of a hazard assessment. Risk analysis involves estimating the damage and costs likely to be experienced in a geographic area over a period of time. Factors included in assessing earthquake risk include population and property distribution in the hazard area, the frequency of earthquake events, landslide susceptibility, buildings, infrastructure and disaster preparedness of

the region. This type of analysis can generate estimates of the damages to the county due to an earthquake event in a specific location. At the time of publication of this plan, data was insufficient to conduct a risk analysis and the software needed to conduct this type of analysis was not available. DOGAMI is leading state initiative in producing earthquake maps and conducting risk analyses of various regions in the state. Map 7 shows the relative geological fault lines within Yamhill County.

Community Earthquake Issues

Earthquake damage occurs because structures cannot withstand severe shaking. Buildings, airports, schools, and lifelines, including highways and phone, gas, and water lines suffer damage in earthquakes and can cause death or injury to humans.

The welfare of homes, major businesses, and public infrastructure is very important. Addressing the integrity of buildings, critical facilities, and infrastructure, and understanding the potential costs to government, businesses, and individuals as a result of an earthquake, are challenges faced by Yamhill County.

Buildings

The built environment is susceptible to damage from earthquakes. Buildings that collapse can trap and bury people, putting lives at risk and creating great costs to clean up the damages. Changes in the seismic zone for the Willamette Valley in 1990 and 1993 lead to increases in the construction standards for buildings in Yamhill County and the rest of the Willamette Valley. In 1993, the seismic zone for the Willamette Valley was upgraded from 2B to 3, requiring stricter construction standards.

In most Oregon communities, including those within Yamhill County, many buildings were built before 1993 when building codes were not as strict. Upgrading existing buildings to resist earthquake forces is more expensive than meeting code requirements for new construction. Only a few buildings in McMinnville have been retrofitted to help them withstand earthquakes, including the McMinnville Community Center, McMinnville Public Library, and McMenanims Hotel Oregon.[42]

State code requires seismic upgrades only when there is significant structural alteration to the building or where there is a change in use that puts building occupants and the community at a greater risk. Therefore, the number of buildings at risk remains high. The lack of funding for such activity is a major issue. Although coordination among county and city building code officials is in progress, much work remains to be done to identify and plan for the risks to older structures.

Infrastructure and Communication

Residents in Yamhill County commute frequently by automobile and public transportation. An earthquake can greatly damage bridges and roads, hampering the movement of people and goods. Damaged

infrastructure strongly affects the economy of the community – it disconnects people from work, school, food, and leisure, and separates businesses from their employees, customers, and suppliers.

Bridge Damage

As mentioned in Section 6 concerning floods, bridges in Yamhill County are also key points of concern if an earthquake occurs in Yamhill County. Bridges are important links in road networks that cross rivers throughout the county.

Even modern bridges can sustain damage during earthquakes, leaving them unsafe for use. Some bridges have failed completely due to strong ground motion. Bridges are a vital transportation link – with even minor damages making some areas inaccessible. Because bridges vary in size, materials, siting, and design, any given earthquake will affect them differently. Of potential concern for Yamhill County is State Highway No. 39 (Salmon River Highway, Highway 18) Spur, which turns into Third Street in McMinnville. The spur provides access to the local hospital, Willamette Valley Medical Center. Part of the spur is a bridge at milepost Y46.75 that crosses the South Yamhill River, which may or may not fail due to an earthquake. Access to Willamette Valley Medical Center from the northern or southern parts of the county requires crossing at least one bridge.

Bridges built before the mid-1970s have a significantly higher risk of suffering structural damage during a moderate-to-large earthquake compared with bridges built after 1980, which contain structural improvements. Much of the interstate highway system was built in the mid to late 1960's.

Damage to Lifelines

Lifelines are the connections between communities and outside services. They include water and gas lines, transportation systems, electricity, and communication networks. Ground shaking and amplification can cause pipes to break, power lines to fall, roads and railways to crack or move, and radio and telephone communication to cease. Disruption to transportation makes it especially difficult to bring in supplies or services. All lifelines need to be usable after an earthquake to allow for rescue, recovery, and rebuilding efforts and to relay important information to the public.

Disruption of Critical Services

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

Businesses

Seismic activity can cause great loss to businesses – both large-scale corporations and small retail shops. When a company is forced to stop

production for just a day, the economic loss can be tremendous, especially when its market is at a national or global level. Seismic activity can create economic loss that presents a burden to small shop owners who may have difficulty recovering from their losses.

Individual Preparedness

A 1999 DOGAMI survey shows that about 39 percent of respondents think an earthquake will occur in Oregon within the next ten years. Only 28 percent of Oregon residents say they are prepared for an earthquake, and prior to the Spring Break Quake of 1993, only three percent of Oregon homeowners had earthquake insurance.[43] About 30 percent of homeowners now have earthquake coverage, according to Insurance Information Services of Oregon and Idaho.[44]

The DOGAMI survey also indicated that only 24 percent correctly identified what to do during an earthquake.[45]

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

Death and Injury

Death and injury can occur both inside and outside of buildings due to falling equipment, furniture, debris, and structural materials. Downed power lines and broken water and gas lines can also endanger human life. Deaths can be prevented with proper building design and individual preparedness.

Fire

Downed power lines or broken gas mains can trigger fires. When fire stations suffer structural or lifeline damage, quick response to suppress fires is less likely. Therefore, it is necessary for fire stations and critical facilities to be well protected from natural disasters.

Debris

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

Mitigation Plan Goals and Existing Activities

Mitigation Plan Goals Addressed

The plan goals addressed by each action item are identified as a means for monitoring and evaluating how well the mitigation plan is achieving its goals following implementation.

The plan goals help to guide the direction of future activities aimed at reducing risk and preventing loss from natural hazards. The goals

listed here serve as checkpoints as agencies and organization begin implementing mitigation action items.

Goal #1: EMERGENCY OPERATIONS

Goal Statement: Coordinate natural hazard mitigation activities, where appropriate, with emergency operations plans and procedures and with various other agencies, as appropriate.

Goal #2: EDUCATION AND OUTREACH

Goal Statement: Develop and implement education and outreach programs to increase public awareness of the risks associated with natural hazards.

Goal #3: PARTNERSHIPS

Goal Statement: Develop effective partnerships with public and private sector organizations and significant agencies and businesses for future natural hazard mitigation efforts.

Goal #4: PREVENTIVE

Goal Statements:

- Develop and implement activities to protect human life, commerce, and property from natural hazards.
- Reduce losses and repetitive damage for chronic hazard events while promoting insurance coverage for catastrophic hazards.

Goal #5: NATURAL RESOURCES UTILIZATION

Goal Statement: Link natural resources management, land use planning, and watershed planning with natural hazard mitigation activities to protect natural systems and allow them to serve natural hazard mitigation functions.

Goal #6: IMPLEMENTATION

Goal Statement: Implement strategies to mitigate the effects of natural hazards.

Existing Mitigation Activities

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

County Programs

Implementation of earthquake mitigation often takes place at the local government level. The Yamhill County Department of Planning and Development is the local agency that enforces zoning codes pertaining

to earthquake hazards. The standards for development are outlined in the Zoning Ordinance. The Building Division addresses the earthquake hazard by requiring new structures to meet current state seismic requirements. Generally, the Planning and Development Department seeks to discourage development in areas that could be prone to flooding landslide, wildfire and/or seismic hazards. Developers in potential hazard-prone areas are required to retain a professional engineer to evaluate level of risk onsite and recommend mitigation measures.

State Programs

Earthquake Awareness Month

April is Earthquake Awareness Month. Oregon Emergency Management (OEM) coordinates activities such as earthquake drills and encourages individuals to strap down computers, heavy furniture and bookshelves in homes and offices.

Earthquake Drills in Schools

School districts conduct earthquake drills regularly throughout Oregon and teach students how to respond when an earthquake occurs.

Prioritization of Oregon Bridges for Seismic Retrofit

In January 1997, the Oregon Department of Transportation (ODOT), Oregon Local Agencies Seismic Committee, and CH2Mhill consultants completed a four-year study of seismic vulnerability for Oregon's bridge inventory. From this assessment, Polk County and the state was able to prioritize bridges for seismic retrofit within the county. Bridges considered structurally safe will be retrofitted or rebuilt to withstand high-water flows, landslides and other natural hazards in addition to seismic events. ODOT can be contacted for more information on the state's bridge inventory.

State Building Codes

The Oregon State Building Codes Division adopts statewide standards for building construction that are administered by the state, cities and counties throughout Oregon. Oregon State Building Code Division (BCD) sets the minimum design and construction standards for new buildings.

The codes apply to new construction and to the alteration of, or addition to, existing structures. Effective April 1, 2003, the new Oregon Dwelling Specialty Code went into effect. The new code is based on the 2000 International Residential Code (IRC) and has Oregon amendments added to reflect changes specific to Oregon. The IRC is based primarily on the 1998 Edition of the International One- and Two-Family Dwelling Code, and has incorporated several significant changes to align it with other model codes. It has been enhanced and expanded to reflect industry advancements and practices, both nationally and locally, and reflects modern industry standards and practices.

The seismic design and lateral bracing criteria are updated to reflect changes that are taking place nationally to embrace modern technology and information. Seismic "zone" terminology has changed to reflect a national move to use seismic design categories. Oregon now has three seismic design categories: the coastal areas are Design Category D2, the valley areas are Design Category D1 and the eastern part of the state is Design Category C. In addition to these seismic zone changes, the state modified its lateral bracing requirements to reflect several interpretive rulings issued over the past several years.

Regional Programs

The Institute for Business and Home Safety (IBHS), a national non-profit organization, is actively providing natural hazards information to the public through the media and public meetings and workshops.

Insurance Information Service of Oregon and Idaho's (IISOI) speaker's bureau visits local communities to discuss loss prevention, insurance information, and effects from other natural hazards events.

Earthquake Mitigation Action Items

The following mitigation action items were formulated through research of regional mitigation plans, natural hazards planning literature, and interviews with local stakeholders. Plan action items were refined through discussions with the mitigation plan steering committee and through an open house at which the county received from the public.

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

This section lists action items identified to reduce the risk from earthquakes in Yamhill County. These action items are designed to meet the mitigation plan goals.

Short-term (ST) Earthquake Action Items

Short-term earthquake action items include general mitigation activities that agencies are capable of implementing during the next two years, given their existing resources and authorities.

ST-EQ #1: Integrate new] earthquake hazard mapping data for Yamhill County and improve technical analysis of earthquake hazards.

Ideas for Implementation

- Update Yamhill County earthquake HAZUS data using more localized data; and

- Conduct risk analysis incorporating HAZUS data and the created hazard maps using GIS technology to identify risk sites and further assist in prioritizing mitigation activities and assessing the adequacy of current land use requirements.

Coordinating Organization:	GIS
Internal Partner:	Public Works, Planning, Emergency Management
External Partner:	OSU, USGS, BLM, MWVCOG, OEM, FEMA, DOGAMI
Timeline:	2 years
Plan Goals Addressed:	Education & Outreach; Partnerships; Preventive; Natural Resources Utilization

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ST-EQ #2: Encourage reduction of nonstructural and structural earthquake hazards in homes, schools, businesses, and government offices.

Ideas for Implementation

- Provide information to government building and school facility managers and teachers on securing bookcases, filing cabinets, light fixtures, and other objects that can cause injuries and block exits;

- Encourage facility managers, business owners, and teachers to refer to FEMA's practical guidebook, *Reducing the Risks of Nonstructural Earthquake Damage*;

- Encourage homeowners and renters to use *Is Your Home Protected from Earthquake Disaster? A Homeowner's Guide to Earthquake Retrofit* (IBHS) for economic and efficient mitigation techniques;

- Work with local building supply outlets to feature checklists/retrofit kits for reducing nonstructural risk;

- Explore partnerships to provide retrofitting classes for homeowners, renters, building professionals, and contractors;

- Conduct periodic safety surveys (vs. inspections) of nonstructural seismic hazards;

- Use home shows to promote nonstructural strategies and mitigation information; and

- Target development located in potential fault zones or in unstable soils for intensive education and retrofitting resources.

Coordinating Organization:	Emergency Management
Internal Partners:	Building, Planning
External Partners:	City building officials, school districts, builders' associations, IBHS, Red Cross, DOGAMI, IISOI, OSSPAC, Yamhill Fire Defense Board, FEMA, OEM
Timeline:	1 to 2 years, on-going
Plan Goals Addressed:	Emergency Operations; Preventive; Natural Resources Utilization; Implementation

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ST-EQ #3: Encourage purchase of earthquake hazard insurance by forming partnerships with the insurance and real estate industries.

Ideas for Implementation

- Provide earthquake insurance information to Yamhill County residents;

- Coordinate with insurance companies and organizations such as the Insurance Information Service of Oregon and Idaho (IISOI) to produce and distribute earthquake insurance information;

- Make contacts with insurance industry representatives to keep current about their requirements, rates, and plans; and

- Work with real estate industry representatives to educate them about what types of structures are resistant to earthquakes.

Coordinating Organization:	Emergency Management
External Partners:	IISOI through local insurance agencies, mortgage companies, insurance and real estate industries, DOGAMI
Timeline:	On-going
Plan Goals Addressed:	Education & Outreach; Preventive; Natural Resources Utilization

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ST-EQ #4: Maintain an inventory of all permitted dams in Yamhill County.

Ideas for Implementation

- Identify funding sources to conduct an analysis of the County's larger dams' vulnerability to seismic shakes, as well as an assessment of the possible liquefiable nature of alluvium remaining in the dam foundation and the stability of nearby landslides; and

- Update appropriate seismic criteria and procedures for evaluating performance of existing dams (varies within each permitted dam Emergency Action Plan).

  ● Susceptibility to damage from flood events

  ● Amount of water impounded

  ● Type of construction

  ● Year completed

  ● Repair work performed

Coordinating Organization:	Emergency Management
External Partners:	Watermasters, Yamhill Basin Council, WRD, McMinnville Power & Light
Timeline:	1 to 5 years
Plan Goals Addressed:	Education and Outreach; Preventive; Natural Resources Utilization

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ST-EQ #5: Identify funding sources for and implement high priority structural and nonstructural retrofits of structures that are identified as seismically vulnerable.

Lack of capital to upgrade structures is a major reason why many public and privately owned buildings and bridges are not retrofitted to stricter seismic standards.

Ideas for Implementation

- Evaluate grant and foundations that support earthquake mitigation activities;

- Provide information for property owners, small businesses, and organizations on sources of funds (loans, grants, etc.);

- Explore options for including seismic retrofitting in existing programs such as low-income housing, insurance reimbursements, and pre- and post-disaster repairs; and

- Adopt an ordinance that authorizes property tax incentives or deferrals to offset the costs of voluntary rehabilitation for existing buildings.

Coordinating Organization:	Emergency Management
Internal Partner:	Building, Planning, County Assessor
External Partners:	IISOI, OSSPAC, local banks, credit unions, SBA, Rural Development (USDA), OECDD; FEMA, OEM
Timeline:	1 to 2 years

Plan Goals Addressed:	Education & Outreach; Partnerships; Implementation

Long-term (LT) Earthquake Action Items

Long-term earthquake action items include general mitigation activities that are likely to take more than two years to implement and may require new or additional resources and/or authorities.

LT-EQ #1: Promote and continue building code standards.

Ideas for Implementation

- Continue building code education, promotion, and utilization to ensure earthquake resistant new construction.

Coordinating Organization:	Building Department
Internal Partner:	Planning
External Partner:	City planning departments, builders, developers, property owners
Timeline:	On-going
Plan Goals Addressed:	Education & Outreach; Preventive; Natural Resources Utilization

LT-EQ #2: Encourage seismic strength evaluations of critical facilities to identify vulnerabilities and to meet current seismic standards.

Ideas for Implementation

- Develop an inventory of schools, universities, and critical facilities that do not meet current seismic standards;

- Retrofit older public buildings to bring them up to current earthquake standards.

- Encourage owners of non-retrofitted reservoirs to upgrade them to meet seismic standards; and

- Encourage all water providers to replace all old cast iron pipes with more ductile iron, and identify partnership opportunities with other agencies for pipe replacement.

Coordinating Organization:	Emergency Management
Internal Partners:	Planning, Building
External Partners:	City planning departments; water service providers; OAWU; school districts, hospitals, ODOT, colleges and universities; dam/reservoir owners/managers; architects, Willamette ESD, Oregon Building Codes Division, WRD
Timeline:	On-going
Plan Goals Addressed:	Emergency Operations; Education & Outreach; Partnerships; Preventive; Implementation

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LT-EQ #3: Identify and enhance water, sewer, electric, gas and other utilities to improve their survivability in an earthquake.

Ideas for Implementation

- Coordinate utility improvements with companies, cities, and Yamhill County.

Coordinating Organization:	Emergency Management
Internal Partners:	Planning, Building, Public Works
External Partner:	City planning departments, utilities
Timeline:	On-going
Plan Goals Addressed:	Education & Outreach; Partnerships; Preventive; Natural Resources Utilization

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LT-EQ #4: Encourage earthquake safety promotion and drills to school children and community groups.

Ideas for Implementation

- Assure that all County residents, regardless of income, disability, or ethnic group, receive information about earthquakes and have the opportunity to mitigate earthquake hazards in their home;

- Conduct safety seminars with community groups to describe earthquake dangers, and steps that can be taken to reduce their impact;

- Develop educational materials in appropriate languages; and

- Encourage County schools to promote earthquake safety education.

Coordinating Organization:	Emergency Management
Internal Partner:	Planning
External Partners:	City planning departments, school districts, community organizations, housing authority
Timeline:	On-going
Plan Goals Addressed:	Emergency Operations; Education & Outreach; Partnerships; Preventive; Natural Resources Utilization

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LT-EQ #5: Improve local capabilities to perform earthquake building safety evaluations.

Ideas for Implementation

- Identify funding sources to offer training in procedures for earthquake building safety evaluations to CERT volunteers through acknowledged CERT teams throughout the County; and

- Identify funding sources to offer periodic training in ATC-20 and ATC-21 procedures for earthquake building safety evaluations and encourage local building officials and other public and private officials (facilities, maintenance, engineering, architecture) to attend.

Coordinating Organization:	Emergency Management
Internal Partner:	Building
External Partners:	FEMA, OEM, Oregon Building Codes Division, IISOI
Timeline:	On-going
Plan Goals Addressed:	Preventive; Implementation

Earthquake Resource Directory

State Resources

Department of Land Conservation and Development (DLCD)

DLCD administers the state's Land Use Planning Program. The program is based on 19 Statewide Planning Goals, including Goal 7, related to natural hazards, also conducts various landslide related mitigation activities. In order to help local governments address natural hazards effectively, DLCD provides technical assistance such as conducting workshops, reviewing local land use plan amendments, and working interactively with other agencies.

Contact: Natural Hazards Program Manager
Address: 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540
Phone: 503-373-0050
Fax: 503-378-6033
Website: http://www.lcd.state.or.us/hazards.html

Oregon Department of Geology and Mineral Industries (DOGAMI)

The mission of the Department of Geology and Mineral Industries is to serve a broad public by providing a cost-effective source of geologic information for Oregonians and to use that information in partnership to reduce the future loss of life and property due to potentially devastating earthquakes, tsunamis, landslides, floods, and other geologic hazards. The Department has mapped earthquake hazards in most of western Oregon.

Contact: Deputy State Geologist, Seismic, Tsunami, and Coastal Hazards Team Leaders
Address: 800 NE Oregon St., Suite 965, Portland, Oregon 97232
Phone: 503-731-4100
Fax: 503-731-4066
Email: james.roddey@state.or.us
Website: http://sarvis.dogami.state.or.us/homepage

Oregon Department of Consumer & Business Services-Building Codes Division

The Building Codes Division (BCD) sets statewide standards for design, construction, and alteration of buildings that include resistance to seismic forces. BCD is active on several earthquake committees and funds construction related continuing education programs. BCD registers persons qualified to inspect buildings as safe or unsafe to occupy following an earthquake and works with OEM to assign inspection teams where they are needed.

Contact: Building Codes Division
Address: 1535 Edgewater St. NW, P.O. Box 14470, Salem, Oregon 97309
Phone: 503-378-4133

Fax: 503-378-2322
Website: http://www.cbs.state.or.us/external

Oregon State Police (OSP)-Office of Emergency Management (OEM)

The purpose of OEM is to execute the Governor's responsibilities to maintain an emergency services system as prescribed in Oregon Revised Statutes Chapter 401 by planning, preparing, and providing for the prevention, mitigation and management of emergencies or disasters that present a threat to the lives and property of citizens of and visitors to the state of Oregon. OEM coordinates disaster support to local governments and works with BCD to deploy additional building inspectors when needed for damage assessment.

Contact: Earthquake and Tsunami Program Coordinator
Address: 3225 State Street, Salem, Oregon 97301
P.O. Box 14370, Salem, OR 97309-5062
Phone: 503-378-2911
Fax: 503-373-7833
Website: http://www.osp.state.or.us/oem/

The Nature of the Northwest Information Center

The Oregon Department of Geology and Mineral Industries and the USDA Forest Service operate the Nature of the Northwest Information Center jointly. It offers selections of maps and publications from state, federal, and private agencies. DOGAMI's earthquake hazard maps can be ordered from this site.

Address: Suite 177, 800 NE Oregon Street # 5, Portland, Oregon 97232
Phone: 503-872-2750
Fax: 503-731-4066
Email: Nature.of.NW@state.or.us
Website: http://www.naturenw.org/geo-earthquakes.htm

Federal Resources

Federal Emergency Management Agency (FEMA)

FEMA is heavily involved with seismic risks in Oregon and has aided in several projects in Portland and Klamath Falls. FEMA is an independent agency of the Federal Government, reporting to the President. FEMA's purpose is to reduce loss of life and property and protect the nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response, and recovery. FEMA coordinates the federal response and provides disaster relief funds following a natural hazard event and works most closely with Oregon Emergency Management (OEM).

Contact: Public Affairs Officer, FEMA, Federal Regional Center,

Address: 130 - 228th Street, St., Bothell, WA 98021-9796
Phone: 425-487-4610
Fax: 425-487-4690
Email: opa@fema.gov
Website: http://www.fema.gov/library/quakef.htm

FEMA – National Earthquake Hazards Reduction Program (NEHRP)

FEMA's earthquake program was established in 1977, under the authority of the Earthquake Hazards Reduction Act of 1977, enacted as Public Law 95-124. The purpose of the National Earthquake Hazards Reduction Program (NEHRP) is to reduce the risks of life and property from future earthquakes. FEMA serves as lead agency among the four primary NEHRP federal partners, responsible for planning and coordinating the Program.

Website: http://www.fema.gov/hazards/earthquakes/nehrp/

U.S. Geological Survey (USGS) Earthquake Hazards Program

The Earthquake Hazard Program is part of the USGS effort to reduce earthquake hazard in the United States. The USGS is the only Federal agency with responsibility for recording and reporting earthquake activity nationwide. Citizens, emergency responders, and engineers rely on the USGS for accurate and timely information on where an earthquake occurred, how much the ground shook in different locations, and what the likelihood is of future significant ground shaking.

Contact: Earthquake Hazard Program, USGS
Address: University of Washington, Department of Earth and Space Sciences, Box 351310, Room 63, Seattle, WA 98195-1310
Website: http://earthquake.usgs.gov/regional/pacnw

USGS National Earthquake Information Center (NEIC)

The USGS is an active seismic research organization that also provides funding for research. (For an example of such research, see Recommended Seismic Publications below). The mission of the National Earthquake Information Center (NEIC) is to rapidly determine location and size of all destructive earthquakes worldwide and to immediately disseminate this information to concerned national and international agencies, scientists, and the general public. As World Data Center for Seismology, Denver, the NEIC compiles and maintains an extensive, global seismic database on earthquake parameters and their effects that serves as a solid foundation for basic and applied earth science research.

Contact: USGS, National Earthquake Information Center
Address: Box 25046; DFC, MS 967; Denver, Colorado 80225-0046
Phone: 303-273-8500
Fax: 303-273-8450
Website: http://neic.usgs.gov

Building Seismic Safety Council (BSSC)

The Building Seismic Safety Council (BSSC), established by the National Institute of Building Sciences (NIBS), deals with complex regulatory, technical, social, and economic issues and develops and promotes building earthquake risk mitigation regulatory provisions for the nation.

Address: 1090 Vermont Avenue, NW, Suite 700, Washington, DC 20005-4905
Phone: 202-289-7800
Fax: 202-289-1092
Website: http://www.bssconline.org/

Western States Seismic Policy Council (WSSPC)

The WSSPC is a regional organization that includes representatives of the earthquake programs of thirteen states (Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon Utah, Washington, and Wyoming), three U.S. territories (American Samoa, Commonwealth of the Northern Mariana Islands and Guam), one Canadian Province (British Columbia), and one Canadian Territory (Yukon). The primary aims of the organization have been to improve public understanding of seismic risk; to improve earthquake preparedness, and to provide a cooperative forum to enhance transfer of mitigation technologies at the local, state, interstate, and national levels.

The mission of the Council is to provide a forum to advance earthquake hazard reduction programs throughout the western region and to develop, recommend, and present seismic policies and programs through information exchange, research and education.

Contact: WSSPC
Address 644 Emerson Street, Suite 22, Palo Alto, CA 94301
Phone: 650-330-1101
Fax: 650-330-1973
Email: wsspc@wsspc.com
Website: http://www.wsspc.org/

Cascadia Region Earthquake Workgroup (CREW)

CREW provides information on regional earthquake hazards, facts and mitigation strategies for the home and business office. CREW is a coalition of private and public representative s working together to improve the ability of Cascadia Region communities to reduce the effects of earthquake events. Members are from Oregon, Washington, California, and British Columbia. Goals are to:

- Promote efforts to reduce the loss of life and property.
- Conduct education efforts to motivate key decision makers to reduce risks associated with earthquakes.

- Foster productive linkages between scientists, critical infrastructure provides, businesses and governmental agencies in order to improve the viability of communities after an earthquake.

Contact: CREW, Executive Director
Address: 3110 Portage Bay Place E, Slip G, Seattle, WA 98102
Phone: 206-328-2533
Fax: 206-328-2533 (call first)
Email: bfreitag@mindspring.com
Website: http://www.crew.org/

Additional Resources

Red Cross

Each year, the American Red Cross responds immediately to more than 67,000 disasters, including house or apartment fires (the majority of disaster responses), hurricanes, floods, earthquakes, tornadoes, hazardous materials spills, transportation accidents, explosions, and other natural and human-created disasters. The Oregon Trail Chapter serves the residents of Clackamas, Clatsop, Columbia, Multnomah, Tillamook, Washington and Yamhill counties.

Contact: American Red Cross, Oregon Trail Chapter
Address: 3131 N Vancouver Ave, Portland, OR 97227-1560
P.O. Box 3200, Portland, OR 97208-3200
Phone: 503-284-1234
Fax: 503-284-4247
Website: http://www.redcross-oregontrail.org
Email: info@redcross-pdx.org

Institute for Business & Home Safety (IBHS)

IBHS was created as an initiative of the insurance industry to reduce damage and losses caused by natural disasters. Their website provides educational resources and on-line publications for insurers, businesses, and homeowners who are interested in taking the initiative to minimize future damages and losses.

Contact: Institute for Business and Home Safety
Address: 1408 North Westshore Boulevard - Suite 208 - Tampa, FL 33607
Phone: 813-286-3400
Fax: 813-286-9960
E-mail: info@ibhs.org
Website: http://www.ibhs.org/

Publications

Planning for Natural Hazards: The Oregon Technical Resource Guide, Department of Land Conservation and Development (July 2000).

Produced by the Community Planning Workshop for the Department of Land Conservation and Development, this is a natural hazards planning and mitigation resource for Oregon cities and counties. It

provides hazard-specific resources and plan evaluation tools. The document was written for local government employees and officials. The Technical Resource Guide includes a natural hazards comprehensive plan review, a hazard mitigation legal issues guide, and five hazard-specific technical resource guides, including: flooding, wildfires, landslides, coastal hazards, and earthquakes. Write, call, fax, or go on-line to obtain this document.

Contact: Natural Hazards Program Manager, DLCD
Address: 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540
Phone: 503-373-0050
Fax: 503-378-6033
Website: http://www.lcd.state.or.us/hazards.html

Environmental, Groundwater and Engineering Geology: Applications for Oregon – Earthquake Risks and Mitigation in Oregon, Yumei Wang, (1998) Oregon Department of Geology and Mineral Industries, Star Publishing.

This paper deals with earthquake risks in Oregon, what is being done today, and what policies and programs are in action to help prevent loss and damage from seismic events. This article also gives a good list of organizations that are doing work in this field within the state. This article is somewhat technical but provides vital information to communities around the state.

Special Paper 29: Earthquake damage in Oregon: Preliminary estimates of future earthquake losses, Yumei Wang, Oregon Department Of Geology And Mineral Industries.

Wang, a geotechnical engineer, analyzed all faults with a ten percent chance of causing an earthquake in the next 50 years and projected potential damage. Wang stresses that these are preliminary figures. "There are two things we could not incorporate into this study that would significantly increase these figures. One is a tsunami. The other is an inventory of unreinforced brick or masonry buildings."

Contact: DOGAMI
Address: 800 NE Oregon St., Suite 965, Portland, Oregon 97232
Phone: 503-731-4100
Fax: 503-731-4066
Website: http://sarvis.dogami.state.or.us/homepage

Land Use Planning for Earthquake Hazard Mitigation: A Handbook for Planners. Wolfe, Myer R. et. al., (1986) University of Colorado, Institute of Behavioral Science, National Science Foundation.

This handbook provides techniques that planners and others can utilize to help mitigate for seismic hazards. It provides information on the effects of earthquakes, sources on risk assessment, and effects

of earthquakes on the built environment. The handbook also gives examples on application and implementation of planning techniques to be used by local communities.

Contact: Natural Hazards Research and Applications Information Center
Address: University of Colorado, 482 UCB, Boulder, CO 80309-0482
Phone: 303-492-6818
Fax: 303-492-2151
Email: hazctr@colorado.edu
Website: http://www.colorado.edu/UCB/Research/IBS/hazards

Using Earthquake Hazard Maps: A Guide for Local Governments in the Portland Metropolitan Region; Evaluation of Earthquake Hazard Maps for the Portland Metropolitan Region. Spangle Associates, (1998/1999) Urban Planning and Research, Portola Valley, California.

These two publications are useful for local governments concerned with land use in earthquake hazard areas. The proximity of Yamhill County to Portland and their interactive communities make these guides applicable to the County. The publications are written in clear and simplistic language and address issues such as how to apply earthquake hazard maps for land use decisions.

Contact: DOGAMI
Address: 800 NE Oregon St., Suite 965, Portland, Oregon 97232
Phone: 503-731-4100
Fax: 503-731-4066
Website: http://sarvis.dogami.state.or.us/homepage

Public Assistance Debris Management Guide, Federal Emergency Management Agency (July 2000).

The Debris Management Guide was developed to assist local officials in planning, mobilizing, organizing, and controlling large-scale debris clearance, removal, and disposal operations. Debris management is generally associated with post-disaster recovery. Developing strategies to ensure strong debris management is a way to integrate debris management within mitigation activities. The *Public Assistance Debris Management Guide* is available in hard copy or on the FEMA website.

Contact: FEMA Distribution Center
Address: 130 - 228th Street, SW, Bothell, WA 98021-9796
Phone: 800-480-2520
Fax: 425-487-4622
Website: http://www.fema.gov/r-n-r/pa/dmgtoc.htm

Earthquake - Endnotes

[1] "Oregon's Plates Are More Worrisome than California's Faults." *The Oregonian*. March 27, 1994: Page 2A.

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[3] Interagency Hazard Mitigation Team. 2000. *State Hazard Mitigation Plan*. Oregon State Police – Office of Emergency Management. Salem, OR.

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[18] Beggs, Charles E. March 21, 2000. "One in Three Homes Insured for Quakes Since Spring Break Shaker." *News-Register*. Available on the World Wide Web http://www.newsregister.com/…/story_print.cfm?story_no=11361. Accessed August 26, 2004.

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[21] Id.

[22] Id.

[23] Id.

[24] "Earthquake Hits Powerlines, Roads." *Statesman Journal*. March 26, 1993. Page 5A.

[25] Id.

[26] Hill, Richard. "Geo Watch Warning Quake Shook Portland 40 Years Ago." *The Oregonian*. October 30, 2002.

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[31] Id.

[32] *Statesman Journal*. April 13, 1949.

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[34] Wong, Ivan G and Jacqueline D.J. Bott. November 1995. "A Look Back at Oregon's Earthquake History, 1841- 1994." *Oregon Geology* 57 (6). 125.

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[36] Hill, Richard. "Geo Watch Warning Quake Shook Portland 40 Years Ago." *The Oregonian*. October 30, 2002.

[37] Community Planning Workshop, 2002.

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[42] Forgey, Pat. March 1, 2001. "Earthquake Causes Little Damage Locally." *News-Register*. Available on the World Wide Web http://www.newsregister.com/…/story_print.cfm?story_no=12716. Accessed August 26, 2004.

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Wide Web http://www.newsregister.com/…/story_print.dfm?story_no=11361. Accessed August 26, 2004.

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[45] Wong, Ivan G and Bott Jacqueline D.J. November 1995. "A Look Back at Oregon's Earthquake History, 1841- 1994." *Oregon Geology* 57 (6). 125.

[45] Id.

[45] Hill, Richard. "Geo Watch Warning Quake Shook Portland 40 Years Ago." *The Oregonian*. October 30, 2002.

[45] Community Planning Workshop, 2002.

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[45] Department of Land Conservation and Development. July 2000. *Planning for Natural Hazards: The Oregon Technical Resource Guide*. Ch. 8, Page 7.

[45] Wang, Y. and J.L. Clark. 1999. "Earthquake Damage in Oregon: Preliminary Estimates of Future Earthquake Losses." Special Paper 29. DOGAMI. Page 57.

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[45] Id.

[45] Community Planning Workshop, 2002