Section 7:
Landslide

Why are Landslides a Threat to Yamhill County?

Landslides are a serious geologic hazard in almost every state in America. Nationally, landslides cause 25 to 50 deaths each year.[1] The best estimates of the direct and indirect costs of landslide damage in the United States range between $1 billion to $2 billion annually.[2] In Oregon, a significant number of locations are at risk to dangerous landslides. While not all landslides result in private property damage, many landslides impact transportation corridors, fuel and energy conduits, and communication facilities.[3] They can also pose a serious threat to human life.

A 1998 study completed by the Oregon Department of Geology and Mineral Industries (DOGAMI) states that although few landslides develop in the Willamette Valley as compared to more mountainous parts of the state, the marine sedimentary rock units in southern Yamhill County and the edges of the valley are susceptible to large slides.[4]

Landslides can be broken down into two categories: (1) rapidly moving; and (2) slow moving. Rapidly-moving landslides (debris flows and earth flows) present the greatest risk to human life, and persons living in or traveling through areas prone to rapidly moving landslides are at increased risk of serious injury. Rapidly moving landslides have also caused most of the recent landslide-related injuries and deaths in Oregon. A rapidly moving debris flow in Douglas County killed five people during the storms of 1996. Slow moving landslides can cause significant property damage, but are less likely to result in serious human injuries.

History of Landslide Events

Currently there is no comprehensive list of landslide events and/or dates for Yamhill County. Landslides probably accompany every major storm system that impacts western Oregon. In recent events, particularly noteworthy landslides accompanied storms in 1964, 1982, 1966 and 1996. Two major landslide-producing winter storms occurred in Oregon during November 1996. Intense rainfall on recently and past logged land as well as previously un-logged areas triggered over 9,500 landslides and debris flows that resulted directly or indirectly in eight fatalities.[5] The storms of 1996 produced thousands of landslides in the Cascade and Oregon Coast mountain ranges.[6]

A DOGAMI study of the western portion of the Salem Hills indicated that slopes nearest to the Willamette River contain the greatest risk of landslide.[7] The study further states, “the rock types within the Salem Hills include weak and low-permeability marine sediments overlain by high-strength basalts with prominent and pervasive discontinuities. These rock types, along with clay-rich residual soils overlying the basalts, provide a setting that is susceptible to water-induced landsliding where slopes are relatively steep and within existing slide masses.”[8]

Many prominent features that help identify ancient landslide terrain are hummocky topography, disrupted drainage patterns, sag ponds, springs, back-tilted bedrock blocks, and subdued head scarps.[9]

Landslide Characteristics

What is a Landslide?

Landslides are downhill or lateral movements of rock, debris, or soil mass. The size of a landslide usually depends on the geology and the landslide triggering mechanism. Landslides initiated by rainfall tend to be smaller, while those initiated by earthquakes may be very large. Slides associated with volcanic eruptions can include as much as one cubic mile of material.

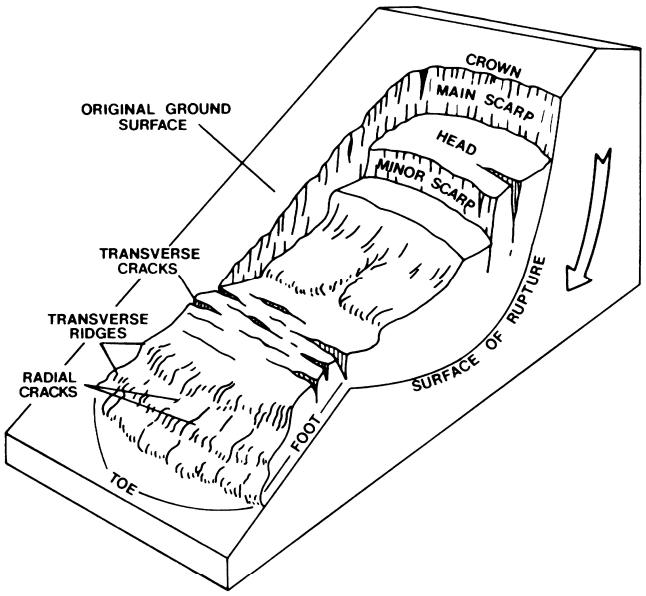
Landslides vary greatly in the volumes of rock and soil involved, the length, width, and depth of the area affected, frequency of occurrence, and speed of movement. With few exceptions, the primary ingredients for landslides are steep slopes, water (moisture content), and weak soils or rocks. Vegetation influences landslides both by binding soil with the roots and by using soil moisture that would otherwise tend to saturate the soil profile. Tree harvesting, fire, and roads are thought to increase the frequency of landslides.

Landslides are given different names depending on the type of failure and their composition and characteristics. Types of landslides include slides, rock falls, and flows.

Slides move in contact with the underlying surface. These movements include rotational slides where sliding material moves along a curved surface, and translational slides where movement occurs along a flat surface. These slides are generally slow moving and can be deep. Slumps are small rotational slides that are generally shallow (See Figure 5.1). Slow-moving landslides can occur on relatively gentle slopes and can cause significant property damage, but are far less likely to result in serious injuries than rapidly moving landslides.[10]

Erosion occurs when ditches or culverts beneath hillside roads become blocked with debris. If the ditches are blocked, run-off from the slopes is inhibited during periods of precipitation. This causes the run-off water to collect in soil, and in some cases, cause a slide. Usually the slides are small (100 to 1,000 cubic yards), but they can be quite large.

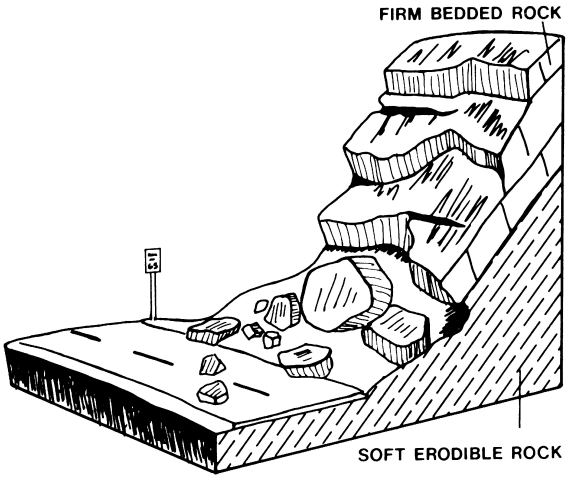
Figure 5.1. Rotational Slide



Source: *Planning for Natural Hazards: The Oregon Technical Resource Guide*, Oregon Department of Land Conservation and Development

Rock falls (see Figure 5.2) occur when blocks of material come loose on steep slopes. Weathering, erosion, or excavations, such as those along highways, can cause falls where the road has been cut through bedrock. They are fast moving with the materials free falling or bouncing down the slope. In falls, material is detached from a steep slope or cliff. The volume of material involved is generally small, but large boulders or blocks of rock can cause significant damage.

Figure 5.2. Rock Fall

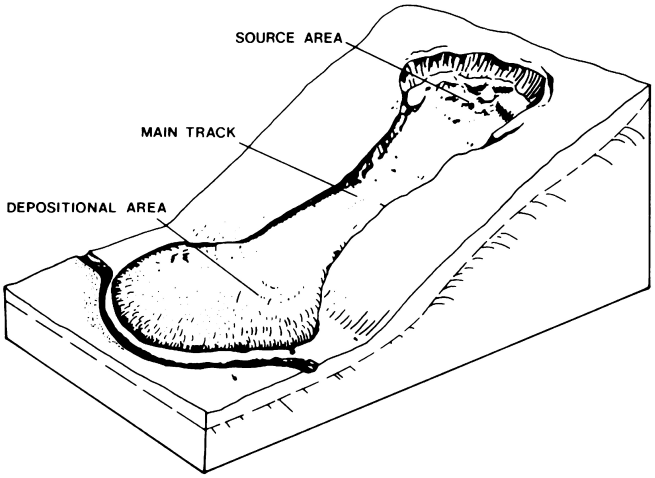


Source: *Planning for Natural Hazards: The Oregon Technical Resource Guide*, Oregon Department of Land Conservation and Development

Flows (see Figure 5.3) are plastic or liquid movements in which land mass (e.g. soil and rock) breaks up and flows during movement. They occur throughout Oregon, but are especially noteworthy in the Cascade and Coast Ranges.

Earthquakes often trigger flows.[11] Debris flows normally occur when a landslide moves downslope as a semi-fluid mass scouring, or partially scouring soils from the slope along its path. Flows are typically rapidly moving and also tend to increase in volume as they scour out the channel.[12] Flows often occur during heavy rainfall, can occur on gentle slopes, and can move rapidly for large distances. One example of a flow in Oregon is the Dodson debris flow that occurred in 1996. This debris flow started high on the Columbia Gorge cliffs, and traveled far down steep canyons to form debris fans at Dodson.[13]

Figure 5.3. Earthflow



Source: *Planning for Natural Hazards: The Oregon Technical Resource Guide*, Oregon Department of Land Conservation and Development

Landslides are typically triggered by periods of heavy rainfall or rapid snowmelt. Earthquakes, volcanic activity, and excavations may also trigger landslides. Certain geologic formations are more susceptible to landslides than others. Human activities, including locating development near steep slopes, can increase susceptibility to landslide events. Landslides on steep slopes are more dangerous because movements can be rapid.

Although landslides are a natural geologic process, the incidence of landslides and their impacts on people can be exacerbated by human activities. Grading for road construction and development can increase slope steepness. Grading and construction can decrease the stability of a hillslope by adding weight to the top of the slope, removing support at the base of the slope, and increasing water content. Other human activities affecting landslides include: excavation, drainage and groundwater alterations, and changes in vegetation.[14]

Landslide Conditions

Natural Conditions

Natural processes can cause landslides or reactivate historical landslide sites. Rainfall-initiated landslides tend to be smaller, while earthquake-induced landslides may be very large, but less frequent. The removal of shoreline supporting material along bodies of water by currents and waves, or undercutting during construction at the base of a slope produces countless small slides each year. Seismic tremors can trigger landslides on slopes historically known to have landslide movement. Earthquakes can also cause additional failure (lateral spreading) that can occur on gentle slopes above steep streams and riverbanks. Landslides are particularly common along stream banks, reservoir shorelines, large lakes, and seacoasts. Steep, concave-shaped slopes with larger drainage areas appear to be more susceptible to landslides than other landforms. Landslides associated with volcanic eruptions can include volumes of over one cubic mile of material. All soil types can be affected by natural landslide triggering conditions.

Excavation and Grading

Slope excavation is common in the development of home sites or roads on sloping terrain. Grading these slopes can result in some slopes that are steeper than the pre-existing natural slopes. Since slope steepness is a major factor in landslides, these steeper slopes can be at an increased risk for landslides. The added weight of fill placed on slopes can also result in an increased landslide hazard. Small landslides can be fairly common along roads, in either the road cut or the road fill. Landslides occurring below new construction sites are indicators of the potential impacts stemming from excavation.

What locations are at risk from landslides and debris flows?

Locations at risk from landslides or debris flows include areas with one or more of the following conditions:

- On or close to steep hills;
- Steep road-cuts or excavations into steep slopes;
- Existing landslides or places of known historic landslides (such sites often have tilted power lines, trees tilted in various directions, cracks in the ground, and irregular-surfaced ground);
- Steep areas where surface runoff is channeled, such as below culverts, V-shaped valleys, canyon bottoms, and steep stream channels;
- Fan-shaped areas of sediment and boulder accumulation at the outlets of canyons, large boulders (2 to 20 feet diameter) perched on soil near fans or adjacent to creeks; and
- Occurrences of logjams in streams.[1]

Drainage and Groundwater Alterations

Water flowing through or over the ground is often the trigger for a landslide. Any activity that increases the amount of water flowing into landslide-prone slopes can increase landslide hazards. Broken or leaking water or sewer lines can be especially problematic, as can water retention facilities that direct water onto slopes. Even lawn irrigation and minor alterations to small streams in landslide prone locations can result in damaging landslides. Ineffective stormwater

management and excess runoff can also cause erosion and increase the risk of landslide hazards. Drainage can be affected naturally by the geology and topography of an area. Development that results in an increase in impervious surface impairs the ability of the land to absorb water and may redirect water to other areas. As a result, more landslides could occur.

Channels, streams, ponding, and erosion on slopes all indicate potential slope problems. Road and driveway drains, gutters, downspouts, and other constructed drainage facilities can concentrate and accelerate flow. Ground saturation and concentrated velocity flow are major causes of slope problems and may trigger landslides.[15]

Changes in Vegetation

Removing vegetation from very steep slopes can increase landslide hazards. The *Storm Impacts Study* conducted by the Oregon Department of Forestry found that landslide hazards in three out of four steeply sloped areas were highest for a period of ten years after timber harvesting.[16] Areas that have experienced wildfire and land clearing for development may have long periods of increased landslide hazard. In addition, woody debris in stream channels (both natural and as a result from logging) may cause the impacts from debris flows to be more severe.[17]

Development

Development sites at the greatest risk from landslides are against the base of very steep slopes, in confined stream channels (small canyons), and on fans (rises) at the mouth of these confined channels. While home development sites do not cause landslides, they put residents and property at risk of landslide impacts. The simplest mitigation measure for this situation is to locate the home out of the impact area, or construct debris flow diversions for homes at risk. Three development-related actions that can put people at risk include:[18]

1. **Creating Steeper Slopes**. Excavation practices, sometimes aggravated by drainage, can reduce the stability of otherwise stable slopes. These failures commonly affect only a small number of homes. Without these excavation practices, there is little risk of landslides in areas not prone to landslide movement.
2. **Development on or Adjacent to Existing Landslides**. Existing landslides are generally at risk of future movement regardless of excavation practices. Excavation and drainage practices can further increase risk of landslides. In many cases, there are no development practices that can completely assure stability. Homeowners and communities in these situations accept some risk of future landslide movement.
3. **Development on Gentle Slopes**. Development on gentle slopes can be subject to landslides that begin a long distance from the development.

Informing new residents, long-time homeowners, and developers about the risks associated with landslides is an important issue related to landslide location and occurrence. Developers that are uninformed about geological

materials and processes may contribute to conditions that trigger landslide activity or increase susceptibility to landslide hazards.[19]

Landslide Hazard Assessment

Hazard Identification

Hazard identification is the first phase of a hazard assessment, and is the process of estimating the geographic extent of the hazard, its intensity, and its probability of occurrence.[20] This process usually results in a hazard map. Hazard maps can provide detailed information in a clear format and can assist in making policy and land use decisions.

Debris flows generally occur during intense periods of rainfall on previously saturated soil. They generally start on steep slopes and accelerate to speeds as great as 35 mph. These rapidly moving landslides have caused most of the recent landslide related injuries and deaths in Oregon.[21] The previous damage and deaths associated with rapidly moving landslides in Oregon have been the catalyst for agencies to map these types of landslides. Currently, two state agencies are involved in mapping debris flows: (1) the Oregon Department of Forestry (ODF); and (2) the Department of Geology and Mineral Industries (DOGAMI).

Vulnerability Assessment

Vulnerability assessment is the second phase of a hazard assessment. It combines the information generated through debris flow identification with an inventory of the existing development exposed to landslide hazards. Vulnerability assessments assist in predicting how different types of property and population groups will be affected by a hazard.[22] The optimum method for doing this analysis at the county or jurisdiction level is to use parcel-specific assessment data on land use and structures.[23] Data that includes specific landslide-prone and debris flow locations in the county can be used to assess the population and total value of property at risk from future landslide occurrences.

While a quantitative vulnerability assessment (an assessment that describes number of lives or amount of property exposed to the hazard) has not yet been conducted for Yamhill County landslide events, there are many qualitative factors (issues relating to what is in danger within a community) that point to potential vulnerability. Landslides can impact major transportation arteries, blocking residents from essential services and businesses. While past landslide events have not caused major property damage or significantly impacted county residents, continuing to map county landslide and debris flow areas will help in preventing future loss.

Risk Analysis

Risk analysis is the third, and most advanced phase of a hazard assessment. It builds upon hazard identification and vulnerability assessments.

Factors included in assessing landslide risk include population and property distribution in the hazard area, the frequency of landslide or debris flow

occurrences, slope steepness, soil characteristics, and precipitation intensity. This type of analysis could generate estimates of the damages to the county due to a landslide or debris flow event in a specific location. Current data is insufficient to conduct a risk analysis and the software needed to conduct this type of analysis was not available.

The Oregon Department of Forestry (ODF) and the Department of Geology and Mineral Industries (DOGAMI) are active in developing maps and collecting data on hazard risk. Developing partnerships with these agencies and other state and federal organizations can facilitate future strides in doing risk analysis for landslide hazards.

Community Landslide Issues

Landslides can affect utility services, transportation systems, and critical lifelines. 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 landslide movements as small as an inch or two.[24]

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.[25] Flood events can also cause landslides, which can have serious impacts on gas lines.

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

County

County Zoning Ordinance

Yamhill County mapped its steep slope (hazardous) areas and adopted steep slope ordinances.

State

Oregon State Senate Bill 12

The fatalities and losses resulting from the 1996 landslide events brought about the passage of Oregon Senate Bill 12, which set site development standards, authorized the mapping of areas subject to rapidly moving landslides and the development of model landslide (steep slope) ordinances. Provisions include:

- Allowing the Oregon State Forester to prevent timber harvest or road construction in or below areas identified by the Department of Forestry as “high risk sites” and where homes or highways are in precarious locations.
- Allowing road officials to close roads that pose risk to human life because of landslides.
- Requiring State agencies to develop, and local officials to distribute, information about hazards of construction on sites that are vulnerable to landslides.

- Establishing a ten-member Task Force on Landslides and Public Safety to assess the problem and develop a solution. It includes legislators and representatives from state natural resource agencies, boards of commissions, local government, and the public.

Debris Flow Mapping

Currently, two state agencies are involved in mapping debris flows: (1) the Oregon Department of Forestry (ODF) and (2) the Department of Geology and Mineral Industries (DOGAMI). Senate Bill 12 requires that the DOGAMI, with cooperation from local governments and the ODF, identify and map landslide-prone areas, or "further review areas." Senate Bill 12 defines a further review area as "an area of land in which further site specific review should occur before land management or building activities begin."[26] ODF is responsible for forecasting and measuring rainfall from storms that may trigger debris flows.

Oregon Department of Forestry (ODF)

The Oregon Department of Forestry has provided a preliminary indication of debris flow (rapidly moving landslides) in western Oregon. Their debris flow maps include the general locations subject to naturally occurring debris flows and include the initiation sites and locations along the paths of potential debris flows (confined stream channels and locations below steep slopes). These maps do not consider the effects of management-related slope alterations (drainage and excavation) that can increase the hazard, nor do they consider very large landslides that could possibly be triggered by volcanic or earthquake activity. Areas identified in these maps are not to be considered "further review areas" as defined by Senate Bill 12 (1999).[27]

Information used to develop the ODF Debris Flow maps include:

- Digital elevation models at 30-meter resolution based on US Geological Survey data, to derive slope steepness and then to develop polygons for assigned hazards. Note that actual slopes are steeper than the digitally elevated models.
- Mapped locations of Tyee soil formation and similar sedimentary geologic units.
- Oregon Department of Forestry *Storm Impacts and Landslides of 1996* study; debris flow initiation and path location data.
- Stream channel confinement near steep hill slopes based on US Geological Survey Digital Raster Graphics.
- Historical information on debris flow occurrence in western Oregon (from Oregon Department of Forestry, US Forest Service, DOGAMI, Bureau of Land Management (BLM), and the Oregon Department of Transportation (ODOT)).
- Fan-shaped land formations below long, steep slopes.

Areas of highest intensity precipitation do not appear to be correlated with known areas of high and extreme debris flow hazard, so precipitation intensity was *not* used to develop risk (hazard) ratings.[28]

Prohibition of Certain Forest Operations

As part of the requirements of Senate Bill 12, ODF is currently administering the deferral of certain forest operations on landslide-prone sites above homes and roads. The Department's policy is that timber harvesting or road construction operations will be prohibited on land where landslides or debris flows pose a significant threat to human safety. Exceptions for salvage or other purposes are considered on an individual basis, but have been infrequent in keeping with the intent of preventing significant risks to human life.[29]

Debris Flow Warning System

Oregon initiated a debris flow warning system in 1997, which involves collaboration between ODF, DOGAMI, ODOT, local law enforcement, NOAA Weather Radio, and local media.

ODF meteorologists are responsible for forecasting storms that may trigger debris flows. Information is broadcast over NOAA Weather Radio and on the Law Enforcement Data System. DOGAMI provides additional information on debris flows to the media. ODOT provides information concerning the location of landslides/debris flows, and alternate transportation routes.[30] ODOT also provides warning signs to motorists in landslide-prone areas during high-risk periods.[31]

Landslide Brochure

DOGAMI developed a landslide public outreach brochure in cooperation with several other state agencies. Forty thousand copies were printed in November1997 and were distributed widely to building codes officials, county planners, local emergency managers, field offices of natural resource agencies, banks, real estate companies, insurance companies, and other outlets. Landslide brochures are available from DOGAMI, OEM, ODF, and the Department of Land Conservation and Development (DLCD).[32]

Oregon State Building Code Standards

The Oregon Building Codes Division adopts statewide standards for building construction that are administered by state and local municipalities throughout Oregon. The One- and Two-Family Dwelling Code and the Structural Specialty Code contain provisions for lot grading and site preparation for the construction of building foundations.

Both codes contain requirements for cut, fill, and sloping of the lot in relationship to the location of the foundation. There are also building setback requirements from the top and bottom of slopes. The codes specify foundation design requirements to accommodate the type of soils, the soil bearing pressure, and the compaction and lateral loads from soil and groundwater on sloped lots. The building official has the authority to require a soils analysis for any project where it appears the site conditions do not meet the requirements of the codes, or that special design considerations must be taken. ORS 455.447 and the Structural Code require a seismic site hazard report for projects that include essential facilities such as hospitals, fire and police stations, emergency response facilities, and special occupancy structures, such as large schools and prisons.[33]

Case Study: Salem Landslide Ordinance

The 1996 flood events contributed to two major landslide events, which forced the City of Salem into litigation. Through FEMA's Hazard Mitigation Grant Program, the City of Salem, Marion County, and DOGAMI received $250,000 to map landslide areas and develop a landslide ordinance.

The ordinance requires the preparation and approval of geological assessments before development occurs in areas identified with a moderate degree of hazard. Those areas then undergo a preliminary review of geologic conditions. The ordinance requires staff to determine if a geotechnical report requiring more information and detail than the geological assessment is necessary. This approach ensures adequate review of proposed development on private property where potentially greater risk requires detailed information to fully identify and address the hazard. Additionally, prior to development, a declaratory statement indicating that the property is within an identified hazard area must be recorded on the property deed. Compliance with the ordinance is required as part of any land use permit and building permit for regulated activities within identified hazard areas.[34]

The Salem ordinance identified four key elements:

1) **Identify the hazard**. DOGAMI produced water-induced and earthquake-induced landslide maps for South Salem and Eola Hills. The ordinance incorporates slope steepness and hazard areas. The slope steepness criteria were formulated to address hillside development, which was not included in the mapping process. Salem's Building and Safety Division created a kiosk where people can print out landslide maps of site-specific areas.

2) **Determine when to regulate**. The city developed a graduated response table to determine the level of site investigation for various types of regulated activities on property within the mapped area. Landslides with moderate or high susceptibility may be subject to regulation (this is determined by the regulated activity).

3) **Establish an assessment process for hazard areas.** The city adopted its assessment process as a procedural ordinance that documents when to require a geological assessment prepared by a Certified Engineering Geologist or a geotechnical report prepared by both a Certified Engineering Geologist and a registered Geotechnical Engineer. When development is in a high-risk area, the city requires the geological assessment and the geotechnical report.

4) **Share the responsibility of hillside development.** Partnerships with state and local officials, residents, and businesses can reduce risk and prevent loss by bringing all their concerns to the table.

Why is the Salem landslide ordinance useful?

Because there is vacant land in landslide areas, it is important to develop landslide hazard mitigation activities. The potential for future development

necessitates strong regulation to reduce risk from potential landslide events.

Salem's landslide ordinance requires that an appropriate level of *study* occur before development occurs. While the process of developing a new ordinance was not without controversy, it was a collaborative project. Collaborative partnerships assist in future implementation. DOGAMI, OEM, DLCD, Marion County, the Board of Examiners, State Engineering Board, and the City of Salem played a role in developing the ordinance.

For more information, contact:
City of Salem
555 Liberty St. SE/Room 305, Salem, OR 97301-3503
Phone: (503) 588-6211
Fax: (503) 588-6005
http://www.open.org/~naturalr/Landslides/landslide_Ord.htm

Landslide 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 actions items were refined through discussions with the mitigation plan steering committee and through an open house at which the county received comments from the public.

The landslide mitigation action items provide direction on specific activities that organizations and residents in Yamhill County can undertake to reduce risk and prevent loss from landslides. 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 landslides in Yamhill County. These action items are designed to meet the mitigation plan goals.

Short-term (ST) Landslide Action Items

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

ST-LS #1: Improve knowledge of landslide hazard areas and understanding of vulnerability and risk to life and property in hazard-prone areas.

Ideas for Implementation

- Incorporate the results of the DOGAMI mapping effort when available into the County Natural Hazards Mitigation Plan Risk Assessment, and other county planning documents;
- Continue mapping county landslide and debris flow areas;
- Identify the location and extent of hazard areas and establish a factual base to support implementation of future measures;
- Analyze the risk of these areas to life, property, and infrastructure; and
- Develop public information to emphasize economic risk when building on potential or historical landslide areas.

Coordinating Organization:	Emergency Management
Internal Partner:	GIS, Public Works, Planning
External Partner:	DOGAMI, ODF, cities
Timeline:	2 years, On-going
Plan Goals Addressed:	Education & Outreach; Partnerships; Preventive; Implementation

ST-LS #2: Encourage construction, site location and design that can be applied to steep slopes to reduce the potential threat of landslides.

Ideas for Implementation

- Reduce driveway cuts into the hillside;
- Adjust the building setback from property lines to minimize building site cuts and fills;
- Require erosion control techniques, such as the temporary use of hay bales, diversion dams, or other physical changes to control stormwater runoff during road and site construction;
- Suggest to property owners to reduce water input into slopes from building roof drains, storm drains, and surface runoff;
- Develop a 'how-to' development and construction guide for homeowners in potential landslide hazard areas; and
- Develop public information to emphasize economic risk when building on potential or historical landslide areas.
- Where appropriate, reduce the number of building sites and corresponding disruption of the natural contour and vegetation; and
- Increase communication and coordination between Yamhill County Public Works and Building Departments.

Coordinating Organization:	Emergency Management, Building and Public Works
Internal Partner:	Planning
External Partners:	DLCD, cities, IBHS
Timeline:	1 to 3 years
Plan Goals Addressed:	Education & Outreach; Partnerships; Preventive; Natural Resources Utilization; Implementation

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ST-LS #3: Identify safe evacuation routes in high-risk debris flow and landslide areas.

Ideas for Implementation

- Identify potential debris removal resources;
- Make available in GIS for access to the public;
- Increase participation in regional committee planning for emergency transportation routes; and
- Identify and publicize information regarding emergency transportation routes.

Coordinating Organization:	Public Works
Internal Partner:	Emergency Management, GIS
External Partner:	ODOT, adjacent counties, DOGAMI
Timeline:	2 years
Plan Goals Addressed:	Emergency Operations; Partnerships; Preventive

ST-LS #4: Compile Relative Landslide Risk maps for Yamhill County.

Note: DOGAMI will make the final determination of "further review areas" for rapidly moving landslides as required by Oregon Senate Bill 12.

Ideas for Implementation

- Once "further review areas" are established by DOGAMI, overlay those areas with utility system maps and tax assessor information to identify potential risk.

Coordinating Organization:	GIS
Internal Partners:	Emergency Management, Planning, Public Works, Assessor's Office
External Partners:	USFS, BLM, water systems, utilities, forest industries, DOGAMI
Timeline:	Depending on DOGAMI funding in this biennium
Plan Goals Addressed:	Emergency Operations; Education & Outreach; Partnerships; Preventive

ST-LS #5: Increase public education related to landslide hazards by distributing DOGAMI landslide informational brochure.

NOTE: DOGAMI produced an information brochure on landslide hazards.

Ideas for Implementation

- Distribute the DOGAMI landslide informational brochure.

Coordinating Organization:	Emergency Management
Internal Partner:	Planning, Public Works
External Partners:	City emergency managers, DOGAMI, OEM, DLCD
Timeline:	1 to 2 years
Plan Goals Addressed:	Education & Outreach; Partnerships

Long-term (LT) Landslide Action Items

Long-term landslide 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-LS #1: Evaluate current landslide warning systems to ensure effectiveness and efficiency and increase coordination between local jurisdictions and ODF for landslide warning systems.

Ideas for Implementation

- Educate high-risk populations about climatic and soil conditions that are conducive to landslides.

Coordinating Organization:	Emergency Management
Internal Partner:	Planning
External Partner:	Builders, developers, property owners, ODF, BLM
Timeline:	On-going
Plan Goals Addressed:	Emergency Operations; Education & Outreach; Preventive

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LT-LS #2: Mitigate activities in identified potential and historical landslide areas through public outreach.

Ideas for Implementation

- Coordinate with property owners to reduce risk in landslide hazard areas;
- Provide information on hazard location to future residents;
- Encourage information about hazard susceptibility on deeds;
- Distribute landslide educational materials to the public; and
- Identify and use existing mechanisms for public outreach (e.g., SWCD, NRCS, watershed councils, OSU Extension, etc.).

Coordinating Organization:	Planning, Emergency Management
Internal Partners:	Public Works
External Partners:	ODF, cities, mortgage companies
Timeline:	3 to 5 years; on-going
Plan Goals Addressed:	Education & Outreach; Partnerships; Preventive; Implementation

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LT-LS #3: Increase coordination between local jurisdictions, emergency responders, homeowners and ODF for landslide warning systems.

Ideas for Implementation

- Educate at-risk home sites about climatic and soil conditions that are conducive to landslides; and
- Develop mitigation and evacuation information and procedures for at-risk home sites.

Coordinating Organization:	Emergency Management
Internal Partner:	Planning, Building
External Partner:	City planning departments
Timeline:	3 to 5 years
Plan Goals Addressed:	Emergency Operations; Education & Outreach; Preventive; Natural Resources Utilization; Implementation

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LT-LS #4: Investigate the development and implementation of a county landslide ordinance.

Ideas for Implementation

- Use financial incentives or disincentives to promote development outside the identified risk areas; and
- Utilize the *Salem Steep Slope/Landslide* ordinance as an example of key components.

Coordinating Organization: Planning
Internal Partner: Emergency Management, GIS, Public Works
External Partner: DOGAMI, ODF
Timeline: 3 to 5 years
Plan Goals Addressed: Preventive; Natural Resources Utilization.

LT-LS #5: Protect existing development in landslide-prone areas.

Ideas for Implementation

- Provide information to residents on landslide prevention. Publications such as FEMA's *Homeowners Landslide Guide for Hillside Flooding, Debris Flows, Erosion, and Landslide Control* and FEMA's *Hillside Drainage* flier have some ideas about reducing landslide susceptibility;
- Encourage easements to restrict certain activities on landslide-prone properties. Easements foregoing the right to develop a property can be either sold or granted to the county or other organizations by property owners;
- Investigate land purchasing programs;
- Use Transfer of Development Rights to transfer development rights of a landslide hazard area by deed, easement, or other legal instrument authorized by local law to another parcel of land that is not prone to landslides;
- Construct debris flow diversions to protect existing properties; and
- Use and publicize the Oregon Department of Foretry's debris flow warning system.

Coordinating Organization: Emergency Management
Internal Partner: Planning
External Partner: DLCD, OEM, FEMA, ODF, cities
Timeline: On-going
Plan Goals Addressed: Partnerships; Education & Outreach; Preventive; Natural Resources Utilization; Implementation

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LT-LS #6: Maintain public and private drainage systems.

Ideas for Implementation

- Ensure that ditches, stormwater facilities, and culverts are inspected and cleared prior to the wet season each year; and
- Encourage the placement of culverts built for 50 to 100-year flood events.

Coordinating Organization:	Public Works
Internal Partner:	GIS, Planning
External Partner:	Cities, BLM
Timeline:	On-going
Plan Goals Addressed:	Education & Outreach; Partnerships; Preventive; Natural Resources Utilization; Implementation

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Landslide Resource Directory

Regional Resources

Yamhill Soil & Water Conservation District (Yamhill SWCD)

The Yamhill SWCD is a subdivision of the state government, led by a locally elected board of directors who serve without pay. The district's charge is to help conserve the land, water, plants, and wildlife resources in Yamhill County. Associated directors, staff, and volunteers to carry out the district activities join the Yamhill SWCD directors. Much of the district's work involves matching governmental assistance with local conservation needs and encouraging land managers to use conservation practices.

Contact: Yamhill Soil & Water Conservation District; Tim Stieber, District Manager
Address: 2200 SW 2nd Street, McMinnville, OR 97128
Phone: 503-472-6403
Fax: 503-472-2459
Website: www.yamhillswcd.org

Yamhill Basin Council

The Yamhill Basin Council formed in 1995 and is a 27-member local advisory group for the Yamhill River and Chehalem Creek watersheds dedicated to addressing local resource management issues. The Council seeks to:

- Conduct and coordinate education, outreach and promotion of watershed information.
- Coordinate monitoring, assessment, and action plan projects.
- Obtain funding for watershed projects.
- Act as a forum for bringing stakeholders together.

Contact: Yamhill Basin Council, Jamie Sheahan, Watershed Coordinator
Address: 636 NE 7th St., McMinnville, OR 97128
Phone: 503-434-7447

State Resources

Department of Land Conservation and Development (DLCD)

Oregon's Department of Land Conservation and Development administers a natural hazards program to assist local governments in meeting statewide Planning Goal 7: Areas Subject to Natural Disasters and Hazards. Activities relating to landslide mitigation include:

- Distribution of model ordinances through which hazards can be mitigated. DLCD advises local governments on which ordinance best meets their needs;
- Reviewing local land use plan amendments for consistency with state landslide programs and regulations and providing direct technical assistance;
- Providing a liaison between pertinent local, state, and federal agencies. DLCD representatives serve on a variety of commissions and ad hoc committees which deal with natural hazards;
- Adopting and amending statewide planning goals and administrative rules relating to natural hazards.

Contact: State Floodplain Manager, Natural Hazards Program Manager
Address: 635 Capitol Street NE, Suite 150
Phone: 503-373-0050
Fax: 503-378-6033
Website: http://www.lcd.state.or.us/hazards.html

Oregon Department of Forestry (ODF)

The mission of the Oregon Department of Forestry is to serve the people of Oregon through the protection, management, and promotion of a healthy forest environment, which will enhance Oregon's livability and economy for today and tomorrow. ODF regulates forest operations to reduce the risk of serious injury or death from rapidly moving landslides related to forest operations, and assists local governments in the siting review of permanent dwellings on and adjacent to forestlands in further review areas.

Contact: Oregon Department of Forestry (Salem Headquarters)
Address: 2600 State Street, Salem, Oregon 97310
Phone: 503-945-7200
Website: http://www.odf.state.or.us

Oregon Department of Forestry Debris Flow Warning Page

The ODF debris flow warning page provides communities with up-to-date access to information regarding potential debris flows. As the lead agency, ODF is responsible for forecasting and measuring rainfall from storms that may trigger debris flows. Advisories and warnings are issued as appropriate. Information is broadcast over NOAA weather radio and on the Law Enforcement Data System. DOGAMI provides additional information on debris flows to the media that convey the information to the public. ODOT also provides warnings to motorists during periods determined to be of highest risk for rapidly moving landslides along areas on state highways

with a history of being most vulnerable. Information is available on the ODF website at www.odf.state.or.us.

Oregon Department of Geology and Mineral Industries (DOGAMI)

DOGAMI is an important agency for landslide mitigation activities in Oregon. Some key functions of DOGAMI are development of geologic data, producing maps, and acting as lead regulator for mining and drilling for geological resources. The agency also provides technical resources for communities and provides public education on geologic hazards. DOGAMI provides data and geologic information to local, state, and federal natural resource agencies, industry, and private groups.

Contact: Department of Geology and Mineral Industries (DOGAMI)
Address: 800 NE Oregon Street, Suite 965, Portland, Oregon 97232
Phone: 503-731-4100
Fax: 503-731-4066
Website: http://sarvis.dogami.state.or.us
Email: info@naturenw.org

Nature of the Northwest

Oregon Department of Geology and Mineral Industries and the USDA Forest Service jointly operate the Nature of the Northwest Information Center. The Center offers a selection of maps and publications from state, federal, and private agencies.

Contact: The Nature of the Northwest Information Center
Address: 800 NE Oregon Street #5, Suite 177**,** Portland, Oregon 97232
Phone: 503-872- 2750
Fax: 503-731-4066
Website: http://www.naturenw.org
Email: Nature.of.Northwest@state.or.us

Oregon Department of Transportation (ODOT)

ODOT provides warnings to motorists during periods determined to be of highest risk of rapidly moving landslides along areas on state highways with a history of being most vulnerable to rapidly moving landslides. ODOT also monitors for landslide activity and responds to slide events on state highways.

Contact: ODOT Transportation Building
Address: 355 Capitol St. NE, Salem, OR 97310
Phone: 888-275-6368
Website: http://www.odot.state.or.us

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

OEM coordinates state resources for rapid and effective response to rapidly moving landslide and other landslide-related emergencies. The Oregon Emergency Response System (OERS) of OEM is a key player in the dissemination of debris flow advisories and warnings. OEM chairs a group that develops and measures landslide hazard mitigation strategies. OEM also administers the FEMA Hazard Mitigation Grant Program, which provides a source of funding for implementing hazard mitigation projects.

OEM also works with other state agencies to develop information for local governments and the public on landslide hazards.

Contact: Oregon Emergency Management
Address: 3225 State Street, Salem, Oregon, 97301
Phone: 503-378-2911
Fax: 503-373-7833
Website: http://www.osp.state.or.us/oem

Portland State University, Department of Geology

Portland State University conducts research and prepares inventories and reports for communities throughout Oregon. Research and projects conducted through the Department of Geology at Portland State University include an inventory of landslides for the Portland metropolitan region after the 1996 and 1997 floods and a subsequent susceptibility report and planning document for Metro.

Contact: Portland State University, Department of Geology
Address: 17 Cramer Hall; 1721 SW Broadway, Box 751, Portland, OR 97201
Phone: 503-725-3022
Website: http://www.geol.pdx.edu
Email: geology@pdx.edu

Federal Resources and Programs

Federal Emergency Management Agency, landslide fact sheet

FEMA's website contains information on strategies to reduce risk and prevent loss from landslides and debris flows.

Contact: Federal Regional Center, Region 10
Address: 130-228th St. SW, Bothell, WA 98021-9796
Phone: 425-487-4600
Website: http://www.fema.gov/library/landslif.htm

Natural Resource Conservation Service (NRCS)

The NRCS produces soil surveys. These may be useful to local governments that are assessing areas with potential development limitations including steep slopes and soil types. They operate many programs dealing with the protection of natural resources.

Contact: NRCS, Oregon Branch
Address: 101 SW Main Street, Suite 1300, Portland, OR 97204
Phone: 503-414-3200
Fax: 503-414-3103
Website: http://www.or.nrcs.usda.gov

US Geological Survey, National Landslide Information Center (NLIC)

The NLIC website provides good information on the programs and resources regarding landslides. The website includes information on the National Landslide Hazards Program Information Center, a bibliography, publications, and current projects. USGS scientists are working to reduce long-term losses and casualties from landslide hazards through better

understanding of the causes and mechanisms of ground failure both nationally and worldwide.

Contact: National Landslide Information Center
Phone: 800-654-4966
Website: http://landslide.usgs.gov

Additional Resources

American Planning Association (APA)

The APA's research department embarked on a program to bring together solutions from multiple disciplines into a single source. The APA Landslides Project will help serve local planning efforts in identifying landslide hazards during the planning process so as to minimize exposure to landslide risks. The APA's website highlights planning efforts to reduce risk and loss from landslides.

Contact: Principal Investigator, Landslides Project
Address: Research Department, American Planning Association
122 S. Michigan Ave., Suite 1600
Chicago, Illinois 60603-6107
Phone: 312-431-9100
Fax: 312-431-9985
Website: http://www.planning.org/landslides
Email: landslides@planning.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/ibhs2

State of Washington, Department of Ecology

The Washington State Department of Ecology manages a landslide website with tips for reducing risk, warning signs, and maps.

Contact: Department of Ecology
Address: PO Box 47600, Olympia, WA 98504-7600
Website: http://www.ecy.wa.gov/programs/sea/landslides
Email: hshi461@ecy.wa.gov

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. The document 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. You can 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

Mileti, Dennis, *Disasters by Design: A Reassessment of Natural Hazards in the United States (1999)* Joseph Henry Press.

This book offers a way to view, study, and manage hazards in the United States that will help foster disaster-resilient communities, higher environmental quality, inter- and intragenerational equity, economic sustainability, and an improved quality of life. The volume provides an overview of what is known about natural hazards, recovery, and mitigation; reveals how research findings have been translated into policies and programs; and advances a sustainable hazard mitigation research agenda.

Olshansky, Robert B., *Planning for Hillside Development* (1996) American Planning Association.

This document describes the history, purpose, and functions of hillside development and regulation and the role of planning, and provides excerpts from hillside plans, ordinances, and guidelines from communities throughout the US.

Olshansky, Robert B. & Rogers, J. David, *Unstable Ground: Landslide Policy in the United States* (1987) Ecology Law Quarterly.

This is about the history and policy of landslide mitigation in the US.

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

FEMA developed the Debris Management Guide 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. While it should be compliant with local and county emergency operations plans, developing strategies to ensure strong debris management is a way to integrate debris management within mitigation activities. The 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

Website: http://www.fema.gov/r-n-r/pa/dmgtoc.htm

USGS Landslide Program Brochure. National Landslide Information Center (NLIC), United States Geologic Survey.

The brochure provides good, general information in simple terminology on the importance of landslide studies and a list of databases, outreach, and exhibits maintained by the NLIC. The brochure also includes information on the types and causes of landslides, rockfalls, and flows.

Contact: USGS- MS 966, Box 25046
Address: Denver, Federal Center, Denver, CO 80225
Phone: 800654-4966
Web: http://geohazards.cr.usgs.gov/

Landslides - Endnotes

[1] Mileti, Dennis. 1999. *Disasters by Design: A Reassessment of Natural Hazards in the United States.* Washington D.C.: Joseph Henry Press.

[2] Brabb, E.E., and B.L Harrod, eds. 1989. *Landslides: Extent and Economic Significance. Proceedings of the 28th International Geological Congress Symposium on Landslides.* Washington D.C., Rotterdam: Balkema.

[3] *USGS Landslide Program Brochure,* National Landslide Information Center, United States Geologic Survey.

[4] Harvey, Andrew F.. and Gary L. Peterson. 1998. *Water-Induced Landslide Hazards, Western Portion of the Salem Hills, Marion County, Oregon.*

[5] Region 3 Mid/Southern Willamette Valley Hazards Assessment.

[6] http://www.fs.fed.us/r6/nr/fid/cr96/cond96.shtml#winter. Accessed August 19, 2004.

[7] Harvey and Peterson. *Water-Induced Landslide Hazards, Western Portion of the Salem Hills, Marion County, Oregon.*

[8] Id.

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[10] Interagency Hazard Mitigation Team. 2000. *State Hazard Mitigation Plan.* Oregon State Police – Office of Emergency Management.

[11] Robert Olson Associates. June 1999. *Metro Regional Hazard Mitigation Policy and Planning Guide.* Portland, OR: Metro.

[12] Id.

[13] Department of Land Conservation and Development. July 2000. *Planning for Natural Hazards: The Oregon Technical Resource Guide.* Ch. 5.

[14] Id.

[15] FEMA. March 1997. *Homeowner's Guide for landslide control, hillside flooding, debris flows, soil erosion.*

[16] Oregon Department of Forestry. 1999. *Storm Impacts and Landslides of 1996 Final Report.*

[17] Department of Land Conservation and Development. July 2000. *Planning for Natural Hazards: The Oregon Technical Resource Guide.* Ch. 5.

[18] Id.

[19] American Institute of Professional Geologists. 1993. *The Citizens' Guide to Geologic Hazard*. American Institute of Professional Geologists.

[20] Burby, R., ed. 1998. *Cooperating with Nature.* Washington D.C.: Joseph Henry Press.

[21] Interagency Hazard Mitigation Team. 2000. *State Hazard Mitigation Plan.* Oregon State Police – Office of Emergency Management.

[22] Burby, R., ed. 1998. *Cooperating with Nature.*. Washington D.C.: Joseph Henry Press.

[23] Id.

[24] Goettel & Associates. February 1998. *Regional All Hazard Mitigation Master Plan for Clackamas County.*

[25] Id.

[26] Interagency Hazard Mitigation Team. 2000. *State Hazard Mitigation Plan.* Oregon State Police – Office of Emergency Management.

[27] Department of Geology and Mineral Industries/Oregon Department of Forestry. 1999. *Western Oregon Debris Flow Hazard Maps: Methodology and Guidance for Map Use.*

[28] Id.

[29] Id.

[30] Region 3 Mid/Southern Willamette Valley Hazards Assessment. November 2003.

[31] Department of Geology and Mineral Industries/Oregon Department of Forestry. 1999. *Western Oregon Debris Flow Hazard Maps: Methodology and Guidance for Map Use.*

[32] Id.

[33] Department of Land Conservation and Development. July 2000. *Planning for Natural Hazards: The Oregon Technical Resource Guide,* Chapter 5.

[34] Id.