Chapter 9
Landslide

(Hazard Analysis Score = 86)

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Why are Landslides a threat to Beaverton?

Landslides are a serious geologic hazard that exists in almost every state in the United States. 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 landslides have had little to no impact in Beaverton, they have created a number of problems throughout Washington County. Although 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.

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.

Landslide Characteristics

What is a Landslide?

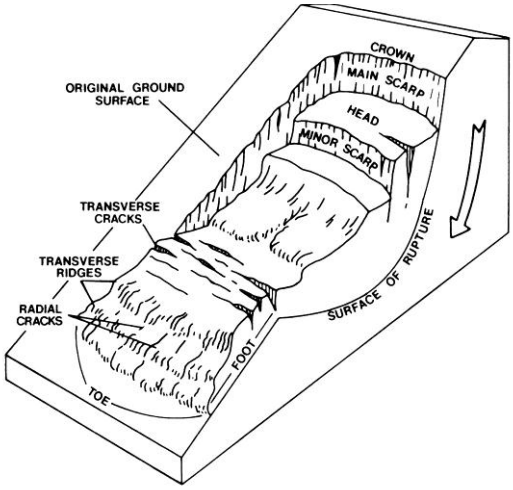
Landslides are downhill or lateral movements of rock, debris, or soil mass. The size of a landslide usually depends on the geology and the triggering mechanism. Landslides initiated by rainfall tend to be smaller, while those initiated by earthquakes may be very large.

Slides associated with volcanic eruptions are typically large and can include as much as one cubic mile of material. Slides caused by erosion occur when ditches or culverts beneath hillside roads become blocked with debris. If the ditches are blocked, run-off from 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 – 1,000 cubic yards), but some have been known to be quite large.

Landslides can 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. Some of the characteristics that determine the type of landslide are the slope of the hillside, moisture content, and the nature of the underlying materials. 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.

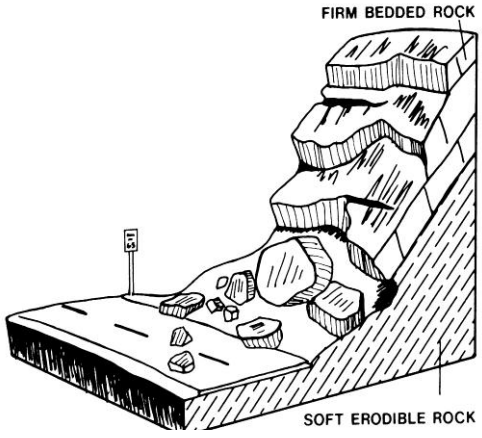
Slides move in contact with the underlying surface. These movements include rotational slides where sliding material moves along a curved surface, and translational slides where movement occurs along a flat surface. These slides are generally slow moving and can be deep. Slumps are small rotational slides that are generally shallow (See Figure 9.1). 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.[4]

Figure 9.1. Rotational Slide



Rock falls (see Figure 9.2) occur when blocks of material come loose on steep slopes. Weathering, erosion, or excavations, such as those along highways, where the road has been cut through bedrock can cause falls. These slides are fast moving with the materials free falling or bouncing down the slope. The total volume of material involved is generally small, but individually the boulders or blocks of rock can be large and can cause significant damage.

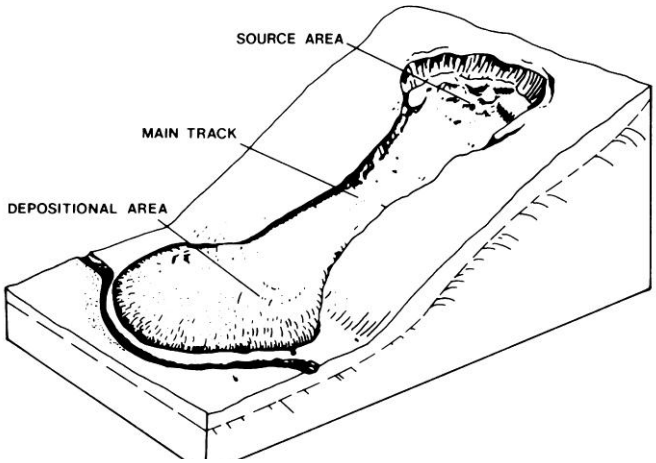
Figure 9.2. Rock Fall



Source: *Planning for Natural Hazards: The Oregon Technical Resource Guide*, DLCD

Flows (see Figure 9.3) are slides in which soil and rock breaks up and flows like a plastic or liquid. 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 fast moving and also tend to increase in volume as they scour out the channel.[5] 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.[6] Earthquakes often trigger flows.[7]

Figure 9.3. Earthflow



Source: *Planning for Natural Hazards: The Oregon Technical Resource Guide*, DLCD

Landslides are typically triggered by periods of heavy rainfall or rapid snowmelt but earthquakes, volcanic activity, and excavations might also trigger them. Certain geologic formations are more susceptible to landslides than others. Human activities, including development on or near steep slopes, can increase susceptibility to landslide events. Because of their general nature, landslides on steep slopes are typically more dangerous because they can occur with little warning and their movements can be very rapid.

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 ground in 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]

Landslide Conditions

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 slope 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.[8]

Natural Conditions

Natural processes can cause landslides or re-activate historical landslide sites. Steep, concave-shaped slopes with larger drainage areas appear to be more susceptible to landslides than other landforms. Rainfall-initiated landslides tend to be smaller but occur frequently, while earthquake-induced landslides may be very large, but are less frequent. Landslides are particularly common along stream banks, reservoir shorelines, large lakes, and the seacoasts. The removal of material supporting the shoreline 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 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 of 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. Additionally, 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 that occur below new construction sites are often indicators of the impacts stemming from excavation.

Drainage and Groundwater Alterations

Water flowing through or over the ground is often a trigger for landslides. Drainage can be affected naturally by the geology and topography of an area or by man-made activities. Any activity that increases the amount of water flowing onto slopes can increase the potential of landslides. Channels, streams, ponding, and erosion on slopes are all indicators of potential slope problems.

Ineffective storm water management, including water retention facilities that direct water onto slopes, and excess runoff can cause erosion and generate landslides. Development that results in an

increase in the amount of impervious surfaces impairs the ability of the land to absorb water and may redirect the run-off into other areas. As a result, more landslides could occur. Broken or leaking water or sewer lines can also be problematic as well as lawn irrigation and minor alterations to small streams in landslide prone locations. 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.[9]

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 10 years after timber harvesting.[10] 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 man-made from logging) may increase the severity the impacts from debris flows.[11]

Development

Development sites with the greatest risk from landslides are those located 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 at the base of slopes do not cause landslides, they do 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:[12]

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.

For more information on soils, contact the Natural Resource Conservation Service:
NRCS, Oregon Branch
101 S.W. Main Street, Suite 1300, Portland, OR 97204
Phone: (503) 414-3200
Fax: (503) 414-3103

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 who are uninformed about geological materials and processes may contribute to conditions that trigger landslide activity or increase susceptibility to landslide hazards.[13]

Beaverton's grading permits development standards require appropriate safeguards when the following soil conditions occur:

- Seasonal, perched, high, or apparent water table;
- High shrink-swell capability;
- Low bearing strength such as compressible organics; and
- Shallow depth to bedrock.[14]

Community Landslide Issues

Landslides can affect utility services, transportation systems, and critical lifelines. In addition to the immediate damages and loss of service that communities may suffer, the 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 electricity are all essential to the community. Loss of electricity has the most widespread impact on the whole community, and can even affect other utilities. For example, even landslide movements as small as an inch or two increase the potential for natural gas pipelines to break.[15]

Source: American Planning Association Landslides

Roads

Roads are subject to closure during landslide events. Since many Beaverton residents are dependent on roads for commuting to work, delays and detours generated by a landslide event will likely have an economic impact on residents and businesses. To evaluate the benefit of landslide mitigation activities for roads, the city should take into

consideration the number of vehicle trips per day over the identified section of road, the increase in travel time the detour around a road closure will cause, and whether the road is used for commercial traffic or emergency access.[16]

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.[17] 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. Landslides in surrounding areas of Beaverton have primarily been slow moving and caused greatest impact to roads and culverts.[18]

(Revised 12/2010) Only been one known landslide has occurred within current city boundaries. The slide occurred on a man-made slope which is part of the Highway 217 overpass over the Beaverton-Hillsdale Highway. There was no direct impact on the roadways, utilities, or structures. Other than that single event, the City of Beaverton has no known locations susceptible to landslides, avalanches, or debris flows. This may change with future annexations of areas to the north and north east of current City boundaries. Based on the single occurrence and existing steep slopes in the City, the probability of future landslide events in the City is moderate. Probability is based on the likelihood of another occurrence within a specified period of time and a medium probability event is likely to occur once within 35 to 50 years.[19]

While recent landslide events near Beaverton have not been the rapidly moving debris flows, the potential for their occurrence exists. Debris flows generally occur during intense periods of rainfall on previously saturated soil. They typically start on steep slopes and can accelerate to speeds as great as 35 mph. Debris flows have caused most of the recent landslide related injuries and deaths in Oregon,[20] and they have been the catalyst for the creation of two state agencies: (1) the Oregon Department of Forestry (ODF); and (2) the Department of Geology and Mineral Industries (DOGAMI) to map these types of landslides.

(Revised 03/2011) ODF has mapped debris flows in some areas of Washington County, including locations subject to naturally occurring debris flows, initiation sites and projected paths. More information on ODF's debris flow maps can be found by contacting ODF directly. Contact information for ODF is included in the consolidated resource directory section of the Multi-Hazard Chapter of this plan. In this plan's Map Section the map titled Natural Hazards notes debris flow and steep slopes in Beaverton.

Metro and Portland State University have also generated a map documenting Landslide Locations (1996-1997) and Zones of High Landslide Potential in the Portland Metropolitan Region.

Vulnerability Assessment

Vulnerability assessment is the second phase of a hazard assessment. It combines the information generated through landslide 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.[21] 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.[22] Data that includes known landslide and debris flow locations 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 been conducted for the Beaverton landslide event, there are many qualitative factors (issues relating to what is in danger within a community) that point to potential vulnerabilities existing in other areas of the city and areas identified for future annexations. 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 City residents, continuing to map City landslide and debris flow areas will help in preventing future loss.

Long-Term Landslide Action Item #1:
Improve knowledge of landslide hazard areas and understanding of vulnerability and risk to life and property in those areas.

See page 9-18 for more information.

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 City due to a landslide or debris flow 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.

The Oregon Department of Forestry and the Department of Geology and Mineral Industries 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.

Mitigation Plan Goals and Existing Activities

Mitigation Plan Goals and Public Priorities

The mitigation plan goals and action items are derived from review of regional and national natural hazards mitigation plans and planning literature, guidance from the Beaverton Natural Hazards Mitigation Plan Steering Committee, and interviews with City of Beaverton stakeholders. The goals for the Beaverton Natural Hazards Mitigation Plan are broad based to include all of the identified hazards addressed in the plan. Goals for the mitigation plan address four categories:

1. Protect Human Life, Commerce, Property and Natural Systems
2. Improve Hazard Communication and Coordination through Partnerships
3. Enhance Emergency Services
4. Ensure Implementation of Mitigation Activities

Existing Mitigation Activities

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

City Programs

City of Beaverton Codes (Revised 9/2010)

Goals, actions, and or regulations related to development on slopes, can be found in Beaverton's Comprehensive Plan, Development Code, City Code, and Engineering Design Manual.

The City's permit process contained in the Ciy's municipal code Chapter 9 section clearly delineates the professional responsibility between public (City Engineer) and private (developer's engineer and geologist). At any time in the life of a permit application or issued permit, Beaverton can require additional study. Such a decision is grounded in the professional judgment of the City Engineer, and not based on a graduated table of specifications used by some jurisdictions. Beaverton's code also tends to be more restrictive based on the planning slope parameters near property lines.

Relevant City regulations include:

- Development Code - Sections 40.03.3.I and 60.15.15.5
- City Code - BC 9.05.035 B 10 & 11, 9.05.110, and 9.05.115

Capital Improvement Plan

The City of Beaverton's Capital Improvements Plan (CIP) is a dynamic document that lists and prioritizes needed improvements and expansions of the City's infrastructure system to maintain adequate service levels to existing City residents and businesses, and to accommodate population growth and land development. The CIP reflects the needs and priorities established by the City and the resources available to the City. The CIP can be modified during the fiscal year, through the supplemental budget process, as needs, priorities, and resources change. The CIP can assist the City of Beaverton in mitigating against severe weather events by improving infrastructure most prone to damage.

Emergency Operation Center (EOC)

The Emergency Operations Center is an established location/facility in which City staff and officials can receive information pertaining to an incident and from which they can provide direction, coordination, and support to emergency operations. City personnel who are assigned to specific positions within the EOC organizational structure staff the EOC. The structure is based on the National Interagency Incident Command System (ICS). The EOC staff provides information and recommendations to the Mayor, through the Incident Commander or as directed, to develop a course of action to respond to and contain, control, and recover from an emergency. Some of the primary functions that are performed at the EOC include: coordination, operations management, planning, information tracking and dissemination, logistical support, financial management and support, and emergency public information.[23]

Emergency Response and Recovery Plan (ERRP)

The Emergency Response and Recovery Plan (ERRP) describes the roles and responsibilities of the departments and personnel for the City of Beaverton during major emergencies or disasters.

The Plan sets forth a strategy and operating guidelines using the National Interagency Incident Management System's ICS adopted by the City for managing its response and recovery activities during disasters and emergencies.

The ERRP's development and maintenance is the basis of the City's emergency response and recovery operations. It includes the following sections and supporting materials:

1. **Basic Plan** - Provides an overview of the City's emergency response organization and policies. It cites the legal authority for emergency operations, summarizes the situations addressed by the plan, explains the general concept of operations, and assigns general responsibilities for emergency planning and operations.
2. **Functional Annexes** - Each annex focuses on one of the critical emergency functions that are typically common for all hazards, which the City will perform in response to an emergency. The

type and scope of an incident will dictate which functional annexes will be needed.

3. **Hazard Specific Appendices** - The appendices provide additional detailed information and special considerations that are applicable to specific hazards. The appendices are to be used in conjunction with the Basic Plan and the Functional Annexes.[24]

Incident Command System

The Incident Command System (ICS) is a management system that may be used for any time of hazard event, and has three main components:

Command - A designated lead person responsible for:

- Assessing the situation and resources
- Developing and implementing an appropriate action plan
- Monitoring the effectiveness of the plan
- Reviewing/modifying the plan as changes occur

Resource Control - Resources must be properly directed to maximize their utilization.

Communication - In order to orchestrate and coordinate the use of resources at an incident, all members of the incident response team must be linked by:

- A well-defined organizational structure
- Clear lines of communication

Transportation Plan

The City of Beaverton's adopted transportation plan is the Transportation Element of the City's Comprehensive Plan. It identifies the transportation improvements needed to accommodate existing and future development in the Beaverton area. The plan projects needs and improvements through 2015.

Beaverton's adopted transportation plan is based on an analysis contained in the Transportation System Plan (TSP), which was developed through a public participation. The development of the TSP and thereafter the more concise Transportation Element, Chapter Six of the Comprehensive Plan, (a summary of the analysis, goals and policies, and improvements) are closely coordinated and intended to be consistent with other jurisdictions' transportation plans. These include Washington County's Transportation Plan, Metro's Regional Transportation Plan and Urban Growth Management Framework Plan, TriMet's short and long-range transit plans, and the State of Oregon Transportation Plan. Coordination with these and other jurisdictions and service agencies is continuous.

County Programs

Washington County Community Development Code

Article IV: Development Standards, 410 Grading and Drainage, 1.2, D (2) states:

> For areas outside the Tualatin River and Oswego Lake sub-basins, an erosion control plan that complies with the requirements of the "Washington County Erosion Control Plans Technical Guidance Book," January 1991, or its successor, is required when, (a) grading requiring a permit is conducted or left in an unfinished state during October 1 through May 1; or (b) land disturbance activities are conducted in geologically unstable areas, on slopes in excess of twenty (20) percent, or there is disturbance of more than six-thousand (6,000) square feet of any drainage hazard area or flood plain area.

410 Grading and Drainage, 3 (permit approval) states:

> Permit approval for construction, grading, cut, or fill is dependent on the following conditions:
>
> - The extent and nature of the proposed grading is appropriate to the use proposed and will not create site disturbance to an extent greater than that required for the use;
> - Proposed grading will not cause erosion to any greater extent than would occur in the absence of development or result in erosion, stream sedimentation, or other adverse off-site effects of hazards to life or property; and
> - Appropriate siting and design safeguards shall ensure structural stability and drainage in areas with soil conditions of seasonal, perched, high or apparent water table, high shrink-swell capability, low bearing strength such as compressible organics, or shallow depth to bedrock.

Article IV: Development Standards, 426, Erosion Control, 4 states:

> Every preliminary plat, site plan, development permit, building permit, or public works project within the Tualatin River and Oswego Lake sub-basins must prepare an erosion control plan. This plan includes a list of best management practices to be applied during construction to control and limit soil erosion. Permitting is dependent upon the development of an erosion control plan. The plan must be prepared in conformance with the Washington County Erosion Control Plans Technical Guidance Book, January 1991, or its successor.

Article IV: Development Standards, 405, Open Space, 1 states:

> Areas defined as confirmed land movement hazard areas, as identified through the application of the standards of Section 410 or mapped as a Significant Natural Area on the Community Plan, shall be preserved as open space.

State Programs

Oregon State Senate Bill 12

The 1997 Legislature passed Senate Bill 12 to address problems caused by landslides and debris flows. 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 10-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 and (2) the Department of Geology and Mineral Industries (DOGAMI). Senate Bill 12 requires that the Department of Geology and Mineral Industries, with cooperation from local governments and the Department of Forestry, 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."[25]

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).[26]

Information used to develop the ODF Debris Flow maps include:

- Digital elevation models at 30-meter resolution, based on US Geological Survey data, were used to derive slope steepness and

then to develop polygons for assigned hazards. Note that actual slopes are steeper than these 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, and the Oregon Department of Transportation).
- 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.[27]

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.[28]

Debris Flow Warning System

The debris flow warning system was initiated in 1997 and involves collaboration between ODF, DOGAMI, the Oregon Department of Transportation (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 through the media. ODOT provides warning signs to motorists in landslide-prone areas during high-risk periods.[29]

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).[30]

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 ground water 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 code, 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.[31]

Impacts from 1996 Landslide Event, Dairy Creek Rd.
Source: Community Planning Workshop

Landslide Mitigation Action Items (Rev 03/2011)

The landslide mitigation action items provide direction on specific activities that cities, organizations, and residents in Beaverton can undertake to reduce risk and prevent loss from landslide events. There are five long-term landslide hazard action items described below. 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.

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

Possible Actions

- 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; and
- Analyze the risk of these areas to life, property, and infrastructure.

Coordinating Organization:	City of Beaverton
Internal Partners:	Community Development Department
External Partners:	Department of Geology and Mineral Industries (DOGAMI), Oregon Department of Forestry (ODF), Clean Water Services. Washington County
Timeline:	On-going
Plan Goals Addressed:	Improve Partnerships for Communication and Coordination; Protect Human Life, Commerce, Property and Natural Systems

LT-LS#2: Limit activities in identified landslide hazard areas through regulation and public outreach.

Possible Actions

- Use the hazard identification and mapping processes to determine where to regulate.
- Coordinate with property owners to reduce risk in landslide hazard areas;
- Provide information on hazard location to future residents; and
- Show hazard susceptibility on deeds.

Coordinating Organization:	City of Beaverton
Internal Partners:	Community Development Department
External Partners:	Oregon Department of Forestry (ODF), Washington County, Committee for Citizen Involvement (CCI)
Timeline:	On-going
Plan Goals Addressed:	Improve Partnerships for Communication and Coordination; Protect Human Life, Commerce, Property and Natural Systems

LT-LS#3: Protect existing development in landslide-prone areas.[32]

Possible Actions

- Provide information to residents on landslide prevention. Publications such as FEMA's Homeowner's Landslide Guide for Hillside Flooding, Debris Flows, Erosion, and Landslide Control and Hillside Drainage Flyer 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 City 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 Forestry's debris flow warning system.

Coordinating Organization:	City of Beaverton
Internal Partners:	Community Development Department
External Partners:	Department of Land Conservation and Development (DLCD), Oregon Emergency Management (OEM), Federal Emergency Management Agency (FEMA), Washington County
Timeline:	On-going
Plan Goals Addressed:	Improve Partnerships for Communication and Coordination; Protect Human Life, Commerce, Property and Natural Systems; Ensure Implementation of Mitigation Activities

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LT-LS#4: Implement construction and subdivision design that can be applied to steep slopes to reduce the potential adverse impacts from development.

Completed – Contained in existing City Codes and Ordinances

Plan Goals Addressed:	Protect Human Life, Commerce, Property and Natural Systems; Ensure Implementation of Mitigation Activities

LT-LS#5: Maintain public and private drainage systems.

Completed – Institutionalized in existing City operations and procedures.

Plan Goals Addressed: Improve Partnerships for Communication and Coordination; Protect Human Life, Commerce, Property and Natural Systems; Ensure Implementation of Mitigation Activities

Landslide Resource Directory

(Revised 03/2011) – See Appendix G: Consolidated Resource Directory.

Landslide Endnotes

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[3] *USGS Landslide Program Brochure,* National Landslide Information Center, United States Geologic Survey.
[4] Interagency Hazard Mitigation Team, *State Hazard Mitigation Plan* (2000) Oregon State Police – Office of Emergency Management.
[5] Ibid.
[6] *Planning for Natural Hazards: The Oregon Technical Resource Guide,* Department of Land Conservation and Development (July 2000), Ch. 5.
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[8] Ibid.
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[10] *Storm Impacts and Landslides of 1996 Final Report* (1999) Oregon Department of Forestry.
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[12] Ibid.
[13] *The Citizens' Guide to Geologic Hazard* (1993) American Institute of Professional Geologists, American Institute of Professional Geologists.
[14] Washington County Development Standards, 410-3.3 Grading and Drainage.
[15] *Regional All Hazard Mitigation Master Plan for Clackamas County* (February 1998) Goettel & Associates.
[16] Ibid.
[17] Burby, R. (Ed.) *Cooperating with Nature* (1998) Washington D.C.: Joseph Henry Press.
[18] *Washington County Hazard Analysis* (May 2000) Washington County Emergency Management.

[19] City of Beaverton, *Emergency Response and Recovery Plan (ERRP)*; *Tab B – Hazard Analysis*; revised April 2010.

"Probability is based on the likelihood of another occurrence within a specified period of time. A high probability incident can be expected once within a 10 to 35 year period, a medium probability once within 35 to 50 years and low, once in 75 to 100 hundred years."

[20] Interagency Hazard Mitigation Team, *State Hazard Mitigation Plan* (2000) Oregon State Police – Office of Emergency Management.
[21] Burby, R. (Ed.) *Cooperating with Nature.* (1998) Washington D.C.: Joseph Henry Press.
[22] Ibid
[23] City of Beaverton Web Page, http://www.ci.beaverton.or.us/departments/emergency/emergency_eoc.html, (Accessed 4/30/03) (Entire Paragraph)

[24] City of Beaverton Web Page, http://www.ci.beaverton.or.us/departments/emergency/emergency_errp.html, (Accessed 4/30/03) (Entire Paragraph)

[25] Interagency Hazard Mitigation Team, *State Hazard Mitigation Plan* (2000) Oregon State Police – Office of Emergency Management.
[26] *Western Oregon Debris Flow Hazard Maps: Methodology and Guidance for Map Use* (1999) Department of Geology and Mineral Industries/Oregon Department of Forestry.
[27] Ibid.
[28] Ibid.
[29] Ibid.
[30] Ibid.
[31] *Planning for Natural Hazards: The Oregon Technical Resource Guide,* Department of Land Conservation and Development (July 2000), Chapter 5.
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