

8.0 LANDSLIDES

8.1 Landslide Overview and Definitions

The term “landslide” refers to a variety of slope instabilities that result in the downward and outward movement of slope-forming materials, including rocks, soils and artificial fill. Four types of landslides are distinguished based on the types of materials involved and the mode of movement. These four types of landslides are illustrated in Figures 8.1 to 8.4 on the following page.

Rockfalls are abrupt movements of masses of geologic materials (rocks and soils) that become detached from steep slopes or cliffs. Movement occurs by free-fall, bouncing and rolling. Falls are strongly influenced by gravity, weathering, undercutting or erosion.

Rotational Slides are those in which the rupture surface is curved concavely upwards and the slide movement is rotational about an axis parallel to the slope. Rotational slides usually have a steep scarp at the upslope end and a bulging “toe” of the slid material at the bottom of the slide. Roads constructed by cut and fill along the side of a slope are prone to slumping on the fill side of the road. Rotational slides may creep slowly or move large distances suddenly.

Translational Slides are those in which the moving material slides along a more or less flat surface at some depth within the ground. Translational slides occur on surfaces of weaknesses, such as faults and bedding planes or at the contact surface between firm rock and overlying loose soils. Translational slides can either creep slowly or move large distances rather suddenly.

Debris Flows (mudflows) are movements in which loose soils, rocks and organic matter combine with entrained water to form slurries that flow rapidly downslope.

All of these types of landslides may cause road blockages by depositing debris on road surfaces or road damage if the road surface itself slides downhill. Utility lines and pipes are prone to breakage in slide areas. Buildings impacted by slides may suffer minor damage from small settlements or be completely destroyed by large ground displacements or by burial in slide debris. Landslides may also result in casualties, as evidenced by 1997 winter storms in Oregon.

There are three main factors that determine susceptibility (potential) for landslides:

- 1) slope,
- 2) soil/rock characteristics, and
- 3) water content.

Steeper slopes are more prone to all types of landslides. Loose, weak rock or soil is more prone to landslides than is more competent rock or dense, firm soils. Finally, water saturated soils or rock with a high water table are much more prone to landslides because the water pore pressure decreases the shear strength of the soil and thus increases the probability of sliding.

Figures 8.1 to 8.4
Major Types of Landslides

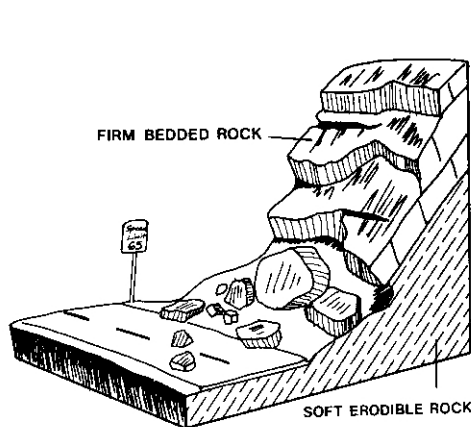


Fig. 8-1. Rockfall

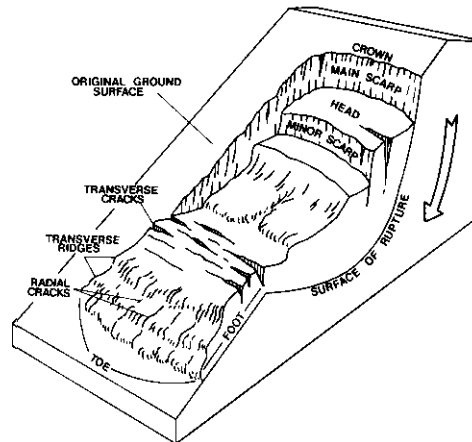


Fig. 8-2. Rotational Landslide

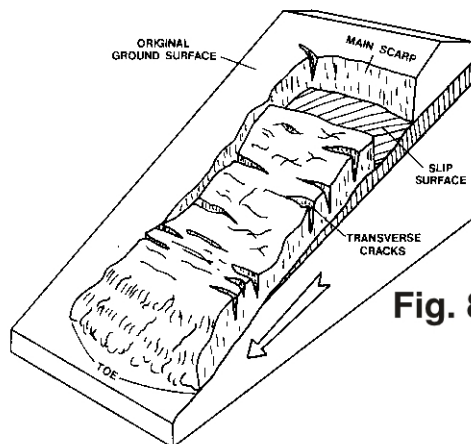


Fig. 8-3. Translational Landslide

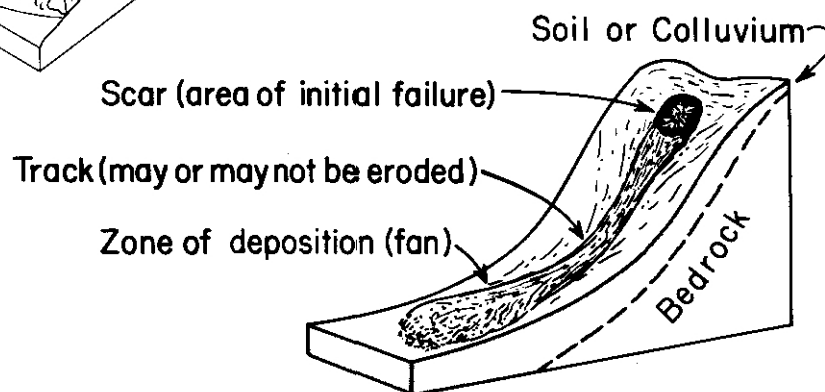


Fig. 8-4. Debris Flow

As noted above, the water content of soils/rock is a major factor in determining the likelihood of sliding for any given slide-prone location. Thus, most landslides happen during rainy months when soils are saturated with water. However, landslides may happen at any time of the year.

In addition to landslides triggered by a combination of slope stability and water content, landslides may also be triggered by earthquakes. Areas prone to seismically triggered landslides are exactly the same as those prone to ordinary (i.e., non-seismic) landslides. As with ordinary landslides, seismically triggered landslides are more likely from earthquakes that occur when soils are saturated with water.

8.2 Landslide Hazard Assessment for Multnomah County

Areas with potential landslide hazards within Multnomah County are shown in Figures 8.5 to 8.8. Landslide hazard areas are locations where landslides have occurred in the past or appear likely to occur in the future. These mapped areas include both developed and undeveloped areas.

Figures 8.5 and 8.6 are DOGAMI mapped potential landslide areas. Figures 8.7 to 8.8 are DOGAMI mapped historical landslide areas.

As shown in these figures, there are two areas of most concern for landslides:

- The west Portland Hills area, including U.S. Highway 30 and the adjacent rail line, and
- The area along Interstate 84 and the Historic Columbia River Highway from Troutdale east to the Multnomah County border.

In addition to these areas, large landslide hazard areas also exist in the hilly eastern portion of Multnomah County. However, this area is lightly developed. As shown on the figures, there are also smaller areas of landslide hazards scattered throughout Multnomah County

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

Figure 8.5
Landslide Hazard Areas: West

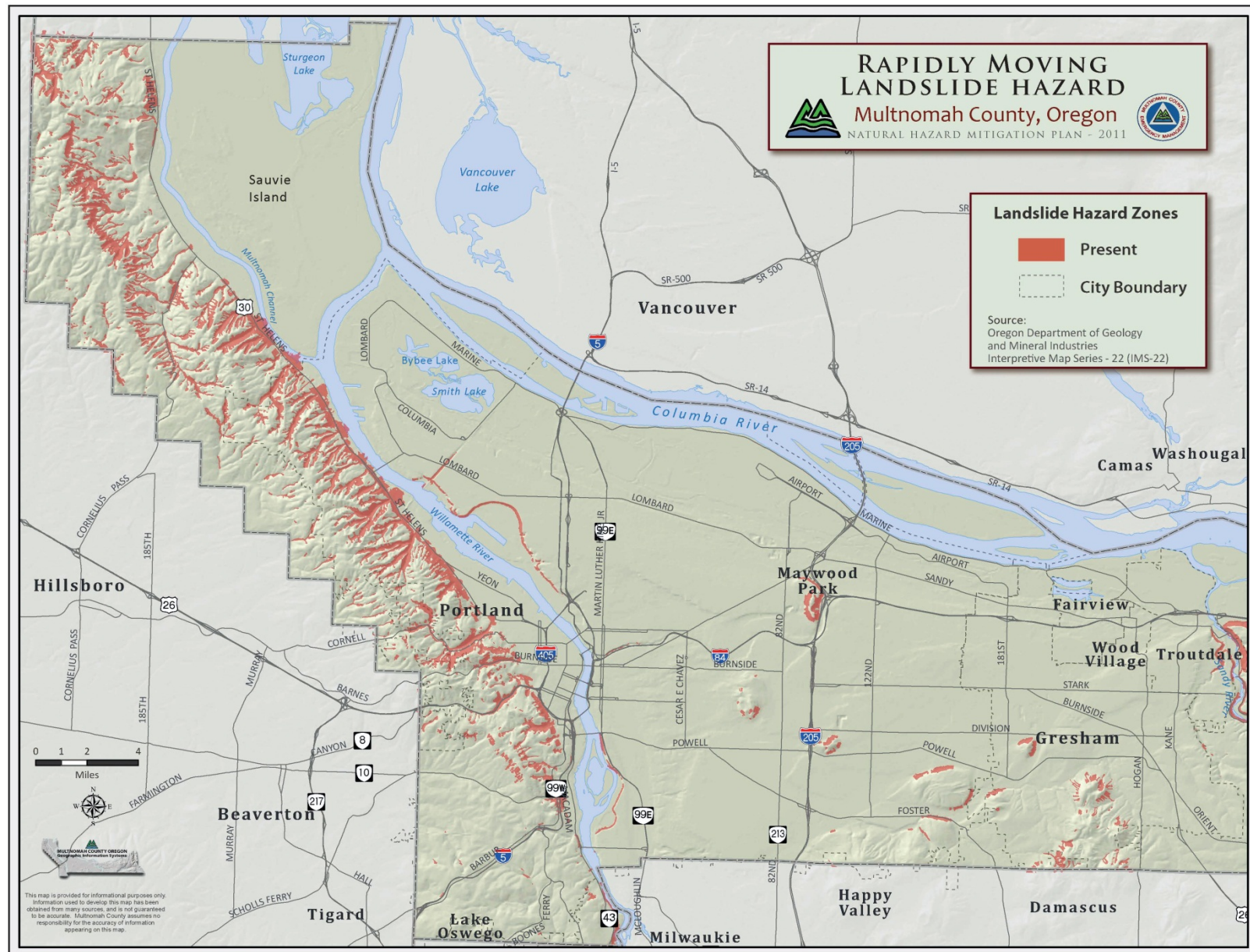


Figure 8.6
Landslide Hazard Areas: East

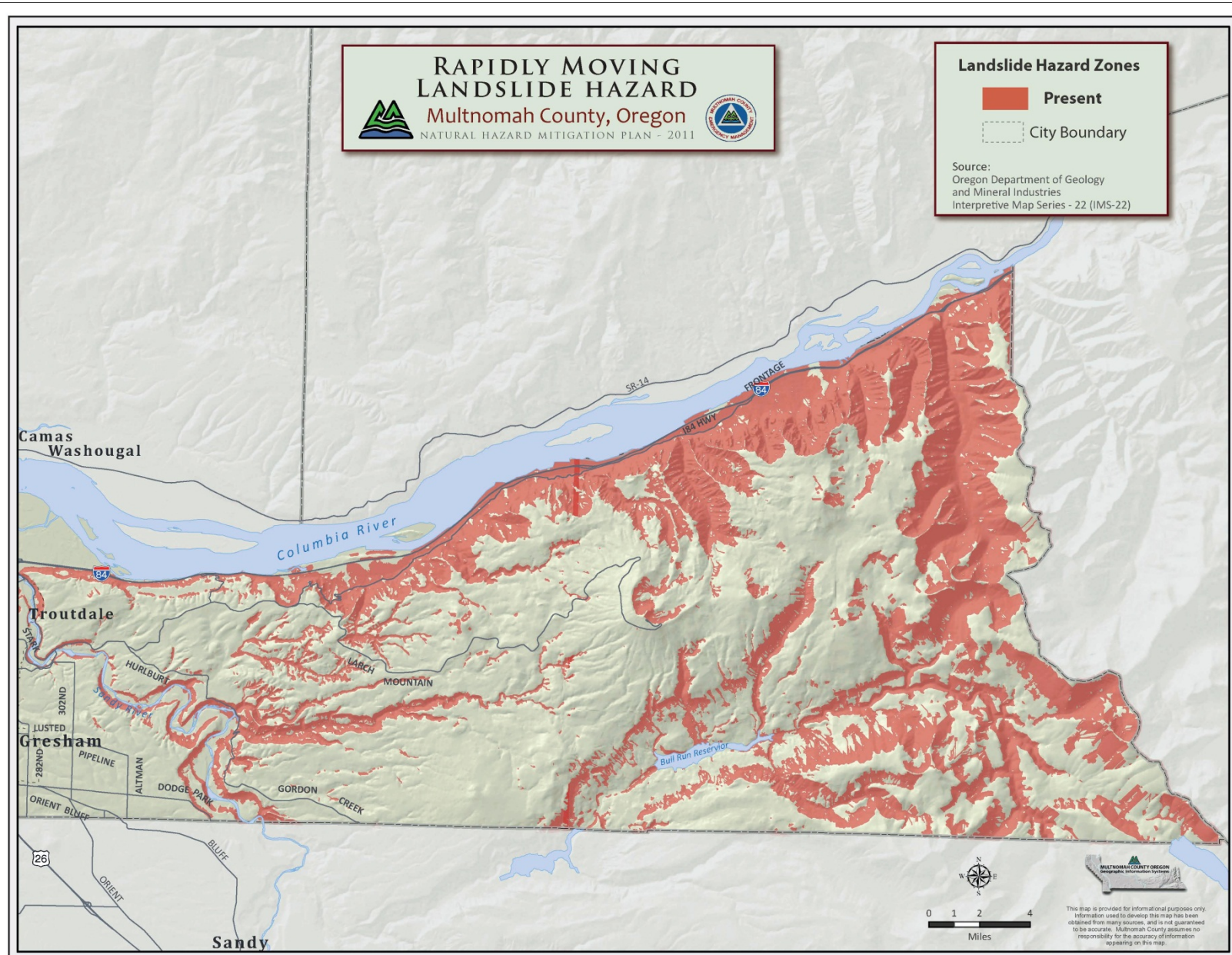


Figure 8.7
DOGAMI Mapped Historical Landslide Areas: West

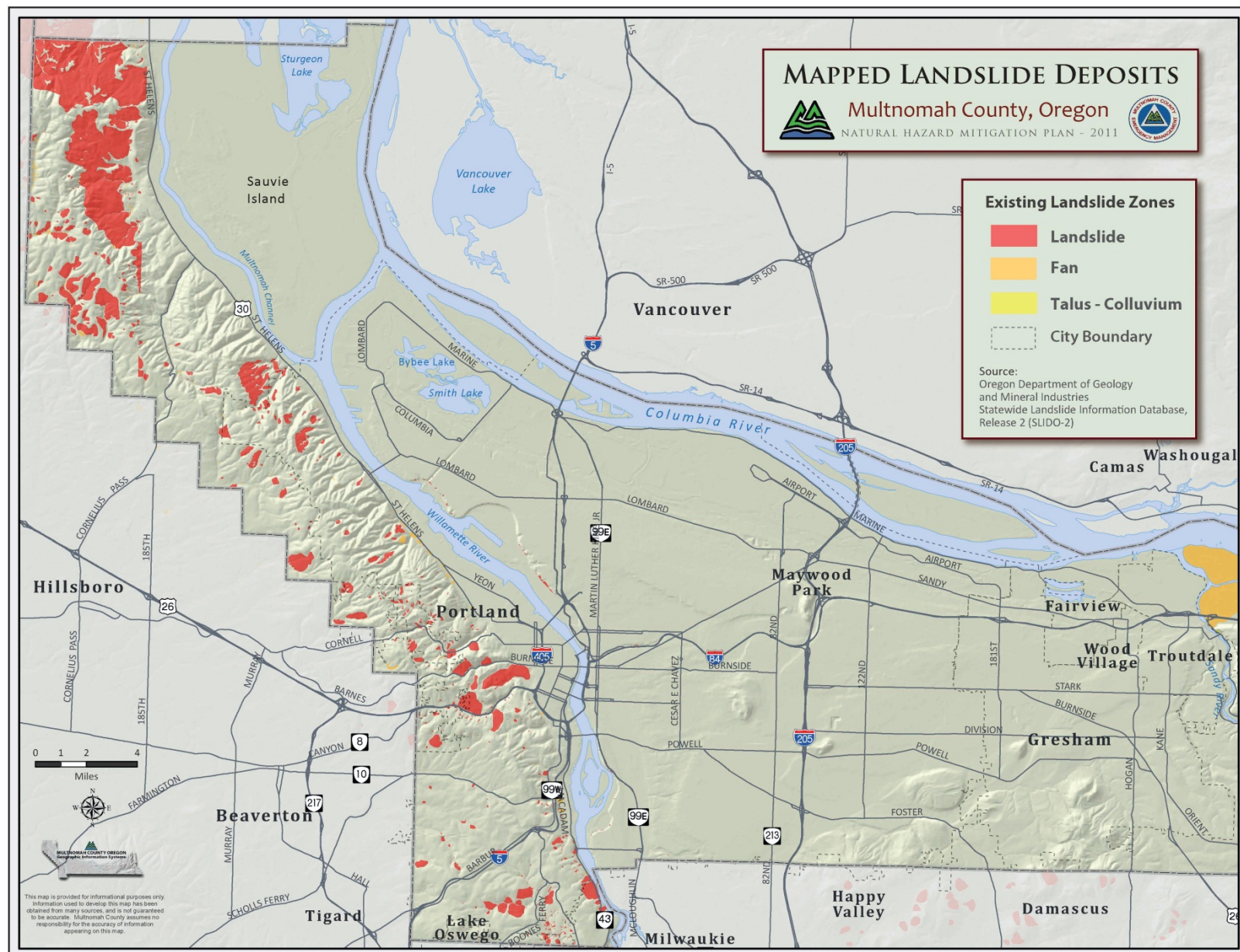
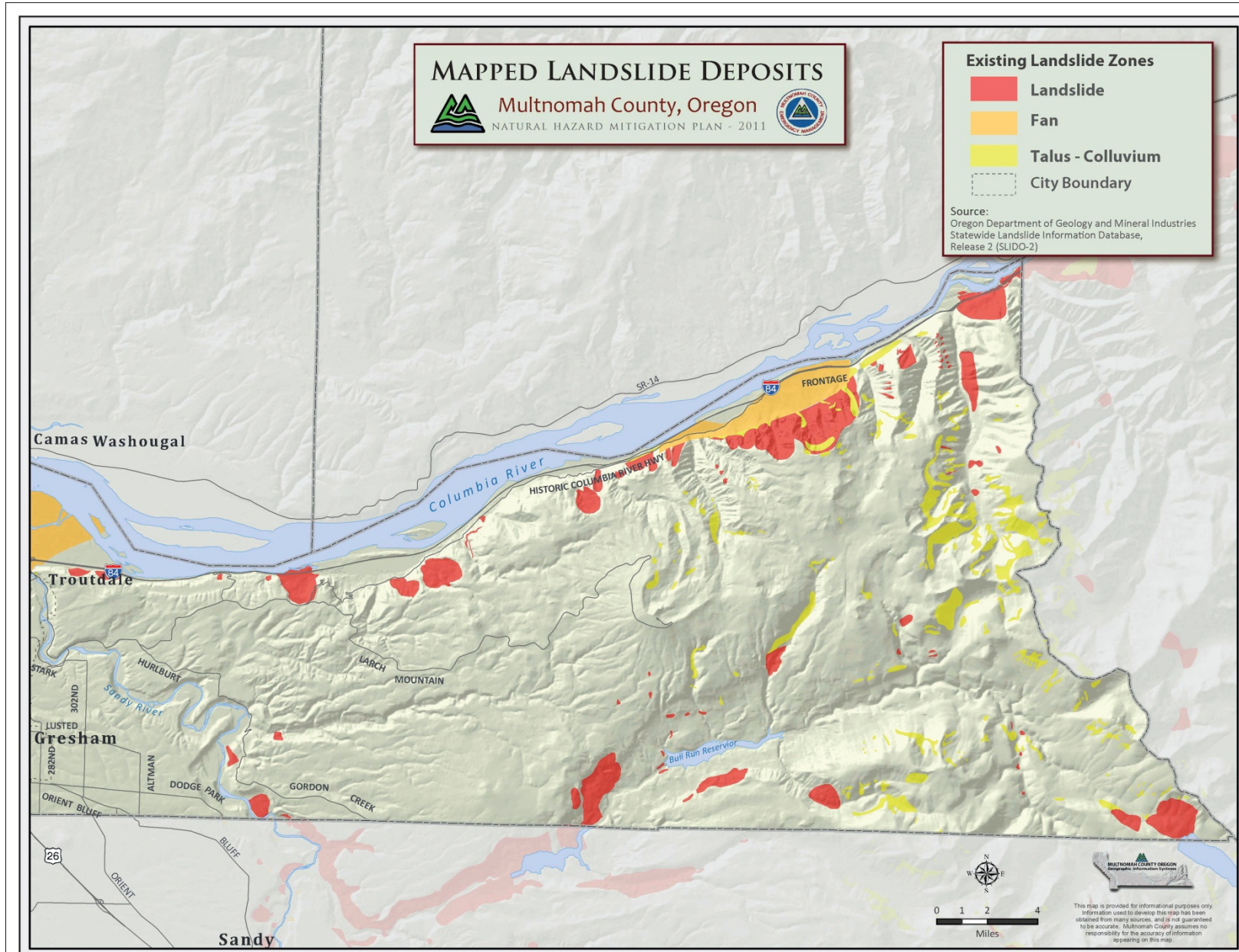


Figure 8.8
DOGAMI Mapped Historical Landslide Areas: East



8.3 Landslide Risk Assessment for Multnomah County

A fully quantitative risk assessment for landslides in Multnomah County, including estimates of the probabilities or return periods of landslides in specific locations, requires far more detailed data than is currently available. Therefore, we address landslide risks only in semi-quantitative terms.

High risk areas for landslides are locations where landslides have occurred in the past or appear likely to occur in the future and there are buildings or infrastructure in these areas. The overlap of landslide hazard areas with developed areas is what results in risk – threats to buildings and infrastructure.

The maps in Figures 8.5, 8.6, 8.7 and 8.8 show that many areas within Multnomah County are likely subject to landslides, including developed areas in the west Portland Hills and important transportation routes (Interstate 84 and the Historic Columbia River Highway in eastern Multnomah County). Significant parts of these areas are within the jurisdictions of incorporated cities and thus not within the County's area of jurisdiction.

There are also landslide hazard areas in undeveloped or very lightly developed areas. Many of these areas are federally owned, including Mt. Hood National Forest and portions of the Columbia River Gorge National Scenic Area.

The tables below show the numbers of buildings within the mapped landslide hazard areas.

Table 8.1
Mapped Landslide Hazard Areas

Landslide Hazard Areas: Unincorporated Portions of Multnomah County									
Data Set	Indust	Commer	MultiFamRes	ParksOpenSpc	MixUseRes	SingleFamRes	MixUseEmpl	Rural	Total
Buildings	0	0	0	0	0	104	0	375	479
County Buildings	0	0	0	0	0	0	0	0	0
Landslide Hazard Area: Incorporated Cities									
Data Set	Indust	Commer	MultiFamRes	ParksOpenSpc	MixUseRes	SingleFamRes	MixUseEmpl	Rural	Total
Buildings	225	0	247	24	165	1,279	26	2	1,968
County Buildings	0	0	0	0	0	0	0	0	0

The potential landslide risk areas within Multnomah County include nearly 500 single family and rural buildings in the unincorporated portions of the county and nearly 2,000 buildings in the incorporated cities. As shown above, there are no county buildings located in mapped landslide hazard areas.

In addition to posing risks for buildings, landslides also pose risks for roads, rail lines and utility systems. Underground utilities such as water, wastewater and natural gas pipes are particularly prone to damage from landslides. Even very small ground displacements of a few inches often result in pipe failures. The

consequences of landslides also include the economic impacts of road closures and utility outages.

Landslides also pose life safety risks. Occupants of buildings or vehicles may be injured or killed by landslides.

The 1996 winter storms resulted in many landslides in Oregon. Areas within Multnomah County where landslides occurred included areas west of the Sandy River: Wilson Road south of Kerslake Road and SE Stark Road about ½ mile west of the Sandy River. There were also several landslides, mostly rockfalls on very steep slopes, along the Historic Columbia River Highway. A debris flow area approximately 3 miles long occurred in the Dodson and Warrendale areas on February 7 and 8, 1996. Interstate 84 and the Union Pacific Railroad were closed for several days, and several residences were destroyed.

The potential impacts of landslides on Multnomah County are summarized in Table 8.2 below.

Table 8.2
Potential Impacts of Landslides on Multnomah County

Inventory	Probable Impacts
Portion of Multnomah County affected	Landslides or debris flows are possible in any of the mapped landslide hazard areas shown in Figures 8.5 to 8.8.
Buildings	In the unincorporated parts of the county, most buildings at risk are residential buildings.
Streets within communities	Street closures possible, but impacts generally limited because of short detour routes.
Roads within and to/from Multnomah County	Potential closures of major highways due to landslides, including Highway 30 and Interstate 84 and many secondary roads.
Rail transportation	Disruptions of rail service possible along the Highway 30 and Interstate 84 corridors.
Electric power	Potential for localized loss of electric power due to landslides affecting power lines in or near Multnomah County.
Other Utilities	Potential outages of water, wastewater and natural gas from pipe breaks from landslides. Probable impacts are localized.
Casualties	Landslides that impact buildings or roads could result in a small number of casualties (deaths and injuries).

The damages and economic losses from landslides are generally low to moderate, with damages and losses ranging from a few thousand dollars to hundreds of thousands of dollars. Damages and losses are generally low because the geographic areas affected are usually small. However, large landslides that affect dozens of homes could result in damages in the range of several million dollars.

Similarly, damages to roads and utilities are generally limited to small areas, often in residential areas, with low to moderate damages and economic losses. However, as with building damages, larger landslides or landslides which affect major roads or highways, including bridges, overpasses and viaducts, or major utility lines could have significantly larger economic impacts.

8.4 Mitigation of Landslide Risk

Mitigation of landslide risks is often quite expensive. In some cases, slope stability can be improved by addition of drainage to reduce pore water pressure, by construction of appropriate retaining walls or by other types of geotechnical remediation. In some cases, buildings can be hardened to reduce damages. An alternative mitigation strategy for already built buildings or infrastructure with high potential for landslide losses is to relocate the facilities outside of known slide areas. Relocation outside of landslide hazard areas is especially important for high occupancy buildings and critical facilities.

The impacts of slide damage on road systems can also be partially addressed by identifying areas of high slide potential or of repetitive past slide damages so that alternative routes for emergency response can be pre-determined.

Mitigation of landslide risk can also be accomplished by effective land use planning to minimize development in slide-prone areas. Generally, such land use planning requires rather detailed geotechnical mapping of slide potential so that high hazard areas can be demarcated without unnecessarily including other areas of low slide potential.

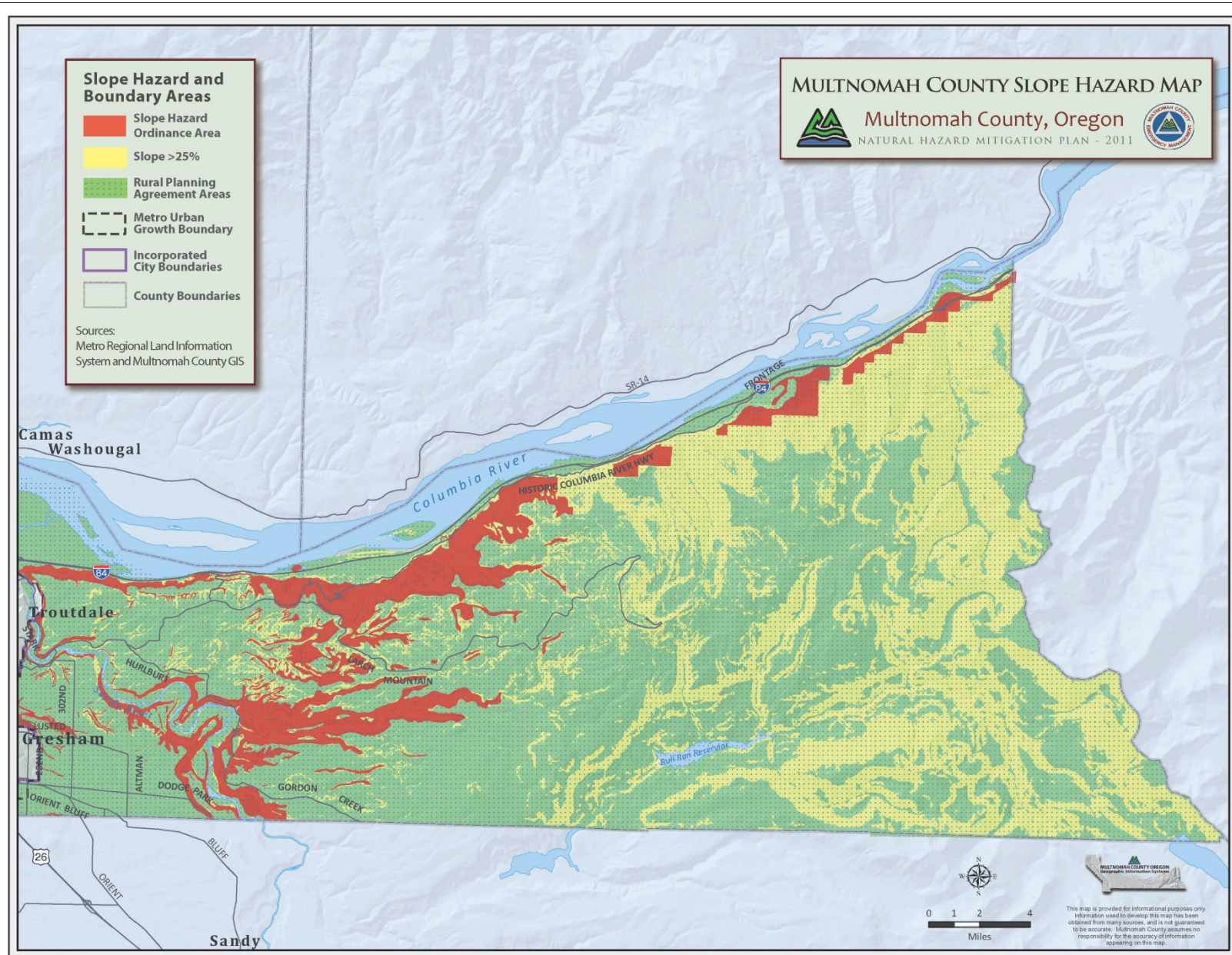
The Multnomah County Hillside Development and Erosion Control Ordinance contains provisions that are intended to minimize loss due to earth movement hazards in rural areas shown on the County's adopted "Slope Hazard Maps" shown on figures 8.9 and 8.10. This mapping was developed based on an engineering study of the county that was completed in 1978. The County mapping was supplemented based on a 1996 engineering study of the Dodson-Warrendale area after debris flow losses there in that year.

New construction on land located in mapped hazard areas or with an average slope of 25% or more requires a Hillside Development Permit. However, there are several exemptions that can allow development to proceed without review. One example is a situation where a parcel having slopes less than 25% but which is located immediately downhill from a steep slope subject to failure (or even downhill from an active landslide) is exempt from review.

Multnomah County's regulatory role for landslides in areas within the Urban Growth Boundary is limited by the Urban Planning Area Agreement (UPAA) between the county and cities, which gives the cities' planning authority within the UPAA. The only unincorporated area that is not covered by city zoning under the UPAA is part of Pleasant Valley along Foster Road. This area is not within the mapped landslide hazard areas.

The table on page 8-13 includes landslide mitigation action items from the master Action Items table in Chapter 4.

Figure 8-10
Regulatory Landslide Hazard Map: East



**Table 8.3
Landslide Mitigation Action Items**

Hazard	Action Item	Coordinating Organizations	Timeline	Plan Goals Addressed				
				Life Safety	Protect Property and Infrastructure	Emergency Management Capabilities	Public Awareness and Education	Environmental Stewardship
Landslide Mitigation Action Items								
Short-Term #1	Inventory utility and communication infrastructure in areas with a history of landslides or which are within mapped landslide hazard areas.	GIS	1-2 Years		X	X	X	
Short-Term #2	Compile inventory of county road segments with a history of landslides or which are within mapped landslide hazard areas.	Transportation	3 Years		X	X		
Short-Term #3	Review the Hillside Development ordinance to consider amendments that address areas at risk from landslides for areas not already identified on the County Slope Hazard Map or otherwise subject to the Hillside Development zoning code.	Planning	3 Years	X	X		X	X
Short-Term #4	Obtain completed detailed lidar-based inventory of historical and active landslides and areas with high landslide risk to update the County's slope hazard maps.	GIS	Ongoing		X	X	X	
Long-Term #1	Encourage the relocation of identified critical or essential facilities and high occupancy facilities in high landslide hazard areas or mitigation of the landslide hazard if feasible.	Multnomah County Emergency Management	Ongoing	X	X	X	X	