CHAPTER 14.
LANDSLIDES AND OTHER MASS MOVEMENTS

14.1 GENERAL BACKGROUND

A landslide is a mass of rock, earth or debris moving down a slope. Landslides may be minor or very large, and can move at slow to very high speeds. They can be initiated by storms, earthquakes, fires, volcanic eruptions, and by human modification of the land.

DEFINITIONS

Landslide—The sliding movement of masses of loosened rock and soil down a hillside or slope. Slope failures occur when the strength of the soils forming the slope is exceeded by the pressure, such as weight or saturation, acting upon them.

Mass Movement—A collective term for landslides, debris flows, falls and sinkholes.

Mudslide (or Mudflow or Debris Flow)—A river of rock, earth, organic matter and other materials saturated with water.

Sinkhole—A collapse depression in the ground with no visible outlet. Its drainage is subterranean. It is commonly vertical-sided or funnel-shaped.

Mudslides or mudflows (or debris flows) are rivers of rock, earth, organic matter and other soil materials saturated with water. They develop in the soil overlying bedrock on sloping surfaces when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt. Water pressure in the pore spaces of the material increases to the point that the internal strength of the soil is drastically weakened. The soil's reduced resistance can then easily be overcome by gravity, changing the earth into a flowing river of mud or "slurry." A debris flow or mudflow can move rapidly down slopes or through channels, and can strike with little or no warning at avalanche speeds. The slurry can travel miles from its source, growing as it descends, picking up trees, boulders, cars and anything else in its path. Although these slides behave as fluids, they pack many times the hydraulic force of water due to the mass of material included in them. Locally, they can be some of the most destructive events in nature.

A sinkhole is a collapse depression in the ground with no visible outlet. Its drainage is subterranean, and it is commonly vertical-sided or funnel-shaped.

All these mass movements are caused by a combination of geological and climate conditions. These include steep topography, as well as the encroaching influence of urbanization. The cool, rainy Pacific Northwest climate ensures that soil moisture levels remain high throughout most of the year, and in fact are often at or near saturation during wet winter months. The geological conditions of western Washington are primarily a legacy of repeated episodes of glacial advance and retreat during the past 2 million years, and one of the most active erosive processes in the 13,000 years since the last ice disappeared has been mass wasting—the action of landslides and mudslides. These vulnerable natural conditions are being steadily affected by human residential, agricultural, commercial and industrial development and the infrastructure that supports it.

14.2 HAZARD PROFILE

Landslides are caused by one or a combination of the following factors: change in slope of the terrain, increased load on the land, shocks and vibrations, change in water content, groundwater movement, frost action, weathering of rocks, and removing or changing the type of vegetation covering slopes. In general, landslide hazard areas are where the land has characteristics that contribute to the risk of the downhill movement of material, such as the following:

- A slope greater than 33 percent
- A history of landslide activity or movement during the last 10,000 years
- Stream or wave activity, which has caused erosion, undercut a bank or cut into a bank to cause the surrounding land to be unstable
- The presence or potential for snow avalanches
- The presence of an alluvial fan, indicating vulnerability to the flow of debris or sediments
- The presence of impermeable soils, such as silt or clay, which are mixed with granular soils such as sand and gravel.

Flows and slides are commonly categorized by the form of initial ground failure, but they may travel in a variety of forms along their paths. Figures 14-1, 14-2, 14-3 and 14-4 show common types of slides in the Puget Sound region and in Snohomish County. The most common is the shallow colluvial slide, occurring particularly in response to intense, short-duration storms. The largest and most destructive are deep-seated slides, although they are less common than other types. Puget Sound's shoreline contains many large, deep-seated dormant landslides. Occasionally large catastrophic slides occur on Puget Sound.

The preponderance of landslides occurs in January after the water table has risen during the wet months of November and December. In addition to the coastal bluffs, land sliding is most prevalent around the slopes of the Puget Sound's steep, linear hills. Water is involved in nearly all cases; and human influence has been identified in more than 80 percent of reported slides.

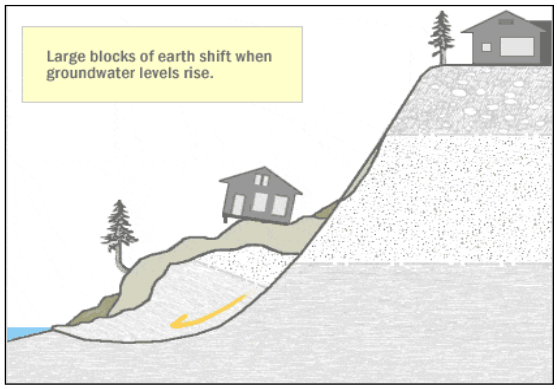


Figure 14-1. Deep Seated Slide

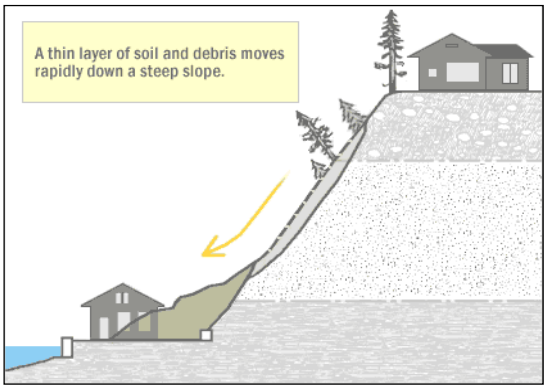


Figure 14-2. Shallow Colluvial Slide

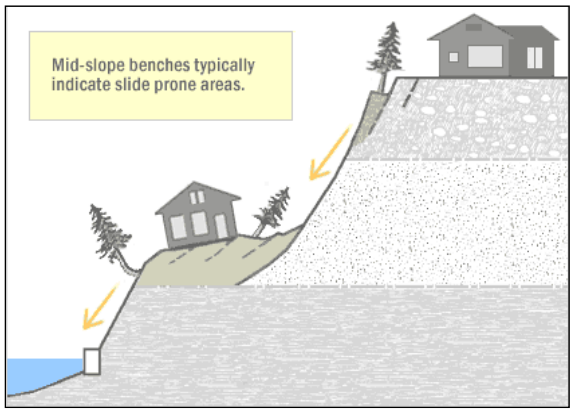


Figure 14-3. Bench Slide

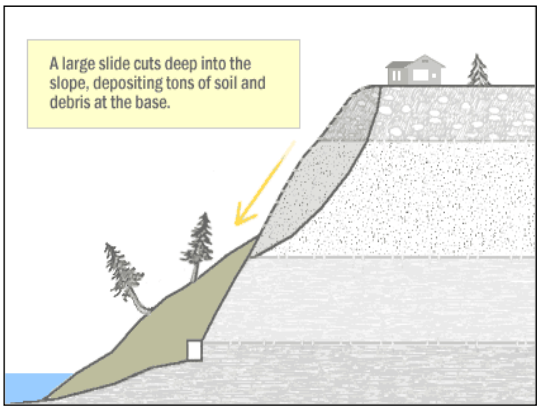


Figure 14-4. Large Slide

14.2.1 Past Events

There is little recorded information for Snohomish County regarding landslides. During the winter storm of 1996-97, more than half of the County's $60-70 million in reported damage occurred as a result of landslides, mudslides and debris flows. Drainage systems and catchment basins could not handle the volume of runoff, focusing the water's energy against vulnerable slopes and man-made structures. In some cases, saturated soils simply became overloaded with the weight of snow and rainwater and collapsed. Private homeowners, particularly in areas where natural drainage has been paved, diverted or otherwise modified by man, reported significant damage. Landslide and mudslide/debris flow activity during this storm caused widespread disruption of surface transportation, closing roads and in one case derailing mail cars from a freight train. The costs of repairing road damage totaled tens of millions of dollars. Given the volume of hazardous substances shipped by road and rail through Snohomish County, it was fortunate that no serious chemical spills occurred as a result of these incidents.

A large slide occurred in Woodway, just north of the Richmond Beach neighborhood, during the early morning of January 15, 1997. It cut 50 feet into the property above, passed over the railroad tracks and knocked a freight train into Puget Sound (see Figure 14-5). Initial estimates placed the volume of the slide at 200,000 to 260,000 cubic yard, but later estimates based on additional data ranged from 100,000 to 200,000 cubic yards. The head of the slide is downslope from the Rosary Heights Convent. The bluff here is about 250 feet high, and the head scarp appears to be about 350 feet wide. The slide deposit extended from the base of the scarp across railroad tracks and into Puget Sound. Except for a large, partially intact slide block resting at the base of the scarp, the deposit consisted mostly of remolded sand and silt, containing logs and boulder-sized, joint-bounded blocks of intact Lawton clay. The remolding indicates that much of the slide broke apart and mobilized into a debris flow.

There are no records in the County of fatalities attributed to mass movement. However, across the Pacific Northwest, a number of deaths have occurred as a result of slides, slope collapses and sinkholes.

Figure 14-5. 1997 Woodway Slide

14.2.2 Location

Map 14-1 shows the landslide hazard areas in Snohomish County. The basis of the mapping is as follows:

- Any area with a combination of:
  - Slopes greater than 33 percent
  - Impermeable soils (typically silt and clay) frequently interbedded with granular soils (predominantly sand and gravel)
  - Springs or groundwater seepage
- Any area that has shown movement during the Holocene epoch (from 12,000 years ago to present), or that is underlain by mass wastage debris of that epoch
- Any area potentially unstable as a result of rapid stream incision, stream bank erosion or undercutting by wave action
- Any area that shows evidence of, or is at risk from, snow avalanches
- Any area located on an alluvial fan, presently subject to or potentially subject to inundation by debris flows or deposition of stream-transported deposits.

The recognition of ancient dormant mass movement sites is important in the identification of areas susceptible to flows and slides because they can be reactivated by earthquakes or by exceptionally wet weather. Also, because they consist of broken materials and frequently involve disruption of groundwater flow, these dormant sites are vulnerable to construction-triggered sliding.

14.2.3 Frequency

Landslides are often triggered by other natural hazards such as earthquakes, heavy rain, floods or wildland fires, so landslide frequency is related to the frequency of these other hazards. In Snohomish County, landslides typically occur during and after major storms. Recent events occurred during the winter storm of 1996-97 and the October 2003 storm, which generated a few landslides, but not as many as expected, since the soil and bedrock in hilly areas were relatively dry. Recent events also occurred during the winter storms of 2006, 2007 and 2009.

14.2.4 Severity

Landslides destroy property and infrastructure and can take the lives of people. Slope failures in the United States result in an average of 25 lives lost per year and an annual cost to society of about $1.5 billion. The 1996-97 storm caused about $30 million to $35 million in damage due to landslides, mudslides and debris flows. This was about half of all damage caused by the storm. The landslides caused by the storm also caused tens of millions of dollars of damage to road infrastructure.

14.2.5 Warning Time

Mass movements can occur suddenly or slowly. The velocity of movement may range from a slow creep of inches per year to many feet per second, depending on slope angle, material and water content. Some methods used to monitor mass movements can provide an idea of the type of movement and the amount of time prior to failure. It is also possible to determine what areas are at risk during general time periods. Assessing the geology, vegetation, and amount of predicted precipitation for an area can help in these predictions. However, there is no practical warning system for individual landslides. The current standard operating procedure is to monitor situations on a case-by-case basis, and respond after the event has occurred. Generally accepted warning signs for landslide activity include:

- Springs, seeps, or saturated ground in areas that have not typically been wet before
- New cracks or unusual bulges in the ground, street pavements or sidewalks
- Soil moving away from foundations
- Ancillary structures such as decks and patios tilting and/or moving relative to the main house
- Tilting or cracking of concrete floors and foundations
- Broken water lines and other underground utilities
- Leaning telephone poles, trees, retaining walls or fences
- Offset fence lines
- Sunken or down-dropped road beds
- Rapid increase in creek water levels, possibly accompanied by increased turbidity (soil content)
- Sudden decrease in creek water levels though rain is still falling or just recently stopped
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- A faint rumbling sound that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together.

14.3 SECONDARY HAZARDS

Landslides can cause several types of secondary effects, such as blocking access to roads, which can isolate residents and businesses and delay commercial, public and private transportation. This could result in economic losses for businesses. Other potential problems resulting from landslides are power and communication failures. Vegetation or poles on slopes can be knocked over, resulting in possible losses to power and communication lines. Landslides also have the potential of destabilizing the foundation of structures, which may result in monetary loss for residents. They also can damage rivers or streams, potentially harming water quality, fisheries and spawning habitat.

14.4 CLIMATE CHANGE IMPACTS

Climate change will impact storm patterns in Washington. This changing of the hydrograph means that the probability of more frequent, intense storms with varying duration will increase. Increase in global temperature will also affect the snowpack and its ability to hold and store water. Warming temperatures will increase the occurrence and duration of droughts, which will increase the probability of wildland fire, which impacts the vegetation that helps to support steep slopes. All of these factors working in unison would increase the probability for landslide occurrences within the planning area.

14.5 EXPOSURE

14.5.1 Population

Population could not be examined by landslide hazard area because census block group areas do not coincide with the risk areas. A population estimate was made using the structure count of buildings within the landslide hazard areas and applying the census value of 2.65 persons per household for Snohomish County. Using this approach, the estimated county population living in landslide risk areas is 13,642. This approach could understate the exposure by as much as a factor of two, so it is reasonable to assume that the exposed population may be as high as 30,000, roughly 5 percent of the total county population.

14.5.2 Property

Table 14-1 shows the number and assessed value of Snohomish County structures exposed to steep slopes. There are 4,669 structures on parcels exposed to steep slopes, worth an estimated $2.075 billion. Ninety-five percent of the exposed structures are dwellings.

Table 14-2 shows the general land use of parcels exposed to landslides. Lands used for forestry or parks are less vulnerable, while lands used for manufactured homes are highly vulnerable. The predominant land uses for parcels in cities are single-family, vacant and manufactured homes. These uses as well as timber are the predominant land uses for exposed parcels in unincorporated Snohomish County.

TABLE 14-1.
SNOHOMISH COUNTY STRUCTURES EXPOSED TO STEEP SLOPES

Jurisdiction	Buildings Exposed	Assessed Value			% of AV
		Structure	Contents	**Total**	
Arlington	49	$10,347,000	$9,237,390	$19,584,390	0.9%
Bothell	175	$32,377,900	$22,670,740	$55,048,640	1.9%
Brier	45	$7,032,900	$4,953,420	$11,986,320	1.8%
Darrington	5	$980,700	$979,450	$1,960,150	1.4%
Edmonds	308	$75,028,000	$52,894,210	$127,922,210	1.9%
Everett	467	$208,200,800	$202,950,500	$411,151,300	2.6%
Gold Bar	2	$179,800	$156,130	$335,930	0.2%
Granite Falls	14	$1,570,400	$1,099,280	$2,669,680	0.7%
Index	2	$205,400	$143,780	$349,180	1.5%
Lake Stevens	51	$13,131,900	$9,443,860	$22,575,760	1.4%
Lynnwood	43	$8,192,300	$5,931,830	$14,124,130	0.3%
Marysville	86	$13,778,900	$9,670,700	$23,449,600	0.6%
Mill Creek	10	$22,048,900	$15,434,230	$37,483,130	1.2%
Monroe	37	$9,978,300	$7,053,360	$17,031,660	0.75%
Mountlake Terrace	192	$72,465,600	$50,784,000	$123,249,600	5.7%
Mukilteo	421	$107,087,800	$76,328,490	$183,416,290	4.6%
Snohomish	62	$18,614,200	$15,992,980	$34,607,180	2.8%
Stanwood	7	$667,100	$470,720	$1,137,820	0.1%
Sultan	6	$738,000	$516,600	$1,254,600	0.3%
Woodway	11	$8,004,800	$5,729,760	$13,734,560	3.8
Unincorporated County	2676	$551,288,650	$410,932,140	$972,220,790	2.52%
Total	**4669**	**$1,161,919,350**	**$903,373,570**	**$2,075,292,920**	**2.1%**

TABLE 14-2.
GENERAL LAND USE OF PARCELS EXPOSED TO LANDSLIDES

General Land Use	Cities	Unincorporated Snohomish County
Agriculture	35	418
Civic/Government	9	2
Fishery	0	5
Forest	10	238
Hotel/Motel	3	0
Industrial/Manufacturing	17	7
Manufactured/Mobile Home	505	1,162
Marine Terminals/Marinas	0	2
Medical/Health	7	0
Mining	13	185
Multi-Family	22	4
Multi-Plex Housing	44	39
Non-Residential Structure	23	161
Open Space	76	162
Other Housing/Group Quarters	1	5
Park/Playground	57	28
Parking	10	0
Recreation/Entertainment	10	33
Reference Account	0	1
Resource Production/Extraction	0	1
Religious	3	6
Retail/Service	115	17
Retirement Home/Orphanage	1	0
Roads	11	31
School/Daycare	13	1
Single Family	4,112	4,904
Timber	26	1,150
Transportation	21	61
Utility	30	48
Vacant	951	4,834
Warehouse	10	1
Water	13	20
Wood Products	1	1
Total	**6,149**	**13,527**

14.5.3 Critical Facilities and Infrastructure

Table 14-3 summarizes the critical facilities exposed to the landslide hazard. No loss estimation of these facilities was performed due to the lack of established damage functions for the landslide hazard. A significant amount of infrastructure (roads, bridges, railroads, and utilities) can be exposed to mass movements. Landslides can block egress and ingress on roads, causing isolation for neighborhoods. Roadway blockages caused by landslides can also create traffic problems, resulting in delays for both public and private transportation. This could result in economic losses for businesses. Other potential problems resulting from landslides are power and communication failures, creating problems for vulnerable populations as well as businesses.

TABLE 14-3.
CRITICAL FACILITIES EXPOSED TO LANDSLIDE HAZARDS

Medical and Health Services	1
Government Function	0
Protective Function	0
Schools	0
Hazmat	0
Other Critical Function	0
Bridges	32
Water	1
Waste Water	2
Communications	0
Total	**36**

Railroads

The BNSF Railway corridor is exposed to landslides along much of its north-south and east-west routes and spurs. These areas include the tracks located along the Puget Sound bluffs from the King County line up to Everett. The Boeing Spur is located in a ravine and is extremely vulnerable. Other areas exposed to landslides include the bluffs north of Stanwood, the Bothell-Snohomish Branch and tracks located in the Cascade Mountains east of Gold Bar leading to Steven's Pass.

Roads

Many of the major roads in Snohomish County are exposed to mass movement hazards. Access to major roads is crucial to life-safety after a disaster event and to response and recovery operations.

Bridges

Landslides can significantly impact road bridges. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use. Using Washington State bridge data, GIS analysis shows that there are 64 bridges that pass through or over landslide prone slopes.

Power Lines

Power lines are generally elevated above steep slopes; but the towers supporting them can be subject to landslides. A landslide could trigger failure of the soil underneath a tower, causing it to collapse and ripping down the lines. Puget Sound Energy lines pass through steep slope areas.

14.5.4 Environment

Environmental problems as a result of mass movements can be numerous. Landslides that fall into streams may significantly impact fish and wildlife habitat, as well as affecting water quality.

14.6 VULNERABILITY

14.6.1 Population

Due to the nature of census block group data, it is difficult to determine demographics of populations vulnerable to mass movements. In general, all of the estimated 13,642 persons that are exposed to landslides hazards (1.9 percent of total county population) are also vulnerable. Due to Snohomish County's increasing population density and the fact that many man-made structures are built on "view property" atop or below bluffs and on steep slopes subject to mass movement, more lives are now endangered by this hazard than ever before.

14.6.2 Property

A study completed for Seattle Public Utilities in 2000 showed that only about 1 percent of the land area of the region is actually vulnerable to landslides or other mass movements. This study also showed that 84 percent of the slides recorded had human related causes, indicating that people ignore signs of potential disaster in order to possess the most desirable land. Consequently, there is greater potential for damage or destruction to private and public property than if stringent landslide policies were adopted.

Although complete historical documentation of the mass movement threat in Snohomish County is lacking, the effects of slide and flow activity seen during the winter storms of 1996-97 suggest a significant vulnerability to such hazards. Countywide, the millions of dollars in damage attributable to mass movement during those storms affected private property and public infrastructure and facilities.

Loss estimations for the landslide hazard are not based on modeling utilizing damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the assessed value of exposed structures. This allows emergency managers to select a range of economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 14-4 shows the general building stock loss estimates in steep slope areas.

14.6.3 Critical Facilities and Infrastructure

Thirty-six critical facilities are exposed to the landslide hazard. A more in-depth analysis of the mitigation measures taken by these facilities to prevent damage from mass movements should be done to determine if they could withstand impacts of a mass movement.

Several types of infrastructure are exposed to mass movements, including transportation, water and sewer and power infrastructure. Highly susceptible areas of the county include the mountain and coastal roads and transportation infrastructure. At this time all infrastructure and transportation corridors identified as exposed to the landslide hazard are considered vulnerable until more information becomes available.

14.6.4 Environment

The environment vulnerable to landslide hazard is the same as the environment exposed to the hazard.

TABLE 14-4.
ESTIMATED BUILDING LOSSES DUE TO LANDSLIDE HAZARD

Jurisdiction	Building Count	Assessed Value	10% Damage	30% Damage	50% Damage
Arlington	49	$19,584,390	$1,958,439	$5,875,317	$9,792,195
Bothell	175	$55,048,640	$5,504,864	$16,514,592	$27,524,320
Brier	45	$11,986,320	$1,198,632	$3,595,896	$5,993,160
Darrington	5	$1,960,150	$196,015	$588,045	$980,075
Edmonds	308	$127,922,210	$12,792,221	$38,376,663	$63,961,105
Everett	467	$411,151,300	$41,115,130	$123,345,390	$205,575,650
Gold Bar	2	$335,930	$33,593	$100,779	$167,965
Granite Falls	14	$2,669,680	$266,968	$800,904	$1,334,840
Index	2	$349,180	$34,918	$104,754	$174,590
Lake Stevens	51	$22,575,760	$2,257,576	$6,772,728	$11,287,880
Lynnwood	43	$14,124,130	$1,412,413	$4,237,239	$7,062,065
Marysville	86	$23,449,600	$2,344,960	$7,034,880	$11,724,800
Mill Creek	10	$37,483,130	$3,748,313	$11,244,939	$18,741,565
Monroe	37	$17,031,660	$1,703,166	$5,109,498	$8,515,830
Mountlake Terrace	192	$123,249,600	$12,324,960	$36,974,880	$61,624,800
Mukilteo	421	$183,416,290	$18,341,629	$55,024,887	$91,708,145
Snohomish	62	$34,607,180	$3,460,718	$10,382,154	$17,303,590
Stanwood	7	$1,137,820	$113,782	$341,346	$568,910
Sultan	6	$1,254,600	$125,460	$376,380	$627,300
Woodway	11	$13,734,560	$1,373,456	$4,120,368	$6,867,280
Unincorporated County	2676	$551,288,650	$55,128,865	$165,386,595	$275,644,325
Total	**4669**	**$1,654,360,780**	**$165,436,078**	**$496,308,234**	**$827,180,390**

14.7 FUTURE TRENDS IN DEVELOPMENT

Landslide hazard areas are included in the "geologically hazardous areas," one category of critical areas regulated under the state GMA for Snohomish County. They are defined as follows:

> "Landslide hazard areas" means areas potentially subject to mass earth movement based on a combination of geologic, topographic, and hydrologic factors, with a vertical height of 10 feet or more. These include the following:
>
> – Areas of historical landslides as evidenced by landslide deposits, avalanche tracks, and areas susceptible to basal undercutting by streams, rivers or waves
>
> – Areas with slopes steeper than 15 percent that intersect geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock, and which contain springs or ground water seeps

– Areas located in a canyon or an active alluvial fan, susceptible to inundation by debris flows or catastrophic flooding.

Snohomish County's 2007 buildable lands report excludes critical areas from consideration as buildable lands due to the scope of regulations affecting them. Based on the findings of this report, Snohomish County and its planning partners appear to be well equipped to deal with future growth and development within the planning area. The landslide hazard portions of the planning area are regulated by County Code (Title 30.62B) as well as by the International Building Code. Development will occur in landslide hazards within the planning area, but it will be regulated such that the degree of risk will be reduced through building standards and performance measures.

14.8 SCENARIO

Major mass movements in Snohomish County occur as a result of soil conditions that have been affected by severe storms, groundwater or human development. The worst-case scenario for mass movement hazards in Snohomish County would generally correspond with a severe storm that had heavy rain and caused flooding. Mass movement is most likely to occur during late winter when the water table is high. A short intense storm could cause saturated soil to move, resulting in landslides. After heavy rains from November to December, soils become saturated with water. As water seeps downward through upper soils that may consist of permeable sands and gravels and accumulates on impermeable silt, it will cause weakness and destabilization in the slope. As rains continue, the groundwater table rises, adding to the weakening of the slope. Gravity, poor drainage, a rising groundwater table and poor soil exacerbate hazardous conditions.

Based on historical events and steep slopes with a potential for instability, the most likely landslide areas are Everett, Mukilteo and Edmonds. However, mass movements can occur anywhere in the county that has been affected by historical landslides or that has steep slopes.

Mass movements are becoming more of a concern as development moves outside of city centers and into areas less developed in terms of infrastructure. Most mass movements would be isolated events affecting specific areas. It is probable that private and public property, including infrastructure, will be affected. Mass movements could affect bridges that pass over landslide prone ravines and knock out rail service through the county. Road obstructions caused by mass movements would create isolation problems for residents and businesses in sparsely developed areas. Property owners exposed to steep slopes may suffer damage to either property or building structures. Landslides carrying vegetation such as shrubs and trees may cause a break in utility lines, cutting off power and communication access to residents.

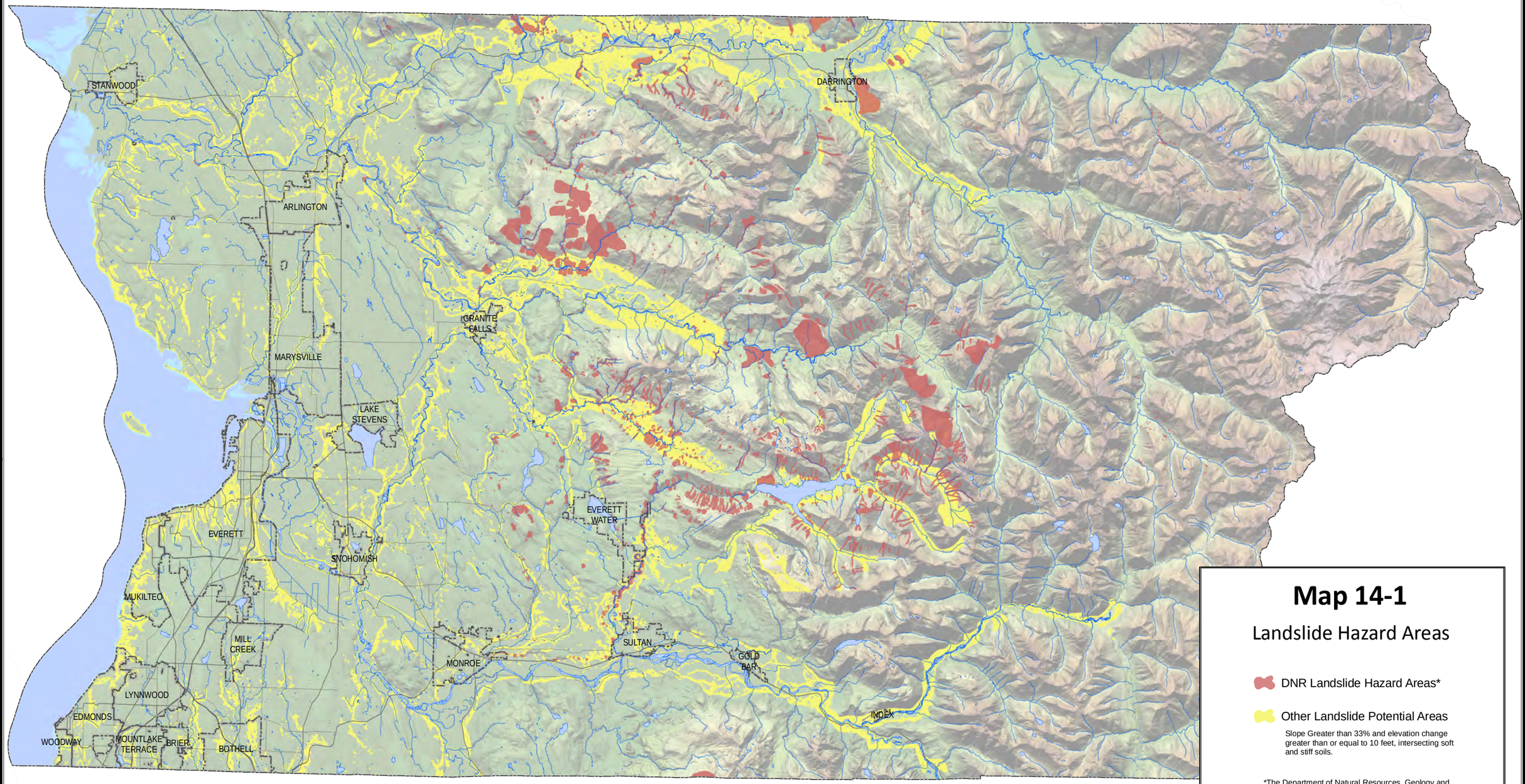
Continued heavy rains and flooding will complicate the problem further. As emergency response resources are applied to problems with flooding, it is possible they will be unavailable to assist with landslides occurring all over Snohomish County.

14.9 ISSUES

Important issues associated with landslides in Snohomish County include the following:

- There are existing homes in mass movement-prone areas, specifically on the Puget Sound shoreline, with the Cities of Everett and Mukilteo being affected significantly.
- Future development could lead to more homes in mass movement prone areas. These areas include the foothills of the Cascades, and steep slope areas above the river floodplains of the North and South Forks Stillaguamish River and the Skykomish River.

- The data and science regarding the mapping and assessment of landslide hazards is constantly evolving. As new data and science become available, assessments of landslide risk should be re-evaluated.
- The impact of climate change on landslides is uncertain. If climate change impacts atmospheric conditions, then exposure to landslide risks in Snohomish County is likely to increase.
- Landslides may cause negative environmental consequences, including water quality degradation.
- The risk associated with the landslide hazard overlaps the risk associated with other hazards such as earthquake, flood and tsunami. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.



Map 14-1

Landslide Hazard Areas

DNR Landslide Hazard Areas*

Other Landslide Potential Areas

Slope Greater than 33% and elevation change greater than or equal to 10 feet, intersecting soft and stiff soils.

*The Department of Natural Resources, Geology and Earth Resources Division (DGER) Landslide dataset is a compilation of landslide data previously mapped by a variety of sources at all scales, and is assessed for reliability by the DGER.

Washington State Department of Natural Resources, Division of Geology and Earth Resources

Snohomish County

Tetra Tech, Inc.
May 2010

Data Sources:
Snohomish County
US Geological Survey
Washington State Department of Natural Resources
Division of Geology and Earth Resources

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0 2.5 5 10 Miles

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