Landslides

Key Points

- Seattle has a lot of steep hills, very wet winters and geology that is prone to landslides. As a result slides occur frequently, especially in the winter. January has the most landslides.
- 8.4% of the city's surface is covered by areas identified as slide prone in the city's Environmentally Critical Areas Ordinance.
- Landslides can be any size. Most are shallow happen on undeveloped land and have minor consequences. A small percentage of landslides are deeper seated. Deep seated landslides are usually bigger and therefore more dangerous that shallow slides, but any slide can be deadly.
- Occasionally swarms of landslides occur within a few days, especially during winter storms. While most of the slides in these swarms are small, some cause extensive damage.
- The response to landslides becomes more difficult when they are part of a larger event like a winter storm.
- Any landslide can be dangerous. A shallow 1997 slide on Bainbridge Island killed a family of four.
- Most insurance policies do not cover damages from landslides making property owners extremely vulnerable to economic loss.
- Most of the land use in potential slide areas is open space, single family residential and right of way. The City of Seattle is the largest owner of landslide prone slopes.
- Landslides can precipitate secondary emergencies, most notably flooding and hazardous materials incidents.
- The City of Seattle has undertaken measures to mitigate vulnerability to landslides. They include inventorying and mapping landslide prone areas, requirements to stabilize building sites during construction, public education, and slope stabilization projects. Mitigation often requires cooperation between private land owners and the City of Seattle.

Context

Nationally, landslides cause over 25 deaths and cost about $1-2 billion per year in the U.S. They are a common natural hazard in Seattle[i]. In parts of the developing world single landslides have killed hundreds of people. In parts of the United States they have destroyed whole neighborhoods. The collapse of Mt. St. Helens during its eruption was one of the largest slides in the world. In understanding that landslides are a very serious class of hazards, it is important to examine the kinds of slides we have in Seattle and what kind of damage they can do.

Causes

Every slope experiences two forces: gravity and forces resisting gravity, such as the nature of the material or slope angle. The ratio of these forces is constantly changing. These changes are usually gradual, but sometimes sudden shifts throw the slope out of balance triggering a landslide. The most frequent triggers for Seattle's landslides are human alteration and groundwater saturation of the slope

Types
Four kinds of slides occur in frequently in Seattle[ii]:

- High Bluff Peel-off – blocks of soil fall from the high bluffs primarily along the cliffs of Puget Sound. Between 3-4% of all slides.
- Groundwater Blowout – groundwater pressure built up at the contact between pervious (sand) and impervious (clay) soil units causes a catastrophic groundwater and soil burst. Between 5-6% of all slides.
- Deep-seated Landslides – deep, rotational or translational slides and slumps caused by groundwater pressures within a hillside. Between 18-19% of all slides*. These are the most dangerous type of slide*.
- Shallow Colluvial (Skin Slide) – shallow and rapid slides on a slope, which may result in a debris flow. Over two-thirds (69%) of all slides are shallow colluvial.

Size
The most common landslides are the shallow colluvial slides; the largest are the deep-seated landslides. About two-thirds of landslides are small, isolated events that cause little or no damage. The largest landslides usually occur on slopes that already have a low margin of safety, often due to weathering and erosion. When these slopes are then struck by a sudden event such as an earthquake, rain or human alteration of the slope, slides occur.

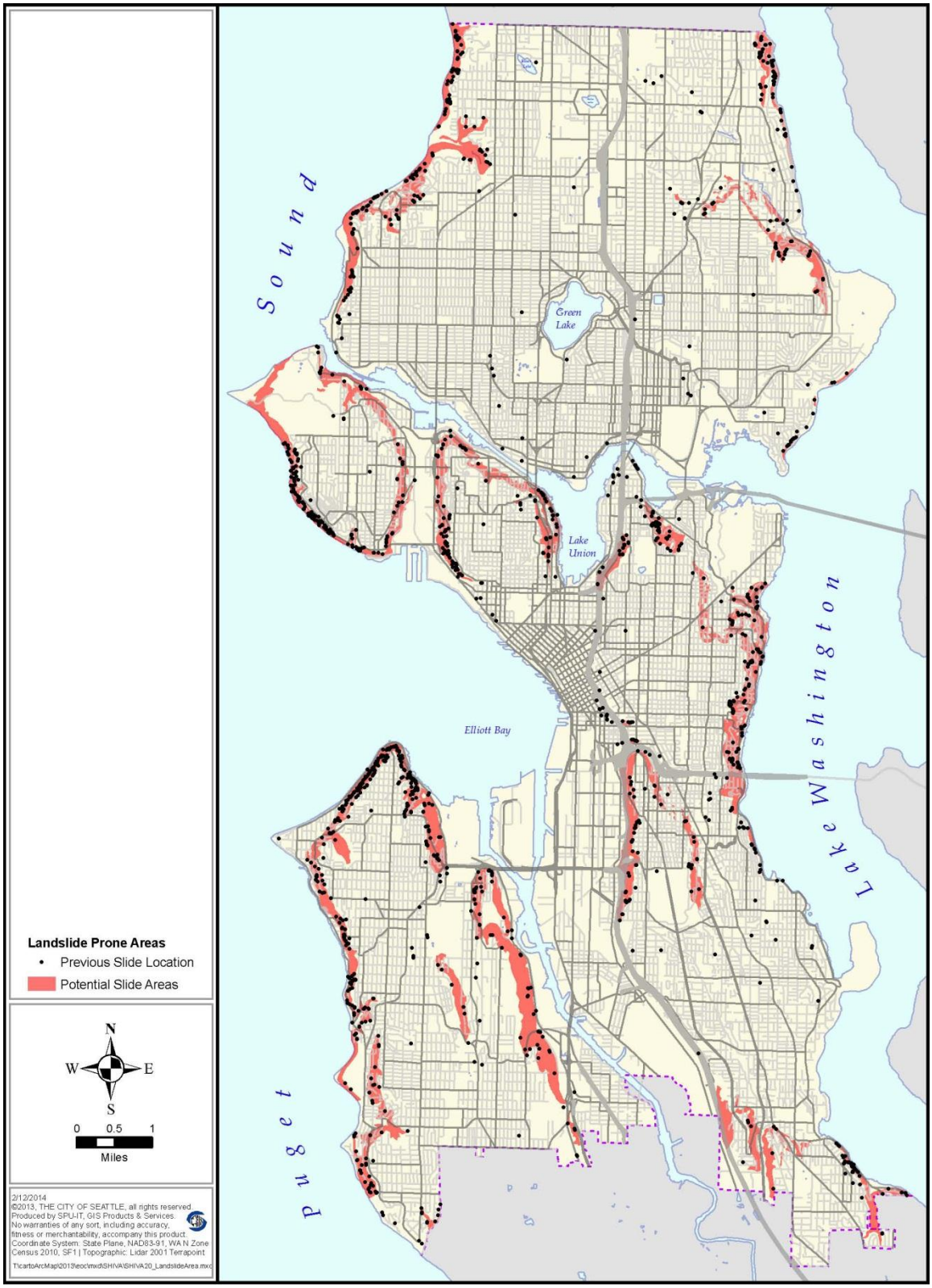
The size of a slide correlates poorly with fatalities. Most fatalities have occurred in relatively small slides, many of which happened at construction sites. Landslides can happen in swarms. These events are often associated with a storm further complicating response.

Timing
Late winter and early spring are the most common times for slides, although most of the documented slides in Seattle have occurred in January[iii]. According to Tubbs the probability of sliding rises after a wet, cold winter, especially if a freeze occurs in late winter and early spring[iv]. The ground becomes saturated over the winter, and then porous following a freeze, so a subsequent rain will penetrate the surface while the high water table will prevent the ground from absorbing it. The water increases the slope stress by adding weight and increasing pore pressure within the soil. Nearly all landslides in Seattle occur when the ground is saturated and most include a human component[v].

Literature and Research
The understanding of Seattle's landslide hazard increased significantly between 2006 and 2008 when eight new papers were published on the geology of Seattle's landslides. Together they were included in a publication called, *Landslides and Engineering Geology in the Seattle, Washington Area*. They all refined Tubbs original work and examined specific types of slides are their triggers.

Of special interest for responders is a tool to estimate when groundwater saturation is reaching the point at which landslides are most common. This tool can be found online at http://landslides.usgs.gov/monitoring/seattle/rtd/plot.php. This work also produced a map of shallow landslide hazards that shows relative likelihood of shallow colluvial slides (i.e., from low to high).

Figure 1. Landslides and Landslide Prone Areas



From the time records began being kept in the 1890s to 2000, Seattle has recorded 1,326 landslides. The events listed below were found in newspaper articles and city records. Only the events that required significant city response are included. Most of them happened during winter storms and involved multiple slides incidents throughout the city. Shannon & Wilson indicated that Seattle's three worst years for landslides were 1966/67, 1985/86 and 1996/97[vi].

1921 Six major slides occur during one weekend[vii].

1934 More than 400 Seattleites battle slides in ten areas of the city. These slides prompted numerous repair projects[viii].

1941 Several slides occur during December around Sand Point[ix].

1947 Several children die when a slide destroys their home[x].

1948 Multiple slide events in Magnolia and Yesler Terrace[xi].

1950 Many slides occurred in the spring. They may have been connected with heavy snowfall as the 1997 events were[xii].

1961 Slides occur in many areas of the city during the spring[xiii].

1965 SR 520 threatened, one lane closed, Roanoke interchange closed[xiv].

1969 Large slides occur on Magnolia Bluff[xv].

1971/72 Slides destroy homes in Madrona causing about $1.8 million in damage. These slides were also probably connected with snowfall[xvi]. Largest number of landslides since 1933/34.

1974 West Seattle experiences multiple slides in the winter. Golden Gardens was also damaged. The mayor authorizes assistance[xvii].

1983 Queen Anne slide closes Aurora for a day. Mud travels as far as Lake Union[xviii].

1985/86 Shannon and Wilson's Seattle Landslide Study reports this as a heavy winter.

1995/96 A large slump along Perkins Lane in Magnolia destroys five homes (January).

1996/97 Over 100 slides reported in the city (January). These slides and the accompanying snow caused approximately $100 million in damages. More slides occurred in March in a continuation of the wet winter.

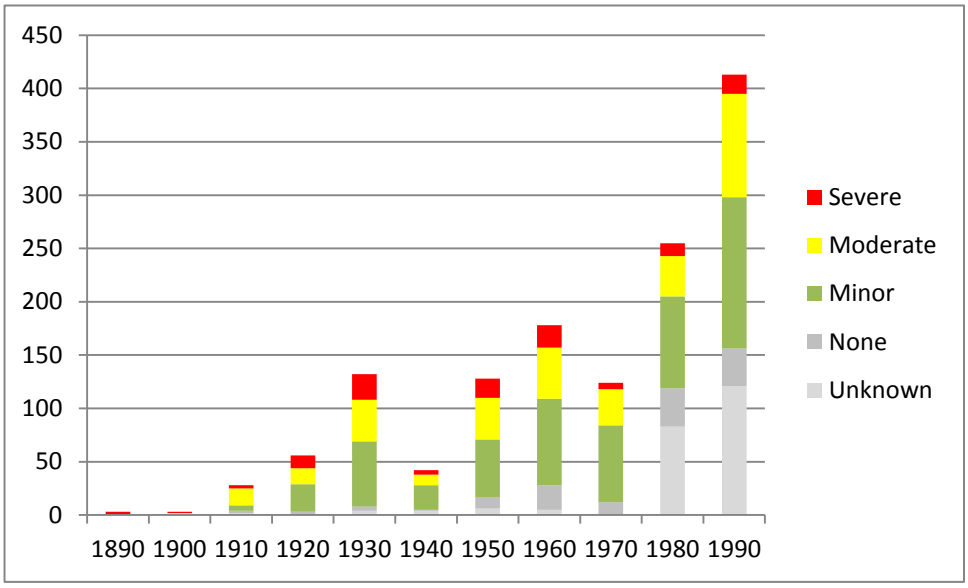
There have been several noticeable historical trends. The first is the occurrence of landslides related to major construction projects, especially the construction of Interstate 5. Newspaper accounts document several landslides along Beacon and Capitol Hills during this time. The second is in a decline in slides in some areas, like the southwest side of Yesler Hill, presumably as a result of its transformation into a dense urban neighborhood.

Geologists have discovered that earthquakes have led to massive landslides in Lake Washington. Whole hillsides have slid into the lake leaving tall Douglas Fir standing upright at the bottom of the lake.

Likelihood of Future Occurrences

The number of landslides recorded by the city is increasing dramatically. Aggressive data collection in the modern era is one reason why; oscillations in weather patterns is another. Development of slide prone slopes probably accounts for much of the increase. Slides on undeveloped property went underreported, whereas now that property is developed and property owners are reporting slides to the city.

Figure 2. Landslides Increasing By Decade



The number of landslides is increasing, and so is the number causing moderate and severe damage. There is simply more property to be damaged. Looking at the percentage of each damage category by decade adds to the picture. It shows that the percentage of severe landslides dropped after 1950 and is holding steady. It also shows a decline in the percentage of slides doing moderate damage from 1950 through the 1980s followed by a sharp increase through the 1990s into 2002. The reasons for these trends are examined below.

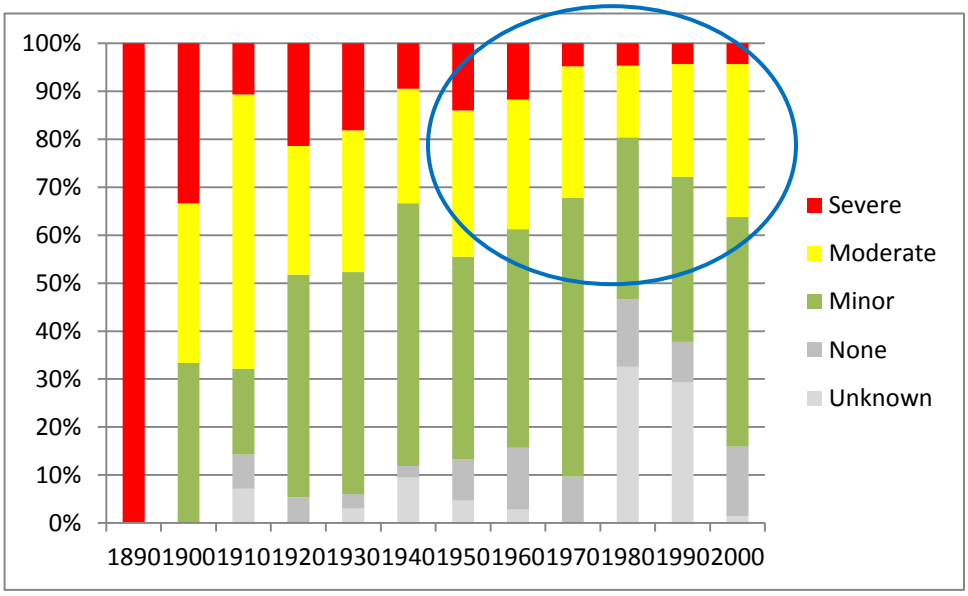
Vulnerability

Understandably, areas within the city's mapped Landslide Prone and Steep Slope areas are more likely to have landslides. What are the conditions that increase the vulnerability of people and property within these mapped areas?

Location and Causation

Landslides are prone to occur on 8.4% of Seattle, near the edges of steep and predominantly linear hills. Eighty-eight percent of the documented landslides in Seattle have occurred either within a steep slope area or potential slide area already mapped by the City of Seattle[xix]. The areas with the greatest number of previous occurrences of landslides are along Alki Avenue in West Seattle and Perkins Lane North in Magnolia, with over 100 documented occurrences each. Other areas with large numbers of recorded slides include Beach Drive Southwest, Pigeon Point, Madrona, Rainier Avenue S.E., Interlaken, Magnolia and Northwest Seattle[xx].

Figure 3. Share of Damage By Decade



Landslides in certain parts of Seattle are increasing, most notably along the slopes along northwest and northeast Seattle, Perkins Lane and Duwamish Head. A few areas, such as the areas around southwest Yesler Hill and the slope along the west side of Beacon Hill, are having fewer landslides.

The most frequent landslides in Seattle are the shallow colluvial slides, especially after intense, short duration storms. Although not as frequent, deep-seated landslides are larger and more destructive in Seattle. The deep-seated landslides are located in Southwest Magnolia, Northwest and Southwest Queen Anne, East Queen Anne, Alki, Admiral Way, West Beacon Hill, Interlaken, Madrona and Pigeon Point[xxi].

Human alteration of the slope is at least a partial cause in 84% of Seattle's landslides. This finding strongly suggests that development, especially non-engineered development, had been playing a big role in driving vulnerability.

Property

Many areas prone to landslides are attractive and expensive property with great views close to the water. As a result, nearly one third of the area designated as landslide prone is single family residential, making those homes vulnerable. A home built underneath a bluff on Bainbridge Island was buried in a landslide in 1997, tragically killing a family of four.

While the City requires new construction to mitigate the landslide hazard, Seattle is largely built out and it is not known how many properties conform to current standards. Furthermore, many mitigation practices are designed to prevent loss of life and not property loss, which is frequently uninsured. The amount of construction in landslide prone areas, especially residential construction, is a vulnerability to the Seattle community.

Transportation / Right of Way

Landslides are mostly a danger to transportation corridors. Air, marine and rail terminals need flat ground and are not in landslide prone areas (although some are adjacent to them). Public right of way, such as roads, railways and trails, accounts for one-quarter of the land within the slide prone areas.

Table 1. Land Use in Landslide Prone Area

Area	Acres	% Seattle	% Area
Seattle	53178.37	100%	
Landslide Prone Area	4471.43	8%	100%

Property in Area	**3342.46**	**6%**	75%
Commercial/Mixed-Use	61.24	0%	1%
Easement	0.03	0%	0%
Industrial	61.39	0%	1%
Major Institution And Public Facilities/Utilities	134.36	0%	3%
Multi-Family	234.23	0%	5%
Parks/Open Space/Cemeteries	327.83	1%	7%
Reservoirs/Water Bodies	0.00	0%	0%
Single Family	1468.48	3%	33%
Unknown	4.79	0%	0%
Vacant	1050.11	2%	23%
Right of Way in Area	**1128.97**	**2%**	25%

Figure 4. Summary of Land Use in Area

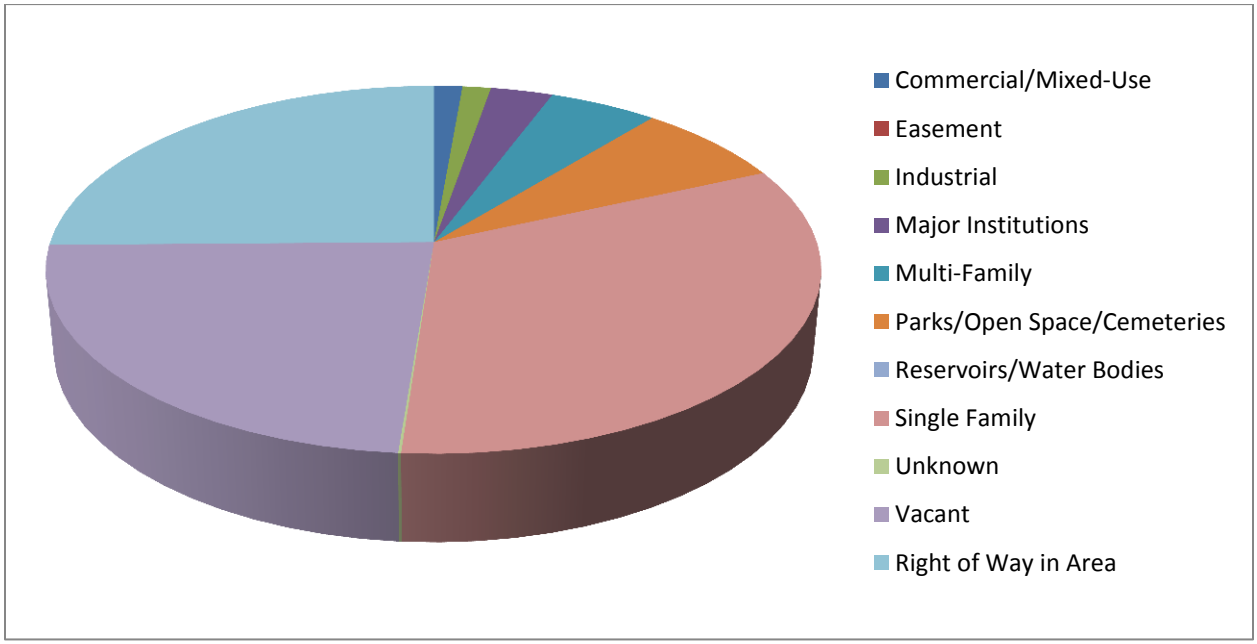


Table 2. Estimated Population, Structures and Assessed Value in Area

Number of Buildings	13,084	Est. Pop
Number of Single Family Units	10,381	21385
Number of Multi-Family Units	10,517	21665
Gross Sq. Footage	49,433,018	
Residential Gross Sq. Footage	40,122,719	
Commercial Gross Sq. Footage	6,055,902	
Total Assessed Value	$ 12,626,534,807	
Estimated Residential Population		43050

Table 3. Critical Facilities within 50ft of Landslide Prone Area.

Medical and Health Services	0
Government Function	0
Protective Function	1
Schools	2
Hazardous Materials Storage Sites	0
Bridges	79
Major Tunnels	0
Water	2
Waste Water	1
Communications	1
Energy	1
Human Services	0
High Population	0
Total	***87***

Table 4. Facilities with Concentrated Vulnerable Populations within 50ft of Landslide Prone Area

Adult Family Homes	13
Boarding House	0
Child Care Centers	5
Nursing Home	1
Intermediate Care Facility	0
Total	***19***

Table 5. Zoning in Landslide Prone Areas.

Zoning Area	Acres	% of Seattle	% of Area
Seattle	53178.37	100%	
Landslide Prone Area	4471.43	8%	100%
Parcel area in zone	**3342.46**	**6%**	75%
Unzoned	0.23	0.00%	0.01%
Commercial - C1	24.03	0.05%	0.54%
Commercial - C2	23.02	0.04%	0.51%
Downtown Harborfront - DH1	0.00	0.00%	0.00%
Downtown Harborfront - DH2	0.00	0.00%	0.00%
Downtown Mixed Commercial - DMC	2.60	0.00%	0.06%
Downtown Mixed Residential/Commercial - DMR	2.00	0.00%	0.04%
Industrial Buffer - IB	45.87	0.09%	1.03%
Industrial Commercial - IC	1.90	0.00%	0.04%
Downtown,International District Mixed - IDM	0.00	0.00%	0.00%
Downtown, International District Residential - IDR	0.00	0.00%	0.00%
General Industrial - IG1	20.42	0.04%	0.46%
General Industrial - IG2	32.96	0.06%	0.74%
Lowrise - LR1	113.40	0.21%	2.54%
Lowrise - LR2	96.33	0.18%	2.15%
Lowrise - LR3	95.17	0.18%	2.13%
Major Institution - MIO	27.85	0.05%	0.62%
MPC			
Multi-Family, Midrise - MR	12.13	0.02%	0.27%
Neighborhood Commercial - NC1	3.88	0.01%	0.09%
Neighborhood Commercial - NC2	3.05	0.01%	0.07%
Neighborhood Commercial - NC3	10.78	0.02%	0.24%
Downtown, Pike Place Market - PMM	0.00	0.00%	0.00%
Downtown, Pioneer Square - PSM	0.00	0.00%	0.00%
Single Family - SF 5000	1215.51	2.29%	27.18%
Single Family - SF 7200	1173.04	2.21%	26.23%
Single Family - SF 9600	431.72	0.81%	9.66%
Neighborhood Commercial, Seattle Mixed- SM	4.12	0.01%	0.09%
Neighborhood Commercial, Seattle Mixed - SMI	0.00	0.00%	0.00%
Neighborhood Commercial, Seattle Mixed Residential - SMR	1.03	0.00%	0.02%
Right of Way	**1128.97**	**2.12%**	25.25%

Table 6. Growth Centers in Landslide Prone Areas.

Urban Centers / Villages and Manufacturing Centers	Acres	% Seattle	% Area	% Center
Seattle	53178	100%		
All Hub and Residential Urban Villages	*5714.5*	*10.75%*		
All Urban Centers	*5715.5*	*6.98%*		
All Manufacturing / Industrial Center	*5716.5*	*11.10%*		
Landslide Prone Area	4471.43	8%	100%	
Hub and Residential Urban Villages in Zone	87.20	0.16%	1.95%	1.53%
Urban Centers in Zone	30.85	0.06%	0.69%	0.83%
Manufacturing / Industrial Center in Zone	141.63	0.27%	3.17%	2.40%

Table 7. Wildlife Area in Landslide Prone Areas

	Acres	% Seattle
Seattle	53178	100%
Landslide Prone Area	4471.43	8%
All Wildlife Habitat Areas	3749.89	7.05%
Wildlife Habitat in Landslide Prone Areas	1473.54	2.77%

(Transportation Continued…) About one-quarter of the slides affect a right of way. Slides can either go over the right of way or they can undermine it or, rarely, both.

The most vulnerable right of way is parallel to the slope. Seattle has many such locations. Some of the more important are the railroad tracks running along Puget Sound in north Seattle, I-5 along parts of Beacon and Capitol Hills and SR 99 Aurora along Queen Anne. Since 2011 two trains have been derailed by landslides in the Seattle-Everett corridor (12/18/2012 and 4/7/2013). In late 2013, BNSF and the State of Washington began a $16 million, multi-year project to mitigate landslides in this corridor.

Most of the time a slide going over a right of way does not damage it and the debris can be cleared in a matter of hours. Exceptions occur if crews are unavailable or complications like downed power lines are present.

Slides that undermine a right of way take longer to repair and cost more. Bridges and other roadway structures are especially vulnerable. In 1996, a landslide destroyed a support of the Magnolia Bridge causing its closure for months. The I-5/I-90 and I-5/Spokane Street Viaduct interchanges are on landslide prone slopes as are ends of the West Seattle Bridge, Ballard Bridge and I-5 Ship Canal Bridge.

Utilities

Utilities, especially underground, are vulnerable to landslides. Drainage systems, because they are often close to slopes by necessity, are the most frequently damaged. About 8% of reported landslides have damaged the city's drainage infrastructure. Another 4% have been associated with water leaks, with the water leak sometimes causing the slide and not the reverse.

Seattle's water, power and sewer lines all cross landslide prone areas. The sewer system is the most exposed to landslide hazards because it has mainlines that run parallel along the base of many landslide prone hill sides, especially in West Seattle, the east side of Queen Anne Hill and in Carkeek Park.Sewer mainlines cross landslide prone slopes in more than seven locations. Seattle water supply lines cross landslides prone areas in three locations: southeast Seattle,

the north end of Beacon Hill and the Interlaken area of Capitol Hill. Power transmission lines cross landslide prone areas in southeast Seattle.

Consequences

History and increasing development in slide prone areas indicate that landslides will continue to be a threat to public safety and property. The 1997 deaths of a Bainbridge Island family underscored the human costs, but threats to property are far more common.

Property damage from the 1974 and 1997 slides was shared roughly equally by the public and private sectors. While too much can be drawn from just two occurrences, this distribution should be studied further. It may reveal trends in property damage pattern that could help prepare the city for future events.

Most of the land in or immediately adjacent to the City's mapped landslide prone areas is residential so it is to be expected that most future property damage will be residential. Historically, the most frequent private damage was to residences. There is little information about severity (i.e., how many homes were destroyed and how many were only damaged). Newspaper articles making frequent reference to "destroyed homes" yield only anecdotal evidence.

Other significant impacts could include the interruption of lifeline services such as water, sewer and transportation. The city's water, gas, sewer, and power lines all cross areas prone to landslides, particularly in Highline, the east side of Beacon Hill, and the east side of West Seattle. Of these areas, Highline is generally the most critical because many of the utility networks have trunks that run through the area. All of the Cedar River water pipelines enter the city in this area.

Transportation corridors could very well be blocked by future slides. Both I-5 and I-90 run through a large slide area around Beacon Hill. Aurora has been blocked by slides along the east face of Queen Anne Hill several times. Since each one of these routes handles thousands of vehicles every day, slides around them have the potential to disrupt large parts of the city.

Landslides often happen in groups over a period of days or even weeks. They usually have the biggest impact in residential areas where they can displace whole blocks of households. Less commonly, they threaten commercial buildings and facilities that house critical services. Their economic impact comes when they block transportation routes or force businesses to vacate their premises. By blocking roads and damaging lifelines they also inhibit the City's ability to deliver critical services to impacted neighborhoods.

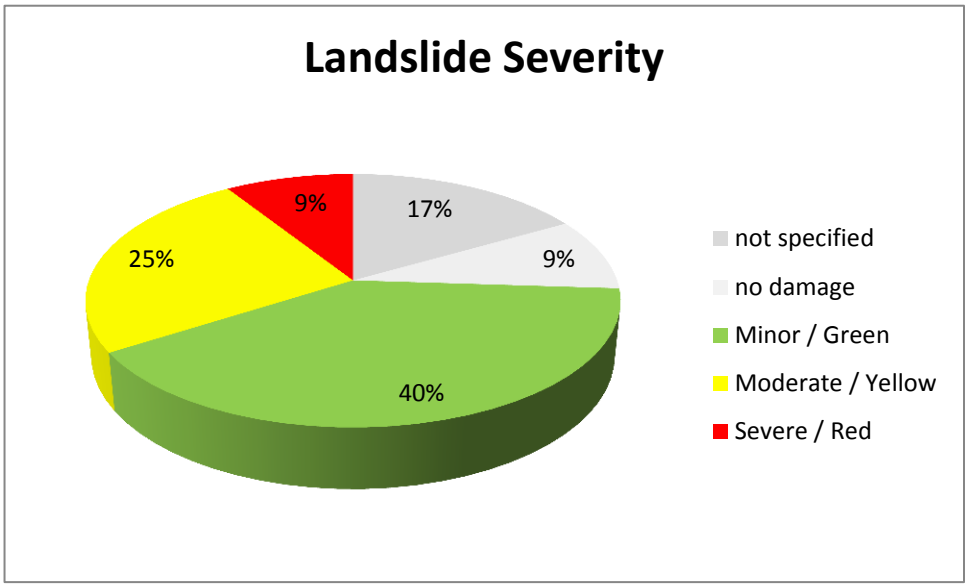
Landslides can induce other disasters. Landslides can cause flooding by blocking rivers, streams and storm drains and lead to releases of hazardous materials by destroying waste and storage sites. Hazardous materials are housed or transported close to potential slide areas in West Seattle, Interbay or along the Burlington Northern tracks running through the Golden Gardens area. Several trains have been derailed by slides in the Puget Sound area, including two in the 1997 slides alone.

Seattle can also be affected by landslides in other parts of the state. Landslides, rock fall and avalanches have closed I-90, Washington's main east-west corridor and SR20 which provides access to Seattle City Light facilities in the North Cascades.

Cumulative Hazard

With landslides ranging from insignificant to massive, they are a hazard whose overall consequence is best analyzed by looking at cumulative impacts. This approach permits the consideration of events that fall below the level of a city emergency but still have a negative effect because of their frequency and their combined effect.

Figure 5. Landslide Severity



Most Likely Scenario

The most likely scenario is an event similar to the 1996/7 landslide event. In this scenario 227 mostly shallow landslides occur over three day period. Most occur on undeveloped property causing little or no damage. 52 cause significant property damage, mostly non-structural. 11 cause major structural damage. Mostly residential areas affected. Some commercial properties damaged. A few major roads blocked. Several roads undermined. Some water, gas and sewer lines are severed. Mitigation measures protect Aurora from major slide.

Category	Impact 1 = low 5 = high	Narrative
Frequency	5	We expect this type of event every 10 - 50 years.
Geographic Scope	4	Landslides occur throughout the City but happen mostly in the 8% of the city previously mapped as prone to landslides.
Duration	3	The landslides occur over a period of five days.
Health Effects, Deaths and Injuries	1	The landslides cause no deaths or injuries. Tension cracks appear at the top of most slopes before they fail allowing residents and businesses to close before the slides occur. Three slides occur without warning and strike buildings, but the residents escape. (SUGGEST increasing to '2')
Displaced Households and Suffering	2	75 people in 32 households are displaced. All except three households are able to find their own shelter with friends and family.
Economy	1	Although 72 buildings are affected and the property owners incur severe loss, the losses do affect the greater Seattle economy in a

Category	Impact 1 = low 5 = high	Narrative
		measureable way.
Environment	2	The landslides create scars on hillsides increasing the potential for erosion. A sewer line is undermined and breaks spilling untreated sewage but the damage is cleaned and repaired quickly.
Structures	2	28 buildings are red tagged including 1 childcare center. The latter was unoccupied when the landslide struck it. 60 buildings are yellow tagged.
Transportation	2	2 bridges are struck and suffer damage that restricts usage to emergency vehicles only. Previous mitigation prevents the Magnolia bridge from being closed completely. Several non-arterial roads are undermined. Mitigation barrier along Aurora stops a slide from blocking it. Several smaller arterials are covered in debris that is removed within 24 hours.
Critical Services and Utilities	1	Several slides break water and sewer lines. A high pressure gas line is undermined but doesn't break. This damage causes localized outages
Confidence in Government	1	The public sees the landslides as natural events. Services are restored quickly. The government is able to maintain the confidence of the public.
Cascading Effects	1	Forecasting of a heightened likelihood of landslides reduced the chance for this incident to trigger secondary hazards. No significant secondary hazards occur.

Maximum Credible Scenario

Seattle certainly has the potential to have big, dangerous and damaging landslides that exceed the destructiveness of 1996/97 event. In this scenario three large deep-seated landslides occur within 72 hours during a storm along with hundreds of smaller slides. The slides occur at night without warning. They destroy multiple structures, destroy roads, start fires and release hazardous materials. A City Light transmission tower coming into Seattle from the south slides. Many lives are lost as the slides crush homes in the night. Massive slides into Puget Sound and Lake Washington cause tsunamis. A freight train is knocked into Puget Sound. Tanks of oil are ruptured.

Category	Impact 1 = low 5 = high	Narrative
Frequency	2	This scenario is considered 1 in 1000 event.
Geographic Scope	3	Almost all of the area identified as landslide prone is affected (8% of the Seattle's landmass).
Duration	3	The slides occur over a 3 hour period. Seattle spends the following 5 days actively responding and many more days in recovery.
Health Effects, Deaths and Injuries	3	42 people are killed and 35 are injured when 20 houses are crushed.
Displaced Households and Suffering	3	240 people are displaced from their homes. Of these 54 need shelter.

Category	Impact 1 = low 5 = high	Narrative
Economy	2	Multiple businesses are affected with concentrations of damage in two areas. The overall City economy suffers minor impacts, but the effects at the neighborhood level are severe.
Environment	3	The landslides strip hundreds of acres of hillsides of vegetation, break numerous sewer lines and knock a train carrying fuel into Puget Sound.
Structures	3	165 buildings are red tagged; 430 are yellow tagged. Several major arterials are undermined; the Magnolia bridge has to be closed when its piers are knocked away.
Transportation	3	Due to bridge and arterial outages, emergency services are delayed reaching Magnolia and parts of West Seattle. Commuters experience long delays.
Critical Services and Utilities	2	A large landslide in South Seattle topples a City Light transmission line. Bonneville Power Administration (BPA) transmissions lines outside the City are affected too. The loss causes a widespread outage lasting 36 hours.
Confidence in Government	3	The incident's magnitude surprises the public. The response takes longer than it expects. As a result it becomes impatient with the pace of response.
Cascading Effects	4	The landslides have caused a major hazardous materials incident and triggered a tsunami.

Conclusions

Landslides are a common, complex and growing problem in Seattle. There is substantial evidence that landslide losses are growing as more property is developed in landslide prone areas. One bright spot is that safety measures seem to be working. Complicating response is the fact that landslides are often secondary to other hazards, such as earthquakes and storms. Following the major slides of 1996/97, the city convened an Interdepartmental Landslide Team to address the problem. Since then, a number of structural and non-structural mitigation measures have been taken. In addition, USGS monitoring of rainfall and soil conditions and availability of new landslide susceptibility maps add greater accuracy to the city's predictive ability.

[i] United States Geological Survey website. http://landslides.usgs.gov/ Accessed 12/24/2009/
[ii] Shannon & Wilson, 2000.
[iii] Shannon & Wilson, 2000.
[iv] Tubbs, 1975.
[v] Shannon & Wilson, 2000.
[vi] Shannon & Wilson, 2000.
[vii] Seattle Times, 12/6/64.
[viii] Seattle Times, 1/22/ 34 and 7/6/34.
[ix] Seattle Times, 12/2/41 and 12/19/41.
[x] Seattle Times, 2/3/47.
[xi] Seattle Times, 2/26/48.
[xii] Seattle Times 4/13/50.
[xiii] Seattle Times: 2/7/61, 2/27/61, 3/3/ 61, 3/14/61, and 4/12/61.

[xiv] Seattle Times 12/31/65.
[xv] Seattle Times 1/8/69.
[xvi] Seattle Times 1/23/72, Tubbs, 1975.
[xvii] Seattle Times, 4/13/74.
[xviii] Fox, 1993.
[xix] Shannon & Wilson, 2000.
[xx] Shannon & Wilson, 2000.
[xxi] Shannon & Wilson, 2000.