1. Risk Assessment

This chapter will describe the risks facing the City of Shoreline from each of eight hazards designated as significant. This chapter will also elaborate upon the hazard definition, vulnerabilities and probable event scenarios. Taken as a whole, this chapter assesses the risk that Shoreline is likely to experience from hazard events.

The following process was used to define risk of each hazard, which is reflected in the organization of the chapter:

- Identify and profile each hazard
- Determine exposure to each hazard
- Assess the vulnerability of exposed infrastructure and facilities
- Identify probability of occurrence, impact and risk rating

1.1. Methodology

Assess hazards

This assessment includes the following information for each hazard:

- Geographic areas most affected by hazard
- Event frequency estimates
- Severity
- Warning time likely to be available for response

Determine exposure

Exposure was determined by overlaying hazards with an inventory of potentially vulnerable structures, facilities, and systems to determine which of them would be exposed to each hazard. The City of Shoreline and King County's GIS database contains extensive coverage of infrastructure, including homes, industry, roads, bridges, oil pipelines, hazardous material storage sites, electricity and water mains.

Assess vulnerability

Vulnerability of the exposed structures and infrastructure were then assessed. Vulnerability was determined by interpreting the combination of probability of hazards in the area occurring with the amount and value of the items exposed.

Determine risk

Risk was determined by first describing a most probable case hazard scenario or impact that might affect the city. Using this scenario, the team estimated future expected losses from hazard events. This is summarized for all hazards in the last section of the risk assessment with each hazard being assigned a risk rating.

Data Sources

This information was gathered from a variety of sources. Frequency and severity indicators include past events and the expert opinions of geologists, emergency management specialists and others. To the extent possible, the hazard location was mapped using Arcview 3.2 GIS. The primary data source was the City of Shoreline and King County's GIS database, which is quite extensive, though other sources were also employed. Hazards not mentioned below employed the general data sources described above.

Earthquake

Earthquake maps involving known faults, soil types and liquefaction zones, which together define the areas most susceptible to shaking during a quake, were provided by the Washington State Department of Natural Resources. The team also used HAZUS, a GIS-based loss estimation tool developed by FEMA, extensively to model earthquakes in the region.

Flood

Flood maps primarily involve third-quarter Federal Emergency Management Agency (FEMA) files, which define the FEMA mapped floodplain and floodway.

Hazardous Materials

Much of the data for this section was gathered from the Hazardous Materials Inventory, provided by the Washington State Department of Ecology. Additionally, health and injury information is provided by the Washington State Department of Health.

1.2. Presidential Declared Disasters

Presidential declared disasters are typically an event that causes more damage than state and local governments/resources can handle without the assistance of the federal government. There is generally not a specific dollar loss threshold that must be met. A Presidential Major Disaster Declaration puts into motion long-term federal recovery programs, some of which are matched by state programs, and designed to help disaster victims, businesses and public entities[1]. The disasters highlighted in gray were ones that had a direct effect on Shoreline.

Table 1 - Presidential Declared Disasters in King County

Declaration No.	Type of Disaster	Date of Disaster
185	Flood	December-64
196	Earthquake	May-65
328	Flood	February-72
492	Flood	December-75
545	Flood, Landslide	December-77
612	Flood	December-79
623	Volcano	May-80
757	Flood, Landslide	January-86
784	Flood	November-86
852	Flood, Landslide, Wind	January-90
883	Flood	November-90
896	Flood	December-90

[1]http://www.fema.gov/library/dproc.shtm

Declaration No.	Type of Disaster	Date of Disaster
981	Wind	January-93
1079	Flood	November - December 1995
1100	Flood	January - February 1996
1159	Ice, Wind, Snow, Landslide, Flood	December 1996-February 1997
1172	Flood, Landslide	March-97
1361	Earthquake	February-00

1.3. Critical Facilities, Infrastructure and Functions

Critical and essential facilities and infrastructure are those that are critical to the health and welfare of the population. These become especially important after any hazard event occurs. Critical and essential facilities included for the City of Shoreline are as follows: police and fire stations, schools, emergency operations centers. Critical infrastructure includes the roads and bridges that provide ingress and egress and allow emergency vehicles access to those in need, the utilities that provide water, electricity and communication services to the community. Also included is Tier II facilities and the railroad, which hold or carry significant amounts of hazardous materials with a potential to impact public health and welfare in a hazard event.

This section provides the results of an exposure analysis where each critical facility and infrastructure has been evaluated to determine the hazards are likely to affect it. Figure 17 shows the critical and essential facilities and infrastructure in the City of Shoreline. In general, the City of Shoreline's critical infrastructure is relatively well located and is exposed to few hazards. A listing of facilities by jurisdiction, highlighting those exposed to hazards, follows below.

The following criteria were used to determine exposure:

- Earthquake: In an earthquake, all of the City of Shoreline will experience potentially damaging ground shaking. An earthquake will affect the entire city and has the potential to cause major structural and/or non-structural damage to any non-retrofitted facility and hamper its functionality. However, those facilities located on NEHRP D & E soils and high liquefaction areas are likely to sustain damages.

- Hazardous Material: There are six reported Tier II facilities located in Shoreline as well as the Washington Department of Health Lab. Any of these facilities and/or infrastructure that either contain hazardous materials or are in close proximity to facilities that contain hazardous materials are potentially exposed to hazardous materials spills. However, the area of exposure and severity of impact is dependent on the type of chemical involved and the mode of release, such as air born, spilled into water or spilled onto concrete. Critical facility exposure to hazardous materials would require an extensive and complex process that is beyond the scope of this project. Hazardous material exposure is therefore eliminated from this analysis.

- In addition, areas adjacent to hazardous material transport routes are more likely to experience exposure. The main local routes for hazardous materials transport are Interstate 5, Aurora Avenue and the railroad located along the west shore of the city. All county government facilities are within close proximity of a transport route and should be considered exposed.

- Severe Weather: Since the entire city is susceptible to severe weather, all critical infrastructure is considered exposed to this hazard. Given that electrical utilities and roads are most often affected by severe weather, all critical infrastructure managers and operators should plan for possible power outages and difficult ingress and egress. Some critical infrastructure, such as power lines, are actually more likely to be impacted or damaged as a result of severe weather.

- Landslide/Sinkholes: Critical facilities are considered exposed to landslides if they are on or below historic landslides or potentially unstable slopes.
- Flooding: Any critical infrastructure within the 100-year floodplain is potentially exposed to flooding.
- Fire: Any critical infrastructure near high fuel areas load areas is exposed to risk from wildfires.
- Volcanic Eruption: Though volcanoes are considered in this plan, they are not likely to cause any major damage in Shoreline. However, there is a potential for the city to be affected by ash fall from an eruption at Glacier Peak or Mt. Rainier possibly creating some regional transportation problems. A few utilities and roads might be affected.
- Tsunami/Seiche: Though tsunamis and seiches are considered in this plan, they are not likely to cause any major damage in Shoreline to critical facilities and infrastructure.

Table 2 describes the hazards that will significantly affect critical facilities and infrastructure based on exposure as described above.

Table 2 - Critical Facility and Infrastructure and Hazards

Hazard Event	Critical Facility/Infrastructure
Earthquake	Infrastructure: Seattle Tolt Supply 3.7 & 2.0 MG Reservoir Communication Tower I-5 Bridges: 145th, 155th, 175th, 185th Railroad Track Facilities: North City Elementary School St. Luke School Syre Elementary Ridgecrest Elementary
Hazardous Materials	Infrastructure: Railroad Facilities: 6 Tier II Facilities Department of Health Lab
Severe Weather	All Critical Infrastructure and Facilities
Landslides/Sinkholes	None
Flooding	None
Fire	None

Hazard Event	Critical Facility/Infrastructure
Volcano	None
Tsunami/Seiche	None

1.4. Earthquakes

Definitions

Earthquake: An earthquake is the shaking of the ground caused by an abrupt shift of rock along a fracture in the earth such as a fault or a contact zone between tectonic plates. Earthquakes are measured in both magnitude and intensity.

Magnitude: Magnitude is the measure of the strength of an earthquake, and is typically measured by the Richter scale. As an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

Intensity: Intensity is a measure of the effects of an earthquake. It is measured by the Mercalli scale and is expressed in Roman numerals.

Peak Ground Acceleration: Peak Ground Acceleration (PGA) is a measure of the highest amplitude of ground shaking that accompanies an earthquake, based on a percentage of the force of gravity.

Subduction Zone Earthquake: This type of quake occurs along two converging plates, attached to one another along their interface. When the interfaces between these two plates slips, a sudden, dramatic release of energy results, propagated along the entire fault line.

Crustal Earthquake: Crustal quakes occur at a depth of 5 to 10 miles beneath the earth's surface and are associated with fault movement within a surface plate.

Benioff Earthquake: Sometimes called "deep quakes," these occur in the Pacific Northwest when the Juan de Fuca plate breaks up underneath the continental plate, approximately 30 miles beneath the earth's surface.

Liquefaction: Liquefaction is the complete failure of soils, occurring when soils lose shear strength and flow horizontally. It is most likely to occur in fine saturated fine grain sands and silts, which behave like viscous fluids when liquefaction occurs. This situation is extremely hazardous to development on the soils that liquefy, and generally results in extreme property damage and threats to life and safety.

Background

An earthquake is a naturally induced shaking of the ground. Earthquakes are caused by the fracture and sliding of rock within the Earth's crust. The earth's crust is divided into eight major pieces (or plates) and many minor plates. These plates are constantly moving, very slowly, over the surface of the globe. As these plates move, stresses are built up in areas where the plates come into contact with each other. Within seconds, an earthquake releases stress that has slowly accumulated within the rock, in some instances over hundreds of years. Sometimes the release occurs near the surface, and sometimes it comes from deep within the crust[2].

[2] http://www.metrokc.gov/prepare/hiva/earthquakes.htm

The impact of any earthquake event is largely a function of ground shaking, liquefaction and distance from the source of the quake. Liquefaction results generally in softer, unconsolidated soils. A program called the National Earthquake Hazard Reduction Program (NEHRP) creates maps based on soil characteristics so that locations potentially subject to liquefaction may be identified. Table 3 provides a description of the NEHRP soil classification.

Table 3: NEHRP Soil Classification System

NEHRP Soil Type	Description	Mean Shear Velocity to 30 m (m/s)
A	Hard Rock	1500
B	Firm to Hard Rock	760-1500
C	Dense soil, soft rock	360-760
D	Stiff Soil	180-360
E	Soft clays	<180
F	Special study soils (liquefiable soils, sensitive clays, organic soils, soft clays > 36 m thick)	

The degree of ground shaking (or damage) caused by an earthquake is often assigned a numerical value from Roman numeral I to XII on the Modified Mercalli (MM) Scale. This helps assess and understand the physical affects of the earthquake. Table 4 provides a comparison of peak ground acceleration to the MM intensity scale.[3]

Table 4: Mercalli Scale and Peak Ground Acceleration Comparison

MM Intensity	Peak Ground Acceleration	Description of Intensity Level
I	0.001	Not felt except by a very few under especially favorable circumstances.
II	0.002	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	0.003	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Duration estimated.
IV	0.007	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	0.015	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	0.03	Felt by all; many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.

[3] Cascadia Region Earthquake Workgroup, Professor Anthony Qamar, University of Washington

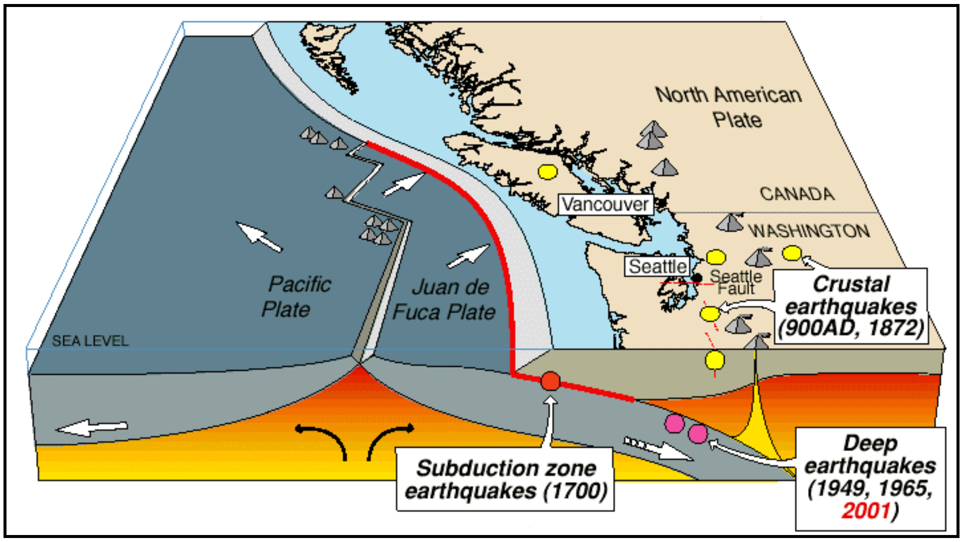
MM Intensity	Peak Ground Acceleration	Description of Intensity Level
VII	0.07	Damage negligible in building of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.
VIII	0.15	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	0.32	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	0.7	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI	-	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII	-	Damage total. Lines of sight and level distorted. Objects thrown into the air.

Earthquake Hazard in Shoreline

Location

In Western Washington, the primary plates of interest are the Juan De Fuca and North American plates. The Juan De Fuca plate moves northeastward with respect to the North American plate at a rate of about 4cm/yr. The boundary where these two plates converge, the Cascadia Subduction Zone, lies approximately 50 miles offshore of the west coastline and extends from the middle of Vancouver Island in British Columbia to northern California. As it collides with the North American plate, the Juan De Fuca plate slides (or subducts) beneath the continent and sinks into the earth's mantle. The collision of the Juan De Fuca and North America plates produces three types of earthquakes. These are subduction zone earthquakes, deep earthquakes and crustal earthquakes. See Figure 1.

Figure 1: Earthquake Types in Western Washington



Subduction Zone

Subduction Zone earthquakes occur along the Cascadia subduction fault, as a direct result of the convergence of these two plates. Although no large earthquakes have occurred along the offshore Cascadia Subduction Zone since historic records began in 1790, similar subduction zones worldwide do produce "great" earthquakes – meaning a magnitude of 8 or larger. A subduction earthquake would be centered off the coast of Washington or Oregon where the plates converge and would typically have a minute or more of strong ground shaking. Usually, these types of earthquakes are immediately followed by damaging tsunamis and numerous large aftershocks.

Benioff (Deep) Zone

As the Juan de Fuca plate subducts beneath North America, it becomes denser than the surrounding mantle rocks and breaks apart under its own weight, causing Benioff zone earthquakes. Beneath Puget Sound the Juan de Fuca plate reaches a depth of 40-60 km and begins to bend even more steeply downward, forming a "knee". It is at this knee where the largest Benioff zone earthquakes occur. Both the 1949 event near Olympia (southwest of Tacoma) and the 1965 event near the Seattle-Tacoma International Airport occurred at the knee.

Crustal Zone

The third source zone is the crust of the North American plate. Of the three source zones, this is the least understood. A variety of lines of evidence lead to the conclusion that the Puget Lowland area is currently shortening north-south at a rate of about 1/2 cm (one-fifth of an inch) per year. Where, and how, this shortening is occurring is not well understood, but at least some of it is occurring on the Seattle fault.

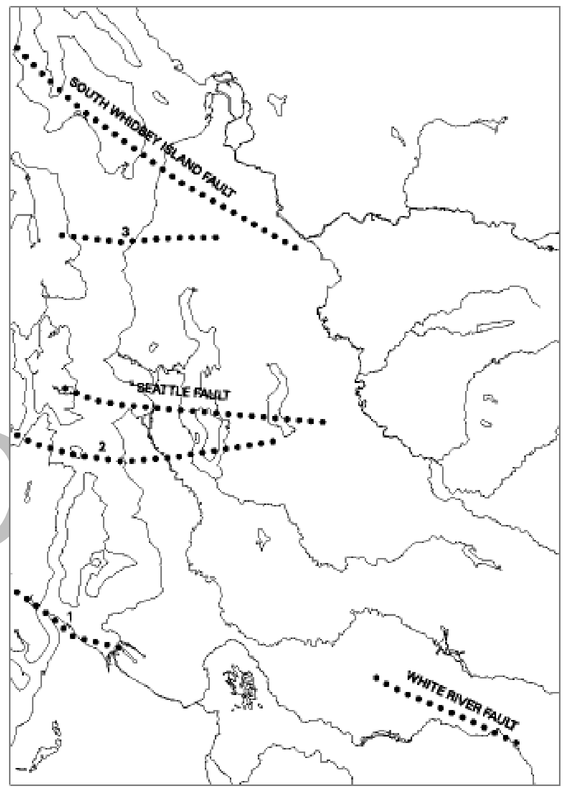
The structure of the crust in the Puget Sound area is complex, with large sedimentary rock-filled basins beneath Tacoma, Seattle and Everett. The Seattle basin is the deepest, at 8-10 km. The Seattle fault forms the south margin of the Seattle basin.

Other active faults may be present in the greater Seattle area, but geologists have only documented young (in the last 14,000 years) motion on the Seattle fault. Currently the Seattle fault zone can be mapped from Dyes Inlet to Lake Washington a distance of approximately 40-kilometers. Slip rates are estimated to be approximately 0.7 to 1.1 millimeters per year (mm/year)[4]. Historical events associated with this fault includes events that occurred at Point Robinson on January 29, 1995[5] with a magnitude 5.0 and at the southwestern end of Bainbridge Island on June 23, 1997 with a magnitude of 4.9[6].

How many other crustal faults pose significant earthquake hazards to the Puget Sound region is not yet known, but geologists and geophysicists are studying the South Whidbey Island fault, the Olympia fault and the Devils Mountain fault for evidence of young earthquakes.

Figure 2 shows the potentially active faults in the Seattle area that could affect Shoreline.

Figure 2: Potentially Active Faults



The NEHRP classification system is used for this earthquake analysis. The majority of the City of Shoreline sits on NEHRP soils C as shown in Figure 18. In the event of an earthquake, NEHRP soils C typically sustain ground shaking well dependent on the magnitude. In Shoreline, the areas that will be most affected by ground shaking are located in NEHRP soils D and E. There are no F soils located with Shoreline.

Frequency

The USGS has created a probabilistic map based on peak ground acceleration that takes into account new information about the Seattle fault zone. The Seattle area, including Shoreline, is in a higher risk area, with a 2% probability of exceedance in a 50-year period of seeing ground

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4 http://geohazards.cr.usgs.gov/pacnw/actflts/sfz.html#intro

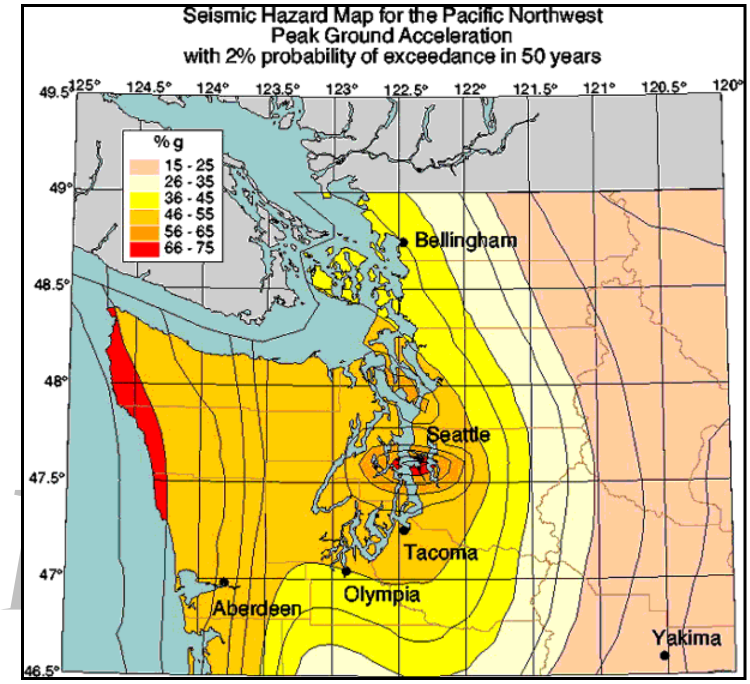
5 Dewberry, S.R., and Crosson, R.S., 1996, The MD5.0 earthquake of January 29, 1995, in the Puget Lowland of western Washington--An event on the Seattle fault?: Bulletin of the Seismological Society of America, v. 86, p. 1167-1172.

6 http://geohazards.cr.usgs.gov/pacnw/actflts/sfz.html#intro

shaking at 70 % of gravity from a Subduction Zone event. Figure 3 displays the expected peak horizontal ground motions for this probability.[7]

Dr. Art Frankel of USGS estimated that a Cascadia Subduction zone earthquake has a 10% to 15% probability of occurrence in 50 years, a crustal zone earthquake, Whidbey and Seattle Faults, has a 2% probability of occurrence in 50 years, and a Benioff zone earthquake has an 85% probability of occurrence in 50 years.

Figure 3: Probabilistic Hazard Map



Severity

The City of Shoreline has the potential to be affected by a subduction, Benioff, or crustal zone earthquake, but historically has been spared the damaging effects of them. A subduction zone earthquake could produce an earthquake with a magnitude as large as an 8.5 in Shoreline. Benioff zone earthquakes as large as magnitude 7.5 are expected everywhere west of the eastern shores of Puget Sound.[8] A crustal zone earthquake could produce a 6.5 magnitude earthquake affecting Shoreline.

Warning Time

There is a large amount of information that is know about possible earthquake locations, however there is no current reliable way to predict what day or month an earthquake will occur at any given location. There is current research that is being done with warning systems that use the low energy waves that precede major earthquakes.[9] These potential warning systems give approximately 40 seconds notice that a major earthquake is about to occur. The warning time is

[7] http://geohazards.cr.usgs.gov/pacnw/hazmap/index.html

[8] http://wrgis.wr.usgs.gov/docs/wgmt/pacnw/lifeline/eqhazards.html

[9] California Institute of Technology, Caltech 336, "System gets the jump on quakes"

very short but it could allow for someone to get under a desk, step away from the hazardous material they are working with or shut down a computer system.

Past Events

The February 28th, 2001 Nisqually Quake with a magnitude of 6.8 is a recent example of a Benioff zone earthquake. The Nisqually earthquake of 2001 caused several damaged chimneys in Shoreline as well as disruption to communication services for approximately 45 minutes.[10]

The last Cascadia Subduction Zone event occurred on January 26th, 1700 and was catastrophic.

Table 5 is a summary of large earthquakes that have occurred in the Puget Sound Region.[11]

Table 5: Large Earthquakes in the Puget Sound Region

Date	Location	Magnitude	Type
1872	North Cascades	7.4	Crustal Zone
1882	Olympic Area	6.0	Benioff Zone
1909	Puget Sound	6.0	Benioff Zone
1915	North Cascades	5.6	--
1918	Vancouver Island	7.0	--
1920	Puget Sound	5.5	--
1932	Central Cascades	5.2	Crustal Zone
1939	Puget Sound	5.8	Benioff Zone
1945	North Bend	5.5	Crustal Zone
1946	Puget Sound	6.3	Benioff Zone
1946	Vancouver Island	7.3	Benioff Zone
1949	Olympia	7.1	Benioff Zone
1965	Puget Sound	6.5	Benioff Zone
1981	Mt. St. Helens	5.5	Crustal Zone
1990	NW Cascades	5.0	Crustal Zone
1995	Robinson Point	5.0	Crustal Zone
1996	Duvall	5.6	--
2001	Nisqually\Puget Sound	6.8	Benioff Zone

Secondary Hazards

Secondary hazards from an earthquake event are numerous. Liquefaction in areas designated by the USGS as high liquefaction is a major concern. Other significant secondary effects of an

[10] Interview, 9.19.03, Tim Dahl, Shoreline Fire
[11] Hazard Identification and Vulnerability Analysis, King County Office of Emergency Management. September 1998

earthquake, such as landslides, wildfires and hazardous materials releases, may also affect Shoreline.

Landslides do not always occur in the first few minutes following an earthquake. It is possible that they can happen days later. There were numerous landslides during and after the 1949 and 1965 earthquakes. Many roads were closed and sections of the railroad track were swept into Puget Sound as a result of these. Steep slopes throughout the greater Seattle area are candidates for earthquake-induced failure. Shoreline is flanked on both the east and west sides by steep slopes increasing chances of susceptibility.

Brush or wildfires can be caused by downed power lines or ruptured gas lines. Shoreline has plentiful open space, which can get very dry during the summer. An earthquake during the summer may cause a fire. In addition there is a power substation located on Meridian Avenue North, which unless properly earthquake secured can cause conflagration.

Hazardous materials can be spilled from ruptured containers. In addition, traffic accidents can occur during ground shaking as well as possible train derailment from buckling tracks or landslides caused by an earthquake.

Vulnerability

Shoreline has a large amount, approximately 82%, of residential and commercial structures that were built prior to 1972, which was when the 1970 Uniform Building Code (UBC) went into effect. This stipulated that all buildings be constructed to at least seismic risk Zone 2 Standards. Buildings in Shoreline built before 1972 can be at risk during earthquakes. These structures can be retrofitted, economically, to withstand expected ground shaking. Houses built after 1972 are in compliance with the 1970 Uniform Building Code resulting in minimizing the damage from seismic risk for these houses. In 1994, seismic risk Zone 3 standards of the UBC went into effect in Western Washington, requiring all new construction to be capable of withstanding the effects of 0.3 times the force of gravity. More recent housing stock, which is mainly infill development, is in compliance with Zone 3 standards. In July of 2004, the state will once again upgrade the building code to follow the International Building Code Standards.

Table 6 shows the number of residential and commercial structures in Shoreline that have been built before and after the 1970 UBC went into affect.

Table 6: Residential & Commercial Building Dates

Type of Structure	Built before 1972	Built during & after 1972	Total	Percentage built before 1972
Single Family	13,122	2,600	15,722	83.5
Multi-Family	58	100	158	36.7
Commercial	497	386	883	56.3
Total	**13,677**	**3,086**	**16,763**	**81.6**

The structures were further separated into categories of structures built on NEHRP D and E soils. A monetary value was assigned based on total taxable land value and taxable improvement value. In addition to these structures, building material was determined. Structures built of un-reinforced masonry are particularly vulnerable to ground shaking. Tables 7, 8 and 9 specify this information.

Table 7: Commercial Structures in Vulnerable Soils

Commercial	NEHRP Soils D	NEHRP Soils E	High Liquefaction
Total # of Structures	118	4	3
# of Structures built before 1972	76	1	1
Total Taxable Land Value of Structures built before 1972	$15,939,900	Value not listed because it is a government property	Value not listed because it is a government property
Total Taxable Improvements Value of Structures built before 1972	$9,817,300	N/A	N/A
Total Taxable Value	$25,757,200	N/A	N/A
Construction Material	31 Masonry, 4 Wood Frame, 5 Prefab Steel	Masonry	Masonry

Table 8: Single-Family Structures in Vulnerable Soils

Single Family	NEHRP Soils D	NEHRP Soils E	High Liquefaction
Total # of Structures	4362	94	106
# of Structures built before 1972	3670	55	64
Total Taxable Land Value of Structures built before 1972	$392,757,946	$14,437,000	$15,994,000
Total Taxable Improvements Value of Structures built before 1972	$544,351,300	$11,099,900	$12,761,900
Total Taxable Value	$937,109,246	$25,536,900	$28,755,900

For single-family structures no data was available on construction material.

Table 9: Multi-Family Structures in Vulnerable Soils

Multi-Family	NEHRP Soils D	NEHRP Soils E	High Liquefaction
Total # of Structures	62	2	2
# of Structures built before	13	1	1

Multi-Family	NEHRP Soils D	NEHRP Soils E	High Liquefaction
1972			
Total Taxable Land Value of Structures built before 1972	$5,452,400	$166,600	$166,600
Total Taxable Improvements Value of Structures built before 1972	$9,716,600	$76,400	$76,400
Total Taxable Value	$15,169,000	$243,000	$243,000
Construction Material	Wood Frame	Wood Frame	Wood Frame

The analysis showed that there are four schools located on D soils. These schools are Syre Elementary, North City Elementary, Ridgecrest Elementary and St. Luke School. The first three schools are public and have all been retrofitted for earthquakes so they are not particularly vulnerable. St. Luke School is a private school and it is undetermined whether or not this building has been seismically upgraded.

There are also two Tier II facilities located on D soils. These are Washington Tree Service Inc and AT&T Wireless Ronald.

Apart from the building stock, there are several other items that may be vulnerable.

CRISTA Ministries has schools, a senior complex, businesses, a radio tower including add-ons for repeater towers and a steam plant; there are approximately 3,000 people during the day both the young and elderly. The water tower located at CRISTA was built in 1972 and has not been retrofitted. The radio tower was built to an earthquake code, but is still a concern since there could be lost communication if there was a problem with the radio tower. Located at CRISTA are concrete high-rise apartments built in 1984 that are located on D soils. Two other buildings of concern is the gym, built in 1962, and another wood structure built in 1935. CRISTA is served by a 4" gas main that is also a concern during an earthquake. CRISTA is an area that could be at risk of isolation during a major earthquake.

In Shoreline, the facility Fircrest currently houses approximately 250 people with developmental disabilities and has approximately 300 to 400 staff during the day[12]. Fircrest is constructed of Type I and II masonry in addition to several wooden structures dating back to the 1940's. The majority of the buildings are not structurally up to current code. During an earthquake this could potentially isolate populations living at this location.

Shoreline Community College has facilities built in the 1960's and 1970's and stores small amounts of hazardous materials. There is a daytime population at the College of approximately 5000-6000 people.

Shoreline has a 400,000-gallon water tank located near NE 180th and 15th Ave NE that has not been seismically retrofitted.

Interstate 5 has five bridges at 145th, 155th, 175th and 185th that do not meet the latest seismic codes. Collapse of these bridges could potentially split the town in half, isolating sections from essential services such as fire and police. The intersection of Meridian and 175th Avenue is built

[12] Interview with Kelly Melton of Fircrest 10.01.03

on pilings with soils that have the potential for liquefaction. This could cause a major problems because it is one of the through routes between the east and west sides of Shoreline. There is also a City owned bridge in Richmond Beach that is located in E soils and does not meet the latest seismic codes. Collapse of this bridge could isolate a small population of residents. There are current plans by the City to upgrade this bridge.

Burlington Northern and Santa Fe (BNSF) Railway Company has railroad tracks that cross through E soils.

The current City Hall Annex building, a converted office building, does not meet seismic codes. This is important because administrative operations are run out of the City Hall and during a disaster event it is important that this is operational.

During an earthquake the power grid can be disrupted. In Shoreline, power is provided by Seattle City Light. A concern is that if the power is lost, the Shoreline Water District currently does not have backup power generators at several pump locations. If power is lost for prolonged periods there will a diminishment and potential loss of domestic water supply. This is a concern because the fire department is dependent on the domestic water supply to fight fires. This could pose a major problem in the event of an earthquake because fire is a secondary hazard to earthquakes and can also cause damage to the power system.

The water system is vulnerable for two main reasons. The first reason is that the water supply may be diminished or potentially lost in cases of prolonged power outages because the Shoreline Water District does not have back up power generators. The second issue is that there is the 60-inch Seattle Tolt pipeline that runs through Shoreline supplying potable water to several reservoirs and communities. Pipeline ruptures during an earthquake can be significant due to possible loss of water to the community and could result in washouts and flooding problems. This pipe can only be shutdown slowly due to the size and the amount of water that travels through it.

Natural gas lines and propane tanks are a vulnerability, especially those located in D and E soils. A high-pressure natural gas line serves Richmond Beach and several properties in this area have propane tanks located on them. This area is a concern because there are D and E soils located in Richmond Beach. Natural gas lines and propane tanks are a concern during an earthquake because if ruptured can cause conflagration.

Scenario

Using HAZUS, a FEMA based earthquake modeling program, a probalistic event showing what the effect of an earthquake was complete for four scenarios. This is explained in the scenario section below. Four earthquake scenarios were tested using HAZUS to predict the possible effects of earthquakes in Shoreline. These are:

- A Cascadia Subduction Zone Event with an 8.5 magnitude
- A 7.0 Benioff Earthquake with a magnitude of 7.0
- A Seattle Fault Earthquake with a magnitude of 6.5
- A South Whidbey Fault Earthquake with a magnitude of 6.5

The effects of each are discussed below.

Cascadia Subduction Zone Earthquake – Magnitude 8.5

A Cascadia Earthquake would produce Peak ground acceleration values ranging from 0.1825 to 0.1925. The lower values are found in the eastern part of the city, with the high values found in the western third of the city (See Figure 4).

Structures

From this event, HAZUS predicts that 45.79% of buildings will experience no damage, with an additional 21.21% experiencing slight damage. Approximately 9.58% will experience extensive damage with an additional 3.61% experiencing complete damage. Residential structures are least vulnerable, with industrial and government buildings being the most.

For low level designed buildings, 71% are predicted to experience moderate to complete damage. 25.74% of moderately designed buildings would experience moderate to complete damage (but less than 1% would experience complete damage).

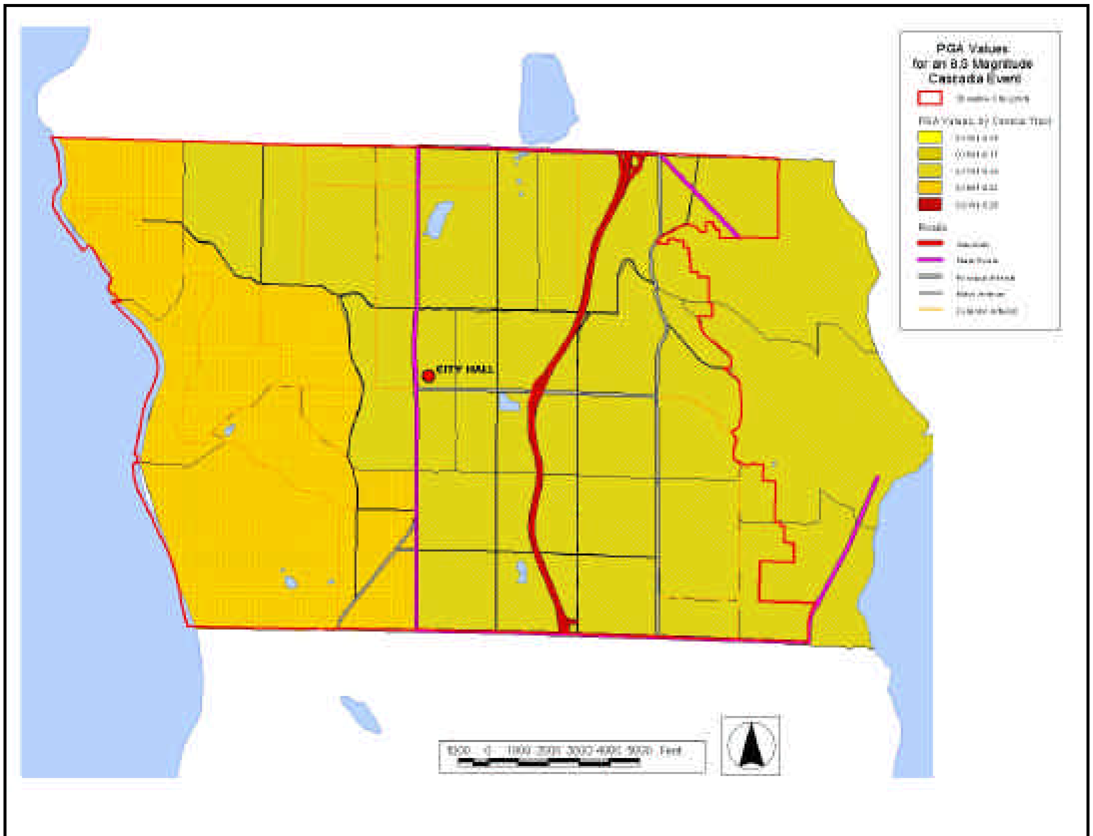
Schools

55% percent of schools would experience at least slight damage in this event, with 4.29% experiencing complete loss. Schools would have 47.17% functionality.

Lifelines

HAZUS shows that 67% of bridges would have no damage, with only 0.03 experiencing complete damage. There is no data available for wastewater facilities and pipelines or potable water facilities and lifelines.

Figure 4: Ground Acceleration from Cascadia Event (in percent gravity)



Benioff Earthquake - Magnitude 7.0

A Benioff Earthquake would create PGA values from 0.1349 to 0.1830. Generally the higher values are found in the southern part of the city, decreasing northward (See Figure 5).

Buildings

HAZUS predicts that 72.35% of buildings would experience no damage. 2.67% would experience extensive or complete damage. Residential buildings are the least vulnerable while industrial buildings are the most.

Approximately 63.43% of low design buildings would experience damage, with 10.89% experiencing extensive or complete damage. 40.30% of moderate design level buildings would experience damage. Of those, 1.43% would experience extensive or complete damage.

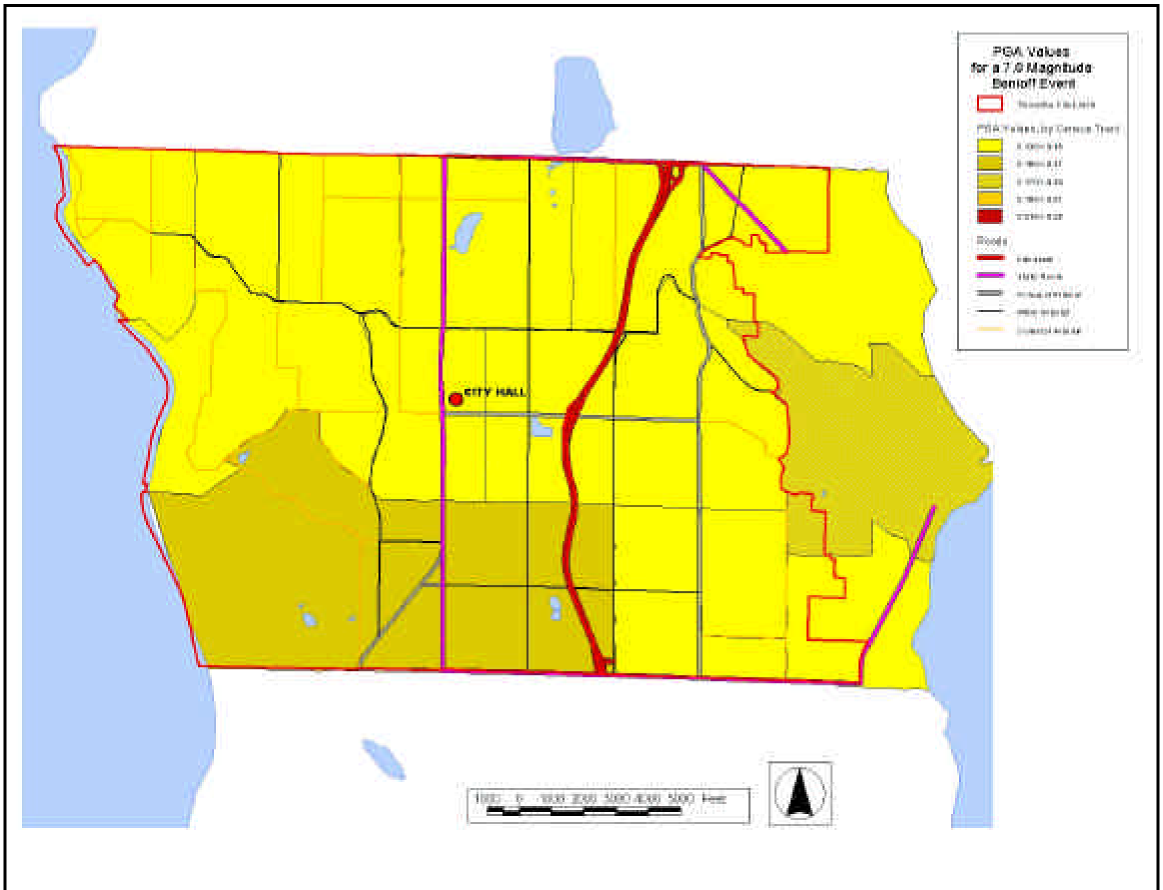
Schools

Approximately 27.79% of buildings would experience damage. There would be a 64.24% functionality of these facilities.

Lifelines

Eight percent of bridges would experience damage, 5% being only slight damage.

Figure 5: Ground Acceleration from Benioff Event (in percent gravity)



Seattle Fault Earthquake - Magnitude 6.5

A Seattle Fault earthquake would create PGA values of between 0.1421 and 0.1903. These are a bit skewed as the model's high area only falls slightly in Shoreline. Generally though the higher values are south and the lower values are north (See Figure 6).

Buildings

Approximately 71.15% of buildings would experience no damage, with an additional 15.24% experiencing slight damage. 2.92% would experience extensive or complete damage. Residential structures are least vulnerable with industrial being most.

Approximately 64.84% of low designed buildings would experience damage. 10.20% would be extensive and 1.43% would be complete. 41.3% of moderately designed buildings would experience damage, with 1.61% experiencing extensive or complete damage.

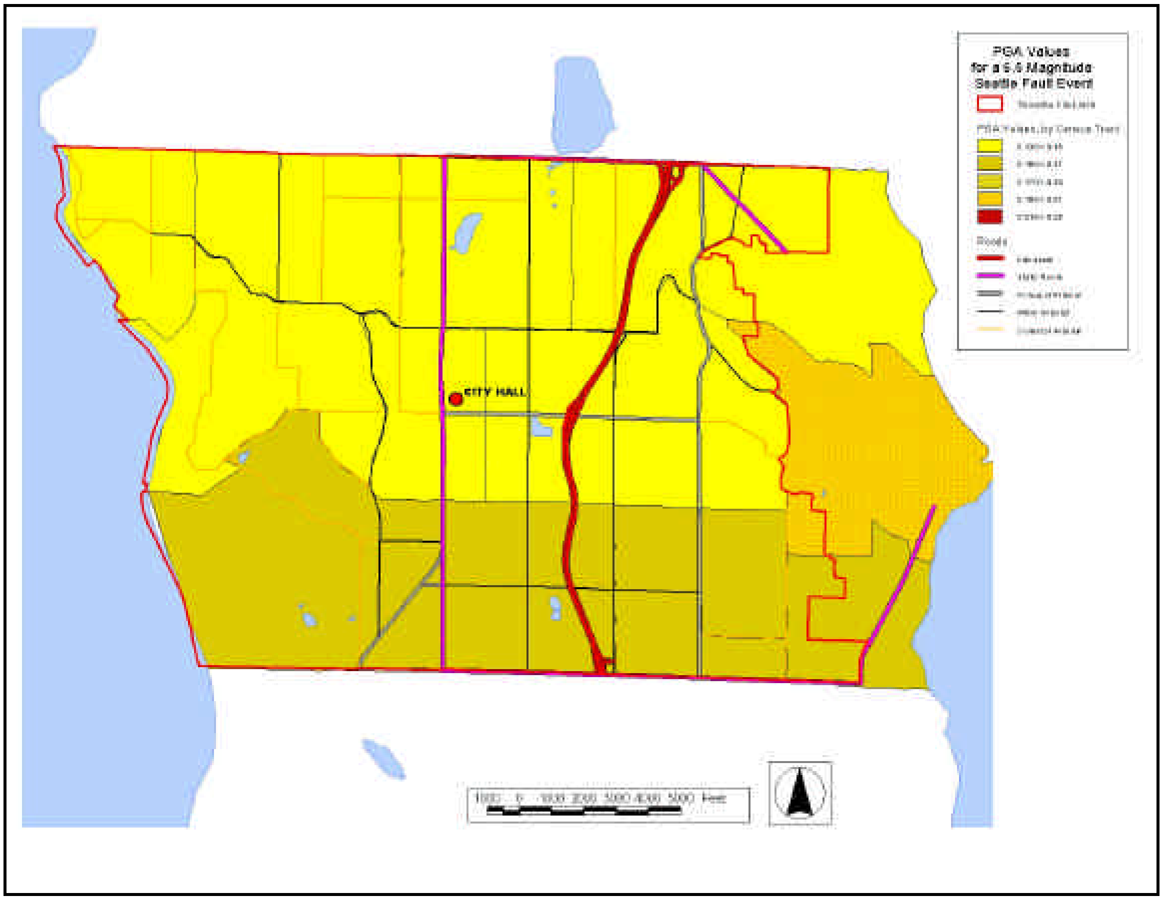
Schools

29% of schools would be damaged, with 3.64 experiencing extensive or complete damage. Schools would have 62.28% functionality.

Lifelines

Nine percent of bridges would be damaged. 3% would have moderate or extensive. There would be no complete damage.

Figure 6: Ground Acceleration from Seattle Event (in percent gravity)



South Whidbey Fault Earthquake – Magnitude 6.5

The PGAs would range from .1706- 0.2449. The highest values would be in the eastern part of the city, with the lowest values in the west (See Figure 7).

Buildings

Approximately 59.65% of buildings would not experience any damage. Another 4.99% would see extensive, and a further 1.01% would experience complete damage. Residential buildings would experience the least amount of damage and industrial buildings would see the most.

Approximately 75.93% of low design buildings would be damaged. Another 16.13% would be extensive, and 3.68% would be complete. 51.20% of moderate designed level buildings would be damaged. 3.17% would have extensive damage and 0.13 would have complete damage.

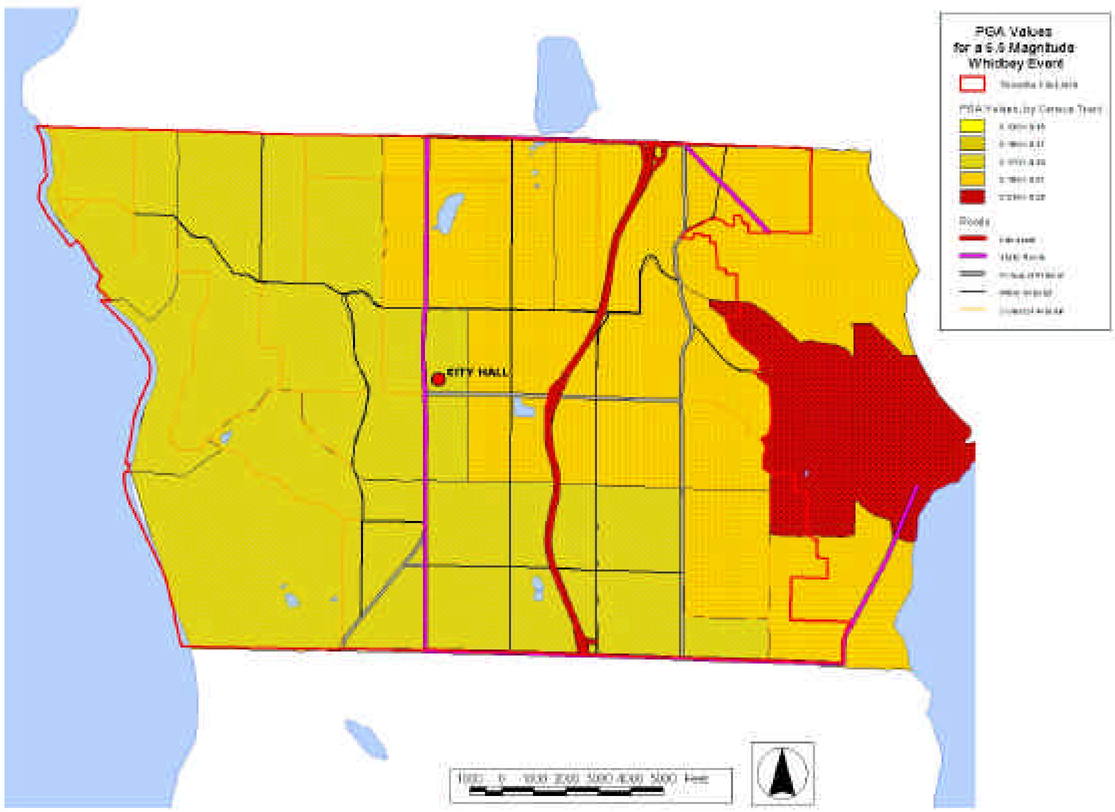
Schools

Approximately 40.57% of schools would be damaged. Another 5.57% would have extensive damage, and 1.21% would have complete damage. Schools would have 46.58% functionality.

Lifelines

Fifteen percent of bridges would be damaged. Another 3% would be extensive or complete damage.

Figure 7: Ground Acceleration from Whidbey Event (in percent gravity)



1.5. Hazardous Materials

Definitions

<u>Tier II Reporter</u>: Under Section 312 of Title III, facilities that store chemicals must provide specific information about the chemicals on site, at any one time, to the State Emergency Response Commission (SERC), Local Emergency Planning Committees (LEPCs), and local fire department. The threshold levels for reporting chemicals stored on site is the threshold planning quantity (TPQ) or 500 pounds at any one time, whichever is less for extremely hazardous substances (EHS); or 10,000 pounds at any one time for hazardous substances.

<u>Hazardous Materials:</u> (sometimes referred to as 'hazmat') have chemical, physical, or biological natures that threaten life, health or property when released. There are several properties or qualities that make a material hazardous, including explosivity, flammability, combustibility, corrosiveness, chemical reactivity, toxicity, and radioactivity. Hazardous materials can also exhibit qualities of a biological agent

<u>Extremely Hazardous Substances</u>: Is a list of substances deemed extremely hazardous under Section 312 of Title III that is the same as the list of substances published in November 1985 by the Administrator in Appendix A of the "Chemical Emergency Preparedness Program Interim Guidance".

Background

Hazardous materials releases occur through spills, leaks, emissions of toxic vapors, or any other process that enables the material to escape its container and enter the environment. Hazardous material incidents that result in a release can cause significant damage to both humans and the environment. The impact of hazardous materials incidents depends on the quantity and physical properties of the chemical. It depends on the type of release that occurred and its proximity to population and businesses.

In 1986, Congress enacted the Emergency Planning and Community Right-to-Know Act (EPCRA) as part of the Superfund Amendments and Reauthorization Act (SARA) as a result of public concern about hazardous material and chemical accidents. This act, known as Title III, establishes requirements for federal, state, and local governments as well as for industry regarding emergency response planning and the public's right to know about hazardous chemicals in their community. The State of Washington has adopted the Federal Title III law and regulations (WAC Chapter 118-40). Title III requires that all facilities or businesses that have reportable quantities of certain chemicals must complete a Tier II Emergency and Hazardous Chemical Inventory report. Each facility does this for each type of Tier II chemical that is present. This must be given to the Local Emergency Planning Committees (LEPC), the local fire department and the Washington Department of Ecology.[13]

Hazardous Materials in Shoreline

Location

A hazardous materials release can occur from two sources: from fixed sites (facilities that hold hazardous materials on site) and from transportation related operations. Because of the small amount of Tier II reporters and the presence of critical transportation infrastructure, Shoreline is more likely to have transportation related hazardous materials release. Besides Tier II reporters and transportation incidents, an area of concern is the Washington Department of Health Lab that is located on the Fircrest campus. The lab has a fairly sizeable number, but in small quantities, of individual chemicals. The lab is not considered a Tier II reporter because of the small quantity of each chemical it stores.

Tier II Reporters

Shoreline has 6 Tier II facilities as of 2003, which are shown in Figure 23. Three of the facilities belonged to AT&T Wireless and reported the presence of sulfuric acid. Other facilities include a Metro Transit Bus Base which contained bus related materials such as diesel fuel and antifreeze; A Seattle City Light substation that has sulfuric acid on site; and the Washington Tree service, which has Ammonium Sulfate onsite. Chevron USA Richmond Beach Asphalt Refinery, as known as Point Wells, located in Snohomish County is also a Tier II reporter that can affect Shoreline. See Table 10 for a complete list of facilities.

Transportation

Three major right-of-ways traverse Shoreline and are used to transport hazardous material. These are the BNSF railroad, which is located along the western shore of the city, State Highway 99/ Aurora Avenue, which runs through the middle of the city, and Interstate 5, which is just east of Aurora Avenue. Although it is not know how much or exactly what is being transported through the area, Shoreline has a similar vulnerability as the rest of King County, which has one of the

[13] Clark County Hazard Mitigation plan, p 45

highest probabilities in the state due to the large amounts of industry and port facilities in the area. Recently there has not been any significant railroad accident in King County; however, Pierce County has recently had a railroad derailment, which spilled boric acid and diesel fuel into Puget Sound.[14]

Frequency

The probability of a hazardous material release in Shoreline is similar to that of King County. Between 1998 and 2001, King County had 27% of all fixed facility spills and 40% of transportation related spills.[15]

Severity

Hazardous material releases can be divided into three categories. These categories are based on the severity of the incident and the emergency response that is warranted by each.[16] A minor incident can be safely cleaned up and managed by one or two people. An isolated incident is one that only affects a single area but has to be handled by more than two people. An unmanageable incident affects large areas and requires immediate response regardless of the quantity involved in the incident.

Hazardous material releases can affect both human and ecological health. The severity depends on the type and amount of chemical released and the effects range from minor to catastrophic.

Warning Time

Hazardous material releases can occur at any time without warning. Once the release has occurred the potentially affected areas will have none or little warning time depending on what chemical was released and the method by which the chemical will travel.

Past Events

The Hazardous Substances Emergency Events Surveillance (HSEES) program, sponsored by the Agency for Toxic Substance and Disease Registry (ATSDR), tracks emergency releases of non-petroleum hazardous substances. Data from 1993 through 2001 was evaluated on events that have occurred in the city of Shoreline and was provided in a report, which found four recorded events in Shoreline during the past nine years.[17]

The first Shoreline HSEES event occurred in 1997 and involved a spill of diazinon with fungicide that was spilled into an open ditch from a spraying truck that had overturned. The driver of the spraying truck experienced minor contusions and was treated at a hospital emergency room and released.

In 1999, a total of three people were treated for respiratory irritation and nausea after they were exposed to a leak of chlorine gas at a swimming pool. Two were taken to an emergency room where they were treated and released. The third person sought treatment from a private doctor. Cause of the leak was unknown.

[14] King County Emergency Management. http://www.metrokc.gov/prepare/hiva/hazmat.htm
[15] Hazardous Substance Emergency Events in Washington State, 1998-2001, Washington State Dept. of Health. http://www.doh.wa.gov/ehp/ts/HSEES/HSEES1998-2001.doc
[16] Hazardous Materials Contingency Plan For Hazardous Materials Spill/Release, University of Toledo http://safety.utoledo.edu/contplan.htm
[17] HSEESP: Hazardous Substance Emergency Events in Shoreline, 1997-2001

In 2000, a valve snapped on a 300-pound cylinder of trifluorobromomethane (Halon 1301) gas, allowing the entire contents to escape to the atmosphere. There were no injuries from this event, which occurred at a governmental facility loading dock.

In 2001 a bus leaked eight gallons of coolant onto a city street. There were no injuries and the spill was cleaned up.

Secondary Hazards

Hazardous material incidents can produce a variety of secondary effects. Fires resulting from hazardous materials releases are the most significant secondary hazard with potential releases caused by earthquakes.

Hazardous material incidents can have a significant effect on the environment. Releases into the environment have the potential to significantly damage soils, water quality, wildlife habitat as well as vegetation. Harm to protected areas and streams, as well as critical habitat for threatened or endangered species is likely. Processes to clean up hazardous material releases are costly and time consuming, resulting in severe environmental and economic impacts. This would most likely occur along the protected shores of Shoreline if a hazardous materials release from a train occurred.

Vulnerability

The most vulnerable buildings and populations are those that are located near the Tier II facilities and near the transportation corridors. The Fircrest campus is vulnerable to a release from the Washington Department of Health Lab. Vulnerable neighborhoods include the Richmond Beach area, which has the access road leading to the Point Wells and the BNSF tracks. The shoreline in this area is also vulnerable. Below in Table 10 is a list of Tier II Reporters for Shoreline as well as the information for Point Wells.

Table 10: Tier Two Reporters

Facility	Address	Chemical	Days Onsite
At&T Wireless Aurora Village	938 N 200th St Ste C Shoreline, Wa 98133-	Sulfuric Acid	365
At&T Wireless Kenwood	14517 15th Ave Ne Shoreline, Wa 98155-	Sulfuric Acid	365
At&T Wireless Ronald	N 167th St & Corliss Intersection N Shoreline, Wa 98133-	Sulfuric Acid	365
Metro Transit North Base	2160 N 163rd St Shoreline, Wa 98133-	Diesel Fuel #2	365
		Ethylene Glycol	365
		Gasoline	365
		Lacquer Thinner	365
		Lube Oil	365
		Transmission Fluid	365
		Waste Antifreeze	365

Facility	Address	Chemical	Days Onsite
		Waste Oil	365
Seattle City Light Shoreline Substation	2136 N 163rd St Shoreline, Wa 98133	Sulfuric Acid	365
Washington Tree Service Inc Seattle	20057 Ballinger Rd Ne Shoreline, Wa 98155	Ammonium Sulfate	365
		Ferrous Sulfate - Heptahydrate	365
		Potassium Chloride	365
		Propane	365
Chevron Usa Richmond Beach Asphalt Refinery	20555 Richmond Beach Dr Nw - Seattle, Wa 98177	Acid Dichromate	365
		Ad-Here	365
		Anti-Foam	365
		Asphalt	365
		Asphalt Emulsifier	365
		Asphalt Extender	365
		Boiler Treatment Chemical	365
		Butanol Ns 198	365
		Calcium Chloride	365
		Cationic Asphalt Emulsion	365
		Cutback Asphalt	365
		Diesel Fuel	365
		Diesel Fuel #2	365
		Elvaloy	365
		Ethylene Glycol	365
		Ferrous Sulfate	365
		Fuel Oil #6	365
		Gas Oil	365
		Gasoline	365
		Gear Compound	365
		Gel Flex Cleaner	365
		Heat Transfer Oil	365
		Hydraulic Oil	365
		Hydrochloric Acid	365
		Hydrogen Sulfide	365
		Indulin W-5	365

Facility	Address	Chemical	Days Onsite
		Lacquer Thinner	365
		Lactol Spirits	365
		Light Cycle Oil	365
		Lubricants	365
		Marine Distillate Oil	365
		Mineral Spirits	365
		Nalclear 7768	365
		Naphtha	365
		Nitrogen	365
		Oil	365
		Oxygen Scavenger	365
		Redicote E-35c	365
		Roofing Asphalt	365
		Silicon	365
		Sodium Chloride	365
		Solvent	365
		Transport Plus 2800	365
		Turbine Oil	365
		Unichem 8162w	365

Scenario

A most likely hazardous materials release would be caused by a traffic accident on Aurora Ave. or on Interstate 5. A fire would erupt sending toxic fumes into the air. Hazardous materials would drain off the road and into nearby Thornton Creek destroying the natural environment. Certain materials could be hazardous to the health of nearby residents, especially those downwind from a release.

Another scenario, which may have more damaging effects, would be from a release caused by a train derailment from an undetected landslide or track malfunction. This would have an effect on those in the Richmond Beach area, especially if a fire occurs. The natural environment would also be jeopardized as the chemicals could drain into Puget Sound, polluting the water and shoreline.

A third scenario is a release from the Tier II facility, train or truck carrying hazardous materials due to an earthquake.

1.6. Severe Weather

Background

Severe weather is one of the most damaging natural hazards. Severe weather can bring heavy rain, high winds, snow and ice and lead to storm surges that flood low lying and coastal areas. Severe weather can lead to secondary effects such as landslides, flooding from streams and poor drainage, and fires, caused by either ruptured gas lines or down electrical lines or even wildfires, caused by lightening and high winds.

King County and the City of Shoreline are subject to various local storms that affect the Pacific Northwest throughout the year, such as wind, snow, ice, hail and potentially tornadoes. Although rare, tornadoes are the most violent weather phenomena known to man. Their funnel shaped clouds rotate at velocities of up to 300 mile per hour and generally affect areas up to a mile wide and seldom more than 16 miles long. Four tornadoes have been sighted in King County since 1950.

Snow storms or blizzards, which are snow storms accompanied by blowing wind or drifting snow, occur occasionally both in Washington State and King County. An ice storm can occur when rain falls out of warm moist upper layer of atmosphere into a dry layer with freezing or sub-freezing air near the ground. Rain freezes on contact with the cold ground and accumulates on exposed surfaces.

Hailstorms occur when freezing water in thunderstorm type clouds accumulate in layers around an icy core. Wind added to hail could batter crops, structures and transportation systems. [18]

The most recent severe storm to affect King County occurred over a multi-day period during the end of December 1996 and beginning of January 1997. This storm shows the potential hazards that can be associated with major storms both primary weather related hazards and secondary hazards including its impacts on infrastructure. This storm, referred to in the media as the Holiday Blast, was a series of three weather systems that included severe snow and ice followed by quick melting and runoff, causing flooding and landslides.

King County and the western part of the Puget Sound region were also heavily impacted by the windstorm that struck on January 20, 1993, Inauguration Day. High winds of 67 at Everett and 60 at Seatac were noted and caused tremendous destruction of public and private structures, power and telephone lines, and trees; South King County was particularly hard hit. Over 280,000 of Puget Power's King County customers were without electricity; damages to Puget Power facilities were estimated around $17 million.

Six other major windstorms have occurred in Western Washington since 1945. The Tacoma Narrows Bridge (1940) and Hood Canal Bridge (1979) were blown down during two of these storms. However, the most severe windstorm to affect this region was the 1962 Columbus Day storm. Sustained winds over 85 mph were recorded; 46 people died and 53,000 homes were damaged throughout the region. [19]

Severe Weather in Shoreline

Location

Severe weather can affect all areas of Shoreline. Strong wind mainly comes from the west and southwest. The wind flows from high to low sea-level pressure through the Chehalis Gap to the south and the Strait of Juan De Fuca to the north.[20] The convergence of these two wind flows is known as the Puget Sound Convergence Zone. Ice will more likely affect those areas at a higher elevation, such as the Highlands.

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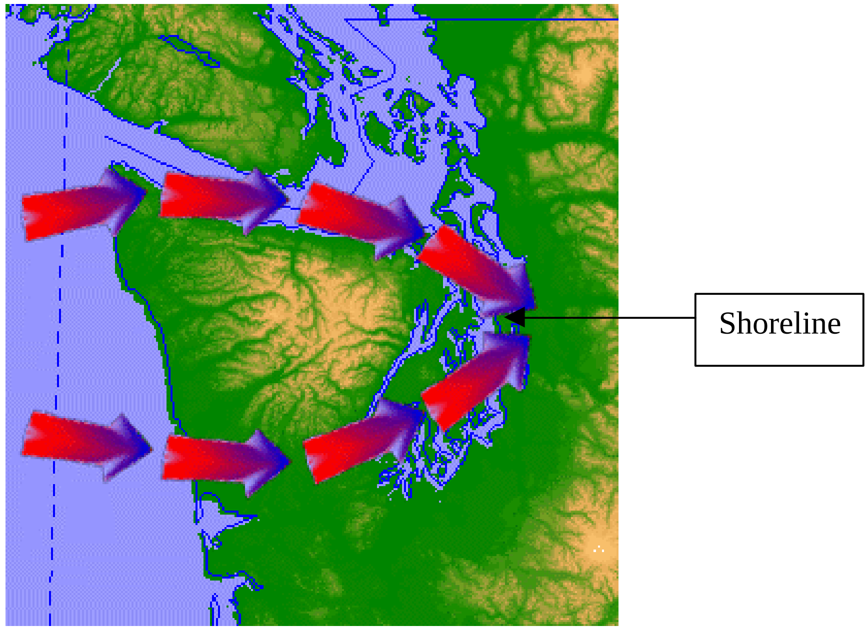
[18] http://www.metrokc.gov/prepare/hiva/storm.htm
[19] http://www.metrokc.gov/prepare/hiva/storm.htm
[20] Nortz, Joseph and Creech, Jay, Puget Sound Wind Speed Data Collection System, http://www.meteorcomm.com/docs/oceans99-wx-paper.PDF

Figure 8: Puget Sound Convergence Zone[21]



Frequency

The National Climatic Data Center has collected information about past severe weather events in King County since 1950. There have been a total of 91 events recorded (minus four avalanches events which is not applicable for Shoreline).[22] The events that caused injury, loss of life or property damage are listed in further detail in Table 11.

Severity

The most common problems associated with severe storms are immobility and loss of utilities. Roads may become impassable due to ice, snow, or from a secondary hazard such as a landslide. Power lines may be downed due to high winds and other services, such as water or phone, may not be able to operate without power. Strong winds have been recorded at 77 kts. in King County. Shoreline had a record-breaking day for rainfall on October 20, 2003. Sea-Tac International Airport reported 5.02 inches of rain in a 24- hour period.[23] This caused flooding problems for several homes as well as the closure of some sections of road. Lightning can cause severe damage and can be deadly. Two major concerns for snowfall are dangerous roadway conditions and collapse of structures due to heavy snow load on roofs. The average annual snowfall for Shoreline is 11.7 inches.[24] In addition, ice can create dangerous situations on the roadways as well as freeze pipes.

Warning Time

A meteorologist can often predict the likelihood of an onset of a severe storm. This can give several days of warning time, however, meteorologists cannot predict the exact time of onset or

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[21] http://www-das.uwyo.edu/~geerts/cwx/notes/chap10/oro_rain.html
[22] http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms
[23] Brice, Pamela, "Flooding in Shoreline, LFP", The Enterprise, October 24, 2003, pg 1 & 14
[24] US National Climatic Data Center Query for Seattle

the severity of the storm. Some storms may come on more quickly and have only a few hours of warning time.

Past Events

Shoreline is affected by the same severe weather than can affect King County and the Puget Sound region in general. Table 11 is a list of severe storms that affected King County that caused injury, loss of life or property damage between 01/01/1950 and 06/30/2003.[25] The total reported damage was $98.347 million with 17 deaths and 65 injuries.

During the 1993 Inauguration Day Wind Storm, Ronald Wastewater District was without power for several hours at all the pump stations.[26]

The 1996-97 Holiday Blast Storm particularly affected Shoreline and the heavy rainfall from it caused a large washout/landslide within Shoreline along 175th Street near 6th Ave that was a federally declared disaster. The 100-foot long sinkhole cost 2 million dollars to repair.[27]

Table 11: Severe Storms affecting King County

Date	Type	Magnitude	Deaths	Injuries	Property Damage
09/28/1962	Tornado	F1	0	0	250K
12/12/1969	Tornado	F3	0	1	250K
12/22/1971	Tornado	F	0	0	25K
4/25/1993	Heavy Rain	N/A	0	14	100K
08/23/1993	Lightning	N/A	1	0	0
11/08/1995	Flood & Heavy Rain	N/A	1	0	0
11/28/1995	Flood & Heavy Rain	N/A	0	0	10.0M
10/15/1996	Lightning	N/A	0	0	95K
11/19/1996	Heavy Snow	N/A	1	22	0
11/30/1996	Lightning	N/A	0	1	0
12/10/1996	Lightning	N/A	0	0	4K
12/28/1996	Heavy Snow	N/A	1	0	0
12/28/1996	Heavy Snow	N/A	1	0	0
12/29/1996	Heavy Rain	N/A	0	0	31.5M
01/01/1997	Flood	N/A	1	0	20.0M
03/20/1997	Flood	N/A	0	0	1.2M
03/30/1997	High Wind	71 kts	2	4	250K
04/03/1997	Lightning	N/A	0	1	0
07/05/1997	Lightning	N/A	0	2	0
10/01/1997	High Wind	45 kts	1	0	0
10/04/1997	Lightning	N/A	0	0	5K
11/23/1998	High Wind	66 kts	0	0	6.5M
01/28/1999	High Wind	65 kts	0	0	500K
02/05/1999	High Wind	65 kts	0	0	11K
03/01/1999	Heavy Rain	N/A	0	0	5.5M

[25] http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms
[26] Ronald Wastewater District Hazard Mitigation Plan, October 2003
[27] http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Date	Type	Magnitude	Deaths	Injuries	Property Damage
03/02/1999	High Wind	61 kts	1	0	3.0M
07/16/1999	Lightning	N/A	0	0	130K
08/03/1999	Lightning	N/A	0	2	650K
10/27/1999	High Wind	48 kts	1	0	100K
11/11/1999	Flood	N/A	0	0	60K
11/17/1999	Heavy Rain	N/A	0	0	85K
01/10/2000	High Wind	64 kts	1	0	12K
01/14/2000	Heavy Rain	N/A	0	15	0
01/16/2000	High Wind	66 kts	1	0	2.8M
02/08/2000	Dry Microburst	0 kts	0	0	25K
12/14/2000	High Wind	77 kts	0	0	2.1M
02/15/2001	Heavy Snow	N/A	0	0	5K
02/28/2001	Mud Slide	N/A	0	0	200K
02/14/2001	Flood	N/A	0	0	40K
11/24/2001	High Wind	61 kts	1	1	20K
12/13/2001	High Wind	60 kts	0	0	800K
12/16/2001	Flood	N/A	0	0	150K
01/07/2002	Flood	N/A	0	0	200K
04/13/2002	High Wind	55 kts	0	0	8.0M
05/29/2002	Blizzard	N/A	3	1	0
12/19/2002	High Wind	56 kts	0	0	380K
12/27/2002	High Wind	52 kts	0	1	3.3M
03/31/2003	Flood	N/A	0	0	100K
TOTAL			**17**	**65**	**98.347M**

Secondary Hazards

The most significant secondary hazards to severe local storms are floods, landslides and electrical hazards (fires) from downed power lines. Rapidly melting snow combined with heavy rain can overwhelm both natural and man-made drainage systems, causing overflow and property destruction. Landslides occur when the soil on slopes becomes oversaturated and fails.

Vulnerabilities

All of Shoreline is vulnerable to severe storms. The Richmond Beach neighborhood is more vulnerable because of its location and limited ingress and egress points creating a possibility of isolation for residents during a severe weather event. It lies near sea level below the bluffs of the city and may be isolated during a snow or ice storm. It can also be affected by a strong storm surge. Properties located along 27th Ave NW would be most affected by a storm surge. The Highlands neighborhood is also vulnerable to isolation due to the topography and limited access points. Power systems may experience downed lines cutting power to residents. Power is lost due to severe storms about four times a year for approximately four to six hours.[28] Trees that are overgrown or have been blown down can create problems for the overhead power lines. The Public Works Department has done a survey and estimates that there are approximately 35,000 trees in Shoreline right of ways.

[28] Shoreline Water District Hazard Mitigation Plan, Draft October 2003

Power outages could result in a disruption to the water systems. Sanitation and water systems could experience contamination or overflow problems.

Scenario

Shoreline would most likely be affected by a combination windstorm/snow storm. The heavy wind would knock out power, disrupting some services, such as water pump stations. Downed trees may make some roads inaccessible. Some Richmond Beach residents and residents on other streets would be isolated because the snow and ice makes the steep roads leading down to them impassable. The vast amounts of water draining would overwhelm the sewer system, causing flooding and possible washouts/sinkholes. Land on some of the steeper slopes may give way and also damage homes and block roads.

1.7. Landslides & Sinkholes

Definitions

Landslide: Landslides can be described as the sliding movement of masses of loosened rock and soil down a hillside or slope. Fundamentally, slope failures occur when the strength of the soils forming the slope exceeds the pressure, such as weight or saturation, acting upon them.

Rotational-Translational slides: type of landslide characterized by the deep failure of slopes, resulting in the flow of large amounts of soil and rock. In general, they occur in cohesive slides masses and are usually saturated clayey soils.

Rock falls: A type of landslide that typically occurs on rock slopes greater than 40% near ridge crests, artificially cut slopes and slopes undercut by active erosion.

Earthflows: Earthflows are slow to rapid down slope movements of saturated clay-rich soils. This type of landslide typically occurs on gentle to moderate slopes but can occur on steeper slopes especially after vegetation removal.

Debris Slides: Debris slides consist of unconsolidated rock or soil that have moved rapidly down slope. They occur on slopes greater than 65%.

Sinkhole: a collapse depression in the ground with no visible outlet. Its drainage is subterranean, its size typically measured in meters or tens of meters, and it is commonly vertical-sided or funnel-shaped.

Background

The term landslide refers to the down slope movement of masses of rock and soil. Landslides are caused by one or a combination of the following factors: change in slope gradient, increasing the load the land must bear, shocks and vibrations, change in water content, ground water movement, frost action, weathering of rocks, and removal or changing the type of vegetation covering slopes.

"By geologic standards, Seattle’s landscape is very, very young. Just 14,000 years ago, the land the city sits on was still under 3,000 feet of ice, part of the Ice Age’s titanic Vashon Glacier, which extended from Canada to south of Olympia. When the ice melted, sea level rose 300 feet and filled the trough the ice had carved, creating Puget Sound. The region is still witnessing the erosion and settling that has followed that tumultuous episode.”[29]

[29] Dietrich, Bill, “The Ground We Walk On”, Seattle Times, January 14, 1997, p A6.

The soil covering much of King County was left behind by the Vashon Glacier and is prone to slides. The top layer, Vashon till, is a stable mix of rocks, dirt, clay and sand that has the consistency of concrete and can be found to depths up to 30 feet. The next layer, Esperance sand, is a permeable mixture of sand and gravel. This sits upon an impermeable layer of clay, Lawton clay, made up of fine sediments and large boulders. It is this boundary between the clay and sand in which sliding occurs; water percolates through the sand and runs laterally on top of the denser clay. "The build up of water pressure floats the sand above the clay creating lubrication for a deep-seated slide."[30]

Landslide hazard areas occur where the land has certain characteristics, which contribute to the risk of the downhill movement of material. These characteristics include:

- A slope greater than 15 percent.
- Landslide activity or movement occurred 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, which indicates 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. [31]

Landslide Hazard in Shoreline

Location

Four types of Landslides can potentially affect Shoreline. They are deep-seated, shallow, bench and large slides. The diagrams below show these different kinds of slides.[32] Puget Sound's shoreline contains many large, deep-seated dormant landslides. Shallow slides are the most common type and the most probable for Shoreline. Occasionally large catastrophic slides occur on Puget Sound. Figure 24 is a map of the landslide hazard areas for Shoreline.

[30] Carter, Don and Scott Maier, "Slide-Wise, Danger Remains Real as Soggy Slopes are Still Unstable", Seattle Times, January 17, 1997 p A8.
[31] http://www.metrokc.gov/prepare/hiva/landslide.htm
[32] http://www.ecy.wa.gov/programs/sea/landslides/about/about.html

Figure 9: Deep seated slide

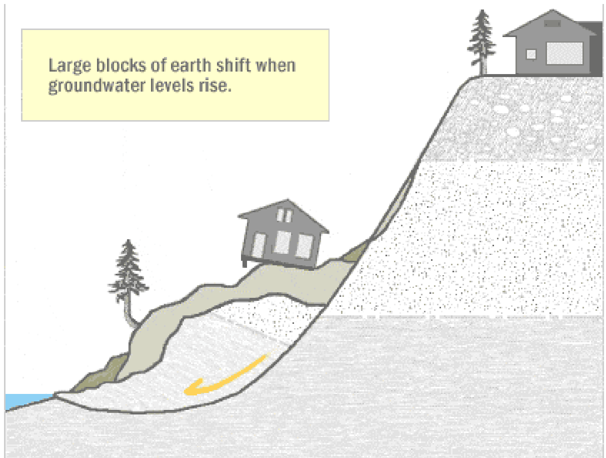


Figure 10: Shallow slide

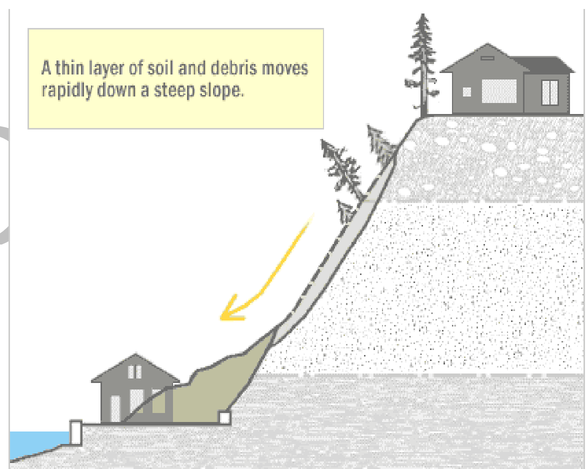


Figure 11: Bench slide

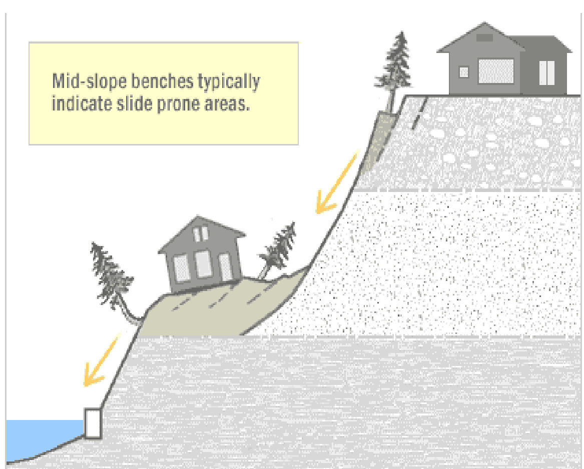
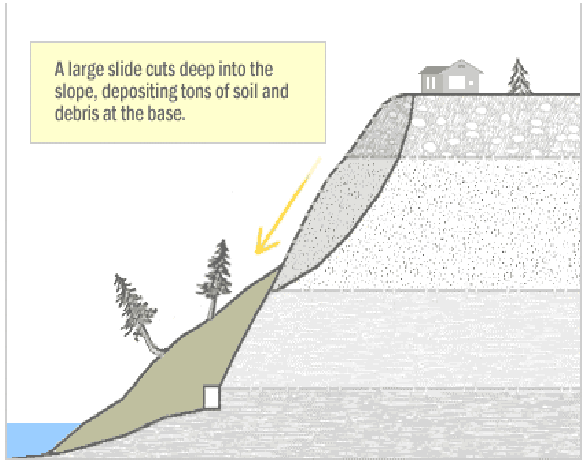


Figure 12: Large slides



Frequency

Landslides are often triggered by other natural hazards such as earthquakes, heavy rain, floods or wildfires. The frequency of a landslide is related to the frequency of earthquakes, heavy rain, floods, and wildfires. In the past, Shoreline has experienced two landslides which are described in further detail in the past events section. King County experienced over 100 landslides during December 1996 and January 1997 and also experienced numerous landslides in 1972 that totaled $1.8 million in damages.[33]

Severity

Landslides destroy property, infrastructure, transportation systems, 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. [34]

Warning Time

Landslides can occur either very suddenly or slowly. There is no way to predict when or where a specific landslide will occur, but it is possible to determine what areas are at risk during general time periods. Assessing the geology, vegetation, and amount of predicted precipitation for a given area can help in these predictions.

Past Events

A large slide occurred in the town of Woodway, just north of the Richmond Beach neighborhood during the early morning of January 15th, 1997. It cut fifty feet into the property above, passed over the railroad tracks and knocked a freight train into the Sound.[35]

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[33] http://www.metrokc.gov/prepare/hiva/landslide.htm
[34] http://www.metrokc.gov/prepare/hiva/landslide.htm
[35] http://www.ecy.wa.gov/programs/sea/landslides/show/woodway.html

Figure 13: Woodway slide: 1997

The Holiday Blast Storm of December and January 1996-97 was the cause of this massive landslide. The storm also caused a large washout/landslide within Shoreline along 175th Street near 6th Ave that was a federally declared disaster. The 100 foot long sinkhole cost 2 million dollars to repair.[36]

In the late 1990's a landslide near Perkin's Way and 23rd Avenue NE damaged Shoreline Water District's water main and cost the District $23,142.[37]

Secondary Hazards

Landslides can typically cause several different types of secondary effects. Landslides can block egress and ingress on roads. This has the potential to cause isolation for affected residents and businesses. Roadway blockages caused by landslides can also create traffic problems resulting in delays for commercial, public and private transportation. This could result in economic losses for businesses. A landslide could also block the BNSF Railroad and this could result in a release of hazardous materials or fire.

Other potential problems resulting from landslides are power and communication failures. Vegetation on slopes or slopes supporting poles can be knocked over resulting in possible losses to power and communication lines. This, in turn, creates communication and power isolation. Landslides have the potential of destabilizing the foundation of structures that may result in monetary loss for residents.

It is possible for landslides to affect environmental processes. Landslides can damage rivers or streams, potentially harming water quality, fisheries and spawning habitat.

Vulnerability

Analysis showed that there were 657 parcels that contained structures located in the Landslide Hazard Area. The total taxable land value for these parcels is $159,585,700; the total taxable improvements value is $243,109,700, with a total taxable value of $402,695,400. The land use of these parcels in landslide hazard areas is broken down in Table 12.

[36] http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms
[37] Shoreline Water District Hazard Mitigation Plan, Draft October 2003

Table 12: Land Use of Parcels in Slide Hazard Areas

Land Use	Total
Apartment	4
Condominium (Residential)	4
Duplex	4
Golf Course	1
Park, Public (Zoo/Arbor)	1
Single Family (Res Use/Zone)	635
Tavern/Lounge	1
Vacant (Single-family)	7
Grand Total	**657**

Besides structures located on landslide areas, lifelines and infrastructure can be affected. Many roads cross through the landslide areas. These are listed in Table 13.

Table 13: Roads in Slide Hazard Areas

Street Name	Length in Slide Hazard Area (ft)	Street Name	Length in Slide Hazard Area (ft)
1ST AV NW	464	NW 175TH ST	3342
2ND AV NW	601	NW 176TH ST	660
3RD AV NW	1133	NW 177TH ST	514
6TH AV NW	782	NW 178TH PL	1003
9TH AV NW	193	NE 179TH ST	801
9TH PL NW	412	NE 180TH ST	275
10TH AV NW	2723	NE 182ND PI	198
12TH AV NW	1721	NE 185TH ST	180
13TH AV NW	2648	NW 185TH ST	262
14TH AV NW	4609	NW 186TH ST	438
15TH AV NE	1309	NW 188TH ST	197
15TH AV NW	3004	NW 190TH PL	443
16TH AV NE	556	NW 190TH ST	317
16TH AV NW	1730	NW 191ST PL	538
17TH AV NW	321	NW 192ND PL	825
17TH PL NW	763	NW 193RD PL	555
20TH AVE NW	1687	NW 193RD ST	317
22ND AVE NE	426	NW 198TH ST	402
22ND AVE NW	1298	NW 199TH ST	396
23RD AVE NW	707	NW 201ST ST	340
23RD CT NE	305	NW 202ND PL	210
23RD LN NE	1054	NW 204TH ST	350
24TH AVE NE	2335	BEACH DR	2714
25TH AVE NE	1286	BOUNDARY LN	320
25TH AVE NW	317	CARLYLE HALL RD N	508
NW 163RD ST	473	CARLYLE HALL RD NW	865
NW 165TH PL	756	GREENWOOD PL N	1098
NW 165TH ST	464	MADRONA DR	1561
NW 166TH ST	624	MADRONA LN	592
NW 167TH ST	1820	NW CHERRY LOOP DR	3807

Street Name	Length in Slide Hazard Area (ft)	Street Name	Length in Slide Hazard Area (ft)
NE 168TH ST	343	NW INNIS ARDEN WY	3126
NW 170TH ST	196	NW SPRINGDALE PL	537
NW 171ST ST	394	OLYMPIC DR	3802
N 171ST ST	1162	PALATINE AV N	1405
NW 172ND ST	618	RICHMOND BEACH DR NW	2161
N 172ND PL	245	SCENIC DR	1483
N 172ND ST	312	SPRINGDALE CT NW	795
NW 175ND CT	216	SPRING DR	1310
NW 175TH PL	290	**Grand Total**	**78944**

25th Ave NE is showing some cracks and signs of moving toward the east into Lake Forest Park.

It is also important to note that the BNSF railroad tracks cross through the landslide hazard area. Not only can a landslide disrupt service, it can cause train derailments, which can potentially lead to a secondary hazard of a hazardous materials release and fire. BNSF has had problems with slides for many years. They have installed landslide alarms that go between milepost 8 and milepost 32. The alarms consist of two strand wire fences that when triggered turn all the lights red on that section of track and this tells the trains to stop. Someone then checks to see what triggered the alarm and whether it is safe to proceed. This helps to prevent train derailments when a landslide occurs.

Scenario

A landslide may occur during or more likely a few days or weeks after a severe storm that saturates the ground. A shallow slide would occur that would damage some homes and some underground infrastructure. Some roads may be blocked.

A worse case scenario would be a large slide similar to the Woodway slide where a large mass of land slides along the developed bluffs of Shoreline, destroying homes and the railroad tracks. If it happens unexpectedly it also causes the derailment of a train carrying hazardous materials, which then are release into Puget Sound and polluting the shore.

1.8. Flooding

Definitions

<u>Base Flood Elevation:</u> The base flood elevation is the elevation of a 100-year flood event, or a flood, which has a 1% chance of occurring in any given year.

<u>Floodplain:</u> Floodplains are generally defined as the lands adjacent to major rivers or streams that have a 1% chance of being flooded in any given year. FEMA has mapped these areas throughout the country, and most communities in the United States regulate development within them.

<u>Floodway:</u> Floodways are areas within a floodplain that are reserved for the purpose of conveying flood discharge without increasing the base flood elevation more that one-foot. Generally speaking, no development is allowed in floodways, as any structures located there would block the flow of floodwaters.

Floodway Fringe: Floodway fringe areas are those lands that are in the floodplain but outside of the floodway. Some development is generally allowed in these areas with a variety of restrictions.

FEMA contracted the Army Corps of engineers to map the floodplains, floodways, and floodway fringes. Figure 14 depicts the relationship among the three designations.

Figure 14: Floodway Schematic

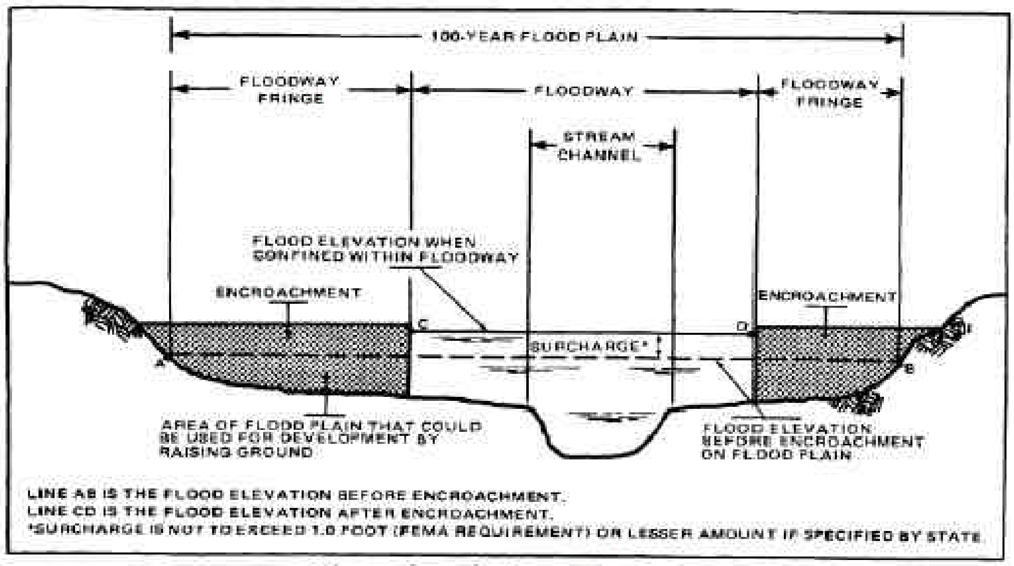


Figure 2. Floodway Schematic

Zero-Rise Floodway: A 'zero-rise' floodway is an area reserved to carry the discharge of a flood without raising the base flood elevation. Some communities have chosen to implement zero-rise floodways because they provide greater flood protection than the floodway described above, which allows a one foot rise in the base flood elevation.

Flood Insurance Rate Map (FIRM): FIRMs are the official maps on which the Flood Insurance Administration has delineated areas of flood risk and risk premium zones.

Low Impact Development: Low Impact Development[38] is a comprehensive land planning and engineering design approach with a goal of maintaining and enhancing the pre-development hydrologic regime of urban and developing watersheds. This design approach incorporates strategic planning with micro-management techniques to achieve environmental protection while allowing for development or infrastructure rehabilitation to occur.

Background

A flood is the inundation of normally dry land resulting from the rising and overflowing of a body of water. It is a natural geologic process that shapes the landscape, provides habitat and creates rich agricultural lands. Human activities and settlements tend to use floodplains, frequently interfering with the natural processes and suffering inconvenience or catastrophe as a result. Human activities encroach upon floodplains, affecting the distribution and timing of drainage, and thereby increasing flood problems. The built environment creates localized flooding problems outside natural floodplains by altering or confining drainage channels. This

[38] Definition from: The Low Impact Development Center, June 2003

increases flood potential in two ways: 1) it reduces the stream's capacity to contain flows; and 2) increases flow rates downstream.

There are basically three types of floods: 1) a rising flood which occurs because of heavy prolonged rain, melting snow or both (this type of flood can impact on both rural, suburban and urban areas in King County); 2) flash floods which are characterized by quick rise and fall of flood levels; and 3) wind-driven flood tides that combine wind and tides to flood coastal areas. [39]

Flooding in Shoreline

Location

Due to its geographical location, Shoreline does not have any of the major rivers in the region that are subject to severe flooding pass through it. Shoreline is drained by one minor stream on the west, Boeing Creek, which flows through the steep bluffs and into Puget Sound and two other minor streams, McAleer Creek and Thornton Creek, which flow in Lake Washington. Boeing Creek and McAleer Creek flow through steep ravines and do not pose much of a hazard to the development above them. Thornton Creek flows through a swampy area parallel to I-5 on the west that has drainage issues and is subject to flooding. The Richmond Beach area is also subject to coastal flooding.

Frequency

Structures located on properties within the FEMA 100 year floodplain have a 1% chance in any given year to experience flooding.

Severity

The City of Shoreline has the temperate climate typical of western Washington. Summers are dry with mild temperatures, and winters are rainy with occasional snow. Average annual rainfall is 38.27 inches and average annual snowfall is 11.7 inches.[40] Flooding in Shoreline has mainly resulted from not enough capacity in the water system during heavy rains. This has led to flooding in roadways and several homes being flooded. The extent of the damage to the homes is undetermined at this time.

Warning Time

Flooding in Shoreline is related to heavy rains causing urban flooding so there is usually several hours of warning time. The number of hours of warning time is usually between 2 and 24 hours but depends on the extent of the flooding.

Past Events

Most of the past flooding problems are related more to poor drainage and presence of impervious soils than to development in delineated floodplains. Specifically the 3rd Avenue NW area of Richmond Beach has had flooding problems for over 20 years and the area near Ronald Bog tends to flood every year[41]. On October 20, 2003 rainfall hit an all time record high in the Shoreline area. Several homes were flooded near 3rd Avenue NW and 185th Street, a property

[39] http://www.metrokc.gov/prepare/hiva/flood.htm
[40] US National Climatic Data Center Query for Seattle

[41] http://cityofshoreline.com/cityhall/projects/bog/index.cfm

was flooded between 10th and 11th Avenue NE at 175th, and 25th Avenue NE near Ballinger Way was closed due to flooding.[42]

See Figure 15 for a picture of flooding near Ronald Bog.

Figure 15: Flooding near Ronald Bog

Vulnerabilities

There are three types of property and infrastructure that are vulnerable to flooding:

Properties along the coast may experience coastal flooding during a strong storm surge. Most vulnerable are the properties along 27th Ave NW and the BNSF railroad tracks.

Analysis shows that there is one FEMA designated floodplain in Shoreline, along Boeing Creek. This designated floodplain is not accurate since the 18 structures located within it have never been flooded and are built upon the bluff of Boeing Creek.

Properties that flood due to poor drainage are also vulnerable. This includes the approximately 20 properties along 3rd Ave NW that flood during or after storms due to poor drainage. The Ronald Bog area (175th St between Meridian Ave and 5th Ave NE) also has approximately 20 homes that flood constantly due to poor drainage.

Scenario

A severe storm with heavy precipitation during a generally wet cold winter that leaves the ground frozen and impervious would be a worse case scenario for flooding in Shoreline. The drainage system would go over capacity, spilling into streets, basements and low-lying areas. Damage would include flooded basements and damaged underground utilities especially in those locations of the Ronald Bog Area.

[42] Brice, Pamela, "Flooding in Shoreline, LFP", The Enterprise, October 24, 2003, pg 1 & 14

1.9. Wildland and Urban Fire

Definitions

Wildland fires: This term refers to any uncontrolled burning of grasslands, brush or woodland areas.

Intermix Area: An area susceptible to wildland or forest fires because wildland vegetation and urban or suburban development occur together. [i]

Background

Triggers that can cause fire are natural, such as lightning, as well as human induced. Humans can directly cause fires with careless campfires, sparks from ATVs, or inappropriate disposal of lit cigarettes. Downed electric lines during windstorms can also cause fires.

Fires are influenced by the amount and condition of fuel present, slopes, wind and temperature. Fires advance through the transmission of heat in the form of conduction, convection and radiation. During the day, fires generally travel uphill. Convection currents and radiation ahead of the fire preheat the fuels and air upslope, allowing the fire to expand rapidly. Radiation has an extreme impact when the fire enters a "chimney," or a v-shaped area on a slope, such as a drainage gully. Additionally, south and west facing slopes tend to be warmest and driest. The situation of heavy dry fuels, on a southwest facing slope with chimneys on a hot day will allow for near explosive expansion of the fire. Wind can strengthen and spread a fire, though large fires can generate their own wind. The heat rising from a large fire will create a thermal column that can rise hundreds or thousands of vertical feet. These vertical columns carry burning embers that are often picked up by prevailing winds and spread. At night, the fire will slow and travel downhill following the cooling airflow.

Fire experts attribute the generally worsening fire risk to increases in the presence of dry, hazardous fuel. Wildfires are most likely to occur between mid-May and October but can occur at any time during the year. Any particularly dry period can increase vulnerability. The probability of a fire in any one locality on any particular day depends on fuel conditions, topography, the time of year, the past and present weather conditions, and the activities (debris burning, land clearing, camping, etc.) that take place in the vicinity. Fires in general can range from isolated burns affecting a few acres or less to severe events. These large fires usually occur when groups of smaller fires merge.

With the presence of such conditions, lighting on dry fuels, recreational uses, interface development or terrorist acts can all trigger fires. The type of ignition (man-made or natural) should be discounted in evaluating the risk. If the conditions are right in a forest for a major fire, any source of ignition (whether natural or human caused) will bring about the same end results.

Fire in Shoreline

Location

Shoreline is an urbanized city but is susceptible to wildland fires that can destroy property and infrastructure. This analysis differs from most wildfire analyses in that Shoreline does not lie in an urban interface/intermix area, and does not have a specified wildfire hazard zone. Nonetheless it is a pertinent risk. The City of Shoreline is susceptible to fires as a result of the numerous steep slopes located throughout. Innis Arden, the Highlands, and Boeing Creek Canyon all have vegetated areas located on slopes. These tend to be heavily vegetated and typically dry out during the summer. Shoreline also has a utility corridor parallel to Aurora Ave, which used to be the Interurban right of way (and is currently being converted to a bike path) that is not maintained and contains grassy/brush areas. In addition, the brush along I-5 can also potentially catch fire. Richmond Beach Park, which faces south, is vulnerable to wildfires. Shoreline also has other pocket areas located on steep slopes or have high fuel loads that have not been specifically identified as of yet but can potentially cause damage.

Frequency

Richmond Beach Park, which faces south, has brush fires approximately every five years. However, urban and brush fires can occur at anytime and are more probable during dry, summer months.

Severity

Fires can burn vegetation and cause loss of life and personal property. Loss of vegetation due to fires may cause erosion and mudslides. There is strong concern for occupants in structures that may catch fire. Fires may also cause the release of hazardous materials and damage utility lines.

Warning Time

The onset of a fire can be sudden and there can be little warning time. The warning time is dependent on the extent of the fire and the speed the fire is traveling.

Past Events

In the late 1960's there was a brush fire in the Boeing Creek Canyon area. This area is very inaccessible for fire vehicles.

On July 5th, 2003 two fires burned 1.5 acres of brush between the Burlington Northern Railroad tracks and the beach at Richmond Beach Saltwater Park. The pedestrian bridge located there was threatened but the fire was put out in time so that there was only minimal damage to the bridge.[43]

The utility corridor parallel to Aurora Ave caught fire on August 18, 2003 scorching a path between 165th and 160th. The fire damaged the exterior of two homes and twelve other property owners reported damage to backyards, outbuildings and landscaping.[44]

Secondary Hazards

Due to the presence of steep slopes, erosion after a wildfire is a risk that may potentially lead also to landslides. The protection provided by foliage and organic matter is removed, leaving the soil fully exposed to wind and water erosion.

Vulnerability

There is any number of vulnerabilities to fires in Shoreline. These fires can spread to homes, businesses, block road and lifelines and create significant economic and environmental damage if fuel loads and vegetation are not properly maintained. Specific areas that, such as Richmond Beach Park is especially vulnerable. In addition, the Highlands neighborhood is a highly vegetated area with potential high fuel loads and limited ingress and egress for emergency vehicles. Vegetated areas in Innis Arden and south of Richmond Beach may also be an area of

[43] The Enterprise, "Fires at Richmond Beach—fireworks may be to blame", July 11, 2003
[44] The Enterprise, "Cigarette caused Shoreline brush fire", August 29, 2003

concern. A steep slopes and land cover map may help to determine general wildland and brush fire hazard locations in Shoreline.

Scenario

A disastrous fire could be caused by a lightening strike or more likely by human error. It would be an extremely dry hot summer and someone would discard a cigarette out the window of a car on I-5 or along the bike path. It is also possible that fires can be set at Richmond Beach Park or the Highlands. Because of the dry conditions and steep slopes, the fire would spread very rapidly, especially if it is a windy day. It spreads before response teams can contain it and then moves in to neighborhoods, sparking a wave of fires that destroys or damages numerous homes.

1.10. Volcano

Definitions

<u>Stratovolcano:</u> The volcanoes in the Cascade Range surrounding Shoreline are all stratovolcanoes. They are typically steep-sided, symmetrical cones of large dimension built of alternating layers of lava flows, volcanic ash, cinders, blocks, and bombs and may rise as much as 8000 feet above their bases.ii

The following is a list of the different types of hazards associated with Cascade Range volcanoes:

<u>Pyroclastic Flows and Surges:</u> Pyroclastic flows are avalanches of hot (570-1470° F), ash, rock fragments and gas that move at high speeds down the sides of a volcano during explosive eruptions or when the edge of a thick, viscous, lava flow or dome breaks apart or collapses. Speeds range from 20 to more than 200 miles per hour.

<u>Lava Flows</u>: Lava flows are normally the least hazardous threat posed by volcanoes. Cascades volcanoes are normally associated with slow moving andesite or dacite lava.

<u>Tephra:</u> The ash and the large volcanic projectiles that erupt from a volcano into the atmosphere are called tephra. The largest fragments 2½ inches) fall back to the ground fairly near the vents, as close as a few feet and as far as 6 mi. The smallest rock fragments (ash) are composed of rock, minerals, and glass that are less than 1/8 inch in diameter. Tephra plume characteristics are affected by wind speed, particle size, and precipitation.

<u>Lahars:</u> Lahars are rapidly flowing mixtures of water and rock debris that originate from volcanoes. While lahars are most commonly associated with eruptions, heavy rains, debris accumulation, and even earthquakes may also trigger them. They may also be termed debris or mud flows.

<u>Debris Flows:</u> Dense mixtures of water-saturated debris that move down-valley; looking and behaving much like flowing concrete. They form when loose masses of unconsolidated material are saturated, become unstable, and move down slope. The source of water varies but includes rainfall, melting snow or ice, and glacial outburst floods.

<u>Debris Avalanches:</u> Volcanoes are prone to debris and mountain rock avalanches that can approach speeds of 100 mph.

<u>Volcanic Gases:</u> All active volcanoes emit gases. These gases may include steam, carbon dioxide, sulfur dioxide, hydrogen sulfide, hydrogen, and fluorine.

<u>Ashfall</u>**:** Volcanoes tend to erupt lavas so thick and charged with gases that they explode into ash rather than flow.

Lateral blasts: These are explosive events in which energy is directed horizontally instead of vertically from a volcano. They are gas charged, hot mixtures of rock, gas and ash that are expelled at speeds up to 650 mph.

Background of Volcano Hazard

A volcano is a vent in the Earth from which molten rock (magma) and gas erupts. There are a wide variety of hazards related to volcanoes and volcanic eruptions. With volcanic eruptions, the hazards are distinguished by the different ways in which volcanic materials and other debris flow from the volcano. The molten rock that erupts from the volcano (lava) forms a hill or mountain around the vent. The lava may flow out as a viscous liquid, or it may explode from the vent as solid or liquid particles.

Volcanic Eruptions in Shoreline

Location

The Cascade Range is a 1,000-mile long chain of volcanoes, which extends from northern California to southern British Columbia. Shoreline does not lie within any basin that would drain any lahars or mudflows from the nearby volcanoes. Nonetheless it would be affected by tephra or an ash fall from either a Mount Rainier or Glacier Peak eruption.

Frequency

Volcanoes in the Cascades erupt at a rate of 1 or 2 every 200 years. Many of these volcanoes have erupted in the recent past and will erupt again in the foreseeable future. Eruptions in the Cascades have occurred at an average rate of 1-2 per century during the last 4,000 years. The U.S. Geological Service (USGS) classifies Glacier Peak, Mt. Adams, Mt. Baker, Mt. Hood, Mt. St. Helens, and Mt. Rainier as being potentially active Washington state volcanoes. Mt. St. Helens is by far the most active volcano in the Cascades, with four major explosive eruptions in the last 515 years.

Severity

A one-inch deep layer of ash weighs an average of ten pounds per square foot causing danger of structural collapse. Ash is harsh, acidic, gritty, and smelly. Ash may also carry a high static charge for up to two days after being ejected from a volcano. An ash cloud combines with rain, sulfur dioxide in the cloud combines with water to form diluted sulfuric acid that may cause minor, but painful burns to the skin, eyes, nose, and throat.

Warning Time

Constant monitoring of all active volcanoes means that there will be more than adequate time for evacuation before an event. Since 1980, the volcano has settled into a pattern of intermittent, moderate and generally nonexplosive activity, and the severity of tephra, explosions, and lava flows have diminished. All episodes, except for one very small event in 1984, have been successfully predicted several days to 3 weeks in advance. However, scientists remain uncertain as to whether the current cycle of explosivity has ended with the 1980 explosion. The possibility of further large-scale events continues for the foreseeable future.[iii]

Past Events

The most famous of past eruptions for Mt. St. Helens occurred May 18, 1980. In this eruption, the elevation of Mt. Saint Helens dropped dramatically from 9,677 feet to 8,364 feet; 23 square miles of volcanic material buried the North Fork of the Toutle River to an average depth of 150 miles. A total of 57 human fatalities resulted from the blast.[iv]

The following table summarizes the eruptions in the area:

Table 14: Past Eruptions in Puget Sound Area

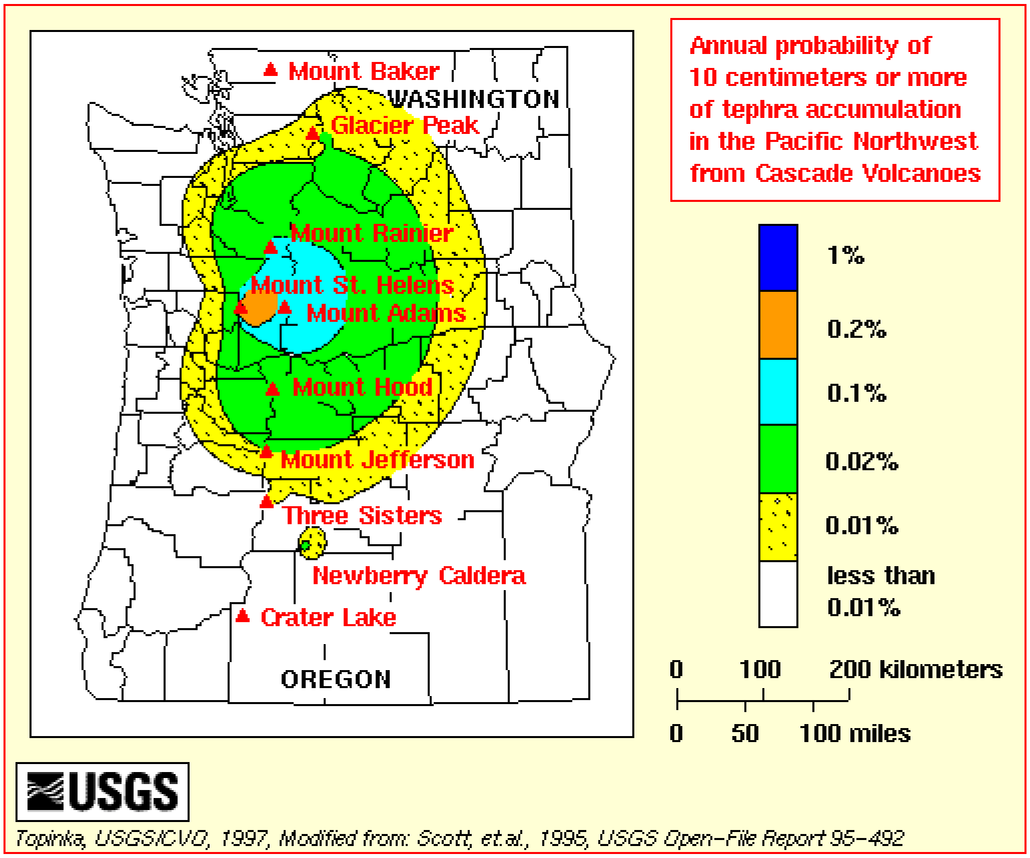
Volcano	Number of Eruptions	Type of Eruptions
Mount Adams	3 in the last 10,000 years, most recent between 1,000 and 2,000 years ago	Andesite lava
Mount Baker	5 eruptions in past 10,000 years; mudflows have been more common (8 in same time period)	Pyroclastic flows, mudflows, ashfall in 1843.
Glacier Peak	8 eruptions in last 13,000 years	Pyroclastic flows and lahars
Mount Rainier	14 eruptions in last 9000 years; also 4 large mudflows	Pyroclastic flows and lahars
Mount St Helens	19 eruptions in last 13,000 years	Pyroclastic flows, mudflows, lava, and ashfall

Vulnerabilities

Shoreline has low vulnerability to volcanic hazards. Tephras can potentially cause the most damage. Ash only ½ inch thick can impede the movement of most vehicles and disrupt transportation, communication, and utility systems. Tephra may cause eye and respiratory problems, particularly for those with existing medical conditions. Ash may also clog ventilation systems and other machinery. It is easily carried by winds and air currents remaining a hazard to machinery and transportation long after the eruption. When tephras are is mixed with rain it becomes a much greater nuisance because wet ash is much heavier, more difficult to remove, and can even cause structures to collapse. Heavy ashfall can drift into roadways, railways, and runways where it becomes slippery and dangerous. Wet ash may also cause electrical shorts. Power lines can be destroyed and roofs may collapse from the ashfall loads. Ash fall also decreases visibility and may cause psychological stress and panic. Figure 16 below depicts the probability of ash accumulation from a Cascade volcano. As is evident, there is little likelihood of major accumulation, but some should be expected. An ash fall may cause secondary hazards such as fire or flooding. Its weight may cause structural collapse.

Vulnerable populations are the elderly, children, and those with weakened immune and respiratory systems. Gases from volcanic eruptions are usually too diluted to constitute danger to a person in normal health, the combination of acidic gas and ash may cause lung problems. Extremely heavy ash can clog breathing passages and cause death.

Figure 16: Probability of Tephra Accumulation from Cascade Volcanoe



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Scenario

Glacier Peak or Mount Rainier would erupt with little warning time with a large explosion, sending ash miles into the air, dispersing and then falling in all directions. Although the mudflows would not affect Shoreline, except economically, it would be affected by the ash fall. The tephra would blanket the city, possibly putting stress on power lines and roofs. A heavy rainstorm could occur, creating a heavy clay from the ashfall. Traffic accidents, reduction in production by business, stressed power lines and residential roofs collapse may occur. The wet ash would also clog storm drains, causing the secondary hazard of flooding.

The dry tephra would also cause respiratory problems for the elderly and infirm people living in the city, particularity affecting those residing at the CRISTA Ministries Facility and at elderly and retirement centers.

1.11. Tsunami/Seiche

Definitions

<u>Tsunami</u>: Tsunamis are sea waves usually caused by displacement of the ocean floor and are typically generated by seismic or volcanic activity or by underwater landslides.

<u>Seiche:</u> A seiche is a standing wave in an enclosed or partly enclosed body of water and normally caused by earthquake activity and can affect harbors, bays, lakes, rivers and canals.

Background

A tsunami consists of a series of high-energy waves that radiate outward like pond ripples from the area in which the generating event occurred. The sequence of tsunami waves arrives at the shore over an extended period. The first wave will be followed by others a few minutes or a few hours later with the following waves generally increasing in size over time. Tsunamis are commonly 60 or more miles from crest to crest and travel at remarkable speeds, often more than 600 miles per hour in the open ocean. They can traverse the entire Pacific Ocean in 20 to 25 hours. These are extremely destructive to life and property. The tsunami caused by the 1883 eruption of Krakatau, caused more than 30,000 fatalities, and the 1886 tsunami on the Sunriku coast of Japan killed about 26,000 people.

Typical signs of a tsunami hazard are earthquakes and/or a sudden and unexpected rise or fall in coastal water. The large waves are often preceded by coastal flooding and a quick recession of the water. Tsunamis are difficult to detect in the open ocean; with waves only one or two feet high. The tsunami's size and speed, as well as the coastal area's form and depth are factors that affect the impact of a tsunami; wave heights of fifty feet are not uncommon. In general, scientists believe it requires an earthquake of at least a magnitude 7 to produce a tsunami.

Seiches are usually earthquake-induced but typically do not occur close to the epicenter of an earthquake, but hundreds of miles away. This is due to the fact that earthquake shock waves close to the epicenter consist of high-frequency vibrations, while those at much greater distances are of lower frequency, which can enhance the rhythmic movement in a body of water. The biggest seiches develop when the period of the ground shaking matches the frequency of oscillation of the waterbody.

Tsunami/Seiche Hazard in Shoreline

Location

Tsunamis affecting Washington State may be induced by an earthquake of local origin, or they may be caused by earthquakes at a considerable distance, such as from Alaska or Japan. Shoreline does not have any major lakes within its area, but a severe quake could create seiches in the small ponds such as Ronald Bog and Echo Lake that could potentially cause damage.

Frequency

The frequency of a tsunami or seiche is related to the frequency of earthquakes and landslides that can produce a tsunami or seiche. There is a low probability of a tsunami or seiche occurring in Shoreline.

Severity

It is unlikely that a tsunami or seiche generated by a distant or Cascadia subduction earthquake would result in much damage in Shoreline. One computer model suggests that a tsunami generated by such an earthquake with a magnitude of 8.5 would only be 0.2 to 0.4- meters in height when it reached the Seattle/Shoreline area. This results from the shielding of the Olympic Peninsula and the Puget Sound islands. However, Puget Sound is vulnerable to tsunamis generated by local crustal earthquakes (such as along the Seattle fault or South Whidbey Island fault) or by submarine landslides triggered by earthquake shaking. This type of tsunami could impact Shoreline. The low-lying areas along the Puget Sound coastline could suffer damage.

Warning Time

Warning vulnerable areas would be nearly impossible due to the close proximity to the origin of the tsunami. The first wave would probably hit coastline areas within minutes.

Past Events

There is no historic record of tsunamis affecting Shoreline or Puget Sound. However, geologic evidence of tsunamis has been found at Cultus Bay on Whidbey Islands and at West Point in Seattle. Researchers believe these tsunamis are evidence of earthquake activity along the Seattle fault.

The area around Shoreline has been affected by seiches, most recently caused by a November 3rd, 2002 when a 7.9 magnitude quake in Alaska shook houseboats loose from their moorings in Lake Union. No damage was reported in Shoreline for this event.

Vulnerability

Properties located along Puget Sound may be vulnerable to tsunamis. There are 33 parcels that could be affected and are located on 27th Ave NW. Properties directly adjacent to ponds or the small lakes in Shoreline may be potentially affected by a seiche caused by a local or distant quake. Echo Lake has development surrounding it, as does Ronald Bog on its south side. Since actual buildings are located a several feet above the lake, the most affected structures would be the piers on Echo Lake and any boats moored to them.

Scenario

The worst-case scenario for a tsunami and seiche would be as a secondary effect of a powerful local earthquake on the Seattle fault or South Whidbey fault zones centered in Puget Sound. This would send a tsunami rushing towards Shoreline with little or no warning time, damaging buildings and property located along the low lying coast in the Richmond Beach area. The tsunami itself would damage the closest buildings and the floods from the storm surge would damage other buildings. The seiche from this quake would also damage the small piers located on Echo Lake and some of the boats docked on them causing property losses for households. The seiche could possible flood some basements of the buildings located near the lake, and the basements of buildings near Ronald Bog.

1.12. Risk Rating

A risk rating has been completed for each of the major hazards described in this plan. For the purposes of this plan, the risk rating is a function of two factors. The first factor describes the probability that a hazard event will occur. The second factor describes the impact of the event. This is typically considered both in number of people affected and amount of dollar loss caused by the hazard event. Estimates of risk for the City of Shoreline were based on the methodology that the City used in preparing their Hazard Inventory and Vulnerability Analysis (HIVA). This fulfills the Washington Administrative Code (WAC 118-30-060(1)) requirement.

Probability of Occurrence

The probability of occurrence of a hazard event provides an estimation of how often the event occurs. This is generally based on the past hazard events that have occurred in the area and the forecast of the event occurring in the future. This is done by assigning a probability factor, which is based on yearly values of occurrence. The numerical value assigned to each category will be used to determine risk rating of each hazard. These are allotted as follows:

- **High -** Hazard event occurs approximately **once every 5 years** (Numerical value **3**)
- **Medium –** Hazard event occurs approximately **once every 50 years** (Numerical value **2**)
- **Low –** Hazard event occurs approximately **once every 100 years** (Numerical value **1**)

Table 15: Probability of Hazards

Hazard Event	Probability	Numerical Value
Earthquake	Medium	2
Hazardous Materials	High	3
Severe Weather	High	3
Landslides/Sinkholes	Medium	2
Flooding	Medium	2
Fire	High	3
Volcano	Low	1
Tsunami/Seiche	Low	1

Impact

The impact of each hazard was divided into two categories, impact to people and impact in dollar loss. These two categories were also assigned weighted values. Impact to people was given a weighted factor of 3 and impact of dollar losses was given a weighted factor of 2. For impact to people the categories were broken down as follows:

- **High -** Hazard event seriously affects **greater than 100 people** (Numerical value **3**)
- **Medium** – Hazard event seriously affects **26-100 people** (Numerical value **2**)
- **Low** – Hazard event seriously affects **0-25 people** (Numerical value **1**)

Table 16: Impact to People from Hazards

Hazard Event	Impact	Numerical Value	Multiplied by weighted value of 3
Earthquake	High	3	9
Hazardous Materials	Medium	2	6
Severe Weather	Medium	2	6
Landslides/Sinkholes	Medium	2	6
Flooding	Medium	2	6
Fire	Low	1	3
Volcano	High	3	9
Tsunami/Seiche	Medium	2	6

For the impact in dollar loss, it was estimated what the dollar loss would be from a major event of each hazard. For impact in dollar loss, the categories were broken down as follows:

- **High** **-** Hazard event causing damages **over $10 million** (Numerical value **3**)
- **Medium** – Hazard event causing damages **between $1 and $10 million** (Numerical value **2**)
- **Low** – Hazard event causing damages **less than $1 million** (Numerical value **1)**

Table 17: Impact in Dollar Losses for Hazards

Hazard Event	Impact	Numerical Value	Multiplied by weighted value of 2
Earthquake	High	3	6
Hazardous Materials	Low	1	2
Severe Weather	Low	1	2
Landslides/Sinkholes	Medium	2	4
Flooding	Medium	2	4
Fire	Low	1	2
Volcano	Medium	2	4
Tsunami/Seiche	Low	1	2

Risk Rating

The risk rating for each hazard was determined by multiplying the assigned numerical value for probability to the weighted numerical value of impact to people added to the weighted numerical value of dollar losses. The following equation expresses the risk rating calculation:

Risk Rating = Probability * Impact (people +dollar losses)

Table 18: Risk Rating

Hazard Event	Probability	Impact	Total (Probability *Impact)
Earthquake	2	9+6=15	**30**
Hazardous Materials	3	6+2=8	**24**
Severe Weather	3	6+2=8	**24**
Landslides/Sinkholes	2	6+4=10	**20**
Flooding	2	6+4=10	**20**
Fire	3	3+2=5	**15**
Volcano	1	9+4=13	**13**
Tsunami/Seiche	1	6+2=8	**8**

The risk ratings were developed to help focus the mitigation strategies to areas that warrant greatest attention. The hazards were given an overall risk rating which ranked them in relation to one another.

The highest risk ratings such as earthquakes, hazardous materials and severe weather warrant major mitigation program with attention to preparedness, response and recovery until the mitigation program has be implemented.

The medium risk ratings such as flooding, landslides/sinkholes and fire warrant modest program effort.

The low risk ratings such as volcano and tsunami/seiche warrant no special mitigation effort although inexpensive or all hazards preparedness, response and recovery measures may be warranted.

Figure 17: Critical & Essential Facilities

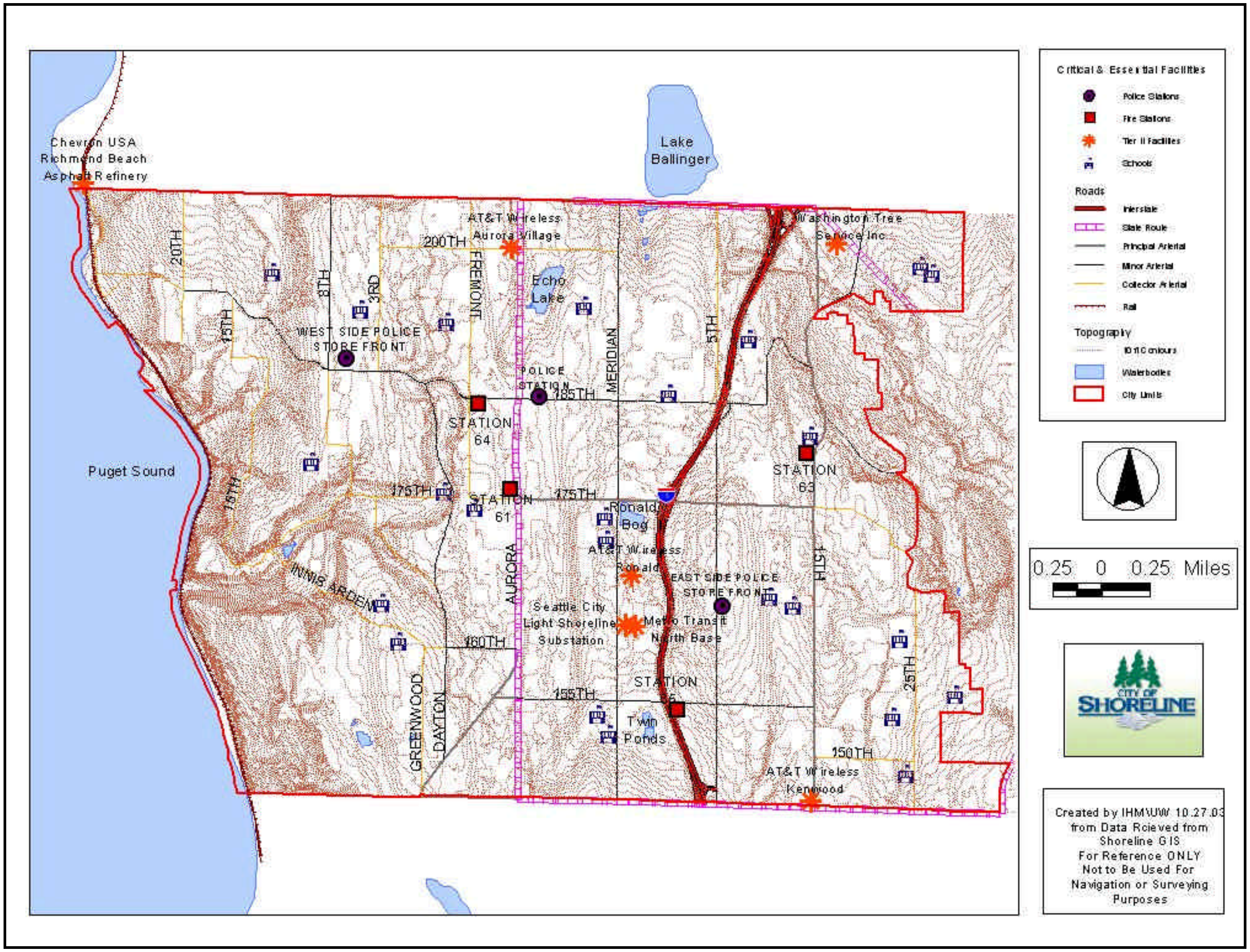


Figure 18: NEHRP Soils

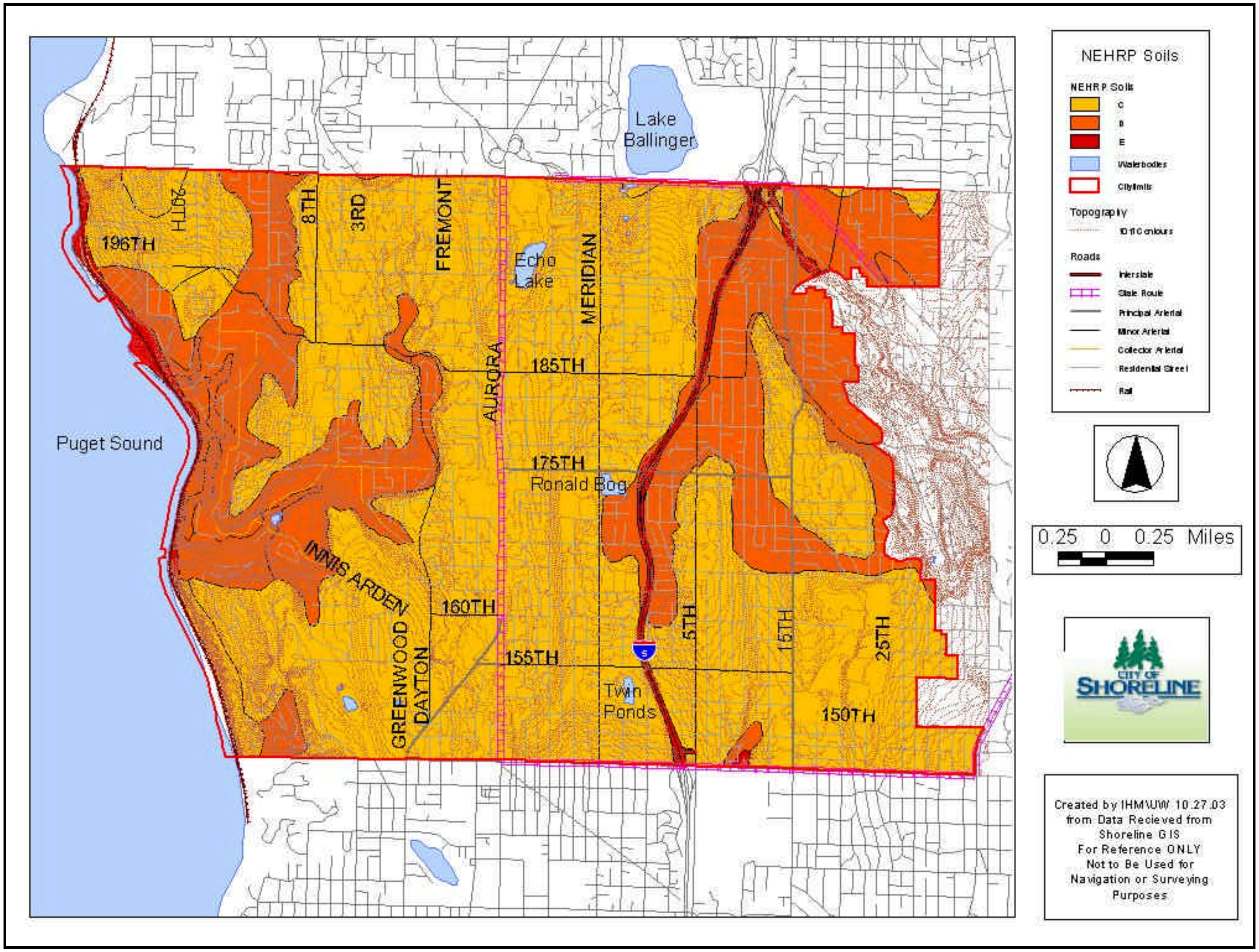


Figure 19: Structures in D Soils

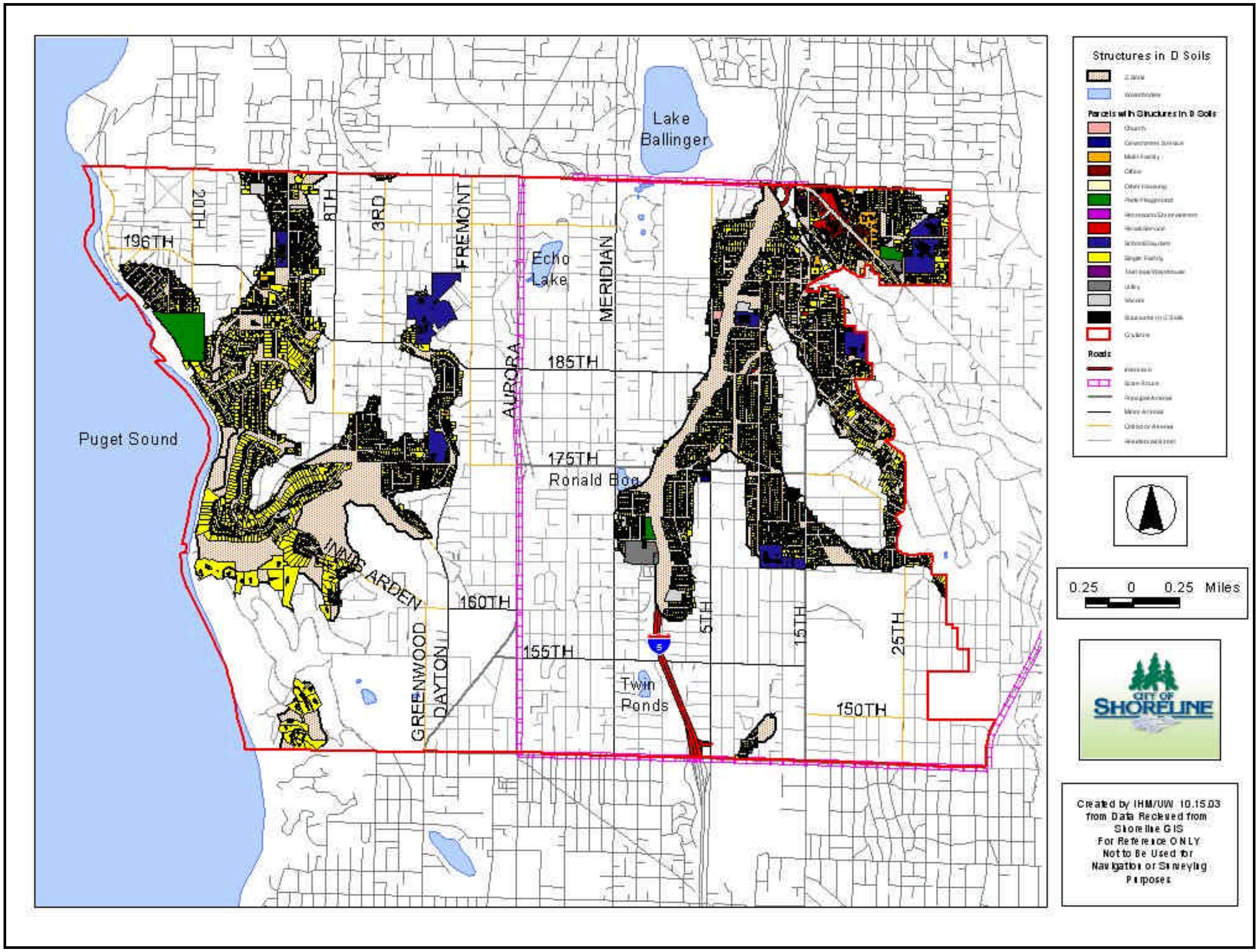


Figure 20: Structures in E Soils

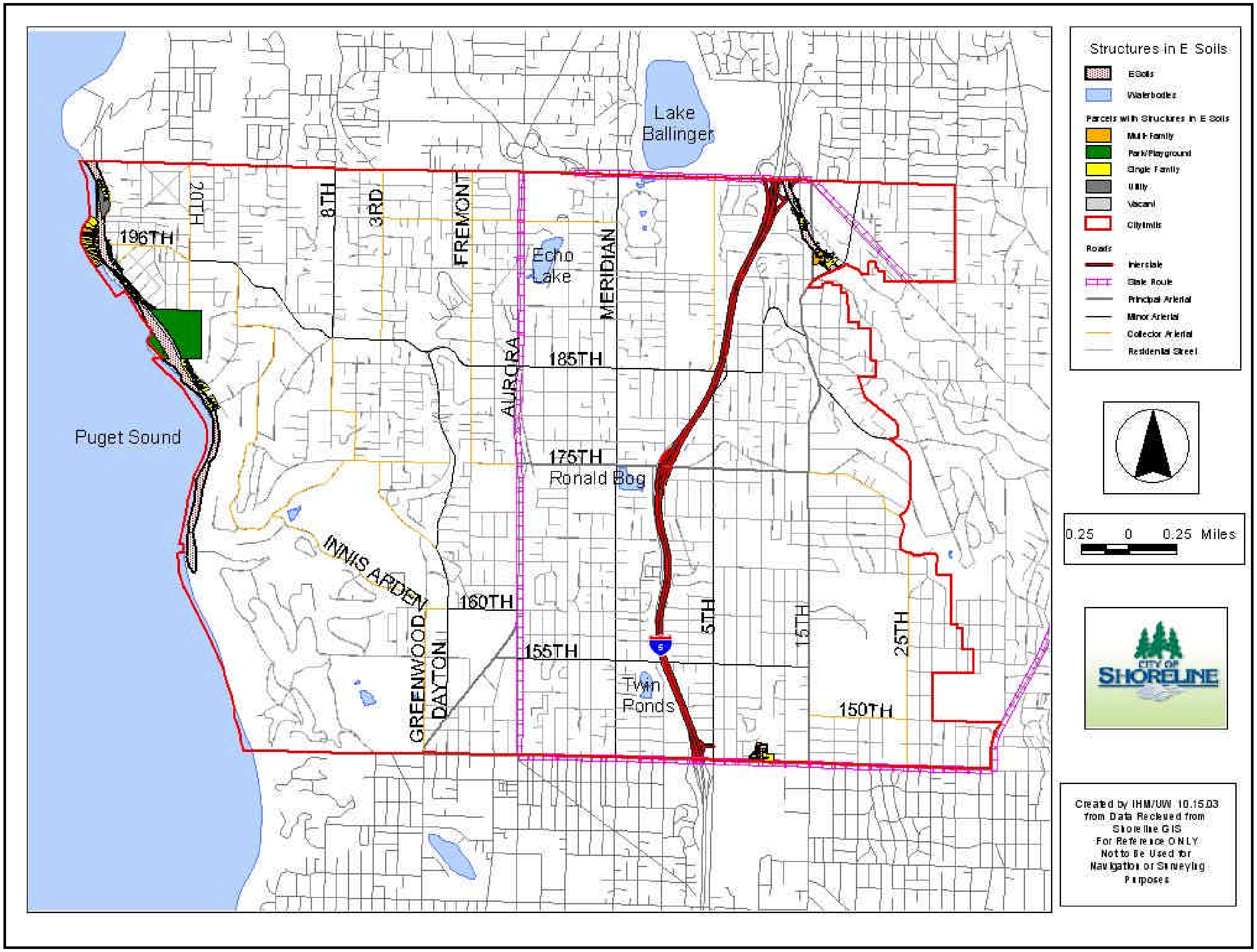


Figure 21: Liquefiable Soils

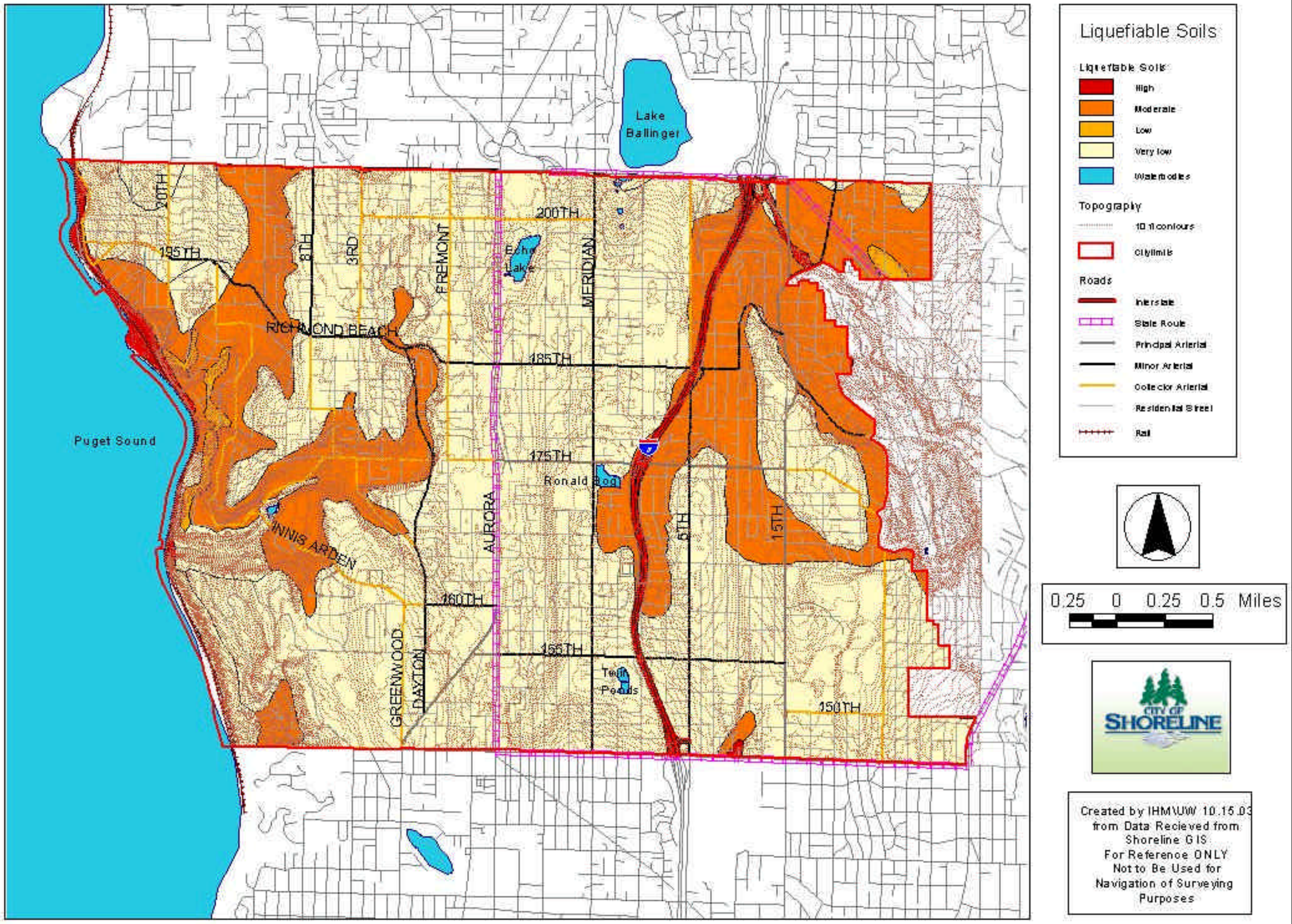


Figure 22: Structures in High Liquefaction

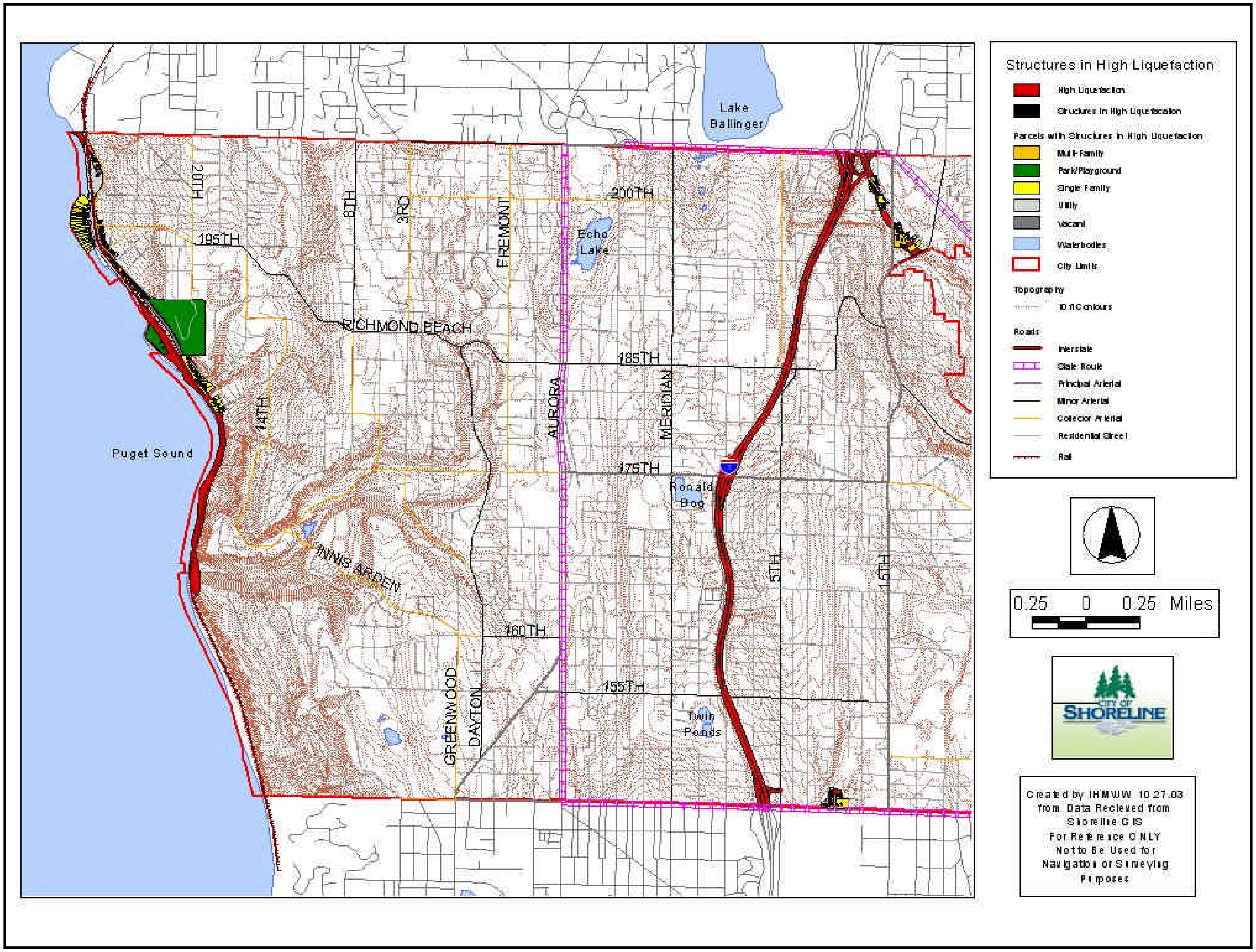


Figure 23: Tier II Facilities

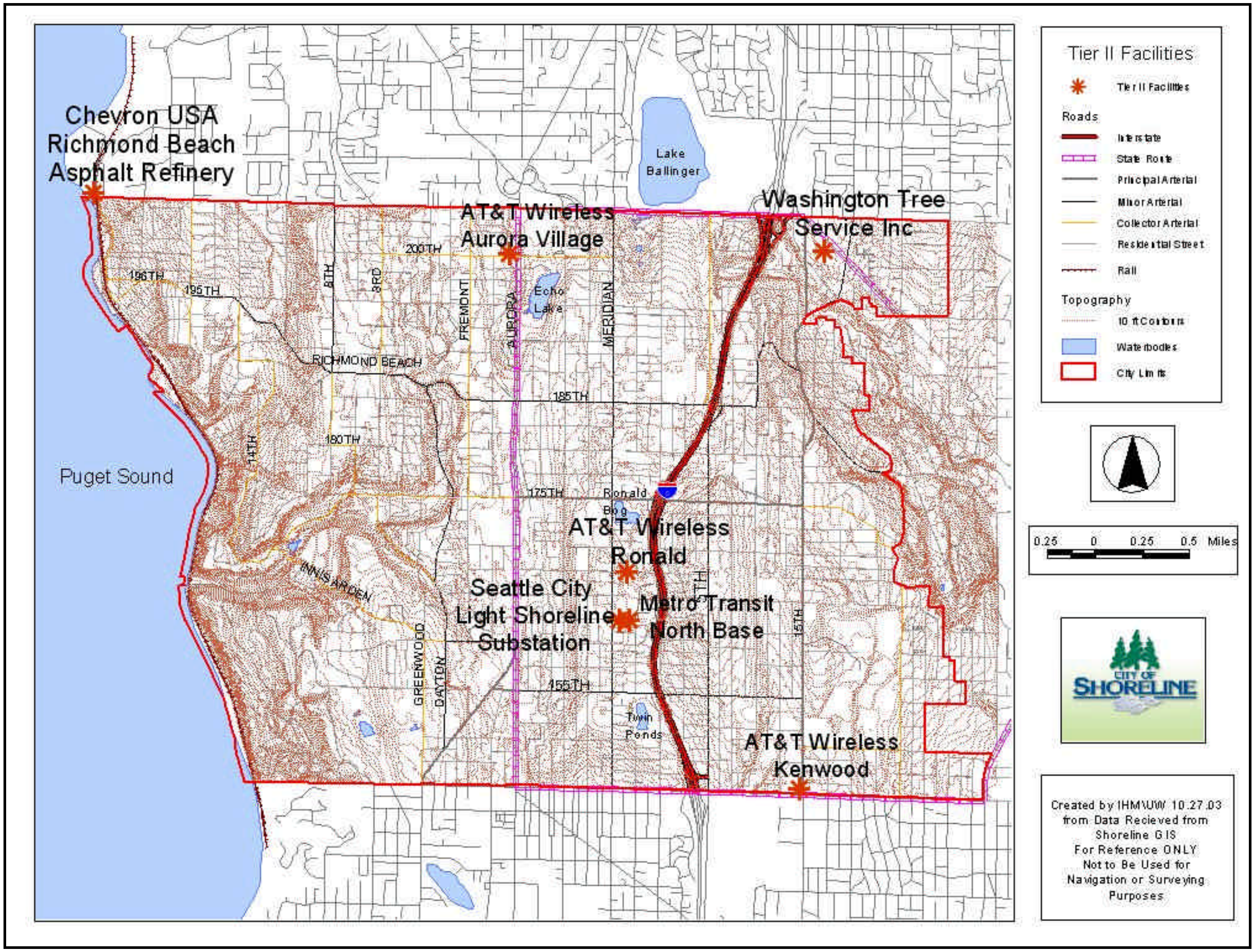


Figure 24: Landslide Hazards

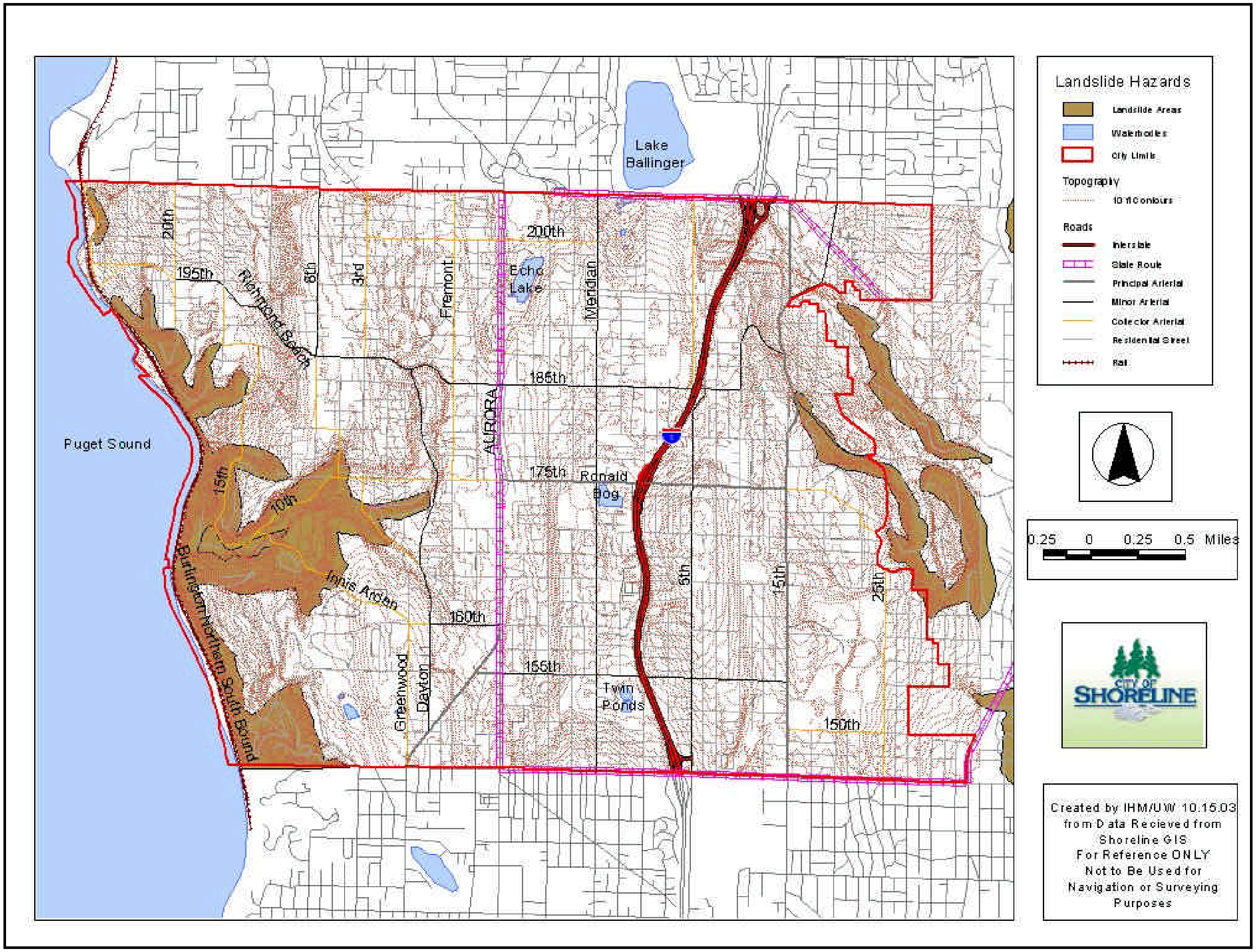


Figure 25: Structures in Landslide Hazards

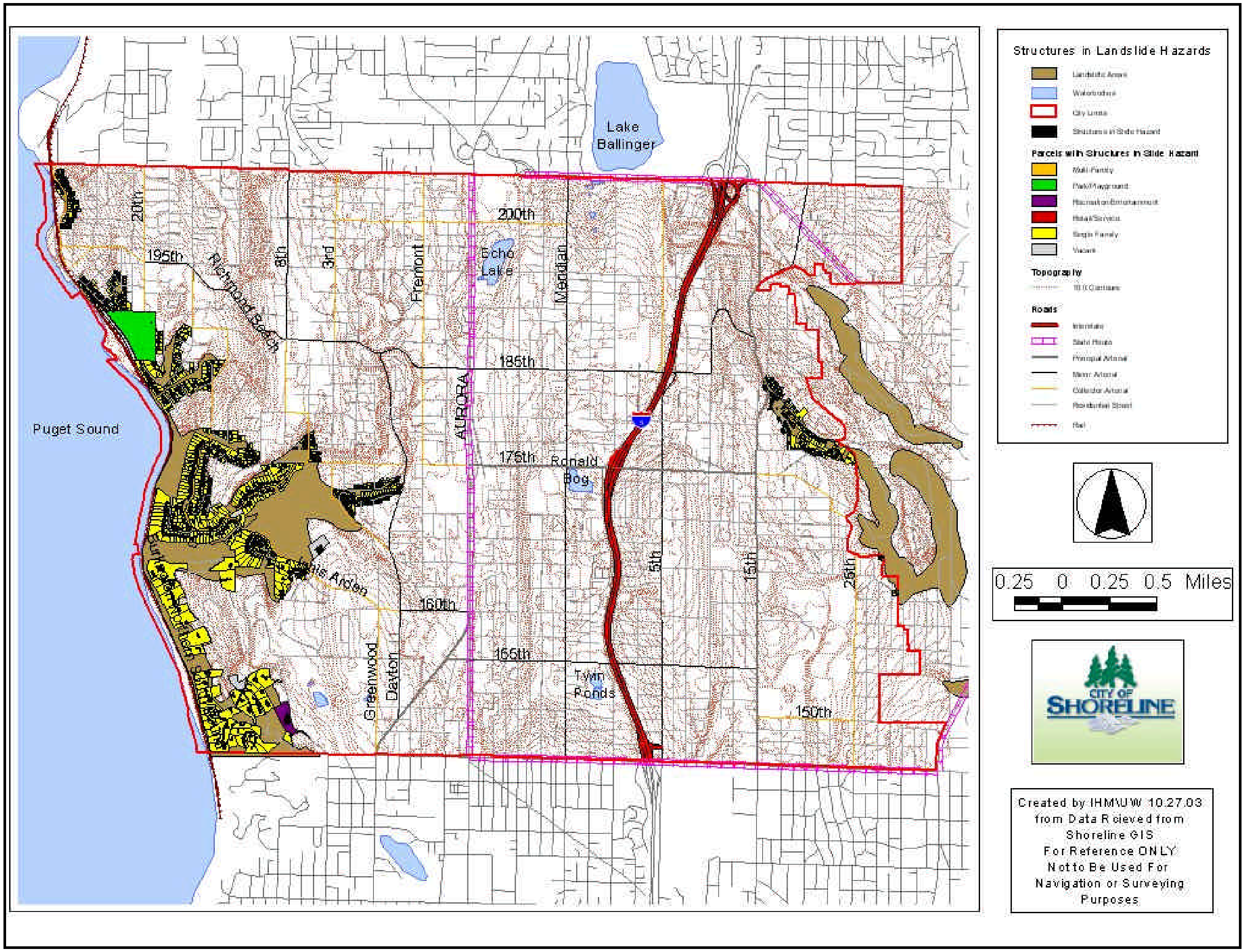
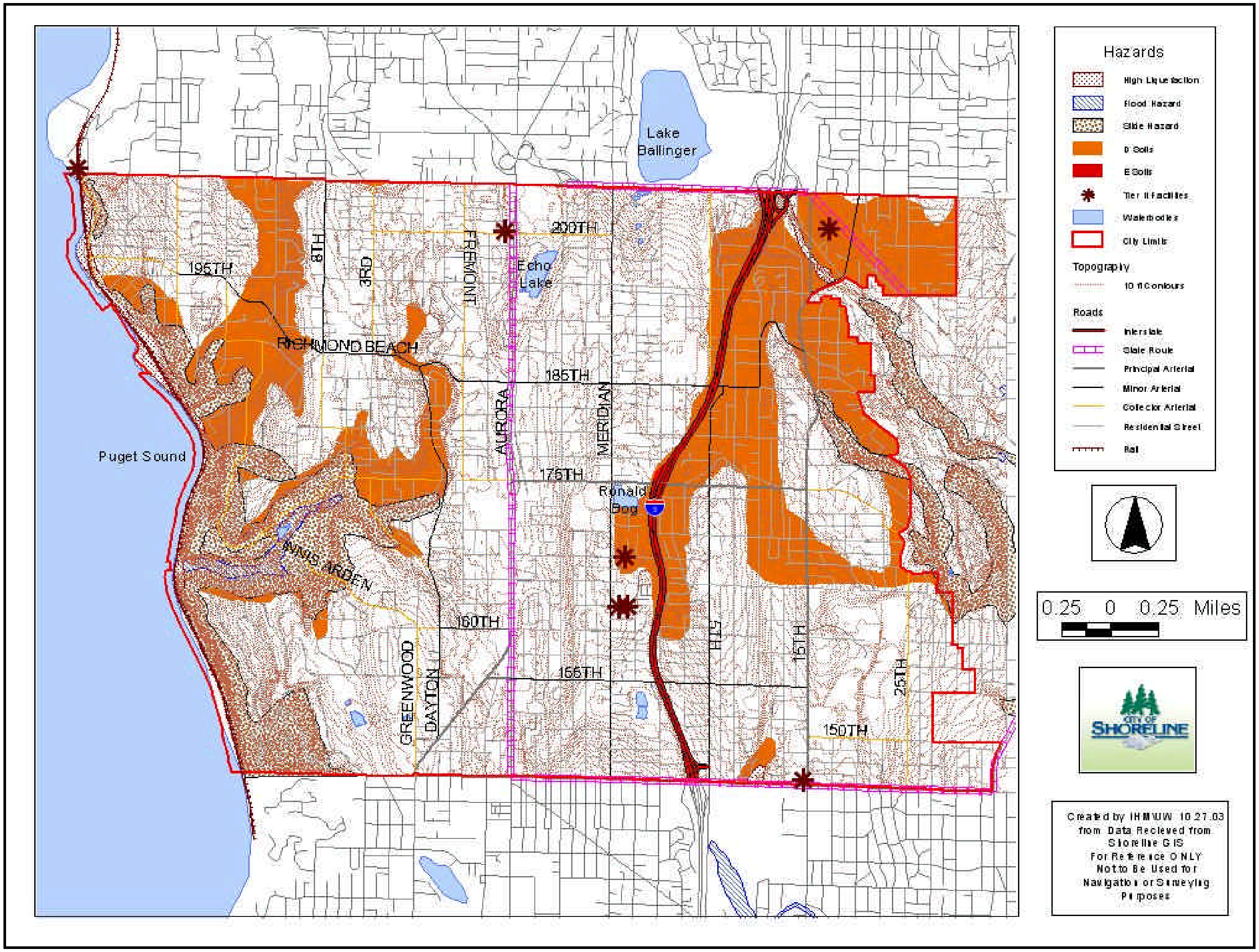


Figure 26: Composite Map of Earthquake, Landslides, Flooding, & Hazardous Materials Hazards



2. Capability Assessment

Capabilities address a community's current capacity to address risks from potential hazard events. The City of Shoreline currently has in place several capabilities to reduce the risk associated with hazard events. This includes public outreach, planning, training, communication and several others. Below a description is provided of Shoreline's general capabilities that apply to each of the eight hazard events. In addition, Table 19 presents capabilities that apply specifically to each hazard.

Public Outreach

The City of Shoreline has a page on its city web site relating emergency preparedness. This is located at http://www.cityofshoreline.com/cityhall/projects/emergency/index.cfm. Periodically the Police Department will publish an article in the community paper regarding health and safety issues.

Training

Community Emergency Response Team (CERT) classes and Employee Emergency Response Team (EERT) classes are available.

Planning

An Emergency Operations Plan was created in June 2003 for the City of Shoreline. It provides a document that city officials and employees can use in a disaster to determine what the chain of command is, where people should go, and what they should do. The plan requires that each Shoreline City Department provide personnel to staff the Emergency Operations Center (EOC) if necessary. The plan also designates the EOC's. The primary location is the Shoreline Fire Department Headquarter Training and Support Facility and the secondary location is the Shoreline Police Station.

The City of Shoreline has an activated Emergency Management Council, which was established in 1996 by Municipal Code 2.50. The Council provides oversight to emergency management activities and those ordinances, resolutions, contracts, rules and regulations that are necessary for emergency management[45].

The Shoreline Water District has a section in their comprehensive plan that discusses emergency operations as well as an appendix that is the Shoreline Water District Emergency Response Program. The District has two emergency interties with the City of Mountlake Terrace that could be used if the main supply station is out of service[46].

The Shoreline Water District, Ronald Wastewater District and the Fire Department are currently working on hazard mitigation plans using the Mitigation 2020 model in coordination with King County. When completed these plans with be appendices to the King County Plan

The Transportation and Parks Department master plans are currently being updated as well as Shoreline's Comprehensive Plan.

The Shoreline Water District has a section in their comprehensive plan that discusses emergency operations as well as an appendix that is the Shoreline Water District Emergency Response Program.[47]

[45] City of Shoreline Emergency Operations Plan: June 2003
[46] Shoreline Water District Comprehensive Water System Plan: Revised March 2001
[47] Shoreline Water District Comprehensive Water System Plan: Revised March 2001

Communication

The City of Shoreline can request that King County activate the Emergency Alert System, which immediately interrupts television and radio broadcast to warn of an emergency situation and provide necessary instructions.

The City of Shoreline Web Site and Government Access Channel 21 will provide information in emergency situations. This method of providing information is limited by staff time and the availability of electricity and cable.

The City of Shoreline can send official vehicles to make announcements via a public address system. This method would most likely be used for evacuations.

Support following a presidential declaration

There is considerable support for risk reduction measures following a federal declaration. Often these programs and their implications are not taken advantage of before permanent repairs are made. Some of the more significant ones include:

- The Hazard Mitigation Grant Program (HMGP) offers assistance for a wide range of mitigation projects following a presidential declaration. Eligibility is restricted to projects that have gone through a comprehensive hazard mitigation planning process.
- Minimal Repair Program often funds risk reduction such as the anchoring of mobile homes.
- The Small Business Administration will fund eligible mitigation measure to qualified owners of damaged homes.

- Outreach is available through Disaster Reconstruction Assistance Centers (DRACs), Recovery Information Centers or Hazard Mitigation Teams.
- Benefit/Cost Mitigation support is available from FEMA on infrastructure repair. To break the damage-rebuild-damage cycle FEMA Region 10 is encouraging communities to:
  - Institute mitigation betterments taking advantage of multi-hazard, multiobjective approaches whenever possible
  - Strengthen existing infrastructure and facilities to more effectively withstand the next disaster
  - Ensure that communities address natural hazards through comprehensive planning

Following a Federal Declaration FEMA can support cost effective mitigation on infrastructure and have published a manual on the subject.

Table 19: Shoreline Capabilities Matrix

Hazard	Planning	Codes	Other
Earthquake	In the Shoreline Capital Improvement Plan 2004 to 2009, there is a plan for the Richmond Beach Overcrossing. This involves designing and constructing a concrete bridge to replace the existing, deteriorating timber structure over the Burlington Northern Railroad at Richmond Beach Drive NW and approximately NW 196th St. This bridge provides sole access to 35 homes on 27th Avenue NW.	Shoreline's Municipal Code, Chapter 15.05, Building and Construction Code, adopted as Ordinance 17 in 1995 uses the King County Building Code, which is Title 16 of the King County Code. Of particular interest is 16.06 of KCC, Disaster damage UBC and 16.04.05047 relating to foundation construction.	The Washington State Department of Natural Resources has updated and improved the NEHRP soils map for the state. This improved map identifies the seismic hazard areas in Shoreline.
Hazardous Materials	An Area Contingency Plan was developed by the State Department of Ecology in cooperation with Federal, State and Local agencies. The purpose of the plan is "to provide orderly implementation of response actions to protect the people and natural resources of the states of Washington, Oregon, and Idaho from the impacts of oil or hazardous substances spills". The plan accounts for potential problems from vessels, offshore facilities, onshore facilities or other sources. The Environmental Protection Agency has responsibility for all spills in inland waters. The United States Coast Guard has responsibility for all spills in coastal waters.[48]	Shoreline has a Hazardous Materials Management Plan under the Shoreline Municipal Code chapter 15.10.210 Section 8001.3.2 amended. Section 8001.3.2 has adopted the Uniform Fire Code, 1994 Edition, as published by the International Fire Code Institute. [Ord. 84 § 8.10, 1996] The Emergency Operation Plan cites that Washington Administrative Code (WAC) 296-62-3112 requires that the Incident Command System be used in responses to hazardous materials incidents[49].	There are currently sixteen hazardous materials response teams in King County. Eight of these are public fire jurisdictions and the Boeing Company operates eight. Private response contractors working with the Environmental Protection Agency and a unit of the Washington State Department of Ecology supplement the hazardous materials teams in King County.[50] Burlington Northern/Santa Fe inspects its tracks frequently and has track and landslide sensors to prevent derailment. Foss Environmental Inc is

[48] http://www.metrokc.gov/prepare/hiva/hazmat.htm
[49] City of Shoreline Emergency Operations Plan: June 2003

Hazard	Planning	Codes	Other
			contracted by Shoreline to aide in the event of a hazardous materials release.
Severe Storms	Snow routes are designated by Shoreline. These roads are cleared first to assure that navigable routes exist throughout the city.	Shoreline Municipal Code, Chapter 15.05, Building and Construction Code (Ordinance 17, 1995) refers to the King County Building Code, Title 16 of the King County Code, see especially: 6.04.5046 Roof design - Snow loads. Section 1605.4 of the Uniform Building Code is not adopted and the following is substituted: Snow loads (UBC 1605.4). The "Snow Load Analysis for Washington" Second Edition (1995), published by the Structural Engineers Association of Washington shall be used in determining snow load. Minimum Snow Load shall be 25 pounds per square feet. (Ord. 14111 § 60, 2001: Ord. 12560 § 50, 1996).	Fircrest, CRISTA Ministries, Department of Health Lab, Point Wells, Ronald Wastewater District and the Police Department all have back up generators.
Landslides and Sinkholes	As part of the Growth Management Act, the City is mandated to address steep slopes as a critical area.	Landslide Hazards are dealt with the Shoreline Municipal Code Chapter 20.80, critical areas. See particularly Subchapter 2 (20.80.210-20.80.250, SMC) Geological Hazard Areas.	Burlington Northern/Santa Fe inspects its tracks frequently and has track and landslide sensors to prevent derailment.
Flooding	Shoreline has Capital Improvement Projects planned or underway seeking to address flooding issues. These typically involve improving the drainage infrastructure. One project is Third Ave. NW Drainage Improvements, which are drainage	Shoreline Municipal Code Chapter 16.12 Flood Damage Prevention (ordinance 115, 1997). Shoreline's Municipal code, Chapter 20.80 critical areas deals with development in Floodplains. Particularly important is Subchapter 5, Flood Hazard Areas (20.80.360-	

[50] http://www.metrokc.gov/prepare/hiva/hazmat.htm

Hazard	Planning	Codes	Other
	improvements along Third Ave. NW that will reduce flooding for more than 20 homes in the area. Another project is the 5th Avenue NE Street Improvements Project (175th St TO 185th St). This project will design and construct a 36 foot two lane street with bike lanes, sidewalks, landscaping, illumination, and drainage that eliminates City flows to the private Pump 25 pond and reduces Ronald Bog flooding. Drainage improvements on NE 180th Street may be included. The city is also has a project for Ronald Bog Drainage improvements. The Ronald Bog Preferred Solutions were adopted by City Council in 2001. These are a Ballfield/detention facility at Cromwell Park, an open stream channel south of Ronald Bog along Corliss Avenue N, watercourse improvements north of 167th Street along Corliss Place, stormwater conveyance line along Serpentine Avenue, and improvement to Pump Station #25 (2nd Pl. and 178th St.). Short-term improvements were completed in 2003. In 2003, the City of Shoreline will be developing a Surface Water Master Plan that will evaluate and recommend solutions for flooding problems and drainage issues throughout the City. The City of Shoreline Public Works	20.80.410 SMC).	

Hazard	Planning	Codes	Other
	Department is currently in the process of creating a Surface Water Management Plan, which is proposed to be completed in June of 2004.		
Fire	In the Shoreline Capital Improvement Plan 2004 to 2009 there is a plan for the Interurban Trail Development. This is a 3.25 mile trail project that includes construction of a pedestrian, bicycle trail including a small parking lot and trail head from North 145th to North 205th Streets primarily along the Seattle City Light power transmission right of way. This will help keep a hazard area maintained which will reduce the potential for fire.	Shoreline Municipal Code Chapter 15.10 is the Fire Code	Fire Department outreach training to the public.
Volcano	Currently nothing in place	Shoreline Municipal Code, Chapter 15.05, Building and Construction Code (Ordinance 17, 1995) This refers to the King County Building Code, Title 16 of the King County Code, see especially: 16.04.5046 Roof design - Snow loads. Section 1605.4 of the Uniform Building Code is not adopted and the following is substituted: snow loads (UBC 1605.4). The "Snow Load Analysis for Washington" Second Edition (1995), published by the Structural Engineers Association of Washington shall be used in determining snow load. Minimum Snow Load shall be 25 pounds per square feet. (Ord. 14111 § 60, 2001: Ord. 12560 § 50, 1996). Buildings	Since all Northwest volcanoes are in a regular seismic zone, tremors are monitored by the USGS and the University of Washington Seismology Lab.

Hazard	Planning	Codes	Other
		codes relating to roof capacities for snow can also be considered a capability for ash falls.	
Tsunami	Currently nothing in place	Currently nothing in place	

[i] Slaughter, R., editor. 1996. *California's I-Zone - Urban/Wildland Fire Prevention & Mitigation*, State of California, Resources Agency, California Department of Forestry & Fire Protection, and California State Fire Marshal, Sacramento, CA 95823-2034, 301 p.

[ii] USGS Cascade Volcano Observatory

[iii] Tilling, Robert I., Lyn Topinka, and Donald Swanson. "Eruptions of Mt. Saint Helens: Past, Present and Future," USGS Special Interest Publication, 1990.

[iv] Brantley and Myers, 1997, Mount St. Helens -- From the 1980 Eruption to 1996: USGS Fact Sheet 070-97