City of Everett
Hazard Inventory and Vulnerability Analysis

July 2011

City of Everett

Hazard Inventory & Vulnerability Analysis

August 2011

Prepared by the University of Washington
Institute for Hazards Mitigation Planning and Research
with the Everett Office of Emergency Management

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Cover Photos

Top, Upper Left - *Port of Everett*, courtesy US Naval Station Everett
Top Right - *Entrance to Everett*, courtesy Dara Salmon
Top, Lower Left - *Colby Ave Looking South Near Hewitt*, 1920s, courtesy Everett Public Library
Bottom Left - *Safe and Sound Summit*, courtesy Dara Salmon
Bottom Right - *Everett Police Department in the old City Hall building*, courtesy Dara Salmon
Bottom Center - *Hewitt Ave Looking West*, ~1900 Postcard, courtesy Everett Public Library
Background Map - *Everett Bridges & Neighborhoods*, courtesy UW Institute for Hazard Mitigation Planning and Research

Executive Summary

2011 Update

The 2011 update of the Everett Hazard Inventory and Vulnerability Analysis (HIVA) and Hazard Mitigation Plan (HMP) reflects the most recent data available and the priorities of Everett and its citizens. While most of the information in the 2006 version of the HIVA and HMP remains current, the 2011 update has made changes in several areas:

- Data related to property values and land uses were updated, with the exposure and vulnerability analysis updated accordingly.
- Maps were updated and incorporated into the text of the HIVA.
- The organization of sections was changed to reduce redundancy and improve readability.
- Non-substantive changes were made to text and wording to improve readability and clarify concepts.
- The area of analysis was changed from the Planning Area established by the Growth Management Act to the actual city limits of Everett. This was done in order to focus the emphasis of the plan on areas where the city has actual governing authority.
- The City of Everett has conducted public outreach efforts to facilitate citizen involvement in the creation, maintenance, and implementation of the HMP.

The hazards for the 2011 HMP are ranked as follows:

1. Earthquakes
2. Severe Storms
3. Pandemics
4. Climate Change
5. Fire
6. Flooding
7. Hazardous Materials
8. Landslides
9. Tsunami & Seiche
10. Volcanic Eruptions

Hazard ranking in the 2006 Plan

1. Earthquake
2. Fire
3. Flooding
4. Hazardous Materials
5. Landslides
6. Severe Weather
7. Tsunami
8. Volcano

Risks to Build Upon

Vulnerable Structures (Unreinforced Masonry and other Pre-Code Structures)

The City has a large number of structures that were built before 1972, when earthquake building codes were first adopted. Unreinforced masonry structures and pre-code houses, especially those that are not secured to their foundations, represent the potential of building loss.

Industry Dependence

Since Everett is dependent on the manufacturing sector for many of its jobs and a large proportion of its tax base, there is an elevated risk of long-term economic harm if a major disaster adversely affects this sector. Manufacturing depends on strong transportation routes, including highway, railway, airport, and seaport facilities. Damage to these facilities would create long-term fiscal and economic challenges for the city as it attempts to recover from a disaster event.

Port Exposure

The areas bordering the Everett shore are at risk from multiple hazards, including earthquake-related ground shaking, liquefaction, and tsunamis. But since, historically these areas have suffered little damage and are planning for additional development, extra caution must be given to reducing associated risks. Coastal facilities could be isolated if bridges and roads are damaged in a disaster.

Isolation

Virtually every hazard has the potential of isolating Everett neighborhoods. Western neighborhoods are built on steep slopes with poor soils, they have few roads and are serviced by bridges that are susceptible to failure. Fires or material spills can cause isolation by limiting road access. Similarly, the Burlington Northern and Santa Fe (BNSF) railroad is at risk of losing connectivity, should a landslide or bridge failure affect part of the line. The effects of isolation are compounded because, even if a disaster causes minimal damage to structures, people could be trapped within their neighborhoods without access to services. Businesses face similar risks from isolation. It is essential to limit this potential isolation to ensure the social and economic resiliency of Everett's communities.

Opportunities to Build Upon

Strong and Trusted Government

Everett has a strong and trustworthy government. The Mayor's Office, City Council, Public Works, Police, Fire, Office of Emergency Management, Office of Neighborhoods and other city departments consistently maintain a strong public presence through outreach and community events.

Strong Economy and Fiscal Stability

Everett has a strong economic base. This strengthens Everett's ability to prepare for and recover from hazardous events. The city's fiscal situation has remained strong throughout the 2007-2009 economic downturn and recovery, ensuring that basic resources necessary for public safety and hazard mitigation, while not limitless, are not eliminated.

Community Emergency Response Support

The Community Emergency Response Team (CERT) program has successfully trained 388 graduates throughout the city, and CERT volunteers remain among the most active community members, conducting public outreach and education throughout the city.

Well-Developed Neighborhood-Based Public Outreach Network

Everett has been innovative in quickly and efficiently disseminating information across large segments of the city's population. Through the commitment of the Office of the Mayor and its hiring public outreach staff for the Office of Emergency Management, and through the Office of Emergency Management's subsequent development of a "network of networks," Everett has improved its capacity to share information and educate the population. The city neighborhood organization and their efforts with "Map your Neighborhood" have also increased the cities outreach capabilities.

Stable Topography

Everett forms a peninsula of elevated stable ground surrounded on three sides by Puget Sound to the west and the Snohomish River to the north and east. The high ground is for the most part comprised of hardened soil compressed under a series of glaciers. The more vulnerable areas are the coastal floodplains, including a mix of landslide deposits and river outwash, where short drainages have cut through what residents call "hard pan." These hard soils are evidence of earthquake resilient soils that are present high above the surrounding floodplain.

Inter-'Island' Connections

Earthquakes and winter storms can isolate neighborhoods, creating 'islands' within the city. Although Everett, as well as each of its neighborhoods, is susceptible to isolation caused by hazard events, the availability of many alternative forms of transportation strengthens the community's resilience and provides connections among these islands. Port facilities, major roads, rails, and nearby airports have created redundancy in both facilities and transit modes.

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ALS	Advanced Life Support
BLS	Basic Life Support
BNSF	Burlington Northern/Santa Fe
CCD	Census County Division
CERT	Community Emergency Response Team
DMA	Disaster Mitigation Act
DRAC	Disaster Reconstruction Assistance Center
EERT	Employee Emergency Response Team
EFD	Everett Fire Department
EHS	Extremely Hazardous Substances
EPCRA	Emergency Planning and Community Right-to-Know Act
EPD	Everett Police Department
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
GIS	Geographic Information System
GMA	Growth Management Act
HIVA	Hazard Inventory and Vulnerability Analysis
HMGP	Hazard Mitigation Grant Program
HMP	Hazard Mitigation Plan
I-5	Interstate 5
IBC	International Building Codes
IPT	Industrial Pretreatment
LEPC	Local Emergency Planning Committee
LPG	Liquefied Petroleum Gas
MLLW	Mean Low Water
MM	Modified Mercalli
MPH	Miles Per Hour
NEHRP	National Earthquake Hazards Reduction Program
NFIP	National Flood Insurance Program
PGA	Peak Ground Acceleration
PSE	Puget Sound Energy
PTWC	Pacific Tsunami Warning Center
PUD	Public Utility District
R	Richter
RCW	Revised Code of Washington
SARA	Superfund Amendments and Reauthorization Act

SCT	Snohomish County Tomorrow's
SEPA	State Environmental Policy Act
SERC	State Emergency Response Commission
SERS	Snohomish County Emergency Radio System
SMA	Everett Management Act
SNODEM	Snohomish County Department of Emergency Management
SNOPAC	Snohomish County Police Staff & Auxiliary Service Center
SR-99	State Route 99
TPQ	Threshold Planning Quantity
TWS	Tsunami Warning System
UBC	Uniform Building Code
UGA	Urban Growth Area
USGS	United States Geological Survey
WAC	Washington Administrative Code
WSDNR	Washington State Department of Natural Resources
WSDOE	Washington State Department of Ecology
WSDOH	Washington State Department of Health
WRIA	Water Resource Inventory Area
WSDOH	Washington State Department of Health
WSDOT	Washington State Department of Transportation

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Section I
Introduction

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Introduction

Purpose

This document is an update to the 2006 Hazard Identification and Vulnerability Analysis (HIVA). Hazard identification is the systematic use of available information to determine what types of disasters may affect a jurisdiction, how often these events are likely to occur, and the potential severity of their consequences. Vulnerability analysis refers to the process used to determine the impact these events and their collateral effects might have on the built and natural environments and systems.

2011 Update

This section has been edited to include additional hazards identified in the Everett Hazard Mitigation Plan, as well as to reflect a new order of importance for the hazards as decided in a December 2010 meeting with Everett's Hazard Mitigation Steering Committee (HMSC).

This document provides information associated with the most probable disaster events that could impact Everett. The processes of hazard identification and vulnerability analysis serve as a foundation for the development of mitigation strategies where appropriate; and for strategies to help prepare for disasters when mitigation is not possible. In cases where preparation is not possible, it shows response strategies for allocating resources and setting priorities to ensure the safety of the public.

The HIVA describes natural hazards that have the potential to impact the people, economy, environment, and property within Everett, Washington. It serves as a basis for citywide emergency management programs and assists local entities in the development of similar documents focused on local hazards. It is the foundation of effective emergency management, and identifies the hazards that local organizations must mitigate, prepare for, respond to, and recover from in order to minimize the effects of disasters.

The HIVA presents an overview of hazards that can cause disasters, as well as the potential vulnerabilities to these hazards. This document expands on information concerning significant hazards detailed in the Washington State HIVA and the Snohomish County HIVA.

In order of importance as set forth by the Everett Hazard Mitigation Steering Committee, these hazards include:

1. Earthquakes
2. Severe Storms
3. Pandemics
4. Climate Change
5. Fire
6. Flooding
7. Hazardous Materials
8. Landslides
9. Tsunami & Seiche
10. Volcanic Eruptions

Terrorism and technological (human caused) disaster mitigation, with the exception of hazardous materials included here, will be addressed in the City of Everett's Terrorism Annex of the Comprehensive Emergency Management Plan (CEMP) which is maintained as confidential information in accordance with the Revised Code of Washington (RCW) 42.56.420 (1) (a).

Criteria and Authority

This document provides information associated with the most probable disaster events that could affect Everett. This plan meets the requirements of the DMA 2000 and the Washington Administrative Code (WAC 118-30-060 (1)) and will be the basis for City of Everett Hazard Mitigation Planning efforts. State law requires all political subdivisions to have an emergency management plan. Chapter 118-30 Washington Administrative Code requires that emergency management plans be based on a written assessment and listing of the hazards to which the political subdivision is vulnerable. This document fulfills the written assessment requirement and is the basis for the City of Everett Comprehensive Emergency Management Plan (CEMP).

Scope

This document addresses potential local disasters and their impacts. Within this scope the plan will:

- Identify probable hazards to which the city may be exposed
- Profile hazard events
- Assess impacts, determine exposure, identify assets, and analyze vulnerability
- Present potential mitigation measures and associated preparedness, response and recovery measures

This plan is applicable for all agencies, organizations, entities, and individuals within the boundaries of the city limits, including city departments and divisions.

Some hazards require in-depth scientific and quantifiable analysis to justify expenditure of money and personnel resources. As an example, floodplain studies may require:

- Mitigation, including building of dikes, dredging of river channels, or removing people and structures from harm's way and allowing for open space
- Preparedness, including public education and sandbag storage
- Response, including evacuation and sheltering of people and pets
- Recovery, including flood debris cleanup and repairs of damaged structures

Some detailed hazard analyses are contained within this plan; other specific hazard analyses may be located elsewhere in reports, programs, and plans (e.g. the Public Works Emergency Response Program and the Jackson Hydroelectric Project Emergency Action Plan). The 2011 Hazard Mitigation Plan, which was updated in tandem with the HIVA, details specific mitigation strategies and plans.

Definitions

Hazard: Any large-scale event, either natural or human-caused, that has the potential to damage property or endanger human life.

Mitigation: Defined by the Federal Emergency Management Agency (FEMA) as "actions that reduce or eliminate the long-term risk to people and property from the effects of hazards."[1] Examples can be structural or non-structural, including municipal or county code that requires earthquake retrofitting or requires higher regulatory standards for new development in floodplains. Mitigation can also include coalition building among organizations to improve their ability to educate the public about risk.

2011 Update

This section has been changed to include definitions of disaster, benefit, and opportunity, and to broaden the definition of risk.

Emergency Preparedness: The steps taken to continuously prepare for human needs during or after an event. Examples of preparedness measures include having enough water and food on hand, or having a plan to reconnect with family members should a disaster occur.

Vulnerability: Any structures and systems in the path of a hazard.

Risk: A function of population or property exposure and vulnerability to a hazard and the frequency with which that hazard occurs.

Disaster: A realized risk.

Opportunity: A positive outcome from the combined interactions of a change event (such as a natural hazard), vulnerability (such as a residential unit), and capabilities (such as mitigation grants).

Benefit: A realized opportunity.

Critical Infrastructure: Any roads, bridges, emergency response facilities, utilities (such as water, electricity and sewer), or other facilities critical to the health and welfare of the population, which are especially important following a hazard event.

Geographic Information System (GIS): A computer software application that relates physical features on the earth to a database. It is mainly used for mapping and analysis. This plan used GIS analysis extensively.

Project Planning Team: The researchers and coordinators from the Institute for Hazard Mitigation Planning and Research at the University of Washington who completed this plan.

1 Federal Emergency Management Agency. (2000). FEMA Document 364: Planning for a Sustainable Future: the Link Between Hazard Mitigation and Livability. Author, 1.

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Section II
Community Profile

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Community Profile

History of the City

Originally called Port Gardner Bay by European settlers, the peninsula now known as Everett, Washington had previously been the home of the Snohomish Tribe. (The tribe was later "restructured" as part of the Tulalip Tribe Confederation with their reservation located north of the city.) In the late 18th and early 19th centuries, with government-granted homesteads and the lure of the region's vast natural resources, European and American settlers began immigrating here from the east.

2011 Update

This section has been edited to reflect data from the 2006-2008 American Community Survey data. Non-substantive changes were made to the phrasing in some of this section.

Named after the son of investor Charles Colby, Everett incorporated as a city in 1893. It began its industrial growth during the late 1890s, containing amongst other industry, a paper mill, smelters, and a nail factory. By the 1900s, the city began growing exponentially. New expansion coincided with the arrival of immigrants, and the city's population tripled over the next decade, from around 8,000 in 1900 to 24,000 in 1910.

By design, Everett set aside most of its waterfront for industry that, by then, included lumber and shingle mills, wood products manufacturers, iron works, shipbuilders, fisheries, and canneries. By 1920, the city had established itself as an international port dominated by the lumber-shingle trade. The lumber-shingle predominance eventually gave way to the papermaking of Weyerhaeuser, Scott (later Kimberly Clark), and the Lowell Paper Mill. Then, as the timber economy began to wane regionally, the city welcomed a shift to aerospace with the arrival of Boeing in the 1960s.

Today Everett enjoys a diverse economy that still has strong roots in its industrial past. In the 1990s, the location of the Navy on Everett's waterfront helped, along with the aerospace, technology, manufacturing and government business, to make Everett a prominent city in the Puget Sound.

History of Disasters

The city of Everett has historically suffered from several different disasters. The Hazard Profile and Vulnerability Assessment section of this document details hazard-specific historic events in Everett.

Geographical Setting

Geography

Everett is the seat of Snohomish County and is its largest city. The city is located at the delta of the Snohomish River in the west central portion of Snohomish County. It borders Port Gardner Bay and includes approximately 15% tidal water within its area of 47.7 square miles. Figure 1 provides a contextual map for Everett and Snohomish County.

Figure 1: Vicinity Map of Snohomish County[2]

Rivers and Streams

The city of Everett is located at the delta of the Snohomish River, which flows from the east and is fed by the Snoqualmie and Skykomish Rivers. Everett is predominantly located within Water Resource Inventory Area (WRIA) 07, otherwise referred to as Snohomish. Most of Everett south of Casino Road is in Lake Washington Water Resource Inventory Area (WRIA) 08.

Mountains and Volcanoes

The Cascade Mountains border the eastern portion of Snohomish County. The nearest volcanically active mountain is Glacier Peak, fifty miles to the east and slightly north.

Forest Resources

The city of Everett has forest resource lands within its watershed in the Sultan River Basin. Much of the county agricultural and forestlands are located in the central and eastern portions of the county.

Soils and Geology

The area surrounding Everett, in the southwest portion of Snohomish County is rich in alluvial and glacial deposits. The physiography of the county includes:

- Nearly level alluvial deposits along the major river valleys
- Glacial till plains, outwash plains, and terraces in the middle of the county
- Mountainous areas in the eastern part of the county

The basic drainage flow is from the Cascade Mountains in the east to the Puget Sound in the west. The North Fork of the Stillaguamish River, along the northern edge of the county, begins at the town

2 Seattle Times. "Snohomish County." Accessed online on 02/23/2011 from http://seattletimes.nwsource.com/art/ news/local/Snohomish/map/snohomish.gif

of Darrington and drains into the Puget Sound. The South Fork, which is in the center of the county, begins at Granite Falls and joins the North Fork at the town of Arlington. The Skykomish River begins at the town of Index in the southern part of the county, flows westerly through the towns of Sultan and Monroe, and joins the Snoqualmie River near the town of Snohomish to form the Snohomish River. The Snohomish River flows northwesterly through Everett to the Puget Sound.

The types of soils found in western Snohomish County and under Everett are primarily Alderwood-Urban Land Complex Soils, at 2%-8% slopes.[3] Alderwood Gravelly Sandy Loam Soils at 15%-25% slopes makes up the second most common soil type in the area. Other soils present in and around Everett include Indianola loamy sand, Kitsap silt loam, Norma loam, and Tokuls gravelly loam at various slopes.

Climate

The annual precipitation around Everett averages 37.8 inches per year. November, December and January are generally the rainiest months of the year while July and August are the driest. Snowfall, which is a rare occurrence, is generally heaviest in the months of December, January, and February. The average temperature in Everett is fifty-one (51) degrees Fahrenheit. Temperatures typically range from seventy-four (74) degrees Fahrenheit during the summer to thirty-three (33) degrees Fahrenheit in the winter, but may experience even greater extremes in severe weather incidents.

Demographics

Why Consider Demographics in Hazard Mitigation Plans?

Effective disaster plans must have a full understanding of all potentially affected population. Certain populations experience a greater risk from disasters. The elderly are more likely to be injured during a disaster, and more likely to need additional assistance after the event. Households and individuals living at or below the poverty line may lack the financial and educational resources to prepare their own survival strategies. At varying levels women, children, and the disabled suffer more from disaster than others in the general population.

The remainder of this section will detail the potentially vulnerable populations residing in Everett.

The city will continue to experience growth because of its location and economic opportunity. Growth will bring an increasing number of potentially vulnerable populations, including:

- Elderly residents (65 and older) in assisted living facilities and living on fixed incomes
- Residents with special needs
- Children

The data for this section is primarily from the United States Census' American Community Survey 2006-2008 Population Survey Estimates. This data is the most precise available with the smallest incidence of error. Additional data was taken from the City of Everett's business information website.

Income

Low-income people experience greater impacts from disasters compared to other members of the general population. Individual households are expected to use private resources to prepare for and

3 United States Department of Agriculture, Natural Resources Conservation Service. "Web Soil Survey." Accessed online on 02/24/2011 from http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

recover from disasters. This expectation means that households living in poverty are at a disadvantage when confronting hazards. Additionally, the impoverished are more likely to occupy poorly-built and inadequately-maintained housing. Mobile or modular homes are more susceptible to damage in hurricanes, tornadoes and floods than other types of housing. The impoverished are more likely to be impacted by disaster, and less likely to fully recover, because of lower-quality housing, less education, and scarcer resources necessary for applying disaster mitigation and recovery strategies.

Compared with the rest of Snohomish County, Everett has a lower median household income by nearly 25%. Nearly 13% of the population is below the poverty level. Table 1 shows a comparison of median household income in Everett, Snohomish County and Washington State.

Table 1: Comparison of Median Household Income[4]

	Median Household Income	Population below poverty level	Children below poverty level	Elderly below poverty level
City of Everett	$49,392	16.6%	25.2%	12.9%
Snohomish County	$65,886	7.8%	10.4%	7.8%
Washington State	$57,234	11.6%	15.1%	8.4%

Age Distribution

The vulnerability of elderly populations can vary quite significantly based on health and economic security. As a demographic, the elderly are more likely than other populations to lack the physical and economic resources necessary for response, to suffer health-related consequences, and to be slower to recover from a major hazard incident.[5] They are more likely to be vision, hearing, and/or mobility impaired, or to experience some form of mental impairment. Furthermore, some of the elderly live in assisted-living facilities, where emergency preparedness requires special considerations. The specific planning attention required for the elderly is becoming increasingly important with the aging of the general American population.

The city of Everett has a younger median age than that of Snohomish County: 33 years of age versus 36.6 years of age for the county. Approximately 65% of the population is under 45 years of age, with the largest proportion of residents falling between 25 and 34 years of age (18.1%).

Table 2 shows the age distribution for the city and the county with the most vulnerable population cohorts highlighted. The city has an equal or higher percentage of population than the county in all but two (ages 5 to 9 and 64 to 74) of these vulnerable age cohorts.

Table 2: Age Distribution in Everett and Snohomish County[6]

Age Cohort (years)	Snohomish County Population*	Snohomish County %	Everett Population	Everett %
0 to 4	45,577	6.8%	8,411	8.2%
5 to 9	46,146	6.9%	6,576	6.4%
10 to 14	47,662	7.1%	5,586	5.5%
15 to 19	47,162	7.0%	3,418	6.2%
20 to 24	41,222	6.1%	8,220	8.0%
25 to 34	93,323	13.9%	18,465	18.1%

4 United States Census, American Community Survey, 2006-2008
5 Morrow, Betty Hearn. "Identifying and Mapping Community Vulnerability." *Disasters,* 23 (1) 1- 18, 1999.
6 United States Census, American Community Survey, 2006-2008

Age Cohort (years)	Snohomish County Population*	Snohomish County %	Everett Population	Everett %
35 to 44	104,833	15.6%	13,610	13.3%
45 to 54	109,858	16.3%	15,252	14.9%
55 to 59	42,727	6.3%	5,617	5.5%
60 to 64	31,142	4.6%	3,788	3.7%
65 to 74	35,173	5.2%	4,831	4.7%
75 to 84	20,623	3.1%	3,765	3.6%
85 +	8,158	1.2%	1,588	1.5%
Total	673,606	100.0%	102,050	100.0%

The Disabled

Disabilities include physical and mental impairments that limit major life activities. This definition does not include the ever-growing group of senior citizens who have a greater number of specials needs, including dementia and Alzheimer's Disease. The Emergency Planning and Community Right to Know Act (EPCRA) and the American with Disabilities Act (ADA) impact local planning decisions.

Race, Ethnicity, and Language

Many researchers have focused on the increased disaster vulnerability that ethnic minorities experience in the United States. Research shows that minorities are less likely to be involved in pre-disaster planning and experience higher mortality rates during a disaster. Furthermore, because higher a proportion of minorities live below the poverty line than the majority population, poverty compounds their vulnerability.

The population of Everett has been generally homogeneous, but is growing more diverse. About 81.1% of the population described themselves as white alone on the 2000 Census. According to the most recent American Community Survey three-year data (2006-2008), 78.6% of Everett identify themselves as white alone. About 93% of the population reported in the 2000 census that they speak only English, while about 8% reported speaking a language other than English, but only 1% of this population reported that they speak English "less than very well." There is some evidence that indicates that this may be changing with the growing proportion of Hispanic or Latino residents and with a decrease to about 80% of the population speaking only English.[7] This indicates that while linguistic isolation may not represent a major percentage of the city's population, appropriate consideration of language options should be included during plan development to offset the documented vulnerability of diverse populations.

Table 3: Race and Ethnicity in the City of Everett[8]

Race	Population in City of Everett	Percentage (%)
Total Population (2000 US Census)	102,050	100.0%
White	80,173	78.6%
Black or African American	3,390	3.3%
American Indian and Alaska Native	790	0.7%
Asian	7,990	7.8%

7 United States Census, American Community Survey, 2006-2008
8 United States Census, American Community Survey, 2006-2008

Race	Population in City of Everett	Percentage (%)
Native Hawaiian and Other Pacific Islander	1,004	0.9%
Some other race	4,170	4.1%
Two or more races	4,533	4.4%
Hispanic or Latino (of any race)*	12,515	12.3%
* Hispanic/ Latino designation is not considered a race by the Census, so therefore individuals selecting Hispanic/Latino ethnicity are also already included in another category for race.		

Economy

Historically, Everett has been an industrial and manufacturing town. The city has many large employers including, but not limited to, Boeing, Kimberly Clark, the Port of Everett, and various service and retail businesses. Everett's manufacturing sector provides the most jobs in the city at 20.8%; educational, health and social services employ 14.9% of the city; while retail, at 13.0%, is the third largest employment sector in the city. In total, Everett has 73,455 jobs.[9]

In Everett, approximately 68.7% of all workers over the age of sixteen commuted to work alone, while a significantly smaller amount, 4% used mass transportation.

2011 Update

This section has been edited to reflect the 2006-2008 American Community Survey data.

Housing

Everett has 44,109 housing units, with 92.4% occupied as of the 2006-2008 ACS.[10] Table 4 details the distribution of these units between renters and owners. With the identification of renters in the city, the agencies responsible for emergency management are better able to plan for these populations.

Table 4: Housing Tenure in Everett

Housing Units	Total	Percentage (%)
Occupied housing units	40,773	100%
Owner-occupied housing units	18,973	46.5%
Renter-occupied housing units	21,800	53.5%

Table 5 details the household types in Everett.[11] Potentially vulnerable populations are highlighted.

Table 5: Household Types in Everett

Households by Type	Total	Percentage (%)
Total households	40,773	100%
Family households (families)	23,457	57.5%
With own children under 18 years	**12,329**	**30.2%**
Married couple family	15,418	37.8%

9 United States Census Bureau. 2000. "DP-3. Profile of Selected Economic Characteristics: 2000." Accessed online on February 27, 2011 from http://factfinder.census.gov/servlet/QTTable?_bm=y&-geo_id=16000US5322640&-qr_name=DEC_2000_SF3_U_DP3&-ds_name=DEC_2000_SF3_U&-_lang=en&-_sse=on

10 United States Census, American Community Survey, 2006-2008

11 United States Census, American Community Survey, 2006-2008

Households by Type	Total	Percentage (%)
With own children under 18 years	6,702	16.4%
Female householder, no husband present	5,517	13.5%
With own children under 18 years	3,988	9.8%
Non-family households	17,316	42.5%
Householder living alone	13,707	33.6%
Householder 65 years and over	**3,735**	**9.2%**
Households with individuals under 18 years	**13,106**	**32.1%**
Households with individuals 65 years and over	**7,262**	**17.8%**

Law

Federal

Disaster Mitigation Act (DMA 2000)

The Disaster Management Act of 2000 (DMA 2000) is the latest legislation to improve the hazard mitigation planning process. It reinforces the importance of mitigation planning and emphasizes planning for disasters before they occur. It specifically addresses planning at the local level, requiring plans to be in place before Hazard Mitigation Grant Program (HMGP) funds are available to communities. This plan meets the requirements of DMA 2000, improving the City of Everett's eligibility for future mitigation funds.

2011 Update

This section has been expanded to include the National Flood Insurance Program (NFIP), to correct the name of the Everett Municipal Code, and to include Everett's Comprehensive Plan Update.

Endangered Species Act (ESA)

The Endangered Species Act (ESA) was enacted in 1973 to conserve any species, and the ecosystems that support them, that are facing depletion or extinction. The act sets forth a process for determining which species are threatened and endangered, and requires the conservation of the critical habitat in which those species live.

Within Everett, there are endangered or threatened species that require protective measures, including orcas and several species of salmon. This affects the hazard mitigation planning process in several ways. In Everett, floods can sometimes negatively affect salmon habitat by damaging riparian vegetation. The ESA does not require flood control, but its emphasis on habitat does make flood control more important. The ESA may also eliminate some of the structural options sometimes used for flood control, such as dams, dikes, and dredging, which can adversely affect critical fish habitat. Additionally, riparian zone development is sometimes limited because of ESA regulations. Reduced or more environmentally conscious development can reduce flood risk.

National Flood Insurance Program (NFIP)

Established in 1968 by the National Flood Insurance Act, FEMA's Flood Insurance and Mitigation Administration runs the National Flood Insurance Program (NFIP). It includes a flood insurance program, directs floodplain management, and maps flood hazards. Community participation in the NFIP is voluntary, and contingent upon adaptation of a floodplain management strategy. Everett has been a participant in the NFIP since 1978. FEMA has recently created new floodplain maps for Everett, but is re-examining those maps to determine if they correctly incorporate tidal influences.

In 2008, the National Marine Fisheries Service issued a Biological Opinion in response to a lawsuit against FEMA and the NFIP filed by the National Wildlife Federation. The lawsuit claimed that implementation of the NFIP was responsible for damaging endangered species habitats, including salmon habitats, in the Puget Sound. This opinion will change how the NFIP is implemented in Everett, as more mitigation efforts may be required for the program.[12]

State

Growth Management Act (GMA)

In 1990, the Washington State Legislature adopted the Growth Management Act (Chapter 36.70A RCW). The Growth Management Act (GMA) mandates that local jurisdictions adopt ordinances that classify, designate, and regulate land use in order to protect critical areas. According to the code, "critical areas" include the following areas and ecosystems: (a) wetlands; (b) areas with a critical recharging effect on aquifers used for potable water; (c) fish and wildlife habitat conservation areas; (d) frequently flooded areas; and (e) geologically hazardous areas (RCW 36.70A.030).

In relation to this plan, Everett's critical areas include the 100-year floodplain, streams and wetland areas, hillside development and geologically hazardous areas, and fish and wildlife habitat. The state GMA regulates development in these areas and, therefore, has the potential to affect hazard vulnerability and exposure at the local level.

Shoreline Management Act (SMA)

The Shoreline Management Act (RCW 90.58) of 1971 is meant to manage and protect the shorelines of the state by regulating development in the shoreline area. A major goal of the act is "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines."

The SMA is important to this plan because some of the areas it governs are floodplains. The SMA regulates development in these areas, which furthers the goal of limiting exposure to flood risk. In Everett, this area includes the floodplains of the Snohomish River, the marine shoreline along Port Gardner Bay, and Silver Lake.

State Environmental Policy Act (SEPA)

The Washington State Environmental Policy Act (SEPA) provides a way to identify environmental impacts that could result from governmental decisions in Washington jurisdictions. These decisions could affect the issuing of permits for private projects, the construction of public facilities, or the adoption of regulations, policies or plans.

Information provided during the SEPA review process helps agency decision-makers, applicants, and the public understand how a proposal will affect the environment. This information can change a proposal to reduce likely impacts, or to deny a proposal when adverse environmental impacts are identified.

City

The Comprehensive Plan

The Comprehensive Plan (Comp Plan), first adopted in 1994, with its most recent update in 2007, is the policy document that guides the growth of Everett until 2025. It includes the required elements on Land Use, Housing, Capital Facilities, Utilities, Transportation, and Shoreline Master Program, plus

12 Federal Emergency Management Agency. 2011. "NFIP and the Endangered Species Act." Accessed online on February 27, 2011 from http://www.fema.gov/about/regions/regionx/nfipesa.shtm

additional elements on Urban Design, Historic Preservation, Parks and Recreation, and Economic Development. Updates are required every ten years, with the next update scheduled for this year. The Comp Plan guides city growth by defining the:

- Desired type, level and spatial distribution of population and job growth
- Transportation, utilities and public facilities necessary to serve this population and employment
- Methods of paying for this infrastructure
- Housing requirements for the community
- Desired physical character of city growth

City of Everett Municipal Code

The Zoning Code defines the uses and densities for certain zones and the standards required for development, such as lot size, setbacks, height, parking, and landscaping. Sections of the City of Everett Municipal Code that directly address hazard mitigation (hazards covered are in parentheses) are:

- Title 8: Health & Safety (Wildfire & Severe Weather)
- Title 14: Water & Sewers (Hazardous Materials & Floods)
- Title 16: Buildings & Construction (Seismic & Urban Fire)
- Title 19: Zoning (Floods, Landslide, Seismic, & Hazardous Materials)
- Title 20: Environment (Hazardous Material, Seismic, & Landslide)

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Section III
Hazard Profile and Vulnerability Assessment

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Hazard Profile & Vulnerability Assessment

Assessment Methodology

The planning team used the most common methodology for assessing hazards and their potential effects on Everett. First, the team identified and profiled the hazards. Then they determined the exposure to those hazards and the vulnerability of what was exposed. Finally, they weighted those factors to measure the combined risk each hazard poses to the city.

2011 Update

This section has been updated to reflect a newer version of ArcGIS and indicate new data sources.

Identifying and Profiling Hazards

This assessment includes the following information for each hazard:

- Geographic areas most affected
- Event frequency estimates
- Severity
- Warning time likely for response
- The identification of associated secondary hazard events

Determining Exposure

Exposure was determined by overlaying hazards with an inventory of potentially vulnerable structures, facilities, and systems to determine which of them are vulnerable to each hazard. The City of Everett and Snohomish County's GIS database contains extensive coverage of city resources that include infrastructure, homes, industry, roads, bridges, pipelines, hazardous material storage sites, and water mains. Exposed resources are those that could be affected or influenced by a hazardous event or condition.

Assessing Vulnerability

Vulnerability of the exposed structures and infrastructure was determined by interpreting the potential weaknesses and problems associated with any particular resource. For example, a structure built before the adoption of the Uniform Building Code (UBC) in 1972, may be more vulnerable to a seismic event than a structure built later.

Determining Risk

Risk was determined by first describing a most probable hazard scenario or impact that might affect Everett. Using this scenario, the project team estimated future expected losses from hazard events. The last section of the risk assessment summarizes the overall risk by assigning each hazard a risk rating. Risk, in short, is the intersection of a natural hazard event, an exposed resource, and a vulnerable population or condition. As an example, a rotting tree branch only poses a risk in severe winds if there is a potential exposed population or critical infrastructure that is located below the tree.

Data Sources

This HMP gathered information 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 project team mapped each hazard location using ArcGIS 9.3. The primary data source was the City of Everett and Snohomish County's GIS database, in addition to other sources. For hazards not mentioned below, the general data sources previously described were employed.

Hazard-Specific Data Sources

Earthquake

The City of Everett provided earthquake maps with information about known faults, soil types and liquefaction zones, the combination of which define what areas are most susceptible to shaking during a quake. The Everett project team also used HAZUS (MR4), a GIS-based loss estimation tool developed by FEMA, to model earthquakes in the region.

Flood

Flood maps were primarily drawn from Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Map (DFIRM) files, which define the FEMA mapped floodplain and floodway. Current DFIRM map adoption is on hold while FEMA resolves recently identified mapping issues.

Hazardous Materials

The Hazardous Materials Inventory, published by the Washington State Department of Ecology (WSDOE), provided much of the data for this section. The Washington State Department of Health (WSDOH) provided health and injury information.

Presidential Disaster Declarations

Presidentially declared disasters are typically events that exceed the capability of local and state government response. The financial burden of response and damages must be documented by the State and submitted via the Governor to the President. Once a particular dollar amount (adjusted for inflation) per capita is reached, it triggers federal assistance programs. A Presidential Major Disaster Declaration puts long-term federal recovery programs into motion, some of which can be matched by state programs that are designed to help disaster victims, businesses and public entities. Table 6 lists all presidentially declared disasters in Snohomish County; those directly affecting Everett are highlighted.

2011 Update

This section has been updated to include declarations after 2003, as well as a summary of the reimbursement requests from Everett for the same period.

Table 6: Snohomish County Presidential Disaster Declarations

Disaster	Type of Event	Date
137	Flood, Wind	October-62
185	Flood	December-64
196	**Earthquake**	**May-65**
492	Flood	December-75
545	Flood, Landslide	December-77
612	Flood	December-79
623	Volcano	May-80
784	Flood	November-86
883	Flood	November-90
896	Flood	December-90
981	Wind	January-93
1079	Flood	November-December 95
1100	Flood	Jan-Feb 96
1159	**Ice, Wind, Snow, Landslide, Flood**	**December 96-February 97**
1172	Flood, Landslide	March-97
1361	**Earthquake**	**February-01**
1499	**Severe Storm, Flooding**	**November-03**
1641	**Severe Storm, Flood, Landslide**	**May-06**
1671	**Severe Storm, Flood, Landslide**	**December-06**
1682	**Severe Winter Storm**	**February-07**
1734	**Severe Storm, Flood, Landslide**	**December-07**
1817	**Severe Winter Storm, Flood, Landslide**	**January-09**
1825	**Severe Winter Storm**	**March-09**

Critical Infrastructure

Critical infrastructure is defined as systems, facilities and functions that are critical to the health and welfare of the population. It also includes the functions, facilities, and physical structures that support the infrastructure. The Department of Homeland Security lists the three key elements of critical infrastructure as: human, property and cyber. Included under these elements are the following key sectors:

- Agriculture and Food
- Public Health and HealthCare
- Water
- Energy
- Banking and Finance
- National Monuments and Icons
- Defense Industrial Base
- Information Technology
- Telecommunications
- Chemical
- Transportation Systems
- Emergency Services
- Postal and Shipping
- Dams
- Critical Manufacturing Sector
- Government Facilities
- Commercial Facilities
- Nuclear Reactors, Materials and Waste

Everett has also defined Schools and Housing as critical infrastructure.

This section provides the results of an exposure analysis that determined how critical infrastructure could be affected by hazards. In general, Everett's critical infrastructure is exposed to several hazards due to its varied geographic distribution. A listing of facilities by location, highlighting those exposed to hazards, follows in the vulnerability assessment section of this document.

Government, Emergency Services, Public Health, and Education

The main offices for the City of Everett are largely located in downtown Everett, in the Wall Street Building on 2930 Wall Street. Due to the diverse nature of managing a medium to large city, administrative offices in Everett are also located in various other locations. Detailed below are some of the critical facilities and infrastructure in Everett, with a partial list of their functions. The list and map is not exhaustive, but rather provides examples of what types of facilities are critical to city operations and management. This section also considers limitations in data and the potential changes to facility location and systems after the publication of this plan.

2011 Update

The analysis area boundary for the HIVA analyses was changed from the urban growth area to the City of Everett boundary in order to focus plan elements on those areas over which the City of Everett has jurisdiction.

The Police Administration Office and North Headquarters of the Everett Police Department (EPD) are located at 3002 Wetmore Avenue in downtown Everett. The EPD divides its service into a north and south patrol, with the latter opening a south precinct in 1999 to better serve the Everett community. The Crime Prevention Program of the Everett Police Department provides citizens with education and outreach, including a Neighborhood Watch program.

The South Everett Police Headquarters is located at 1121 SE Everett Mall Way. This facility, purchased in 1999, houses the Everett Police Department on the ground floor, Snohomish County Police Staff & Auxiliary Service Center (SNOPAC) e-911 dispatch center, and Snohomish County Emergency Radio System (SERS).[13] Snohomish County participates in the emergency radio system with other local governments. The Cities of Brier, Edmonds, Everett, Lynnwood, Marysville, Mill Creek, Mountlake Terrace, Mukilteo, Woodway, and Snohomish County are jointly responsible for the financing of SERS. Everett's Office of Emergency Management maintains the City of Everett Emergency Operations Center (EOC) at the South Precinct and responds to crisis using the National Incident Management System (NIMS).

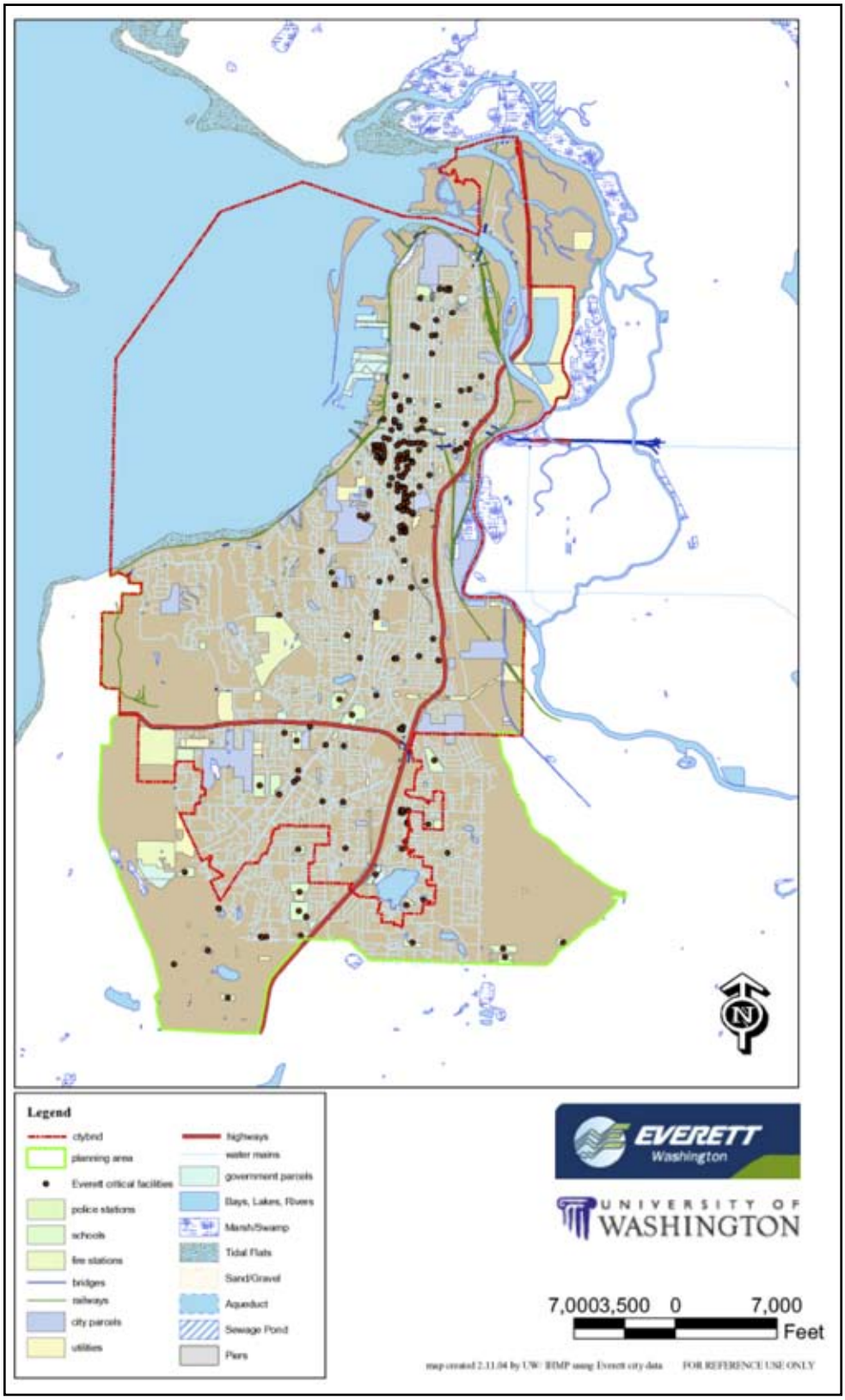
The City of Everett Fire Department (EFD) serves the city via six (6) fire stations and a central administrative complex, located on 2811 Oakes Avenue. The EFD staffs six (6) fire engines, two (2) ladder trucks, three (3) Advanced Life Support (ALS) Paramedic units, Hazardous Material response and rescue units, and one (1) Basic Life Support (BLS) unit, available twenty-four hours a day, seven days a week.[14]

While there are many health care facilities in Everett, there are two major hospitals: Providence Everett Medical Center Colby Campus, located on 1321 Colby Avenue, and its Pacific Campus, located on 916 Pacific Avenue. Since the previous plan update, the Center completed an extension to Providence's Colby Campus, which increases hospital capacity by around 200%.

There are many educational centers in Everett. While children are especially vulnerable during a hazard event, the Everett School District has paid considerable attention to disaster preparation. Where required, they have retrofitted school buildings with earthquake stability measures. The District must continue to pay special attention to addressing the vulnerabilities in school-related facilities and emergency preparedness. These retrofits were not considered during the previous vulnerability assessment conducted in 2006; however, they are considered in this update of the Hazard Mitigation Plan.

13 City of Everett website. "Everett Police." Accessed online on November 12, 2010 from http://www.ci.everett.wa.us/default.aspx?ID=53
14 City of Everett website. "Fire in Everett." http://www.ci.everett.wa.us/default.aspx?ID=44

Figure 2: Critical Facilities and Infrastructure



Critical Utilities and Transportation

Utilities

Everett's water distribution system relies primarily on gravity. The Water Filtration Plant, located at a higher elevation and east of the city, conveys water via three forty-eight-inch and one fifty-one-inch transmission lines to Everett and most of Snohomish County.[15] Sections of two of the forty-eight-inch lines have recently been replaced. The Kimberly-Clark paper mill draws untreated water from a dedicated open reservoir, while the city's potable water is treated and stored in large closed reservoirs and pumped to other water districts for distribution; this system provides water to 80% of Snohomish County.[16] The source of water is the Sultan Basin Watershed in the Cascade Mountains. The water collected in Spada Lake Reservoir is then diverted to the Lake Chaplin Reservoir, where it is treated in the Water Filtration Plant at the base of the fifty-foot earthen dam that defines the south-end of the reservoir. Public access is restricted at the Spada Lake Reservoir and other important locations along Everett's water treatment system.

The Water Pollution Control Facility, located on Smith Island in north Everett, handles wastewater for 136,000 people through 32 lift stations and 345 miles of sewer pipe located throughout the city.[17] The treatment facility consists of 157 acres of non-aerated ponds, 30 acres of aerated ponds, and a mechanical treatment unit that serves Everett and a small portion of the following:

- Alderwood Water District
- Silver Lake Water District
- Mukilteo Water District
- Snohomish County Landfill
- City of Marysville

Everett has two wastewater collection systems, with one serving the northern third of the city and one serving the southern two-thirds. The northern system combines both storm sewer drain and sanitary sewer and routes them to the facility. The southern system is designed to collect only sanitary sewage.

The city's wastewater system also requires that specific industries pre-treat their effluent before it enters the system. In 1987, the Everett Industrial Pretreatment (IPT) Program was started to help companies find ways to remove pollutants from their own wastewater. The IPT program monitors industries to help keep pollutants such as acids, solvents and heavy metals from entering the city's sanitary sewer lines.

The Snohomish County Public Utility District (PUD) No. 1 offices are located on 2320 California Street. The largest municipal corporation in the state has been providing electricity to Snohomish County and Camano Island since 1949. The service area of the Snohomish County PUD covers 2,200 square miles and maintains over 6,046 miles of distribution lines. The PUD serves 288,691 residential customers and 29,444 commercial customers.

Puget Sound Energy (PSE), based out of Bellevue, Washington, provides natural gas service to Everett. A project with Williams Northwest Pipeline Company is currently under review that would bring

15 City of Everett. 2009. "2009 Utilities Report." Accessed online on November 12, 2010 from http://www.ci.everett.wa.us/Get_PDF.aspx?pdfID=4043
16 *Ibid.*
17 *Ibid.*

natural gas supplies for power generation in Everett. The pipeline is scheduled to begin construction in 2012 for completion in the fall of that year.

Transportation

The major north-south route serving Everett. Interstate 5 (I-5), crosses over the Snohomish River floodplain at the northeast corner of the city. State Route 529, formerly the old Highway 99, also connects Everett to Marysville, providing a secondary north-south route across the Snohomish River delta. The major east-west route for Everett is State Route 2. US Highway 2 also crosses over the Snohomish River as it heads east. This highway parallels the Burlington Northern/Santa Fe (BNSF) railroad route that travels east towards the cities of Snohomish and Sultan and the Cascade Mountains. Other major routes directly serving Everett include Highway 99 to the north and south, and State Route 526, serving the southern areas of the city.

Snow routes along the interstate and major highways that serve Everett are primarily the responsibility of the Washington State Department of Transportation (WSDOT) and their highway maintenance division. While the service crews maintain the roads to provide a clear route, during periods of severe snow or ice storms, these routes may experience periods of closure.

The Burlington Northern/Santa Fe (BNSF) railroad travels along two separate routes through Everett. One line travels east-west through downtown Everett, traveling through the BNSF tunnel between California Street & Hewitt Avenue, just south of the Everett Fire Department Headquarters, emerging to the west along Everett's waterfront. The second line travels along the Snohomish River north, "around the horn," and splits, with one line going north to Canada, and the other continuing south to Seattle. This second line intersects the first line at the Everett waterfront and then follows the Puget Sound shoreline to Seattle. The Seattle Sounder uses the BNSF line through an agreement among Burlington Northern Railroad, Amtrak, Snohomish County, and Sound Transit. The Everett Amtrak Cascade Station is located at 3201 Smith Avenue, just southwest of the BNSF tunnel. Everett Station is an intermodal transportation center that serves as a hub for commuter and long-distance rail and bus service, and houses some classes for a number of learning institutions.

There are two major rail yards in Everett. Both the Delta Yard and West Yard, along Everett's waterfront, handle mixed traffic.

The Port of Everett, created in 1918, is situated on Port Gardner Bay at the mouth of the Snohomish River. The Port operates piers, wharfs, warehouses, and cold storage plants, together with rail, water and terminal facilities. The Port District encompasses major areas of western Snohomish County that include Everett. The Port operates eight berths on approximately one hundred acres of land. The three terminals (Hewitt, Pacific, and South) handle approximately one million tons of cargo per year and are served by the BNSF rail line. The terminals are concrete decks and piers and include a refrigerated warehouse, a log yard, an intermodal container facility and a 55,000-ton concrete storage dome. The Port also has a marina that provides moorage to approximately 2,000 vessels. While predominately open to the public, the marina provides moorage to commercial fishing vessels as well.

Jetty Island, owned by the Port of Everett since 1929, has provided a protected harbor and navigation channel since the late 1800s. The 2500-foot long, 15-foot Mean Lower Low Water (MLLW) high sand berm created from newly dredged material from the harbor bottom has provided a benefit to both the port activities and the environment by providing habitat for salmon as well as various birds, including bald eagles.

The Port also has future redevelopment plans, including business parks and residential developments. Several of these projects were placed on hold due to the recent economic downturn. Others

are currently under construction. Some recent and upcoming projects include the Waterfront Center business development and a new Port headquarters.

The city of Everett is serviced by one airport certified for carrier operations. Located just outside southern Everett, in Snohomish County, Paine Field is the largest nearby airfield outside of King County. The airport is home to 615 aircraft, services over 500 aircraft per day and has a portion of its flight path located over Everett.[18] Paine Field also provides all flight services for the Everett Boeing wide-body airplane factory, located just north of the airport.

Trends in Development

According to the Snohomish County Buildable Lands Report, the Buildable Lands program monitors the amount and density of residential, commercial, and industrial development that has occurred in Snohomish County and its cities since the adoption of each jurisdiction's GMA comprehensive plan. Under the GMA (RCW 36.70A.215), the county and cities are required to measure actual densities, and determine whether there is enough remaining residential, commercial, and industrial land supply within the designated Urban Growth Areas (UGA) to accommodate future growth.

In analyzing Everett's UGA targets, the planning team considered only the residential population targets contained in the Buildable Lands Report. For parcels exposed to natural hazards that were identified as buildable lands, planning could consider hazard mitigation as one of the goals for future decisions. Table 7 below details the parcels exposed to natural hazards within Everett. This table has been updated to reflect data changes. The number of parcels has changed considerably due to a change in the boundary used for analysis. For this update, the Everett city limits are used in place of the previously used Everett planning area. This change allows the plan to focus on all areas where the City of Everett has jurisdiction.

Table 7: Parcels Exposed to Natural Hazards

Natural Hazard Exposure	Number of Parcels	Percentage of Total (%)
Parcels	32,457	100%
Earthquake:		
NEHRP D Soils	5,579	17%
NEHRP E Soils	455	1.4%
NEHRP F Soils	2	<1%
Hazardous Material:		
Tier II Facility & Rail	1,500	4%
Interstate 5	5,661	16%
Landslide	847	2.6%
Flooding	196	0.6%
Severe Weather	32,457	100%
Volcano	32,457	100%

18 Paine Field website. "About Our Airport." Accessed online on February 28, 2011 from http://www.painefield.com/about.html

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Earthquakes

Definitions

Earthquake: 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: The measure of the strength of an earthquake, typically measured by the Richter (R) 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: A measure of the effects of an earthquake, based on the Modified Mercalli (MM) scale and is expressed in Roman numerals.

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

2011 Update

Updates for 2011 include minor wording and definition changes along with a revision of the South Whidbey Island Fault scenario based on new data provided by the State of Washington. This scenario is now shown to be significantly more destructive than previously thought.

Other changes: updated geologic data for the liquefaction susceptibility and seismic site class of Everett soils, updated information explaining that all Everett schools are now built and/or retrofitted to life safety codes, and consideration of unreinforced masonry structures in analysis.

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

Crustal Earthquake: A type of earthquake that occurs at a depth of five to ten miles beneath the earth's surface and is associated with fault movement within a surface plate.

Benioff Earthquake: Sometimes called "deep quakes," a type of earthquake that occurs in the Pacific Northwest when the Juan de Fuca plate breaks up underneath the continental plate, approximately thirty miles beneath the earth's surface.

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

Ground Rupture: A surface failure or deformation caused by earthquake-induced strong motion. Generally these occur above or near surface faults.

Un-Reinforced Masonry: Structures typified by load bearing walls or posts with no metal reinforcement. Elements, such as the wall, floor, and roof are rarely connected. These structures are extremely vulnerable to any situation that transfers energy in any direction except with the force of gravity (down).

Tilt-Up Building: A building constructed in a two-step process: First, slabs of concrete, which will become the walls, are cast horizontally on or off site. Then, after curing, they are lifted (tilted) with a crane and set on prepared foundations to form the exterior walls. The walls are then "tied" with rebar or other means to form economical means of constructing a building.

General Background

Earthquakes are naturally occurring groundshaking events caused by the 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 thousands of years. Sometimes the release occurs near the surface, and sometimes it comes from deep within the crust.

The impact of any earthquake event is largely a function of groundshaking, liquefaction, and distance from the source of the quake. Liquefaction occurs in softer, unconsolidated soils. A program called the National Earthquake Hazard Reduction Program (NEHRP) creates maps based on soil characteristics to identify locations potentially subject to liquefaction. Table 8 provides a description of the NEHRP soil classification.

Table 8: 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 NEHRP classification system was used for this earthquake analysis. The majority of Everett sits on NEHRP soil class C, which is relatively stable in the event of an earthquake. In Everett, the areas that will be most affected by ground shaking are located in NEHRP soil classes D and E. There are some small areas of F soils located in Everett, generally along the Snohomish River delta, around the Port of Everett and in the waterfront along the Puget Sound. There are very few structures on F soils.

The degree of 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 effects of the earthquake. Table 9 provides a comparison of peak ground acceleration to the MM intensity scale.[19]

Table 9: Modified 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.

19 Cascadia Region Earthquake Workgroup, Professor Anthony Qamar, University of Washington

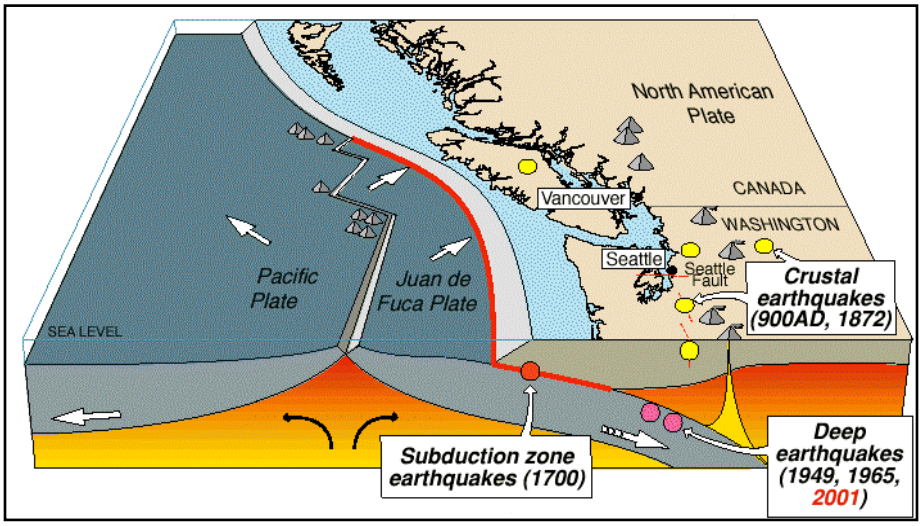
MM Intensity	Peak Ground Acceleration	Description of Intensity Level
III	0.003	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration similar to the passing of a truck. Duration 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 motorcars 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.
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 motorcars.
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, and 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.

* Peak Ground Acceleration over .7 are generally not differentiated due to the high level of associated damage.

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 four centimeters per year. The boundary where these two plates converge, the Cascadia Subduction Zone, lies approximately fifty 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: subduction zone, Benioff (deep) zone, and crustal zone. Figure 3 details the earthquake types affecting our region.

Figure 3: 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 Cascadia Subduction Zone since historic records began in 1790, similar subduction zones worldwide do produce "great" earthquakes – meaning a magnitude of 8 or larger. However, paleoseismic evidence suggests that there may have been as many as five of these devastating energy releases in the past 2000 years, with a very irregular recurrence interval of 150 to 1100 years. Written tsunami records from Japan, correlated with studies of partially submerged forests in coastal Washington and Oregon, give a probable date for the most recent of these huge quakes as January 26, 1700.[20]

A subduction zone 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, damaging tsunamis and numerous large aftershocks immediately follows this type of earthquake. The world's greatest earthquakes are observed at subduction zone boundaries. These magnitudes R8+ to R9.5 thrust-type subduction earthquakes occur from time to time as two converging plates slide past one another.

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 forty to sixty kilometers (twenty-five to thirty-seven miles) 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. The 2001 Nisqually earthquake was the most recent Benioff quake.

Crustal Zone

The third source zone is the crust of the North American plate. Of the three source zones, this is the least understood. The structure of the crust in the Puget Sound area is complex, with large sedimentary rock-filled basins beneath Tacoma, Seattle and Everett. Several sources of evidence lead to the

20 Tetra Tech. 2010. "Snohomish County Natural Hazards Plan Update Vol. I: Planning Area Wide Elements." 12-6.

conclusion that the Puget Lowland area is currently shortening north-south at a rate of about half a centimeter (one-fifth of an inch) per year. More than 90% of all Pacific Northwest earthquakes occur along the crustal plate boundary between the Juan de Fuca plate and the North American plate.[21]

Shallow earthquakes of magnitude up to R7+ can happen anywhere in the Puget Sound region. These earthquakes have the potential to cause greater loss of life and property in Snohomish County than any other kind of disaster.[22] Crustal earthquakes are the least predictable of Puget Sound's seismic threats, and also are the most likely to be followed by significant aftershocks. Following a great (R7.0+) crustal quake, one of the greatest dangers to human life is that buildings or other structures damaged in the initial shock, but still in use and believed to be safe, could collapse in a strong after-shock.[23]

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 forty kilometers. Historical events associated with this fault includes events that occurred at Point Robinson on January 29, 1995[24] with a magnitude 5.0 and at the southwestern end of Bainbridge Island on June 23, 1997 with a magnitude of 4.9.

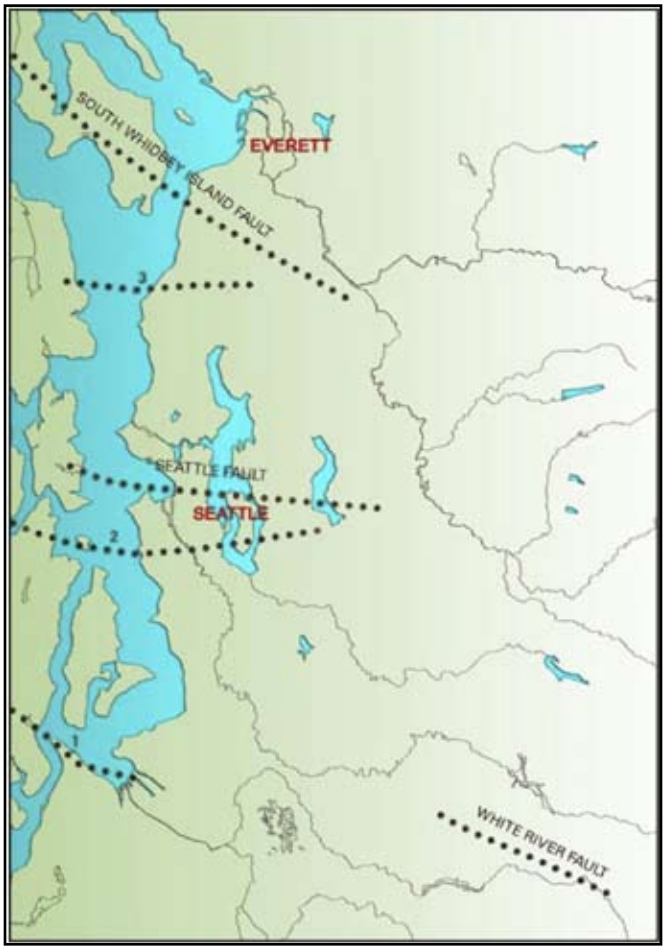
In Snohomish County, the most intense effects of these quakes extended along the South Stillaguamish River valley from Granite Falls to Arlington, and along the Snohomish and Skykomish River Valleys from Everett to Snohomish and Monroe. Within this area the effects included fallen chimneys and building cornices; cracked plaster; broken water and gas mains; damaged docks, bridges, and water storage tanks; cracked ground and pavement; and landslides, mudflows, and debris slides.

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 4 shows the potentially active faults in the Puget Sound that could affect Everett.

21 Snohomish County Natural Hazards Plan Update Vol. 1: Planning Area Wide Elements, 12-6.
22 Snohomish County Natural Hazards Plan Update Vol. 1: Planning Area Wide Elements, 12-7.
23 Snohomish County Natural Hazards Plan Update Vol. 1: Planning Area Wide Elements, 12-7.
24 Dewberry, S.R., and Crosson, R.S., "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* 86 (1996): 1167-1172.

Figure 4: Potentially Active Crustal Faults in the Puget Sound

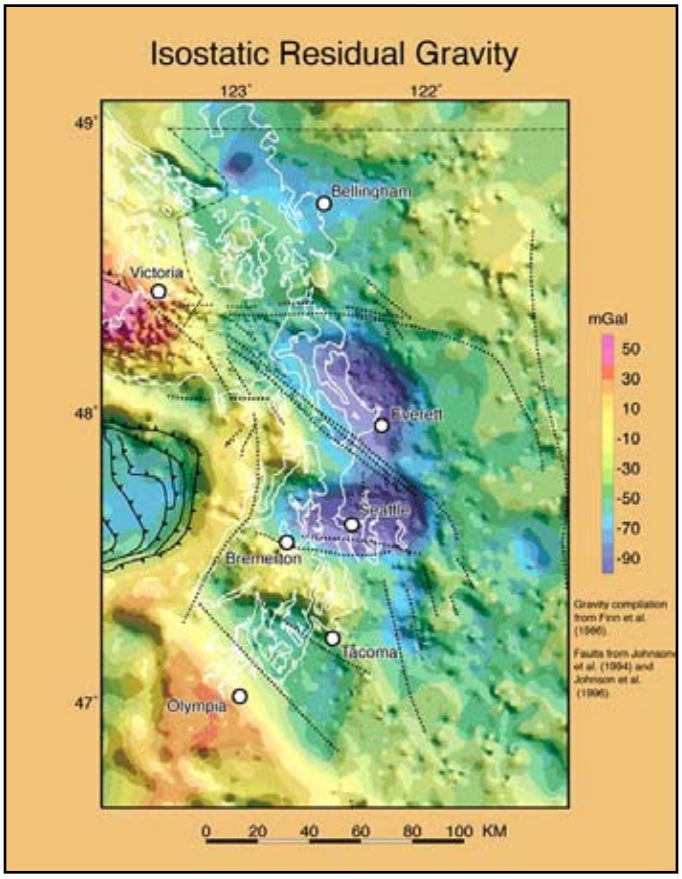


The Everett Basin

Another important factor when considering seismic activity and hazards in Everett is the "Everett Basin". Tacoma, Seattle and Everett are each situated above sedimentary basins, which affect the impacts that earthquakes have in each city. A basin is a deep, bowl-shaped geologic feature that is filled with softer soils and contained by bedrock and other harder materials. These basins can amplify the effects of seismic waves on the surface soils above the basin. Fortunately for Everett, this influence on seismic activity is not as strong as in Seattle and Tacoma. According to the U.S. Geological Survey (USGS), "the amplitudes of the resonance peaks increase southward, with the amplification in the Everett basin being the lowest and the amplification in the Tacoma basin is the highest."[25] The USGS only speculates as to the differences attributed to the low amplification around Everett, but they suspect that higher compaction of soils during the last glaciation period is at least partially responsible, with receding glaciers exposing areas of southern Puget Sound for longer periods of time. Figure 5 shows some of the basins in the Puget Sound region.

25 Pratt, Thomas L. 2003. The Influence of Sedimentary Basins on Ground Shaking in the Puget Lowland, Washington State. Geological Society of America *Abstracts with Programs*, 1(6): 478. Accessed online on February 28, 2011 from http://gsa.confex.com/gsa/2003AM/finalprogram/abstract_67889.htm

Figure 5: Isostatic Residual Gravity in the Everett Basin

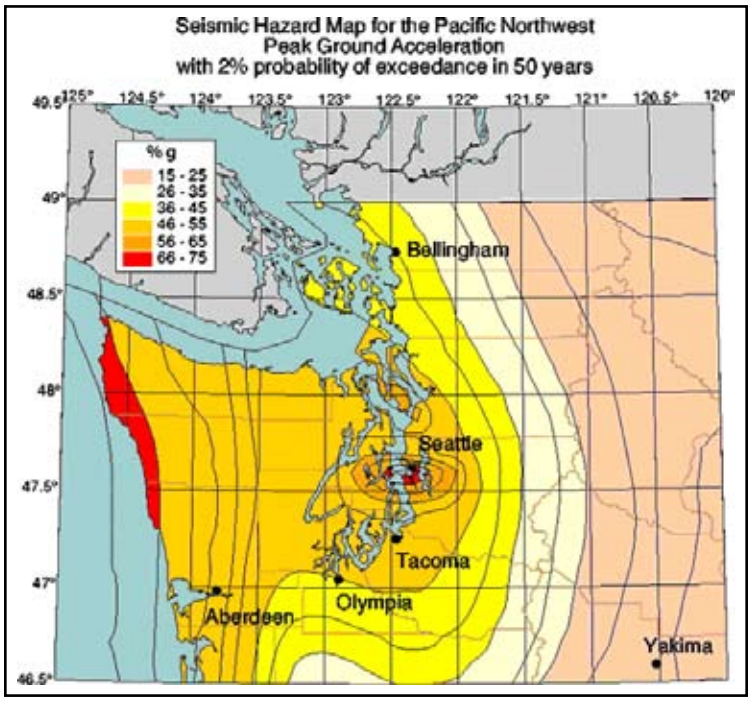


Frequency

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, which includes Everett, is in a higher risk area, with a 2% probability of exceedance in a 50-year period of seeing ground shaking at 70% of gravity from a Subduction Zone event. In other words, there is a 2% chance that a major earthquake will occur in Washington in the next fifty years that will create significant ground shaking in Everett and Seattle. Figure 6 displays the expected peak horizontal ground motions for this probability.

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

Figure 6: Probabilistic Hazard Map[26]



Severity

A subduction zone earthquake could produce an earthquake with a magnitude as large as a 9.0 located on the Pacific Coast of Washington. Benioff zone earthquakes as large as magnitude 7.5 are expected everywhere west of the eastern shores of Puget Sound.[27] A crustal zone earthquake could produce a 6.5 magnitude earthquake affecting Everett. The city of Everett has the potential to be affected by a subduction, Benioff, or crustal zone earthquake, but historically has been spared their most damaging effects.

Warning Time

There is a large amount of information about possible earthquake locations; however there is no current reliable way to predict when an earthquake will occur at any given location. There is new research on warning systems that use the low energy waves that precede major earthquakes.[28] These potential warning systems give approximately forty seconds' notice that a major earthquake is about to occur. This could be enough time for children to get under a desk, or for employees to step away from the hazardous material they are working with or to shut down a computer system.

Past Events

Recently, there has been a study of earthquake activity in the Snohomish Delta region, which includes Everett. In particular, scientists have found two crustal events, one occurring around 900-950 AD and another sometime between 1450-1620 AD. The study took soil samples from the delta and found

26 United States Geologic Survey. 2006. "Peak Ground Acceleration." Accessed online on March 1, 2011 from http://geomaps.wr.usgs.gov/pacnw/lifeline/eqhazards.html
27 United States Geologic Survey. 2006. "Earthquake Hazards." Accessed online on March 1, 2011 from http://geomaps.wr.usgs.gov/pacnw/lifeline/eqhazards.html
28 California Institute of Technology, Caltech 336, "System gets the jump on quakes"

evidence of liquefaction through upward thrusts of sand and woody debris.[29] These seismic events occurred at regular intervals from 130 AD to 1640 AD.

The February 28th, 2001 Nisqually Earthquake with a magnitude of 6.8 is a recent example of a Benioff zone earthquake. The last Cascadia Subduction Zone event occurred on January 26th, 1700 and was catastrophic. Table 10 is a summary of large earthquakes that have occurred in the Puget Sound Region, with those affecting Snohomish County highlighted in gray.

Table 10: 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	Mount 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

Past Events in Everett and Snohomish County

The following are the largest earthquakes that have occurred in historic time in Puget Sound:[30]

- 1872: 7.4 (estimated) Richter scale—shallow origin—approximately seventy-five miles northeast of Everett near Mount Baker and just east of the Cascade crest (largest recorded earthquake in Washington). No record of any fatalities in Snohomish County.
- 1949: 7.1 Richter scale—deep origin—Nisqually Delta area north of Olympia. No Snohomish County fatalities.
- 1965: 6.5 Richter scale—deep origin—near Renton. No Snohomish County fatalities.
- 2001: 6.8 Richter scale—deep origin—Nisqually Delta area north of Olympia. No Snohomish County fatalities, 13 injuries (all minor). Estimated damages: $2-$3 million.

29 Bourgeois, Joanne and Johnson, Samuel Y. "Geologic evidence of earthquakes at the Snohomish delta, Washington, in the past 1200 years, " Geological Society of America, 2001, GSA Bulletin Vol.113, p. 482-494
30 Snohomish County Natural Hazards Plan Update Vol. 1: Planning Area Wide Elements, 12-6.

The largest earthquake to occur in western Washington during the modern era took place on April 13, 1949. The magnitude of the earthquake was measured at 7.1 on the R Scale (R7.1); it had a maximum intensity of VIII-IX on the MM Scale, based upon damage to the human-built environment. The epicenter was located between Tacoma and Olympia. Strong shaking during the Olympia earthquake lasted about twenty seconds.

During the 1965 earthquake, two of three 48-inch water supply lines were broken in Everett where the trestle carrying them crossed an area of seismically vulnerable soil.[31]

The second largest and most recent earthquake within Puget Sound occurred February 28, 2001 with an epicenter again located north of Olympia in the vicinity of the Nisqually River Delta. This earthquake measured 6.8 on the R Scale (R6.8) and caused damage throughout the state from Bellingham to Vancouver between the Olympics and eastern Washington. Twenty-two of the state's counties were included in the federal disaster declaration for the quake. Snohomish County's damages were relatively light (between $2 and $3 million for public and private sector combined) and casualties were exceptionally light (thirteen injuries, all minor). A few older, un-reinforced masonry structures suffered significant damage, but there were no building collapses in the county.

The greatest shaking and highest percentage of damaged structures were in the main stem river valleys and the cities or towns built along the rivers: Darrington, Sultan, Monroe, and Snohomish.

Earthquakes have also affected the Puget Sound area with epicenters located outside of the region. An example is the large (7.4R) earthquake that occurred August 22, 1949 near the Queen Charlotte Islands. The quake's epicenter was located 600 miles north of Seattle.

Secondary Hazards

Secondary hazards from an earthquake event are numerous and could potentially have an even greater impact than the actual seismic event. One major concern is liquefaction in areas designated by the USGS as 'high risk'. Other significant secondary effects of an earthquake, such as landslides, urban fire conflagrations, wildland fires, and hazardous materials releases, may also affect Everett and surrounding Snohomish County.

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 in the Puget Sound Region during and after the 1949 and 1965 earthquakes; many roads were closed and sections of railroad track were swept into Puget Sound as a result.

Brush or wildfires can be caused by downed power lines or ruptured gas lines. An earthquake during the summer may cause a wildland fire due to drier conditions. Also, urban fires may occur due to gas line leaks or breaks and broken water heaters.

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.

A major, but rare, secondary hazard from earthquakes are tsunamis, or waves produced by earth shaking. Landslides in Everett or surrounding shorelines abutting the Puget Sound could cause tsunamis of the greatest magnitude or severity. Additionally, they can occur with large, subduction zone earthquakes in the area. There is historical evidence to suggest that one such event occurred off of Camano Head on Whidbey Island. Whether or not an earthquake produced this tsunami is

31 Noson, Linda et al. "Where Has Earthquake Damage Occurred in Washington State?" Accessed online on April 1, 2011 from http://www.ess.washington.edu/SEIS/PNSN/INFO_GENERAL/NQT/where_damage.html

unclear, but Native American oral accounts tell of a series of waves that wiped out a village on Gedney (Hat) Island.[32] This event inundated an area close to Everett's port and its economic lifeline to global and transoceanic trade. Underwater or submarine landslides off the coast of Mukilteo could trigger another tsunami.[33] The danger of Pacific Ocean-borne tsunamis generated by Subduction Zone earthquakes is of little or no consequence to Everett. The real risk is presented by tsunamis produced by landslides—submarine and subaerial—in and around Puget Sound.

Exposure and Vulnerability

Population

In general, the city lies on NEHRP C soils, but it also has some areas of D, E, and a minimal amount of F soils (See Figure 8 for details). The E soil areas are of most concern since they demonstrate a high level of potential liquefaction during earthquake events. In general, these soils are located along the Snohomish River floodplain and delta, and along the city's waterfront and port. While these areas of Everett do not contain many residential structures, the daytime, working population is exposed to earthquake hazards, and the City of Everett still needs to be aware of vulnerable populations working in these areas.

2011 Update

Population data inconsistent with the updated American Community Survey data has been removed and/ or replaced.

Residential populations located on D and E soils are a concern. In Everett there are only forty-one residential structures located on E soils, but many homes are located on D Soils along the slopes to Everett's waterfront and along the eastern edge of the city, near the Snohomish River floodplain, as well as a narrow band that crosses the peninsula near its base. Also, the large number of creek ravines that separate areas of the city could potentially lead to isolation issues should a major seismic event occur.

There are two vulnerable populations that have been identified in Everett: those under 10 years of age and those over 65 years of age. In Everett, the population under 10 years old is 14,987, and the population over 65 is 10,184. Populations in hospitals and schools are especially vulnerable to a seismic event because of age and potential ambulatory limitations. The Providence Everett Medical Center Colby Campus, serving approximately 19,000 patients a year, is the largest exposed facility and is located on C soils that are fairly stable in a seismic event. The Pacific Campus, which also includes some long-term elderly care, is located on the slightly more vulnerable D soils, making it potentially more vulnerable to impacts from an earthquake.

The time of day an earthquake occurs would determine how much of the total population is vulnerable. During daytime hours there is more activity in the downtown, commercial and industrial areas of Everett. An event that occurred during the day could affect much of the population in these areas. A nighttime event would place the greater populations in residential areas of Everett at a higher level of vulnerability.

32 Gonzalez, F. et al. Puget Sound Tsunami Sources—2002 Workshop Report. P. 11-13.
33 Gonzalez, F. et al. Puget Sound Tsunami Sources—2002 Workshop Report. P.13.

Property

It is important to begin to identify properties located on E soils, which are the most vulnerable in a seismic event. Generally, the properties in Everett located on E soils are located along the Snohomish River floodplain and along the city's waterfront. Table 11 details the parcels exposed to various soils in Everett, while Table 12 details the parcels at liquefaction risk.

2011 Update

This section includes updated data tables and new soil type designations: Type C-D and Type D-E. The removal of two tanks on BNSF property is also reflected.

Table 11: Value of Parcels on Less Stable Soils in Everett

Soil Rating	# of Parcels	% of Total Parcels	Improvement Value
C – D	4,018	12%	$ 722,163,200
D	1,561	5%	$564,607,000
E	455	1%	$110,208,400
F	2	<1%	$18,700
Total	6,036	100%	$ 1,396,997,300

Table 12: Parcel Liquefaction Susceptibility

Liquefaction Risk	# of Parcels	% of Total Parcels	Improvement Value
High	290	1%	$ 442,900,000
Moderate - High	533	2%	$ 78,383,800
Very Low - Low	3,232	10%	
Low	128	<1%	
Very Low	28,267	87%	
N/A	7	<1%	
Total	32,457	100%	$521,283,800

Everett has a large amount, approximately 82%, of residential and commercial structures that were built prior to 1972, when the 1970 Uniform Building Code (UBC) went into effect. The UBC stipulated that all buildings be constructed to at least seismic risk Zone 3 Standards. Buildings in Everett built before 1972 are at higher risk during earthquakes, unless they were retrofitted to withstand expected ground shaking. Houses built after 1972 are more likely to be in compliance with the 1970 UBC and should experience reduced damage from seismic events. 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 once again upgraded the building code to follow the International Building Code (IBC) Standards.

By selecting buildings that were constructed prior to 1972, it was determined that sixty-eight (68) of these are located on parcels with grade E soils. The total value of these parcels is relatively small at $21,720,900. Other vulnerable properties include single-width unreinforced masonry and concrete and tilt-up structures. Table 13 summarizes this data. No new data has been created in the last 5 years, so the numbers reflect the 2006 calculations.

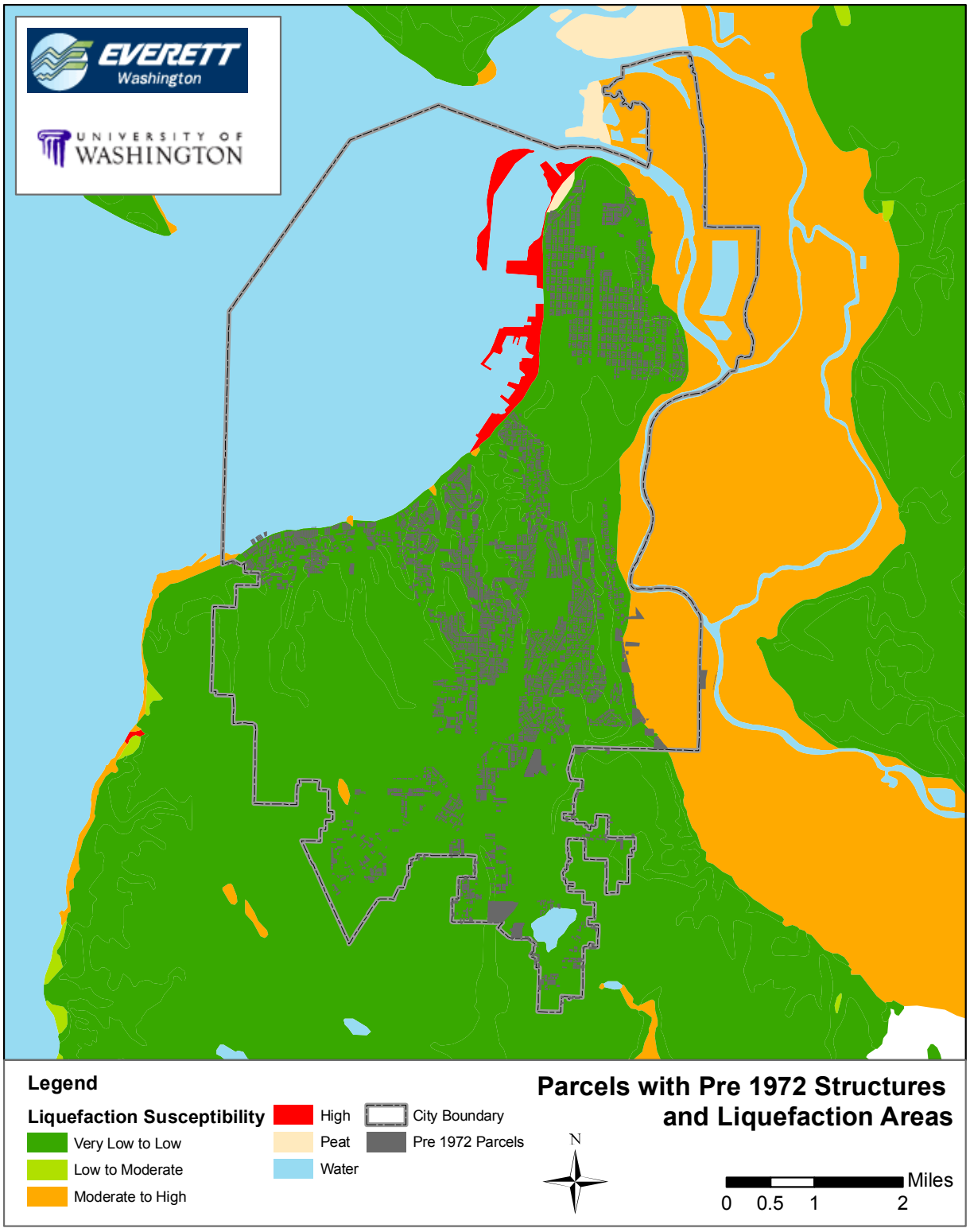
Table 13: Parcel Liquefaction Susceptibility

	Number of Parcels	Total Value
Pre 1972 Buildings	68	$21,720,900

In addition to structures built before 1972, at risk buildings include:

- Single-family and duplex structures: light frame wood-frame buildings constructed before 1976 and light frame wood buildings constructed prior to 1960
- Concrete structures lacking ductile connections
- Buildings located on unconsolidated fill sites
- Tilt-up concrete buildings with inadequate roof-wall connections constructed prior to 1997
- Critical structures (assembly occupancies, large structures, structures on compacted fill)
- Multiple story buildings with small floor plates constructed prior to 1976

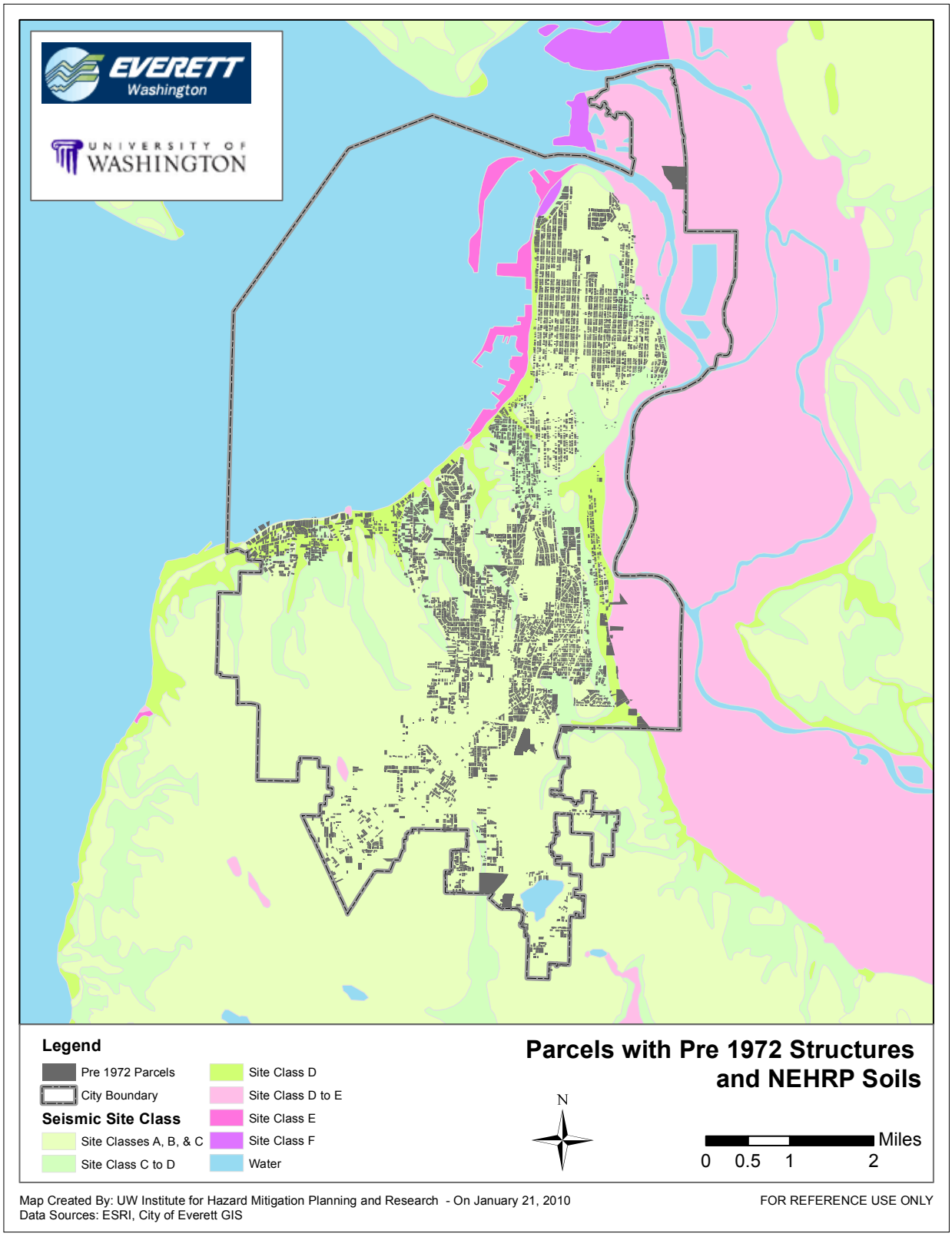
FIGURE 7: PARCELS WITH PRE-1972 STRUCTURES AND LIQUEFACTION AREAS



Map Created By: UW Institute for Hazard Mitigation Planning and Research - On January 21, 2010
Data Sources: ESRI, City of Everett GIS

FOR REFERENCE USE ONLY

FIGURE 8: PARCELS WITH PRE-1972 STRUCTURES AND NERHP SOILS



Critical Facilities

All critical facilities are exposed to seismic hazards, although those located on E soils may have a higher potential for damage due to their location. It is important to identify exposed facilities and to develop mitigation strategies for them in case of an earthquake event. Table 14 details exposed critical facilities on E soils.

Table 14: Critical Facility Exposure

Critical Facility Categories	Number of Parcels/ Facilities on E Soils
Police Facilities	0
Fire Department Facilities (all Navy)	1
Fire Stations	0
Medical Facilities	0
Educational Facilities	0
Government Facilities (7 on Navy Property)	8
Electrical Facilities	6
Natural Gas Facilities	2
Water Facilities	5
Sewage Treatment Facilities	3
Solid Waste Treatment Facilities	1
Total	26

Structures

The City of Everett applied seismic codes requiring the anchoring of structures to their foundations in 1972. There are only 68 structures built prior to 1972 in the city that are located on E Soils. The total value of these structures is $21,720,900. Conversely, the number of pre-1972 structures that were built on D soils is fairly high, with 2,798 structures at a value of $365,675,500.

Providence Everett Medical Center's Colby and Pacific Campuses have had many add-ons over the years. Due to its exposure, the Pacific Campus of the Providence Everett Medical Center should be considered for evaluation of seismic resistance.

Many offices within the city are older tilt-up buildings or were constructed of unreinforced masonry. The vast majority of residential buildings in the city are wood framed. Some commercial buildings are classified as fire-resistant buildings. There are quite a few downtown buildings that are single-width unreinforced masonry. The city of Everett has a limited number of structures located on E soils. Table 15 details the types of soils that all 56,710 structures in Everett are exposed to.

Table 15: Exposed Structures in Everett

Site Class	Number of Buildings	Percentage of Total Structures
City of Everett	56,710	100%
Site Class C to D	5,894	10%
Site Class D	1,823	3%
Site Class D to E	776	1%
Site Class E	160	<1%
Site Class F	19	<1%

Unreinforced Masonry Buildings[34]

Unreinforced masonry (URM) buildings typically have masonry walls (mostly brick) with no steel reinforcing bars embedded within them. The most common type of URM construction in the United States is brick wall facing with wood-frame floors and roof. Everett's URM buildings were constructed from the 1880's to the 1940's, before west coast earthquake codes prohibited unreinforced masonry construction methods.

There are about one hundred URM buildings in downtown Everett, and more distributed throughout the city in historic neighborhoods. The surveyed URM structures in the downtown area have a total improvement value of over $72 million. Everett's URM buildings have a higher likelihood of collapse during the next projected earthquake and pose three types of risk: injury, property damage, and loss of use.

Everett's downtown central business district and historic neighborhoods have the highest concentration of URM buildings. The presence of URM buildings in Everett's historic neighborhoods maintains the character and prominence of the neighborhoods, and their loss would significantly alter their historic significance. URM building damage and collapse poses a life safety risk to people in and near the buildings during and after an earthquake. Their collapse would also present physical barriers into and out of the downtown after an event. Prioritizing URM building retrofits therefore simultaneously reduces up to three types of risk.

BNSF Tunnel

The Burlington Northern train tunnel, which travels beneath the downtown area of Everett, was built in the 1920's. It is constructed of unreinforced concrete, spans seven blocks between Marine View and Oakes streets, and has no vents or fans. As an unreinforced concrete structure, it is vulnerable to collapse during a seismic event, which could damage the roadway and structures above, a number of which are URMs.

Figure 9a indicates the exposed parcels by land use and Figure 9b by total market value. Exposed parcels are any parcels within 150 feet of the rail tunnel.

34 Photo: Everett Police Headquarters (previously City Hall), courtesy Dara Salmon.

Figure 9: a) Land Use of Parcels Exposed To Tunnel Collapse

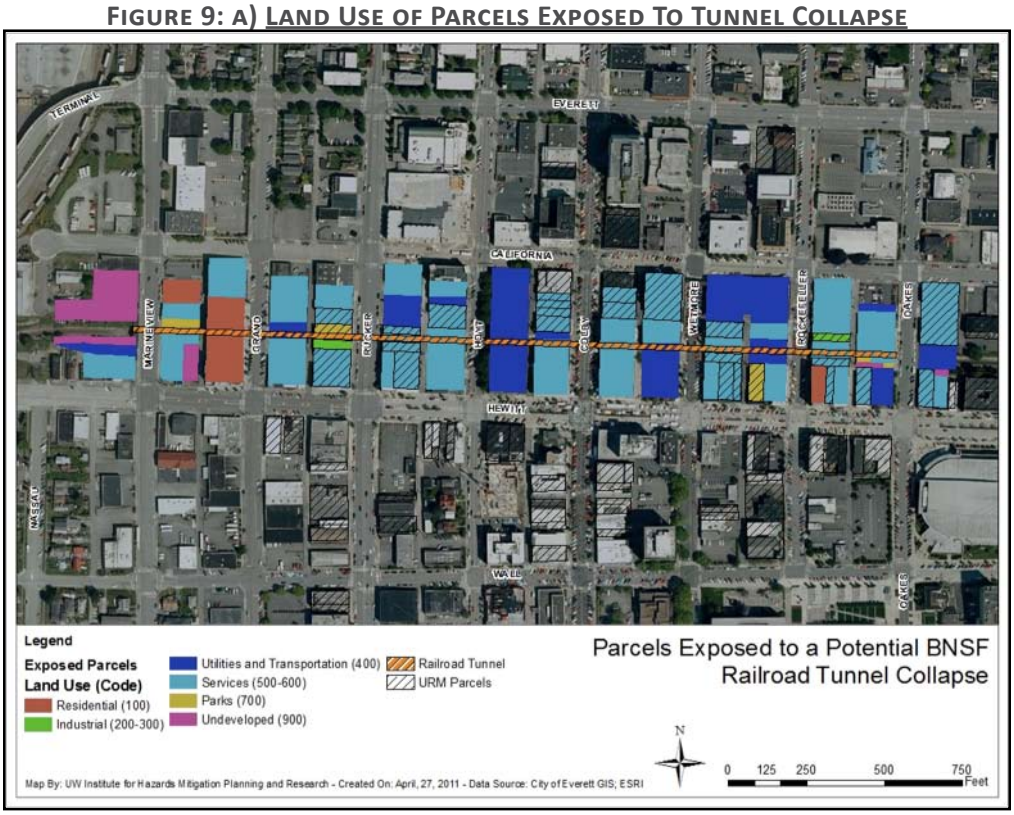
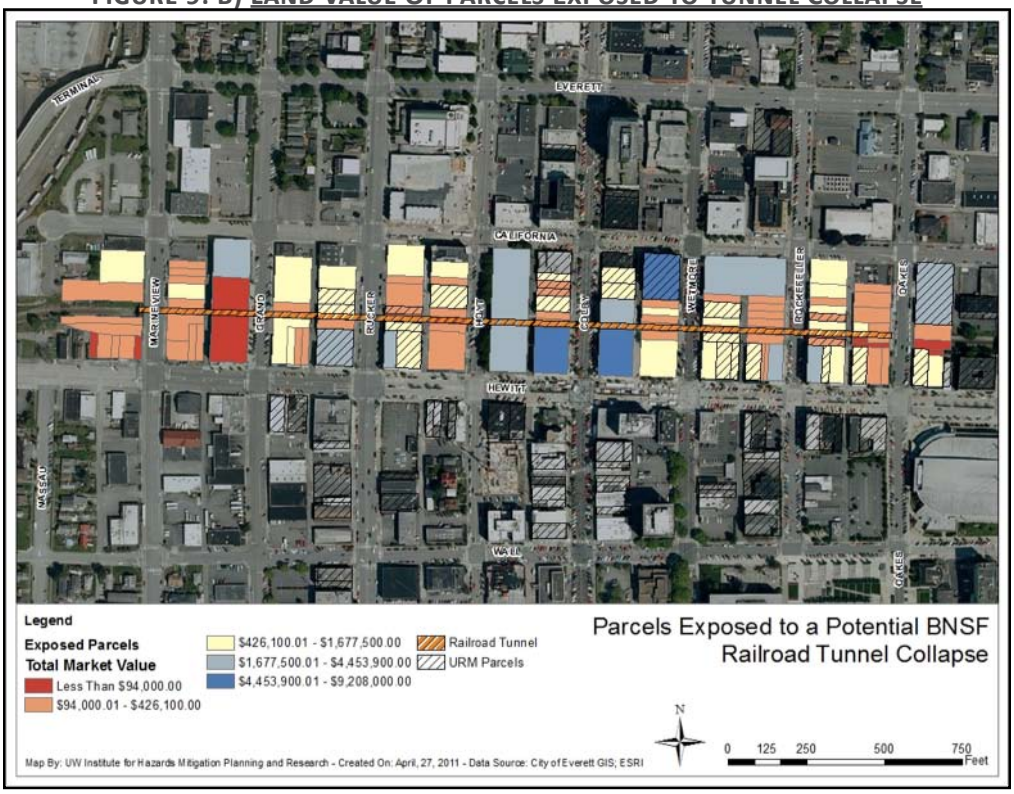


Figure 9: b) Land Value Of Parcels Exposed To Tunnel Collapse



Port, Marina, and the Waterfront

The City of Everett is planning major redevelopment of port property within the next few years to help enhance its waterfront. Planned improvements include condominiums, restaurants, and small businesses. Most of these structures are low-rise, light-weight structures of a commercial or industrial nature that will be built on softer NEHRP E soils. The Naval Station in Everett is generally self-sufficient and has about 450 sailors and civilians assigned full time, with a total of approximately 6,000 people stationed out of Everett.[35] The Naval Station in Everett would be likely to act autonomously when responding to damage from seismic activity.

2011 Update

This update recognizes plans for marina development and the Biological Opinion. Soils remain relevant.

The Kimberly Clark paper mill is a brick building built in the late 1920's. Kimberly Clark also owns the adjacent mill, built in 1954. The older structure is unreinforced masonry and has been modified many times. An assessment of the structure for seismic risk has not been completed. A failing of the building is the possible isolation issues for the working population along the waterfront with the potential closure of West Marine Drive, its adjacent railroads, and its pedestrian overpass.

Another risk is the hazardous materials transported on the BNSF railroad. Currently, there are no monitors for hazardous material releases at the Delta yard or along the rail line, which travels at the foot of landslide-prone areas on the west side of the city.

The NMFS Biological Opinion discussed in the Flood section of this document impacts Everett shorelands, and development would have to incorporate its requirements.

35 U.S. Navy. "CNIC Naval Station Everett." Accessed online on March 2, 2011 from http://www.cnic.navy.mil/everett/index.htm

Critical Infrastructure

Transportation Systems

The principal routes servicing Everett, including Interstate 5 (I-5), US Highway 2, and State Highway 99 (SR 99), cross softer soils and may not be functional following earthquake events, which could potentially lead to isolation of the city.

2011 Update

Data related to utility length and soil type have been updated where new data was available.

I-5, the major north-south route serving Everett, is more vulnerable to earthquake-induced blockage than SR 99 and US Highway 2 because of the large number of overpasses crossing I-5. Additionally, bridge failure throughout the city, as well as along I-5 and US Highway 2, could isolate the city from other areas in the Puget Sound region.

Approximately four miles of I-5 are located on E soils north of the city. Should sections of the interstate fail during a major seismic event, it is possible that evacuation along these routes may be compromised to the north, and outside assistance and supplies from that direction would be cut off or delayed.

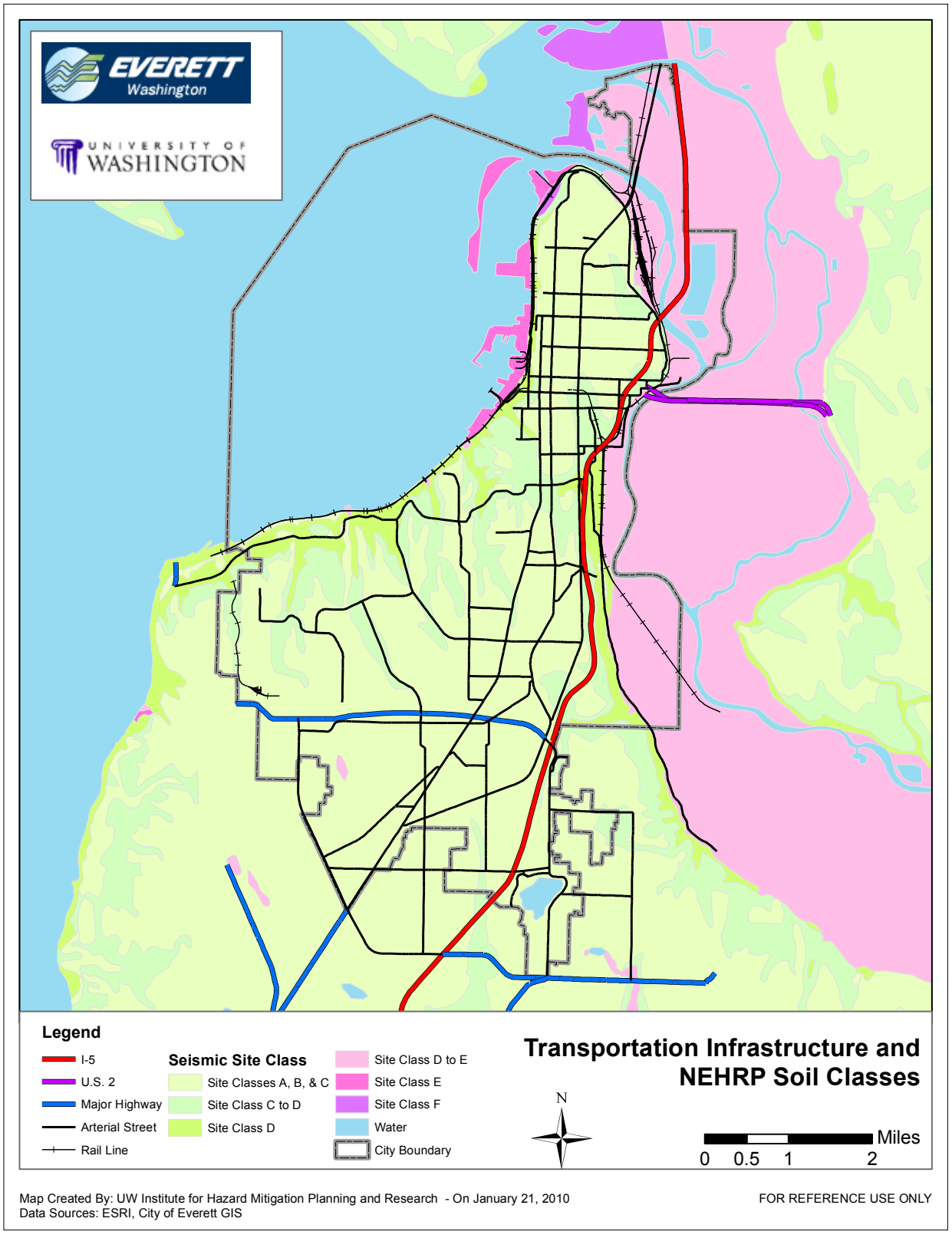
US Highway 2 also has a significant length of roadway constructed on E soils where it crosses over the Snohomish River delta east of the city. This trestled area is particularly vulnerable to damage or collapse, likely rendering this route unusable after an event.

SR 99 North, due to its age and partial utilization of older trestles, makes its vulnerability to route failure higher than that of I-5. US Highway 2 is also more at risk of a failure of its structure due to its traversing over soft soils, as opposed to a risk of blockage from overhead structures.

SR 99 South does not include bridges, and there are several surface roads along the southern route that increase redundancy, making travel south more assured.

Everett has eighty bridges, totaling 6.57 miles, any one of which could fail during an earthquake and isolate a neighborhood from emergency supplies and assistance. There are also approximately 62 miles of Everett rail lines constructed on E soils that are at risk of disruption.

Figure 10: NEHRP Soils in Everett and Exposed Transportation Infrastructure



Water

Water transmission lines cross E and F soils and their vulnerability is a major concern. Similarly many of the city's water distribution lines serving both the commercial and residential areas of Everett and Snohomish County are vulnerable to seismic ground shaking.

Currently, none of the city's water transmission and distribution lines have seismic shut-off valves. However, these lines have pressure sensors that would alarm staff that a break may have occurred, whereby a shutdown process could be initiated. Water loss would be the most immediate effect of a break. Depending on the number and severity of breaks, there could be an extended disruption of potable water to parts of the city and county.

The reservoir reserves for the city could provide three to four days of supply in an emergency. The City of Everett can also draw water from the dedicated Kimberly Clark water transmission line.

Public Works has pre-staged backup water transmission pipe sections to replace damaged pipe following a small failure. The assessment of the water system's resources are detailed in the Public Works Maintenance and Operations Process.

Most of Everett's reservoirs were built between the 1910s and the 1940s of reinforced concrete with flexible joints. Most of these older reservoirs are below-ground and have survived past earthquakes. Newer reservoirs are above-ground tanks and stand pipes.

The city's water system has 33.6 miles of water mains exposed to Classes D, E, and F soils. Breaks along any of these mains could result in a temporary loss of service to many residential and commercial customers.

Wastewater

Sewer lines cross E soils and are vulnerable to earthquakes. A break along the city's sewer lines could affect surrounding populations and natural areas. A sewer pipe rupture could temporarily leach sewage onto the ground or access ground water and surface water.

The City of Everett sewer system has pipes of varying ages and types of construction. There are thirty-three (33) miles of sewer pipe in Everett exposed to D, E, and F Soil Classes.

The sewage treatment plant is located on Smith Island, northeast of the city. Nearly all structures at the plant are constructed on pilings on E soils of the Snohomish River floodplain. To help mitigate flooding impacts, the perimeter of the facility is surrounded by a dike system that meets the Army Corps of Engineers PL 84-99 program requirements.

Telecommunications

Communication blackouts have occurred in the past. Of note was the blackout that occurred in the eastern portion of the U.S. and Canada during the summer of 2003. Communication resiliency is increasing now with text messaging and internet advances. There is a new 800-MHz emergency radio system available to Everett police and fire departments that offers reliable communications for first responders.

Electricity

Transmission lines are vulnerable to ground shaking and liquefaction, especially those traversing E and F Soils. Landslides, ice loading and foliage also threaten transmission and distribution lines.

Schools

The current 2009 International Building Code (IBC) regulates the construction of new and substantially improved schools.

Since 1990, all the schools in Everett have been retrofitted to FEMA 178 standards or ASCE 31-03 standards. These are life safety standards designed to ensure the survival of building occupants, rather than standards for the long-term resilience of the buildings themselves. All new schools in Everett are built in accordance with updated local codes.

Impact Scenarios

An earthquake along the South Whidbey Island Fault, Seattle Fault or Cascadia Subduction Zone could have major impacts on Everett. Buildings could collapse, roads could become impassible and neighborhoods could become isolated.

2011 Update

The Update includes an updated HAZUS generated scenario for an earthquake along the South Whidbey Island Fault.

A tsunami generated from a Seattle fault earthquake or from Possession Beach would cause further damage and isolation, as would landslides along the western shore.

Using FEMA generated software Hazards US (HAZUS), an earthquake-modeling program, four earthquake scenarios were run to predict the possible effects in Everett. These include:

- A Cascadia Subduction Zone Event with an 9.0 magnitude
- A Benioff Earthquake with a magnitude of 7.0
- A Seattle Fault Earthquake with a magnitude of 7.2
- A South Whidbey Fault Earthquake with a magnitude of 7.4

The effects of each are discussed below.

The HAZUS default database was used in estimating the anticipated level of damage to buildings. This database does not take into account the numerous seismic upgrades that have been completed over the past decade in the Everett School District facilities. Therefore, the HAZUS prediction likely overestimates the anticipated level of damage to schools.

A new version of HAZUS was released after the initial analysis was complete. Using the same scenarios in the new software yielded no significant changes to the results. Maps generated with the new software may appear different than those displayed during the planning process due to their use of standardized colors assigned to the Modified Mercalli (MM) scale.

9.0 Cascadia Subduction Zone Earthquake

A Cascadia Earthquake would produce Mercalli Intensity PGAs of VI to VII.

Buildings

From this event, HAZUS predicts that 45% of buildings are likely to experience no damage, with an additional 21% experiencing slight damage. Residential structures are the least vulnerable with only 6.3% at risk of moderate to complete damage. Industrial, commercial, and government buildings are the most vulnerable. More than half (54.57%) of the unreinforced masonry structures in the downtown could experience moderate, extensive or complete damage.

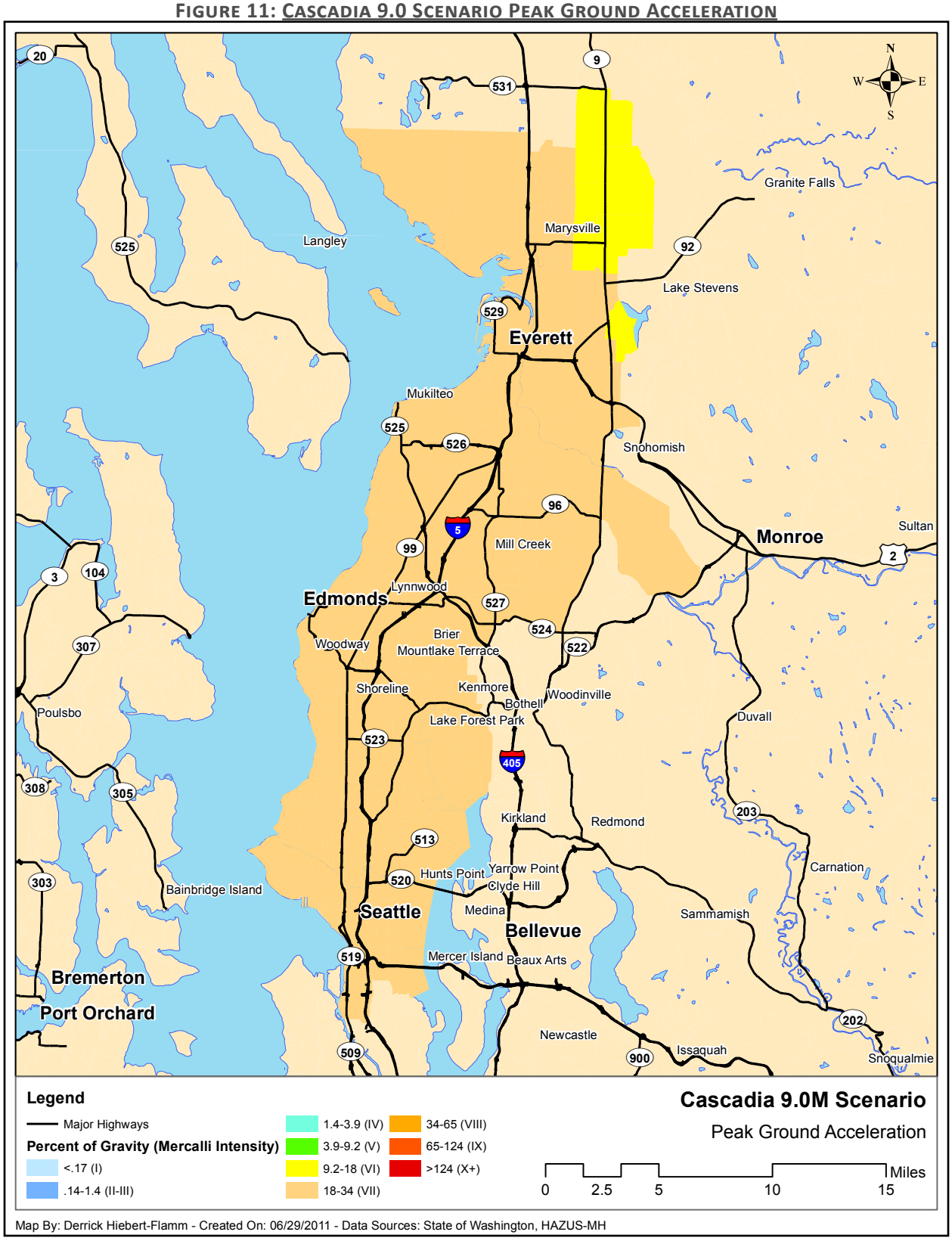
Schools

25% of schools could experience moderate to complete loss in this event, but none are predicted to have complete loss. Schools are not predicted to lose functionality in this event. As noted above, HAZUS could be overestimating potential school damages.

Lifelines

HAZUS predicts that no bridges or highways within the city will have moderate or extensive damage. The I-5 Bridge crossing the Snohomish delta/Ebey Slough may experience 26-50% damage.

FIGURE 11: CASCADIA 9.0 SCENARIO PEAK GROUND ACCELERATION



7.0 Benioff Earthquake

The epicenter of a Benioff quake could be located nearly anywhere in the Puget Sound region, with no one area at greater risk. This scenario is based on a 'worst-case' event of an epicenter directly under downtown Everett in order to determine the most severe possible effects from a deep earthquake.

A Benioff Earthquake would create Mercalli intensities from VI-VII throughout the city, depending on soil type.

Buildings

HAZUS predicts that 8% of buildings could experience at least moderate damage. Residential buildings are the least vulnerable, with less than 7% at risk of moderate to complete damage, while industrial buildings are the most vulnerable. HAZUS predicts that due to damage to their homes, 211 residents will seek temporary shelter. This is largely from its prediction that 286 "Other Residential" structures, which include multi-family housing, could experience extensive damage; forty of these structures could be completely destroyed. Fifty single-family homes are also at risk of extensive to complete damage.

Of the unreinforced masonry structures in the city, 33% are at risk of moderate to complete damage in this scenario.

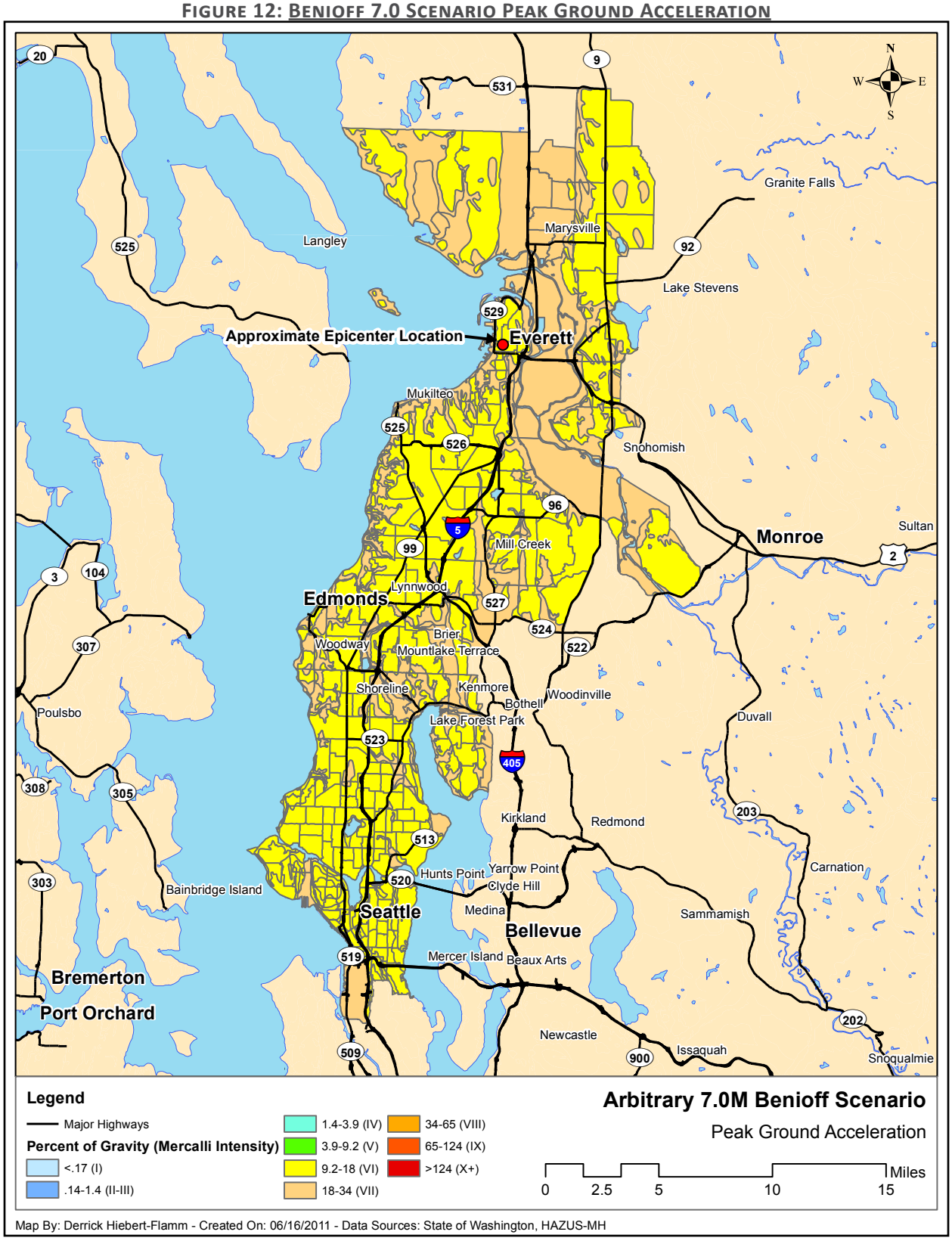
Schools

Approximately 18% of educational buildings could experience moderate or extensive damage. All schools are expected to be functional following the event.

Lifelines

There are no bridges or highways predicted to be more than moderately damaged or to lose more than half of their functionality in this scenario. As in the Cascadia scenario, the I-5 bridge crossing Ebey Slough may experience the greatest damage, between 26-50%.

Figure 12: Benioff 7.0 Scenario Peak Ground Acceleration



6.5 Seattle Fault Earthquake

A Seattle Fault earthquake could create Mercalli Intensity PGA values of VI. Higher PGA values and more extensive damage would likely begin south of Edmonds, increasing southward to the faultline in downtown Seattle.

Buildings

No buildings in Everett are expected to see complete damage from a Seattle quake. Less than 1% of all buildings, including housing structures, are at risk of more than slight damage in this scenario. Less than 7% of unreinforced masonry structures are predicted to experience moderate or extensive damage.

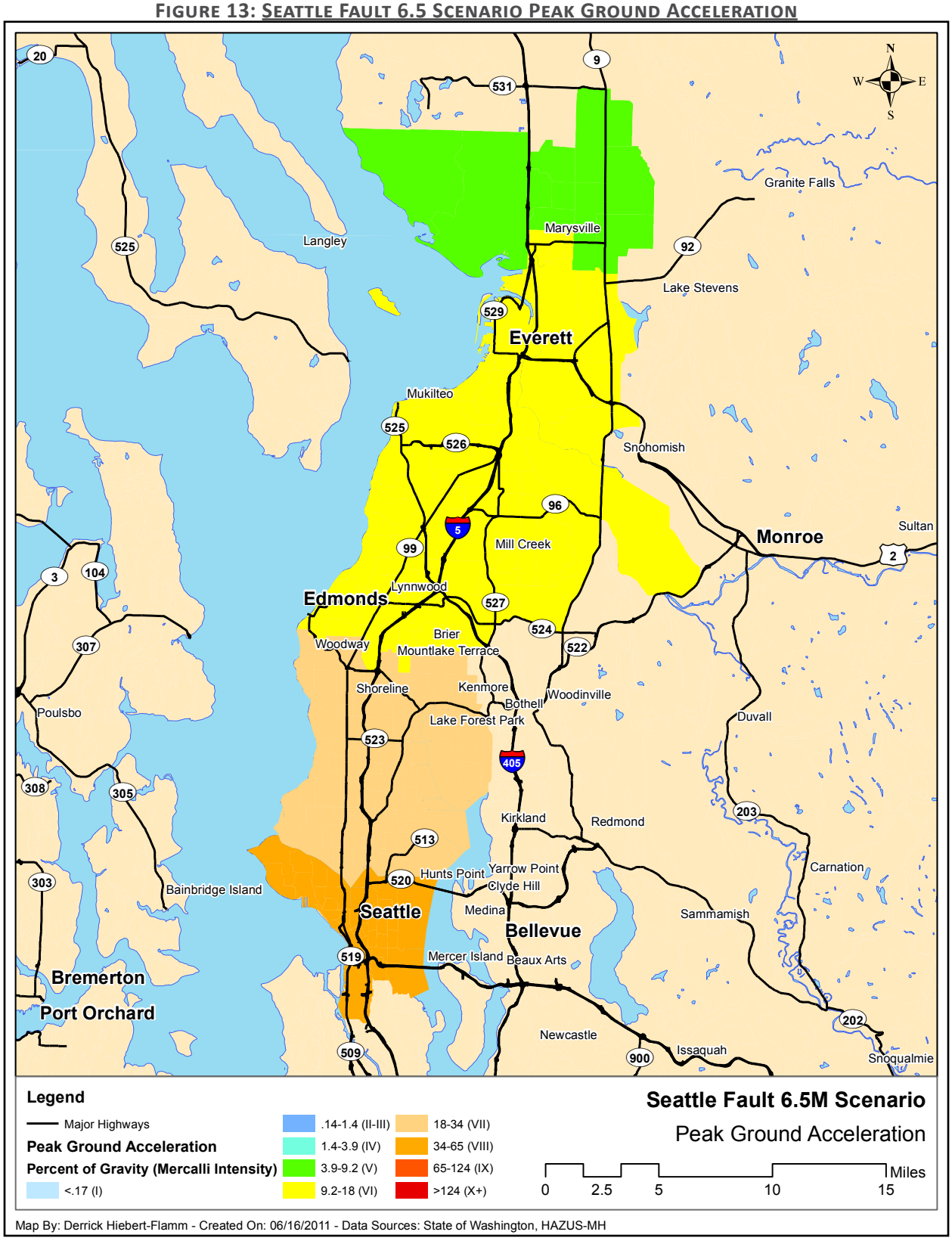
Schools

Less than 10% of schools are at risk of any damage, with less than 2% predicted to see more than slight damage. No schools are expected to have less than 50% functionality.

Lifelines

No bridges or highways are predicted to lose more than 50% functionality or have moderate damage in this model. Multiple bridges in the Seattle area may have moderate to extensive damage and lose functionality, which could affect supply lines into Everett businesses and hospitals.

FIGURE 13: SEATTLE FAULT 6.5 SCENARIO PEAK GROUND ACCELERATION



7.4 South Whidbey Island Fault Earthquake

The South Whidbey Island Fault scenario was recreated by the State of Washington using improved data on the extent and potential damage from an earthquake on the South Whidbey Island Fault. The scenario was developed using HAZUS-MH for a 7.4 magnitude earthquake. For Everett, an earthquake along this fault would cause extensive damage. While a major cause of the additional increase in damage triggered by this scenario is the increase in earthquake magnitude, the mapping of the fault has also become more accurate and the placement of the epicenter for this scenario is more proximate to Everett.

The peak ground acceleration values could range from Mercalli Intensity VII - IX. The highest values would be in the southern parts of the city with the lowest values in the north. The middle portion of the city could experience high PGA as well, ranging between 34-46% gravity.

Buildings

Wooden structures would likely fare the best and unreinforced masonry the worst. For all building types, except wood, the risk of moderate damage extends up toward the middle of the city. In the northern parts of the city, the risk of moderate damage is halved to 40%-50%.

Unreinforced masonry buildings will face the most severe damage in the city. Almost 99% of unreinforced masonry building in the city are at risk of moderate to complete damage. This scenario predicts that 188 URM buildings, over half, could be completely destroyed. The probability for extensive damage ranges from greater than 50% for buildings in the northern census tracts of Everett to greater than 97% in the southern census tracts.

While less than 1% of single-family homes are at risk of complete damage, almost 14% of other residential structures, including apartment buildings, could be destroyed. Over 9,000 houses are at risk of moderate damage, or one third of the single-family homes in the city. HAZUS predicts that 1,951 residents will seek temporary shelter.

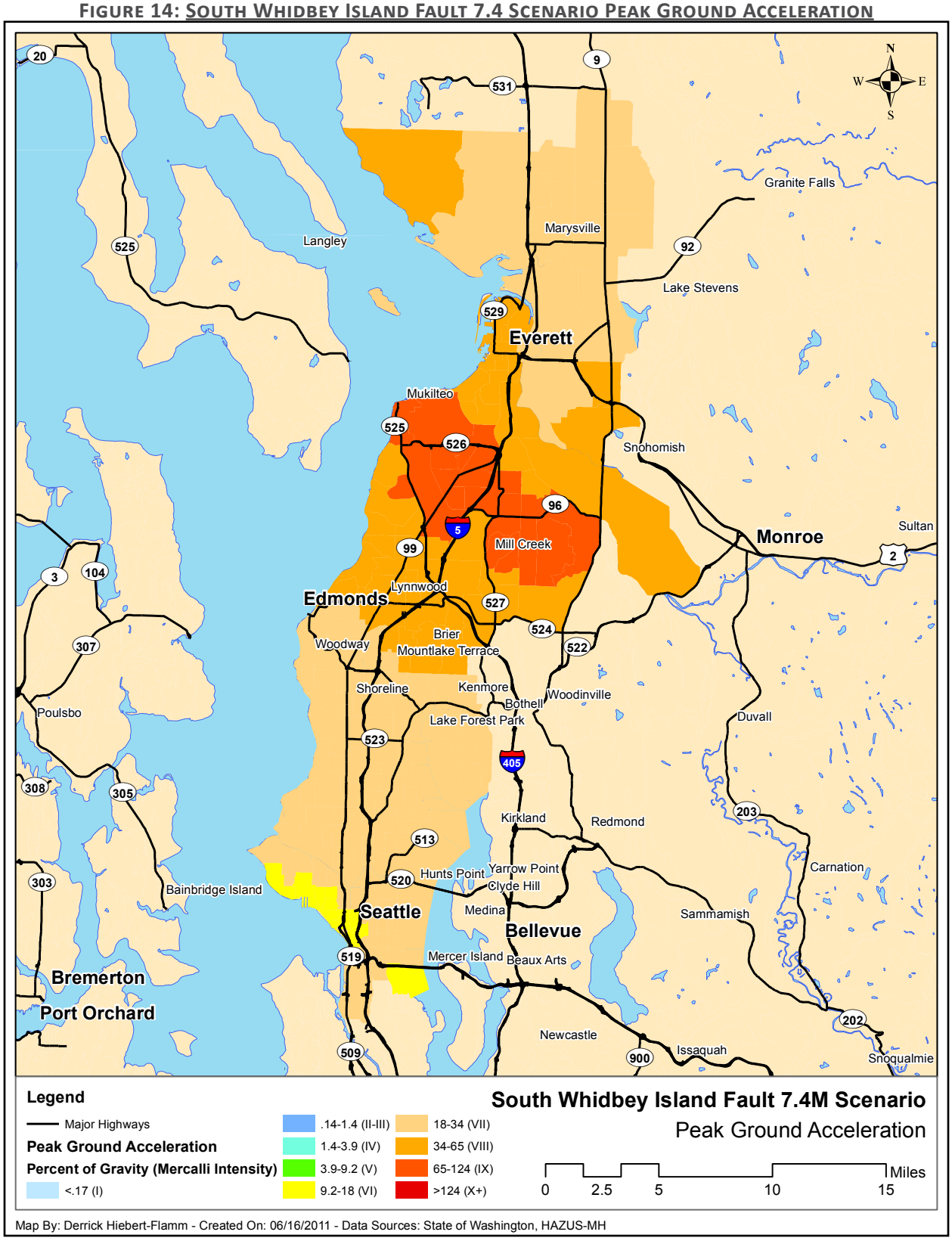
Essential Facilities

Hospitals are not expected to experience anything more than moderate structural damage, though their functionality will be at a reduced level following the disaster. The Colby campus of the Providence Regional Medical Center will experience less damage than its sister branch due to its location on more stable soils and being further from the epicenter of the earthquake.

Lifelines

Most bridges in and around Everett, and in all directions, would be damaged. Most, especially those heading south on I-5 and east on U.S. 2, would be below 75% functionality on day 1 following the earthquake. No significant improvement would be expected within the first two weeks due to the extent of destruction. The bridge on U.S. 99 connecting the northern part of the city to Marysville would also likely be severely damaged or destroyed. The roads without bridges, however, are expected to remain usable, leaving U.S. 99 heading south as the most viable means of transporting goods to and from the city.

FIGURE 14: SOUTH WHIDBEY ISLAND FAULT 7.4 SCENARIO PEAK GROUND ACCELERATION



Probability of Occurrence

"Probabilistic Event Model"

A "probabilistic event" was modeled as a summary of each of the potential earthquake sources: crustal faults, subduction zone, and Benioff events. HAZUS was employed once more to produce this model. Each earthquake source is weighted by its probability of occurrence and all known sources are included in the model.

The probabilistic event model in HAZUS also produces outputs for 100-year and 500-year earthquake events. Snohomish County conducted a HAZUS run for these probabilistic events and predicted structural and content losses of $134,586,730 and $40,967,883 respectively for a 100-year event for a total of $175,554,613, and structural and content losses of $713,355,851 and $198,024,244 respectively for a 500-year event for a total of $911,380,096.[36]

Issues

As in each of the above scenarios, Everett is at risk of experiencing:

- Conflagration of wooden homes
- Collapse of critical and essential facilities
- Loss in functionality of key systems
- Isolation of neighborhoods, particularly within the western portion of the city
- Landslides along the western slopes
- Liquefaction along drainages and to levee and levee systems

36 Snohomish County Natural Hazards Plan Update Vol. I: Planning Area Wide Elements, 12-14

Severe Weather

Definitions

Severe Weather: Includes windstorms, tornados, ice and snowstorms, and thunderstorms.

Tornado: Severe weather event characterized by funnel clouds of varying sizes that generate high speed winds. They can affect areas that vary in width and length. Tornadoes can come from lines of cumulonimbus clouds or from a single storm cloud. They are measured using the Fujita Scale ranging from F0 to F6. In 2007, the US moved to the Enhanced Fujita scale, which ranges from EF0, beginning with winds at 73 MPH, to EF5, with winds over 322 MPH.

Ice Storms/Freezing Rain: Ice storms occur when rain falls from warm moist upper layers of the atmosphere into a colder, drier layer near the ground. The rain freezes on contact with the cold ground and accumulates on exposed surfaces.

2011 Update

This section has been updated to include a definition events included in the definition of severe weather, a new tornado measuring scale, more recent severe weather events in the lists and tables, and National Climatic Data Center information on severe weather events near Everett. Information gained through recent climate change research has also been included. Non-substantive changes to wording have been made.

Windstorms: Severe weather events that can arise from several sources: southwesterly winds are associated with strong storms moving onto the coast from the Pacific Ocean. Southern winds parallel to the Cascade Mountains are the strongest and most destructive winds. Windstorms tend to damage ridgelines that face into the winds. There is a common pattern that begins with a strong Pacific storm that approaches Washington from the southwest. As the storm passes west of Washington, strong east winds increase along the eastern foothills. As the storm begins to move north, the Cascade winds decrease, but then the southeast winds increase along the coast and the north interior. Lastly, the storm moves inland, due north between the Cascade and Olympic Mountain range. Wind speeds increase because of topography between Seattle and Bellingham along the I-5 corridor. This scenario is a common source of windstorms in Everett.

Snowstorms: Severe weather events that are more frequent in the higher elevations of the eastern part of Snohomish County, but can occur in the lower elevations as well. In general, the Cascade Mountain Range acts as a barrier to cold air developing in the eastern part of the state. However, cooler air can enter the valley through low points or advance downriver. When this occurs, it can cause snowstorms in even the lower elevations of the county. Typically, the snow melts rapidly as a result of the warmer air in the valley.

Thunderstorm: The most common of severe weather systems. Typically twenty-five kilometers in diameter and lasting thirty minutes from birth to decay, thunderstorms are underrated hazards. Lightning, which occurs with all thunderstorms, is a serious threat to human life nationwide. Heavy rains dumped in a small area over a very short time can lead to flash flooding. Strong winds, hail, and tornadoes are also dangers associated with thunderstorms.

Hailstorms: Hailstorms occur when freezing water in thunderstorm-type clouds accumulate in layers around an icy core. Wind added to hail could batter crops and structures, and impact traffic on most of the city's transportation systems.

General Background

Severe weather has historically been the most frequent natural hazard affecting the Puget Sound. As seen in Table 16, every year of the past fifteen years has had at least one recorded severe weather event. Severe weather can bring heavy rain, high winds, snow, and ice and can lead to storm surges that flood low lying and coastal areas. Severe weather can lead to secondary effects such as landslides and flooding from streams and drainage systems. Severe weather can also lead to fires caused by either ruptured gas lines or downed electrical lines, or even wildfires caused by lightning and high winds.

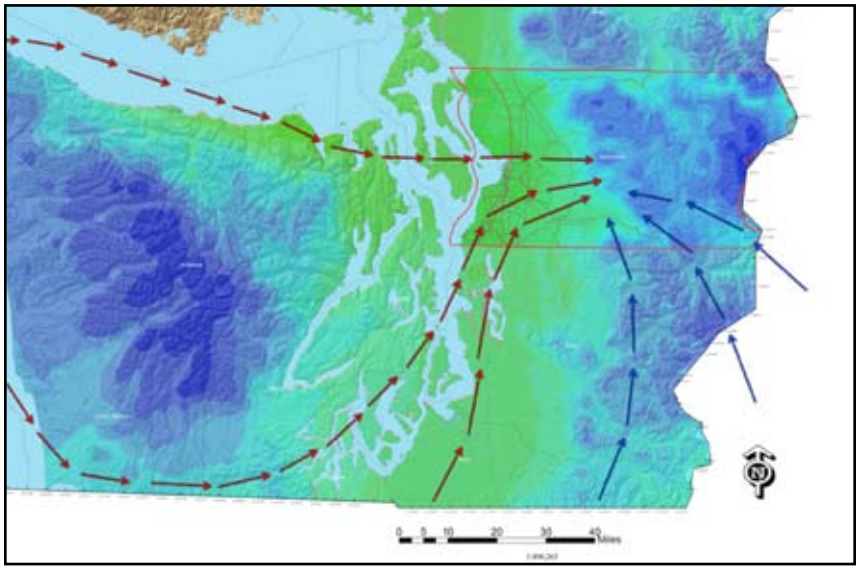
Snohomish County and Everett are subject to various local storms that affect the Pacific Northwest throughout the year, such as wind, snow, ice, hail, and, potentially, tornadoes. Although rare, tornadoes are the most violent weather phenomena known to man. Their funnel shaped clouds rotate at velocities of up to 300 mile per hour and can affect areas up to a mile wide and sixteen miles long. Since 1950, several tornadoes have been reported in Snohomish County, with the most recent one in May 2005. The nature of the tornadoes in Washington is not as severe as the major tornadoes in the Midwest. Washington twisters are generally short in duration, small in diameter, and may only affect a few blocks of urbanized areas. The highest F-Class (Fujita) of tornado recorded in the county was F-2, recorded in both 1970 and 1986, with winds ranging from 113-157 miles per hour (MPH).

Snow storms or blizzards, which are snow storms accompanied by blowing wind or drifting snow, occur occasionally both in Washington State and Snohomish County.

Location

Storms impact the entire region, with consequences for all of Everett and its environs. Everett lies within the convergence zone of air coming from the Pacific Ocean and around the Olympic Mountains. This wind pattern makes the area especially prone to extreme weather events. Figure 15 illustrates the wind patterns bringing many storms to Everett.

Figure 15: Wind Patterns Impacting Everett



Frequency

The National Climatic Data Center has collected information about past severe weather events in Snohomish County since 1950. There have been a total of thirty-one events recorded. The events that caused injury, loss of life or property damage are listed in further detail in the table below.[37] Severe storms are likely to become more frequent as the impacts of climate change increase the probability of extreme weather events.[38] As the events become more powerful and more frequent, mitigation efforts to reduce the risks they pose will also become more complex and more expensive.

Table 16: Storm Incidents in Snohomish County 1970-2010

Location	Date	Time	Type	Mag.	Deaths	Injuries	Damage
1 Snohomish	11/24/70	0800	Tornado	F2	0	0	25K
2 Snohomish	10/26/71	1555	Tornado	F1	0	0	25K
3 Snohomish	4/28/76	1545	Tstm Wind	0 kts.	0	0	0
4 Snohomish	5/13/86	1200	Tornado	F2	0	0	0K
5 Snohomish	9/9/88	2100	Tstm Wind	0 kts.	0	0	0
6 Snohomish	1/25/93	1700	Flood	N/A	0	0	50K
7 Snohomish	10/27/94	1704	Funnel Cloud	N/A	0	0	0
8 Marysville	9/15/96	1330	Lightning	N/A	1	0	0
9 Edmonds	1/15/97	2230	Mudslide	N/A	0	0	0
10 Lynnwood	4/10/97	1600	Lightning	N/A	0	0	35K
11 Lake Stevens	5/31/97	1700	Funnel Cloud	N/A	0	0	0
12 Stanwood	5/31/97	600	Urban/ Stream Flooding	N/A	0	0	5K
13 Arlington	8/6/97	1400	Lightning	N/A	0	1	0
14 Snohomish	8/24/97	1711	Tornado	F0	0	0	0
15 Snohomish	12/8/97	1510	Funnel Cloud	N/A	0	0	0
16 Everett	6/8/98	517	Lightning	N/A	0	0	0
17 Countywide	8/3/99	1800	Lightning	N/A	0	0	0
18 Stanwood	4/22/00	1445	Funnel Cloud	N/A	0	0	0
19 Everett Arpt	3/13/01	1409	Hail	0.75”	0	0	0
20 Countywide	8/21/01	800	Heavy Rain	N/A	0	0	0
21 Countywide	11/13/01	1900	Heavy Rain	N/A	0	0	0
22 Central Portion	5/28/04	1200	Funnel Cloud	N/A	0	0	0
23 Stanwood	6/5/04	450	Tornado	F0	0	0	0
24 Countywide	8/6/04	1100	Heavy Rain	N/A	0	0	20K
25 Brier	9/1/04	1400	Lightning	N/A	0	0	5K
26 Arlington	5/18/05	1850	Tornado	F1	0	0	6K
27 Monroe	5/19/05	1130	Hail	0.40”	0	0	0
28 Darrington	6/21/05	1550	Tstm Wind	50 kts.	0	0	0

37 NOAA Satellite and Information Service. 2011. “Storm Events.” Accessed online on March 6, 2011 from http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

38 United States Environmental Protection Agency. 2009. “Extreme Events.” Accessed online on March 6, 2011 from http://www.epa.gov/climatechange/effects/extreme.html

Location	Date	Time	Type	Mag.	Deaths	Injuries	Damage
29 Everett	9/9/05	630	Lightning	N/A	0	0	2K
30 Edmonds	10/1/05	1700	Lightning	N/A	0	0	2K
31 Marysville	4/15/06	1512	Hail	1.00”	0	0	0
32 Sultan	6/16/06	1250	Tornado	F0	0	0	0
33 Snohomish	11/4/06	1716	Flood	N/A	0	0	3.3M
34 Everett	4/24/07	1720	Funnel Cloud	N/A	0	0	0K
35 Lynnwood	12/3/07	000	Heavy Rain	N/A	0	0	10.0M
36 Edmonds	11/4/08	1500	Lightning	N/A	0	0	25K
37 Monroe	11/12/08	1500	Flood	N/A	0	0	100K
38 Gold Bar	1/7/09	1500	Flood	N/A	0	0	6.5M
39 Everett	4/24/10	1856	Funnel Cloud	N/A	0	0	0K
TOTALS:					1	1	$20.1M

Warning Time

A meteorologist can often predict the onset of a severe storm. This can give several days of warning time. However, meteorologists cannot predict the exact time of onset or the severity of the storm. Some storms may develop quickly and have little to no warning time.

Past Events

Six major windstorms occurred in Western Washington between 1940 and 1993. 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; forty-six (46) people died and 53,000 homes were damaged throughout the region.

January 20, 1993 – The Inauguration Day Wind Storm

- Federal Disaster #981: Stafford Act disaster assistance provided – $24.2 million.
- Snohomish County and the western part of the Puget Sound region were heavily impacted. High winds of 67 MPH at Everett and 60 MPH at SeaTac caused tremendous destruction of public and private structures, power and telephone lines, and trees. Damages to Puget Power facilities were estimated around $17 million.
- At least 79 homes were destroyed, 581 suffered major damage and 1,702 experienced minor damage. The wind sustained speeds in the mid 60’s in the Puget Sound region. Power was out for about 750,000 customers in the Puget Sound Area. A state of emergency was declared in the cities of Auburn, Bellevue, Normandy Park, Renton and Seattle, and the counties of King, Pierce, Snohomish, Thurston and Wahkiakum. Five (5) people were killed in King County.
- The Evergreen Point Floating Bridge sustained $500,000 in damage, and both of the Lake Washington floating bridges were closed due to unusually high waves at the height of the storm. Total loss for the State of Washington was estimated at $130 million. The storm is one of the most costly since the Columbus Day storm noted above, which cost $40 million in 1962.

February 1996 – Storm with Widespread Flooding, Snowmelt, Mudslides in

Washington, Oregon, and Idaho

- Federal Disaster #1100. Stafford Act disaster assistance provided – $113 million. Small Business Administration disaster loans approved - $61.2 million. One of the top ten weather events in Washington during the twentieth century, according to the National Weather Service, Seattle Forecast Office.

2011 Update

Older and less relevant profiles of previous events were removed and replaced with newer profiles of recent severe weather events in Everett and Snohomish County.

- Heavy rainfall, mild temperatures and snowmelt caused flooding and mudslides in several counties throughout the state. This storm caused major flooding on rivers of western and southeast Washington. It was the highest flood of record for many southwest Washington rivers, including the Chehalis, Skookumchuck, and Nisqually.
- There were three (3) deaths, ten (10) people injured. Nearly 8,000 homes were damaged or destroyed. Traffic flow both east and west, and north and south along major highways was shut down for several days. An avalanche closed Interstate 90 at Snoqualmie Pass. Mudslides in Cowlitz County and flooding in Lewis County closed Interstate 5. Damage throughout the Pacific Northwest was estimated at $800 million.

December 1996 - January 1997 – Ice, Wind, Flooding, Snow loading, Landslides

- Federal Disaster #1159. Stafford Act disaster assistance provided $83 million. Small Business Administration approved $31.7 million in loans.
- This storm, referred to in the media as the Holiday Blast, was a series of three weather systems that included severe snow, rain and ice followed by quick melting and runoff that caused flooding and landslides. The system dropped twelve to sixteen inches of snow in many areas of Puget Sound, causing road closures, school closures, and the loss of many man-hours at work. The storm had effects as far south as Portland, Oregon.
- There was a total of twenty-four (24) deaths; $140 million (est.) in insured losses; and 250,000 people who lost power.

December 14-15 2006 – Hanukkah-Eve Windstorm

- Hurricane-force winds reaching sixty-nine (69) miles per hour at Seattle-Tacoma International Airport. Wind speeds of sixty-six (66) miles per hour were recorded in Everett.[39]
- A State of Emergency declared for seventeen (17) western Washington counties. The storm left fourteen (14) people dead in Washington from the effect of the storm and from carbon monoxide poisoning as residents brought outdoor grills inside for warmth.[40] Four (4) others died in Oregon and British Columbia.
- 1.5 million Customers were left without power, some for up to eleven days. Damages exceeded $217 million in Washington and $316 million in the Cascadia region. The windstorm was the most damaging since the 1993 Inauguration Day storm.

39 Read, Wolf. 2007. December 14-15th Windstorm. Accessed online on March 28, 2011 from http://www.climate.washington.edu/stormking/December2006.html

40 Wilma, David. Hanukkah eve windstorm ravages Western Washington on December 14 and 15, 2006. Accessed online on March 28, 2011 from http://www.historylink.org/_content/printer_friendly/pf_output.cfm?file_id=8042

Secondary Hazards

The most significant secondary hazards to severe local storms are floods, landslides, and electrical hazards, which may cause fires from downed power lines. 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 knots in King County.

Two major concerns for snowfall are dangerous roadway conditions and collapse of structures due to heavy snow load on roofs. Roads may become impassable due to ice, snow, or from a secondary hazard such as a landslide.

Landslides may occur when the soil on slopes becomes oversaturated and fails. Lightning can cause severe damage and can be deadly.

Rapidly melting snow combined with heavy rain can overwhelm both natural and man-made drainage systems, causing overflow and property destruction. Seattle-Tacoma International Airport reported 5.02 inches of rain in a twenty-four hour period.[41] This caused flooding problems for several homes as well as the closure of some sections of road.

Severe weather is also a secondary hazard of climate change as it is expected to increase in frequency and intensity as climate change progresses.

Exposure and Vulnerability

Population

The entire city and residential population of Everett is exposed to severe weather events. Some areas have greater exposure to high winds due to their elevation.

The commuting population is also exposed to severe weather. Falling or downed trees can create severe hazards on roadways. Snowy and icy road conditions can cause low visibility and fatal crashes.

The most vulnerable populations in severe weather are those over sixty-five, the disabled, small children and those on fixed incomes. These populations face isolation and exposure during severe weather events. The distribution of vulnerable cohorts is covered in the Community Profile section of this document.

Property

All property could be vulnerable during severe weather events, but those structures in poor condition or in particularly vulnerable locations risk the most damage. Structures on higher elevations and on ridges are more prone to wind damage. Also, those located under or near overhead lines or near large trees may be vulnerable to falling ice or may be damaged in the event of a collapse. Additionally, Everett has experienced structure loss due to snow loading in the past, and the accumulation of snow on flat-roofed buildings remains a concern.

Environment

Severe weather events are generally accepted as a naturally occurring event. Natural habitats such as streams, ponds, and trees are exposed to the elements during a severe storm and risk major damage and destruction. Storm drainage runoff and a potential hazardous material release as a secondary hazard may contribute to the potential for environmental degradation in incidents of severe weather.

41 Brice, Pamela, "Flooding in Shoreline, LFP", The Enterprise, October 24, 2003, pp. 1 & 14.

Critical Infrastructure

Transportation Systems

Local roads, particularly those on steeper slopes, are vulnerable to severe weather. These roads can become icy or impassable in severe weather events and may cause isolation issues for Everett. Snow or ice storms may delay local air traffic. Icy conditions on roads may cause traffic back-ups or street closures.

Electricity and Telecommunications

Power lines, phone lines, and cable lines are vulnerable to high winds, ice storms and tornadoes. Overhead lines that intersect with tree limbs are particularly vulnerable to damage in the event of high winds or ice if those limbs collapse or are blown down. Loss of power and heat can be secondary effects of these severe storms and may leave certain populations more exposed. This could also lead to isolation issues if residents are unable to call for assistance.

Impact Scenario

The impact of severe weather on Everett would be dependent upon the nature of the event. Typically severe weather events are more common, and therefore community and personal recovery tends to be easier. Although these events can cause widespread inconvenience and costly damage, they are, historically, less hazardous to human life.

The effects upon Snohomish County of a strong thunderstorm, tornado, windstorm, or ice storm are likely to be similar: fallen trees, downed power lines, interruption of transportation lifelines, and damaged homes and public buildings. Fatalities are uncommon in western Washington, but they do occur. The usual effects of a tornado are roads blocked by debris and extensive power outages. In the case of extremely high winds some buildings may be damaged or destroyed. Due to the typically short warning period, livestock are commonly the victims of a tornado or windstorm.

If a major tornado struck a populated area in Snohomish County, damage could be widespread. Businesses could be forced to close for an extended period or permanently, fatalities could be high, many people could be homeless for an extended period, and routine services such as telephone or power could be disrupted.

The effects of an ice storm or snowstorm are downed power lines and trees and a large increase in traffic accidents. These storms can cause death by exposure, heart failure due to shoveling or other strenuous activity, traffic accidents (over 85% of ice storm deaths are caused by traffic accidents), and carbon monoxide poisoning when outdoor heaters and generators are brought indoors.

Probability of Occurrence

The National Climactic Data Center (NCDC) for Snohomish County has recorded thirty-nine (39) events in the past sixty years. During this time period, these severe weather events have occurred on average about every two to three years.

Frequency of storms will also increase due to climate change. According to the United States Environmental Protection Agency and the International Panel on Climate Change, the frequency and intensity of weather events, including droughts, thunderstorms, ice storms, snowstorms, and windstorms, is likely to rise as climate change continues to progress.[42]

42 United States Environmental Protection Agency. 2009. "Extreme Events." Accessed online on March 6, 2011 from http://www.epa.gov/climatechange/effects/extreme.html

Issues

One of the major issues of concern in severe weather conditions is isolation due to impassability of bridges that lead to and from Everett. This could limit access for emergency personnel during these types of events.

Power supplies are also at risk during events. Their redundancy and the availability of generators could be important.

Older structures not built to code are more vulnerable to severe weather events, especially roof-collapse from snow accumulation and from windstorms.

Epidemics/Pandemics

Definitions

Epidemic: More cases of a disease than normal.[43]

Pandemic: A worldwide epidemic of a disease.[44]

Virulence: A measure of the severity of the disease an organism is capable of causing.

Mode of Transmission: How the disease is passed from person to person.

2011 Update

Information about the 2009 H1N1 pandemic has been added.

Influenza: A respiratory illness characterized by fever, muscle aches, sore throat, nonproductive cough, and general malaise.[45]

General Background

Epidemics are defined as a higher than normal occurrence of a disease, while pandemics are worldwide epidemics of a disease. One common epidemic is the annual influenza, which circulates both locally and worldwide. As a result of "genetic drift," or the influenza virus constantly changing its genetic make-up, many flu strains may be circulating at any given time.[46] Because of this, new flu vaccines must be developed each year to help protect individuals against the current flu strain. Though the flu generally exists as local epidemics, certain conditions may lead to a worldwide pandemic. If the genetic make-up of the flu virus shifts suddenly and dramatically, a novel strain could develop. Because of its novelty, many people may not be naturally immune to such a strain, and because of its sudden development, vaccine development may not be fast enough to protect a population. If a novel strain is easily transmitted from person to person, it could quickly spread throughout the world and cause a pandemic, the effects of which include serious illness, hospitalizations, and death. However, most novel viruses are not easily spread and are usually identified in and confined to a few individuals.

The most famous influenza pandemic was the 1918 Spanish Flu. This flu strain caused more than 20 million deaths in addition to illness in 20%-40% of the worldwide population.[47] It was particularly virulent, as many individuals began feeling ill in the morning and were dead by the evening. Individuals who did not die directly as a result of flu infection often died of complications such as pneumonia. The most recent influenza pandemic was the 1968 Hong Kong Flu. However, this pandemic was relatively mild, especially in comparison to the Spanish Flu. There are a few potential reasons for this reduced virulence. The Hong Kong Flu was similar to a flu strain circulated in 1957; it peaked in December, when many children were home from school and therefore not infecting their classmates; and improved medical care and antibiotics intended to address the bacterial conditions caused indirectly by the flu were widely available.

43 World Health Organization. 2011. "Global Alert and Response: Pandemic Preparedness." Accessed online on March 6, 2011 from http://www.who.int/csr/disease/influenza/pandemic/en/
44 World Health Organization. 2011. "Global Alert and Response: Pandemic Preparedness." Accessed online on March 6, 2011 from http://www.who.int/csr/disease/influenza/pandemic/en/
45 Snohomish County HIVA Vol. IV 3-298
46 Snohomish County HIVA Vol. IV 3-298
47 Snohomish County HIVA Vol. IV 3-302

Other diseases with epidemic and/or pandemic potential include Methicillin-resistant Staphylococcus aureus (MRSA), West Nile Virus, Severe Acute Respiratory Syndrome (SARS), measles, hepatitis, tuberculosis (TB), E-Coli, Lyme disease, Hantavirus Pulmonary Syndrome (HPS), HIV/AIDS, and leptospirosis.

In some areas, global climate change has the potential to increase the frequency and severity of epidemic and pandemic disease. In the cases of zoonotic transmissions, when a disease spreads from animals to humans, a changing climate and changing landscape means that humans are coming into contact with wildlife, insects, and other creatures that have moved closer to human settlements.[48] Warmer climates are more hospitable to insects like mosquitoes, which can carry malaria, the West Nile Virus, and other illnesses. Deforestation and other forms of habitat destruction force the creatures that lost their habitat into closer contact with humans. Movement of climate change "refugees" may increase population density, which in turn leads to closer human contact and can contribute to unsanitary conditions.[49] As will be discussed below, dense and/or unsanitary living conditions increase the risk of disease transmission.

Past Events

The city of Everett has directly experienced the effects and risks associated with pandemics in the 2009 H1N1 response and mass vaccination. H1N1, a novel type A influenza virus, began affecting significant numbers of people worldwide during the spring of 2009. The number of infections led the federal Department of Health and Human Services to issue a nationwide public health emergency declaration. As the typical fall/winter flu season approached, Snohomish County began planning for a potentially widespread flu infection. Preparations included continuity of operations plans, information dissemination to citizens about preventing infection and spread of infection, and information gathering on how the medical community could stop or decrease infection rates in the Snohomish County population.

Snohomish County proclaimed a State of Emergency in October 2009 in order to detect, confirm, and combat the H1N1 virus, to prepare the county for reception and distribution of the H1N1 vaccine, and to meet Washington State guidelines for vaccine administration.

The H1N1 flu escalated to epidemic proportions quickly and affected high-risk populations more severely than other populations. The Snohomish County Mass Vaccination Steering Committee, with medical community participation that was chaired by a local doctor, decided to provide vaccination clinics in order to protect the community, especially those members of high-risk populations.

A total of nineteen vaccination clinics took place during two days in October. These clinics targeted high-risk groups, including pregnant women, children, teachers, and childcare workers. Approximately 28,000 vaccines were administered over the two days, and additional shipments received in November 2009 were distributed to established medical providers. Restrictions on vaccines were lifted in December 2009, and anyone in Snohomish County who wanted the vaccine could get it.

The Snohomish County/Everett 2009 H1N1 response was a remarkable success. The response involved cooperation between many different entities, including the City of Everett Office of Emergency Management, Snohomish Health District, Snohomish County Department of Emergency Management, Boeing, multiple school districts, multiple medical facilities and clinics, various communities within

48 Pike, Brian L. et al. 2010." Origin and Prevention of Pandemics." *Emerging Infections*. p1638.
49 Burgiel, Stanley W. and Muir, Adrianna A. 2010. "Invasive Species, Climate Change, and Ecosystem-Based Adaptation: Addressing Multiple Drivers of Global Change. Global Invasive Species Program. p 25.

Snohomish County, Everett Community College, the American Red Cross, and Community Emergency Response Team members.[50]

Location

There are a few physical and social characteristics that put certain localities at higher risk for spread of disease and higher potential for epidemic development. These include areas with:

- High levels of poverty
- Dense population
- Poor sanitary conditions
- Reduced access to health care[51]

Frequency

The most common epidemic is the annual spread of influenza viruses. Flu epidemics occur almost every year and generally during the winter months. The frequency of other disease epidemics varies with specific disease and the presence or absence of certain conditions. For example, high rates of unprotected sexual encounters or drug abuse in a particular population or community can put it at higher risk for disease epidemics.

Severity

The severity of annual flu strains varies by strain and demographic factors. The very young, the elderly, pregnant women, and those with pre-existing chronic health problems are more likely to contract the flu and may experience more serious effects of the disease. On average, influenza epidemics in the United States result in approximately 114,000 hospitalizations and 20,000 deaths per year.[52]

Warning Time

Because most influenza strains circulate worldwide at roughly the same time of year, there is adequate warning time for the development of vaccines. In a normal year, the three or four flu strains circulating around the world are previously identified and are similar to other recently circulating strains.[53] Due to these characteristics, each year a vaccine for the most common and worrisome flu strains is developed and made available to the general public before the flu season begins. In the case of influenza pandemic, it is estimated that there will be one to six months between the identification of a novel flu virus and outbreaks in the U.S. Warning times associated with other diseases vary by disease and locality.

Secondary Hazards

Secondary hazards of epidemics include indirect health effects and slowing of, or damage to, economic productivity and services. For example, common complications of the flu include pneumonia, bronchitis, sinus infections, and ear infections. These complications generally affect high-risk populations such as young children, elderly, and those with pre-existing chronic health conditions. There

50 Snohomish County. 2009. Snohomish County Unified Command for H1N1 response and Mass vaccination Clinic Support. After Action Report. p 2-3.
51 Snohomish County. 2009. Snohomish County Unified Command for H1N1 response and Mass vaccination Clinic Support. After Action Report. p 9.
52 Snohomish County HIVA Vol. IV 3-305
53 Snohomish County HIVA Vol. IV 3-300

may be damage to or a slowing of production levels in industrial and light-industrial factories and other office situations due to worker sick days.

Exposure and Vulnerability

Population

Risk of exposure to a disease is tied to its mode of transmission. For example, the average person generally has a higher chance of contracting a disease transmitted through a sneeze or cough than one contracted through direct fecal-oral transmission. Individuals with high risk of exposure to epidemic and/or pandemic disease include those who work and travel in foreign countries, those who live in previously undeveloped natural areas, health-care workers, and other first responders. Individuals who travel globally are at higher risk of being exposed to diseases they may not have been exposed to previously and thus may not be immune to, and also have a higher potential to spread disease as they travel from place to place. Living in previously undeveloped natural areas can put urban residents in contact with wild animals, which can carry and transmit diseases. Health-care workers and other first responders have higher risks of exposure simply due to their proximity to ill individuals.

The demographic groups at higher risk of contracting and feeling significant effects of diseases include the very young, the elderly, pregnant women, and those with pre-existing chronic health conditions. In addition, individuals who have not received vaccinations, individuals living in unsanitary conditions, individuals who have poor personal hygiene, and individuals who engage in high-risk sexual behavior and drug use have higher levels of vulnerability, as these conditions and behaviors can negatively affect the immune system and overall health.

Other populations with higher vulnerability to the direct effects of a disease and potential complications include those with limited financial resources, those without easy access to health-care facilities, individuals who live alone or lack competent caretakers, populations with limited English-speaking abilities, and communities that may be isolated from health-care facilities in the event of a compounding hazard (i.e. severe flooding during an epidemic flu season).

Critical Infrastructure

Commercial Facilities, Government, Critical Manufacturing, and Transportation Systems

Many businesses, industries, and services are vulnerable to the effects of an epidemic or pandemic. These effects include loss of productivity, service, and employee work hours due to illness. Every public and private agency is vulnerable to the direct and indirect effects of an epidemic or pandemic. However, businesses that are able to allow employees to work from home may be less vulnerable, as employees can avoid transmitting or contracting diseases in the workplace.

Impact Scenario

The potential impact of a pandemic is massive. The Center for Disease Control and Prevention estimates that in the event of a pandemic, in the United States alone, up to 200 million people will be infected; between 40 and 100 million individuals will become clinically ill; between 18 and 45 million individuals will require outpatient care; between 300 and 800 thousand individuals will be hospitalized; and between 88 and 300 thousand people will die.[54]

Table 17 outlines the phases that will be declared at the national level in the event of a pandemic.[55]

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55 Snohomish County HIVA Vol. IV 3-309

Table 17: National Response Plan Structure for Pandemics

Pandemic Phase	Definition
Novel Virus Alert	Novel virus detected in one or more humans. Little or no immunity in the general population potential, but not inevitable precursor to a pandemic
Pandemic Alert	Novel virus demonstrates sustained person-to-person transmission and causes multiple cases in the same geographic area
Pandemic Imminent	Novel virus causing unusually high rates of morbidity and/or mortality in multiple, widespread geographic areas
Pandemic	Further spread with involvement of multiple continents; formal declaration made
"Second Wave"	Recrudescence of epidemic activity within several months following the initial wave of infection
Pandemic Over	Cessation of successive pandemic "waves," accompanied by the return (in the U.S.) of the more typical wintertime "epidemic" cycle

Probability of Occurrence

Though not every year is an influenza epidemic year, worldwide populations are exposed to flu strains every year. Influenza pandemics occur every few decades. Probabilities of epidemics and/or pandemics of other diseases vary by disease, disease virulence, and mode of transmission.

Issues

Beyond the hospitalizations and deaths possible in an epidemic or pandemic situation, loss of productivity and profit due to the effects of disease is arguably the largest threat to Everett. Everett is home to many high-profile industrial and service operations, including Boeing, Naval Station Everett, Providence Medical Center, Snohomish County Government, City of Everett Government, Kimberly-Clark Corporation, Everett Community College, and the Everett Marina. Epidemic or pandemic situations resulting in widespread illness would lead to significant shortages in work hours and service levels.

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Climate Change

Definitions

Climate Change: Changes in climate patterns at a local, regional or global scale.

Climate: Measures of temperature, humidity, precipitation, atmospheric pressure, and other meteorological conditions over a long period of time in a given area. This data is useful in establishing predictable patterns useful for organizing human endeavors in an area.

2011 Update

Climate change is a new addition to this plan.

Weather: A short term or current measurement of meteorological conditions in an area.

Global Warming: A measured increase in global temperatures over the past decades.

Greenhouse Gas: A gas that absorbs and emits infrared radiation, including water vapor, carbon dioxide, methane, nitrous oxide, and ozone. These gases trap heat entering the earth's atmosphere and warm the planet.

General Background

Climate change is a term referring to a global shift in climate patterns that has been occurring for decades. Recently, scientific consensus on this phenomenon is that emissions of some greenhouse gases are accelerating due, in large part, to human activity. These gases trap heat in our atmosphere, leading to global warming. The excess heat in the atmosphere has led to numerous shifts in climate, and thus to shifts in weather patterns that lead to various smaller consequences, including increased evaporation and subsequent precipitation, earlier snowmelt, and shifting seasonal changes. Figure 16 shows the historical and projected changes in carbon dioxide, a greenhouse gas.

Figure 16: Historical and Projected Atmospheric Carbon Concentrations[56]

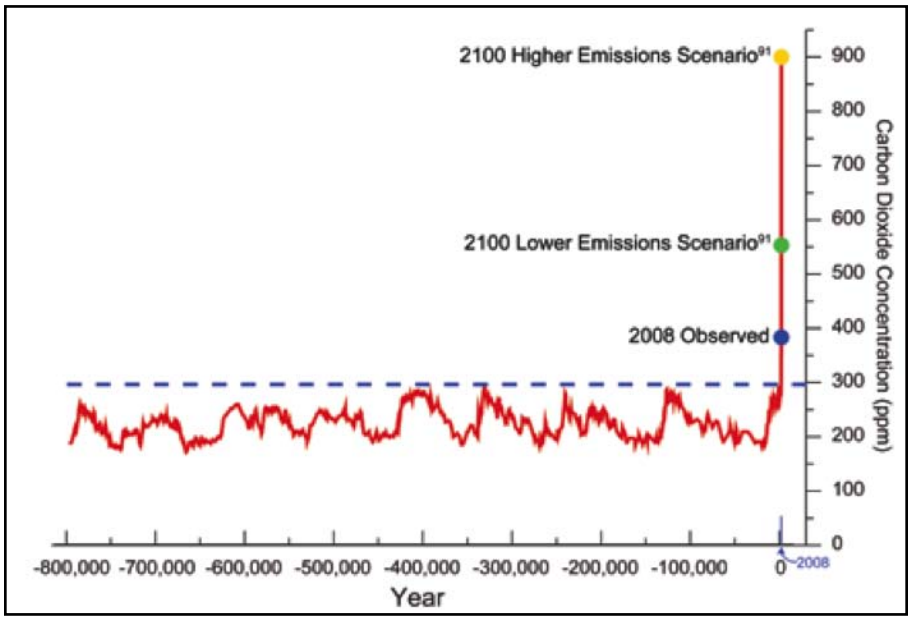
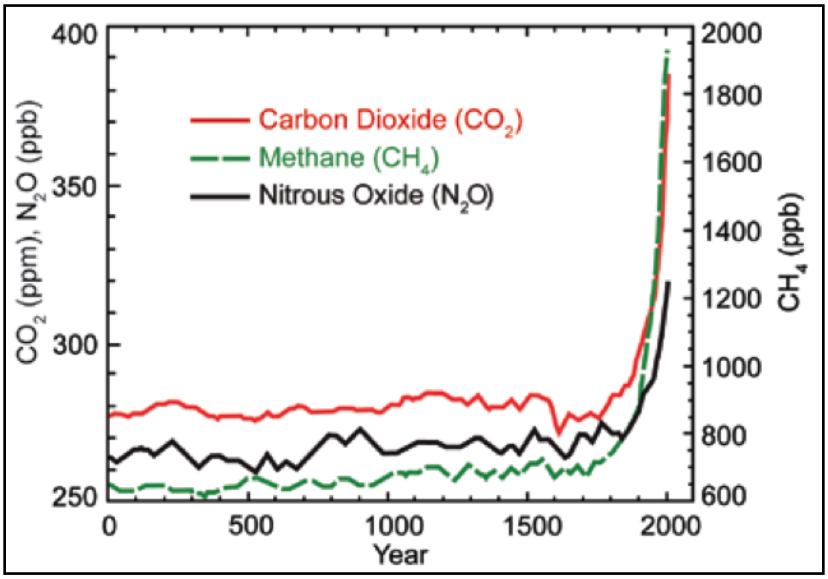


Figure 17 shows the historical change in three greenhouse gases.

Figure 17: Historical Greenhouse Gas Levels[57]



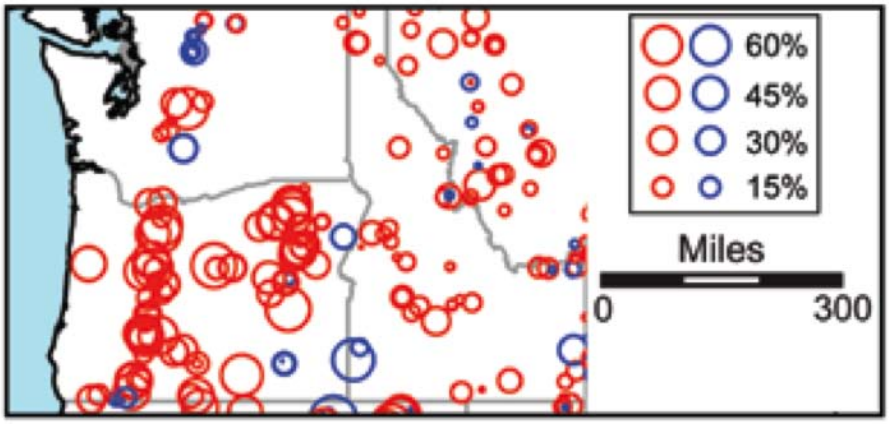
Scientific consensus about changing global climate patterns solidified around the 2007 Intergovernmental Panel on Climate Change (IPCC) report, which summarized data about and made predictions on the future impacts of climate change.[58] A 2006 study by the Climate Leadership Initiative on the impacts of climate change on Washington State identified several indications that

56 US Climate Change Research Program. (2009). "Global Climate Change Impacts in the United States." Cambridge University Press: New York. p. 27.
57 Global Climate Change Impacts in the United States, 13.
58 Solomon, S. et al. (2007). "Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change." Cambridge University Press: Cambridge, UK. Accessed online on April 3, 2011 from http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html

the climate of Washington State is already changing, including increased average temperatures, the retreat of glaciers, decrease in snowpack, and increase in wildfires over the last few decades.[59]

Impacts of climate change are already being measured in the Pacific Northwest. Glaciers and snowpack in the Cascades have been in retreat in the last few decades. The map below shows changes in the measured snowmelt on April 1 from 1950 to 2002.

Figure 18: Changes in Snowmelt on April 1st, 1950-2002[60]



Climate change is a significant hazard for Everett, but its impact will be felt most as it influences the frequency and severity of other known hazards. The nature of climate change also makes it more difficult to predict the patterns of future climatic events.

Location

Climate change may influence the location of other hazard events in Everett. For instance, increased temperatures may make the threat of fires more widespread. Increased severe weather events and heat waves will impact all of Everett.

Frequency

The frequency of other hazard events that already impact Everett may be influenced by climate change. Seasonal events may shift in timeframe. The 2006 report explains how reduced snowpack and a shift from snow to rain in winter may reduce the incidence of rain on snow winter flooding events, but more flooding may occur later in the spring.[61] Severe storms may occur more frequently.

Severity

Climate change could influence the frequency and severity of other hazards mentioned in this HIVA, including severe storms and flooding. Increased summer temperatures will increase the risk of fires, especially wildfires. While it is difficult to predict the long-term severity of climate change impacts to Everett, it is likely that the nearest-term impacts will be through the increase in the frequency and severity of hazards as well as through the appearance of new hazards such as drought and heat waves.

59 Washington Economic Steering Committee and the Climate Change Leadership Initiative Institute for Sustainable Environment. (2006). "Impacts of Climate Change on Washington's Economy: A Preliminary Assessment of Risks and opportunities." University of Oregon, pp. 7-8.
60 Global Climate Change Impacts in the United States, 14.
61 Global Climate Change Impacts in the United States, 135.

Secondary Hazards

Increases in average temperatures expand the habitat range of invasive species, which could damage forests and spread diseases, including West Nile virus and Lyme disease. These changes in habitat may also change the influence of endangered or economically important local species, such as salmon.

One hazard not already introduced in this report that will increase with climate change is the hazard of heat waves. Temperatures will become higher for longer time periods during summer months. Heat waves kill more people than all other weather events, and the most impacted are the young, elderly, sick, or overweight individuals in a population.[62]

In many ways, hazards such as severe weather, landslides, fire, flooding, and pandemics can all be considered secondary hazards to climate change. Severe weather will be more common and damaging due to the increased warming of the atmosphere (the input of energy into a system produces 'work', in this case in the form of weather). Increases in severe weather events mean more heavy downpours, which increases the risk of flooding and landslides. Fire risk is directly related to temperature and precipitation, and as droughts begin to appear in western Washington along with higher temperatures, fires will be more common. The weather conditions that facilitate the spread of disease and pandemics, such as those mentioned above, are also related to climate change.

Exposure and Vulnerability

Population

The entire population is exposed to risks posed by climate change. Those elements of the population most at risk from weather-related events, such as the young, the sick, and the elderly, are also most vulnerable to climate change impacts.

Property

Severe weather-related events are already a leading cause of property damage, and the amount of damage is expected to increase as the frequency and severity of events increases.

Critical Infrastructure

Water

Everett obtains its water from reservoirs fed by snowmelt. As climate change reduces snowpack in the Cascade Range, the water system will be threatened. A decrease in snowpack is already being observed throughout the Pacific Northwest.[63]

Transportation Systems

Sea-level rise may impact the Port of Everett and endanger its facilities. Furthermore, increases in river peak flow will cause an increase in the sedimentation of the port area and necessitate additional dredging.

62 American Red Cross. "Heat Wave Safety Checklist." Accessed online on April 3, 2011 from http://www.redcross.org/portal/site/en/menuitem.53fabf6cc033f17a2b1ecfbf43181aa0/?vgnextoid=1750779a32ecb110VgnVCM10000089f0870aRCRD&currPage=bf10779a32ecb110VgnVCM10000089f0870aRCRD

63 USGS website. (2009). "Fifty-Year Record of Glacier Change Reveals Shifting Climate in the Pacific Northwest and Alaska, USA." Accessed online on April 3, 2011 from http://pubs.usgs.gov/fs/2009/3046/

Health and Healthcare

The potential increase in heat waves and other hazards will add stress to healthcare resources and increase the risk of already vulnerable elements of the population to hospitalization for weather and heat-related illnesses and injuries.

Environment

Climate change may unbalance delicate ecosystems, including salmon habitats. Increased temperatures will shift seasons, and may inhibit the growth and life cycles of native species and encourage the spread of non-native species to areas previously unsuited for them. Nutrient concentrations in oceans and lakes may shift, which further disrupts food supplies and habitats.[64]

Impact Scenario

The July 2010 heat wave in Russia illustrated some of the complicated interaction between unpredictable or extreme changes in climate and the hazards they directly or indirectly impact. July 2010 was the warmest month in western Russia in the last 130 years. The heat and lack of rainfall created drought conditions that aided the spread of wildfires. The death toll from this event may have been as high as 15,000. There was an almost two-fold increase in the natural death rate for that time period, with deaths resulting from the fires, as well as from the poor air quality caused by those fires.[65] While western Washington and western Russia have different climate conditions, increased heat waves may be expected to bring similar consequences if they occur in this area.

Issues

Our climate is changing and there is agreement among the scientific community that, as a result, the frequency of each of the following impacts is increasing:

- Higher intensity storms
- Hotter and dryer summers
- Cascade drainages having higher winter and lower summer flows
- Additional stresses to biological natural systems, including forest regeneration.
- Insects and disease vector introduction

64 USFWS. (2010). "Climate Change in the Pacific Northwest." Accessed online on April 3, 2011 from http://www.fws.gov/pacific/Climatechange/changepnw.html

65 Kim, Lucian and LLevitov, Maria. (August 10,2010). "Russia Heat Wave May Kill 15000, Have $15 Billion of GDF." Bloomburg News L.P. Accessed online on April 3, 2011 from http://www.bloomberg.com/news/2010-08-10/russia-may-lose-15-000-lives-15-billion-of-economic-output-in-heat-wave.html

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Urban and Urban Interface Fire

Definitions

Wildland fires: Uncontrolled burning of grasslands, brush or woodland areas.

Urban Interface fires: Conflagrations in an area susceptible to fires as a result of wildland vegetation and urban or suburban development occurring in close proximity to each other.[66]

Urban Fire: Conflagrations caused by or coming from a building or other urban related source.

General Background

2011 Update

Information about Climate Change has been added to this section. Vulnerable structure data has been updated.

Events that cause fire outbreaks can be natural, such as lightning, or human-induced. Humans can directly cause uncontrolled wildland or urban fires with careless outdoor fires, kitchen fires, or inappropriate disposal of lit cigarettes. Downed electric lines during windstorms can also cause fires. Fire is a serious threat as a secondary hazard following an earthquake. Ruptured gas lines as well as the failure of electrical utilities can cause fires as a result of earthquake or landslide activity. Additionally, the water supply may be interrupted, making fire-fighting efforts much more difficult.

Fires are influenced by the amount and condition of available fuel, slopes, wind, and ambient temperature. Fires advance by transmitting heat through conduction, convection, and radiation. During the day, fires generally travel uphill. Convection currents and heat 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. South and west facing slopes tend to be warmest and driest. The combination of heavy dry fuels on a southwest-facing slope with "chimneys" on a hot day can create near explosive expansion of the fire. Wind can strengthen and spread a fire, and large fires can also 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, driven by the cooling airflow.

Fire experts attribute the generally worsening fire risk to increases in the presence of dry, hazardous fuel. Fires 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, industrial activities, etc.) that take place in the vicinity. Fires, in general, can range from severe events to isolated burns affecting less than a few acres.

The volume and humidity of fuel loads, as well as slope and aspect, affect the exposure and vulnerability of any given site to fire hazard. The type of ignition (man-made or natural) should be discounted in evaluating the risk. If the conditions are right for a major fire, any source of ignition (whether natural or human-caused) will bring about the same end results.

66 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, p. 301.

From a risk management standpoint, the most effective objective is to reduce or eliminate the vulnerability of the community to fire hazards—since the exposure to fire hazard can come from so many possible sources.

Location

Everett is an urbanized city and is generally not susceptible to wildland fires. Everett does not have any extensive urban interface areas, but does contain steep ravines filled with natural growth that are adjacent to extensive residential and commercial properties. Additionally, Everett contains industrial and manufacturing areas, which may increase the potential of an urban fire. Both of these land uses have a greater exposure to fire hazard than most other areas in the city, increasing the vulnerability of the surrounding areas to fire hazard.

New developments and subdivisions in more forested areas expand the areas at risk of fire.

Severity

Fires can burn vegetation and cause loss of life and personal property. The primary concern associated with fire hazard is the threat to human life and safety. Property and environmental damage are also important, though prioritized below life safety. Loss of vegetation due to fires may increase the potential for erosion and mudslides. Fires may also cause the release of hazardous materials and damage utility transmission lines.

Generally, the risk of fire increases with drought, and the risk of a large fire grows with the addition of factors such as steep slopes and wind. One of the impacts of climate change is the increased frequency and intensity of drought, and therefore also the risk of fire.

Warning Time

The onset of a fire can be sudden, with little warning time. The warning time is dependent on the extent of the fire and the speed the fire is traveling. A warning system, or lack thereof, is also a factor affecting warning time.

Past Events

Historically, fires in Everett could be characterized as mill-related incidents, and have had localized impacts in the highly urbanized areas typical of Everett. The county, though, has had several wildland fire incidents in the past.

Since 1979, Snohomish County has experienced only two forest fires of 100 acres or more. During the El Niño summer of 1997, a 750-acre fire in the Marblemount area is attributed to a lengthened growing season, warmer-than-normal temperatures and heavy windfalls from the previous year's storms. There is no record of any large wildfires (greater than 1500 acres) occurring in the county since 1900. The Washington State Department of Natural Resources has records of 845 wildland fire incidents dating back to 1970. The federal government has federal forest fire records dating back to 1987, in which time they have recorded 210 fires in federal forests in Snohomish County.

Secondary Hazards

In steep slope areas, erosion after a fire is a risk that may potentially lead to landslides. During a fire, the protection and stability provided by foliage and organic matter is removed, leaving the soil exposed to wind and water erosion.

Exposure and Vulnerability

In the case of fire, exposure is unpredictable. There are certain factors, such as the presence of gas lines or proximity to an industrial area, which may increase the probability of exposure to fire hazards. Structures near the industrial areas of Everett and urban interface areas have a greater exposure to fire hazards. It is important to note, however, that the exposure to fire hazard comes from so many possible sources that mitigation and prevention efforts should be concentrated on reducing vulnerability. Additionally, Everett does not have any extensive urban interface zones, so wildland fire risk is low.

Structural vulnerability to fire hazards is based in part on steepness of slopes, the density and moisture content of the fuel load, construction materials, and the proximity of neighboring wooden structures. Fires can spread to homes or businesses, and also block roads or other lifelines. This type of hazard can create significant economic and environmental damage if fuel loads and vegetation are not properly maintained.

Many buildings in the north end are wooden structures. Wood homes in close proximity to each other are especially vulnerable to fires. In downtown and the north end of Everett, there is a concentration of wood homes on lots smaller than 5,000 square feet. Throughout the city there are many wood structures on lots smaller than 10,000 square feet. Smaller lot zones are at greater risk of fire spreading rapidly through the neighborhood, especially during windy conditions. The state has a rigorous program for boiler inspections for commercial and government buildings, so these are less of a concern than residences. Many of the new "view homes" on high slopes were built on larger lots and should be less vulnerable to fire. The availability of water to fight fires is another potential vulnerability. Fortunately, in Everett there is a good distribution of water lines and fire hydrants. In the case of fire as a result of earthquake, the fire-fighting capability may be diminished by a ruptured water line.

Table 18 illustrates the number of vulnerable wood structures on smaller lots in Everett, as well as the assessed value of the improvements on the site.

Table 18: Vulnerable Wood Structures on Small Lots in Everett

Parcel Sizes	Number	Area (SF)	Improvement Value ($)	Total Value ($)
Wood structures on parcels <5,000 SF	2668	10,144,876	$199,483,200	$371,116,700
Wood structures on parcels <2,500 SF	226	436,160	$13,379,400	$25,892,100
Wood structures on parcels <1,250 SF	8	9,105	$427,900	$884,200

Issues

The following steps could be accomplished to preclude major loss of life due to fire in Everett:

1. Implement fire prevention education and enforcement programs. Since humans often trigger urban fires and wildfires, this could significantly reduce the threat of fire in the city.
2. Continue development of enhanced wildfire detection systems (such as infrared cameras or wireless sensor networks in areas of concern) and emergency communications capabilities. The importance of immediate reporting of any fire events must be impressed on local residents and users of forested lands in and around Everett.
3. Expand upon existing warning systems such as MyState and the Emergency Alert System to quickly alert local residents in case of fire.

4. Detail primary and secondary escape routes with an evacuation plan for major transportation corridors. Land use planning criteria could ensure that adequate escape routes are provided for new developments in forested areas.
5. Implement fire-safe development planning and appropriate wildfire mitigation strategies for the city as a whole, as well as individual property owners, including:
    a. Requiring the use of fire-resistant roofing materials
    b. Requiring the maintenance of defensible "clear zones" around residential structures
    c. Requiring ingress, egress and turnaround provisions for emergency response units
    d. Requiring the adequate water supply to support fire response
    e. Developing local ordinances (including enforcement) to control hazardous practices (trash burning, campfires, fireworks, etc.)
    f. Ensuring home addresses are clearly visible

Flooding

Definitions

Flood: Defined by the National Flood Insurance Program (NFIP) as:

> "A general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties (at least one of which is your property) from: (1) overflow of inland or tidal waters, (2) unusual and rapid accumulation or runoff of surface waters from any source, (3) a mudflow or (4) the collapse or subsidence of land along the shore of a lake or similar body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels that result in a flood."

2011 Update

Information on national worldwide flood loss has been removed from this section. The data tables have been updated based on more recent GIS parcel data, new FEMA floodplain data and a recent Biological Opinion.

Base Flood Elevation: Elevation of a 100-year flood event, or a flood, which has a 1% chance of occurring in any given year.

Floodplain: 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.

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

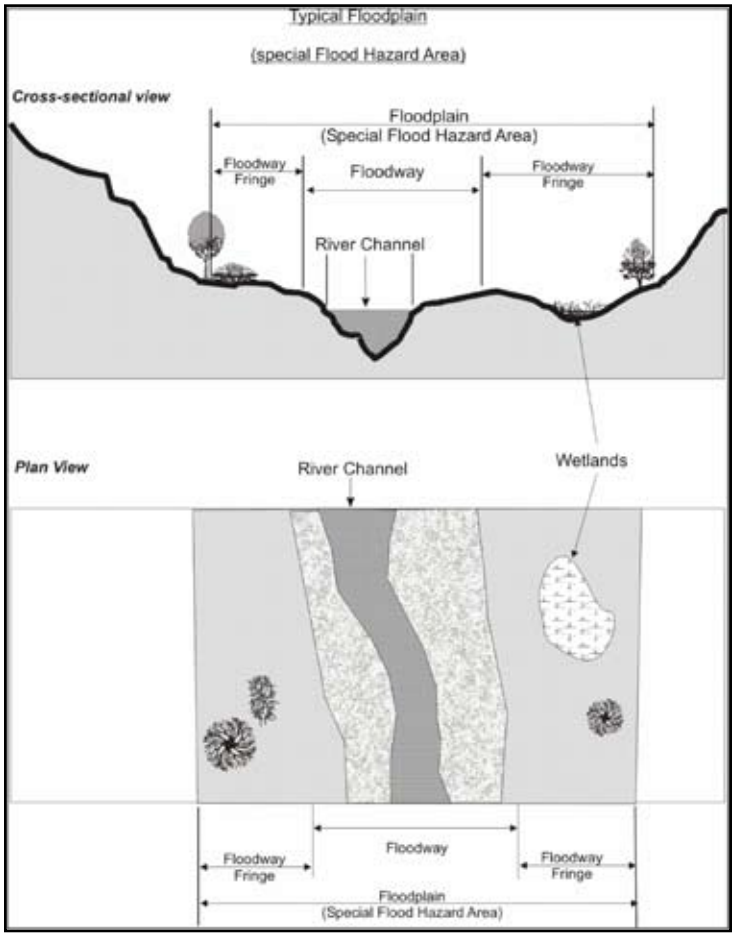
Floodway Fringe: Lands that are in the floodplain but outside of the floodway. Some development is generally allowed in these areas with a variety of restrictions. FEMA contracted the Army Corps of engineers to map the floodplains, floodways, and floodway fringes. Figure 19 depicts the relationship among the three designations.

Zero-Rise Floodway: 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): Official maps on which the Flood Insurance Administration has delineated areas of flood risk and risk premium zones.

Low Impact Development (LID): 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.

Figure 19: Floodway Schematic



General Background

Flooding 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 increases flood potential in two ways: 1) it reduces the stream's capacity to contain flows; and 2) increases flow rates downstream. Climate change is impacting the timing, frequency, and severity of flooding worldwide. In the Pacific Northwest, early spring flooding may be reduced due to smaller snowpack, but later spring flooding may occur more often due to earlier snowmelt.[67]

Damages resulting from flood are the most common and widespread of all natural disasters within Washington State. Most communities have experienced some flooding, after spring rains, heavy thunderstorms, or winter snow thaws. Flooding for most west draining Cascade rivers, accompany late autumn or winter storm events and is enhanced when warmer weather causes the snow to melt

67 Washington Economic Steering Committee and the Climate Leadership Initiative Institute for a Sustainable Environment University of Oregon. 2006. "Impact of Climate Change on Washington's Economy: A Preliminary Assessment of Risks and Opportunities."

by contributing flows to the rain caused discharge. Cascade river reaches are short and flooding generally develops over a few days.

Of all the natural disasters that affect Snohomish County, floods are the most common and, on a year-to-year basis, cause the most property damage throughout western Washington. There are three types of floods that affect the county:

Riverine flooding

Most residents of Snohomish County are familiar with the annual conditions responsible for the potential of riverine flooding. "Flood season" begins in mid-November and continues to mid-February. The first element leading to a potential flood is a heavy, fresh snow in the mountains. If a weather front with warm winds, usually from the southeast and heavy rainfall follows the snow before it has a chance to settle and solidify, a flood potential exists. It is rare for rain to cause flooding without the other elements being present. High tides may be responsible for holding up the normal discharge of river runoff into Puget Sound, while low tides facilitate the discharge from the Snohomish and Stillaguamish River systems.

Tidal flooding

The potential for flooding in low-lying coastal areas exists when unfavorable atmospheric conditions (i.e. very low pressure) occur simultaneously with periods of unusually high tides. No significant damage has been experienced in Snohomish County in the recent past due to tidal flooding. Storm surges, also known as storm tides, can affect a number of beachfront areas within Snohomish County. Generally, storm surges are caused by an increase in the usual tide level by a combination of low atmospheric pressure and onshore winds. During a storm surge tides may run from two to four feet above the predicted tide level. Storm surges can usually be predicted up to 12 hours before occurrence; however, only an approximate height can be predicted because of the large number of variables. The effects of a storm surge generally range from salt-water inundation to the battering of beachhead property by water driven debris. The beachfront areas in Snohomish County most likely to receive storm surge damage are near Mukilteo, Marysville, the Tulalip Reservation, Hat Island and Stanwood. Property most often damaged by storm surge includes beachfront homes and businesses, bulkheads, marinas, docks and ferry terminals.

Flash flooding and surface flooding

Several factors contribute to flash flooding. The two key elements are rainfall intensity and duration. Topography, soil conditions, urbanization and ground cover also play an important role. Flash floods occur within a few minutes to a few hours of excessive rainfall, a dam or levee failure, or a sudden release of water held by an ice or log jam. They can roll boulders, tear out trees, destroy buildings and bridges, and scour out new stream channels. Most flood deaths are due to flash floods. Flash flooding can occur in the upper valleys and tributary systems of the Skokomish, Pilchuck, White Chuck and Sauk Rivers.

Reducing Flood Damage

The most effective method of reducing flood damage is through mitigation. Mitigation includes any activities that prevent an emergency, reduce the chance of an emergency happening, or lessen the damaging effects of unavoidable emergencies. Investing in mitigation steps now, such as, engaging in floodplain management activities, constructing barriers, such as levees, and purchasing flood insurance will help reduce the amount of structural damage to your home and financial loss from building and crop damage should a flood or flash flood occur.

Snohomish Basin

The Snohomish River flows twenty-three miles from the confluence of the Snoqualmie and the Skykomish Rivers at the city of Monroe to Port Gardner Bay in Everett. The drainage basin extends from an elevation of 8,000 feet in the Cascade Mountains to sea level at Everett. Tidal action affects river stages in the lower thirteen miles. The river's gradient is approximately one foot per mile. At bank full the width of the river channel varies from 35 to 500 feet.

Location

The Snohomish River flows around the Everett peninsula draining into Puget Sound. Floodplains surround Everett on three sides. Land included in the floodplain includes the Port of Everett and several industrial sites. The city has developed plans for a multi use residential and commercial development along the North Eastern floodplain.

A majority of the frequently flooded area of the city would experience nuisance flooding where on average, water would only affect isolated areas. Most of the widespread flooding would occur in the lower lying areas of the waterfront and industrially zoned areas along the Snohomish River. With little or no residential parcels in these areas, the risk of widespread impacts is low.

Past Events

The history of flooding in Everett and Snohomish County is an important part of its identity. Historical records indicate that documentation of flooding along the rivers in Snohomish County dates back to the nineteenth century, when pioneers first settled in the area. This section describes the major historic flood events affecting Everett and Snohomish County. This section also provides a list of federally declared disasters in Snohomish County due to flooding, as shown in Table 19. These declarations represent the most severe flooding events since 1956 that have been compensated with federal money.

2011 Update

This section has been updated to include more recent Federal Flooding Disaster Data, climate change information, and a discussion of the National Marine and Fisheries Agency Biological Opinion.

Table 19: Snohomish County Federal Disasters Due to Flooding

Date	Disaster Number
December, 1964	185
December, 1975	492
December, 1977	545
December, 1979	612
November, 1986	784
November, 1990	883
December, 1990	896
November, 1995	1079
February, 1996	1100
December, 1996	1159
November, 2003	1499
May, 2006	1641

Date	Disaster Number
December, 2006	1682
December, 2007	174
January, 2009	1817
March, 2009	1825

Winter floods inundate most of the County's floodplains every three to ten years. Flooding in Snohomish County is characterized by a combination of warm rainfall followed by heavy low-level snow. These storm patterns initially saturate the soil with the first rainfall and then cause flooding and property damage with the second storm. Flash flooding is typically caused by slow-moving thunderstorms or heavy rains associated with spring or early summer storm systems. Each River Basin has unique characteristics that contribute to different levels of flooding and damage.

1995-1996 Flooding

The classic ingredients for wintertime flooding are a heavy snow pack over nearly saturated or frozen ground, followed by a rapid rise in temperature and heavy rain. The wet and warm weather contributes to significant snowmelt, resulting in excessive runoff that often leads to flooding. These conditions resulted in large-scale flooding throughout the Pacific Northwest during December 1996.

Most of the precipitation fell during two distinct periods in November and December. The first period lasted from the November 16 until the December 13..By December 13, the six-week precipitation totals were five to fifteen inches above the mean in many areas of northwestern Washington.

Over the next ten days (December 14 to December 23), cooler and drier conditions dominated the Northwest, with the heaviest precipitation (2-4 inches) falling primarily as snow. This period was followed by a rapid increase in temperature and a return to excessive precipitation during the next ten days (December 24 through January 2), with 17 to 34 inches of precipitation falling on orographically favored areas and more than six inches falling elsewhere throughout the affected region. Due to the extremely warm weather during the period, much of this precipitation fell as rain. This wet and warm weather produced significant snowmelt at lower and middle elevations, resulting in severe flooding throughout the Northwest. During this period, the liquid water runoff (rainfall plus snowmelt) exceeded 11 inches in many areas.[68]

Exposure and Vulnerability

Population

The total improvement dollar value for single-family residential parcels within the 100-year floodplain has been estimated at about $5,149,700.

Isolation

The probability that a large portion of the city's population would be isolated during a major flood event is low, due once again to the elevation of the city in relation to the riverine floodplain. The city as a whole may experience isolation from areas east of the city, along US Highway 2.

Property

Tables 20 and 21 detail the properties vulnerable to flooding by land use and market value.

68 Halpert and Bell, 1996.

Table 20: Exposed Parcels in the Snohomish River Floodplain – Parcel Count

Parcel Count	Flood Zone		
Land Use (Code)	500-Year Flood	100-Year Flood	Total
Residential (100)	17	34	51
Manufacturing (200 & 300)	13	57	70
Utilities and Transportation (400)	3	62	65
Services (500 & 600)	23	37	60
Parks (700)		128	128
Farming and Mining (800)	4	37	41
Open Space (900)	24	200	224
Grand Total	84	555	639

Table 21: Exposed Parcels in the Snohomish River Floodplain – Parcel Value

Parcel Improvement Value	Flood Zone		
Land Use (Code)	500-Year Flood	100-Year Flood	Total
Residential (100)	$1,624,400	$5,335,600	$6,960,000
Manufacturing (200 & 300)	$6,025,600	$39,733,600	$45,759,200
Utilities and Transportation (400)	$219,500	$69,440,300	$69,659,800
Services (500 & 600)	$314,245,300	$10,913,400	$325,158,700
Parks (700)	$0	$29,217,200	$29,217,200
Farming and Mining (800)	$419,200	$1,193,100	$1,612,300
Open Space (900)	$0	$550,600	$550,600
Grand Total	$322,534,000	$156,383,800	$478,917,800

Repetitive Loss Properties

There are no Repetitive Loss Properties in Everett. There are only three (3) properties in the study area with a cumulative total premium or claim payment of over $5000. Two are commercial properties, one of which is in a basement. The only residential property with historically high losses has been rebuilt in such a way that it is no longer eligible for NFIP coverage.

FIGURE 20: EXPOSED FLOODPLAIN PARCELS BY LAND USE TYPE

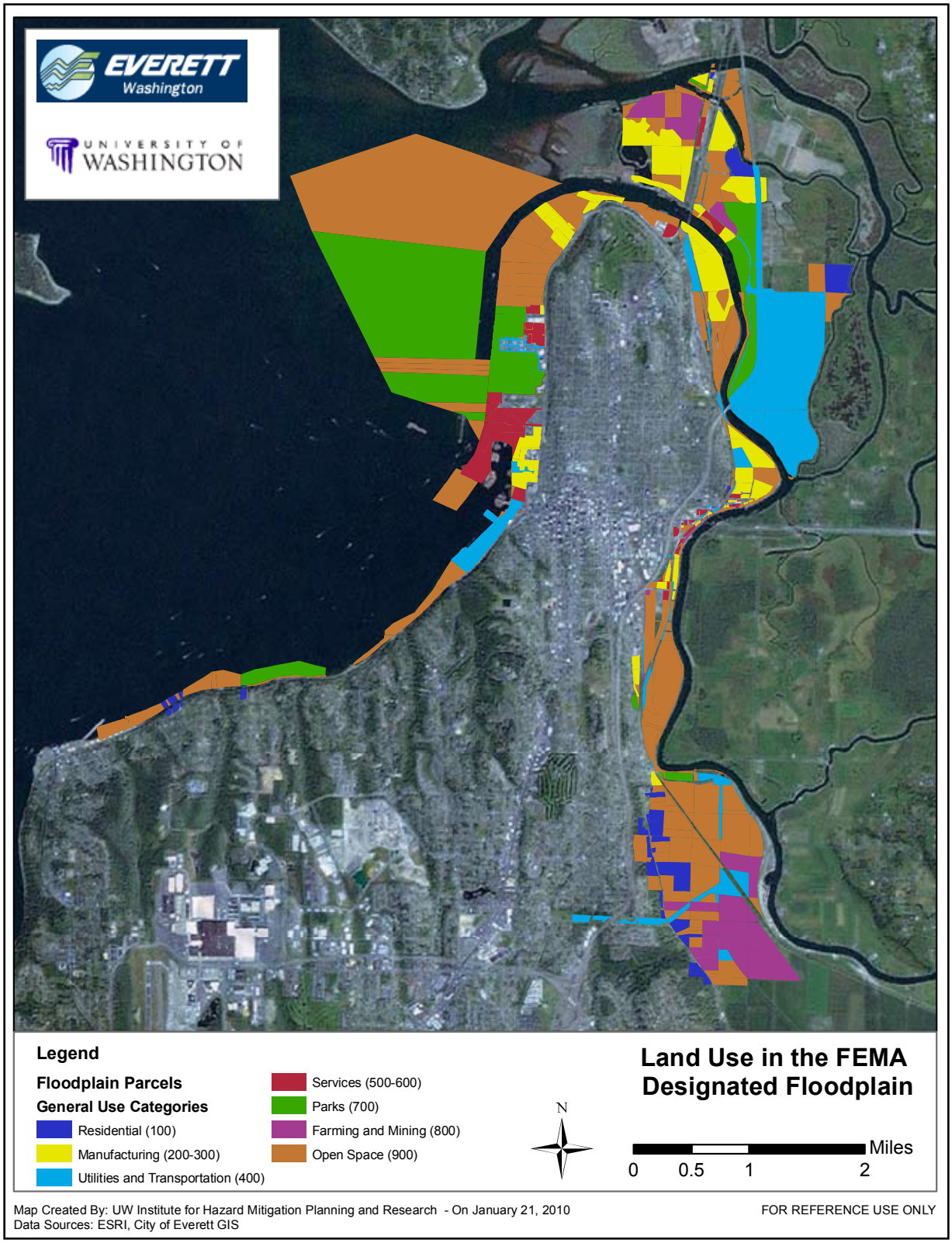
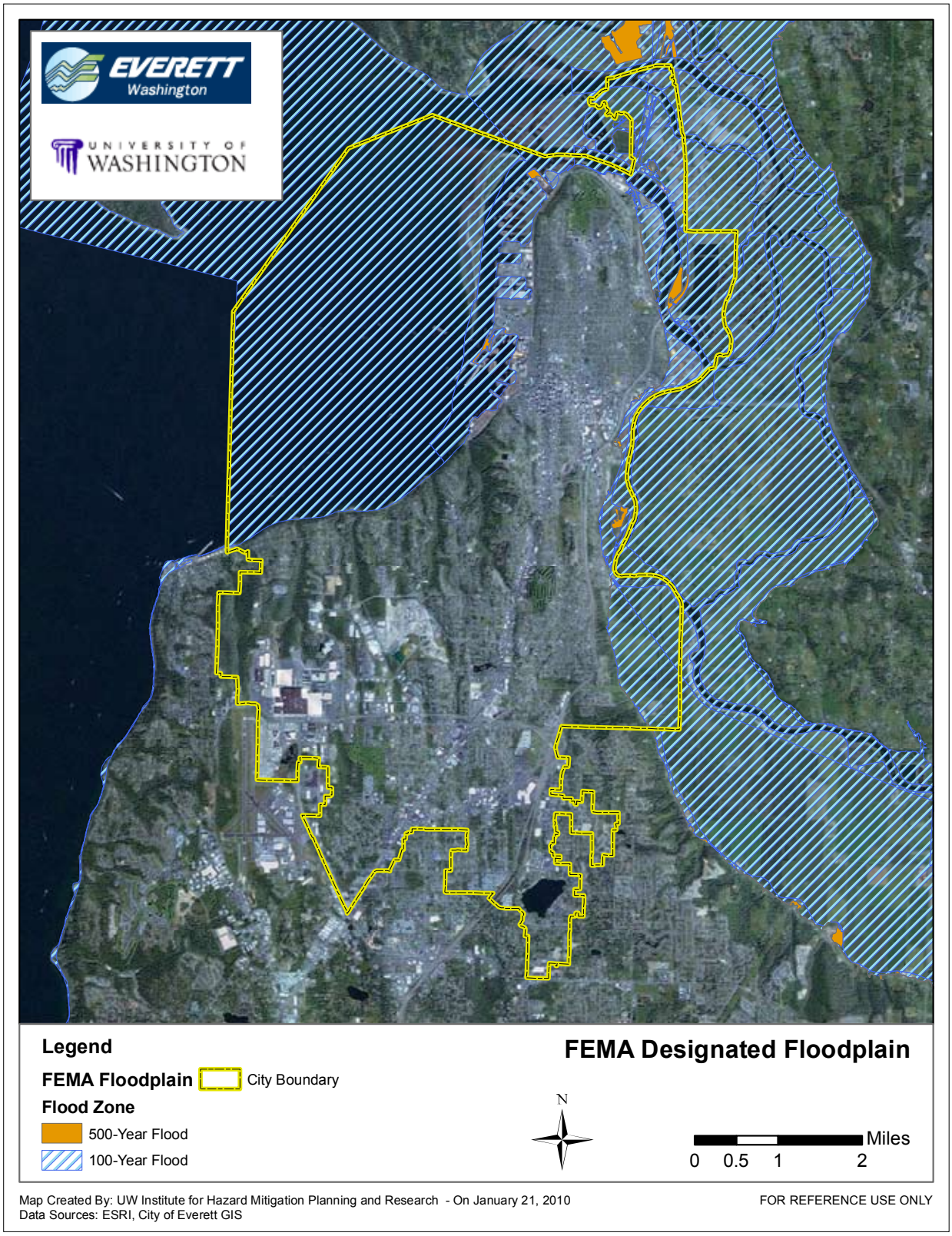


Figure 21: Everett 100-Year and 500-Year Floodplain



Critical Facilities

Industrial lands, the Port of Everett, and the wastewater treatment facility on Smith Island are behind dikes but lie within the 100-year floodplain and are at risk from flooding.

Critical Infrastructure

Transportation Systems

Portions of State Route 2 and the BNSF Railroad are vulnerable to large floods due to the damming effect of supports. These may become weak or may suffer damage when exposed to heavy pressure from riverborne debris and velocity waters. I-5 is also vulnerable where it crosses over the Snohomish River to the north of the city.

The BNSF Railway, as it crosses north around Everett, is vulnerable to flooding. The railway crosses more flood-prone lands as it heads east into the county. The Port of Everett is at risk from flooding from the Snohomish and from coastal storms and tsunamis.

Water and Wastewater

Water transmission lines run from Sultan to Everett across streams, rivers and floodplains. The lines are protected by Snohomish County Diking Districts 1 and 6.

The wastewater treatment facility in Everett may be vulnerable to flooding damage. The treatment plant is located on Smith Island, northeast of the city. To help mitigate flood damage, the facility has a dike surrounding its perimeter as part of Diking District 5.

Wastewater may discharge into the river should the facility flood.

Environment

The Snohomish River is a recognized habitat area for native salmon and as such falls under section 167 of the Revised Code of Washington. RCW 167 states that all jurisdictions shall use the best available science in regulating critical areas with policies that protect and enhance the habitat.

Floods are generally accepted as part of the natural weather cycle common to western Washington. Detrimental effects to the environment are normally associated with the secondary hazards associated with and caused by flooding.

Since these waterways are part of a larger natural system they may be vulnerable to contamination wastewater releases, not only from local floods, but also from flooding that may occur upstream from Everett. The principal point source would include the open aeration ponds of the Everett Wastewater Treatment Facility.

Impact Scenario

Flooding could originate from Puget Sound or the Snohomish River. Other sources of flooding could include isolated stormwater flooding within Everett.

Each source of flooding brings different characteristics. Depending on the type of flooding that occurs, the impacts will be different. Riverine flooding is most likely to occur in the winter months due to fresh snowmelt and this type of flooding does not pose as much of a threat to the city. It does pose a threat to the industrial and commercial areas along the Snohomish River floodplain and coastal floodplain bordering Puget Sound.

Flash flooding may occur on the very short drainages along the Cities Western bluffs. This type of flooding is more likely to occur in summer and fall months.

Probability of Occurrence

Flooding (coastal, stormwater, and riverine) is as commonly associated with severe weather events. The probability of occurrence is similar to that of severe weather. Climate change will not shift traditional flooding patterns. Annual discharges may not change with Climate Change, but the frequency of intense winter storms will. There will be more heavy rains and onshore surf. Upland forests will be stressed and die-offs may occur reducing storage and increasing the rate of discharge. Development within the floodplain areas will also increase the frequency of flood damage since more people and property will become exposed unless mitigation actions are undertaken to reduce flood risk.

Issues

Everett is a mature city with relatively few vacant or open parcels. A desire to continue to grow has focused attention on the possibility of development in the low-lying areas in and around the floodplain.

Historically, the risk of flooding to Everett-area properties has been low, even though there are some properties within the floodplain. Continuing this low level of risk is dependent upon maintaining the low density and low value of projects built within floodplain areas, and upon constructing new projects in a way that mitigates their flood risk.

National Marine Fisheries Service Biological Opinion

In response to a lawsuit brought by the National Wildlife Federation against FEMA, the National Marine and Fisheries Service have mandated new requirements in the enforcement of the National Flood Insurance Program. These changes are designed to prevent harm to endangered species, including salmon and orcas. All localities in the Puget Sound area must bring their local floodplain regulations into compliance with the new regulations. Alternatively, they may have each project in the floodplain independently approved by the city, after which FEMA will review the adequacy of implementation during their Community Assistance Visit (CAV). Everett is currently in the approval process for their modified floodplain regulations.

Hazardous Materials

Definitions

Brownfield: Properties that are abandoned or under-used because of historic environmental contamination.

Extremely Hazardous Substances: List of substances deemed extremely hazardous under Section 312 of Title III (see below). It is based on the list of substances published in November 1985 by the Administrator in Appendix A of the ''Chemical Emergency Preparedness Program Interim Guidance''.

Hazardous Materials: Sometimes referred to as 'hazmat', refers to materials that have chemical, physical, or biological natures that threaten life, health or the environment when released. There are several properties or qualities that make a material hazardous, including flammability, combustibility, corrosiveness, chemical reactivity, toxicity, radioactivity and explosive potential. Hazardous materials can also possess a biological agent threat.

2011 Update

This section was updated to include a new list of hazardous materials facilities and updated information about the risk and frequency of hazardous material releases. The section on exposure and vulnerability exhibited redundancies and were combined.

Tier II Report: Facilities storing chemicals are required, under Section 312 of Title III (see below), to provide specific information about the chemicals that they are storing onsite to the State Emergency Response Commission, Local Emergency Planning Committees, and local fire department. The threshold levels for reporting chemicals stored onsite is either the Threshold Planning Quantity (TPQ) or 500 pounds at any one time, whichever is less for Extremely Hazardous Substances; or 10,000 pounds at any one time for Hazardous Maaterials.

General Background

Hazardous materials are released 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 people, the environment and the ecosystem. The impact of hazardous materials incidents depends on the quantity and physical properties of the release, the type of incident that occurred, and its proximity to exposures. Concerns associated with a hazardous material incident include the evacuation of vulnerable populations, clean up and recovery efforts, and the short- and long-term economic impact on vulnerable spaces.

Title III

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 LEPC, the local fire department and the Washington Department of Ecology.

Location

Everett has had a long history of industry, with early settlers moving to the peninsula to utilize the vast natural resources the Puget Sound offers. By the late 1800s and early 1900s, Everett's business practice dedicated its waterfront to industrial uses. With the presence of the railroad, the introduction of pulp and paper manufacturing in the early 1900s, the addition of Boeing manufacturing in the 1960s and the U.S. Navy Carrier Lincoln Homeport construction and designation in the 1990s, Everett now boasts a diverse economic base built on its early industrial heritage.

2011 Update

This section has been updated to include information on the sale of the Everett Landfill.

A hazardous materials release can occur from two sources:

- Fixed sites (facilities that process or store hazardous materials on site)
- Transportation related operations

Because of the industrial, commercial and manufacturing nature of Everett's economic base, and the presence of practically every form of transportation network, the likelihood of a Tier II release or a transportation-related release of hazardous materials is high.

Everett Landfill

The Everett Landfill, closed since 1975, has recently been proposed as the site of several new development proposals. In 1998, after many actions to clean up potential leachate and the aftermath of several tire fires in the 1980s, the City of Everett received a grant from the U.S. Environmental Protection Agency to evaluate the site for "Brownfield" redevelopment opportunities.[69] There is proposed new development in the tire fire area on the Simpson Mill site, but there are methane issues to consider with the capped landfill. Future development plans are contingent on the mitigation of environmentally-based restrictions on the site.

Industry

Everett is a city built on industry. The standard industrial practices of previous time periods have created enormous human and environmental costs for later generations.

As an example, arsenic, lead and other metals have contaminated an approximate 600-acre site located in northeast Everett. The contamination was caused by emissions from the Everett Smelter between 1894 and 1912, and by material left behind when the smelter was demolished between 1912 and 1915. Asarco purchased the Everett Smelter in 1904 and assumed operations at that time. The property was sold in various parcels between 1915 and 1936, and homes were built on many of the parcels.

A Washington State Department of Ecology Order, entered in Snohomish County Superior Court (June 2002), mandated the removal and cover of the most contaminated areas. Of the thirty-seven houses included, twenty-eight were removed. Hazardous levels of heavy metals were removed at a depth to two feet, and a warning barrier then placed in the area. The cleanup of the nine remaining houses is complete and the WSDOE has certified the homes as safe. In 2004 the Everett Housing Authority purchased the recovered eighteen acres for $3.4 million for future residential development. Prospective buyers are informed of the history and restrictions of the property.

The Kimberly-Clark Everett facility is located at 2600 Federal Avenue. The facility primarily consists of a bleached sulfite pulp mill, paper machines, and utility boilers. Chemicals used in the pulping and

69 City of Everett website. "City Hall of Everett." Accessed online on March 5, 2011 from http://www.everettwa.org/cityhall/default.asp?sectionid=4&parentid=16&subid=1&subid2=0

bleaching processes would be the primary hazard that could affect the community in the event of a natural disaster. In the sulfite pulping operation, wood chips are cooked utilizing ammonium bisulfite cooking acid prepared on site. The cooking acid is prepared with sulfur dioxide (purchased) and an aqueous solution of ammonia (prepared on site with anhydrous ammonia and water). The pulp bleaching system utilizes chlorine dioxide solution manufactured at the mill. As of 2000, the mill no longer uses elemental chlorine.

Kimberly-Clark also operates an industrial wastewater treatment plant at the Everett site. This plant is operated 24 hours per day, 365 days per year. Treatment involves pH adjustment, biological secondary treatment, solids settling and sludge dewatering. The primary parameters of daily monitoring and treatment for water quality are 1),Biochemical Oxygen Demand (BOD), which measures the oxygen demand of wastewater; if BOD is too high, oxygen is consumed from the receiving water, 2) Total Suspended Solids (TSS), which adds to turbidity of the receiving water, and 3) pH. Sludge is dewatered and conveyed to the hog fuel boiler on-site for incineration. Treated effluent discharges into Port Gardner Bay.

Port of Everett and Waterfront

The Port's terminals include concrete decks and piers, a refrigerated warehouse, a log yard, an intermodal container facility and a 55,000-ton alumina storage dome. The large, chilled warehouse facility utilizes ammonia and other chemicals. Everett Marina, one of the largest small boat harbors on the West Coast, is a potential source of small (usually less than five gallons) fuel spills. The proximity of hundreds of small boats with varying fuel tank capacities presents the potential for frequent minor spills, as well as for a major marina fire.

The U.S. Naval Station at Everett is home port to a number of assigned surface vessels. The base has a Marine Spill Response Team that is capable of rapidly and effectively handling accidental releases on the facility.

Utilities and Transmission Lines

Natural gas, commercial propane and commercial butane, and liquefied petroleum gas (LPG) gas pipelines serve several storage farms in Snohomish County, as well as all major cities and towns. Olympic Pipeline Company maintains two major liquid petroleum product pipelines through Snohomish County. Williams Natural Gas also operates a major north-south pipeline carrying vapor petroleum products.

A proposed Williams Company nine-mile-long lateral pipeline, which would provide an additional 133 million cubic feet of natural gas per day, would service a proposed co-generation power plant in the Everett Delta area near the Legion Memorial Golf course in northeast Everett.

Tier II Reporters

There are numerous Tier II facilities within Everett's city limits and over 250 within Snohomish County. Table 22 lists the names and locations of some Tier II facilities. There are approximately 100 Tier II reporting facilities in Everett; however, the majority of them are smaller, such as gas stations, and do not pose a serious threat to a wide area. Therefore, only those facilities that store materials capable of causing widespread injury upon release are listed here.

Table 22: Tier II Facilities in Everett

Tier II Facility	Location (in Everett):
Achilles USA Inc	1407 80th St SW
Aramark Uniform Services Inc Everett	7200 Hardeson Rd
ATT Everett	2505 W Casino Rd
ATT Mobility Paine Field 11413	1118 80th St SW
Blue Streak Finishers Ltd 80th St	1520 80th St SW
BNSF Railway Everett	3429 15th St
Boeing Cag Everett	3003 W Casino Rd
CBI Services	5500 S 1st Ave
Cemex Everett Plant	6300 Glenwood Ave
Cemex N Everett Plant	222 W Marine View Dr
Cintas Corp 460	6400 Merrill Creek Pkwy
Coastal Manufacturing Inc	6700 Hardeson Rd Ste 103
Eldorado Stone Llc Everett	1200 Industry St
Everett Steel Companies	3126 Hill Ave
Everett Water Pollution Control Facility	4027 4th St SE
Fluke Evergreen Way	9028 Evergreen Way
Fluke Seaway	6920 Seaway Blvd
Food Services Of America Everett	1001 Shuksan Way
Glacier Northwest Inc Everett Plant	2222 Ross Ave NE
Kimberly Clark Worldwide	2600 Federal Ave
Level 3 Communications Everett	1121 SE Everett Mall Way
Marine Spill Response Corp	1330 Industry Street
Pepsi Cola Bottling Co Everett	1118 80th St SW
Rolling Frito-Lay Sales LP Everett	1808 Merrill Creek Pkwy
Smith Island Hot Plant	2111 Ross Ave
SNBL USA Ltd	6605 Merrill Creek Pkwy

Most transport of hazardous materials through Snohomish County and Everett is accomplished either by rail or by I-5, the major interstate route on the west coast.

The BNSF railroad travels along two separate routes through Everett. One line travels east-west through downtown Everett. This line travels through the BNSF tunnel between California Street & Hewitt Avenue from Oakes Avenue to West Marine View Drive and then west along Everett's waterfront. The second line travels along the Snohomish River north, "around the horn," with the line splitting, with one line going south to Seattle and one line going north to Canada. This second line intersects the first line at the Everett waterfront and then follows the Puget Sound shoreline to Seattle.

The Seattle Sounder uses the BNSF line through an agreement among Burlington Northern Railroad, Amtrak, Snohomish County and Sound Transit. The Everett Rail Station for the Sounder and Amtrak is located on 3201 Smith Avenue. This represents the main passenger terminal along the BNSF rail line.

This east-west rail corridor is also the location of State Route 2 as it travels east over the Cascade Mountains. BNSF and the LEPC have information on how much hazardous material is transported on this railway. This rail line is a major thoroughfare, taking materials from Everett to eastern Washington and beyond.

A significant percentage of the material hauled by rail into Snohomish County travels from Tacoma to Everett. The chemicals carried along this route include chlorine, caustic soda, anhydrous ammonia, and methanol. The most common materials shipped through Snohomish County include LPG, vinyl chloride, methanol, and motor fuel anti-knock compound. The east/west rail corridor typically carries lesser amounts of methanol, chlorine, and LPG. The I-5, US-2, SR-99 and SR-526 corridors handle most of the roadway hazmat transport in Snohomish County. However, much of this traffic may subsequently travel short distances along a few heavily used arterials serving the Port of Everett, Boeing, and other industrial areas. Over 50% of the hazardous materials shipped by roadway includes diesel fuel, gasoline, aviation fuels, various motor/hydraulic oils, LPG, and other petroleum products.[70] The following make up the bulk of the remaining materials:

- Caustic soda
- Sulfuric acid
- Hydrochloric acid
- Nitric acid
- Phosphoric acid
- Oxygen
- Anhydrous ammonia
- Sodium chlorate

There are two major rail yards in Everett. Delta Yard and the West Yard, located along Everett's waterfront handle mixed traffic, which include cargo, passenger trains, and garbage. At the Delta yard, there are two large propane tanks. Hazardous materials that pass through the yards could pose a hazard to the surrounding area in the event of an accidental release.

Some of the other materials passing through the county via the highway system could potentially include low-level radioactive wastes, Class C explosives, blasting agents, corrosives, and other hazardous materials.

Marine transport is responsible for a very small percentage of the county's total tonnage of hazardous materials. Large monthly barge shipments of chlorine and caustic soda to Everett's Kimberly-Clark paper/pulp plant were replaced with smaller truck shipments, which do not include chlorine, when the company changed over to a chlorine dioxide bleaching process in the fall of 2000. Additionally, shipments of aluminum ore are delivered to the Alumina Dome located at the Hewitt Terminal.

Transport of hazardous materials by air is essentially confined to the actual fuels and lubricating fluids carried on board aircraft as a normal function of flight operations. While Paine Field Airport does have a significant air traffic load, the total quantities of non-fuel substances are relatively small. Paine Field has 2.3 million gallons of aviation fuel stored on site to service the approximately 500 aircraft using the airport daily.

70 Snohomish County Hazard Identification and Vulnerability Analysis, Snohomish County Department of Emergency Management, January 1, 2002

Figure 22: Everett Tier II Facility Locations and Major Transportation Routes

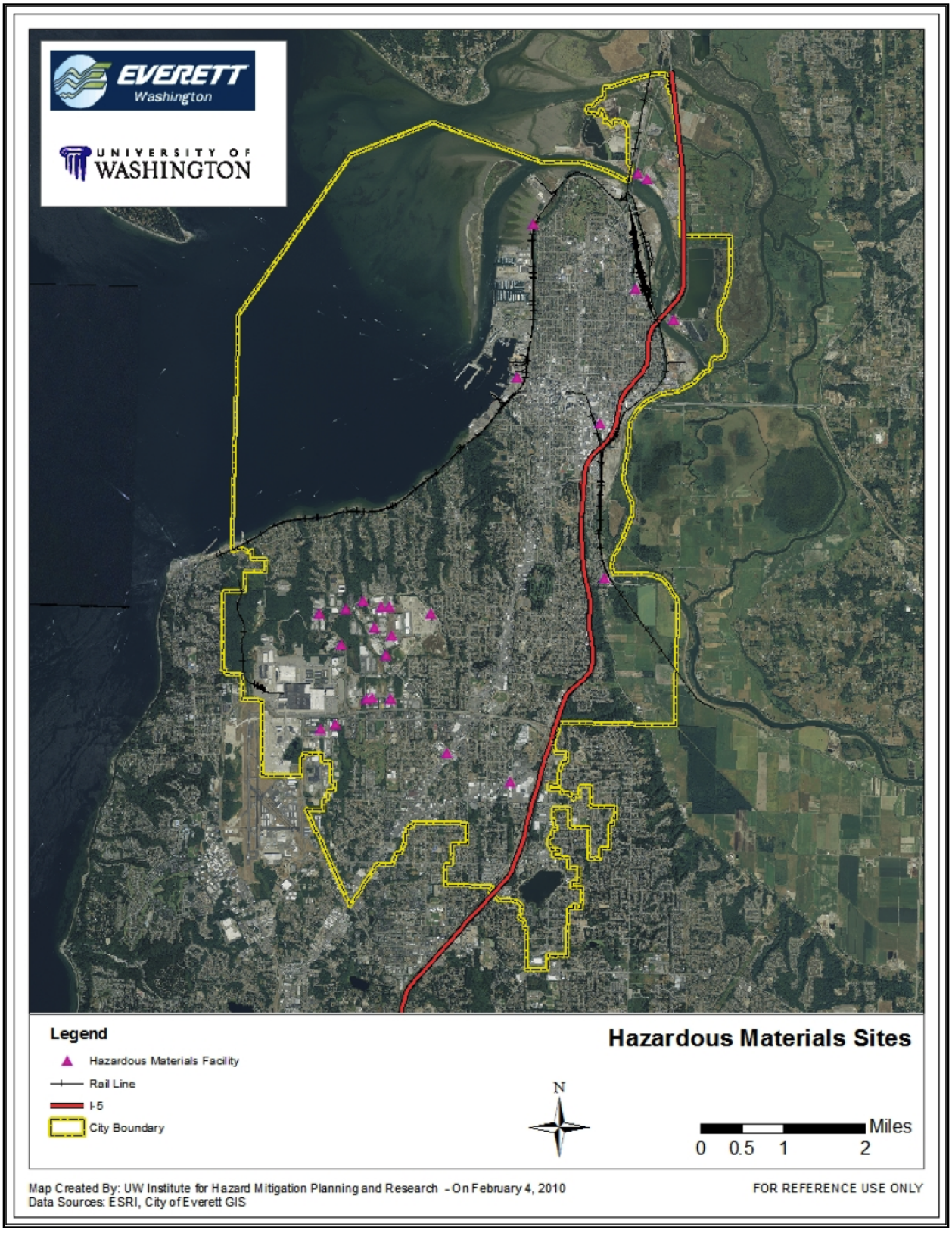
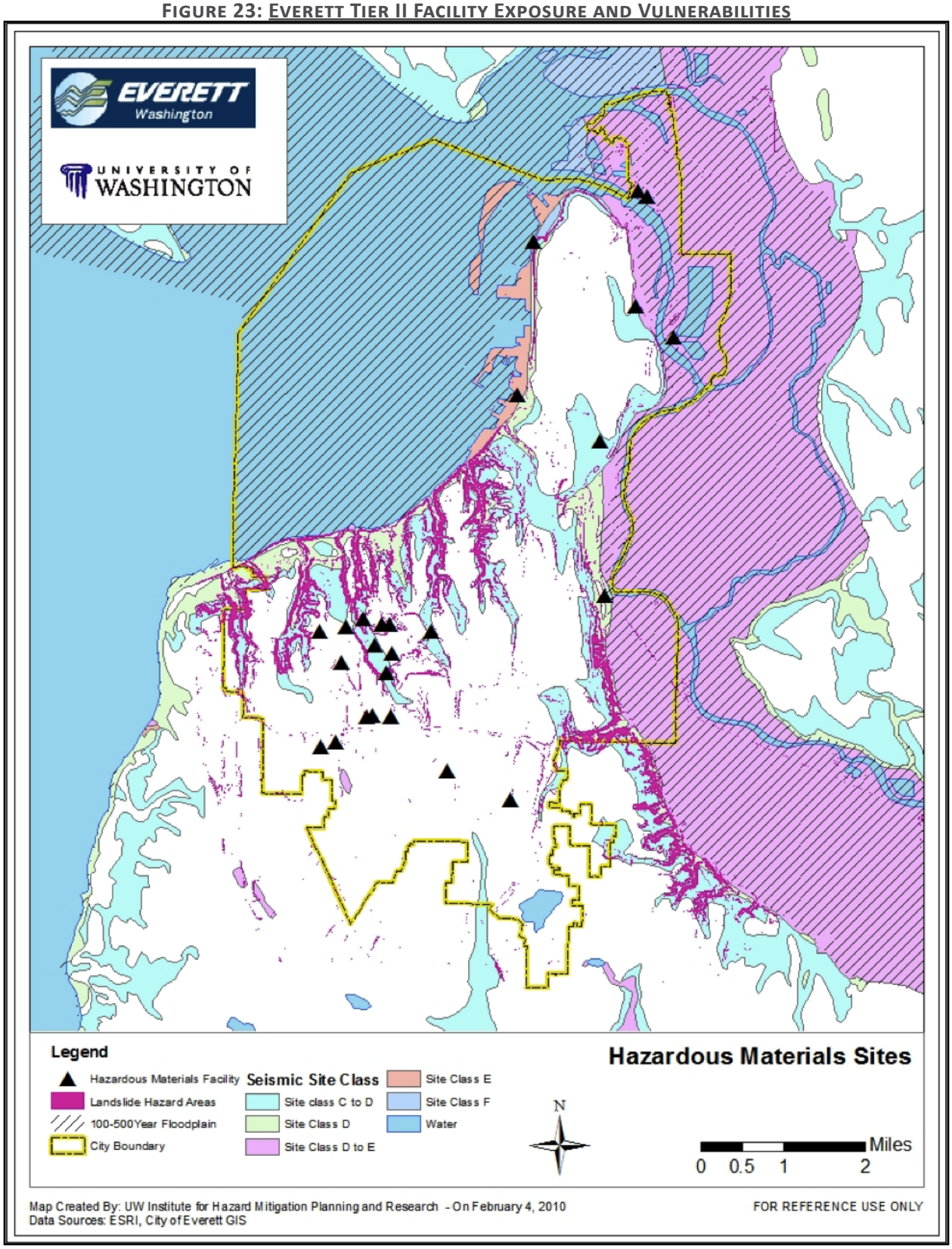


FIGURE 23: EVERETT TIER II FACILITY EXPOSURE AND VULNERABILITIES



Frequency

The probability of a hazardous materials release in Everett is higher than the rest of Snohomish County. Over half of the Tier II Facilities in the county are located in Everett. Additionally, the confluence of major transportation and rail lines in the city, as well as the location of the Port of Everett along Everett's waterfront, increases the potential of a hazardous materials incident from a transportation related accident.

Within Washington State, Snohomish County's Local Emergency Planning Committee (LEPC) jurisdictional area contains the second most Tier II reporting facilities (following King County).[71] Accordingly, Snohomish County also had some of the highest numbers of chemical releases. In total for 2007, the latest date for which data is currently available, a total of 535,843 pounds of hazardous materials were released into the air and water. The most commonly released chemicals include zinc, methanol (usually related to paper mills), lead, lead compounds, barium compounds, hydrochloric acid, nitrate compounds, styrene, ammonia, and carbonyl sulfide.

Kimberly-Clark Worldwide, located in Everett, was responsible for 280,771 pounds of material released on site. Twelve separate materials were included in this release. Boeing was the other large emitter in Everett and Snohomish County, with thirteen materials reaching a release total of 91,252 pounds.

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.[72]

- 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.
- A large-scale incident affects large areas and requires immediate response regardless of the quantity involved in the incident.

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

As a way of measuring risk, the Environmental Protection Agency uses the Risk Screening Environmental Indicators (RSEI) computer program to prioritize those releases that might be of health concern to the public.[73] The program considers for an event scenario the amount of chemical released, the impact on people, the extent of human exposure, the fate and transport of the chemical, and the chemical toxicity. On a facility level, the Kimberly-Clark facility ranks the highest in terms of RSEI risk score.

Warning Time

Hazardous materials releases can occur at any time without warning. Once the release has occurred the potentially affected areas may have little or no warning time, depending on which chemical was released and the method by which the chemical will travel. The initial identification of specific hazardous materials types can increase response capabilities.

71 Tier II Facilities Report, 2007, 5-16
72 Hazardous Materials Contingency Plan for Hazardous Materials Spill/Release. University of Toledo. Accessed online from http://safety.utoledo.edu/contplan.htm
73 Tier II Facility Reporter, 16

Secondary Hazards

Hazardous materials incidents can produce a variety of secondary effects. Fires resulting from hazardous materials releases are the most significant secondary hazard. Additionally, hazardous materials releases could be a secondary hazard of other natural hazards. This may include earthquakes, landslides, severe storms, flooding, and urban or wildland fires.

Hazardous materials incidents can have a significant effect on the environment. Releases into the environment have the potential to significantly damage soils, water quality, wildlife habitat, and vegetation. Harm to protected areas and streams, as well as critical habitat for threatened or endangered species is likely. Processes to clean up hazardous materials releases are often costly and time consuming, resulting in severe environmental and economic impacts.

Exposure and Vulnerability

Population

In the event of a hazardous materials exposure, there could be several populations that would be at risk, depending on the type of event that initiated the exposure:

- In the event of a train derailment in the city, several blocks of downtown and the north end of the city could be vulnerable to exposure. The time of day would be a significant factor in determining the impacts to the population.
- An event at a Tier II facility along the waterfront could not only affect Everett, but potentially many other areas along the Puget Sound. Because most of Everett's waterfront is dedicated to industry, residential exposure may be limited. The potential redevelopment and inclusion of residential structures in the marina may force planning efforts to consider the future risk associated with these populations, as well as and already-existing, but small, populations living on boats in the marina.
- An event that impacts pipelines (such as a natural gas line) may have widespread effects, but not necessarily on any specific population. Most damage would be to the environment and the exposed population in the immediate vicinity of the event.
- If a Tier II facility or hazardous materials pipeline is located upstream from a particular residential cluster, the population downstream may be at a higher risk of exposure from water-borne contaminants.
- Populations upwind (generally east of the Puget Sound) from a potential airborne chemical release may be at a higher risk as the airborne plume moves outward from the source.

The most vulnerable populations are those located in relatively close proximity (quarter mile) to Tier II facilities, although once pollutants are introduced to natural systems, such as air and water, they can be spread to surrounding areas very quickly. Furthermore, those populations living on or near facilities situated on poor soils are at an elevated level of risk.

Populations located downstream and downwind from Tier II facilities are more vulnerable to the effects of hazardous materials.

Property

It is difficult to assess the vulnerability of properties located near Tier II facilities without knowing what kind of hazardous material is being released and in what quantity, although it can be assumed that those located closer to Tier II facilities would incur the most damage. In determining vulnerability, we generalized that the area within a quarter-mile radius from the source of the event would incur the highest level of exposure. While hazardous materials releases can vary in the means of emission, quantity, and timing, this planning tool was used to set geographic limits on the planning and response efforts for future mitigation plan development.

For the 2011 update, the number of parcels within a quarter mile of a Tier II facility or railway was confirmed, and the total land value was updated.

There are 6,050 parcels located within a quarter mile of the BNSF railroad that runs through Everett. The structures on the vulnerable properties and their inhabitants could be exposed to a higher risk of effect from hazardous materials at the time of release. Table 23 details the potential number of properties at risk to hazardous materials.

Table 23: Parcels within ¼ Mile of Hazardous Materials Sources in Everett

	Number of Parcels	Improvement Value
¼ Mile Distance from Tier II Facility or Railway	8,182	$3,665,816,000

Critical Facilities

Transportation infrastructure such as Interstate 5, the Port of Everett, and the BNSF railway are used to transport hazardous materials. Therefore these facilities are vulnerable to potential disruption in the event of a materials release.

Critical Infrastructure

Transportation Systems

Exposed transportation infrastructure includes local roads, major roads and the rail tracks that pass through the city. In the event of a chemical spill or leak, this could lead to closure of transportation routes to and from the city, especially in the event of an accident that may physically block the routes.

Water

Water-related utilities could be exposed to a chemical release in the event of both an earthquake related hazardous materials release or a traffic related incident.

Environment

Prevailing winds flow from west to east. An airborne hazardous materials event could expose a major portion of the city.

The environment is highly vulnerable to hazardous materials spill events. Since the city is located along the Puget Sound, the spread of any chemical release may affect other areas of the Puget Sound in a short amount of time. Additionally, if fuel transmission lines serving Everett are broken, adjacent drainages may be affected. Subsurface spills that follow groundwater movement may expose downstream populations and natural areas.

Consideration must also be made of the tidal influence of the Pacific Ocean, via the Puget Sound, on the Snohomish River. A high tide may potentially change the flow of the river east (normally upstream) and cause a longer period of exposure to a hazardous material spill in this area.

Since the BNSF railroad follows closely along the Snohomish River floodplain and delta, it exposes the watershed to potential hazardous materials spills. This is not only true for Everett, but for any point upstream along the Snohomish River, and its tributaries. Additionally, an earthquake could expose the city to a chemical release from one of the Tier II facilities located upstream from the city along the Snohomish River.

Impact Scenario

A possible chemical spill from a Tier II facility in Everett could have a variety of impacts. They range from an isolated leak to a large-scale spill with catastrophic effects on the surrounding environment. These types of hazardous materials releases could have impacts that span jurisdictional boundaries as well as have long lasting impacts for many years to come. This is a major concern for Everett and the surrounding area.

A hazardous materials release in the waters around Everett would potentially have a wide area of impact, depending on the volume and type of material released. As mentioned earlier, coastal cities face many incidents of marine-based pollution.

Issues

An issue with hazardous materials is that the city has little direct control over their location. The city cannot change the path of the BNSF railway or the location of major facilities that use hazardous materials.

There is also the issue of isolated land uses that may cause contamination during flooding such as fertilizer leaks from surrounding farms.

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Landslides, Mass Movements, and Sinkholes

Definitions

Landslide: Sliding movement of masses of loosened rock and soil down a hillside or slope. Slope failures occur when the strength of the soils forming the slope cannot hold up to the pressure, such as weight or saturation, acting upon them.

Rotational-Translational slides: A 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 slide masses and are usually saturated clayey soils. These types of slides are sometimes referred to as 'deep-seated' landslides.

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.

Earth Flows: 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: Unconsolidated rock or soils that have moved rapidly down slope. They occur on slopes greater than 65%.

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

General Background

Landslides are caused by one or a combination of the following factors: change in slope gradient, increase in the load the land must bear, shocks and vibrations, change in water content, ground water movement, frost action, weathering of rocks, or removal of or change in the type of vegetation that covers slopes.

2011 Update

Some quotes and content in this section were removed due to an inability to locate and verify the sources used in the previous HIVA.

"By geologic standards, Seattle's (Puget Sound'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."[74] In the Puget Sound lowlands, landslide events occur annually.

The soil covering much of the Puget Sound lowlands, including Everett, 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 thirty feet. The next layer, Esperance sand, is a permeable mixture of sand and gravel. This sits upon an impermeable layer of 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.

74 Dietrich, Bill. (January 14, 1997). "The Ground We Walk On." Seattle Times, p A6.

"The build-up of water pressure floats the sand above the clay, creating lubrication for a deep-seated slide."[75]

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

- A slope greater than or equal to 25%, which is generally defined as an "environmentally sensitive area" (40% as defined in the Everett Municipal Code)
- Landslide activity or movement that 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

Location

Four types of landslides can potentially affect Puget Sound lowlands, including Everett. They are: deep-seated, shallow, bench and large slides. Figure 24 indicates landslide hazard areas in Everett. Figure 25 and Figure 26 show facility, property, and infrastructure exposure to landslide hazards in Everett.

Figures 27a through 27d show the different kinds of landslides.[76] Puget Sound's shoreline contains many large, deep-seated dormant landslides. Shallow slides are the most common type of mass movement in Puget Sound. Occasionally large catastrophic slides occur on Puget Sound.

75 Carter, Don and Scott Maier. (January 17, 1997). "Slide-Wise, Danger Remains Real as Soggy Slopes are Still Unstable." Seattle Times, p A8.
76 Washington State Department of Ecology. "Puget Sound Landslides." Accessed online on April 1, 2011 from http://www.ecy.wa.gov/programs/sea/landslides/about/about.html

Figure 24: Everett Landslide Hazard Areas

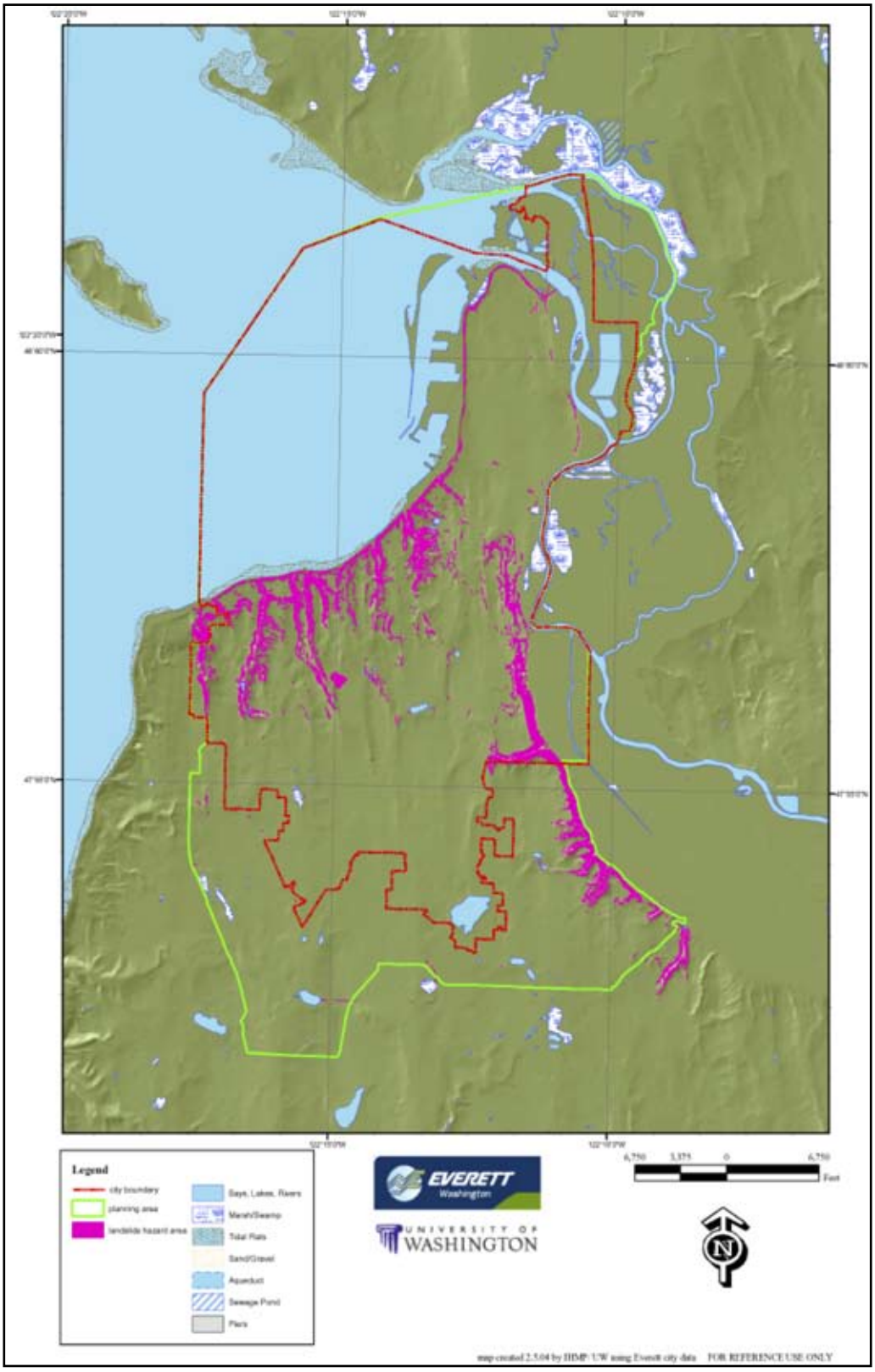


Figure 25: Landslide hazard Areas with Exposed Roads and Bridges

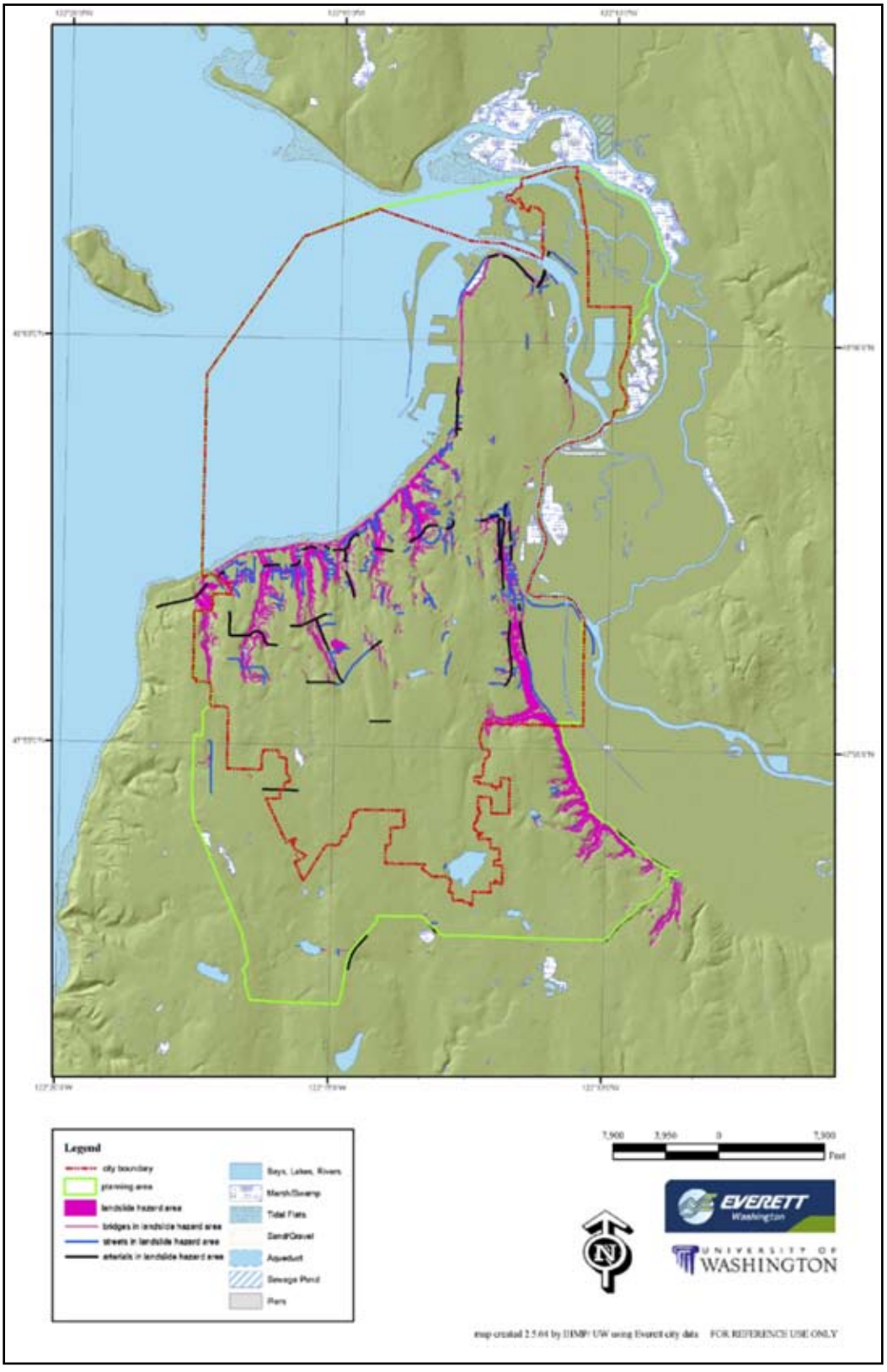


Figure 26: Critical Facilities and Residential Parcels in landslide Areas

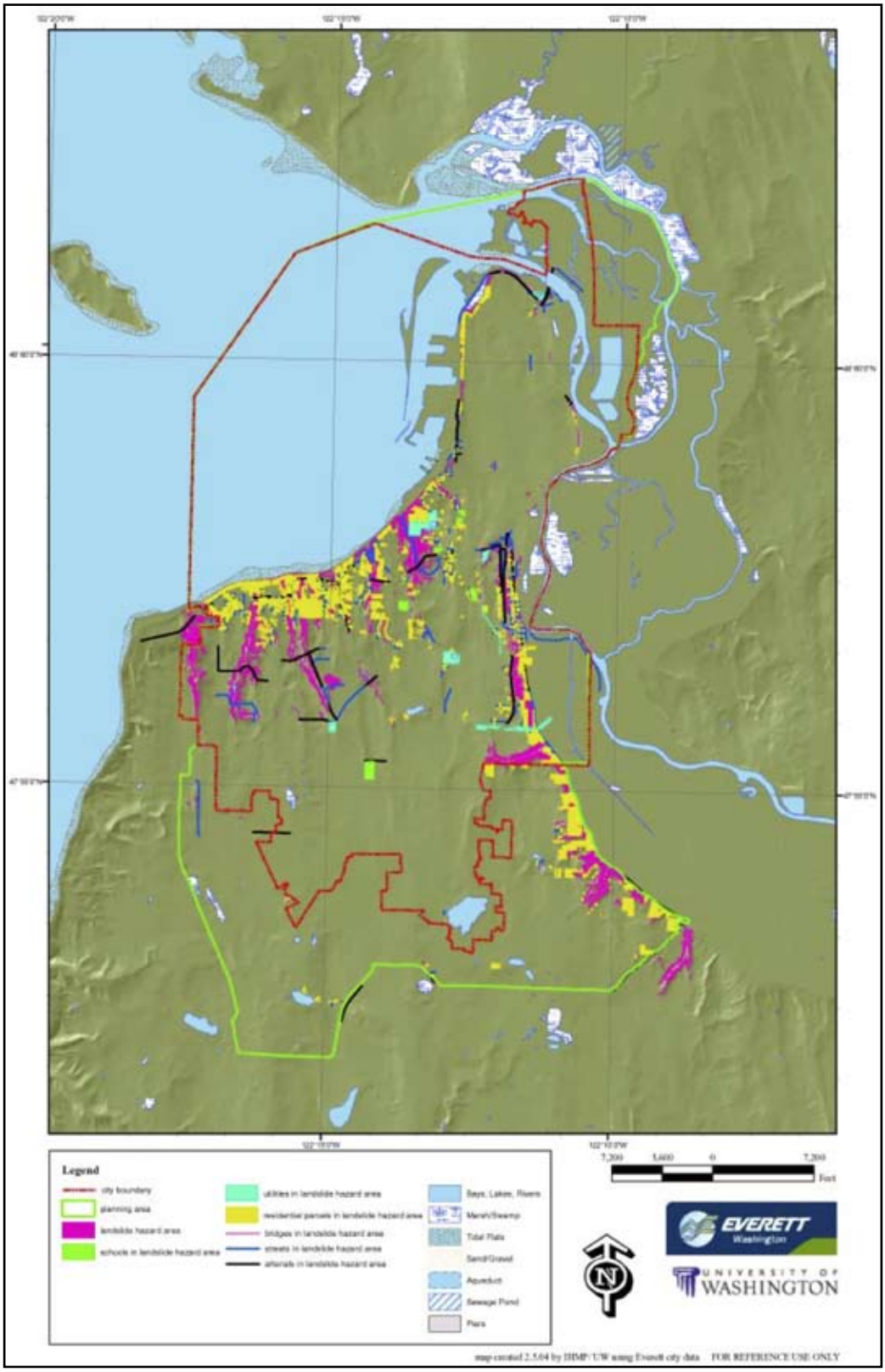


Figure 27: A) Deep-seated Slide

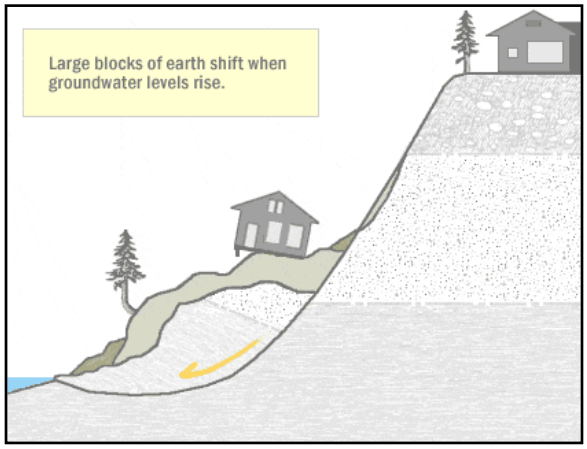


Figure 27: C) Bench Slide

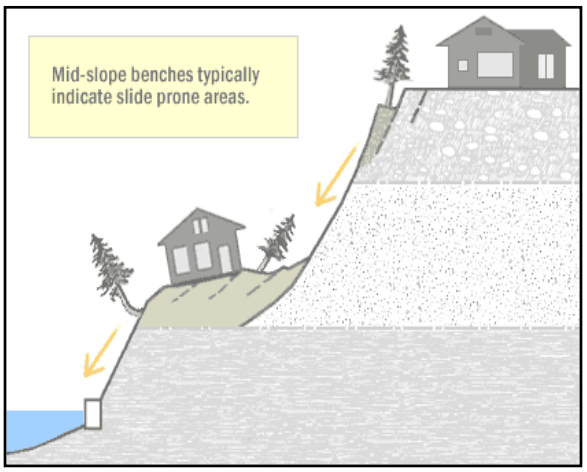


Figure 27: B) Shallow Slide

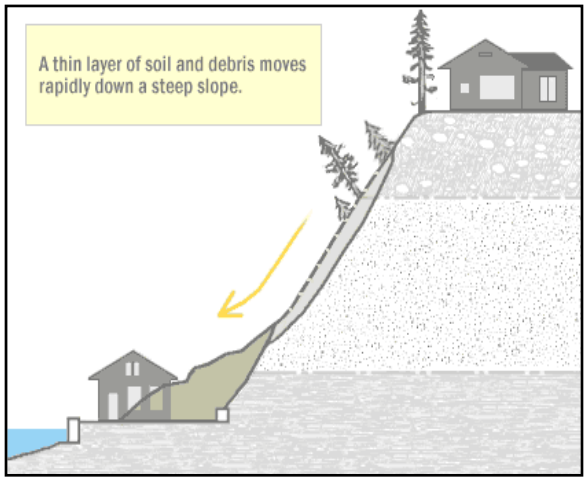
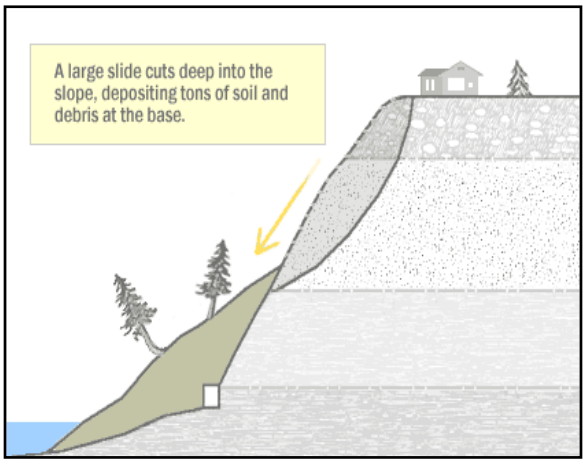


Figure 27: D) Large Slide



Frequency

Landslides are often triggered by other natural hazards such as earthquakes, heavy rain, floods or wildfires (through erosion), with heavy rain and other severe weather events triggering most of the landslides. The winter of 1996 and 1997 is a recent example of widespread landslides triggered largely by heavy rains.

This illustrates the very real possibility of widespread landslide hazards as triggered by severe storm conditions, a natural hazard with a high frequency. The frequency of landslides is highly variable, though there is an observable seasonal bias, with more events in the wetter winter and spring months. Storms and heavy rainfall (which becomes infiltrated groundwater) triggered significant numbers of landslides in 1972, 1986, 1990, 1996, and 1997.

Severity

Landslides can cause fatalities, as well as destroy property, infrastructure, and transportation systems. Slope failures in the United States result in an average of twenty-five to fifty lives lost per year, and an annual cost to society of between $1.6 and $3.2 billion annually.[77]

2011 Update

Section updated to reflect new fatality and cost data.

Warning Time

Landslides can occur either very suddenly or slowly. Land movement that occurs extremely slowly, with a low level of immediate impact, is sometimes referred to as creep. 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 topography, geology, vegetation cover, and amount of predicted precipitation for a given area can help in making these predictions.

Past Events

In January 1997, a massive landslide in Snohomish County pushed five freight cars into Puget Sound and knocked out a hundred yards of track used regularly by Sounder, Amtrak, and Burlington Northern rail lines. The Woodway landslide moved some 100,000 cubic meters of material over the BNSF line, missing a 650-person Amtrak passenger car that had passed the area of the slide just two hours earlier.

In March 2011, a landslide in the Valley View neighborhood of Everett claimed two homes and at the time of this writing is endangering at least one more. The slide, near Burl Avenue and Panaview Boulevard, appeared after heavy rains weakened the already-unstable slopes in the at-risk area. Damages are expected to run into the hundreds of thousands of dollars.

While the GIS analysis of landslide-prone areas in Everett is based on soil types and slope grades, it is also important to consider historic slides. For this reason, the following figures have been included as background material in this document. The Unstable Recent Slide and Unstable Old Slide categories are of special interest in profiling the landslide hazard. These maps also illustrate the heavily modified nature of the Everett coast.

77 USGS Landslides Hazards Program. (2010). "Frequently Asked Questions." Accessed on March 6, 2011 from http://landslides.usgs.gov/learning/faq/

Map Legend for Figures 28a and 28b

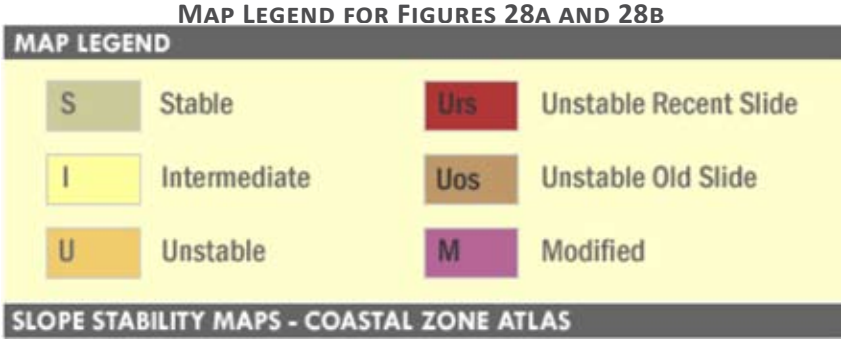
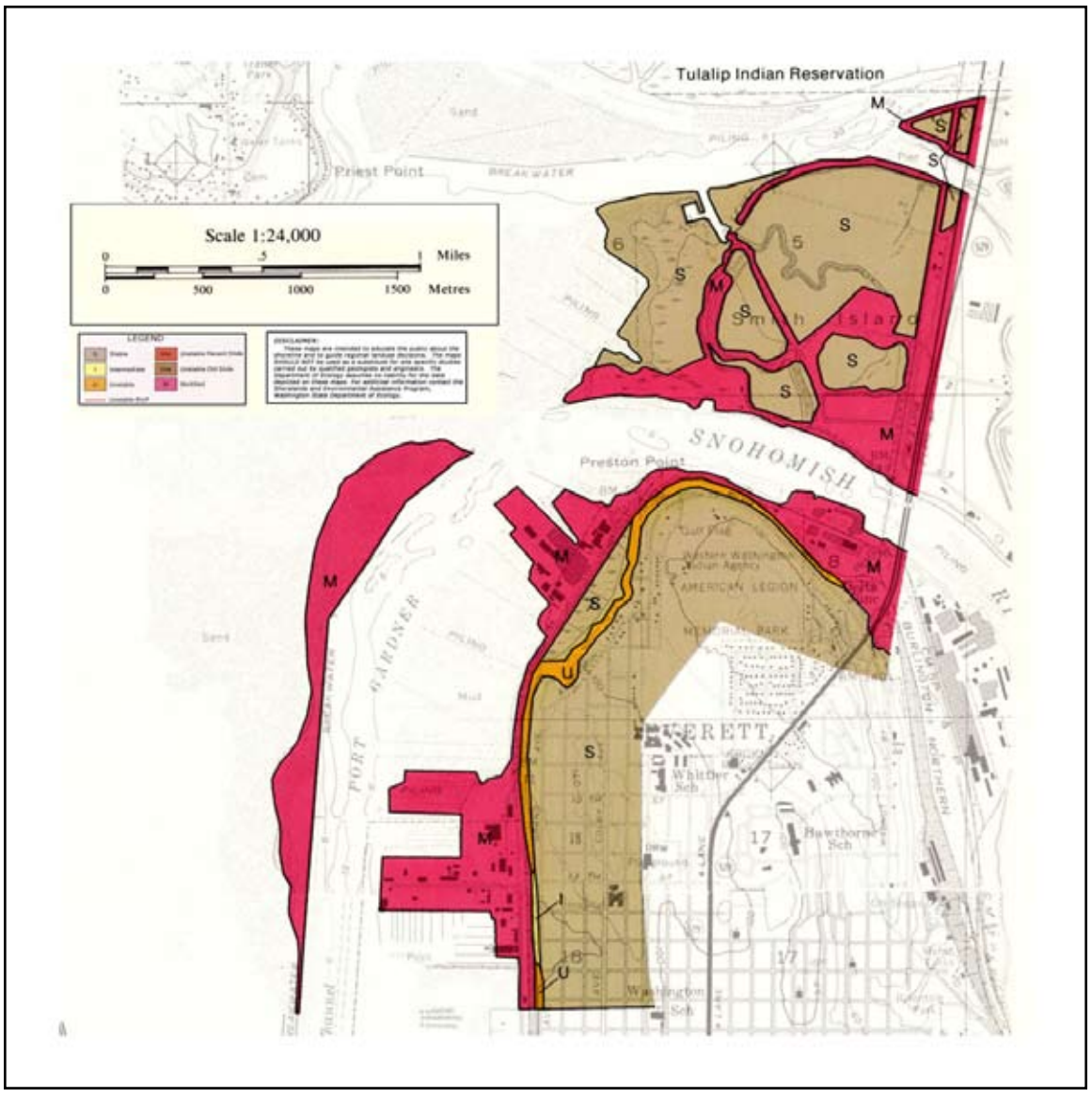
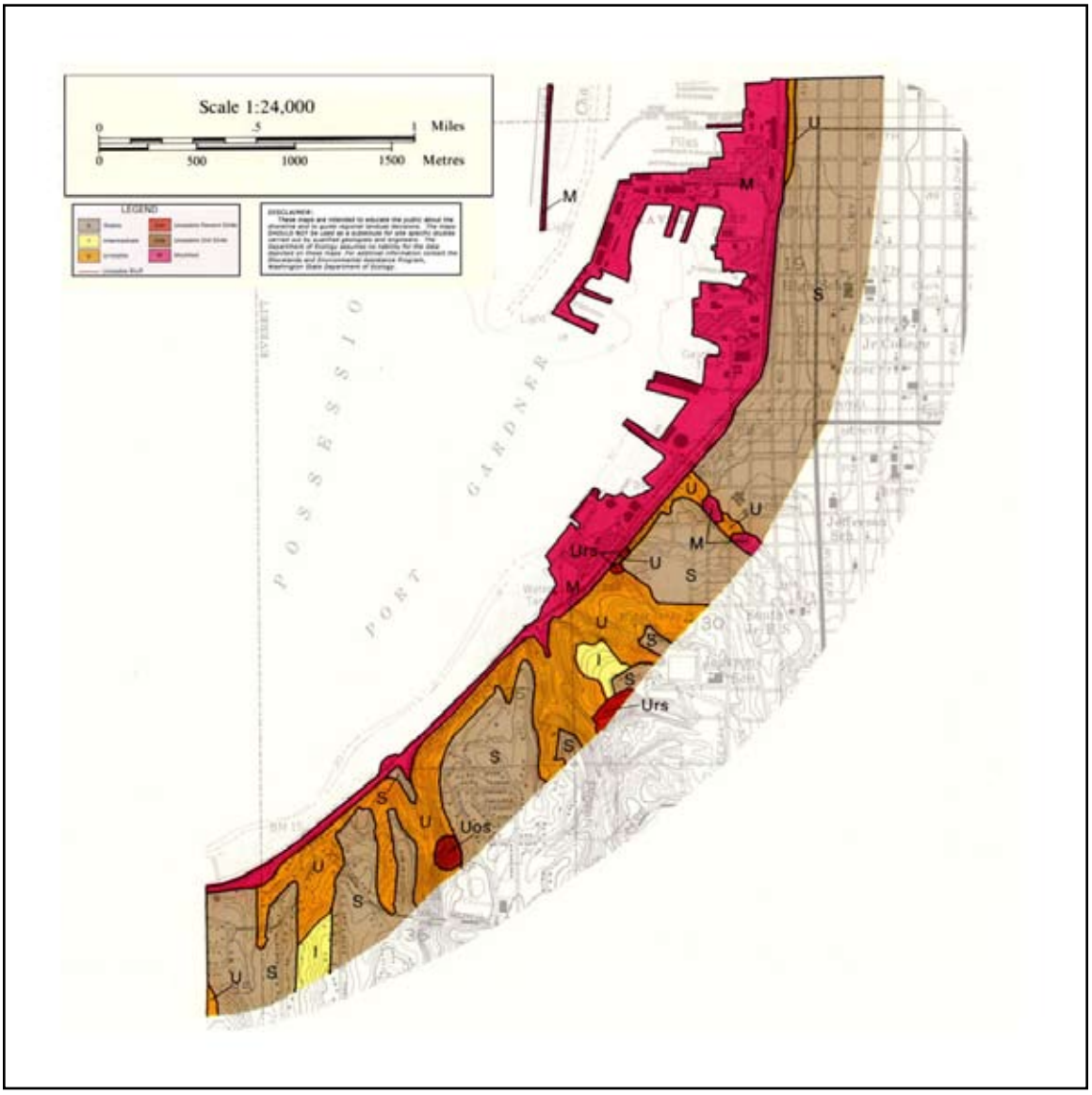


Figure 28: A) Landslide Prone Areas – North Everett[78]



78 Washington State Department of Ecology. Accessed online on March 6, 2011 from http://www.ecy.wa.gov/programs/sea/femaweb/Snohomish/SN_6Aith.jpg

Figure 28: B) Landslide Prone Areas – South Everett[79]



Secondary Hazards

Landslides can typically cause several secondary effects. They can block egress and ingress on roads, which 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, which could result in economic losses for businesses. A landslide can also block the Burlington Northern Santa Fe Railroad, which could result in a release of hazardous materials, or an urban or wildland fire.

Other potential problems resulting from landslides are power and communication failures. Vegetation on slopes or slopes supporting power poles can be knocked over, resulting in possible losses of power and communication lines. This, in turn, creates communication and power isolation. Landslides have

79 Washington State Department of Ecology. Accessed online on March 6, 2011 from http://www.ecy.wa.gov/programs/sea/femaweb/Snohomish/SN_7ith.jpg

the potential for destabilizing the foundation of structures that would result in monetary loss for owners.

While they are a normal occurrence of geological processes, it is possible for landslides to have a major effect on ecological systems. Landslides can damage rivers or streams, potentially harming water quality, fisheries, and spawning habitat.

Additionally, landslides can cause fires if gas lines are disturbed or ruptured. Conversely, fires, and the loss of vegetation can trigger landslides, since the anchoring qualities of vegetation are lost when the plants are damaged.

Exposure and Vulnerability

Population

The steep slopes found in Everett are primarily located along the edges of the city as the landscape slopes down to either the Puget Sound and Everett waterfront or the Snohomish River floodplain. For the most part, landslide-prone areas follow along the general location of the E soils, with the toe of the steep slopes located in E soils.

The vulnerable population in this case is the population living in homes at the toes of the slopes that are located on E soils, as well as the buildings located at the tops of steep slopes that could possibly collapse in the event of an earthquake or heavy rains. Figure 26 shows residential parcels, schools and other critical facilities located in landslide hazard areas.

Property

GIS analysis showed that there are 4,825 parcels that fall on or within a hazardous slope area. There are 4,062 buildings within forty-five (45) feet of a steep slope area, the distance within which it is considered a landslide risk.

Table 24: Land of Parcels in Landslide Prone Areas in Everett

Parcel Count By Land Use	Slope Class		Total
Land Use (Code)	3	4	
Residential (100)	374	827	1201
Manufacturing (200 & 300)	5	1	6
Transportation and Utility (400)	7	11	18
Services (500 & 600)	11	12	23
Parks (700)	1	15	16
Open Space (900)	56	196	252
Grand Total	454	1062	1516

Table 25: Improvement Value of Landslide Prone Parcels in Everett

Improvement Value By Land Use	Slope Class		Total
Land Uses (Code)	3	4	
Residential (100)	$93,248,500	$207,376,600	$300,625,100
Manufacturing (200 & 300)	$22,432,300	$18,426,200	$40,858,500
Transportation and Utility (400)	$13,325,200	$15,549,600	$28,874,800
Services (500 & 600)	$60,505,000	$4,497,600	$65,002,600
Parks (700)	$0	$3,022,200	$3,022,200
Open Space (900)	$0	$329,800	$329,800
Grand Total	$189,511,000	$249,202,000	$438,713,000

In addition to building structures in the hazard area, the transportation network is also prone to damage from landslide hazards. There are quite a few streets in Everett that are both exposed and vulnerable. Additionally, many segments of the BNSF railway cross over landslide-prone area. Figure 27 illustrates the spatial distribution of streets, bridges, and arterial segments in Everett that are vulnerable to landslide hazards. The street and arterial groups are non-exclusive.

Environment

Landslides may pose a threat to the environment through a hazardous materials release due to a Tier II facility, road or railway being damaged during a landslide. Of the Tier II Facilities in Everett, nine (nearly 25%) are in landslide-prone areas.

Critical Infrastructure

Transportation Systems

Major transportation routes could be exposed to landslide hazards.

Along Possession Sound, the western edge of Everett, the BNSF rail line is exposed to landslide prone areas as it heads south out of the city. Additionally, the rail lines that cross the eastern section of the city, near the Snohomish River floodplain, are also exposed to the same landslide hazard.

Not only can a landslide disrupt service, but it can cause train derailments, which can 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 on some sections of the track between Seattle and Everett. The alarms consist of two-strand wire fences that, when triggered, turn all the lights red on that section of track and stop the trains. Employees then physically check what triggered the alarm to determine whether it is safe to proceed. This system is designed to help prevent train derailments when a landslide occurs.

No critical or essential facilities are located near landslide hazards. Critical systems, such as water mains, transmission lines, etc. are potentially vulnerable to damage as they cross over landslide-prone areas.

Figure 27 illustrates the spatial distribution of arterials in Everett vulnerable to landslide hazards. Table 26 details the street and arterial segments in Everett that are exposed and vulnerable to landslide hazards. Street and arterial designations are non-exclusive groupings.

Table 26: Street Segment Exposure to Landslide Areas in Everett

Street Landslide Exposure	Street	Arterial
Number of Segments	268	79
Total Length (FT)	216,304	89,606
Mean Length (FT)	807	1,134

Water and Electricity

Utility transmission lines (both above and below ground) located in areas prone to landslides may make populations serviced by these transmission lines vulnerable to service interruption.

Impact Scenario

Everett's steep slopes could be an issue if there was an earthquake in the area that caused slope failure or if there were heavy rains that caused the slopes to slump. Steep slope failure could cause significant damage to structures built at the toe of the slope, and also to transportation systems, creating isolation issues. Another possible scenario is a landslide that causes the derailment of a train carrying hazardous materials.

A more common scenario is a landslide that occurs during, or more likely a few days or weeks after, a severe storm that saturates the ground. This shallow slide could damage some homes and some underground infrastructure. Some roads are likely to be blocked.

A worst-case scenario is a large slide where a large mass of land fails along the developed bluffs of Everett, destroying homes, streets, and the railroad tracks. If it happens as a train is passing, this could also derail a train carrying hazardous materials, which could then be released into Puget Sound or the surrounding area. The prevailing winds would be likely to carry the chemical plume into downtown Everett.

Issues

The time of occurrence of a landslide is crucial in determining vulnerable residential populations' level of risk. A landslide occurring at night could potentially have devastating effects on vulnerable populations.

Evacuation routes and isolation from landslide blockages of roads or rail lines are another major issue. Consideration must be given to the identification of multiple evacuation and response routes for the many areas of the city prone to landslides.

Landslides are dangerous secondary hazards to other events including earthquakes and severe weather. If climate change causes an increase in the number and severity of severe weather events, the probability of landslide occurrence will also increase.

Tsunami and Seiche

Definitions

Tsunami: A series of traveling ocean waves of extremely long wavelength generated by seafloor disturbances associated primarily with earthquakes. Underwater volcanic eruptions and landslides, and very rarely large meteorite impacts, can also generate tsunamis.

Seiche (say-sh): A series of standing waves in an enclosed or partly enclosed body of water.

2011 Update

The update incorporates the result of a tsunami model, run by the Washington State Department of Natural Resources for the City of Everett and based on earthquakes along the Seattle Fault and the South Whidbey Island Fault. The inundation map (Figure 29) is taken from the Seattle Fault M7.3 scenario. An additional consideration is the possibility of a seiche generated by a landslide at Possession Beach (across the water from Everett).

General Background

Tsunami

In the deep ocean, a tsunami's length from wave crest to wave crest may be a sixty miles or more, but with a wave height of three feet or less. They normally cannot be felt aboard ships nor can they be seen from the air in the open ocean. In the deep ocean, tsunami waves can travel unnoticed at the speed of a commercial jet plane. They can move from one side of the Pacific Ocean to the other in less than a day. Scientists can predict when a tsunami will arrive since the speed of the waves varies with the square root of the water depth.

Tsunamis arrive in near shore waters as a series of successive "crests" (high water levels) and "troughs" (low water levels). These successive crests and troughs usually occur ten to forty-five minutes apart but can range anywhere from five to ninety minutes apart. Tsunamis travel much more slowly in shallow, coastal waters because the wave energy begins to "feel bottom;" at the same time, their wave heights increase dramatically. Offshore and coastal features affect the size and impact of tsunami waves. Reefs, bays, entrances to rivers, undersea ridges, and the slope of the beach all help to modify a tsunami as it attacks the coastline. When the tsunami reaches the coast and moves inland, the water level can rise more than fifty feet for tsunamis of distant origin and over 160 feet for tsunami waves generated near an earthquake's epicenter or a volcanic blast. The first wave may not be the largest in the series of waves. Because of arrival angles and shoreline geography and geometry, one coastal community may see no damaging wave activity while in another nearby community destructive waves can be large and violent. The flooding can extend inland a mile or more, covering large expanses of land with water and debris.

Not all earthquakes produce tsunamis. To generate a tsunami, an earthquake must occur underneath or near the ocean, be very large (approximately Richter magnitude 7 or greater) and create vertical movement of the sea floor. All oceanic regions of the world can experience tsunamis, but in the Pacific Ocean there is a much more frequent occurrence of large, destructive tsunamis because of the many great earthquakes along the margins of the "Pacific Ring of Fire" (so called because 75% of the world's volcanoes are located at the edges of the Pacific). Despite the great size of the Pacific, covering more than a third of the Earth's total area, tsunami waves can traverse the ocean's entire basin in twenty to twenty-five hours. However, people living in regions where large earthquakes occur may find that the tsunami waves will reach their shores within minutes of the earthquake. For these reasons, the tsunami threat to many areas (Alaska or the U.S. West Coast, for example) can be immediate for

tsunamis from nearby earthquakes that take only a few minutes to reach coastal areas, or less urgent for tsunamis from distant earthquakes that take three to twenty-two hours to reach coastal areas.

Submarine volcanic eruptions also have the potential to produce truly enormous tsunami waves. The great Krakatau Volcano eruption of 1883 generated giant waves reaching heights of 130 feet above sea level, killing tens of thousands of people and wiping out numerous coastal villages.

Tsunamis affecting Washington State may be induced by geologic events of local origin, or by earthquakes originating as far away as Alaska or South America. Typical signs of a tsunami hazard are earthquakes and/or sudden and unexpected rise or fall in coastal water. Coastal flooding and a quick recession of the water often precede the large waves.

Aside from the tremendous hydraulic force of the tsunami waves themselves, floating debris carried by a tsunami can endanger human lives and batter inland structures. Ships moored at piers and in harbors often are swamped and sunk or are left battered and stranded high on the shore. Breakwaters and piers collapse, sometimes because of scouring actions that sweep away their foundation material, and sometimes because of the sheer impact of the waves. Railroad yards and oil tanks situated near the waterfront are particularly vulnerable, and, frequently, the resulting oil fires are spread by the waves.

Port facilities, naval facilities, fishing fleets, and public utilities are often the backbone of the economy of the affected areas, and these are the resources that generally receive the most severe damage. Until debris can be cleared, wharves and piers rebuilt, utilities restored, and the fishing fleets reconstituted, communities may find themselves without fuel, food, and employment. Wherever water transport is a vital means of supply, disruption of coastal systems caused by tsunamis can have far reaching economic effects.

Seiche

Seiches are normally caused by earthquake activity or by above or below-water landslides and can affect harbors, bays, lakes, rivers and canals. In the majority of instances, earthquake-induced seiches 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 water body.

Seiches create a “sloshing” effect on bodies of water and liquids in containers. This primary effect can cause damage to moored boats, piers, and facilities close to the water. Secondary problems, including landslides and floods, are related to accelerated water movements and elevated water levels.

December 26, 2004 Tsunami in South Asia

On the morning of December 26, 2004 a magnitude 9.3 earthquake struck off the northwest coast of the Indonesian island of Sumatra. The earthquake resulted from a complex slip on the fault where the oceanic portion of the Indian Plate slides under the island of Sumatra, part of the Eurasian Plate. The earthquake deformed the ocean floor, pushing the overlying water into a tsunami wave. The tsunami wave devastated nearby areas where the wave may have been as high as eighty feet tall, and killed nearly 300,000 residents of nations in the region and tourists from around the world. Cost in dollars was in the hundreds of billions. The tsunami wave itself also traveled the globe, and was measured in the Pacific Ocean and many other places by tide gauges. Measurements in California exceeded sixteen inches in height, while New Jersey saw water level fluctuations as great as thirteen inches. Eyewitness accounts, photos, and videos provided unprecedented documentation of the event.

March 11, 2011 Tsunami in Japan

A 9.0M undersea mega-thrust earthquake off the coast of the Oshika Peninsula in the Tohoku prefecture in Japan triggered destructive tsunami waves of up to 124 feet that struck almost immediately following the earthquake, and that traveled up to six miles inland. Tsunami warnings were issued along with evacuation orders along the Japanese Pacific coast and in many other countries, including the United States. The earthquake resulted in nearly 15,000 deaths with over 10,000 still missing as of April 20th, 2011. The vast majority of the deaths were by drowning. According to the Japanese government, the combined cost from the earthquake and the tsunami could reach $309 billion, making it the most expensive natural disaster in history.

The tsunami demonstrated the extreme impact of such an event on even a well-prepared country. Approximately 181.5 square miles of land were inundated in Japan, where entire towns were destroyed. The tsunami traveled across the Pacific Ocean and began hitting coastlines through Asia, Australia, and the Americas. Damage in the United States included the destruction of the Crescent City, California harbor, and much of its fishing fleet, by 8-foot high waves, costing tens of millions of dollars in damages. The advanced warning provided to coastal American cities and the flood of devastating images from Japan helped reinforce the importance of evacuation, although there was only one reported death in the United States.

Impact on the West Coast of United States[80]

Tsunamis are a threat to life and property to anyone living near the ocean. From 1895 to 1995, 454 tsunamis were recorded in the Pacific Basin. Ninety-four of these tsunamis killed over 51,000 coastal residents during the past century. Recent tsunamis have struck Nicaragua, Indonesia, Chile, and Japan, killing several thousand people. Property damage due to these waves was nearly one billion dollars. Historically, tsunamis originating in the northern Pacific and along the west coast of South America have caused more damage on the west coast of the United States than tsunamis originating in Japan and the Southwest Pacific. For example, the 1960 Chile Earthquake generated a Pacific-wide tsunami that caused widespread death and destruction in Chile, Hawaii, Japan and other areas in the Pacific. In contrast, the tsunami generated by the 1883 eruption of Krakatau Volcano in Indonesia caused more than 30,000 fatalities and the 1886 tsunami on the Sunriku coast of Japan killed about 26,000 people, but neither of these events was destructive outside their immediate locales.

Here in the Northwest, a tsunami hit the Washington coast after the great 1964 Alaska earthquake; in places wave heights reached 4.5 meters. No deaths were reported in this state but it caused $115,000 in damage (Harold Mofjeld, 2001). This same tsunami killed eleven people and caused $7.4 million damage in Crescent City, California.[81] Scientific

80 Photo: Josh Jackson, The Times Standard. (March 11, 2011). "Crescent City tsunami damage." Accessed online on March 20, 2011 from http://www.latimes.com/news/local/la-na-west-coast-tsunami-pictures,0,7063502.photogallery

81 LA Times. (March 13, 2011). "Crescent City Comes to Grips with Tsunami's Devastation." Accessed online on March 20, 2011 from http://www.latimes.com/news/local/la-me-japan-quake-crescent-

studies indicate that local tsunamis generated off the northern California, Oregon and Washington coast could reach Washington shores within three to thirty minutes after the earthquake is felt. The March 2011 9.0M earthquake and tsunami that hit Japan spawned eight-foot high waves along the west coast of the United States, destroying harbors and coastal structures and causing, for example, $20 million damage to Crescent City, California. The waves destroyed boats moored in the Crescent City marina, incapacitating the city's fishing and recreational fleets, as well as the local economy.

The waves, though of a greater magnitude, had impacts similar to what could happen to the Everett marina and port should it be hit with a tsunami or seiche. Dock structures would be destroyed and boats mangled among the debris. Even if Everett received minimal impacts from the earthquake itself, as a port-dependent city the effects of a tsunami could be especially challenging.

The National Tsunami Hazard Mitigation Program

The National Tsunami Hazard Mitigation Program is designed to reduce the impact of tsunamis through hazard assessment, warning guidance, mitigation and a strong public awareness and outreach program.

Recent revelations about the potential for a great subduction zone earthquake off the Washington, Oregon, and Northern California coastlines have led to several studies about the effect of a local tsunami generated in this source area. Local tsunami waves may reach nearby coastal communities within minutes of the earthquake with little or no time to issue formal warnings. The states feel that they do not have the support or the proper tools to educate coastal residents or alert them of this hazard, and that they need a comprehensive mitigation program to fill the void. FEMA estimates that a Cascadia Subduction Zone earthquake/tsunami could cost $25-125 billion in damages to the region. If one assumes that the tsunami would cause 5% of these losses, then the tsunami losses would total between $1.25 and $6.25 billion. Even more significant, is the population directly at risk from a Cascadia tsunami. About 300,000 people live or work in coastal regions that could be affected, and at least as many tourists travel through these areas each year. Some tourism and financial corporations already plan for and educate employees about tsunamis. Others are interested but do not know where to begin and are unaware of the potential losses in terms of lives, operations, and clients.

Tsunami Warning Systems

Destructive tsunamis need to be quickly detected and warnings issued as soon as possible because orderly evacuation of many coastal communities requires several hours. Since it is known that the speed of tsunamis varies with water depth, the prediction of tsunami arrival times at coastal locations is possible once the epicenter has been determined. But it is not yet possible to predict the wave height at a specific coastal location. Another indeterminable feature of a tsunami is how many successive waves there will be in the series, although there is rarely only one.

The Tsunami Warning System (TWS) in the Pacific, comprised of twenty-six (26) participating international Member States, monitors seismological and tidal stations throughout the Pacific Basin. The Pacific Tsunami Warning Center (PTWC) is the operational center of the Pacific TWS. Located in Honolulu, Hawaii, PTWC provides tsunami warning information to national authorities throughout the Pacific Basin. In this system, a tsunami watch is a message that an earthquake, which could cause a tsunami, has occurred in the Pacific Basin. A tsunami warning warns that a tsunami is spreading across the Pacific Ocean. Estimated times of arrival at various locations are included in the alerts.

There are also regional warning systems for coasts in or close to areas capable of producing tsunamis. Due to the rapid arrival of waves following generation, these warnings must be issued on the basis

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of earthquake magnitude and location alone. The devastation associated with the 1964 Alaskan earthquake and tsunami led to the creation of the Alaska Regional Tsunami Warning System in 1967. It serves as the regional warning center for Alaska, British Columbia, Washington, Oregon and California. This system was intended to detect, locate and calculate the magnitude of earthquakes in the Pacific Northwest region as quickly as possible and issue warnings to communities close to the epicenter.

Location

Tsunami waves could be generated anywhere by ruptures along the Seattle Fault. They could also be created by a subduction zone event along the Cascadia Subduction Zone. There is no record of generation from a South Whidbey Island Fault event, although secondary landslides on Possession Beach could cause a seiche.

The most exposed and vulnerable location is the Port. Following an earthquake, evacuation could be difficult due to liquefaction and prolonged ground shaking.

Frequency

Tsunami or seiche events are infrequent since they require a major release of energy from an earthquake or landslide to initiate. They are most likely to occur along with an earthquake event, although a landslide brought about by severe weather or another event on Possession Beach increases the likelihood of a seiche occurring independently of an earthquake.

Severity

Computer models indicate that locally induced tsunamis from the Cascadia Subduction Zone could generate waves of six to sixty-five feet in height along the Washington Coast. A particular concern is the possibility of a tsunami generated by a subduction zone earthquake in which the triggering fault could be located at a sufficient distance (i.e., offshore from northern California or northern British Columbia) that Washington coastal residents and tourists would not feel ground shaking. One computer model suggests that a tsunami generated by a subduction zone earthquake with a magnitude of R8.5 would only be six to sixteen inches in height when it reached Seattle. For the subduction zone earthquake, there is a general consensus that a subduction zone earthquake tsunami would not have a dramatic impact to Everett due to the buffering effects of Whidbey Island.[82] It is possible that waves from this event would go unnoticed in Everett in all but the highest tide.

Based on the data from a tsunami caused by an earthquake along the Seattle Fault, however, it is expected that wave elevations will be between 2.5 to 5 feet. This is expected to be the most severe event scenario; however, it is also the least likely due to the low frequency of earthquakes along the Seattle Fault.

A seiche caused by a landslide in the active landslide area of Possession Beach on Whidbey Island could also be generated, although there is not a sufficient column of water to cause a major tsunami.

The tides have a major impact on the potential severity of a tsunami or seiche event. At lower tides, there may be little to no impact from any event scenario, though with extremely high tides, the impact would be greater.

82 Snohomish County Natural Hazards Plan Update Vol. I: Planning Area Wide Elements, 16-3.

Warning Time

Tsunamis generated by major subduction zone earthquakes along the Strait of Juan de Fuca would have travel times of over ninety minutes to reach Everett. The Olympic Peninsula and the Puget Sound islands shield the central and southern Sound from extreme tsunami heights.

An event generated by a Possession Beach landslide would provide tens of minutes to evacuate, which is likely to be enough time to evacuate the port area should those in the area be aware of the need to move to higher ground following any ground shaking.

A Seattle Fault event would potentially provide the least warning time (minutes), but enough time that people in the port area who are fit and aware would have time to evacuate to higher ground. The key element of preparedness for this event is awareness that, should prolonged (greater than two minutes) of ground shaking occur, residents must use this as their warning and leave for higher ground immediately.

Past Events

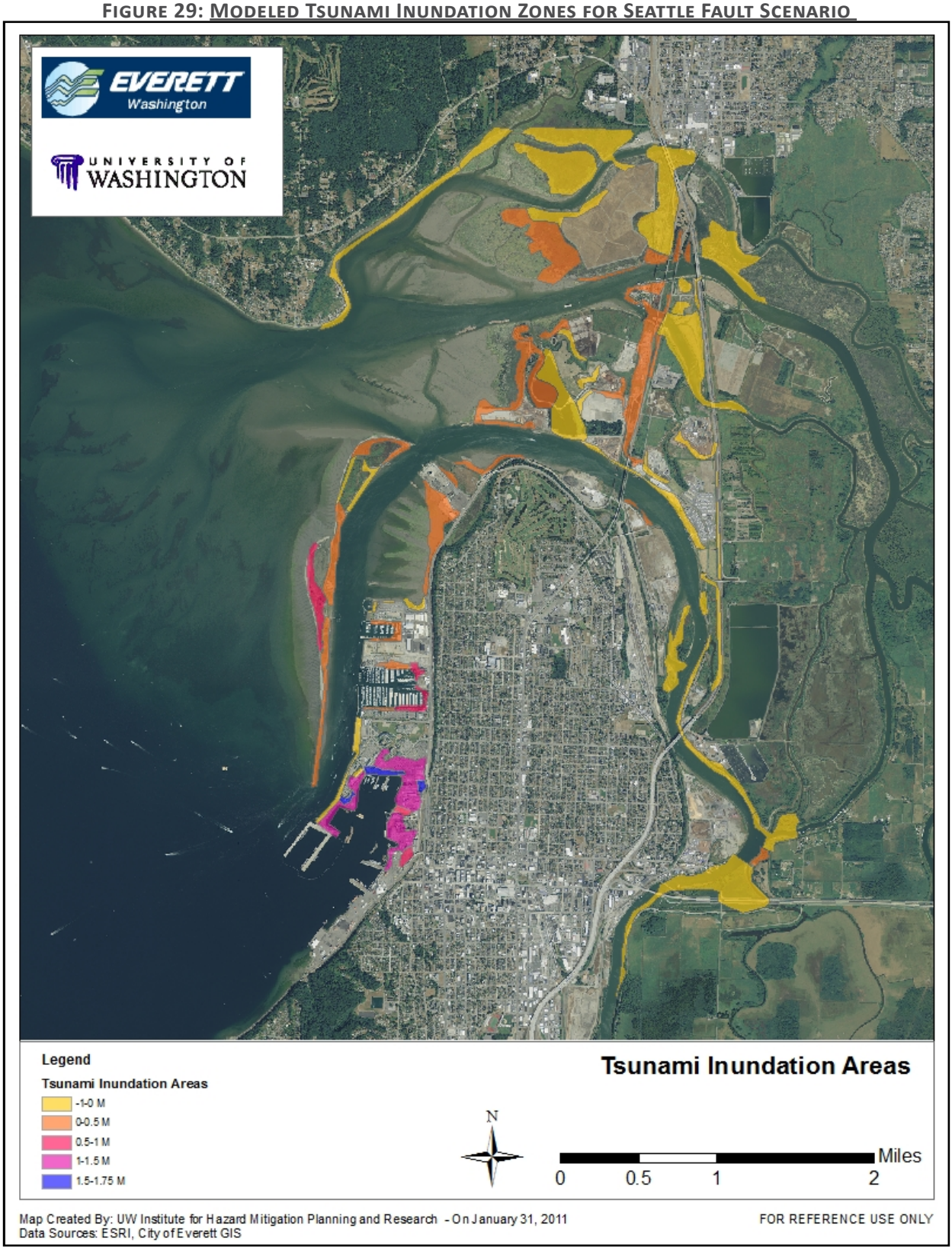
Within Puget Sound, no written records exist of damaging waves. However, verbal accounts among the Snohomish Tribe reported by Colin Tweddell in 1953 describe a great landslide induced wave caused by the collapse of Camano Head at the south end of Camano Island around the 1820s-1830s. The slide itself is said to have buried a small village, and the resulting tsunami drowned "…men and women, and some of the children…" who may have been clamming on Hat (Gedney) Island, two miles to the south.[83] Bathymetry between Camano Head and Hat Island could have contributed to the size and destructive power of the wave.[84]

Geologic evidence of tsunamis has been found at Cultus Bay on Whidbey Island and at West Point in Seattle. Researchers believe these tsunami deposits are evidence of earthquake activity along the Seattle Fault or other shallow crustal Puget Sound faults.

Puget Sound has experienced seiches in historical times. In 1891, an earthquake near Port Angeles caused an eight-foot seiche in Lake Washington. Seiches generated by the 1949 Queen Charlotte Islands earthquake were reported on Lake Union and Lake Washington. The 1964 Alaska earthquake created seiches on fourteen inland bodies of water in Washington, including Lake Union where several pleasure craft, houseboats and floats sustained minor damage.

83 HistoryLink.org. "Point 3: Camano Head. Southern Tip of Camano Island." Accessed online on March 6, 2011 from http://www.historylink.org/index.cfm?DisplayPage=cybertour.cfm&fileId=9151&frame=3
84 Koshimura, Shun-ichi, Andrew Moore, and Harold Mofjeld, 2001, Simulation of paleotsunamis in Puget Sound, Washington, International Tsunami Symposium, Seattle, Washington, August 7-10, 2001.

Figure 29: Modeled Tsunami Inundation Zones for Seattle Fault Scenario



Exposure and Vulnerability

People

Of particular concern is the Everett waterfront, because of the U.S. Naval Station and the Everett Marina. Navy personnel living and working aboard ship and live-aboards at the Marina are at risk in the event of a Puget Sound tsunami. Residents of Hat Island are vulnerable to waves generated within the Possession Sound basin, by any cause.

Property

Most areas in Everett will be above the tsunami elevation. The impact in Everett will be largely limited to areas at the Port and along the river. The areas along the river are mostly undeveloped. The marina will be adversely impacted, as will be the Port and Navy base. The Navy base will face the most severe impacts with wave elevations of 1 meter to 1.75 meters. As the Port of Everett continues to plan for the possible development of waterfront areas, however, the inventory of at-risk areas, property, and people will likely increase and should be mitigated.

Large containers of hazardous chemicals, delivered by rail and stored at various locations along the Everett waterfront, also represent a source of potential tsunami vulnerability. Snohomish County may also be susceptible to seiches caused by earthquakes. Larger lakes such as Spada, Stevens, and Goodwin could resonate with a major quake to produce damage along their shores. Additional vulnerabilities include water storage tanks and containers of liquid hazardous materials, which can also be affected by the rhythmic ground motion.

Tetra Tech, on behalf of Snohomish County, conducted a tsunami exposure analysis using a modified version of the HAZUS coastal flooding model. By using a depth grid created from the tsunami inundation area analysis conducted for the Seattle Fault 7.3M earthquake, it was determined that property exposure in Everett for building structure in contents is $411,402,600 and $453,534,590 respectively for a total of $864,937,190. There are eighty-nine (89) buildings exposed.[85]

Critical Infrastructure

Transportation Systems

Although the Burlington Northern/Santa Fe Railroad represents a relatively small segment of the county's commercial/industrial supply network, the location of the rails along the vulnerable coastline would ensure that a large tsunami would interrupt this transportation system. Damage to tracks and/or rolling stock would have significant short-term economic impact.

Issues

Early warning, coupled with education of the affected populations, proper zoning, and suitable structural design can aid in reducing the disastrous effect of this natural hazard. If warning is received early enough (two to five hours), which is possible for tsunamis generated at a distance, hasty preventive action can be taken: people can be evacuated, ships can clear harbors or seek safer anchorage, planes and railroad rolling stock can be moved, buildings can be closed, shuttered, and sandbagged. For tsunamis generated by local earthquakes or landslide events, however, the time from initiation of a tsunami to its arrival at shore can be less than a minute. Residents in areas susceptible to tsunamis should be made aware of the need to seek high ground if they feel strong ground shaking. Coastal communities should identify evacuation routes even if they do not have good information about potential inundation areas.

85 Snohomish County Natural Hazards Plan Update Vol. I: Planning Area Wide Elements, 16-6.

Because Everett is most vulnerable to tsunamis produced by local earthquakes and landslides, comprehensive educational programs that keep the public informed of the dangers and steps to be taken for personal protection are especially important. Given the scenario of a shallow tsunamigenic quake occurring in Puget Sound, there may not be enough time between the triggering event and the arrival of the first wave for effective warning.

Seiches that occur in the Puget Sound or inland bodies of water have the potential to cause property damage and casualties. Public education on seiches is normally included in disaster preparedness classes as a subset of earthquake damage. Although much work has been done on disaster preparedness for the public, local governments, emergency planners and citizens need to recognize the danger of seiche as part of earthquake hazards. For Everett, the risk of a seiche caused by a landslide in the Possession Beach area of Whidbey Island (an active landslide area) exists. If such an event were to occur, the low-lying areas by the marina would likely be inundated. Furthermore, a Possession Beach landslide-caused seiche could be more severe than a tsunami caused by earthquakes; however, its severity is difficult to predict.

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Volcanic Eruptions

Definitions

2011 Update

This section has been updated to include information related to more recent activity at Mount St. Helens. Non-substantive wording changes were also made.

Stratovolcano: Also known as composite volcanoes, 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. The volcanoes in the Cascade Range surrounding Everett are all stratovolcanoes.

Pyroclastic Flows and Surges: 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 of pyroclastic flows range from 20 to more than 200 MPH.

Lava Flows: Normally the least hazardous threat posed by volcanoes. Cascades volcanoes are normally associated with slow moving andesite or dacite lava.

Tephra: 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 six miles. The smallest rock fragments (ash) are composed of rock, minerals, and glass that are less than an eighth of an inch in diameter. Tephra plume characteristics are affected by wind speed, particle size, and precipitation. When ash is trapped in the clouds it affects climate over a global area.

Lahars: Rapidly flowing mixtures of water and rock debris that originate from volcanoes. While lahars are most commonly associated with eruptions, they can also be triggered by heavy rains, debris accumulation, and even earthquakes. Lahars are commonly termed debris or mud flows.

Debris Flows: 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. While lahars are debris flows, not all debris flows are lahars.

Debris Avalanches: Volcanoes are prone to debris and mountain rock avalanches that can approach speeds of 100 MPH.

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

Ashfall**:** What happens when volcanoes erupt lavas so thick and charged with gases that they explode into ash, instead of becoming lava flows.

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.

General Background

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.

Location

The Cascade Range is a thousand-mile long chain of volcanoes, which extends from northern California to southern British Columbia. Everett does not lie within any basin that would drain 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

Eruptions in the Cascades have occurred at an average rate of one or two per century during the last 4,000 years. Many of these volcanoes have erupted in the recent past and will erupt again in the foreseeable future. USGS classifies Glacier Peak, Mount Adams, Mount Baker, Mount Hood, Mount St. Helens, and Mount Rainier as being potentially active Washington state volcanoes. Mount St. Helens is by far the most active volcano in the Cascades, with four major explosive eruptions in the last 515 years.[86] More recently, Mount St. Helens underwent an eruption series from 2004-2008, though it had few impacts on the surrounding region.[87]

Severity

A one-inch deep layer of ash weighs an average of ten pounds per square foot causing a danger of structural collapse. Ash is harsh, acidic, gritty, and it has a sulfuric odor. Ash may also carry a high static charge for up to two days after being ejected from a volcano. When 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 should be more than adequate time for evacuation before an event. Since 1980, Mount St. Helen's has settled into a pattern of intermittent, moderate and generally non-explosive activity, and the severity of tephra, explosions, and lava flows has diminished. All episodes, except for one very small event in 1984, have been successfully predicted several days to three 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.[88]

86 USGS website. (2008). "Description: Mount St. Helens Volcano." Accessed online on March 6, 2011 from http://vulcan.wr.usgs.gov/Volcanoes/MSH/description_msh.html
87 Diefenbach, Angela K, Guffanti, Marianne, and Ewert, John W. (2009). Chronology and References of Volcanic Eruptions and Selected Unrest in the United States, 1980-2008. USGS Open File Report. Accessed online on March 6, 2011 from http://pubs.usgs.gov/of/2009/1118/of2009-1118.pdf
88 Tilling, Robert I., Lyn Topinka, and Donald Swanson. "Eruptions of Mt. Saint Helens: Past, Present and Future," USGS Special Interest Publication, 1990.

Past Events

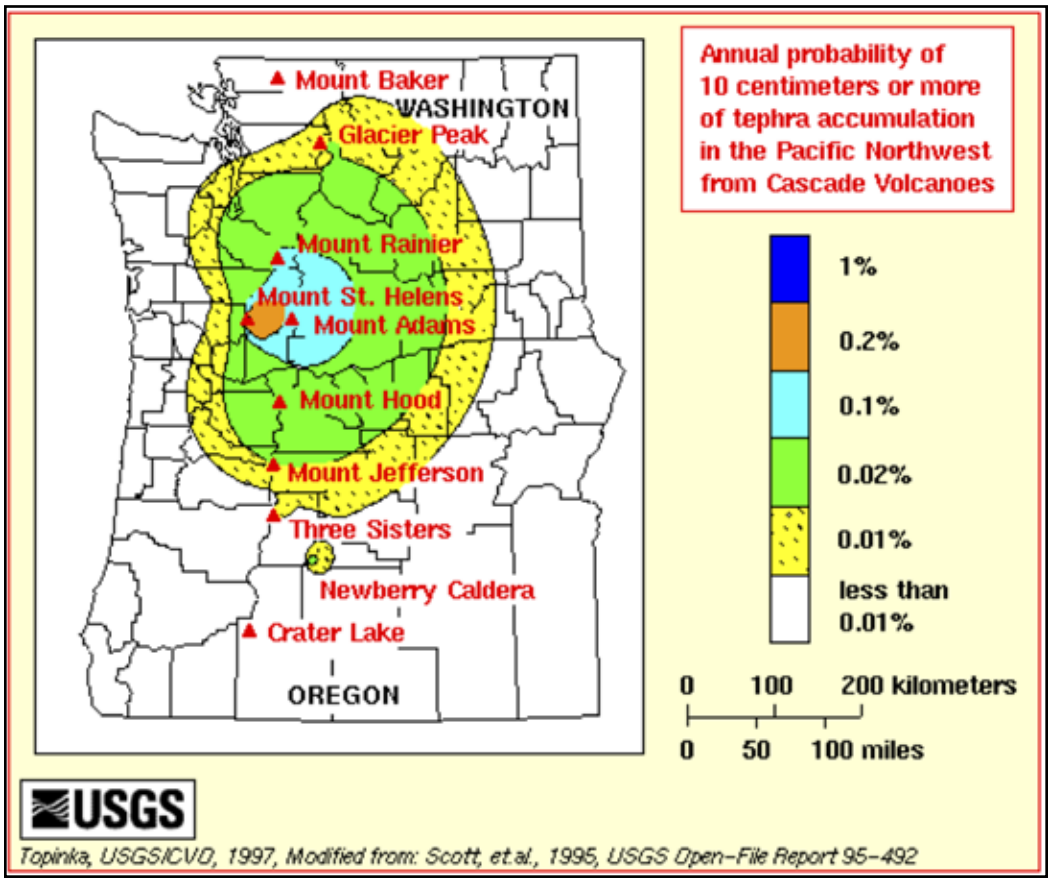
The most famous of past eruptions for Mount St. Helens occurred May 18, 1980. In this eruption, the elevation of Mount St. Helens dropped dramatically from 9,677 feet to 8,364 feet; 23 square miles of volcanic material buried the North Fork of the Toutle River to an average depth of 150 feet. A total of 57 human fatalities resulted from the blast.[89]

Table 27 summarizes the eruptions in the region:

Table 27: Past Eruptions in the 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, ash fall 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 ash fall

Figure 30: Probability of Tephra Accumulation from Cascade Volcanoes



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

Exposure and Vulnerability

Population

In the event of a volcanic eruption in the Cascade Range, particularly from Glacier Peak, the entire population of Everett is vulnerable to the low severity but widespread effects of a volcanic eruption, such as ash fall. This population would be vulnerable to the damaging effects of volcanic ash fall that contains sulfuric acid and can cause damage to skin, eyes, nose and throat. The most vulnerable populations would be the elderly, very young and those that already experience ear, nose, and throat problems.

Property

All property in Everett is vulnerable to damage from a volcanic eruption, particularly from ash fall. Depending on the quantity received, the accumulation of ash on rooftops, especially when combined with rainfall, could lead to excessive weight and, in rare cases, structural collapse. Again, the severity of a volcanic event in Everett would be low, with effects generally being inconveniences associated with fallout material.

Critical Facilities

All critical facilities in Everett would be exposed to ground shaking and ash fall. These would include all emergency facilities located in the downtown area of Everett, as well as facilities such as the wastewater treatment plant in the southwest section of the city and the water treatment plant located east of the city. All of the schools located within Everett would be exposed. While a major eruption of Glacier Peak probably would not impact Everett directly with a debris flow, it could still have indirect effects on transportation and medical systems. Ash clouds could impact the flight schedules from local airports.

Critical Infrastructure

All infrastructures would be exposed to the effects of a volcanic eruption. This includes all utilities and transportation networks in Everett. Underground utilities would be exposed to ground shaking related to a volcanic blast, and overhead utilities would be exposed to the related ash fall from a volcanic eruption. Transportation routes could potentially be blocked by ash fall.

Transportation Systems

All transportation routes in Everett would be exposed to damage from a volcanic blast. Ash accumulation on roads could create hazardous driving conditions as well as limit visibility for drivers. Transportation routes could be strained by traffic from those evacuating from, or responding to, nearby volcanic eruptions. Ash clouds could impact travel to and from local airports.

Water, Wastewater, Electricity, and Telecommunications

All utilities are exposed to ash fall from a volcanic blast. Most vulnerable are overhead utility and telecommunication lines, although it is not likely that they would accumulate ash fall or collapse under its weight. Additionally, ash is conductive when wet and could electrically short out exposed utility power.[90] One significant impact of volcanic ash fallout on a sewer/drainage system is the clogging of catch basins, pipes, and treatment plant basins with the ash that is washed into the system by rainfall and street cleaning.

90 CREW. "Information about Volcanic Ash." Accessed online on March 6, 2011 from http://www.crew.org/volcanic-ash.php

Environment

The environment is highly exposed to the effects of a volcanic eruption. Even if the related ash fall from a volcanic eruption were to fall elsewhere, it could still be carried to Everett by the surrounding rivers and streams. A volcanic blast would expose the local environment to many effects such as compromised air quality and many other elements that could harm local vegetation and water quality.

The environment is very vulnerable to the effects of a volcanic eruption. Everett rivers and streams are vulnerable to damage due to ash fall, especially since ash fall can be carried to the city by means of the Snohomish River. The sulfuric acid contained in volcanic ash can be extremely damaging to area vegetation, wildlife, and water and air quality.

Impact Scenario

In the event of a volcanic eruption at Glacier Peak in the Cascade Range, there could potentially be ash fall accumulation in Everett. Very little of the population would be directly exposed, but all property, critical facilities and infrastructure would be vulnerable. Ash accumulation on rooftops could lead to collapse of older buildings and those that are not reinforced.

Issues

In the event of a volcanic eruption in the Cascade Range it is very likely that a very large area will be affected. Even if Everett is not directly affected, it will most likely feel the impact from the surrounding area.

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Neighborhood Risk Profiles Annex

Neighborhoods Overview Map

DISCLAIMER: Maps are based on best available data. This data is not always accurate. Please be aware that maps are to be used for reference use only. Especially, building age parcel data is incomplete and fails to include building ages for all parcels displayed.

Neighborhood Risk Profiles

Everett's greatest vulnerability, the potential isolation of areas throughout the city, can be overcome by the strength of its neighborhoods. During a disaster, the 'islands' that are created by impassable roads and terrain will force residents to rely on the people and resources in their immediate area. After a disaster, communities often come together to support their neighbors and rebuild the areas in which they live.

The following section is a summary of the risks and opportunities in each neighborhood. This is a preliminary framework that will be expanded over the next several years through public meetings, education, training, and projects. This effort is being coordinated through the Office of Neighborhoods, Office of Emergency Management, and Department of Planning. In time, each neighborhood will have a detailed profile including sub-populations, languages, potential projects, and active citizen groups.

2011 Update

Neighborhood Risk Profiles are a new addition to the plan.

Each neighborhood profile includes a count of residents who have graduated from Community Emergency Response Team (CERT) training as of August 9, 2011. CERT is a program organized by FEMA where community members are trained by authorized first responders in disaster preparedness, disaster fire suppression, basic disaster medical operations, and light search and rescue operations. CERT members can give critical support of first responders, provide immediate assistance to victims, and organize spontaneous volunteers at a disaster site. CERT members can also help with non-emergency projects that help improve the safety of the community[91]. There are currently 331 CERT graduates in Everett, plus 58 that live elsewhere in Snohomish County but may work within the city, and six (6) that live in Mukilteo that may also work in Everett.

The neighborhoods profiled are:

- Bayside
- Boulevard Bluffs
- Cascade View
- Delta
- Everett Mall South
- Evergreen
- Glacier View
- Harborview-Seahurst-Glenhaven
- Holly
- Lowell
- Northwest Everett
- Pinehurst
- Port Gardner
- Riverside
- Silver Lake
- South Forest Park
- Valley View
- View Ridge-Madison
- Westmont

91 Citizen Corps: Community Emergency Response Team. http://www.citizencorps.gov/partnersandaffiliates/cert.shtm. Accessed on August 14, 2011.

Earthquake Household Displacement

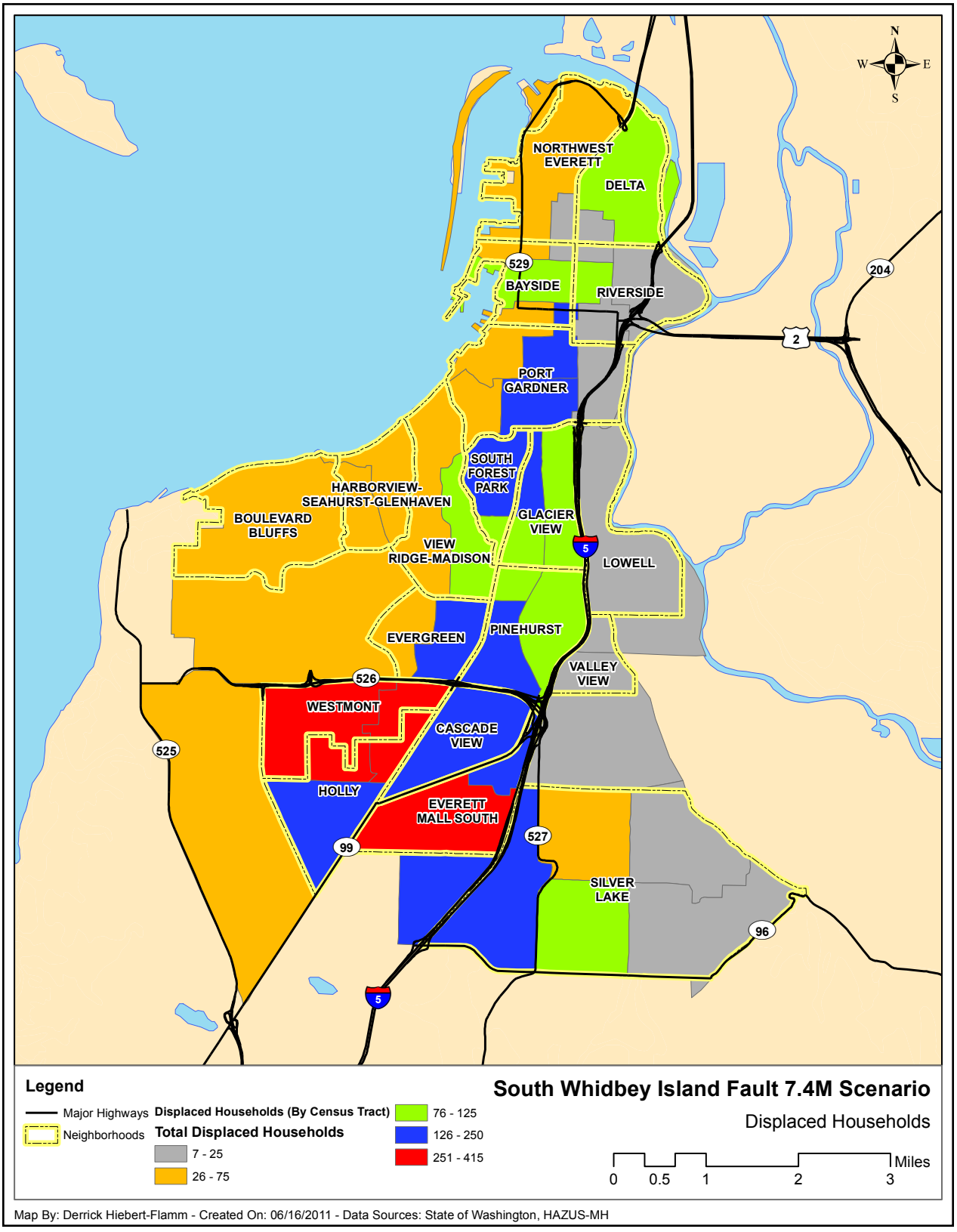
Using HAZUS-MH, the project planning team ran four earthquake scenarios, as detailed in the HIVA: Cascadia subduction zone, Benioff, Seattle Fault and South Whidbey Island Fault. The first three scenarios projected minimal to no damage of single-family and other housing structures. The South Whidbey Island Fault scenario, however, projected that hundreds of homes could experience extensive to complete damage.

The planning team then broke down the number of displaced households by census tract. The census tracts do not directly correlate with neighborhood boundaries, but it does provide an idea of the possible shelter requirements for each area. The information could also help neighborhoods decide how to prioritize mitigation programs such as structural retrofits.

One of the limitations of this type of analysis is that the Seismic Soil Class of each census tract is averaged, and steep slopes are not considered. As a result, the eastern neighborhoods were predicted to have lower displacement rates than the rest of the city; this contradicts the fact that more vulnerable Seismic Soil Classes D and E, combined with neighborhoods near steep slopes, is likely to result in extensive to complete damage of several homes.

Figure 31 shows the household displacement by census tract, overlaid with general neighborhood areas.

FIGURE 31: SOUTH WHIDBEY ISLAND FAULT SCENARIO DISPLACED HOUSEHOLDS

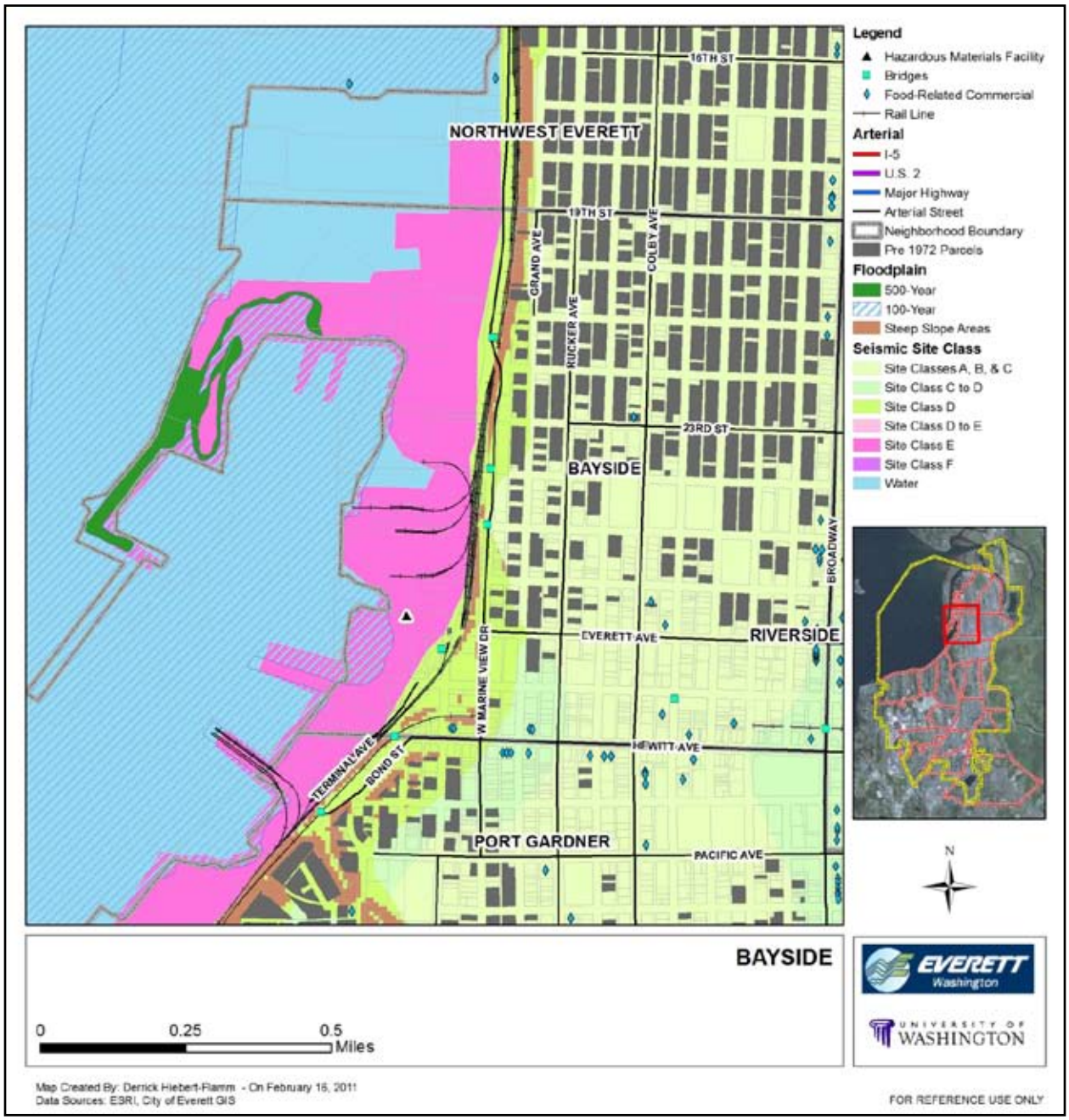


Bayside

The Bayside neighborhood contains a portion of downtown Everett, some single-family and multi-family residential areas, a large section of the port, and much of the naval base. While most of the residential areas are on stable soils, the industrial and port facilities lie on unstable site classes D and E. At least one Hazardous Materials facility lies on E soils: the Kimberly-Clark plant. Furthermore, the BNSF railway runs along the bluff. The railway tunnel, an unreinforced, unvented concrete structure, runs through the southern section of the neighborhood. Portions of the downtown also contain unreinforced masonry structures that are likely to be damaged in an earthquake. The port areas are exposed to tsunami/seiche inundation, although the residential areas would not be impacted by this hazard. A steep bluff divides the residential and port areas, leaving this area at risk from landslides.

While sections of the neighborhood are at risk from the aforementioned hazards, the most populated residential areas are relatively secure. The greatest threat to the residential areas comes from potential hazardous material spills and earthquakes due to the number of houses built prior to the imposition of the 1972 building codes.

Bayside currently has thirty-six (36) CERT graduates.

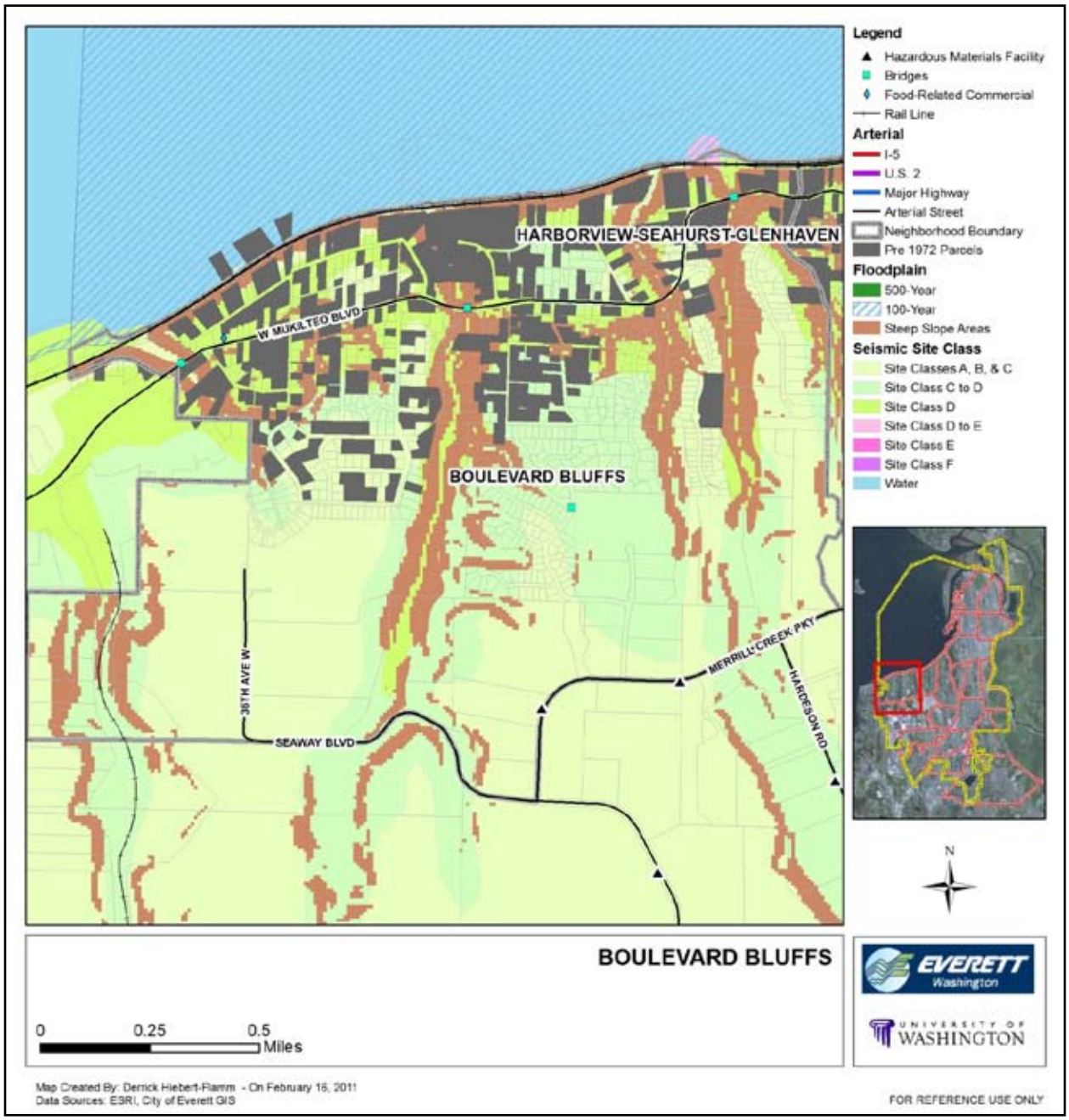

NORTHWEST EVERETT
BAYSIDE
RIVERSIDE
PORT GARDNER
16TH ST
19TH ST
23RD ST
EVERETT AVE
HEWITT AVE
PACIFIC AVE
GRAND AVE
RUCKER AVE
COLBY AVE
BROADWAY
W MARINE VIEW DR
BOND ST
TERMINAL AVE
Legend
Hazardous Materials Facility
Bridges
Food-Related Commercial
Rail Line
Arterial
I-5
U.S. 2
Major Highway
Arterial Street
Neighborhood Boundary
Pre 1972 Parcels
Floodplain
500-Year
100-Year
Steep Slope Areas
Seismic Site Class
Site Classes A, B, & C
Site Class C to D
Site Class D
Site Class D to E
Site Class E
Site Class F
Water
N
BAYSIDE
0 0.25 0.5 Miles
EVERETT Washington
UNIVERSITY OF WASHINGTON
Map Created By: Derrick Hiebert-Flamm - On February 16, 2011
Data Sources: ESRI, City of Everett GIS
FOR REFERENCE USE ONLY

Boulevard Bluffs

Steep slopes and large swaths of site classes C and D soils dominate the Boulevard Bluffs neighborhood, located in southwest Everett. The BNSF railway runs along the bluff next to the water. The soil classes and the existence of steep slopes make this area especially susceptible to landslides and earthquakes. The BNSF railway and the 7+ hazardous materials facilities lying just beyond the southern boundary of the neighborhood also leaves the area at risk from hazardous materials spills. Finally, the area has relatively few major streets, which, combined with the steep slopes and older bridges, increases the likelihood of isolation in the event of a hazard such as an ice storm or earthquake. There are several planned and existing pedestrian trails in the area that provide alternatives; however, a lack of nearby commercial business centers means that, even should the trails be passable, there would be few places to go.

A majority of the residential structures in Boulevard Bluffs were built prior to the 1972 building codes. Also, most of these structures are located in the steep slope areas. It is likely that homes in this area would be susceptible to damage following a major earthquake, especially given their proximity to the South Whidbey Island Fault. Furthermore, many of these slopes are heavily forested, increasing the risk of wildfire.

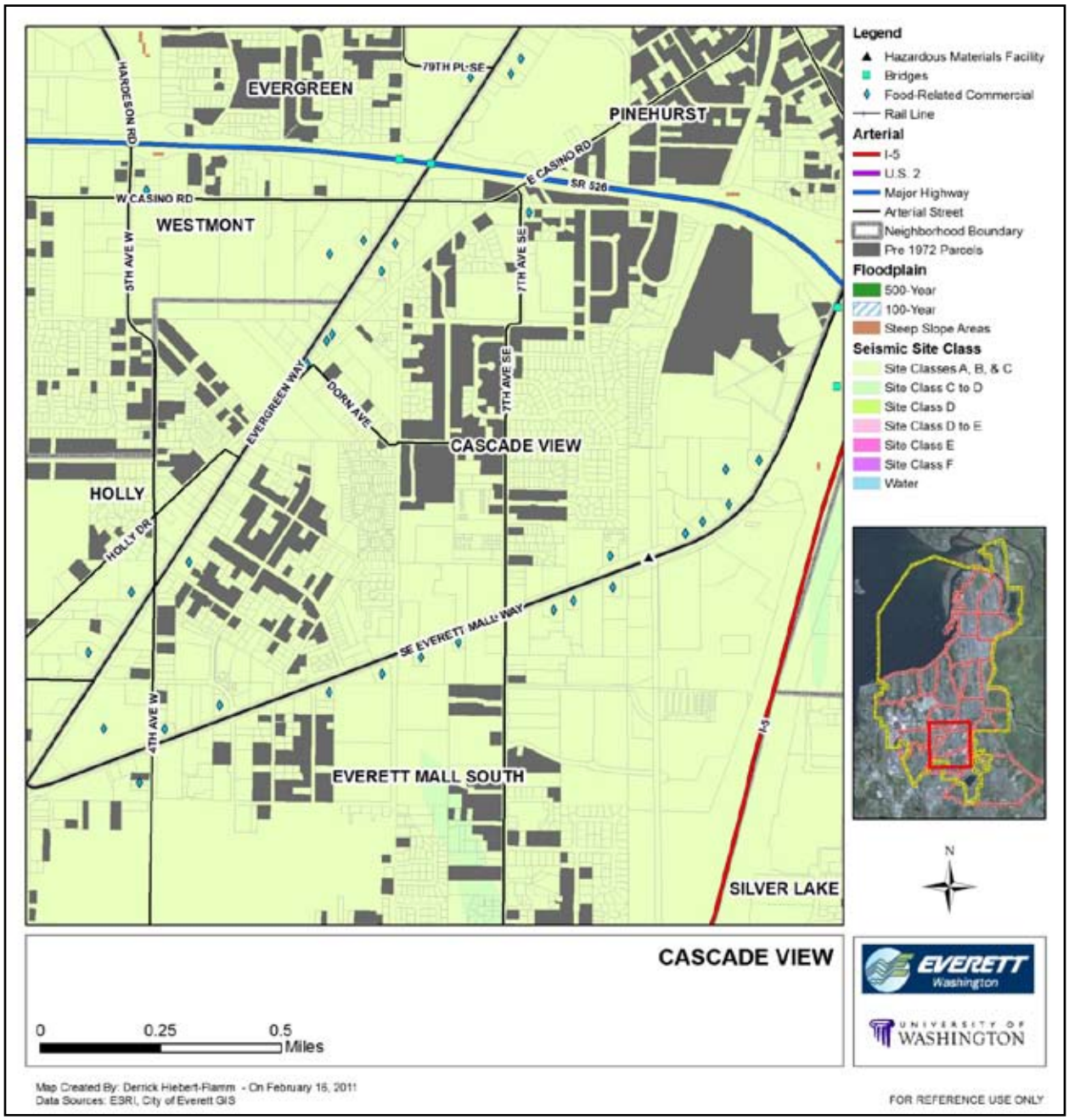
There are currently ten (10) CERT graduates living in the neighborhood.


Legend
Hazardous Materials Facility
Bridges
Food-Related Commercial
Rail Line
Arterial
I-5
U.S. 2
Major Highway
Arterial Street
Neighborhood Boundary
Pre 1972 Parcels
Floodplain
500-Year
100-Year
Steep Slope Areas
Seismic Site Class
Site Classes A, B, & C
Site Class C to D
Site Class D
Site Class D to E
Site Class E
Site Class F
Water
HARBORVIEW-SEAHURST-GLENHAVEN
W MUKILTEO BLVD
BOULEVARD BLUFFS
36TH AVE W
SEAWAY BLVD
MERRILL CREEK PKY
HARDESON RD
N
BOULEVARD BLUFFS
0 0.25 0.5 Miles
EVERETT Washington
UNIVERSITY OF WASHINGTON
Map Created By: Derrick Hiebert-Flamm - On February 16, 2011
Data Sources: ESRI, City of Everett GIS
FOR REFERENCE USE ONLY

Cascade View

Cascade View is one of several south-central Everett neighborhoods with a lower hazard risk than other neighborhoods Although approximately half of the residential structures were built prior to 1972, the area does not lie on steep slopes or unstable soils. Because of this, the earthquake damage risk is low even though it is closer to the South Whidbey Island fault running south of Everett. The greatest potential risk is its proximity to several hazardous materials facilities and transit routes, especially I-5 and SR 527. These transit routes also reduce the risk of isolation, as does the proximity of large numbers of commercial facilities, although both I-5 and SR 527 have a number of bridges and overpasses that may become impassable following an earthquake.

There are currently eighteen (18) CERT graduates living in the neighborhood.


EVERGREEN
PINEHURST
WESTMONT
CASCADE VIEW
HOLLY
EVERETT MALL SOUTH
SILVER LAKE
79TH PL SE
HARDESON RD
E CASINO RD
SR 526
W CASINO RD
5TH AVE W
7TH AVE SE
EVERGREEN WAY
DORN AVE
HOLLY DR
SE EVERETT MALL WAY
4TH AVE W
I-5
Legend
Hazardous Materials Facility
Bridges
Food-Related Commercial
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I-5
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Major Highway
Arterial Street
Neighborhood Boundary
Pre 1972 Parcels
Floodplain
500-Year
100-Year
Steep Slope Areas
Seismic Site Class
Site Classes A, B, & C
Site Class C to D
Site Class D
Site Class D to E
Site Class E
Site Class F
Water
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CASCADE VIEW
0 0.25 0.5 Miles
EVERETT Washington
UNIVERSITY OF WASHINGTON
Map Created By: Derrick Hiebert-Flamm - On February 16, 2011
Data Sources: ESRI, City of Everett GIS
FOR REFERENCE USE ONLY

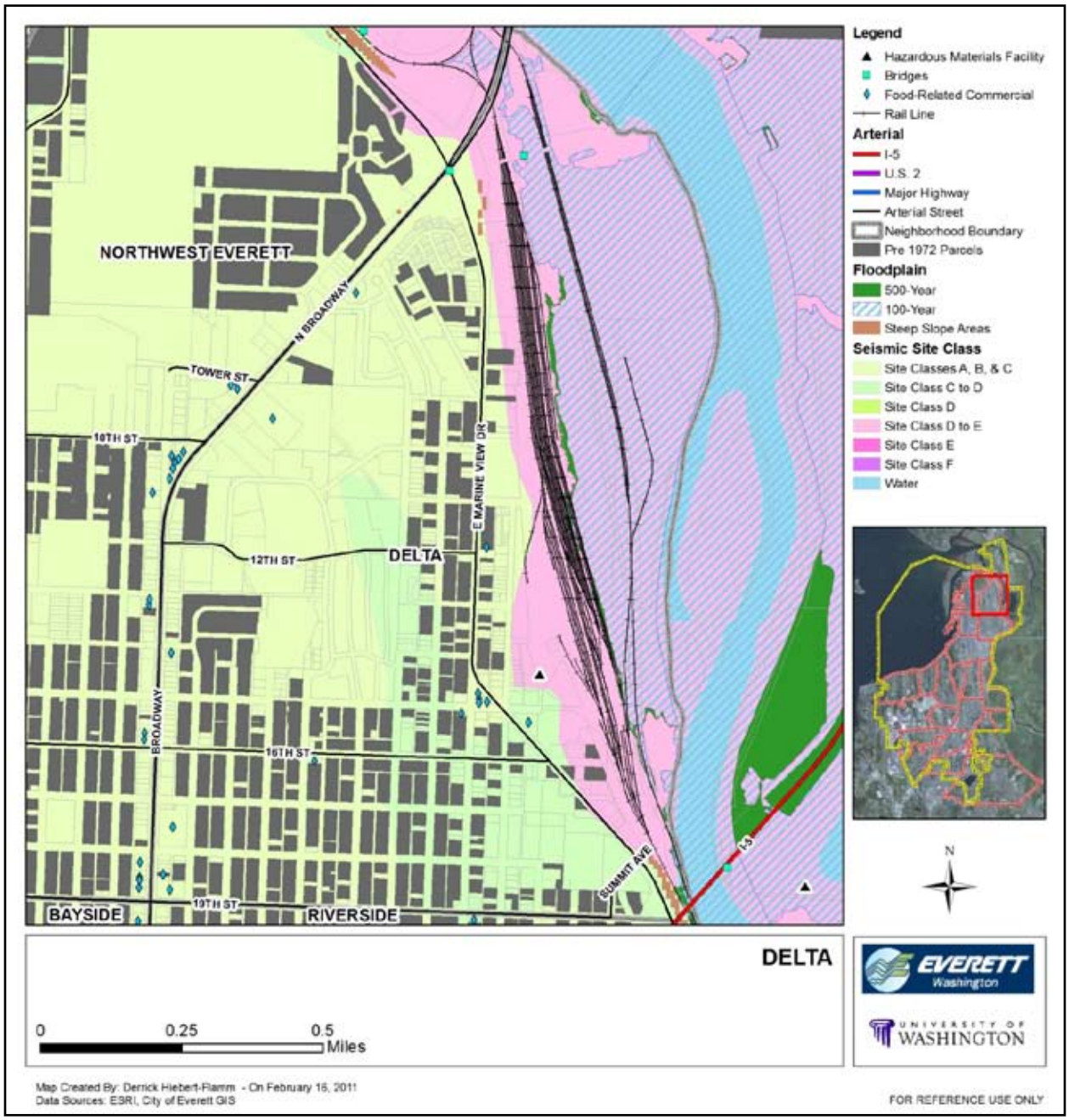
Delta

The Delta neighborhood, lying at the northern end of Everett, has a slightly lower risk from earthquakes due to its greater distance from the South Whidbey Island fault. Most of the older structures are on stable soils, with only a few on site class C to D. The area does contain a large number of unreinforced masonry buildings, which are known to fare badly during earthquakes.

Due to its proximity to the trainyards, rail lines and a BNSF Hazardous Materials facility, all of which lie in or near the Snohomish River floodplain and on site class D to E soils, the area is at risk of hazardous materials events and from flooding. Most of this area is undeveloped and includes few residential buildings. The rail tunnel, which runs under several downtown blocks, may carry trains with hazardous material cargo that could be released if an earthquake causes a tunnel collapse.

The neighborhood benefits from the existence of large numbers of major streets and few bridges, combined with no steep slope areas, which reduces potential isolation. There is also a significant number of nearby commercial facilities, as well as several pedestrian trails.

There are currently sixteen (16) CERT graduates in the neighborhood.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Pre 1972 Parcels
Floodplain
500-Year
100-Year
Steep Slope Areas
Seismic Site Class
Site Classes A, B, & C
Site Class C to D
Site Class D
Site Class D to E
Site Class E
Site Class F
Water
NORTHWEST EVERETT
N BROADWAY
TOWER ST
16TH ST
12TH ST
DELTA
E MARINE VIEW DR
BROADWAY
16TH ST
SUMMIT AVE
I-5
19TH ST
BAYSIDE
RIVERSIDE
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DELTA
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EVERETT Washington
UNIVERSITY OF WASHINGTON
Map Created By: Derrick Hiebert-Ramm - On February 16, 2011
Data Sources: ESRI, City of Everett GIS
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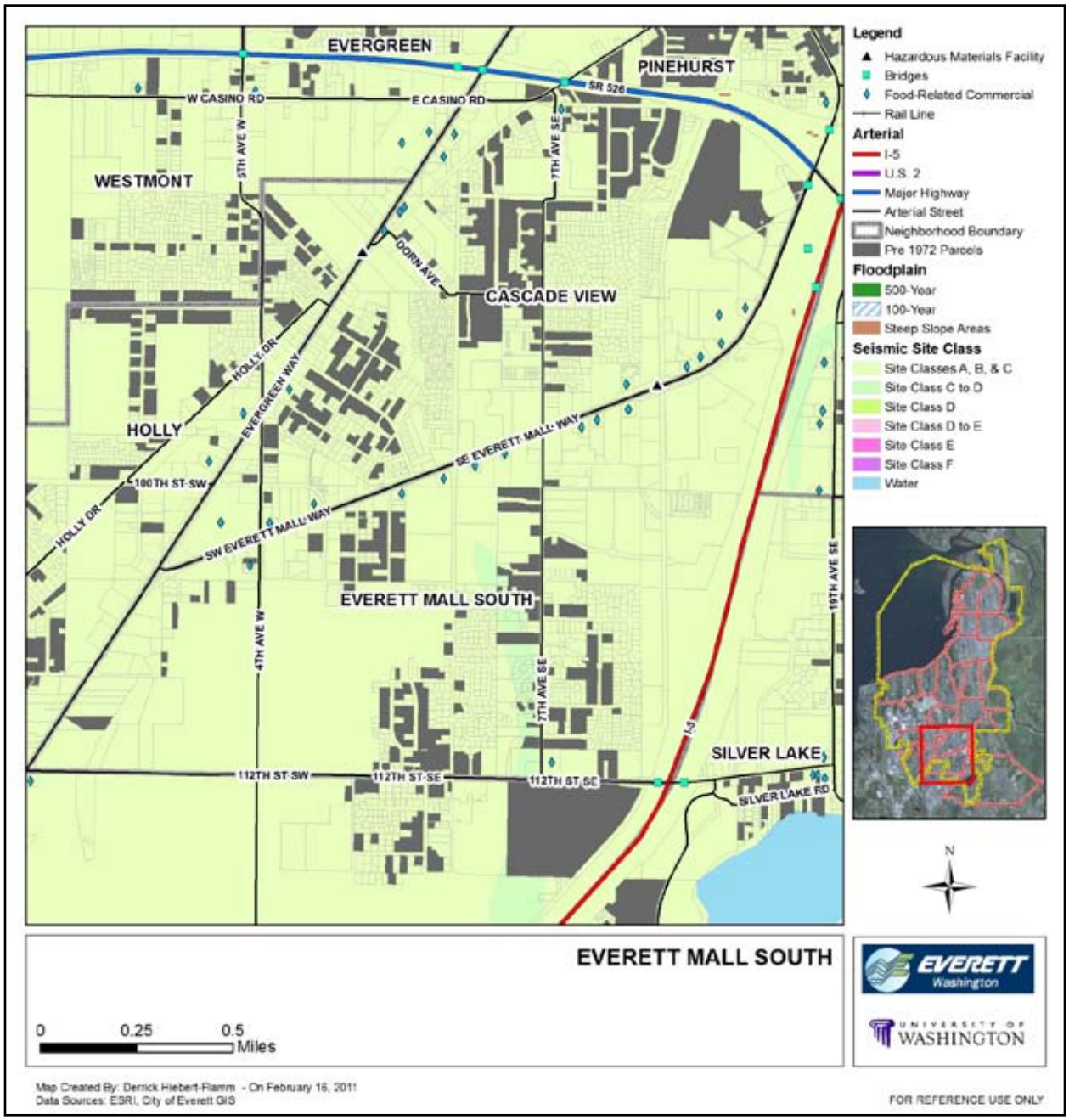
Everett Mall South

Everett Mall South is another one of the south-central Everett neighborhoods with a low hazard risk. Less than half of the residential structures were built prior to 1972, and the area does not lie on steep slopes or unstable soils. Because of this, the earthquake damage risk is low even though it is closer to the South Whidbey Island fault running south of Everett.

The greatest potential risks are its proximity to several hazardous materials facilities and transit routes, especially I- 5, and the possibility of severe earthquake damage to the mall, which could cause large numbers of people to be trapped or injured in the event of building failure. The transit routes reduce the risk of isolation, as does the proximity of large numbers of commercial facilities.

There are currently ten (10) CERT graduates in the neighborhood.


EVERGREEN
PINEHURST
WESTMONT
CASCADE VIEW
HOLLY
EVERETT MALL SOUTH
SILVER LAKE
W CASINO RD
E CASINO RD
SR 526
5TH AVE W
7TH AVE SE
DORN AVE
HOLLY DR
EVERGREEN WAY
100TH ST SW
SE EVERETT MALL WAY
SW EVERETT MALL WAY
4TH AVE W
19TH AVE SE
I-5
112TH ST SW
112TH ST SE
112TH ST SE
SILVER LAKE RD
Legend
Hazardous Materials Facility
Bridges
Food-Related Commercial
Rail Line
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I-5
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Neighborhood Boundary
Pre 1972 Parcels
Floodplain
500-Year
100-Year
Steep Slope Areas
Seismic Site Class
Site Classes A, B, & C
Site Class C to D
Site Class D
Site Class D to E
Site Class E
Site Class F
Water
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EVERETT MALL SOUTH
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Miles
EVERETT
Washington
UNIVERSITY OF WASHINGTON
Map Created By: Derrick Hiebert-Flamm - On February 16, 2011
Data Sources: ESRI, City of Everett GIS
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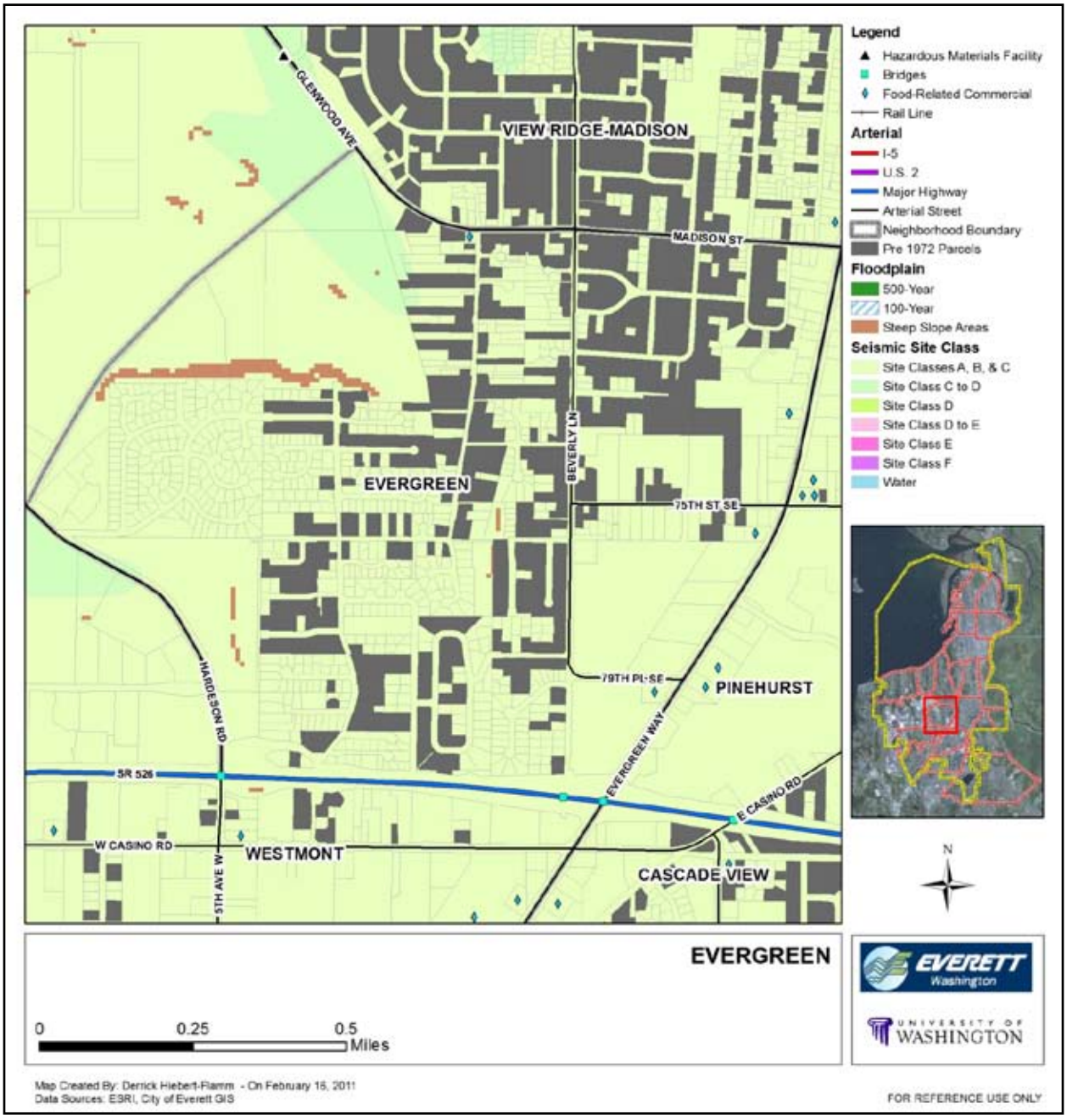
Evergreen

Evergreen is a central Everett neighborhood with a low hazard risk. Although many of the residential structures were built prior to 1972, few structures outside of the 75th street corridor lie on steep slopes or unstable soils. Transportation routes reduce the risk of isolation, as does the proximity of large numbers of commercial facilities, though they are concentrated mainly in the eastern portion of the neighborhood. Ten hazardous materials facilities are located within a mile of the western border. This, along with the high number of pre-1972 structures, constitutes the greatest source of risk for the neighborhood.

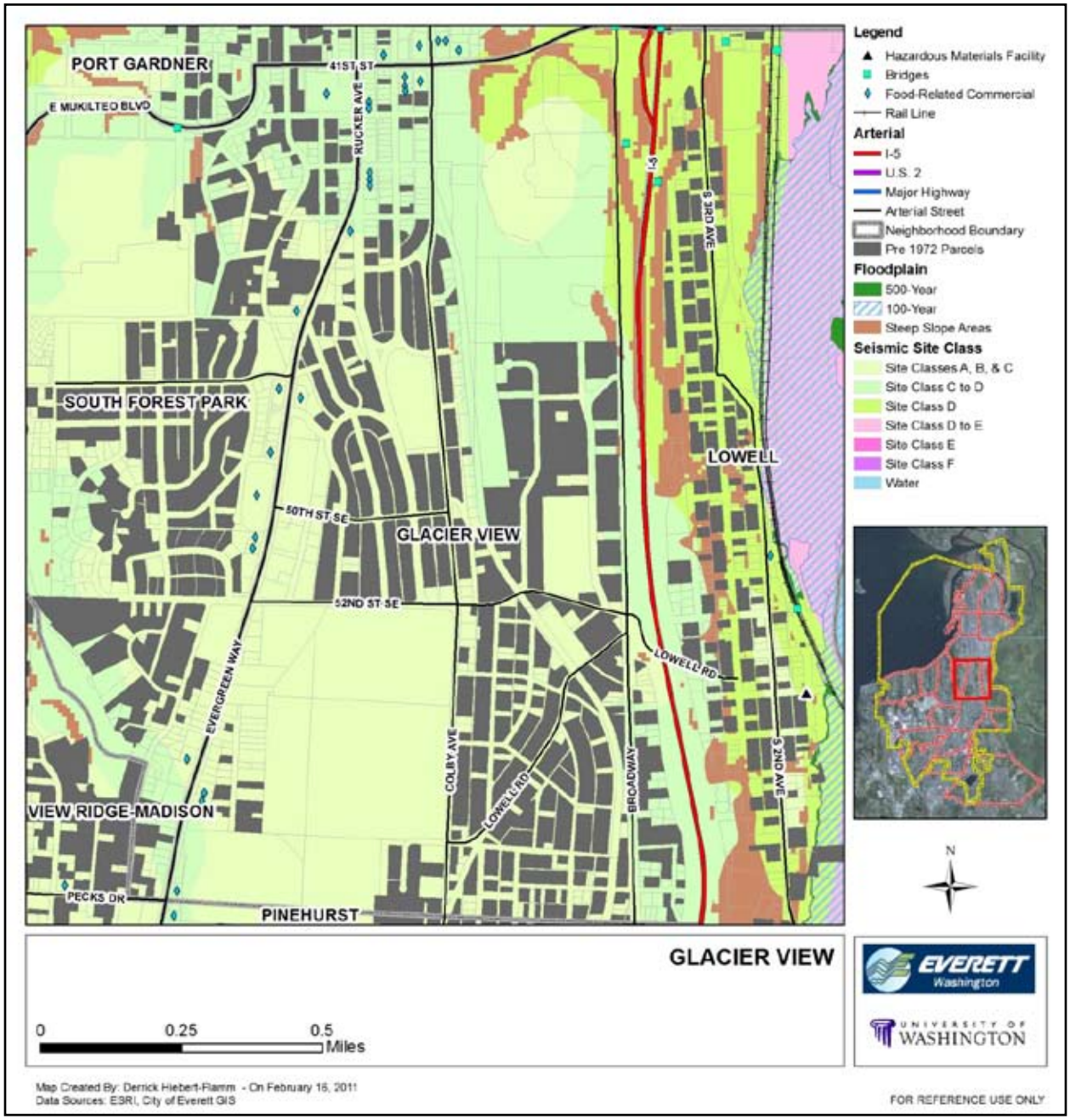
There are currently five (5) CERT graduates living in Evergreen.



Glacier View

Glacier View is a central Everett neighborhood with a low hazard risk despite the large number of pre-1972 structures. It lies on major arterial routes, including Highway 99 and I-5, and its steep slope areas are mostly undeveloped. There are some site class C to D soils along the edge of the neighborhood near the slope areas that would be likely to face the most damage during an earthquake event, but there are few older structures built in those areas.. The neighborhood is exposed to hazardous materials through its proximity to I-5, though this also offers benefits of protection against isolation, along with Evergreen Way.

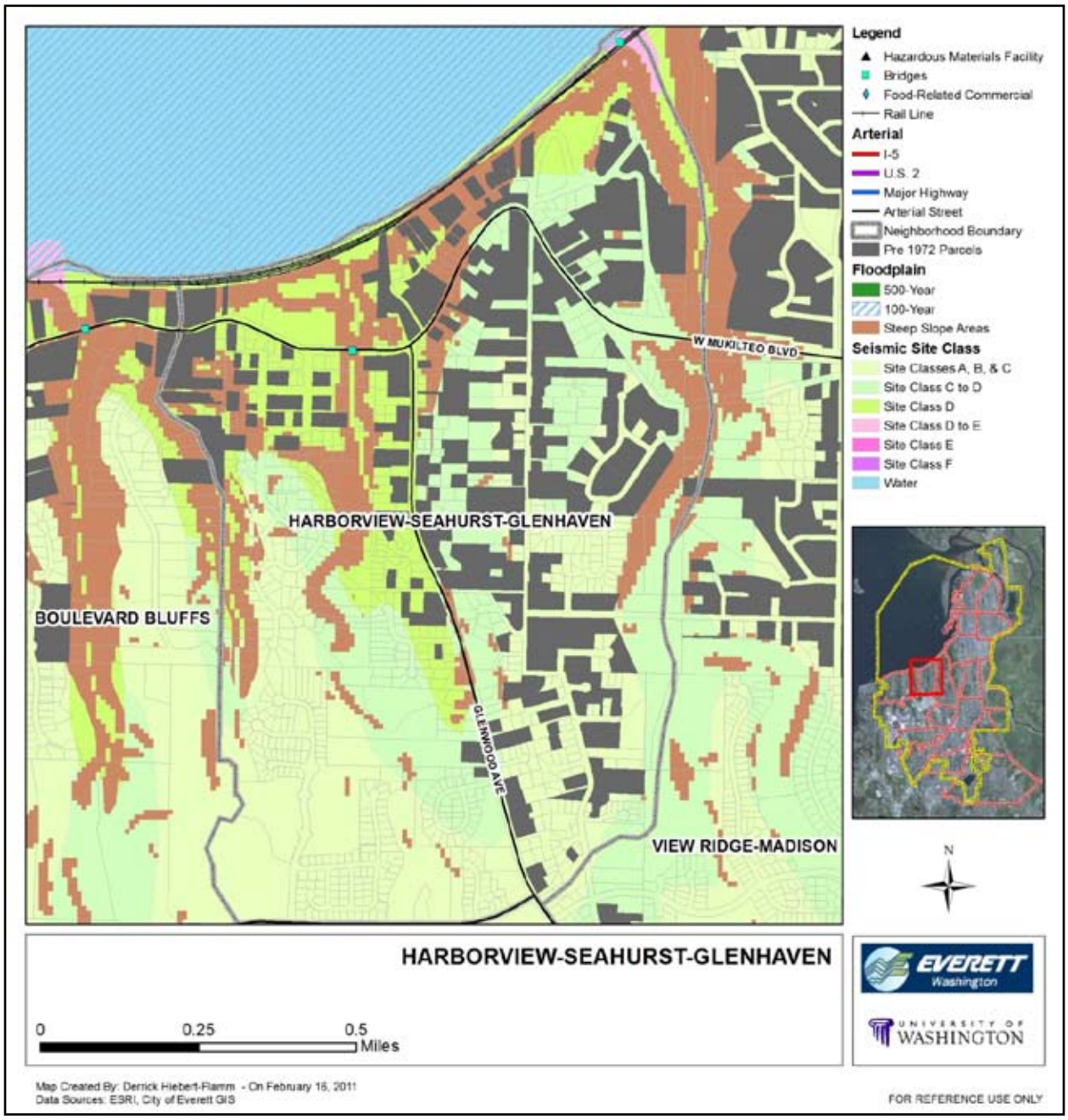
There are currently three (3) CERT graduates in Glacier View.



Harborview-Seahurst-Glenhaven

Steep slopes and large swaths of site classes C and D soils dominate the Harborview-Seahurst-Glenhaven neighborhood in southwest Everett. The BNSF railway runs along the bluff next to the water. The soil class and the existence of steep slopes make this area especially susceptible to landslides and earthquakes. The BNSF railway and the 7+ hazardous materials facilities lying just beyond the southern boundary of the neighborhood also leaves the area at risk from hazardous materials spills. The area has relatively few major streets, and this, combined with the steep slopes and older bridges susceptible to collapse, increases the likelihood of isolation. There are several planned and existing pedestrian trails in the area that provide alternatives; however, there are virtually no commercial businesses within walking distance.

There are currently sixteen (16) CERT graduates in the neighborhood.


Legend
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Pre 1972 Parcels
Floodplain
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Site Classes A, B, & C
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Site Class D
Site Class D to E
Site Class E
Site Class F
Water
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HARBORVIEW-SEAHURST-GLENHAVEN
BOULEVARD BLUFFS
GLENWOOD AVE
VIEW RIDGE-MADISON
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Miles
EVERETT
Washington
UNIVERSITY OF WASHINGTON
Map Created By: Derrick Hiebert-Ramm - On February 16, 2011
Data Sources: ESRI, City of Everett GIS
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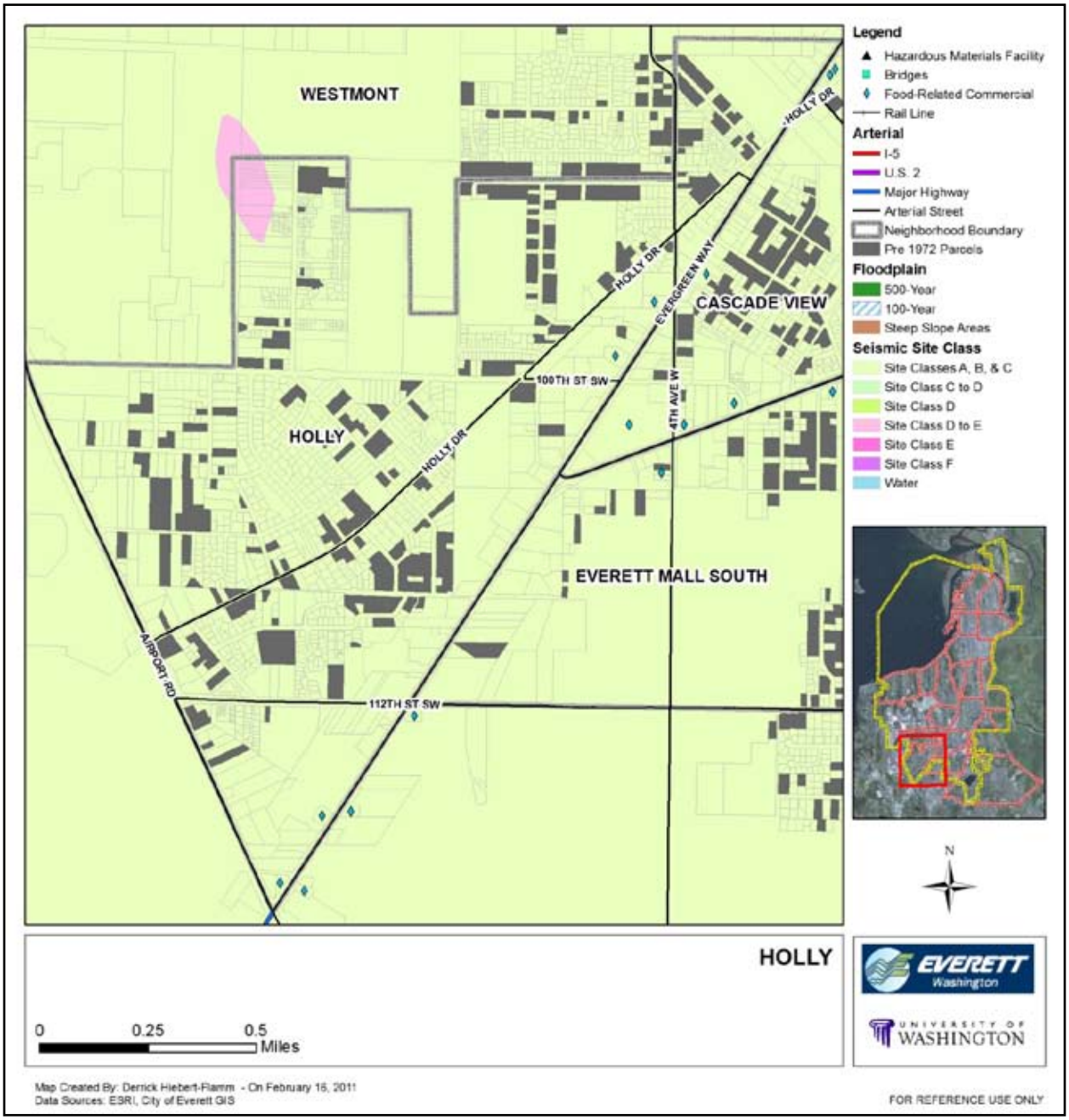
Holly

Holly is a south Everett neighborhood with a low hazard risk. Less than half of the residential structures were built prior to 1972, and the area does not lie on steep slopes or unstable soils. Because of this, the earthquake damage risk is low even though it is closer to the South Whidbey Island fault running south of Everett.

The greatest potential risk is from its proximity of several hazardous materials facilities and transit routes, including I-5 and Paine Field. The transit routes also reduce the risk of isolation, however, as does the large number of nearby commercial facilities.

There are currently sixteen (16) CERT graduates living in the neighborhood.


WESTMONT
HOLLY
CASCADE VIEW
EVERETT MALL SOUTH
HOLLY DR
EVERGREEN WAY
100TH ST SW
4TH AVE W
AIRPORT RD
112TH ST SW
Legend
Hazardous Materials Facility
Bridges
Food-Related Commercial
Rail Line
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Major Highway
Arterial Street
Neighborhood Boundary
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Steep Slope Areas
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Site Classes A, B, & C
Site Class C to D
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EVERETT Washington
UNIVERSITY OF WASHINGTON
Map Created By: Derrick Hiebert-Flamm - On February 16, 2011
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Lowell

The Lowell neighborhood contains large swaths of agricultural land in the east and pre-1972 structures along its western boundary, between I-5 and the railway. This location, between two potential hazardous material transit routes and near one hazardous material facility, places the area at risk of hazardous materials exposure during disasters. Site classes D and D to E soils dominate the entire area, with most of the development in site class D to E areas. The developed area lies along a steep slope area, leaving the neighborhood vulnerable to landslides. This combination of steep slopes, older buildings, hazardous facilities routes, and poor soils means this neighborhood faces elevated risk from major hazards, especially earthquakes.

As noted, the census-tract-level analysis does not take these factors into account, and thus HAZUS-MH's prediction of low amounts of household displacement is likely inaccurate.

Large sections of Lowell also lie within the Snohomish River floodplain. While these areas are generally open space or farmland, there are some areas of manufacturing, utilities, and residential uses that are also exposed. This exposure may increase as FEMA continues to update local floodplain designations.

Finally, the combination of hazards to which the neighborhood is exposed puts it at risk of isolation. Floods and landslides could cut some areas off from the rest of the neighborhood and the city, potentially stranding people. Workers at manufacturing and utility sites in the area would be most at risk. Much of the housing in the area is cut off from neighboring areas by steep slopes.

There is currently one (1) CERT graduate living in Lowell.


PORT GARDNER
GLACIER VIEW
PINEHURST
LOWELL
VALLEY VIEW
BROADWAY
S 3RD AVE
52ND ST SE
LOWELL RD
S 2ND AVE
COLBY AVE
LOWELL RD
LARMER RD
MADISON ST
I-5
Legend
Hazardous Materials Facility
Bridges
Food-Related Commercial
Rail Line
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Major Highway
Arterial Street
Neighborhood Boundary
Pre 1972 Parcels
Floodplain
500-Year
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Steep Slope Areas
Seismic Site Class
Site Classes A, B, & C
Site Class C to D
Site Class D
Site Class D to E
Site Class E
Site Class F
Water
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LOWELL
0 0.25 0.5 Miles
EVERETT Washington
UNIVERSITY OF WASHINGTON
Map Created By: Derrick Hiebert-Flamm - On February 16, 2011
Data Sources: ESRI, City of Everett GIS
FOR REFERENCE USE ONLY

Northwest Everett

The Northwest Everett neighborhood shares many of the same risks as Bayside. It contains large amounts of pre-1972 structures, single family residential areas, the college, a large section of the port, and much of the naval base. While most of the residential areas are on stable soils, the industrial and port facilities lie on unstable site classes D and E. The residential structures lying along the steep sloped bluff (next to the BNSF railway) are at risk of landslides and are on site class D soils. This railway also carries hazardous materials, creating the risk of exposure from an event here. The port areas are exposed to tsunami/seiche inundation, though the residential areas would not be impacted.

While the neighborhood is at risk from hazardous materials, landslide, tsunami, and earthquake, the most populated residential areas are relatively secure. The greatest risk to the residential areas is from earthquakes due to the majority of buildings constructed prior to 1972 building codes.

The area faces a relatively low risk of isolation due to the abundance of major streets and the small numbers of steep slopes. The port area could be isolated in the event of a disaster that destroys access roads to that area.

The northern portion of the neighborhood is at risk of flooding; however, most of this area has few buildings, with the exception of a single warehouse parcel.

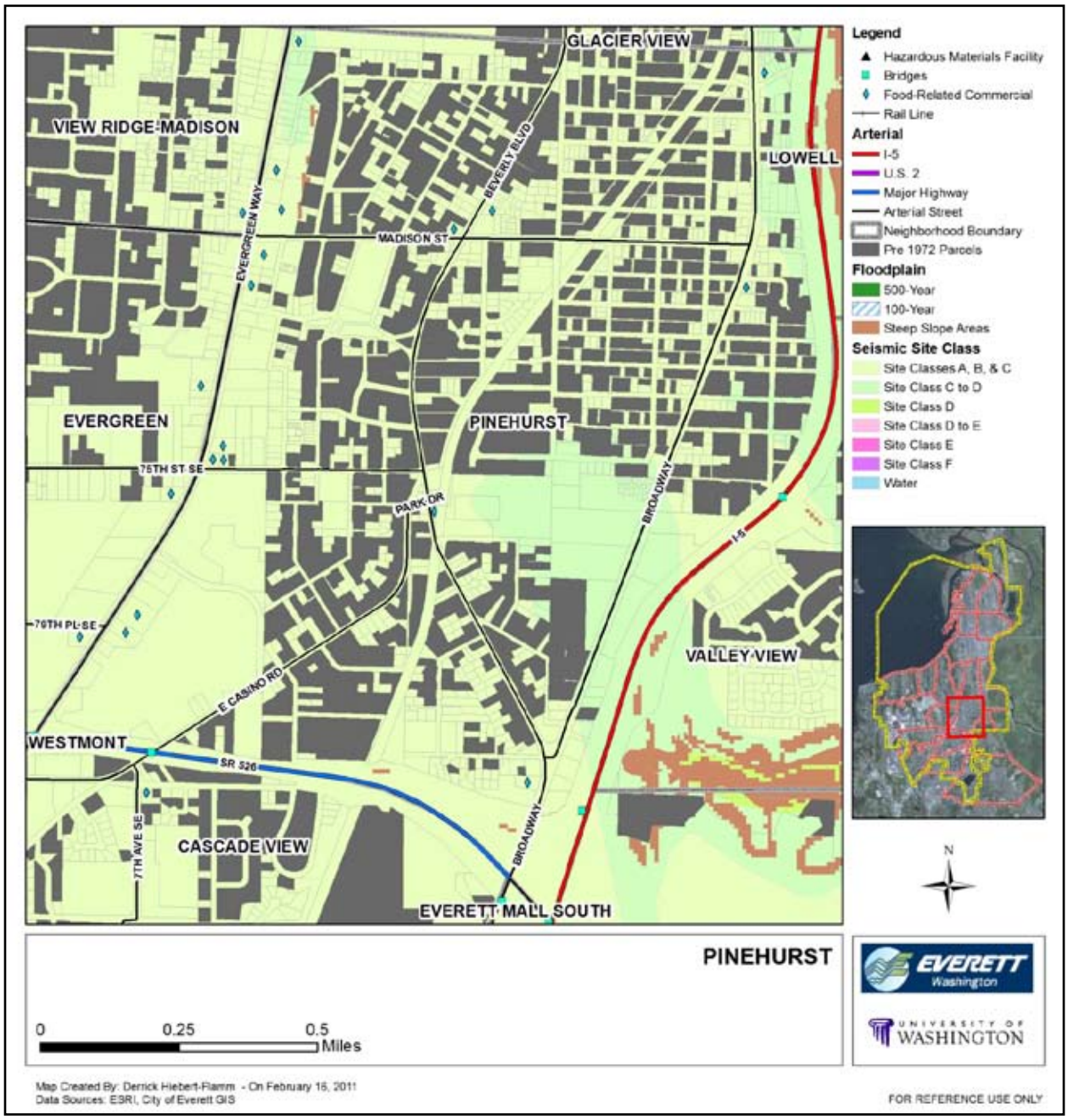
There are currently twenty-five (25) CERT graduates living in the neighborhood.


Legend
Hazardous Materials Facility
Bridges
Food-Related Commercial
Rail Line
Arterial
I-5
U.S. 2
Major Highway
Arterial Street
Neighborhood Boundary
Pre 1972 Parcels
Floodplain
500-Year
100-Year
Steep Slope Areas
Seismic Site Class
Site Classes A, B, & C
Site Class C to D
Site Class D
Site Class D to E
Site Class E
Site Class F
Water
ALVERSON BLVD
COLBY AVE
N BROADWAY
TOWER ST
NORTHWEST EVERETT
10TH ST
12TH ST
DELTA
E MARINE VIEW DR
W MARINE VIEW DR
BROADWAY
16TH ST
19TH ST
BAYSIDE
RIVERSIDE
N
NORTHWEST EVERETT
0
0.25
0.5
Miles
EVERETT
Washington
UNIVERSITY OF WASHINGTON
Map Created By: Derrick Hiebert-Ramm - On February 16, 2011
Data Sources: ESRI, City of Everett GIS
FOR REFERENCE USE ONLY

Pinehurst

Pinehurst is one of several south-central Everett neighborhoods with a low hazard risk. Although almost all of the residential structures were built prior to 1972, the area does not lie on steep slopes or unstable soils. The greatest potential risk is its proximity to I-5, a hazardous materials transit route. Transit routes also reduce the risk of isolation, as does the proximity of large numbers of commercial facilities. The western portion of the neighborhood may be more secure than the eastern portion, since it is closer to existing commercial facilities and further from I-5 and steep slopes.

There are currently twenty-one (21) CERT graduates living in Pinehurst.


GLACIER VIEW
VIEW RIDGE-MADISON
LOWELL
EVERGREEN WAY
BEVERLY BLVD
MADISON ST
EVERGREEN
PINEHURST
75TH ST SE
PARK DR
BROADWAY
I-5
76TH PL SE
VALLEY VIEW
E CASINO RD
WESTMONT
SR 526
7TH AVE SE
CASCADE VIEW
EVERETT MALL SOUTH
Legend
Hazardous Materials Facility
Bridges
Food-Related Commercial
Rail Line
Arterial
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U.S. 2
Major Highway
Arterial Street
Neighborhood Boundary
Pre 1972 Parcels
Floodplain
500-Year
100-Year
Steep Slope Areas
Seismic Site Class
Site Classes A, B, & C
Site Class C to D
Site Class D
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Site Class E
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PINEHURST
0 0.25 0.5 Miles
EVERETT Washington
UNIVERSITY OF WASHINGTON
Map Created By: Derrick Hiebert-Ramm - On February 16, 2011
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Port Gardner

Port Gardner is a larger neighborhood stretching east-west through the middle of Everett. Steep slopes, rail lines, and Port Gardner Bay border its west, and rail lines and I-5 border it on the east. It contains a large amount of forested area in the southwest. There is a single Hazardous Materials facility on the northeast edge, operated by Everett Steel. Most of the construction is pre-1972, including potentially large numbers of unreinforced masonry structures in the downtown. Much of the area is covered by site class C to D soils, with additional site class D in the steep slope and river areas and site class D to E in the floodplain. There is also site class E soil in the port area.

The combination of these factors indicate that the area is at risk for: landslides in the steep slope areas; earthquakes in those areas with poor soils, on or around steep slopes, or with older structures and unreinforced masonry; tsunami in the port area; hazardous materials spills from I-5, the railroad, and the Hazardous Materials facility; flooding in the Snohomish River floodplain and Port Gardner bay; and wildfire in areas bordering forested slopes. While the number of potential hazards is great, the risk is concentrated in the western half of the neighborhood with its poor soils and greater landslide risk, and in the areas with unreinforced masonry, which are always more susceptible to earthquake damage. The rest of the neighborhood would be relatively secure, as it is built on better soils and is not at risk of isolation.

There are currently forty (40) CERT graduates in the neighborhood.


Legend
Hazardous Materials Facility
Bridges
Food-Related Commercial
Rail Line
Arterial
I-5
U.S. 2
Major Highway
Arterial Street
Neighborhood Boundary
Pre 1972 Parcels
Floodplain
500-Year
100-Year
Steep Slope Areas
Seismic Site Class
Site Classes A, B, & C
Site Class C to D
Site Class D
Site Class D to E
Site Class E
Site Class F
Water
BAYSIDE
EVERETT AVE
RIVERSIDE
HEWITT AVE
PACIFIC AVE
TERMINAL AVE
BOND ST
W MARINE VIEW DR
NASSAU ST
RUCKER AVE
COLBY AVE
MAPLE ST
CHESTNUT ST
ECLIPSE MILL RD
35TH ST
PORT GARDNER
36TH ST
37TH ST
38TH ST
SMITH AVE
41ST ST
I-5
VIEW RIDGE-MADISON
SOUTH FOREST PARK
EVERGREEN WAY
GLACIER VIEW
BROADWAY
S 3RD AVE
LOWELL
47TH ST SE
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PORT GARDNER
0 0.25 0.5 Miles
EVERETT Washington
UNIVERSITY OF WASHINGTON
Map Created By: Derrick Hiebert-Flamm - On February 16, 2011
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Riverside

Riverside is a large neighborhood in eastern Everett. It benefits from stable soils in most of the area and little exposure to steep slopes, while several riverside parcels with docks, shipping, and other industrial activity are exposed to the Snohomish River floodplain. These activities are conducted on poor, site class D to E soils. With the major transportation thoroughfares of I-5, U.S. 2, and the railroad extending into the neighborhood, the area could be at risk from hazardous materials incidents. These and other arterial streets also reduce the area's risk of isolation.

Although the neighborhood is dominated by pre-code construction, those areas are not exposed to any particular seismic, slope, or other related hazard. Without any additional exposure, pre-code housing that is not secured to its foundations remains especially susceptible to earthquake damage. Should these structures be retrofitted to secure their foundations, it would limit the potential impact from a major disaster in the neighborhood.

There are currently twenty-seven (27) CERT graduates residing in Riverside.


NORTHWEST EVERETT
DELTA
BAYSIDE
RIVERSIDE
PORT GARDNER
E MARINE VIEW DR
19TH ST
BROADWAY
SUMMIT AVE
E GRAND AVE
I-5
23RD ST
EVERETT AVE
RAILWAY AVE
HEWITT AVE
MAPLE ST
CHESTNUT ST
US 2
PACIFIC AVE
SMITH AVE
ECLIPSE MILL RD
Legend
Hazardous Materials Facility
Bridges
Food-Related Commercial
Rail Line
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I-5
U.S. 2
Major Highway
Arterial Street
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Pre 1972 Parcels
Floodplain
500-Year
100-Year
Steep Slope Areas
Seismic Site Class
Site Classes A, B, & C
Site Class C to D
Site Class D
Site Class D to E
Site Class E
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Miles
EVERETT
Washington
UNIVERSITY OF WASHINGTON
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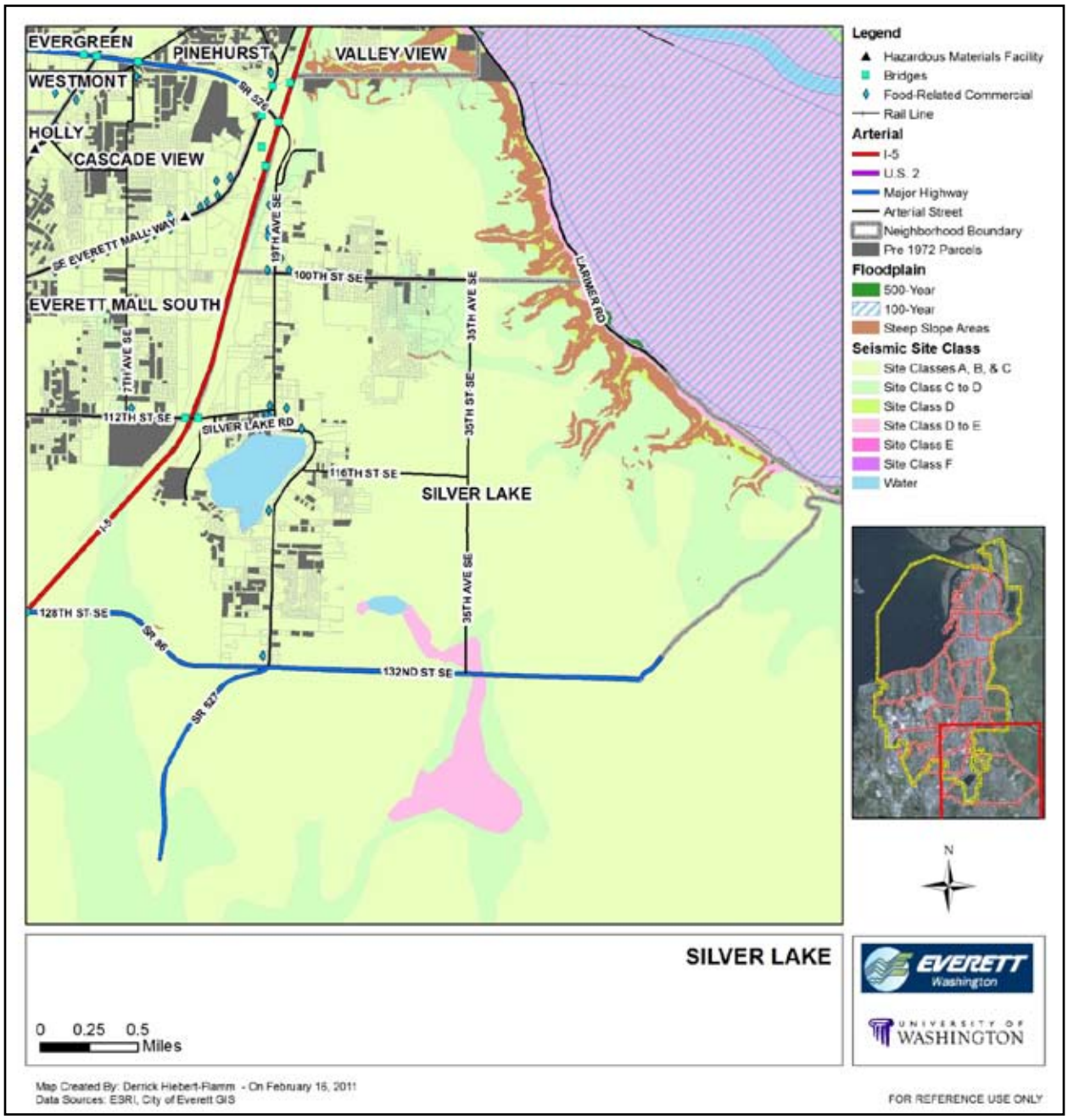
Silver Lake

Silver Lake is a very large neighborhood in southeast Everett. It is dominated almost entirely by post-1972 construction, which will help reduce its earthquake risk even though it is one of the closest areas to a potential South Whidbey Island fault event. It has some construction in the steep slope and forested areas along its east edge, which exposes some homes to risk of landslide and wildfire, although these homes are not built on the slopes themselves. The land is relatively flat and there are several arterials, but disaster response following an earthquake may be a concern due to the curvilinear streetscape and subdivision character. It is possible that some parts of the neighborhood may become impassible if one or two streets are blocked. If the eastern and western portions of the neighborhood are cut off from one another, only the western portion will have access to commercial businesses for supplies.

There are currently thirty-nine (39) CERT graduates who are residents of Silver Lake.


EVERGREEN
PINEHURST
VALLEY VIEW
WESTMONT
HOLLY
CASCADE VIEW
SR 526
19TH AVE SE
SE EVERETT MALL WAY
100TH ST SE
35TH AVE SE
LARIMER RD
EVERETT MALL SOUTH
7TH AVE SE
112TH ST SE
SILVER LAKE RD
116TH ST SE
35TH ST SE
SILVER LAKE
I-5
128TH ST SE
SR 96
132ND ST SE
SR 527
35TH AVE SE
Legend
Hazardous Materials Facility
Bridges
Food-Related Commercial
Rail Line
Arterial
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U.S. 2
Major Highway
Arterial Street
Neighborhood Boundary
Pre 1972 Parcels
Floodplain
500-Year
100-Year
Steep Slope Areas
Seismic Site Class
Site Classes A, B, & C
Site Class C to D
Site Class D
Site Class D to E
Site Class E
Site Class F
Water
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SILVER LAKE
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Miles
EVERETT
Washington
UNIVERSITY OF WASHINGTON
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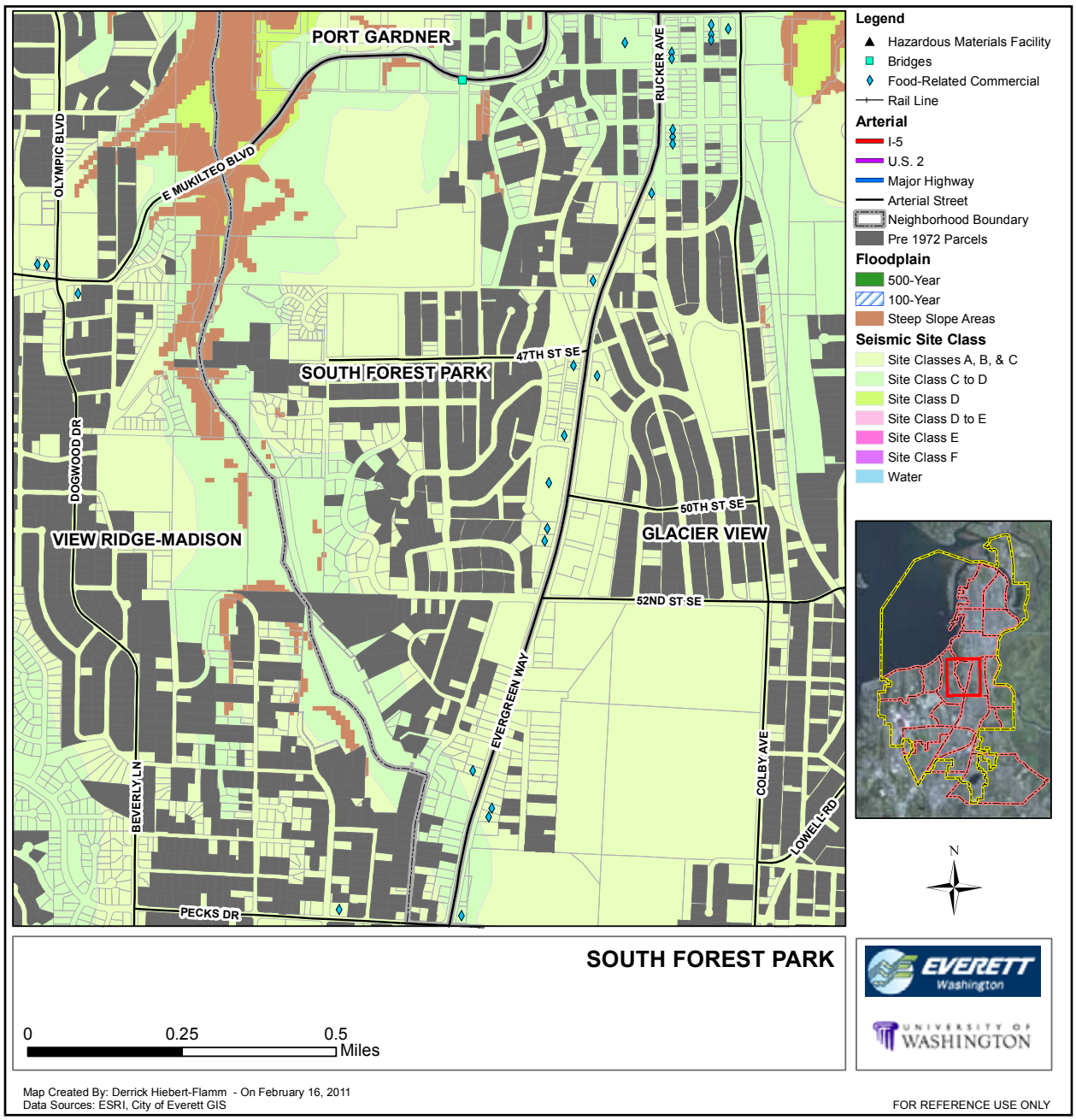
South Forest Park

South Forest Park is a central Everett neighborhood that is situated around Forest Park. It faces a moderate amount of risk from steep slope construction, pre-1972 structures, and the possibility of wildfire in Forest Park. There are some site class C to D soils along the edge of the neighborhood, bordering the slope areas that are likely to face the most damage during an earthquake event, but there are relatively few older structures built in those areas. The neighborhood also benefits from proximity to commercial businesses along the 99/Evergreen Way corridor, which helps to reduce the risk of isolation, as does the low number of bridges along major roadways. In the case of a fire, earthquake, or landslide event, homes situated in and around the Forest Park area would be at risk of isolation. Furthermore, visitors to Forest Park could be trapped there if there is no time to evacuate before a disaster.

There are currently twelve (12) CERT graduates living in the neighborhood.


PORT GARDNER
SOUTH FOREST PARK
VIEW RIDGE-MADISON
GLACIER VIEW
OLYMPIC BLVD
E MUKILTEO BLVD
RUCKER AVE
47TH ST SE
50TH ST SE
52ND ST SE
DOGWOOD DR
BEVERLY LN
EVERGREEN WAY
COLBY AVE
LOWELL RD
PECKS DR
Legend
Hazardous Materials Facility
Bridges
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Rail Line
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Site Class C to D
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Site Class E
Site Class F
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SOUTH FOREST PARK
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Miles
EVERETT Washington
UNIVERSITY OF WASHINGTON
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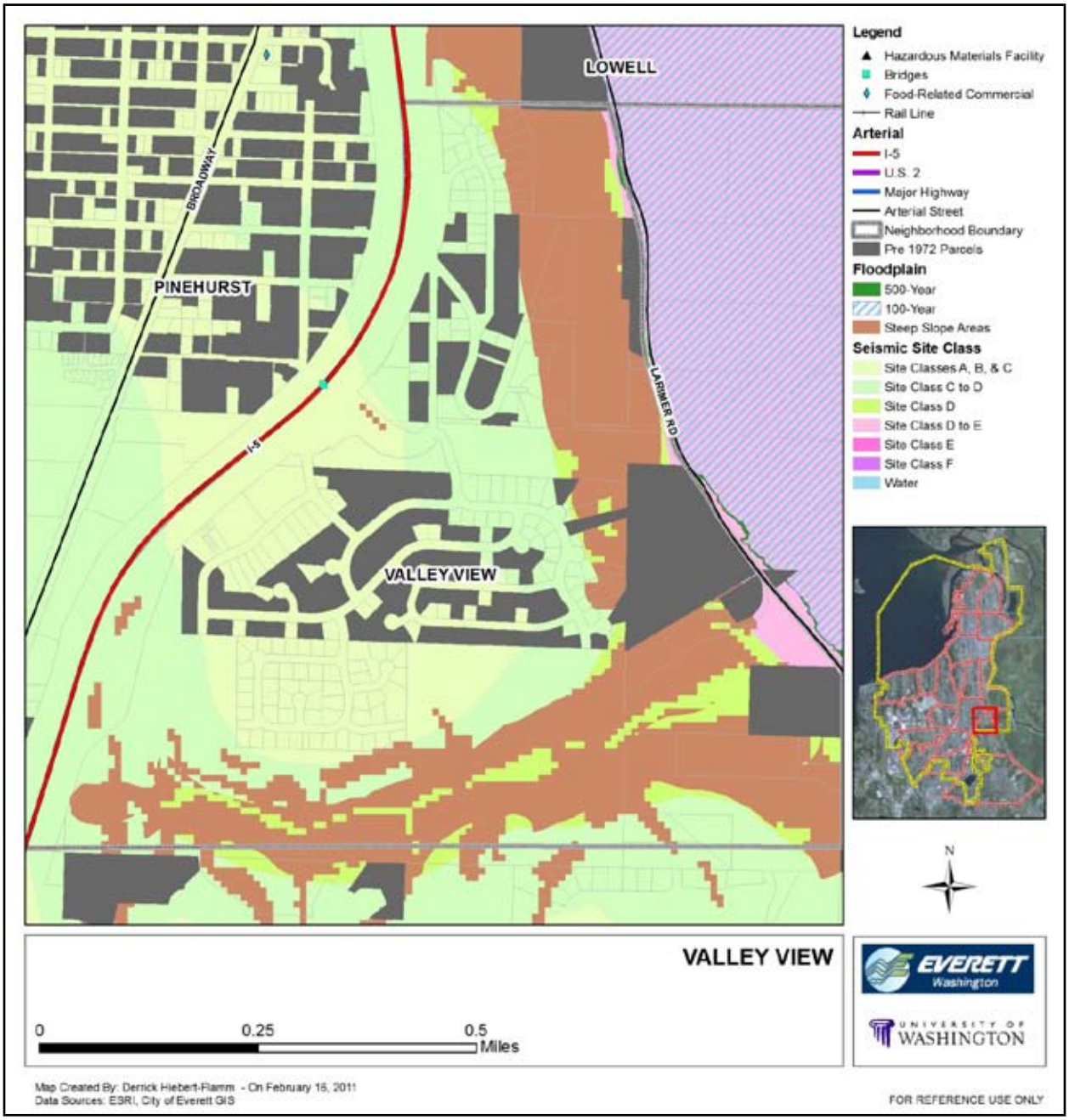
Valley View

Though relatively small in size, Valley View has been the focus of the news media recently due to severe landslides. Most of Valley View is exposed to site class C to D or site class D soils and there is substantial construction on steep slope areas.

As noted, census tract-level analysis does not take these factors into account, and therefore HAZUS-MH's prediction of low amounts of household displacement is likely inaccurate.

Although bordered by I-5 to its west, there is only one street that goes into the neighborhood, meaning that it is especially prone to isolation. Sound walls along I-5 present barriers to residents who may wish to leave the area on foot should the roads become impassable. The neighborhood's isolation risk is well recognized by Everett emergency management officials and its landslide risk has been repeatedly demonstrated. Following a major event such as an earthquake, the area would likely become inaccessible and face significant damage due to landslides, as well as isolation.

There are currently six (6) CERT resident graduates in the neighborhood.


LOWELL
BROADWAY
PINEHURST
I-5
LARMER RD
VALLEY VIEW
Legend
Hazardous Materials Facility
Bridges
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Water
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VALLEY VIEW
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Miles
EVERETT
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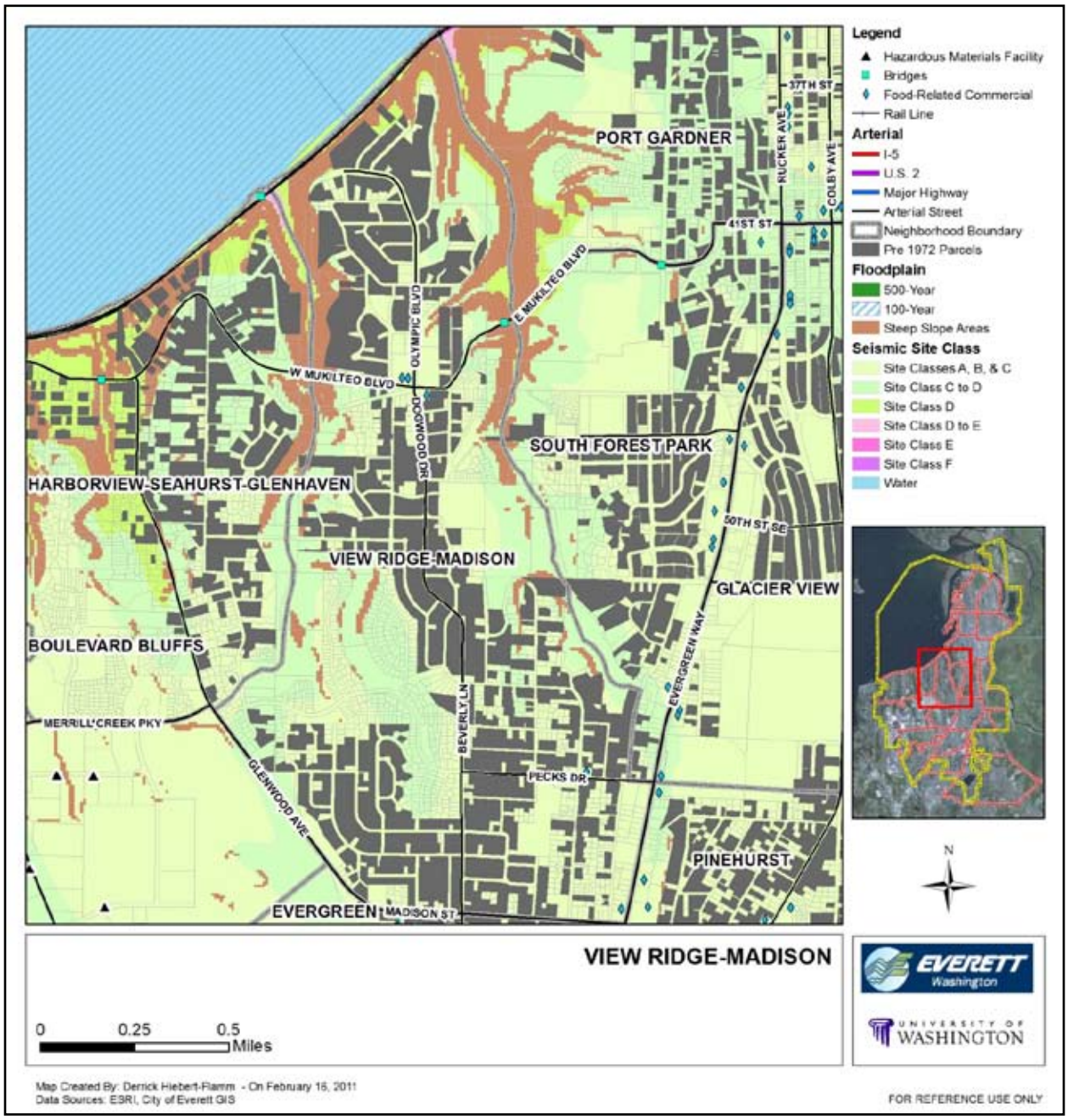
View Ridge-Madison

The View Ridge-Madison neighborhood stretches from the waters of Possession Sound down to south-central Everett. It is bordered on three sides by steep slope areas, many of which contain site class C to D and site class D soils, and by the BNSF railway at the north end of the neighborhood, which could expose it to hazardous materials events. The area is also dominated by structures built prior to the introduction of the 1972 building code. With substantial forested areas, there is a risk of wildfire. Due to the relatively small number of major streets and large number of steep slopes, much of the neighborhood is at an elevated risk of isolation.

The risk varies widely throughout the neighborhood. Those areas on steeper slopes–-northwest, northeast, and north-–face the greatest risk from wildfire, landslide, earthquake, and isolation. The southern portion of the neighborhood has access to major streets and commercial business, and does not border steep slopes or poor soils. Much of the poorer soil in the south is not built upon. A singular source of risk in the southern part of the neighborhood is the CEMEX plant, a Hazardous Materials facility.

There are currently twenty-six (26) CERT graduates residing in the neighborhood.


Legend
Hazardous Materials Facility
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Site Class C to D
Site Class D
Site Class D to E
Site Class E
Site Class F
Water
PORT GARDNER
SOUTH FOREST PARK
HARBORVIEW-SEAHURST-GLENHAVEN
VIEW RIDGE-MADISON
GLACIER VIEW
BOULEVARD BLUFFS
PINEHURST
EVERGREEN
37TH ST
41ST ST
NUCKER AVE
COLBY AVE
E MUKILTEO BLVD
W MUKILTEO BLVD
OLD CLIPPER LO
DOGWOOD DR
50TH ST SE
EVERGREEN WAY
BEVERLY LN
MERRILL CREEK PKY
GLENWOOD AVE
PECKS DR
MADISON ST
N
VIEW RIDGE-MADISON
0 0.25 0.5 Miles
EVERETT Washington
UNIVERSITY OF WASHINGTON
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Westmont

Westmont is a southwest Everett neighborhood with few risks beyond a chance of exposure to hazardous materials release due to its proximity to Paine Field. The area has few pre-1972 structures, a low risk of isolation, no steep slopes, good soils, and little forested area. There are six hazardous materials facilities in or near the neighborhood. Its location in south Everett means that it is closer to a potential South Whidbey Island fault event, so the potential for a release from these facilities is elevated, even though they are built on good soils.

There are currently four (4) CERT graduates in Westmont.