



Natural Hazards Mitigation Action Plan

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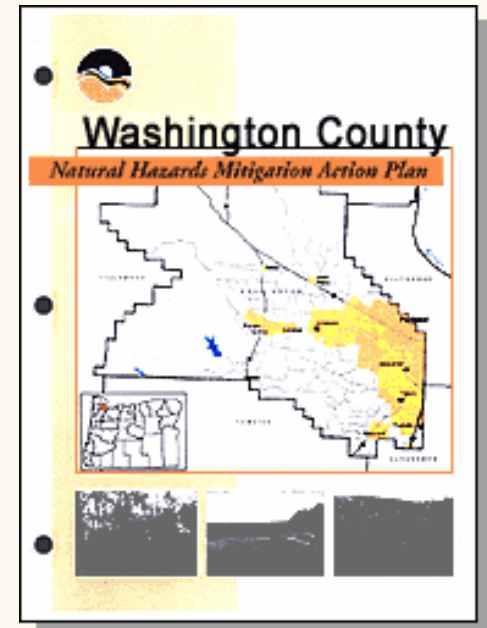
Office of Emergency Management



1. [Who does the Mitigation Plan Affect?](#)
2. [How Do I Use the Plan?](#)
3. [Plan Overview](#)

Washington County has suffered devastating losses from natural disasters. County residents are well aware of the economic loss, damaged infrastructure, and loss of life caused by floods, windstorms, and other natural hazards.

The Washington County Natural Hazards Mitigation Action Plan is a guide for reducing negative outcomes from natural hazard events. The plan provides a set of action items to reduce risk from natural hazards through education and outreach programs, the development of partnerships, and implementation of preventative activities such as land use or watershed programs.



The resources and information within the mitigation plan: (1) establish a foundation for coordination and collaboration among agencies and the public in Washington County; (2) identify and prioritize future mitigation projects; and (3) assist in meeting qualifications for federal assistance programs.

The mitigation plan works in conjunction with other County plans, including the County comprehensive land use and emergency operations plans.

Who does the Mitigation Plan Affect?



The Washington County Natural Hazards Mitigation Action Plan affects unincorporated urban areas, and the rural, unincorporated areas of the County. The resources and background information in the plan are applicable countywide, and the goals and recommendations can lay groundwork for local mitigation plans and partnerships.

How Do I Use the Plan?



Each section of the mitigation plan provides specific information and resources to assist people in understanding the County and the hazard-specific issues facing citizens, businesses, government, and the environment. Combined, the sections work together to create a mitigation plan that guides the mission to reduce risk and prevent loss from future natural hazard events.

The mitigation plan contains an overview/five-year action plan, ten sections, six appendices and several maps. Each section of the plan is described below.

Plan Overview

The executive summary, introduction, county profile, and multi-hazard section provide information on the background, purpose, and process used to develop the Washington County Natural Hazards Mitigation Action Plan.

[Executive Summary: Five-Year Action Plan](#)

The Five-Year Action Plan provides an overview of the mitigation plan mission, goals, and action items. The plan action items are included in this section, and address multi-hazard issues, as well as hazard-specific activities that can be implemented to reduce risk and prevent loss from future natural hazard events.

[Section 1: Introduction](#)

The Introduction describes the background and purpose of developing the mitigation plan for Washington County.

[Section 2: Planning for Natural Hazards in Washington County](#)

This section presents the history, geography, demographics, and socioeconomics of Washington County. It serves as a tool to provide an historical perspective of natural hazards in the County.

[Section 3: Multi-Hazard Goals and Action Items](#)

This section provides information on the process used to develop goals and action items that cut across the seven natural hazards addressed in the mitigation plan.

Hazard-specific Information

Five chronic hazards and two catastrophic hazards are addressed in this plan. Chronic hazards occur with some regularity and may be predicted through historic evidence and scientific methods. The chronic hazards addressed in the plan include:

[Section 4: Flood](#)

[Section 5: Landslide](#)

[Section 6: Severe Winter Storm](#)

[Section 7: Windstorm](#)

[Section 8: Wildfire](#)

Catastrophic hazards do not occur with the frequency of chronic hazards, but can have devastating impacts on life, property, and the environment. The two catastrophic hazards presented in the plan are:

[Sections 9: Earthquake](#)

[Section 10: Volcanic Eruption](#)

Each of the hazard-specific sections includes information on the history, hazard causes and characteristics, hazard assessment, goals and action items, and local, state, and national resources.

Plan Appendices

The plan appendices are designed to provide users of the Washington County Natural Hazards Mitigation Action Plan with additional information to assist them in understanding the contents of the mitigation plan, and potential resources to assist them with implementation.

Appendix A: Plan Resource Directory

[Appendix A: County Resources](#)

[Appendix A: Federal Resources](#)

[Appendix A: Resource Directory](#)

[Appendix A: State Resources](#)

[Appendix A: Additional Resources](#)

The resource directory includes county, regional, state, and national resources and programs that may be of technical or financial assistance to Washington County during plan implementation.

[Appendix B: Public Participation Process](#)

This appendix includes specific information on the various public processes used during development of the plan.

[Appendix C: Benefit Cost Analysis](#)

This section describes FEMA's requirements for benefit cost analysis in natural hazards mitigation, as well as various approaches for conducting economic analysis of proposed mitigation activities.

[Appendix D: List of Acronyms](#)

This section provides a list of acronyms for county, regional, state, and federal agencies and organizations that may be referred to within the Washington County Natural Hazards Mitigation Plan.

[Appendix E: Plan Maintenance and Action Prioritization Methodology](#)

This section provides the process, procedures and timing of maintaining this plan.

Appendix F: Mitigation Capability Assessment Forms

[Appendix F: Mitigation Capability Assessment Form](#)

[Appendix F: Mitigation Capability Assessment Form Worksheet](#)

This section provides a form for assessing the level of immediate capability for each action item.

Maps

Various maps of the County are used to illustrate specific hazards.

Washington County Maps:

[Base Map 1.1](#)

[Floodplain Map 4.1](#)

[Drainage Hazard Area Map 4.2](#)

[Slope Map 5.1](#)

[Landslide/Debris Flow Map 5.2](#)

[Precipitation Map 6.1](#)

[Wildfire Map 8.1](#)

[Repetitive Flood Loss Map 4.0](#)

[Tualatin Basin Floodplain Map](#)

[Earthquake Map](#)

[Mt. St. Helens Ashfall Map](#)

For further information about the mitigation plan or to learn how you can provide assistance with mitigation activities, contact the Washington County Emergency Management Office at **503-642-0394**.

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Executive Summary: Five-Year Action Plan Matrix

The Washington County Natural Hazards Mitigation Action Plan includes resources and information to assist county residents, public and private sector organizations, and others interested in participating in planning for natural hazards. The mitigation plan provides recommendations for activities that will assist Washington County in reducing risk and preventing loss from future natural hazard events. The action items address multi-hazard issues, as well as activities for flood, landslide, severe winter storm, windstorm, wildfire, earthquake, and volcanic eruption hazards.

How is the Plan Organized?

The Mitigation Plan contains a five-year action plan matrix, background on the purpose and methodology used to develop the mitigation plan, a profile of Washington County, sections on seven natural hazards that occur within the county, and several appendices. All of the sections are described in detail in Section 1, the plan introduction.

Who Participated in Developing the Plan?

The Washington County Natural Hazards Mitigation Action Plan is the result of a collaborative effort between Washington County citizens, public agencies, non-profit organizations, the private sector, and state and regional organizations. Public participation played a key role in development of goals and action items. The research team conducted interviews with stakeholders across the county, held a public workshop, and reviewed information on flood mitigation issues from a survey conducted by Clean Water Services (formerly Unified Sewerage Agency) for the development of their Surface Water Management Framework. A project steering committee guided the process of developing the plan. The steering committee was comprised of representatives from:

- Washington County Office of Emergency Management;
- Washington County Department of Land Use and Transportation;
- Clean Water Services;
- Tualatin River Watershed Council;
- Oregon Emergency Management;
- Portland General Electric;
- Westside Economic Alliance; and
- Metro Regional Government.

What is the Plan Mission?

The mission of the Washington County Natural Hazards Mitigation Action Plan is to assist in reducing risk, preventing loss, and protecting life, property, and the environment from future natural hazard events. The plan fosters coordinated partnerships and the development of multi-objective strategies for mitigation.



CleanWater Services



METRO



What are the Plan Goals?

The plan goals describe the overall direction that Washington County agencies, organizations, and citizens can take to work toward mitigating risk from natural hazards. The eleven goals are listed below by topic area.

Life, Property, and Natural Systems

- Develop and implement activities to protect human life, commerce, property, and natural systems from natural hazards.
- Reduce insurance losses and repetitive claims for chronic hazard events while promoting insurance coverage for catastrophic hazards.
- Evaluate county guidelines, codes, and permitting processes in addressing natural hazard mitigation.
- Link watershed planning, natural resource management, and land use planning with natural hazard mitigation activities to protect vital habitat and water quality.
- Preserve and rehabilitate natural systems to serve natural hazard mitigation functions.

Public Awareness and Partnerships

- **Education:** Develop and implement education programs to increase awareness among citizens, local, county, and regional agencies, non-profit organizations, business, and industry.
- **Outreach:** Develop and conduct outreach programs to increase the number of local, county, and regional activities implemented by public and private sector organizations.
- **Partnerships and Coordination:** Strengthen communication and coordinate participation in and between public agencies, citizens, non-profit organizations, business, and industry.

Emergency Services

- Strengthen emergency operations by increasing collaboration and coordination among public agencies, non-profit organizations, business, and industry.
- Coordinate natural hazard mitigation activities, where appropriate, with emergency operations plans and procedures.

Implementation

- Promote leadership within public agencies to implement natural hazard mitigation activities.

How are the Action Items Organized?

The action items are organized within the matrix at the end of this section and are categorized as multi-hazard or hazard-specific. Data collection and research and the public participation process resulted in the development of these action items. The matrix includes the following information for each action item:

- **Coordinating Organization.** The coordinating organization is the public agency with regulatory responsibility to address natural hazards, or that is willing and able to organize resources, find appropriate funding, or oversee activity implementation, monitoring, and evaluation. Coordinating organizations may include local, county, or regional agencies that are capable of or responsible for implementing activities and programs.
- **Partner Organizations.** Partner organizations are agencies or public/private sector organizations that may be able to assist in the implementation of action items by providing relevant resources to the coordinating organization. Partner organizations may include local, regional, state, or federal agencies, as well as local and regional public and private sector organizations.

The partner organizations listed in the Washington County Mitigation Action Plans are potential partners recommended by the project steering committee, but not necessarily contacted during the development of the mitigation plan. Partner organizations should be contacted by the coordinating organization to establish commitment of time and or resources to action items.

- **Timeline.** Action items include both short and long-term activities. Each action item includes an estimate of the timeline for implementation. *Short-term action items (ST)* are activities which county agencies are capable of implementing with existing resources and authorities within one to two years. *Long-term action items (LT)* may require new or additional resources or authorities, and may take between one and five years to implement.
- **Ideas for Implementation.** Each action item includes ideas for implementation and potential resources, which may include grant programs or human resources. The matrix includes the page number within the mitigation plan where this information can be found.
- **Plan Goals Addressed.** The plan goals addressed by each action item are included as a way to monitor and evaluate how well the mitigation plan is achieving its goals once implementation begins. The plan goals are organized into the following four areas:
 1. Life, Property, and Natural Systems
 2. Public Awareness and Partnerships
 3. Emergency Services
 4. Implementation

What Acronyms are in the Action Plan Matrix?

County and Regional

For a more comprehensive list of county, state and federal acronyms, see Appendix D of the Washington County Natural Hazards Mitigation Action Plan

BCD	Building Codes Division
CREW	Cascadia Region Earthquake Workgroup
CWS	Clean Water Services (formerly Unified Sewerage Agency)
IISOI	Insurance Information Services of Oregon & Idaho
JWC	Joint Water Commission
Metro	Metropolitan Regional Government
PGE	Portland General Electric
NN	Northwest Natural Gas
PPO	Private Property Owner
TPAC	Tualatin Public Awareness Committee
TRWC	Tualatin River Watershed Council
TVFR	Tualatin Valley Fire and Rescue
TVID	Tualatin Valley Irrigation District
TVWD	Tualatin Valley Water District
WC	Washington County Public Agencies: Emergency Management, Land Use and Transportation
WCFDB	Washington County Fire Defense Board
WEA	Westside Economic Alliance
Cities	Washington County cities listed as partner organizations include: Banks, Beaverton, Cornelius, Durham, Forest Grove, Gaston, Hillsboro, King City, North Plains, Sherwood, Tigard, and Tualatin

State

AGC	Association of General Contractors
CPW	Community Planning Workshop (University of Oregon)
DLCD	Department of Land Conservation & Development (State of Oregon)
DOGAMI	Department of Geology & Mineral Industries (State of Oregon)
ESD	Education Service District
NRCS	Natural Resources Conservation Service
ODF	Oregon Department of Forestry
ODOT	Oregon Department of Transportation
OEM	Office of Emergency Management (Oregon State Police)
ONHW	Oregon Natural Hazards Workshop (University of Oregon)
OSFM	Oregon State Fire Marshal
OSSPAC	Oregon Seismic Safety Policy Advisory Commission

State (Continued)

OSU	Oregon State University
PSU	Portland State University

Federal

BOR	Bureau of Reclamation
FEMA	Federal Emergency Management Agency
HMGP	Hazard Mitigation Grant Program
IBHS	Institute for Business Home Safety
NFIP	National Floodplain Insurance Program
NOAA	National Oceanic & Atmospheric Administration
NWS	National Weather Service
SWCD	Soil and Water Conservation District
USFS	United States Forest Service
USGS	United States Geological Survey
USGS-CVO	USGS – Cascades Volcano Observatory

Section 1:

Introduction

Washington County has suffered devastating losses from natural disasters. County residents are aware of the economic loss, damaged infrastructure, and loss of life caused by floods, windstorms, and other natural hazards.

Washington County was declared a Presidential Disaster area twice in the last decade. The severe windstorm in December of 1995, which caused the death of four people in Oregon, brought Washington County its first declaration. The massive flood events in 1996 caused further damage and loss to the county and led to the second disaster declaration.

As a result of these events and in an effort to reduce future disaster-related losses, Washington County Emergency Management (WCEM) initiated development of this Natural Hazards Mitigation Action Plan in 2000. The County received one third of the plan development costs from the Flood Mitigation Assistance (FMA) Program, a Federal Emergency Management Agency grant program. The development of a mitigation plan is a requirement for acceptance of the FMA funds. WCEM provided the additional funds to finance the plan.

Why Develop a Mitigation Plan?

The rising costs of natural disasters have led to a renewed interest in identifying effective ways to reduce vulnerability to disasters. Communities face a number of barriers to implementing natural hazard risk reduction measures. Natural hazards mitigation plans assist communities in reducing risk from natural hazards by identifying resources, information, and strategies for risk reduction, while helping to guide and coordinate mitigation activities throughout the county.

The plan provides a set of action items to reduce risk from natural hazards through education and outreach programs, the development of partnerships, and implementation of preventative activities such as land use or watershed programs.

The resources and information within the mitigation plan: (1) establish a foundation for coordination and collaboration among agencies and the public in Washington County; (2) identify and prioritize future mitigation projects; and (3) assist in meeting qualifications for federal assistance programs.

Washington County Natural Hazards Mitigation Action Plan
Mission: *To assist in reducing risk, preventing loss, and protecting life, property, and the environment from future natural hazard events.*

What is natural hazard mitigation? *Natural hazard mitigation is the development and implementation of activities designed to reduce or eliminate impacts resulting from natural hazards.*

The mitigation plan works in conjunction with other county plans, including the county comprehensive land use and emergency operations plans.

Who does the Mitigation Plan Affect?

The Washington County Natural Hazards Mitigation Action Plan affects unincorporated urban areas, and the rural, unincorporated areas of the county. Map 1.1 shows cities, urban unincorporated areas, and major roads and rivers in Washington County. While this plan does not establish requirements for the twelve cities in the county, it does provide them with a framework for planning for natural hazards. The resources and background information in the plan are applicable countywide, and the goals and recommendations can lay groundwork for local mitigation plans and partnerships.

Natural Hazard Land Use Policy in Oregon

Planning for natural hazards is an integral element of Oregon's statewide land use planning program, which began in 1973. All Oregon cities and counties have comprehensive plans and implementing ordinances that are required to comply with the statewide planning goals. The continuing challenge faced by local officials and state government is to keep this network of coordinated local plans effective in responding to the changing conditions and needs of Oregon communities.

Appendix A: The Mitigation Plan Resource Directory, and each hazard section of this plan, provides information on county, state, and federal mitigation resources and programs.

This is particularly true in the case of planning for natural hazards where communities must balance development pressures with detailed information on the nature and extent of hazards. Oregon's land use program has given its communities and citizens a unique opportunity to ensure that natural hazards are

addressed in the development and implementation of local comprehensive plans.

In 1996, FEMA estimated that Oregon saves about \$10 million a year in flood losses because of strong land-use planning. Statewide land use planning Goal 7: Planning for Natural Hazards, calls for local plans to include inventories, policies, and ordinances to guide development in hazard areas. Goal 7, along with other land use planning goals, has helped to reduce losses from natural hazards.

State Support for Natural Hazard Mitigation

All mitigation is local, and the primary responsibility for development and implementation of risk reduction strategies and policies lies with local jurisdictions. Local jurisdictions, however, are not alone. Partners and resources exist at the state and federal levels. Numerous Oregon

state agencies have a role in natural hazards and natural hazard mitigation. Some of the key agencies include:¹

- **Oregon Office of Emergency Management (OEM)** is responsible for disaster mitigation, preparedness, response, recovery, and the administration of federal funds after a major disaster declaration;
- **Building Codes Division (BCD)** and local counterparts, are responsible for construction and for some hazards that are building-specific in their occurrence (such as earthquakes); also included are provisions for expansive soils, and damage assessment of buildings after an earthquake;
- **Oregon Department of Forestry (ODF)** is responsible for all aspects of wildland fire protection on private, state, and – in Western Oregon – BLM forestlands and administers forest practices regulations, including landslide mitigation, on non-federal lands;²
- **Oregon Department of Geology and Mineral Industries (DOGAMI)** is responsible for geologic hazard characterization, public education, the development of partnerships aimed at reducing risk, and exceptions (based on science-based refinement of tsunami inundation zone delineation) to state mandated tsunami zone restrictions; and
- **Department of Land Conservation and Development (DLCD)** has major responsibilities for planning-based hazard management including implementation of land use planning and Goal 7 (natural hazards), with attention given to hazard assessments and hazard mitigation.

Plan Methodology

Information in the mitigation action plan is based on research from a variety of sources. Community Planning Workshop (CPW) at the University of Oregon conducted data research and analysis, facilitated steering committee meetings and public workshops, and developed the final mitigation plan. The research methods and various contributions to the plan include:

- **Input from an executive steering committee:** The committee, organized in October 2000, helped guide development of the mitigation plan. The committee played an integral role in developing the mission, goals, and action items for the mitigation plan. The committee consisted of fourteen people representing agencies and organizations in Washington County, including:

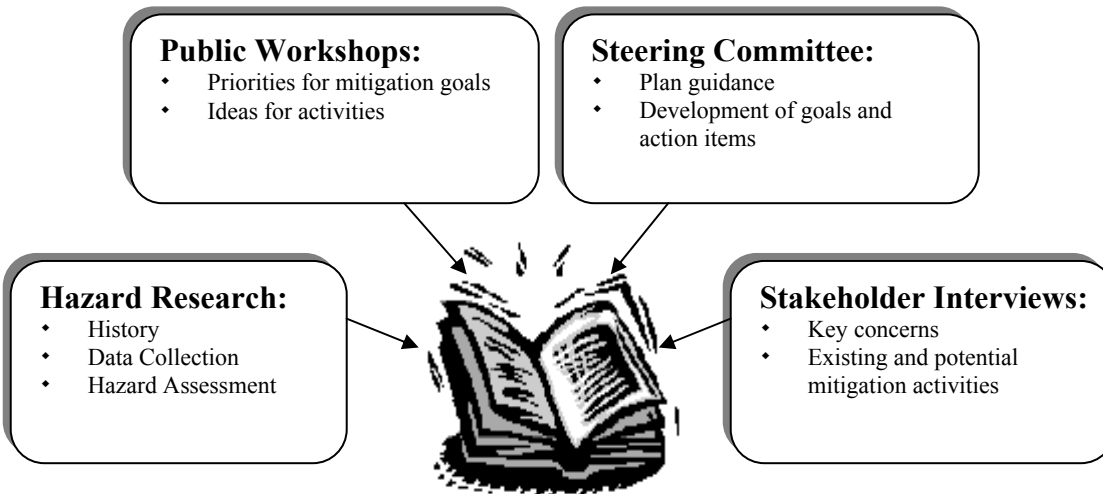
¹ Agency descriptions (with the exception of the ODF description) are derived from: OR Department of Geology and Mineral Industries, Special Paper 31, *Mitigating Geologic Hazards in Oregon: A Technical Reference Manual*, 1999.

² Oregon State Police, Office of Emergency Management, *State Natural Hazards Mitigation Plan*, June 2000

- Washington County Office of Emergency Management;
 - Washington County Dept. of Land Use and Transportation;
 - Clean Water Services;
 - Metro Regional Government;
 - Oregon Emergency Management;
 - Portland General Electric;
 - Westside Economic Alliance; and
 - Tualatin River Watershed Council.
- **Stakeholder interviews:** The CPW research team conducted 25 interviews with individuals and specialists from organizations interested in natural hazards planning. The interviews identified common concerns related to natural hazards and identified key long and short-term activities to reduce risk from natural hazards.
 - **Statewide and national plan review:** CPW reviewed natural hazard mitigation plans from around the country. CPW also examined current FEMA planning standards, the FEMA Flood Mitigation Assistance Program requirements, and the National Flood Insurance Program's Community Rating System. Reference materials also consisted of community and county mitigation plans from around Oregon, including:
 - *Metro's Regional Hazard Mitigation Policy and Planning Guide;*
 - *Planning For Natural Hazards: Oregon Technical Resource Guide (DLCD);*
 - *State of Oregon Natural Hazards Mitigation Plan (OEM);* and
 - *Post-Disaster Hazard Mitigation Planning Guidance for State and Local Governments (OEM).*
 - **Hazard specific research:** CPW collected data and compiled research on seven specific hazards: flood, landslide, severe winter storm, windstorm, wildfire, earthquake, and volcanic eruption. Research materials came from state agencies including OEM, DOGAMI, DLCD, BCD, and ODF. CPW identified current mitigation activities, resources and programs, and potential action items from research materials and stakeholder interviews.
 - **Public workshops:** CPW facilitated two public workshops to gather comments and ideas from Washington County citizens about mitigation planning and priorities for mitigation plan goals.

The resources and information cited in the mitigation plan provide a strong local perspective and help identify strategies and activities to make Washington County more disaster resilient. **Figure 1.1** shows the mitigation planning process components and the key outcomes.

Figure 1.1. Hazard Mitigation Planning Process



Hazard Assessment

Conducting a hazard assessment can provide information on the location of hazards, the value of existing land and property in hazard locations, and an analysis of risk to life, property, and the environment that may result from natural hazard events. Specifically, the three levels of a hazard assessment are as follows:

- 1) ***Hazard Identification*** identifies the geographic extent of the hazard, the intensity of the hazard, and the probability of its occurrence. Maps are frequently used to display hazard identification data.
- 2) ***Vulnerability Assessment*** combines hazard identification with an inventory of the existing (or planned) property and population exposed to a hazard.
- 3) ***Risk Analysis*** involves estimating the damage, injuries, and financial losses likely to be sustained in a geographic area over a given period of time. This level of analysis involves using mathematical models. The two measurable components of risk analysis are magnitude of the harm that may result and the likelihood of the harm occurring.

Hazard assessments are subject to the availability of hazard-specific data. Gathering data for a hazard assessment requires a commitment of resources on the part of participating organizations and agencies. Each hazard-specific section of the Washington County mitigation plan includes a section on hazard identification using data and information from county, state, or federal agency sources.

CPW conducted a vulnerability assessment for the flood hazard using Geographic Information Systems (GIS) to identify the geographic extent of the hazard and assess the land use and value at risk from the flood hazard. The vulnerability assessment for the earthquake hazard is addressed in part from FEMA’s HAZUS analysis model. Insufficient data exists to conduct vulnerability assessments and risk analyses for the

other hazards addressed in the plan: landslide, severe winter storm, windstorm, wildfire, and volcanic eruption.

Regardless of the data available for hazard assessments, there are numerous strategies the county can take to reduce risk. These strategies are described in the action items detailed in section 3 of this plan.

Mitigation strategies can further reduce disruption to critical services, reduce the risk to human life, and alleviate damage to personal and public property and infrastructure. Action items throughout the hazard sections provide recommendations to collect further data to map hazard locations and conduct hazard assessments.

THREE PHASES OF HAZARD ASSESSMENT:

Hazard Identification → **Vulnerability Assessment** → **Risk Analysis**

How Do I Use the Plan?

Each section of the mitigation plan provides specific information and resources to assist people in understanding the County and the hazard-specific issues facing citizens, businesses, government, and the environment. Combined, the sections work together to create a mitigation plan that guides the mission to reduce risk and prevent loss from future natural hazard events.

The structure of the plan enables people to use a section of interest to them. It also allows county government to review and update sections when new data becomes available. The ability to update individual sections of the mitigation plan places less of a financial burden on the county. Decision makers can allocate funding and staff resources to selected pieces in need of review, thereby avoiding a full update, which can be costly and time-consuming. New data can be easily incorporated, resulting in a natural hazards mitigation plan that remains current and relevant to Washington County.

The mitigation plan contains an overview/five-year action plan, ten sections, and six appendices. Each section of the plan is described below.

Plan Overview

The executive summary, introduction, county profile, and multi-hazard section provide information on the background, purpose, and process used to develop the Washington County Natural Hazards Mitigation Action Plan.

Executive Summary: Five-Year Action Plan

The *Five-Year Action Plan* provides an overview of the mitigation plan mission, goals, and action items. The plan action items are included in this section, and address multi-hazard issues, as well as hazard-specific activities that can be implemented to reduce risk and prevent loss from future natural hazard events.

Section 1: Introduction

The *Introduction* describes the background and purpose of developing the mitigation plan for Washington County.

Section 2: Planning for Natural Hazards in Washington County

This section presents the history, geography, demographics, and socio-economics of Washington County. It serves as a tool to provide an historical perspective of natural hazards in the county.

Section 3: Multi-Hazard Goals and Action Items

This section provides information on the process used to develop goals and action items that cut across the seven natural hazards addressed in the mitigation plan.

Hazard-specific Information

Five chronic hazards and two catastrophic hazards are addressed in this plan. Chronic hazards occur with some regularity and may be predicted through historic evidence and scientific methods. The chronic hazards addressed in the plan include:

Section 4: Flood

Section 5: Landslide

Section 6: Severe Winter Storm

Section 7: Windstorm

Section 8: Wildfire

Catastrophic hazards do not occur with the frequency of chronic hazards, but can have devastating impacts on life, property, and the environment. The two catastrophic hazards presented in the plan.

Sections 9: Earthquake

Section 10: Volcanic Eruption

Each of the hazard-specific sections includes information on the history, hazard causes and characteristics, hazard assessment, goals and action items, and local, state, and national resources.

Plan Appendices

The plan appendices are designed to provide users of the Washington County Natural Hazards Mitigation Action Plan with additional information to assist them in understanding the contents of the mitigation plan, and potential resources to assist them with implementation.

Appendix A: Plan Resource Directory

The resource directory includes county, regional, state, and national resources and programs that may be of technical or financial assistance to Washington County during plan implementation.

Appendix B: Public Participation Process

This appendix includes specific information on the various public processes used during development of the plan.

Appendix C: Benefit Cost Analysis

This section describes FEMA's requirements for benefit cost analysis in natural hazards mitigation, as well as various approaches for conducting economic analysis of proposed mitigation activities.

Appendix D: List of Acronyms

This section provides a list of acronyms for county, regional, state, and federal agencies and organizations that may be referred to within the Washington County Natural Hazards Mitigation Plan.

Appendix E: Plan Maintenance and Action Prioritization Methodology

This section provides the process, procedures and timing of maintaining this plan.

Appendix F: Mitigation Capability Assessment Form

This section provides a form for assessing the level of immediate capability for each action item.

Section 2: Community Profile

Why Plan for Natural Hazards in Washington County?

Natural hazards impact citizens, property, the environment, and the economy of Washington County. Flooding, landslides, windstorms, severe winter storms, and earthquakes have exposed Washington County residents and businesses to the financial and emotional costs of recovering after natural disasters. The risk associated with natural hazards increases as more people move to areas affected by natural hazards. The inevitability of natural hazards, and the growing population and activity within the County, create an urgent need to develop strategies, coordinate resources, and increase public awareness to reduce risk and prevent loss from future natural hazard events.

History of Natural Hazards in

Washington County

Washington County was most recently affected by the February 28, 2001, 6.8-magnitude earthquake centered near Anderson Island in Pierce County, Washington. The earthquake was felt strongly throughout western Washington and alarmed many Oregonians. While the effects in Washington County were not great, the earthquake affected some schools and local businesses. Portland and the surrounding areas have records of earthquake events, including a 5.3 magnitude earthquake in 1877, a 5.5 magnitude earthquake in 1962, and a 5.5 magnitude earthquake in 1993.¹ Oregon ranks third in the nation for potential earthquake losses, which are projected to exceed \$12 billion in case of a major event in the Cascadia Region Subduction Zone. Although faults in Washington County are currently considered to be non-active, the location of faults, slope instability, and the prevalence of certain soils subject to liquefaction and amplification in the County make it highly prone to potential loss from future earthquakes.

Other natural hazard events occurring over the last two decades include major flooding, landslide and storm events, as well as impact suffered from neighboring volcanic eruptions in Washington State. The Columbus Day storm in 1962 was the most destructive storm to ever occur in Oregon in recorded history, both in loss of life and property damage. The city of Hillsboro recorded 90 mph wind gusts during that event. A major windstorm in 1995 resulted in a presidential disaster declaration.

Recognizing population trends and understanding the demographics and physical characteristics of a community is an essential part of planning for natural hazard events.

In 1964, the county experienced a 100-year flood event that caused more than \$150 million in losses statewide. Thirty-two years later in 1996, a similar event struck the state. In Washington County, the 1996 flood events drove the Tualatin River over its banks and into the downtown business district of the city of Tualatin. Damage estimates in the county for the 1996 flood event totaled more than \$5 million, and the federal government declared the county a disaster area.

Areas in the west hills of Portland, and along the western edge of Washington County are prone to landslides and debris flows. Washington County's most recent major landslide event occurred on December 3, 1996, when a large landslide prompted officials to close Dixie Mountain Road. This closure impacted local Christmas tree farms, and forced area residents to take detours of up to 16 miles. No homes were directly in the path, although county maps show 260 tax lots in the vicinity of the slide area and nearby hills.²

While wildfire and volcanic eruptions have had less of an impact on county residents, they still pose significant risk in terms of potential occurrence and loss throughout Washington County. Wildfires are a natural part of the ecosystem in Oregon and present a substantial hazard when threatening life and property in growing communities.

The major risk associated with volcanic eruption in Washington County is ash fall. Mount Hood and Mount St. Helens are two active volcanoes in the vicinity of Washington County. Mount Hood is east of Washington County and is more than 500,000 years old. It has had two significant eruptive periods, one about 1,500 years ago and another about 200 years ago.³ Mount St. Helens is located in southern Washington State and has been active throughout its 50,000-year lifetime. The most recent eruption of Mount St. Helens occurred on May 18, 1980, with five smaller explosive eruptions in a period of five months.⁴

As described above, Washington County has experienced many natural disasters in recent history. Those disasters provide a greater urgency for developing and implementing strategies, and increasing public awareness to reduce risk and prevent loss in anticipation of future natural hazard events.



Hagg Lake Reservoir, Source: Community Planning Workshop

Geography and the Environment

Washington County is located in northwestern Oregon, just west of the city of Portland. The county is primarily rural on the west and heavily developed on the east. The agricultural industry dominates in the rural areas and light manufacturing and retail industries dominate in the urban areas.

Washington County is part of the tri-county metro area comprised of Multnomah, Clackamas, and Washington Counties. The western part of Washington County, where it meets the mountains of the Northern Oregon Coast Range, is forty miles from the Pacific Ocean.⁵ Dominant features of the county landscape are the Coast Range Mountains on the west, the Tualatin Mountains on the north, the West Hills of Portland on the east, and the Chehalem Mountains on the south. Also prominent are Cooper and Bull Mountains in the southeast and Bald Peak in the southwest. The agriculturally rich Tualatin Valley lies between the mountain ranges and hills.

Most of Washington County is in the Tualatin Valley between the northern Oregon Coast Range to the west and the Cascade Range to the east. The valley ranges from 120 to 300 feet above sea level. The topography is rolling and lacks dramatic changes in elevation except in the foothills and mountains surrounding the central valley. The foothills and the uplands range in elevation from 1,300 to 3,500 feet. The highest point in the county is Saddle Mountain in the Northern Oregon Coast Range near the border of Tillamook and Washington Counties with an elevation of 3,464 feet.⁶

Washington County has a long growing season and mild temperatures, which lead to a wide range of agricultural activities. Seasonal flooding, high ground water, and soil erosion cause most of the non-urban drainage problems in the county. When maintained in their natural state, Washington County's wetlands control runoff and decrease soil erosion and water

This plan addresses flood, landslide, wildfire, severe winter storm, windstorm, earthquake, and volcanic eruption hazards. It provides recommendations for strategies to reduce risk and prevent loss from future events that may occur in Washington County.



Scoggins Dam
Source: Bureau of Reclamation

pollution while reducing potential damage from flooding, and helping to recharge groundwater supplies.⁷

Tualatin River

The Tualatin River, one of the many natural features of the county, starts in the northern Oregon Coast Range and flows to the Willamette River near the city of West Linn. The Tualatin River is a major source of drinking water for the cities of Cornelius, Hillsboro, and Beaverton. It is also a source of irrigation water and provides aquaculture and recreation opportunities for many Washington County communities. The Tualatin River also serves as a channel for the discharge of treated sewage.

The Tualatin River has numerous tributaries. Wapato Creek drains from the Chehalem Mountains; Scoggins and Gales Creeks drain part of the Coast Range; McFee and Chicken Creeks drain the northeast slopes of the Chehalem Mountains and Fanno Creek drains the valley floor and Portland's west hills.⁸ Beaverton creek, a tributary to Rock Creek, drains a large portion of the valley and the west hills of the Portland. Dairy Creek with McKay Creek as a tributary drains portions of the Coast Range and Tualatin Mountains.

The river and its tributaries flow through low foothills, terraces, and floodplains that naturally drain the area under normal circumstances. It is generally a slow moving river draining and preventing flooding through the collection and flow of water from rain and snow melt in the Coast Range Mountains.

Scoggins Dam, located near the town of Gaston in southwestern Washington County, stores runoff from the Scoggins Creek watershed. The dam forms a reservoir, Henry Hagg Lake, which provides active water storage capacity of about 56,000 acre-feet. The dam and reservoir are owned by the Bureau of Reclamation and operated by the Tualatin Valley Irrigation District. The project provides flood control, irrigation water, municipal water supply, water quality benefits, and recreation.⁹

Climate

Washington County's climate is moderate year-round. The western edge of the county is only forty miles from the Pacific Ocean, which provides a modified marine climate. Extreme summer and winter temperatures are moderated by the airflow moving across the county from the Pacific Ocean. The Cascade Mountains to the east of the county act as a barrier that prevents the colder continental air masses originating in the arctic areas of Canada from reaching Washington County. Occasionally, extreme temperatures can occur when the airflow comes in from the east flowing

west through the Columbia Gorge and across the Cascade Mountains. If the east winds occur when rain is falling, the result can be freezing rain and snow in Washington County.

Much of Washington County is protected from severe wind and weather conditions by the surrounding mountain ranges. Snowfall is relatively rare with only about five days of measurable snowfall each year. The few times that snow falls each year, it generally melts off within one to three days. Ice can occur more frequently in higher elevations in the county.

The rainy season in Western Oregon and Washington County happens between October and April, when approximately 81% of the yearly rainfall occurs. Most of Washington County has an average annual precipitation of between 30 and 70 inches, with parts of the Coast Range in the west receiving over 70 inches. Strong storm systems can develop at higher altitudes in the upper level flow over the Pacific during the rainy season and bring rain to the lower elevations and snow to the higher elevations.

Minerals and Soils

The characteristics of the minerals and soils present in Washington County indicate the potential types of hazards that may occur. Rock hardness and soil characteristics can determine whether or not an area will be prone to geologic hazards such as landslides. The four mineral and soil types in Washington County are valley fill and semi-consolidated sedimentary rocks, basaltic lavas, marine sedimentary rocks, and Eocene age volcanic and sedimentary rocks.¹⁰

The surface material includes unconsolidated, fine-grained deposits of Willamette silt, sand, and gravel, and recent floodplain deposits. Torrential flood events can lay down large deposits of sand and gravel. Sandy silt and silt containing clay are moderately dense and firm, and are primarily considered to be prone to liquefaction, an earthquake related hazard. Basaltic lava consists mainly of weathered and non-weathered, dense, fine-grained basalt. Though the characteristic of this lava may offer solid foundation support, landslides are common in many of these areas where weathered residual soil overlies the basalt. Understanding the geologic characteristics of Washington County is an important step in hazard mitigation and avoiding at-risk development.

Other Significant Geologic Features

Washington County, like most of the Pacific Northwest, lies over the area of Cascadia Subduction Zone, where the Juan de Fuca and North American Plates meet under the earth's crust. The presence of crustal faults within Washington County also indicates potential seismic activity within the county. There are active volcanoes in the vicinity of the county, including Mt. St. Helens in the south of Washington State, and Mt. Hood, southeast of Portland.

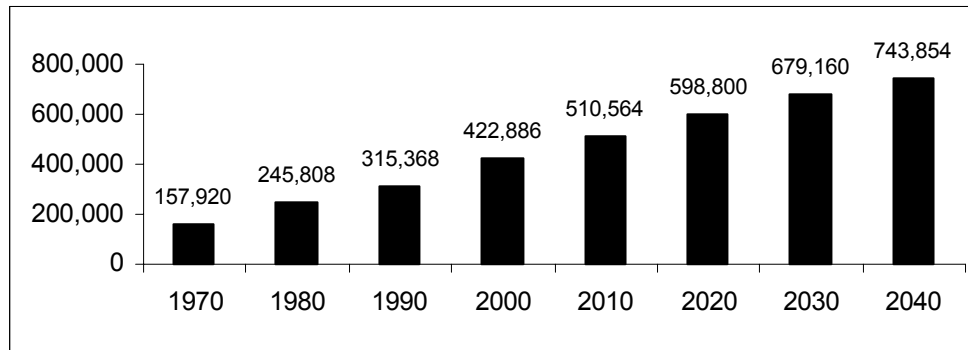
Identifying risks posed by natural hazards, and developing strategies to reduce the impact of a hazard event can assist in protecting the life and property of citizens and communities. Local residents and businesses can

work together with the county to create a natural hazards mitigation plan that addresses the potential impacts of hazard events.

Population and Demographics

Washington County's population grew 43% from 1990 to 2000 according to the 2000 US Census.¹¹ Washington County was the third fastest growing county in Oregon during this 10-year span. The rapid population growth is projected to continue (as shown in Figure 2.1), according to the Oregon Office of Economic Analysis.

Figure 2.1.
Washington County Population



Source: Source: Oregon Office of Economic Analysis

The population of Washington County is 445,342, according to the 2000 Census, and is projected to increase in the future. The largest cities in the county are Beaverton and Hillsboro, with 2000 populations of 79,129 and 70,186 respectively. The increase of people living in non-urban or rural areas changes how agencies prepare for and respond to natural hazards. For example, more people living in the urban fringe can increase the risk of fire. Wildfire has an increased chance of starting due to human activities in the urban/rural interface, and has the potential to injure more people and cause more property damage.¹²

Furthermore, increased density can affect risk. For example, narrower streets are more difficult for emergency service vehicles to navigate, the higher ratio of residents to emergency responders affects response times, and homes located closer together increase the chance of fires spreading.

Table 2.1.
Washington County Incorporated Communities

City	1990 Population	2000 Population	% Change, 1999-2000
Banks	563	1,286	128%
Beaverton	53,310	79,129	43%
Cornelius	6,148	9,652	57%
Durham	748	1,382	85%
Forest Grove	13,559	17,708	31%
Gaston	563	600	7%
Hillsboro	37,520	70,186	87%
King City	2,060	1,949	-5%
North Plains	972	1,605	65%
Sherwood	3,093	11,791	281%
Tigard	29,344	41,223	41%
Tualatin	15,013	22,791	52%

Source: 2000 Census

In 1999-2000, the twelve incorporated communities, including the section of Portland within the county, comprised about 60% of the county population, leaving 40% of the population in unincorporated areas. Table 2.1. shows the percent change in Washington County's twelve incorporated communities from 1990 to 2000. Population in incorporated areas has increased in this time span 59%, whereas population has increased by 27% in unincorporated areas, as shown in Table 2.2.¹³

Table 2.2.
Washington County Population, Incorporated and Unincorporated

Year	Incorporated	Unincorporated
1990	162,893	148,661
2000	259,302	189,040
% change (1990-2000)	59%	27%

Source: 2000 Census

Natural hazards do not discriminate, but the impacts in terms of loss and the ability to recover vary greatly among groups.¹⁴ According to Peggy Stahl of the FEMA Preparedness, Training, and Exercise Directorate, 80% of the disaster burden falls on the public, and within that number, a disproportionate burden is placed upon special needs groups: women, children, minorities, and the poor.¹⁵

According to the 2000 US Census, 49,735 Hispanics or Latinos, 11.2% of the county's total population, currently reside in Washington County.¹⁶ Further, the 2000 US Census reports that 29,552 (6.6%) residents are Asian

and 2,335 (1.1%) are American Indian and Alaska Native.¹⁷ The ethnic and cultural diversity suggests a need to provide multi-lingual services.

In 1995, a total of 7.1% of county residents were living in poverty: 9% of those were persons under the age of 18, and 6.8% were persons over the age of 65.¹⁸ Vulnerable populations, including seniors, disabled citizens, women, and children, as well those people living in poverty, may be impacted by natural hazards mitigation. Examining the reach of hazard mitigation policies to special needs populations may assist in increasing access to services and programs.¹⁹ FEMA's Office of Equal Rights addresses this need by suggesting that agencies and organizations planning for natural hazards identify special needs populations, make recovery centers more accessible, and review practices and procedures to remedy any discrimination in relief application or assistance.²⁰

The cost of natural hazards recovery can place unequal financial responsibility on the general population when only a small proportion may benefit from government funds used to rebuild private structures.²¹ Discussions about natural hazards that include local citizen groups, insurance companies, and other public and private sector organizations can help to ensure that all members of the population are a part of decision-making processes.

This plan provides background information to assist in understanding demographics, socio-economic issues and the physical environment at risk from natural hazards, as well as mitigation techniques and resources to address a broad range of county issues.

Land and Development

Land in the Tualatin Basin is comprised mainly of forested headwater slopes, agricultural land, and land developed for urban use, totaling 712 square miles (about 456,000 acres).²² Land use in Washington County includes urban development, high-tech industries, agriculture and farming activities, forests, rural residential, and recreational uses.²³ Development patterns are generally low in density away from the urban areas.

To ensure that rural development occurs in a manner that will help protect agricultural land and other natural lands from premature development, the Metropolitan Service District (Metro), with participation from counties and cities, drew a twenty year Urban Growth Boundary (UGB) around the tri-county region. Metro is the directly elected regional government that serves more than 1.3 million residents in Clackamas, Multnomah, and Washington counties and twenty-four cities in the Portland, Oregon, metropolitan area. Metro's primary mission is to manage growth in this region.²⁴ Buildable lands within the UGB were intended to satisfy the demands of population and employment growth for a 20-year period.²⁵

Land use management decisions are influenced by the location and incidence of natural hazards. Understanding the nature and severity of the

hazard is essential in determining appropriate land use. Hazard assessment is a mechanism that can provide this information.

Housing and Community Development

To accommodate the growing population, an investment must be made in developing adequate community infrastructure and services in Washington County. Washington County issued 2,855 multi-family building permits, and 3,433 single-family building permits in 1997, indicating substantial growth in housing structures for new residents in the area.²⁶ Senior centers, nursing homes, group homes, assisted living centers, hospices, child care facilities, multi-purpose centers, and youth centers additionally provide housing, shelter, and support to County residents.

In past years, the Washington County Community Development Department has financed a variety of facilities, programs, and improvements through Community Development Block Grants. Lower income neighborhoods have been revitalized with projects such as street improvements and parking, sidewalks and aesthetics, structural improvements, parks, and drainage, water, and sewer systems. To date, approximately \$40 million have been invested in housing and community development projects benefiting income-qualified residents throughout the county.²⁷

There is an increased concentration of resources and capital in Washington County. The best indicator of this fact is the increasing per capita personal income in the region since the 1970's. Personal per capita income is an estimate of total personal income divided by the total population. This estimate can be used to compare economic areas as a whole, but it does not reflect how the income is distributed among residents of the area being examined. The county's per capita personal income is also increasing relative to the Oregon and US average per capita incomes, resulting in a more affluent community than the average population.²⁸



The John Henry House, Beaverton, Oregon

Source: Washington County Land Use and Transportation Department

Employment and Industry

Employment in Washington County has increased by approximately 26,000 jobs in the last five years, reflecting increased employment opportunities to meet the needs of a growing population.²⁹ Industrial, high technology, administrative, and retail sectors continue to grow and develop to provide valuable goods, services, and work for Washington County residents.³⁰ However, risk of potential loss may be greater at major industrial and employment centers. Large employers, such as Nike, Tektronix, and Intel, have relatively higher numbers of employees, as well as a vested interest in support and high-tech infrastructure concentrated at their locations.

Mitigation activities are needed at the business level to ensure the safety and welfare of workers and limit damage to industrial infrastructure. Employees are highly mobile, commuting from all over the surrounding area to industrial and business centers. This creates a greater dependency on roads, communications, accessibility and emergency plans to reunite people with their families. Before a natural hazard event, large and small businesses can develop strategies to prepare for natural hazards, respond efficiently, and prevent loss of life and property.

Transportation and Commuting Patterns

Washington County is the second largest county in the Portland Metropolitan Statistical Area (PMSA). Over the past decade, the PMSA experienced rapid growth in employment and population.³¹ In the 1990's, transportation systems in Washington County expanded and evolved, increasing in complexity in order to meet the needs of the growing region.



170th Avenue, toward Tualatin Valley Highway, Source: Washington County Dept. of Land Use and Transportation

In rural Washington County, the transportation choices are limited to mostly private automobiles traveling over state highways and county roads. The rural road system performs two basic functions: (1) providing general mobility for the residents in the rural areas, and (2) accommodating the movements of agricultural and forest products to market. The rural transportation system was not designed to accommodate large volumes of traffic on a daily basis.

Urban Washington County meets its current transportation needs through a mixture of municipal road systems, county roads, state and federal highways, and a regional transit system (Tri-Met). Tri-Met provides both bus and light rail service to the county and to the larger Portland metropolitan area. The newly opened Washington County Westside Light Rail

is aligned in an east and west direction following Highways 26 and 217 to Beaverton and continues west to the Hillsboro Government Center. The light rail system provides rail transit connections between Hillsboro, the east Portland suburb of Gresham, the Portland airport, and the Portland Exposition Center.

According to Oregon Employment Department: 2000 Regional Economic Profile for Region 2, approximately 40% of the working population in Washington County commuted to destinations outside of the county, primarily to Multnomah County.³² However, a rapid growth rate in the high technology industry of Washington County has changed commuting patterns. In 2000, many Washington County residents did not commute to downtown Portland. Rather, they commuted to jobs within the county. Further, rapid job growth drew more commuters into Washington County, as workers living outside the county held one-third of the jobs within the county.³³ The new commuting patterns result in higher numbers of people traveling through the county. According to data from Metro's 2000 Regional Transportation Plan, the numbers of people traveling on US 26 at peak hours increased significantly between 1994 and 2000. Eastbound automobile travel is up 48%, and eastbound transit travel along the same corridor is up 1,600%. The increase in transit numbers can be primarily attributed to the construction of the Washington County Westside light rail system.³⁴ Bridges in Washington County are part of the state and interstate highway system. Most bridges are not seismically retrofitted, creating significant risk to the commuting population.

Major highways in the county include Interstate 5, State Highway 26, which runs from southeast to northwest, linking Portland to the coast, and State Highway 6, which branches off 26 and runs west to the coast. State Highway 217 is a bypass route that links Interstate 5 to Highway 26. State Highway 47 runs north south and links the western cities of Banks, Forest Grove, and Gaston to Columbia and Yamhill Counties.³⁵ As daily transit rises, there is an increased risk that a natural hazard event will disrupt the travel plans of residents across the region. Localized flooding can render roads unusable. A severe winter storm has the potential to disrupt the daily driving routine of thousands of people. Natural hazards can disrupt automobile traffic and shut down local transit systems.



Barnes Road south of Cornell Road
Source: Washington County Dept. Land Use and Transportation.

Critical Facilities and Infrastructure

Facilities critical to government response and recovery activities (i.e., life safety and property and environmental protection) include: 911 centers, emergency operations centers, police and fire stations, public works facilities, sewer and water facilities, hospitals, bridges and roads, shelters, and more. Facilities that, if damaged, could cause serious secondary impacts may also be considered “critical.” A hazardous material facility is one example of this type of critical facility.³⁶

Critical and essential facilities are those facilities that are vital to the continued delivery of key government services or that may significantly impact the public’s ability to recover from the emergency. These facilities may include: buildings such as the jail, law enforcement center, public services building, community corrections center, the courthouse, and juvenile services building and other public facilities such as schools.³⁷ Maps 2.1 – 2.3 on the following pages illustrate the critical facilities, public infrastructure, and emergency transportation routes in the urban unincorporated areas and rural jurisdictions within Washington County.

Summary

Natural hazard mitigation strategies can reduce impacts concentrated at large employment and industrial centers, public infrastructure, and critical facilities. Natural hazard mitigation for industries and employers may include developing relationships with emergency management services and their employees before disaster strikes, and establishing mitigation strategies together. Collaboration among the public and private sector to create mitigation plans and actions can reduce impacts of natural hazards.

Section Endnotes

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Section 3:

Multi-Hazard Goals and Action Items

This section provides information on the process used to develop goals and action items that cut across the seven natural hazards addressed in the mitigation plan. It also describes the framework that focuses the plan on developing successful mitigation strategies. The framework is made up of three parts: the *Mission*, *Goals*, and *Action Items*.

Mission

The *mission* of the Washington County Natural Hazards Mitigation Action Plan is to assist in reducing risk, preventing loss, and protecting life, property, and the environment from future natural hazard events. The plan fosters coordinated partnerships and the development of multi-objective strategies for mitigation.

Goals

The plan *goals* describe the overall directions that Washington County agencies, organizations, and citizens can take to work toward mitigating risk from natural hazards. The goals are stepping stones between the broad direction of the mission statement and the specific recommendations that are outlined in the action items.

Action Items

The *action items* are detailed recommendations for activities that county agencies, organizations, and citizens could engage in to reduce risk.

Mitigation Plan Goals and Public Participation

The plan goals help to guide direction of future activities aimed at reducing risk and preventing loss from natural hazards. The goals listed here serve as checkpoints as agencies and organizations begin implementing mitigation action items.

Public participation during development of the mitigation plan assisted in creating plan goals. Meetings with the project steering committee, stakeholder interviews, and a public workshop served as methods to obtain input and identify priorities in developing goals for reducing risk and preventing loss from natural hazards in Washington County.

A May 15, 2001 public workshop resulted in public ranking of the plan goals and an in-depth discussion of potential action items. The twelve participants that attended the workshop included representatives from public agencies, private organizations, and Washington County residents. The public process generated ideas for action items. Participants shared ideas and strategies for public outreach and education and potential activities to assist in meeting plan goals.

Table 3.1 illustrates the goals presented during the public workshop and the results of the first, second, and third choices for plan goals made by workshop participants. Appendix B contains specific ideas and information shared during the workshop.

Table 3.1.
Washington County Natural Hazard Mitigation Goals

Goal Category		Goal Statement	Public Choice 1 st –3 points 2 nd –2 points 3 rd –1 point	Total Score
Life, Property, and Natural Systems	a.	Develop and implement activities to protect human life, commerce, property, and natural systems from natural hazards.	16	46
	b.	Reduce insurance losses and repetitive claims for chronic hazard events while promoting insurance coverage for catastrophic hazards.	5	
	c.	Evaluate county guidelines, codes, and permitting processes in addressing natural hazard mitigation.	1	
	d.	Link watershed planning, natural resource management, and land use planning with natural hazard mitigation activities to protect vital habitat and water quality.	13	
	e.	Preserve and rehabilitate natural systems to serve natural hazard mitigation functions.	11	
Public Awareness and Partnerships	f.	Education: Develop and implement education programs to increase awareness among citizens, local, county, and regional agencies, non-profit organizations, business, and industry.	13	15
	g.	Outreach: Develop and conduct outreach programs to increase the number of local, county, and regional activities implemented by public and private sector organizations.	0	
	h.	Partnerships and Coordination: Strengthen communication and coordinate participation in and between public agencies, citizens, non-profit organizations, business, and industry.	2	
Emergency Services	i.	Strengthen emergency operations by increasing collaboration and coordination among public agencies, non-profit organizations, business, and industry.	5	7
	j.	Coordinate natural hazard mitigation activities, where appropriate, with emergency operations plans and procedures.	2	
Implementation	k.	Promote leadership within public agencies to implement natural hazard mitigation activities.	4	4

Natural Hazard Mitigation Plan Action Items

The mitigation plan identifies short and long-term action items developed through data collection and research, and the public participation process. Mitigation plan activities may be considered for funding through federal and state grant programs, and through the Federal Emergency Management Agency’s Hazard Mitigation Grant Program, should funds be made available. Action items address multi-hazard (MH) and hazard specific issues. To help ensure activity implementation, each action item includes information on timeline, coordinating and partner organizations, and plan goal(s) addressed.

- **Coordinating Organization.** The coordinating organization is the public agency with regulatory responsibility to address natural hazards, or that is willing and able to organize resources, find appropriate funding, or oversee activity implementation, monitoring, and evaluation. Coordinating organizations may include local, county, or regional agencies that are capable of or responsible for implementing activities and programs.
- **Partner Organizations.** Partner organizations are agencies or public/private sector organizations that may be able to assist in the implementation of action items by providing relevant resources to the coordinating organization. Partner organizations may include local, regional, state, or federal agencies, as well as local and regional public and private sector organizations.

The partner organizations listed in the mitigation action plan are potential partners recommended by the project steering committee, but not necessarily contacted during the development of the plan. Partner organizations should be contacted by the coordinating organization to establish commitment of time and or resources to action items.

- **Timeline.** Action items include both short and long-term activities. Each action item includes an estimate of the timeline for implementation. *Short-term action items (ST)* are activities which county agencies may implement with existing resources and authorities within one to two years. *Long-term action items (LT)* may require new or additional resources or authorities, and may take between one and five years to implement.
- **Ideas for Implementation.** Each action item includes ideas for implementation and potential resources, which may include grant programs or human resources.
- **Plan Goals Addressed.** The plan goals addressed by each action item are included as a way to monitor and evaluate how well the mitigation plan is achieving its goals once implementation begins. The plan goals are organized into the following four areas:
 1. Life, Property, and Natural Systems
 2. Public Awareness and Partnerships
 3. Emergency Services
 4. Implementation

Multi-Hazard Action Items (MH)

Multi-hazard action items are those activities that cut across all seven hazards in the mitigation plan: flood, landslide, wildfire, severe winter storm, windstorm, earthquake, and volcanic eruption. There are eight short-term and three long-term multi-hazard action items described below. Each action item is followed by ideas for implementation, which can be used by the steering committee and local decision makers in pursuing strategies for implementation.

ST-MH#1: Identify and pursue funding opportunities to develop and implement local and county mitigation activities.

Funding and human resources are essential to implement mitigation activities. Potential funding or human resource opportunities may exist for individual mitigation projects.

Ideas for Implementation:

- Explore financial options (such as bond measures);
- Develop incentives for local governments, citizens, and businesses to pursue hazard mitigation efforts;
- Mandate that a certain amount of county resources and assistance be allocated to mitigation projects; and
- Partner with other organizations and agencies in Washington County to identify grant programs and foundations that may support mitigation activities.

Coordinating Organization: Washington County

Partner Organizations: Clean Water Services, Westside Economic Alliance, Tualatin River Watershed Council, Cities

Timeline: Ongoing

Plan Goals Addressed: Implementation; Public Awareness and Partnerships; Life, Property, and Natural Systems

ST-MH#2: Establish a Washington County Natural Hazards Mitigation Committee to facilitate implementation, monitoring, and evaluation of countywide mitigation activities.

Ideas for Implementation:

- Establish clear roles for participants and meet regularly to pursue and evaluate implementation of mitigation strategies;
- Oversee implementation of the mitigation plan;
- Facilitate the development or update of local mitigation plans that are consistent with the regional goals and framework of the Washington County Natural Hazards Mitigation Action Plan; and
- Work with cities and county government to develop strategies for implementation of plan activities.

ST-MH#2, continued

Coordinating Organization: Washington County

Partner Organizations: Metro, Clean Water Services, Westside Economic Alliance, Tualatin River Watershed Council, Portland General Electric, Northwest Natural, Washington County Fire Defense Board, Tualatin Valley Water District, Oregon Office of Emergency Management, Cities

Timeline: 6 months

Plan Goals Addressed: Public Awareness and Partnerships

ST-MH#3: Present the mitigation plan to appropriate stakeholders to discuss and plan for implementation of specific action items.

Ideas for Implementation:

- Present the Washington County Natural Hazards Mitigation Action Plan to the County Commissioners, Cities, Oregon Office of Emergency Management, and Metro;
- Present the Flood Mitigation Section to Clean Water Services and Tualatin River Watershed Council;
- Present the Landslide Mitigation Section to the county land use and transportation department;
- Present the Wildfire Mitigation Section to the Washington County Fire Defense Board;
- Present the Severe Winter Storm and Windstorm Mitigation Sections to representatives from utilities including Portland General Electric, Northwest Natural, and the various water and irrigation districts in the county; and
- Present the Earthquake Mitigation Section to the Westside Economic Alliance, members of the Washington County insurance industry, and local school districts.

Coordinating Organization: Washington County

Partner Organizations: Metro, Clean Water Services, Westside Economic Alliance, Tualatin River Watershed Council, Portland General Electric, Northwest Natural, Washington County Fire Defense Board, Tualatin Valley Water District, Oregon Office of Emergency Management, Cities

Timeline: 6 months

Plan Goals Addressed: Public Awareness and Partnerships

ST-MH#4: Identify, improve, and sustain collaborative programs focusing on the real estate and insurance industries, public and private sector organizations, and individuals.

ST-MH#4, continued

Ideas for Implementation:

- Distribute information about flood, fire, and other forms of natural hazards insurance to property owners in areas identified to be at risk through hazards mapping;
- Expand real estate disclosure requirements to address natural hazard exposures;
- Develop a one-page handout on types of insurance and deliver through county utility or service agencies (e.g., PGE or CWS);
- Develop informational brochures and materials aimed at hazards mitigation; and
- Develop incentives for individuals and businesses that engage in mitigation activities.

Coordinating Organization: Washington County

Partner Organizations: Oregon Office of Emergency Management, Clean Water Services, Portland General Electric

Timeline: Ongoing

Plan Goals Addressed: Public Awareness and Partnerships; Life, Property, and Natural Systems

ST-MH#5: Develop public and private partnerships to foster natural hazard program coordination and collaboration in Washington County.

Ideas for Implementation:

- Identify all organizations within Washington County that have programs or interests in natural hazards mitigation;
- Develop partnerships between land use planners, geologists, and emergency managers to implement specific mitigation projects;
- Establish neighborhood emergency service and mitigation volunteer teams to collaborate with Washington County Emergency Management;
- Develop formal collaborations with businesses in the county; and
- Encourage Metro to reconvene the Natural Hazards Technical Advisory Committee to review, update, and develop strategies for implementation of Chapter 5 (Natural Hazards) of the Metro Regional Framework Plan. Include land use planning representatives in the committee's composition.

Coordinating Organization: Washington County

Partner Organizations: Metro, Clean Water Services, Westside Economic Alliance, Portland State University

Timeline: Ongoing

Plan Goals Addressed: Public Awareness and Partnerships

ST-MH#6: Develop benchmarks for a disaster resistant county.

Ideas for Implementation:

- Establish benchmarks to provide measurable standards to evaluate the effectiveness of mitigation policies and programs, and provide a mechanism to update and change the mitigation plan and emergency operations documents to meet the needs of Washington County communities and organizations;
- Perform a review of statewide Planning Goal 7 as it applies to local and county jurisdictions;
- Monitor hazard mitigation implementation by jurisdictions and participating organizations through surveys and other reporting methods;
- Develop annual updates for the Natural Hazards Mitigation Action Plan based on new information;
- Conduct a full review of the Natural Hazards Mitigation Action Plan every three years by evaluating mitigation successes, failures, and areas that were not addressed;
- Evaluate local plans and activities to determine consistency with existing county codes and any new requirements (such as Goal 7); and
- Review and update the Washington County Emergency Operations Plan every 5 years.

Coordinating Organization: Washington County

Partner Organizations: Oregon Office of Emergency Management, Oregon Department of Land Conservation and Development

Timeline: Ongoing

Plan Goals Addressed: Implementation; Emergency Services

ST-MH#7: Develop inventories of at-risk buildings and infrastructure and prioritize mitigation projects based on those providing the most benefit (at the least cost) to county residents.

(See Appendix C for information on approaches for economic analysis)

Ideas for Implementation:

- Develop an inventory of unreinforced masonry buildings to target for mitigation in rural and unincorporated areas;
- Develop an inventory of mobile homes for flood, windstorm, and earthquake mitigation and consider adoption of ordinances that require structural mitigation for these hazards;
- Identify at-risk bridges from flood or earthquake hazards, identify enhancements, and implement projects needed to reduce the risks;

ST-MH#7, continued

- Adopt engineering/construction standards that facilitate post-disaster repair/replacement of damaged government infrastructure to a condition that exceeds the pre-disaster condition;
- Review and improve utility operations and services to mitigate for natural hazards; and
- Ensure that government facilities are adequately insured against natural hazards. (The Stafford Act for public assistance requires that government facilities and homeowners that have received disaster assistance purchase insurance that is equal to or greater than the initial cost of recovery and restoration provided through public assistance funds.)

Coordinating Organization: Washington County

Partner Organizations: Clean Water Services, Portland General Electric, Northwest Natural, Tualatin Valley Water District

Timeline: 1-2 years

Plan Goals Addressed: Life, Property, and Natural Systems; Emergency Services

ST-MH#8: Strengthen emergency services by updating the County Emergency Operations Plan, linking emergency services with mitigation programs, and enhancing public education.

Ideas for Implementation:

- Update the Emergency Operations Plan to reflect hazard-specific and demographic information within the county;
- Inform the public of natural hazard response and mitigation strategies;
- Invite the public to participate in annual natural hazard disaster drills;
- Identify and create an information database on the location of centers with major concentrations of seniors and persons with disabilities (e.g., senior housing facilities and assisted living centers), and develop strategies for notification and evacuation;
- Update the Washington County Hazard Analysis with new information as it becomes available; and
- Present strategies for implementation of this action item to cities.

Coordinating Organization: Washington County

Partner Organizations: Oregon Office of Emergency Management, Cities

Timeline: 1-2 years

Plan Goals Addressed: Emergency Services; Life, Property, and Natural Systems; Public Awareness and Partnerships

LT-MH#1: Develop, enhance, and implement education programs aimed at mitigating natural hazards, and reducing the risk to citizens, public agencies, private property owners, businesses, and schools.

Ideas for Implementation:

Outreach

- Develop and complete a baseline survey to gather perceptions of private citizens and the business community regarding natural hazard risks and identify mitigation needs. Repeat the survey in five years to monitor successes and failures of natural hazard mitigation programs;
- Create appropriate outreach programs to meet identified needs;
- Identify research institutions and programs that can provide technical assistance in natural hazards research and mitigation;
- Make the Washington County Natural Hazards Mitigation Action Plan available to the public by publishing the plan electronically on the county and emergency management websites. Specifically, consider the following:
 - a. Creating a centralized information database to serve the county so residents can easily access relevant information;
 - b. Developing an information website that includes information specific to Washington County residents, including scientific information on earthquakes, building codes, insurance companies providing earthquake insurance for county residents, and educational information on damage prevention; and
 - c. Developing a list serve to provide Internet discussions and information sharing.
- Present strategies for implementation of this action item to cities.

Education

- Develop curriculum for school programs and adult education on reducing risk and preventing loss from natural hazards;
- Conduct natural hazards awareness programs in schools and community centers;
- Develop Spanish-language education materials; and
- Conduct workshops for public and private sector organizations to raise awareness of mitigation activities and programs.

Coordinating Organization: Washington County

Partner Organizations: Westside Economic Alliance, IBHS, CWS, School Districts, OEM, Cascadia Region Earthquake Workgroup, IISOI, OSSPAC, Oregon Natural Hazards Workshop, Tualatin Public Awareness Committee, Cities

Timeline: 1-5 years

Plan Goals Addressed: Public Awareness and Partnerships; Life, Property, and Natural Systems

LT-MH#2: Increase technical knowledge of natural hazards and mitigation strategies in Washington County and implement policies and programs on the basis of that knowledge.

Ideas for Implementation:

- Create and update hazards maps as a basis for site-specific mitigation requirements;
- Maintain a GIS inventory of all critical facilities, large employers, public assembly areas, and lifelines, and use GIS to evaluate the vulnerability of lifeline routes by comparing current routes with hazard-prone areas; and
- Ensure local comprehensive land use plans and implementing development standards are updated if statewide Planning Goal 7, Areas Subject to Natural Disaster and Hazards, is changed.

Coordinating Organization: Washington County

Partner Organizations: Clean Water Services, Metro, Department of Geology and Mineral Industries, Oregon Department of Forestry, Oregon Department of Land Conservation and Development

Timeline: Ongoing

Plan Goals Addressed: Life, Property, and Natural Systems; Emergency Services; Implementation

LT-MH#3: Use technical knowledge of natural ecosystems to link natural resource management and land use organizations to mitigation activities and technical assistance.

Ideas for Implementation:

- Develop and enhance ordinances that protect natural systems and resources to mitigate for natural hazards;
- Pursue vegetation and restoration practices that assist in enhancing and restoring the natural and beneficial functions of the watershed; and
- Develop education and outreach programs that focus on protecting natural systems as a mitigation activity.

Coordinating Organization: Washington County

Partner Organizations: Clean Water Services, Tualatin River Watershed Council, Metro, Washington County Fire Defense Board

Timeline: Ongoing

Plan Goals Addressed: Life, Property, and Natural Systems; Public Awareness and Partnerships

Section 4: Flood

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Why are Floods a Threat to Washington County?

In 1996, many rivers and creeks throughout the Willamette River watershed rose to 100-year flood levels. Washington County experienced flooding in both rural and urban areas. The Tualatin River and its tributaries were filled beyond capacity. Tualatin River floodwaters caused significant damage, most significantly to portions of the business district of the city of Tualatin. The County sought and received a Presidential Disaster Declaration to obtain federal assistance for its flood recovery effort.

Residents in Washington County share a statewide concern about flood issues. According to the National Flood Insurance Program (NFIP), Oregon has 256 flood prone communities in all 36 counties of the state.¹ That number includes a majority of Oregon's 240 incorporated communities and counties. Flooding can cause severe damage to public and private property and pose a threat to life and safety. Oregon's largest economic loss from natural disasters has resulted from flooding.² During the Christmas Flood of 1964, over \$157 million dollars in damage was done, and 20 Oregonians lost their lives.³

History of Flooding in Washington County

Between the 1850's and the present, human activity significantly changed the hydrology of the Willamette watershed, including changes to the Tualatin Basin. Hydroelectric dams and flood control systems were constructed throughout the drainage basin. Private and public organizations engaged in the dewatering of wetlands, the draining of floodplains, and diking along some sections of the river. More recently, increasing urbanization has contributed to changes in basin hydrology. Prior to human alteration of the river system, rivers in the region flooded larger areas more often. The Portland District of the Army Corps of Engineers estimates that the Corps' \$1.2 billion investment in flood storage projects in the region has already prevented \$20 billion in flood damages.⁴

Floods that have occurred since the installation of flood control structures more accurately reflect the types and levels of flooding that Washington County can expect in the future. The flood events that took place in 1964 and 1996 were the most damaging events in Washington County during the modern era of flood control. In February of 1996, an unusually deep, low elevation snow pack in the Cascades and Coast Range was soaked for four days by precipitation coming from a subtropical storm off the Pacific Ocean. The four-day rainfall total in Hillsboro was 6.70 inches, surpassing the previous record of 5.91 inches set in 1974.⁵

Between February 8 and 10, 1996, the Tualatin River overflowed its banks and flooded areas within the floodplain. Washington County suffered almost \$10 million in damage from the event; statewide damages surpassed \$280 million.⁶ National Flood Insurance Program claims from the event surpassed \$2.3 million for the County alone.⁷

Known as the "Christmas Flood," the flood of December 1964 was rated as a 100-year event by FEMA. The conditions resulting in the floods of 1964 were similar to the causes of the 1996 floods. Warm, prolonged rainfall on a low level snow pack quickly filled local streams and rivers.

Flooding in the County isn't just linked to major events such as the floods of 1964 and 1996. From 1977 to 1999, the National Flood Insurance Program (NFIP) paid flood insurance claims in Washington County in 12 of 22 years.

Previous Flood Losses in Washington County

Since 1977, the NFIP has paid over \$2.5 million in claims for flood damage to Washington County properties (see Table 4.1).

Table 4.1. Washington County Flood Damage 1977-1999 (in millions)

Type	Incorporated Washington County	Unincorporated Washington County
Assessed Property Value*	\$15.2	\$12.3
Reported damage to buildings	\$1.1	\$1.8
Reported damage to contents	\$0.8	\$0.2
Total of claims paid	\$1.1	\$1.6
Repetitive Loss (from 1977-1999)		
Assessed Property Value**	(NA)	\$6.8
Reported damage to buildings	(NA)	\$1.0
Building Damages Claims paid	(NA)	\$0.9

Source: Dennis Sigrist, Oregon Emergency Management

* Assessed property value of property owners who filed flood damage claims with the NFIP.

** Assessed property value of property owners who filed flood damage claims with the NFIP more than once.

From 1977 to 1999, properties in incorporated areas of Washington County accounted for 41% of the claims paid under the NFIP. Properties in unincorporated parts of the County accounted for 59% of the NFIP claims paid. Over half of the claims paid in unincorporated Washington County were paid on properties that have suffered damage from more than one flood event.

The annual payment by the NFIP to Washington County residents varies from year to year. The risk of local flooding changes based on the amount of rain received during the wet season. Flood events are more likely to occur during years with higher-than-average rainfall totals. Other factors can also affect the level of flood damage that occurs each year. Over time, development of the landscape (filling and paving activities) can significantly affect flood patterns, levels, and damages. Mitigation activities can help to avoid flood damage to development in the floodplain.

Table 4.2. Largest Annual Totals – NFIP Claim Payments, 1977-1999

Year	NFIP Payment
1977	\$38,186
1980	\$26,047
1982	\$98,876
1996	\$2,358,591

Source: Dennis Sigrist, Oregon Emergency Management

NFIP payments for the 1996 flood event account for over 90% of the payments made between 1977 and 1999. The average annual countywide payment for this period is \$216,000. If the 1996 payment total is separated out, the average annual payment for the remaining years is \$21,000.

NFIP Repetitive Flood Loss Properties

Federal flood loss data provided by the National Flood Insurance Program (NFIP) identifies a number of repetitive flood loss properties in Washington County. The aggregated repetitive flood loss data are shown in Table 4.3 and depicted graphically (by general area of flooding) in Map 4.0. There are, undoubtedly, other repetitive flood loss properties in the county. Their existence, however, is not well known since they have not carried NFIP ‘flood insurance’ in the past or do not have a current NFIP policy.

According to the NFIP, a repetitive loss is one that has had two or more losses reported where \$1,000 or more was paid on each loss. The two losses must have occurred within ten years of each other and be at least ten days apart. The flood losses displayed in Table 4.3 meet these criteria. Only losses dating back to January 1, 1978 that have been closed (claim settled and paid) are considered by the NFIP.

The NFIP has further refined the pool of repetitive loss properties into Target-loss and Pilot-loss properties. Target-loss properties are defined as those with four or more losses or two or more losses with total payments greater than the value of the property. There are two Target-loss properties in Washington County.

FEMA has also identified through NFIP insurance data a select list of repetitive flood loss properties that exhibit a level of risk that may be cost-effective to mitigate. These properties, which are called Pilot-loss, have experienced four or more insured flood losses or have the highest severity of flooding (i.e., cumulative losses paid exceeds the property value), with some properties satisfying both criteria. There is one Pilot-loss property in Washington County. The Target-loss and Pilot-loss property categories are included in Table 4.3.

Federal Flood Insurance

NFIP payments represent a fraction of the total losses incurred as a result of flood events. Only property within communities that participate in the NFIP is eligible for federal flood insurance. If a community does not participate in the NFIP, property owners in the community cannot be federally insured against flood hazards. Additionally, between 25% and 30% of the NFIP's claims come from outside high-flood-risk areas. However, most landowners outside of designated flood hazard areas may not have flood insurance.

Source: FEMA website:
<http://www.fema.gov>

Refer to Short-Term Action Item(s) #1-3 for a complete description of the plan’s recommendation related to mitigating flood losses to homes and businesses.

Table 4.3

NFIP Repetitive Flood Loss Property Summary

Number of Properties	Repetitive Losses Per Property	Cumulative Losses for Properties¹	Repetitive Loss Property Category
19	2	\$535,816.37	Repetitive Loss, Target-Loss & Pilot-Loss
1	3	\$23,371.63	Repetitive Loss only
1 ²	4	\$51,303.61	Repetitive Loss only
21	TOTAL	\$610,491.61	All Categories

Source: NFIP Flood Loss Data, 2003

What Factors Create Flood Risk?

Flooding occurs when climate (or weather patterns), geology, and hydrology combine to create conditions where water flows outside of its usual course. In Washington County, geography and climatological conditions combine to create chronic seasonal flooding conditions.

Precipitation

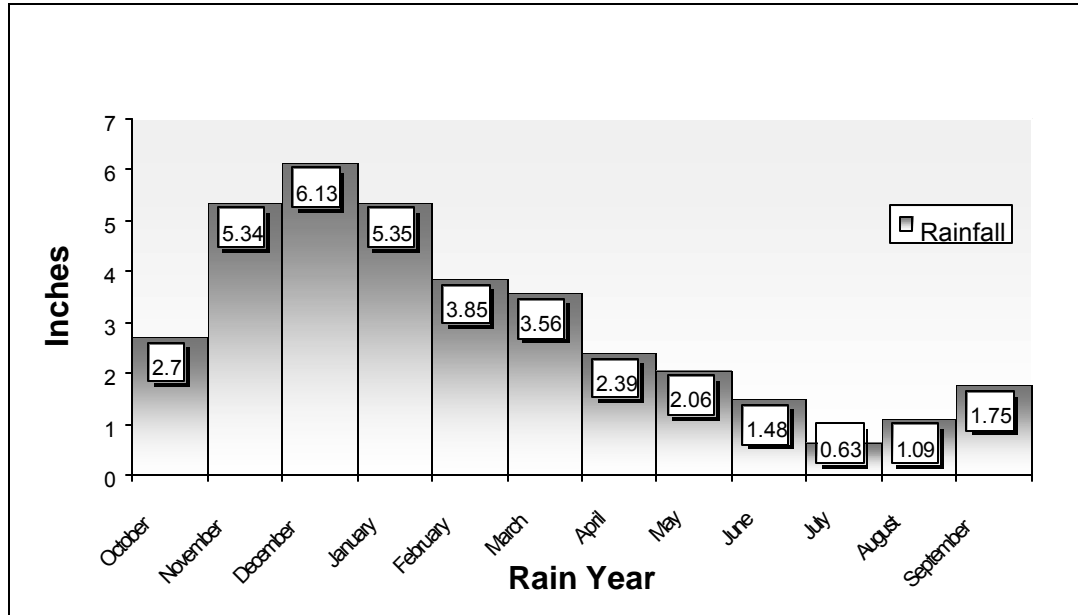
Flooding is most common from October through April, when storms from the Pacific Ocean, 60 miles away, bring intense rainfall to the area.⁸ Washington County receives approximately 40 inches of rain on average each year. Most of the precipitation, however, occurs during the seven wettest months of the year, October through April. Rain totals are measured for the ‘water year’, from October 1st of one year to September 30th the following year. During the rainy season, monthly rainfall totals average far higher than other months of the year. Figure 4.1 is based on Portland rainfall data; however, the pattern of precipitation is applicable to Washington County. The average annual precipitation for Portland is 36.30 inches. Approximately 81% of the annual precipitation falls during the seven months between October and April.

The consistent, drenching precipitation of the rainy season saturates Washington County and often fills the Tualatin River and its tributaries close to their maximum levels. When rivers and streams rise and exceed their channel capacity, water spills out onto the surrounding floodplain. Washington County typically experiences flooding after more than three days of heavy rainfall (i.e., saturated conditions).

¹ Includes payments for both structure and contents

² This specific property is a multi-unit/family dwelling

Figure 4.1. Average Monthly Rainfall for Portland, Oregon



Source: Oregon Climate Service

Climatic Conditions:

Low-level snows and prolonged ice events have significant impacts on flooding events in Washington County. The 1996 flood was greatly exacerbated by a multi-day freeze and snowfall that preceded the rain. The frozen ground limited absorption of the rainfall.

For more information on snow and ice events, refer to section 6 of this plan, Severe Winter Storm.

Annually, more than 1.1 million acre-feet of water flow out of the Tualatin River watershed into the Willamette River (including water imported from the Trask and Bull Run Reservoirs). Nearly 85% of this flow is discharged during November through March, and less than 3% typically is discharged during June through October.⁹

Geography and Geology

The Tualatin River drainage basin is approximately 43 miles long and 29 miles wide and covers an area of 712 square miles.¹⁰ An early settler to the area, Peter Ogden, described the Tualatin Valley of the 1800’s as “mostly water connected by swamps.” Soils on the valley floor include poorly drained clay soils.¹¹ The poorly drained soils often form into wetlands. These areas are capable of holding water for extended periods of time.

The broad flood plain of the valley can be easily inundated by floodwaters. Wet, rainy season storms move in from the Pacific, dropping heavy precipitation into the “bowl-shaped” valley. Flooding in the valley becomes a problem when human activities infringe on the natural floodplain. The map on the following page illustrates the Tualatin Basin floodplain.

Characteristics of Flooding in Washington County

Two types of flooding primarily affect Washington County: riverine flooding and urban flooding. In addition, any low-lying area has the potential to flood. Flooding of developed areas may occur when the amount of rainfall and runoff exceeds a storm water system's (ditch or sewer) capability to remove it.¹²

Riverine Flooding

Riverine flooding, the overbank flooding of rivers and streams, is the largest single form of flooding in Washington County. Rivers and streams in the County regularly overflow their banks and inundate low-lying areas. The natural processes of riverine flooding add sediment and nutrients to fertile floodplain areas. Flooding in large river systems typically results from large-scale weather systems that generate prolonged rainfall over a wide geographic area, causing flooding in hundreds of smaller streams, which then drain into the major rivers.¹³

Shallow area flooding is a special type of riverine flooding. FEMA defines shallow flood hazards as areas that are inundated by the 100-year flood with flood depths of only 1 to 3 feet. These areas are generally flooded by low velocity sheet flows of water.

Flood Maps

Floodplain maps 4.1 and 4.2 illustrate 100-year floodplain areas, drainage hazard areas, and vacant lots within the 100-year floodplain in Washington County.

Urban Flooding

As land is converted from fields or woodlands to roads and parking lots, it loses its ability to absorb rainfall. Approximately 21% of the Tualatin watershed is in urban land uses.¹⁴ The percentage of urbanized land is growing each year. Urbanization of the watershed changes the hydrologic systems of the basin. Heavy rainfall collects and flows faster on impervious concrete and asphalt surfaces. The water moves from the clouds, to the ground, and into streams at a much faster rate in urban areas. Adding these elements to the hydrological systems can result in floodwaters that rise very rapidly and peak with what is often violent force.

During periods of urban flooding, streets can become swift moving rivers and basements can fill with water. Storm drains often back up with vegetative debris causing additional, localized flooding.

What is a Floodplain?

A floodplain is a land area adjacent to a river, stream, lake, estuary, or other water body that is subject to flooding. These areas, if left undisturbed, act to store excess floodwater. The floodplain is made up of two sections: the flood fringe and the floodway.

What is the Effect of Development on Floods?

When structures or fill are placed in the floodway, water is displaced. Development raises the base flood elevation by forcing the river to compensate for the flow space obstructed by the inserted structures and/or fill. When structures or materials are added to the floodway and no fill is removed to compensate, serious problems can arise. Floodwaters may be forced away from historic floodplain areas. As a result, other existing floodplain areas may experience floodwaters that rise above historic levels.

Local governments must require engineer certification that proposed developments will not cause the base flood (100-year flood) elevation to rise. Displacement of only a few inches of water can mean the difference between no structural damage occurring in a given flood event, and the inundation of many homes, businesses, and other facilities. Careful attention should be paid to development that occurs within the floodway to ensure that structures are prepared to withstand base flood events.

In Washington County, development proposed for floodplain areas must demonstrate, through hydraulic and hydrologic analysis, how the proposed development will affect flood levels in the floodplain and the drainage hazard areas (25-year floodplains). The cumulative effect of the proposal, based on full development of the basin according to the applicable Community Plans and Rural/Natural Resource Plans, must not raise the base flood elevation more than one foot at any point in the 100-floodplain. Any property expected to experience an increase in flood elevation as a result of development must contain no structures, and have prior consent of the property owner. In drainage hazard areas, development will not result in any increase to the drainage hazard area elevation at any point in the community.¹⁵

In highly urbanized areas, increased paving can lead to an increase in volume and velocity of runoff after a rainfall event, exacerbating the potential flood hazards. Care should be taken in the development and implementation of stormwater management systems to ensure that these runoff waters are dealt with effectively.¹⁶

What is the Floodway?

The floodway is one of two main sections that make up the floodplain. Floodways are defined for regulatory purposes. Unlike floodplains, floodways do not reflect a recognizable geologic feature. For National Flood Insurance Program (NFIP) purposes, floodways are defined as the channel of a river or stream, and the overbank areas adjacent to the channel. The floodway carries the bulk of the floodwater downstream and is usually the area where water velocities and forces are the greatest. NFIP regulations require that the floodway be kept open and free from development or other structures, so that flood flows are not obstructed or diverted onto other properties. The NFIP floodway definition is “the channel of a river or other watercourse and adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot. Floodways are not mapped for all rivers and streams but are generally mapped in developed areas.

What is the Flood Fringe?

The flood fringe refers to the outer portions of the floodplain, beginning at the edge of the floodway and continuing outward. This is the area where development is most likely to occur, and where precautions to protect life and property need to be taken.

Development:

For floodplain ordinance purposes, development is broadly defined to mean “any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation, or drilling operations or storage of equipment or materials.” The definition of development for floodplain purposes is generally broader and includes more activities than the definition of development used in other sections of local land use ordinances.

Base Flood Elevation (BFE)

The term “Base Flood Elevation” refers to the elevation (normally measured in feet above sea level), which the base flood is expected to reach. Base flood elevations can be set at levels other than the 100-year flood. Some communities choose to use higher frequency flood events as their base flood elevation for certain activities, using lower frequency events for others. For example, for the purpose of stormwater management, a 25-year flood event might serve as the base flood elevation, while the 500-year flood event may serve as base flood elevation for the tie down of mobile homes. The regulations of the National Flood Insurance Program focus on development in the 100-year floodplain.

How are Flood-Prone Areas Identified?

Flood maps and Flood Insurance Studies are often used to identify flood-prone areas. The National Flood Insurance Program (NFIP) was established in 1968 as a means of providing low cost flood insurance to the nation’s flood-prone communities. The NFIP also reduces flood losses through regulations that focus on building codes and what we have come to know as “sound floodplain management.”¹⁷ In

Washington County Floodplain Code
For more information on the Floodplain Code, refer to Existing Mitigation Activities on page 4-20.

Washington County, the NFIP and related building code regulations went into effect in 1974. NFIP regulations (44 Code of Federal Regulations (CFR) Chapter 1, Section 60.3) require that all new construction in floodplains must be elevated at or above base flood level. The Oregon Building Code requires new construction to be elevated to one foot above the base flood elevation. Communities participating in the NFIP may adopt regulations that are more stringent than those contained in 44 CFR 60.3, but not less stringent.¹⁸ In Washington County, all homes legally constructed in the floodplain after January 1974 must be mitigated to NFIP standards with the first floor being elevated at least one foot above base flood level.

FIRM Maps and Flood Insurance Studies

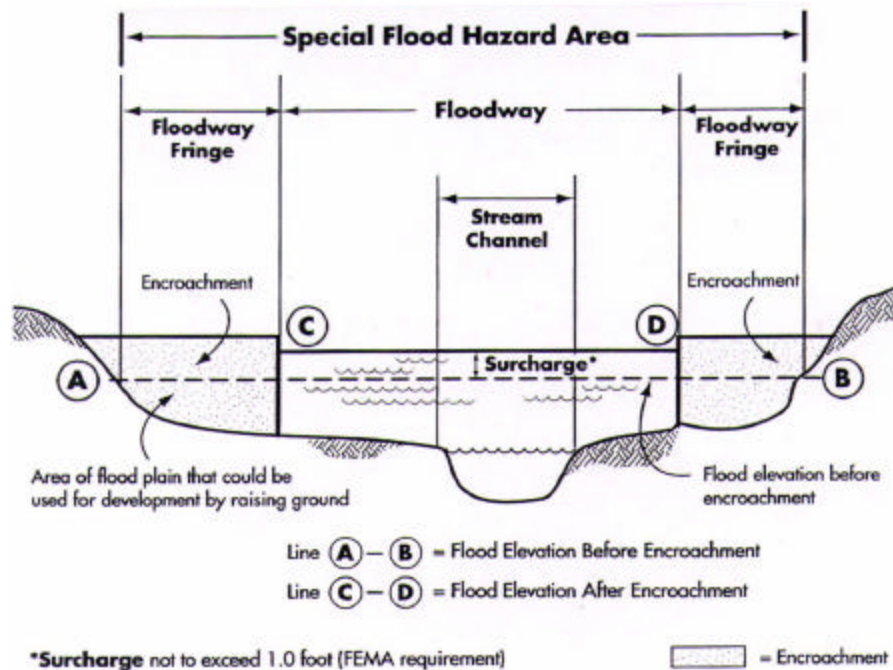
Floodplain maps are the basis for implementing floodplain regulations and for delineating flood insurance purchase requirements. A Flood Insurance Rate Map (FIRM) is the official map produced by the Federal Emergency Management Agency (FEMA), which delineates Special Flood Hazard Areas or floodplains where National Flood Insurance Program regulations apply. FIRMs are also used by insurance agents and mortgage lenders to determine if flood insurance is required and what insurance rates should apply.

Washington County also identifies Drainage Hazard Areas within Special Flood Hazard Areas. Drainage Hazard Areas include property that falls within the

25-year flood plain boundary. Developments in these areas receive special consideration from the County, and must meet additional standards. Water surface elevations are combined with topographic data to develop FIRMs (Flood Insurance Rate Maps). FIRMs illustrate areas that would be inundated during a 100-year flood, floodway areas, and elevations marking the 100-year-flood level. In some cases they also include base flood elevations (BFEs) and areas located within the 500-year floodplain.

Flood Insurance Studies and FIRMs produced for the National Flood Insurance Program (NFIP) provide assessments of the probability of flooding at a given location. FEMA conducted many Flood Insurance Studies in the late 1970s and early 1980s. These studies and maps represent flood risk at the point in time when FEMA completed the studies. *They do not reflect changes within the study area that might affect flooding since the studies.* For example, many areas in Washington County have experienced significant urbanization and changes in hydrology during the past 20 years. Floodplain maps within Clean Water Services' jurisdiction will be updated by December 2001. Other floodplain maps, specifically for rural areas, have not been updated to reflect recent changes in land use.

**Figure 4.2
Floodplain Schematic**



Source: Floodplain Management in Missouri. (March 1999) Missouri Emergency Management Agency

Flood Mapping Methods and Techniques

Although many communities rely exclusively on FIRMs to characterize the risk of flooding in their area, some jurisdictions develop their own flood hazard maps. They use high-water marks from flood events or aerial photos, in

conjunction with the FEMA maps, to better reflect the true flood risk for their communities.

The use of GIS (Geographic Information System) is becoming an important tool for flood hazard mapping. FIRM maps can be imported directly into GIS, which then allows for GIS analysis of flood hazard areas. Communities find it particularly useful to overlay flood hazard areas on tax assessment parcel maps. This allows a community to evaluate the flood hazard risk for a specific parcel during review of a development request. Coordination between FEMA and local planning jurisdictions is the key to making a strong connection with GIS technology for the purpose of flood hazard mapping. Clean Water Services and FEMA will complete an update of floodplain maps in Washington County in 2001.

FEMA and the Environmental Systems Research Institute (ESRI), a private company, have formed a partnership to provide multi-hazard maps and information to the public via the Internet. ESRI produces GIS software, including ArcView© and ArcInfo©. The ESRI web site has information on GIS technology and downloadable maps. The hazards maps provided on the ESRI site will assist communities in evaluating geographic information about natural hazards. Flood information for most Oregon communities is available on the ESRI web site. Visit <http://www.esri.com> for more information.

Community Flood Issues

Development in the floodplains of Washington County will continue to be at risk from flooding. Flood damage occurs on a regular basis throughout the County. During certain years, property losses resulting from flood damage is extensive. NFIP payment for 1996 flood damages in Washington County was 531 times greater than the three previous years combined.

The single largest impact on human communities from flood events is the loss of life and property. Washington County has experienced millions of dollars in flood damage in the past three decades. Property loss from floods strikes both private property and public property. Public sector impacts (e.g., impacts to water and sewer systems, roads, etc.) statewide resulted in approximately two-thirds of the damage from the 1996 flood events.¹⁹

Many citizens are concerned about the relationship between rapid urban growth and flood damage. While there are no strong sentiments to stop growth, some County residents are concerned that growth is pushing development into floodplains. Clean Water Services (CWS) manages surface water for a large portion of Washington County. In a survey of stakeholders, CWS (formerly Unified Sewerage Agency) found that there was a desired connection on the part of the stakeholders between flood control, water quality, the mitigation of growth impacts, and the effectiveness of land use systems.²⁰

Types of property loss that can occur as a result of flood events

The type of property damage caused by flood events depends on the depth and velocity of the floodwaters. Faster moving floodwaters can wash buildings off their foundations and sweep cars downstream. Pipelines, bridges, and other infrastructure can be damaged when high waters combine with flood debris. Extensive flood damage can be caused by basement flooding and landslide damage related to soil saturation from flood events. Seepage into basements or daylight basements is common during

flood events, not only in or near floodplains, but also on hillsides and other areas that are far removed from floodplains.²¹ Most flood damage is caused by water saturating materials susceptible to loss (e.g., wood, insulation, wallboard, fabric, furnishings, floor coverings, and appliances). Most of the losses in the 1996 floods were due to saturation damage.²²

Private property flood issues

In 1996, flood damage to private property totaled one-third of damages statewide.²³ In Washington County, damage occurred to structures in the floodplain, as well as structures impacted by localized urban flooding (but not necessarily in the floodplain). Damage also occurred to structures impacted by landslides caused by heavy precipitation. A high level of flood damage during the 1996 floods occurred to those structures that were constructed prior to the adoption of floodplain management measures required by the National Flood Insurance Program. The concentration of damage clearly demonstrates the success of the mitigation measures required and implemented through the NFIP.²⁴

Washington County regulates floodplain development through Floodplain Drainage Area Development Standards. The standards are located in Section 421 of the Washington County Community Development Code. Flood events also pose a risk to structures outside of identified floodplains. Outside of official floodplains and county designated Drainage Hazard Areas, the county does not provide flood regulations. There are, however, drainage standards provided under Section 410 of the Community Development Code, and under Clean Water Services' drainage standards.

Homes

Housing losses accounted for the largest share of private property damage during the 1996 flood events.²⁵ Homes with access to rivers and creeks may be located in areas especially at risk to chronic flooding. Washington County flood ordinances provide baseline rules governing the construction of homes within identified floodplains. Flood damage problems may continue to arise for homes that were constructed prior to the implementation of the County Floodplain and Drainage Hazard Area Development Standards. Flood damage may also occur to homes constructed according to County standards, as the County cannot guarantee that adherence will prevent flood damage.²⁶

Homes in frequently flooded areas can also suffer damage to septic systems and drain fields. Homes in rural floodplain areas often depend on private sewage treatment systems. Inundation of these systems may result in leakage of wastewater into surrounding areas. In many cases, flooding damage to homes renders them unlivable. In the wake of the 1996 floods, Washington County received almost \$1.5 million in Disaster Housing Assistance Program funds. The Federal Government provides disaster funding for people who cannot, or should not, live in their homes because of damage or other disaster related reasons.²⁷ Table 4.4 illustrates Washington County's rank as the seventh highest county in the state for total flood damage during the 1996 events, and as the fourth highest county for housing disaster assistance. Housing Assistance funds went primarily to urban counties with high populations and relatively high property values.²⁸

Table 4.4. 1996 Oregon County Losses and Housing Program Fund Payments

<u>County Losses</u>	<u>Housing Fund Payments to Counties</u>
1.) Tillamook	1.) Clackamas
2.) Clackamas	2.) Marion (tied)
3.) Multnomah	2.) Columbia (tied)
4.) Marion	4.) Washington
5.) Columbia	5.) Multnomah
6.) Lane	6.) Tillamook
7.) Washington	7.) Linn

Source: 1996 Flooding and Landslides and Stream Erosion In the State of Oregon

Manufactured Homes

Statewide, the 1996 floods destroyed 156 housing units. Of those units, 61% were mobile homes and trailers.²⁹ Many older manufactured home parks are located in floodplain areas. Manufactured homes have a lower level of structural stability than stick-built homes. Manufactured homes in floodplain zones must be anchored to provide additional structural stability during flood events. Because of confusion in the late 1980's resulting from multiple changes in NFIP regulations, there are some communities that do not actively enforce anchoring requirements. Lack of enforcement of manufactured home construction standards in floodplains can contribute to severe damages from flood events.³⁰

Business/Industry

Flood events impact businesses by damaging property and by interrupting business. Flood events can cut off customer access to a business as well as close a business for repairs. The 1996 flood damaged many businesses in Tualatin and caused extensive losses to the county's agricultural and nursery-stock industries. A quick response to the needs of businesses affected by flood events can help a community maintain economic vitality in the face of flood damage. Responses to business damages can include funding to assist owners in elevating or relocating flood-prone business structures.³¹

Public infrastructure

Publicly owned facilities are a key component of daily life for all citizens of the County. Damage to public water and sewer systems, transportation networks, flood control facilities, emergency facilities, and offices can hinder the ability of the government to deliver services. Government can take action to reduce risk to public infrastructure from flood events. Government can also take action to craft public policy that reduces risk to private property from flood events.

Buildings and Roads

In the wake of the 1996 flood events, damage to public buildings statewide represented 34% of total public losses.³² Of particular importance during flood events are critical facilities located in flood hazard areas (i.e., facilities that are critical to government response and recovery activities). During natural hazard events, or any type of emergency or disaster, dependable road connections are critical for providing emergency services. Roads systems in Washington County are maintained by multiple jurisdictions. Federal, state, county, and city

governments all have a stake in protecting roads from flood damage. More than 50% of public assistance appropriations to Washington County following the 1996 floods were to repair damages to the road system.³³ Road networks often traverse floodplain and floodway areas. Transportation agencies responsible for road maintenance are typically aware of roads at risk from flooding.

Bridges

Bridges are key points of concern during flood events for two primary reasons: (1) they are often important links in road networks, crossing water courses or other significant natural features, and (2) they can be obstructions in watercourses, inhibiting the flow of water during flood events. For example, the bridge that crosses the east fork of Dairy Creek in the northwestern part of the County falls under both points listed above. The bridge provides road access to rural County residents on the west side of Dairy Creek, and piers anchored in the middle of the creek support the bridge. During the 1996 flood events, a County bridge on Dairy Creek obstructed the flow of water and debris in the stream, resulting in a temporary dam that contributed to the flooding of nearby properties. Had the bridge been destroyed, local residents would have been severely inconvenienced.

Storm Water Systems

Local drainage problems are common throughout the region. Several communities have drainage master plans, and local public works staffs often know of local drainage threats. The problems often are present where open ditches enter culverts or go underground into storm sewers. In addition, high water tables in some areas can mean wet crawl spaces, yards, and basements after storms because the accumulated water does not drain quickly into a stream or storm sewer. The filling of ditches and swales near buildings or the dumping of debris that can inhibit or prevent the flow of water can compound these problems. Inadequate maintenance, especially following leaf accumulation in the fall, can also contribute to the flood hazard in urban areas.³⁴

Water/Wastewater Treatment Facilities

Portions of Washington County draw drinking water from the Bull Run Reservoir, located outside of the County, as well as from watersheds on the west side of the County. The Joint Water Commission (JWC) Water Treatment Plant processes water from the Tualatin River, Scoggins Creek, and Barney Reservoir. The plant faces significant risk during flood events. During the February 1996 flood events, the JWC Plant was surrounded on all sides by floodwaters.³⁵ The plant was able to maintain operations by instituting emergency procedures. In 2001, the JWC is developing an emergency operations plan that will assist management during hazard events. The JWC faced another significant challenge during the 1996 events—treating water with high levels of turbidity. According to the JWC Plant Operations Manager, water turbidity during the 1996 events was “something we had never seen before.” The JWC Plant can treat high turbidity levels in the water. However, the cost of treating the water increases with turbidity levels. High turbidity levels can be attributed to land use practices up stream that result in increased erosion (e.g., vegetation removal and landslides). Changes in land use practices within the watershed could assist in reducing turbidity levels during flood events.

Clean Water Services (CWS) operates four wastewater treatment plants in the Tualatin Basin at Durham Creek, Rock Creek, Hillsboro, and Forest Grove. The wastewater treatment plant facilities are located adjacent to the floodplain and were not flooded in 1996. The volume of water entering the plants during flood events can be problematic. A new wet weather outfall was recently installed at Rock Creek to improve discharge capacity and structures at risk of flooding have been elevated/flood proofed. CWS is working to improve the tightness of the conveyance system to minimize treatment of non-sewage waters. All four waste water treatment plants have back-up emergency power supplies. Also, the Forest Grove and Hillsboro plants are linked to the Rock Creek plant, so if there were problems at these smaller facilities, the sewage could be treated at Rock Creek. CWS also owns and operates a laboratory and future main office on the edge of the Jackson Bottom Wetlands Preserve in Hillsboro. The site was surrounded by floodwaters in the two flood events of 1996. Access to these facilities is important but not critical.

Parks and Open Space

Current efforts to increase public open space in the County have been paired with the need to restore and preserve natural systems that provide wildlife habitat and help to mitigate flood events. Public parks and publicly owned open spaces can provide a buffer between flood hazards and private property. The Jackson Bottom Wetlands Preserve consists of 650 acres of publicly owned wetlands within the city limits of Hillsboro. Jackson Bottom is managed for wildlife habitat and water quality, as well as passive recreation.³⁶ Preserved open space in the floodplain can help mitigate flood impacts by reducing the amount of allowable development in flood hazard areas. Preserving natural wetlands systems can assist in absorbing water during flood events and providing storage for treated effluent from wastewater treatment plants.

Flood Management Projects

Flood management structures can assist in regulating flood levels by adjusting water flows upstream of flood-prone areas. Scoggins Dam and Henry Hagg Reservoir located on Scoggins Creek in western Washington County provide flood control to help mitigate flood damages downstream of the dam. Although the dam provides some flood protection, it controls only 5% of the drainage into the Tualatin River. The expense of large water detention projects to mitigate flood damages may be a prohibitive factor for local jurisdictions. In 2001, there is still significant emphasis in Washington County on water detention and conveyance projects as a solution to flood damage issues. However, detention or conveyance projects may not be the most cost-effective way to decrease flood damages in high frequency or severely flood-prone areas. Individual property mitigation projects within an affected area may be more effective at reducing flood damage, and less expensive than large detention or conveyance projects that may simply shift the problem downstream.³⁷

Additional flood control projects include levees, diversions, and channel modifications. Levees provide a barrier of earth, steel, or concrete erected between the watercourse and the property to be protected. However, levees may result in the displacement of floodwaters to surrounding properties. Diversion channels direct floodwater to a different location, reducing damage to property within the floodplain or floodway. Diversions may protect certain properties; however, water

diversion may force flood impacts onto new areas. Channel modifications increase the capacity of a stream or river channel to carry water. Channel modifications may not be appropriate for sensitive natural systems within riparian areas.

Floods and Natural Systems

Maintaining and restoring natural systems help mitigate the impact of flood events on the built environment. Flooding changes the natural environment and hydrology of an affected area. High water can be beneficial to the natural processes within a floodplain, and can benefit riparian areas.

Riparian Areas

Riparian areas are important transitional areas, which link water and land ecosystems. Vegetation in riparian areas is dependent on stream processes, such as flooding, and often is composed of plants that require large amounts of water, like willows and cottonwood trees. Healthy vegetation in riparian buffers can reduce streamside erosion.³⁸ During flood events, high water can cause significant erosion. Well-managed riparian areas can reduce the amount of erosion and help to protect water quality during flood events.

Wetlands

Many floodplain and stream-associated wetlands absorb and store storm water flows, which reduces flood velocities and stream bank erosion. Preserving these wetlands reduces flood damage and the need for expensive flood control devices such as levees. When the storms are over, many wetlands augment summer stream flows by slowly releasing the stored water back to the stream system.³⁹ Wetlands are highly effective at removing nitrogen, phosphorous, heavy metals, and other pollutants from water. For this reason, artificial wetlands are often constructed for cleaning stormwater runoff and for tertiary treatment (polishing) of wastewater. Wetlands bordering streams and rivers and those that intercept runoff from fields and roads provide this valuable service free of charge.⁴⁰

Water Quality

The Tualatin River is a sediment-based system. High turbidity is part of its “normal” condition due to the dominance of silts and clays on the valley floor. Streams naturally carry some quantity of sediment (called bed load). When the scouring and deposition of sediments is excessive (i.e., beyond normal bed movement) turbidity becomes a problem in the stream. High flows can generate very high turbidity and suspended solids in the main stem and many of the tributaries. Significant flood events in 1995 and 1996 have increased concern for flood management and control in the watershed.

Title 3: (Metro Code 3.07.310-3.07.370), Water Quality and Flood Management Conservation⁴¹

The goal of the Stream and Floodplain Protection Plan (Title 3) of Metro Regional Government’s Framework plan is to protect the region’s health and public safety by reducing flood and landslide hazards, controlling soil erosion, and reducing pollution of the region’s waterways. Title 3 implements Oregon Land Use Goals 6 and 7 by protecting streams, rivers, wetlands, and floodplains by avoiding, limiting, or mitigating the impact on these areas from development.

Title 3 contains performance standards to protect against flooding. The standards limit development in a manner that requires balanced cut and fill, and requires

floor elevations at least one foot above the flood hazard standard. The areas subject to these requirements have been mapped and adopted by Metro Council. The areas are the FEMA 100-year floodplain and the area of inundation for the February 1996 flood. Title 3 also contains performance standards related to streams, rivers, and wetlands. The purpose of these standards is to protect and allow enhancement of water quality. The water quality areas are rivers and streams with a protected vegetated corridor width depending on the slope of the stream and the number of acres drained by the stream. The performance standards require erosion and sediment control, planting of native vegetation on the stream banks when new development occurs, and prohibition of the storage of uncontained hazardous material in water quality areas.

Flood Hazard Assessment

Hazard Identification

Hazard identification is the first phase of flood hazard assessment. Identification is the process of estimating (1) the geographic extent of the floodplain (i.e., the area at risk from flooding), (2) the intensity of the flooding that can be expected in specific areas of the floodplain, and (3) the probability of occurrence of flood events. This process usually results in a floodplain map. Floodplain maps provide detailed public information that can assist planning jurisdictions in making policy and land use decisions. In Washington County, the Army Corps of Engineers, the Federal Emergency Management Agency (FEMA), and the Washington County Department of Land Use and Transportation have developed floodplain maps. Each map of the floodplain provides important data for determining the areas that fall within the floodplain. To identify the flood hazard area, or floodplain, the County uses the maps from all three agencies. The map that is used depends upon the specific parcel or area in question, and which map provides the best available data for that area. The most conservative best available data, including the Flood Insurance Rate Maps, shall be used for floodplain management purposes.

Data sources

In 1974, the Army Corps of Engineers mapped the 100-year floodplain for the Tualatin River Basin. In 1980, FEMA mapped the 100-year and 500-year floodplains in Washington County. The County has updated portions of the Corps and FEMA maps through smaller drainage studies throughout the County. The County also provides 25-year floodplain data for Tualatin River tributaries, also referenced as the County's Drainage Hazard Areas. Clean Water Services (CWS) is currently in the process of updating floodplain data. The CWS data will become the best available data when it is completed.

The floodplains in Washington County are generally located along the Tualatin River and its tributaries. There are approximately 43,436 acres within the 100-year floodplain boundaries in the County jurisdiction. There are approximately 53,000 acres within the County Drainage Hazard Areas.

Vulnerability Assessment

Vulnerability assessment is the second phase of flood hazard assessment. It combines the floodplain in boundary, generated through hazard identification, with an inventory of the property within the floodplain. It identifies the number of properties at risk from flooding, and the dollar value of the property at risk. Using the floodplain data for Washington County, CPW worked with Washington County to conduct a preliminary vulnerability assessment for flood and drainage hazard areas.

Floodplain Code

Section 421 of the Washington County Community Development Code details requirements for development in floodplains and drainage hazard areas. The overlay zone requirements can help to reduce the vulnerability of new structures in flood hazard areas. The location of structures on tax lots can also affect the vulnerability of the structures to flooding. For more information, see page 4-20.

100-year Floodplain Process

There are approximately 43,436 acres within the 100-year floodplain in Washington County. About 37,640 of these acres are outside of the UGBs in the County Jurisdiction. There are 2,967 tax lots in the County jurisdiction that intersect the 100-year floodplain, comprising a total of 82,343 acres.

Not all of these tax lots, however, lay completely within the floodplain, or have actual structures that are at risk to flood events.

To begin determining an approximation of vulnerable property within the 100-year floodplain, CPW began by culling out all single family homes built after 1974. These homes have all been mitigated per requirements set forth by County and Federal requirements for elevating homes above base-flood elevation. Washington County Assessment and Taxation officials reviewed maps with site-specific parcels for three Washington County property codes: 203, 238, and 711, to determine if a built structure was within the 100-year floodplain boundary. All parcels in these property codes were excluded from the final number for the total number of vulnerable property, as none were found to have any property within the 100-year floodplain.

From the remaining data, CPW calculated those parcels that have 40% or more of their total acreage within the 100-year floodplain. From this process, the calculation resulted in a total of 1,505 tax lots and 27,484.92 acres of vulnerable property within the 100-year floodplain in Washington County. The total value of the land is \$72,221,160. The total value of the buildings on this land is \$63,665,346. These numbers, however, are an approximation of vulnerable property within the floodplain. Up-to-date flood hazard maps and site-specific analysis of all parcels within the floodplain will result in a more accurate number of acres and dollar value of property vulnerable to a 100-year flood event.

Table 4.5. Flood Hazard Vulnerability Assessment
(County Jurisdiction)

Acres in the 100-year Floodplain	37,640
All Tax lots within the 100-year Floodplain (all or partial)	2,967
Acres within 100-year Floodplain (40% or more)	27,485
Tax lots within the 100-year Floodplain (40% or more)	1,505
Total Land Value	\$72,221,160
Total Building Value	\$63,665,346

Source: Washington County GIS data; analysis by CPW, 2001

Drainage Hazard Area Process

There are approximately 53,000 acres within the Drainage Hazard Areas in Washington County. Of this, 45,458 acres are outside of the UGBs in the County Jurisdiction. There are 4,669 tax lots in the County jurisdiction that intersect the Drainage Hazard Areas comprising a total of 659,658 acres. Not all of these tax lots, however, lay completely within the floodplain, or have actual structures that are at risk to flood events.

From the original data set for Washington County Drainage Hazard Areas CPW calculated those parcels that have 40% or more of their total acreage within Drainage Hazard Areas. From this process, the calculation resulted in a total of 1,288 tax lots and 8,575 acres of vulnerable property within the Drainage Hazard Areas in Washington County. The total value of the land is \$73,180,560. The total value of the buildings on this land is \$49,126,422. These numbers, however, are an approximation of vulnerable property within the floodplain. Up-to-date drainage hazard area maps and site-specific analysis of all parcels within the drainage hazard areas will result in a more accurate number for the acres and dollar value of property vulnerable to a 100-year flood event.

Table 4.6. Drainage Hazard Area Vulnerability Assessment
(County Jurisdiction)

Acres within Drainage Hazard Areas	45,458
All Tax lots within Drainage Hazard Areas (all or partial)	4,669
Acres within Drainage Hazard Areas (40% or more)	8,575
Tax lots within Drainage Hazard Areas (40% or more)	1,288
Total Land Value	\$73,180,560
Total Building Value	\$49,126,422

Source: Washington County GIS data; analysis by CPW, 2001

Risk Analysis

Risk analysis is the third and most advanced phase of a hazard assessment. It builds upon the hazard identification and vulnerability assessment.

A flood risk analysis for Washington County should include two components: (1) the amount of loss to both property and life that may result from a flood

event (defined through the vulnerability assessment); and (2) the number of flood events expected to occur over time. Within the broad components of a risk analysis, it is possible to predict the severity of damage from a range of events. For example, a risk analysis can be conducted for both 25-year floodplains (Drainage Hazard Areas), and 100-year floodplains. Over time, the Drainage Hazard Areas will flood more often than areas within a 100-year floodplain, exposing properties in Drainage Hazard Areas to a greater risk of flood damage. However, depending on the impacts resulting from a 25-year flood event versus a 100-year flood event, and the amount of life and property exposed to the different hazard events, the level of risk may vary.

Flow velocity models can assist in predicting the amount of damage expected from different magnitudes of flood events. The data used to develop these models is based on hydrological analysis of landscape features. Changes in the landscape, often associated with human development, can alter the flow velocity and the severity of damage that can be expected from a flood event.

Using GIS technology and flow velocity models, it is possible to map the damage that can be expected from both flood events over time. It is also possible to pinpoint the effects of certain flood events on individual properties.

At the time of publication of this plan, data was insufficient to conduct a risk analysis for flood events in Washington County. However, Clean Water Services is currently developing new floodplain data for significant urban sections of the County. Fostering partnerships between Clean Water Service, County land use planners, and the State Floodplain Manager at the Department of Land Conservation and Development will help to support the development of improved floodplain data throughout the County. This plan includes recommendations for building partnerships that will support the development of a flood risk analysis in Washington County.

Long-Term Flood Action Item #6:

Enhance data and mapping for floodplain information within the County, and identify and map flood-prone areas outside of designated floodplains.

See page 4-29 for more information.

Mitigation Plan Goals and Existing Activities

Mitigation Plan Goals and Public Priorities

To review the mitigation plan goals, go to section 3, page 2 of the Washington County Natural Hazards Mitigation Action Plan.

The mitigation plan goals and action items are derived from review of regional and national natural hazards mitigation plans and planning literature, guidance from the Washington County Natural Hazards Mitigation Plan Steering Committee, and interviews with Washington County stakeholders. The goals for the Washington County Natural Hazards Mitigation Action Plan are broad based to include all of the identified hazards addressed in the plan. Goals for this mitigation plan address four categories:

1. Life, Property, and Natural Systems
2. Public Awareness and Partnerships
3. Emergency Services
4. Implementation

A public workshop was held on May 15, 2001 to identify public priorities for the plan goals and discuss strategies to achieve them. The goal statements and a summary of the public workshop outcomes can be found in Section Three of this plan. All comments from the public workshop are documented in Appendix B.

Through a voting process, the participants identified goal statements in the category of Life, Property, and Natural Systems as their top priority. This section describes existing mitigation activities and flood action items. Multi-hazard action items (i.e., those that broadly address all of the identified hazards) are described in Section Three. Mitigation plan action items are designed to help meet the overall goals of the mitigation plan.

Existing Mitigation Activities

Existing mitigation activities include current mitigation programs and activities that are being implemented by county, regional, state, or federal agencies or organizations.

Local Programs

Washington County Codes

The Community Development Code, *Section 421: Floodplain and Drainage Hazard Area Development*, was first adopted in November 1973, and became effective in January 1974. The current standards were adopted in 1983. These standards direct that the 1974 Corps of Engineers maps and the 1980 FEMA Flood Insurance Rate Maps, including the Flood Boundary and Floodway Maps be used to determine the floodplain, floodway, and Drainage Hazard Areas of Washington County. All lots of record established after 1974 have buildable area outside of the delineated floodplain or Drainage Hazard Area boundaries. Legal lots of record established prior to 1974 may not have buildable area outside of the floodplain. Any building within the floodplain must adhere to the provisions in Section 421.

Affected Properties

Section 421 provides development guidelines for properties in the floodplain, and properties that are within 250 feet of a delineated floodplain. The floodplain is determined through the use of maps and data from FEMA, Army Corps of Engineers, Washington County, and Clean Water Services. The County policy is to use the most current data available to delineate the floodplain in relation to property lines.

Mitigation Requirements

Section 421 requires the following:

- Landowners must submit a detailed delineation of the floodplain in areas planned for development.
- All fill below flood surface elevation (i.e., in the floodplain) be accompanied by an equal or greater amount of cut on the development site.
- Landowners are allowed to avoid the on-site requirement of the cut and fill rule by developing a drainage master plan for the site, or providing off-site excavation to meet the amount of cut required to balance the fill in the floodplain.
- Construction of a new dwelling in the floodplain is prohibited if the property in question has a suitable site for development that is not in the floodplain.
- All new or improved residences (including manufactured homes), and lots for subdivisions and partitions must be elevated at least 1 foot above base flood elevation.
- All new or improved non-residential buildings must be flood-proofed, or elevated to or above base flood elevation.

Acquisition and Protection of Open Space in the Floodplain

Public, private, and non-profit organizations have acquired open space within the floodplain. Washington County, Metro, the city of Hillsboro, and the Oregon Wetlands Joint Venture are among the organizations that have acquired floodplain open space in order to protect natural flood hazard mitigation systems and prevent further development in the floodplain. Clean Water Services owns floodplain open space for use in conjunction with wastewater treatment facilities.

Regional Surface Water Management

Clean Water Services (CWS) manages surface water for all urban municipalities in the County, as well as urban, unincorporated areas within the urban growth boundary. CWS manages surface water with respect to flood management. The Surface Water Management Program, in coordination with local jurisdictions, seeks to provide and maintain urban area surface water management facilities, policies, practices, and controls that protect the public's health, safety, and property. The program also seeks to conserve, and where possible, enhance and restore, the natural

Clean Water Services

For further information, visit the CWS website at:

<http://www.cleanwaterservices.org>

systems of the Tualatin River Basin. CWS is authorized by state law to set fees and charges for connection to and use of, the public facilities and public services related to surface water management.⁴²

Healthy Streams Plan

Clean Water Services began the development of the Healthy Streams Plan concept in October of 1999, following the listing of winter steelhead and spring Chinook as threatened species under the Endangered Species Act. The purpose of the project is to develop a watershed-based plan that integrates the requirements of the Clean Water Act (CWA) and the Endangered Species Act (ESA) in a manner that promotes overall stream health. The plan will identify and prioritize specific projects, policies, and programmatic changes needed to further improve water quality, manage flooding and floodplains, and provide for aquatic species recovery in the Tualatin River Basin. The Healthy Streams Plan has six major components outlined below in chronological order. All components are expected to be completed by Winter 2002.

Actions

- Watersheds 2000 Inventory (topography, ecological survey, hydrology/hydraulic modeling);
- Fish friendly reviews of existing activities;
- Economic analysis and funding strategy development;
- Public values analysis;
- Programmatic and policy focus areas (impervious cover, vegetated corridors, landscape management, hydrology/hydraulics, storm water pretreatment); and
- Document preparation and final plan approval.

Clean Water Services has been working with project partners in the basin including: Washington County, cities in Washington County, Tualatin Hills Park and Recreation District, Metro, the Soil and Water Conservation District, and the Federal Emergency Management Agency.

Integrated Water Resources Management

The Water Managers of Washington County developed an Integrated Water Resources Management Plan (IWRM) to help collaboratively manage water resources throughout the County.

The water needs of the Tualatin Basin are projected to double by 2050, with conservation alone unable to make up the shortfall. The IWRM plan recognizes the diverse needs and priorities of water users and regulators and has been reviewed by the Tualatin River Watershed Council, a voluntary forum of watershed stakeholders who represent varying interests. A stakeholder survey found unanimous agreement that the top priorities for water management must be to protect the environment and promote sustainability.

When the IWRM plan is implemented, priority action items are those that meet multiple objectives. Two recommendations would increase storm water and floodwater retention, increase tributary flows, and improve the overall health of

the watershed. They include promoting wetland and riparian restoration, and evaluating opportunities for small in-line or off-line storage.

The plan also recommends that the following be considered priorities:

- Implement tributary management activities;
- Evaluate replacing tributary irrigation water with other supplies; and
- Evaluate new sources of water supply (Portland/Bull Run, Willamette River, Hagg Lake)

Tualatin River Watershed Council Action Plan

The Tualatin River Watershed Council Action Plan contains the Watershed Council's goals, objectives, and priority action items for the Tualatin River Basin. The Plan describes specific ways to participate in protecting and restoring degraded areas through public, private, and volunteer efforts. The Plan lists 10 priority action items, including promoting practices that improve watershed functions, working with other organizations to implement the Integrated Water Resource Management plan, and improving citizen awareness and education opportunities with respect to watershed issues.

State Programs

State of Oregon Floodplain and Floodway Removal/Fill Law

The Oregon Removal/Fill Law, which is administered by the Oregon Division of State Lands, requires a permit for activities that would remove or fill 50 cubic yards or more of material in waters of the state (e.g., streams, lakes, wetlands). Clean Water Services, partner cities, and Washington County must comply with the removal/fill laws when designing and building facilities, and have related responsibilities when dealing with private development and other construction projects.⁴³

Oregon's Wetlands Protection Program

Oregon's Wetlands Program was created in 1989 to integrate federal and state rules concerning wetlands protection with the Oregon Land Use Planning Program. The Wetlands Program has a mandate to work closely with local governments and the Division of State Lands (DSL) to improve land use planning approaches to wetlands conservation. A Local Wetlands Inventory (LWI) is one component of that program. DSL also develops technical manuals, conducts wetlands workshops for planners, provides grant funds for wetlands planning, and works directly with local governments on wetlands planning tasks.

Oregon Wetlands Joint Venture

The Oregon Wetlands Joint Venture is a coalition of private conservation, waterfowl, fisheries, and agriculture organizations working with government agencies to protect and restore important wetland habitats. The organization is currently involved in purchasing and restoring more than 1,000 acres in the Tualatin River floodplain.⁴⁴

Student Watershed Research Project (SWRP)

Although not directly involved in flood hazard mitigation projects, SWRP is an example of a local education program that works with issues of water quality and watershed health. SWRP is a partnership between schools in the Portland

Metropolitan Area and scientists specializing in watershed issues. The project provides education opportunities for students by involving them in data gathering activities in local watersheds.

Federal Programs

National Weather Service

The National Weather Service provides flood watches, warnings, and informational statements for rivers in Washington County. The majority of the County falls in the NWS “Willamette Tributary” region. The far western and northwestern portions of the County fall in the “SW Washington/NW Oregon” region.

National Resources Conservation Service (NRCS), US Department of Agriculture

NRCS provides a suite of federal programs designed to assist state and local governments and landowners in mitigating the impacts of flood events. The Watershed Surveys and Planning Program and the Small Watershed Program provide technical and financial assistance to help participants solve natural resource and related economic problems on a watershed basis. The Wetlands Reserve Program and the Flood Risk Reduction Program provide financial incentives to landowners to put aside land that is either a wetland resource, or that experiences frequent flooding. The Emergency Watershed Protection Program (EWP) provides technical and financial assistance to clearing debris from clogged waterways, restoring vegetation, and stabilizing riverbanks. The measures taken under EWP must be environmentally and economically sound and generally benefit more than one property.

Federal Emergency Management Agency (FEMA) Programs

FEMA provides maps of flood hazard areas, various publications related to flood mitigation, funding for flood mitigation projects, and technical assistance.

National Flood Insurance Program (NFIP)

Oregon has 256 flood-prone communities. Flood insurance is available to citizens in communities that adopt and implement NFIP siting and building standards. The standards are applied to development that occurs within a delineated floodplain, a drainage hazard area, and properties within 250 feet of a floodplain boundary. These areas are depicted on federal Flood Insurance Rate Maps available through the County. Oregon’s Department of Land Conservation and Development is the state’s NFIP coordinating agency.

The Community Rating System (CRS)

The Community Rating System (CRS) recognizes community floodplain management efforts that go beyond the minimum requirements of the NFIP. Property owners within the County would receive reduced NFIP flood insurance premiums if the County implements floodplain management practices that qualify it for a CRS rating. For further information on the CRS, visit FEMA’s website at <http://www.fema.gov/nfip/crs.htm>.

Flood Mitigation Action Items

The flood mitigation action items provide direction on specific activities that organizations and residents in Washington County can undertake to reduce risk and prevent loss from flood events. There are six short-term and six long-term flood hazard action items described below. Each action item is followed by ideas for implementation, which can be used by the steering committee and local decision makers in pursuing strategies for implementation.

To review the multi-hazard mitigation action items, refer to section 3, page 4 of the Washington County Natural Hazards Mitigation Action Plan.

ST-FL#1: Adopt stricter elevation requirements for development within the floodplain.

Ideas for Implementation

- Evaluate elevation requirements for new residential and non-residential structures in the unincorporated floodplain area. Currently, residential structures must be elevated to one foot above the 100-year base flood elevation. Non-residential structures must be at or above the 100-year base flood elevation.
- Raise the base elevation requirement for new residential construction to two or three feet above base flood elevation, or greater. An increased elevation standard is one activity the County can engage in to receive credit from the NFIP Community Rating System Program.

Coordinating Organization: Washington County
Partner Organizations: Cities, CWS, DLCD
Timeline: 1-3 years
Plan Goals Addressed: Life, Property, and Natural Systems

ST-FL#2: Implement the steps needed for Washington County to become a participant in the NFIP's Community Rating System.

Ideas for Implementation

- County officials should review the requirements for CRS participation and assess the steps needed to obtain certification.
- County officials should pursue certification under the CRS program.

Coordinating Organization: Washington County
Partner Organizations: Cities, CWS, DLCD
Timeline: 1-3 years
Plan Goals Addressed: Life, Property, and Natural Systems

ST-FL#3: Prepare an inventory of repetitively flooded properties within the Tualatin Basin. Analyze each property to identify viable mitigation options. Reduce the number of repetitive flood loss properties.

Ideas for Implementation

- Use insurance claim data from FEMA and OEM to identify properties in the County that have filed more than one National Flood Insurance Program (NFIP) insurance claim. Some properties that have experienced repetitive flood damage may not be enrolled in the NFIP (e.g., properties not in the floodplain, but experiencing damage from urban flooding). Data concerning these properties may be more difficult to obtain.
- Map each property relative to the floodplain and Drainage Hazard Areas.
- Consider identified properties for mitigation activities. Funding for mitigation may be available through FEMA's Hazard Mitigation Grant or Flood Mitigation Assistance programs.

Coordinating Organization: Washington County

Partner Organizations: OEM, DLCD, FEMA, NRCS, Cities, CWS

Timeline: Ongoing

Plan Goals Addressed: Life, Property, and Natural Systems

ST-FL#4: Identify critical public infrastructure and facilities located in flood hazard areas and highlight those facilities as a focus for mitigation and preparedness measures.

Critical facilities fall into two principal categories: (1) buildings, bridges, roadways, or locations vital to emergency response efforts, and (2) those facilities that, if damaged, could cause secondary or compound disasters (e.g., sewer and gas lines).^{xlv}

Ideas for Implementation

- Establish which critical facilities are at risk from flood events.
- Develop strategies to mitigate risk to these facilities, or to utilize alternative facilities should flood events cause damages to the facilities in question.

Coordinating Organization: Washington County

Partner Organizations: Portland General Electric, Northwest Natural Gas, Tualatin Valley Water District, Cities, CWS

Timeline: 1-3 years

Plan Goals Addressed: Emergency Services

ST-FL#5: Identify non-natural floodway obstructions for all parts of unincorporated Washington County.

Ideas for Implementation

- Map culverts in unincorporated areas of the County.
- Prepare an inventory of culverts that historically create flooding problems and target them for retrofitting.
- Prepare an inventory of urban drainage problems.
- Identify causes and potential mitigation actions for urban drainage problem areas.

Coordinating Organization: CWS, Washington County
Partner Organization: TRWC, NRCS, SWCD, Cities, ODF
Timeline: Ongoing
Plan Goals Addressed: Life, Property, and Natural Systems

ST-FL#6: Maintain and/or increase flood storage capacity.

Ideas for Implementation

- Pursue consistent implementation of balance cut and fill and no net loss of flood storage capacity and no adverse impact.

Coordinating Organization: Washington County
Partner Organizations: Metro, DLCD, CWS, Cities
Timeline: 18 months
Plan Goals Addressed: Life, Property, and Natural Systems

LT-FL#1: Develop acquisition and management strategies to preserve open space in the floodplain.

Ideas for Implementation

- Develop a comprehensive strategy for acquiring and managing floodplain open space in Washington County.
- Explore funding for open space acquisition from federal (e.g., FEMA Hazard Mitigation Grant Program), state, regional, and local governments, as well as private and non-profit organizations.
- Consolidate funds to manage public open space in floodplains. Organizations in the County that manage floodplain open space should consider combining resources in a single countywide fund. Potentially managed by CWS, this fund could be used for regional management of floodplain open space in the Tualatin River Basin.

Coordinating Organization: Washington County
Partner Organizations: Cities, CWS, TRWC, Metro, FEMA
Timeline: Ongoing
Plan Goals Addressed: Life, Property, and Natural Systems

LT-FL#2: Develop strategies to enhance the use of open space within the floodplain for flood mitigation, fish habitat, and water quality issues.

Ideas for Implementation

- Develop a regional partnership between flood mitigation organizations/programs and fish habitat enhancement organizations/programs.
- Identify sites where environmental restoration work can benefit flood mitigation, fish habitat, and water quality.
- Work with landowners to develop flood management practices that provide healthy fish habitat.

Coordinating Organization: Tualatin River Watershed Council (areas outside UGB) CWS (areas within UGB)

Partner Organizations: Cities, Washington County, ODFW, NRCS, SWCD

Timeline: Ongoing

Plan Goals Addressed: Life, Property, and Natural Systems

LT-FL#3: Develop outreach programs to business organizations that must manage for flood protection.

Ideas for Implementation

- Create a flood education curriculum and a speaker-training program.
- Develop a contact list of businesses that may have an interest in flood mitigation or flood response issues.
- Recruit individuals to speak to businesses/employees about flood issues.

Coordinating Organization: Washington County

Partner Organizations: CWS, TRWC, Tualatin Riverkeepers, IISOI, Cities, DLCD, OEM

Timeline: Ongoing

Plan Goals Addressed: Public Awareness and Partnerships

LT-FL#4: Integrate a flood hazard component into local watershed education programs.

Ideas for Implementation

- Identify existing watershed education programs (e.g., Student Watershed Research Project, Community Watershed Stewardship Program, Tualatin Riverkeepers) and determine which programs would support a flood education component.
- Collaborate with existing program managers to develop a flood education component that supports the fish habitat and water quality education curriculums.

LT-FL#4, continued

Coordinating Organization: Washington County

Partner Organizations: CWS, Tualatin River Watershed Council, TPAC, NRCS, SWCD, Cities

Timeline: Ongoing

Plan Goals Addressed: Public Awareness and Partnerships

LT-FL#5: Develop and implement a surface water management plan for areas outside the urban growth boundary.

Ideas for Implementation

- Establish a framework to extend the current surface water management plan to areas outside the urban growth boundary. Focus on connecting current systems and plans to areas not currently within surface water management plan boundaries.

Coordinating Organization: Washington County

Partner Organization: Cities, CWS, TRWC, ODF, SWCD

Timeline: Ongoing

Plan Goals Addressed: Life, Property, and Natural Systems

LT-FL#6: Enhance data and mapping for floodplain information within the County, and identify and map flood-prone areas outside of designated floodplains.

Ideas for Implementation

- Identify and provide mitigation guidance to owners of properties at risk from flooding that are not within designated Special Flood Hazard Areas.
- Prepare floodplain maps for all local streams not currently mapped on Flood Insurance Rate Maps or County maps, with special attention focused on mapping rural and unincorporated areas. The maps should show the expected frequency of flooding, the level of flooding, and the areas subject to inundation. The maps can be used for planning, risk analysis, and emergency management.

Coordinating Organization: Outside UGB: Washington County and Cities Inside UGB: Cities, CWS

Partner Organization: CWS, NRCS, SWCD

Timeline: 1-5 years

Plan Goals Addressed: Life, Property, and Natural Systems

Flood Resource Directory

County Resources

Washington County Office of Emergency Management

The Washington County Emergency Management Program exists pursuant to ORS 401 to guide the county's preparations for, response to, and recovery from major emergencies and disasters. The program is organized under the county sheriff's office and oversees preparation and maintenance of the county's emergency operations plan and emergency operations center and the training and exercising of designated staff.

Unique to Washington County is a consolidated office that brings the emergency management staffs from four jurisdictions together into a single office to enhance disaster preparedness activities countywide.

The Office of Consolidated Emergency Management (OCEM) for Washington County was formed in 1995 by Intergovernmental Agreement between Washington County, the cities of Beaverton and Hillsboro, and Tualatin Valley Fire and Rescue. The organization's mission statement indicates that "The Office of Consolidated Emergency Management for Washington County is committed to the development and maintenance of a countywide, integrated system to prepare for, respond to, recover from, and mitigate against disasters."

For more information on county, state and federal natural hazard mitigation programs and activities, refer to *Appendix A: Resource Directory*

Contact: Director, Office of Consolidated Emergency Management of Washington County
Address: 20665 SW Blanton St., Aloha, OR, 97007
Phone: (503) 642-0371
Website: <http://www.ocem.org>
Email: info@ocem.org

Washington County Department of Land Use and Transportation

The Department of Land Use and Transportation prepares, implements, and enforces the Community Development Code in areas under County jurisdiction. Section 421 of the Community Development Code deals specifically with development in and around floodplains. The County maintains the data and maps that delineate the floodplains and also provides land use maps that identify comprehensive plan designations and zoning for all parcels under County jurisdiction.

Contact: Washington County Department of Land Use and Transportation
Address: 155 N First Ave. Suite 350, MS 13, Hillsboro, OR 97124
Phone: (503) 846-3872
Fax: (503) 846-2908
Website: <http://www.co.washington.or.us/>
Email: lutdir@co.washington.or.us

Clean Water Services (CWS)

Clean Water Services (formerly the Unified Sewerage Agency) provides sanitary sewer and storm water management services to large portions of Washington County. CWS works with the County and cities within the County to build and maintain public drainage systems that meet public needs and comply with regulations set by the Oregon Department of Environment Quality. CWS maintains storm sewers and pipelines, open drainage ditches, and stormwater detention ponds. CWS also develops long-term flood management plans, including, but not limited to protection of riparian buffer areas and wetland preservation. CWS is slated to complete the Watersheds 2000 project in 2001, an inventory of the location and condition of the stream (surface water) system in the Tualatin Basin.

Contact: Clean Water Services
Address: 2550 SW Hillsboro Highway, Hillsboro, OR 97123
Phone: (503) 681-3600
Fax: (503) 681-3603
Website: <http://www.cleanwaterservices.org/>

Tualatin River Watershed Council

The Tualatin River Watershed Council was initiated in 1993 to provide more coordinated and integrated resource planning for the Tualatin River watershed. Its purpose is to address watershed management issues in the Tualatin Basin and provide a framework for coordination and cooperation among key interests. The Council consists of 19 members representing various stakeholders in the watershed including citizens, local governments, agriculture, business, and industry, environmental groups, forestry, water and sewer districts, neighborhood associations, and educators.^{xlvi}

Contact: Council Coordinator
Address: 1080 SW Baseline Building B, Suite B-2, Hillsboro, OR 97123
Phone: (503) 648-3174 ext. 116
Website: <http://www.trwc.org>

Tualatin Riverkeepers

The Tualatin Riverkeepers provide volunteer-based educational and monitoring programs for the Tualatin River Basin. Programs include van tours, canoe trips, speaking engagements, and river cleanups. They focus on preserving the “biotic integrity” of the river system.

Contact: Executive Director
Address: 16340 S.W. Beef Bend Rd., Sherwood, OR 97140
Phone: (503) 590-5813
Website: <http://www.teleport.com/~triverk/>
Email: info@tualatinriverkeepers.org

Tualatin Valley Irrigation District

The Tualatin Valley Irrigation District's objectives are (1) to distribute water on a fair and equitable basis to each water user according to his or her right, (2) to use the best methods of water management to assure efficient, economic operation and provide the best possible service to water users, (3) to operate and maintain a system capable of storing and delivering water to users when needed, and (4) to encourage wise use and conservation of water resources.

Contact: Tualatin Valley Irrigation District
Address: 2330 Elm Street, Forest Grove, OR 97116
Phone: (503) 357-3118
Email: water@tvid.org

Regional Resources

Metro Regional Government

Metro is the directly elected regional government that serves more than 1.3 million residents in Clackamas, Multnomah, and Washington counties and 24 cities in the Portland metropolitan area. Chapter 5 of Metro's Regional Framework Plan addresses natural hazards. Metro's Natural Hazards Program is a service of the Growth Management Services Department's Data Resource Center. Their web pages relate to natural hazards that may impact the Portland metropolitan area. Their links provide information about the natural hazards in the Portland metropolitan area and suggest tools for reducing potential damages before disaster strikes. Metro produced the *Regional Hazard Mitigation Policy and Planning Guide* in 1999 to assist local governments in planning for future natural hazard events.

Contact 1: Metro Regional Government
Address: 600 NE Grand Ave, Portland, OR 97232-2736
Phone: (503) 797-1839
Fax: (503) 797-1911
Website: <http://www.metro.dst.or.us/metro/growth/gms.html>
Email: 2040@metro-region.org

Contact 2: Metro Data Resource Center
Website: <http://storefront.metro.dst.or.us/drc/nathaz/nathaz.cfm>
Email: drc@metro.dst.or.us

State Resources

Department of Land Conservation and Development (DLCD)

DLCD administers the state's Land Use Planning Program. The program is based on 19 Statewide Planning Goals, including Goal 7, related to natural hazards, with flood as its major focus. DLCD serves as the federally designated agency to coordinate floodplain management in Oregon. They also conduct various landslide related mitigation activities. In order to help local governments address natural hazards effectively, DLCD provides technical assistance such as conducting workshops, reviewing local land use plan amendments, and working interactively with other agencies.

Contact: Natural Hazards Program Manager, DLCD
Address: 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540
Phone: (503) 373-0050
Fax: (503) 378-6033
Website: <http://www.lcd.state.or.us/hazards.html>

Oregon Floodplain Coordinator: (503) 373-0050 ext. 255

Office of Homeland Security -Office of Emergency Management (OEM)

OEM administers FEMA's Hazard Mitigation Grant Program, which provides post-disaster monies for acquisition, elevation, relocation, and demolition of structures located in the floodplain. OEM also administers FEMA's Flood Mitigation Assistance Program. This program provides assistance for NFIP insured structures only. OEM also helps local jurisdictions to develop hazard mitigation plans. OEM is heavily involved in flood damage assessment and works mainly with disaster recovery and hazard mitigation programs. OEM provides training for local governments through workshops on recovery and mitigation. OEM also helps implement and manage federal disaster recovery programs.

Contact: Office of Emergency Management
Address: 3225 State Street, Salem, OR 97301
Phone: (503) 378-2911
Fax: (503) 378-7833
Website: <http://www.oem.state.or.us/oem/>
OEM Hazard Mitigation Officer: (503) 378-2911 ext. 22247
Recovery and Mitigation Specialist: (503) 378-2911 ext. 22240

Oregon Department of Fish and Wildlife (ODFW)

ODFW's mission is to protect and enhance Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations. ODFW regulates stream activity and engages in stream enhancement activities.

Contact: ODFW
Address: 3406 Terry Avenue NE, Salem, OR 97303
Phone: (503) 947-6000
Website: <http://www.dfw.state.or.us/>
Email: Odfw.Info@state.or.us

Oregon Division of State Lands (DSL)

DSL is a regulatory agency, responsible for administration of Oregon's Removal-Fill Law. This law is intended to protect, conserve, and make the best use of the state's water resources. It generally requires a permit from DSL to remove, fill, or alter more than 50 cubic yards of material within the bed or banks of waters of the state. Exceptions are in state scenic waterways and areas designated essential salmon habitat, where a permit is required for all instream activity, regardless of size. DSL and the US Army Corps of Engineers may issue these permits jointly.

Contact: Division of State Lands
Address: 775 Summer Street NE, Suite 100, Salem, OR 97301-1279
Phone: (503) 378-3805
Fax: (503) 378-4844
Website: <http://statelands.dsl.state.or.us/>
Assistant Director: (503) 378-3805, ext. 279
Western Region Manager: (503) 378-3805, ext. 244

Oregon Water Resources Department (WRD)

The WRD's mission is to serve the public by practicing and promoting wise long-term water management. The WRD provides services through 19 watermaster

offices throughout the state. In addition, five regional offices provide services based on geographic regions. The Department's main administration is performed from the central office in Salem.

Contact: WRD
Address: 158 12th ST. NE, Salem, OR 97301-4172
Phone: (503) 378-8455
Website: <http://www.wrd.state.or.us/index.shtml>
http://www.co.washington.or.us/dptmts/wtr_mstr/wtr_mstr.htm

Federal Resources and Programs

Federal Emergency Management Agency (FEMA)

FEMA provides maps of flood hazard areas, various publications related to flood mitigation, funding for flood mitigation projects, and technical assistance. FEMA also operates the National Flood Insurance Program. FEMA's mission is "to reduce loss of life and property and protect the nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response and recovery." FEMA Region X serves the northwestern states of Alaska, Idaho, Oregon, and Washington.

Contact: FEMA, Federal Regional Center, Region 10
Address: 228th St. SW, Bothell, WA 98021-9796
Phone: (425) 487-4678
Website: <http://www.fema.gov>

To obtain FEMA publications:

Phone: (800) 480-2520

To obtain FEMA maps:

Contact: Map Service Center
Address: P.O. Box 1038, Jessup, Maryland 20794-1038
Phone: (800) 358-9616
Fax: (800) 358-9620

United States Geological Survey (USGS)

The USGS website provides current streamflow conditions at USGS gauging stations in Oregon and throughout the Pacific Northwest. The Oregon USGS office is responsible for water-resources investigations for Oregon and part of southern Washington. Their office cooperates with more than 40 local, state, and federal agencies in Oregon. Cooperative activities include water-resources data collection and interpretive water-availability and water-quality studies.

Contact: USGS Oregon District Office
Address: 10615 S.E. Cherry Blossom Dr., Portland, OR 97216
Phone: (503) 251-3200
Fax: (503) 251-3470
Website: <http://oregon.usgs.gov>
Email: info-or@usgs.gov

Bureau of Reclamation

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. The Bureau of Reclamation owns Scoggins

Dam in Washington County and prepares emergency action plans for events at the dam.

Contact: Bureau of Reclamation, Pacific Northwest Region
Address: 1150 N. Curtis Road, Boise, ID 83706
Phone: (208) 378-5012
Website: <http://www.pn.usbr.gov/contact/index.shtml>

Army Corps of Engineers

The Corps of Engineers administers a permit program to ensure that the nation's waterways are used in the public interest. Any person, firm, or agency planning to work in waters of the United States must first obtain a permit from the Army Corps of Engineers. In Oregon, joint permits may be issued with the Division of State Lands. The Corps is responsible for the protection and development of the nation's water resources, including navigation, flood control, energy production through hydropower management, water supply storage and recreation.

Contact: US Army Corps of Engineers-Portland District, Floodplain Information Branch
Address: P.O. Box 2946, Portland, OR 97208-2946
Phone: (503) 808-4874
Fax: (503) 808-4875
Website: <http://www.nwp.usace.army.mil/>

National Weather Service, Portland Bureau

The National Weather Service provides flood watches, warnings, and informational statements for rivers in Washington County. The majority of the County falls in the NWS "Willamette Tributary" region. The far western and northwestern portions of the County fall in the "SW Washington/NW Oregon" region. The NWS Portland office provides river level information online and by phone.

Contact: National Weather Service, Portland Bureau
Address: P.O. Box 2946, Portland, OR 97208-2946
Phone: (503) 261-9246 or (503) 261-9247
Fax: (503) 808-4875
Website: http://www.wrh.noaa.gov/Portland/public_hydro/

Washington County Soil and Water Conservation District (SWCD)

The SWCD works in partnership with the Natural Resource Conservation Service to promote soil and water conservation in Washington County. SWCD works with agricultural interests and landowners to provide information on natural resource conservation practices. The partnership blends individual member resources to offer technical and financial assistance in planning and applying natural resource conservation practices and systems. Areas of focus include: erosion management, wetlands preservation and restoration, resource inventories, watershed assessments, and conservation education.

Contact: Washington County Soil and Water Conservation District
Address: 1080 SW Baseline Building B, Suite B-2, Hillsboro, OR 97123
Phone: (503) 681-0953
Fax: (503) 640-1332
Website: <http://www.swcd.net/>

National Resources Conservation Service (NRCS), US Department of Agriculture (USDA)

NRCS provides a suite of federal programs designed to assist state and local governments, and landowners in mitigating the impacts of flood events. The Watershed Surveys and Planning Program and the Small Watershed Program provide technical and financial assistance to help participants solve natural resource and related economic problems on a watershed basis. The Wetlands Reserve Program and the Flood Risk Reduction Program provide financial incentives to landowners to put aside land that is either a wetland resource or experiences frequent flooding. The Emergency Watershed Protection Program (EWP) provides technical and financial assistance for clearing debris from clogged waterways, restoring vegetation, and stabilizing riverbanks. The measures taken under the EWP must be environmentally and economically sound and generally benefit more than one property.

Contact: USDA-NRCS
Address: 1080 SW Baseline, Bldg B, Suite B-2, Hillsboro 97123-3823
Phone: (503) 648-3174
Fax: (503) 640-1332
Website: <http://www.swcd.net/>

Additional Resources

The National Flood Insurance Program

The National Flood Insurance Program (NFIP) Website is a subsection of the Federal Emergency Management Agency (FEMA) site (<http://www.fema.gov>). The NFIP information is intended for both the general public and the many organizations and agencies participating in the program. It includes information about the NFIP and other flood disaster assistance available from the Federal Government. It also provides access to the newly revised NFIP booklet: *Answers to Questions about the National Flood Insurance Program*.

Contact: The National Flood Insurance Program
Phone: (888) FLOOD29 or (800) 427-5593
Website: <http://www.fema.gov/nfip>

The Association of State Floodplain Managers

The Association of State Floodplain Managers is an organization of professionals involved in floodplain management, flood hazard mitigation, the National Flood Insurance Program, and flood preparedness, warning, and recovery. ASFPM fosters communication among those responsible for flood hazard activities, provides technical advice to governments and other entities about proposed actions or policies that will affect flood hazards, and encourages flood hazard research, education, and training. The ASFPM Web site includes information on how to become a member, the organization's constitution and bylaws, directories of officers and committees, a publications list, information on upcoming conferences, a history of the association, and other useful information and Internet links.

Contact: The Association of State Floodplain Managers
Address: 2809 Fish Hatchery Road, Madison, WI 53713
Phone: (608) 274-0123
Website: <http://www.floods.org>

USGS Water Resources

This web page offers current US water news; extensive current (including real-time) and historical water data; numerous fact sheets and other publications; various technical resources; descriptions of ongoing water survey programs; local water information; and connections to other sources of water information.

Contact: USGS Water Resources
Phone: (503) 251-3200
Website: <http://water.usgs.gov> or <http://water.usgs.gov/public/realtime.html>
Email: info-or@usgs.gov

Office of Hydrology, National Weather Service

The National Weather Service's Office of Hydrology (OH) and its Hydrological Information Center offer information on floods and other aquatic disasters. This site offers current and historical data including an archive of past flood summaries, information on current hydrologic conditions, water supply outlooks, an Automated Local Flood Warning Systems Handbook, Natural Disaster Survey Reports, and other scientific publications on hydrology and flooding.

Contact: Office of Hydrology, National Weather Service
Website: <http://www.nws.noaa.gov/oh> or <http://www.nws.noaa.gov/oh/hic/>

The Floodplain Management Association

The Floodplain Management website was established by the Floodplain Management Association (FMA) to serve the entire floodplain management community. It includes full-text articles, a calendar of upcoming events, a list of positions available, an index of publications available free or at nominal cost, a list of associations, a list of firms and consultants in floodplain management, an index of newsletters dealing with flood issues (with hypertext links if available), a section on the basics of floodplain management, a list of frequently asked questions (FAQs) about the Website, and, of course, a copious catalog of Web links.

Contact: Floodplain Managers Association
Website: <http://www.floodplain.org>
Email: admin@floodplain.org

Northwest Regional Floodplain Managers Association (NORFMA)

This site is a resource for floodplains, fisheries, and river engineering information for the Northwest. This site provides technical information, articles, and Internet links in the field of floodplain and fisheries management.

Contact: Northwest Regional Floodplain Managers Association
Website: <http://www.norfma.org/>

FEMA's List of Flood Related Websites

This site contains a long list of flood related Internet sites from "American Heritage Rivers" to "The Weather Channel," and is a good starting point for flood information on the Internet.

Contact: Federal Emergency Management Agency.
Phone: (800) 480-2520
Website: <http://www.fema.gov/nfip/related.htm>

Publications

Planning for Natural Hazards: The Oregon Technical Resource Guide,
Department of Land Conservation and Development (July 2000).

Produced by the Community Planning Workshop for the Department of Land Conservation and Development, this is a natural hazards planning and mitigation resource for Oregon cities and counties. It provides hazard-specific resources and plan evaluation tools. The document was written for local government employees and officials. The Technical Resource Guide includes a natural hazards comprehensive plan review, a hazard mitigation legal issues guide, and five hazard-specific technical resource guides, including: flooding, wildfires, landslides, coastal hazards, and earthquakes. This document is available online. You can also write, call, or fax to obtain this document:

Contact: Natural Hazards Program Manager, Department of Land Conservation and Development
Address: 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540
Phone: (503) 373-0050
Fax: (503) 378-6033
Website: <http://www.lcd.state.or.us/hazards.html>

NFIP Community Rating System Coordinator's Manual. FEMA/NFIP.
Indianapolis, IN.

This informative brochure explains how the Community Rating System works and what the benefits are to communities. It explains in detail the CRS point system, and what activities communities can pursue to earn points. These points then add up to the "rating" for the community, and flood insurance premium discounts are calculated based upon that "rating." The brochure also provides a table on the percent discount realized for each rating (1-10). Instructions on how to apply to be a CRS community are also included.

Contact: NFIP Community Rating System
Phone: (800) 480-2520 or (317) 848-2898
Website: <http://www.fema.gov/nfip/crs.htm>

Floodplain Management: A Local Floodplain Administrator's Guide to the NFIP.
FEMA-Region 10. Bothell, WA.

This document discusses floodplain processes and terminology. It contains floodplain management and mitigation strategies, as well as information on the NFIP, CRS, Community Assistance Visits, and floodplain development standards.

Contact: National Flood Insurance Program
Phone: (800) 480-2520
Website: <http://www.fema.gov/nfip/>

Flood Hazard Mitigation Planning: A Community Guide, (June 1997),
Massachusetts Department of Environmental Management.

This informative guide offers a ten-step process for successful flood hazard mitigation. Steps include: map hazards, determine potential damage areas, take an inventory of facilities in the flood zone, determine what is or is not being

done about flooding, identify gaps in protection, brainstorm alternatives and actions, determine feasible actions, coordinate with others, prioritize actions, develop strategies for implementation, and adopt and monitor the plan.

Contact: Massachusetts Flood Hazard Management Program
Phone: (617) 626-1250
Website: <http://www.magnet.state.ma.us/dem/programs/mitigate>

Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials, (February 1987), FEMA-116.

This guidebook offers a table on actions that communities can take to reduce flood losses. It also offers a table with sources for floodplain mapping assistance for the various types of flooding hazards. There is information on various types of flood hazards with regard to existing mitigation efforts and options for action (policy and programs, mapping, regulatory, non-regulatory). Types of flooding which are covered include alluvial fan, areas behind levees, areas below unsafe dams, coastal flooding, flash floods, fluctuating lake level floods, ground failure triggered by earthquakes, ice jam flooding, and mudslides.

Contact: Federal Emergency Management Agency
Phone: (800) 480-2520
Website: <http://www.fema.gov>

Oregon Model Flood Damage Prevention Ordinance, (January 1999), FEMA/DLCD.

This is an example of how to write an ordinance that complies with NFIP/FEMA standards. Communities can simply adopt this ordinance, word for word, filling in the blanks specific to their community or jurisdiction.

Contact: Department of Land Conservation and Development
Phone: (503) 373-0050
Website: <http://www.lcd.state.or.us/hazards.html>

Flood Endnotes

¹ The Interagency Hazards Mitigation Team, *State Hazard Mitigation Plan*, (Oregon State Police – Office of Emergency Management, June 2000).

² *Planning for Natural Hazards: The Oregon Technical Resource Guide*, Department of Land Conservation and Development (July 2000), Ch. 4.

³ Ibid.

⁴ U.S Army Corps of Engineers, Portland District, Website: <https://www.nwp.usace.army.mil/history.htm> (May 2001).

⁵ Oregon Climate Service, Website: <http://www.ocs.orst.edu/reports/flood96/> (March 2001).

⁶ February 1996 Flooding and Landslides and Stream Erosion in the State of Oregon. The Interagency Hazards Mitigation Team (1996) Oregon State Police – Office of Emergency Management.

⁷ Dennis Sigrist. Oregon Emergency Management, Washington County Cumulative NFIP Loss Data. (February 2001).

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- ⁸ The Interagency Hazards Mitigation Team, *State Hazard Mitigation Plan*, (Oregon State Police – Office of Emergency Management, June 2000).
- ⁹ Tualatin River Watershed Council, <http://www.trwc.org/> (February 2001).
- ¹⁰ Ibid.
- ¹¹ Ibid.
- ¹² Washington County Office of Consolidated Emergency Management, website: <http://www.co.washington.or.us/ocem/floods.htm>
- ¹³ *Planning for Natural Hazards: The Oregon Technical Resource Guide*, Department of Land Conservation and Development (July 2000), Ch. 4.
- ¹⁴ Tualatin River Watershed Council, <http://www.trwc.org/> (March 2001).
- ¹⁵ Washington County Code, 421 – *Floodplain and Drainage Hazard Area Development*
- ¹⁶ *Planning for Natural Hazards: The Oregon Technical Resource Guide*, Department of Land Conservation and Development (July 2000), Ch. 4.
- ¹⁷ *Floodplain Management: a Local Administrator's Guide to the National Flood Insurance Program*. FEMA, Region 10.
- ¹⁸ Ibid.
- ¹⁹ Ibid.
- ²⁰ *Surface Water Management Framework*. (January 2001). Clean Water Services (formerly Unified Sewerage Agency.)
- ²¹ February 1996 *Flooding and Landslides and Stream Erosion in the State of Oregon*. The Interagency Hazards Mitigation Team (1996) Oregon State Police – Office of Emergency Management.
- ²² *Regional Hazard Mitigation Policy and Planning Guide*. (June 1999). Metro Regional Government.
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- ³⁴ *Regional Hazard Mitigation Policy and Planning Guide*. (June 1999). Metro Regional Government.
- ³⁵ Personal Interview. Fishback, Dale. March 3, 2001.
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⁴⁰ Ibid.

⁴¹ Title 3, Metro Regional Framework Plan,
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⁴³ *Surface Water Management Framework*. (January 2001). Clean Water Services (formerly Unified Sewerage Agency.)

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<http://www.dfw.state.or.us/ODFwhtml/Wetlands/about.htm> (May 2001).

⁴⁵ *Regional Hazard Mitigation Policy and Planning Guide*. (June 1999). Metro Regional Government.

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Section 5: Landslide

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Why are Landslides a Threat to Washington County?

As development continues to occur on the steep slopes of Washington County, the combination of annual rainfall and soil composition will put new development, existing development, and infrastructure at an increased risk from landslide events.

Landslides are a serious geologic hazard in almost every state in America. Nationally, landslides cause 25 to 50 deaths each year.¹ The best estimates of the direct and indirect costs of landslide damage in the United States range between \$1 billion to \$2 billion annually.² In Oregon, a significant number of locations are at risk to dangerous landslides. While not all landslides result in private property damage, many landslides impact transportation corridors, fuel and energy conduits, and communication facilities.³ They can also pose a serious threat to human life.

Landslides can be broken down into two categories: (1) rapidly moving; and (2) slow moving. Rapidly moving landslides (debris flows and earth flows) present the greatest risk to human life, and persons living in or traveling through areas prone to rapidly moving landslides are at increased risk of serious injury. Rapidly moving landslides have also caused most of the recent landslide-related injuries and deaths in Oregon. A rapidly moving debris flow in Douglas County killed five people during the storms of 1996. Slow moving landslides can cause significant property damage, but are less likely to result in serious human injuries.

History of Landslide Events and Impacts

Landslides affecting Washington County in recent years have primarily been slow moving, impacting roads and culverts.⁴ The 1996 landslide events had a large economic impact on communities in the county. In December 1996, a large landslide closed Dixie Mountain Road. While no homes were directly in its path, the landslide affected approximately 60 households. The landslide also caused the Peterson Rock Quarry to shut down on November 22, 1996, after county officials saw signs that the road was slipping.⁵

The road closure forced the construction of two new bridges and a quarter-mile of new road to eliminate a detour of about thirteen miles. Construction of the route cost approximately one million dollars. This figure, however, does not address costs to the public in detour travel, or to the Christmas tree farms located above the slide that may have incurred business losses.⁶

Damage from the 1996 Carpenter Creek slide cost about three hundred thousand dollars to repair. The Sherman's Mill slide, also in 1996, has yet to be repaired. The cost of repairing damage from this slide could potentially cost five hundred thousand to one million dollars.⁷

For ideas on protecting existing development in landslide-prone areas, refer to Landslide Action Item #3 in this section.

Landslide Characteristics

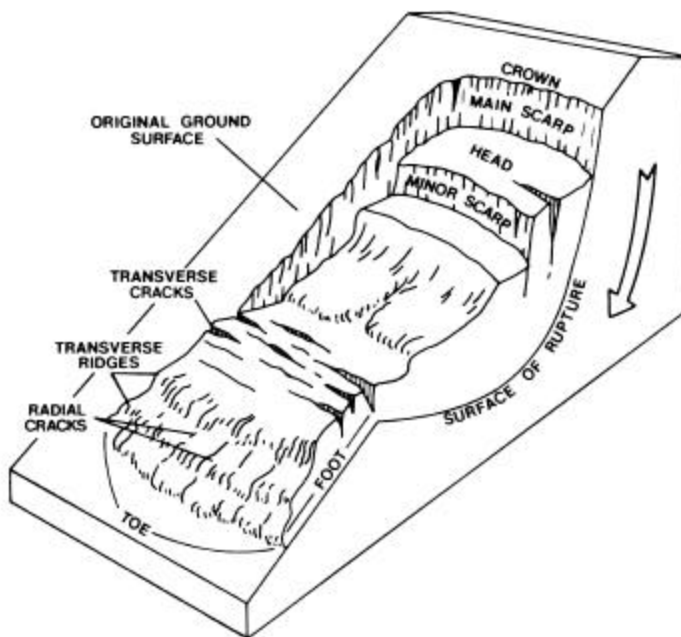
What is a Landslide?

Landslides are downhill or lateral movements of rock, debris, or soil mass. The size of a landslide usually depends on the geology and the landslide triggering mechanism. Landslides initiated by rainfall tend to be smaller, while those initiated by earthquakes may be very large. Slides associated with volcanic eruptions can include as much as one cubic mile of material.

Landslides vary greatly in the volumes of rock and soil involved, the length, width, and depth of the area affected, frequency of occurrence, and speed of movement. Some characteristics that determine the type of landslide are slope of the hillside, moisture content, and the nature of the underlying materials. Landslides are given different names depending on the type of failure and their composition and characteristics. Types of landslides include slides, rock falls, and flows.

Slides move in contact with the underlying surface. These movements include rotational slides where sliding material moves along a curved surface, and translational slides where movement occurs along a flat surface. These slides are generally slow moving and can be deep. Slumps are small

Figure 5.1. Rotational Slide



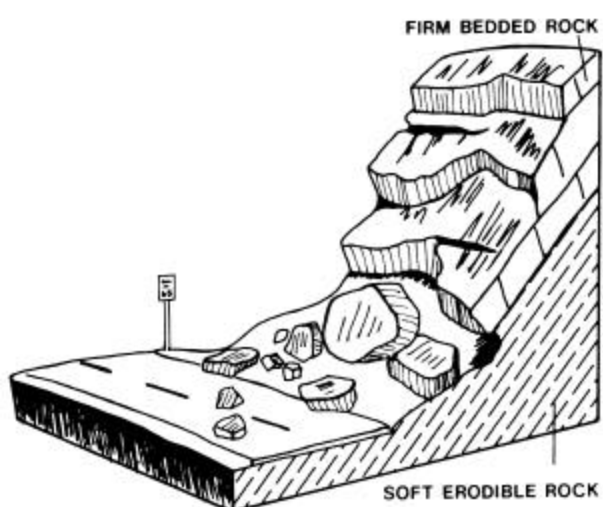
rotational slides that are generally shallow (See Figure 5.1). Slow-moving landslides can occur on relatively gentle slopes and can cause significant property damage, but are far less likely to result in serious injuries than rapidly moving landslides.⁸

Slides caused by **erosion** are the most common type of landslide in Washington County. These occur when ditches or culverts beneath hillside roads become blocked with debris. If the ditches are blocked, run-off from slopes is inhibited during periods of precipitation. This causes the run-off water to collect in soil, and in some cases, cause a slide. Usually the slides are small (100 – 1,000 cubic yards), but they can be quite large, such as the Sherman's Mill slide, which has grown to several hundred thousand cubic yards.

Rock falls (see Figure 5.2) occur when blocks of material come loose on steep slopes. Weathering, erosion, or excavations, such as those along highways, can cause falls where the road

Source: *Planning for Natural Hazards: The Oregon Technical Resource Guide*, DLCD

Figure 5.2. Rock Fall



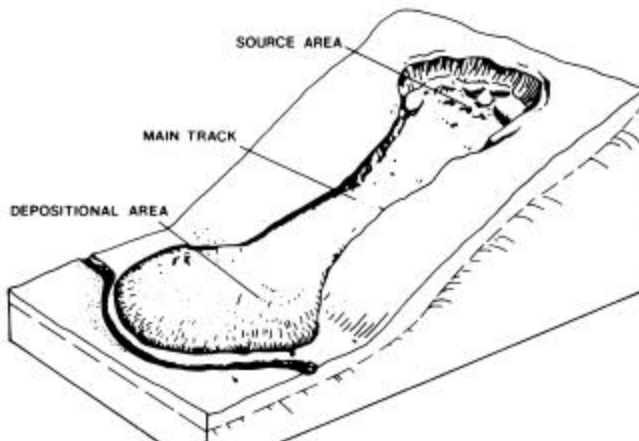
Source: *Planning for Natural Hazards: The Oregon Technical Resource Guide*, DLCDC

has been cut through bedrock. They are fast moving with the materials free falling or bouncing down the slope. In falls, material is detached from a steep slope or cliff. The volume of material involved is generally small, but large boulders or blocks of rock can cause significant damage.

Flows (see Figure 5.3) are plastic or liquid movements in which land mass (e.g. soil and rock) breaks up and flows during movement. Earthquakes often trigger flows.⁹ Debris flows normally occur when a landslide moves downslope as a semi-fluid mass scouring, or partially scouring soils from the slope

along its path. Flows are typically rapidly moving and also tend to increase in volume as they scour out the channel.¹⁰ Flows often occur during heavy rainfall, can occur on gentle slopes, and can move rapidly for large

Figure 5.3. Earthflow



Source: *Planning for Natural Hazards: The Oregon Technical Resource Guide*, DLCDC

distances. One example of a flow in Oregon is the Dodson debris flow that occurred in 1996. This debris flow started high on the Columbia Gorge cliffs, and traveled far down steep canyons to form debris fans at Dodson.¹¹

Landslides are typically triggered by periods of heavy rainfall or rapid snowmelt.

Earthquakes, volcanic activity, and excavations may also trigger landslides. Certain geologic formations are more susceptible to landslides than others. Human activities, including locating development near steep slopes, can increase susceptibility to landslide events. Landslides on steep slopes are more dangerous because movements can be rapid.

Although landslides are a natural geologic process, the incidence of landslides and their impacts on people can be exacerbated by human activities. Grading for road construction and development can increase slope steepness. Grading and construction can decrease the stability of a hillslope by adding weight to the top of the slope, removing support at the base of the slope, and increasing water content. Other human activities affecting landslides include: excavation, drainage and groundwater alterations, and changes in vegetation.¹²

What locations are at risk from landslides and debris flows?

Locations at risk from landslides or debris flows include areas with one or more of the following conditions:

- On or close to steep hills;
- Steep road-cuts or excavations into steep slopes;
- Existing landslides or places of known historic landslides (such sites often have tilted power lines, trees tilted in various directions, cracks in the ground, and irregular-surfaced ground);
- Steep areas where surface runoff is channeled, such as below culverts, V-shaped valleys, canyon bottoms, and steep stream channels;
- Fan-shaped areas of sediment and boulder accumulation at the outlets of canyons, large boulders (2 to 20 feet diameter) perched on soil near fans or adjacent to creeks; and
- Occurrences of logjams in streams.¹

Landslide Conditions

Natural Conditions

Natural processes can cause landslides or re-activate historical landslide sites. Rainfall-initiated landslides tend to be smaller, while earthquake-induced landslides may be very large, but less frequent. The removal of shoreline supporting material along bodies of water by currents and waves, or undercutting during construction at the base of a slope produces countless small slides each year. Seismic tremors can trigger landslides on slopes historically known to have landslide movement. Earthquakes can also cause additional failure (lateral spreading) that can occur on gentle slopes above steep streams and riverbanks. Landslides are particularly common along stream banks, reservoir shorelines, large lakes, and seacoasts. Steep, concave-shaped slopes with larger drainage areas appear to be more susceptible to landslides than other landforms. Landslides associated with volcanic eruptions can include volumes of over one cubic mile of material. All soil types can be affected by natural landslide triggering conditions.

Excavation and Grading

Slope excavation is common in the development of home sites or roads on sloping terrain. Grading these slopes can result in some slopes that are steeper than the pre-existing natural slopes. Since slope steepness is a major factor in landslides, these steeper slopes can be at an increased risk for landslides. The added weight of fill placed on slopes can also result in an increased landslide hazard. Small landslides can be fairly common along roads, in either the road cut or the road fill. Landslides occurring below new construction sites are indicators of the potential impacts stemming from excavation.

Drainage and Groundwater Alterations

Water flowing through or over the ground is often the trigger for a landslide. Any activity that increases the amount of water flowing into landslide-prone slopes can increase landslide hazards. Broken or leaking water or sewer lines can be especially problematic, as can water retention facilities that direct water onto slopes. However, even lawn irrigation and minor alterations to small streams in landslide prone locations can result in damaging landslides. Ineffective storm water management and excess runoff can also cause erosion and increase the risk of landslide hazards. Drainage can be affected naturally by the geology and topography of an area. Development that results in an increase in impervious surface impairs the ability of the land to absorb water and may redirect water to other areas. As a result, more landslides could occur.

Channels, streams, ponding, and erosion on slopes all indicate potential slope problems. Road and driveway drains, gutters, downspouts, and other constructed drainage facilities can concentrate and accelerate flow. Ground saturation and concentrated velocity flow are major causes of slope problems and may trigger landslides.¹³

Changes in Vegetation

Removing vegetation from very steep slopes can increase landslide hazards. The *Storm Impacts Study* conducted by the Oregon Department of Forestry found that landslide hazards in three out of four steeply sloped areas were highest for a period of 10 years after timber harvesting.¹⁴

Areas that have experienced wildfire and land clearing for development may have long periods of increased landslide hazard. In addition, woody debris in stream channels (both natural and man-made from logging) may cause the impacts from debris flows to be more severe.¹⁵

Development

Development sites at the greatest risk from landslides are against the base of very steep slopes, in confined stream channels (small canyons), and on fans (rises) at the mouth of these confined channels. While home development sites do not cause landslides, they put residents and property at risk of landslide impacts. The simplest mitigation measure

For more information on soils, contact the Natural Resource Conservation Service:

NRCS, Oregon Branch
101 S.W. Main Street,
Suite 1300, Portland, OR
97204

Phone: (503) 414-3200

Fax: (503) 414-3103

for this situation is to locate the home out of the impact area, or construct debris flow diversions for homes at risk. Three development-related actions that can put people at risk include:¹⁶

1. **Creating Steeper Slopes.** Excavation practices, sometimes aggravated by drainage, can reduce the stability of otherwise stable slopes. These failures commonly affect only a small number of homes. Without these excavation practices, there is little risk of landslides in areas not prone to landslide movement.
2. **Development on or Adjacent to Existing Landslides.** Existing landslides are generally at risk of future movement regardless of excavation practices. Excavation and drainage practices can further increase risk of landslides. In many cases, there are no development practices that can completely assure stability. Homeowners and communities in these situations accept some risk of future landslide movement.
3. **Development on Gentle Slopes.** Development on gentle slopes can be subject to landslides that begin a long distance from the development.

Informing new residents, long-time homeowners, and developers about the risks associated with landslides is an important issue related to landslide location and occurrence. Developers that are uninformed about geological materials and processes may contribute to conditions that trigger landslide activity or increase susceptibility to landslide hazards.¹⁷

Washington County has procedures that must be followed when applying for a grading permit. The Development Standards state that appropriate safeguards are required when the following soil conditions occur:

- Seasonal, perched, high, or apparent water table;
- High shrink-swell capability;
- Low bearing strength such as compressible organics; and
- Shallow depth to bedrock.¹⁸

Community Landslide Issues

Landslides can affect utility services, transportation systems, and critical lifelines. Communities may suffer immediate damages and loss of service. Disruption of infrastructure, roads, and critical facilities may also have a long-term effect on the economy. Utilities, including potable water, wastewater, telecommunications, natural gas, and electric power are all essential to service community needs. Loss of electricity has the most widespread impact on other utilities and on the whole community. Natural gas pipes may also be at risk of breakage from landslide movements as small as an inch or two.¹⁹

Roads and bridges are subject to closure during landslide events. Because many Washington County residents are dependent on roads and bridges for travel to work, delays and detours are likely to have an economic impact on county residents and businesses. To evaluate landslide mitigation for roads, the community can assess the number of vehicle trips per day, detour time around a road closure, and road use for commercial traffic or emergency access.²⁰

Lifelines and critical facilities should remain accessible if possible during a natural hazard event. The impact of closed transportation arteries may be increased if the closed road or bridge is a critical lifeline to hospitals or other emergency facilities. Therefore, inspection and repair of critical transportation facilities and routes is essential and should receive high priority. Losses of power and phone service are also potential consequences of landslide events. Due to heavy rains, soil erosion in hillside areas can be accelerated, resulting in loss of soil support beneath high voltage transmission towers in hillsides and remote areas.²¹ Flood events can also cause landslides, which can have serious impacts on gas lines.



Source: American Planning Association Landslides

Landslide Hazard Assessment

Hazard Identification

Hazard identification is the first phase of a hazard assessment, and is the process of estimating the geographic extent of the hazard, its intensity, and its probability of occurrence.²² This process usually results in a hazard map. Hazard maps can provide detailed information in a clear format and can assist in making policy and land use decisions. Washington County's most recent landslides have primarily been slow moving and caused greatest impact to roads and culverts.²³

While recent landslide events have not been rapidly moving, they can occur in Washington County. Debris flows generally occur during intense periods of rainfall on previously saturated soil. They generally start on steep slopes and accelerate to speeds as great as 35 mph. These rapidly moving landslides have caused most of the recent landslide related injuries and deaths in Oregon.²⁴ The previous damage and deaths associated with rapidly moving landslides in Oregon have been the catalyst for agencies to map these types of landslides. Currently, two state agencies are involved in mapping debris flows: (1) the Oregon Department of Forestry (ODF); and (2) the Department of Geology and Mineral Industries (DOGAMI).

ODF has mapped debris flows in some areas of Washington County. ODF's debris flow maps include locations subject to naturally occurring debris flows and include the initiation sites and projected paths. More information on ODF's debris flow maps can be found by contacting ODF directly. Contact information for ODF is included in the resource directory section of this mitigation plan on page 5-11.

Table 5.1 illustrates the February 1996 landslide events. Map 5.1 illustrates the historic landslides mapped by Washington County and debris flow areas in Washington County mapped by ODF.

Vulnerability Assessment

Vulnerability assessment is the second phase of a hazard assessment. It combines the information generated through debris flow identification with an inventory of the existing development exposed to landslide hazards. Vulnerability assessments assist in predicting how different types of property and population groups will be affected by a hazard.²⁵ The optimum method for doing this analysis at the county or jurisdiction level is to use parcel-specific assessment data on land use and structures.²⁶ Data that includes specific landslide-prone and debris flow locations in the county can be used to assess the population and total value of property at risk from future landslide occurrences.

While a quantitative vulnerability assessment (an assessment that describes number of lives or amount of property exposed to the hazard) has not yet been conducted for Washington County landslide events, there are many qualitative factors (issues relating to what is in danger within a community) that point to

potential vulnerability. Landslides can impact major transportation arteries, blocking residents from essential services and businesses. While past landslide events have not caused major property damage or significantly impacted county residents, continuing to map county landslide and debris flow areas will help in preventing future loss.

Risk Analysis

Risk analysis is the third, and most advanced phase of a hazard assessment. It builds upon hazard identification and vulnerability assessments.

Factors included in assessing landslide risk include population and property distribution in the hazard area, the frequency of landslide or debris flow occurrences, slope steepness, soil characteristics, and precipitation intensity. This type of analysis could generate estimates of the damages to the county due to a landslide or debris flow event in a specific location. At the time of publication of this plan, data was insufficient to conduct a risk analysis and the software needed to conduct this type of analysis was not available.

The Oregon Department of Forestry and the Department of Geology and Mineral Industries are active in developing maps and collecting data on hazard risk. Developing partnerships with these agencies and other state and federal organizations can facilitate future strides in doing risk analysis for landslide hazards.

***Long-Term Landslide
Action Item #1:***

Improve knowledge of landslide hazard areas and understanding of vulnerability and risk to life and property in those areas.

See page 5-17 for more information.

Table 5.1. 1996 Landslides in Washington County

Location	Type of Landslide	Dates of Occurrence	Status
1251 Catlin Crest	Earthflow	4/96	fixed
2.4 miles up Murphy Rd. off Dairy Creek Rd.	Earthflow	2/96	fixed
785 SW 67th Place/Curran Daniel Ln.	Slump	2/96	unfixed
Bacona Rd. 3.4 miles north of Highway 26 and .25 mile	Earthflow	2/96	fixed
Below Clapshaw Hill Rd. about .75 miles east of Gales	Earthflow	2/96	unfixed
Bragga Rd. .5 miles off Meacham Rd.	Earthflow/Debris	2/96	fixed
Carpenter Creek Rd. 1.5 miles up from Stringtown Rd.	Debris Flow	2/96	fixed
Clapshaw Hill Rd. .5 miles east of Gales Creek Rd.	Slump-Earthflow	2/96	fixed
Collins Rd. .15 miles north of Northup Rd.	Earthflow	2/96	fixed
Dairy Creek Rd., next to 26090	Debris Flow	2/96	fixed
David Hill Rd. 1.5 miles east of Gales Creek Rd.	Earthflow	2/96	fixed
David Hill Rd. 1.75 miles east of Gales Creek Rd.	Earthflow	2/96	fixed
Dixie Mountain Rd. 1.1 miles north of Northrup Rd.	Earthflow	2/96	unfixed
Eberly Rd .5 mi N of Cedar Canyon Rd.	Earthflow	2/96	fixed
Gnos Rd. .5 miles up from Iowa Hill Rd.	Earthflow	2/96	fixed
Greener Rd.	Slump-Earthflow	2/96	fixed
Greener Rd. .4 miles up	Earthflow	2/96	fixed
Hartwick Rd. .7 miles from Cedar Canyon Rd.	Earthflow	2/96	fixed
HWY 217 (mile post 1.8)/Beaverton Hillsdale Hwy	Slump-Earthflow	2/96	fixed
HWY 26 (west bound) Off ramp for Canyon Rd.	Slump-Earthflow	2/96	unfixed
I-5(south, east side mile post 286.6, near Wilsonville	Earthflow	2/96	unfixed
Jackson Quarry on Jackson Quarry Rd.	Slump	2/96	unfixed
Jackson Quarry Rd. 1 mile north of Helevetia Rd.	Slump-Earthflow	2/96	fixed
Killin Rd. .5 miles north of Cedar Canyon Rd.	Earthflow	2/96	fixed
Miller Rd./Barnes Rd.	Earthflow	2/96	fixed
Nowakowski Rd. 1.3 miles west of Highway 47	Earthflow	2/96	fixed
Old Wilson River Rd. .5 miles east of Thornburgh Rd.	Earthflow	2/96	fixed
Sellers Rd. just north of Linklater Rd.	Earthflow	2/96	unfixed
Soda Springs Rd. about a mile up from town	Slump-Earthflow	2/96	fixed
Strassel Rd. 1.6 miles south of Highway 26	Earthflow	2/96	fixed
Strassel Rd. 1.7 miles south of Highway 26	Earthflow	2/96	unfixed
Strassel Rd. 1.7 miles south of Highway 26	Earthflow	2/96	fixed
Strohmayer Rd. .2 miles east of Shearer Hill Tree Far	Slump-Earthflow	2/96	fixed
SW Benchview Pl, Bull Mountain	Slump	2/96	unfixed
Timber Rd. .7 miles north of Route 7	Earthflow	2/96	fixed
Timber Rd. 1.1 miles north of Route 6	Earthflow	2/96	fixed
Timber Rd. about 2 miles south of Timber	Earthflow	2/96	fixed
W. Burnside/Barnes Rd.	Earthflow	2/96	fixed
West shore of Henry Hagg Lake in Sain Crk drainage	Earthflow	2/96	fixed

Mitigation Plan Goals and Existing Activities

Mitigation Plan Goals and Public Priorities

The mitigation plan goals and action items are derived from review of regional and national natural hazards mitigation plans and planning literature, guidance from the Washington County Natural Hazards Mitigation Plan Steering Committee, and interviews with Washington County stakeholders. The goals for the Washington County Natural Hazards Mitigation Action Plan are broad based to include all of the identified hazards addressed in the plan. Goals for the mitigation plan address four categories:

1. Life, Property, and Natural Systems
2. Public Awareness and Partnerships
3. Emergency Services
4. Implementation

A public workshop was held on May 15, 2001 to identify public priorities for the plan goals and discuss strategies to achieve them. The goal statements and a summary of the public workshop outcomes can be found in Section Three of this plan. All comments from the public workshop are documented in Appendix B.

Through a voting process, the public identified goal statements in the category of Life, Property, and Natural Systems as their top priority. This section describes existing mitigation activities and landslide action items. Multi-hazard action items (i.e., those that broadly address all of the identified hazards) are described in Section Three. Mitigation plan action items are designed to help meet the overall goals of the mitigation plan.

To review the mitigation plan goals, go to section 3, page 2 of the Washington County Natural Hazards Mitigation Action Plan.

Existing Mitigation Activities

Existing mitigation activities include current mitigation programs and activities that are being implemented by county, regional, state, or federal agencies or organizations.

County

Washington County Community Development Code

Article IV: Development Standards, 410 Grading and Drainage, 1.2, D (2) states:

For areas outside the Tualatin River and Oswego Lake sub-basins, an erosion control plan that complies with the requirements of the “Washington County Erosion Control Plans Technical Guidance Book,” January 1991, or its successor, is required when, (a) grading requiring a permit is conducted or left in an unfinished state during October 1

through May 1; or (b) land disturbance activities are conducted in geologically unstable areas, on slopes in excess of twenty (20) percent, or there is disturbance of more than six-thousand (6,000) square feet of any drainage hazard area or flood plain area.

410 Grading and Drainage, 3 (permit approval) states:

Permit approval for construction, grading, cut, or fill is dependent on the following conditions:

- The extent and nature of the proposed grading is appropriate to the use proposed and will not create site disturbance to an extent greater than that required for the use;
- Proposed grading will not cause erosion to any greater extent than would occur in the absence of development or result in erosion, stream sedimentation, or other adverse off-site effects of hazards to life or property; and
- Appropriate siting and design safeguards shall ensure structural stability and drainage in areas with soil conditions of seasonal, perched, high or apparent water table, high shrink-swell capability, low bearing strength such as compressible organics, or shallow depth to bedrock.

National Flood Insurance Program (NFIP) Coverage for Mudslide Damage

Some landslides are eligible for coverage through the NFIP. Contact a local insurance carrier for more information on the NFIP landslide coverage at 1-800-427-4661.

Article IV: Development Standards, 426, Erosion Control, 4 states:

Every preliminary plat, site plan, development permit, building permit, or public works project within the Tualatin River and Oswego Lake sub-basins must prepare an erosion control plan. This plan includes a list of best management practices to be applied during construction to control and limit soil erosion. Permitting is dependent upon the development of an erosion control plan. The plan must be prepared in conformance with the Washington County Erosion Control Plans Technical Guidance Book, January 1991, or its successor.

Article IV: Development Standards, 405, Open Space, 1 states:

Areas defined as confirmed land movement hazard areas, as identified through the application of the standards of Section 410 or mapped as a Significant Natural Area on the Community Plan, shall be preserved as open space.

State

Oregon State Senate Bill 12

The 1997 Legislature passed Senate Bill 12 to address problems caused by landslides and debris flows. Provisions include:

- Allowing the Oregon State Forester to prevent timber harvest or road construction in or below areas identified by the Department of Forestry

as “high risk sites” and where homes or highways are in precarious locations.

- Allowing road officials to close roads that pose risk to human life because of landslides.
- Requiring State agencies to develop, and local officials to distribute, information about hazards of construction on sites that are vulnerable to landslides.
- Establishing a 10-member Task Force on Landslides and Public Safety to assess the problem and develop a solution. It includes legislators and representatives from state natural resource agencies, boards of commissions, local government, and the public.

Debris Flow Mapping

Currently, two state agencies are involved in mapping debris flows: (1) the Oregon Department of Forestry and (2) the Department of Geology and Mineral Industries (DOGAMI). Senate Bill 12 requires that the Department of Geology and Mineral Industries, with cooperation from local governments and the Department of Forestry, identify and map landslide-prone areas, or “further review areas.” Senate Bill 12 defines a further review area as “an area of land in which further site specific review should occur before land management or building activities begin.”²⁷

Oregon Department of Forestry (ODF)

The Oregon Department of Forestry has provided a preliminary indication of debris flow (rapidly moving landslides) in western Oregon. Their debris flow maps include the general locations subject to naturally occurring debris flows and include the initiation sites and locations along the paths of potential debris flows (confined stream channels and locations below steep slopes). These maps do not consider the effects of management-related slope alterations (drainage and excavation) that can increase the hazard, nor do they consider very large landslides that could possibly be triggered by volcanic or earthquake activity. Areas identified in these maps are not to be considered “further review areas” as defined by Senate Bill 12 (1999).²⁸

Information used to develop the ODF Debris Flow maps include:

- Digital elevation models at 30-meter resolution, based on US Geological Survey data, were used to derive slope steepness and then to develop polygons for assigned hazards. Note that actual slopes are steeper than these digitally elevated models.
- Mapped locations of Tyee soil formation and similar sedimentary geologic units.
- Oregon Department of Forestry *Storm Impacts and Landslides of 1996* study; debris flow initiation and path location data.
- Stream channel confinement near steep hill slopes based on US Geological Survey Digital Raster Graphics.

- Historical information on debris flow occurrence in western Oregon (from Oregon Department of Forestry, US Forest Service, DOGAMI, Bureau of Land Management, and the Oregon Department of Transportation).
- Fan-shaped land formations below long, steep slopes.
- Areas of highest intensity precipitation do not appear to be correlated with known areas of high and extreme debris flow hazard, so precipitation intensity was *not* used to develop risk (hazard) ratings.²⁹

Prohibition of Certain Forest Operations

As part of the requirements of Senate Bill 12, ODF is currently administering the deferral of certain forest operations on landslide-prone sites above homes and roads. The Department's policy is that timber harvesting or road construction operations will be prohibited on land where landslides or debris flows pose a significant threat to human safety. Exceptions for salvage or other purposes are considered on an individual basis, but have been infrequent in keeping with the intent of preventing significant risks to human life.³⁰

Debris Flow Warning System

The debris flow warning system was initiated in 1997 and involves collaboration between ODF, DOGAMI, the Oregon Department of Transportation (ODOT), local law enforcement, NOAA Weather Radio, and local media.

ODF meteorologists are responsible for forecasting storms that may trigger debris flows. Information is broadcast over NOAA Weather Radio, and on the Law Enforcement Data System. DOGAMI provides additional information on debris flows through the media. ODOT provides warning signs to motorists in landslide-prone areas during high-risk periods.³¹

Landslide Brochure

DOGAMI developed a landslide public outreach brochure in cooperation with several other state agencies. Forty thousand copies were printed in November 1997 and were distributed widely to building codes officials, county planners, local emergency managers, field offices of natural resource agencies, banks, real estate companies, insurance companies, and other outlets. Landslide brochures are available from DOGAMI, OEM, ODF, and the Department of Land Conservation and Development (DLCD).³²

Oregon State Building Code Standards

The Oregon Building Codes Division adopts statewide standards for building construction that are administered by state and local municipalities throughout Oregon. The One- and Two-Family Dwelling Code and the Structural Specialty Code contain provisions for lot grading and site preparation for the construction of building foundations.

Both codes contain requirements for cut, fill, and sloping of the lot in relationship to the location of the foundation. There are also building setback requirements from the top and bottom of slopes. The codes specify

foundation design requirements to accommodate the type of soils, the soil bearing pressure, and the compaction and lateral loads from soil and ground water on sloped lots. The building official has the authority to require a soils analysis for any project where it appears the site conditions do not meet the requirements of the code, or that special design considerations must be taken. ORS 455.447 and the Structural Code require a seismic site hazard report for projects that include essential facilities such as hospitals, fire and police stations, emergency response facilities, and special occupancy structures, such as large schools and prisons.³³

Case Study: Salem Landslide Ordinance

The 1996 flood events contributed to two major landslide events, which forced the city into litigation. Through FEMA's Hazard Mitigation Grant Program, the city of Salem, Marion County, and DOGAMI received \$250,000 to map landslide areas and develop a landslide ordinance.

The ordinance requires the preparation and approval of geological assessments before development occurs in areas identified with a moderate degree of hazard. Those areas then undergo a preliminary review of geologic conditions. The ordinance requires staff to determine if a geotechnical report requiring more information and detail than the geological assessment is

necessary. This approach ensures adequate review of proposed development on private property where potentially greater risk requires more detailed information to fully identify and address the hazard.

Additionally, prior to development, a declaratory statement indicating that the property is within an identified hazard area must be recorded on the

property deed. Compliance with the ordinance is required as part of any land use permit and building permit for regulated activities within identified hazard areas.³⁴



Impacts from 1996 Landslide Event, Dairy Creek Rd.
Source: Community Planning Workshop

The Salem ordinance identified four key elements:

- 1) **Identify the hazard.** DOGAMI produced water-induced and earthquake-induced landslide maps for South Salem and Eola Hills. The ordinance incorporates slope steepness and hazard areas. The slope

steepness criteria were done to address hillside development, which was not included in the mapping process. Additionally, Salem's Building and Safety Division has a kiosk where people can print out relative landslide maps of site-specific areas.

- 2) **Determine when to regulate.** The city developed a graduated response table that is used to determine the level of site investigation for various types of regulated activities on property within the mapped area. Landslides with moderate or high susceptibility may be subject to regulation (this is determined by the regulated activity).
- 3) **Establish an assessment process for hazard areas.** This is a procedural ordinance that documents when to require a geological assessment prepared by a Certified Engineering Geologist or a geotechnical report prepared by both a Certified Engineering Geologist and a registered Geotechnical Engineer. When development is in a high-risk area, both the geological assessment and the geotechnical report are required. Defining the roles was an important part of this process.
- 4) **Share the responsibility of hillside development.** Partnerships with state and local officials, residents, and businesses can reduce risk and prevent loss by bringing all their concerns to the table.

Why is the Salem landslide ordinance useful?

The percentage of vacant land in landslide areas underscores the necessity of developing landslide hazard mitigation activities. The potential for future development necessitates strong regulation to reduce risk from potential landslide events.

The ordinance requires that an appropriate level of *study* occur before development occurs. While the process of developing a new ordinance was not without controversy, it was a collaborative project. Collaborative partnerships assist in future implementation. DOGAMI, OEM, DLCD, Marion County, the Board of Examiners, State Engineering Board, and city of Salem played a role in developing the ordinance.

For more information, contact:

City of Salem

555 Liberty St. SE/Room 305, Salem, OR 97301-3503

Phone: (503) 588-6211

Fax: (503) 588-6005

http://www.open.org/~naturalr/Landslides/landslide_Ord.htm

Landslide Mitigation Action Items

The landslide mitigation action items provide direction on specific activities that cities, organizations, and residents in Washington County can undertake to reduce risk and prevent loss from landslide events. There are five long-term landslide hazard action items described below. Each action item is followed by ideas for implementation, which can be used by the steering committee and local decision makers in pursuing strategies for implementation.

To review the multi-hazard mitigation action items, refer to section 3, page 4 of the Washington County Natural Hazards Mitigation Action Plan.

LT-LS#1: Improve knowledge of landslide hazard areas and understanding of vulnerability and risk to life and property in those areas.

Ideas for Implementation

- Continue mapping county landslide and debris flow areas.
- Identify the location and extent of hazard areas and establish a factual base to support implementation of future measures; and
- Analyze the risk of these areas to life, property, and infrastructure.

Coordinating Organization: Washington County,
Partner Organizations: DOGAMI, ODF, Clean Water Services, Cities
Timeline: Ongoing
Plan Goals Addressed: Public Awareness and Partnerships; Life, Property, and Natural Systems

LT-LS#2: Limit activities in identified landslide hazard areas through regulation and public outreach.

Ideas for Implementation

- Use the hazard identification and mapping processes to determine where to regulate. For example, develop a system, such as Salem’s graduated response table, to determine where regulation should occur;
- Coordinate with property owners to reduce risk in landslide hazard areas;
- Provide information on hazard location to future residents; and
- Show hazard susceptibility on deeds.

Coordinating Organization: Washington County
Partner Organizations: Oregon Department of Forestry, Cities
Timeline: Ongoing
Plan Goals Addressed: Life, Property, and Natural Systems; Public Awareness and Partnerships

LT-LS#3: Protect existing development in landslide-prone areas.³⁵

Ideas for Implementation

- Provide information to residents on landslide prevention. Publications such as FEMA's Homeowner's Landslide Guide for Hillside Flooding, Debris Flows, Erosion, and Landslide Control and Hillside Drainage Flyer have some ideas about reducing landslide susceptibility;
- Encourage easements to restrict certain activities on landslide-prone properties. Easements foregoing the right to develop a property can be either sold or granted to the County or other organizations by property owners;
- Investigate land purchasing programs;
- Use Transfer of Development Rights to transfer development rights of a landslide hazard area by deed, easement, or other legal instrument authorized by local law to another parcel of land that is not prone to landslides;
- Construct debris flow diversions to protect existing properties; and
- Use and publicize the Oregon Department of Forestry's debris flow warning system.

Coordinating Organization: Washington County

Partner Organizations: Department of Land Conservation and Development, OEM, FEMA, Cities

Timeline: Ongoing

Plan Goals Addressed: Public Awareness and Partnerships; Life, Property and Natural Systems; Implementation

LT-LS#4: Implement construction and subdivision design that can be applied to steep slopes to reduce the potential adverse impacts from development.

Ideas for Implementation

- Where appropriate, reduce the number of building sites and corresponding disruption of the natural contour and vegetation;
- Remove access from alleys on the uphill side of a street;
- Reduce driveway cuts into the hillside;
- Adjust the building setback from property lines to minimize building site cuts and fills;
- Regulate the amount of vegetation cleared off hillside lots;
- Require erosion control techniques, such as the temporary use of hay bales, diversion dams, or other physical changes to control storm runoff during road and site construction; and

LT-LS#4, continued

- Reduce water input into slopes from building roof drains, storm drains, and surface runoff.

Coordinating Organization: Washington County

Partner Organizations: Department of Land Conservation and Development, Clean Water Services, Cities

Timeline: 1-3 years

Plan Goals Addressed: Life, Property, and Natural Systems; Implementation

LT-LS#5: Maintain public and private drainage systems.

Ideas for Implementation

- Ensure that ditches, storm water facilities, and culverts are inspected and cleared prior to the wet season each year.

Coordinating Organization: Washington County

Partner Organizations: Clean Water Services, Cities, PPO

Timeline: Ongoing

Plan Goals Addressed: Life, Property, and Natural Systems; Public Awareness and Partnerships; Implementation

Landslide Resource Directory

County Resources

Washington County Community Development Code (WCCDC)

The following sections in the Washington County Community Development Code relate to landslide reduction by requiring reports or landscaping to reduce the occurrence of landslides.

- WCCDC Section 404 Master Planning
- WCCDC Section 410 Grading and Drainage
- WCCDC Section 426 Erosion Control

Contact: Washington County Land Use and Transportation Department
Address: Washington County Land Development Services Division, 155 N. First Avenue, Suite 350, Hillsboro, OR 97124
Phone: (503) 846-8761
Fax: (503) 846-2908
Website: <http://www.co.washington.or.us/deptmts/lut/plan99/>
Email: lutplan@co.washington.or.us

Washington County Office of Emergency Management

The Washington County Emergency Management Program exists pursuant to ORS 401 to guide the county's preparations for, response to, and recovery from major emergencies and disasters. The program is organized under the county sheriff's office and oversees preparation and maintenance of the county's emergency operations plan and emergency operations center and the training and exercising of designated staff.

Unique to Washington County is a consolidated office that brings the emergency management staffs from four jurisdictions together into a single office to enhance disaster preparedness activities countywide. The Office of Consolidated Emergency Management (OCEM) for Washington County was formed in 1995 by Intergovernmental Agreement between Washington County, the cities of Beaverton and Hillsboro, and Tualatin Valley Fire and Rescue. The organization's mission statement indicates that "The Office of Consolidated Emergency Management for Washington County is committed to the development and maintenance of a countywide, integrated system to prepare for, respond to, recover from, and mitigate against disasters."

Contact: Director, Washington County Emergency Management
Address: 20665 SW Blanton St. Aloha, OR, 97007
Phone: (503) 642.0371
Website: <http://www.ocem.org>
Email: info@ocem.org

For more information on county, state and federal natural hazard mitigation programs and activities, refer to *Appendix A: Resource Directory*

Regional Resources

Metro Regional Government

Metro is the directly elected regional government that serves more than 1.3 million residents in Clackamas, Multnomah, and Washington counties and 24 cities in the Portland metropolitan area. Chapter 5 of Metro's Regional Framework Plan addresses natural hazards. Metro's Natural Hazards Program is a service of the Growth Management Services Department's Data Resource Center. Their web pages relate to natural hazards that may impact the Portland metropolitan area. Their links provide information about the natural hazards in the Portland metropolitan area and suggest tools for reducing potential damages before disaster strikes. Metro produced the *Regional Hazard Mitigation Policy and Planning Guide* in 1999 to assist local governments in planning for future natural hazard events.

Contact 1: Metro Regional Government
Address: 600 NE Grand Ave, Portland, OR 97232-2736
Phone: (503) 797-1839
Fax: (503) 797-1911
Website: <http://www.metro.dst.or.us/metro/growth/gms.html>
Email: 2040@metro-region.org

Contact 2: Metro Data Resource Center
Website: <http://storefront.metro.dst.or.us/drc/nathaz/nathaz.cfm>
Email: drc@metro.dst.or.us

State Resources

Department of Land Conservation and Development (DLCD)

Oregon's Department of Land Conservation and Development administers a natural hazards program to assist local governments in meeting statewide Planning Goal 7: Areas Subject to Natural Disasters and Hazards. Activities relating to landslide mitigation include:

- Distribution of model ordinances through which hazards can be mitigated. DLCD advises local governments on which ordinance best meets their needs;
- Reviewing local land use plan amendments for consistency with state landslide programs and regulations and providing direct technical assistance;
- Providing a liaison between pertinent local, state, and federal agencies. DLCD representatives serve on a variety of commissions and ad hoc committees which deal with natural hazards;
- Adopting and amending statewide planning goals and administrative rules relating to natural hazards.

Contact: State Floodplain Manager, Natural Hazards Program Manager
Address: 635 Capitol Street NE, Suite 150
Phone: (503) 373-0050
Fax: (503) 378-6033
Website: <http://www.lcd.state.or.us/hazards.html>

Oregon Department of Forestry (ODF)

The mission of the Oregon Department of Forestry is to serve the people of Oregon through the protection, management, and promotion of a healthy forest environment, which will enhance Oregon's livability and economy for today and tomorrow. ODF regulates forest operations to reduce the risk of serious injury or death from rapidly moving landslides related to forest operations, and assists local governments in the siting review of permanent dwellings on and adjacent to forestlands in further review areas.

Contact: Oregon Department of Forestry, Northwest Oregon
Address: 801 Gales Creek Road, Forest Grove, Oregon 97116-1199
Phone: (503) 359-7448
Website: <http://www.odf.state.or.us>

Oregon Department of Forestry Debris Flow Warning Page

The ODF debris flow warning page provides communities with up-to-date access to information regarding potential debris flows. As the lead agency, ODF is responsible for forecasting and measuring rainfall from storms that may trigger debris flows. Advisories and warnings are issued as appropriate. Information is broadcast over NOAA weather radio and on the Law Enforcement Data System. DOGAMI provides additional information on debris flows to the media that convey the information to the public. ODOT also provides warnings to motorists during periods determined to be of highest risk for rapidly moving landslides along areas on state highways with a history of being most vulnerable. Information is available on the ODF website at www.odf.state.or.us.

Oregon Department of Geology and Mineral Industries (DOGAMI)

DOGAMI is an important agency for landslide mitigation activities in Oregon. Some key functions of DOGAMI are development of geologic data, producing maps, and acting as lead regulator for mining and drilling for geological resources. The agency also provides technical resources for communities and provides public education on geologic hazards. DOGAMI provides data and geologic information to local, state, and federal natural resource agencies, industry, and private groups.

Contact: DOGAMI
Address: 800 NE Oregon Street, Suite 965, Portland, Oregon 97232
Phone: (503) 731-4100
Fax: (503) 731-4066
Website: <http://sarvis.dogami.state.or.us>
Email: info@naturenw.org

Nature of the Northwest

Oregon Department of Geology and Mineral Industries and the USDA Forest Service jointly operate the Nature of the Northwest Information Center. The Center offers a selection of maps and publications from state, federal, and private agencies.

Contact: The Nature of the Northwest Information Center
Address: 800 NE Oregon Street #5, Suite 177, Portland, Oregon 97232

Phone: (503) 872- 2750
Fax: (503) 731-4066
Website: <http://www.naturenw.org>
Email: Nature.of.Northwest@state.or.us

Oregon Department of Transportation (ODOT)

ODOT provides warnings to motorists during periods determined to be of highest risk of rapidly moving landslides along areas on state highways with a history of being most vulnerable to rapidly moving landslides. ODOT also monitors for landslide activity and responds to slide events on state highways.

Contact: ODOT Transportation Building
Address: 355 Capitol St. NE, Salem, OR 97310
Phone: (888) 275-6368
Website: <http://www.odot.state.or.us>

Oregon State Police (OSP)-Office of Emergency Management (OEM)

OEM coordinates state resources for rapid and effective response to rapidly moving landslide and other landslide-related emergencies. The Oregon Emergency Response System (OERS) of OEM is a key player in the dissemination of debris flow advisories and warnings. OEM chairs a group that develops and measures landslide hazard mitigation strategies. OEM also administers the FEMA Hazard Mitigation Grant Program, which provides a source of funding for implementing hazard mitigation projects. OEM also works with other state agencies to develop information for local governments and the public on landslide hazards.

Contact: Oregon Emergency Management
Address: 595 Cottage Street NE
Phone: (503) 378-2911
Fax: (503) 588-1378
Website: <http://www.osp.state.or.us/oem>

Portland State University, Department of Geology

Portland State University conducts research and prepares inventories and reports for communities throughout Oregon. Research and projects conducted through the Department of Geology at Portland State University include an inventory of landslides for the Portland metropolitan region after the 1996 and 1997 floods and a subsequent susceptibility report and planning document for Metro in Portland.

Contact: Portland State University, Department of Geology
Address: 17 Cramer Hall; 1721 SW Broadway, Box 751, Portland, OR 97207
Phone: (503) 725-3389
Website: <http://www.geol.pdx.edu>

Federal Resources and Programs

Federal Emergency Management Agency, landslide fact sheet

FEMA's website contains information on strategies to reduce risk and prevent loss from landslides and debris flows.

Contact: Federal Regional Center, Region 10
Address: 130-228th St. SW, Bothell, WA 98021-9796
Phone: (425) 487-4678
Website: <http://www.fema.gov/library/landslif.htm>

Natural Resource Conservation Service (NRCS)

The NRCS produces soil surveys. These may be useful to local governments who are assessing areas with potential development limitations including steep slopes and soil types. They operate many programs dealing with the protection of natural resources.

Contact: NRCS, Oregon Branch
Address: 101 S.W. Main Street, Suite 1300, Portland, OR 97204
Phone: (503) 414-3200
Fax: (503) 414-3103
Website: <http://www.or.nrcs.usda.gov>

US Geological Survey, National Landslide Information Center (NLIC)

The NLIC website provides good information on the programs and resources regarding landslides. The page includes information on the National Landslide Hazards Program Information Center, a bibliography, publications, and current projects. USGS scientists are working to reduce long-term losses and casualties from landslide hazards through better understanding of the causes and mechanisms of ground failure both nationally and worldwide.

Contact: National Landslide Information Center
Phone: (800) 654-4966
Website: <http://landslide.usgs.gov>

Additional Resources

American Planning Association (APA)

The APA's research department embarked on a program to bring together solutions from multiple disciplines into a single source. It will help serve local planning efforts in identifying landslide hazards during the planning process so as to minimize exposure to landslide risks. The APA's website highlights planning efforts to reduce risk and loss from landslides.

Contact: Principal Investigator, Landslides Project
Address: Research Department, American Planning Association
122 S. Michigan Ave., Suite 1600
Chicago, Illinois 60603-6107
Phone: (312) 431-9100
Fax: (312) 431-9985
Website: <http://www.planning.org/landslides>
Email: landslides@planning.org

American Red Cross

The American Red Cross is a humanitarian organization, led by volunteers, that provides relief to victims of disasters and helps people prevent, prepare for, and respond to emergencies. The Oregon Trail Chapter was chartered as

a Red Cross unit in 1917. The chapter serves the residents of Clackamas, Columbia, Multnomah, Washington, Yamhill, and Tillamook counties. The Oregon Trail Chapter provides a variety of community services which are consistent with the Red Cross mission and meet the specific needs of this area, including disaster planning, preparedness, and education.

Contact: American Red Cross, Oregon Trail Chapter
Address: P.O. Box 3200, Portland, OR 97208-3200
Phone: (503) 284-1234
Fax: (503) 284-4247
Website: <http://www.redcross-pdx.org>
<http://www.redcross.org/services/disaster/keepsafe/volcano.html>
Email: info@redcross-pdx.org

Institute for Business & Home Safety (IBHS)

IBHS was created as an initiative of the insurance industry to reduce damage and losses caused by natural disasters. Their website provides educational resources and on-line publications for insurers, businesses, and homeowners who are interested in taking the initiative to minimize future damages and losses.

Contact: Institute for Business and Home Safety
Address: 1408 North Westshore Boulevard - Suite 208 - Tampa, FL 33607
Phone: (813) 286-3400
Fax: (813) 286-9960
E-mail: info@ibhs.org
Website: <http://www.ibhs.org/ibhs2>

State of Washington, Department of Ecology

The Washington State Department of Ecology has a landslide website with tips for reducing risk, warning signs, and maps.

Contact: Department of Ecology
Address: PO Box 47600, Olympia, WA 98504-7600
Website: <http://www.ecy.wa.gov/programs/sea/landslides>
Email: hshi461@ecy.wa.gov

Publications

Planning for Natural Hazards: The Oregon Technical Resource Guide, Department of Land Conservation and Development (July 2000).

Produced by the Community Planning Workshop for the Department of Land Conservation and Development, this is a natural hazards planning and mitigation resource for Oregon cities and counties. It provides hazard-specific resources and plan evaluation tools. The document was written for local government employees and officials. The Technical Resource Guide includes a natural hazards comprehensive plan review, a hazard mitigation legal issues guide, and five hazard-specific technical resource guides, including: flooding, wildfires, landslides, coastal hazards, and earthquakes. You can write, call, fax, or go on-line to obtain this document.

Contact: Natural Hazards Program Manager, DLCDD
Address: 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540
Phone: (503) 373-0050
Fax: (503) 378-6033
Website: <http://www.lcd.state.or.us/hazards.html>

Mileti, Dennis, *Disasters by Design: A Reassessment of Natural Hazards in the United States* (1999) Joseph Henry Press.

This book offers a way to view, study, and manage hazards in the United States that will help foster disaster-resilient communities, higher environmental quality, inter- and intragenerational equity, economic sustainability, and an improved quality of life. The volume provides an overview of what is known about natural hazards, recovery, and mitigation; reveals how research findings have been translated into policies and programs; and advances a sustainable hazard mitigation research agenda.

Olshansky, Robert B., *Planning for Hillside Development* (1996) American Planning Association.

This document describes the history, purpose, and functions of hillside development and regulation and the role of planning, and provides excerpts from hillside plans, ordinances, and guidelines from communities throughout the US.

Olshansky, Robert B. & Rogers, J. David, *Unstable Ground: Landslide Policy in the United States* (1987) Ecology Law Quarterly.

This is about the history and policy of landslide mitigation in the US.

Public Assistance Debris Management Guide (July 2000) Federal Emergency Management Agency

The Debris Management Guide was developed to assist local officials in planning, mobilizing, organizing, and controlling large-scale debris clearance, removal, and disposal operations. Debris management is generally associated with post-disaster recovery. While it should be compliant with local and county emergency operations plans, developing strategies to ensure strong debris management is a way to integrate debris management within mitigation activities. The Guide is available in hard copy or on the FEMA website.

Contact: FEMA Distribution Center
Address: 130 228th Street, SW, Bothell, WA 98021-9796
Phone: (800) 480-2520
Website: <http://www.fema.gov/r-n-r/pa/dmgtoc.htm>

USGS Landslide Program Brochure. National Landslide Information Center (NLIC), United States Geologic Survey

The brochure provides good, general information in simple terminology on the importance of landslide studies and a list of databases, outreach, and exhibits maintained by the NLIC. The brochure also includes information on the types and causes of landslides, rockfalls, and flows.

Contact: USGS- MS 966, Box 25046
Address: Denver, Federal Center, Denver, CO 80225
Phone: (800) 654-4966
Web: <http://geohazards.cr.usgs.gov/>

Landslide Endnotes

- ¹ Mileti, Dennis, *Disasters by Design: A Reassessment of Natural Hazards in the United States* (1999) Joseph Henry Press, Washington D.C.
- ² Brabb, E.E., and B.L Harrod. (Eds) *Landslides: Extent and Economic Significance. Proceedings of the 28th International Geological Congress Symposium on Landslides.* (1989) Washington D.C., Rotterdam: Balkema.
- ³ *USGS Landslide Program Brochure*, National Landslide Information Center, United States Geologic Survey.
- ⁴ *Washington County Hazard Analysis* (May 2000) Washington County Emergency Management.
- ⁵ *Oregonian*, December 12, 1996.
- ⁶ Personal Interview, Greg Clemmons, Washington County Land Use and Transportation Department, March 2001.
- ⁷ *Ibid.*
- ⁸ Interagency Hazard Mitigation Team, *State Hazard Mitigation Plan* (2000) Oregon State Police – Office of Emergency Management.
- ⁹ Robert Olson Associates, *Metro Regional Hazard Mitigation Policy and Planning Guide* (June 1999) Metro.
- ¹⁰ *Ibid.*
- ¹¹ *Planning for Natural Hazards: The Oregon Technical Resource Guide*, Department of Land Conservation and Development (July 2000), Ch. 5.
- ¹² *Ibid.*
- ¹³ *Homeowner's Guide for landslide control, hillside flooding, debris flows, soil erosion*, (March 1997).
- ¹⁴ *Storm Impacts and Landslides of 1996 Final Report* (1999) Oregon Department of Forestry.
- ¹⁵ *Planning for Natural Hazards: The Oregon Technical Resource Guide*, Department of Land Conservation and Development (July 2000), Ch. 5.
- ¹⁶ *Ibid.*
- ¹⁷ *The Citizens' Guide to Geologic Hazard* (1993) American Institute of Professional Geologists, American Institute of Professional Geologists.
- ¹⁸ Washington County Development Standards, 410-3.3 Grading and Drainage.
- ¹⁹ *Regional All Hazard Mitigation Master Plan for Clackamas County* (February 1998) Goettel & Associates.
- ²⁰ *Ibid.*
- ²¹ *Ibid.*
- ²² Burby, R. (Ed.) *Cooperating with Nature* (1998) Washington D.C.: Joseph Henry Press.
- ²³ *Washington County Hazard Analysis* (May 2000) Washington County Emergency Management.
- ²⁴ Interagency Hazard Mitigation Team, *State Hazard Mitigation Plan* (2000) Oregon State Police – Office of Emergency Management.
- ²⁵ Burby, R. (Ed.) *Cooperating with Nature.* (1998) Washington D.C.: Joseph Henry Press.
- ²⁶ *Ibid.*
- ²⁷ Interagency Hazard Mitigation Team, *State Hazard Mitigation Plan* (2000) Oregon State Police – Office of Emergency Management.
- ²⁸ *Western Oregon Debris Flow Hazard Maps: Methodology and Guidance for Map Use* (1999) Department of Geology and Mineral Industries/Oregon Department of Forestry.
- ²⁹ *Ibid.*
- ³⁰ *Ibid.*
- ³¹ *Ibid.*
- ³² *Ibid.*
- ³³ *Planning for Natural Hazards: The Oregon Technical Resource Guide*, Department of Land Conservation and Development (July 2000), Chapter 5.
- ³⁴ *Ibid.*
- ³⁵ *Landslide Hazards and Planning, Guidebook Draft Table of Contents*, (July 2001) American Planning Association.

Section 6: Severe Winter Storm

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Why are Severe Winter Storms a Threat to Washington County?

Severe winter storms pose a significant risk to life and property in Washington County by creating conditions that disrupt essential regional systems such as public utilities, telecommunications, and transportation routes. Severe winter storms can produce rain, freezing rain, ice, snow, cold temperatures, and wind. Ice storms accompanied by high winds can have destructive impacts, especially to trees, power lines, and utility services. Severe ice storms occur more frequently in areas exposed to east winds blowing out of the Columbia River Gorge. Severe freezes, where high temperatures remain below freezing for five or more days, occur every three to five years in Washington County. Severe or prolonged snow events occur less frequently, but have widespread impacts on people and property in the County.



Willamette Valley Snowstorm, 1969
Source: National Weather Service

Historical Severe Winter Storm Events

Destructive storms, producing heavy snow and paralyzing ice, have occurred throughout Washington County's history, most notably in 1937 and 1950. A serious storm in February 1937 resulted in the death of five people in the Portland area. Record snowfalls in Portland created snowdrifts up to 25 feet in height, and a low temperature of 17 degrees Fahrenheit. Schools and businesses were closed and flood damage was reported in downtown Portland basements as the snow melted.¹ All major highways were closed, shutting off the main transportation arteries for travel and business.

The “Friday the 13th” storm produced “devastating wind and snow” over a five day period in January 1950. During the night of January 12, the temperature fluctuated “wildly, accompanied by thunder” and heavy snow. The temperature dropped about 20 degrees, then rose 20 degrees, and then dropped another 20 degrees within a 5-hour time span. Snow melted and then refroze as it hit the ground, creating dangerously icy roads. Power lines were knocked down, communications were severed, and roads and schools were closed.²

Records kept since 1892 document a number of significant snow events in Washington County. The National Weather Service’s precipitation and snow gauge in Forest Grove documented the following historic snow events over the past century.

January 1950

There were three severe storms in January 1950, with very little time separating them. Their net effect was a nearly continuous storm. The storm had severe effects on infrastructure, residents, and businesses across the state. Deep snow drifts closed all highways west of the Cascades and through the Columbia River Gorge. Sleet that turned to freezing rain caused unsafe conditions on highways and damaged trees and power lines. During a severe sleet event on January 18, hundreds of motorists were stranded in the Columbia River Gorge. The stranded motorists had to be rescued by train, even though all rail traffic had considerable difficulty and many delays in getting through the Gorge. Freezing rain downed many trees and power lines, creating widespread power outages across northwestern Oregon. Hundreds of thousands of dollars in damage to public and private property occurred. Hillsboro reported 42.4 inches of snowfall during this event.³

January/February 1937

While the January/February 1937 storm had statewide impacts, heavy snowfalls were largely confined to the western slopes of the Cascades and the Willamette Valley. Deep snowdrifts blocked major highways and most minor roads in northern Oregon and the Cascade mountain passes for several days.⁴

December 1919

The December 1919 snowstorm was the third heaviest snowfall-producing storm to hit Oregon on record. The Columbia River froze over, closing the river to navigation from the confluence with the Willamette River upstream. The snowstorm affected nearly every part of the state, with heavy snow falling over a widespread area.⁵

January 1909

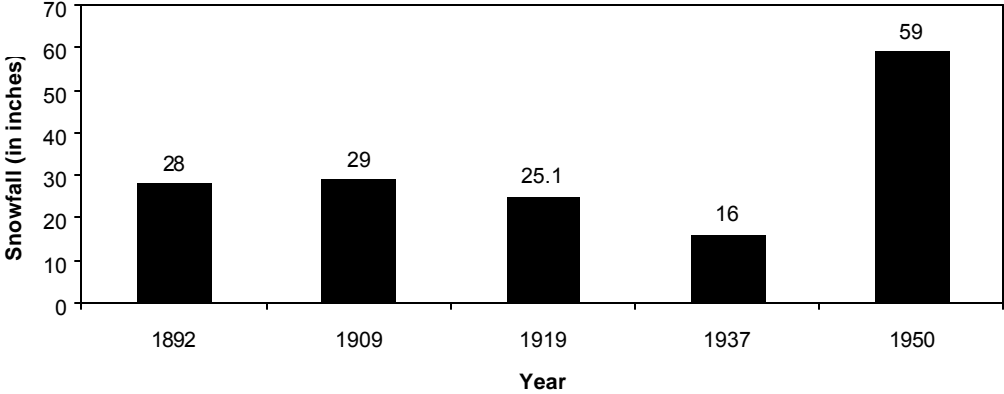
A six-day storm in January 1909 brought many locations more snow than is normally accumulated in an entire year.⁶

December 1892

From December 20 to 23, 1892, substantial snow fell across most of northern Oregon, with the greatest snowfall reported over northwestern Oregon, where storm totals ranged from 15 to 30 inches.⁷

Figure 6.1 illustrates the level of snowfall reported in the city of Forest Grove, Washington County, for the storm events reported above.

Figure 6.1. Severe Snow Storms in Forest Grove, Oregon



Source: National Weather Service, Portland Bureau

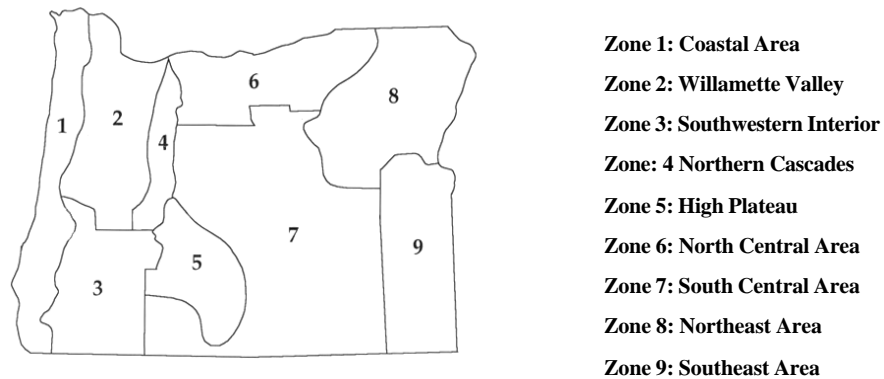
Characteristics of Severe Winter Storms in Washington County

Weather patterns⁸

Severe winter storms affecting Washington County typically originate in the Gulf of Alaska and in the central Pacific Ocean. These storms are most common from October through March.⁹ Most of Washington County has average annual precipitation of between 30 and 70 inches, with parts of the Coast Range in the west receiving over 70 inches.¹⁰

The National Climatic Data Center has established climate zones in the US for areas that have similar temperature and precipitation characteristics. Oregon’s latitude, topography, and nearness to the Pacific Ocean give the state diversified climates. Washington County is in Zone 2 (Figure 6.2). Washington County’s climate generally consists of wet winters and dry summers, with 90 percent of the precipitation occurring between October and May. Only nine percent of the annual rainfall occurs between June and September, with three percent occurring in July and August. There is an average of only five days per year of measurable snow with snowfall accumulations rarely measuring more than two inches.¹¹

Figure 6.2.
Oregon Climate Zones



Source: Taylor, George H. and Hannan, Chris, *The Oregon Weather Book*, OSU Press (1999)

Snow

While snow is relatively rare in western Oregon, the break in the natural Cascades barrier, the Columbia Gorge, provides a low-level passage through the mountains. Cold air, which lies east of the Cascades, often moves westward through the Gorge, and funnels cold air into the Portland Area. If a wet Pacific storm happens to reach the area at the same time, larger than average snow events may result.¹²

An example of this type of snowstorm event occurred in January 1980, when strong storms, accompanied by snow, ice, wind, and freezing rain hit Oregon statewide. Impacts in the Portland area alone included 200,000 customers left without power or phone service for several days, 125 boats, with a combined value of over \$3 million dollars, sunk in the Gorge and Portland, and one fatality.

Ice

Ice storms occasionally occur in northern areas of Oregon, resulting from cold air flowing westward through the Columbia Gorge.¹³ Like snow, ice storms are comprised of cold temperatures and moisture, but subtle changes can result in varying types of ice formation, including freezing rain, sleet, and hail.¹⁴

Freezing rain can be the most damaging of ice formations. While sleet and hail can create hazards for motorists when it accumulates, freezing rain can cause the most dangerous conditions within a community. Ice buildup can bring down trees, communication towers, and wires creating hazards for property owners, motorists, and pedestrians alike. The most common freezing rain problems occur near the Columbia Gorge. As noted above, the Gorge is the most significant east-west air passage through the Cascades. Rain arriving from the west can fall on frozen streets, cars, and other sub-freezing surfaces, creating dangerous conditions.¹⁵

Severe Winter Storm Community Issues

Life and Property

Winter storms are deceptive killers. Many of the deaths that occur are indirectly related to the actual storm, including deaths resulting from traffic accidents on icy roads, heart attacks while shoveling snow, and hypothermia from prolonged exposure to the cold.

Property is at risk due to flooding (see section 4-1) and landslides (see section 5-1) resulting from heavy snow melt. Trees, power lines, telephone lines, and television and radio antennas can be impacted by ice, wind, snow, and falling trees and limbs. Soil that is saturated can cause trees to lose their ability to stand and can be uprooted falling on houses, cars, utilities and other property. Similarly, if streets are icy, it is difficult for emergency personnel to travel and may pose a secondary threat to life if police, fire, and medical personnel cannot respond to calls.¹⁶

Washington County's higher elevations have greater exposure to snow and ice. They are less vulnerable, however, to economic loss as there are fewer people and structures in those areas.

Roads and Bridges

Snow and ice events resulting in icy road conditions can lead to major traffic accidents. Roads blocked by fallen trees during a windstorm may have tragic consequences for people who need access to emergency services. The ability to travel after a natural hazard event is a priority issue for County residents, organizations, and providers of essential services such as hospitals and utilities. Washington County and other jurisdictions in the region have identified emergency transportation routes that will receive high priority for assessment, clearance, and restoration following a natural hazard event. These routes will be used to move personnel and supplies throughout the region and to bring in support from outside the area.

The roads in Washington County are owned by different agencies, including the state, the County, and local municipalities. ODOT and Washington County coordinate snow plowing in areas that have higher elevations and may become hazardous as freezing temperatures result in icy roads.

Power Lines

Historically, falling trees have been the major cause of power outages resulting in interruption of services and damaged property. In addition, falling trees can bring electric power lines down, creating the possibility of lethal electric shock. Snow and ice events can also damage utility lines and cause prolonged power outages.

Rising population growth and new infrastructure in the county creates a higher probability for damage to occur from severe winter storms as more life and property are exposed to risk. Most of the development in Washington County is fairly new, including the electric utilities. Washington County does not produce any electric power or have any electric generating facilities.¹⁷ The substations and distribution stations are

designed to seismic standards. However, many overhead wires are at risk from snow and ice accumulations that are beyond the design specifications.

Water Lines

The most frequent water system problem related to cold weather is a break in cast iron mainlines. Breaks frequently occur during severe freeze events, as well as during extreme cooling periods during the months of October, November, and December. The last severe freeze that affected the Tualatin Valley Water District water system occurred in December of 1998. Over a period of nine days, the system experienced four or five mainline breaks. The most extensive damage resulted from a 10-inch main break near the intersection of SW 185th and the Tualatin Valley Highway. The break resulted in temporary loss of service to three or four houses and approximately \$60,000 in street and pipe repairs.

Another common problem during severe freeze events is the failure of commercial and residential water lines. Inadequately insulated potable water and fire sprinkler pipes can rupture and do extensive damage to property. During the December 1998 freeze, local fire agencies were kept busy for days responding to waterline breaks and assisting homeowners and businesses with water removal.

Severe Winter Storm Hazard Assessment

Hazard Identification

A severe winter storm is generally a prolonged event involving snow or ice. The characteristics of severe winter storms are determined by a number of meteorological factors including the amount and extent of snow or ice, air temperature, wind speed, and event duration, and can affect the county from the northwest and southeast, and from the Columbia River Gorge.

Precipitation, an additional element of severe winter storms, is measured by gauging stations located in Hillsboro and Forest Grove. The National Weather Service, Portland Bureau, monitors the stations and provides public warnings on storm, snow, and ice events as appropriate. Map 6.1 shows the average annual precipitation in Washington County.

Vulnerability Assessment

Vulnerability assessment is the second phase of a hazard assessment. It combines the information generated through severe winter storm identification with an inventory of the existing development exposed to this hazard assisting in the prediction of how different types of property and population groups will be affected by a hazard.¹⁸ Data including the areas exposed to winter storms in the County can be used to assess the population and total value of property at risk from severe storms.

While a quantitative vulnerability assessment (an assessment that describes number of lives or amount of property exposed to the hazard) has not yet been conducted for Washington County severe winter storm events, there are many qualitative factors (issues relating to what is in danger within a community) that point to potential vulnerability. Severe winter storms can cause power outages and transportation and economic disruptions, and pose a high risk for injuries and loss of life. The events can also be typified by a need to shelter and care for adversely impacted individuals. The County has suffered severe winter storms in the past that brought economic hardship and affected the life safety of county residents. Future severe winter storms may cause similar impacts countywide.

Long-Term Severe Winter Storm Action Item #3: Map and publicize locations around the county that have the highest incidence of extreme weather.
See page 6-11 for more information.

Risk Analysis

Risk analysis is the third, and most advanced phase of a hazard assessment. It is conducted by use of mathematical models and relies on information compiled during hazard identification and vulnerability assessments. Factors included in assessing severe winter storm risk include population and property distribution in the hazard area, the frequency of severe winter storm events, and information on trees, utilities, and infrastructure that may be impacted by severe winter storms. When sufficient data is collected for hazard identification and vulnerability assessment, a risk analysis can be completed. Insufficient data currently exists to complete a risk analysis.

Mitigation Plan Goals and Existing Activities

To review the mitigation plan goals, go to section 3, page 2 of the Washington County Natural Hazards Mitigation Action Plan.

Mitigation Plan Goals and Public Priorities

The mitigation plan goals and action items are derived from review of regional and national natural hazards mitigation plans and planning literature, guidance from the Washington County Natural Hazards Mitigation Plan Steering Committee, and interviews with Washington County stakeholders. The goals for the Washington County Natural Hazards Mitigation Action Plan are broad based to include all of the identified hazards addressed in the plan. Goals for this mitigation plan address four categories:

1. Life, Property, and Natural Systems
2. Public Awareness and Partnerships
3. Emergency Services
4. Implementation

A public workshop was held on May 15, 2001 to identify public priorities for the plan goals and discuss strategies to achieve them. The goal statements and a summary of the public workshop outcomes can be found in Section Three of this plan. All comments from the public workshop are documented in Appendix B.

Through a voting process, the participants identified goal statements in the category of Life, Property, and Natural Systems as their top priority. This section describes existing mitigation activities and severe winter storm action items. Multi-hazard action items (i.e., those that broadly address all of the identified hazards) are described in Section Three. Mitigation plan action items are designed to help meet the overall goals of the mitigation plan.

Existing Mitigation Activities

Existing mitigation activities include current mitigation programs and activities that are being implemented by county, regional, state, or federal agencies or organizations.

County

Tualatin Valley Water District

To assist in protecting customers from the impacts of cold weather, the Tualatin Valley Water District (TVWD) provides press releases to major media outlets to inform residents of predicted cold weather events, and to provide tips on how to avoid damage to plumbing systems.

In the storms in 1996, TVWD lost power to pump stations. The main operations center and most pump stations have back-up generators to provide emergency power. However, if power is not available, pumps and gauges cannot function, and the system operators cannot accurately determine the amount of water available for use.

Portland General Electric

Through the Right Tree-Right Place program, Portland General Electric (PGE) educates homeowners, landscapers, and tree propagators on tree species that will not be subject to ongoing stress by constant trimming. PGE distributes brochures that list low-growing trees that fit within the utility right-of-way and are compatible with small urban planting strips. The brochure includes information on how to select the correct tree, the energy-saving benefits of trees, and proper planting and pruning techniques. PGE offers tree owners a certificate to help defray the cost of a new tree that replaces one that is inappropriate.

PGE also runs a tree-trimming program and keeps a database of information in order to build profiles of trees that cause power line outages. PGE foresters work with local government and the public to assess and identify situations in which trees or power lines put life and property at risk. Calls and faxes to PGE's tree-trimming program result in immediate response by PGE to clear roads of fallen trees. PGE's database of tree failures intends to identify those trees that are at an above average risk.

Federal

National Weather Service

The Portland Office of the National Weather Service issues severe winter storm watches and warnings when appropriate to alert government agencies and the public of possible or impending weather events. The watches and warnings are broadcast over NOAA weather radio and are forwarded to the local media for retransmission using the Emergency Alert System.

Severe Winter Storm Mitigation Action Items

To review the multi-hazard mitigation action items, refer to section 3, page 4 of the Washington County Natural Hazards Mitigation Action Plan.

The severe winter storm mitigation action items provide direction on specific activities that organizations and residents in Washington County can undertake to reduce risk and prevent loss from severe winter storm events. There are five long-term severe winter storm action items described below. Each action item is followed by ideas for implementation, which can be used by the steering committee and local decision makers in pursuing strategies for implementation.

LT-WS#1: Increase public awareness of severe winter storm and windstorm mitigation activities.

Ideas for Implementation

- Collect existing information on public education materials for protecting life, property, and the environment from severe winter storm events.
- Identify and collect additional information and programs as necessary.
- Distribute educational materials to Washington County residents and public and private sector organizations.

Coordinating Organization: Washington County
Partner Organizations: Forest Grove Light and Power, West Oregon Electric Cooperative, Joint Water Commission, Northwest Natural, PGE, Tualatin Valley Water District, Cities
Timeline: Ongoing
Plan Goals Addressed: Life, Property, and Natural Systems; Public Awareness and Partnerships; Emergency Services

LT-WS#2: Develop and implement programs to keep trees from threatening lives, property, and public infrastructure during windstorm and severe winter storm events.

Ideas for Implementation

- Partner with responsible agencies and organizations to develop landscaping and tree programs that have less impact on above ground utility lines and roads.
- Develop partnerships between utility providers and County and local public works agencies to document known hazard areas and minimize risks.

Coordinating Organization: Washington County
Partner Organizations: PGE, Forest Grove Light and Power, West Oregon Electric Cooperative, Cities
Timeline: Ongoing
Plan Goals Addressed: Life, Property, and Natural Systems

LT-WS#3: Map and publicize locations around the county that have the highest incidence of damage from extreme weather.

Ideas for Implementation

- Identify a responsible agency for central collection and reporting of storm data. Data collected should include:
 1. Records of ice and snow in localities throughout the county.
 2. Maps of the locations within the county most vulnerable to snow and ice, including roads, bridges, and utility lines.
 3. Injury and property damage estimates, including locations.
- Identify a responsible agency to collect and transfer data to the National Climate Data Center, Oregon Climate Service, FEMA, or any other agency concerned with the incidence of storms, to help establish and maintain baseline and historic records of storm events.
- Identify public infrastructure and facilities subject to closures due to snowfall and ice hazards during winter storms.

Coordinating Organization: Washington County
Partner Organizations: National Weather Service, NOAA, ODOT, OCS
Timeline: Ongoing
Plan Goals Addressed: Life, Property, and Natural Systems; Public Awareness and Partnerships,

LT-WS#4: Support/encourage electrical utilities to use underground construction methods where possible to reduce power outages from windstorms and severe winter storms.

Ideas for Implementation

- Increase the use of underground utilities where possible.

Coordinating Organization: Washington County
Partner Organizations: PGE, Forest Grove Light and Power, West Oregon Electric Cooperative
Timeline: Ongoing
Plan Goals Addressed: Life, Property, and Natural Systems

LT-WS#5: Develop and implement, or enhance strategies for debris management for windstorm and severe winter storm events

Ideas for Implementation

- Develop coordinated management strategies for de-icing roads, plowing snow, clearing roads of fallen trees, and clearing debris from public and private property.

Coordinating Organization: Washington County
Partner Organization: Cities, METRO
Timeline: Ongoing
Plan Goals Addressed: Life, Property, and Natural Systems

For more information on debris management strategies, refer to FEMA's Public Assistance Debris Management Guide. (See Resources Section on page 6-15, 16)

Severe Winter Storm Resources

County Resources

For more information on county, state and federal natural hazard mitigation programs and activities, refer to *Appendix A: Resource Directory*

Washington County Office of Emergency Management

The Washington County Emergency Management Program exists pursuant to ORS 401 to guide the county's preparations for, response to, and recovery from major emergencies and disasters. The program is organized under the county sheriff's office and oversees preparation and maintenance of the county's emergency operations plan and emergency operations center and the training and exercising of designated staff.

Unique to Washington County is a consolidated office that brings the emergency management staffs from four jurisdictions together into a single office to enhance disaster preparedness activities countywide. The Office of Consolidated Emergency Management (OCEM) for Washington County was formed in 1995 by Intergovernmental Agreement between Washington County, the cities of Beaverton and Hillsboro, and Tualatin Valley Fire and Rescue. The organization's mission statement indicates that "The Office of Consolidated Emergency Management for Washington County is committed to the development and maintenance of a countywide, integrated system to prepare for, respond to, recover from, and mitigate against disasters."

Contact: Director, Washington County Emergency Management
Address: 20665 SW Blanton St. Aloha, OR, 97007
Phone: (503) 642.0371
Website: <http://www.ocem.org>
Email: info@ocem.org

Washington County Land Use and Transportation Department

The Washington County Land Use and Transportation Department plans, builds, and maintains the County's transportation systems and prepares, implements, and enforces land use plans and policies.

Contact: Washington County Land Use and Transportation
Address: Land Use and Transportation Department, 155 N. First Avenue, Suite 350, Hillsboro, OR 97124
Phone: (503) 846-3470
Website: <http://www.co.washington.or.us/deptmts/lt/lt.htm>
Email: lutdir@co.washington.or.us

Clean Water Services (CWS)

Clean Water Services (formerly the Unified Sewerage Agency) provides sanitary sewer and storm water management services to large portions of Washington County. CWS works with the County and the cities within the County to build and maintain public drainage systems that meet public need and comply with regulations set by the Oregon Department of Environment Quality. CWS maintains storm sewers and pipelines, open drainage ditches, and stormwater detention ponds. CWS also develops long-term flood

management plans, including, but not limited to, protection of riparian buffer areas and wetland preservation.

Contact: Clean Water Services
Address: 155 N. First Ave. Suite 270, Hillsboro, OR 97124
Phone: (503) 846-8621
Fax: (503) 846-3525
Website: <http://www.cleanwaterservices.org>

Regional Resources

Metro Regional Government

Metro is the directly elected regional government that serves more than 1.3 million residents in Clackamas, Multnomah, and Washington counties and 24 cities in the Portland metropolitan area. Chapter 5 of Metro's Regional Framework Plan addresses natural hazards. Metro's Natural Hazards Program is a service of the Growth Management Services Department's Data Resource Center. Their web pages relate to natural hazards that may impact the Portland metropolitan area. Their links provide information about the natural hazards in the Portland metropolitan area and suggest tools for reducing potential damages before disaster strikes. Metro produced the *Regional Hazard Mitigation Policy and Planning Guide* in 1999 to assist local governments in planning for future natural hazard events.

Contact 1: Metro Regional Government
Address: 600 NE Grand Ave, Portland, OR 97232-2736
Phone: (503) 797-1839
Fax: (503) 797-1911
Website: <http://www.metro.dst.or.us/metro/growth/gms.html>
Email: 2040@metro-region.org

Contact 2: Metro Data Resource Center
Website: <http://storefront.metro.dst.or.us/drc/nathaz/nathaz.cfm>
Email: drc@metro.dst.or.us

State Resources

Department of Land Conservation and Development (DLCD)

DLCD administers the state's Land Use Planning Program. The program is based on 19 statewide planning goals, including Goal 7, related to natural hazards, with flood as its major focus. In order to help local governments address natural hazards effectively, DLCD provides technical assistance such as conducting workshops, reviewing local land use plan amendments, and working interactively with other agencies.

Contact: Natural Hazards Program Manager, DLCD
Address: 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540
Phone: (503) 373-0050
Fax: (503) 378-6033
Website: <http://www.lcd.state.or.us/hazards.html>

Oregon Climate Service

The Oregon Climate Service collects, manages, and maintains Oregon weather and climate data. OCS provides weather and climate information to those within and outside the state of Oregon and educates the citizens of Oregon on current and emerging climate issues. OCS also performs independent research related to weather and climate issues.

Contact: Oregon Climate Service
Address: Oregon Climate Service, Oregon State University
Strand Ag Hall Room 316, Corvallis, OR 97331-2209
Phone: (541) 737-5705
Website: <http://www.ocs.orst.edu>
Email: oregon@oce.orst.edu

Oregon State Police (OSP)-Office of Emergency Management (OEM)

The purpose of OEM is to execute the Governor's responsibilities to maintain an emergency services system as prescribed in Oregon Revised Statutes Chapter 401 by planning, preparing, and providing for the prevention, mitigation, and management of emergencies or disasters that present a threat to the lives and property of citizens of and visitors to the state of Oregon.

Contact: Office of Emergency Management
Address: 595 Cottage Street NE, Salem, OR 97310
Phone: (503) 378-2911
Fax: (503) 588-1378
Website: <http://www.osp.state.or.us/oem>

Federal Resources

Federal Emergency Management Agency (FEMA)

FEMA's mission is "to reduce loss of life and property and protect our nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response and recovery." FEMA Region X serves the northwestern states of Alaska, Idaho, Oregon, and Washington.

Contact: FEMA, Federal Regional Center, Region 10
Address: 130-228th St. SW, Bothell, WA 98021-9796
Phone: (425) 487-4678
Website: <http://www.fema.gov/Reg-X/index.htm>

National Oceanic and Atmospheric Administration (NOAA)

NOAA's historical role has been to predict environmental changes, protect life and property, provide decision makers with reliable scientific information, and foster global environmental stewardship.

Contact: National Oceanic and Atmospheric Administration
Address: 14th Street & Constitution Avenue, NW, Room 6013, Washington, DC 20230
Phone: (202) 482-6090
Fax: (202) 482-3154
Website: <http://www.noaa.gov>
Email: answers@noaa.gov

National Weather Service, Portland Bureau

The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and infrastructure, which can be used by other governmental agencies, the private sector, the public, and the global community.

Contact: National Weather Service
Address: 5241 NE 122nd Ave, Portland, Oregon 97230
Phone: (503) 326-2340
Website: <http://nimbo.wrh.noaa.gov/Portland>
Email: clinton.rockey@noaa.gov

Additional Resources

American Red Cross

The American Red Cross is a humanitarian organization, led by volunteers, that provides relief to victims of disasters and helps people prevent, prepare for, and respond to emergencies. The Oregon Trail Chapter was chartered as a Red Cross unit in 1917. The chapter serves the residents of Clackamas, Columbia, Multnomah, Washington, Yamhill, and Tillamook counties. The Oregon Trail Chapter provides a variety of community services which are consistent with the Red Cross mission and meet the specific needs of this area, including disaster planning, preparedness, and education.

Contact: American Red Cross, Oregon Trail Chapter
Address: P.O. Box 3200, Portland, OR 97208-3200
Phone: (503) 284-1234
Fax: (503) 284-4247
Website: <http://www.redcross-pdx.org> <http://www.redcross.org/services/disaster>
Email: info@redcross-pdx.org

Institute for Business & Home Safety (IBHS)

IBHS was created as an initiative of the insurance industry to reduce damage and losses caused by natural disasters. Their website provides educational resources and on-line publications for insurers, businesses, and homeowners who are interested in taking the initiative to minimize future damages and losses.

Contact: Institute for Business and Home Safety
Address: 1408 North Westshore Boulevard - Suite 208 - Tampa, FL 33607
Phone: (813) 286-3400
Fax: (813) 286-9960
E-mail: info@ibhs.org
Website: <http://www.ibhs.org/ibhs2>

Public Assistance Debris Management Guide, Federal Emergency Management Agency (July 2000).

The Debris Management Guide was developed to assist local officials in planning, mobilizing, organizing, and controlling large-scale debris clearance, removal, and disposal operations. Debris management is generally associated with post-disaster recovery. While it should be compliant with local and county emergency operations plans, developing strategies to ensure strong debris management is a way to integrate debris management within mitigation activities. The *Public Assistance Debris Management Guide* is available in hard copy or on the FEMA website.

Contact: FEMA Distribution Center
Address: 130 228th Street, SW, Bothell, WA 98021-9796
Phone: (800) 480-2520
Fax: (425) 487-4622
Website: <http://www.fema.gov/r-n-r/pa/dmgtoc.htm>

Severe Winter Storm Endnotes

¹ The Oregonian, February 2, 1937.

² The Oregonian, January 14, 1950.

³ National Weather Service, Portland Bureau, (March 2001).
<http://www.wrh.noaa.gov/Portland/snowstorm.html>.

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⁵ Ibid.

⁶ Ibid.

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⁸ *Oregon Environmental Atlas*, (1988) Oregon Department of Environmental Quality. Cartographic Center, Geography Department, Portland State University.

⁹ Interagency Hazard Mitigation Team, *State Hazard Mitigation Plan (2000)* Oregon State Police – Office of Emergency Management.

¹⁰ Ibid.

¹¹ National Weather Service, Portland Bureau, (March 2001).
<http://www.wrh.noaa.gov/Portland/snowstorm.html>.

¹² Taylor, George H. and Hannan, Chris, *The Oregon Weather Book*, (1999) Oregon State University Press.

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¹⁵ Ibid.

¹⁶ Robert Olson Associates, *Metro Regional Hazard Mitigation Policy and Planning Guide*, (June 1999), Metro.

¹⁷ Portland General Electric (April 2001),
http://www.portlandgeneral.com/main_plants.asp.

¹⁸ Burby, R. (Ed.) *Cooperating with Nature: Confronting Natural Hazards with Land Use Planning for Sustainable Communities*. Washington D.C. (1998), Joseph Henry Press.

Section 7: Windstorm

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Why are Windstorms a Threat to Washington County?

Windstorms can have devastating effects on the lives, property, infrastructure, and vital lifelines of any community. Although not common occurrences in Washington County, straight-line and cyclonic winds of damaging strength have periodically impacted the county. A windstorm in 1995 damaged numerous homes, businesses, and public facilities, generated tons of disaster-related debris, and caused local governments to spend several million dollars to deal with the storm's impacts throughout the state. Oregon received \$2.8 million through the Federal Emergency Management Agency's (FEMA) Public Assistance program to repair and restore damaged infrastructure. Approximately \$420,000 was allocated toward mitigation activities through FEMA's Hazard Mitigation Grant Program. Washington County sought and received a Presidential Disaster Declaration to recover from the event.

Historical Windstorm Events

Columbus Day Windstorm October 1962¹

The Columbus Day storm in 1962 was the most destructive windstorm ever recorded in Oregon, both in terms of loss of life and property damage. Damage was most severe in the Willamette Valley.² The storm killed thirty-eight people and did upwards of \$200 million in damage. Hundreds of thousands of homes were without power for short periods of time, while others were without power for two to three weeks. More than 50,000 homes were seriously damaged, and nearly 100 were completely destroyed. Entire fruit and nut orchards were destroyed and livestock killed as barns and trees blew over onto animals. Intense wind speeds were recorded in the metropolitan areas with gusts of 116 mph on the Portland Morrison Bridge and peak gusts in Hillsboro of 90mph.



1962 Columbus Day Windstorm,
Source: National Weather Service

June 1966 Tornado

A small, short-lived tornado near Forest Grove in June 1966 moved from the southwest to northwest through a corn field and prune orchard, uprooting 20 to 25 prune trees. The tornado occurred during the late afternoon, had a path length of one-fourth mile and was 60 yards in width at the widest point. There was no other significant damage reported with the tornado. Heavy rain occurred at the same time, but no hail or lightning was reported.³

November 1981 Windstorm

November 1981 saw two successive windstorms on November 13 and 14. Wind gusts in Portland were recorded at 71 mph on the first day and 57 mph on the second day. Eleven people were killed and \$50 million in damages were reported as a result of the two storms. Numerous injuries resulted from wind-blown debris in western Washington and Oregon. There were hundreds of downed trees and power lines across the Pacific Northwest. Roof damage was common. Downed power lines caused massive power outages. Estimates indicated that nearly 500,000 homes were without power for at least a short time during the weekend. Many airports across Oregon and Washington suffered damage. At the Hillsboro airport, one airplane was flipped upside down and several hangers were damaged.⁴

November 1991 Tornado

A tornado in November of 1991 touched down near an office district in Tualatin. It lifted two dumpsters and threw them into a parked van and sucked open an office door, ripping out the ceiling tiles.⁵

December 1993 Tornado

The December 8, 1993 tornado near Newberg was the most powerful tornado in Oregon in many years. It originated from a cold front and a deep surface low pressure center that moved across the Willamette Valley. Six veal calves were killed, a dairy farm was damaged, roofs were blown off some small buildings, and many trees were broken. People reported that the funnel was sucking water from the Willamette River as it moved northeast and greatly damaged a mobile home park. A tree at least 2 feet in diameter was snapped off six feet above the ground and hit a two story house.⁶

December 1995 Windstorm

On December 11, 1995 a large low pressure storm approached the Southern Oregon-Northern California coast and began to slow and intensify.⁷ The National Weather Service issued high wind warnings for the coast and inland valleys as the storm center tracked north along the Oregon coast. Peak winds hit Washington County on December 12. Gusts of over 100 mph occurred along the coast while gusts in the Willamette Valley exceeded 60 mph. Hundreds of thousands of people in the state lost power, and there was widespread damage to homes, buildings, and boats. Four Oregonians lost their lives during the storm.⁸

Characteristics of Windstorms in Washington County

Straight-line and cyclonic winds both occur in Washington County. Far more common are straight-line winds, which originate as a downdraft of rain-cooled air, and reach the ground and spread out rapidly. Straight-line winds can produce gusts of up to 100 mph. Though the County is rarely subjected to cyclonic winds, several tornados have occurred in the past few decades.

A majority of the destructive surface winds in Oregon come out of the southwest. Under certain conditions, very strong east winds may occur, but these are usually limited to small areas in the vicinity of the Columbia River Gorge or other low mountain passes.

The more frequent and widespread strong winds from the southwest are associated with storms moving onto the coast from the Pacific Ocean. If the winds are from the west, they are often stronger on the coast than in the interior valleys due to the north-south orientation of the Coast Range and Cascades. These mountain ranges obstruct and slow the westerly surface winds.

The most destructive winds are those which blow from the south, parallel to the major mountain ranges. The Columbus Day Storm of 1962 was a classic example of a south wind storm. The storm developed well off the coast of



1962 Columbus Day Windstorm,
Source: National Weather Service

California, moved to the northeast, and then turned north and paralleled the Oregon coast.

The Cascade Mountain Range acts as a barrier to keep cold continental air masses originating in the arctic areas of Canada from invading western Oregon.⁹ However, outbreaks of cold arctic air from east of the Cascades occasionally spill into Portland and the metro area bringing cold east winds. If the east winds occur when rain is falling

over the metropolitan area, a shallow layer of cold air forms along the Columbia River. In and near this cold air, freezing rain and snow will occur over eastern and northern Portland.¹⁰

Chinook winds are strong easterly winds coming out of the Columbia Gorge. Chinook is a native Indian word meaning “snow eater.” The Chinook wind is a warm dry wind that often leads to the rapid disappearance of snow, and can gust up to 100 miles per hour. The gusts are caused by rapid atmospheric pressure changes. Studies have shown that these changes can result in physiological and psychological reactions in humans such as headaches and increased irritability.¹¹

The valley floor in Washington County generally does not feel severe effects of the east winds and storms because it is somewhat protected by the Tualatin Mountains in the eastern part of the County. Mountainous terrain slows down wind movement, which is why Oregon’s sheltered valley areas have the slowest wind speed in the state. However, in the foothills, the wind speeds may increase as down-sloping winds from the mountains.¹²

Windstorm Community Issues

Life and Property

Windstorms have the ability to cause damage over 100 miles from the center of storm activity. Isolated wind phenomena in the mountainous regions have more localized effects. Winds near the earth's surface and associated pressure effects on walls, doors, windows, and roofs, may cause structural components, the elements that provide the buildings structure, to fail.

Wind pressure can create a direct and frontal assault on a structure, pushing walls, doors, and windows inward. Conversely, passing currents can create lift and suction forces that act to pull building components and surfaces outward. The effects of winds are magnified in the upper levels of multi-story structures. As positive and negative forces impact the buildings protective envelope (doors, windows, and walls), the result can be roof or building component failures and considerable structural damage. The effects of wind speed are shown in Table 7.1.

Table 7.1. The Effect of Wind Speed

WIND SPEED (MPH)	WIND EFFECTS
25-31	Large branches will be in motion.
32-38	Whole trees in motion; inconvenience felt walking against the wind.
39-54	Twigs and small branches may break off of trees; wind generally impedes progress when walking; high profile vehicles such as trucks and motor homes may be difficult to control.
55-74	Potential damage to TV antennas; may push over shallow rooted trees especially if the soil is saturated.
75-95	Potential for minimal structural damage, particularly to unanchored mobile homes; power lines, signs, and tree branches may be blown down.
96-110	Moderate structural damage to walls, roofs and windows; large signs and tree branches blown down; moving vehicles pushed off roads.
111-130	Extensive structural damage to walls, roofs, and windows; trees blown down; mobile homes may be destroyed.
131-155	Extreme damage to structures and roofs; trees uprooted or snapped.
Greater than 155	Catastrophic damage; structures destroyed.

Source: Washington County Office of Consolidated Emergency Management

Debris carried along by extreme winds can directly contribute to loss of life and indirectly to the failure of protective building envelopes, siding, or walls of buildings. When severe windstorms strike a community, downed trees, power lines, and damaged property can be major hindrances to emergency response and disaster recovery.

Infrastructure

Washington County is susceptible to direct impacts on infrastructure and property, and indirect costs stemming from business closures and lost work time resulting from windstorms. Storm winds can damage buildings, power lines, and other property and infrastructure by means of falling trees and branches. During wet winters, saturated soils cause trees to become less stable and more vulnerable to uprooting from high winds.

Damage to infrastructure resulting from windstorm events include collapsed or damaged buildings, damaged or blocked roads and bridges, damaged traffic signals, streetlights, and parks, among others. Roads blocked by fallen trees during a windstorm may have severe consequences to people who need access to emergency services. Emergency response operations can be complicated when roads are blocked or when power supplies are interrupted.¹³

Industry and commerce can suffer losses from interruptions in electric service and from extended road closures. They can also sustain direct losses to buildings, personnel, and other vital equipment. There are direct consequences to the local economy resulting from windstorms related to both physical damages and interrupted services.

Utilities

Historically, falling trees have been the major cause of power outages. Windstorms can cause flying debris and downed utility lines. For example, tree limbs breaking in winds of only 45 mph can be thrown over 75 feet. As such, overhead power lines can be damaged even in relatively minor windstorm events. Utility lines brought down by summer thunderstorms have also been known to cause fires, which start in dry roadside vegetation.¹⁴ Falling trees can bring electric power lines down to the pavement, creating the possibility of lethal electric shock.

Rising population growth and new infrastructure in the county creates a higher probability for damage to occur from windstorms as more life and property are exposed to risk. Most of the development in Washington County is fairly new, including the electric utilities. Washington County does not produce any electric power or have any electric generating facilities.¹⁵ The substations and distribution stations are designed to seismic standards. However, many overhead wires remain at risk from wind, snow, and ice that are beyond the design specifications.

Increasingly, Washington County's electric infrastructure is placed underground which lessens the risk from windstorms. However, older parts of the county may have electrical utilities above ground.

Tree Failure and Resulting Power Line Outages

Table 7.2 describes general tree failure information for Washington County. This information illustrates the types of trees, wind speed, location, and stand type of tree failures that have resulted in power outages between 1992 and 2001.

Table 7.2. Report on Tree failures Causing Power Outages in Washington County, 1992 through 2001

By Occurrence:		By Wind Speed:	
Douglas Fir	31%	Less than 10 mph	17%
Oregon Ash	13%	10-30 mph	43%
Bigleaf Maple	12%	Greater than 30 mph	40%
Red Alder	8%		
Oregon White Oak	8%		
By Location:		By Stand Type:	
Rural road	57%	Natural stand	79%
Residential yard	31%	Planted	19%
Cross country right of way	4%		
Commercial	2%		
Greenway	2%		
Street tree	2%		

Source: Portland General Electric, Forester's Office, 2001

Tables 7.3 and 7.4 are Tree Failure Profiles developed by Portland General Electric (PGE) for two of the most common tree failures in the PGE service territory. The profiles are developed from the data collected and used by PGE foresters in targeting "at-risk" trees during routine vegetation maintenance cycles.

Table 7.3. Tree Failure Profile - Species: Douglas fir (*Pseudotsuga menziesii*)

Failed Part	Description of failure/ Tree characteristics	Associated defects/ Indicators	Environment	Management History
BRANCH Frequency: High	Small dia. branches from mature trees; can sail up to 75 ft & wrap lines. Overhanging branch failure from snow/ice loading.	Evidence of previous branch failures.	Exposure to winds/gusts greater than 40 mph. Line downwind.	Side trimmed trees.
TRUNK Frequency: Low	Failure of multiple tops.	Old topping cut, previous break, decay present.	Wind or ice storms.	Previous topping.
	Interior trees, 3-8" dia.	Intermediate/suppressed trees.	Wind, snow/ice loading, recent exposure.	Thinning of stand, exposure as edge tree.
	Dead tree of any size in close proximity to line.	Entire tree dead for some time.	Line downwind.	
ROOT Frequency: High	Trees of all ages.	Evidence of other root failures.	Slight to moderate wind.	Site disturbance; leave trees from logging or development.
	Small, interior trees.	Poor taper, low live crown ratio, aggravating site characteristics.	Slight to moderate wind.	Thinning of stand; overstocked, unmanaged stands.

Source: Portland General Electric, Forester's Office, 2001; © Portland General Electric Co.

Table 7.4. Tree Failure Profile - Species: Bigleaf Maple (*Acer macrophyllum*)

Failed Part	Description of failure/ Tree characteristics	Associated defects/ Indicators	Environment	Management History
BRANCH Frequency: High	Mature trees; scaffold branches; or during full leaf-out.	Decay present at multiple branch attachment. Codominant stems with included bark.	Heavy rains after leaf-out in spring; heavy fall rains. Exposure to winds/gusts greater than 30 mph. Line downwind, ivy covered.	Natural and previously pruned; history of side trimming.
TRUNK Frequency: Low	Trunk failure at base of tree up to 12 feet.	Decay present in trunk or at base.	On a slope, line downwind, or ivy covered.	In unmanaged or natural areas.

Source: Portland General Electric, Forester's Office, 2001; © Portland General Electric Co.

Windstorm Hazard Assessment

Hazard Identification

A windstorm is generally a short duration event involving straight-line winds and/or gusts in excess of 50 mph. Windstorms affect areas of the County with significant tree stands, as well as areas with exposed property, major infrastructure, and above ground utility lines. The lower wind speeds typical in the lower valleys are still high enough to knock down trees, bring down power lines, and cause other property damage. Mountainous sections of the county experience much higher winds under more varied conditions. Because of the local nature of wind hazards in the mountains, a high-resolution wind speed map would be required to accurately identify the degree of wind hazard throughout the county. Such a map could identify wind hazards other than tree-falls, such as winds high enough to cause various degrees of structural damage.

**Long-Term
Windstorm Action
Item #3:** Map and publicize locations around the county that have the highest incidence of extreme weather. See page 7-12 for more information

Vulnerability Assessment

Vulnerability assessment is the second phase of a hazard assessment. It combines the information generated through windstorm identification with an inventory of the existing development exposed to this hazard. This assists in predicting how different types of property and population groups will be affected by a hazard.¹⁶ Data that includes areas exposed to windstorm hazards in the County can be used to assess the population and total value of property at risk from windstorm events.

While a quantitative vulnerability assessment (an assessment that describes number of lives or amount of property exposed to the hazard) has not yet been conducted for Washington County windstorms, there are many qualitative factors (issues relating to what is in danger within a community) that point to potential vulnerability. Windstorms can cause power outages, transportation and economic disruptions, and significant property damage and pose a high risk for injuries and loss of life. They can also be typified by a need to shelter and care for individuals impacted by the events. Several destructive windstorms, (most notably the 1962 Columbus Day storm and the December 12, 1995 windstorm) brought economic hardship and affected the life safety of county residents. Future windstorms may cause similar impacts countywide.

Risk Analysis

Risk analysis is the third, and most advanced phase of a hazard assessment. It is conducted by use of mathematical models and relies on information compiled during hazard identification and vulnerability assessments. Factors included in windstorm risk analysis include population and property distribution in the hazard area, the frequency of windstorm events, and information on the types of trees and failure rates most susceptible to windstorm events. When sufficient data is collected for hazard identification and vulnerability assessment, a risk analysis can be completed. Insufficient data currently exists to complete a risk analysis.

Mitigation Plan Goals and Existing Activities

Mitigation Plan Goals and Public Priorities

The mitigation plan goals and action items are derived from a review of regional and national natural hazards mitigation plans and planning literature, guidance from the Washington County Natural Hazards Mitigation Plan Steering Committee, and interviews with Washington County stakeholders. The goals for the Washington County Natural Hazards Mitigation Action Plan are broad based to include all of the identified hazards addressed in the plan. Goals for this mitigation plan address four categories:

1. Life, Property, and Natural Systems
2. Public Awareness and Partnerships
3. Emergency Services
4. Implementation

A public workshop was held on May 15, 2001 to identify public priorities for the plan goals and discuss strategies to achieve them. The goal statements and a summary of the public workshop outcomes can be found in Section Three of this plan. All comments from the public workshop are documented in Appendix B.

Through a voting process, the participants identified goal statements in the category of Life, Property, and Natural Systems as the ir top priority. This section describes existing mitigation activities and windstorm action items. Multi-hazard action items (i.e., those that broadly address all of the identified hazards) are described in Section Three. Mitigation plan action items are designed to help meet the overall goals of the mitigation plan.

To review the mitigation plan goals, go to section 3, page 2 of the Washington County Natural Hazards Mitigation Action

Existing Mitigation Activities

Existing mitigation activities include current mitigation programs and activities that are being implemented by county, regional, state, or federal agencies or organizations.

County

Tualatin Valley Water District

Tualatin Valley Water District's (TVWD) exposure to windstorms is primarily limited to power loss. In the 1995 windstorm, TVWD's main operations station lost power for approximately twelve hours. During storms in 1996, TVWD lost power to pump stations. The main operations center and most pump stations have back-up generators to provide emergency power. However, if power is not available, pumps and gauges cannot function, and the system operators cannot accurately determine the

amount of water available for use. Additionally, during the storms of 1996, TVWD paid visits to approximately ten-percent of its customers. Many of the visits were weather related. Rolling blackouts can pose serious problems to the water system. During summer, when water use is extremely high, emergency generators may provide power to meet peak demand.

Portland General Electric

Through the Right Tree-Right Place program, Portland General Electric (PGE) educates homeowners, landscapers, and tree propagators on tree species that will not be subject to ongoing stress by constant trimming. PGE distributes brochures that list low-growing trees that fit within the utility right-of-way and are compatible with small urban planting strips. The brochure includes information on how to select the correct tree, the energy-saving benefits of trees, and proper planting and pruning techniques. PGE offers tree owners a certificate to help defray the cost of a new tree that replaces one that is inappropriate.

PGE also runs a tree-trimming program and keeps a database of information in order to build profiles of trees that cause power line outages. PGE foresters work with local government and the public to assess and identify situations in which trees or power lines put life and property at risk. Calls and faxes to PGE's tree-trimming program result in immediate response by PGE to clear roads of fallen trees. PGE's database of tree failures intends to identify those trees that are at an above average risk.

Federal

National Weather Service

The Portland Office of the National Weather Service issues severe winter storm watches and warnings when appropriate to alert government agencies and the public of possible or impending weather events. The watches and warnings are broadcast over NOAA weather radio and are forwarded to the local media for retransmission using the Emergency Alert System.



1962 Columbus Day Windstorm,
Source: National Weather Service

Windstorm Mitigation Action Items

The windstorm mitigation action items provide direction on specific activities that organizations and residents in Washington County can undertake to reduce risk and prevent loss from windstorm events. There are five long-term windstorm action items described below. Each action item is followed by ideas for implementation, which can be used by the steering committee and local decision makers in pursuing strategies for implementation.

To review the multi-hazard mitigation action items, refer to section 3, page 4 of the Washington County Natural Hazards Mitigation Action Plan.

LT-WS#1: Increase public awareness of windstorm mitigation activities.

Ideas for Implementation

- Collect existing information on public education materials for protecting life, property, and the environment from windstorm events.
- Identify and collect additional information and programs as necessary.
- Distribute educational materials to Washington County residents and public and private sector organizations.

Coordinating Organization: Washington County
Partner Organizations: Forest Grove Light and Power, West Oregon Electric Cooperative, Joint Water Commission, Northwest Natural, PGE, Tualatin Valley Water District, Cities
Timeline: Ongoing
Plan Goals Addressed: Life, Property, and Natural Systems; Public Awareness and Partnerships; Emergency Services

LT-WS#2: Develop and implement programs to keep trees from threatening lives, property, and public infrastructure during windstorm events.

Ideas for Implementation

- Partner with responsible agencies and organizations to design and implement tree programs that reduce risk to life, property, and utility systems.
- Develop partnerships between utility providers and County and local public works agencies to document known hazard areas.

Coordinating Organization: Washington County
Partner Organizations: PGE, Forest Grove Light and Power, West Oregon Electric Cooperative, Cities
Timeline: Ongoing
Plan Goals Addressed: Life, Property, and Natural Systems

LT-WS#3: Map and publicize locations around the county that have the highest incidence of damage from extreme weather.

Ideas for Implementation

- Identify a responsible agency for central collection and reporting of storm data. Data collected should include:
 1. Windstorm data (sustained speeds, gusts, storm durations) for localities throughout the county.
 2. Maps of the locations within the county, which are most vulnerable to high winds.
 3. Injury and property damage estimates, including locations.
- Identify a responsible agency to collect and transfer data to the National Climate Data Center, Oregon Climate Service, FEMA, or other agencies concerned with the incidence of storms, to help establish and maintain baseline and historic records of storm events.
- Identify public infrastructure and facilities subject to damage or closure during windstorm events.

Coordinating Organization: Washington County

Partner Organizations: National Weather Service, NOAA, OCS

Timeline: Ongoing

Plan Goals Addressed: Life, Property, and Natural Systems

LT-WS#4: Support/encourage electrical utilities to use underground construction methods where possible to reduce power outages from windstorms.

Ideas for Implementation

- Increase the use of underground utilities where possible.

Coordinating Organization: Washington County

Partner Organizations: PGE, Forest Grove Light and Power, West Oregon Electric Cooperative

Timeline: Ongoing

Plan Goals Addressed: Life, Property, and Natural Systems

LT-WS#5: Develop and implement or enhance strategies for debris management for windstorm events

Ideas for Implementation

- Develop coordinated management strategies for clearing roads of fallen trees and clearing debris from public and private property.

Coordinating Organization: Washington County

Partner Organizations: Cities

Timeline: Ongoing

Plan Goals Addressed: Life, Property, and Natural Systems

For more information on debris management strategies, refer to FEMA's Public Assistance Debris Management Guide. (See Resources

Windstorm Resources

County Resources

Washington County Office of Emergency Management

The Washington County Emergency Management Program exists pursuant to ORS 401 to guide the county's preparations for, response to, and recovery from major emergencies and disasters. The program is organized under the county sheriff's office and oversees preparation and maintenance of the county's emergency operations plan and emergency operations center and the training and exercising of designated staff.

Unique to Washington County is a consolidated office that brings the emergency management staffs from four jurisdictions together into a single office to enhance disaster preparedness activities countywide. The Office of Consolidated Emergency Management (OCEM) for Washington County was formed in 1995 by Intergovernmental Agreement between Washington County, the cities of Beaverton and Hillsboro, and Tualatin Valley Fire and Rescue. The organization's mission statement indicates that "The Office of Consolidated Emergency Management for Washington County is committed to the development and maintenance of a countywide, integrated system to prepare for, respond to, recover from, and mitigate against disasters."

For more information on county, state and federal natural hazard mitigation programs and activities, refer to *Appendix A: Resource Directory*

Contact: Director, Washington County Emergency Management
Address: 20665 SW Blanton St. Aloha, OR, 97007
Phone: (503) 642-0371
Website: <http://www.ocem.org>
Email: info@ocem.org

Washington County Land Use and Transportation Department

The Washington County Land Use and Transportation Department plans, builds and maintains the County's transportation systems and prepares, implements, and enforces land use plans and policies.

Contact: Washington County Land Use and Transportation
Address: 155 N. First Avenue, Suite 350, Hillsboro, OR 97124
Phone: (503) 846-3470
Website: <http://www.co.washington.or.us/deptmts/lut/lut.htm>
Email: lutdir@co.washington.or.us

Regional Resources

Metro Regional Government

Metro is the directly elected regional government that serves more than 1.3 million residents in Clackamas, Multnomah, and Washington counties and 24 cities in the Portland metropolitan area. Chapter 5 of Metro's Regional Framework Plan addresses natural hazards. Metro's Natural Hazards Program is a service of the Growth Management Services Department's

Data Resource Center. Their web pages relate to natural hazards that may impact the Portland metropolitan area. Their links provide information about the natural hazards in the Portland metropolitan area and suggest tools for reducing potential damages before disaster strikes. Metro produced the *Regional Hazard Mitigation Policy and Planning Guide* in 1999 to assist local governments in planning for future natural hazard events.

Contact 1: Metro Regional Government
Address: 600 NE Grand Ave, Portland, OR 97232-2736
Phone: (503) 797-1839
Fax: (503) 797-1911
Website: <http://www.metro.dst.or.us/metro/growth/gms.html>
Email: 2040@metro-region.org

Contact 2: Metro Data Resource Center
Website: <http://storefront.metro.dst.or.us/drc/nathaz/nathaz.cfm>
Email: drc@metro.dst.or.us

State Resources

Oregon Department of Consumer and Business Services

The Building Codes Division of Oregon's Department of Consumer and Business Services is responsible for administering statewide building codes. Its responsibilities include adoption of statewide construction standards that help create disaster-resistant buildings, particularly for flood, wildfire, wind, foundation stability, and seismic hazards.

Contact: Building Codes Division
Address: 1535 Edgewater St. NW, P.O. Box 14470, Salem, OR 97309
Phone: (503) 373-4133
Fax: (503) 378-2322
Website: <http://www.cbs.state.or.us/external/bcd>

Oregon Climate Service

The Oregon Climate Service collects, manages, and maintains Oregon weather and climate data. OCS provides weather and climate information to those within and outside the state of Oregon and educates the citizens of Oregon on current and emerging climate issues. OCS also performs independent research related to weather and climate issues.

Contact: Oregon Climate Service
Address: Oregon Climate Service, Oregon State University
Strand Ag Hall Room 316, Corvallis, OR 97331-2209
Phone: (541) 737-5705
Website: <http://www.ocs.orst.edu>
Email: oregon@oce.orst.edu

Oregon State Police (OSP)-Office of Emergency Management (OEM)

The purpose of OEM is to execute the Governor's responsibilities to maintain an emergency services system as prescribed in Oregon Revised Statutes Chapter 401 by planning, preparing, and providing for the prevention, mitigation, and management of emergencies or disasters that

present a threat to the lives and property of citizens of and visitors to the state of Oregon.

Contact: Office of Emergency Management
Address: 595 Cottage Street NE, Salem, OR 97310
Phone: (503) 378-2911
Fax: (503) 588-1378
Website: <http://www.osp.state.or.us/oem>

Federal Resources

Federal Emergency Management Agency (FEMA)

FEMA's mission is "to reduce loss of life and property and protect our nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response and recovery." FEMA Region X serves the northwestern states of Alaska, Idaho, Oregon, and Washington.

Contact: FEMA, Federal Regional Center, Region 10
Address: 130-228 St. SW, Bothell, WA 98021-9796
Phone: (425) 487-4678
Website: <http://www.fema.gov/Reg-X/index.htm>

National Weather Service, Portland Bureau

The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters, and ocean areas for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and infrastructure, which can be used by other governmental agencies, the private sector, the public, and the global community.

Contact: National Weather Service
Address: 5241 NE 122nd Ave, Portland, Oregon 97230
Phone: (503) 326-2340
Website: <http://nimbo.wrh.noaa.gov/Portland>
Email: clinton.rockey@noaa.gov

National Oceanic and Atmospheric Administration (NOAA)

NOAA's historical role has been to predict environmental changes, protect life and property, provide decision makers with reliable scientific information, and foster global environmental stewardship.

Contact: National Oceanic and Atmospheric Administration
Address: 14th Street & Constitution Avenue, NW, Room 6013, Washington, DC 20230
Phone: (202) 482-6090
Fax: (202) 482-3154
Website: <http://www.noaa.gov>
Email: answers@noaa.gov

Additional Resources

American Red Cross

The American Red Cross is a humanitarian organization, led by volunteers, that provides relief to victims of disasters and helps people prevent, prepare for, and respond to emergencies. The Oregon Trail Chapter was chartered as a Red Cross unit in 1917. The chapter serves the residents of Clackamas, Columbia, Multnomah, Washington, Yamhill, and Tillamook counties. The Oregon Trail Chapter provides a variety of community services which are consistent with the Red Cross mission and meet the specific needs of this area, including disaster planning, preparedness, and education.

Contact: American Red Cross, Oregon Trail Chapter
Address: P.O. Box 3200, Portland, OR 97208-3200
Phone: (503) 284-1234
Fax: (503) 284-4247
Website: <http://www.redcross-pdx.org> or www.redcross.org/services/disaster
Email: info@redcross-pdx.org

Institute for Business & Home Safety (IBHS)

IBHS was created as an initiative of the insurance industry to reduce damage and losses caused by natural disasters. Their website provides educational resources and on-line publications for insurers, businesses, and homeowners who are interested in taking the initiative to minimize future damages and losses.

Contact: Institute for Business and Home Safety
Address: 1408 North Westshore Boulevard - Suite 208 - Tampa, FL 33607
Phone: (813) 286-3400
Fax: (813) 286-9960
E-mail: info@ibhs.org
Website: <http://www.ibhs.org/ibhs2/>

Public Assistance Debris Management Guide, Federal Emergency Management Agency (July 2000).

The Debris Management Guide was developed to assist local officials in planning, mobilizing, organizing, and controlling large-scale debris clearance, removal, and disposal operations. Debris management is generally associated with post-disaster recovery. While it should be compliant with local and county emergency operations plans, developing strategies to ensure strong debris management is a way to integrate debris management within mitigation activities. The *Public Assistance Debris Management Guide* is available in hard copy or on the FEMA website.

Contact: FEMA Distribution Center
Address: 130 228th Street, SW, Bothell, WA 98021-9796
Phone: (800) 480-2520
Fax: (425) 487-4622
Website: <http://www.fema.gov/r-n-r/pa/dmgtoc.htm>

Windstorm Endnotes

¹ National Weather Service, Portland Bureau, (March 2001) www.wrh.noaa.gov/Portland.

² Ibid.

³ Ibid.

⁴ Ibid.

⁵ Ibid.

⁶ Ibid.

⁷ Report from George Taylor Oregon Climatologist from the Oregon Climate Service (December 1995), <http://www.ocs.orst.edu>.

⁸ National Weather Service – Portland, Oregon, (March 2001)
<http://www.wrh.noaa.gov/Portland/history.html>.

⁹ Ibid.

¹⁰ Ibid.

¹¹ Chinook Country, (June 2001) <http://members.home.net/gardner>.

¹² Ibid.

¹³ Interagency Hazard Mitigation Team, *State Hazard Mitigation Plan (2000)* Oregon State Police – Office of Emergency Management.

¹⁴ Personal interview. Winfrey, Greg. March 2001.

¹⁵ Portland General Electric, <http://www.portlandgeneral.com>, (April 2001).

¹⁶ Burby, R. (Ed.) *Cooperating with Nature: Confronting Natural Hazards with Land Use Planning for Sustainable Communities*. (1998) Washington D.C.: Joseph Henry Press.

Section 8: Wildfire

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Jim Wolf, Oregon Department of Forestry

Why is Wildfire a Threat to Washington County?

Fires are a natural part of the ecosystem in Oregon but present a substantial hazard when threatening life and property in growing communities. Although wildfires are more common to the arid areas of Eastern Oregon, there is still potential for losses due to wildland-urban interface fires in Washington County. Wildfire is defined as any fire occurring on wildlands that requires suppression response.¹ The wildfire hazard is often characterized by an increased fire risk in the urban interface zone. The interface is the urban-rural fringe where homes and other structures are built into a densely forested or natural landscape. If left unchecked, it is likely that fires in these areas will threaten lives and property.

While Washington County has not been impacted by historic wildfire events, wildfire has caused substantial destruction to nearby Oregon communities. In 1990, Bend’s Awbrey Hall Fire destroyed 21 homes, causing approximately \$9 million in damage and costing over \$2 million to suppress, and became one of Oregon’s most destructive fires in recent history. In 1996, Bend’s Skeleton Fire burned over 17,000 acres and damaged or destroyed 30 homes and structures. In that same year, 218,000 acres were burned, 600 homes were threatened, and 44 homes were lost statewide.²

“The heightened awareness of the 2000 fire season attracted an unprecedented commitment from Congress to protect communities, watersheds, and species at risk, and will make fire management a top federal priority for years to come.”

The Nature Conservancy Magazine -
May/June 2001

Table 8.1 lists major fires that occurred in Oregon from 1848 to 1966.

Table 8.1. Historic Fires in Oregon (1848-1966)

Year	Fire	# of acres burned
1848	Nestucca	290,000
1849	Siletz	800,000
1853	Yaquina	482,000
1865	Silverton	988,000
1868	Coos Bay	296,000
1933	Tillamook	240,000
1936	Bandon	143,000
1939	Saddle Mountain	190,000
1945	Wilson River/Salmonberry	180,000
1951	North Fork/Elkhorn	33,000
1966	Oxbow	44,000

Source: “Atlas of Oregon,” William G. Loy, et al, University of Oregon Books, 1976. Oregon Department of Forestry, “Tillamook Burn to Tillamook State Forest,” revised 1993.

During the 2000 fire season, more than 7.5 million acres of public and private lands burned in the US, resulting in loss of property, damage to resources, and disruption of community services. Taxpayers spent more than \$1.6 billion to combat 90,000 fires nationwide.³ Many of these fires burned in wildland/urban interface areas and exceeded the fire suppression capabilities of those areas. The magnitude of the year 2000 fires is the result of two primary factors: (1) severe drought, accompanied by a series of storms that produce thousands of lightning strikes and windy conditions; and (2) the effects of wildfire suppression over the past century that has led to buildup of brush and small diameter trees in the nation's forests and rangelands.⁴

Table 8.2 illustrates the fire suppression costs for state, private, and federal lands protected by the Oregon Department of Forestry between 1985 and 2000.

Table 8.2. History of Fire Suppression Costs 1985-2000

Year	Suppression Costs in \$\$
1985	3,268,644
1986	5,847,018
1987	32,080,746
1988	13,192,596
1989	6,394,593
1990	8,279,974
1991	5,381,192
1992	17,000,000
1993	4,023,033
1994	21,100,000
1995	4,360,349
1996	5,066,227
1997	1,210,692
1998	2,056,343
1999	5,320,555
2000	5,750,862

*Figures apply to the 15.8 million acres of state, private, and federal lands protected by the Oregon Department of Forestry. Source: Oregon Department of Forestry: <http://www.odf.state.or.us>

Wildfire Characteristics

There are three categories of interface fire:⁵

- The classic wildland-urban interface exists where well-defined urban and suburban development presses up against open expanses of wildland areas;

- The mixed wildland-urban interface is characterized by isolated homes, subdivisions, and small communities situated predominantly in wildland settings; and
- The occluded wildland-urban interface exists where islands of wildland vegetation occur inside a largely urbanized area.

Certain conditions must be present for significant interface fires to occur. The most common are hot, dry, and windy weather; the inability of fire protection forces to contain or suppress the fire; the occurrence of multiple fires that overwhelm committed resources; and a large fuel load (dense vegetation).⁶ Once a fire has started, several conditions influence its behavior, including fuel, topography, weather, drought, and development.

“With more Oregonians than ever living in forests that have grown thicker than ever through decades of strict fire suppression, even modest fires can quickly consume lives, homes, and the millions of dollars it costs to fight them.”

The Oregonian,
Feb. 26, 2001

The Interface

One challenge Washington County faces is from the increasing number of houses being built in the urban/rural fringe compared to twenty years ago. Since the 1970s, Oregon's growing population has expanded further and further into traditional resource lands such as forestland. The “interface” between urban and suburban areas and the resource lands created by this expansion has produced a significant increase in threats to life and property from fires, and has pushed existing fire protection systems beyond original or current design or capability.⁷ Property owners in the interface are not aware of the problems and threats they face. Therefore, many owners have done very little to manage or offset fire hazards or risks on their own property. Furthermore, human activities increase the incidence of fire ignition and potential damage.

Fuel⁸

Fuel is the material that feeds a fire, and is a key factor in wildfire behavior. Fuel is classified by volume and by type. Volume is described in terms of “fuel loading,” or the amount of available vegetative fuel. The type of fuel also influences wildfire. Oregon, as a western state with prevalent conifer, brush, and rangeland fuel types, is subject to more frequent wildfires than other regions of the nation. An important element in understanding the danger of wildfire is the availability of diverse fuels in the landscape, such as natural vegetation, manmade structures, and combustible materials. A house surrounded by brushy growth rather than cleared space allows for greater continuity of fuel and increases the fire’s ability to spread. After decades of fire suppression, “dog-hair” thickets have accumulated. These enable high intensity fires to flare and spread rapidly. Because of the many different possible “fuels” found in the interface landscape, firefighters have a difficult time predicting how fires will react or spread.

Topography⁹

Topography influences the movement of air, thereby directing a fire's course. For example, if the percentage of uphill slope doubles, the rate of spread in wildfire will likely double. Gulches and canyons can funnel air and act as chimneys, which intensify fire behavior and cause the fire to spread faster. Solar heating of dry, south-facing slopes produces upslope drafts that can complicate fire behavior. Unfortunately, hillsides with hazardous topographic characteristics are also desirable residential areas in many communities. This underscores the need for wildfire hazard mitigation and increased education and outreach to homeowners living in interface areas.

Weather¹⁰

Weather patterns combined with certain geographic locations can create a favorable climate for wildfire activity. Areas where annual precipitation is less than 30 inches per year are extremely fire susceptible.¹¹ High-risk areas in Oregon share a hot, dry season in late summer and early fall when high temperatures and low humidity favor fire activity. Predominant wind directions may guide a fire's path.

Drought

Recent concerns about the effects of climate change, particularly drought, are contributing to concerns about wildfire vulnerability. The term *drought* is applied to a period in which an unusual scarcity of rain causes a serious hydrological imbalance. Unusually dry winters, or significantly less rainfall than normal, can lead to relatively drier conditions, and leave reservoirs and water tables lower. Drought leads to problems with irrigation, and may contribute to additional fires, or additional difficulties in fighting fires. However, most fuel types (not including grasses) require two or three years of drought before the fuel becomes dangerously dry. Drought contributes to the frequency and intensity of fires. A recent Oregonian article reported: "Favorable weather last year helped the Northwest emerge largely unscathed from a fire season that scorched other parts of the West. But the forests remain thick with timber and with homes. And this winter has brought the Northwest far less snow and rain than usual, which could give a greater foothold to the flames that are sure to come."¹²



Development

Growth and development in forested areas is increasing the number of human-made structures in the interface in Oregon. Wildfire has an effect on development, yet development can also influence wildfire. Owners often prefer homes that are private, have scenic views, are nestled in vegetation, and use natural materials. A private setting may be far from public roads, or hidden behind a narrow, curving driveway. These conditions, however, make evacuation and

firefighting difficult. The scenic views found along mountain ridges can also mean areas of dangerous topography. Natural vegetation contributes to scenic beauty, but it may also provide a ready trail of fuel leading a fire directly to the combustible fuels of the home itself.¹³

Community Wildfire Issues

Characteristics of Growth and Development in the Interface

People living in or near wildland settings in Washington County are vulnerable to the threat of wildfire. Washington County is located in a valley surrounded by hills. The vegetation consists of an assortment of grasses, shrubs, and deciduous and coniferous trees. Washington County residents seeking rural, isolated homes are increasingly occupying the heavily forested landscapes, and steep slopes of the county's surrounding hills. Problems can arise as new development increases the amount of fuel without coordinated thinning of the forests and creation of defensible space around homes.

The forested hills surrounding the county are considered to be interface areas. The development of homes and other structures is encroaching into the forest wildland and natural areas and is expanding the wildland-urban interface. The interface neighborhoods are characterized by a diverse mixture of varying housing structures, development patterns, ornamental and natural vegetation, and natural fuels.

In the event of a wildfire, vegetation, structures, and other flammables can merge into unwieldy and unpredictable events. Factors germane to the fighting of such fires include access, firebreaks, proximity of water sources, distance from fire station, and available firefighting personnel and equipment. Reviewing past wildland/urban interface fires shows that many structures are destroyed or damaged by wildfire for one or more of the following reasons:¹⁴

- Combustible roofing material;
- Wood construction;
- Structures with no defensible space;
- Fire department with poor access to structures;
- Subdivisions located in heavy natural fuel types;
- Structures located on steep slopes covered with flammable vegetation;
- Limited water supply; and
- Winds over 30 miles per hour.

Road Access

Of particular concern to firefighters are the rural areas with narrow roadways and few routes of egress, or routes with very limited accessibility.

Water Supply

Remote and rural areas face the added challenge of a lack of adequate water supply and hydrant taps. Rural areas are characteristically outfitted with small diameter pipe water systems, inadequate to provide sustained fire-fighting flows.

Rural Services

People moving from more urban areas frequently have high expectations for fire protection services. Often, new residents do not realize that they are living outside of a fire protection district, or that the services provided are not the same as in an urban area. The diversity and amount of equipment and the number of personnel can be substantially limited in rural areas. Fire protection may rely more on the landowner's personal initiative to take measures to protect his or her own property. Therefore, public education and awareness may play a greater role in rural or interface areas. However, great improvements in fire protection techniques are being made to accommodate for large, rapidly spreading fires that threaten large numbers of homes in interface areas.

Growth and development in rural areas of Washington County greatly influence the wildfire hazard in the urban/wildland interface. Washington County has been fortunate that the historical losses from wildfires have been relatively low when compared to the potential for such losses.¹⁵ Many areas recently ravaged by wildfire in California and the Southwest share many of the same characteristics of urban fringe development that Washington County is currently experiencing. This growth and development increases the public need for natural hazards mitigation planning in the county.

Figure 8.1. Defensible Space¹⁶



Wildfire Hazard Assessment

Wildfire Hazard Identification

Hazard identification is the first phase of a hazard assessment, and is the process of estimating the geographic extent of the hazard, its intensity, and its probability of occurrence.¹⁷ This process usually results in a hazard map. Hazard maps can provide detailed information in a clear format that provides public information and can assist in making policy and land use decisions.

Wildfire hazard areas are commonly identified in regions of the wildland/urban interface. Ranges of the wildfire hazard are further determined by the ease of fire ignition due to natural or human conditions and the difficulty of fire suppression. The wildfire hazard is also magnified by several factors related to fire suppression/control, such as the surrounding fuel load, weather, topography, and property characteristics. Generally, hazard identification rating systems are based on weighted factors of fuels, weather, and topography. Indicators of least dangerous to most dangerous illustrate each category. For example:

Roads and Signage

Steep; narrow; poorly signed	3
One or two of the above	2
Meets all requirements	1

Water Supply

None, except domestic	3
Hydrant, tank, or pool over 500 feet away	2
Hydrant, tank, or pool within 500 feet	1

Location of the Structure

Top of steep slope with brush/grass below	3
Mid-slope with clearance	2
Level with lawn, or watered groundcover	1

In order to determine the “base hazard factor” of specific wildfire hazard sites and interface regions, several factors must be taken into account.

Categories used to assess the base hazard factor include:

- Topographic location, characteristics, and fuels;
- Site/building construction and design;
- Site/region fuel profile (landscaping);
- Defensible space;
- Accessibility;
- Fire protection response; and
- Water availability.

The use of Geographic Information System (GIS) technology in recent years has been a great asset to fire hazard assessment, allowing further integration of fuels, weather, and topography data for such ends as fire behavior prediction, watershed evaluation, mitigation strategies, and hazard

mapping. An Oregon Department of Forestry study found approximately 122,982 acres of wildland/urban interface in Washington County. Map 8.1 illustrates these findings.

Vulnerability Assessment

Vulnerability assessment is the second phase of a hazard assessment. It combines the information generated through hazard identification with an inventory of the existing development exposed to wildfire. Vulnerability assessments assist in predicting how different types of property and population groups will be affected by a hazard.¹⁸ Data that includes the location of interface areas in the county can be used to assess the population and total value of property at risk from wildfire.

While a quantitative vulnerability assessment (an assessment that describes number of lives or amount of property exposed to the hazard) has not yet been conducted for Washington County wildfire events, there are many qualitative factors (issues relating to what is in danger within a community) that point to potential vulnerability. Approximately 13% of the land within the County is public forestland managed by the US Bureau of Land Management and Oregon Department of Forestry. A larger percentage of land is woodland used for recreation or private commercial purposes. Most of these lands lie on the county's extreme north, west, and south boundaries. In addition to these lands, there are many pockets of forested land scattered throughout the County. Whether lying in rural, undeveloped areas or alongside heavily developed commercial or residential properties, these lands pose a significant wildland/urban interface fire threat. Although the County has no history of fires rising to the level of major emergency or disaster, the potential will remain well into the future.

Risk Analysis

Risk analysis is the third, and most advanced phase of a hazard assessment. It builds upon hazard identification and vulnerability assessments.

Key factors included in assessing wildfire risk include ignition sources, building materials and design, community design, structural density, slope, vegetative fuel, fire occurrence, and weather, as well as occurrences of drought. At the time of publication of this plan, data was insufficient to conduct a risk analysis and the software needed to conduct this type of analysis was not available.

The National Wildland/Urban Fire Protection Program has developed a Wildland/Urban Fire Hazard Assessment Methodology tool for communities to assess their risk to wildfire. For more information on wildfire hazard assessment refer to www.Firewise.org.

**Long-Term Wildfire
Action Item #1:** Encourage creation of wildland/urban interface maps to direct development requirements that lessen the impact and potential for wildfire.
See page 8-20 for more information.

Mitigation Plan Goals and Existing Activities

Mitigation Plan Goals and Public Priorities

The mitigation plan goals and action items are derived from review of regional and national natural hazards mitigation plans and planning literature, guidance from the Washington County Natural Hazards Mitigation Plan Steering Committee, and interviews with Washington County stakeholders. The goals for the Washington County Natural Hazards Mitigation Action Plan are broad based to include all of the identified hazards addressed in the plan. Goals for this mitigation plan address four categories:

1. Life, Property, and Natural Systems
2. Public Awareness and Partnerships
3. Emergency Services
4. Implementation

A public workshop was held on May 15, 2001 to identify public priorities for the plan goals and discuss strategies to achieve them. The goal statements and a summary of the public workshop outcomes can be found in Section Three of this plan. All comments from the public workshop are documented in Appendix B. Through a voting process, the public identified goal statements in the category of Life, Property, and Natural Systems as their top priority. This section describes existing mitigation activities and wildfire action items. Multi-hazard action items (i.e., those that broadly address all of the identified hazards) are described in Section Three. Mitigation plan action items are designed to help meet the overall goals of the mitigation plan.

To review the mitigation plan goals, go to section 3, page 2 of the Washington County Natural Hazards Mitigation Action Plan.

Existing Mitigation Activities

Existing mitigation activities include current mitigation programs and activities that are being implemented by county, regional, state, or federal agencies or organizations.

Local Programs

County, state, and local jurisdictions establish building codes that apply to new development, dwellings and structures, retrofitting, and siting. Some fire mitigation standards covered by codes are:

- Locating in a fire protection district or ensuring fire protection through contract;
- Identification of water supply;
- Provision of adequate road access;
- Establishing fire breaks;
- Meeting slope/grade requirements;
- Using fire retardant roofs in wildfire hazard zones; and
- Installing spark arresters on chimneys.

Fire Mitigation

Many fire fighting crews are actively working on public education and homeowner responsibility by visiting neighborhoods and explaining hazards to citizens. They hand deliver informative brochures and encourage citizens to clearly mark their address on the roadway to ensure more rapid and accurate response to calls and better access. They have identified wildland/urban interface areas using criteria outlined by the Department of Forestry.

State Programs

Oregon Revised Statute 215.730:

ORS 215.730, Additional Criteria for Forestland Dwellings, provides criteria for approving dwellings located on lands zoned for forest and mixed agriculture/forest use. Under its provisions, county governments must require through the land use process, as a condition of approval, that single-family dwellings on lands zoned as forestland meet the following requirements:

1. Dwelling has a fire retardant roof;
2. Dwelling will not be sited on a slope of greater than 40 percent;
3. Evidence is provided that the domestic water supply is from a source authorized by the Water Resources Department and not from a Class II stream as designated by the State Board of Forestry;
4. Dwelling is located upon a parcel within a fire protection district or is provided with residential fire protection by contract;
5. If dwelling is not within a fire protection district, the applicant provides evidence that the applicant has asked to be included in the nearest such district;
6. If dwelling has a chimney or chimneys, each chimney has a spark arrester; and
7. Dwelling owner provides and maintains a primary fuel-free break and secondary break areas on land surrounding the dwelling that is owned or controlled by the owner.

If a governing body determines that meeting the fourth requirement is impractical, local officials can approve an alternative means for protecting the dwelling from fire hazards.

For more information on forestland zones consult the Oregon Department of Land Conservation and Development; Statewide Goal 4 – Forestlands and Oregon Administrative Rules 660-006.

Oregon Revised Statute 477.015-061

Provisions in ORS 477.015-061, Urban Interface Fire Protection, were established through efforts of the Oregon Department of Forestry, the Office of the State Fire Marshal, fire service agencies from across the state, and the Commissioners of Deschutes, Jefferson, and Jackson Counties. It is innovative legislation designed to address the expanding interface wildfire problem within Oregon Department of Forestry Fire Protection Districts. Full implementation of the statute will occur on or after January 1, 2002. The statute does the following:

1. Directs the State Forester to establish a system of classifying forestland-urban interface areas;
2. Defines forestland-urban interface areas;
3. Provides education to property owners about fire hazards in forestland-urban interface areas. Allows for a forestland-urban interface county committee to establish classification standards;
4. Requires maps identifying classified areas to be made public;
5. Requires public hearings and mailings to affected property owners on proposed classifications;
6. Allows property owners appeal rights;
7. Directs the Board of Forestry to promulgate rules that set minimum acceptable standards to minimize and mitigate fire hazards within forestland-urban interface areas; and
8. Creates a certification system for property owners meeting acceptable standards. Establishes a \$100,000 liability limit for cost of suppressing fires, if certification requirements are not met.

Oregon Revised Statute, Chapter 478: Rural Fire Protection Districts

ORS 478, Rural Fire Protection Districts, includes the following provisions, among others, related to wildfire hazard mitigation:

478.120 Inclusion of forestland in district. The authority to include forestland within a rural fire protection district pursuant to ORS 478.010 (2)(c) applies to forestland within the exterior boundaries of an existing district and to forestland on which structures subject to damage by fire have been added after July 20, 1973.

478.140 Procedure for adding land to district by consent of owner. Any owner consenting to add the forestland of the owner to the district under ORS 478.010 (2)(c) shall do so on forms supplied by the Department of Revenue. The owner shall file the original with the district. The district shall forward a copy to the assessor of each county in which the land is located, within 20 days of receipt.

478.910 Adoption of fire prevention code. A district board may, in accordance with ORS 198.510 to 198.600, adopt a fire prevention code.

478.920 Scope of fire prevention code. The fire prevention code may provide reasonable regulations relating to:

- (1) Prevention and suppression of fires.
- (2) Mobile fire apparatus means of approach to buildings and structures.
- (3) Providing fire-fighting water supplies and fire detection and suppression apparatus adequate for the protection of buildings and structures.
- (4) Storage and use of combustibles and explosives.
- (5) Construction, maintenance and regulation of fire escapes.
- (6) Means and adequacy of exit in case of fires and the regulation and maintenance of fire and life safety features in factories, asylums, hospitals, churches, schools, halls, theaters, amphitheaters, all buildings, except private residences, which are occupied for sleeping purposes, and all other places where large numbers of persons work, live, or congregate from time to time for any purpose.
- (7) Requiring the issuance of permits by the fire chief of the district before burning trash or waste materials.
- (8) Providing for the inspection of premises by officers designated by the board of directors, and requiring the removal of fire hazards found on premises at such inspections.

478.927 Building permit review for fire prevention code. A district adopting a fire prevention code shall provide plan review at the agency of the city or county responsible for the issuance of building permits for the orderly administration of that portion of the fire prevention code prior to the issuance of building permits.

Senate Bill 360

Senate Bill 360, passed in 1997, is state legislation put in place to address the growing wildland/urban interface problem. The bill has three purposes:

1. To provide an interface fire protection system in Oregon to minimize cost and risk and maximize effectiveness and efficiency;
2. To promote and encourage property owners' efforts to minimize and mitigate fire hazards and risks; and
3. To promote and encourage involvement of all levels of government and the private sector in interface solutions.¹⁹

The bill has a five-year implementation plan that includes public education and outreach, and the development of rules, standards, and guidelines that address landowner and agency responsibilities. The success of Senate Bill 360 depends upon cooperation among local and regional fire departments, fire prevention cooperatives, and the Oregon Department of Forestry, which means interagency collaboration is vital for successful implementation of the bill. This cooperation is important in all aspects of wildland firefighting. Resources and funding are often limited, and no single agency has enough resources to tackle a tough fire season alone. The introductory language of

Senate Bill 360 states: “The fire protection needs of the interface must be satisfied if we are to meet the basic policy of the protection of human life, natural resources, and personal property. This protection must be provided in an efficient and effective manner, and in a cooperative partnership approach between property owners, local citizens, government leaders, and fire protection agencies.”

Oregon Department of Forestry

ODF is involved with local fire chiefs and local fire departments to provide training. Local firefighters can get a range of experience from exposure to wildland firefighting. Local firefighters can also obtain their red card (wildland fire training documentation), and attend extensive workshops combining elements of structural and wildland firefighting, defending homes, and operations experience. ²⁰

ODF has been involved with emergency managers to provide support during non-fire events and for years, ODF has worked with industrial partners (big timber companies) to share equipment in the case of extremely large fires. ²¹

“New data from National Forest Service fire ecologists shows that for every dollar spent on prescribed burning, forest thinning and the training of fire-management personnel, seven dollars worth of savings are realized in the costs of having to extinguish big fires. When that ratio is placed in the context of an average \$1 billion spent annually over the past decade on fire suppression, the implications of foresighted fire management are profound.”

The Nature Conservancy Magazine –
May/June 2001

Federal Programs

The proposed role of the federal land managing agencies in the wildland/urban interface is reducing fuel hazards on the lands they administer; cooperating in prevention and education programs; providing technical and financial assistance; and developing agreements, partnerships, and relationships with property owners, local protection agencies, states, and other stakeholders in wildland/urban interface areas. These relationships focus on activities before a fire occurs, which render structures and communities safer and better able to survive a fire occurrence.²²

The Federal Government has few mechanisms to encourage incentives to resolve the problems in rural, unincorporated areas. There are two programs delivered through the US Forest Service to assist in meeting the needs of rural areas: the Rural Fire Prevention and Control (RFPC) and Rural Community Fire Protection (RCFP). These programs provide cost-share

grants to rural fire districts. The annual federal share of these programs has remained relatively stable, totaling approximately \$16 million and \$3 million, respectively. Renewed focus of these programs, emphasizing local solutions, is encouraged.

Federal Emergency Management Agency Programs

The Federal Emergency Management Agency (FEMA) is directly responsible

for providing fire suppression assistance grants and, in certain cases, major disaster assistance and hazard mitigation grants in response to fires. The role of FEMA in the wildland/urban interface is to encourage comprehensive disaster preparedness plans and programs, increase the capability of state and local governments, and provide for a greater understanding of FEMA's programs at the federal, state, and local levels.²³

Fire Suppression Assistance Grants

Fire Suppression Assistance Grants may be provided to a state with an approved hazard mitigation plan for the suppression of a forest or grassland fire that threatens to become a major disaster on public or private lands. These grants are provided to protect life and improved property, and encourage the development and implementation of viable multi-hazard mitigation measures, and provide training to clarify FEMA's programs. The grant may include funds for equipment, supplies, and personnel. A Fire Suppression Assistance Grant is the form of assistance most often provided by FEMA to a state for a fire. The grants are cost-shared with states. FEMA's US Fire

States must have an approved hazard mitigation plan in place to receive either a Fire Suppression Assistance Grant or a Hazard Mitigation Grant.

“In the past 15 years, state and federal agencies have spent more than \$140 million battling blazes in Oregon’s forests, putting thousands of firefighters on the firelines and supplementing them with aircraft, bulldozers, fire engines and – in the busiest years – military forces.”

The Oregonian, Feb. 25, 2001

Administration (USFA) provides public education materials addressing wildland/urban interface issues, and the USFA's National Fire Academy provides training programs.²⁴

Hazard Mitigation Grant Program

Following a major disaster declaration, the FEMA Hazard Mitigation Grant Program provides funding for long-term hazard mitigation projects and activities to reduce the possibility of damages from all future fire hazards and to reduce the costs to the nation for responding to and recovering from the disaster.

National Wildland/Urban Interface Fire Protection Program

Federal agencies can use the National Wildland/Urban Interface Fire Protection Program to focus on wildland/urban interface fire protection issues and actions. The Western Governors' Association (WGA) can act as a catalyst to involve state agencies, as well as local and private stakeholders, with the objective of developing an implementation plan to achieve a uniform, integrated national approach to hazard and risk assessment and fire prevention and protection in the wildland/urban interface. The program helps states develop viable and comprehensive wildland fire mitigation plans and performance-based partnerships.

US Forest Service

The US Forest Service (USFS) is involved in a fuel-loading program implemented to assess fuels and reduce hazardous buildup on US forestlands. The USFS is a cooperating agency and, while it has little to no jurisdiction in the lower valleys, it has an interest in preventing fires in the interface, as fires often burn up the hills and into the higher elevation US forestlands.²⁵

Other Mitigation Programs and Activities

Some areas of the country are facing wildland/urban issues collaboratively. These are model programs that include local solutions. Summit County, Colorado, has developed a hazard and risk assessment process that mitigates hazards through zoning requirements. In California, the Los Angeles County Fire Department has retrofitted more than 100 fire engines with fire retardant foam capability, and Orange County is evaluating a pilot insurance grading and rating schedule specific to the wildland/urban interface. All are examples of successful programs that demonstrate the value of pre-suppression and prevention efforts when combined with property owner support to mitigate hazards within the wildland/urban interface.²⁶

Prescribed Burning

The health and condition of a forest will determine the magnitude of a wildfire. If fuels – slash, dry or dead vegetation, fallen limbs and branches – are allowed to accumulate over long periods of time without being methodically cleared, fire can move more quickly and destroy everything in its path. The results are more catastrophic than if the fuels are periodically eliminated. Prescribed burning is the most efficient method to get rid of these fuels. In 1998, 3,000 prescribed fires were used to burn approximately 163,000 acres statewide.²⁷

Firewise

Firewise is a program developed within the National Wildland/ Urban Interface Fire Protection Program, and it is the primary federal program addressing interface fire. It is administered through the National Wildfire Coordinating Group whose extensive list of participants includes a wide range of federal agencies. The program is intended to empower planners and decision makers at the local level. Through conferences and information dissemination, Firewise increases support for interface wildfire mitigation by educating professionals and the general public about hazard evaluation and policy implementation techniques. Firewise offers online wildfire protection information and checklists, as well as listings of other publications, videos, and conferences. The interactive home page allows users to ask fire protection experts questions, and to register for new information as it becomes available.

For more information on the Firewise program, contact:

The Wildland/Urban Interface Fire Program

C/o The National Fire Protection Association

1 Batterymarch Park, Quincy, MA 02269 - <http://www.firewise.org>

FireFree Program

FireFree is a unique private/public program for interface wildfire mitigation involving partnerships between an insurance company and local government agencies. It is an example of an effective non-regulatory approach to hazard mitigation. Originating in Bend, the program was developed in response to the city's "Skeleton Fire" of 1996, which burned over 17,000 acres and damaged or destroyed 30 homes and structures.²⁶ Bend sought to create a new kind of public education initiative that emphasized local involvement. SAFECO Insurance Corporation was a willing collaborator in this effort. Bend's pilot program included:

- A short video production featuring local citizens as actors, made available at local video stores, libraries, and fire stations;
- Two city-wide yard debris removal events;
- A 30-minute program on a model FireFree home, aired on a local cable television station; and
- Distribution of brochures, featuring a property owner's evaluation checklist and a listing of fire-resistant indigenous plants.

The success of the program helped to secure \$300,000 in Federal Emergency Management Agency (FEMA) "Project Impact" matching funds. By fostering local community involvement, FireFree also has the potential for building support for sound interface wildfire policy.

For information on
FireFree, contact:

SAFECO Plaza T-8,
Seattle, WA 98185,

(206) 545-6188

<http://www.FireFree.org>

Wildfire Mitigation Action Items

The wildfire mitigation action items provide direction on specific activities that organizations and residents in Washington County can undertake to reduce risk and prevent loss from wildfire events. There are three short-term and four long-term wildfire hazard action items described below. Each action item is followed by ideas for implementation, which can be used by the steering committee and local decision makers in pursuing strategies for implementation.

To review the multi-hazard mitigation action items, refer to section 3, page 4 of the Washington County Natural Hazards Mitigation Action Plan.

ST-WF#1: Educate agency personnel on federal cost-share and grant programs, Fire Protection Agreements, and other related federal programs so the full array of assistance available to local agencies is understood.

Ideas for Implementation:

- Investigate potential funding opportunities for individual mitigation projects.
- Develop, approve, and promote Fire Protection Agreements and partnerships to clarify roles and responsibilities and to provide for fire mitigation activities and suppression preparedness.

Coordinating Organization: Washington County, Washington County Fire Defense Board

Partner Organizations: ODF, Oregon State Fire Marshal, FEMA

Timeline: 1-2 years

Plan Goals Addressed: Implementation; Public Awareness and Partnerships

ST-WF#2: Encourage disclosure of the level of fire protection/suppression service available and the fire insurance rating for property.

Ideas for Implementation:

- Encourage the use of hazard-specific information to identify wildfire hazard areas, and promote the use of mitigation strategies and opportunities to reduce risks.
- Assess available fire suppression assistance and disseminate information about opportunities to the public.

Coordinating Organization: Washington County, Washington County Fire Defense Board

Partner Organizations: DLCD, Oregon State Fire Marshal, ODF, Insurance and Real Estate Industries

Timeline: 1-2 years

Plan Goals Addressed: Life, Property, and Natural Systems; Public Awareness and Partnerships; Emergency Services

ST-WF#3: Inventory and map alternative firefighting water sources and encourage the development of additional sources.

Ideas for Implementation:

- Advocate for water storage facilities with fire-resistant electrical pump systems in developments outside of fire protection districts that are not connected to a community water or hydrant system.
- Maintain access roads and ramps to manmade natural water sources.

Coordinating Organization: Washington County, Washington County Fire Defense Board
Partner Organizations: Clean Water Services, TVWD, ODF, Cities
Timeline: 6 months
Plan Goals Addressed: Life, Property, and Natural Systems; Emergency Services

LT-WF#1: Encourage creation of wildland/urban interface maps to direct development requirements that lesson the impact of a potential for wildfire.

Ideas for Implementation:

- Identify and establish a data-collection mechanism in coordination with county, state, and local governments, fire agencies, the insurance industry, and the National Fire Protection Association.
- Using collected data and research, assess the nature and scope of the wildland/urban interface fire problem in the county.

Coordinating Organization: Washington County, Washington County Fire Defense Board
Partner Organizations: Water Districts, ODF, OSFM, Cities
Timeline: 1-3 years
Plan Goals Addressed: Life, Property, and Natural Systems; Implementation

LT-WF#2: Develop and implement, and/or enhance outreach and education programs designed to minimize exposure to wildfire hazards.

Ideas for Implementation:

Outreach

- Visit wildland/urban interface neighborhoods and rural areas and conduct education and outreach activities;
- Conduct specific community-based demonstration projects of fire prevention and mitigation in the urban interface;

LT-WF#2, continued

- Establish neighborhood “drive-through” activities that pinpoint site-specific mitigation activities. Fire crews can give property owners personal suggestions and assistance; and
- Perform public outreach and information activities at Washington County fire stations by creating “Wildfire Awareness Week” activities. Fire stations can hold open houses and allow the public to visit, see the equipment, and discuss wildfire mitigation with the station crews.

Education

- Encourage the development of public awareness programs and land use development policies that ensure specific recommendations for wildfire mitigation policies, programs, and community-based activities; and
- Develop a “preventative approach” campaign by educating the public on hazardous human activities that must be regulated and controlled because of the danger of starting fires, including residential pile burning and industrial slash burning, campfires, smoking, and the use of fireplaces without spark arrestors.

Coordinating Organization: Washington County, Washington County Fire Defense Board

Partner Organizations: School Districts, Oregon Emergency Management, ODF, FireWise, FireFree, Cities

Timeline: Ongoing

Plan Goals Addressed: Public Awareness and Partnerships; Life, Property, and Natural Systems

LT-WF#3: Increase communication, coordination, and collaboration between wildland/urban interface property owners and county officials to address inherent risks in wildland/urban interface areas, available prevention/protection measures, and federal mitigation assistance programs.

Ideas for Implementation:

- Encourage County and fire officials to work closely with landowners and/or developers who choose to build in the wildland/urban interface to identify and mitigate conditions that aggravate wildland/urban interface wildfire hazards, including:
 - Limited access for emergency equipment due to width and grade of roadways;
 - Inadequate water supplies and the spacing, consistency, and species of vegetation around structures;
 - Inadequate fuel breaks, or lack of defensible space;
 - Highly flammable construction materials;
 - Building lots and subdivisions that are not in compliance with state and local land use and fire protection regulations; and

LT-WF#3, continued

- Inadequate entry/escape routes.
- Encourage all new homes and major remodels involving roofs or additions that are located in the interface to have fire resistant roofs.
- Provide education and training to the public to assess if their homes meet fire safety performance standards.
- Encourage the public to evaluate access routes to rural homes for fire-fighting vehicles and to develop passable routes if they do not exist.

Coordinating Organization: Washington County, Washington County Fire Defense Board,

Partner Organizations: ODF, OSFM, Cities

Timeline: 1-5 years

Plan Goals Addressed: Public Awareness and Partnerships; Life, Property and Natural Systems; Emergency Services

LT-WF#4: Implement fire mitigation activities in a manner consistent with County goals of promoting sustainable ecological management and community stability.

Ideas for Implementation:

- Use a variety of appropriate tools (prescribed fire application, fuel reduction through grass/timber/brush removal, small diameter forest product based industries, etc.) to address the complex issue of mitigating wildfire hazards in urban/interface areas.
- Clear trimmings, trees, brush, and other debris completely from sites when performing routine maintenance and landscaping to reduce fire risk.

Coordinating Organization: Washington County, Washington County Fire Defense Board

Partner Organizations: ODF, Tualatin River Watershed Council, Utility service providers, THPRD, PGE, OSFM, Cities

Timeline: 1-5 years

Plan Goals Addressed: Life, Property and Natural Systems; Public Awareness and Partnerships; Implementation

Wildfire Resource Directory

County Resources

Washington County Building Services Division

The Building Services Division issues a variety of building permits and enforces building codes. It also works on countywide coordination among city building code officials to improve the effectiveness of building inspection during an unscheduled event.

Contact: Washington County Building Official
Address: Washington County Building Services Division, Land Use and Transportation Department, 155 N. First Avenue, Suite 350-12, Hillsboro, OR 97124
Phone: (503) 846-3470
Fax: (503) 846-3993
Website: http://www.co.washington.or.us/deptmts/lut/land_dev/bld_serv.htm

For more information on county, state and federal natural hazard mitigation programs and activities, refer to *Appendix A: Resource Directory*

Washington County Office of Emergency Management

The Washington County Emergency Management Program exists pursuant to ORS 401 to guide the county's preparations for, response to, and recovery from major emergencies and disasters. The program is organized under the county sheriff's office and oversees preparation and maintenance of the county's emergency operations plan and emergency operations center and the training and exercising of designated staff.

Unique to Washington County is a consolidated office that brings the emergency management staffs from four jurisdictions together into a single office to enhance disaster preparedness activities countywide. The Office of Consolidated Emergency Management (OCEM) for Washington County was formed in 1995 by Intergovernmental Agreement between Washington County, the cities of Beaverton and Hillsboro, and Tualatin Valley Fire and Rescue. The organization's mission statement indicates that "The Office of Consolidated Emergency Management for Washington County is committed to the development and maintenance of a countywide, integrated system to prepare for, respond to, recover from, and mitigate against disasters."

Contact: Director, Washington County Emergency Management
Address: 20665 SW Blanton St. Aloha, OR, 97007
Phone: (503) 642-0371
Website: <http://www.ocem.org>
Email: info@ocem.org

Washington County Fire Defense Board

The Washington County Fire Defense Board is comprised of all the local fire chiefs within the county and also includes ex-officio representatives from the State Fire Marshal's Office and the Oregon Department of Forestry. Pursuant to the Oregon Fire Service Mobilization Plan, the Fire Defense Board is charged with the following responsibilities:

- Develop a fire service plan with provisions permitting local departments to respond with mutual aid forces upon request of other local departments in the county.
- Administer the State Fire Mobilization Plan within the county.
- Maintain response procedures for alert, transfer, and dispatch of fire fighting equipment and personnel.
- Maintain liaison with other agencies capable of augmenting fire-fighting resources.
- Maintain inventories of fire fighting equipment in the county.
- Develop dispatch plans for mobilization requests and conduct exercises as necessary to ensure efficient operations.
- Develop expedient procedures for providing and dispatching incident command overhead teams and logistical support.
- Hold regular meetings.

The Washington County Fire Defense Board meets regularly with representatives from a number of other agencies in the county to coordinate prevention and response activities and issues. Those agencies/individuals include the county sheriff's office, Metro West Ambulance, the Washington County Consolidated Communications Agency (County 911), the Washington County Emergency Medical Services Coordinator, Washington County Emergency Management, and the Washington County Building Services Division. For contact information for the Washington County Fire Defense Board, contact the Oregon State Fire Marshal.

Contact: Oregon State Fire Marshal
Address: 4760 Portland Road NE, Salem, Oregon 97305-1760
Phone: (503) 378-3473
Fax: (503) 373-1825
Website: <http://159.121.82.250/>
Email: oregon.sfm@state.or.us

Regional Resources

Metro Regional Government

Metro is the directly elected regional government that serves more than 1.3 million residents in Clackamas, Multnomah, and Washington counties and 24 cities in the Portland metropolitan area. Chapter 5 of Metro's Regional Framework Plan addresses natural hazards. Metro's Natural Hazards Program is a service of the Growth Management Services Department's Data Resource Center. Their web pages relate to natural hazards that may impact the Portland metropolitan area. Their links provide information about the natural hazards in the Portland metropolitan area and suggest tools for reducing potential damages before disaster strikes. Metro produced the *Regional Hazard Mitigation Policy and Planning Guide* in 1999 to assist local governments in planning for future natural hazard events.

Contact 1: Metro Regional Government
Address: 600 NE Grand Ave, Portland, OR 97232-2736
Phone: (503) 797-1839
Fax: (503) 797-1911
Website: <http://www.metro.dst.or.us/metro/growth/gms.html>
Email: 2040@metro-region.org

Contact 2: Metro Data Resource Center
Website: <http://storefront.metro.dst.or.us/drc/nathaz/nathaz.cfm>
Email: drc@metro.dst.or.us

State Resources

Department of Land Conservation and Development (DLCD)

DLCD administers the state's Land Use Planning Program. The program is based on 19 Statewide Planning Goals, including Goal 7, related to natural hazards, with flood as its major focus. DLCD serves as the federally designated agency to coordinate floodplain management in Oregon. They also conduct various landslide related mitigation activities. In order to help local governments address natural hazards effectively, DLCD provides technical assistance such as conducting workshops, reviewing local land use plan amendments, and working interactively with other agencies.

Contact: Natural Hazards Program Manager, DLCD
Address: 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540
Phone: (503) 373-0050
Fax: (503) 378-6033
Website: <http://www.lcd.state.or.us/hazards.html>

Oregon Department of Consumer and Business Services

The Building Codes Division of Oregon's Department of Consumer and Business Services is responsible for administering statewide building codes. Its responsibilities include adoption of statewide construction standards that help create disaster-resistant buildings, particularly for flood, wildfire, wind, foundation stability, and seismic hazards. Information about wildfire-related building codes is found through this department.

Contact: Building Codes Division
Address: 1535 Edgewater St. NW, P.O. Box 14470, Salem, OR 97309

Phone: (503) 373-4133
Fax: (503) 378-2322
Website: <http://www.cbs.state.or.us/external/bcd>

Oregon Department of Forestry (ODF)

ODF's Fire Prevention Unit is involved in interface wildfire mitigation and provides information about Oregon's Wildfire Hazard Zones. The Protection From Fire section of the ODF website includes Oregon-specific fire protection resources. Wildfire condition reports can be accessed on the website as well. ODF's Protection from Fire Program works to do the following:

- Clarify roles of ODF, landowners, and other agencies in relation to wildland fire protection in Oregon;
- Strengthen the role of forest landowners and the forest industry in the protection system;
- Understand and respond to needs for improving forest health conditions and the role/use of prescribed fire in relation to mixed ownerships, forest fuels and insects and disease; and
- Understand and respond to needs for improving the wildland/urban interface situation.

Contact: Oregon Department of Forestry, Fire Prevention Unit
Address: 2600 State Street, Salem, Oregon 97310
Phone: (503) 945-7440
Website: <http://www.odf.state.or.us/fireprot.htm>

Oregon State Police (OSP)-Office of Emergency Management (OEM)

The purpose of OEM is to execute the Governor's responsibilities to maintain an emergency services system as prescribed in Oregon Revised Statutes Chapter 401 by planning, preparing, and providing for the prevention, mitigation, and management of emergencies or disasters that present a threat to the lives and property of citizens of and visitors to the state of Oregon.

Contact: Office of Emergency Management
Address: 595 Cottage Street NE, Salem, OR 97310
Phone: (503) 378-2911
Fax: (503) 588-1378
Website: <http://www.osp.state.or.us/oem/>

Office of the State Fire Marshal (OSFM)

The Prevention Unit of Oregon's Office of the State Fire Marshal contains 19 Deputy State Fire Marshals located in various regions. The responsibilities of these deputies include public education for local fire districts and inspection of businesses, public assemblies, schools, daycare centers, and adult foster homes. The State Fire Marshal's Community Education Services unit works to keep Oregonians safe from fires and injury by providing them with the knowledge to protect themselves and their property.

Contact: Oregon State Fire Marshal
Address: 4760 Portland Road NE, Salem, Oregon 97305-1760
Phone: (503) 378-3473
Fax: (503) 373-1825
Website: <http://159.121.82.250/> Oregon Laws on Fire Protection:
http://159.121.82.250/SFM_Admin/firelaws.htm
Email: oregon.sfm@state.or.us

Federal Resources and Programs

Federal Emergency Management Agency (FEMA)

FEMA's mission is "to reduce loss of life and property and protect our nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response and recovery." FEMA Region X serves the northwestern states of Alaska, Idaho, Oregon, and Washington.

Contact: FEMA, Federal Regional Center, Region 10
Address: 130-228th St. SW, Bothell, WA 98021-9796
Phone: (425) 487-4678
Website: <http://www.fema.gov/Reg-X/index.htm>

Federal Wildland Fire Policy, Wildland/Urban Interface Protection

This is a report describing federal policy and interface fire. Areas of needed improvement are identified and addressed through recommended goals and actions.

Website: <http://www.fs.fed.us/land/wdfire7c.htm>

National Fire Protection Association (NFPA)

This is the principal federal agency involved in the National Wildland/Urban Interface Fire Protection Initiative. NFPA has information on the Initiative's programs and documents. Other members of the initiative include: the National Association of State Foresters, the US Department of Agriculture Forest Service, the US Department of the Interior, and the United States Fire Administration.

Contact: Public Fire Protection Division
Address: 1 Battery March Park, P.O. Box 9101, Quincy, MA 02269-9101
Phone : (617) 770-3000

National Interagency Fire Center (NIFC)

The NIFC in Boise, Idaho is the nation's support center for wildland firefighting. Seven federal agencies work together to coordinate and support wildland fire and disaster operations. These agencies include the Bureau of Indian Affairs, Bureau of Land Management, Forest Service, Fish and Wildlife Service, National Park Service, National Weather Service, and Office of Aircraft Services.

Website: <http://www.nifc.gov/>

United States Fire Administration (USFA) of the Federal Emergency Management Agency (FEMA)

As an entity of the Federal Emergency Management Agency, the mission of the USFA is to reduce life and economic losses due to fire and related emergencies through leadership, advocacy, coordination, and support.

Contact: USFA, Planning Branch, Mitigation Directorate
Address: 16825 S. Seton Ave., Emmitsburg, MD 21727
Phone: (301) 447-1000
Website: <http://www.fema.gov/mit/wfmit.htm> - Wildfire Mitigation Planning
<http://www.usfa.fema.gov/index.htm> - USFA Homepage
<http://www.usfa.fema.gov/wildfire/> - USFA Resources on Wildfire

Additional Resources

American Red Cross

The American Red Cross is a humanitarian organization, led by volunteers, that provides relief to victims of disasters and helps people prevent, prepare for, and respond to emergencies. The Oregon Trail Chapter was chartered as a Red Cross unit in 1917. The chapter serves the residents of Clackamas, Columbia, Multnomah, Washington, Yamhill, and Tillamook counties. The Oregon Trail Chapter provides a variety of community services which are consistent with the Red Cross mission and meet the specific needs of this area, including disaster planning, preparedness, and education.

Contact: American Red Cross, Oregon Trail Chapter
Address: P.O. Box 3200, Portland, OR 97208-3200
Phone: (503) 284-1234
Fax: (503) 284-4247
Email: info@redcross-pdx.org
Website: <http://www.redcross-pdx.org>
<http://www.redcross.org/services/disaster/keepsafe/volcano.html>

Institute for Business & Home Safety (IBHS)

IBHS was created as an initiative of the insurance industry to reduce damage and losses caused by natural disasters. This website provides educational resources and on-line publications for insurers, businesses, and homeowners who are interested in taking the initiative to minimize future damages and losses.

Contact: Institute for Business and Home Safety
Address: 1408 North Westshore Boulevard - Suite 208 - Tampa, FL 33607
Phone: (813) 286-3400
Fax: (813) 286-9960
E-mail: info@ibhs.org
Website: <http://www.ibhs.org/ibhs2>

FireFree Program to Promote Home Safety

In a pioneering effort to address wildfire danger in Bend, Oregon, four local agencies and a Fortune 500 corporation joined together to create "FireFree! Get In The Zone," a public education campaign designed to increase resident participation in wildfire safety and mitigate losses. Spearheaded by SAFECO Corporation, the partnership includes the Bend Fire Department, Deschutes County Rural Fire Protection District #2, Bend City Planning, and The Deschutes National Forest.

The Oregon Department of Forestry and a number of local government agencies and businesses have joined the program.

Contact: FireFree
Address: 63377 Jamison St., Bend, OR 97701
Phone: (541) 318-0459
E-mail: dcrfpd2@dcrfpd2.com
Website: <http://www.firefree.org>

Firewise – The National Wildland/Urban Interface Fire program

Firewise maintains a Website designed for people who live in wildfire-prone areas, but it also can be of use to local planners and decision makers. The site offers online wildfire protection information and checklists, as well as listings of other publications, videos, and conferences.

Contact: Firewise
E-mail: firewise@firewise.org
Website: <http://www.firewise.org/>

Publications

National Fire Protection Association Standard 299: Protection of Life and Property from Wildfire. National Wildland/Urban Interface Fire Protection Program, (1991). National Fire Protection Association, Washington, D.C.

This document, developed by the NFPA Forest and Rural Fire Protection Committee, provides criteria for fire agencies, land use planners, architects, developers, and local governments to use in the development of areas that may be threatened by wildfire. To obtain this resource:

Contact: National Fire Protection Association Publications
Phone: (800) 344-3555
Website: <http://www.nfpa.org> or <http://www.firewise.org>

An International Collection of Wildland-Urban Interface Resource Materials (Information Report NOR-X-344). Hirsch, K., Pinedo, M., & Greenlee, J. (1996). Edmonton, Alberta: Canadian Forest Service.

This is a comprehensive bibliography of interface wildfire materials. Over 2,000 resources are included, grouped under the categories of general and technical reports, newspaper articles, and public education materials. The citation format allows the reader to obtain most items through a library or directly from the publisher. The bibliography is available in hard copy or diskette at no cost. It is also available in downloadable PDF form. To obtain this resource:

Contact: Canadian Forest Service, Northern Forestry Centre, I-Zone Series
Phone: (780) 435-7210
Website: <http://www.prefire.ucfpl.ucop.edu/uwibib.htm>

Wildland/Urban Interface Fire Hazard Assessment Methodology. National Wildland/Urban Interface Fire Protection Program, (1998), NFPA, Washington, D.C. To obtain this resource:

Contact: Firewise (NFPA Public Fire Protection Division)

Phone: (617) 984-7486
Website: <http://www.firewise.org>

Fire Protection in the Wildland/Urban Interface: Everyone's Responsibility. National Wildland/Urban Interface Fire Protection Program. (1998). Washington, D.C.: Author. To obtain this resource:

Contact: Firewise (NFPA Public Fire Protection Division)
Phone: (617) 984-7486
Website: <http://www.firewise.org>

Planning for Natural Hazards: The Oregon Technical Resource Guide, Department of Land Conservation and Development (July 2000).

Produced by the Community Planning Workshop for the Department of Land Conservation and Development, this is a natural hazards planning and mitigation resource for Oregon cities and counties. It provides hazard-specific resources and plan evaluation tools. The document was written for local staffs and officials. The Technical Resource Guide includes a natural hazards comprehensive plan review, a hazard mitigation legal issues guide, and five hazard-specific technical resource guides, including: flooding, wildfires, landslides, coastal hazards, and earthquakes. This document is available online. You can also write, call, or fax to obtain this document:

Contact: Natural Hazards Program Manager
Address: 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540
Phone: (503) 373-0050
Fax: (503) 378-6033
Website: <http://www.lcd.state.or.us/hazards.html>

Wildfire Endnotes

¹ Colorado State Forest Service, (July 2001),
<http://205.169.13.227/depts/emmgmt/wildfireproblem.htm>.

² *Planning for Natural Hazards: The Oregon Technical Resource Guide*, (July 2000), Department of Land Conservation and Development, Ch. 7.

³ Wilkinson, Todd. "Prometheus Unbound," (May/June 2001), Nature Conservancy.

⁴ National Interagency Fire Center, *National Register of Urban Wildland Interface Communities Within the Vicinity of Federal Lands that are at High Risk from Wildfire.* (May 2001)
<http://www.nifc.gov/fireplan/fedreg.html>.

⁵ *Planning for Natural Hazards: The Oregon Technical Resource Guide*, (July 2000), Department of Land Conservation and Development, Ch. 7.

⁶ Robert Olson Associates, *Metro Regional Hazard Mitigation Policy and Planning Guide*, (June 1999), Metro.

⁷ Introductory language in Senate Bill 360, (July 2001), ODF website,
<http://www.odf.state.or.us/fireprot/sb360.html>.

⁸ *Planning for Natural Hazards: The Oregon Technical Resource Guide*, (July 2000), Department of Land Conservation and Development, Ch. 7.

⁹ *Planning for Natural Hazards: The Oregon Technical Resource Guide*, (July 2000), Department of Land Conservation and Development, Ch. 7.

¹⁰ Ibid.

¹¹ Ibid.

¹² The Oregonian, Feb. 25, 2001.

¹³ *Planning for Natural Hazards: The Oregon Technical Resource Guide*, (July 2000), Department of Land Conservation and Development, Ch. 7.

¹⁴ Colorado State Forest Service, (July 2001), <http://205.169.13.227/depts/emgmt/wildfireproblem.htm>.

¹⁵ *Planning for Natural Hazards: The Oregon Technical Resource Guide*, (July 2000), Department of Land Conservation and Development, Ch. 7.

¹⁶ *Planning for Natural Hazards: The Oregon Technical Resource Guide*, (July 2000), Department of Land Conservation and Development, Ch. 7.

¹⁷ Burby, R. (Ed.) *Cooperating with Nature: Confronting Natural Hazards with Land Use Planning for Sustainable Communities*. Washington D.C., (1998) Joseph Henry Press.

¹⁸ Ibid.

¹⁹ Oregon Department of Forestry, (1999) Oregon Forests Report.

²⁰ Personal Interview. Jim Wolf, Oregon Department of Forestry, February 28, 2001.

²¹ Ibid.

²² Federal Wildland Fire Policy, (July 2001), <http://www.fs.fed.us/land/wdfire7c.htm>.

²³ Ibid.

²⁴ Ibid.

²⁵ Personal Interview. M.J. Harvey, United States Forest Service, March 1, 2001.

²⁶ Ibid.

²⁷ Ibid.

Section 9: Earthquake

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Why Are Earthquakes a Threat to Washington County?

On February 28, 2001, a 6.8-magnitude earthquake centered near Anderson Island in Pierce County, Washington was felt strongly throughout western Washington and in many areas of western Oregon. The tremor was felt in Portland and the surrounding area, including Washington County. While the impacts of this quake were not severe in Oregon the state ranks third in the nation for earthquake damage estimates in the future. Projected losses in the Cascadia region alone could exceed \$12 billion, 30,000 destroyed buildings, and 8,000 lives lost in the event of a magnitude 8.5 Cascadia Subduction Zone earthquake.¹

Social and geological records show that Oregon has a history of seismic events. Recent research suggests that the Cascadia Subduction Zone is capable of producing magnitude 9 earthquakes. The existence of active faults in Portland Metro Area and other areas of the state are suspected but not confirmed in many cases. Where known to exist, it is believed that they are capable of generating magnitude 7 earthquakes. Earthquakes pose serious threat to many Oregon communities. Local governments, planners, and engineers must consider the threat as they seek to balance development and risk. Identifying locations susceptible to seismic activity generated by local faults or the Cascadia Subduction Zone, adopting strong policies and implementing measures, and using other mitigation techniques are essential to reducing risk from seismic hazards in Washington County.²

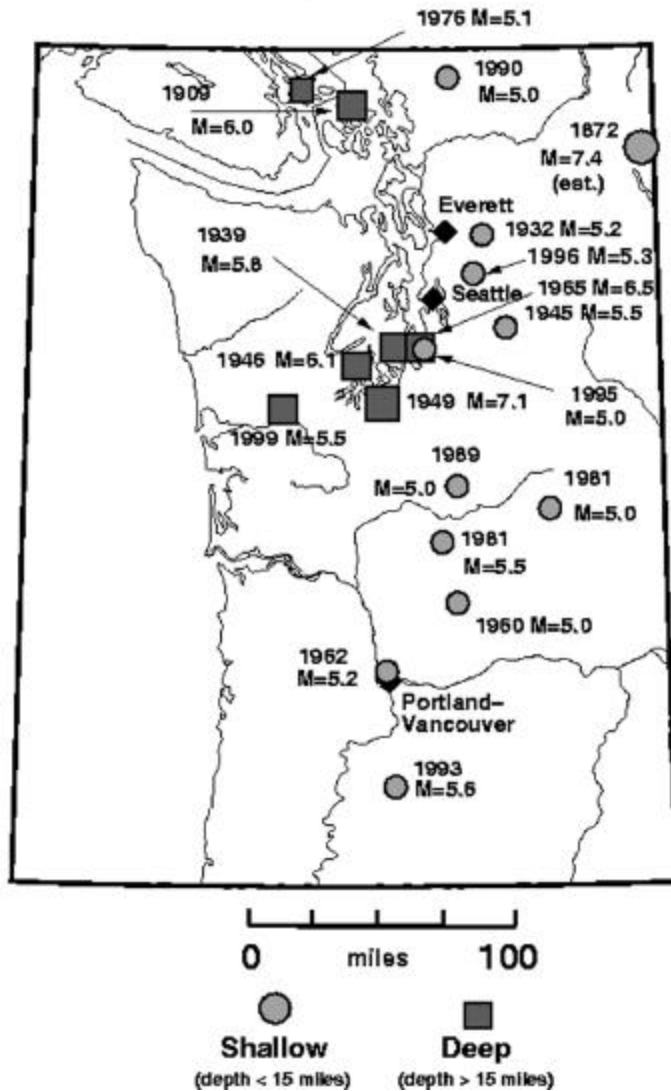
History of Earthquake Events in Washington County

Dating back to 1841, there have been more than 6,000 earthquakes in Oregon, most with a magnitude below three. Portland and its surrounding region is potentially the most seismically active area within Oregon.³ The Portland metropolitan region has encountered seventeen earthquakes of an estimated magnitude of four and greater, with major earthquakes in 1877 (magnitude 5.3), 1962 (magnitude 5.2), and 1993 (magnitude 5.6). Records also indicate that earthquakes in the Puget Sound Region, such as the 1949 magnitude 7.1 event near Olympia, WA, and the 1965 magnitude 6.5 event located between Seattle and Tacoma, can cause damage in Portland.⁴

February 28, 2001, Magnitude 6.8

The February 28, 2001 Nisqually earthquake caused high-rise office buildings in Portland to sway for 20 to 30 seconds and some exterior cosmetic cracks of the Public Safety Building in Hillsboro.⁵ The Nisqually earthquake was centered near Anderson Island in Pierce County (11 miles northeast of Olympia, Washington) was felt strongly throughout western Washington, and left 320 people with mostly minor injuries.⁶ While only a dozen people were left homeless in Olympia, initial estimates for the quake put damage to Seattle and Olympia at approximately \$2 billion.⁷

Selected Earthquakes since 1872



Source: Wong, Ivan G and Bott Jacqueline D.J. (November 1995). A look back at Oregon's earthquake history, 1841-1994. *Oregon Geology* 57 (6). 125.

March 25, 1993, Magnitude 5.6

The March 25, 1993 earthquake near Scotts Mills, Oregon, 32 miles from Portland, was a shallow crustal earthquake recorded at magnitude 5.6. This earthquake caused damage mostly within a radius of about 25 miles, primarily in the communities of Molalla, Woodburn, Newberg, and McMinnville. While there were no reported injuries, structural damages did occur. Damage to public facilities in the affected counties was estimated to be over \$6 million, not including damage to state government buildings or bridges.⁸ The thirty-plus damaged public buildings were mostly old masonry buildings that required rebuilding. At least four fire stations, one telephone facility handling the area's 911 calls, sixteen schools, five city halls, and a medical center, police station, correctional facility, and library were damaged in the earthquake.

Causes and Characteristics of Earthquakes in Washington County

Most large earthquakes in the Pacific Northwest are shallow crustal, deep intraplate, or subduction zone earthquakes. These earthquakes can have great impact on Oregon communities, including those in Washington County. The city of Portland, which lies just east of Washington County, has at least three crustal faults beneath it. Washington County also has several crustal faults of its own that could generate an earthquake of magnitude 6.5 or larger.

Crustal Fault Earthquakes

Crustal fault earthquakes are the most common of earthquakes and occur at relatively shallow depths of 6-12 miles below the surface.⁹ While most crustal fault earthquakes are smaller than magnitude 4 and generally create little or no damage, they can produce earthquakes of magnitudes up to 7 and cause extensive damage.

Faults within Washington County include the Tualatin-Sherwood, Oatfield, Costco, and Gales Creek faults.¹⁰ Though scientists have yet to determine if they are active, these faults are still considered potential earthquake

sources. The 30-mile long Portland Hills Fault, which runs in a northwest to southeast direction through Portland, was confirmed to be an active fault by DOGAMI in May 2001.¹¹ This indicates that Portland and its neighbors face future damages from a magnitude 6.5 or larger earthquake.¹²

Deep Intraplate Earthquake

Occurring at depths from 25 to 40 miles below the earth's surface in the subducting oceanic crust, deep intraplate earthquakes can reach up to magnitude 7.5.¹³ The February 28, 2001 earthquake in Washington State was a deep intraplate earthquake. It produced a rolling motion which was felt from Vancouver, British Columbia to Coos Bay, Oregon and east to Salt Lake City, Utah. A 1965 magnitude 6.5 intraplate earthquake centered south of Seattle-Tacoma International Airport caused seven deaths.¹⁴

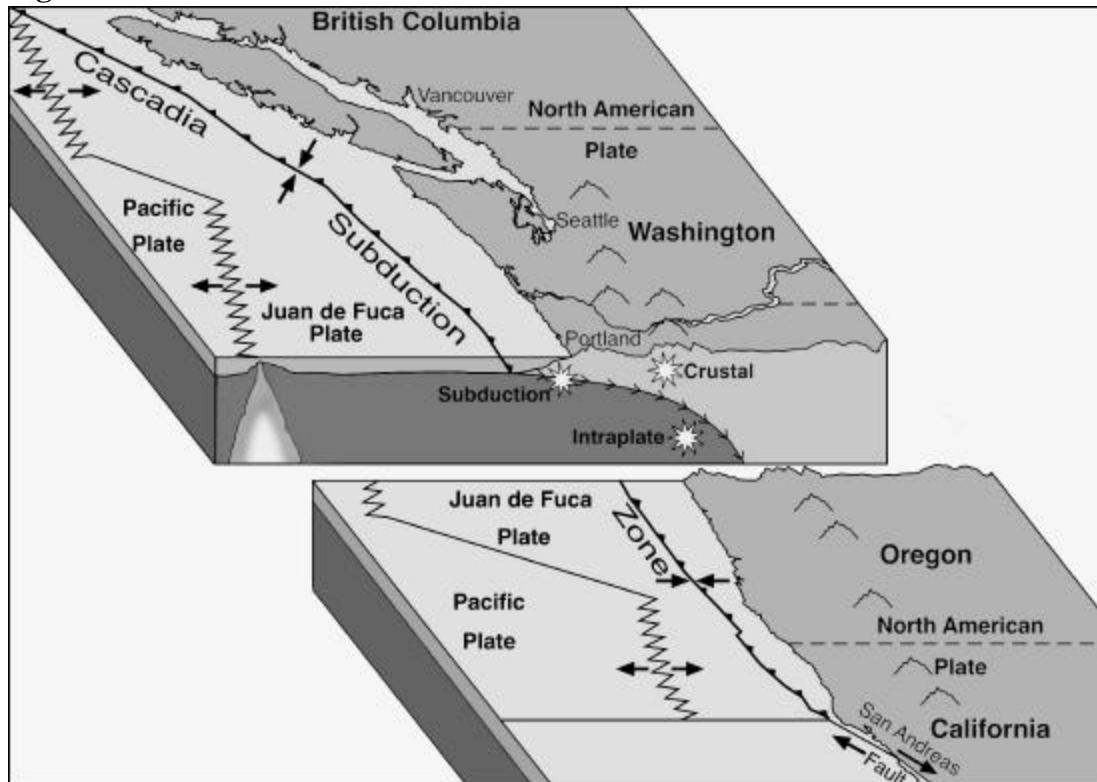
Subduction Zone Earthquakes

The Pacific Northwest is located at a convergent plate boundary, where the Juan de Fuca and North American tectonic plates meet. The two plates are converging at a rate of about 1-2 inches per year. This boundary is called the Cascadia Subduction Zone. It extends from British Columbia to northern California. Subduction zone earthquakes are caused by the abrupt release of slowly accumulated stress.¹⁵

Subduction zones similar to the Cascadia Subduction Zone have produced earthquakes with magnitudes of 8 or larger. Historic subduction zone earthquakes include the 1960 Chile (magnitude 9.5) and the 1964 southern Alaska (magnitude 9.2) earthquakes.¹⁶

Geologic evidence shows that the Cascadia Subduction Zone has generated great earthquakes, most recently about 300 years ago. It is generally accepted to have been magnitude 9 or greater. The average recurrence interval of these great Cascadia earthquakes is approximately 500 years, with gaps between events as small as 200 years and as large as 1000 years. Such earthquakes may cause great damage to the coastal area of Oregon as well as inland areas in western Oregon including Washington County. Shaking from a large subduction zone earthquake could last up to five minutes¹⁷

Figure 9.2. Cascadia Subduction Zone¹⁸



Earthquake Related Hazards

Ground shaking, landslides, liquefaction, and amplification are the specific hazards associated with earthquakes. The severity of these hazards depends on several factors, including soil and slope conditions, proximity to the fault, earthquake magnitude, and the type of earthquake.

Ground Shaking

Ground shaking is the motion felt on the earth's surface caused by seismic waves generated by the earthquake. It is the primary cause of earthquake damage. The strength of ground shaking depends on the magnitude of the earthquake, the type of fault, and distance from the epicenter (where the earthquake originates). Buildings on poorly consolidated and thick soils will typically see more damage than buildings on consolidated soils and bedrock.

Earthquake-induced Landslides

Earthquake-induced landslides are secondary earthquake hazards that occur from ground shaking. They can destroy the roads, buildings, utilities, and other critical facilities necessary to respond to recover from an earthquake. Many communities in Oregon, including Washington County, have a high likelihood of encountering such risks, especially in areas with steep slopes.¹⁹

Refer to Section 5 of the Mitigation Plan for information on the landslide hazard.

This is a major hazard in Washington County, particularly in old landslide areas such as the West Hills of Portland, on Cooper and Bull Mountains, in

the Chehalem Mountains, and in the Coast Range along the western edge of Washington County.

Liquefaction

Liquefaction occurs when ground shaking causes wet granular soils to change from a solid state to a liquid state. This results in the loss of soil strength and the soil's ability to support weight. Buildings and their occupants are at risk when the ground can no longer support these buildings and structures.²⁰ Areas adjacent to the Tualatin River and its major tributaries are prone to liquefaction.

Amplification

Soils and soft sedimentary rocks near the earth's surface can modify ground shaking caused by earthquakes. One of these modifications is amplification. Amplification increases the magnitude of the seismic waves generated by the earthquake. The amount of amplification is determined by the thickness of geologic materials and their physical properties. Buildings and structures built on soft and unconsolidated soils can face greater risk.²¹

Amplification can also occur in areas with deep sediment filled basins. The Tualatin Valley is a good example. The thick sediments and the bowl shape of the basin combine to amplify ground shaking.²²

Community Earthquake Issues

Earthquake damage occurs because humans have built structures that cannot withstand severe shaking. Buildings, airports, schools, and lifelines (highways and phone, gas, and water lines) suffer damage in earthquakes and can cause death or injury to humans.

The welfare of homes, major businesses, and public infrastructure is very important. Addressing the reliability of buildings, critical facilities, and infrastructure, and understanding the potential costs to government, businesses, and individuals as a result of an earthquake, are challenges faced by Washington County.

Project Impact Seattle provides retrofitting classes for homeowners and building professionals and contractors.

For more information, go to www.ci.seattle.wa.us/projectimpact/

Buildings

The built environment is susceptible to damage from earthquakes. Buildings that collapse can trap and bury people. Lives are at risk and the cost to clean up the damages is great. In most Oregon communities, including Washington County, many buildings were built before 1990 when building codes were not as strict. In addition, retrofitting is not required except under certain conditions and is expensive. Therefore, the number of buildings at risk remains high. The Oregon Building Codes Division revised its construction standards for new buildings to make them more resistant to seismic events. Washington County, which follows the State Building Codes, is within Zone 3. Washington County has not conducted a building inventory for its unincorporated areas (though Metro has inventoried incorporated areas). At-risk buildings are not quantified nor spatially

identified.²³ The lack of funding for such activity is a major issue. Some of the buildings in older downtown areas such as Hillsboro are more susceptible to earthquake damage because they are made of unreinforced brick and concrete. Although coordination among county and city building code officials is in progress, much work remains to be done to identify and plan for the risks posed by older structures.

Infrastructure and Communication

Residents in Washington County commute frequently by automobiles and public transportation such as buses and light rail. An earthquake can greatly damage bridges and roads, hampering the movement of people and goods. Damaged infrastructure strongly affects the economy of the community – it disconnects people from work, school, food, and leisure, and separates businesses from their customers and suppliers. The Scoggins Dam located in the Coast Range of Washington County, may be subjected to strong ground shaking as a result of moderate to very large earthquakes nearby. Landslides around the reservoir rim are numerous. Although there is no evidence that these slides are active, their stability during an earthquake is uncertain.²⁴

Bridge Damage

Even modern bridges can sustain damage during earthquakes, leaving them unsafe for use. Some bridges have failed completely due to strong ground motion. Bridges are a vital transportation link – with even minor damages making some areas inaccessible. Because bridges vary in size, materials, siting, and design, any given earthquake will affect them differently. Bridges built before the mid-1970's have a significantly higher risk of suffering structural damage during a moderate to large earthquake compared with those built after 1980 when design improvements were made. Much of the interstate highway system was built in the mid to late 1960's. In the *Prioritization of Oregon Bridges for Seismic Retrofit Report*, Washington County's Rood Bridge over the Tualatin River ranked eighty-seventh on the list. Thus, it should be considered a retrofitting priority if funding for such activity becomes available in Washington County.²⁵

Damage to Lifelines

Lifelines are the connections between communities and outside services. They include water and gas lines, transportation systems, electricity, and communication networks. Ground shaking and amplification can cause pipes to break open, power lines to fall, roads and railways to crack or move, and radio and telephone communication to cease. Disruption to transportation makes it especially difficult to bring in supplies or services. All lifelines need to be usable after an earthquake to allow for rescue, recovery, and rebuilding efforts and to relay important information to the public.

Disruption of Critical Facilities²⁶

Critical facilities include police stations, fire stations, hospitals, shelters, and other facilities that provide important services to the community. These facilities and their services need to be functional after an earthquake event. Many critical facilities are housed in older buildings that are not up to current seismic codes.

Conduct a baseline survey to understand earthquake hazard risk perception for individuals and businesses to help prioritize mitigation activities and improve information dissemination.

Businesses

Seismic activity can cause great loss to businesses; both large-scale corporations and small retail shops. When a company is forced to stop production for just a day, the economic loss can be tremendous, especially when its market is at a national or global level. Seismic activity can create economic loss that presents a burden to small shop owners who may have difficulty recovering from their losses.

Individual Preparedness

A 1999 DOGAMI survey shows that about 39% of respondents think an earthquake will occur in Oregon within the next 10 years.²⁷ Only 28% of Oregon residents say they are prepared for an earthquake, and 22% have earthquake insurance. In addition, only 24% correctly identified what to do during an earthquake.

Because the potential for earthquake occurrences and earthquake-related property damage is relatively high, increasing individual preparedness is a significant need. Strapping down heavy furniture, water heaters, and expensive personal property as well as being earthquake insured, are just a few steps individuals can take to prepare for an earthquake.

Death and Injury

Death and injury can occur both inside and outside of buildings due to falling equipment, furniture, debris, and structural materials. Downed power lines and broken water and gas lines can also endanger human life.

Fire

Downed power lines or broken gas mains can trigger fires. When fire stations suffer building or lifeline damage, quick response to quench fires is less likely.

Debris

After damage to a variety of structures, much time is spent cleaning up brick, glass, wood, steel or concrete building elements, office and home contents, and other materials. Developing strong debris management strategies can assist in post-disaster recovery.

For more information on debris management strategies, refer to FEMA's Public Assistance Debris Management Guide.
(See resources on page 9-25, 26)

Earthquake Hazard Assessment

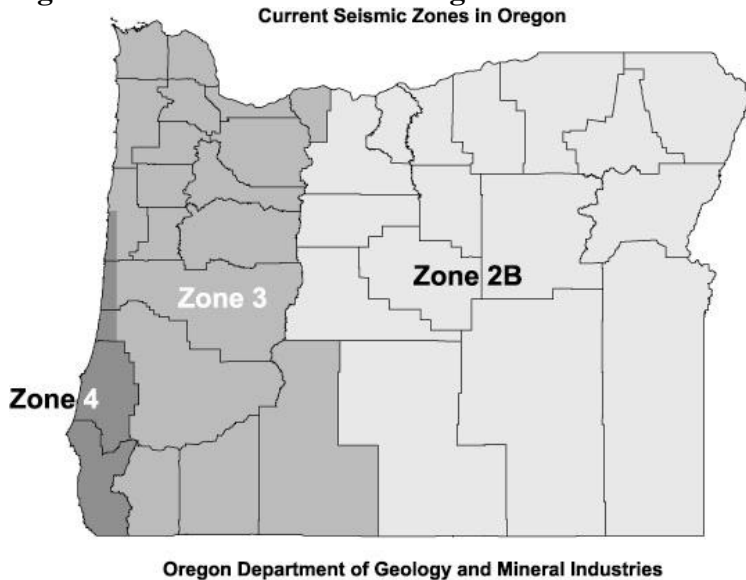
Hazard Identification

The Oregon Department of Geology and Mineral Industries (DOGAMI), in partnership with other state and federal agencies, has undertaken a rigorous program in Oregon to identify seismic hazards, including active fault identification, bedrock shaking, tsunami inundation zones, ground motion amplification, liquefaction, and earthquake induced landslides. Seismic hazard maps have been published and are available for many communities in Oregon through DOGAMI²⁸.

Local faults, including the Tualatin-Sherwood and Costco faults, have been identified as having a potential to cause crustal fault earthquakes. Earthquake-induced landslides are possible in areas with steep slopes, especially in old landslide areas such as the West Hills of Portland and the Coast Range at the western edge of Washington County. They are also possible in the Tualatin and Chehalem Mountains which border the county on the north and south respectively. Soil liquefaction and ground-shaking along the floor of the Tualatin Valley are potential risks faced by the County. Washington County's location also puts it at risk from a Cascadia Subduction Zone earthquake. The DOGAMI map on the next page illustrates maximum earthquake shaking expected in Oregon with a frequency of occurrence of once in 1000 years.

The Oregon Building Codes Division revised and upgraded its construction standards for new buildings to make them resistant to seismic events. The State Building Codes reflect three seismic zones. An increase in zone number reflects increased seismic activity. The *Current Seismic Zones* map below shows that Washington County is within Zone 3. Many buildings in Washington County were built prior to the imposition of Zone 3 code requirements.

Figure 9.3. Seismic Zones in Oregon



Vulnerability Assessment

Vulnerability assessment combines the information generated through hazard identification with an inventory of the existing property exposed to the hazard, helping to predict how different types of property and population groups will be affected by a hazard.²⁹ At risk from earthquake damage are large stocks of old buildings and bridges, many high tech and hazardous materials facilities, extensive sewer, water, and natural gas pipelines, an earthen dam, a petroleum pipeline, and other critical facilities and private property located in the county.

FEMA's software program, HAZUS, uses mathematical formulas and information about building stock, local geology and the location and size of potential earthquakes, economic data, and other information to estimate losses from a potential earthquake.³⁰ While the database for Oregon has errors, DOGAMI used the software and produced a report in 1999 that estimated the losses for a Cascadia Subduction Zone earthquake (magnitude 8.5) and the 500-year earthquake. The Cascadia Subduction Zone refers to the offshore fault that runs from northern California to Vancouver Island. It is less than 100 miles off the coast of Oregon, and is capable of generating magnitude 9 earthquakes and large tsunamis. Table 9.1 on the following page shows potential impacts from both of these earthquake scenarios. While this information has a degree of uncertainty, it is still useful for mitigation planning purposes to predict potential losses.³¹

Washington County ranked second in the state for the highest economic loss and loss ratio category. However, the loss could actually be higher because the HAZUS software underestimates potential damages to unreinforced brick and masonry buildings, which is also the major cause of earthquake injuries.

Risk Analysis

Long-Term Earthquake Action

Item #2: Expand earthquake hazard mapping for Washington County and improve technical analysis of earthquake hazards.

See page 9-17 for more information.

Risk analysis is the third phase of a hazard assessment. Risk analysis involves estimating the damage and costs likely to be experienced in a geographic area over a period of time.³²

Factors included in assessing earthquake risk include population and property distribution in the hazard area, the frequency of earthquake events, landslide susceptibility, buildings, infrastructure, and disaster preparedness of the region. This type of analysis can generate estimates of the damages to the County due to an earthquake event in a specific location. At the time of publication of this plan, data was insufficient to conduct a risk analysis and the software needed to conduct this type of analysis was not available. DOGAMI is leading state initiatives in producing relative earthquake maps and conducting risk analyses of various regions in the state.

Table 9.1. Estimated Earthquake Damage Summary for Washington County

Washington County	8.5 Cascadia Subduction Zone event	500-year model
Injuries	555	2,910
Deaths	10	62
Displaced households	2,062	7,666
Short term shelter needs	1,284	4,660
Economic losses for buildings	\$931 million	\$3.8 billion
<i>Operational the day after the quake:</i>		
Fire stations	66%	NA
Police stations	64%	NA
Schools	64%	NA
Bridges	79%	NA
<i>Economic losses to:</i>		
Highways	\$15 million	\$61 million
Airports	\$5 million	\$23 million
<i>Communication systems:</i>		
Economic losses	\$752,000	\$4 million
Operating the day of the quake	60%	NA
Debris generated (Thousands of tons)	763	2,817

Source: Wang, Yumei and J.L. Clark, "Earthquake damage in Oregon: Preliminary estimates of future earthquake losses", Special Paper 29, DOGAMI, 1999, p 57.

The Metro GIS Natural Hazards website has on-line interactive risk scenario maps for the Cascadia Subduction Zone and a magnitude 6.5 crustal fault map.

Mitigation Plan Goals and Existing Activities

Mitigation Plan Goals and Public Priorities

To review the mitigation plan goals, go to section 3, page 2 of the Washington County Natural Hazards Mitigation Action Plan.

The mitigation plan goals and action items are derived from review of regional and national natural hazards mitigation plans and planning literature, guidance from the Washington County Natural Hazards Mitigation Plan Steering Committee, and interviews with Washington County stakeholders. The goals for the Washington County Natural Hazards Mitigation Action Plan are broad based to include all of the identified hazards addressed in the plan. Goals for this mitigation plan address four categories:

1. Life, Property, and Natural Systems
2. Public Awareness and Partnerships
3. Emergency Services
4. Implementation

A public workshop was held on May 15, 2001 to identify public priorities for the plan goals and discuss strategies to achieve them. The goal statements and a summary of the public workshop outcomes can be found in Section Three of this plan. All comments from the public workshop are documented in Appendix B.

Through a voting process, the participants identified goal statements in the category of Life, Property, and Natural Systems as their top priority. This section describes existing mitigation activities and earthquake action items. Multi-hazard action items (i.e., those that broadly address all of the identified hazards) are described in Section Three. Mitigation plan action items are designed to help meet the overall goals of the mitigation plan.

Existing Mitigation Activities

Existing mitigation activities include current mitigation programs and activities that are being implemented by county, regional, state, or federal agencies or organizations.

State Earthquake Legislation

Senate Bill 13: Seismic Event Preparation

Senate Bill 13, signed by the Governor on June 14, 2001, requires each state and local agency and persons employing 250 or more full-time employees to develop seismic preparation procedures and inform their employees about the procedures. Further, the bill requires agencies to conduct drills in accordance with Office of Emergency Management guidelines. These drills must include “familiarization with routes and methods of exiting the building and methods of duck, cover and hold during an earthquake.”

Senate Bill 14: Seismic Surveys For School Buildings

The Governor signed Senate Bill 14 on July 19, 2001. It requires the State Board of Higher Education to provide for seismic safety surveys of buildings that have a capacity of 250 or more persons and are routinely used for student activities by public institutions or departments under the control of the board. A seismic safety survey is not required for any building that has previously undergone a seismic safety survey or that has been constructed to the state building code standards in effect for the seismic zone classification. Subject to available funding, if a building is found to pose an undue risk to life and safety during a seismic event, a plan shall be developed for seismic rehabilitation or other seismic risk reducing activities. All seismic rehabilitation or other actions to reduce seismic risk must be completed before January 1, 2032, subject to available funding.

Senate Bill 15: Seismic Surveys For Hospital Buildings

The Governor signed Senate Bill 15 on July 19, 2001. It requires the Health Division to provide for seismic safety surveys of hospital buildings that contain an acute inpatient care facility. Seismic surveys shall also be conducted on fire stations, police stations, sheriffs' offices, and similar facilities subject to available funding. The surveys should be completed by January 1, 2007.

A seismic survey is not required for any building that has undergone a survey or that has been constructed to the state building code standards in effect for the seismic zone classification at the site. Subject to available funding, if a building is evaluated and found to pose an undue risk to life and safety during a seismic event, the acute inpatient care facility, fire department, fire district or law enforcement agency using the building shall develop a plan for seismic rehabilitation of the building or for other actions to reduce the risk. All seismic rehabilitations or other actions to reduce the risk must be completed before January 1, 2022, subject to available funding.

Washington County Code, 1997³³

Chapter 14.04 of the Washington County Code is the Uniform Building Code. This code provides for the regulation of building construction, the abatement of nuisances, and administration of standards, including enforcement, of the State Building Code. This code is necessary for the protection of the public health, safety, and general welfare of the residents and citizens of the County. This code applies to the construction, alteration, moving, demolition, repair, maintenance, and work associated with any building or structure except those located in a public way.

School Upgrading – Forest Grove District

The Forest Grove School District assessed their school buildings after identifying damages from the 1993 Scotts Mills earthquake. A bond was passed to pay for restoration and remodeling of all school buildings in the district to make them seismically stable. Ten upgrading projects have since been completed in the district. Assessing

Recommendations for developing inventories of at-risk buildings and infrastructure are described in Short-Term, Multi-Hazard Action Item #7 on pg. 3-7 of the mitigation plan.

and upgrading school buildings in the Forest Grove School District has increased their resilience to seismic hazards and decreased the potential risk facing school children.

To review the multi-hazard mitigation action items, refer to section 3, page 4 of the Washington County Natural Hazards Mitigation Action Plan.

Coordination Among County Building Officials

All of the larger cities in Washington County have a building official. They work closely together with the county Building Official to enforce building codes and coordinate efficient inspection routines during an event. The county Building Services Division has mapped out critical facilities and major public buildings so that when an event occurs, inspections can be conducted quickly and effectively.

Businesses/Private Sector

Intel, the largest business in Washington County, has developed an elaborate emergency system, using available resources and foresight to invest for long-term business continuity. Intel constructed their buildings to stricter development standards than were required by code. They also partnered with the county to organize an earthquake forum in 2000 to discuss mitigation activities for business and government.

Earthquake Awareness Month

April is Earthquake Awareness Month. During the month, the State Office of Emergency Management encourages individuals to strap down computers, heavy furniture, and bookshelves. Washington County coordinated a full-scale earthquake drill in April 2001.

Earthquake Education

Earthquake education in schools is ongoing in Oregon. Schools conduct periodic earthquake drills and educate students how to respond when an earthquake event occurs.

Metro Regional Guide

Metro worked with the Federal Emergency Management Agency to identify seismic areas and produce new earthquake maps. It also produced a report on guidelines for natural hazards mitigation. Metro conducted a building inventory to evaluate seismic strength, specifically for commercial and multi-family buildings such as apartments, in 1998. Incorporating this information, Metro produced a report, "Using Earthquake Hazard Maps for Land Use Planning and Building Permit Administration," which can be widely applied by local governments in Washington County.

Improving education and outreach is one of the core goals of this mitigation plan. For more ideas on how to increase earthquake hazards awareness, see Long-Term, Multi-Hazard Action Item #1 on pg. 3-9.

Earthquake Mitigation Action Items

The earthquake mitigation action items provide direction on specific activities that cities, organizations, and residents in Washington County can undertake to reduce risk and prevent loss from earthquake events. There are five short-term and three long-term earthquake hazard action items described below. Each action item is followed by ideas for implementation, which can be used by the steering committee and local decision makers in pursuing strategies for implementation.

ST-EQ#1: Identify funding sources or establish tax incentives to retrofit structures that are identified as seismically vulnerable.

Lack of capital to upgrade structures is a major reason why many public and privately owned buildings and bridges are not retrofitted to stricter seismic standards.

Ideas for Implementation

- Provide information for property owners, small businesses, and organizations on sources of funds (loans, grants, etc.); and
- Adopt an ordinance that authorizes property tax incentives or deferrals to offset the costs of voluntary rehabilitation for existing buildings.

Coordinating Organization: Washington County

Partner Organizations: IISOI, OSSPAC, Local banks, Credit Unions

Timeline: Ongoing

Plan Goals Addressed: Implementation; Public Awareness and Partnerships

ST-EQ#2: Encourage purchase of earthquake hazard insurance.

Ideas for Implementation

- Provide earthquake insurance information to customers.

Coordinating Organization: IISOI

Partner Organizations: Washington County, Insurance and Real Estate Industries

Timeline: Ongoing

Plan Goals Addressed: Life, Property, and Natural Systems

ST-EQ#3: Pursue regulatory mandates for structural mitigation of critical facilities from earthquake threats.

Ideas for Implementation

- Mandate that government buildings, critical facilities, bridges, and roads be retrofitted to stricter seismic standards;
- Encourage the state legislature to mandate retrofitting activities?

ST-EQ#3, continued

Coordinating Organization: Washington County
Partner Organizations: OEM, ODOT, BCD, DOGAMI, OSSPAC
Timeline: 1-2 years
Plan Goals Addressed: Life, Property, and Natural Systems

ST-EQ#4: Encourage public/private partnerships with building contractors and architects to pursue specific retrofitting projects.

Ideas for Implementation

- Develop incentives (tax incentives or public recognition) for private contractors and architects to work on retrofitting public buildings and other infrastructure. This may help to minimize the funding shortage issue that has caused a number of high-risk sites to remain without retrofitting.

Coordinating Organization: Washington County
Partner Organizations: Associated General Contractors, Architectural firms, County/City Building Officials, Oregon Building Codes Division
Timeline: Ongoing
Plan Goals Addressed: Public Awareness and Partnerships

ST-EQ#5: Seek reductions in nonstructural hazards in homes, schools, businesses, and government offices.

Ideas for Implementation

- Provide training to government building and school facility managers and teachers on securing bookcases, filing cabinets, light fixtures, and other objects that can cause injuries and block exits;
- Encourage facility managers, business owners, and teachers to refer to FEMA's practical guidebook: *Reducing the Risks of Nonstructural Earthquake Damage*;
- Conduct periodic safety inspections of nonstructural seismic hazards;
- Encourage homeowners to use *Is Your Home Protected from Earthquake Disaster? A Homeowner's Guide to Earthquake Retrofit* (IBHS) for economic and efficient mitigation techniques;³⁴ and
- Organize retrofitting classes for homeowners, building professionals, and contractors. Refer to Project Impact Seattle for more ideas.

Coordinating Organization: Washington County
Partner Organizations: City/County Building Officials, IISOL, OSSPAC, IBHS Commission, WCFDB, School Districts
Timeline: Ongoing
Plan Goals Addressed: Life, Property, and Natural Systems; Emergency Services; Implementation

For ideas on funding opportunities for structural mitigation activities see Short-term Multi-Hazard Mitigation Action Item #1 on pg. 3-4

LT-EQ#1: Develop strategies to assist schools and universities, government infrastructure, and critical facilities to meet current seismic standards.

Ideas for Implementation

- Develop an inventory of schools, universities, and critical facilities that do not meet current seismic standards; and
- Conduct an in-depth analysis of Scoggins Dam vulnerability to seismic shakes, as well as an assessment of the possible liquefiable nature of alluvium remaining in the dam foundation and the stability of nearby landslides.³⁵

Coordinating Organization: Washington County

Partner Organizations: Pacific Northwest Region - US Bureau of Reclamation, School Districts, Universities, AGC, Architects, Cities, Engineers, Northwest Region ESD, TVID, City/County Building Officials, Oregon Building Codes Division, Engineers

Timeline: 1-5 years

Plan Goals Addressed: Life, Property, and Natural Systems; Emergency Services.

LT-EQ#2: Expand earthquake hazard mapping for Washington County and improve technical analysis of earthquake hazards.

DOGAMI has produced a series of earthquake hazards maps for most of the incorporated areas of the Portland metropolitan region. Such maps are not available for the more rural cities and unincorporated areas of Washington County. Hazard assessment is limited due to insufficient information.

Ideas for Implementation

- Complete mapping of the earthquake hazard throughout Washington County;
- Update Washington County earthquake HAZUS data to improve accuracy of the vulnerability assessment for Washington County;
- Encourage local government officials to use Metro's earthquake hazards reports and reference the earthquake maps when making land use decisions; and
- Conduct risk analysis incorporating HAZUS data and the created hazard maps using GIS technology to identify risk sites and further assist in prioritizing mitigation activities and regulating land use.

Coordinating Organization: Washington County

Partner Organizations: DOGAMI, METRO, PSU, OSU, FEMA

Timeline: 1-5 years

Plan Goals Addressed: Life, Property, and Natural Systems; Emergency Services; Implementation

LT-EQ#3: Improve local capabilities to perform earthquake building safety evaluations and to record and manage building inventory data.

Ideas for Implementation

- Offer periodic training in ATC-20 and ATC-21 procedures for earthquake building safety evaluations and encourage local building officials and other public and private officials (facilities, maintenance, engineering, architecture) to attend;
- Encourage development of a countywide building inventory database; and
- Foster coordination between county and city building officials.

Coordinating Organization: Washington County

Partner Organizations: PSU, OSU, Oregon Building Codes Division, County and City Building Officials

Timeline: Ongoing

Plan Goals Addressed: Life, Property, and Natural Systems; Emergency Services; Implementation

Resource Directory

County Resources

Washington County Building Services Division

The Building Services Division issues a variety of permits and enforces building codes. It also works on countywide coordination among building code officials to improve the effectiveness of building inspections during an unscheduled event.

Contact: Washington County Building Official
Address: 155 N. First Avenue, Suite 350-12, Hillsboro, OR 97124
Phone: (503) 846-3470
Fax: (503) 846-3993
Website: http://www.co.washington.or.us/deptmts/lut/land_dev.htm

For more information on county, state and federal natural hazard mitigation programs and activities, refer to *Appendix A: Resource Directory*

Washington County Department of Land Use and Transportation

The Washington County Land Use and Transportation Department plans, builds, and maintains the County's transportation systems and prepares, implements, and enforces land use plans, policies, and related state and county mandates.

Contact: Washington County Land Development Services Division
Phone: (503) 846-3470
Fax: (503) 846-4412
Address: 155 N. First Avenue, Suite 350 Hillsboro, OR 97124
Website: <http://www.co.washington.or.us/deptmts/lut/lut.htm>
Email: lutdir@co.washington.or.us

Washington County Office of Emergency Management

The Washington County Emergency Management Program exists pursuant to ORS 401 to guide the county's preparations for, response to, and recovery from major emergencies and disasters. The program is organized under the county sheriff's office and oversees preparation and maintenance of the county's emergency operations plan and emergency operations center and the training and exercising of designated staff.

Unique to Washington County is a consolidated office that brings the emergency management staffs from four jurisdictions together into a single office to enhance disaster preparedness activities countywide. The Office of Consolidated Emergency Management (OCEM) for Washington County was formed in 1995 by Intergovernmental Agreement between Washington County, the cities of Beaverton and Hillsboro, and Tualatin Valley Fire and Rescue. The organization's mission statement indicates that "The Office of Consolidated Emergency Management for Washington County is committed to the development and maintenance of a countywide, integrated system to prepare for, respond to, recover from, and mitigate against disasters."

Contact: Director, Washington County Emergency Management
Address: 20665 SW Blanton St. Aloha, OR, 97007
Phone: (503) 642.0371

Website: <http://www.ocem.org>
Email: info@ocem.org

Regional Resources

Metro Regional Government

Metro is the directly elected regional government that serves more than 1.3 million residents in Clackamas, Multnomah, and Washington counties and 24 cities in the Portland metropolitan area. Chapter 5 of Metro's Regional Framework Plan addresses natural hazards. Metro's Natural Hazards Program is a service of the Growth Management Services Department's Data Resource Center. Their web pages relate to natural hazards that may impact the Portland metropolitan area. Their links provide information about the natural hazards in the Portland metropolitan area and suggest tools for reducing potential damages before disaster strikes. Metro produced the *Regional Hazard Mitigation Policy and Planning Guide* in 1999 to assist local governments in planning for future natural hazard events.

Contact 1: Metro Regional Government
Address: 600 NE Grand Ave, Portland, OR 97232-2736
Phone: (503) 797-1839
Fax: (503) 797-1911
Website: <http://www.metro.dst.or.us/metro/growth/gms.html>
Email: 2040@metro-region.org

Contact 2: Metro Data Resource Center
Website: <http://storefront.metro.dst.or.us/drc/nathaz/nathaz.cfm>
Email: drc@metro.dst.or.us

Northwest GeoData Clearinghouse, Department of Geology – Portland State University

Portland State University conducts geologic research and prepares inventories and reports for communities throughout Oregon. The GeoData Clearinghouse provides geologic information on earthquakes in the Northwest. It is especially useful for finding earthquake-related maps or links to geospatial mapping sites around the nation.

Contact: Department of Geology
Address: Portland State University P.O. Box 751, Portland OR 97207-0751
Phone: (503) 725-3022
Fax: (503) 725-3025
Website: <http://www.metro.dst.or.us/metro/growth/gms.html>

State Resources

Department of Land Conservation and Development (DLCD)

DLCD administers the state's Land Use Planning Program. The program is based on 19 Statewide Planning Goals, including Goal 7, related to natural hazards, with flood as its major focus. DLCD serves as the federally designated agency to coordinate floodplain management in Oregon. They also conduct various landslide related mitigation activities. In order to help local governments address natural hazards effectively, DLCD provides

technical assistance such as conducting workshops, reviewing local land use plan amendments, and working interactively with other agencies.

Contact: Natural Hazards Program Manager
Address: 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540
Phone: (503) 373-0050
Fax: (503) 378-6033
Website: <http://www.lcd.state.or.us/hazards.html>

Oregon Department of Geology and Mineral Industries (DOGAMI)

The mission of the Department of Geology and Mineral Industries is to serve a broad public by providing a cost-effective source of geologic information for Oregonians and to use that information in partnership to reduce the future loss of life and property due to potentially devastating earthquakes, tsunamis, landslides, floods, and other geologic hazards. The Department has mapped earthquake hazards in most of western Oregon.

Contacts: Deputy State Geologist, Seismic, Tsunami, and Coastal Hazards Team Leaders
Address: 800 NE Oregon St., Suite 965, Portland, Oregon 97232
Phone: (503) 731-4100
Fax: (503) 731-4066
Website: <http://sarvis.dogami.state.or.us/homepage>

Oregon Department of Consumer & Business Services-Building Codes Division

The Building Codes Division (BCD) sets statewide standards for design, construction, and alteration of buildings that include resistance to seismic forces. BCD is active on several earthquake committees and funds construction related continuing education programs. BCD registers persons qualified to inspect buildings as safe or unsafe to occupy following an earthquake and works with OEM to assign inspection teams where they are needed.

Contact: Building Codes Division
Address: 1535 Edgewater St. NW, P.O. Box 14470, Salem, Oregon 97309
Phone: (503) 378-4133
Fax: (503) 378-2322
Website: <http://www.cbs.state.or.us/external>

Oregon State Police (OSP)-Office of Emergency Management (OEM)

The purpose of OEM is to execute the Governor's responsibilities to maintain an emergency services system as prescribed in Oregon Revised Statutes Chapter 401 by planning, preparing, and providing for the prevention, mitigation and management of emergencies or disasters that present a threat to the lives and property of citizens of and visitors to the state of Oregon. OEM coordinates disaster support to local governments and works with BCD to deploy additional building inspectors when needed for damage assessment.

Contact: Earthquake and Tsunami Program Coordinator
Address: 595 Cottage St. NE, Salem, Oregon 97301
Phone: (503) 378-2911
Fax: (503) 588-1378

Website: <http://www.osp.state.or.us/oem/>

The Nature of the Northwest Information Center

The Nature of the Northwest Information Center is operated jointly by the Oregon Department of Geology and Mineral Industries and the USDA Forest Service. It offers selections of maps and publications from state, federal, and private agencies. DOGAMI's earthquake hazard maps can be ordered from this site.

Address: Suite 177, 800 NE Oregon Street # 5, Portland, Oregon 97232
Phone: (503) 872-2750
Fax: (503) 731-4066
Email: Nature.of.NW@state.or.us
Website: <http://www.naturenw.org/geo-earthquakes.htm>

Federal Resources and Programs

Federal Emergency Management Agency (FEMA)

FEMA is heavily involved with seismic risks in Oregon and has aided in several projects in Portland and Klamath Falls. The Federal Emergency Management Agency (FEMA) is an independent agency of the Federal Government, reporting to the President. FEMA's purpose is to reduce loss of life and property and protect the nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response, and recovery. FEMA coordinates the federal response and provides disaster relief funds following a natural hazard event and works most closely with Oregon Emergency Management (OEM).

Contact: Public Affairs Officer, FEMA, Federal Regional Center,
Address: 130 228th Street, St., Bothell, WA 98021-9796
Phone: (425) 487-4610
Fax: (425) 487-4690
Website: <http://www.fema.gov/library/quakef.htm>
Email: opa@fema.gov

US Geological Survey (USGS)

The USGS is an active seismic research organization that also provides funding for research. (For an example of such research, see Recommended Seismic Publications below).

Contact: USGS, National Earthquake Information Center
Address: Box 25046; DFC, MS 967; Denver, Colorado 80225
Phone: (303) 273-8500
Fax: (303) 273-8450
Website: <http://neic.usgs.gov>

Building Seismic Safety Council (BSSC)

The Building Seismic Safety Council (BSSC), established by the National Institute of Building Sciences (NIBS), deals with complex regulatory, technical, social, and economic issues and develops and promotes building earthquake risk mitigation regulatory provisions for the nation.

Address: 1090 Vermont Avenue, NW, Suite 700, Washington, DC 20005
Phone: (202) 289-7800
Fax: (202) 289-109
Website: <http://www.bssconline.org/>

Additional Resources

American Red Cross

The American Red Cross is a humanitarian organization, led by volunteers, that provides relief to victims of disasters and helps people prevent, prepare for, and respond to emergencies. The Oregon Trail Chapter was chartered as a Red Cross unit in 1917. The chapter serves the residents of Clackamas, Columbia, Multnomah, Washington, Yamhill, and Tillamook counties. The Oregon Trail Chapter provides a variety of community services which are consistent with the Red Cross mission and meet the specific needs of this area, including disaster planning, preparedness, and education.

Contact: American Red Cross, Oregon Trail Chapter
Address: P.O. Box 3200, Portland, OR 97208-3200
Phone: (503) 284-1234
Fax: (503) 284-4247
Website: <http://www.redcross-pdx.org> or <http://www.redcross.org>
Email: info@redcross-pdx.org

Cascadia Region Earthquake Workgroup (CREW)

The Cascadia Region Earthquake Workgroup provides information on regional earthquake hazards, facts, and mitigation strategies for homes and businesses. The Cascadia Region Earthquake Workgroup (CREW) is a non-profit coalition of private and public representatives working together to improve the ability of Cascadia Region communities to reduce the effects of earthquake events. Members are from Oregon, Washington, California, and British Columbia. CREW's goals are to:

- Promote efforts to reduce the loss of life and property;
- Conduct education efforts to motivate key decision makers to reduce risks associated with earthquakes; and
- Foster productive linkages between scientists, critical infrastructure providers, businesses, and governmental agencies in order to improve the viability of communities after an earthquake event.

Contact: CREW, Executive Director
Address: 1330A S. 2nd Street, #105; Mount Vernon, WA 98273
Phone: (360) 336-5494
Fax: (360) 336-2837
Website: <http://www.crew.org>

Institute for Business & Home Safety (IBHS)

IBHS was created as an initiative of the insurance industry to reduce damage and losses caused by natural disasters. Their website provides educational resources and on-line publications for insurers, businesses, and homeowners who are interested in taking the initiative to minimize future damages and losses.

Contact: Institute for Business and Home Safety
Address: 1408 North Westshore Boulevard - Suite 208 - Tampa, FL 33607
Phone: (813) 286-3400
Fax: (813) 286-9960
E-mail: info@ibhs.org
Website: <http://www.ibhs.org/ibhs2/>

Western States Seismic Policy Council Earthquake Program Information Center (WSSPC)

WSSPC is a regional earthquake consortium funded mainly by the Federal Emergency Management Agency. Its website is a great earthquake resource, with information clearly categorized - from policy to engineering to education.

Contact: Western States Seismic Policy Council
Address: 125 California Avenue, Suite D201, #1, Palo Alto, CA 94306
Phone: (650) 330-1101
Fax: (650) 326-1769
E-mail: wsspc@wsspc.org
Website: <http://www.wsspc.org/home.html>

Publications

Planning for Natural Hazards: The Oregon Technical Resource Guide, Department of Land Conservation and Development (July 2000).

Produced by the Community Planning Workshop for the Department of Land Conservation and Development, this is a natural hazards planning and mitigation resource for Oregon cities and counties. It provides hazard-specific resources and plan evaluation tools. The document was written for local government employees and officials. The Technical Resource Guide includes a natural hazards comprehensive plan review, a hazard mitigation legal issues guide, and five hazard-specific technical resource guides, including: flooding, wildfires, landslides, coastal hazards, and earthquakes. You can write, call, fax, or go on-line to obtain this document.

Contact: Natural Hazards Program Manager, DLCD
Address: 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540
Phone: (503) 373-0050
Fax: (503) 378-6033
Website: <http://www.lcd.state.or.us/hazards.html>

Environmental, Groundwater and Engineering Geology: Applications for Oregon – Earthquake Risks and Mitigation in Oregon, Yumei Wang, (1998) Oregon Department of Geology and Mineral Industries, Star Publishing.

This paper deals with earthquake risks in Oregon, what is being done today, and what policies and programs are in action to help prevent loss and damage from seismic events. This article also gives a good list of organizations that are doing work in this field within the state. This article is somewhat technical but provides vital information to communities around the state.

Contact: DOGAMI
Address: 800 NE Oregon St., Suite 965, Portland, Oregon 97232
Phone: (503) 731-4100
Fax: (503) 731-4066
Website: <http://sarvis.dogami.state.or.us/homepage>

Land Use Planning for Earthquake Hazard Mitigation: A Handbook for Planners, Wolfe, Myer R. et. al., (1986) University of Colorado, Institute of Behavioral Science, National Science Foundation.

This handbook provides techniques that planners and others can utilize to help mitigate for seismic hazards. It provides information on the effects of earthquakes, sources on risk assessment, and effects of earthquakes on the built environment. The handbook also gives examples on application and implementation of planning techniques to be used by local communities.

Contact: Natural Hazards Research and Applications Information Center
Address: University of Colorado, 482 UCB, Boulder, CO 80309-0482
Phone: (303) 492-6818
Fax: (303) 492-2151
Website: <http://www.colorado.edu/UCB/Research/IBS/hazards>

Using Earthquake Hazard Maps: A Guide for Local Governments in the Portland Metropolitan Region; Evaluation of Earthquake Hazard Maps for the Portland Metropolitan Region Spangle Associates, (1998/1999) Urban Planning and Research, Portola Valley, California.

These two publications are useful for local governments concerned with land use in earthquake hazard areas. The proximity of Washington County to Portland and their interactive communities make these guides applicable to the County. The publications are written in clear and simplistic language and address issues such as how to apply earthquake hazard maps for land use decisions.

Contact: DOGAMI
Address: 800 NE Oregon St., Suite 965, Portland, Oregon 97232
Phone: (503) 731-4100
Fax: (503) 731-4066
Website: <http://sarvis.dogami.state.or.us/homepage>

Public Assistance Debris Management Guide, Federal Emergency Management Agency (July 2000).

The Debris Management Guide was developed to assist local officials in planning, mobilizing, organizing, and controlling large-scale debris clearance, removal, and disposal operations. Debris management is generally associated with post-disaster recovery. While it should be

compliant with local and county emergency operations plans, developing strategies to ensure strong debris management is a way to integrate debris management within mitigation activities. The *Public Assistance Debris Management Guide* is available in hard copy or on the FEMA website.

Contact: FEMA Distribution Center
Address: 130 228th Street, SW, Bothell, WA 98021 -9796
Phone: (800) 480-2520
Fax: (425) 487-4622
Website: <http://www.fema.gov/r-n-r/pa/dmgtoc.htm>

Earthquake Endnotes

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- ¹⁵ *Questions and Answers on Earthquakes in Washington and Oregon* (February 2001) www.geophys.washington.edu/seis/pnsn/info_general/faq.html.
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Section 10: Volcanic Eruption

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Why is Volcanic Eruption a Threat to Washington County?

Washington County and the Pacific Northwest lie on the “Ring of Fire,” an area of very active volcanic activity surrounding the Pacific Basin. Volcanic eruptions occur regularly along the Ring of Fire, in part, because of the movement of the Earth’s tectonic plates. The Earth's outermost shell, the lithosphere, is broken into a series of slabs known as tectonic plates. These plates are rigid, but they float on a hotter, softer layer in the Earth's mantle. As the plates move about on the layer beneath them, they spread apart, collide, or slide past each other. Volcanoes occur most frequently at the boundaries of these plates and volcanic eruptions occur when the hotter, molten materials, or magma, rise to the surface.

The primary threat to lives and property from active volcanoes is from violent eruptions that unleash tremendous blast forces, generate mud and debris flows, and produce flying debris and ash clouds. The immediate danger area in a volcanic eruption generally lies within a 20-mile radius of the blast site. However, impacts can extend 100 miles or more from the eruption site. Although there are no active volcanoes in Washington County, there are a number of active volcanoes within the 100-mile danger area that do pose a threat to county residents and property. The threat they pose is associated primarily with ash fall.

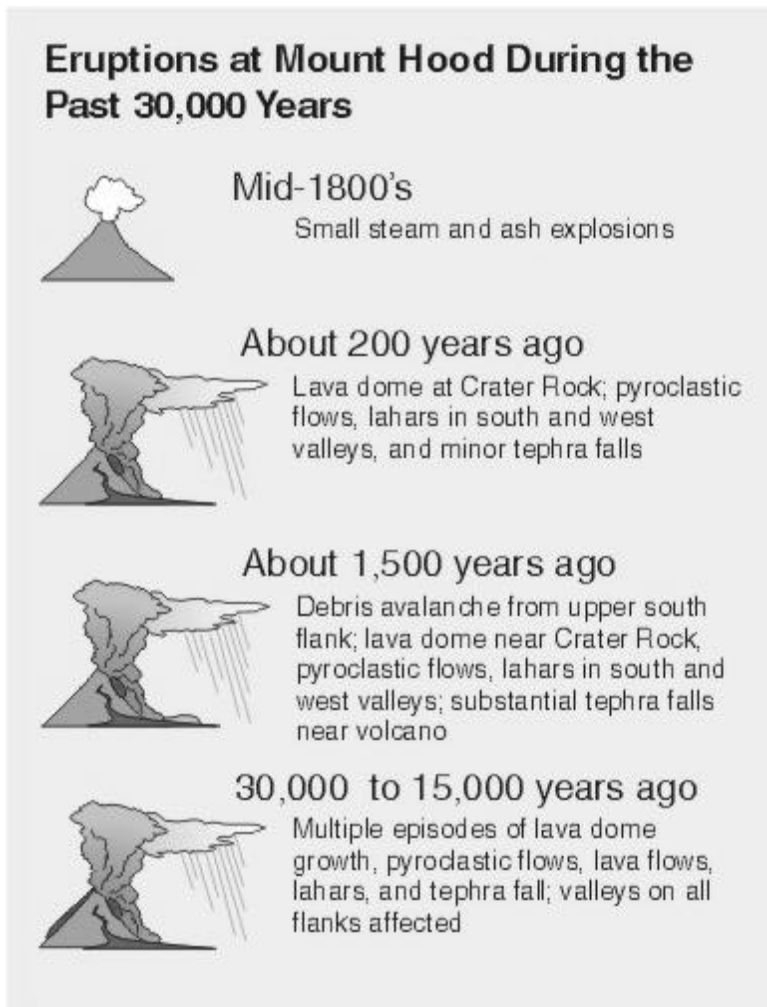
Population growth in Washington County and the Pacific Northwest near the region’s many volcanoes has led scientists to identify the volcanoes of the Cascades Range as having the greatest potential impact on society in the United States.¹

History of Volcanic Eruption Events Affecting Washington County

There are five major volcanoes in the Cascade region that are in relative proximity and pose a potential threat to Washington County. They include Mount St. Helens, Mount Hood, Mount Rainier, Mount Adams, and Mount Jefferson. Of the five, all are known or suspected to be active and most have geological records that indicate past histories of explosive eruptions with large ash releases. Only Mount Hood has no geological evidence of large explosive events, though it still poses a threat of ash releases to Washington County. Mount Hood and Mount St. Helens pose the greatest threat to Washington County in terms of potential impact, and are described in more detail below.

Mount Hood is located about 50 miles southeast of Portland. It has been recurrently active over the past 50,000 years. It has had two significant eruptive periods in recent times; one about 1,500 years ago and another about 200 years ago. Figure 10.1 shows the major geologic events in the Mount Hood Region during the past 30,000 years.

Figure 10.1. Eruption at Mount Hood



Source: USGS

While Mount Hood has shown no recent signs of volcanic activity, scientists predict the next eruption will consist of small explosions generating pyroclastic flows, ash clouds, and lahars (mud and debris flows).

Mount St. Helens, located in southwestern Washington about fifty miles northeast of Portland, is fifty thousand years old. Over the past 521 years, it has produced four major explosive eruptions and dozens of smaller eruptions. The May 18, 1980 eruption was followed by five smaller explosive eruptions over a period of five months.² A series of 16 dome-building eruptions through October 1986 constructed the new, 880 foot high, lava dome in the crater formed by the May 18, 1980 eruption. An historic eruption occurring in 1480 A.D. was about five times larger than the May 18, 1980 eruption. Figure 10.2 shows the timeline of Mount St. Helens' eruption events.

Case Study: Mount St. Helens³

The May 18, 1980 eruption of Mount St. Helens was preceded by about two months of precursor activity, including dome building, minor earthquakes, and venting of gasses. The lateral blast, debris avalanche, and mudflows associated with the eruption caused extensive loss of life and widespread

destruction of property. The eruption triggered a Richter magnitude 5.1 earthquake about one mile beneath the volcano. In the six-year period after the initial eruption, hundreds of small ash emissions at Mount St. Helens occurred.

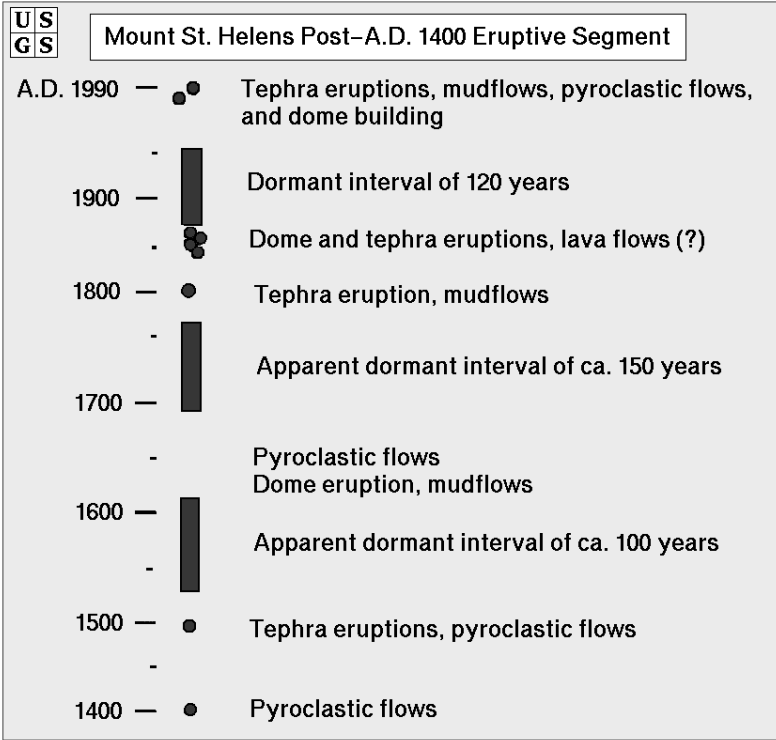
The eruption of Mount St. Helens took the lives of 57 people and nearly 7,000 big game animals. All birds and most small mammals in the area were killed, as were twelve million Chinook and Coho salmon fingerlings that perished when their hatcheries were destroyed.

Damage to the built environment within the immediate hazard vicinity included twenty-seven bridges, about two hundred homes, more than 185 miles of highways and roads, and fifteen miles of railways. Ash from the eruption column and cloud spread across the United States in three days and circled around the Earth in fifteen days. Detectable amounts of ash were noted in an area covering 22,000 square miles. Debris flows quickly filled the Toutle and Cowlitz Rivers and ultimately flowed into the Columbia River at Longview, Washington. The debris blocked the main shipping channel in the Columbia, stranded ships in port, and closed the ports of

Portland, Vancouver, and Kalama for over a month. Several water and sewage treatment facilities were also damaged or destroyed. The estimated damage attributed to the eruption was \$1.1 billion.

A few millimeters of ash fell onto Washington County during small events on May 25, June 12, and October 16-18, 1980. The May 25 event left ash covering buildings, vehicles, lawns, streets, and agricultural fields. For days, even weeks afterward, residents and government officials worked to clear away the fine powder. Local hospitals treated a large number of patients suffering from respiratory problems attributed to the ash. They handed out surgical masks to help filter the ash, but the masks were largely ineffective. Residents and government officials worked aggressively to remove the ash deposits by flushing them into storm drains or sweeping them up and hauling them to landfill sites. Parks and outdoor swimming pools were particularly hard hit. Pools had to be drained and the filters cleaned. Ash also worked its way into equipment causing premature failures or requiring unscheduled maintenance.

Figure 10.2. Mount St. Helens Post-1400 A.D. Eruptive Segment



Source: USGS

Characteristics of Volcanic Eruptions

Volcanoes are mountains that are built by the accumulation of their own eruptive products – lava flows, lava bombs (crusted over lava blobs), ash flows, and tephra (airborne ash and dust). A volcano is usually built around a vent that connects with reservoirs of molten rock (magma) below the surface of the Earth.⁴ The term volcano also refers to the opening or vent through which the molten rock and associated gases are expelled.

The impact of ash fall less than 1mm ash thickness could cause the following:

- Act as an irritant to lungs and eyes.
- Airports will close due to the potential damage to aircraft.
- Possible minor damage to vehicles, houses, and equipment caused by fine abrasive ash.
- Possible contamination of water supplies, particularly roof-fed tank supplies.
- Dust (or mud) affects road visibility and traction for an extended period.

Source: www.gns.cri.nz/earthact/volcanoes/hazards/index.htm

Active volcanoes can cause explosive or effusive eruptions. Thick and sticky magma usually causes explosive eruptions, which can produce fine volcanic ashes that rise many miles into the atmosphere in enormous eruption columns. Explosive activity also causes widespread tephra fall, pyroclastic flows and surges, debris avalanches, landslides, lahars, earthquakes, and flash floods. Effusive eruptions are characterized more by flowing or gushing magma than by violent blasts. They typically produce fragmented rocks from erupting lava and surrounding parent rock.⁵

Hazards Related to Volcanic Eruptions

Tephra

Tephra consists of sand-sized or finer particles of volcanic rock and larger fragments. During explosive eruptions, tephra, together with a mixture of hot volcanic gases, is ejected rapidly into the air from volcanic vents. The suspended materials are carried high into the atmosphere and begin to move downwind. As the ash particles cool or become moisture laden they start to fall under the influence of gravity. The larger fragments fall near the volcanic vent, while finer particles drift downwind as a large cloud and then fall to the ground to form a blanket-like ash deposit.

Tephra introduces a number of hazards including the impact of falling fragments, the suspension of abrasive particles in the air and water, and the burial of structures, transportation routes, and vegetation. Tephra can also threaten public health, clog drainage systems, and create major debris management problems. The 1980 eruption of Mount St. Helens, for example, injected tephra to altitudes of twelve to twenty miles and deposited it over an area of 40,000 square miles or more. The direction and velocity of the wind, along with the magnitude and duration of the eruption, determine the location, size, and shape of the tephra fall. Wind forecasts from National Weather Service and models of ash dispersal developed by volcanologists can provide short-term forecasts for areas that might be subject to ash fall.

Washington County must be aware of the potential tephra hazards that can arise from eruptions at Mount St. Helens, Mount Rainier, Mount Adams, and Mount Jefferson. Although Mount Hood may pose a tephra hazard, the geological evidence suggests that the volcano does not typically erupt in an explosive, tephra-producing manner.

Lahars

Melting snow and ice caused by pyroclastic flows and surges can generate lahars, also called volcanic mudflows or debris flows. Lahars are rapidly flowing, water-saturated mixtures of mud and rock fragments. Lahars range in consistency from mixtures resembling freshly mixed concrete to very muddy water, and can carry materials as large as truck size boulders. Past lahars at Mount Hood completely buried valley floors in the Sandy, Hood, and White River drainages. Nothing significant has been documented for drainages within Washington County. However, water from the Bull Run Watershed, which provides a great amount of drinking water to the County, could be affected directly or indirectly by lahars from Mount Hood.

Lava Flows⁶

Magma under the Earth that reaches the surface is called lava. Lava flows downhill and is channeled into river valleys. A lava flow only affects terrain that is down-slope from its vent. While lava flows are destructive, they are not normally life threatening. In Washington County, there are a few geologically young volcanic structures in the Sylvan Hills area. The west portal of the Max tunnel is in a lava flow that is fairly young (a few hundred thousand years old). There are ninety-five named and unnamed Boring Lava Field vents in the Portland area. The Swede Hill area, on the northeastern side of Beaverton, has seven vent locations, with four of them named.⁷

There is a very low probability of a volcanic eruption beginning in the county. However, if an eruption occurred, it would likely be effusive and form lava flows.⁸

For more information on the Boring Lava Field in Portland, Oregon, visit:
<http://vulcan.wr.usgs.gov/Volcanoes/Oregon/BoringLavaField>

Earthquakes⁹

Volcanic eruptions can be triggered by earthquakes or cause them. An earthquake produced by stress changes in solid rock from injection or withdrawal of magma (molten rock) is called a volcano-tectonic earthquake. The other categories of volcanic earthquakes, called long period earthquakes, are produced by the injection of magma into surrounding rock. Volcanic earthquakes tend to be mostly small and not a problem for areas tens of miles from the volcano. For specific hazards related to earthquakes, see Section 9 of this document.

Directed Blasts, Pyroclastic Flows and Volcanic Landslides

Directed blasts, also known as lateral blasts, are sideways-directed volcanic explosions that can shoot large pieces of rock at high speeds for several miles.¹⁰ Pyroclastic flows are fluid mixtures of hot rock fragments, ash, and gases that sweep down the flanks of volcanoes. Landslides, or debris avalanches, are a rapid downhill movement of rocky material, snow, or ice.¹¹ Though these hazards could cause great impact to communities near an erupting volcano; they do not pose a threat to Washington County residents.

Community Volcanic Eruption Issues

Volcanic eruption is not an immediate threat to the residents of Washington County, as there are no active volcanoes within the County. Nevertheless, the presence of a few geologically young volcanic structures in the County and the secondary threats caused by volcanoes in the Cascade region must be considered. Volcanic ash can contaminate water supplies, cause electrical storms, create health problems, and collapse roofs.¹² Additionally, lahars from Mount Hood can cause the loss of a major potable water supply for the county.

Building and Infrastructure Damage

Washington County is not within the major hazard zones of any Cascade volcanoes. It is not likely to encounter any major building or infrastructure damage where buildings could be buried, smashed, or carried away by lahar, pyroclastic flow, or landslide. The primary impacts facing county residents are related to ash fall.

Ash fall of about 0.4 inch is capable of creating temporary disruptions of transportation operations and sewage disposal and water treatment systems. Highways and roads could be closed for hours, days, or weeks afterwards. The series of eruptions at Mount St. Helens in 1980 caused Interstate 90 from Seattle to Spokane to close for a week. US 26 in Oregon faced similar problems. The impact of the ash fall caused the Portland International Airport to close for a few days. The airport faced a series of challenges in cleaning up the ash that accumulated on its runways.

The fine-grained, gritty ash can also cause substantial problems for internal-combustion engines and other mechanical and electrical equipment. The ash can contaminate oil systems, clog air filters, and scratch moving surfaces. Fine ash can also cause short circuits in electrical transformers, which in turn cause power blackouts. Sewage disposal systems, high tech facilities, and other critical industries in Washington County face these challenges.

Pollution and Visibility

Ash fallout from an eruption column can blanket areas within a few miles of the vent with a thick layer of pumice. High-altitude winds may carry finer ash from tens to hundreds of miles from the volcano, posing a hazard to flying aircraft, particularly those with jet engines.¹³ Fine ash in water supplies will cause brief muddiness and chemical contamination. The Tualatin River and the Bull Run Watershed, which provide most of the drinking water for Washington County residents, face potential pollution by ash fall. Air quality in Washington County could also be affected. For individuals with breathing problems, a few millimeters of ash fall may cause difficulties in breathing.¹⁴

Ash fall also decreases visibility and disrupts daily activities. For example, some individuals may encounter eye irritation. Visibility is especially a concern for airports, where passenger and airfreight movement could be disturbed. When the ash fall produced by the Mount St. Helens' eruption started to blow towards Oregon in June 1980, some of the airlines at the Portland International Airport responded immediately by stopping their

service. Hillsboro Airport, which lies in Washington County and handles a large volume of private aircraft, would certainly have to curtail or cease operations during an ash fall event.

Economy

Volcanic eruptions can disrupt the normal flow of commerce and daily human activity without causing severe physical harm or damage. Ash that is a few inches thick can halt traffic, and cause rapid wear of machinery, clog air filters, block drains, creeks, water intakes, and impact agriculture.¹⁵ Removal and disposal of large volumes of deposited ash can also have significant impacts on government and business.



Figure 10.4 impacts of tephra in Anchorage, Alaska, after an eruption of Mount Spurr. Source: USGS.

The interconnectedness of the region's economy can be disturbed after a volcanic eruption. The Mount St.

Helens' May 1980 eruption demonstrated the negative affect on the tourism industry. Conventions, meetings, and social gatherings were canceled or postponed in cities and resorts throughout Washington and Oregon in areas not initially affected by the eruption.

Transportation of goods from Washington County to nearby communities directly impacted by an eruption may also be halted. Subsequent airport closures can disrupt airline schedules for travelers. Clouds of ash often cause electrical storms that start fires and damp ash can short-circuit electrical systems and disrupt radio communication. Volcanic activity can also lead to the closure of nearby recreation areas as a safety precaution long before the activity ever culminates into an eruption.¹⁶

Volcanic Eruption Hazard Assessment

Hazard Identification

The USGS/Cascades Volcano Observatory (CVO) produced volcanic hazard zonation reports for Mount St. Helens and Mount Hood in 1995 and 1997. The reports include a description of potential hazards that may occur to immediate communities. Though this information may not pertain to Washington County, the CVO created an updated annual probability of tephra fall map for the Cascade region in 2001, which could be a rough guide for Washington County in forecasting potential tephra hazard problems.

The map is based on the combined likelihood of tephra-producing eruptions occurring at Cascade volcanoes. Probability zones extend farther east of the range because winds blow from westerly directions most of the time. The map shows annual probabilities for a fall of one centimeter (about 0.4 inch). The patterns on the map show the dominating influence of Mount St. Helens as a tephra producer. Because small eruptions are more numerous than large eruptions, the probability of a thick tephra fall at a given locality is lower than that of a thin tephra fall. The annual probability of a fall of one centimeter or more of tephra is about 1 in 10,000 for Washington County. This is small when compared to other risks faced by the county. The USGS map on the following page illustrates potential tephra fall in the region.

Vulnerability Assessment

Vulnerability assessment is the second phase of a hazard assessment. It combines information generated through hazard identification with an inventory of the existing development exposed to volcanic eruptions. Vulnerability assessments assist in predicting how different types of property and population groups will be affected by a hazard.¹⁷ Data that includes areas susceptible to ash fall in the county can be used to assess the population and total value of property at risk from volcanic eruption events.

Long-Term Volcanic Eruption Hazard

Action Item #1:

Collaborate with operators of critical facilities and industries on ash fall emergency response.

See page 10-13 for more information.

While a quantitative vulnerability assessment (an assessment that describes number of lives or amount of property exposed to the hazard) has not yet been conducted for Washington County volcanic eruption events, there are many qualitative factors (issues relating to what is in danger within a community) that point to potential vulnerability. Washington County faces no direct threat from a volcanic eruption. However, its proximity to a number of Cascade Range volcanoes places the County at risk from ash fallout originating from such an event.

The County also faces an indirect threat to its water supply based on a volcanic scenario impacting the Bull Run Water System. The impacts of a significant ash fall are substantial. Persons with respiratory problems are endangered, transportation, communications, and other lifeline services are

interrupted, drainage systems become overloaded/clogged, buildings can become structurally threatened, and the economy takes a major hit. Any future eruption of a nearby volcano (e.g., Hood, St. Helens, or Adams) occurring during a period of easterly winds would likely have adverse consequences for the County.

Risk Analysis

Risk analysis is the third, and most advanced phase of a hazard assessment. It builds upon hazard identification and vulnerability assessments. Key factors included in assessing risk from volcanic eruptions and ash fall include population and property distribution in the hazard area, the frequency of events, and potential wind direction. At the time of publication of this plan, data was insufficient to conduct a risk analysis and the software needed to conduct this type of analysis was not available.

Mitigation Plan Goals and Existing Activities

To review the mitigation plan goals, go to section 3, page 2 of the Washington County Natural Hazards Mitigation Action Plan.

Mitigation Plan Goals and Public Priorities

The mitigation plan goals and action items are derived from review of regional and national natural hazards mitigation plans and planning literature, guidance from the Washington County Natural Hazards Mitigation Plan Steering Committee, and interviews with Washington County stakeholders. The goals for the Washington County Natural Hazards Mitigation Action Plan are broad based to include all of the identified hazards addressed in the plan. Goals for this mitigation plan address four categories:

1. Life, Property, and Natural Systems
2. Public Awareness and Partnerships
3. Emergency Services
4. Implementation

A public workshop was held on May 15, 2001 to identify public priorities for the plan goals and discuss strategies to achieve them. The goal statements and a summary of the public workshop outcomes can be found in Section Three of this plan. All comments from the public workshop are documented in Appendix B.

Through a voting process, the public identified goal statements in the category of Life, Property, and Natural Systems as their top priority. This section describes existing mitigation activities and volcanic eruption hazard action items. Multi-hazard action items (i.e., those that broadly address all of the identified hazards) are described in Section Three. Mitigation plan action items are designed to help meet the overall goals of the mitigation plan.

Existing Mitigation Activities

Existing mitigation activities include current mitigation programs and activities that are being implemented by county, regional, state, or federal agencies or organizations.

Monitoring Volcanic Activity at Mount Hood and Mount St. Helens

The USGS collaborated with scientists from the Geophysics Program at the University of Washington to monitor seismic activity at both Mount St. Helens and Mount Hood after the May 1980 eruption at Mount St. Helens.¹⁸ When unusual activity is observed, scientists immediately notify government officials and the public. The US Forest Service serves as the primary dissemination agency for emergency information. As the activity changes, USGS scientists provide updated advisories and meet with local, state, and federal officials to discuss the hazards and appropriate levels of emergency response. The experience since 1980 at Mount St. Helens and elsewhere indicates that monitoring is sufficient for scientists to detect the ascent of fresh magma that must take place before another large eruption. This information will enhance warnings and facilitate updated assessments of the hazard.

In addition, the USGS and the National Weather Service monitor lahar and flood hazards at Mount St. Helens. The latter agency has responsibility for providing warnings of floods, including lahars. These monitoring activities not only help nearby communities, but can also provide significant benefit to the Pacific Northwest, including Washington County.

Volcanic Event Notification

Emergency Coordination

An emergency coordination center (ECC) was established at the US Forest Service (USFS) facility in Vancouver, Washington after the 1980 eruption of Mount St. Helens. A communications network and telephone call-down procedure was developed to facilitate rapid dissemination of information about the activity of the volcano. Information was also disseminated through public meetings, press conferences, and briefings with governmental agencies and private businesses. Currently, the system has the capability of issuing written predictions weeks in advance of most eruptions. This eliminates the need for 24-hour duty for both USFS/ECC and CVO staff except when eruptions are imminent. It can enter all predictions and updates into a computer "news" system for easy review by those on the call-down list; update volcanic activity reports when the volcano is quiet; and develop a seismic alarm to alert scientists to small events that occur without precursors.

Education and Outreach

USGS Video Programs

One good example of education and outreach the USGS has undertaken is the production of a series of videos related to volcanic eruption. The USGS has produced a video program "At Risk: Volcano Hazards from Mount Hood, Oregon." The video describes and illustrates the types of volcanic hazards posed by Mount Hood, and shows areas near the volcano that could be affected by future activity. The video was produced to provide nearby residents, businesses, and public agencies basic information about future potential hazards from the volcano.¹⁹

Volcanic Eruption Mitigation Action Items

The volcanic eruption mitigation action items provide direction on specific activities that cities, organizations, and residents in Washington County can undertake to reduce risk and prevent loss from volcanic eruption events. There are three short-term and two long-term volcano hazard action items described below. Each action item is followed by ideas for implementation, which can be used by the steering committee and local decision makers in pursuing strategies for implementation.

To review the multi-hazard mitigation action items, refer to section 3, page 4 of the Washington County Natural Hazards Mitigation Action Plan.

ST-VE#1: Collaborate with operators of critical facilities and industries on ash fall emergency response.

The Intel Corporation has taken the initiative to consult scientists on the probability of problems associated with volcanic eruptions in the Cascade region.

Ideas for Implementation

- Collaborate and exchange experiences and knowledge among facility managers of critical industries in the county to reduce the impact of ash fall on their sites.

Coordinating Organization: Washington County

Partner Organizations: USGS-CVO, major industries, DOGAMI, USFS Port of Portland, Cities

Timeline: 1-2 years

Plan Goals Addressed: Public Awareness and Partnerships

ST-VE#2: Collaborate with USGS-CVO and related agencies to create warning messages that provide appropriate ash fall response information.

Research has shown that warnings that are not specific in terms of areas affected or precautionary actions that should be prescribed, or that lack a sense of urgency, will result in low responses.

Ideas for Implementation

- Collaborate with USGS-CVO, FAA, National Weather Service, law enforcement offices, and the media to develop a warning message framework that is more appropriate for the county so that communities and individuals have a clear sense of how to respond.

Coordinating Organization: Washington County

Partner Organizations: USGS-CVO, FAA, DOGAMI, OEM, National Weather Service, law enforcement offices, media

Timeline: Ongoing

Plan Goals Addressed: Public Awareness and Partnerships

ST-VE#3: Increase understanding of volcanic eruptions and their potential impact to Washington County residents.

Education is an effective way to relate how an infrequent hazard event could affect the daily life of a county resident.

Ideas for Implementation

- Promote and make available the USGS volcanic eruption videotape and other appropriate materials at schools, community centers, critical facilities, and major businesses.

Coordinating Organization: Washington County

Partner Organizations: USGS-CVO, DOGAMI, School Districts, major critical facilities and businesses, Cities, Cable TV

Timeline: Ongoing

Plan Goals Addressed: Public Awareness and Partnerships

LT-VE#1: Pursue useful information and mapping of ashfall to assist in identifying impacts to Washington County.

Ideas for Implementation

- Contact State and federal research institutions for available data.

Coordinating Organization: Washington County

Partner Organizations: USGS-CVO, **Timeline:** 1-5 years

Plan Goals Addressed: Life, Property, and Natural Systems; Emergency Services; Implementation

LT-VE#2: Monitor and enhance response and recovery programs and develop and implement public education programs for volcanic eruption hazards.

Ideas for Implementation

- Determine critical activities that must be implemented for varying degrees of ash fall.
- Create a hazard-specific annex in the Washington County Emergency Operations Plan that defines the special concerns created by ash fall. (e.g., health, cleanup; impacts to high tech and other industries).
- Develop basic public education materials that describe volcanic eruption hazards, potential impacts, and appropriate response and mitigation activities.
- Create volcanic eruption hazard scenarios for Washington County to determine potential problems the county may face with varying amounts of ash fall.

Coordinating Organization: Washington County

Partner Organizations: USGS-CVO, Cities

Timeline: Ongoing

Plan Goals Addressed: Life, Property, and Natural Systems; Emergency Services; Implementation

Volcanic Eruption Hazard Resources

County Resources

For more information on county, state and federal natural hazard mitigation programs and activities, refer to *Appendix A: Resource Directory*

Washington County Office of Emergency Management

The Washington County Emergency Management Program exists pursuant to ORS 401 to guide the county's preparations for, response to, and recovery from major emergencies and disasters. The program is organized under the county sheriff's office and oversees preparation and maintenance of the county's emergency operations plan and emergency operations center and the training and exercising of designated staff.

Unique to Washington County is a consolidated office that brings the emergency management staffs from four jurisdictions together into a single office to enhance disaster preparedness activities countywide. The Office of Consolidated Emergency Management (OCEM) for Washington County was formed in 1995 by Intergovernmental Agreement between Washington County, the cities of Beaverton and Hillsboro, and Tualatin Valley Fire and Rescue. The organization's mission statement indicates that "The Office of Consolidated Emergency Management for Washington County is committed to the development and maintenance of a countywide, integrated system to prepare for, respond to, recover from, and mitigate against disasters."

Contact: Director, Washington County Emergency Management
Address: 20665 SW Blanton St. Aloha, OR, 97007
Phone: (503) 642-0371
Website: <http://www.ocem.org>
Email: info@ocem.org

Regional Resources

Metro Regional Government

Metro is the directly elected regional government that serves more than 1.3 million residents in Clackamas, Multnomah, and Washington counties and 24 cities in the Portland metropolitan area. Chapter 5 of Metro's Regional Framework Plan addresses natural hazards. Metro's Natural Hazards Program is a service of the Growth Management Services Department's Data Resource Center. Their web pages relate to natural hazards that may impact the Portland metropolitan area. Their links provide information about the natural hazards in the Portland metropolitan area and suggest tools for reducing potential damages before disaster strikes. Metro produced the *Regional Hazard Mitigation Policy and Planning Guide* in 1999 to assist local governments in planning for future natural hazard events.

Contact 1: Metro Regional Government
Address: 600 NE Grand Ave, Portland, OR 97232-2736
Phone: (503) 797-1839
Fax: (503) 797-1911
Website: <http://www.metro.dst.or.us/metro/growth/gms.html>
Email: 2040@metro-region.org

Contact 2: Metro Data Resource Center
Website: <http://storefront.metro.dst.or.us/drc/nathaz/nathaz.cfm>
Email: drc@metro.dst.or.us

State Resources

Department of Land Conservation and Development (DLCD)

DLCD administers the state's Land Use Planning Program. The program is based on 19 Statewide Planning Goals, including Goal 7, related to natural hazards, with flood as its major focus. DLCD serves as the federally designated agency to coordinate floodplain management in Oregon. They also conduct various landslide-related mitigation activities. In order to help local governments address natural hazards effectively, DLCD provides technical assistance such as conducting workshops, reviewing local land use plan amendments, and working interactively with other agencies.

Contact: Natural Hazards Program Manager
Address: 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540
Phone: (503) 373-0050
Fax: (503) 378-6033
Website: <http://www.lcd.state.or.us/hazards.html>

Oregon State Police (OSP)-Office of Emergency Management (OEM)

The purpose of OEM is to execute the Governor's responsibilities to maintain an emergency services system as prescribed in Oregon Revised Statutes Chapter 401 by planning, preparing, and providing for the prevention, mitigation, and management of emergencies or disasters that present a threat to the lives and property of citizens of and visitors to the state of Oregon.

Contact: Office of Emergency Management
Address: 595 Cottage Street NE, Salem, OR 97310
Phone: (503) 378-2911
Fax: (503) 588-1378
Website: <http://www.osp.state.or.us/oem>

Federal Resources and Programs

USGS-David A. Johnston Cascades Volcano Observatory (CVO)

CVO provides accurate and timely information pertinent to assessment, warning, and mitigation of natural hazards. It provides warnings during volcanic crises by monitoring volcanoes and interpreting results in the context of current hazard assessments. It also provides information for use in land-use management, emergency response plans, and public education.

Contact: CVO
Address: 5400 MacArthur Blvd, Vancouver, WA 98661
Phone: (360) 993-8900
Fax: (360) 993-8980
Website: http://vulcan.wr.usgs.gov/CVO_Info/framework.html

National Weather Service, Portland Bureau

The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and infrastructure, which can be used by other governmental agencies, the private sector, the public, and the global community.

Contact: National Weather Service
Address: 5241 NE 122nd Ave, Portland, Oregon 97230
Phone: (503) 326-2340
Website: <http://nimbo.wrh.noaa.gov/Portland>

Federal Emergency Management Agency (FEMA)

The Federal Emergency Management Agency (FEMA) is an independent agency of the federal government, reporting to the President. FEMA's purpose is to reduce loss of life and property and protect the nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response and recovery. FEMA provides disaster relief funds following a natural hazard and works closely with the Oregon State Police - Office of Emergency Management.

Contact: Public Affairs Officer
Address: 130 228th Street, St., Bothell, WA 98021-9796
Phone: (425) 487-4610
Fax: (425) 487-4690
Website: <http://www.fema.gov/library/volcano.htm>
Email: opa@fema.gov

Additional Resources

American Red Cross

The American Red Cross is a humanitarian organization, led by volunteers, that provides relief to victims of disasters and helps people prevent, prepare for, and respond to emergencies. The Oregon Trail Chapter was chartered as a Red Cross unit in 1917. The chapter serves the residents of Clackamas, Columbia, Multnomah, Washington, Yamhill, and Tillamook counties. The Oregon Trail Chapter provides a variety of community services which are consistent with the Red Cross mission and meet the specific needs of this area, including disaster planning, preparedness, and education.

Contact: American Red Cross, Oregon Trail Chapter
Address: P.O. Box 3200, Portland, OR 97208-3200
Phone: (503) 284-1234
Fax: (503) 284-4247
Website: <http://www.redcross-pdx.org>
Email: info@redcross-pdx.org

Institute for Business & Home Safety (IBHS)

IBHS was created as an initiative of the insurance industry to reduce damage and losses caused by natural disasters. Their website provides

educational resources and on-line publications for insurers, businesses, and homeowners who are interested in taking the initiative to minimize future damages and losses.

Contact: Institute for Business and Home Safety
Address: 1408 North Westshore Boulevard - Suite 208, Tampa, FL 33607
Phone: (813) 286-3400
Fax: (813) 286-9960
E-mail: info@ibhs.org
Website: <http://www.ibhs.org/ibhs2>

Institute of Geological & Nuclear Sciences Limited (GNS)

GNS has an excellent website that describes volcanic hazards in New Zealand. It provides simple and informative descriptions of volcanic hazards that are useful for communities around the world. It discusses the types of volcanic hazards and emergency response and mitigation actions that could be implemented.

Contact: Institute of Geological & Nuclear Sciences
Address: 69 Gracefield Rd, PO Box 30-368, Lower Hutt, New Zealand
Phone: (04) 570-1444
E-mail: info@ibhs.org
Website: <http://www.gns.cri.nz/earthact/volcanoes/hazards/index.htm>

Publications

Volcanic-Hazard Zonation for Mount St. Helens, Washington Open-File Report 95-497 (1995) USGS-CVO

Produced by the USGS-CVO in 1995, this report explains the various hazardous geologic processes of Mount St. Helens and the types of hazards and damages that have occurred at Mount St. Helens. It also includes valuable references and suggested reading.

Contact: USGS-CVO
Address: 5400 MacArthur Blvd, Vancouver, WA 98661
Phone: (360) 993-8900
Fax: (360) 993-8980
Website: <http://vulcan.wr.usgs.gov/Volcanoes/MSH/Hazards>

Volcano Hazards in the Mount Hood Region, Oregon Open-File Report 97-89 (1997) USGS-CVO

Produced by the USGS-CVO in 1997, this report documents past hazardous events that have occurred at Mount Hood and includes several volcano hazard maps. It also discusses hazard forecasts and warnings as well as ways to protect oneself from volcano hazards.

Contact: USGS-CVO
Address: 5400 MacArthur Blvd, Vancouver, WA 98661
Phone: (360) 993-8900
Website: <http://vulcan.wr.usgs.gov/Volcanoes/MSH/Hazards>

Public Assistance Debris Management Guide, Federal Emergency Management Agency (July 2000).

Debris management is generally associated with post-disaster recovery. While debris management should be compliant with local and county emergency operations plans, developing management strategies to ensure strong debris management during and after a natural hazard event is a way to integrate debris management with mitigation. The *Public Assistance Debris Management Guide* is available in hard copy or on the FEMA website.

Contact: FEMA Distribution Center
Address: 130 228th Street, SW, Bothell, WA 98021-9796
Phone: (800) 480-2520
Fax: (425) 487-4622
Website: <http://www.fema.gov/r-n-r/pa/dmgtoc.htm>

Volcanic Eruption Endnotes

- ¹ Dzurisin, Dan, Peter H. Stauffer, and James W. Hendley II, *Living With Volcanic Risk in the Cascades*, (2000) USGS Fact Sheet 165-97.
- ² *Volcanic Hazard Zonation for Mount St. Helens, Washington* (1995), USGS, Open-File-Report 95-497.
- ³ *May 18, 1980 Eruption of Mount St. Helens Summary*, <http://vulcan.wr.usgs.gov/Volcanoes> (March 2001) USGS.
- ⁴ *What is a Volcano?* (June 2001) USGS, vulcan.wr.usgs.gov/Outreach/AboutVolcanoes.
- ⁵ Riley, Colleen M., *A Basic Guide to Volcanic Hazards* (March 2001), Michigan Technological University, www.geo.mtu.edu/volcanoes/hazards/primer.
- ⁶ *Volcanic Hazard Zonation for Mount St. Helens, Washington* (1995), USGS, Open-File-Report 95-497.
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- ¹⁰ *Volcanoes* (March 2001), FEMA, www.fema.gov/library/volcano.htm.
- ¹¹ Wright and Pierson, *Living With Volcanoes*, (1973, 1992) USGS Volcano Hazards Program Circular.
- ¹² Ibid.
- ¹³ *Volcano Hazards of the Lassen Volcanic National Park Area*, (March 2001), USGS.
- ¹⁴ Ibid.
- ¹⁵ Ibid.
- ¹⁶ Personal Interview. Cashman, Kathy, University of Oregon Department of Volcanology, March 14, 2001.
- ¹⁷ Burby, R. (Ed.) *Cooperating with Nature*. (1998) Washington D.C. Joseph Henry Press.
- ¹⁸ *Volcano Hazards in the Mount Hood Region and Mount St. Helens*, (April 2001), USGS, vulcan.wr.usgs.gov/Volcanoes/Hood/Hazards.
- ¹⁹ Educational Video Programs: (April 2001), USGS, volcanoes.usgs.gov/Products.

Appendix A: Resource Directory

The following matrix outlines county and regional, state, and federal programs and resources related to natural hazards mitigation.

County and Regional Resources and Programs				
Hazard	Agency	Contact Information	Program	Type of Assistance
Flood	Clean Water Services (CWS)	Clean Water Services, 2550 SW Hillsboro Hwy, Hillsboro, OR 97123, (503) 681-3600, http://www.usa-cleanwater.org/	Water Resources and Surface Water Management	CWS (formerly the Unified Sewerage Agency) provides sanitary sewer and storm water management services to large portions of Washington County. CWS works with the County and the cities within the County to build and maintain public drainage systems that meet public need and comply with regulations set by the Oregon Department of Environment Quality. CWS maintains storm sewers and pipelines, open drainage ditches, and stormwater detention ponds. CWS also develops long-term flood management plans, including, but not limited to, protection of riparian buffer areas and wetland preservation. CWS is slated to complete the Watersheds 2000 project in 2001, an inventory of the location and condition of the stream (surface water) system in the Tualatin Basin.
Flood	Tualatin River Watershed Council (TRWC)	TRWC Coordinator, 1080 SW Baseline Building B, Suite B-2, Hillsboro, OR 97123, (503) 648-3174 ext. 116, www.trwc.org	Watershed Planning	The TRWC was formed in 1993 to provide more coordinated and integrated resource planning for the Tualatin River Watershed. Its purpose is to address watershed management issues in the Tualatin Basin and provide a framework for coordination and cooperation among key interests.
Flood and Landslide	Washington County Soil and Water Conservation District (SWCD)	Washington County SWCD, 1080 SW Baseline Building B, Suite B-2, Hillsboro, OR 97123, (503) 681-0953	Soil and Water Conservation	The SWCD works with the Natural Resource Conservation Service to promote soil and water conservation in Washington County. The organizations work with agricultural interests and landowners to provide information on natural resource conservation practices. The partnership blends individual member resources to offer technical and financial assistance in planning and applying natural resource conservation practices and systems. Areas of focus include: erosion management, wetlands preservation and restoration, resource inventories, watershed assessments, and conservation education.
Multi-hazard	Metropolitan Regional Government	600 NE Grand Ave., Portland, OR 97232-2736, (503) 797-1839, www.metro.dst.or.us/metro	Regional Planning and Policy for Natural Hazards	Metro's primary mission is to manage growth in Clackamas, Multnomah, and Washington counties and the 24 cities in the Portland, Oregon, metropolitan area. Its current role in regional land-use planning and growth management is an outgrowth of its role in establishing the urban growth boundary, transportation planning and data management.
Multi-hazard	Washington County Building Services Division	155 N. 1st Ave., Suite 350-12, Hillsboro, OR 97124, (503) 846-3470, www.co.washington.or.us	Building Codes	Issues permits and enforces building codes. Works on countywide coordination among city building code officials to improve the effectiveness of building inspection during an unscheduled event.

County and Regional Resources and Programs				
Hazard	Agency	Contact Information	Program	Type of Assistance
Multi-hazard	Washington County Department of Land Use and Transportation	155 N. 1st Ave., Suite 350-12, Hillsboro, OR 97124, (503) 846-3470, www.co.washington.or.us	Land Use and Transportation	Washington County Land Use and Transportation Department plans, builds and maintains the County's transportation systems and prepares, implements, and enforces land use plans, policies, and related State and County mandates.
Multi-hazard	Washington County Office of Emergency Management	20665 SW Blanton St. Aloha, OR, 97007 (503) 642-0374, www.ocem.org, info@ocem.org	Emergency Management	The Emergency Management Program exists pursuant to ORS 401 to guide the county's preparations for, response to, and recovery from major emergencies and disasters. The program is organized under the county's sheriff's office and oversees preparation and maintenance of the county's emergency operations plan and emergency operations center and the training and exercising of designated staff.
Wildfire	Washington County Fire Defense Board (WCFDB)	Oregon State Fire Marshal, 4760 Portland Road NE, Salem, Oregon 97305-1760, (503) 378-3473	Wildfire Prevention and Response	The WCFDB is comprised of all the local fire chiefs within the County and also includes ex-officio representatives from the State Fire Marshal's Office and the Oregon Department of Forestry.

Federal Resources and Programs				
Hazard	Agency	Contact Information	Program	Type of Assistance
Earthquake	FEMA, Department of Interior - US Geological Survey, Office of Emergency Management	Oregon Earthquake/ Tsunami Program Coordinator, 3225 State Street Salem, OR 97301, (503) 378-2911 #22237	National Earthquake Hazards Reduction Program	Seismic mapping for US. (OEM and DOGAMI receive funding for these programs.)
				Training, planning, and technical assistance under grants to states or local jurisdictions. Technical and planning assistance for activities associated with hazards mitigation.
Flood	Bureau of Reclamation	Bureau of Reclamation, Pacific Northwest Region, 1150 N. Curtis Road, Boise, ID 83706, (208) 378-5012, http://www.pn.usbr.gov/contact/index.shtml	Dam Safety	The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. The Bureau of Reclamation owns Scoggins Dam in Washington County and prepares emergency action plans for events at the dam.
Flood	Department of Defense (DOD) - US Army Corps of Engineers (USACE)	USACE-Portland District, Floodplain Information Branch, P.O. Box 2946, Portland, OR 97208-2946, (503) 808-4874, www.nwp.usace.army.mil	Aquatic ecosystem restoration	Direct support for carrying out aquatic ecosystem restoration projects that will improve the quality of the environment.
			Water Resources	USACE administers a permit program to ensure that the nation's waters are used in the public interest. In Oregon, joint permits may be issued with the Division of State Lands. USACE is responsible for the protection and development of the nation's water resources, including navigation, flood control, energy production through hydropower management, water supply storage and recreation.
			Floodplain Management	Technical and planning assistance at the local, regional, or national level to support effective floodplain management.
			Beneficial uses/dredged materials	Project assistance to protect, restore, and create aquatic and ecologically-related habitats, including wetlands, pertaining to dredging an authorized federal navigation project.
			Flood Control Works	Direct planning and construction grants for non-structural alternatives to the structural rehabilitation of flood control works damaged in floods.
			Improvement of the environment	Modifies structures and/or operations or water resources projects constructed by the USACE, or restoring areas where a USACE project contributed to the degradation of the area.
			Planning Assistance to states	Technical and planning assistance for the preparation of comprehensive plans for the development, utilization and conservation of water and related land resources

Federal Resources and Programs				
Hazard	Agency	Contact Information	Program	Type of Assistance
Flood	Environmental Protection Agency (EPA)	EPA Wetlands Hotline: (800) 832-7828 or EPA Headquarters, Office of Water, Chief, Wetlands Strategies and State Programs, (202) 260-6045	Wetlands protection - development grants	Grants to support the development and enhancement of state and tribal wetlands protection programs.
			Clean Water Act	Grants to states to implement point-source programs, including support for non-structural watershed resource restoration activities.
Flood	Federal Emergency Management Agency (FEMA)	Region X 130 228th St. SW Southwest Bothell, WA 98021, www.fema.gov	Flood Mitigation Assistance Program	Grants to states and communities for pre-disaster mitigation to help reduce or eliminate the long-term risk of flood damage to structures insurable under the National Flood Insurance Program.
			NFIP	Formula grants to states to assist communities to comply with NFIP floodplain management requirements (Community Assistance Program). Makes available flood insurance to residents of communities that adopt and enforce minimum floodplain management requirements. Also provides Flood Insurance Rate Maps and floodplain management maps for all NFIP communities.
			Mapping Advisory Council	Technical guidance and advice to coordinate FEMA's map modernization efforts for the National Flood Insurance Program (NFIP).
			Flood Hazard Mapping/ Cooperative Technical Partners	The CTP initiative fosters partnerships with communities, states, and/or regional agencies to fully integrate them into FEMA's flood hazard mapping process. FEMA will maintain its national standards for NFIP mapping while building on local, state, and regional mapping knowledge and capabilities. This collaboration will make more resources available for flood hazard data collection and mapping efforts nationwide.
Flood	Fish and Wildlife Service (FWS)	National Coordinator, Ecological Services: (703) 358-2201	Partners for Fish and Wildlife	Financial and technical assistance to private landowners interested in pursuing restoration projects affecting wetlands and riparian habitats.
		North American Waterfowl and Wetlands Office (703) 358-1784	North American Wetland Conservation Fund	Cost-share grants to stimulate public/private partnerships for the protection, restoration and management of wetland habitats.

Federal Resources and Programs				
Hazard	Agency	Contact Information	Program	Type of Assistance
Flood	National Oceanic and Atmospheric Administration (NOAA)	5241 NE 122nd Avenue, Portland, OR 97230-1089, (503) 326-2340	Flood Forecasting/ Preparedness	Collection, interpretation, and dissemination of up to date hydrologic data including interpretation of magnitude and frequency of past and expected water flows.
			Northwest River Forecast Center	Provide hydrologic support and forecasts. Eligibility: Other National Weather Offices, and Federal Agencies.
Flood	US Forest Service	Pacific Northwest Region, PO Box 3623, Portland, OR 97208-3625 (503) 326-3360	Flood Program	Intent to correct damage caused by the 1996 lands administrated by the Forest Service.
Flood	USDA-Natural Resource Conservation Service (NRCS)	Water Resources Department 101 SW Main Street, Suite 1300, Portland, OR 97204 (503) 414-3204, www.nrcs.usda.gov	Cooperative River Basin Program	Intent to provide planning assistance for development of coordinated water and related land resource programs. Priority is to solve upstream rural community problems with wetland preservation (This is a cooperative program with other USDA agencies). Eligibility: Federal, state, regional, and local government
			Watershed protection/flood prevention program	Technical and financial assistance for installing works of improvement to protect, develop, and utilize land or water resources in small watersheds under 250,000 acres
			Watershed Surveys and Planning	Surveys and planning studies for appraising water and related resources, and formulating alternative plans for conservation use and development. Grants and advisory/counseling services to assist with planning and implementation improvement.
			Wetlands Reserve Program	Financial and technical assistance to protect and restore wetlands through easements and restoration agreements.
Flood	USGS	USGS, Chief, Office of Surface Water, (703) 648-5303	Stream gauging/ flood monitoring network	Operation of a network of over 7,000 stream gauging stations that provide data on the flood characteristics of rivers.
		USGS - National Mapping Division, (573) 308-3802	Mapping standards support	Expertise in mapping and digital data standards to support the National Flood Insurance Program.

Federal Resources and Programs				
Hazard	Agency	Contact Information	Program	Type of Assistance
Flood and Landslide	US Forest Service	Pacific Northwest Region, PO Box 3623, Portland, OR 97208-3625, (503) 326-6637	Watershed Restoration Program	Programs to study landslides in Federal watersheds and to identify highest propriety projects through watershed analysis.
Flood, Earthquake	FEMA	Region X 130 228th St. SW Southwest Bothell, WA 98021, www.fema.gov	National Dam Safety Program	Technical assistance, training and grants to help improve State dam safety and programs.
Multi-hazard	Department of Commerce (DOC), Economic Development Administration (EDA)	EDA Disaster Recovery Coordinator, (800) 345-1222, www.doc.gov/eda	Disaster Mitigation Planning	Technical and planning assistance grants for capacity building and mitigation project activities focusing on creating disaster resistant jobs and workplaces
			Post-Disaster Economic Recovery Grants	Grant funding to assist with the long-term economic recovery of communities, industries, and firms adversely impacted by disasters.
Multi-hazard	Department of Housing and Urban Development (HUD)	Community Planning and Development, Grant Programs, Office of Affordable Housing, (800) 998-9999	Disaster Recovery Initiative	Grants to fund gaps in available recovery assistance after disasters (including mitigation).
			Public Housing Modernization Reserve	Funding to public housing agencies for modernization needs resulting from natural disasters (including elevation, floodproofing, and retrofit.)
			HOME Investments Partnerships Program	Grants to States, local government and consortia for permanent and transitional housing (including support for property acquisition and rehabilitation) for low-income persons.
			Community Development Block Grant	Grants to entitled cities and urban counties (e.g. housing, a suitable living environment, expanded economic opportunities) in non-entitled areas, for low-income and moderate-income persons. Also contact, Oregon Economic and Community Development Department.

Federal Resources and Programs				
Hazard	Agency	Contact Information	Program	Type of Assistance
Multi-hazard	FEMA	Region X 130 228th St. SW Southwest Bothell, WA 98021, www.fema.gov	Emergency Management/Mitigation Training	Training in disaster mitigation, preparedness, planning.
			Hazard Mitigation Grant Program	Grants to states and communities for implementing long-term hazard mitigation measures following a major disaster declaration.
			Public Assistance Program	Grants to states and communities to repair damaged infrastructure and public facilities and help restore government or government-related services. Mitigation funding is available for work related to damaged components of the eligible building or structure.
Multi-hazard	Fish and Wildlife Service (FWS)	Division of Realty, National Coordinator, (703) 358-1713	Land Acquisition	Acquires or purchases easements on high-quality lands and waters for inclusion into the National Wildlife Refuge System
Multi-hazard	National Oceanic and Atmospheric Administration (NOAA)	5241 NE 122nd Avenue, Portland, OR 97230-1089, (503) 326-2340, www.noaa.gov/ answers@noaa.gov	Environmental Stewardship	NOAA's historical role has been to predict environmental changes, protect life and property, provide decision makers with reliable scientific information, and foster global environmental stewardship.
Multi-hazard	Small Business Administration	PO Box 13795 Sacramento, CA 95853-4795 (916) 566-7258	Disaster Loan Program for Homewoners and Businesses	Provide for three types of disaster loans: Home disaster loans, Business physical disaster loans, Economic Injury Disaster Loans (EIDL) Eligibility: Home or business owners who qualify. Home loan up to \$2000,000, Business loans up to \$1,500,000 and EIDL up to \$1,500,000.
Multi-hazard	The National Weather Service (NWS)	NWS, 5241 NE 122nd Ave., Portland, OR 97230, (503) 326-2340, http://nimbo.wrh.noaa.gov/Portland	Climate Information	NWS provides weather, hydrologic, and climate forecasts and warnings for the US, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and infrastructure, which can be used by other governmental agencies, the private sector, the public, and the global community.

Federal Resources and Programs				
Hazard	Agency	Contact Information	Program	Type of Assistance
Multi-hazard	US Department of Agriculture (USDA) - Farm Service Agency (FSA)	Farm Loan Programs, PO Box 1300 Tualatin, OR, (503) 692-6830	Conservation	Transfers title of certain inventory farm properties owned by FSA to federal and state agencies for conservation purposes (including the restoration of wetlands and floodplain areas to reduce future flood potential.)
			Debt Cancellation Conservation Easements	Intent to reduce the debt of delinquent borrowers in exchange for conservation easements placed on environmentally sensitive real property. Easement secures FSA loans.
			HR-2667 Emergency Farm Loans	Intent to assist counties where physical damage or loss substantially affected farming, ranching, or agriculture. Eligibility: Farmers, ranchers, and agriculture operators
Multi-hazard	US Forest Service	Pacific Northwest Region, PO Box 3623, Portland, OR 97208, (503) 326-6212	Community Assistance	Rural development projects. Eligibility to communities.
Multi-hazard	USDA - Rural Development	101 SW Main St. Suite 1300, Portland, OR 97204, (503) 414-3366	Business and Industry Loan Guarantees	Intent to improve economic and environmental conditions. Eligibility: Rural areas outside a city of 50,000 or more population and its immediate adjacent urbanized areas. Priority given to applications for projects in open country, rural communities, and towns of 25,000 population or less.
		101 SW Main St. Suite 1300, Portland, OR 97204, (503) 414-3366	Community Programs Guaranteed Loans	Provide guarantee loans made by eligible lenders for water and waste disposal facilities and other essential community facilities including Public Safety, Health Care, and Public Service facilities. Eligibility: public and private non-profit organizations. Borrowers in rural areas can receive \$10,000 for water and waste disposal facilities for \$20,000 for other community facilities.
Multi-hazard	USDA - Rural Housing/Utilities services	Community Programs, (202) 720-1502	Rural Development Assistance	Grants, loans, and technical assistance in addressing rehabilitation, health, and safety needs in primarily low-income rural areas.
				Direct and guaranteed rural economic loans and business enterprise grants to address utility issues and development needs.
Multi-hazard	USDA-Natural Resource Conservation Service (NRCS)	National Office (202) 690-0848 or 101 SW Main Street, Suite 1300, Portland, OR 97204 (503) 414-3204, www.nrcs.usda.gov	Emergency Watershed Protection	Provides technical and financial assistance for relief from imminent hazards in small watersheds, and to reduce vulnerability of life and property in small watershed areas damaged by severe natural hazard events.
			Environmental Quality Incentives	Technical, educational, and limited financial assistance to encourage environmental enhancement
			Land Protection	Technical assistance for run-off retardation and soil erosion prevention to reduce hazards to life and property
			Erosion Control	Maintains soil surveys of counties or other areas to assist with farming, conservation, mitigation or related purposes.

Federal Resources and Programs

Hazard	Agency	Contact Information	Program	Type of Assistance
Multi-hazard	United State Geological Survey (USGS)	USGS Oregon District Office, 10615 S.E. Cherry Blossom Dr., Portland, OR 97216, (503) 251-3200, dc_or@usgs.gov, http://www.usgs.gov	National Digital Orthophoto Program	Develops topographic quadrangles for use in mapping of flood and other hazards
			Natural Hazards Mitigation and Research	The USGS conducts research on the conditions, issues, and problems of the natural resources in the nation. This information is useful for natural hazards mitigation and planning and is provided by USGS through its publications, maps, brochures and educational guidebooks. USGS also maintains websites at its various regional centers.
Volcano	United State Geological Survey (USGS)	Volcano Hazards Program Coordinator, (703) 648-6708 or (650) 329-5228 dc_or@usgs.gov, http://www.usgs.gov	Volcano Hazards Program	Volcano hazard warnings and operation of four volcano observatories to monitor and assess volcano hazard risk.
Wildfire	National Fire Protection Association (NFPA)	Public Fire Protection Division, P.O. Box 9101, Quincy, MA 02269-9101, (617) 770-3000	National Wildland/ Urban Interface Fire Protection	This is the principal federal agency involved in the National Wildland/Urban Interface Fire Protection Initiative. NFPA has information on the initiative's programs and documents.
Wildfire	United States Fire Administration (USFA)	16825 S. Seton Ave., Emmitsburg, MD 21727, (301) 447-1000, www.usfa.fema.gov	Wildfire Mitigation	As an entity of the Federal Emergency Management Agency, the mission of the USFA is to reduce life and economic losses due to fire and related emergencies through leadership, advocacy, coordination, and support.

State Resources and Programs				
Hazard	Program	Agency	Contact Information	Type of Assistance
Earthquake and Landslide	Geologic Information and Mapping Capabilities	Oregon Department of Geology and Mineral Industries (DOGAMI)	DOGAMI, 800 NE Oregon St., Suite 965, Portland, OR 97232, (503) 731-4100, http://sarvis.dogami.state.or.us/homepage	DOGAMI's mission is to serve a broad public by providing a cost-effective source of geologic information for Oregonians and to use that information in partnership to reduce the future loss of life and property due to geologic hazards. Some key functions of DOGAMI are development of geologic data for Oregon, producing maps, and acting as lead regulator for mining and drilling for geological resources.
Earthquake and Landslide	Research and Inventories	Portland State University - Department of Geology	Portland State University, Department of Geology, 17 Cramer Hall, 1721 SW Broadway, PO Box 751, Portland, OR 97207, (503) 725-3389	Portland State University conducts research and prepares inventories and reports for communities throughout Oregon. Research and projects conducted through the Department of Geology at Portland State University include earthquake research as well as an inventory of landslides for the Portland metropolitan region after the 1996 and 1997 floods and a subsequent susceptibility report and planning document for Metro Regional Government in Portland.
Flood	Stream Activity	Oregon Department of Fish and Wildlife (ODFW)	3406 Terry Ave NE, Salem, OR 97303, 503-947-6000, www.dfw.state.or.us/ , Odfw.Info@state.or.us	ODFW's mission is to protect and enhance Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations. ODFW regulates stream activity, and engages in stream enhancement activities.
Flood	Water Resources	Oregon Division of State Lands (DSL)	DSL, 775 Summer St. NE, Suite 100, Salem, OR 97301, (503) 378-3805, http://statelands.dsl.state.or.us/	DSL is a regulatory agency, responsible for administration of Oregon's Removal-Fill Law. This law is intended to protect, conserve, and allow the best use of the state's water resources. It generally requires a permit from DSL to remove, fill, or alter more than 50 cubic yards of material within the bed or banks of waters of the state. Exceptions are in State Scenic Waterways and areas designated essential salmon habitat, where a permit is required for all instream activity, regardless of size. These permits may be issued jointly by DSL and the U.S. Army Corps of Engineers.
Flood	Water Resources	Oregon Water Resources Department (WRD)	WRD, 158 12th ST. NE, Salem, OR 97301-4172, (503) 378-8455, http://www.wrd.state.or.us/in dex.shtml or http://www.co.washington.or.us/dptmnts/wtr_mstr/wtr_mstr.htm	The WRD's mission is to serve the public by practicing and promoting wise long-term water management. The WRD provides services through 19 watermaster offices throughout the state. In addition, five regional offices provide services based on geographic regions (left). The Department's main administration is performed from the central office in Salem.

State Resources and Programs

Hazard	Program	Agency	Contact Information	Type of Assistance
Landslide and Wildfire	Landslide/ Debris Flow Warnings and Fire Protection	Oregon Department of Forestry (ODF)	801 Gales Creek Road, Forest Grove, OR 97116, (503) 359-7448, www.odf.state.or.us or 2600 State Street, Salem, OR 97310, (503) 945-7446	The mission of the Oregon Department of Forestry is to serve the people of Oregon through the protection, management, and promotion of a healthy forest environment. ODF regulates forest operations to reduce the risk of serious injury or death from rapidly moving landslides related to forest operations, and assists local governments in the siting review of permanent dwellings on and adjacent to forestlands in further review areas.
Multi-hazard	Earthquake Mitigation	Office of Emergency Management (OEM)	Earthquake and Tsunami Program Coordinator, (503) 378-2911 ext. 22237	OEM coordinates the initial response to an earthquake including on-site inspectors providing damage assessment. OEM also holds a statewide emergency response exercise pertaining to a possible Cascadia subduction zone earthquake.
	Flood Mitigation		Hazard Mitigation Officer, (503) 378-2911 ext. 22247, Recovery and Mitigation Specialist, (503) 378-2911 ext. 22240, 3225 State Street, Salem, OR 97301, www.oem.state.or.us/oem	OEM administers FEMA's Hazard Mitigation Grant Program, which provides monies for acquisition, elevation, relocation, and demolition of structures located in the floodplain. OEM also administers FEMA's Flood Mitigation Assistance Program as well as implements and manages federal disaster recovery programs.
	Senate Bill 12/Landslide Mitigation			In relation to Senate Bill 12 and rapidly moving landslide hazards, OEM coordinates state resources for rapid and effective response to landslide-related emergencies. It also works with other state agencies to develop information for local governments and the public on landslide hazards.
	Emergency Management and Mitigation Programs			The purpose of OEM is to execute the Governor's responsibilities to maintain an emergency services system as prescribed in Oregon Revised Statutes Chapter 401 by planning, preparing, and providing for the prevention, mitigation, and management of emergencies or disasters that present a threat to the lives and property of citizens of and visitors to the state of Oregon.
Multi-hazard	State Land Use Planning Program	Department of Land Conservation and Development (DLCD)	DLCD, 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540, (503) 373-0050, http://www.lcd.state.or.us/hazards.html	DLCD administers the State's Land Use Planning Program. DLCD serves as Oregon's federally designated agency to coordinate floodplain management in Oregon. They also conduct various landslide related mitigation activities.

State Resources and Programs				
Hazard	Program	Agency	Contact Information	Type of Assistance
Multi-hazard	Hazard Related Publications	Nature of the Northwest Information Center (NNIC)	NNIC, 800 NE Oregon St. #5, Suite 177, Portland, OR 97232, (503) 872- 2750, www.naturenw.org, Nature.of.Northwest@state.or.us	The Nature of the Northwest Information Center is operated jointly by DOGAMI and the USDA Forest Service. It offers a selection of maps and publications from state, federal, and private agencies.
Multi-hazard	Climate Information	Oregon Climate Service (OCS)	OCS, Oregon State University, Strand Ag Hall Room 316, Corvallis, OR 97331, (541) 737-5705, www.ocs.orst.edu, email: oregon@oce.orst.edu	The Oregon Climate Service collects, manages, and maintains Oregon weather and climate data. OCS provides weather and climate information to those within and outside the state of Oregon and educates the citizens of Oregon on current and emerging climate issues. OCS also performs independent research related to weather and climate issues.
Multi-hazard	Building Codes	Oregon Department of Consumer and Business Services	1535 Edgewater St. NW, P.O. Box 14470, Salem, OR 97309, (503) 373-4133, www.cbs.state.or.us/external/bcd	The Building Codes Division of Oregon's Department of Consumer and Business Services is responsible for administering statewide building codes. Its responsibilities include adoption of statewide construction standards that help create disaster-resistant buildings, particularly for flood, wildfire, wind, foundation stability, and seismic hazards. Information about wildfire related building codes is found through this department.
Wildfire	Fire Protection and Prevention	Office of the State Fire Marshal (OSFM)	OSFM, 4760 Portland Rd. NE, Salem, OR 97305-1760, (503) 378-3473, http://159.121.82.250 oregon.sfm@state.or.us	The Prevention Unit of Oregon's Office of the State Fire Marshal contains 19 Deputy State Fire Marshals located in various regions. The responsibilities of these Deputies include public education for local fire districts and inspection of businesses, public assemblies, schools, daycare centers, and adult foster homes. The State Fire Marshal's Community Education Services unit works to keep Oregonians safe from fires and injury by providing them with the knowledge to protect themselves and their property.

Additional Resources and Programs				
Hazard	Agency	Contact Information	Program	Type of Assistance
Landslide	American Planning Association (APA)	122 S. Michigan Ave., Suite 1600, Chicago, IL 60603-6107 (312) 431-9100, http://www.planning.org/landslides , landslides@planning.org	Minimizing Landslide Risk	The APA's research department embarked on a program to bring together solutions from multiple disciplines into a single source. It will help serve local planning efforts in identifying landslide hazards sufficiently early in the planning process so as to minimize exposure to landslide risks. The APA's website highlights planning efforts to reduce risk and loss from landslides.
Landslide	State of Washington, Department of Ecology	Department of Ecology, PO Box 47600, Olympia, WA 98504, http://www.ecy.wa.gov/programs/sea/landslides/	Landslide Mitigation	The Washington State Department of Ecology has a landslide website with tips for reducing risk, warning signs, and maps.
Multi-hazard	American Red Cross	American Red Cross, Oregon Trail Chapter, P.O. Box 3200, Portland, OR 97208-3200, 503-284-1234, http://www.redcross-pdx.org , info@redcross-pdx.org	Emergency prevention, preparedness, and response	The Oregon Trail Chapter was chartered as a Red Cross unit in 1917. The chapter serves the residents of Clackamas, Columbia, Multnomah, Washington, Yamhill and Tillamook counties. The American Red Cross is a humanitarian organization, led by volunteers, that provides relief to victims of disasters and helps people prevent, prepare for, and respond to emergencies. The Oregon Chapter provides a variety of community services consistent with the Red Cross mission and meet the specific needs of this area, including disaster planning, preparedness, and education.
Multi-hazard	Institute for Business & Home Safety (IBHS)	IBHS, 1408 North Westshore Boulevard - Suite 208 - Tampa, FL 33607, (813) 286-3400, info@ibhs.org , http://www.ibhs.org/ibhs2	Business Education and Resources	IBHS was created as an initiative of the insurance industry to reduce damage and losses caused by natural disasters. Their website provides educational resources and on-line publications for insurers, businesses, and homeowners who are interested in taking the initiative to minimize future damages and losses.
Multi-hazard	Department of Land Conservation and Development (DLCD)	Natural Hazards Program Manager, DLCD, 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540, (503) 373-0050, http://www.lcd.state.or.us/hazards.html	Planning for Natural Hazards: The Oregon Technical Resource Guide	This is a natural hazards planning and mitigation resource for Oregon cities and counties. It provides hazard-specific resources and plan evaluation tools. The document was written for local staffs and officials. The Technical Resource Guide includes a natural hazards comprehensive plan review, a hazard mitigation legal issues guide, and five hazard-specific technical resource guides, including: flooding, wildfires, landslides, coastal hazards, and earthquakes. This document is available online. You can write, call or fax to obtain this document.

Additional Resources and Programs				
Hazard	Agency	Contact Information	Program	Type of Assistance
Multi-hazard	Association of Contingency Planners, International	http://www.acp-international.com/	Internet Resource	The Association of Contingency Planners is a non-profit trade association dedicated to fostering continued professional growth and development in effective Contingency 7Business Resumption Planning.
Multi-hazard	Health and Human Services Department	http://ndms.dhhs.gov/index.html	Internet Resource	OEP is an office within the U.S. Department of Health and Human Services and has the Departmental responsibility for managing and coordinating federal health, medical, and health related social services and recovery to major emergencies and federally declared disasters.
Multi-hazard	International Association of Emergency Managers	http://www.iaem.com/	Internet Resource	IAEM is a non-profit educational organization dedicated to promoting the goals of saving lives and protecting property during emergencies and disasters.
Multi-hazard	The National Domestic Preparedness Office, FBI	http://www.ndpo.gov/	Internet Resource	NDPO coordinated all federal efforts, including those of the DOD, FBI, FEMA, Department of Health and Human Services, Department of Energy, and the EPA, and assists state and local emergency responders with planning, training, equipment, and exercises needs necessary to respond to a weapon of mass destruction incident.
Multi-hazard	OR Emergency Management Association	http://www.oregonemergency.com/	Internet Resource	The OEMA is a statewide association of individuals who share an interest in the emergency management profession.
Flood	Association of State Floodplain Managers	http://www.floods.org	Internet Resource	The Association of State Floodplain Managers is an organization of professionals involved in floodplain management, flood hazard mitigation, the National Flood Insurance Program, and flood preparedness, warning and recovery.
Multi-hazard	CBS News Disaster Links	http://cbsnews.com/network/hdocs/digitaldan/disaster	Internet Resource	This site provides various links to disaster resources.
Multi-hazard	The National Emergency Management Association	http://www.nemaweb.org/index.cfm	Internet Resource	NEMA is the professional association of state, pacific, and Caribbean insular state emergency management directors.
Multi-hazard	National Voluntary Organizations Active in Disasters	http://www.nvoad.org/	Internet Resource	NVOAD coordinates planning efforts by many voluntary organizations responding to disaster. Member organizations provide more effective and less duplication in service by getting together before disasters strike.

Appendix B:

Public Process

Public participation is a key component to strategic planning processes. Citizen participation offers citizens the chance to voice their ideas, interests, and opinions. Oregon's land use planning system addresses the need for public process in Statewide Land Use Planning Goal 1: Citizen Involvement, which ensures the opportunity for citizens to be involved in the planning process. The Federal Emergency Management Agency also requires public input during the development of flood mitigation plans.

The Washington County Natural Hazards Mitigation Action Plan integrates a cross-section of citizen input throughout the planning process. To accomplish this goal, the Community Planning Workshop and Consolidated Emergency Management developed a public participation process through three components: (1) by developing a project steering committee comprised of knowledgeable individuals representative of the community; (2) by conducting stakeholder interviews to target the specialized knowledge of individuals working with populations or areas at risk from natural hazards; and (3) by conducting two public workshops to identify common concerns and ideas regarding hazard mitigation and to discuss specific goals and actions of the mitigation plan.

Integrating public participation in the Washington County Natural Hazards Mitigation Action Plan resulted in an increase in public awareness about the plan development process and mitigation opportunities, plan action items that reflect a community issues and concerns, and new ideas and perspectives.

Steering Committee

Community Planning Workshop and Washington County Consolidated Emergency Management selected representatives from a range of Washington County agencies and organizations to participate on the executive steering committee. Steering committee members have an understanding of how the community is structured and how residents, businesses, and the environment may be affected by natural hazard events. The steering committee guided the development of the plan, and assisted in developing plan goals and action items, identifying stakeholders, and sharing local expertise to create a more comprehensive plan. Table B.1 lists the various people and organizations that participated on the Washington County Natural Hazards Mitigation Plan Steering Committee.

**Table B.1.
Mitigation Plan Steering Committee**

Steering Committee	Organization
Domonic Biggi	Westside Economic Alliance/Beaverton Foods
Greg Clemmons	Washington County Land Use and Transportation Dept.
Mark Darienzo	Oregon Emergency Management
Jeff Davis	Washington County Land Use and Transportation Dept.
Mary Davis	Washington County Emergency Management
Dave Ford	Portland General Electric
Sue Gries	Tualatin River Watershed Council
Vicki Harguth	Washington County Emergency Management
Steven Muir	Washington County Emergency Management
Jim Perkins	Washington County Land Use and Transportation Dept.
Rick Raetz	Washington County Land Use and Transportation Dept.
Scott Porter	Washington County Emergency Management
Paul Schaefer	Washington County Land Use and Transportation Dept.
Dennis Sigrist	Oregon Emergency Management
Kendra Smith	Clean Water Services
Gerald Uba	Metro
Ross VanLoo	Washington County Land Use and Transportation Dept.

Steering Committee Meeting #1: October 24, 2000

Community Planning Workshop (CPW) provided an overview to the steering committee about the Community Service Center, CPW, and Oregon Natural Hazard Workshop at the University of Oregon. CPW also presented the project methodology and the draft framework for the Washington County Natural Hazard Mitigation Plan. Steering Committee members were asked to discuss their goals for the mitigation plan, and potential outcomes for how they could use the plan in the future.

Goals to reduce risk from natural hazards:

Protect Life and Property

- Minimize loss of life, personal injury, property damage, and economic impacts (to the public and government) during natural hazard events.

Partnerships

- Foster cooperative and connected mitigation planning.
- Develop better knowledge of existing mitigation activities by partners.
- Reduce duplication of efforts and combine use of resources and funding.

- Form regional partnerships to address risks and coordinate activities.
- Engage in strategic planning countywide to reduce risks and promote mitigation.
- Develop a framework for local agencies to use as guidelines.
- Reduce future costs of disaster response and recovery.

Increase Public Awareness

- Increase awareness of community, neighborhood, and homeowners' actions that can impact risk reduction from natural hazards.
- Share this plan with local communities and open up discussion on ways to reduce future risk.
- Reduce claims against the NFIP.

Land Use/Transportation Planning

- Improve land use planning activities to the extent that risks from natural hazards are considered in zoning and other land use activities.
- Reduce flood and landscape vulnerability.
- Align land development planners and building codes staff to address changes in codes and/or zoning to reduce risks.
- Identify hazards in the region and develop maps from current data.
- Ensure that road and bridge related hazards are managed and coordinated with stakeholders (e.g., ODOT, cities, fire, sheriff, etc.).

Business

- Improve business awareness - the actions of business can impact risk reduction from natural hazards.
- Encourage pre-disaster mitigation programs (e.g., Project Impact and Small Business Administration).

Design Standards and Building Inventories

- Identify and catalog public structures susceptible to damage.
- Formalize design standards.
- Standardize designs of structures throughout the region.
- Upgrade existing substandard structures.
- Be inclusive of all hazards in designs (not just flood and earthquake).
- Develop a building inventory (rapid visual assessment – ATC 21).
- Develop non-structural earthquake hazard mitigation site assessments for essential, special occupancy structures.
- Develop local inventory and geologic data (lifeline/transportation hardening) for use in HAZUS.

Potential outcomes of the Mitigation Action Plan:

Risk Reduction

- A road map for risk reduction (not a sit-on-the-shelf plan)
- Working toward the goals established to reduce our future risk

Partnerships

- Build connections between emergency management and land use planning (development, engineering/design, surface water management)
- Information sharing
- Communication with all stakeholders on a continuing basis
- A document that can be referred to by those involved with hazards

Public Education

- Public education piece for use by businesses in developing their operations plans and activities
- Local, historic, story telling information to educate stakeholders/officials/citizens
- A training tool
- Information to teach the impact and extent of natural hazards
- A reference manual to be used during an event and following an event in the recovery effort

Future Mitigation Plans and Projects

- Facilitate/motivate development of other plans in the tri-county area.
- Direction for HMGP money and Project Impact
- Identified activities that can be done now and don't require a lot of funding to accomplish
- Background information for project and budget proposals
- Community Rating System eligibility for the County
- An effective guide for use of pre and post disaster mitigation dollars

Land Use Planning

- A guide for future land use activities, including zoning that prohibits development of high hazard areas, or stipulates the right development for a variety of hazard areas
- A guide for building permit approval processes
- Current information to use with all technical data
- A requirement to catalogue existing infrastructure
- Formal design standards

Steering Committee Meeting #2: December 11, 2000

CPW provided a summary of the first meeting, and a document highlighting steering committee goals for reducing risk and potential outcomes of the mitigation plan for the County. Tasks accomplished at the meeting included:

- A review of the projected timeline and phases of developing the plan;
- A review and discussion of the draft outline of the plan;
- Identification of resources for demographic, economic, and hazard-specific information;
- Discussion of stakeholder groups and identification of potential stakeholders; and

- Discussion of the first public workshop to be held in mid-February.

Steering Committee Meeting #3: February 13, 2001

CPW facilitated the third steering committee in conjunction with a public workshop (see public workshops below) at the Washington County Public Services Building in Hillsboro, Oregon. The public workshop was not held due lack of attendance; however, the CPW team and the steering committee discussed ways of increasing public support and continued discussing the plan in general.

Steering Committee Meeting #4: April 17, 2001

The fourth steering committee meeting was held on April 17, 2001 at the Washington County 911 center in Beaverton, Oregon. This meeting was a chance for the team to update the steering committee plan development and was also a goal-setting session for the steering committee. CPW discussed methods to advertise the second public workshop, including targeting County residents through the “Friends Newsletter,” a publication through the Oregon State University Extension Office with a distribution of 16,000. Other advertising options discussed included flyers to members of Washington County Citizen Participation Organizations (distribution 9,000) and invitations to the steering committee and stakeholders. One person suggested that information be made available on the county website.

CPW student Adam Zimmerman presented the process used by the CPW team to research and develop preliminary goals, including input from the steering committee, stakeholder interviews, a survey from the Clean Water Services, and research from other mitigation plans. The steering committee reviewed the preliminary goal statements and had a chance to discuss and clarify any questions. Participants used scorecards to determine if the statements were good as written or if they required modification. These were tallied and used to facilitate further discussion. Ideas from the discussion were recorded and later incorporated into the mitigation plan.

Steering Committee Meeting #5: May 15, 2001

The fifth steering committee meeting was held on May 15, 2001 at the Public Services Building in Hillsboro, Oregon. CPW gave an overview of the refined goals and discussed the hazard sections that were under review by various steering committee members. CPW facilitated a session to work through the 12 multi-hazard action items. Input and suggestions provided during this meeting were incorporated into the multi-hazard action items presented in the plan.

Steering Committee Meeting #6: June 14, 2001

The sixth steering committee meeting was held on June 14, 2001 at the Washington County 911 center in Beaverton, Oregon. CPW gave an update on the plan’s progress and facilitated a discussion of the “next steps” and implementation of the mitigation plan. CPW led a session to review the 10 refined multi-hazard action items and the additional 46 hazard-specific action items. Input and suggestions provided during this meeting were incorporated into the multi-natural hazard action items in the plan.

Stakeholders Interviews

Stakeholders interviewed for the mitigation plan represented agencies and organizations throughout Washington County. The information provided by the stakeholders was integrated into the mitigation plan in the sections relating to current mitigation activities and action items and in the resource directory. Transcripts from the stakeholder interviews can be found at the Washington County Office of Emergency Management.

Table B.2
Mitigation Plan Stakeholders

Stakeholder	Organization
Domonic Biggi	Beaverton Foods/Westside Economic Alliance
Karl Borg	Joint Water Commission
Kevin Brice	Washington County Building Official
Cindy Catto	Building Contractors – AGC
Greg Clemmons	Washington County Land Use and Transportation Dept.
Mark Darienzo	Oregon Emergency Management
Dale Fishback	Tualatin Valley Water District
Krista Fisher	Insurance Information Office of Oregon and Idaho
Jeff Grunewald	Tualatin Valley Fire and Rescue
Pam Herinckx	Soil and Water Conservation District
Dave Johnson	Oregon Department of Forestry
Cleve Joiner	Tualatin Valley Fire and Rescue
Jeff Jurens	Hillsboro Fire Department
Bert Kile	American Red Cross
Jay Kravitz	Washington County Health Department
Ron Kroop	Oregon Department of Transportation
Sue Marshal	Tualatin Riverkeepers
Dean Moberg	Natural Resources Conservation Service
Kendra Smith	Clean Water Services
Joan Smith	Washington County Historical Society
Allan Stewart	Northwest Natural
Gerald Uba	Metro
Ross VanLoo	Washington County Land Use and Transportation Dept.
Greg Weller	Ellis Esslick (Architecture Firm)

Public Meetings

CPW coordinated two public workshops in Washington County to gather public ideas and opinions about the mitigation plan goals and activities.

First Public Workshop

The first public workshop was held on February 13, 2001 at the Washington County Public Services Building in Hillsboro, Oregon. The workshop did not occur due to lack of participants. The steering committee and CPW took the opportunity to discuss the mitigation plan goals and methods to increase participation at the second workshop.

Purpose

The first public workshop was designed to facilitate a process to allow citizens to comment on the plan goals and priorities concerning natural hazards mitigation for Washington County.

Invitation Process

Washington County placed public notification advertisements in the Oregonian and in local newspapers in Beaverton, Hillsboro, and Forest Grove.

Second Public Workshop

The second public workshop was held on May 15, 2001 at the Washington County Public Services Building in Hillsboro, Oregon. Thirteen people attended this workshop. CPW team led participants in a process to choose the goals they felt to be most important.

Purpose

The purpose of the public workshop was to identify public priorities concerning goals for natural hazards mitigation in Washington County and brainstorm potential activities related to risk reduction and loss prevention.

Invitation Process

Community Planning Workshop placed an advertisement in the Oregon State University Extension Service, "Friends Newsletter," with a distribution of 16,000. CPW also sent flyers to members of Washington County Citizen Participation Organizations (distribution 9,000) and invitations to the steering committee and stakeholders. Washington County placed public notification advertisements on the Washington County website, in the Oregonian, and in Beaverton, Hillsboro, and Forest Grove newspapers.

Appendix C:

Economic Analysis of Natural Hazard Mitigation Projects

Benefit/cost analysis is a key mechanism used by the state Office of Emergency Management (OEM), the Federal Emergency Management Agency, and other state and federal agencies in evaluating hazard mitigation projects, and is required by the Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 93-288, as amended.

This appendix outlines several approaches for conducting economic analysis of natural hazard mitigation projects. It describes the importance of implementing mitigation activities, different approaches to economic analysis of mitigation strategies, and methods to calculate costs and benefits associated with mitigation strategies. Information in this section is derived in part from: The Interagency Hazards Mitigation Team, *State Hazard Mitigation Plan*, (Oregon State Police – Office of Emergency Management, 2000), and Federal Emergency Management Agency Publication 331, *Report on Costs and Benefits of Natural Hazard Mitigation*.

This section is not intended to provide a comprehensive description of benefit/cost analysis, nor is it intended to provide the details of economic analysis methods that can be used to evaluate local projects. It is intended to (1) raise benefit/cost analysis as an important issue, and (2) provide some background on how economic analysis can be used to evaluate mitigation projects.

Why Evaluate Mitigation Strategies?

Mitigation activities reduce the cost of disasters by minimizing property damage, injuries, and the potential for loss of life, and by reducing emergency response costs, which would otherwise be incurred. Evaluating natural hazard mitigation provides decision-makers with an understanding of the potential benefits and costs of an activity, as well as a basis upon which to compare alternative projects.

Evaluating mitigation projects is a complex and difficult undertaking, which is influenced by many variables. First, natural disasters affect all segments of the communities they strike, including individuals, businesses, and public services such as fire, police, utilities, and schools. Second, while some of the direct and indirect costs of disaster damages are measurable, some of the costs are non-financial and difficult to quantify in dollars. Third, many of the impacts of such events produce “ripple-effects” throughout the community, greatly increasing the disaster’s social and economic consequences.

While not easily accomplished, there is value, from a public policy perspective, in assessing the positive and negative impacts from mitigation activities, and obtaining an instructive benefit/cost comparison. Otherwise, the decision to pursue or not pursue various mitigation options would not be based on an objective understanding of the net benefit or loss associated with these actions.

What are Some Economic Analysis Approaches for Mitigation Strategies?

The approaches used to identify the costs and benefits associated with natural hazard mitigation strategies, measures, or projects fall into two general categories: benefit/cost analysis and cost-effectiveness analysis. The distinction between the two methods is the way in which the relative costs and benefits are measured. Additionally, there are varying approaches to assessing the value of mitigation for public sector and private sector activities.

Benefit/cost Analysis

Benefit/cost analysis is used in natural hazards mitigation to show if the benefits to life and property protected through mitigation efforts exceed the cost of the mitigation activity. Conducting benefit/cost analysis for a mitigation activity can assist communities in determining whether a project is worth undertaking now, in order to avoid disaster-related damages later. Benefit/cost analysis is based on calculating the frequency and severity of a hazard, avoided future damages, and risk.

In benefit/cost analysis, all costs and benefits are evaluated in terms of dollars, and a net benefit/cost ratio is computed to determine whether a project should be implemented (i.e., if net benefits exceed net costs, the project is worth pursuing). A project must have a benefit/cost ratio greater than 1 in order to be funded.

Cost-Effectiveness Analysis

Cost-effectiveness analysis evaluates how best to spend a given amount of money to achieve a specific goal. This type of analysis, however, does not necessarily measure costs and benefits in terms of dollars. Determining the economic feasibility of mitigating natural hazards can also be organized according to the perspective of those with an economic interest in the outcome. Hence, economic analysis approaches are covered for both public and private sectors as follows.

Investing in public sector mitigation activities

Evaluating mitigation strategies in the public sector is complicated because it involves estimating all of the economic benefits and costs regardless of who realizes them, and potentially to a large number of people and economic entities. Some benefits cannot be evaluated monetarily, but still affect the public in profound ways. Economists have developed methods to evaluate the economic feasibility of public decisions that involve a diverse set of beneficiaries and non-market benefits.

Investing in private sector mitigation activities

Private sector mitigation projects may occur on the basis of one of two approaches: it may be mandated by a regulation or standard, or it may be economically justified on its own merits. A building or landowner, whether a private entity or a public agency, required to conform to a mandated standard may consider the following options:

1. Request cost sharing from public agencies;
2. Dispose of the building or land either by sale or demolition;

3. Change the designated use of the building or land and change the hazard mitigation compliance requirement; or
4. Evaluate the most feasible alternatives and initiate the most cost effective hazard mitigation alternative.

The sale of a building or land triggers another set of concerns. For example, real estate disclosure laws can be developed which require sellers of real property to disclose known defects and deficiencies in the property, including earthquake weaknesses and hazards to prospective purchasers. Correcting deficiencies can be expensive and time consuming, but their existence can prevent the sale of the building. Conditions of a sale regarding the deficiencies and the price of the building can be negotiated between a buyer and seller.

How can an Economic Analysis be Conducted?

Benefit/cost analysis and cost-effectiveness analysis are important tools in evaluating whether or not to implement a mitigation activity. A framework for evaluating alternative mitigation activities is outlined below:

1. Identify the Alternatives

Alternatives for reducing risk from natural hazards can include structural projects to enhance disaster resistance, education and outreach, and acquisition or demolition of exposed properties, among others. Different mitigation project can assist in minimizing risk to natural hazards, but do so at varying economic costs.

Estimating the costs and benefits of a hazard mitigation strategy can be a complex process.

Employing the services of a specialist can assist in this process.

2. Calculate the Costs and Benefits

Choosing economic criteria is essential to systematically calculating costs and benefits of mitigation projects and selecting the most appropriate alternative. Potential economic criteria to evaluate alternatives include:

- **Determine the project cost.** This may include initial project development costs, and repair and operating costs of maintaining projects over time.
- **Estimate the benefits.** Projecting the benefits, or cash flow resulting from a project can be difficult. Expected future returns from the mitigation effort depend on the correct specification of the risk and the effectiveness of the project, which may not be well known. Expected future costs depend on the physical durability and potential economic obsolescence of the investment. This is difficult to project. These considerations will also provide guidance in selecting an appropriate salvage value. Future tax structures and rates must be projected. Financing alternatives must be researched, and they may include retained earnings, bond and stock issues, and commercial loans.
- **Consider costs and benefits to society and the environment.** These are not easily measured, but can be assessed through a variety of economic tools including existence value or contingent value theories. These theories provide quantitative data on the value people attribute to physical or social environments. Even without hard data, however, impacts of structural projects

to the physical environment or to society should be considered when implementing mitigation projects.

- **Determine the correct discount rate.** Determination of the discount rate can just be the risk-free cost of capital, but it may include the decision maker's time preference and also a risk premium. Including inflation should also be considered.

3. Analyze and Rank the Alternatives

Once costs and benefits have been quantified, economic analysis tools can rank the alternatives. Two methods for determining the best alternative given varying costs and benefits include net present value and internal rate of return.

- **Net present value.** Net present value is the value of the expected future returns of an investment minus the value of expected future cost expressed in today's dollars. If the net present value is greater than the project costs, the project may be determined feasible for implementation. Selecting the discount rate, and identifying the present and future costs and benefits of the project calculates the net present value of projects.
- **Internal Rate of Return.** Using the *internal rate of return* method to evaluate mitigation projects provides the interest rate equivalent to the dollar returns expected from the project. Once the rate has been calculated, it can be compared to rates earned by investing in alternative projects. Projects may be feasible to implement when the internal rate of return is greater than the total costs of the project.

Once the mitigation projects are ranked on the basis of economic criteria, decision-makers can consider other factors, such as risk, project effectiveness, and economic, environmental, and social returns in choosing the appropriate project for implementation.

How are Benefits of Mitigation Calculated?

Economic Returns of Natural Hazard Mitigation

The estimation of economic returns, which accrue to building or landowner as a result of natural hazard mitigation, is difficult. Owners evaluating the economic feasibility of mitigation should consider reductions in physical damages and financial losses. A partial list follows:

- Building damages avoided
- Content damages avoided
- Inventory damages avoided
- Rental income losses avoided
- Relocation and disruption expenses avoided
- Proprietor's income losses avoided

These parameters can be estimated using observed prices, costs, and engineering data. The difficult part is to correctly determine the effectiveness of the hazard mitigation project and the resulting reduction in damages and losses. Equally as difficult is assessing the probability that an event will occur. The damages and

losses should only include those that will be borne by the owner. The salvage value of the investment can be important in determining economic feasibility. Salvage value becomes more important as the time horizon of the owner declines. This is important because most businesses depreciate assets over a period of time.

Additional Costs from Natural Hazards

Property owners should also assess changes in a broader set of factors that can change as a result of a large natural disaster. These are usually termed “indirect” effects, but they can have a very direct effect on the economic value of the owner’s building or land. They can be positive or negative, and include changes in the following:

- Commodity and resource prices
- Availability of resource supplies
- Commodity and resource demand changes
- Building and land values
- Capital availability and interest rates
- Availability of labor
- Economic structure
- Infrastructure
- Regional exports and imports
- Local, state, and national regulations and policies
- Insurance availability and rates

Changes in the resources and industries listed above are more difficult to estimate and require models that are structured to estimate total economic impacts. Total economic impacts are the sum of direct and indirect economic impacts. Total economic impact models are usually not combined with economic feasibility models. Many models exist to estimate total economic impacts of changes in an economy. Decision makers should understand the total economic impacts of natural disasters in order to calculate the benefits of a mitigation activity. This suggests that understanding the local economy is an important first step in being able to understand the potential impacts of a disaster, and the benefits of mitigation activities.

Additional Considerations

Conducting an economic analysis for potential mitigation activities can assist decision-makers in choosing the most appropriate strategy for their community to reduce risk and prevent loss from natural hazards. Economic analysis can also save time and resources from being spent on inappropriate or unfeasible projects. Several resources and models are listed on the following page that can assist in conducting an economic analysis for natural hazard mitigation activities.

Benefit/cost analysis is complicated, and the numbers may divert attention from other important issues. It is important to consider the qualitative factors of a project associated with mitigation that cannot be evaluated economically. There are

alternative approaches to implementing mitigation projects. Many communities are looking towards developing multi-objective projects. With this in mind, opportunity rises to develop strategies that integrate natural hazard mitigation with projects related to watersheds, environmental planning, community economic development, and small business development, among others. Incorporating natural hazard mitigation with other community projects can increase the viability of project implementation.

Resources

CUREe Kajima Project, *Methodologies For Evaluating The Socio-Economic Consequences Of Large Earthquakes*, Task 7.2 Economic Impact Analysis, Prepared by University of California, Berkeley Team, Robert A. Olson, VSP Associates, Team Leader; John M. Eidinger, G&E Engineering Systems; Kenneth A. Goettel, Goettel and Associates Inc.; and Gerald L. Horner, Hazard Mitigation Economics Inc., 1997.

Federal Emergency Management Agency, *Benefit/Cost Analysis of Hazard Mitigation Projects*, Riverine Flood, Version 1.05, Hazard Mitigation Economics Inc., 1996.

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Goettel & Horner Inc., *Earthquake Risk Analysis Volume III: The Economic Feasibility of Seismic Rehabilitation of Buildings in The City of Portland*, Submitted to the Bureau of Buildings, City of Portland, August 30, 1995.

Goettel & Horner Inc., *Benefit/Cost Analysis of Hazard Mitigation Projects Volume V, Earthquakes*, Prepared for FEMA's Hazard Mitigation Branch, October 25, 1995.

Horner, Gerald, *Benefit/Cost Methodologies for Use in Evaluating the Cost Effectiveness of Proposed Hazard Mitigation Measures*, Robert Olson Associates, Prepared for Oregon State Police, Office of Emergency Management, July 1999.

Interagency Hazards Mitigation Team, *State Hazard Mitigation Plan*, (Oregon State Police – Office of Emergency Management, 2000).

Risk Management Solutions, Inc., *Development of a Standardized Earthquake Loss Estimation Methodology*, National Institute of Building Sciences, Volume I and II, 1994.

VSP Associates, Inc., *A Benefit/Cost Model for the Seismic Rehabilitation of Buildings*, Volumes 1 & 2, Federal Emergency Management Agency, FEMA Publication Numbers 227 and 228, 1991.

VSP Associates, Inc., *Benefit/Cost Analysis of Hazard Mitigation Projects: Section 404 Hazard Mitigation Program and Section 406 Public Assistance Program*, Volume 3: *Seismic Hazard Mitigation Projects*, 1993.

VSP Associates, Inc., *Seismic Rehabilitation of Federal Buildings: A Benefit/Cost Model*, Volume 1, Federal Emergency Management Agency, FEMA Publication Number 255, 1994.

Appendix D: List of Acronyms

County and Regional

CPO	Citizen Participation Organization
CREW	Cascadia Region Earthquake Workgroup
CWS	Clean Water Services (formerly Unified Sewerage Agency)
IISOI	Insurance and Information Services of Oregon & Idaho
JWC	Joint Water Commission
Metro	Metropolitan Regional Government
OCEM	Office of Consolidated Emergency Management
PGE	Portland General Electric
NN	Northwest Natural Gas
PPO	Private Property Owner
TPAC	Tualatin Public Awareness Committee
TRWC	Tualatin River Watershed Council
TVFR	Tualatin Valley Fire and Rescue
TVID	Tualatin Valley Irrigation District
TVWD	Tualatin Valley Water District
WCCEM	Washington County Consolidated Office of EM
WCFDB	Washington County Fire Defense Board
WCLUT	Washington County Dept. of Land Use and Transportation
WEA	Westside Economic Alliance

Oregon

AGC	Associated General Contractors
AOC	Association of Oregon Counties
BCD	Building Codes Division
BPA	Bonneville Power Administration
CPW	Community Planning Workshop
DAS	Department of Administrative Services
DCBS	Department of Consumer and Business Services
DEQ	Department of Environmental Quality
DLCD	Department of Land Conservation and Development
DOGAMI	Department of Geology and Mineral Industries
DSL	Division of State Lands
ESD	Education Service District
GIHMT	Governor's Interagency Hazard Mitigation Team
GNRO	Governor's Natural Resources Offices
LCDC	Land Conservation and Development Commission

LOC	League of Oregon Cities
OCS	Oregon Climate Service
ODA	Oregon Department of Agriculture
ODF	Oregon Department of Forestry
ODWF	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
OEM	Office of Emergency Management
OEMA	Oregon Emergency Management Association
OERS	Oregon Emergency Response System
OHIRA	Oregon Hazard Identification and Risk Assessment
ONHW	Oregon Natural Hazards Workshop
ORS	Oregon Revised Statutes
OSFM	Office of State Fire Marshal
OSP	Oregon State Police
OSSPAC	Oregon Seismic Safety Policy Advisory Commission
OSU	Oregon State University
OUS	Oregon University System
OWEB	Oregon Watershed Enhancement Board
PSU	Portland State University
PUC	Public Utility Commission
WRD	Water Resources Department

Federal

AASHTO	American Assc. of State Highway and Trans. Officials
ATC	Applied Technology Council
b/ca	benefit/cost analysis
BOR	Bureau of Reclamation
BFE	Base Flood Elevation
BLM	Bureau of Land Management
BSSC	Building Seismic Safety Council
CDBG	Community Development Block Grant
CFR	Code of Federal Regulations
CRS	Community Rating System
CVO	Cascades Volcano Observatory
EDA	Economic Development Administration
EPA	Environmental Protection Agency
ER	Emergency Relief
EWP	Emergency Watershed Protection
FAS	Federal Aid System

FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FMA	Flood Mitigation Assistance
FTE	Full Time Equivalent
GIS	Geographic Information System
GNS	Institute of Geological and Nuclear Sciences
GSA	General Services Administration
HAZUS	Hazards U.S.
HMGP	Hazard Mitigation Grant Program
HMST	Hazard Mitigation Survey Team
HUD	Housing and Urban Development
IBHS	Institute for Business and Home Safety
ICC	Increased Cost of Compliance
IHMT	Interagency Hazard Mitigation Team
NCDC	National Climate Data Center
NFIP	National Flood Insurance Program
NFPA	National Fire Protection Association
NHMP	National Hazard Mitigation Plan
NIBS	National Institute of Building Sciences
NIFC	National Interagency Fire Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
SBA	Small Business Administration
SEAO	Structural Engineers Association of Oregon
SHMO	State Hazard Mitigation Officer
SWCD	Soil and Water Conservation District
TDR	Transfer of Development Rights
UGB	Urban Growth Boundary
URM	Unreinforced Masonry
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USFA	United States Fire Administration
USFS	United States Forest Service
USGS	United States Geological Survey
WSSPC	Western States Seismic Policy Council

Appendix E:

Plan Maintenance & Action Item Prioritization Methodology

Background

This appendix of the plan details the formal process established to ensure that the Washington County Natural Hazards Mitigation Action Plan remains an active and relevant document. It includes a schedule for monitoring and evaluating the plan annually and producing a plan revision every five years. It also describes how the County will integrate public participation throughout the plan maintenance process. Finally, this appendix explains how the County will incorporate the mitigation strategies outlined in the Plan into existing planning mechanisms such as the County comprehensive land use plan, capital improvement plans, and building codes.

Implementing the Plan

The success of the Washington County Natural Hazard Mitigation Action Plan depends on how well the identified action items are implemented. In an effort to ensure that the activities identified are implemented, the following steps will be taken. The plan will be formally adopted, a coordinating body will be assigned, a convener will be designated, the identified activities will be prioritized and evaluated, and finally, the plan will be implemented through existing plans, programs, and policies.

Plan Adoption

The Washington County Board of Commissioners will be responsible for adopting the Washington County Natural Hazards Mitigation Action Plan and providing the support necessary to ensure plan implementation. Once the plan has been adopted by Resolution and Order, the County Emergency Manager will be responsible for submitting it to the State Hazard Mitigation Officer at Oregon Emergency Management. Oregon Emergency Management will submit the plan to the Federal Emergency Management Agency (FEMA) for review. This review will address the federal criteria outlined in FEMA's Flood Mitigation Assistance program and in the October 1, 2002 Mitigation Planning Final Interim Rule amending 44 CFR Part 201.6. Upon acceptance of the plan by FEMA, Washington County will gain eligibility for Flood Mitigation Assistance, Hazard Mitigation Grant Program and Pre-Disaster Mitigation funds.

Coordinating Body

The Washington County Hazard Mitigation Steering Committee will be responsible for coordinating implementation of plan action items and undertaking the formal review process. The County Administrator's Office will ensure that representatives are assigned from appropriate County departments including, but not limited to the departments and divisions represented on the original Hazard Mitigation Steering Committee. The County formed the Hazard Mitigation Steering Committee to assist with development of the plan. At the time of

plan development, the Committee consisted of members from local, regional, and state agencies, organizations, and citizens, including:

- Washington County Emergency Management
- Westside Economic Alliance
- Portland General Electric
- Washington County Land Use and Transportation
- Clean Water Services
- Tualatin River Watershed Council
- Metro Regional Government
- Oregon Office of Emergency Management

In order to make this committee as broad and useful as possible, the committee will engage other relevant organizations and agencies in hazard mitigation. As a minimum, participation from the following agencies and or organizations will be pursued:

- The insurance industry
- A professional organization such as the Home Builders Association
- The Washington County Citizen Participation Organization (CPO)

The Hazard Mitigation Steering Committee will have no less than quarterly meetings, which will be scheduled once the final Hazard Mitigation Steering Committee has been established. These meetings will provide an opportunity to discuss the status of action items and maintain the partnerships essential for sustainability of the Plan.

Convener

Although the County Administrator will maintain ownership of the Washington County Natural Hazard Mitigation Action Plan, the County's Emergency Manager and the Director of Land Use and Transportation will share the role of convener. They will assign tasks such as updating and presenting the plan to committee members. The Emergency Manager will take responsibility for facilitating Hazard Mitigation Steering Committee meetings and informing members of the status of the Plan. Plan implementation and evaluation will be a shared responsibility among all of the assigned Hazard Mitigation Steering Committee members.

Implementation through Existing Programs

Washington County addresses statewide planning goals and legislative requirements through its comprehensive land use plan, capital improvement plans, and building codes. The Natural Hazard Mitigation Action Plan is non-regulatory in nature and provides a series of recommendations – many of which are closely related to the goals and objectives of existing planning programs. To the extent possible, the County will incorporate the recommended mitigation action items into existing programs and procedures. These goals and action items will help the County address statewide land use planning Goal 7, which was developed to protect life and property from natural disasters and hazards through planning strategies that restrict development in areas of known hazards. Goal 7 requires that local governments base development plans on inventories of known areas of natural disasters and hazards and limit the intensity of development by the degree to which the natural hazard occurs within the areas of proposed development. The County can use review of this plan as an avenue to update the Goal

7: Natural Hazards element of its comprehensive plan and to integrate mitigation into zoning and planning documents.

The County Building Services Division is responsible for administering building codes in the County. After adoption of the Mitigation Plan, they will work with the State Building Codes Division to ensure that the County adopts, and is enforcing, the minimum standards established in the State Building Code. In addition, the Hazard Mitigation Steering Committee will work with County building officials to advocate for more stringent building codes regarding natural hazard mitigation at the state level. This is intended to ensure that life safety criteria are met for new construction.

Capital improvement planning that occurs in the future will also contribute to the goals in the Mitigation Plan. Many county departments develop Capital Improvement Plans (CIPs) and review them on an annual basis. At the time of annual review, the Hazard Mitigation Steering Committee will work with the departments to integrate the Washington County Natural Hazard Mitigation Action Plan into appropriate sections of the CIPs.

Within one year of formal adoption of the Mitigation Plan, the County will initiate efforts to identify appropriate changes to its existing planning mechanisms. Changes will be incorporated within five years of Mitigation Plan adoption. Hazard Mitigation Steering Committee meetings will provide an opportunity for committee members to report back on the progress of integrating mitigation planning elements and action items into County planning documents and procedures.

Economic Analysis of Mitigation Projects

FEMA's methods of identifying the costs and benefits associated with natural hazard mitigation strategies, measures, or projects fall into two general categories: benefit/cost analysis and cost-effectiveness analysis. Conducting a benefit/cost analysis for a mitigation activity can assist communities in determining whether a project is worth undertaking now, in order to avoid disaster-related damages later. A cost-effectiveness analysis evaluates how best to spend a given amount of money to achieve a specific goal. Determining the economic feasibility of mitigating natural hazards provides decision-makers with an understanding of the potential benefits and costs of an activity, as well as a basis upon which to compare alternative projects.

The Hazard Mitigation Steering Committee will use FEMA-approved cost benefit methodologies as a tool for identifying and prioritizing mitigation action items when applying for federal mitigation funding. For other projects and funding sources, the Hazard Mitigation Steering Committee will use other approaches to understand the costs and benefits of each action item and develop a prioritized list. For more information regarding economic analysis of mitigation action items, please see Appendix C of the plan.

Evaluating and Updating the Plan

Formal Review Process

Washington County has developed a method to ensure that a regular review and update of the Hazard Mitigation Plan occurs. All committee members will be responsible for monitoring and evaluating the progress of the plan's mitigation strategies. As stated before, the Committee will meet quarterly to evaluate the progress of the mitigation strategies. In addition, the Emergency Manager will be responsible for organizing a plan review meeting at least annually. The

purpose of the annual review meeting will be to determine the effectiveness of programs and to reflect changes in land development or programs that may affect mitigation priorities. Every five years the plan will be submitted to FEMA for a formal review.

At the annual review meeting, the Committee will review each goal and objective to determine their relevance to changing situations in the County, as well as changes in state or federal policies, and to ensure they are addressing current and expected conditions. The Committee will also review the risk assessment portion of the Plan to determine if the information should be updated or modified. The designated parties responsible for the various implementation actions will report on the status of their projects and note which implementation processes worked well, any difficulties encountered, how coordination efforts were proceeding, and which strategies should be revised.

The Emergency Management Office will be responsible for making any changes and updates to the plan before submitting the final document to the Hazard Mitigation Steering Committee members, and presenting it to the County Commissioners for approval. All approved plan amendments will then be submitted to the State Hazard Mitigation Officer for review. If the Committee determines that no changes to the Plan are necessary, they will give a justification for this determination to the State Hazard Mitigation Officer. Every five years, the updated plan will be submitted to the State Hazard Mitigation Officer and the Federal Emergency Management Agency for review.

Continued Public Involvement

Washington County is committed to involving the public directly in the maintenance and update of the Hazard Mitigation Plan. Although the Hazard Mitigation Steering Committee members are responsible for annual review and update of the Plan and represent the public to some extent, the public will still have an opportunity to provide direct feedback about the Plan. The plan includes the address and the phone number of Washington County Emergency Management, which is responsible for tracking public comments about the plan. The County Administrator's Office will support public involvement through existing community organizations, the County Website, and "Updates," a Washington County Land Use and Transportation newsletter.

Copies of the plan and annual revisions will be sent to the Citizen Participation Organizations (CPOs). Notifications of public meetings to discuss the plan will be made to the CPOs. In addition, revisions to the plan will be publicized in "Updates." Copies of the Plan and any proposed changes will also be posted on the County Website. This site will contain an email address and phone number to which people can direct their comments and concerns.

A public meeting will be held after each annual evaluation or when deemed necessary by the Hazard Mitigation Steering Committee. The meetings will provide a forum in which the public can express their concerns, opinions, and ideas about the plan. As much as possible, the public meetings will be incorporated into existing public venues and forums. The County Emergency Manager will be responsible for using County and other resources to publicize the annual public meetings and maintain public involvement.

Methodology for Prioritizing Plan Action Items

To prioritize the plan’s action items, the County utilized a multi-tiered approach. A prioritized list of action items was developed by assessing the importance of each item relative to the plan’s goals and the hazard(s) each item addressed. The prioritized list of action items serves simply as a starting point for the implementation of mitigation activities.

The method by which the Hazard Mitigation Steering Committee prioritized the plan action items is summarized below. This methodology will also be used when prioritizing action items in the future.

Step One: Ranking and Scoring Plan Goals

The first step in the prioritization process was to rank and score plan goals. The Hazard Mitigation Steering committee completed this during plan development by examining and voting on the importance of each of the plan’s four goals. The methodology used by the steering committee was to conduct a “dot prioritization” activity to determine the relative priority of each goal. Steering committee members used a voting sheet with four different colored adhesive “dots.” Each “dot” had a number assigned to it ranging from one to three points (three being the highest value). They placed a single “dot” on each of the plan goals, thereby ranking the importance of each goal in making Washington County more disaster resilient. The goals were selected regardless of how easy each would be to accomplish. The results of the voting were:

Highest Priority:	Life, Property, and Natural Systems
2 nd Highest Priority:	Public Awareness and Partnerships
3 rd Highest Priority:	Emergency Services
4 th Highest Priority:	Implementation

Each action item was then examined according to the plan goals addressed and the priority those goals were assigned. In this step, action items were assigned the following number of points for addressing each goal:

4 Points:	Life, Property, and Natural Systems
3 Points:	Public Awareness and Partnerships
2 Points:	Emergency Services
1 Point:	Implementation

Action items that addressed multiple goals were assigned points for each of the goals they addressed.

Step Two: Ranking and Scoring Community Hazards

The second step in prioritizing the plan’s action items was to examine the hazards they were associated with and where these hazards ranked in terms of community risk.

To rank the hazards, the County’s Hazard Analysis was utilized. The hazard analysis identified various hazards, both man-made and natural, that may threaten Washington County. The hazard analysis examined each of these hazards based on history, vulnerability, maximum threat, and probability.

A formula was used to produce an overall score for each hazard’s risk. Consistent with the analysis, the hazards identified in this plan were ranked in the following order or priority:

severe winter storm, wind storm, flood, earthquake, volcanic eruption, wildfire, and landslide. Depending on the hazards each action item addresses, the following points were assigned:

- 10 Points: Multi-Hazard
- 7 Points: Severe Winter Storm
- 6 Points: Wind Storm
- 5 Points: Flood
- 4 Points: Earthquake
- 3 Points: Volcanic Eruption
- 2 Points: Wildfire
- 1 Point: Landslide

Multi-Hazard action items received the most points since they addressed multiple hazards.

Step Three: Prioritizing Action Items

The final step in the prioritization process was to calculate an Action Item Priority Score for and assign a priority to each action item. The score was calculated by adding the goal and hazard points from Steps One and Two for each item. Priorities were assigned based on the score; the higher the score, the higher the priority. As the need arose, the Committee set priorities for items with equal scores.

The Hazard Mitigation Steering Committee computed the Action Item Priority Scores for all items identified during initial plan development. The one action item which did not follow this prioritization process was Multi-Hazard Short Term Action Item #2: establish a Washington County Natural Hazards Mitigation Committee to facilitate implementation, monitoring, and evaluation of countywide mitigation activities. This action item was instead placed as the first priority because it was seen as crucial to ensuring plan implementation.

A list of the plan's action items and their associated Action Item Priority Scores and priorities are included in the Action Item Matrix, which is part of the Plan's Executive Summary. During annual review of the plan, new and completed action items will be identified and appropriate changes made to the Action Item Matrix. New action items will be scored using Steps One and Two above and the entire list reprioritized in accordance with Step Three.

Assessing Implementation Capabilities

The Hazard Mitigation Steering Committee and the leadership of Washington County have the option to implement any of the action items at any time. The option to consider any action item for implementation at any given time allows the Committee to alter mitigation strategies as new situations arise, such as funding opportunities that could support pursuit of lower priority action items.

Along with the prioritized Action Item Matrix, a Capability Assessment Matrix is also included and is found in Appendix F. The Capability Assessment is a very simple tool designed to assess the operational, financial, and administrative capabilities of those organizations associated with the plan's action items to determine which items in the prioritized list can be implemented using existing resources and which items will require additional support. The concept of the Capability Assessment is to further refine how and when the plan's actions items are implemented based on the implementing organization's capability.

The Washington County Natural Hazards Mitigation Committee, headed by the County Office of Emergency Management, will coordinate implementation of the plan's action items, with overall guidance from the County.

In examining the feasibility of the plan's prioritized action items, benefit-cost analysis will be encouraged for all structural mitigation projects. See Appendix C for more information on this process.

WASHINGTON COUNTY MITIGATION CAPABILITY ASSESSMENT

Agency Name	Related Internal Partners	Action Item Associated With	Local Point of Contact	Level of Immediate Capability			Comments from Agency Regarding Capability	Status
				High (Can Immediately Implement)	Medium	Low (Need for Great Deal of Funding, Staff, Time)		

Appendix F: Capability Assessment Matrix

Background

The Capability Assessment Matrix is a very simple tool designed to assess the operational, financial, and administrative capabilities of those organizations associated with the plan's action items to determine which items in the prioritized list can be implemented using existing resources and which items will require additional support.

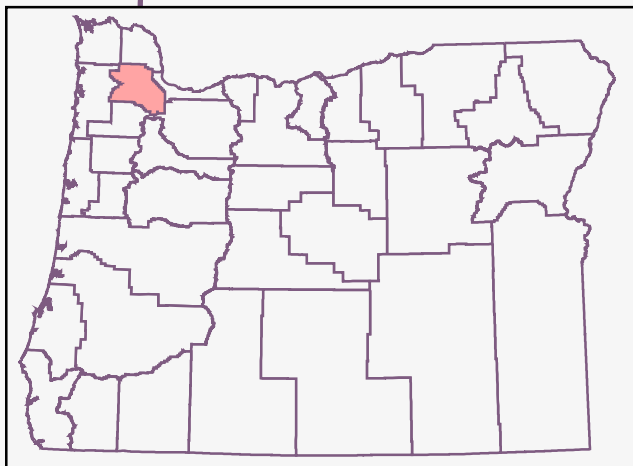
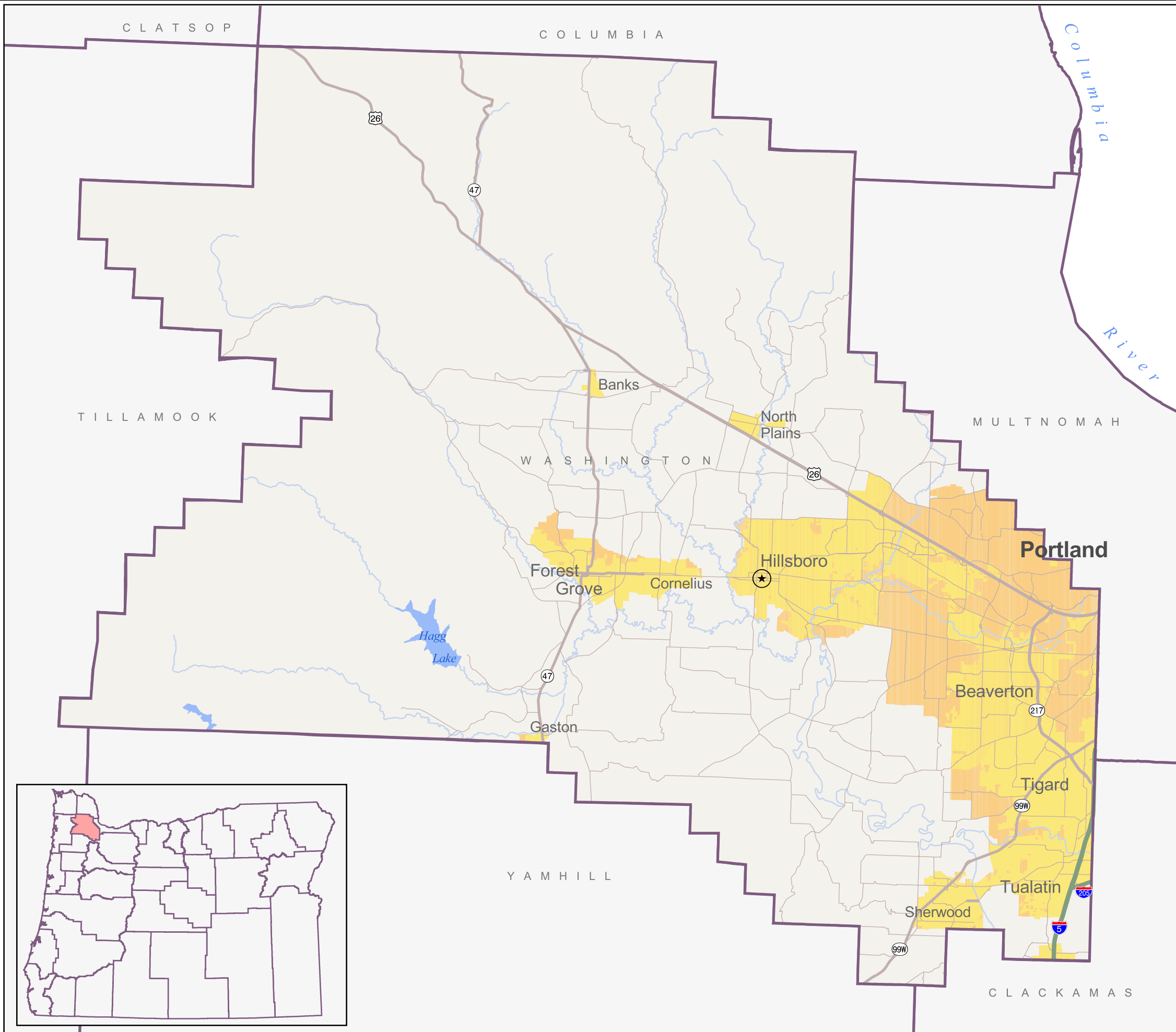
Implementing the Plan

The Mitigation Committee, headed by the County Office of Emergency Management, will coordinate implementation of the plan's action items, with overall guidance from the County. During quarterly meetings of the Washington County Natural Hazards Mitigation Committee, the Capability Assessment Matrix will be used to evaluate the level of immediate capability of individual action items and to further refine how and when the plan's actions items are implemented based on the implementing organization's capability.

Sample

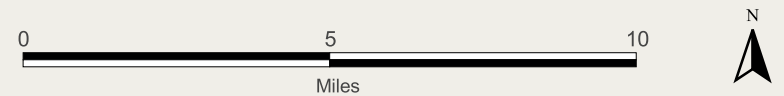
Following is a copy of the Capability Assessment Matrix.

Map 1.1 Washington County

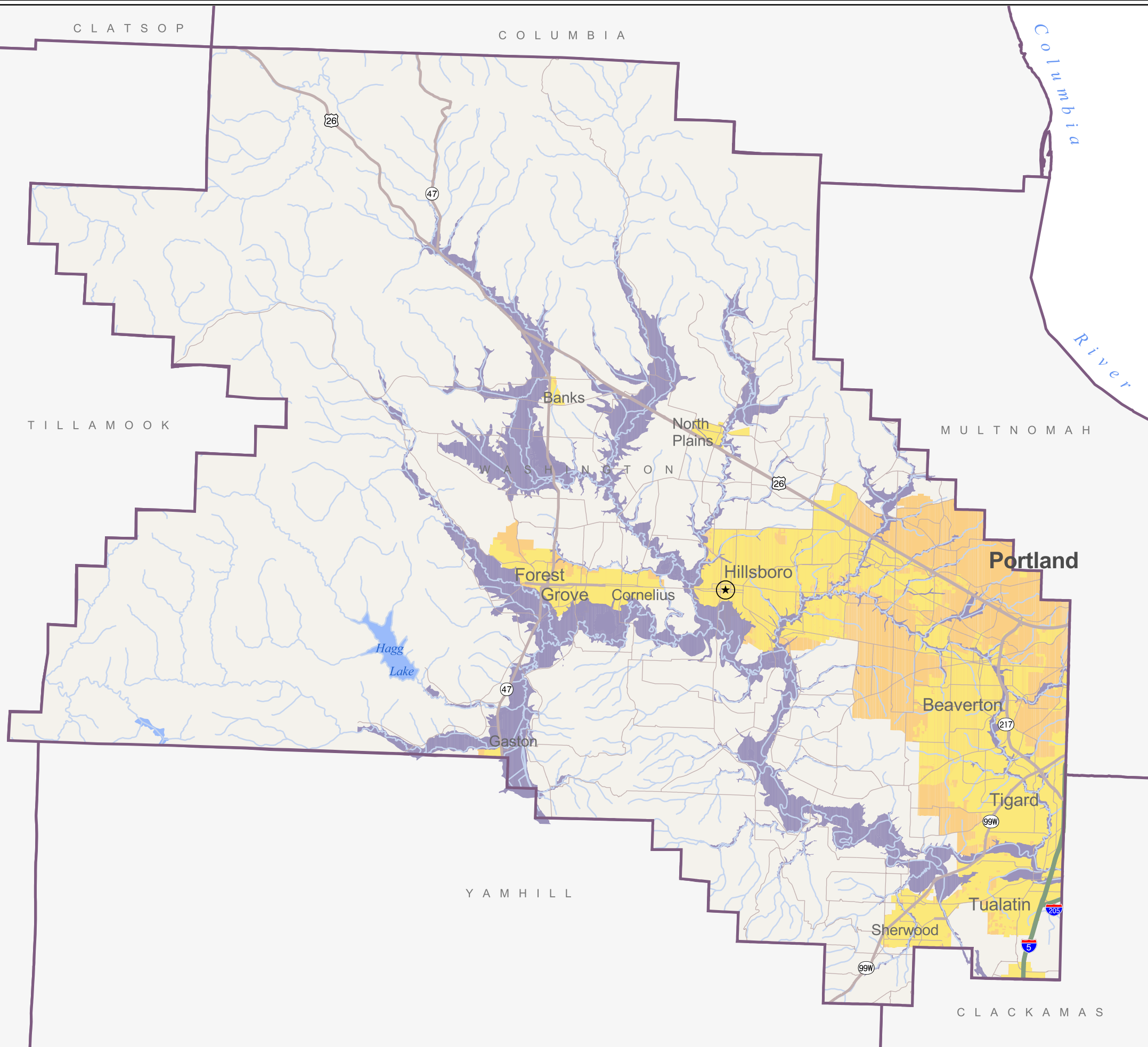


- County Seat**
- Interstates**
- Highways**
- Roads**
- County Boundary**
- Rivers**
- Lakes**
- Cities**
- Urban Unincorporated Areas**

Data Source: Data courtesy of Washington County.

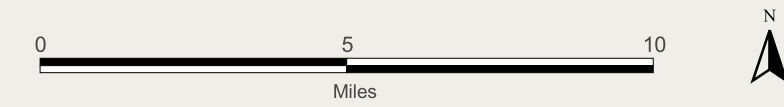


Map 4.1 Washington County 100-Year Floodplain

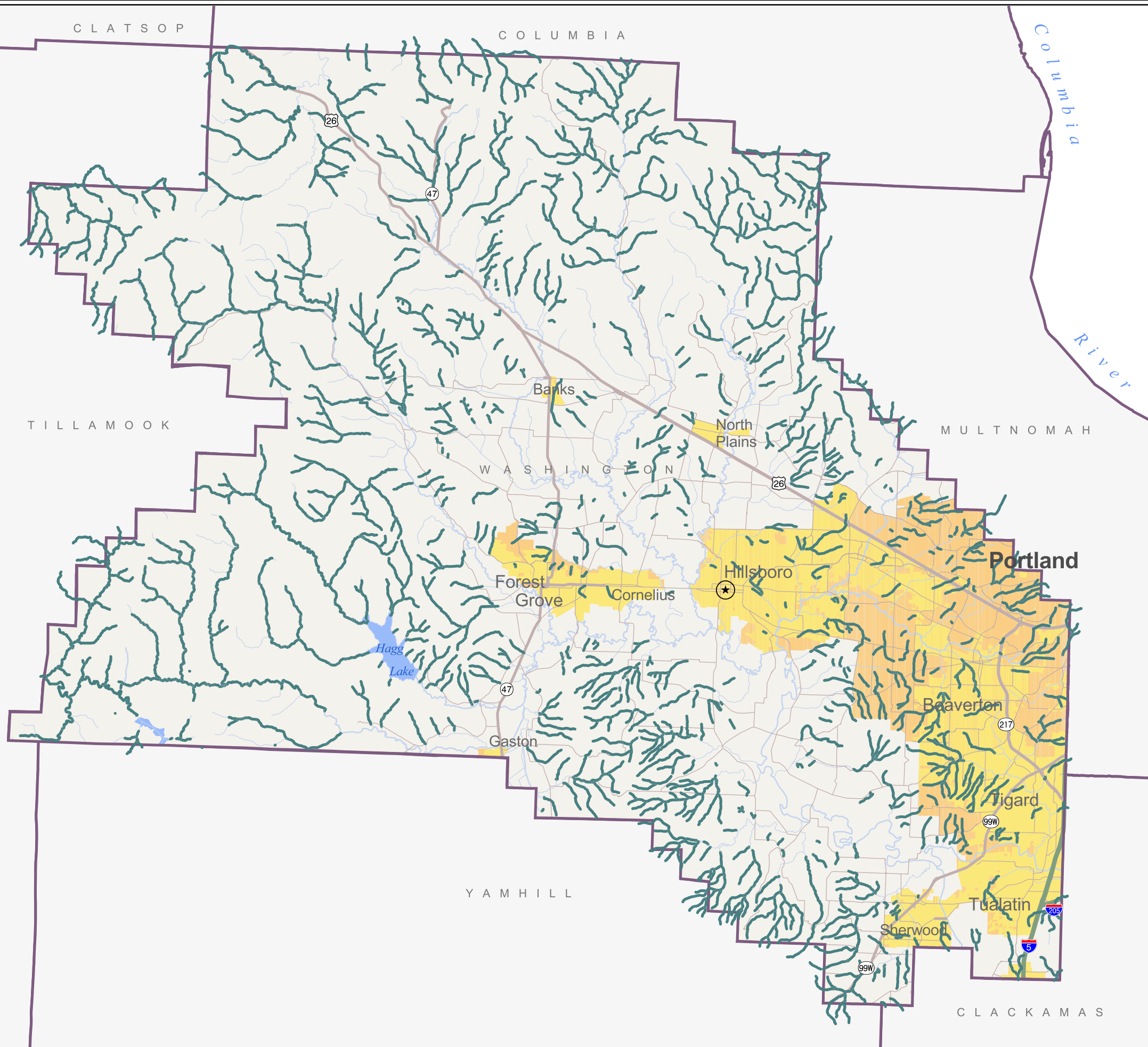


- 100-year Floodplain (43,436 Acres)
- ★ County Seat
- Interstates
- Highways
- Roads
- County Boundary
- Rivers
- Lakes
- Cities
- Urban Unincorporated Areas

Data Source: Data courtesy of Washington County. The floodplain data combines Army Corps of Engineer data (1974) with County FEMA flood data (1980).



Map 4.2 Washington County Drainage Hazard Area

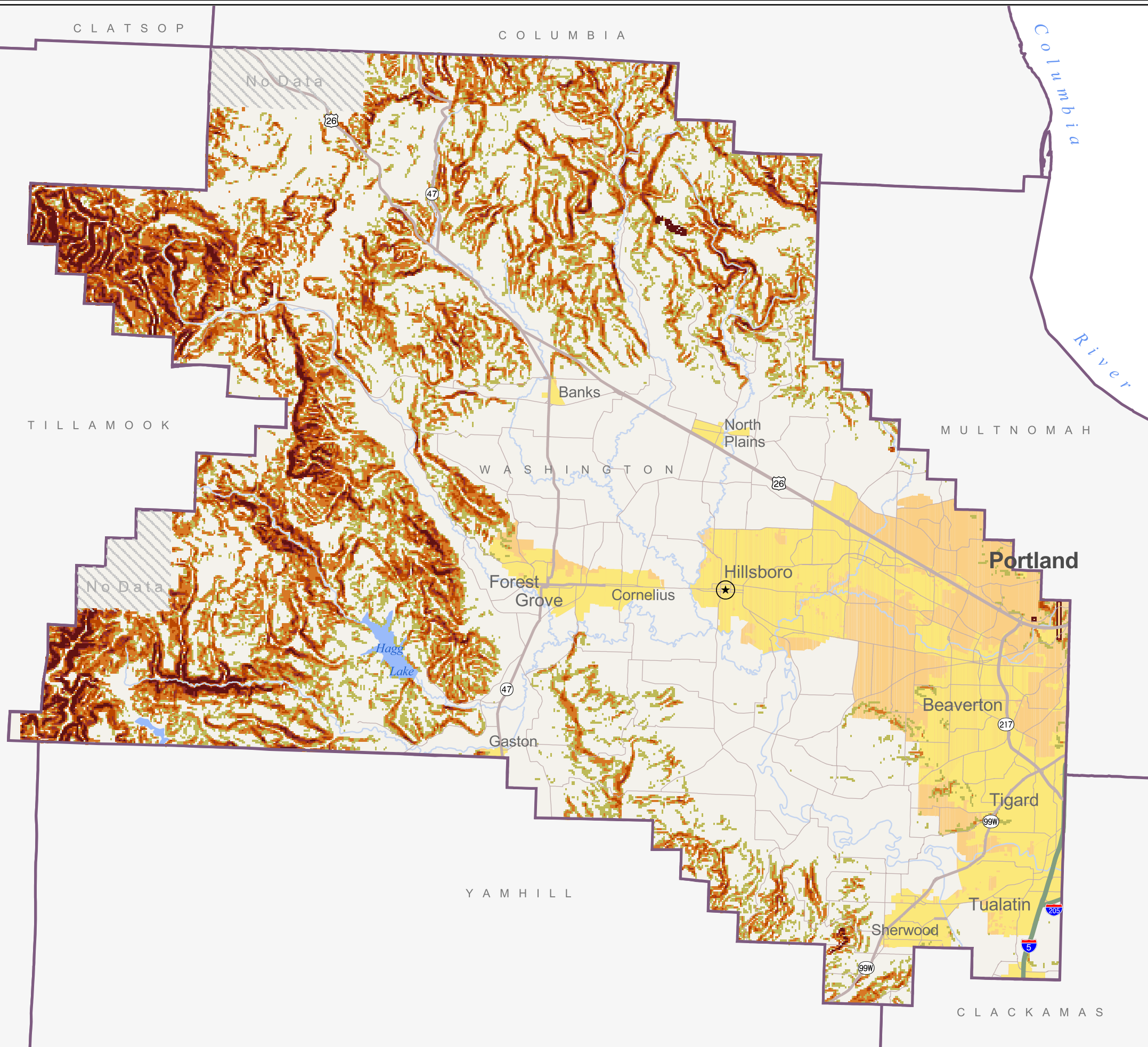


- Drainage Hazard Area (53,000 Acres)
- County Seat
- Interstates
- Highways
- Roads
- County Boundary
- Rivers
- Lakes
- Cities
- Urban Unincorporated Areas

Data Source: Data courtesy of Washington County.



Map 5.1 Washington County Slope



Percent Slope

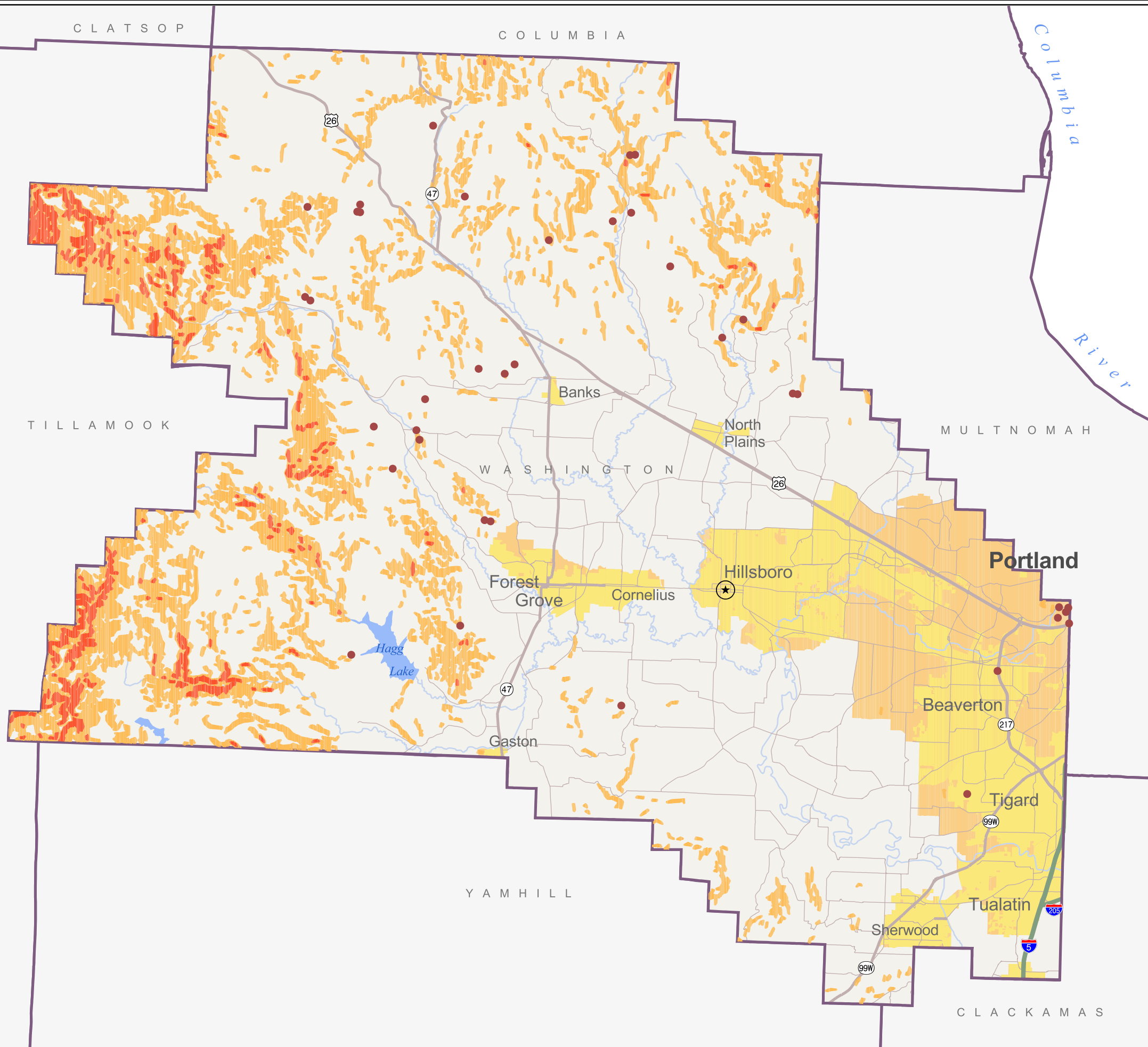
- 15 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- Over 50
- No Data

★ **County Seat**
 Interstates
 Highways
 Roads
 County Boundary
 Rivers
 Lakes
 Cities
 Urban Unincorporated Areas

Data Source: Data courtesy of Washington County.



Map 5.2 Washington County Landslide and Debris Flow Hazard Areas

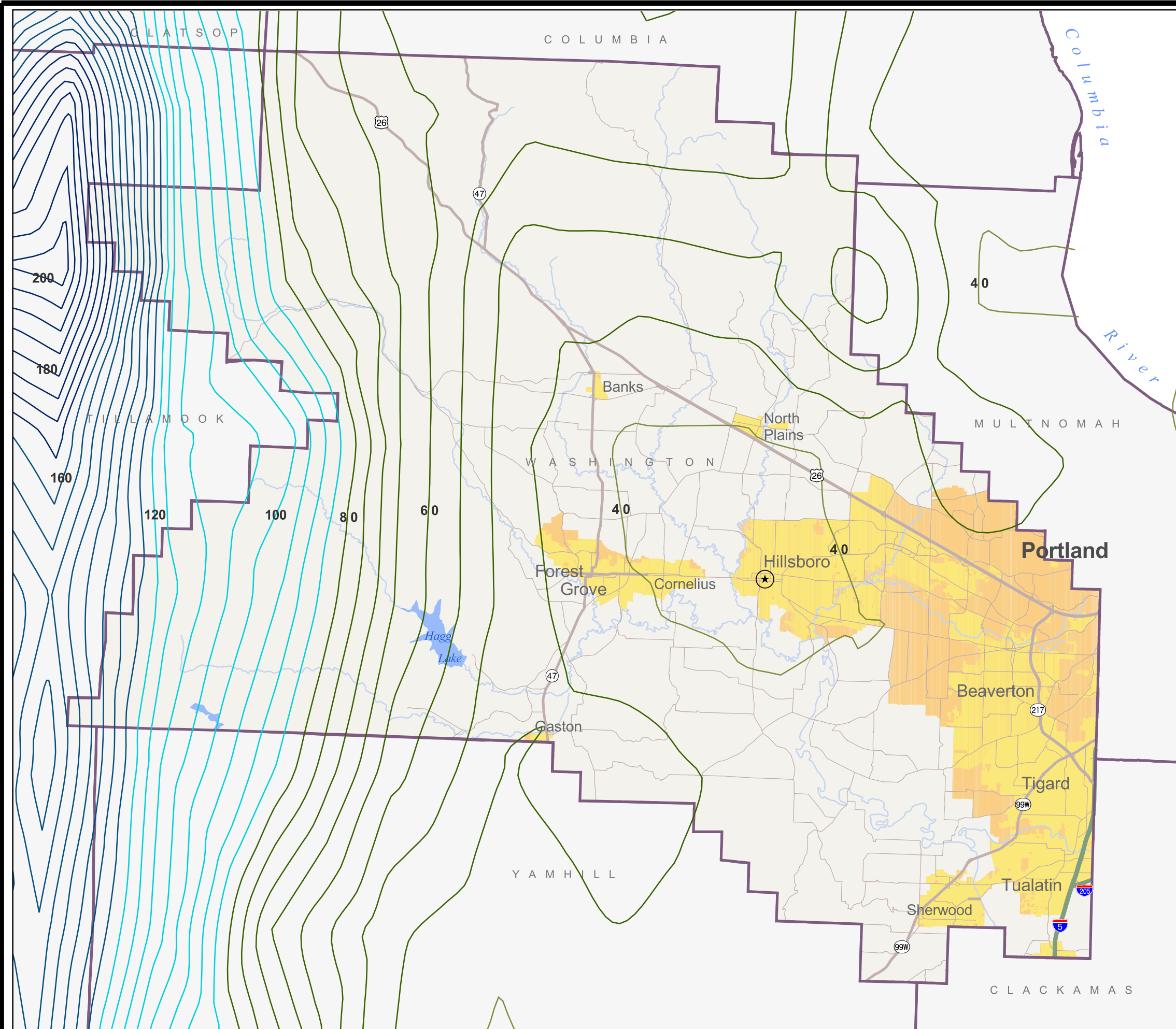


- Debris Flow**
- High Hazard Areas (9,136 Acres)
 - Moderate Hazard Areas (68,399 Acres)
 - Landslides Occurences in February 1996
-
- ★ County Seat
 - Interstates
 - Highways
 - Roads
 - County Boundary
 - Rivers
 - Lakes
 - Cities
 - Urban Unincorporated Areas

Data Source: The debris flow data is courtesy of the Oregon Department of Forestry (ODF) Geographic Information Systems (<http://www.odf.state.or.us/gis/debris.html>). All other data courtesy of Washington County.



Map 6.1 Washington County Average Annual Precipitation



Precipitation (Inches)

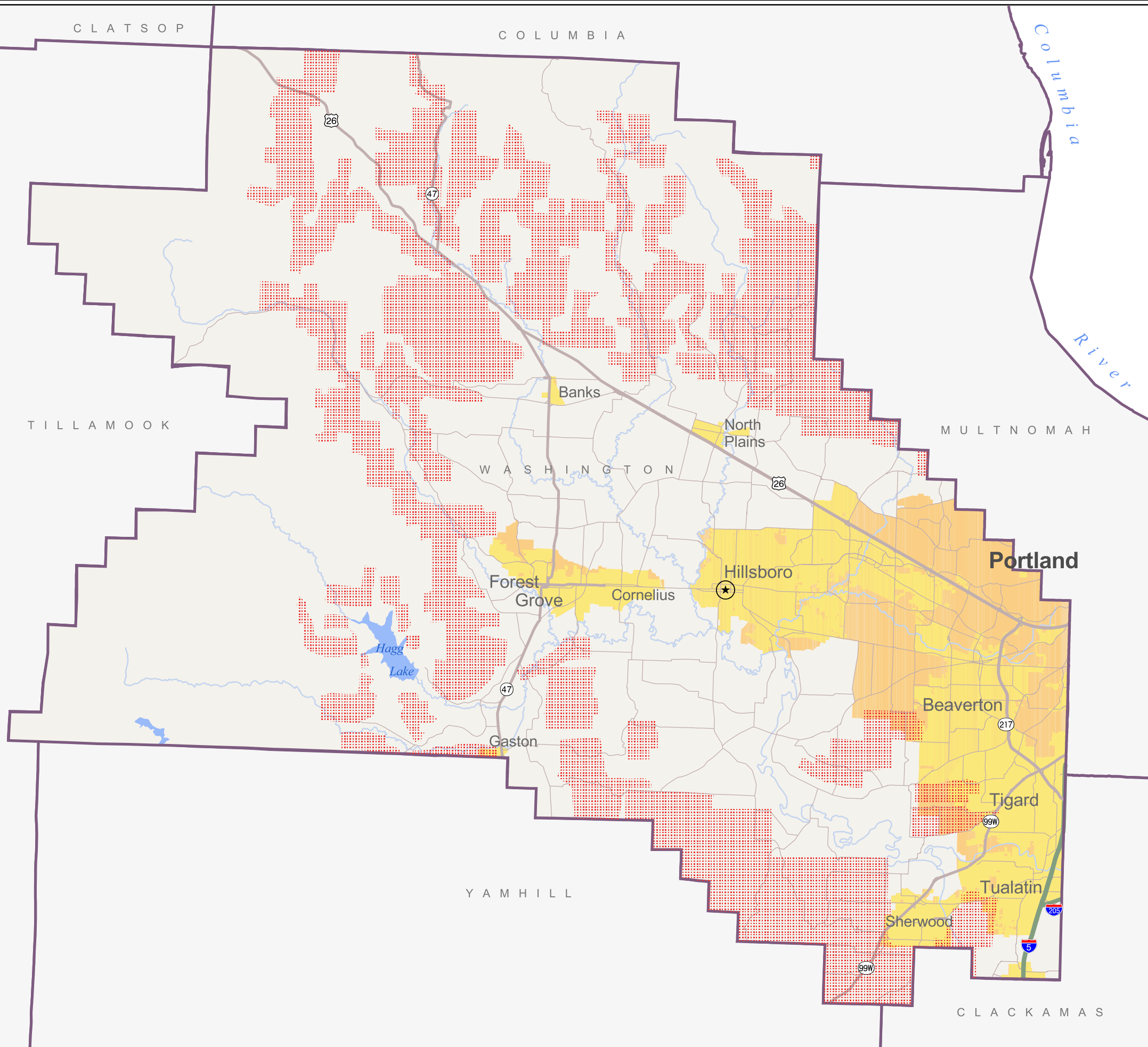
- 0 - 40
- 41 - 80
- 81 - 120
- 121 - 160
- 161 - 200




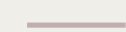


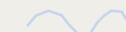



- ★ County Seat
- Interstates
- Highways
- Roads
- County Boundary
- ~ Rivers
- ~ Lakes
- Cities
- Urban Unincorporated Areas

Data Source: Annual precipitation data is from the USGS via the OGDC (SSCGIS) web site. All other data courtesy of Washington County



Map 8.1 Washington County Wildfire Risk Areas



-  ODF Urban Wildland Interface (122,982 Acres)
-  County Seat
-  Interstates
-  Highways
-  Roads
-  County Boundary
-  Rivers
-  Lakes
-  Cities
-  Urban Unincorporated Areas

Data Source: The Oregon Department of Forestry (ODF) Urban Wildland Interface (1996) data is raw data courtesy of Oregon Department of Forestry. All other data courtesy of Washington County.

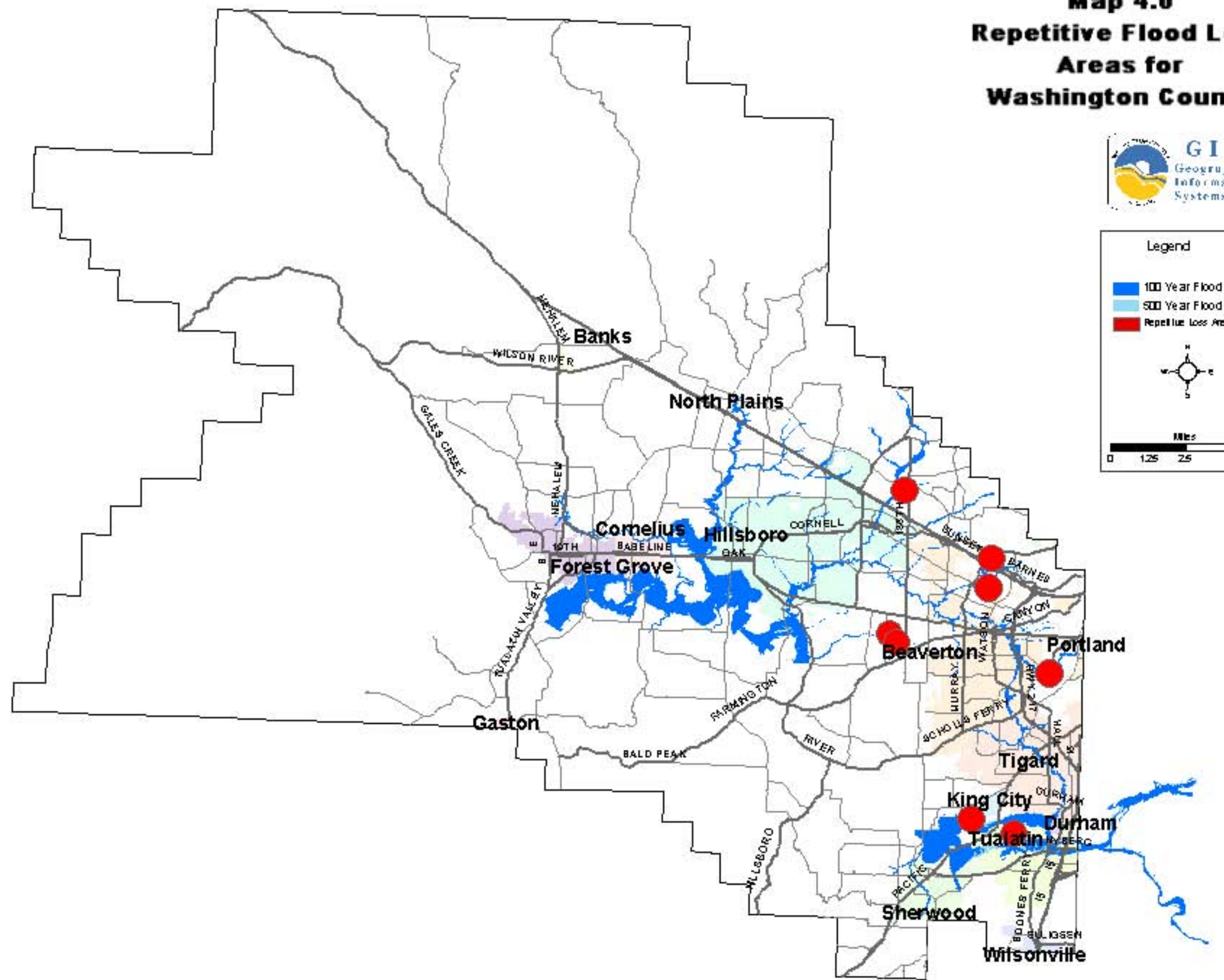


Map 4.0 Repetitive Flood Loss Areas for Washington County



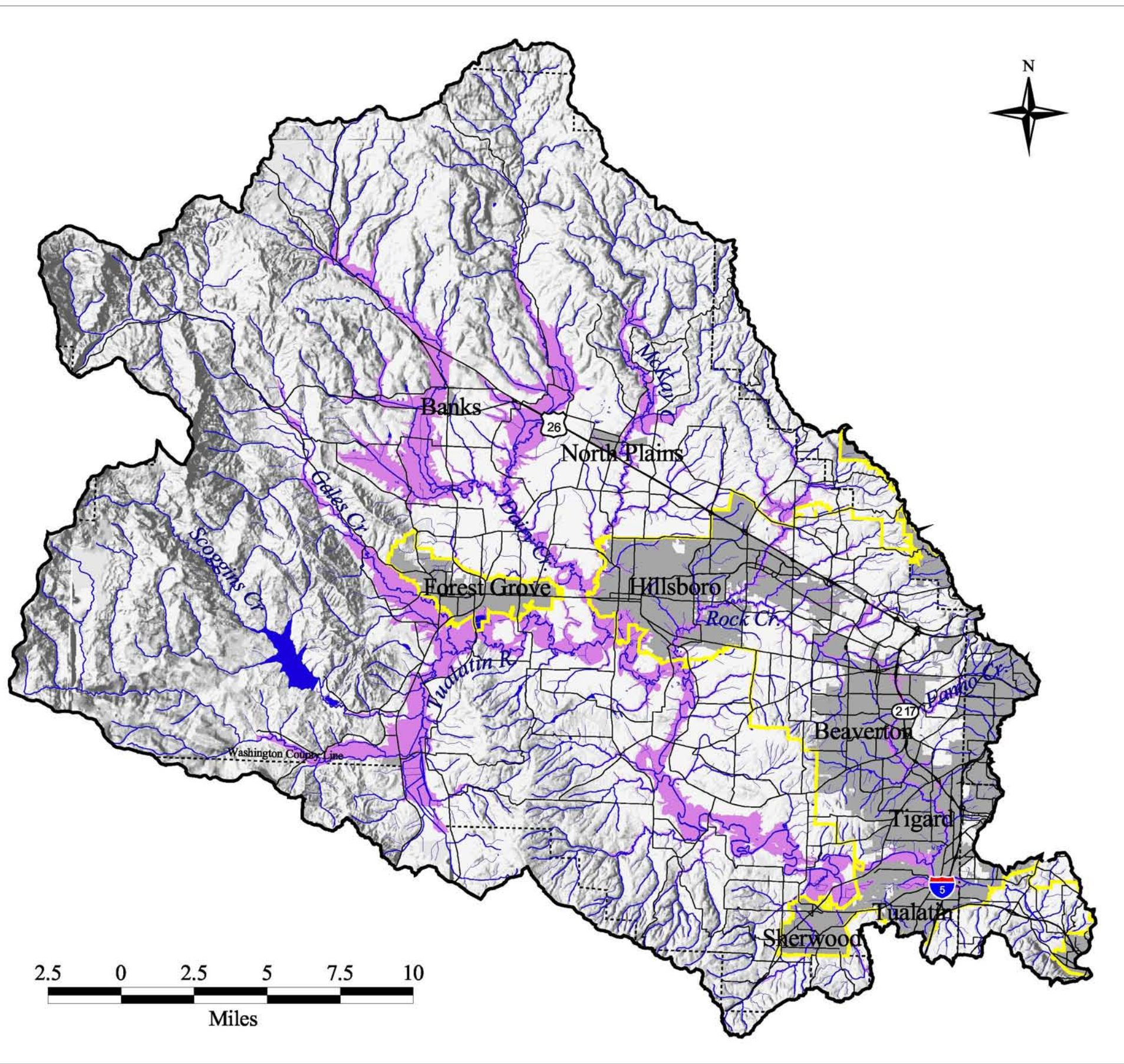
Legend









- 100 Year Flood
- 500 Year Flood
- Repetitive Loss Areas

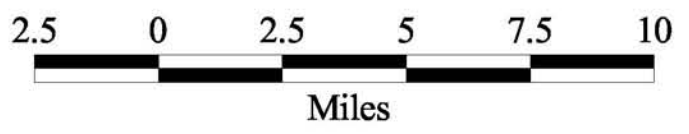


The information on this map was derived from digital databases on Washington County's GIS. Care was taken in the creation of this map, however Washington County cannot accept any responsibility for errors, omissions, or positional accuracy. Therefore there are no warranties which accompany this product. Notification of any errors will be appreciated.

Tualatin Basin Floodplain



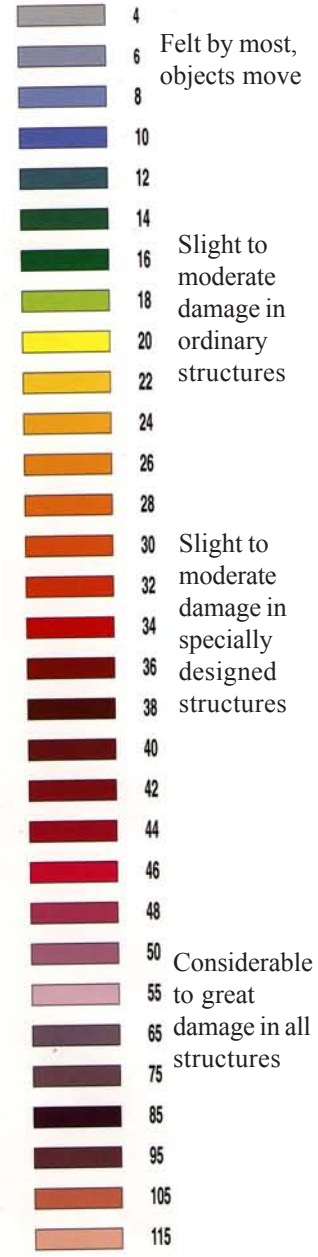
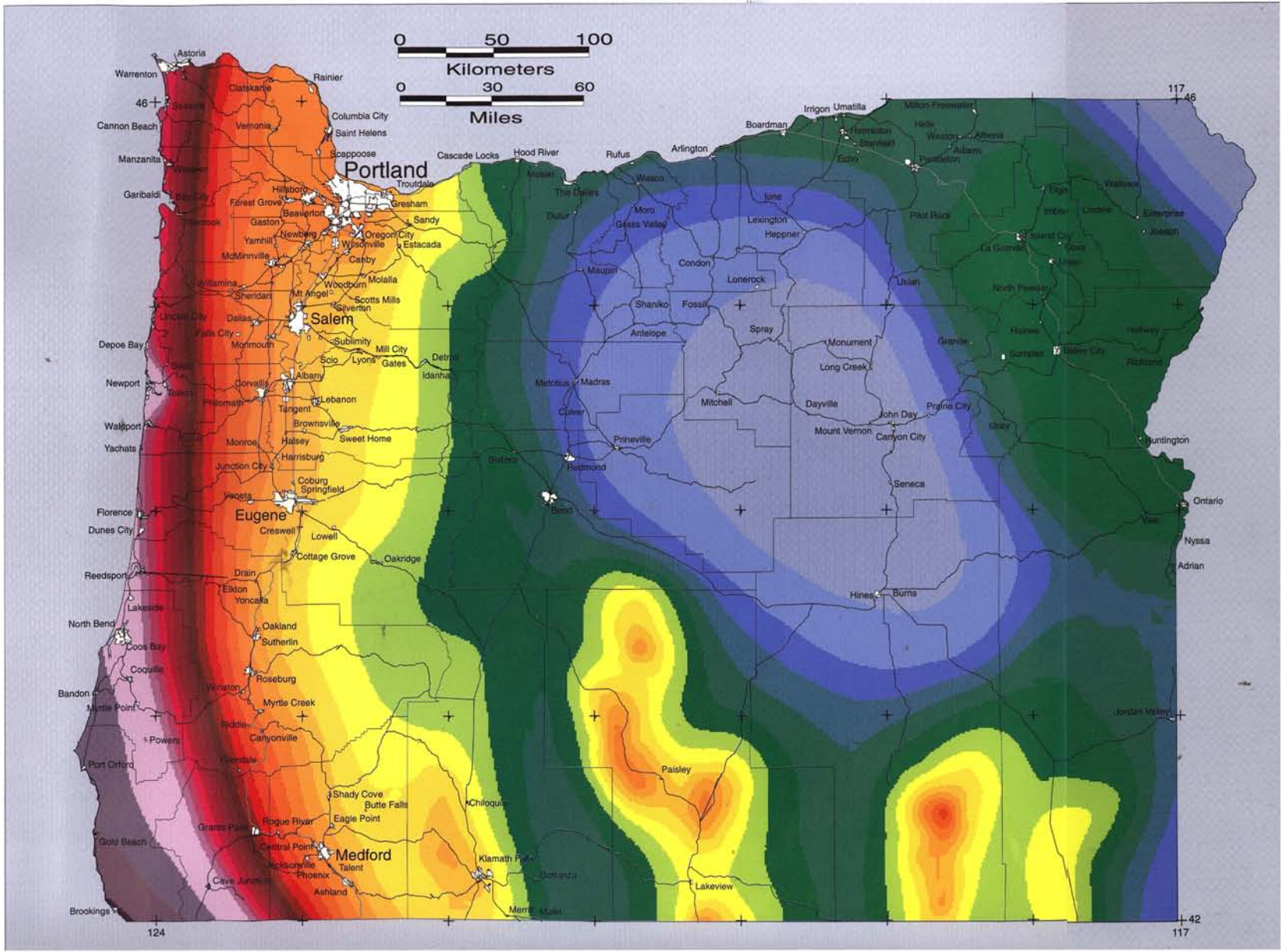
-  Tualatin River Basin
-  Rivers
-  Lakes and Reservoirs
-  Floodplain
-  Metro Urban Growth Boundary
-  County Boundary
-  City Limits
-  Freeways, Arterials



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Map of Maximum Earthquake Shaking (Peak Ground Acceleration) expected in Oregon with a frequency of occurrence of once in 1000 years (5% chance of occurrence in any 50 year period)



Earthquake Hazards Maps for Oregon, Dogami, 1996.

ANNUAL PROBABILITY 1 CM TEPHRA FALL

