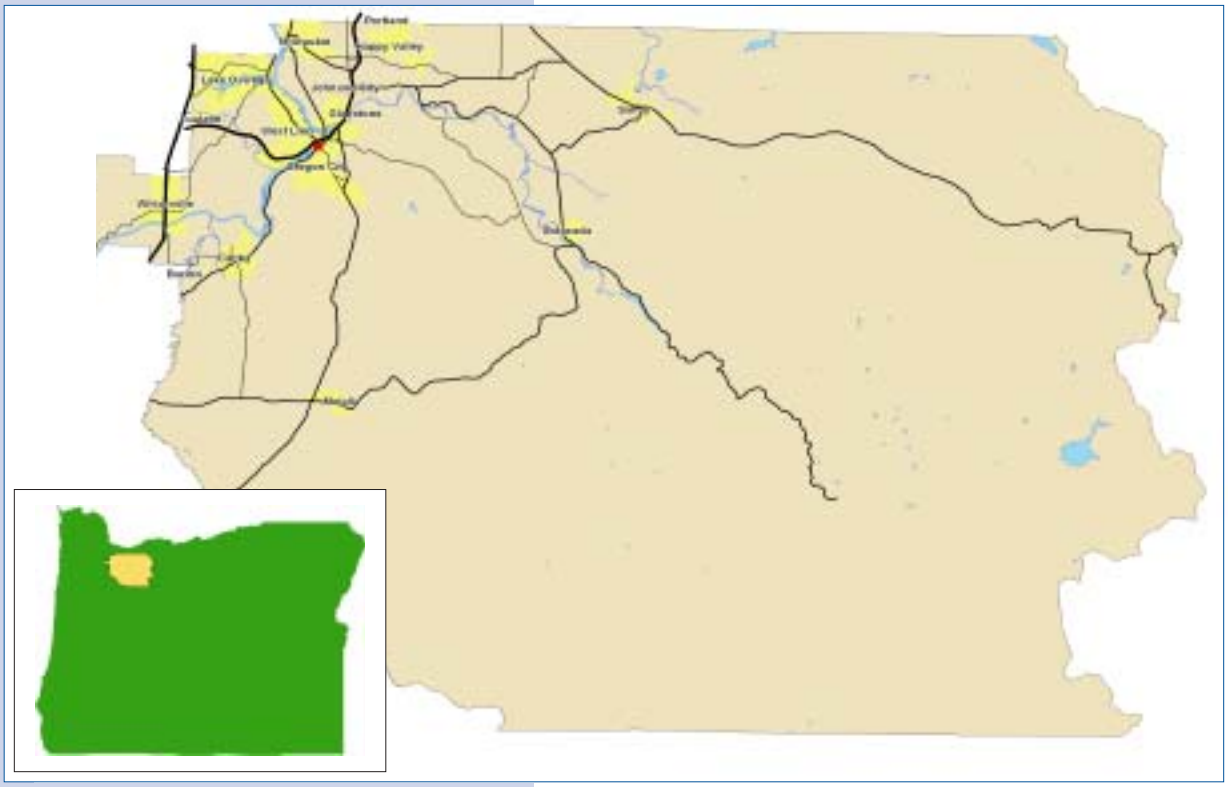
Clackamas County

Natural Hazards Mitigation Plan



ONHW

Partners for Disaster Resistance

Oregon, Showcase State

Clackamas County

Natural Hazards Mitigation Plan

Report for:

Clackamas County Emergency Management

2200 Kaen Road
Oregon City, OR 97045

Prepared by:

Resource Assistance for Rural Environments/Oregon Natural Hazards Workgroup

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Special Thanks & Acknowledgements

Project Steering Committee:

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Funding Acknowledgements:

Clackamas County partnered with the Oregon Natural Hazards Workgroup, a program within the University of Oregon's Community Service Center to develop the Clackamas County Natural Hazards Mitigation Plan. Funding for this project was made possible through the Federal Emergency Management Agency Project Impact Program, the Public Entity Risk Institute, the Partners for Disaster Resistance: Oregon Showcase State Program, and the Oregon Natural Hazards Workgroup.

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PARTNERS for DISASTER RESISTANCE
Oregon, Showcase State

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Oregon Natural Hazards Workgroup

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Executive Summary:
Five-Year Action Plan Matrix

The Clackamas 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 a list of activities that may assist Clackamas 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 Clackamas 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 Clackamas County Natural Hazards Mitigation Action Plan is the result of a collaborative effort between Clackamas County citizens, public agencies, non-profit organizations, the private sector, and regional and state organizations. Public participation played a key role in development of goals and action items. Interviews were conducted with stakeholders across the county, and two public workshops were held to include Clackamas County residents in plan development. A project Steering Committee guided the process of developing the plan. The Steering Committee was comprised of representatives from:

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What is the Plan Mission?

The mission of the Clackamas County Natural Hazards Mitigation Plan is to promote sound public policy designed to protect citizens, critical facilities, infrastructure, private property, and the environment from natural hazards. This can be achieved by increasing public awareness, documenting the resources for risk reduction and loss-prevention, and identifying activities to guide the county towards building a safer, more sustainable community.

What are the Plan Goals?

The plan goals describe the overall direction that Clackamas 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 outlined in the action items.

Protect Life and Property

- Implement activities that assist in protecting lives by making homes, businesses, infrastructure, critical facilities, and other property more resistant to losses from natural hazards.
- Reduce losses and repetitive damages for chronic hazard events while promoting insurance coverage for catastrophic hazards.
- Improve hazard assessment information to make recommendations for discouraging new development and encouraging preventative measures for existing development in areas vulnerable to natural hazards.

Public Awareness

- Develop and implement education and outreach programs to increase public awareness of the risks associated with natural hazards.

- Provide information on tools, partnership opportunities, and funding resources to assist in implementing mitigation activities.

Natural Systems

- Balance watershed planning, natural resource management, and land use planning with natural hazard mitigation to protect life, property, and the environment.
- Preserve, rehabilitate, and enhance natural systems to serve natural hazard mitigation functions.

Partnerships and Implementation

- Strengthen communication and coordinate participation among and within public agencies, citizens, non-profit organizations, business, and industry to gain a vested interest in implementation.
- Encourage leadership within public and private sector organizations to prioritize and implement local, county, and regional hazard mitigation activities.

Emergency Services

- Establish policy to ensure mitigation projects for critical facilities, services, and infrastructure.
- Strengthen emergency operations by increasing collaboration and coordination among public agencies, non-profit organizations, business, and industry.
- Coordinate and integrate natural hazard mitigation activities, where appropriate, with emergency operations plans and procedures.

How are the Action Items Organized?

The *action items* are a listing of activities in which county agencies and citizens can be engaged to reduce risk. Each action item includes an estimate of the timeline for implementation. *Short-term action items (ST)* are activities that 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.

The action items are organized within the following matrix, which lists all of the multi-hazard and hazard-specific action items included in the mitigation plan. Data collection and research and the public participation process resulted in the development of these action items (see Appendix B). 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.
- **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. Protect Life and Property
    2. Public Awareness
    3. Natural Systems
    4. Partnerships and Implementation
    5. Emergency Services

- **Partner Organizations**. The Partner organizations are not listed with the individual action items or in the plan matrix. Partner organizations are listed in Appendix A, of this plan and 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. *The partner organizations listed in the Resource Directory of the Clackamas County Natural Hazards Mitigation Plan are potential partners recommended by the project steering committee, but were 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 resources to action items.*

How Will the Plan be Implemented, Monitored, and Evaluated?

The Plan Maintenance Section of this document details the formal process that will ensure that the Clackamas County Natural Hazards Mitigation Plan remains an active and relevant document. The plan maintenance process includes a schedule for monitoring and evaluating the Plan annually and producing a plan revision every five years. This section describes how the county will integrate public participation throughout the plan maintenance process. Finally, this section includes an explanation of how Clackamas County government intends to incorporate the mitigation strategies outlined in this Plan into existing planning mechanisms such as the County Comprehensive Land Use Plan, Capital Improvement Plans, and Building Codes.

Plan Adoption

The Board of County Commissioners (BCC) will be responsible for adopting the Clackamas County Natural Hazards Mitigation Plan. This governing body has the authority to promote sound public policy regarding natural hazards.

Coordinating Body

A Clackamas County Hazard Mitigation Advisory Committee will be responsible for coordinating implementation of Plan action items and undertaking the formal review process. The BCC will assign representatives from county agencies, including, but not limited to, the current Hazard Mitigation Advisory Committee members.

Convener

The BCC will adopt the Clackamas County Natural Hazard Mitigation Plan, and the Hazard Mitigation Advisory Committee will take responsibility for plan implementation. The County Administrator will serve as a ***convener*** to facilitate the Hazard Mitigation Advisory Committee meetings, and will assign tasks such as updating and presenting the Plan to the members of the committee. Plan implementation and evaluation will be a shared responsibility among all of the Natural Hazard Advisory Committee Members.

Implementation through Existing Programs

Clackamas County addresses statewide planning goals and legislative requirements through its Comprehensive Land Use Plan, Capital Improvement Plans, and county Building Codes. The Natural Hazard Mitigation Plan provides a series of recommendations that are closely

related to the goals and objectives of these existing planning programs. Clackamas County will have the opportunity to implement recommended mitigation action items through existing programs and procedures. Upon adoption of the Mitigation Plan, the county will assist local municipalities in developing their natural hazard mitigation goals and actions by providing the Mitigation Plan as a baseline of information on the natural hazards that impact the county.

Economic Analysis of Mitigation Projects

The Federal Emergency Management Agency's approaches to identify costs and benefits associated with natural hazard mitigation strategies or projects fall into two general categories: benefit/cost analysis and cost-effectiveness analysis. 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. 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 can provide 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.

Formal Review Process

The Clackamas County Natural Hazards Mitigation Plan will be evaluated on an annual basis to determine the effectiveness of programs, and to reflect changes in land development or programs that may affect mitigation priorities. The evaluation process includes a firm schedule and timeline, and identifies the local agencies and organizations participating in plan evaluation. The convener will be responsible for contacting the Hazard Mitigation Advisory Committee members and organizing the annual meeting. Committee members will be responsible for monitoring and evaluating the progress of the mitigation strategies in the Plan.

Continued Public Involvement

Clackamas County is dedicated to involving the public directly in the continual review and updates of the Hazard Mitigation Plan. Copies of the plan will be catalogued and kept at all of the public libraries in the county. The existence and location of these copies will be publicized in the quarterly county newsletter "Citizen News", which reaches every mailing address in the county. The plan also includes the address and the phone number of the county Planning Division, responsible for keeping track of public comments on the Plan. In addition, copies of the Plan and any proposed changes will be posted on the county website. This site will also contain an email address and phone number to which people can direct their comments and concerns.

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Natural Hazard	Action Item	Coordinating Organization	Timeline	Ideas for Implementation	Plan Goals Addressed				
					Protect Life and Property	Public Awareness	Natural Systems	Partnerships & Implementation	Emergency Services
Multi-Hazard Mitigation Action Items									
Short-Term Multi-Hazard #1	Integrate the goals and action items from the Clackamas County Natural Hazard Mitigation Plan into existing regulatory documents and programs where appropriate.	Hazard Mitigation Advisory Committee	Ongoing	pg. 4-5				✓	
Short-Term Multi-Hazard #2	Identify and pursue funding opportunities to develop and implement local and county mitigation activities.	County Dept. of Development and Transportation, County Emergency Management	Ongoing	pg. 4-5				✓	
Short-Term Multi-Hazard #3	Establish a formal role for the Clackamas County Natural Hazards Mitigation Committee to develop a sustainable process for implementing, monitoring, and evaluating countywide mitigation activities.	Hazard Mitigaiton Advisory Committee	Ongoing	pg. 4-6				✓	
Short-Term Multi-Hazard #4	Identify, improve, and sustain collaborative programs focusing on the real estate and insurance industries, public and private sector organizations, and individuals to avoid activity that increases risk to natural hazards.	County Emergency Management, County Public and Government Relations, County Economic Development	Ongoing	pg. 4-6	✓	✓		✓	
Short-Term Multi-Hazard #5	Develop public and private partnerships to foster natural hazard mitigation program coordination and collaboration in Clackamas County.	County Emergency Management, County Economic Development, County Dept. of Development	Ongoing	pg. 4-7				✓	
Short-Term Multi-Hazard #6	Develop inventories of at-risk buildings and infrastructure and prioritize mitigation projects.	County Emergency Management, County Dept. of Development and Transportation, County Geographic Information Systems	1-2 Years	pg. 4-7	✓			✓	
Long-Term Multi-Hazard #1	Strengthen emergency services preparedness and response by linking emergency services with natural hazard mitigation programs, and enhancing public education on a regional scale.	County Emergency Management, County Dept. of Development and Transportation	Ongoing	pg.4-8					✓

Natural Hazard	Action Item	Coordinating Organization	Timeline	Ideas for Implementation	Plan Goals Addressed				
					Protect Life and Property	Public Awareness	Natural Systems	Partnerships & Implementation	Emergency Services
Long-Term Multi-Hazard #2	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.	County Public and Government Relations, County Geographic Information Systems, County Social Services	Ongoing	pg.4-9	✓	✓			
Long-Term Multi-Hazard #3	Use technical knowledge of natural ecosystems and events to link natural resource management and land use organizations to mitigation activities and technical assistance.	County Dept. of Transportation and Development, Water Environment Services	Ongoing	pg. 4-10			✓		
Flood Mitigation Action Items									
Short-Term Flood #1	Analyze each repetitive flood property within Clackamas County and identify feasible mitigation options.	Hazard Mitigation Advisory Committee	1-2 Years	pg. 6-25	✓			✓	
Short-Term Flood #2	Recommend revisions to requirements for development within the floodplain, where appropriate.	County Dept. of Transportation and Development, County Geographic Information Services, Water Environment Services	1-2 Years	pg. 6-25	✓				
Short-Term Flood #3	Develop better flood warning systems.	County Emergency Management, County Public and Government Relations, Dept. of Transportation and Development	1-2 Years	pg. 6-26	✓				✓
Long-Term Flood #1	Enhance data and mapping for floodplain information within the County, and identify and map flood-prone areas outside of designated floodplains.	County Geographic Information Services, County Dept. of Transportation and Development, Water Environment Services	3 Years	pg. 6-26	✓				
Long-Term Flood #2	Encourage development of acquisition and management strategies to preserve open space for flood mitigation, fish habitat, and water quality in the floodplain.	County Dept. of Transportation and Development, Water Environment Services	5 Years	pg. 6-27	✓		✓		
Long-Term Flood #3	Identify surface water drainage obstructions for all parts of unincorporated Clackamas County.	County Roads Division, Water Environment Services, County Geographic Information Systems	5 Years	pg. 6-27	✓				

Natural Hazard	Action Item	Coordinating Organization	Timeline	Ideas for Implementation	Plan Goals Addressed				
					Protect Life and Property	Public Awareness	Natural Systems	Partnerships & Implementation	Emergency Services
Long-Term Flood #4	Establish a framework to compile and coordinate surface water management plans and data throughout the county.	Water Environment Services, County Planning Division, Geographic Information Systems	3-5 Years	pg. 6-28	✓			✓	
Landslide Mitigation Action Items									
Short-Term Landslide #1	Improve knowledge of landslide hazard areas and understanding of vulnerability and risk to life and property in hazard-prone areas.	Hazard Mitigation Advisory Committee	2 Years	pg. 7-14	✓	✓			
Short-Term Landslide #2	Encourage construction and subdivision design that can be applied to steep slopes to reduce the potential adverse impacts from development.	County Dept. of Transportation and Development, Water Environmnet Services	3 Years	pg. 7-14	✓			✓	
Short-Term Landslide #3	Identify safe evacuation routes in high-risk debris flow and landslide areas.	County Dept. of Transportation and Development	2 Years	pg. 7-15	✓				✓
Long-Term Landslide #1	Evaluate current landslide warning systems to ensure effectiveness and efficiency and increase coordination between local jurisdictions and ODF for landslide warning systems.	Hazard Mitigation Advisory Committee	3-5 Years	pg. 7-15	✓			✓	✓
Long-Term Landslide #2	Limit activities in identified potential and historical landslide areas through regulation and public outreach.	Hazard Mitigation Advisory Committee	Ongoing	pg. 7-15	✓	✓	✓		
Wildfire Mitigation Action Items									
Short-Term Wildfire #1	Enhance emergency services to increase the efficiency of wildfire response and recovery activities.	Clackamas County Fire Defense Board	2 Years	pg. 8-19					✓
Short-Term Wildfire #2	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.	Clackamas County Fire Defense Board	1-2 Years	pg. 8-19	✓			✓	

Natural Hazard	Action Item	Coordinating Organization	Timeline	Ideas for Implementation	Plan Goals Addressed				
					Protect Life and Property	Public Awareness	Natural Systems	Partnerships & Implementation	Emergency Services
Short-Term Wildfire #3	Inventory alternative firefighting water sources and encourage the development of additional sources.	Clackamas Fire Defense Board	1 Year	pg. 8-20					
Long-Term Wildfire #1	Encourage development and dissemination of maps relating to the fire hazard to help educate and assist builders and homeowners in being engaged in wildfire mitigation activities, and to help guide emergency services during response.	County Geographic Information Systems	1-3 Years	pg. 8-20	✓				
Long-Term Wildfire #2	Enhance outreach and education programs aimed at mitigating wildfire hazards and reducing or preventing the exposure of citizens, public agencies, private property owners, and businesses to natural hazards.	Clackamas Fire Defense Board, Individual Fire Depts.	Ongoing	pg. 8-20	✓	✓			
Long-Term Wildfire #3	Increase communication, coordination, and collaboration between wildland/urban interface property owners, local and county planners, and fire prevention crews and officials to address risks, existing mitigation measures, and federal assistance programs.	Clackamas County Fire Defense Board, Individual Fire Depts.	Ongoing	pg. 8-21	✓	✓		✓	✓
Long-Term Wildfire #4	Encourage implementation wildfire mitigation activities in a manner consistent with the goals of promoting sustainable ecological management and community stability.	Clackamas Fire Defense Board, Individual Fire Depts.	Ongoing	pg. 8-22			✓		
Severe Winter Storm Mitigation Action Items									
Short-Term Winter Storm#1	Enhance strategies for debris management for severe winter storm events.	County Roads Division	2 Years	pg. 9-9				✓	✓
Short-Term Winter Storm#2	Develop and implement programs to coordinate maintenance and mitigation activities to reduce risk to public infrastructure from severe winter storms.	Hazard Mitigation Advisory Committee	2 Years	pg. 9-10				✓	✓

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Long-Term Winter Storm #1	Increase public awareness of severe winter storm mitigation activities.	Hazard Mitigation Advisory Committee	Ongoing	pg. 9-10	✓	✓			
Long-Term Winter Storm #2	Enhance weather monitoring to attain earlier severe winter storm warnings.	Hazard Mitigation Advisory Committee	Ongoing	pg. 9-10	✓	✓			
Windstorm Mitigation Action Items									
Short-Term Windstorm #1	Develop and implement programs to keep trees from threatening lives, property, and public infrastructure during windstorm events.	County Dept. of Transportation and Development	2 Years	pg. 10-9				✓	✓
Short-Term Windstorm #2	Enhance strategies for debris management for windstorm events.	County Roads Division	2 Years	pg. 10-9				✓	✓
Long-Term Windstorm #1	Map and publicize locations around the county that have the highest incidence of extreme windstorms.	County Geographic Information Systems	5 Years	pg. 10-10	✓	✓		✓	
Long-Term Windstorm #2	Support/encourage electrical utilities to use underground construction methods where possible to reduce power outages from windstorms.	Hazard Mitigation Advisory Committee	5 Years	pg. 10-10			✓	✓	
Long-Term Windstorm #3	Increase public awareness of windstorm mitigation activities.	Hazard Mitigation Advisory Committee	Ongoing	pg. 10-10	✓	✓			
Long-Term Windstorm #4	Encourage development and enforcement of wind-resistant building siting and construction codes.	County Building Division	Ongoing	pg. 10-11	✓	✓			
Earthquake Mitigation Action Items									

Natural Hazard	Action Item	Coordinating Organization	Timeline	Ideas for Implementation	Plan Goals Addressed				
					Protect Life and Property	Public Awareness	Natural Systems	Partnerships & Implementation	Emergency Services
Short-Term Earthquake #1	Integrate new earthquake hazard mapping data for Clackamas County and improve technical analysis of earthquake hazards.	Clackamas County Geographic Information Systems	2 Years	pg. 11-23	✓			✓	
Short-Term Earthquake #2	Incorporate the Regional Earthquake Transportation Evacuation Routes developed by the Regional Emergency Managers Group into appropriate planning documents.	Clackamas County Emergency Management	2 Years	pg. 11-23					✓
Long-Term Earthquake #1	Identify funding sources for structural and nonstructural retrofitting of structures that are identified as seismically vulnerable.	Hazard Mitigation Advisory Committee	Ongoing	pg. 11-24		✓		✓	
Long-Term Earthquake #2	Encourage purchase of earthquake hazard insurance.	Hazard Mitigation Advisory Committee	Ongoing	pg. 11-24	✓	✓			
Long-Term Earthquake #3	Encourage seismic strength evaluations of critical facilities in the County to identify vulnerabilities for mitigation of schools and universities, public infrastructure, and critical facilities to meet current seismic standards.	Hazard Mitigation Advisory Committee	5 Years	pg. 11-24	✓				✓
Long-Term Earthquake #4	Encourage reduction of nonstructural and structural earthquake hazards in homes, schools, businesses, and government offices.	Hazard Mitigation Advisory Committee	Ongoing	pg. 11-25	✓	✓			✓
Volcanic Eruption Mitigation Action Items									
Short-Term Volcano #1	Work with the state and other impacted jurisdictions to revise the Mount Hood Inter-Agency Coordination Plan from 1997-2002.	County Emergency Management	1-2 Years	pg. 12-15		✓		✓	✓
Short-Term Volcano #2	Collaborate with USGS-CVO and related agencies to develop ash fall models that are specific to Clackamas County.	County Emergency Management, County Geographic Information Systems	2 Years	pg. 12-15	✓	✓		✓	
Long-Term Volcano #1	Strengthen response and recovery programs and develop and implement public education programs for volcanic eruption hazards.	County Emergency Management	5 Years	pg. 12-15	✓	✓		✓	✓

How Will the Plan be Implemented, Monitored, and Evaluated?

The Plan Maintenance Section of this document details the formal process that will ensure that the Clackamas County Natural Hazards Mitigation Plan remains an active and relevant document. The plan maintenance process includes a schedule for monitoring and evaluating the Plan annually and producing a plan revision every five years. This section describes how the county will integrate public participation throughout the plan maintenance process. Finally, this section includes an explanation of how Clackamas County government intends to incorporate the mitigation strategies outlined in this Plan into existing planning mechanisms such as the County Comprehensive Land Use Plan, Capital Improvement Plans, and Building Codes.

Plan Adoption

The Board of County Commissioners (BCC) will be responsible for adopting the Clackamas County Natural Hazards Mitigation Plan. This governing body has the authority to promote sound public policy regarding natural hazards.

Coordinating Body

A Clackamas County Hazard Mitigation Advisory Committee will be responsible for coordinating implementation of Plan action items and undertaking the formal review process. The BCC will assign representatives from county agencies, including, but not limited to, the current Hazard Mitigation Advisory Committee members.

Convener

The BCC will adopt the Clackamas County Natural Hazard Mitigation Plan, and the Hazard Mitigation Advisory Committee will take responsibility for plan implementation. The County Administrator will serve as a ***convener*** to facilitate the Hazard Mitigation Advisory Committee meetings, and will assign tasks such as updating and presenting the Plan to the members of the committee. Plan implementation and evaluation will be a shared responsibility among all of the Natural Hazard Advisory Committee Members.

Implementation through Existing Programs

Clackamas County addresses statewide planning goals and legislative requirements through its Comprehensive Land Use Plan, Capital Improvement Plans, and county Building Codes. The Natural Hazard Mitigation Plan provides a series of recommendations that are closely

related to the goals and objectives of these existing planning programs. Clackamas County will have the opportunity to implement recommended mitigation action items through existing programs and procedures. Upon adoption of the Mitigation Plan, the county will assist local municipalities in developing their natural hazard mitigation goals and actions by providing the Mitigation Plan as a baseline of information on the natural hazards that impact the county.

Economic Analysis of Mitigation Projects

The Federal Emergency Management Agency's approaches to identify costs and benefits associated with natural hazard mitigation strategies or projects fall into two general categories: benefit/cost analysis and cost-effectiveness analysis. 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. 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 can provide 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.

Formal Review Process

The Clackamas County Natural Hazards Mitigation Plan will be evaluated on an annual basis to determine the effectiveness of programs, and to reflect changes in land development or programs that may affect mitigation priorities. The evaluation process includes a firm schedule and timeline, and identifies the local agencies and organizations participating in plan evaluation. The convener will be responsible for contacting the Hazard Mitigation Advisory Committee members and organizing the annual meeting. Committee members will be responsible for monitoring and evaluating the progress of the mitigation strategies in the Plan.

Continued Public Involvement

Clackamas County is dedicated to involving the public directly in the continual review and updates of the Hazard Mitigation Plan. Copies of the plan will be catalogued and kept at all of the public libraries in the county. The existence and location of these copies will be publicized in the quarterly county newsletter "Citizen News", which reaches every mailing address in the county. The plan also includes the address and the phone number of the county Planning Division, responsible for keeping track of public comments on the Plan. In addition, copies of the Plan and any proposed changes will be posted on the county website. This site will also contain an email address and phone number to which people can direct their comments and concerns.

Section 1:
Introduction

Throughout history, the residents of Clackamas County have dealt with the various natural hazards affecting the area. Photos, journal entries, and newspapers from the mid to late 1800's show that the residents of the area dealt with high water, severe windstorms, harsh winter storms, wildfires, earthquakes, landslides, and even volcanic activity. Although there were fewer people in the area, the natural hazards adversely affected the lives of those who depended on the land and climate conditions for food and welfare. As the population of the county increases, the exposure to natural hazards creates an even higher risk than experienced historically.

Clackamas County is the third most populous county in Oregon, and is characterized by the unique and attractive landscape that connects the various communities throughout the area. However, the potential impacts of natural hazards associated with the terrain make the environment and population vulnerable to natural disaster situations. The county is subject to flooding, earthquakes, landslides, wildfires, severe winter storms, windstorms, and volcanic activity. It is impossible to predict exactly when these disasters will occur, or the extent to which they will affect the county. However, with careful planning and collaboration among public agencies, private sector organizations, and citizens within the community, it is possible to minimize the losses that can result from natural disasters.

Clackamas County most recently experienced large-scale destruction during the severe weather events in February 1996. The Clackamas and Willamette Rivers and their tributaries swelled beyond the 100-year flood level, causing flooding in both rural and urban areas. Prolonged precipitation accompanied by an early snowmelt caused very unstable soil conditions, resulting in many landslides and debris flows in the county. A significant amount of building damage was incurred by structures outside of identified flood hazard areas.

The damage to Clackamas County businesses, residences, and infrastructure was estimated at about $50 million, which is 20% of the county government's annual budget. The county sought and received a Presidential Disaster Declaration to obtain federal assistance for its flood recovery effort. The Clackamas County Risk Management Office estimated that the flood of February 1996 directly or indirectly affected three-quarters of the county's 342,861 residents. Claims filed under the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP) from Clackamas County residences and businesses accounted for almost one-third of the entire claims throughout the state in 1996. In addition to federal disaster relief funds, Clackamas County sought

and received disaster relief money from the Hazard Mitigation Grant Program. This program helps communities engage in mitigation activities designed to reduce losses from future natural hazard events.

Phase I of the Clackamas County Natural Hazards Mitigation Plan

One of the results of the 1996 flood events was an increased awareness of the natural hazards that pose a risk to Clackamas County residents. Various county departments agreed to make natural hazard mitigation a priority and began convening as the Hazard Mitigation Advisory Committee. This committee encouraged the development of a county-wide Natural Hazard Mitigation Plan, and developed a process to complete this plan in a series of two phases. The county contracted Goetell and Associates to complete Phase I in 1998. Phase I resulted in a mitigation plan that documented historical hazard information and included an engineering report outlining the risks posed by earthquakes, floods, landslides, winter storms, and utility outage hazards.

In 1998, FEMA selected Clackamas County to be a Project Impact Community. The Project Impact grant allowed the county to access federal funds for the development of hazard mitigation model projects. Using these funds, Clackamas County entered into an interagency agreement with the University of Oregon's Community Service Center (CSC) to complete Phase II of the Clackamas County Natural Hazard Mitigation Plan. The partnership with the CSC allowed the county to access the Resource Assistance for Rural Environments (RARE) program, the Community Planning Workshop (CPW), and the Oregon Natural Hazards Workgroup (ONHW) to help facilitate the development of the Clackamas County Natural Hazard Mitigation Plan.

Why Develop a Mitigation Plan?

The rising cost of natural disasters has led to a renewed interest in identifying effective ways to reduce vulnerability to disasters. Natural hazard 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 Clackamas County; (2) identify and prioritize future mitigation projects; and (3) assist in meeting the requirements of federal assistance programs. The mitigation plan works in conjunction

with other county plans, including the County Comprehensive Land Use and Emergency Operations Plans.

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

Whom Does the Mitigation Plan Affect?

The Clackamas County Natural Hazards Mitigation Plan affects unincorporated urban areas, and the rural, unincorporated areas of the county. Map 1 shows cities, urban unincorporated areas, and major roads and rivers in Clackamas County. While this plan does not establish requirements for the cities in the county, it does provide them with a framework for planning for natural hazards. The resources and background information in the plan is applicable county-wide, 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.

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.

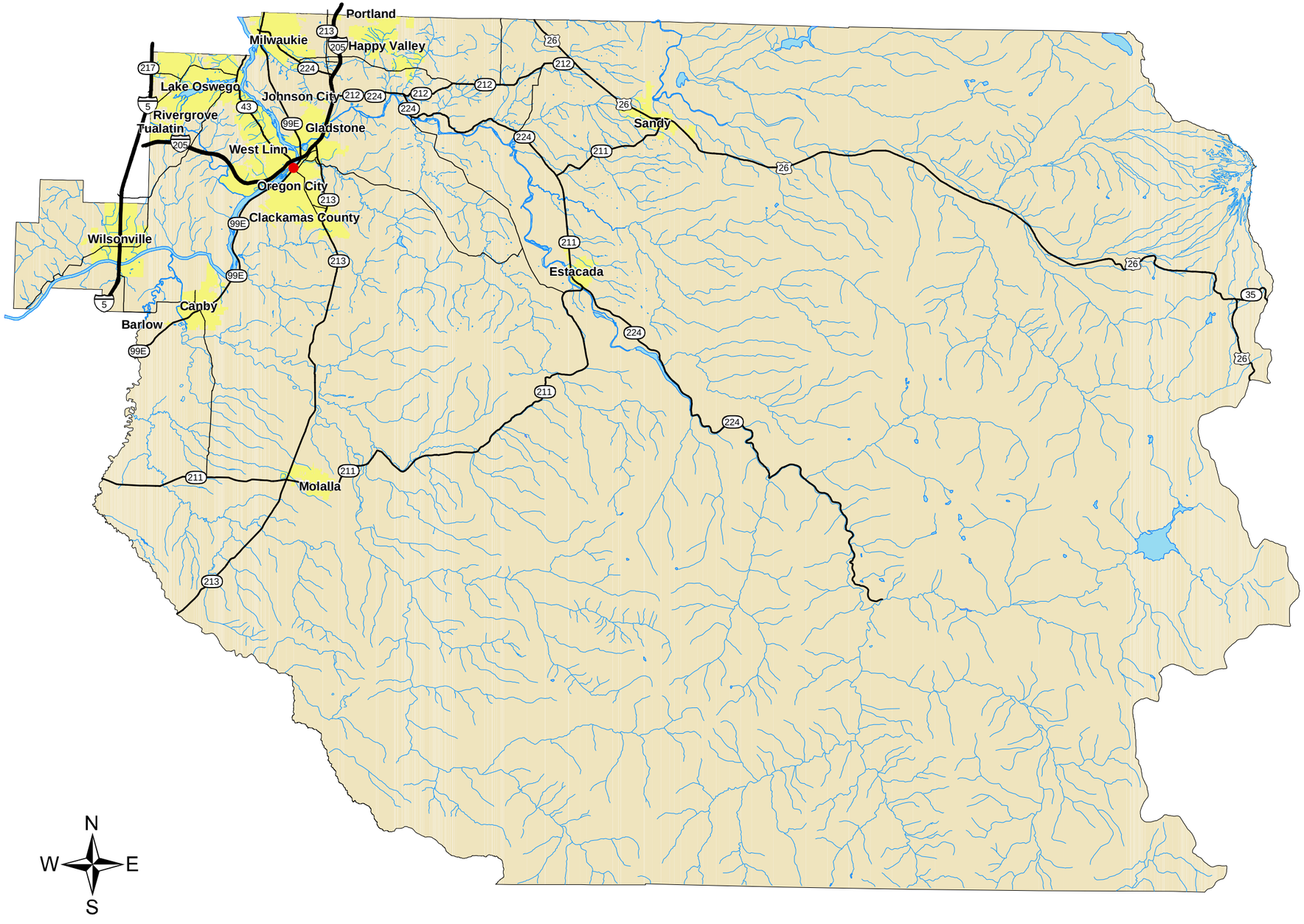
In 1996, FEMA estimated that Oregon saves about $10 million a year in flood losses because of strong land-use planning. Statewide land use planning Goal 7: Planning for Natural Hazards, calls for local plans to include inventories, policies, and ordinances to guide development in hazard areas. Goal 7,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

Map 1

Clackamas County



- County Seat
- Cities
- County Boundary
- Rivers, Creeks, and Streams
- Major Rivers and Lakes
- Interstate
- Highway
- Roads

Data Source: City Limits are maintained by Metro. The County Boundary, Hydrology, and Street layers are maintained by Clackamas County GIS Staff.

1 inch equals 5 miles

Miles

8 4 0 8

Clackamas County

GEOGRAPHIC INFORMATION SYSTEMS

DEPARTMENT OF INFORMATION SERVICES/GEOGRAPHIC INFORMATION SYSTEMS
121 LIBRARY COURT
OREGON CITY, OREGON 97045

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

- **Oregon State Police - 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)** is responsible 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.

[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

Plan Methodology

Information in the Mitigation Plan is based on research from a variety of sources. RARE/ONHW 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 the steering committee: The Hazard Mitigation Advisory Committee convened about every 6 to 8 weeks (a total of 8 meetings) to 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 representatives of public and private agencies and organizations in Clackamas County, including:

- Clackamas County Building Services
- Clackamas County Emergency Management
- Clackamas County Finance
- Clackamas County GIS
- Clackamas County Planning
- Clackamas County Project Impact
- Clackamas County Public Information Officer
- Clackamas County Roads Department
- Clackamas County Social Services
- Clackamas County Water Environment Services
- Clackamas Fire Defense Board
- Clackamas River Basin Council
- Department of Geology and Mineral Industries
- Eagle Creek/ Barton Community Planning Organization
- Federal Emergency Management Agency
- OEM Earthquake Specialist

Stakeholder interviews: The RARE participant 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. A complete listing of all stakeholders is located in Appendix B. Stakeholders interviewed for the plan included representatives from:

- Water Providers
- School Districts
- Fire Departments

- Tourism Development Council
- Utility Providers
- Local Businesses

State and federal guidelines and requirements for mitigation plans: RARE/ONHW examined existing mitigation plans from around the country, current FEMA planning standards, the FEMA Flood Mitigation Assistance Program requirements, and the National Flood Insurance Program's Community Rating System. Statewide reference materials consisted of community and county mitigation plans, including:

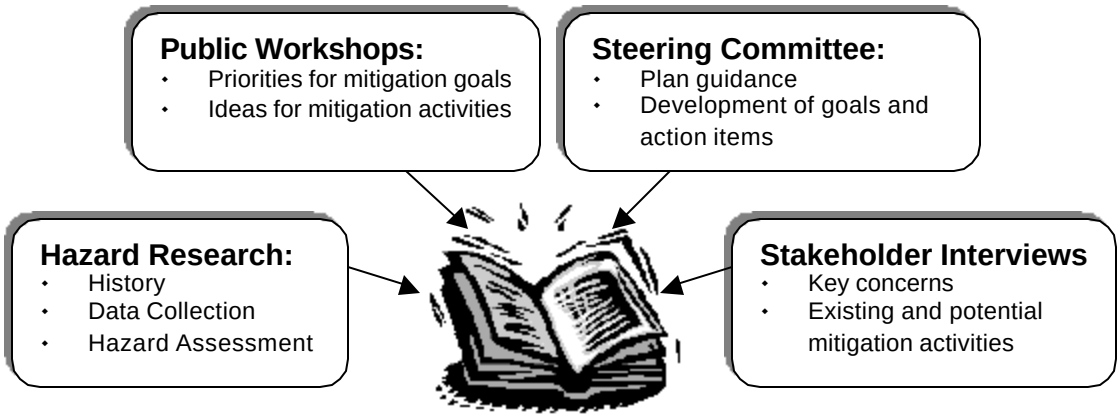
- Clackamas County All Hazard Mitigation Plan;
- Clackamas County All Hazard Mitigation Plan: Final Engineering Report;
- Oregon City Hazard Mitigation Plan;
- Metro's Regional Hazard Mitigation Policy and Planning Guide;
- *Planning For Natural Hazards: Oregon Technical Resource Guide* (DLCD);
- State of Oregon Natural Hazards Mitigation Plan (OEM); and
- Post-Disaster Hazard Mitigation Planning Guidance for State and Local Governments (OEM).

Hazard specific research: RARE/ONHW collected data and compiled research on seven 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. The RARE participant conducted research by referencing historical local newspapers, interviewing residents, and locating Clackamas County information in recent and historical scientific documents. The RARE participant identified current mitigation activities, resources and programs, and potential action items from research materials and stakeholder interviews.

Public workshops: ONHW assisted the RARE participant in facilitating two public workshops to gather comments and ideas from Clackamas County citizens about mitigation planning and priorities for mitigation plan goals. The first workshop, held February 26, 2002, attracted 15 citizens, and the second, held July 23, 2002, brought 8 citizens. Many of the residents in attendance were representatives from Clackamas County Community Planning Organizations.

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

Figure 1.1. Hazard Mitigation Planning Process



How Do I Use the Plan?

Each section of the mitigation plan provides information and resources to assist people in understanding the county and the hazard-related issues facing citizens, businesses, and the environment. Combined, the sections of the plan work together to create a document 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 Clackamas County.

The mitigation plan is organized in three volumes. Volume I contains an executive summary, introduction, county profile, risk assessment and multi-hazard section. Volume II contains the seven natural hazard sections and Volume III includes five appendices. Each section of the plan is described below.

Volume I: 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 Clackamas County.

Section 2: Community Profile

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

Section 3: Risk Assessment

This section provides information on hazard identification, vulnerability and risk associated with natural hazards in Clackamas County.

Section 4: 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.

Section 5: Plan Maintenance

This section provides information on plan implementation, monitoring and evaluation.

Volume II: 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 6: Flood***
- ***Section 7: Landslide***
- ***Section 8: Wildfire***
- ***Section 9: Severe Winter Storm***
- ***Section 10: Windstorm***

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 11: Earthquake***

- ***Section 12: 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.

Volume III: Resources

The plan appendices are designed to provide users of the Clackamas County Natural Hazards Mitigation 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 and/or financial assistance to Clackamas 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 Clackamas County Natural Hazards Mitigation Plan.

Section 2:
Community Profile

Why Plan for Natural Hazards in Clackamas County?

Natural hazards impact citizens, property, the environment, and the economy of Clackamas County. Flooding, landslides, windstorms, severe winter storms, volcanoes, and earthquakes have exposed Clackamas 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. Identifying risks posed by natural hazards, and developing strategies to reduce the impact of a hazard event can assist in protecting 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.

Geography and the Environment

Clackamas County has an area of 1,879 square miles and is located along the Willamette River in Northwestern Oregon. About one-eighth of the land area in Clackamas County is incorporated, while the majority is unincorporated. More than three-fourths of the county's area lies in the lower Willamette River basin. Other major river basins include the Clackamas, Molalla, Pudding, and Tualatin, all of which flow into the Willamette. The remaining one-fourth of the county is within the Sandy River basin, a tributary of the Columbia River.[1]

Elevations in the county range from the 11,235-foot peak at Mt. Hood to a low of 55 feet in Oregon City located on the shores of the Willamette River. There are a variety of complex eco-regions, including high-altitude forests, foothills, lowlands and valleys, prairie terraces, and riparian forest. Clackamas County has two major physiographic regions that should be considered in planning for natural hazards: the Willamette River Valley, and the Cascade Range Mountains. The Willamette Valley, in western Clackamas County, is the most heavily populated portion and is characterized by flat or gently hilly topography. The Cascade Range, in eastern and southern Clackamas County, has a relatively small population and is characterized by heavily forested slopes.[2]

Clackamas is as rich in history as it is in natural resources. It was one of the four original Oregon counties established in 1843. Oregon City, the county seat, was the first incorporated city west of the Rockies, the first capital of the Oregon Territorial Government (in 1848), the site of the first legislative session, and the official end of the Oregon Trail. Portland and Gresham in Multnomah County border Northern Clackamas County. Washington County lies to the west, Marion County to the south, and Hood River and Wasco Counties to the east. Clackamas County is part of the tri-county metro area comprised of Multnomah, Clackamas, and Washington Counties. The county is bisected north to south by Interstate 205 and east to west by Highway 26. Interstate 5 passes through the county near Wilsonville on the western edge of the county, and a railroad line travels north and south the length of the county carrying both passengers and freight.

Clackamas County has a long growing season and mild temperatures, which lead to a wide range of agricultural activities. Seasonal flooding, high ground water levels, and soil erosion cause most of the non-urban drainage problems in the county. When maintained in their natural state, Clackamas County's wetlands control runoff and decrease soil erosion and water pollution while reducing potential damage from flooding and helping to recharge water supplies.

Major Rivers

Willamette River

The Willamette River Basin covers 11,500 square miles, encompassing more than 5,000 miles of rivers and tributaries. The Willamette River is a vital, multi-purpose waterway that touches the lives of millions of people along its banks and throughout the Pacific Northwest. An important historical and cultural resource, the Willamette provides natural beauty, abundant wildlife, and varied recreational opportunities.[3] The US Army Corps of Engineers (ACOE) operates and maintains 13 reservoirs in the Willamette Basin. These federal reservoirs in the middle and upper Willamette Basin were authorized for construction beginning in the late 1930s. The projects have a combined storage capacity of over 1.6 million acre-feet. While only a small percentage of the total storage is currently under contract, summer release from the reservoirs provides in-stream benefits for fish, wildlife, navigation, and water quality. Recreational use at many of the projects is also significant[6]. The Willamette River has generated economic growth and promoted quality of life for the past 150 years. It is a source of power, irrigation, forestry, agriculture, and recreation. However, to achieve these benefits, the structure and integrity of the river have been compromised, as population growth and development have strained the land and water.

Clackamas River

The Clackamas River received its name from the Clackamas Indian tribe that once lived along the river. The Clackamas River begins high on the slopes of Olallie Butte (elevation 6,000 feet) and flows towards

its confluence with the Willamette River near Gladstone and Oregon City (elevation 12 feet). The river travels nearly 83 miles in its journey, and carves a channel through basalt rock as the river drifts beneath old growth Douglas fir. This river was added to the Federal Wild and Scenic River System in 1988, and qualifies as "outstandingly remarkable" in five different resource categories-- recreation, fish, wildlife, historic, and vegetation. Fourteen miles of the Roaring River, which drains into the Clackamas, is also designated as "wild and scenic." Four sections of the River are also listed as a State Scenic Waterway (82 miles total).[4]

The Clackamas River Basin is largely forested but has large areas of pasture used for grazing. More than 200,000 people depend on the Clackamas River for their drinking water. Parts of three streams/rivers within the watershed are listed as "water-quality limited" on the state's 303(d) list, mostly for high water temperatures in the summer. These include the: lower Clackamas River (river mouth to River Mill Dam), Fish Creek (mouth to headwaters), and Eagle Creek (mouth to wilderness boundary). Occurrences of taste and odor problems in drinking water from the river have increased in recent years, apparently due to blue-green algae blooms. Upon request of a local consortium of drinking water providers, a proposal was developed to examine nutrient, algae, and water quality conditions basin wide.[5]

The Clackamas River and its tributaries provide numerous spawning and rearing areas for steelhead, as well as Coho and Chinook salmon. However, the Endangered Species Act listed the river's steelhead as "threatened" on March 13th, 1998. The watershed is home to two wilderness areas: the Salmon-Huckleberry Wilderness and the Bull of the Woods Wilderness. More than 72 percent of land in the watershed is publicly owned, predominantly by the U.S. Forest Service.[6]

Sandy River

The Sandy River originates high on the slopes of Mt. Hood, located about 50 miles east of Portland. The headwaters are beneath Reid and Sandy Glaciers at 6000 feet in elevation. From there the river flows due west through the Hoodland Corridor. It cascades past the communities of Welches, Brightwood and Sandy, then turns north to enter the Columbia River near Troutdale, which is 10 miles east of Portland, Oregon. Two separate sections of the Sandy River have been designated Federal Wild and Scenic Waterways. The upper Sandy originates from the high glaciers of Mt. Hood; riverside trails offer spectacular scenery, easily observed geologic features, unique plant communities, and other wilderness experiences. Just outside Portland, the lower Sandy flows through a deep, winding, forested gorge known for its anadromous fish runs, botanical diversity, recreational boating, and beautiful parks.[7]

Climate

The climate of the Willamette Valley is relatively mild throughout the year, characterized by cool, wet winters and warm, dry summers.

Temperatures rarely exceed 90˚F in the summer months (April-August), and rarely drop below 30˚F in the winter months (September-March). The average growing season is about 150-180 days in the lower valley, and 110-130 days in the foothills (starting at 800 ft.). Because Clackamas County spans a wide range of physiographic regions, there is considerable variation in precipitation, with elevation as the largest factor in precipitation totals. Moving east from Oregon City at 55 ft. to Mt Hood at 11,235 ft, annual precipitation averages range from 47.06 inches to over 86.03 inches, respectively (see Map 2 at the end of this section). This change in elevation causes a significant increase in precipitation, both in the form of rain and snow. Although the majority of the county enjoys a fairly mild winter with less than 5-10 inches of snow per year, the areas surrounding the snow-capped volcano, Mt. Hood, are covered with snow for the majority of the winter months.[8]

Minerals and Soils

The characteristics of the minerals and soils present in Clackamas 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 earthquakes and landslides. Some of Oregon's richest soils are located in areas surrounding Canby, Sandy, Molalla, and Wilsonville. In fact, 87% of non-urban soil is classified as productive, agricultural land. These deep alluvial soils are rich in minerals and are great for agriculture, but serve to amplify the effects of earthquakes. Steep slopes toward the Cascade Range increase the potential for landslides. The four mineral and soil types in Clackamas County are valley fill and semi-consolidated sedimentary rocks, basaltic lavas, marine sedimentary rocks, and Eocene-age volcanic and sedimentary rocks.[9]

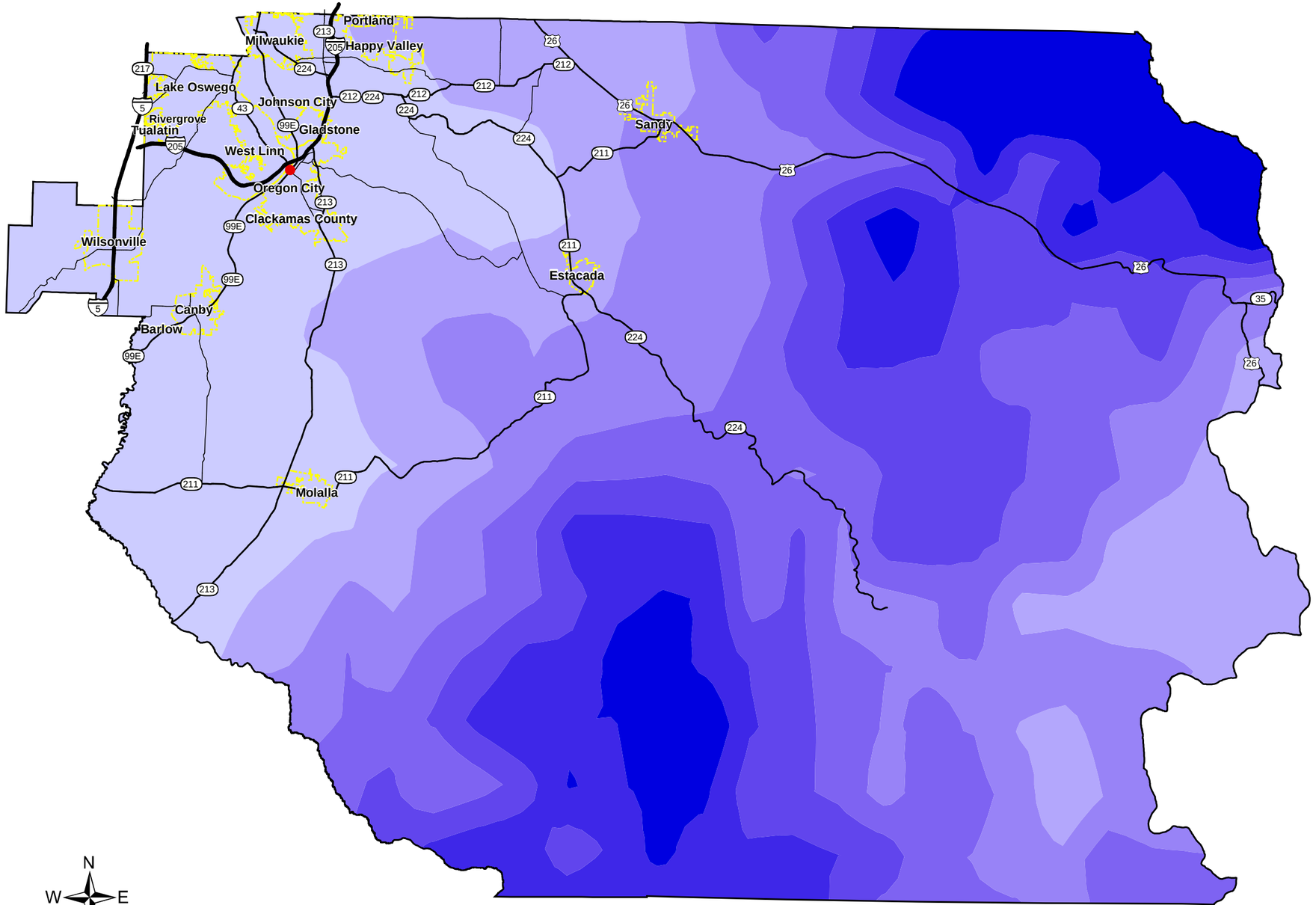
The surface material includes unconsolidated, fine–grained deposits of Willamette silt, sand, gravel, and recent floodplain deposits. Torrential flood events can introduce large deposits of sand and gravel. Sandy silt and silt containing clay are moderately dense and firm, and are primarily considered to be prone to liquefaction, an earthquake related hazard. Basaltic lava consists mainly of weathered and non-weathered, dense, fine-grained basalt. Though the characteristics 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 Clackamas County is an important step in hazard mitigation and avoiding at-risk development.[10]

Other Significant Geologic Features

Clackamas County, like most of the Pacific Northwest, lies over the area of Cascadia Subduction Zone where the North American crustal plate overrides the Juan de Fuca plate underneath the earth's crust. The fault along these two plates creates a structural sag at the Willamette River Valley. Volcanoes are present along this structural

Map 2

CLACKAMAS COUNTY AVERAGE PRECIPITATION



County Seat
Cities
County Boundary

30 Year Average Rainfall

- 40 - 50 Inches
- 51 - 60 Inches
- 61 - 70 Inches
- 71 - 80 Inches
- 81 - 90 Inches
- 91 - 100 Inches
- 101 + Inches

Interstate
Highway
Roads

Data Source: City Limits are maintained by Metro. The County Boundary, Hydrology, and Street layers are maintained by Clackamas County GIS Staff.
Thirty year precipitation information was provided by the Oregon State Climate Center.

1 inch equals 5 miles

Miles

8 4 0 8

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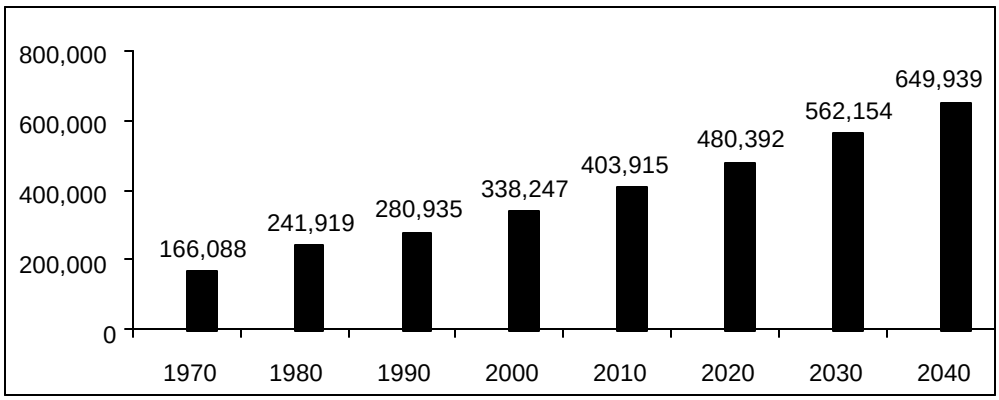
sag, and the activity on these mountains is caused by the buoyant melted rock of the Juan de Fuca plate, as it rises to the surface.

Population and Demographics

Clackamas County, one of the most rapidly growing counties in the state, has a population of about 343,000 in an area of 1,879 square miles. The population of Clackamas County has steadily increased from 1850 through 2000, and increased 19% from 1990 to 2000 according to the 2000 Census. This rapid population growth is projected to continue (as shown in Figure 2-1), according to the Oregon Office of Economic Analysis.

Figure 2-1. Historic and Projected Clackamas County Population



Source: Oregon Office of Economic Analysis

Clackamas is the third most populous county in the state, trailing only Multnomah (641,900) and Washington (397,600) counties. One in ten Oregonians called the county home in 1998, with the majority living in the rapidly expanding northwest region. The largest cities in the county are Lake Oswego and Oregon City, with 2000 populations of 34,110 and 23,405, respectively.

Table 2-1. Clackamas County Incorporated Communities

City	1990 Population	2000 Population	% Change, 1990-2000
Barlow	118	125	6%
Canby	8,990	12,595	29%
Estacada	2,016	2,200	8%
Gladstone	10,152	11,695	13%
Happy Valley	1,519	3,965	62%
Johnson City	586	615	5%
Lake Oswego*	30,576	34,110	10%
Miwaukee	18,670	20,075	7%
Molalla	3,637	5,670	36%
Oregon City	14,698	23,405	37%
Portland*	707	747	5%
Rivergrove	294	310	5%
Sandy	4,154	5,300	22%
Tualatin*	1,406	2,664	47%
Wilsonville*	7,096	12,985	45%
West Linn	16,367	22,835	28%

Source: Clackamas County website
*City has population in more than one county

In 1999-2000, the sixteen incorporated communities within the county comprised about half of the county population, leaving the other half of the population in unincorporated areas. Table 2-1 shows the percent change in Clackamas County's sixteen incorporated communities from 1990 to 2000. Population in incorporated areas has increased 29% in this time span, whereas population has increased by 9% in unincorporated areas, as shown in Table 2-2.[11]

Table 2-2. Clackamas County Population, Incorporated and Unincorporated

Year	Incorporated	Unincorporated
1990	118,727	160,123
2000	166,573	176,288
% Change (1990-2000)	29%	9%

Source: 2000 Census

The increase of people living in Clackamas County creates more community exposure, and changes how agencies prepare for and respond to natural hazards. For example, more people living on the urban fringe can increase 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. 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 chances of fires spreading.

Natural hazards do not discriminate, but the impacts in terms of vulnerability and the ability to recover vary greatly among the population.[12] According to Peggy Stahl of the Federal Emergency Management Agency (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.[13]

According to the 2000 census, 17,383 Hispanics or Latinos currently reside in Clackamas County. This population makes up 5.1% of the county's total population. The 2000 US Census reports that 10,662 (3.1%) residents are Asian, and 10,045 (2.9%) are American Indian, Alaskan Native, or other ethnic descent. The ethnic and cultural diversity suggests a need to address multi-cultural needs and services.

Although the percentage of poverty in Clackamas County (6.9%) is about half that of the state's (12.4%), 18.8% of the people living in poverty in Clackamas County are under 18 years old, and 19.9% are over 65.[14] Vulnerable populations, including seniors, disabled citizens, women, and children, as well as those people living in poverty, may be disproportionately impacted by natural hazards. Examining the reach of hazard mitigation policies to special needs populations may assist in increasing access to services and programs. FEMA's Office of Equal Rights addresses this need by suggesting that agencies and organizations planning for natural disasters identify special needs populations, make recovery centers more accessible, and review practices and procedures to remedy any discrimination in relief application or assistance.[15]

The cost of natural hazards recovery can place an unequal financial responsibility on the general population when only a small proportion may benefit from governmental funds used to rebuild private structures.[16] Discussions about natural hazards that include local citizen groups, insurance companies, and other public and private sector organizations can help ensure that all members of the population are a part of the decision-making processes.

Land and Development

When the pioneers first settled in Clackamas County, natural resources appeared infinite. They cleared forests, carved towns from the wilderness, and used waterways as arterials of commerce. Some lands were valued for certain uses more than others. The alluvial valley of the Willamette River was among the first areas to be cleared for agriculture. The falls in Oregon City was one of the first industrial sites. From the earliest days, the value of the land in the area was recognized and exploited for man's benefit. Throughout the years, the limitations of the resources in the county have created a heightened awareness of the benefits of land use and development regulations. The

steadily growing population in the county demands strong land use planning and community involvement.[17]

The Clackamas County Comprehensive Plan designates the use and development of private land, including agricultural land, river corridors, forestland and residential and commercial areas. This plan is one of the county's most important tools in addressing environmental challenges including transportation and air quality; growth management; conservation of natural resources; clean water and open space.[18]

The resources and natural systems of Clackamas County are the most enduring and tangible assets for its communities and their economies and environment. River corridors, farm fields, marshes, scenic outlooks, wildflowers, spawning beds for salmon, deer and elk wintering areas, magnificent stands of trees along Oatfield Ridge, or reservoirs of hot water beneath the slopes of Mt. Hood are all part of the wealth of Clackamas County's environment.

To ensure that rural development occurs in a manner that will help protect agricultural land and other natural lands from premature development, a regional government was formed to serve residents in Clackamas, Multnomah, and Washington counties and twenty-four cities in the Portland metropolitan area. This regional government is termed Metro, and the primary mission of this entity is to manage growth in this region.[19] Urban Growth Boundaries were developed to identify buildable lands that are intended to satisfy the demands of population and employment growth for a 20-year period.

Housing and Community Development

The attractive nature of Clackamas County with its rural settings and smaller cities, along with relatively low interest rates from late 1996 to the spring of 1999, has contributed a great deal to a strong real estate market. The average annual in-migration throughout the 1990s has a rate of more than 1.5%, which has kept the demand for housing at similar levels as in prior years. Residential values increased from 1997 to 1998 at an average of 4.9% from 1996 to 1997. Demand for low to medium priced homes continues to be strong. The average value for homes in rural and urban Clackamas County are comparable, estimated at $190,000.[20]

To address development issues, the Community Development Agency has engaged in activities that promote the quality of life for the citizens of Clackamas County. The large-scale effort is termed the Clackamas County Community Program, and includes neighborhood and other public facility improvements, rehabilitation of existing housing, and new housing development. Program activities must primarily benefit households or individuals who meet U.S. Department of Housing and Urban Development (HUD) low and moderate-income limits.

HUD provides funding for Clackamas County's Community Program. Active federal programs include Community Development Block Grants (CDBG), Emergency Shelter Grants (ESG) and the HOME Investment Partnership Program.[21] The primary resource available to address non-housing community development needs is the Community Development Block Grant (CDBG). Clackamas County's ESG allocation for the year 2000 will be $87,000, the same amount as the 1999 allocation. The County plans to distribute the funds to selected existing shelters to assist with covering operating costs.

The Clackamas County Economic Development Commission (EDC) is a body that helps to promote economic prosperity throughout the county. The EDC's mission is to promote development while maintaining quality of life and integrity of the environment.[22]

There is an increased concentration of resources and capital in Clackamas County.[23] The best indicator of this fact is the increasing per capita personal income in the region since the 1970's. 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 Oregon's and the United State's average per capita incomes, resulting in a more affluent community than the average population.[24]

Employment and Industry

Agriculture, timber, manufacturing, and commerce are Clackamas County's principal employment and industrial activities. The county business climate has been strong and growing with concentrations of metals fabrication, machinery, and computer hardware and software firms. Clackamas County provided over 126,000 jobs in 1998, or about 8% of statewide covered employment. Trade-related industries accounted for the largest percentage (30%), followed by services (23%) manufacturing (14%) and government (12%). The county also had significant employment in construction (7%); finance, insurance, and real estate (6%); and transportation, communications, and utilities (4%). Farming, forestry, and fishing provided a large number of jobs, but are not covered by unemployment insurance, so they cannot be quantified, but are estimated to be about 4%.[25]

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 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

Clackamas County is the largest county in the Portland Metropolitan Statistical Area (PMSA). Over the past decade, the PMSA experienced rapid growth in employment and population. There has been a 33% increase in vehicle licensing transactions and a 44% increase in vehicle miles traveled in Clackamas County alone [22]. In the 1990's, transportation systems in Clackamas County expanded and evolved, increasing complexity in order to meet the needs of the growing region. The county's 1,436-mile road system includes 276 urban road miles, 1160 rural road miles, and 158 bridges.[26]

In rural Clackamas 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 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 Clackamas County meets its current transportation needs through a mixture of municipal road systems, county roads, state and federal highways, a regional transit system (Tri-Met), and various city-contracted bus systems. Tri-Met provides both bus and light rail service to the county and to the larger Portland metropolitan area. In addition to this service, the county promotes alternative transportation activities. The Pedestrian Bikeway Advisory Committee was formed to encourage safe bicycling and walking as a significant means of transportation in Clackamas County. Its goals include the development of a coordinated system of safe and convenient bikeways and walkways, the stimulation of public awareness and the examination of current and future financing options and budget strategies for bicycle and pedestrian projects. The county also supports the Canby Ferry, which can transport nine vehicles per trip across the Willamette River to Wilsonville.

According to Oregon Employment Department: 2000-Regional Economic Profile for Region 15, close to 55 percent of Clackamas County's population works outside of the county, which is a significantly greater proportion than in any of the three other counties in the metropolitan area. This suggests that population growth in the county is a more suburban phenomenon, where residents work on Portland but prefer to live outside the urban core. However, a rapid growth rate in the high technology industry in Clackamas County has attracted commuters to travel in the opposite direction as well, with more than one in three jobs in Clackamas County filled by non-residents.

The county is well served by Interstates 5 and 205, tying the region to the Portland Metropolitan area. The county's seven biggest cities can be found near these major transportation corridors. Interstate 5 runs north-south, connecting Portland to the state capital, Salem. Interstate

205, and nearby State Highways 99E, 43, and 213 offer convenient access to the county and surrounding areas. Highway 26 runs east-west, and can be used to travel towards the coast, or to Mt. Hood. 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.

Community Profile Endnotes

[1] Clackamas county website: http://www.co.clackamas.or.us/co_dev/cityrev.html

[2] All Hazard Mitigation Plan Clackamas County, Oregon. G&E Engineering Systems Report 32.07.01, Revision. September 23, 1998.

[3] http://www.willamette.edu/~broesler/riverweb/mainframeset.htm

[4] http://www.metro-region.org/metro/growth/water/atlasfacts.html

[5] http://oregon.usgs.gov/clackamas/or176.html

[6] http://oregon.usgs.gov/clackamas/or176.html

[7] http://www.nps.gov/rivers/wsr-sandy.html

[8] Taylor, George H. , Hannan, Chris, The Climate of Oregon (1999). Oregon State University Press. Corvallis, Orgon.

[9] Schlicker, Herbert G. and Deacon, Robert J., *Engineering geology of the Tualatin Valley Region, Oregon* (1967), (Bulletin 60). Oregon: Department of Geology and Mineral Industries.

[10] Schlicker, Herbert G. and Deacon, Robert J., *Engineering geology of the Tualatin Valley Region, Oregon* (1967), (Bulletin 60). Oregon: Department of Geology and Mineral Industries.

[11] US Bureau of Census, 1990 and 2000 Redistricting Data (P.L. 94-171), Office of Economic Analysis, DAS, State of Oregon.

[12] Hazards Workshop *Session Summary #16, Disasters, Diversity, and Equity*. Annual Hazards Workshop, (July 12, 2000) University of Colorado, Boulder.

[13] http://www.fema.gov/

[14] US Bureau of Census, 1990 and 2000 Redistricting Data (P.L. 94-171), Office of Economic Analysis, DAS, State of Oregon.

[15] Hazards Workshop *Session Summary #16, Disasters, Diversity, and Equity*. Annual

Hazards Workshop, (July 12, 2000) University of Colorado, Boulder.

[16] Ibid

[17] Clackamas County Comprehensive Land Use Plan, 1992.

[18] Clackamas County Comprehensive Land Use Plan, 2000.

[19] Metro http://www.metro.dst.or.us/metro/growth/ugbursa/ugb.html (February 2001).

[20] http://www.co.clackamas.or.us/dtd/buserv/

[21] http://www.hud.gov/

[22] Ibid

[23] http://www.co.clackamas.or.us/cd/

[24] Oregon Economic and Community Development: http://www.econ.state.or.us/,

(February 2001).

[25] Oregon Employment Department: 2000 Regional Economic Profile: Region Fifteen,

(October 1999).

[26] http://www.co.clackamas.or.us/dtd/

Section 3:
Risk Assessment

What is a Risk Assessment?

Conducting a risk 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 risk assessment are as follows:

1) ***Hazard Identification*** identifies the geographic extent and intensity of the hazard, the intensity of the hazard, and the probability of its occurrence. Maps are frequently used to display hazard identification data. Clackamas County identified seven major hazards that consistently affect this geographic area. These hazards – floods, landslides, wildfires, earthquakes, severe winter storms, windstorms, and volcanoes – were identified through an extensive process that utilized input from the Hazard Mitigation Advisory Committee (comprised of representatives from FEMA Region Ten, county agencies, community groups, the Department of Oregon Emergency Management, and the Oregon Natural Hazard Workgroup), as well as recommendations from the Goetell and Associates engineering firm, which developed Phase I of the Clackamas County Natural Hazard Mitigation Plan. The geographic extent of each of the identified hazards has been identified by the Clackamas County GIS department using the best available data, and is illustrated by the maps listed in Table 3-1.

2) ***Profiling Hazard Events*** describes the causes and characteristics of each hazard, how it has affected Clackamas County in the past, and what part of Clackamas County's population, infrastructure, and environment has historically been vulnerable to each specific hazard. A profile of each hazard discussed in this plan is provided in each hazard section. For a full description of the history of hazard specific events, please see the appropriate hazard chapter.

3) ***Vulnerability Assessment/Inventorying Assets*** combines hazard identification with an inventory of the existing (or planned) property and population exposed to a hazard. Critical facilities are of particular concern because these entities provide essential products and services to the general public that are necessary to preserve the welfare and quality of life in the county and fulfill important public safety, emergency response, and/or disaster recovery functions. The critical facilities have been identified, mapped, and are illustrated in Map 3 at the end of this section. A description of the critical facilities in the county is also provided in this section. In addition, this plan includes a community issues summary in each hazard

section to identify the most vulnerable and problematic areas in the county, including critical facilities, and other public and private property.

4) ***Risk Analysis/Estimating Potential Losses*** 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. Describing vulnerability in terms of dollar losses provides the community and the state with a common framework in which to measure the effects of hazards on assets. Using the best available data, Goetell and Associates estimated potential losses from the natural hazards discussed in the plan. For each hazard where data was available, quantitative estimates for potential losses are included in the hazard assessment.

5) ***Assessing Vulnerability/ Analyzing Development Trends*** provides a general description of land uses and development trends within the community so that mitigation options can be considered in land use planning and future land use decisions. This plan provides comprehensive description of the character of Clackamas County in the Community Profile. This description includes the geography and environment, population and demographics, land use and development, housing and community development, employment and industry, and transportation and commuting patterns. Analyzing these components of Clackamas County can help in identifying potential problem areas, and can serve as a guide for incorporating the goals and ideas contained in this mitigation plan into other community development plans.

Table 3-1. List of Hazard Mitigation Plan Maps

Map #	Type of Map	Section of the Plan
1	Base Map of Clackamas County	Section 1: Introduction
2	Precipitation	Section 2: Community Profile
3	Critical Facilities	Section 3: Risk Assessment
4	Essential Facilities	Section 3: Risk Assessment
5	Infrastructure	Section 3: Risk Assessment
6	County 100-Year Flood plain	Section 6: Flood
7	River basin Map	Section 6: Flood
8	Landslide & Debris Flow Areas	Section 7: Landslides
9	Metro Landslide Areas	Section 7: Landslides
10	Slope Map	Section 7: Landslides
11	Fire Districts	Section 8: Wildfire
12	Wildfire Risk Areas	Section 8: Wildfire
13	DOGAMI earthquake map	Section 11: Earthquake
14	Volcano Risk Area	Section 12: Volcanic Eruption

***Note**: The information on the maps in this plan was derived from Clackamas County's GIS. Care was taken in the creation of these maps, but is provided "as is." Clackamas County cannot accept any responsibility for any errors, omissions or positional accuracy, and therefore, there are no warranties that accompany these products (the maps). Although information from Land Surveys may have been used in the creation of these products, in no way does this product represent or constitute a Land Survey. Users are cautioned to field verify information on this product before making any decisions.*

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 plan includes a section on hazard identification using data and information from county or state agency sources.

Clackamas County 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: landslides,

THREE PHASES OF HAZARD ASSESSMENT:

Hazard Identification → Vulnerability Assessment → Risk Analysis

severe winter storms, windstorms, wildfires, and volcanic eruptions.

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 each hazard section 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.

Federal Requirements for Risk Assessment

Recent federal regulations for hazard mitigation plans outlined in 44 CFR Part 201 include a requirement for risk assessment. This risk assessment requirement is intended to provide information that will help communities to identify and prioritize mitigation activities that will reduce losses from the identified hazards. There are seven hazards profiled in the mitigation plan, including floods, landslides, wildfires, earthquakes, winter storms, windstorms, and volcanic eruptions. The Federal criteria for risk assessment and information on how the Clackamas County Natural Hazard Mitigation Plan meets those criteria is outlined in Table 3-2 below.

Table 3-2. Federal Criteria for Risk Assessment

Section 322 Requirement	How is this addressed?
Identifying Hazards	Each hazard section includes an inventory of the best available data sources that identify hazard areas. To the extent GIS data are available, the county developed maps identifying the location of the hazard in the county. The Executive Summary and the Risk Assessment sections of the plan include a list of the hazard maps.
Profiling Hazard Events	Each hazard section includes documentation of the history, and causes and characteristics of the hazard in the county.
Assessing Vulnerability: Identifying Assets	Where data is available, the vulnerability assessment for each hazard addressed in the mitigation plan includes an inventory of all publicly owned land within hazardous areas. Each hazard section provides information on vulnerable areas in the county in the Community Issues section. Each hazard section also identifies potential mitigation strategies.
Assessing Vulnerability: Estimating Potential Losses	The Risk Assessment Section of this mitigation plan identifies key critical facilities and lifelines in the county and includes a map of these facilities. Vulnerability assessments have been completed for the hazards addressed in the plan, and quantitative estimates were made for each hazard where data was available.
Assessing Vulnerability: Analyzing Development Trends	The Clackamas County Profile Section of this plan provides a description of the development trends in the county, including the geography and environment, population and demographics, land use and development, housing and community development, employment and industry, and transportation and commuting patterns.

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 shelters. 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.

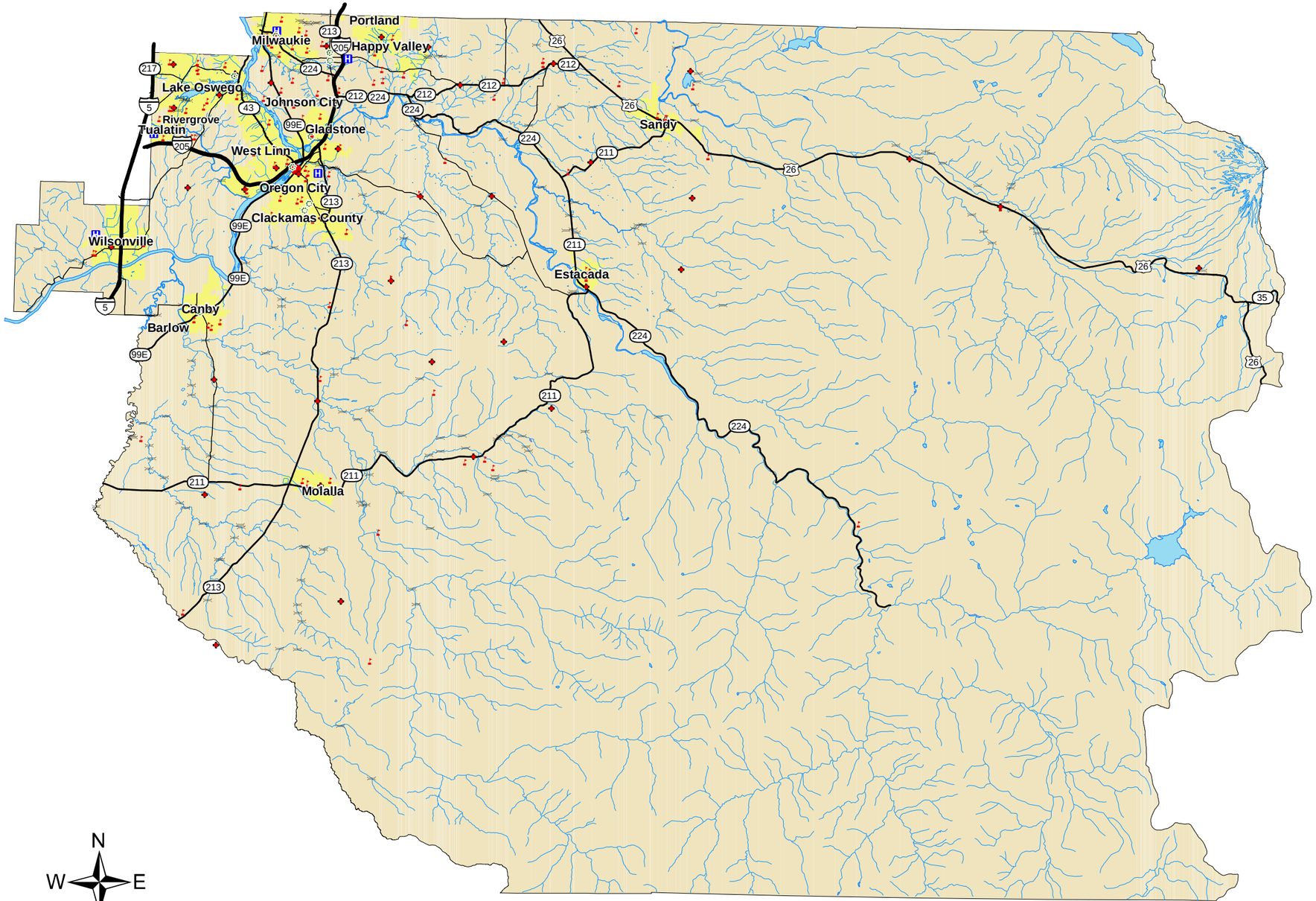
Critical and essential facilities are those facilities that are vital to the continued delivery of key government services or that may significantly impact the public's ability to recover from the emergency. These facilities may include: buildings such as the jail, law enforcement center, public services building, community corrections center, the courthouse, and juvenile services building and other public facilities such as schools. The maps on the following pages illustrate the critical facilities, essential facilities, public infrastructure, and emergency transportation routes within Clackamas County.

Summary

Natural hazard mitigation strategies can reduce the 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 the impacts of natural hazards.

Map 3

Critical Facilities



- Bridges
- Fire Stations
- Law Enforcement Offices
- Hospital
- County Seat
- Schools
- Cities
- County Boundary
- Rivers, Creeks, and Streams
- Major Rivers and Lakes
- Interstate
- Highway
- Roads

Data Source: City Limits are maintained by Metro. The County Boundary, Hydrology, and Street layers are maintained by Clackamas County GIS Staff.

1 inch equals 5 miles

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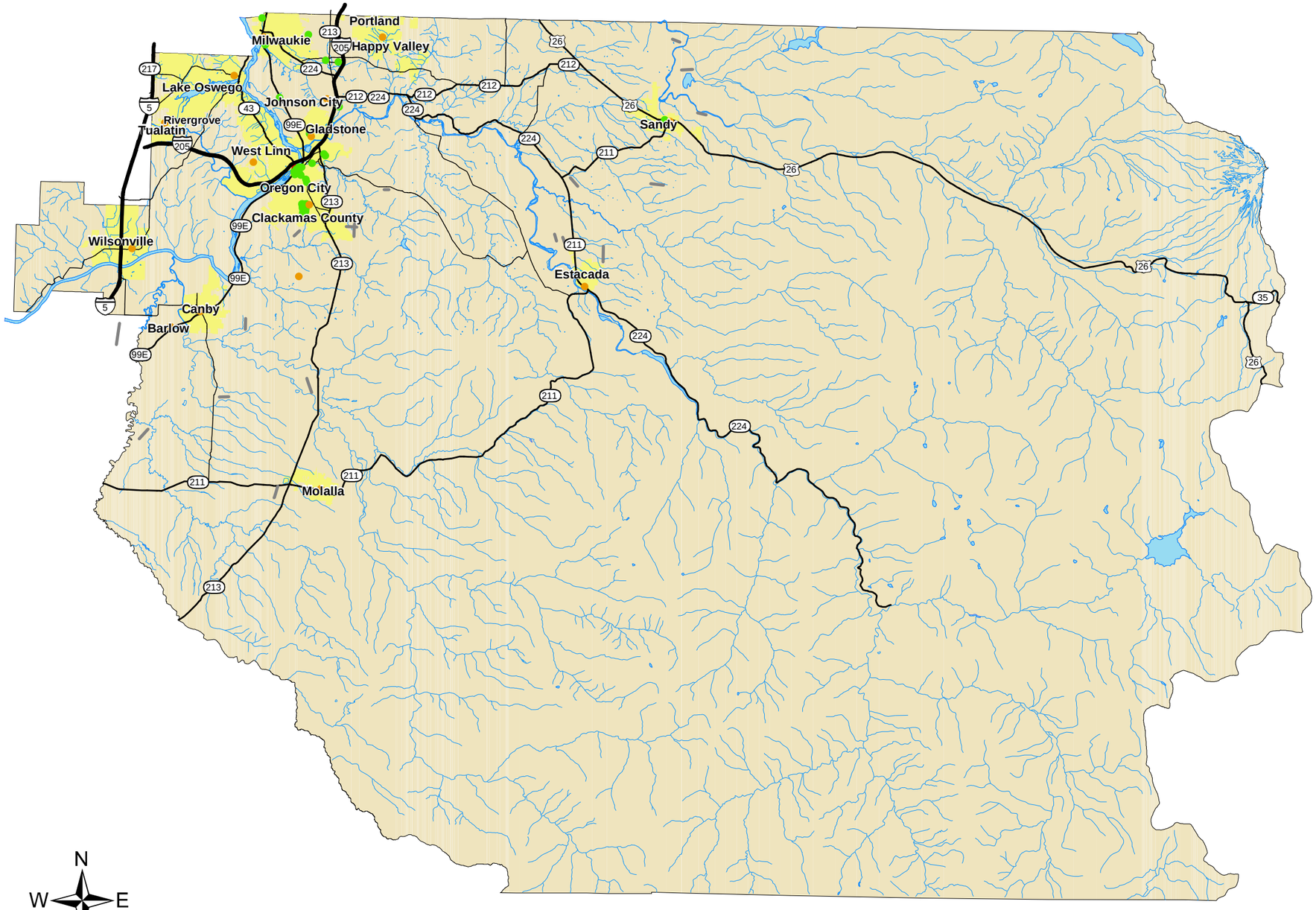
Map 4

Essential Facilities



- City Hall
- County Buildings
- County Seat
- Cities
- County Boundary
- Airport Runways
- Rivers, Creeks, and Streams
- Major Rivers and Lakes
- Interstate
- Highway
- Roads

Data Source: City Limits are maintained by Metro. The County Boundary, Hydrology, and Street layers are maintained by Clackamas County GIS Staff.

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Miles

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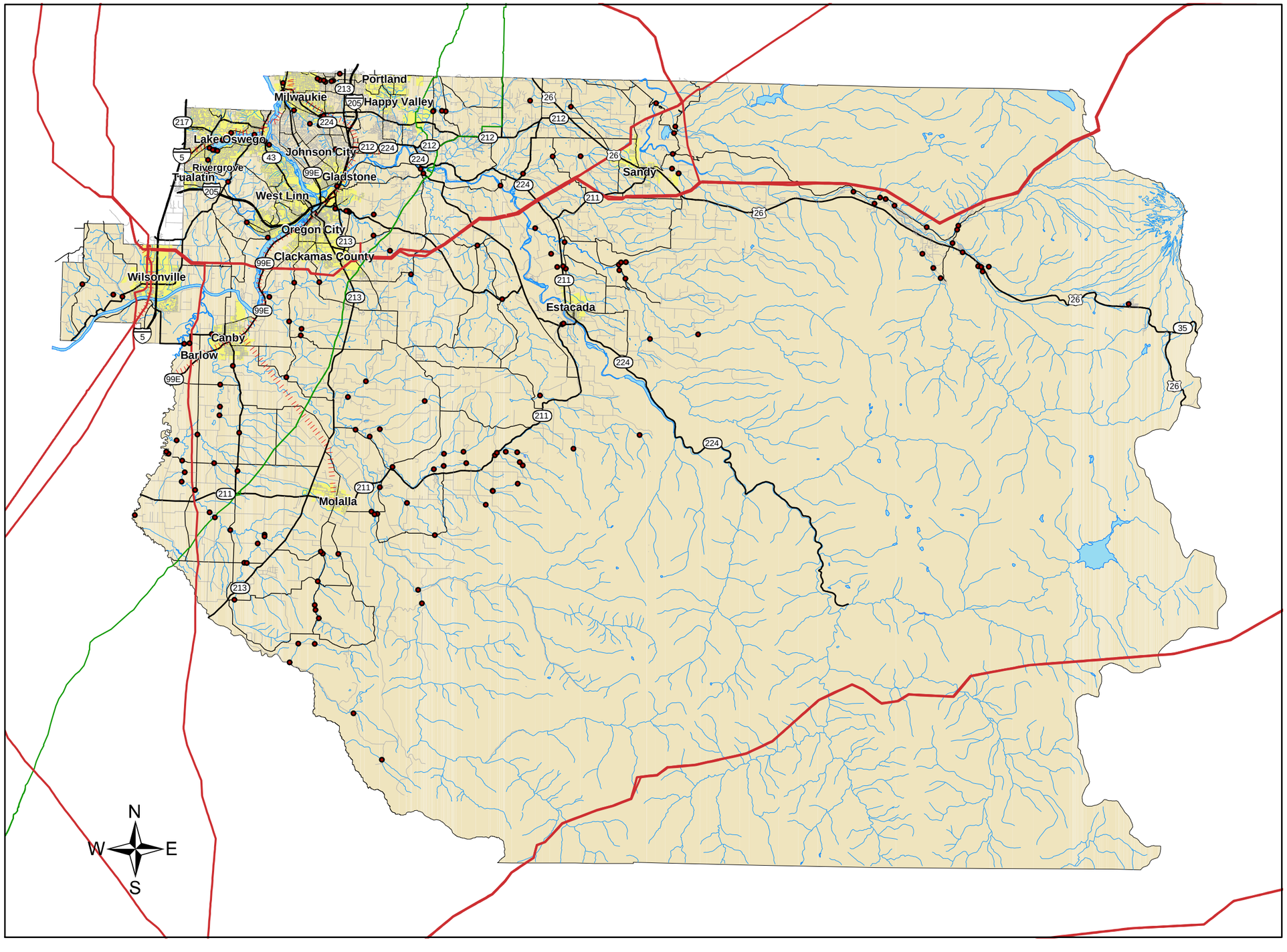
Map 5

Clackamas County Infrastructure



- Bridges
- Cities
- County Boundary
- BPA Power Lines
- Natural Gas Lines
- Railroads
- Rivers, Creeks, and Streams
- Major Rivers and Lakes
- Interstate
- Highway
- Roads

Data Source: City Limits are maintained by Metro. The County Boundary, Hydrology, and Street layers are maintained by Clackamas County GIS Staff.

Natural Gas Lines are from Northwest Natural Gas.

Bonneville Power Administration provided the 1999 Power lines data.

1 inch equals 5 miles

Miles

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Section 4:
Multi-Hazard Goals and Action Items

This section provides information on the process used to develop goals and action items that pertain to 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 Clackamas County Natural Hazards Mitigation Plan is to promote sound public policy designed to protect citizens, critical facilities, infrastructure, private property, and the environment from natural hazards. This can be achieved by increasing public awareness, documenting the resources for risk reduction and loss-prevention, and identifying activities to guide the county towards building a safer, more sustainable community.

Goals

The plan *goals* describe the overall direction that Clackamas County agencies, organizations, and citizens can take to minimize the impacts of 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 a listing of activities in which county agencies and citizens can be engaged to reduce risk. Each action item includes an estimate of the timeline for implementation. *Short-term action items (ST)* are activities that 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.

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.

Protect Life and Property

- Implement activities that assist in protecting lives by making homes, businesses, infrastructure, critical facilities, and other property more resistant to natural hazards.

- Reduce losses and repetitive damages for chronic hazard events while promoting insurance coverage for catastrophic hazards.
- Improve hazard assessment information to make recommendations for discouraging new development and encouraging preventative measures for existing development in areas vulnerable to natural hazards.

Public Awareness

- Develop and implement education and outreach programs to increase public awareness of the risks associated with natural hazards.
- Provide information on tools, partnership opportunities, and funding resources to assist in implementing mitigation activities.

Natural Systems

- Balance watershed planning, natural resource management, and land use planning with natural hazard mitigation to protect life, property, and the environment.
- Preserve, rehabilitate, and enhance natural systems to serve natural hazard mitigation functions.

Partnerships and Implementation

- Strengthen communication and coordinate participation among and within public agencies, citizens, non-profit organizations, business, and industry to gain a vested interest in implementation.
- Encourage leadership within public and private sector organizations to prioritize and implement local, county, and regional hazard mitigation activities.

Emergency Services

- Establish policy to ensure mitigation projects for critical facilities, services, and infrastructure.
- Strengthen emergency operations by increasing collaboration and coordination among public agencies, non-profit organizations, business, and industry.
- Coordinate and integrate natural hazard mitigation activities, where appropriate, with emergency operations plans and procedures.

Public Participation

Public input 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 Clackamas County.

On February 26, 2002, the first public workshop was held to gather ideas from Clackamas County residents regarding the goals for the Clackamas County Natural Hazards Mitigation Plan. The 25 attendees included representatives from public agencies, private organizations, Community Planning Organizations, and private residents. The attendees identified goals for the plan by examining the issues and concerns that they have had regarding natural hazards, and further discussed potential action items for the Plan. The second public workshop was held July 23, 2002 to review mitigation plan action items and provide the participants with a chance to comment on the final plan recommendations. Eight members of Community Planning Organizations attended this workshop.

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 when other funds are made available through the county. Action items address multi-hazard (MH) and hazard specific issues. To help ensure activity implementation, each action item includes information on the timeline and coordinating organizations. Upon implementation, the coordinating organizations may look to partner organizations for resources and technical assistance. A description of the partner organizations is provided in Appendix A, the resource directory of this plan.

- **Coordinating Organization**. The coordinating organization is the organization 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.
- **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 that 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.

Multi-Hazard Action Items (MH)

Multi-hazard action items are those activities that pertain to all seven hazards in the mitigation plan: flood, landslide, wildfire, severe winter storm, windstorm, earthquake, and volcanic eruption. There are six short-term and three long-term multi-hazard action items described below.

ST-MH#1: Integrate the goals and action items from the Clackamas County Natural Hazard Mitigation Plan into existing regulatory documents and programs, where appropriate.

Ideas for Implementation:

- Use the mitigation plan to help the county's Comprehensive Land Use Plan meet State Land Use Planning Goal 7, designed to protect life and property from natural disasters and hazards through planning strategies that restrict development in areas of known hazards;
- Integrate the county's mitigation plan into current capital improvement plans to ensure that development does not encroach on known hazard areas; and
- Partner with other organizations and agencies with similar goals to promote building codes that are more disaster resistant at the state level.

Coordinating Organization: Hazard Mitigation Advisory Committee
Timeline: Ongoing
Plan Goals Addressed: Partnerships and Implementation

ST-MH#2: Identify and pursue funding opportunities to develop and implement local and county mitigation activities.

Ideas for Implementation:

- Develop incentives for local governments, citizens, and businesses to pursue hazard mitigation projects;
- Allocate county resources and assistance to mitigation projects when possible; and
- Partner with other organizations and agencies in Clackamas County to identify grant programs and foundations that may support mitigation activities.

Coordinating Organization: County Dept. of Transportation and Development, County Emergency Management
Timeline: Ongoing
Plan Goals Addressed: Partnerships and Implementation

ST-MH#3: Establish a formal role for the Clackamas County Natural Hazards Mitigation Committee to develop a sustainable process for implementing, monitoring, and evaluating countywide mitigation activities.

Ideas for Implementation:

- Establish clear roles for participants, meeting regularly to pursue and evaluate implementation of mitigation strategies.
- Oversee implementation of the mitigation plan.
- Establish measurable standards to evaluate mitigation policies and programs and provide a mechanism to update and revise the mitigation plan.
- Monitor hazard mitigation implementation by jurisdictions and participating organizations through surveys and other reporting methods.
- Develop updates for the Natural Hazards Mitigation Action Plan based on new information.
- Conduct a full review of the Natural Hazards Mitigation Action Plan every 5 years by evaluating mitigation successes, failures, and areas that were not addressed.
- Provide training for Committee members to remain current on developing issues in the natural hazard loss reduction field.

Coordinating Organization:	Hazard Mitigation Advisory Committee
Timeline:	Ongoing
Plan Goals Addressed:	Partnerships and Implementation

ST-MH#4: Identify, improve, and sustain collaborative programs focusing on the real estate and insurance industries, public and private sector organizations, and individuals to avoid activity that increases risk to natural hazards.

Ideas for Implementation:

- Distribute information about flood, fire, earthquake, and other forms of natural hazards insurance to property owners in areas identified to be at risk through hazard mapping.
- Develop a one-page handout on types of insurance and deliver through county utility or service agencies.
- Educate individuals and businesses on the benefit of engaging in mitigation activities such as developing impact analyses.
- Pinpoint areas of high risk and transfer the cost of risk to property owners through insurance (rather than to the public).
- Encourage the development of unifying organizations to ensure communication and dissemination of natural hazard mitigation information.

- Identify activities for private sector and citizen involvement such as nonstructural seismic daycare retrofits.

Coordinating Organization:	County Emergency Management, County Public and Government Relations, County Economic Development
Timeline:	Ongoing
Plan Goals Addressed:	Protect Life and Property, Public Awareness, Partnerships and Implementation

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

Ideas for Implementation:

- Work with city governments to develop local Natural Hazards Mitigation Plans that are consistent with the goals and framework of the county plan.
- Identify all organizations within Clackamas County that have programs or interests in natural hazards mitigation.
- Involve private businesses throughout the county in mitigation planning.
- Improve communication between ODOT and county road departments, and work together to prioritize and identify strategies to deal with road problems.
- Establish protocol for communication electric providers and the Department of Transportation and Development to assure rapid restoration of transportation capabilities.

Coordinating Organization:	County Emergency Management, County Economic Development, County Dept. of Transportation and Development
Timeline:	Ongoing
Plan Goals Addressed:	Partnerships and Implementation

ST-MH#6: Develop inventories of at-risk buildings and infrastructure and prioritize mitigation projects.

Ideas for Implementation:

- Identify critical facilities at risk from natural hazards events.
- Develop strategies to mitigate risk to these facilities, or to utilize alternative facilities should natural hazards events cause damages to the facilities in question.
- Incorporate the building inventory developed by the Department of Geology and Mineral Industries (Dec. 2002) into the hazard assessment.

- Identify bridges at risk from flood or earthquake hazards, identify enhancements, and implement projects needed to reduce the risks.

Coordinating Organization: County Emergency Management, County Dept. of Transportation and Development, County Geographic Information Systems
Timeline: 1-2 Years
Plan Goals Addressed: Protect Life and Property, Partnerships and Implementation

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LT-MH#1: Strengthen emergency services preparedness and response by linking emergency services with natural hazard mitigation programs, and enhancing public education on a regional scale.

Ideas for Implementation:

- Educate private property owners on limitations of bridges and dangers associated with them.
- Develop a process to encourage private property owners to upgrade their bridges to support weight of fire trucks and emergency vehicles.
- Encourage individual and family preparedness through public education projects such as safety fairs.
- Coordinate the maintenance of emergency transportation routes though communication among the County Roads Department, neighboring jurisdictions, and the Oregon Department of Transportation.
- Identify opportunities for partnering with citizens, private contractors, and other jurisdictions to increase availability of equipment and manpower for efficiency of response efforts.
- Work with Community Planning Organizations (CPO's) and other neighborhood groups to establish community response teams.
- Familiarize public officials of requirements regarding public assistance for disaster response.

Coordinating Organization: County Emergency Management, County Department of Development and Transportation
Timeline: Ongoing
Plan Goals Addressed: Emergency Services

LT-MH#2: 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:

- Make the Clackamas County Natural Hazards Mitigation Plan available to the public by publishing the plan electronically on the county and emergency management websites.
  - Enhance C-map capabilities by creating a website that includes information specific to Clackamas County residents, including site-specific hazards information, building codes information, insurance companies that provide earthquake insurance for county residents, and educational information on damage prevention.
  - Develop a web page to facilitate Internet discussions and information sharing.
- 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.
- Develop outreach programs to business organizations that must prepare for flooding events.
- Develop adult and child educational programs to be used by local radio and cable stations.
- Use local radio and cable stations as a conduit for advertising public forums.

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.
- Conduct workshops for public and private sector organizations to raise awareness of mitigation activities and programs.
- Develop outreach materials for mitigation, preparedness, response and recovery.

Coordinating Organization:	Public and Government Relations, County Geographic Information Systems, County Social Services
Timeline:	Ongoing
Plan Goals Addressed:	Public Awareness, Protect Life and Property

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

Ideas for Implementation:

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

Coordinating Organization:	County Dept. of Transportation and Development, Water Environment Services
Timeline:	Ongoing
Plan Goals Addressed:	Natural Systems

Section 5:
Plan Maintenance

The plan maintenance section of this document details the formal process that will ensure that the Clackamas County Natural Hazards Mitigation Plan remains an active and relevant document. The plan maintenance process includes a schedule for monitoring and evaluating the Plan annually and producing a plan revision every five years. This section describes how the county will integrate public participation throughout the plan maintenance process. Finally, this section includes an explanation of how Clackamas County government intends to incorporate the mitigation strategies outlined in this Plan into existing planning mechanisms such as the County Comprehensive Land Use Plan, Capital Improvement Plans, and Building Codes.

Monitoring and Implementing the Plan

Plan Adoption

The Board of County Commissioners (BCC) will be responsible for adopting the Clackamas County Natural Hazards Mitigation Plan. This governing body has the authority to promote sound public policy regarding natural hazards. Once the plan has been adopted, the County Emergency Manager will be responsible for submitting it to the State Hazard Mitigation Officer at Oregon Emergency Management. Oregon Emergency Management will then submit the plan to the Federal Emergency Management Agency (FEMA) for review. This review will address the federal criteria outlined in FEMA Interim Final Rule 44 CFR Part 201. Upon acceptance by FEMA, Clackamas County will gain eligibility for Hazard Mitigation Grant Program funds.

Coordinating Body

A Clackamas County Hazard Mitigation Committee will be responsible for coordinating implementation of plan action items and undertaking the formal review process. The BCC will assign representatives from county agencies, including, but not limited to, the current Hazard Mitigation Advisory Committee members. The county has formed a Hazard Mitigation Committee that consists of members from local agencies, organizations, and citizens, and includes the following:

- Clackamas County Emergency Management
- Clackamas County Finance
- Clackamas Fire Defense Board
- Clackamas County Geographic Information System
- Clackamas County Planning Division
- Clackamas County Project Impact

- Clackamas County Public Information Officer
- Clackamas County Roads Division
- Clackamas County Social Services
- Clackamas County Building Services
- Clackamas River Basin Council
- Clackamas County Water Environment Services
- Department of Geology and Mineral Industries
- Eagle Creek/ Barton Community Planning Organization
- Federal Emergency Management Agency
- Oregon Emergency Management

In order to make this committee as broad and useful as possible, the County Administrator will engage other relevant organizations and agencies in hazard mitigation. The recommendations for adding to the Hazard Mitigation Advisory Committee include:

- An elected official
- A representative from the Chamber of Commerce
- An insurance representative
- Rural and urban Community Planning Organization representatives
- A city manager
- Representation from a professional organizations such as the Home Builders Association
- County Administrator

The Hazard Mitigation Advisory Committee will meet no less than quarterly. Meeting dates will be scheduled once the final Hazard Mitigation Advisory Committee has been established. These meetings will provide an opportunity to discuss the progress of the action items and maintain the partnerships that are essential for the sustainability of the mitigation plan.

Convener

The BCC will adopt the Clackamas County Natural Hazard Mitigation Plan, and the Hazard Mitigation Advisory Committee will take responsibility for plan implementation. The County Administrator will serve as a ***convener*** to facilitate the Hazard Mitigation Advisory Committee meetings, and will assign tasks such as updating and presenting the Plan to the members of the committee. Plan implementation and evaluation will be a shared responsibility among all of the Natural Hazard Advisory Committee Members.

Implementation through Existing Programs

Clackamas County addresses statewide planning goals and legislative requirements through its Comprehensive Land Use Plan, Capital Improvement Plans, and County Building Codes. The Natural Hazard Mitigation Plan provides a series of recommendations – many of which are closely related to the goals and objectives of existing planning programs. Clackamas County will have the opportunity to implement recommended mitigation action items through existing programs and procedures.

Upon adoption of the mitigation plan, the county will assist local municipalities in developing their natural hazard mitigation goals and actions by providing the Clackamas County Natural Hazards Mitigation Plan as a baseline of information on the natural hazards that impact the county. These goals and action items will help local governments, as well as the Clackamas County Planning Department address Statewide Land-use Planning Goal 7. Goal 7 assists communities in protecting 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 that the intensity of development should be limited by the degree to which the natural hazard occurs within the areas of proposed development. Local jurisdictions and the county can use periodic review as an avenue to update the Goal 7: Natural Hazards element of their comprehensive plan and to integrate mitigation into zoning and planning documents.

The county Building Division is responsible for administering the building codes in local municipalities. After the adoption of the mitigation plan, they will work with the State Building Code Office to make sure that the county adopts, and is enforcing, the minimum standards established in the New State Building Code. In addition, the Hazard Advisory Committee will work with other agencies at the state level to review, develop and ensure building codes that are adequate to mitigate or present damage by natural hazards. This is to ensure that life-safety criteria are met for new construction.

The goals and action items in the mitigation plan may be achieved through activities recommended in the county's Capital Improvement Plans (CIP). Various county departments develop CIP plans, and review them on an annual basis. Upon annual review of the CIPs, the Hazard Mitigation Advisory Committee will work with the county departments to identify areas that the hazard mitigation plan action items are consistent with CIP planning goals and integrate them where appropriate.

Within six months of formal adoption of the mitigation plan, the recommendations listed above will be incorporated into the process of existing planning mechanisms at the county level. The meetings of the Hazard Mitigation Advisory Committee will provide an opportunity for

committee members to report back on the progress made on the integration of mitigation planning elements into county planning documents and procedures.

Economic Analysis of Mitigation Projects

FEMA's approaches 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. 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. 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 can provide 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.

Given federal funding, the Hazard Mitigation Advisory Committee will use a FEMA-approved benefit/cost analysis approach to identify and prioritize mitigation action items. For other projects and funding sources, the Hazard Mitigation Advisory 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

The Clackamas County Natural Hazards Mitigation Plan will be evaluated on an annual basis to determine the effectiveness of programs, and to reflect changes in land development or programs that may affect mitigation priorities. The evaluation process includes a firm schedule and timeline, and identifies the local agencies and organizations participating in plan evaluation. The convener or designee will be responsible for contacting the Hazard Mitigation Advisory Committee members and organizing the annual meeting. Committee members will be responsible for monitoring and evaluating the progress of the mitigation strategies in the Plan.

The committee will review the goals and action items to determine their relevance to changing situations in the county, as well as changes in State or Federal policy, 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 this information should be updated or modified, given any new available data. The coordinating organizations responsible for the various action items will report on the status of their projects, the success of various implementation processes, difficulties encountered, success of coordination efforts, and which strategies should be revised.

The convener will assign the duty of updating the plan to one or more of the committee members. The designated committee members will have three months to make appropriate changes to the Plan before submitting it to the Hazard Committee members, and presenting it to the BCC. The Hazard Mitigation Advisory Committee will also notify all holders of the county plan when changes have been made. 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

Clackamas County is dedicated to involving the public directly in review and updates of the Hazard Mitigation Plan. The Hazard Mitigation Committee members are responsible for the annual review and update of the plan.

The public will also have the opportunity to provide feedback about the Plan. Copies of the Plan will be catalogued and kept at all of the appropriate agencies in the county. The existence andlocation of these copies will be publicized in the quarterly county newsletter "Citizen News", which reaches every household in the county. The plan also includes the address and the phone number of the county Planning Division, responsible for keeping track of public comments on the Plan.

In addition, copies of the plan and any proposed changes will be posted on the county website. This site will also contain an email address and phone number to which people can direct their comments and concerns.

A public meeting will also be held after each annual evaluation or when deemed necessary by the Hazard Mitigation Advisory Committee. The meetings will provide the public a forum for which they can express its concerns, opinions, or ideas about the Plan. The County Public Information Officer will be responsible for using county resources to publicize the annual public meetings and maintain public involvement through the public access channel, webpage, and newspapers.

Section 6:
Flood

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Why are Floods a Threat to Clackamas County?

Clackamas County has several large rivers and smaller tributaries that are susceptible to annual flooding events. Flooding poses a threat to life and safety, and can cause severe damage to public and private property.

The county was most recently affected by the seasonal flooding of the Clackamas and Willamette Rivers in January 1997. However, the devastation brought about by the regional floods of February and November 1996 far surpassed the county's normal seasonal flood events, such as that in 1997.

In February 1996, prolonged precipitation accompanied by an early snowmelt caused many rivers and creeks throughout the Willamette River watershed to rise to 100-year flood levels. The Clackamas and Willamette Rivers and their tributaries were filled beyond capacity, causing flooding in both rural and urban areas. The confluence of these two rivers occurs just north of Oregon City, where the floodwaters caused significant damage to a large portion of the business district in Oregon City.

The damage to Clackamas County businesses, residences, and infrastructure was estimated at about $50 million, which is 20% of the county's annual budget. The county sought and received a Presidential Disaster Declaration to obtain federal assistance for its flood recovery effort. The Clackamas County Risk Management Office estimated that the flood of February 1996 directly or indirectly affected three quarters of the county's 342,861 residents. Claims filed under the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP) from Clackamas County residences and businesses accounted for almost one-third of the entire claims throughout the state in 1996.

Still recovering from the February floods, the county was hit with a major storm on November 10 and 11, 1996. The storm delivered at least 2.8 inches of rain in one night - a weather event that occurs an average of once every 205 years. Many of the rivers and smaller tributaries in the county quickly reached their flood levels, causing both urban and riverine flooding. Although the damage from this event was not as severe as the February floods, it did warrant road closures and the evacuation of homes in the 100-year floodplain.[1]

The 1996 floods caused a statewide loss of $400 million in damages, as 26 major rivers rose to flood stage. More than 100 Red Cross and Salvation Army shelters were opened, and 23,000 residents fled their homes. Seven casualties were reported, and 50 people were injured. An estimated 1,700 Oregonians lost their jobs due to flooding, and the Small Business Association (SBA) loaned Oregon businesses over $40.5 million to assist with recovery efforts.[2]

Although this flood was a large-scale disaster, it was not unprecedented. During the Christmas Flood of 1964, over $157 million in damage was done, and 20 Oregonians lost their lives.[3]

Residents in Clackamas County share a statewide concern about flood issues. According to the NFIP, Oregon has 256 flood-prone communities within the 36 counties of the state. Although all of the counties in the state are vulnerable to flooding events, the risk of loss is much more pronounced in some counties than others. For example, according to NFIP claims data, Clackamas County is responsible for about one-third of the state's total flood losses.[4]

History of Flooding in Clackamas County

Clackamas County has many rivers and small tributaries in both unincorporated and incorporated areas that are susceptible to flooding. Major floods have affected the citizens of the county since as early as 1861, when it was reported that the streets of Oregon City were inundated with about four feet of Willamette overbank flow. Table 6-1 illustrates major flood events on the Willamette and Clackamas Rivers. Although the 1996 floods were devastating to the entire region, the floods of 1861, 1890, and 1964 were larger. All four floods have been estimated to exceed the 100-year or base flood.[5]

Table 6-1. Major Flood Events on the Willamette and Clackamas Rivers Since 1861

Willamette River	Clackamas River
1861	1923
1890	1931
1924	1960
1943	1964
1948	1996
1964	
1996	

Source: Oregon City Stream Data

The properties in and near the floodplains of Clackamas County are subject to flooding events almost annually. Since flooding is such a pervasive problem throughout the county, many residents have purchased flood insurance to help recover from losses incurred from flooding events. Flood insurance covers only the improved land, or the actual building structure. Although flood insurance assists in recovery, it can provide an inappropriate sense of protection from flooding. Many residents who have had flood damage rebuild in the same vulnerable areas, only to be flooded again. These properties are termed ***repetitive loss*** properties, and are very troublesome because they continue to expose lives and valuable property to the flooding hazard. Local governments as well as federal agencies such as FEMA recognize this pitfall in floodplain insurance, and attempt to remove the risk from

repetitive loss properties through projects such as acquiring land and relocating the home, or by elevating the structure.

Continued repetitive loss claims from flood events lead to an increased amount of damage caused by floods, higher insurance rates, and contribute to the rising cost of taxpayer funded disaster relief for flood victims.[6] The total claims and repetitive loss claims that have been filed with FEMA since 1978 are illustrated in Table 6-2. It is important to note, however, that many properties in the county are not insured from flood events, so the total damage from floods cannot be represented by the claims data. Table 6-2 illustrates the repetitive loss properties that are responsible for a large quantity of the total claims paid. The total assessed value for the structures on repetitive loss properties in the unincorporated and incorporated areas in the county are $6,498,770 and $15,014,630, respectively.

Table 6-2. Clackamas County Flood Damage (1978 - 2001)

Type	Incorporated Cities in Clackamas County	Unincorporated Areas in Clackamas County
Reported damage to buildings	$4,588,534	$1,884,801
Reported damage to contents	$636,929	$287,107
Total of claims paid	$4,397,724	$1,983,854
Repetitive Loss (from 1980- 2001)		
Reported damage to buildings	$1,090,346	$1,504,489
Reported damage to contents	$581,084	$152,863
Total of claims paid	**$1,671,431**	**$1,657,352**

Source: Dennis Sigrist, Oregon Emergency Management

Table 6-3. Largest Annual Totals - NFIP Claim Payments

Year	NFIP Payment
1996	$5,819,280
1997	$234,241
1995	$136,272
1999	$32,891

Source: Dennis Sigrist, Oregon Emergency Management

What Factors Create Flood Risk?

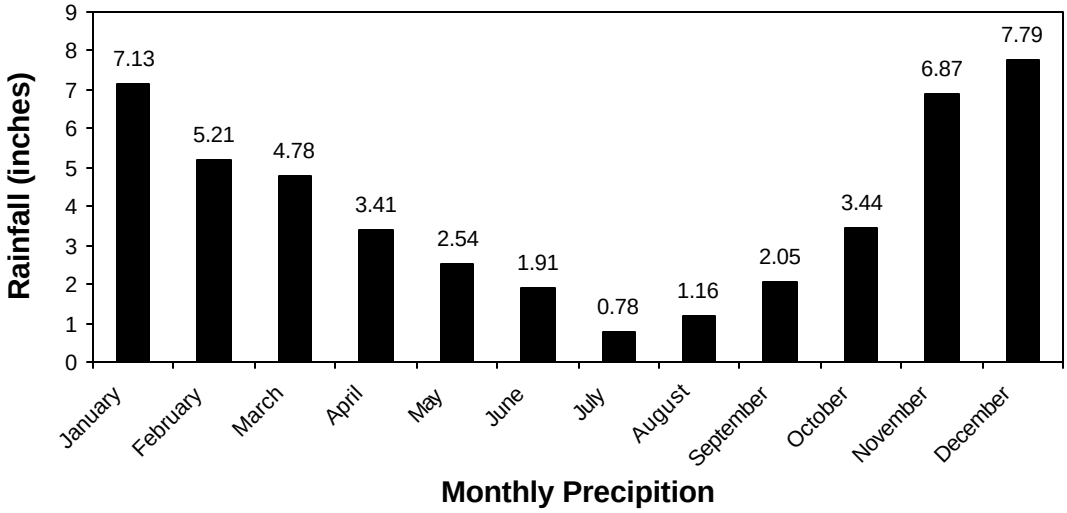
Flooding occurs when climate (or weather patterns), geology, and hydrology combine to create conditions where water flows outside of its usual course. In Clackamas County, geography and climate combine to create chronic seasonal flooding conditions.

Precipitation

Because Clackamas County spans a wide range of climatic and geologic regions, there is considerable variation in precipitation, with elevation being the largest factor in precipitation totals. Moving east from Oregon City at 55 feet above sea level to Mt Hood at 11,235 feet above sea level, annual precipitation averages range from 47.06 inches to over 124.51 inches, respectively. This change in elevation causes a significant increase in precipitation, in the form of both rain and snow. Although the majority of the county enjoys a fairly mild winter, with less than 5-10 inches of snow per year, the higher elevations surrounding Mt. Hood are covered with snow for the majority of the winter months. This is of primary concern when dealing with potential flood events. Mt. Hood's snowmelt provides a continuous water source throughout the year, and can be a major contributor to high waters.[7]

Flooding is most common from October through April, when storms from the Pacific Ocean, 60 miles away, bring intense rainfall to the area.[8] Clackamas County receives approximately 40 inches of rain on average each year. During the rainy season, monthly rainfall totals average far higher than other months of the year (as shown in Figure 6.1). This results in high water, particularly in December and January. The larger floods are the result of heavy rains of two-day to five-day durations augmented by snowmelt at a time when the soil is near saturation from previous rains. Frozen topsoil also contributes to the frequency of floods.[9]

Figure 6.1. Average Monthly Rainfall for Oregon City, Oregon



Source: The Climate of Oregon

Geography and Geology

A large portion of Clackamas County's area lies in the lower Willamette River basin. The broad floodplain of the valley can be easily inundated

by floodwaters. The surface material includes poorly drained, unconsolidated, fine-grained deposits of Willamette silt, sand, and gravel. Torrential flood events can introduce large deposits of sand and gravel that assist in the drainage of the otherwise poorly drained soils.[10]

The flood events in Clackamas County usually occur when storms move in from the Pacific, dropping heavy precipitation into the Willamette valley. Flooding in the valley becomes a problem when human activities infringe on the natural floodplain.

Flood Terminology

Floodplain

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

100-Year Flood

The 100-year flooding event is the flood having a one percent chance of being equaled or exceeded in magnitude in any given year. Contrary to popular belief, it is not a flood occurring once every 100 years. The 100-year floodplain is the area adjoining a river, stream, or watercourse covered by water in the event of a 100-year flood. Map 6 illustrates the 100-year floodplain in Clackamas County.

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 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 that would obstruct or divert flood flows onto other properties. Clackamas County regulations prohibit all development in the floodway. 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.

Flood Fringe

The flood fringe refers to the outer portions of the floodplain, beginning at the edge of the floodway and continuing outward. In 703.03E of the Clackamas County Zoning and Development Ordinance (ZDO), the flood fringe is defined as “the land area, which is outside of the stream’s floodway, but is subject to periodic inundation by regular flooding.”[11]

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 by Clackamas County ZDO (703.03C) to mean "any manmade 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 located within the area of special flood hazard." 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) that 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, while using lower frequency events for others. For example, for the purpose of storm water 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 NFIP focus on development in the 100-year floodplain.[12]

Characteristics of Flooding

Two types of flooding primarily affect Clackamas County: riverine flooding and urban flooding (see descriptions below). In addition, any low-lying area has the potential to flood. The flooding of developed areas may occur when the amount of water generated from rainfall and runoff exceeds a storm water system's (ditch or sewer) capability to remove it.[13]

Riverine Flooding

Riverine flooding is the overbank flooding of rivers and streams. 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.[14] Map 7 shows the various river basins in Clackamas County.

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 one to three feet. These areas are generally flooded by low velocity sheet flows of water.

Urban Flooding

As land is converted from fields or woodlands to roads and parking lots, it loses its ability to absorb rainfall. Urbanization of a 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 violent force.

Almost one-eighth of the area in Clackamas County is incorporated, and has a high concentration of impermeable surfaces that either collect water, or concentrate the flow of water in unnatural channels. 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.

Dam Failure Flooding

Loss of life and damage to structures, roads, utilities and crops may result from a dam failure. Economic losses can also result from a lowered tax base and lack of utility profits. These effects would certainly accompany the failure of one of the major dams in Clackamas County. There are a total of 173 dams in Clackamas County holding billions of gallons of water in reservoirs. Because dam failure can have severe consequences, FEMA requires that all dam owners develop Emergency Action Plans (EAP) for warning, evacuation, and post-flood actions. Although there may be coordination with county officials in the development of the EAP, the responsibility for developing potential flood inundation maps and facilitation of emergency response is the responsibility of the dam owner. For more detailed information regarding dam failure flooding, and potential flood inundation zones for a particular dam in the county, refer to the Clackamas County Emergency Action Plan.[15]

What is the Effect of Development on Floods?

When structures or fill are placed in the floodway or floodplain, water is displaced. Development raises the river levels 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 or floodplain 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 to ensure that proposed developments will not adversely affect the flood carrying capacity of the Special Flood Hazard Area (SFHA). 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 given to development that occurs within the floodway to ensure that structures are prepared to withstand base flood events.

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 storm water management systems to ensure that these runoff waters are dealt with effectively.[16]

How are Flood-Prone Areas Identified?

Flood maps and Flood Insurance Studies (FIS) are often used to identify flood-prone areas. The 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 "sound floodplain management."[17] In Clackamas County, the NFIP and related building code regulations went into effect on March 1, 1978. 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 1 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 Clackamas County, all homes legally constructed in the floodplain after March 1, 1978 must be mitigated to NFIP standards with the first floor being elevated at least one foot above base flood level.

Flood Insurance Rate Maps (FIRM) and Flood Insurance Studies (FIS)

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 FEMA, which delineates SFHA in communities where NFIP 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.

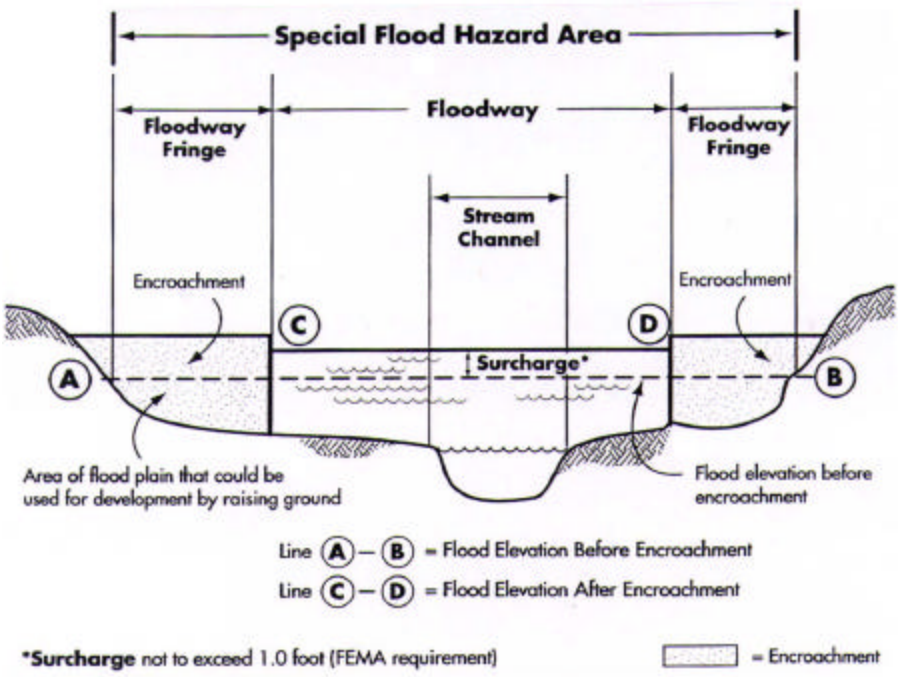
Water surface elevations are combined with topographic data to develop FIRMs. FIRMs illustrate areas that would be inundated during a 100-year flood, floodway areas, and elevations marking the 100-year-flood level. In some cases they also include base flood elevations (BFEs) and areas located within the 500-year floodplain.[19]

Flood Insurance Studies and FIRMs produced for the 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. However, it is important to note that not all 100-year or 500-year floodplains have been mapped by FEMA. It is estimated that the flood maps cover 95% of the total population in Clackamas County. A significant portion (over 50%) of the entire land area in Clackamas County has not been mapped, because a large percentage of land in the mountainous Cascade Range is federally owned and managed.

FEMA flood maps are not entirely accurate. These studies and maps represent flood risk at the point in time when FEMA completed the

studies, and does not incorporate planning for floodplain changes in the future due to new development. Although FEMA is considering changing that policy, it is optional for local communities. The FEMA FIRM map for Clackamas County was completed in 1987. Man-made and natural changes to the environment have changed the course of many of the rivers in the county, as well as their associated floodplain boundaries.[20]

Figure 6-2. 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, there are some flood-prone areas that are not mapped but remain susceptible to flooding. These areas include locations next to small creeks, local drainage areas, and areas susceptible to manmade flooding. About 10% to 20% of all flood-related damage from past floods in Clackamas County is located outside the boundaries of the FEMA's FIRMs.[21]

In order to address this lack of data, Clackamas County, as well as other jurisdictions, has taken efforts to develop more localized flood hazard maps. One method that has been employed includes using high-water marks from flood events or aerial photos, in conjunction with the FEMA maps, to better reflect the true flood risk.

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 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.

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 are intended to 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.

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 the creation of a floodplain map. Floodplain maps provide detailed information that can assist jurisdictions in making policies and land-use decisions.

Phase One of the Clackamas County Natural Hazard Mitigation Plan used electronic versions of the 1980 FEMA flood maps for hazard identification and loss estimates. According to the FEMA FIRMs published in 1987 for Clackamas County(Map 6), the land area in the 100-year floodplain exceeds 35 square miles. Additionally, the 100-year flood threatens over 79 miles of road.[22]

Data Sources

FEMA mapped the 100-year and 500-year floodplains through the Flood Insurance Study (FIS) in conjunction with the United States Army Corps of Engineers (USACE) in August of 1987. There were previous studies done, including a Housing and Urban Development (HUD) study, which mapped the floodplain in March of 1978. This is when Clackamas County initially entered into the NFIP. The county has updated portions of the USACE and FEMA maps through smaller drainage studies in the county since that time.

Water Environment Services (WES) led a project in upper Kellogg Creek to re-map the floodplain. FEMA approved the maps and the county adopted them. Currently, the county Planning Division is

working with WES to conduct an FIS on Richardson and Rock Creeks, neither of which has an official FEMA-approved floodplain associated with them. However, as urban development inches its way towards these two basins, it is necessary to document the vulnerable properties along these streams.

The City of Portland has just updated the floodplain mapping for Johnson Creek, which includes all portions of urban Clackamas County, including Cities and the unincorporated parts. The study stopped right before the City of Gresham boundary, so the rural parts of Clackamas County weren't included.

There are also numerous, individual Letters of Map Amendments throughout the county. This is a letter from FEMA that indicates that specific portions of a property are outside of the floodplain. Currently, the county's GIS department is developing floodplain maps in riparian areas at detailed 2-foot contour intervals. Once this project is complete, the county will pursue developing a Cooperative Technical Partnership with FEMA so that these maps can be used to create better local FIRM maps.

Vulnerability Assessment

Vulnerability assessment is the second step of flood-hazard assessment. It combines the floodplain boundary, generated through hazard identification, with an inventory of the property within the floodplain. Understanding the population and property exposed to natural hazards will assist in reducing risk and preventing loss from future events.

Because site-specific inventory data and inundation levels given for a particular flood event (10-year, 25-year, 50-year, 100-year, 500-year) are not readily available, calculating a community's vulnerability to flood events is not straightforward. The amount of property in the floodplain, as well as the type and value of structures on those properties, should be calculated to provide a working estimate for potential flood losses. Figure 6.4 below describes the number of acres, tax lots, and the value of property within Clackamas County's 100-year floodplain.

Table 6.4. Flood Hazard Vulnerability Assessment

Acres in the 100-year Floodplain	24,168
All Tax lots within the 100-year Floodplain all or partial)	8,403
Total Property Value in the 100-year Floodplain	$3,066,215,644*

Source: Clackamas County Geographic Information Systems

* Value of property in the 100-year floodplain may include property in tax lots that intersect the floodplain, including property that does not physically reside in the floodplain itself.

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 Clackamas County should include two components: (1) the life and value of property that may incur losses from a flood event (defined through the vulnerability assessment); and (2) the number and type 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.

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.

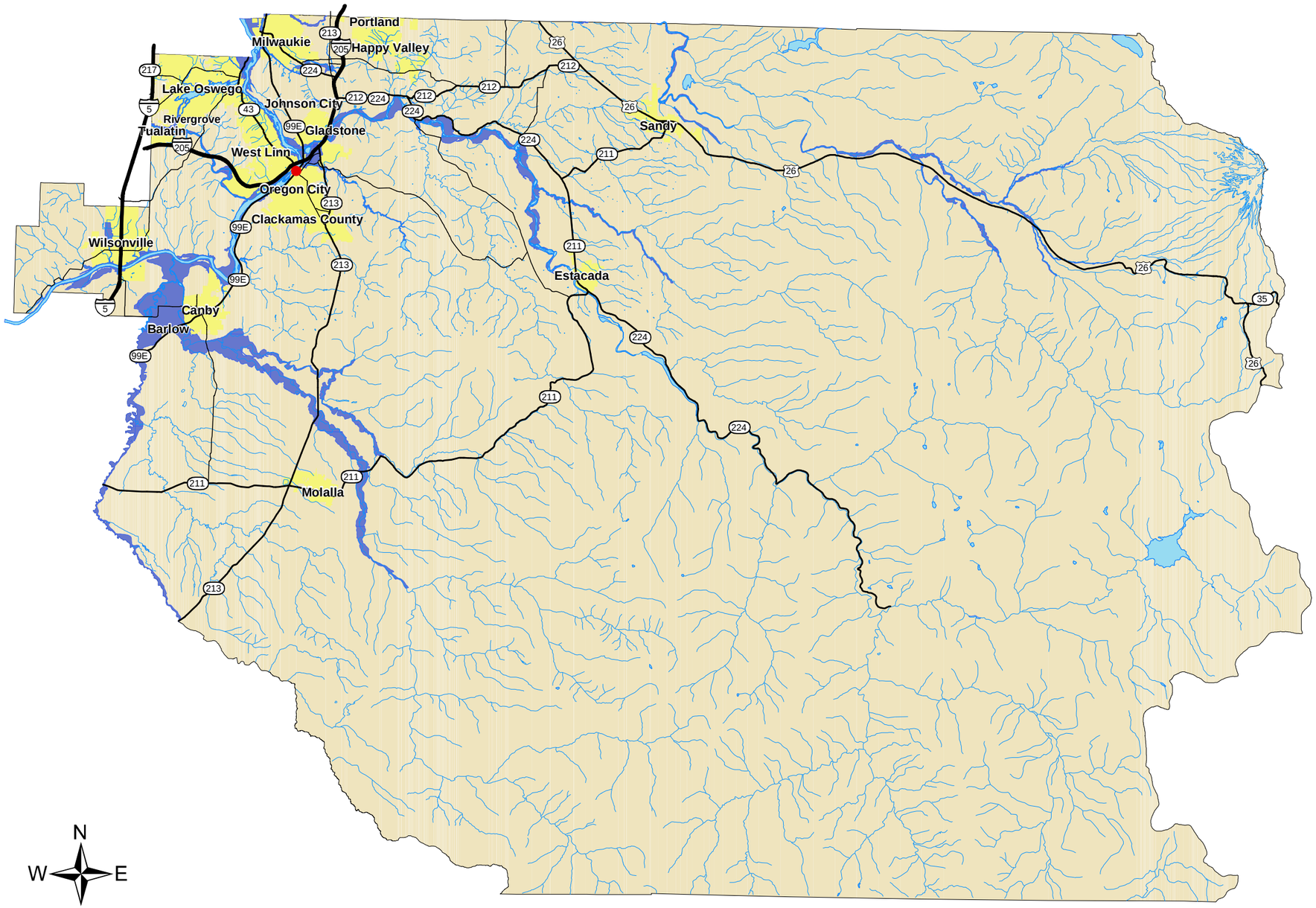
Using GIS technology and flow velocity models, it is possible to map the damage that can be expected from flood events over time. It is also possible to pinpoint the effects of certain flood events on individual properties.

At the time of publication of this plan, data was insufficient to conduct a risk analysis for flood events in Clackamas County. However, the current mapping projects being led by the county Planning Division and by WES will result in better data that will assist in understanding risk. This plan includes recommendations for building partnerships that will support the development of a flood risk analysis in Clackamas County.

Map 6

FEMA Firm

100-year Flood Plain



N
W E
S

County Seat
Cities
County Boundary
Rivers, Creeks, and Streams
FEMA 100-Year Flood Plain
Major Rivers and Lakes

Interstate
Highway
Roads

Data Source: City Limits are maintained by Metro. The County Boundary, Hydrology, and Street layers are maintained by Clackamas County GIS Staff.

The flood plain data is from the Federal Emergency Management Agency. The data is from November 2000.

1 inch equals 5 miles

Miles

8 4 0 8

Clackamas County

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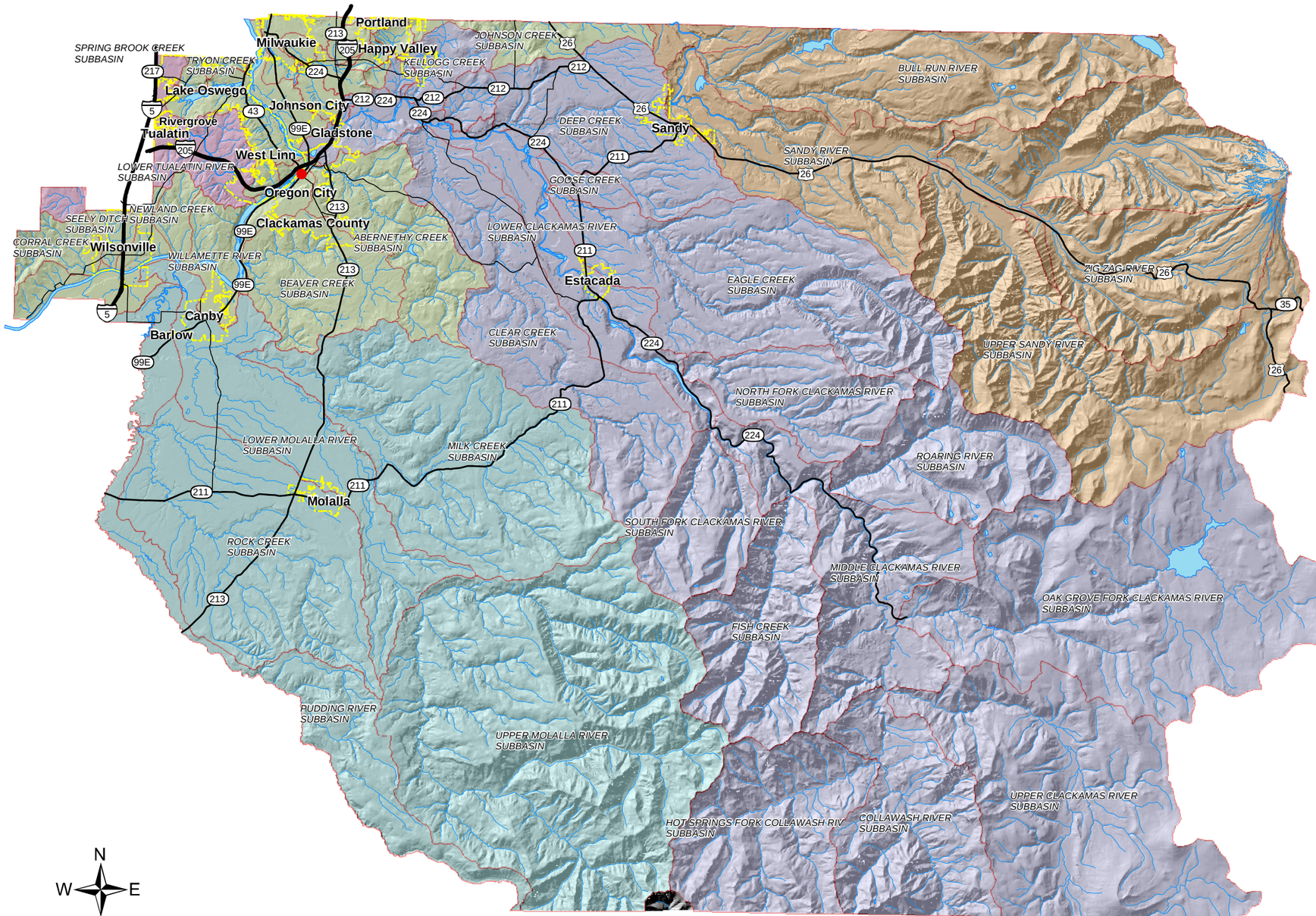
CLACKAMAS COUNTY GIS | JONMCD | FemaFirm.MDX | AUGUST 27, 2002

Map 7

CLACKAMAS COUNTY RIVER SUBBASINS



- County Seat
- Cities
- Rivers, Creeks, and Streams
- Major Rivers and Lakes

Basin Name

- Clackamas River
- Molalla River
- Sandy River
- Tualitan River
- Willamette River

- Interstate
- Highway
- Roads

Data Source: City Limits are maintained by Metro. The County Boundary, Hydrology, and Street layers are maintained by Clackamas County GIS Staff.

The river subbasin information was clipped by the county boundary. The basis may extend beyond the boundaries shown on this map. The subbasin infromation was provided to Clackamas County by Water Environmental Services.

1 inch equals 5 miles

Miles

8 4 0 8

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Community Flood Issues

What is Susceptible to Damage During a Flood Event?

The largest impact on communities from flood events is the loss of life and property. During certain years, property losses resulting from flood damage are extensive. Development in the floodplains of Clackamas County will continue to be at risk from flooding because flood damage occurs on a regular basis throughout the county.

Property loss from floods strikes both private 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.[23]

Property Loss Resulting from Flooding 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 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.[24] Most flood damage is caused by water saturating materials susceptible to loss (e.g., wood, insulation, wallboard, fabric, furnishings, floor coverings, and appliances).

Homes

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, and inundation of these systems may result in leakage of wastewater into surrounding areas. In many cases, flood damage to homes renders them unlivable.

In the wake of the 1996 floods, Clackamas County received over $3 million in Disaster Housing Funds from FEMA, over $500,000 in Individual and Family Grants from FEMA, and almost $11 million in home loans from the Small Business Administration (SBA) (see Tables 6-5 and 6-6). 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.[25]

Table 6-5. Partitioning of FEMA Assistance in 1996

Applications Approved

	Disaster Housing		Individual and Family Grant	
County	Number	Amount	Number	Amount
Clackamas	1,056	$3,121,226	279	$543,674

Source: Small Business Association

Table 6-6. SBA Assistance in 1996

SBA Applications Approved

County	Home Loans		Business Physical Loans		Business Economic Injury Loans	
Clackamas	Number	Amount	Number	Amount	Number	Amount
	358	$10,987,800	81	$7,889,700	32	$1,558,100

Source: Small Business Association

Clackamas County is ranked as the second highest county in the state for total flood damage during the 1996 events, and as the highest county for housing disaster assistance (as illustrated in Table 6.7). Housing Assistance funds went primarily to urban counties with high populations and relatively high property values.[26]

Table 6.7. Oregon County Losses and Housing Program Fund Payments in 1996

County Losses	Housing Fund Payments to Counties
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. Many older manufactured home parks are located in floodplain areas. Manufactured homes have a lower level of structural stability than stick-built homes, and must be anchored to provide additional structural stability during flood events. Because of confusion in the late 1980s 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.[27]

According to the Clackamas County Planning Division, the mobile home parks listed below have some portion of their property in the 100-year floodplain. The safety of these parks and their compliance with land use planning and building codes, as well as FEMA NFIP requirements, warrants further investigation. [it might be helpful to have a map or specific addresses for these parks]

- Forest Park Mobile Home Village located along Highway 99E
- Carver Mobile Village located on SE Hwy 224 *(about 50% in the floodplain)*
- Riverbend Mobile Home Park located SE Hwy 212
- Riverview Mobile Home Park located on Hwy 224
- Clackamas River Village located on SE 135th

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. 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.[28]

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, as well as craft public policy that reduces risk to private property from flood events.

There are a variety of drinking water, surface water, and wastewater service providers throughout the county. During flooding events, the infrastructure that supports the water service providers in the county can be damaged and sometimes destroyed. For example, Clackamas River Water District almost lost power to its lower lift pump station during the February 1996 flood because it is located in the 100-year floodplain.[29]

Buildings

In the wake of the 1996 flood events, damage to public buildings statewide represented 34% of total public losses.[30] Of particular importance during flood events are facilities located in flood hazard areas that are critical to government response and recovery activities.

Roads

During natural hazard events, or any type of emergency or disaster, dependable road connections are critical for providing emergency services. Roads systems in Clackamas County are maintained by

multiple jurisdictions. Federal, state, county, and city governments all have a stake in protecting roads from flood damage. 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 because they are important links in road networks, watercourse crossings, and they can be obstructions in watercourses, inhibiting the flow of water during flood events. The bridges in Clackamas County are state, county, city, or privately owned. A state-designated inspector must inspect all state, county, and city bridges every two years, but private bridges are not inspected, and can be very dangerous. The inspections are rigorous, looking at everything from seismic capability to erosion and scour. Upon inspection, the bridges are subject to a sufficiency score. This score uses a scale of 1 to 100 with 1 being the worst rating. Then the bridges are ranked throughout the state according to their score. The state then prioritizes the bridge repair according to each score. If the bridge receives a sufficiency score of less that 50, it is on the list for upgrading and rehabilitation. If it scores over 50, it is not included on the list. The smaller, more economically feasible repairs to county bridges are the responsibility of the county Roads Division. The larger projects require funding through the Highway Bridge Replacement and Rehabilitation program (HBRR). HBRR provides 80% of funding, and the county is responsible for 20%.[31]

The five highest priority bridges in the county are currently being upgraded by replacing the earthquake resistant bearing pads using county funds. These bridges include:

- Carver Truss Bridge
- Feyrer Park Bridge
- Mulino Road Bridge
- Eagle Creek Bridge
- Oatfield Road Bridge

Storm Water Systems

Local drainage problems are common throughout the region. Several communities have drainage master plans, and local public works staff are often aware of local drainage threats. The problems are often 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. Filled ditches and swales near buildings can inhibit or prevent the flow of water and compound these problems. Inadequate maintenance,

especially following leaf accumulation in the fall, can also contribute to the flood hazard in urban areas.[32]

Water/Wastewater Treatment Facilities

There are six sanitary districts in the unincorporated areas of the county, three surface water management districts, and five sewage treatment facilities. There are also numerous water service districts in Clackamas County. Some cities, such as Canby, provide water to their residents directly.

Water Quality

Environmental quality varies widely among the waterways in Clackamas County. Significant portions of the Clackamas and Sandy Rivers have been designated as Federal Wild and Scenic and State Scenic Waterways, while the State Department of Environmental Quality has identified sections of the Pudding, Molalla, Kellogg Creek, Johnson Creek, Lower Tualatin, and Willamette as water quality limited. Problems include bacteria, toxins, temperature, and habitat modification. The water quality in the Clackamas River is excellent and an important source of drinking water for the county. However, parts of the Clackamas and Sandy have temperature problems. The water is too warm to be an ideal habitat for certain cold water fish species.[33]

Clackamas County currently has Water Quality and Floodplain ordinances within the ZDO (chapters 703, 704 & 705). The county is currently working with the regional government, Metro, to implement the Stream and Floodplain Protection Plan (Title 3). The goal of Title 3 is to protect the region's health and public safety by reducing flood and landslide hazards, control soil erosion and reduce pollution of the region's waterways. The county has current ordinances that address each of these concerns and will be working with Metro in assessing the consistency of current regulations with Metro's goals.

Title 3: (Metro Code 3.07.310-3.07.370), Water Quality and Flood Management Conservation[34]

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. More information on this can be found at http://www.metro.dst.or.us/.

Existing Flood Mitigation Activities

Flood mitigation activities listed here include current mitigation programs and activities that are being implemented by Clackamas County agencies or organizations.

Clackamas County Codes

Clackamas County uses building codes, zoning codes, and various planning strategies to address the Oregon Land-Use Planning Goal 7, which aims at restricting development in areas of known hazards, and applying the appropriate safeguards.

- **Mitigation Requirements:** All habitable floors must be 1 foot above floodplain, and developer must complete a Floodplain Development Permit Application as outlined in Subsection 703 (Flood Management District) of the ZDO.
  - Affected Properties: All development in the floodplain.
- **Mitigation Requirements:** Subsections of Section 800 of the ZDO prohibiting this type of development in identified hazard areas.
  - **Affected Properties:** Essential facilities, major structures, hazardous facilities and special occupancy structures.
- **Mitigation Requirements**: Natural Resource Districts (ZDO Section 400) that by their very nature allow minimal or zero development; Protection of Natural Features (ZDO Subsection 1002); Building Siting and Orientation (ZDO Subsection 1005.03, Point B); Designation of the River and Stream Conservation Area (RSCA, ZDO Subsection 704); Designation of the Willamette River Greenway (WRG, ZDO Subsection 705), Designation of the Conservation Wetland District (CW, ZDO Subsection 709)
  - **Affected Properties:** Development in areas that could be prone to flooding, landslide, wildfire and / or seismic hazards.

State of Oregon Floodplain and Floodway Removal/Fill Law

The Oregon Removal/Fill Law, which is administered by the Oregon Division of State Lands (DSL), 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).

Clackamas County complies with the removal/fill laws when designing and building facilities, and has related responsibilities when dealing with private development and other construction projects. An inventory of wetlands inside the Urban Growth Boundary (UGB), has been developed locally, and there is a National Wetland Inventory maintained by the Division of State Lands (DSL). Each wetland in the local Clackamas County inventory has been assessed according to size and quality. There are specific processes unique to each wetland assessment that a developer must adhere to when considering adding fill to the area. Generally, any would-be permittee who has done or proposes to do more than 50 cubic yards of grading in a wetland is referred to DSL, the USACE and Oregon Department of Fish and Wildlife (ODFW) for permitting and consultation.

Acquisition and Protection of Open Space in the Floodplain

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.

In 1999, the county partnered with Oregon City to obtain funds for the acquisition of four properties along Abernethy Creek, which has been historically prone to flooding. During the 1990s, the county Development Agency worked with the Parks Division to acquire land on either side of Southeast 82nd Avenue in the Sunnybrook Service Center vicinity. This land provides a trail system for recreation and is used for flood storage capacity for numerous drainages. 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.

Water Districts

All of the water districts in the county are in the process of replacing old cast iron pipes with more ductile iron pipes, which will be more resilient in disaster situations. During a disaster, water districts in the region work together to provide water for Clackamas County citizens. For example, Clackamas River Water has built inter-ties with, South Fork Water, Oak Lodge, and Sunrise Water Authority for emergency situations. The Clackamas River Water is also in the process of installing an additional pump station adjacent to the new service building.[35]

Natural Systems

Maintaining and restoring natural systems help to 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. The best flood control techniques work to control water using the natural features such as wetlands that assist in water storage and bank stability.

Riparian Areas

Riparian areas are important transitional areas that 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, such as willows and cottonwood trees. Healthy vegetation in riparian buffers can reduce streamside erosion.[36] During flood events, high water can cause significant erosion.

Population growth and development have strained the land and water, and the community has responded by supporting various improvement projects, such as the Willamette Restoration Strategy, which identifies

effective actions to address problems. The Willamette Restoration Initiative, established by State Executive Order 98-18 in 1998, developed this project. The goal of the project is to develop a basin wide strategy to protect and restore river, habitat and riparian areas.[37] Well-managed riparian areas can reduce the amount of erosion and help to protect water quality during flood events.

Wastewater Management

There are a variety of wastewater service providers in the county, ranging from cities to service districts, and even some private service providers. Working with each district, the Wastewater Maintenance Services and Wastewater Treatment Services Division operates and maintain the infrastructure that helps to keep the waters of Clackamas County clean and pure.

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.[38] 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 storm water 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.[39] Many wetland restoration projects have been initiated and completed by various organizations throughout the county.

Many detention ponds are constructed wetlands. Some of these detention ponds are being retrofitted by Water Environment Services (WES) to use shade to cool stormwater and to provide proper ecosystem function. WES has taken the lead on many of these projects, removing invasive plant species and debris, and replacing the invasive plant species with more appropriate and substantial vegetation. In addition, as illustrated in Table 6-8, WES has been involved in many stream restoration projects throughout their Surface Water Districts.

Table 6-8. Stream Restoration Projects for Clackamas County Service District One & Surface Water Management Agency
- to be completed in December 2003

Name of Project	Region	Anticipated Date of Completion
Mt. Scott Creek Restoration	CCSD#1	Completed
Deer Creek Restoration	CCSD#1	Completed
Phillips Creek Restoration	CCSD#1	Completed
Cedar Creek Restoration	CCSD#1	Completed
Trillium Creek Restoration	CCSD#1	2002
Wilson Creek Restoration	SWMACC	2002
Fields Creek Restoration	SWMACC	2002
Saum Creek Restoration	SWMACC	2002

Source: Karen Streeter, Endangered Species Coordinator (Water Environment Services)

Stormwater Systems

There are a variety of surface water management providers in the county that manage water quality and stormwater runoff from new development. An example of one of the service providers is WES. WES is conducting an inventory of storm water systems for the unincorporated areas in the Clackamas County Service District #1 (northern part of the county), which will be completed in November 2002.

Flood Management Projects

Flood management structures can assist in regulating flood levels by adjusting water flows upstream of flood-prone areas. There are a total of 173 dams in Clackamas County holding billions of gallons of water in reservoirs. Releases of water from the major reservoirs are designed to protect Clackamas County from high floodwaters. The largest reservoirs include:

- Bull Run Dam 2 - 20,500 acre-feet (Bull Run River)
- Timothy Lake - 66,000 acre-feet (Clackamas River)
- River Mill - 12,200 acre-feet (Clackamas River)
- North Fork Arch - 10,000 acre-feet (Clackamas River)

The Development Agency led the construction of the North Clackamas Regional Flood Control Detention Facility, which is located South of Harmony Road, west of 82nd Avenue. The site is about 87 acres, and includes an earthen detention berm and remotely monitored outlet control gates. The detention facility is designed to store 112-acre feet of floodwaters, which is a 17-year storm event. The impetus for construction was down-stream flooding. Tax increment financing provided 100% of the funding. The site has performed as expected, but no large storms greater than a 7-year event has occurred since the project was completed. The facility will help prevent and control

flooding up to a point, but is not designed to remove the threat of flooding in all of the downstream floodplains.

Community Issues Summary

Clackamas County works to mitigate problems regarding flood issues when they arise. However, funding, time and manpower are often unavailable, causing the problems to go unresolved. Some areas in the county are more susceptible to flooding issues, and have incurred repetitive losses. Clackamas County Emergency Management has documented the problem areas in the community, and they are listed in Table 6-7.

The USACE has been engaged in helping Clackamas County Emergency Management identify problem areas, and in some cases, has partnered with property owners to mitigate flooding and associated stream bank problems. However, many of these projects have not been maintained because the USACE is moving away from in-stream stabilization projects. The USACE does help to maintain a levee in the Clackamas River, and will continue to assist the county in appropriate mitigation projects.[40]

Table 6-7. Locations of Identified Flooding Problems

Location	River
Tranquility Lane	Clackamas River
Paradise Park	Clackamas River
Welches	Salmon River
Lolo Pass	Zig Zag River
Timberline	Sandy River
Dickie Prairie Road	Molalla
Feryer Park/ Shady Dell	Molalla
Alder Creek Area	Alder Creek
Canby	Pudding River
Dogwood Drive/ Rivergrove	Tualatin
Oregon City	Confluence of Willamette River and Clackamas River
Johnson Creek Basin	Johnson Creek
Abernethy Creek Basin	Abernethy Creek

Source: Clackamas County Emergency Management, 2002.

Flood Mitigation Action Items

The flood mitigation action items provide direction on specific activities that organizations and residents in Clackamas County can undertake to reduce risk and prevent loss from flood events. 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-FL#1: Analyze each repetitive flood property within Clackamas County and identify feasible mitigation options.

Ideas for Implementation

- Identify appropriate and feasible mitigation activities for identified repetitive flood properties. Funding may be available through FEMA's Hazard Mitigation Grant and Flood Mitigation Assistance Programs and the Pre-disaster Mitigation Program;
- Contact repetitive loss property owners to discuss mitigation opportunities, and determine interest should future project opportunities arise; and
- Explore options for incentives to encourage property owners to engage in mitigation.

Coordinating Organization:	Hazard Mitigation Advisory Committee
Timeline:	1-2 years
Plan Goals Addressed:	Protect Life and Property, Partnerships and Implementation

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ST-FL#2: Recommend revisions to requirements for development within the floodplain, where appropriate

Ideas for Implementation

- Evaluate elevation requirements for new residential and non-residential structures in the unincorporated floodplain area;
- Explore raising 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;
- Identify opportunities to upgrade Federal Insurance Rate Map, and arrange for Cooperative Technical Partnership mapping upgrades for select areas; and
- Identify alternatives to reduce development in the floodplain.

Coordinating Organization: County Department of Transportation and Development, County Geographic Information Services, Water Environment Services
Timeline: 1-2 years
Plan Goals Addressed: Protect Life and Property

ST-FL#3: Develop better flood warning systems.

Ideas for Implementation

- Coordinate with appropriate organizations to evaluate the need for more stream gauges; and
- Distribute information regarding flooding to the general public efficiently.

Coordinating Organization: County Emergency Management, County Public and Government Relations, Department of Transportation and Development
Timeline: 1-2 years
Plan Goals Addressed: Protect Life and Property, Emergency Services

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LT-FL#1: Enhance data and mapping for floodplain information within the county, and identify and map flood-prone areas outside of designated floodplains.

Ideas for Implementation

- Apply for FEMA's cooperative technical partnership using the 2-foot contour interval floodplain mapping data acquired by Clackamas County GIS;
- Use WES inventory and mapping data to update the flood-loss estimates for Clackamas County; and
- Encourage the development of 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: County Geographic Information Services, County Department of Transportation and Development, Water Environment Services
Timeline: 3 years (as funding allows)
Plan Goals Addressed: Protect Life and Property

LT-FL#2: Encourage development of acquisition and management strategies to preserve open space for flood mitigation, fish habitat, and water quality in the floodplain.

Ideas for Implementation

- Develop a comprehensive strategy for acquiring and managing floodplain open space in Clackamas County;
- Explore funding for property acquisition from federal (e.g., FEMA Hazard Mitigation Grant Program), state, regional, and local governments, as well as private and non-profit organizations, trails programs, fish programs as well as options for special appropriations;
- Develop a regional partnership between flood mitigation, fish habitat, and water quality enhancement organizations/programs to improve educational 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; and
- Identify existing watershed education programs and determine which programs would support a flood education component.

Coordinating Organization:	County Department of Transportation and Development, Water Environment Services
Timeline:	5 years
Plan Goals Addressed:	Natural Systems, Protect Life and Property

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LT-FL#3: Identify surface water drainage obstructions for all parts of unincorporated Clackamas 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; and
- Prepare an inventory of major urban drainage problems, and identify causes and potential mitigation actions for urban drainage problem areas.

Coordinating Organization:	County Roads Division, Water Environment Services, County Geographic Information Systems
Timeline:	5 years
Plan Goals Addressed:	Protect Life and Property

LT-FL#4: Establish a framework to compile and coordinate surface water management plans and data throughout the county.

Ideas for Implementation

- Develop surface water management plans for areas that are not currently within surface water management plan boundaries.

Coordinating Organization:	Water Environment Services, County Planning Division, Geographic Information Systems
Timeline:	3-5 years
Plan Goals Addressed:	Protect Life and Property, Partnerships and Implementation

Flood Resource Directory

The following resource directory lists the resources and programs that can assist county communities and organizations. The resource directory will provide contact information for local, county, regional, state and federal programs that deal with natural hazards.

County Resources

Watershed Councils

Willamette Riverkeepers

Contact: Chair
Address: 380 SE Spokane St., Suite 305, Portland. OR 97202
Phone: (503) 223-6418
Website: www.willamette-riverkeeper.org
Email: info@willamette-riverkeeper.org

Johnson Creek WS Council

Contact: Chair
Address: PO Box 82584 Portland, OR 97282
Phone: (503) 239-3932
Website: www.jcwc.org
Email: kim@jcwc.org

Hood River WS Council

Contact: Chair
Address: 3007 Experiment Station Road Hood River, OR 97031
Phone: (541) 386-2275
Email: hcoccoli@aol.com

Clackamas River Basin Council

Contact: Chair
Address: Box 1869 Clackamas Oregon 97015
Phone: (503) 650-1256
Website: www.clackamasriver.org
Email: crbc@teleport.com

Tualatin WS Council

Contact: Chair
Address: 1080 SW Baseline Building B, Suite B-2 Hillsboro, OR 97123
Phone: (503) 648-3174x116
Website: http://www.trwc.org/
Email: tualatinwc@yahoo.com

Friends of Kellogg/ Mt. Scott

Contact: Chair
Address: PO Box 22373 Milwakie 97222
Phone: 503-653-7875
Email: fourcreeks@aol.com

State Resources

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.

Contact: Division of State Lands
Website: http://statelands.dsl.state.or.us/

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.[41]

Contact: Oregon Wetlands Joint Venture
Website: http://wetlands.dfw.state.or.us/

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.

Contact: Student Watershed Research Project
Address: 20000 NW Walker Road, Beaverton, OR 97006
Fax: (503) 748-1388
Website: http://www.swrp.org/

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: 2501 SW First Avenue, PO Box 59, Portland, OR 97207
Phone: (503) 872-5268
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

National Flood Insurance Program (NFIP)

Oregon has 256 flood-prone communities. Flood insurance is available to citizens in communities that adopt and implement NFIP 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.

Contact: National Flood Insurance Program
Website: http://www.fema.gov/nfip/

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.

Contact: National Flood Insurance Program
Website: http://www.fema.gov/nfip/crs.htm

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 a catalog of Web links.

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

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

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

National Weather Service, Portland Bureau

The National Weather Service provides flood watches, warnings, and informational statements for rivers in Clackamas 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/

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/

Farm Services Agency, US Department of Agriculture Clackamas-Multnomah County FSA

Stabilizing farm income, helping farmers conserve land and water resources, providing credit to new or disadvantaged farmers and ranchers, and helping farm operations recover from the effects of disaster are the missions of the U.S. Department of Agriculture's Farm Service Agency (FSA).

Contact: County Executive Director
Address: 256 Warner Milne Road, Oregon City, Oregon 97045-4096
Phone: (503) 655-3144
Fax: (503) 656-3143
Website: http://www.fsa.usda.gov/pas/default.asp

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 clear debris from clogged waterways, restore vegetation, and stabilizing riverbanks. The measures taken under EWP must be environmentally and economically sound and generally benefit more that one property.

Contact: Resource Conservationist
Address: 256 Warner Milne Rd, Oregon City, Oregon 97045-4014
Phone: (503) 655-3144
Website: http://www.nrcs.usda.gov/

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

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

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.

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/

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.

Contact: Natural Hazards Program Manager, DLCD
Address: 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540
Phone: (503) 373-0050
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 10-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).

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] *All Hazard Mitigation Plan Clackamas County, Oregon*. G&E Engineering Systems Report 32.07.01, Revision 0. September 23, 1998.

[2] Interagency Hazard Mitigation Team, *State Hazard Mitigation Plan* (2000) Oregon Emergency Management.

[3] Ibid

[4] Dennis Sigrist. Oregon Emergency Management, Clackamas County Cumulative FIP Loss Data. (February 2001).

[5] *Oregon City Hazard Mitigation Plan*. Robert Olson Associates, Inc., French and Associates, Ltd. 1998.

[6] National Flood Insurance Program: http://www.fema.gov/nfip (April 2002).

[7] Taylor, George H., Hannan, Chris, The Climate of Oregon (1999). Oregon State University Press. Corvallis, Oregon.

[8] Interagency Hazard Mitigation Team, *State Hazard Mitigation Plan* (2000) Oregon Emergency Management.

[9] Taylor, George H., Hannan, Chris, The Climate of Oregon (1999). Oregon State University Press. Corvallis, Oregon.

[10] Geologic Hazards of the Bull Run Watershed Multnomah and Clackamas Counties, Oregon. DOGAMI. Bulletin 82. 1974

[11] Clackamas County Zoning and Development Ordinance. June, 2002.

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

[13] *All Hazard Mitigation Plan Clackamas County, Oregon*. G&E Engineering Systems Report 32.07.01, Revision 0. September 23, 1998.

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

[15] http://www.fema.gov/mit/eap_d.htm

[16] *Floodplain Management: a Local Administrator's Guide to the National Flood Insurance Program*. FEMA, Region 10.

[17] Ibid.

[18] Ibid.

[19] Ibid.

[20] All Hazard Mitigation Plan Clackamas County, Oregon. G&E Engineering Systems Report 32.07.01, Revision 0. September 23, 1998.

[21] Ibid.

[22] Ibid.

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

[24] Ibid.

[25] Ibid.

[26] Ibid.

[27] Ibid.

[28] Ibid.

[29] Personal Interview. Feb. 8 , 2002. Larry Stevens (Clackamas River Water)

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

[31] Personal Interview. March 15, 2002. Dave Conrad (Clackamas Roads Division)

[32] *Regional Hazard Mitigation Policy and Planning Guid*e. (June 1999). Metro.

[33] Clackamas county website: http://www.co.clackamas.or.us

[34] Title 3, Metro Regional Framework Plan, www.multnomah.lib.or.us/metro/growth/tfplan/funcsum.html (July 2001).

[35] Personal Interview. April 12, 2002. Larry Stevens (Clackamas River Water)

[36] Tualatin River Watershed Council, http://www.trwc.org/ (February 2001).

[37]http://www.willamette.edu/~broesler/riverweb/mainframeset.htm

[38] *Department of State Lands, Wetlands Functions and Assessmen*t, Website: http://statelands.dsl.state.or.us/fact5.pdf (May 2001)

[39] Ibid.

[40] Personal Interview. July 30, 2002. Les Miller, Dick Gamble (USACE).

[41] Oregon Wetlands Joint Venture, Website: http://www.dfw.state.or.us/ODFwhtml/Wetlands/about.htm (May 2001).

Section 7:
Landslide

Table of Contents

Why are Landslides a Threat to Clackamas County?

Landslides are a serious geologic hazard in almost every state in America. Nationally, landslides cause 25 to 50 deaths each year.[1] The best estimate of direct and indirect costs of landslide damage in the United States range between $1 and $2 billion annually.[2] In Oregon, a significant number of locations are in danger of being impacted by 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 present the greatest risk to human life, and people 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 four 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 are a common hazard in around Oregon. In fact, a prominent theme of the 1996 flood disaster was that a significant amount of building damage affected structures outside of identified flood hazard areas. Many of the 5,000 Clackamas County applicants eligible for FEMA housing assistance grants were not floodplain cases, but were landslide and erosion losses.[4]

In many parts of the Clackamas County, weathering and the decomposition of geologic materials produces conditions conducive to landslides. Human activity has further exacerbated the landslide problem in many parts of the county. A study conducted by Dr. Scott Burns at Portland State University found that changes to the slope through cutting or filling increased the risk of landslides in 76% of the 701 inventoried landslides in the Metro region. The study documented 48 landslides that occurred in Oregon City in February 1996, and found that only about half the slides were considered natural.[5]

Landslides in Clackamas County are not a localized problem. For example, sediment generated by the slides can affect regional water quality. During the winter of 1972, a relatively small landslide on the north fork of the Bull Run River in the western Cascades introduced a large volume of silt and clay into Portland's main water supply reservoir. Consequently, the city's water supply was discolored for several weeks.[6]

Many landslides are difficult to mitigate, particularly in areas of large historic movement with weak underlying geologic materials. As communities continue to modify the terrain and influence natural

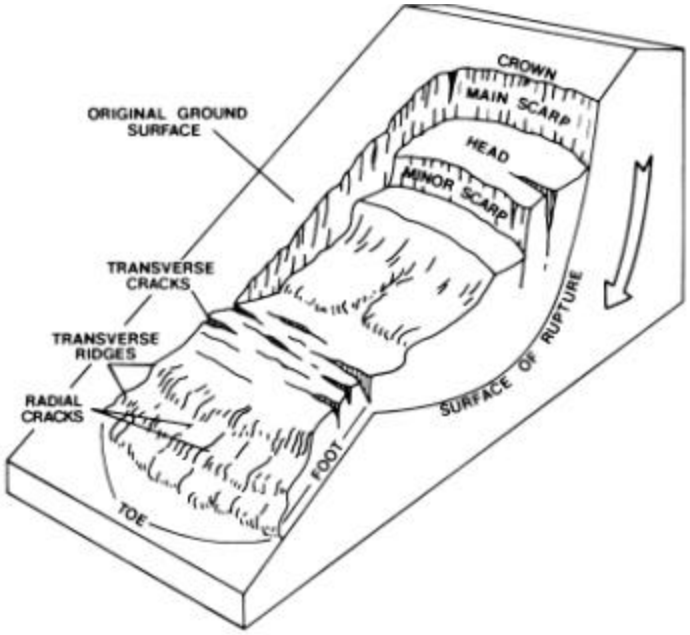
processes, it is important to be aware of the physical properties of the underlying bedrock as it, along with climate, dictates hazardous terrain. Without proper planning, landslides will continue to threaten the safety of people, property, and infrastructure.

Landslide Characteristics

What is a Landslide?

Landslides are downhill movements of rock, debris, or soil mass. The size of a landslide usually depends on the geology and the initial cause of the landslide. Landslides vary greatly in their volume of rock and soil, 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 in Clackamas County include slides, rock falls, and earth flows.

Figure 7.1. Rotational Slide



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

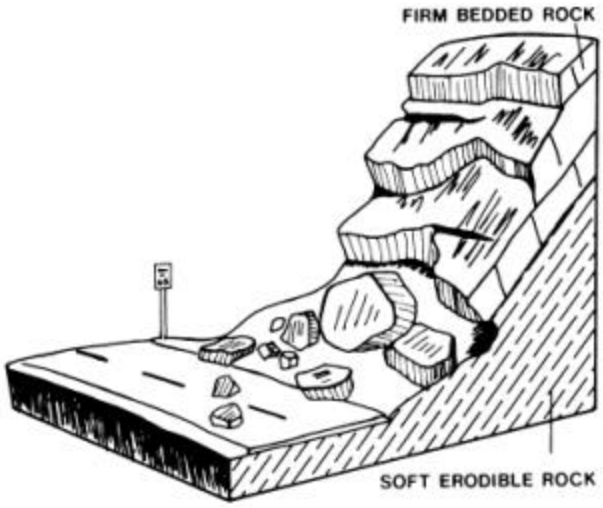
Slides move in contact with the underlying surface. These movements include rotational slides where sliding material moves along a curved surface, and translational slides where movement occurs along a flat surface. These slides are generally slow moving and can be deep. Slumps are small rotational slides that are generally shallow (See Figure 7.1). 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.[7]

Washouts caused by **erosion** are also relatively common in Clackamas 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 larger.

Rock falls (see Figure 7.2) 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 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.

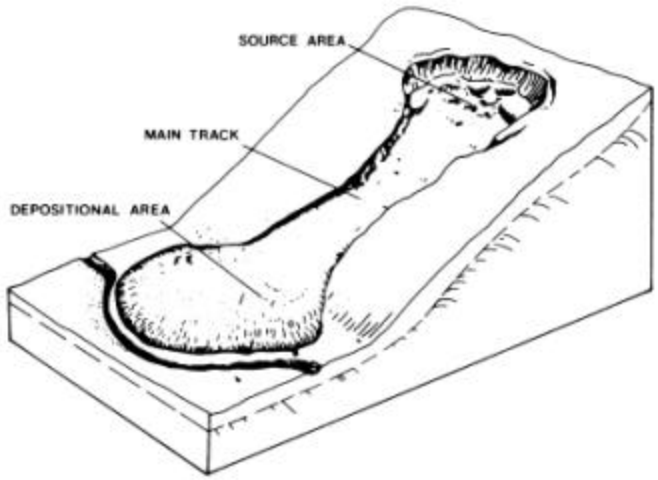
Figure 7.2. Rock Fall



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

Earth flows (see Figure 7.3) are plastic or liquid movements in which land mass (e.g. soil and rock) breaks up and flows during movement. Earthquakes often trigger flows. [8] 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.[9] Flows often occur during heavy rainfall, can occur on gentle slopes, and can move rapidly for large 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.[10]

Figure 7.3. Earth Flow



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

Landslide Conditions

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 effecting landslides include: excavation, drainage and groundwater alterations, and changes in vegetation.[11]

Natural Conditions

Natural processes can cause landslides or re-activate historical landslide sites. The removal or undercutting of shoreline-supporting material along bodies of water by currents and waves 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.

Particularly Hazardous Landslide Areas

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;
- 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; and
- Fan-shaped areas of sediment and boulder accumulation at the outlets of canyons.

Impacts of Development

Although landslides are a natural occurrence, human impacts can substantially affect the potential for landslide failures in Clackamas County. Proper planning can be exercised to reduce the threat of safety of people, property, and infrastructure.

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 above ground is often the trigger for landslides. 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. 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.[12]

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 roughly 10 years after timber harvesting.[13] 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.[14]

Landslide Hazard Assessment

Hazard Identification

Identifying hazardous locations is an essential step towards implementing more informed mitigation activities. The Oregon Department of Forestry (ODF) and the Department of Geology and Mineral Industries (DOGAMI) are active in developing maps and collecting data on hazard risk. Map 8 depicts the ODF data for debris flow hazards in Clackamas County. This map shows areas that are in moderate and high debris flow hazard areas using slope, geology, and soil type as determinates.

A partnership with DOGAMI has been established under Clackamas County Project Impact to develop multiple items of information for landslide hazard identification and mitigation in Clackamas County. The primary product of the partnership will be a comprehensive regional landslide hazard map of the county. In addition, a landslide inventory database and a digital compilation of known landslide topography will be available for Clackamas County. The combination of these digital datasets should be extremely valuable for local geologists, engineers, planners, and policy makers interested in addressing landslide hazards and developing targeted and efficient mitigation programs. DOGAMI has performed this type of work for the Metro area, as shown in Map 9. This hazard map depicts only landslide and slump hazard areas in the northwest portion of Clackamas County.

Vulnerability and Risk

Vulnerability assessment for landslides will assist in predicting how different types of property and population groups will be affected by a hazard.[15] 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. The Clackamas County Planning Division uses percent slope as an indicator of hill slope stability. The county uses a 20% or greater threshold to identify potentially unstable hill slopes. Map 10 shows percent slope for Clackamas County. An estimated 559,330 acres in the county exceeds this 20% slope threshold, indicating that almost 50% of the land in Clackamas County has potentially unstable soil.

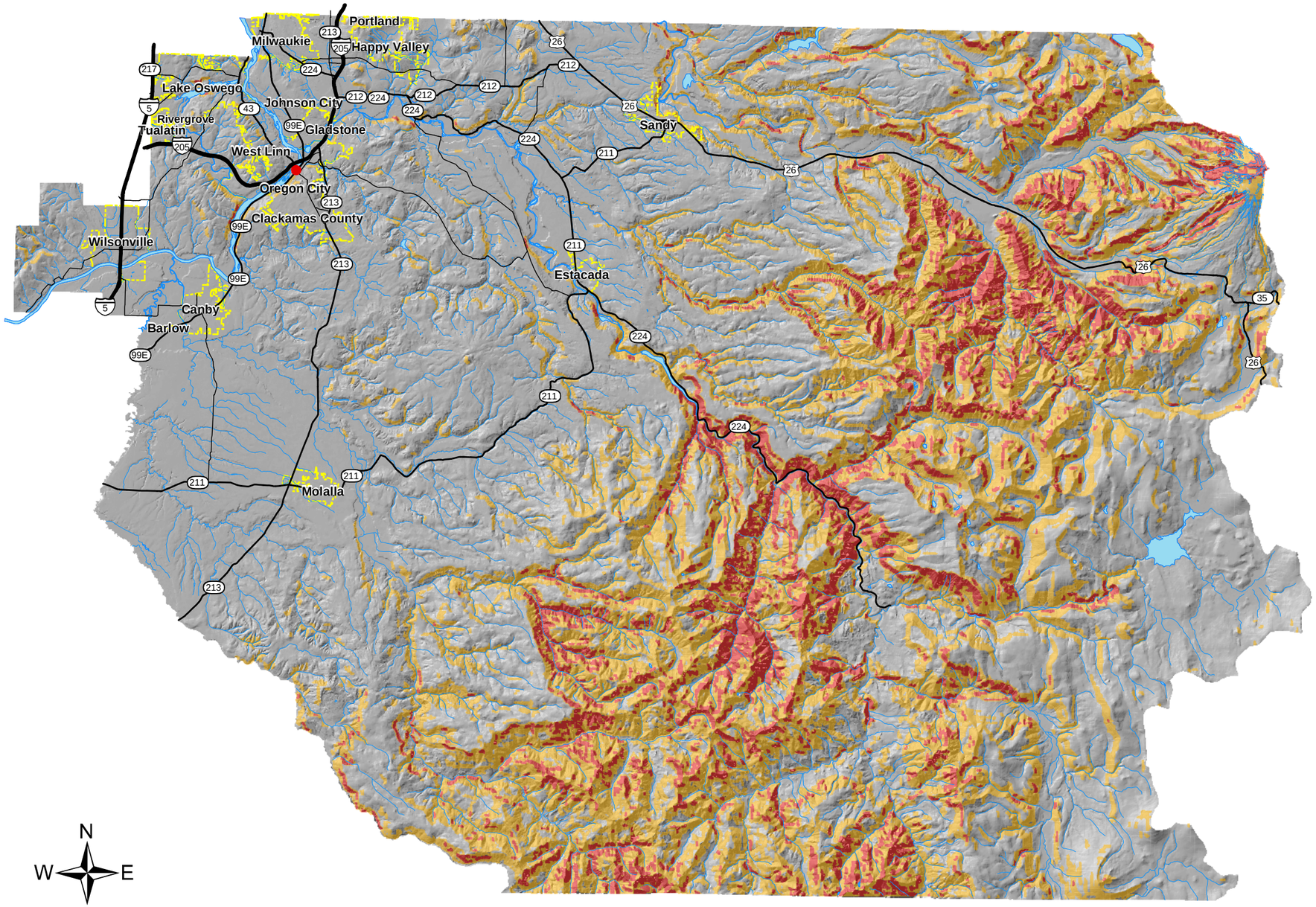
While a quantitative vulnerability assessment (an assessment that describes number of lives or amount of property exposed to the hazard) has not yet been conducted for Clackamas County landslide events, there are many qualitative factors that point to potential vulnerability. Landslides can impact major 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.

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 specific landslide or debris flow event. 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. However, Phase I of the Clackamas County Natural Hazards Mitigation Plan, Final Engineering report developed in 1998 estimated losses due to landslides in Clackamas County.[16] Although detailed landslide data is not available for the county, this plan identifies loss estimates for the landslide hazard areas based on significant slope areas. This approach reflects only slope angle, and does not account for factors such as local soil and bedrock conditions. The results of the report are summarized in Table 7.1.

Table 7.1 Landslide Loss Estimates for Clackamas County

Storm	Wood Buildings	Steel Buildings	Concrete and Masonry Buildings	Roads and Highways
25 Year	$412,000	$10,500	$62,000	$787,000
100 Year	$723,000	$19,000	$109,000	$1,353,000

Source: *"All Hazard Mitigation Plan: Clackamas County, Oregon".* G&E Engineering Systems Report 32.07.01, Revision 0. September 23, 1998.



Map 8

Clackamas County Debris Flow Hazards

- County Seat
- Cities
- Major Rivers and Lakes
- Rivers, Creeks, and Streams

Debris Flow Hazard

- High
- Moderate

- Interstate
- Highway
- Roads

Data Source: City Limits are maintained by Metro. The County Boundary, Hydrology, and Street layers are maintained by Clackamas County GIS Staff.

The Debris Flow Hazards Data is from the Oregon Department of Forestry. This map provides a priliminary indication of debris flow hazard for Clackamas County. The data is static. It was released in 12/01/1999.

1 inch equals 5 miles

Miles

8 4 0 8

Clackamas County

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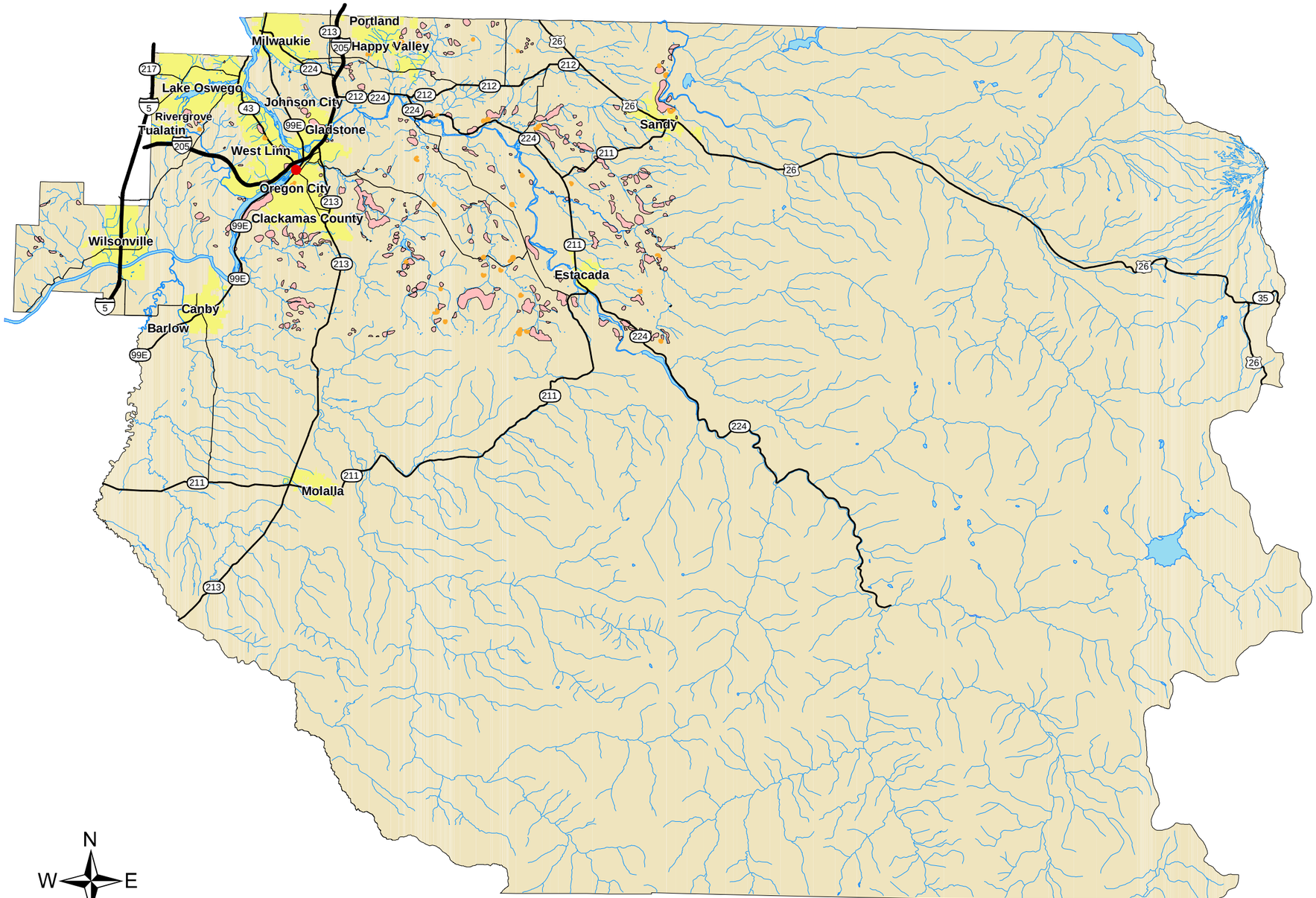
CLACKAMAS COUNTY GIS | JONMCD | DebriFlow.MDX | AUGUST 27, 2002

Map 9

Slump and Earth Flows, and Landslides, Northwest Clackamas County



Slump and Earth Flow
Landslides
Rivers, Creeks, and Streams
Major Rivers and Lakes
County Seat
Cities
County Boundary

Interstate
Highway
Roads

Data Source: City Limits are maintained by Metro. The County Boundary, Hydrology, and Street layers are maintained by Clackamas County GIS Staff.

The geohazards data was digitized from the DOGAMI 1979, Bulletin 99, Geology and Geologic Hazards of Northwestern Clackamas County, Oregon.

DOGAMI is currently creating a county-wide geohazard data layer.

1 inch equals 5 miles

Miles

8 4 0 8

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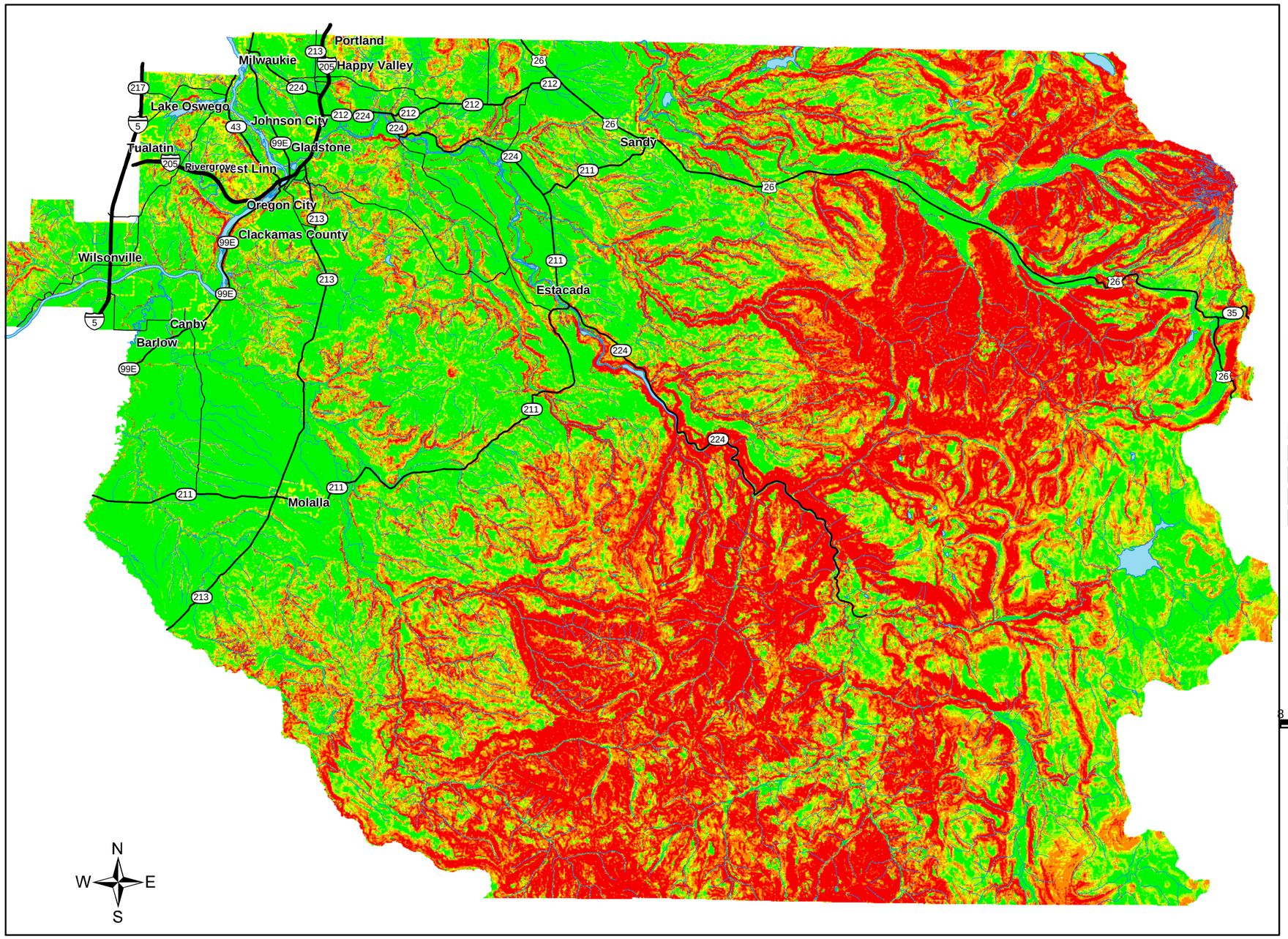
Map 10

CLACKAMAS COUNTY SLOPE



Cities
Rivers, Creeks, and Streams
Major Rivers and Lakes
Interstate
Highway
Roads

Percent of Slope

- 0 - 9.9
- 10 - 14.9
- 15 - 19.9
- 20 - 34.9
- >= 35

Data Source: City Limits are maintained by Metro. The County Boundary, Hydrology, and Street layers are maintained by Clackamas County GIS Staff.
The precent of slope was calculated using the USGS 10-meter Digital Elelvation Model.

1 inch equals 5 miles

Miles

8 4 0 8

Clackamas County

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CLACKAMAS COUNTY GIS | JONMCD | SLOPE.MDX | AUGUST 27, 2002

Community Landslide Issues

What is Susceptible to Landslides?

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.[17]

Roads and Bridges

Large losses incurred from landslide hazards in Clackamas County have been associated with roads.[18] The Clackamas County Roads Division is responsible for responding to slides that inhibit the flow of traffic or are damaging a road or a bridge. The roads department does its best to communicate with residents impacted by landslides, but can usually only repair the road itself, as well as the areas adjacent to the slide where the county has the right of way.

It is not cost effective to mitigate all slides because of limited funds and the fact that some historical slides are likely to become active again even with mitigation measures. The county Roads Division alleviates problem areas by grading slides, and by installing new drainage systems on the slopes to divert water from the landslides. This type of response activity is often the most cost-effective in the short-term, but is only temporary. Unfortunately, many property owners are unaware of slides and the dangers associated with them.

Lifelines and critical facilities

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 -critical for hospitals and 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.[19] Flood events can also cause landslides, which can have serious impacts on gas lines that are located in vulnerable soils.

Landslide Mitigation Activities

Landslide mitigation activities include current mitigation programs and activities that are being implemented by local or county organizations.

County

Clackamas County Zoning Code

Clackamas County addresses development on steep slopes in subsection 1003.02 (Hazards to Safety) of the Zoning Development Ordinance (ZDO). This section outlines standards for steep slope hazard areas on slopes of 20 percent or more. Generally, the ordinance requires soils and engineering geologic studies for developments proposed on slopes of 20 percent or greater. More detailed surface and subsurface investigations shall be warranted if indicated by engineering and geologic studies to sufficiently describe existing conditions. This may include soils, vegetation, geologic formations, and drainage patterns. Site evaluations may also occur where stability might be lessened by proposed grading/filling or land clearing.

Regional Hazard Mapping

Clackamas County, under the Project Impact grant, has partnered with the Department of Geology and Mineral Industries (DOGAMI) to develop a consistent and comprehensive regional landslide hazard map of the county. This regional hazard mapping will expand on the earthquake-induced hazard mapping to include other likely initiation mechanisms (such as heavy rainfall). Complementary products to accompany the hazard map include a landslide inventory database (building on a previous 1996-97 consolidation effort by DOGAMI) and a digital compilation of known landslide topography. The combination of these digital data sets should be extremely valuable for local geologists, engineers, planners, and policy makers interested in addressing landslide hazards and developing targeted and efficient mitigation programs. The project will be completed in December 2002.

Community Issues Summary

Communities in Clackamas County face problems in identifying locations of landslides because landslides are difficult to inventory. Landslides are so prevalent in parts of the county, that it is not feasible to identify all hazard areas. In addition, there is no landslide insurance and records of landslide losses and locations are often unavailable. The county Department of Transportation and Development, however, does deal with landslides and their repercussions quite frequently. The following table has been constructed through information available from county departments. This is not an exhaustive list of landslides in the county, but it provides examples of problem areas, and mitigation projects in which the county has been involved.

Table 7.2 Recently Active Landslides

Recently Active Slides	Repair Costs	Description of Repair Activities
Bull Run Road	NA	This slide is too big to stabilize without substantial engineering and funding. The Roads Division has removed the road regraded the surface, and repaved the road in some areas. The Roads Division partnered with Portland Water to add a manifold and reconstruct the drainage in problem areas.
Gronlund Road	$5,587	There are three active slides along this road. One has been repaired with a buttress, and one has been repaired by removing loading from the top of the slide. This area is unstable due to oversteepened slopes by property owners.
Clackamas River Drive	$29,370	This area is very unstable. The Roads Division is consistently repairing this road and the adjacent slopes. The slopes will not become stable until they have unloaded enough material to reach their angle of repose. In the Cape Horn area, the Roads Dept. removed trees where roots were threatening the integrity of the brittle sandstone bedrock.
South End Road	NA	This area is comprised of soft colluvium, which slides very easily downslope. The Roads Division has replaced some of this material with a more compact aggregate. In addition, impermeable drainage ditches were installed to redirect flows, and some material was removed to reduce loading.
Upper Road	NA	The Bureau of Land Management owns this property, and has done some repairs including drainage diversion and grading.
Kitzmiller Road	NA	Drainage has been installed to redirect flows.
Dickey Prairie Road	NA	Drainage has been installed to redirect flows. This is a dead end road, so it threatens the lifeline of at least one property owner.
Tickle Creek Road	NA	Drainage has been installed to redirect flows.
Heiple Road	NA	Drainage has been installed to redirect flows. This is a dead end road, so it threatens the lifeline of at least one property owner.

Table 7.3 Less Frequently Active Landslides

Less frequently Active Slides	Description of Repair Activities
Knox Road	This is a dead end road, so it threatens the lifeline of at least one property owner.
Graves Road	This is a dead end road, so it threatens the lifeline of at least one property owner.
Ringo Road	This is a very large, historical slide located on private property.

Table 7.4 Repaired Landslides

Repaired Slides	Cost	Federal Highway Agency (FHWA)	Description of Repair Activities
Maple Lane Rd.	NA	NA	The Road Division imposed drainage structures on this slide, and graded the slope to the angle of repose to stabilize this slide.
Tower Drive	$68,219	NA	Repairs included debris clearing and excavation, infill of agglomerate.
Lusted Rd.	$1,604	$261	Repairs included debris clearing and excavation, and new drainage installation.
Sleepy Hollow Drive	$88,747	NA	Repairs included debris clearing and excavation, storm pipe and new drainage installation, culvert installation, man hole installation, stone embankment, rip rap basins, rip rap dams, agglomerate backfill, soil cap, and erosion control planting.
Loader Rd.	$14,937	NA	Repairs included debris clearing and excavation, storm pipe and new drainage installation, culvert installation, infill of agglomerate.
South Ridge Rd.	$78,201	$75,313	Repairs included debris clearing and excavation, storm pipe installation, infill of basaltic agglomerate.
Salmon River Rd.	$188,895	$177,807	This slide is particularly hazardous, as there are structures located here. At one point, structures were moved approximately 200 feet. Repairs included debris clearing, storm pipe installation, removal of aluminum culvert and replacement with granular backfill.
Central Point Rd.	$24,891	$46	Repairs included debris clearing and excavation, and new drainage installation.
Metzler Park Rd.	$89,750	NA	Repairs included debris clearing and excavation, storm pipe and new drainage installation, embankment installation, riprap, and erosion control planting.
Thayer Rd. Slide	$191,572	NA	Repairs included debris clearing and excavation, storm pipe and new drainage installation, culvert installation, infill of agglomerate.
Barton Park	$77,245	NA	Removal of debris, backfill with stony agglomerate, installation of erosion curbs.
Wilsonville	$126,527	$113,378	Repairs included debris clearing and excavation, storm pipe and new drainage installation, stone embankment installation, riprap, and erosion control planting.
Judd Rd.	$26,773	NA	Repairs included debris clearing and excavation, storm pipe and new drainage installation, road improvement, agglomerate backfill, and erosion control planting.
Duus Rd.	$79, 720.50	NA	Repairs included debris clearing and excavation, storm pipe and new drainage installation, agglomerate backfill, and erosion control planting.
S W Mountain Rd. 1	$296,119	$261,013	Repairs included debris clearing and excavation, storm pipe and new drainage installation, culvert installation, catch basin installation, agglomerate backfill, stone embankment, and erosion control planting.

Table 7.4 Repaired Landslides *(Continued)*

Repaired Slides	Cost	FHWA	Description of Repair Activities
Mountain Rd. 2	$264,642	$261,020	Repairs included debris clearing and excavation, storm pipe and new drainage installation, culvert installation, stone embankment, wire retaining wall, agglomerate backfill, and erosion control planting.
Fabion Loop Slide	$14,099	NA	Removal of debris, backfill with stony agglomerate, drainage installation, roadway restoration.
Elk Park Rd.	$44,340	NA	Repairs included debris clearing and excavation, storm pipe and new drainage installation, culvert removal and installation, agglomerate backfill, and fill eroded road bed.
Feyrer Park Rd.	$58,771	$52,735	Repairs included debris clearing and excavation, storm pipe and new drainage installation, agglomerate backfill. County Engineering has installed monitoring devices on this landslide to determine the stability of the repaired slopes

Landslide Mitigation Action Items

The landslide mitigation action items provide direction on specific activities that cities, organizations, and residents in Clackamas County can undertake to reduce risk and prevent loss from landslide events. 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-LS#1: Improve knowledge of landslide hazard areas and understanding of vulnerability and risk to life and property in hazard-prone areas.

Ideas for Implementation

- Incorporate the results from the DOGAMI mapping effort into the Clackamas County Natural Hazards Mitigation Plan Risk Assessment, and other county planning documents; and
- Develop public information to emphasize economic risk when building on potential or historical landslide areas.

Coordinating Organization:	Clackamas County Geographic Information Systems, Hazard Mitigation Advisory Committee
Timeline:	2 years
Plan Goals Addressed:	Protect Life and property, Public Awareness

---

ST-LS#2: Encourage construction and subdivision design that can be applied to steep slopes to reduce the potential adverse impacts from development.

Ideas for Implementation

- Increase communication and coordination between the county Soils and Building Divisions.

Coordinating Organization:	Clackamas County Department of Transportation and Development, Water Environment Services
Timeline:	3 years
Plan Goals Addressed:	Protect Life and Property, Partnerships and Implementation

---

ST-LS#3: Identify safe evacuation routes in high-risk debris flow and landslide areas.

Ideas for Implementation

- Identify potential debris removal resources;
- Increase participation in regional committee planning for emergency transportation routes; and
- Identify and publicize information regarding emergency transportation routes.

Coordinating Organization:	Clackamas County Department of Transportation and Development
Timeline:	2 years
Plan Goals Addressed:	Protect Life and Property, Emergency Services

---

LT-LS#1: Evaluate current landslide warning systems to ensure effectiveness and efficiency and increase coordination between local jurisdictions and ODF for landslide warning systems.

Ideas for Implementation

- Educate high-risk populations about climatic and soil conditions that are conducive to landslides.

Coordinating Organization:	Hazard Mitigation Advisory Committee
Timeline:	3-5 years
Plan Goals Addressed:	Protect Life and Property, Emergency Services, Partnerships and Implementation

---

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

Ideas for Implementation

- Analyze existing regulations regarding development in landslide prone areas;
- Identify existing mechanisms for public outreach (e.g., SWCD, NRCS, watershed councils, etc.).

Coordinating Organization:	Hazard Mitigation Advisory Committee
Timeline:	Ongoing
Plan Goals Addressed:	Protect Life and Property, Public Awareness, Natural Systems

Landslide Resource Directory

State Resources

Oregon State Building Codes Division

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 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 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.[20]

Contact: Oregon State Building Codes Division
Address: 1535 Edgewater St. NW, P.O. Box 14470, Salem, OR 97309
Phone: (503) 373-4133
Website: http://www.cbs.state.or.us/external/bcd

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, and producing geologic hazard maps. The agency also provides technical resources for communities and 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

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.

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.[21]

Oregon Debris Flow Warning Page

The Oregon Debris Flow Warning page provides communities with up-to-date access to information regarding potential debris flows. The Debris Flow Warning system was initiated in 1997 and involves collaboration between ODF, DOGAMI, the Oregon Department of Transportation (ODOT), local law enforcement agencies, NOAA Weather Radio, and local media. The 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 provided to emergency services 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.

Contact: ODF
Address: 2600 State Street, Salem, OR, 97310
Phone: (503) 945-7200
Fax: (503) 945-7212
Website: http://www.odf.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

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 (FEMA), 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

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; and
- Appointing the Department of Geology and Mineral Industries, with cooperation from local governments and the Department of Forestry, to identify and map rapidly moving landslides 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."22

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.[23]

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. The landslide brochure is available from DOGAMI, OEM, ODF, and the Department of Land Conservation and Development (DLCD).[24]

Contact: Department of Geology and Mineral Industries
Address: 800 NE Oregon Street, Suite 965**,** Portland, Oregon 97232
Phone: (503) 731-4100
Fax: (503) 731-4066
Website: http://www.oregongeology.com

Nature of the Northwest

The 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, Portland, Oregon 97232
Phone: (503) 872- 2750
Fax: (503) 731-4066
Website: http://www.naturenw.org
Email: Nature.of.Northwest@state.or.us

Publications

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, rock falls, and earth flows.

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

Burns, Burns, James, and Hinchke. *Landslides in Portland, Oregon Metropolitan Area* (resulting from Storm of 1996: Inventory, Map Data, and Evaluation.)

This paper provides an inventory of landslides resulting from the 1996 storm events. It is an excellent resource for determining the location and casue of many of the slides that occurred in this region.

R. Jon Hofmeister. *Slope Failures in Oregon. GIS Inventory for Three 1996/97 Storm Events.* Oregon Department of Geologic and Mineral Industries. Special Paper 34.

The objective of this project was to collect and consolidate data on Oregon landslides associated with severe storm events in February 1996, November 1996, and December 1996/January 1997.

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] Interagency Hazard Mitigation Team, *State Hazard Mitigation Plan* (2000) Oregon Emergency Management.

[5] Burns, Burns, James, and Hinchke. Landslides in Portland, Oregon Metropolitan Area (resulting from Storm of 1996: Inventory, Map Data, and Evaluation.)

[6] Schlicker, Ht., and Finlayson Ct. (1979) Geologic and Geohazards of NW Clackamas County. Bulletin 99. DOGAMI, OR.)

[7] Interagency Hazard Mitigation Team, *State Hazard Mitigation Plan* (2000) Oregon Emergency Management.

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

[9] Ibid.

[10] *Planning for Natural Hazards: The Oregon Technical Resource Guide,* Department of Land Conservation and Development (July 2000), Ch. 5.

[11] Ibid.

[12] *Homeowner's Guide for landslide control, hillside flooding, debris flows, soil erosion,* (March 1997).

[13] *Storm Impacts and Landslides of 1996 Final Report* (1999) Oregon Department of Forestry.

[14] *Planning for Natural Hazards: The Oregon Technical Resource Guide,* Department of Land Conservation and Development (July 2000), Ch. 5.

[15] Burby, R. (Ed.) *Cooperating with Nature.* (1998) Washington D.C.: Joseph Henry Press.

[16] Goettal et al.

[17] *"All Hazard Mitigation Plan: Clackamas County, Oregon".* G&E Engineering Systems Report 32.07.01, Revision 0. September 23, 1998.

[18] Ibid

[19] Ibid.

[20] *Planning for Natural Hazards: The Oregon Technical Resource Guide,* Department of Land Conservation and Development (July 2000), Chapter 5.

[21] Ibid.

[22] Interagency Hazard Mitigation Team, *State Hazard Mitigation Plan* (2000) Oregon Emergency Management.

[23] Ibid.

[24] Ibid.

Section 8:
Wildfire

Table of Contents

Why are Wildfires a Threat to Clackamas County?

Fires are a natural part of the ecosystem in Oregon. However, wildfires can present a substantial hazard to life and property in growing communities. There are potential for losses due to wildland/urban interface fires in Clackamas County. According to the Oregon State Fire Marshal, there were over one thousand reportable fires in Clackamas County in 2000.

Oregon Fires, 2002

The summer of 2002 marks the most destructive wildfire season in recorded history. This year-to-date, there have been 736 statistical fires totaling 84,752 acres on Oregon Department of Forestry protected lands. Some 258 fires were lightning-caused totaling 81,395 acres, and 478 were human-caused totaling 3,357 acres. Last year at this time there had been 924 statistical fires totaling 50,404 acres. Some 376 were lightning-caused totaling 46,772 acres, and 548 were human-caused totaling 3,632 acres. Prior to 2002, the worst fire season in recent history occurred in 1987. At this point in the season that year, there had been 1,087 fires totaling 19,427 acres.[1] Table 8-1 reports the fire statistics for the largest fires in Oregon as of August 2002.

Table 8-1. US Forest Service reported fire statistics for 2002 (last updated in August 2002)

Incident Name	State	*Lead Agency	Size (acres)	Percent Contained	Estimate of Containment	Personnel	Structures Lost
Biscuit	OR	FS	500,068	90	8/31	3,221	13
Tiller Complex	OR	FS	66,355	75	9/15	1,785	0
Apple	OR	FS	10,200	30	9/5	1,129	0
Quartz Mt. Complex	WA	FS	1,074	0	Unknown	28	0

Source: United States Forest Service

Apple (Umpqua National Forest): This fire was 21 miles east of Glide, and encompassed 9,800 acres. Twenty residences were threatened.

Tiller Complex (Umpqua National Forest): Fire at 75 percent contained. This 65,824-acre fire, consists of eight large and numerous small fires, is on the Tiller Ranger District and in the Rogue-Umpqua Divide Wilderness Area, 25 miles east of Canyonville. Sixty-seven residences were threatened.

Biscuit Fire (Siskiyou National Forest): This fire cost more than $100 million to fight, and was located in southern Oregon and northern California. The fire began on July 13, 2002 and reached 500,023 acres in August 2002. Estimated to be one of Oregon's largest in recorded history, the Biscuit Fire encompasses most of the Kalmiopsis Wilderness. The boundary of the Biscuit Fire stretches from 10 miles

east of the coastal community of Brookings, Oregon; south into northern California; east to the Illinois Valley; and north to within a few miles of the Rogue River. There were 274 structures threatened by this fire. Four residences and nine outbuildings were lost.[2]

Historic Fires in Oregon

In 1990, Bend's Awbrey Hall Fire became one of Oregon's most destructive fires in recent history as it destroyed 21 homes, caused approximately $9 million in damage and cost over $2 million to suppress . 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.[3] Table 8-2 lists the major wildfires that occurred in Oregon between 1848 and 1966.

Table 8-2. Large 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.[4] Many of these fires burned in wildland/urban interface areas and exceeded the fire suppression capabilities of those areas. The magnitude of the 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.[5] Table 8-3 illustrates fire suppression costs for state, private, and federal lands protected by the Oregon Department of Forestry (ODF) between 1985 and 2000.

Table 8-3. Fire Suppression Costs in Oregon 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

Source: Oregon Department of Forestry: http://www.odf.state.or.us *Figures apply to the 15.8 million acres of state, private, and federal lands protected by ODF.

Wildfire Characteristics

There are three categories of interface fire:[6]

- 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 conditions include: 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).[7] Once a fire has started, several conditions influence its behavior, including fuel, topography, weather, drought, and development.

The Interface

One challenge Clackamas County faces regarding the wildfire hazard is from the increasing number of houses being built on 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 including forestlands. 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 and capability.[8] 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.

Fuel[9]

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, 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.

Topography[10]

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.

Weather

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.

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. [12]

Wildfire Hazard Assessment

Wildfire Hazard Identification

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. Table 8-4 illustrates a rating system to identify wildfire hazard risk (with a score of 3 equaling the most danger and a score of 1 equaling the least danger.)

Table 8-4. Hazard Identification Rating System

Category	Indicator	Rating
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.

Vulnerability and Risk

Clackamas County residents are served by a variety of local fire districts and fire departments, as well as state and federal fire districts (Map 11). 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, and direct these fire districts in fire prevention and recovery. Clackamas Fire District 1 and Clackamas County Geographic Information Systems (GIS) recently completed a wildfire hazard map for northwestern Clackamas County (Map 12). This map identifies the wildland/urban interface in Clackamas Fire District 1, and shows approximately 44,896 acres in this district that are subject to the wildfire hazard.

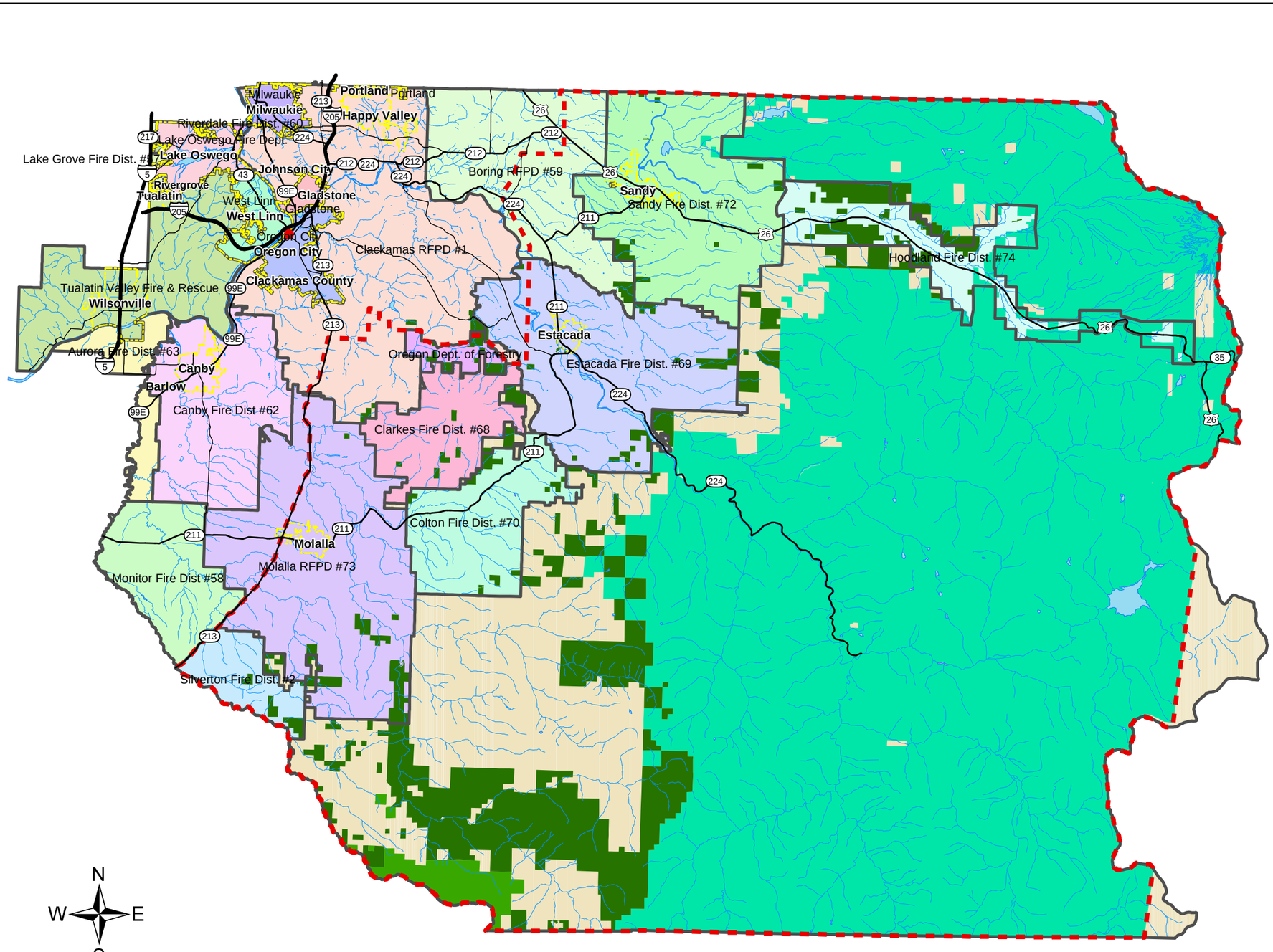
Clackamas County recently received a grant to identify and map wildfire hazard areas for the remainder of the county using satellite data and GIS analysis under the direction of the county's Fire Defense Board, the Emergency Management Coordinator, and in accordance with Oregon Administrative Rule, Division 44, (OAR 629-044-0200 through 00260) 'Criteria for Determination of Wildfire Hazard Zones'. Four-section aerial photography maps will be provided for each fire agency in the county, ODF, and the Clackamas County Emergency Operations Center. Each agency will receive map books to help define wildland interface areas, identify structures in the threatened areas, support local interpretation of wildland interface zones developed on a regional level, and provide a snapshot of vulnerability to assist mutual aid responders. Additional information layers (hydrants, hazardous materials facilities, schools, etc.) may be displayed, as data is available and requested. Maps and a mosaic of 2000 aerial photography (in 2' pixel size) will also be provided for each district.

The county has a large number of acres that are susceptible to wildland fires. Including federal lands, the areas of potential wildfires comprise an estimated 70% of the county. The mitigation plan will have a direct impact on the health, welfare and safety of residents who live in or near areas of potential wildfires in Clackamas County. The forthcoming wildfire hazard maps will assist county fire districts and departments in developing fire plans to address the areas most vulnerable to wildfires in Clackamas County.

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. The National Wildland/Urban Fire Protection Program has developed the Wildland/Urban Fire Hazard Assessment Methodology tool for communities to assess their risk to wildfire. For more information on wildfire hazard assessment refer to http://www.Firewise.org.

Map 11

Clackamas County Fire Districts



- County Seat
- Cities
- County Boundary
- ODF Protection Boundary
- BLM
- ODF
- USFS
- Rivers, Creeks, and Streams
- Major Rivers and Lakes
- Interstate
- Highway
- Roads

Note: Unitied States Forest Service contracts with Oregon Department of Forestery for Fire Protection Service. The Bureau of Land Manage does not have a similiar contract.
Clackamas RFPD #1 serves the City of Milwaukie and Clarkes Fire District #68.
Tualatin Valley Fire and Rescue serves the City of Lake Oswego and City of West Linn.

Data Source: City Limits are maintained by Metro. The County Boundary, Fire Districts, Hydrology, and Street layers are maintained by Clackamas County GIS Staff.
Public Lands layer was created from public records.

1 inch equals 5 miles

Miles
8 4 0 8

Clackamas County

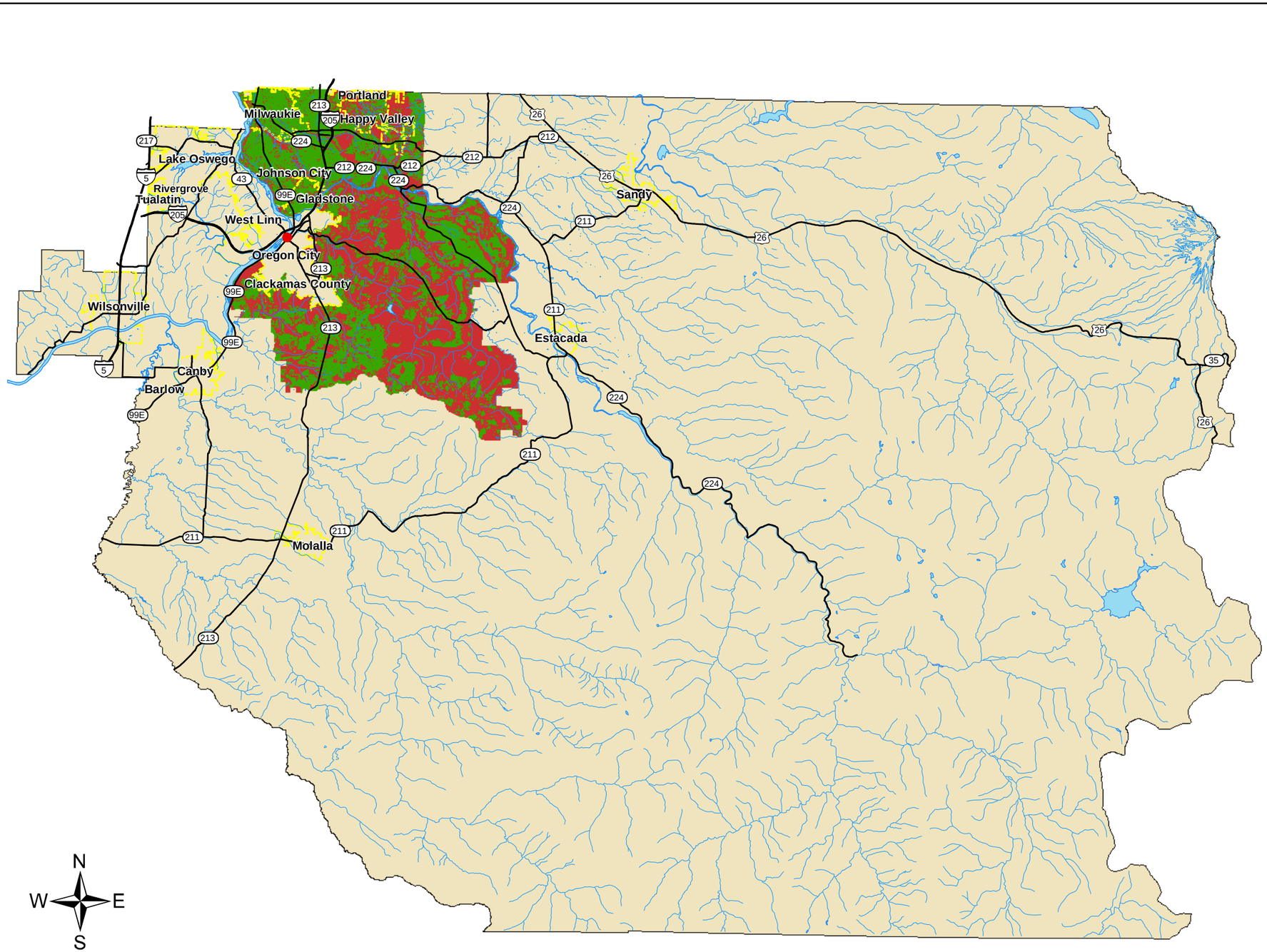
GEOGRAPHIC INFORMATION SYSTEMS

DEPARTMENT OF INFORMATION SERVICES/GEOGRAPHIC INFORMATION SYSTEMS
121 LIBRARY COURT
OREGON CITY, OREGON 97045

CLACKAMAS COUNTY GIS | JONMCD | FireDistricts.MDX | AUGUST 27, 2002

Map 12

Wildfire Hazards



No Wildfile Hazard
Wildfire Hazard
Major Rivers and Lakes
County Seat
Cities
County Boundary
Rivers, Creeks, and Streams

Interstate
Highway
Roads

Data Source: City Limits are maintained by Metro. The County Boundary, Hydrology, and Street layers are maintained by Clackamas County GIS Staff.
The wildfire data was provided to Clackamas County by Clackamas County Fire District 1in the year 2000.
Additional county wide wildfire information will be available in 2003.

1 inch equals 5 miles

Miles

8 4 0 8

Clackamas County

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Community Wildfire Issues

What is Susceptible to Wildfire?

Growth and Development in the Interface

The forested hills surrounding the county are considered to be interface areas. The development of homes and other structures is encroaching onto 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 a fire station, and available firefighting personnel and equipment. Reviewing past wildland/urban interface fires shows that many structures are destroyed or damaged for one or more of the following reasons:[13]

- 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

Road access is a major issue for all emergency service providers. As development encroaches into the rural areas of the county, the number of houses without adequate turn-around space is increasing. Developers are not required to provide adequate space for emergency vehicles in single-family residential homes, causing emergency workers to have difficulty doing their jobs because they cannot access houses. As fire trucks are large, firefighters are challenged by narrow roads and limited access. When there is doubt concerning the stability of a residential bridge, or adequate turn around space, the fire fighters can only work to remove the occupants, but cannot save the structure.

Water Supply

Fire fighters in remote and rural areas are faced by limited water supply and lack of hydrant taps. Rural areas are characteristically outfitted with small diameter pipe water systems, inadequate for providing sustained fire fighting flows. Some rural fire districts are

adapting to these conditions by developing secondary water sources. For example, the Hoodland fire district maintains dry hydrants near some of the lakes and ponds for access to water during fire emergencies.

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, as well as 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 Clackamas County influence the wildland/urban interface. While historical losses from wildfires in Clackamas County have been relatively low, the county shares many of the same characteristics of urban fringe development as areas recently ravaged by wildfire in California and the Southwest. This growth and development increases the public need for natural hazards mitigation planning in the county.

Wildfire 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

Clackamas County residents are served by a variety of local fire districts and fire departments, as well as state and federal fire districts (Map 11). Although each district or department is responsible for fire related issues in specific geographic areas, they work together to keep Clackamas County residents safe from fire. The Clackamas County Fire Defense Board (CCFDB) is an organization that promotes partnerships among the various fire service providers in the county. This board meets on a regular basis to ensure coordination of resources on a regional scale. The members of this board are responsible for developing and maintaining the CCFDB Fire Resources Management Plan, which documents the available resources and defined protocol for providing large-scale emergency response and adequate levels of emergency services during an emergency. In addition to the CCFDB, many of the fire jurisdictions in the county have partnered to form co-ops, to assist in fire prevention education and outreach, train Citizen Emergency Responders Teams (CERT), and ensure availability of resources.

The fire departments and districts provide essential public services in the communities they serve, and their duties far surpass extinguishing

fires. In fact, many of the districts and departments provide other services to their jurisdictions, including Emergency Medical Technicians (EMT) and paramedics who can begin treatment and stabilize sick and injured patients before an ambulance arrives.

All of the fire service providers in the county are dedicated to fire prevention, and use their resources to educate the public to reduce the threat of the fire hazard, especially in the wildland/urban interface.

Fire prevention professionals throughout the county have taken the lead in providing many useful and educational services to Clackamas County residents, such as:

- Home fire safety inspection;
- Assistance developing home fire escape plans;
- Business Inspections;
- Woodstove installation inspections;
- Free smoke detectors to district residents who qualify;
- Fire extinguisher operation classes;
- Citizen Emergency Response Team training;
- School, church, and civic group fire safety education presentations;
- Fire cause determination;
- Counseling for juvenile fire-setters;
- Teaching fire prevention in schools;
- Conducting CPR classes;
- Teaching proper use of fire extinguishers;
- Coordinating educational programs with other agencies, hospitals, and schools; and
- Answering citizens' questions regarding fire hazards.

County Codes

The Clackamas County Zoning Development Ordinance detail the setback, coverage, depth, corner vision, and structure height requirements of each development district to provide fire safety and protection of all structures. In addition, section 510 in the Unified Building Codes documents further fire resistant standards in regard to roofing. Building inspectors are responsible for enforcing these criteria in single-family residential structures. Fire districts work with the county Building Division to ensure safety in commercial structures.

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, as a condition of approval, that single-family dwellings on lands zoned as forestland meet the following requirements:

- Dwelling has a fire retardant roof;
- Dwelling will not be sited on a slope of greater than 40 percent;
- 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;
- Dwelling is located upon a parcel within a fire protection district or is provided with residential fire protection by contract;
- 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;
- If dwelling has a chimney or chimneys, each chimney has a spark arrester; and
- 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.

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:

- Directs the State Forester to establish a system of classifying forestland-urban interface areas;
- Defines forestland-urban interface areas;
- 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;
- Requires maps identifying classified areas to be made public;

- Requires public hearings and mailings to affected property owners on proposed classifications;
- Allows property owners appeal rights;
- 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
- 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 that requires approval 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:

- To provide an interface fire protection system in Oregon to minimize cost and risk and maximize effectiveness and efficiency;
- To promote and encourage property owners' efforts to minimize and mitigate fire hazards and risks; and
- To promote and encourage involvement of all levels of government and the private sector in interface solutions.[14]

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)

ODF is involved with local fire chiefs and local fire departments to provide training. Local firefighters 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.[15]

ODF has been involved with emergency managers to provide support during non-fire events and for years, ODF has worked with industrial partners (e.g., timber companies) to share equipment in the case of extremely large fires.[16]

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.[17]

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 (FEMA) Programs

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.[18]

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 Administration (USFA) provides public education materials addressing wildland/urban

interface issues, and the USFA's National Fire Academy provides training programs.

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.

U.S. Forest Service

The U.S. 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.[19]

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. [20]

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.[21]

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.

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.

Wildfire Mitigation Action Items

The wildfire mitigation action items provide direction on specific activities that organizations and residents in Clackamas County can undertake to reduce risk and prevent loss from wildfire events. 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-WF#1: Enhance emergency services to increase the efficiency of wildfire response and recovery activities.

Ideas for Implementation:

- Install more fire reporting stations for better access and coverage;
- Develop a county call list that includes all at-risk urban /wildland interface residents in the Clackamas County jurisdiction in order to contact them during evacuations; and
- Inventory bridges on evacuation routes, assess the bridges for their ability to support fire apparatus ingress, and encourage replacement of unstable bridges.

Coordinating Organization: Clackamas Fire Defense Board
Timeline: 2 years
Plan Goals Addressed: Emergency Services

ST-WF#2: 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; and
- 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: Clackamas Fire Defense Board
Timeline: 1-2 years
Plan Goals Addressed: Protect Life and Property, Public Awareness

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ST-WF#3: Inventory 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; and
- Develop a protocol for fire jurisdictions and water districts to communicate all hydrant outages and water shortage information.

Coordinating Organization: Clackamas Fire Defense Board
Timeline: 1 year
Plan Goals Addressed: Protect Life and Property

LT-WF#1: Encourage development and dissemination of maps relating to the fire hazard to help educate and assist builders and homeowners in being engaged in wildfire mitigation activities, and to help guide emergency services during response.

Ideas for Implementation:

- Update wildland/urban interface maps using data derived from the Clackamas County satellite-mapping project;
- Conduct risk analysis incorporating data and the created hazard maps using GIS technology to identify risk sites and further assist in prioritizing mitigation activities; and
- Encourage coordination between fire jurisdictions and sanitary districts to make sure that the most accurate elevation maps are being used.

Coordinating Organization: County Geographic Information Systems Department
Timeline: 1-3 years
Plan Goals Addressed: Protect Life and Property

LT-WF#2: Enhance outreach and education programs aimed at mitigating wildfire hazards and reducing or preventing the exposure of citizens, public agencies, private property owners, and businesses to natural hazards.

Ideas for Implementation:

- Encourage the hiring of fire prevention and education personnel to oversee education programs;
- Visit 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;
- 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 Clackamas 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.

Coordinating Organization:	Clackamas Fire Defense Board, Individual Fire Departments
Timeline:	Ongoing
Plan Goals Addressed:	Protect Life and Property, Public Awareness

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LT-WF#3: Increase communication, coordination, and collaboration between wildland/urban interface property owners, local and county planners, and fire prevention crews and officials to address risks, existing mitigation measures, and federal assistance programs.

Ideas for Implementation:

- Encourage single-family residences to have fire plans and practice evacuation routes;
- Encourage fire inspections in residential homes by fire departments to increase awareness among homeowners and potential fire responders;
- Encourage a standard for the State Fire Marshall to evaluate fire plans and emergency plans;
- Require fire department notification of new business applications to ensure that appropriate fire plans have been developed;
- Encourage local zoning and planning entities 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
- 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 and residential sprinkler systems; and
- 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: Clackamas Fire Defense Board, Individual Fire Departments
Timeline: Ongoing
Plan Goals Addressed: Protect Life and Property, Public Awareness, Emergency Services, Partnerships and Implementation

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LT-WF#4: Encourage implementation of wildfire mitigation activities in a manner consistent with the goals of promoting sustainable ecological management and community stability.

Ideas for Implementation:

- Employ mechanical thinning and prescribed burning to abate the risk of catastrophic fire and restore the more natural regime of high frequency, low-intensity burns. Prescribed burning can provide benefit to ecosystems by thinning hazardous vegetation and restoring ecological diversity to areas homogenized by invasive plants; and
- Clear trimmings, trees, brush, and other debris completely from sites when performing routine maintenance and landscaping to reduce fire risk.

Coordinating Organization: Clackamas Fire Defense Board, Individual Fire Departments
Timeline: Ongoing
Plan Goals Addressed: Natural Systems

Wildfire Resource Directory

County Resources

Boring Fire District
Contact: Fire Chief
Address: PO Box 85, 28655 SE Hwy 212, Boring Oregon 97009-0085
Phone: (503) 663-4638
Fax: (503) 663-5792
Website: http://www.boringfire.com/

Canby Fire District
Contact: Fire Chief
Address: 221 South Pine Street, Canby, Oregon 97013
Phone: (503) 266-5851
Fax: (503) 266-1320
Website: http://www.canbyfire.org/
Email: tkunze@canbyfire.org

Clackamas Co. Fire District #1
Contact: Fire Chief
Address: 11300 S.E. Fuller Road Milwaukie, Oregon 97222
Phone: (503) 655-8534
Fax: (503) 655-8538
Website: http://www.clackamasfire.com/
Email: randybru@ccfd1.com

Colton Fire District
Contact: Fire Chief
Address: PO BOX 71 COLTON OR 97017
Phone: (503) 824-2545
Fax: (503) 824-2546
Email: Crfpd70@colton.com

Estacada Fire District
Contact: Fire Chief
Address: PO BOX 608 ESTACADA OR 97023-0608
Phone: (503) 630-7712
Fax: (503) 630-7757
Email: llong@estacadafire.com

Gladstone Fire Department
Contact: Fire Chief
Address: 555 PORTLAND AVE GLADSTONE OR 97027
Phone: (503) 656-4253
Fax: (503) 650-8938
Email: Glad@spiritone.com

Hoodland Fire District
Contact: Fire Chief
Address: 69634 E Hwy 26 Welches Oregon USA 97067
Phone: (503) 622-3256
Fax: (503) 622-3125
Website: http://www.hoodlandfire.org/
Email: davidolson@hoodlandfire.org

Lake Oswego Fire Department
Contact: Fire Chief
Address: 300 B Avenue P.O. Box 369, Lake Oswego, OR 97034
Phone: (503) 635-0275
Fax: (503) 635-0376
Website: http://www.ci.oswego.or.us/fire/fire.htm
Email: semrad@ci.oswego.or.us

Molalla Fire District
Contact: Fire Chief
Address: 320 N. MOLALLA AVE. MOLALLA, OREGON
Phone: (503) 829-2200
Fax: (503) 829-5794
Website: http://www.molallafire.org/
Email: misso@molallafire.org

Monitor Rural Fire District
Contact: Fire Chief
Phone: (503) 634-2570
Fax: (503) 634-2600
Email: chief81@molalla.net

Sandy Fire District
Contact: Fire Chief
Address: 17460 SE Bruns Sandy, Oregon 97055
Phone: (503) 668-8093
Fax: (503) 668-7941
Website: http://www.sandyfire.com/
Email: gmcqueen@sandyfire.com

Tualatin Valley Fire & Rescue
Contact: Fire Chief
Address: 20665 SW Blanton Street, Aloha, Oregon 97007
Phone: (503) 649-8577
Fax: (503) 642-4814
Website: http://www.tvfr.com
Email: johnsojd@tvfr.com

Clackamas Fire Defense Board
Contact: Fire Chief, Administrator
Phone: 655-8534
Fax: 266-1320
Email: tkunze@canbyfire.org

State Resources

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

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 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.

Contact: National Interagency Fire Center
Address: 3833 S. Development Avenue, Boise, ID 83705-5354
Phone: (208) 387-5512
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

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

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Section 9:
Severe Winter Storm

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Why are Severe Winter Storms a Threat to Clackamas County?

Severe winter storms pose a significant risk to life and property in Clackamas 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 Clackamas County. Severe or prolonged snow events occur less frequently, but have widespread impacts on people and property in the county.

Historical Severe Winter Storm Events

Destructive storms producing heavy snow and ice have occurred throughout Clackamas County's history, most notably in 1937 and 1950. A serious winter 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 resulted in 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. All major highways were closed, blocking the main transportation arteries for travel and business.

On January 13th, 1950 a severe winter storm produced "devastating wind and snow" over a five day period. During the night of January 12, the temperature fluctuated wildly, and was 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.

SNOWSTORMS

January 9-12, 1998

From January 9-12, 1998, artic air from southeast Washington brought snow and freezing rain into Clackamas County and extended to the Oregon/Idaho border. The Portland area received 5 inches of snow, while other nearby areas received 12 inches.[1]

February 18-19, 1993

On February 18, 1993, a wet Pacific weather system moved to the Oregon coast from California. The storm began with freezing rain in the southern Willamette Valley, and moved north toward Clackamas County. When the system hit cold air, it caused heavy snow to fall, ranging from 6 to 12 inches.[2] Clackamas County schools were closed as well as the circuit court. Among the court proceedings interrupted by

the snowstorm was an aggravated murder trial nearing the end of its third week. Clackamas County Police reported that many automobiles stalled, skidded into ditches, or slid into each other. On the afternoon of February 20, a pickup with three youths veered off Oregon 224, and teetered on the brink of a 50-foot drop to the Clackamas River. Eventually they were helped to safety by firefighters.[3]

January 26-27, 1956

Originating in northwestern Oregon, this snowstorm moved north on January 26 and 27, 1956 to strike the Clackamas County area, which received as much as 10 inches of snow. Many schools were forced to close. Traffic accidents were frequent from snow being packed down into ice. The Portland area reported 390 accidents in three days.[4]

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 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.

January 1937

While the January/February 1937 storm had state-wide 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.

December 1919

The December 1919 snowstorm was recorded as the third heaviest snowfall-producing storm in Oregon. 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 brought many locations more snow than is usually accumulated in one year.

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. [6]

ICE STORMS

February 2-4, 1996

This event began with cold air trapped in western Oregon. Once a warmer front blew in over the cold air, a severe ice storm was created. Traffic accidents and power outages plauged the Willamette Valley. Freezing rain fell for two days, causing a 100-car pileup between Clackamas County and Salem. One fatality occurred in a different traffic accident.[7]

January, 1978

In January, 1978, a moist storm system from the west created rain that froze as it hit the ground. At one point, over an inch of rain had covered everything with ice. In some areas around Clackamas ounty, power outages lasted for more than 10 days.[8]

January 30-31, 1963

This ice storm, ocurring on January 30-31st, 1963, combined with snow to form severe ice conditions on roadways in and around Clackamas County. As a result, one death, and many injuries were reported. Large numbers of power lines were downed and schools were closed due to road conditions.[9]

EXTREME COLD WEATHER STORMS

February 1-8, 1989

In some areas around Oregon, the wind chill during the week of February 1-8, 1989 was 30-60 degrees below zero. Three people died in car accidents and two people froze to death.[10] Six persons were taken to Mount Hood Community Hospital after a flame ignited from a blowtorch being used to thaw pipes at an indoor pool near Sandy. All Clackamas County schools were closed for at least two school days, and some, such as Clarkes and Welches, were closed for three days.[11]

January 24-31, 1957

Setting another record, January of 1957 brought some of the coldest weather Oregon had ever experienced. Weather stations near Clackamas County dropped into the single digits. Portland had twelve consecutive days when the temperature did not go above freezing.[12]

December 15-26, 1924

At the time, this event in 1924 was recorded as the coldest December ever in Oregon. The two-week cold period was long and severe. Most streams and rivers were frozen and blocked with ice. Automobiles were driven across the Willamette River.[13]

Characteristics of Severe Winter Storms

Weather Patterns[14]

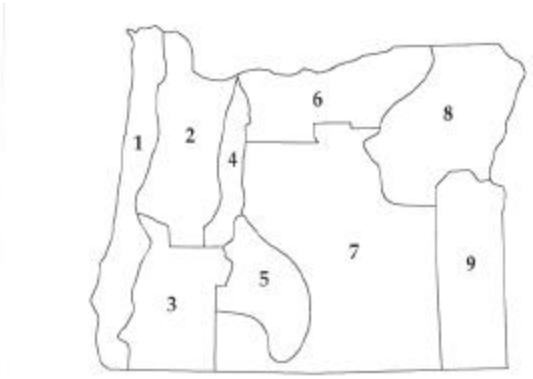
Severe winter storms affecting Clackamas County typically originate in the Gulf of Alaska and in the central Pacific Ocean. These storms are most common from October through March.[15] Most of Clackamas County has average annual precipitation of between 30 and 70 inches,

with parts of the Coast Range in the west receiving over 70 inches.[16] 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. Clackamas County is in Zone 2 (Figure 9-1). The county's climate generally consists of wet winters and dry summers.

Normal distribution of precipitation is about 50% of the annual total from December through February, lesser amounts in the spring and fall, and very little during summer months. [17] There is an average of only five days per year of measurable snow with snowfall accumulations rarely measuring more than two inches.[18]

Figure 9-1. Oregon Climate Zones

Zone 1: Coastal Area
Zone 2: Willamette Valley
Zone 3: Southwestern Interior
Zone: 4 Northern Cascades
Zone 5: High Plateau
Zone 6: North Central Area
Zone 7: South Central Area
Zone 8: Northeast Area
Zone 9: Southeast Area



Source: Taylor, George H. and Hannan, Chris, *The Oregon Climate 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.[19]

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 one fatality, 200,000 customers left without power or phone service for several days, and 125 boats, with a combined value of over $3 million dollars, sank in the Columbia Gorge.

Ice

Ice storms occasionally occur in northern areas of Oregon, resulting from cold air flowing westward through the Columbia Gorge.[20] 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.[21]

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 originating from the west can fall on frozen streets, cars, and other sub-freezing surfaces, creating dangerous conditions.[22]

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 the amount and extent of snow or ice, air temperature, wind speed, and event duration. Severe storms can affect the county from the northwest and southeast, and from the Columbia River Gorge. If a severe ice storm occurs within Clackamas County, there may be prolonged power outages over widespread areas. The probability of such an ice storm is uncertain due to limited historical records, but is considered less likely than a severe ice storm in the Columbia River Gorge, given the usual meteorological patterns for the area. The National Weather Service, Portland Bureau, monitors the stations and provides public warnings on storm, snow, and ice events as appropriate.

Vulnerability and Risk

A vulnerability assessment that describes the number of lives or amount of property exposed to elements of severe winter storms has not yet been conducted for Clackamas County. However, severe winter storms can cause power outages, transportation and economic disruptions, and pose a high risk for injuries and loss of life. The events can also require needed 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.

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.

Community Winter Storm Issues

What is Susceptible to Winter Storms?

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. Saturated soil can cause trees to lose their ability to stand and fall 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.[23]

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.

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 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.

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. 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 cause extensive damage to property.

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

Water Districts

All of the water districts in the county are in the process of replacing old cast iron pipes with more ductile iron pipes, which will be more resilient in disaster situations. When disasters occur, water districts in the region work together to provide water for Clackamas County citizens. For example, Clackamas River Water District has inter-ties with South Fork Water, Oak Lodge, and Sunrise Water Authority for emergency situations.

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 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 re-transmission using the Emergency Alert System.

Severe Winter Storm Mitigation Action Items

The severe winter storm mitigation action items provide direction on specific activities that organizations and residents in Clackamas County can undertake to reduce risk and prevent loss from severe winter storm events. 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-SWS#1: Enhance strategies for debris management for 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:	Clackamas County Roads Division
Timeline	2 years
Plan Goals Addressed:	Partnerships and Implementation, Emergency Services

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ST-SWS#2: Develop and implement programs to coordinate maintenance and mitigation activities to reduce risk to public infrastructure from severe winter storms.

Ideas for Implementation

- Partner with responsible agencies and organizations to design and implement programs that reduce risk to life, property, and utility systems; and
- Develop partnerships between utility providers and county and local public works agencies to document known hazard areas.

Coordinating Organization:	Hazard Mitigation Advisory Committee
Timeline	2 years
Plan Goals Addressed:	Emergency Services, Partnerships and Implementation

LT-SWS#1: Increase public awareness of severe winter storm mitigation activities.

Ideas for Implementation

- Collect information on public education materials for protecting life, property, and the environment from severe winter storm events;
- Distribute educational materials to Clackamas residents and public and private sector organizations regarding evacuation routes during road closures; and
- Target the vulnerable populace for disseminating preparedness information.

Coordinating Organization:	Hazard Mitigation Advisory Committee
Timeline	Ongoing
Plan Goals Addressed:	Public Awareness, Protect Life and Property

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LT-SWS#2: Enhance weather monitoring to attain earlier severe winter storm warnings.

Ideas for Implementation

- Coordinate with appropriate organizations to evaluate the need for more weather stations and/or weather instrumentation.

Coordinating Organization:	Hazard Mitigation Advisory Committee
Timeline	Ongoing
Plan Goals Addressed:	Public Awareness, Protect Life and Property

Severe Winter Storm Resources

State Resources

Oregon Climate Service

The Oregon Climate Service (OCS) 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

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

Federal Resources

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

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

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Section 10:
Windstorm

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Why are Windstorms a Threat to Clackamas County?

When a strong windstorm strikes a community, it leaves behind a distinctive trail. Trees toppled over on buildings and cars, downed power lines crisscrossing the roads, and widespread power outages are a few of the signs that a windstorm has struck. After such an event, it can take communities days, weeks, or longer to return to normal activities. In addition to costly structural damages, windstorms can cause injury or even death.

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 impact 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. While Clackamas County did not receive a Presidential Disaster Declaration for this storm, many other counties in the state did, illustrating the severity of these storms.

Historical Windstorm Events

October 1954 Tornado

On October 22, a resident of Clackamas County spotted a small funnel-shaped twister that touched down briefly from black thunderclouds 15 miles southwest of Portland in the Tualatin Valley. The tornado had a path length of only one-half mile and 15 yards wide, so there was little reported damage.

April 1957 Tornado

April 12 - 14, 1957, was one of the most memorable times in Clackamas County's history of tornadoes. On the afternoon of April 12, a dark storm cloud appeared near the city of Sandy. Two funnel clouds emerged and reached downward, eventually touching ground and combining to become a 50-yard wide tornado. The tornado churned through the farmland of Sandy heading toward the Cascades, and released hailstones one-fourth to one-half of an inch thick. Large fir trees were lifted 30-40 feet above the ground. A large barn was lifted off its foundation, carried several hundred feet in the air, and then dropped back to the ground, shattering it to pieces. Roofs from houses and barns were torn off and some farm buildings were carried considerable distances before being destroyed. A similar event occurred August 20, 1979 when a tornado with a 2-mile path swept through the Sandy area, destroying many buildings and causing power outages.[1]

Columbus Day Windstorm October 1962[2]

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.[3] The storm

killed thirty-eight people and did upwards of $200 million in damage (over $800 million in today's dollars).[4] 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. The storm destroyed fruit and nut orchards and killed scores of livestock. Intense wind speeds were recorded in the metropolitan areas with gusts of 116 mph on Portland's Morrison Bridge.

April 1972

The windstorm on April 5, 1972 has been described as an exceptionally destructive windstorm, as it was the most devastating tornado in Oregon's recorded weather history. It first touched down at the South edge of the Columbia River, damaging four boat moorages on Marine Drive. The tornado damaged fifty cabin cruisers and destroyed a dry rock, boathouses and dock shelters. The funnel, described as a "black mass," was not observed locally due to flying debris and mud. Several people reported seeing water being drawn up into the cloud midriver, before crossing the Oregon/Washington State line and continuing onto the Washington shore. Observers were unable to see across the Columbia River due to the tremendous amount of water vapor suspended in the air. The fifty-yard wide tornado continued its nine-mile path across the east side of Vancouver to the Brush Prairie area, causing six deaths, 300 injuries and $5 to $6 million in damage in Washington alone.

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. Across the Pacific Northwest, hundreds of downed trees and power lines caused massive power outages and roof damage. Estimates indicated that nearly 500,000 homes were without power for at least a short time during the weekend. Numerous airports across Oregon and Washington suffered damage.

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.[5] The National Weather Service issued high wind warnings for the coast and inland valleys as the storm center tracked north along the Oregon coast. 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.[6]

Although Clackamas County did not receive a presidential disaster declaration, a significant amount of damage occurred as a result of the

windstorm. Severely damaged areas included Lake Oswego, Wilsonville, Milwaukie, Oregon City. Throughout the county, the windstorm tore roofs from buildings, uprooted or otherwise damaged many trees, and knocked out electric and telephone service to approximately half of the county's residents. One fatality was reported, and five people were injuried in the storm. Clackamas County Emergency Mangement provided a coordinationg point for the utility company, Red Cross, and other critical agencies.

Characteristics of Windstorms

The most frequent surface winds in Oregon are from the southwest. These widespread winds are associated with storms moving onto the coast from the Pacific Ocean. Winds coming from the south are the most destructive. The Columbus Day Storm of 1962 was an example of this type of windstorm. 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.[7]

West winds generate from the Pacific Ocean and are strong along the coast, but slow down inland due to the obstruction of the Coastal and Cascade mountain ranges.[8] Prevailing winds in Oregon vary with the seasons. In summer, the most common wind directions are from the west or northwest; in winter, they are from the south and east. However, local topography plays a major role in affecting wind direction. For example, the north-south orientation of the Willamette Valley channels the wind most of the time, causing predominately north and south winds.[9]

Tornadoes

Tornadoes are the most concentrated and violent storms produced by the earth's atmosphere. They are created by a vortex of rotating winds and strong vertical motion, which possess remarkable strength and cause widespread damage. Wind speeds in excess of 300 mph have been observed within tornadoes, and it is suspected that some tornado winds exceed 400 mph. The low pressure at the center of a tornado can destroy buildings and other structures it passes over. Tornadoes are most common in the Midwest, and are more infrequent and generally small west of the Rockies. Nonetheless, Oregon and other western states have experienced tornadoes on occasion, many of which have produced significant damage and occasionally injury or death.

Oregon's tornadoes can be formed in association with large Pacific storms arriving from the west. Most of them however, are caused by intense local thunderstorms. These storms also produce lightning, hail, and heavy rain, and are more common during the warm season from April to October.[10]

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 and 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. Unfortunately, high-resolution wind maps were not available at the time of this publication, so a precise wind hazard analysis could not be performed.

Vulnerability and Risk

A vulnerability assessment that describes the number of lives and amount of property exposed to the wind hazard has not yet been conducted for Clackamas County windstorms. However, there are many issues related to what is in danger within communities experiencing windstorms. 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.

Factors that should be 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.

Community Windstorm Issues

What is Susceptible to Windstorms?

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 impacting walls, doors, windows, and roofs, may cause structural components 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 building's 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 10-1.

Table 10-1. 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

Storm winds can damage buildings, power lines, and other property and infrastructure due to falling trees and branches. During wet winters, saturated soils cause trees to become less stable and more vulnerable to uprooting from high winds.

Windstorms can result in 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.[11] 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 in Clackamas County. 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.[12] 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.

Existing Mitigation Activities

One of the most common problems associated with windstorms is power outage. High winds commonly occur during winter storms, and can cause trees to bend, sag, or fail (tree limbs or entire trees), coming into contact with nearby distribution power lines. Fallen trees can cause short-circuiting and conductor overloading. Wind-induced damage to the power system causes power outages to customers, incurs cost to make repairs, and in some cases can lead to ignitions that start wild land fires. The basic strategy adopted by power companies to avoid wind-induced damage is to maintain adequate separation between its transmission circuits and trees. This is done with tree height limitations and ongoing tree trimming. In addition, Portland General Electric (PGE), the primary power provider for Clackamas County residents, maintains an inventory of tree failures by type of tree, wind speed, type of stand, and type of failure (Table 10-2). PGE uses this data to identify the most appropriate vegetation for withstanding windstorms, and further advises customers in vegetative planting and pruning.[13]

Table 10-2 Tree Failures Resulting in Power Line Outages

	All Trees	Douglas Fir	Blk Cottonwood	Bigleaf Maple	Red Alder
Occurrence	72%	26%	18%	16%	12%
Type of Failure					
Branch	18%	38%	33%	13%	0%
Scaffold Branch	18%	0%	11%	25%	17%
Trunk	34%	31%	56%	38%	33%
Root	30%	31%	0%	25%	50%
Wind Speed					
less than 10 mph	13%	0%	0%	17%	67%
10 - 30 mph	49%	56%	67%	50%	33%
greater than 30 mph	38%	44%	33%	33%	0%
Stand Type					
Natural	87%	92%	100%	100%	100%
Planted	13%	8%	0%	0%	0%
Type of Defect Present					
Decay	28%	24%	15%	33%	40%
Weak Branch Attachment	10%	12%	8%	10%	0%
Codominant Stem	9%	6%	15%	10%	7%
Failed Portion Dead	15%	18%	15%	5%	27%
Root Rot	5%	18%	0%	5%	7%
Crack / Split	8%	0%	0%	19%	7%
Lean	8%	6%	15%	5%	13%
Multiple Tops	2%	6%	0%	5%	0%
Canker or Gall	2%	0%	0%	5%	0%
Poor Taper / Suppressed	2%	0%	8%	0%	0%
End Weight	3%	0%	8%	5%	0%
Dense Crown	1%	0%	0%	0%	0%
Root Pruned	0%	0%	0%	0%	0%
No Defect Apparent	5%	12%	15%	0%	0%
	All Trees	**Douglas Fir**	**Blk Cottonwood**	**Bigleaf Maple**	**Red Alder**
Location					
Residential	43%	36%	11%	60%	50%
Commercial	0%	0%	0%	0%	0%
Greenway	4%	7%	0%	10%	0%
Street Tree	8%	21%	0%	0%	0%
Rural Road	45%	36%	89%	30%	50%

Source: Dave Johnson, PGE Emergency Operations Manager

Windstorm Mitigation Action Items

The windstorm mitigation action items provide direction on specific activities that organizations and residents in Clackamas County can undertake to reduce risk and prevent loss from windstorm events. 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-WS#1: 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 disseminate education information to property owners to reduce risk from tree failure to life, property, and utility systems;
- Develop partnerships between utility providers and county and local public works agencies to document known hazard areas; and
- Identify potentially hazardous trees in urban areas.

Coordinating Organization:	Clackamas County Department of Transportation and Development
Timeline	2 years
Plan Goals Addressed:	Emergency Services, Partnerships and Implementation

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ST-WS#2: 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:	Clackamas County Roads Division
Timeline	2 years
Plan Goals Addressed:	Emergency Services, Partnerships and Implementation

LT-WS#1: Map and publicize locations around the county that have the highest incidence of extreme windstorms.

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; and
    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; and
- Identify public infrastructure and facilities subject to damage or closure during windstorm events.

Coordinating Organization:	Clackamas County Geographic Information Systems
Timeline	5 years
Plan Goals Addressed:	Public Awareness, Protect Life and Property, Partnerships and Implementation

---

LT-WS#2: 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:	Hazard Mitigation Advisory Committee
Timeline:	5 years
Plan Goals Addressed:	Natural Systems, Partnerships and Implementation

---

LT-WS#3: Increase public awareness of windstorm mitigation activities.

Ideas for Implementation

- Collect information on public education materials for protecting life, property, and the environment from windstorm events; and

- Distribute educational materials to Clackamas County residents and public and private sector organizations regarding preparedness for no power situations.

Coordinating Organization: Hazard Mitigation Advisory Committee
Timeline Ongoing
Plan Goals Addressed: Public Awareness, Protect Life and Property

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LT-WS#4: Encourage development and enforcement of wind-resistant building siting and construction codes.

Ideas for Implementation

- Evaluate current building codes for efficiency in protecting structures from wind damage.

Coordinating Organization: Clackamas County Building Division
Timeline Ongoing
Plan Goals Addressed: Public Awareness, Protect Life and Property

Windstorm Resource Directory

State Resources

Oregon Climate Service

The Oregon Climate Service (OCS) 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

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

Federal Resources

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

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] Taylor, George H, Holly Bohman, and Luke Foster. "A History of Tornadoes in Oregon." August 1996. OCS, OSU. http://www.ocs.orst.edu

[2] National Weather Service, Portland Bureau, (March 2001) http://www.wrh.noaa.gov/Portland.

[3] National Weather Service, Portland Bureau, (February 2002) http://www.wrh.noaa.gov/Portland.

[4] National Weather Service, Portland Bureau, (February 2002), http://www.wrh.noaa.gov/Portland.

[5] Report from George Taylor Oregon Climatologist from the Oregon Climate Service (December 1995), http://www.ocs.orst.edu.

[6] National Weather Service – Portland, Oregon, (March 2001) http://www.wrh.noaa.gov/Portland/history.html.

[7] Chinook Country, (June 2001) http://members.home.net/gardner.

[8] National Weather Service, Portland Bureau, (February 2002), http://www.wrh.noaa.gov/Portland.

[9] Hannan, Chris and George H. Taylor. The Climate of Oregon. 1999. Oregon State University Press.

[10] Taylor, George H, Holly Bohman, and Luke Foster. "A History of Tornadoes in Oregon." August 1996. Oregon Climate Service, Oregon State University. http://www.ocs.orst.edu

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

[12] Personal interview. Winfrey, Greg. March 2001.

[13] Personal Interview, Johnson, Dave. April 2002.

Section 11:
Earthquake

Table of Contents

Why Are Earthquakes a Threat to Clackamas County?

The most recent earthquake event affecting Clackamas County was the February 28, 2001 Nisqually earthquake. The epicenter of the 6.8-magnitude earthquake was near Anderson Island in Pierce County, Washington, and shook western Washington and areas of western Oregon. Residents in the surrounding area, including Clackamas County felt the tremor. While the impacts of this quake were not severe in Oregon, the economic losses in Washington are estimated at $1 to $2 billion. Oregon ranks third in the nation for earthquake damage estimates in the future. Projected losses in the Cascadia region alone could exceed $12 billion, with over 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. Furthermore, there is evidence of the existence of faults in Portland Metropolitan Area, as well as other areas of the state. Where known to exist, it is believed that they are capable of generating magnitude 7 earthquakes. Earthquakes pose a 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 Clackamas County.[2]

Most of the earthquake mapping and mitigation efforts made in Oregon have been accomplished in the past two decades, and public awareness has risen remarkably during this time. Major federal, state, and local government agencies and private organizations support earthquake risk reduction, and have made significant contributions in reducing the adverse impacts of earthquakes. Despite the progress, the majority of Oregon communities remain unprepared because there is a general lack of understanding regarding earthquake hazards among Oregonians.[3]

To better understand the earthquake hazard, the scientific community has looked at historical records and accelerated research on crustal faults, which are among the sources of the earthquakes occurring in the Clackamas County region. Historical earthquake records can generally be divided into records of the pre-instrumental period and the instrumental period. In the absence of instrumentation, the detection of earthquakes is based on observations and felt reports, and are dependent upon population density and distribution. Since Oregon was sparsely populated in the 1800s, the detection of pre-instrumental earthquakes is quite difficult. However, populations in some regions in or near the Willamette Valley and along the Columbia River began growing as early as the 1850s, including Portland (1840), Salem (1844),

Hillsboro (1845), Forest Grove (1850), Eugene (1852), McMinnville (1853), and Tillamook (1866). Newspapers from these towns provide a good source of historical documentation of earthquakes of a magnitude five or greater since about 1850.[4] The seismic risk is more severe today than in the past because population is increasing.

History of Earthquake Events in Clackamas County

Dating back to 1841, there have been more than 6,000-recorded earthquakes in Oregon, most with a magnitude below three. Portland and its surrounding region is potentially the most seismically active area within Oregon.[5] 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).

Although seismograph stations were established as early as 1906 in Seattle and 1944 in Corvallis, improved seismograph coverage of the Portland region did not begin until 1980, when the University of Washington expanded its regional network into northwestern Oregon. Table 11-1 describes the historical earthquake events that have affected Clackamas County.

Table 11-1. Historical Earthquake Events

Date	Event	Magnitude
October 12, 1877	Two events occurred on this day, one at 9:00 am PST near Cascades, Washington, and one at 1:53 PST near Portland, where it caused chimneys to break, and was felt as far north as the Puget Sound. The total felt area is estimated to be 16,900 mi2.	5.3
February 3, 1892	The motion from this earthquake lasted 30 seconds and was reported as the most severe shock ever felt in Portland. The earthquake was felt over an area of more than 10,400 mi2.	5.0
April 2, 1896	This earthquake was felt in Portland, and a single shock of brief duration was also felt as far south as Salem. The earthquake was felt over an area of about 1,040 mi2 and is thought to have occurred close to McMinnville, which was the location of the greatest felt intensity.	4.0
July 19, 1930	An earthquake occurred near Perrydale, Oregon, a town about 12 miles northwest of Salem.	4.0
December 29, 1941	Most residents of Portland felt a strong earthquake. The earthquake caused chimneys to crack, vases to overturn, trees to shake, and a school bell to ring. The epicenter is assigned to the Portland area, the location of the maximum intensity. Effects were also felt in Vancouver and Woodland, Washington.	4 .5

Table 11-1. Historical Earthquake Events (continued)

Date	Event	Magnitude
December 15, 1953	Slight damage was sustained in Portland and Roy, Oregon, and in Vancouver, Washington. The location of this event is well-constrained in a small zone between Vancouver and Portland.	4 .5
November 16, 1957	An earthquake shook the area just north of Salem. Some people felt a single sharp, blast-like jolt, while others said vibrations lasted for several seconds. The felt area was about 5,440 mi2.	4 .5
August 18, 1961	An earthquake was felt in and around the towns of Lebanon and Albany south of Salem. This earthquake was felt over an area of 7,320 mi2 from southwest Lane County in Oregon to Cowlitz County in Washington.	4 .5
September 15 and 17, 1962	These earthquakes occurred approximately in the same vicinity as Siouxon Peak in southwestern Washington. The events occurred near Cougar, Washington, in Gifford Pinchot National Forest. The felt areas are 8,800mi2, and 9,720 mi2, respectively.	4.8 and 5.1
November 6, 1961	An earthquake was widely felt over an area of 9,200mi2 in northwest Oregon and southwest Washington. It was felt principally in Portland and Glenwood..	5.0
November 5, 1962	This earthquake occurred in Portland, and a crack 21ft long and 4cm wide appeared on a road between Tillamook and Oceanside, Oregon. In Vancouver, Washington, a large chandelier fell, and a jail elevator was put out of service. The location of this event was 9.3 northeast of downtown Portland at a depth of 10 miles.	5.5
December 26, 1963	This earthquake was felt over an area of only 4,280 mi2, and damage was slight. Plaster cracked in a few places, and books and pictures fell in North Plains and Timber, Oregon, and Toutle, Washington.	4.5
1965 find month	This Earthquake was centered south of Seattle-Tacoma International Airport and caused seven deaths.	6.5
February 13, 1981	The 1981 Elk Lake, Washington, earthquake, the largest known earthquake associated with Mount St. Helens seismic zone. At least six aftershocks of magnitude 2.9 to 3.6 were felt in Kidd Valley, 8 miles east of Toutle, that night and the following day. The largest aftershock was felt as far south as Vancouver.	2.9 to 3.6
March 25, 1993	This earthquake occurred near Scotts Mills, Oregon, on the south Clackamas County border, and was a shallow crustal earthquake. It caused damage mostly within a radius of about 25 miles, primarily in the communities of Molalla, Woodburn, Newberg, and McMinnville. Damage to public facilities in the affected counties was estimated to be over $6 million, not including damage to state government buildings or bridges. 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.	5.6
February 28, 2001	The 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. The Nisqually earthquake was centered near Anderson Island in Pierce County (11 miles northeast of Olympia, Washington) was felt strongly throughout western Washington, cost the state of Washington from $1 to 2 billion in damages, and left 320 people with mostly minor injuries.6	6.8

Source: Wong, Ivan G and Bott Jacqueline D.J. (November 1995)

Causes and Characteristics of Earthquakes in Clackamas 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.

Crustal Fault Earthquakes

Crustal fault earthquakes are the most common earthquakes and occur at relatively shallow depths of 6-12 miles below the surface.[7] 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, which cause extensive damage. Clackamas County has seven documented crustal faults that could cause serious damage to buildings and infrastructure. These include: Portland Hills, Sandy River, Bolton, Mount Angel, Grant Butte, Clackamas Creek, and Mount Hood. These faults could generate earthquakes 6.5 or larger.

Deep Intraplate Earthquakes

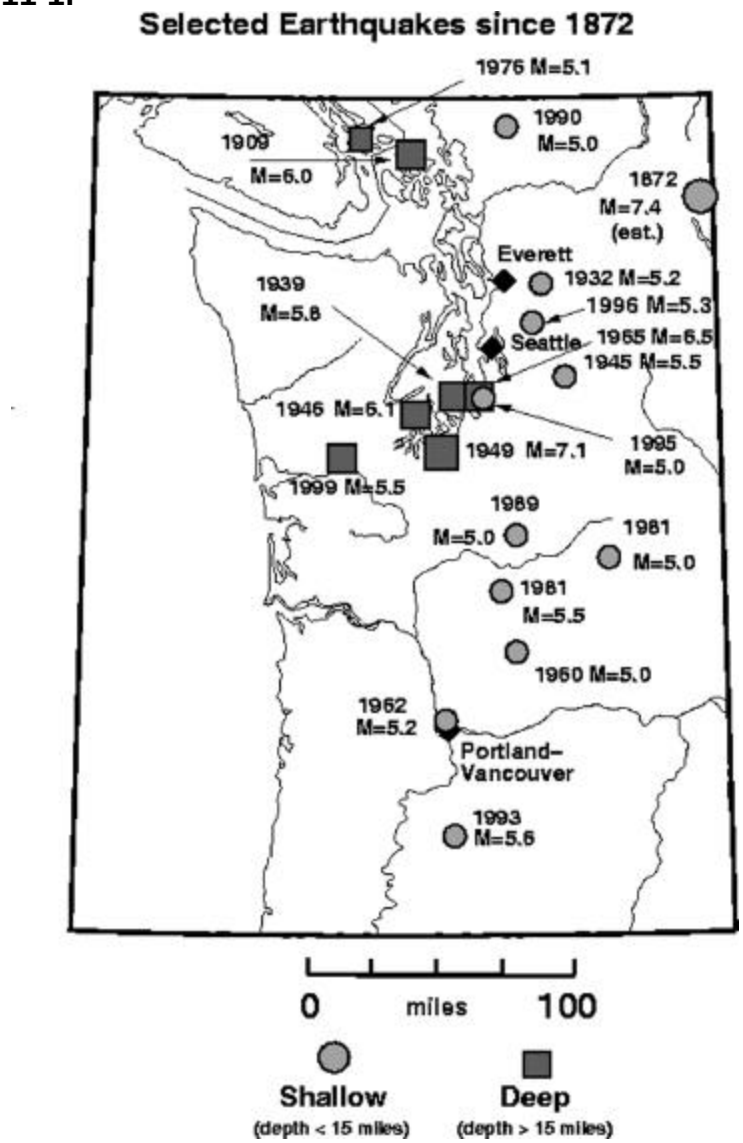
Occurring at depths from 25 to 40 miles below the earth's surface in the subducting oceanic crust, deep intraplate earthquakes can reach up to magnitude 7.5.[8] The February 28, 2001 earthquake in Washington State was a deep intraplate earthquake. It produced a rolling motion that was felt from Vancouver, 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.[9]

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.[10]

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 1964 southern Alaska (magnitude 9.2) earthquakes.[11]

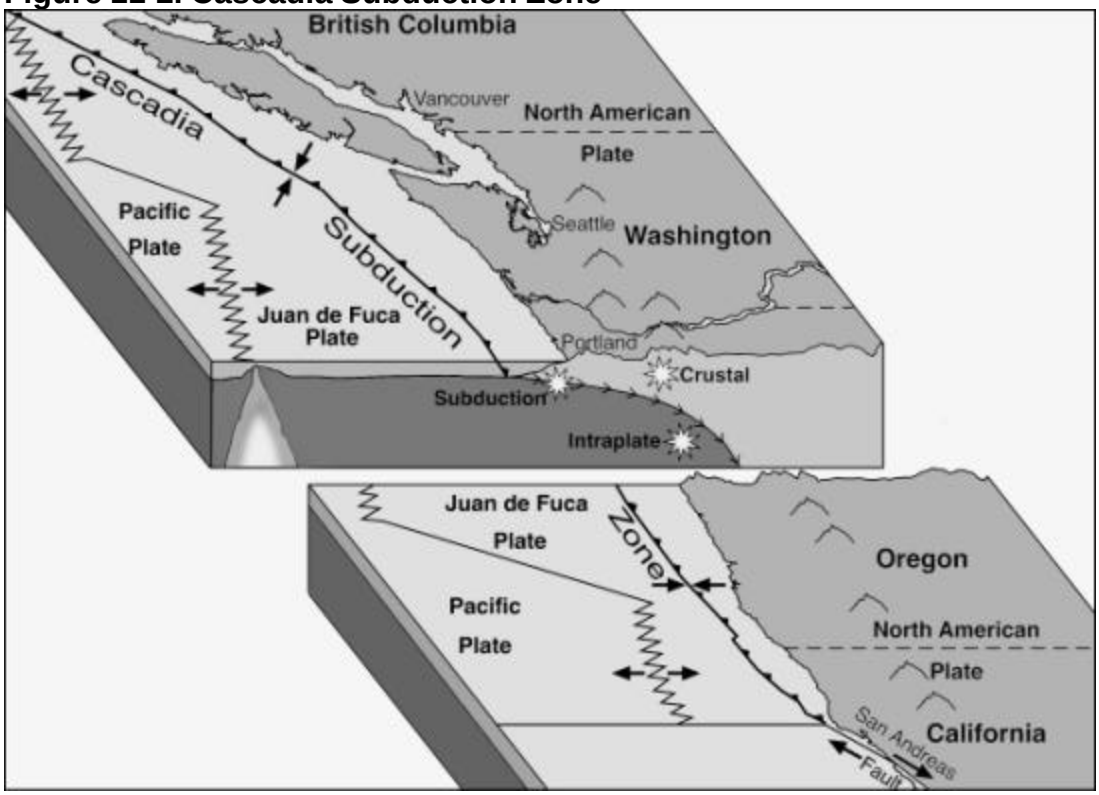
Figure 11-1.



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.

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 1,000 years. Such earthquakes may cause great damage to the coastal area of Oregon as well as inland areas in western Oregon. Shaking from a large subduction zone earthquake could last up to five minutes.[12]

Figure 11-2. Cascadia Subduction Zone[13]



Source: *Planning for Natural Hazards: The Oregon Technical Resource Guide,* Department of Land Conservation and Development (July 2000), Ch. 8, pp. 7.

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 and recover from an earthquake. Many communities in Oregon have a high likelihood of encountering such risks, especially in areas with steep slopes.[14]

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.[15]

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 influenced by the thickness of geologic materials and their physical properties. Buildings and structures built on soft and unconsolidated soils can face greater risk.[16] Amplification can also occur in areas with deep sediment filled basins and on ridge tops.

Earthquake Hazard Assessment

Hazard Identification

The Department of Geologic and Mineral Industries (DOGAMI), in partnership with other state and federal agencies, has undertaken a rigorous program in Oregon to identify seismic hazards and risks, 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 DOGAMI.[17] Map 13 illustrates the earthquake hazard areas in Clackamas County.

According to the "*All Hazard Mitigation Plan: Clackamas County, Oregon*"[18], there are nine known sources of earthquakes affecting the county. Two deep intraplate sources of earthquakes lie on the Cascadia Subduction Zone, while seven known faults are crustal, meaning they lie within the North American Plate, within Clackamas County. Each fault in the county has a varying recurrence interval. Following are descriptions of the potential earthquake events for six of the crustal faults in Clackamas County. The return intervals for these events are not well-established but are listed approximately in the "*All Hazard Mitigation Plan: Clackamas County, Oregon*".[19]

Portland Hills Magnitude 6.9. This represents the worst-case earthquake that could affect the urban areas of Clackamas County. The return interval for this event is approximately 10,000 to 20,000 years.

Mount Angel Magnitude 6.9. This represents the maximum magnitude event on this fault, located adjacent to southwestern Clackamas County, distant to the urbanized area. This event represents a larger magnitude event than the Scotts Mill event, and represents the worst-case earthquake to affect the southwest part of the county. The return interval for this event is around 20,000 years.

Grand Butte Magnitude 6.7. This represents the maximum magnitude event on this fault, located in north central Clackamas County, distant from the urbanized area. The return interval for this event is not well established, but is believed to be in the 8,000 to 10,000 year range.

Mount Hood Magnitude 6.6. This represents the maximum magnitude event on this fault, located in eastern Clackamas County, distant from the urbanized area. The return interval for this event is approximately 5,000 years.

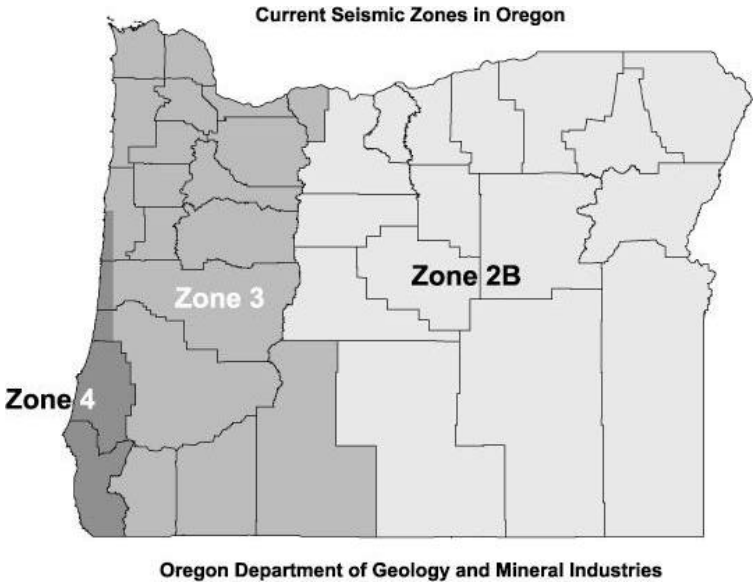
Sandy River magnitude 6.5. This represents the maximum magnitude event on this fault, located in north central Clackamas County, moderately close to the urbanized area. The return interval for this event is approximately 50,000 to 60,000 years.

Bolton Magnitude 6.5. This represents the maximum magnitude event on this fault, located in western Clackamas County, distant to the

urbanized area. This event represents a larger magnitude event than the Scotts Mills event, and represents the worst-case earthquake to affect the southwest part of the county. The return interval for this event is not well established, but is most likely to be in the 20,000-year range.

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 Clackamas County is within Zone 3. Many buildings in Clackamas County were built prior to the imposition of Zone 3 code requirements, established in 1993.

Figure 11-3. Seismic Zones in Oregon



Vulnerability Assessment

The effects of earthquakes span a large area, and an earthquake occurring in the county would probably be felt throughout the county. However, the degree to which the earthquakes are felt, and the damages associated with them may vary. 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. The areas that are particularly vulnerable to potential earthquakes in the county have been identified as those areas near the crustal fault lines.

The relative or secondary earthquake hazards, which are liquefaction, ground shaking, amplification, and earthquake-induced landslides, can be just as devastating as the earthquake. DOGAMI is currently

conducting research regarding the location and potential damage associated with secondary earthquake hazards. In 1998, the "*All Hazard Mitigation Plan: Clackamas County, Oregon*"[20] identified areas in the county most vulnerable to 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. Table 11-2 identifies the local population centers in Clackamas County that have soils vulnerable to liquefaction.

Table 11-2. Liquefaction Potential in Clackamas County

Population Center	Liquefaction Susceptibility	Primary locations
Milwaukie	Low to Moderate	Central Areas; industrial areas; Low elsewhere.
Lake Oswego	Low	Low to moderate in some central areas.
Gladstone	Low	Central areas. Low to moderate in northwest area
Oregon City	Low to Very Low	Low to moderate in northern part of town near Clackamas River
Sandy	Low	
Barlow	Moderate	Also floodplain west of Canby
Canby	Low	
Wilsonville	Low	

Source: *"All Hazard Mitigation Plan: Clackamas County, Oregon".* G&E Engineering Systems Report 32.07.01, Revision 0. September 23, 1998.

Risk Analysis

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[21]. 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.

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.[22] Estimates of earthquake loss potential for ten earthquake scenarios (eight of which are for current building stock exposed to maximum earthquakes on eight different faults, one assuming upgraded buildings, and one considering a moderate sized earthquake in the southwest portion of the county) are

presented in the "*All Hazard Mitigation Plan: Clackamas County, Oregon*". [23] Loss estimations for each scenario were derived using the HAZUS model, using the best available data (Tables 11-3 – 11-5). County GIS grouped the data by census tract, building type, and building occupancy. This allowed large quantities of data to be managed at moderate effort, while maintaining reasonably accurate risk estimates. However, detailed information at the tax lot scale would greatly improve the accuracy of the earthquake loss assessment. The following is a summary of the earthquake scenario analysis. While this information has a degree of uncertainty, it is still useful for mitigation planning purposes to predict potential losses.[24] For more detailed information regarding methods and loss information, see the "*All Hazard Mitigation Plan Clackamas County, Oregon*". G&E Engineering Systems Report 32.07.01, Revision 0. September 23, 1998.

- For Clackamas County, a magnitude 6.9 earthquake on the Portland Hills Fault is likely to cause greater damage than a magnitude 8.5 earthquake on the Cascadia Subduction Zone. This is because the Portland Hills Fault is much closer to Clackamas County than the Subduction Zone, thus the levels of ground shaking and expected damages are higher.
- The Portland Hills Fault would produce a crustal earthquake. This type of earthquake would be felt throughout the county.
- A Portland Hills earthquake is expected to cause about $4 billion in direct building damages in Clackamas County. Total direct damages and losses will be about twice that amount for the county.
- The worst possible earthquake for Clackamas County, in terms of damages and casualties, is a Portland Hills Earthquake. However, based on the recurrence intervals, a Cascadia Subduction Zone earthquake is more likely to affect the county. The recurrence intervals are approximately 20 to 40 times shorter than those for earthquakes on the Portland Hills Fault.
- Due to the high risk, but low probability of earthquakes in Clackamas County, widespread mitigation of seismic hazards is probably not called for in the case of most typical buildings. New buildings will be built in accordance with current Seismic Zone 3 requirements. Thus, the seismic capacity of the Clackamas County building stock will improve over time as the existing stock is gradually replaced and/or upgraded.
- Structural retrofit of buildings and infrastructure should focus on buildings that are most vulnerable to seismic damage, and are most important to the community, such as schools, hospitals, and other critical facilities. Priorities should include buildings on soft soil sites subject to amplification of ground motion and/or liquefaction.

- Non-structural bracing of equipment and contents is often the most cost-effective type of seismic mitigation. Inexpensive bracing and anchoring may protect expensive equipment whose function is critical in hospitals or power companies.

Table 11-3. Summary of All Maximum Earthquakes (HAZUS Model)

Earthquake	Daytime Fatalities	Direct Damage Losses ($Billion)	No. Buildings in Complete Damage State	Displaced People Requiring Emergency Shelter
Portland Hills M 6.9	210	$3.98	9,971	15,000
Sandy River M 6.5	48	$1.16	2,179	4,600
Bolton M6.5	124	$2.53	4,224	7,000
Grant Butte M 6.7	92	$1.99	3,372	7,800
Mount Hood M 6.6	3	$0.13	223	600
Mount Angel M 6.6	23	$0.69	660	2,100
CSZ Intraslab M 7.5	45	$1.23	1,013	3,800
CSZ Interface M 8.5	53	$1.39	1,300	4,500

Source: All Hazard Mitigation Plan Clackamas County, Oregon. G&E Engineering Systems Report 32.07.01, Revision 0. September 23, 1998.

Table 11-4. Portland Hills Magnitude 6.9 Earthquake (Upgraded Inventory HAZUS Model)

Inventory Condition	Instant Fatalities if Earthquake Occurs in Daytime	Direct Damage Losses ($ Billion)	No. of Buildings in Complete Damage State	Displaced People Requiring Emergency Shelter
As Is	210	$3.98	9,971	15,000
Fully Upgraded	18	$1.07	1,199	800

Source: All Hazard Mitigation Plan Clackamas County, Oregon. G&E Engineering Systems Report 32.07.01, Revision 0. September 23, 1998.

Table 11-5. Effect of Smaller Magnitude Earthquakes (HAZUS Model)

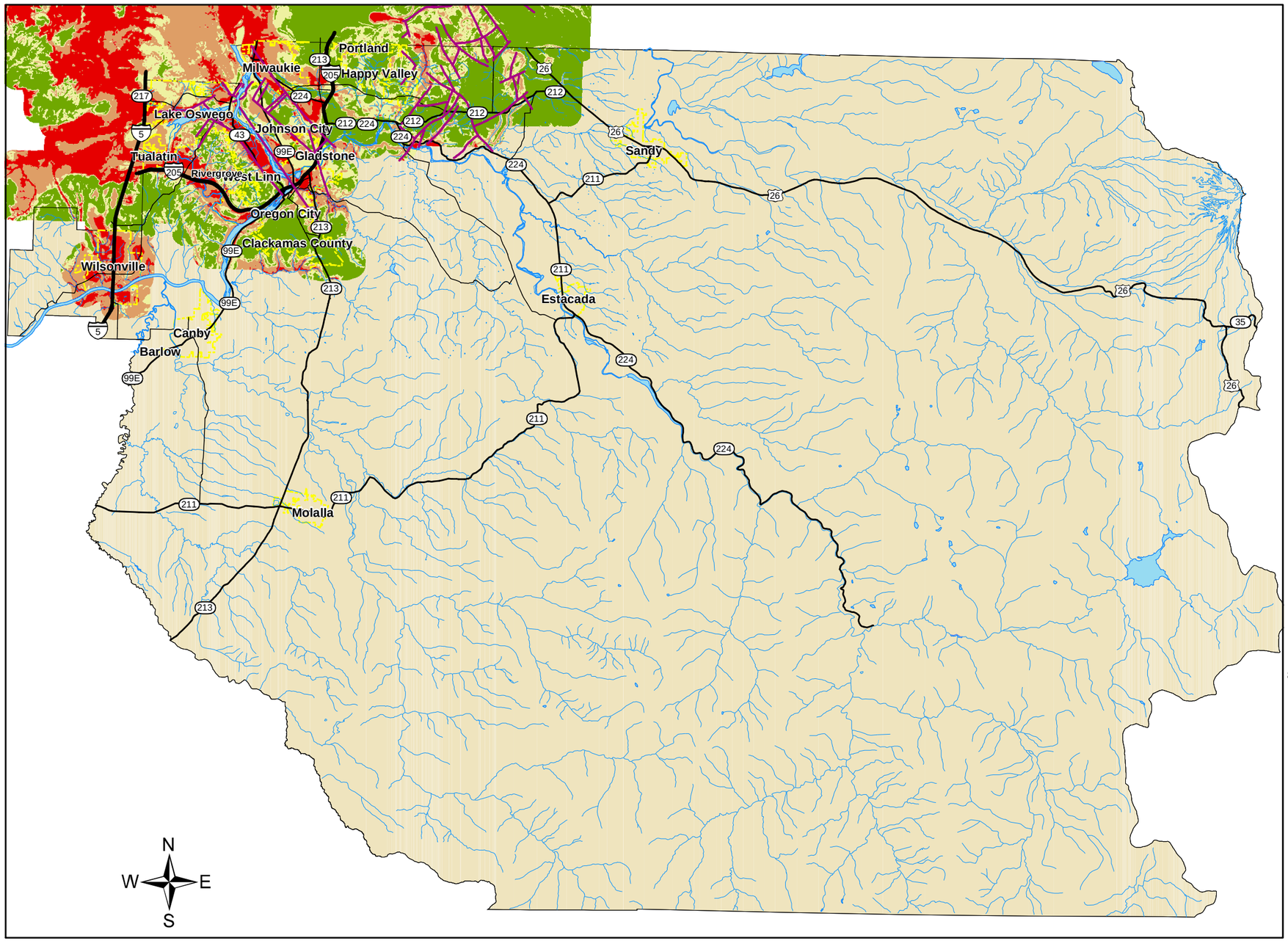
Earthquake	Daytime Fatalities	Direct Damage Losses ($Billion)	Number of Buildings in Complete Damage State	Displaced People Requiring Emergency Shelter
Mount Angel M 6.9	23	$0.069	660	2,100
Mount Angel M 5.6	1	$0.04	14	90

Source: All Hazard Mitigation Plan Clackamas County, Oregon. G&E Engineering Systems Report 32.07.01, Revision 0. September 23, 1998.

DOGAMI is leading state initiatives in producing relative earthquake maps and conducting risk analyses of various regions in the state. Currently, DOGAMI is leading a project in Clackamas County to research the effects of local geology on the baseline earthquake hazard, and also the relative or secondary earthquake hazards which are liquefaction, ground shaking amplification, and earthquake-induced landslides. In addition to producing earthquake hazard maps, DOGAMI has partnered with Portland State University to develop a building inventory for the county. This research will be completed in December of 2002, and the data should be analyzed to update the earthquake risk assessment for Clackamas County.

Map 13

CLACKAMAS COUNTY METRO AREA EARTHQUAKE HAZARDS



Faults

Severity of Damage

- A - Heavy Damage
- B
- C
- D - Light Damage
- Cities
- County Boundary
- Major Rivers and Lakes
- Rivers, Creeks, and Streams

- Interstate
- Highway
- Roads

Data Source: City Limits are maintained by Metro. The County Boundary, Hydrology, and Street layers are maintained by Clackamas County GIS Staff.

The geological hazards information displayed on this map was created by the Oregon Department of Geology.

DOGMI is currently developing a county wide geology layer.

Fault information was digitized from the 1979 Geology and Geologic Haxards of Northwestern Clackamas County, Oregon. Bullentin 99.

1 inch equals 5 miles

Miles

8 4 0 8

Clackamas County

GEOGRAPHIC INFORMATION SYSTEMS

DEPARTMENT OF INFORMATION SERVICES/GEOGRAPHIC INFORMATION SYSTEMS
121 LIBRARY COURT
OREGON CITY, OREGON 97045

CLACKAMAS COUNTY GIS | JONMCD | Earthquakes2.MDX | AUGUST 27, 2002

Community Earthquake Issues

What is Susceptible to Earthquakes?

Earthquake damage occurs because humans have built structures that cannot withstand severe shaking. Buildings, airports, schools, and lifelines (highways and utility 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 the county.

Dams

There are a total of 173 dams in Clackamas County holding billions of gallons of water in reservoirs. Releases of water from the major reservoirs are designed to protect Clackamas County from high floodwaters. Seismic activity can compromise the dam structures, and the resultant downstream flooding would cause catastrophic flooding. The largest reservoirs include:

- Bull Run Dam 2 – 20,500 acre-feet (Bull Run River)
- Timothy Lake – 66,000 acre-feet (Clackamas River)
- River Mill – 12,200 acre-feet (Clackamas River)
- North Fork Arch – 10,000 acre-feet (Clackamas River)

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 Clackamas County, many buildings were built before 1993 when building codes were not as strict. In addition, retrofitting is not required except under certain conditions and can be 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. Clackamas County, which follows the State Building Codes, is within Zone 3.

In any effort dealing with losses from natural hazards, the existing inventory of man-made structures and lifeline infrastructure must be established. Clackamas County Building Services has an archive of building permits, but there is no building inventory dataset. Clackamas County Building Services is working with DOGAMI and Portland State University to develop a building inventory for Clackamas County. The building inventory will include tax lot data and be used to conduct risk assessment analyses for the county.

Infrastructure and Communication

Residents in Clackamas 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 because it disconnects people from work, school, food, and leisure, and separates businesses from their customers and suppliers.

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. The bridges in Clackamas County are state, county, city, or privately owned. A state-designated inspector must inspect all state, county, and city bridges every two years, and the inspections are rigorous, looking at everything from seismic capability to erosion and scour. However, private bridges are not inspected, and can be very dangerous.

Upon inspection, the bridges are subject to a sufficiency score. This score uses a scale of 1 to 100 with 1 being the worst rating. The bridges are ranked throughout the state according to their score. The state then prioritizes the bridge repair according to each score. If the bridge receives a sufficiency score of less that 50, it is on the list for upgrading and rehabilitation. If it scores over 50, it is not included on the list. Small repairs to county bridges may be done in house, while the larger projects require funding through the Highway Bridge Replacement and Rehabilitation program (HBRR). HBRR provides 80% of funding, and the county is responsible for 20%.[25] The Clackamas County Roads Department has prioritized the county bridges based on local knowledge, and sufficiency scores (Table 11-6).

Table 11-6. Community Issue Summary

Community Issue		Issue at stake	Potential/Existing Solution
Bridges	Carver Truss Bridge Freyer Park Bridge Mulino Road Bridge Eagle Creek Bridge Oatfield Road Bridge	Five highest priority bridges in the county are currently being upgraded.	Currently being upgraded by replacing the earthquake resistant bearing pads using county funds.
Lack of Building Inventory Data	Although Clackamas County Building Services has records of all building permits, there is no building inventory data set.	The existing inventory of manmade structures and lifeline infrastructure must be incorporated into the risk assessment to derive an accurate estimate of losses for Clackamas County.	DOGAMI and Portland State University are working with Clackamas County Building Services in constructing a building inventory data set for Clackamas County

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. 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 Services[26]

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.

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 large and 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. 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.[27]

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, and anchoring buildings to foundations 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 collapsed buildings 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 extinguish 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.

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.

Clackamas County Code

Implementation of earthquake mitigation policy often takes place at the local government level. The Clackamas County Department of Transportation and Development is the local agency that enforces zoning codes pertaining to earthquake hazards through the Planning and Building Codes Departments. The standards for development are outlined in the Unified Zoning Ordinance (ZDO). The ZDO addresses the earthquake hazard in ZDO Section 400 (Natural Resource Districts), ZDO Subsection 1002 (Protection of Natural Features), and ZDO Subsection 1005.03, Point B (Building Siting and Orientation). Generally, these codes seeks to discourage development in areas that could be prone to flooding, landslide, wildfire and / or seismic hazards, therefore "letting such events naturally recur" and allowing "the beneficial effects that natural hazards can have on natural resources and the environment" to occur (Clackamas County ZDO). Developers in potential hazard-prone areas are required to retain a professional engineer to evaluate level of risk onsite and recommend mitigation measures.

Coordination Among County Building Officials

The Oregon State Building Code Division (BCD) sets the minimum design and construction standards for new buildings. In 1993, BCD upgraded the Oregon Specialty Code (OSSC) seismic zone rating, which requires that new buildings be built at a higher seismic standard. Since 1993, BCD also requires that site-specific seismic hazard investigations be performed for new essential facilities, major structures, hazardous facilities, and special occupancy structures such as schools, hospitals, and emergency response facilities.

The county enforces the Unified Building Code (UBC), as adopted by the BCD to insure building code standards in new construction. Codes related to Natural Hazard Mitigation are Chapter 16 of the UBC. It introduces seismic zones, which are rated from 1-4 depending on risk. Each zone has different standards that are specific to the level of risk. The following sections of the UBC address the earthquake hazard: 1605.2.1 (Distribution of Horizontal Sheer); 1605.2.2 (Stability against Overturning); 1626 (Seismic); 1605.2.3 (Anchorage); and 1632, 1633.2.8, 1633.2.9 deal with specific earthquake hazards.

Businesses/Private Sector

Natural Hazards have a devastating impact on businesses. In fact, of all businesses which close following a disaster, more than 43% never reopen, and an additional 29% close for good within the next two years.[28] The Institute of Business and Home Safety has developed "Open for Business", which is a disaster planning toolkit to help guide

businesses in preparing for and dealing with the adverse affects of natural hazards. The kit integrates protection from natural disasters into the company's risk reduction measures to safeguard employees, customers, and the investment itself. The guide helps businesses secure human and physical resources during disasters, and helps to develop strategies to maintain business continuity before, during, and after a disaster occurs.

Senate Bill 13: Seismic Event Preparation

Senate Bill 13, signed by Governor Kitzhaber 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." Each state and local agency and employer with 250 or more full-time employees shall maintain a file that documents the date the earthquake drill was conducted. Oregon Emergency Management (OEM) was tasked to write the Oregon Administrative Rule (OAR) for this bill. The draft rule went out for public comment in February 2002, and was revised based on public comment. The final rule (OAR 104-020-000-040) went into effect April 1, 2002.

Senate Bill 14: Seismic Surveys For School Buildings

The Governor signed Senate Bill 14 on July 19, 2001, which 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.

Senate Bill 15: Seismic Surveys For Hospital Buildings

The Governor signed Senate Bill 15 on July 19, 2001, which requires the Health Division to provide for seismic safety surveys of hospital buildings that contain an acute in-patient 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.

Senate Joint Resolution 21 & 22 (SJR 21 &SJR 22)

These measures would allow the state to issue general obligation bonds to assess need for seismic rehabilitation and to conduct seismic rehabilitation of public education buildings and emergency services buildings. The resolutions limit the amount of indebtedness to one-fifth of one percent of the real market value of all property in the state. The sources of repayment are listed as: the General Fund, lottery funds, tobacco settlement funds, and other appropriations but not including ad valorem property taxes. SJR 21 & SJR 22 will be referred to the public for vote in November 2002.

Earthquake Education

All three of the state's major public universities (University of Oregon, Oregon State University, and Portland State University) are involved with earthquake education in some capacity. At these institutions, the federally funded work conducted tends to be oriented towards basic research, whereas state funded work typically has more practical application.

The Department of Education is generally concerned with seismic safety in schools. It supports the required monthly earthquake drills mandated in Oregon Revised Statutes (ORS 336.072). The Department is not authorized to mandate seismic safety efforts in schools but can make recommendations to local school districts on such issues. It encourages the use of a curriculum produced by FEMA that focuses on mitigating non-structural hazards in schools and assists schools in obtaining funds for these purposes. Each year, Oregon Emergency Management provides information to facilitate school earthquake drills statewide. Currently, eight Clackamas County schools have committed to performing earthquake drills. These include: Sunnyside Elementary (Clackamas); Bethelem Church Pre-School (Lake Oswego); Lake Oswego High (Lake Oswego); View Acres Elementary (Milwaukie); Ardenwald Elementary (Milwaukie); Ogden Middle (Oregon City); Sandy High School (Sandy); and Welches School (Welches).

Clackamas County Project Impact has been conducting education outreach in the local schools. Letters were sent to each School District in the county offering them the opportunity to identify a classroom for seismic non-structural mitigation. They were encouraged to identify environments that differed from the norm like a daycare, sports storage area, science lab and kitchen.

Metro Regional Guide

Metro worked with FEMA and DOGAMI to identify seismic areas and produce new earthquake maps. Metro 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 Clackamas County.

Earthquake Mitigation Action Items

The earthquake mitigation action items provide guidance on suggesting specific activities that agencies, organizations, and residents in Clackamas County can undertake to reduce risk and prevent loss from earthquake events. 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: Integrate new earthquake hazard mapping data for Clackamas County and improve technical analysis of earthquake hazards.

Ideas for Implementation

- Update Clackamas County earthquake HAZUS data using more localized data including the building inventory from the DOGAMI project to improve accuracy of the vulnerability assessment for Clackamas County; 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 assessing the adequacy of current land use requirements.

Coordinating Organization:	Clackamas County Geographic Information Systems
Timeline:	2 years
Plan Goals Addressed:	Partnerships and Implementation, Protect Life and Property

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ST-EQ#2: Incorporate the Regional Earthquake Transportation Evacuation Routes developed by the Regional Emergency Managers Group into appropriate planning documents.

Ideas for Implementation

- Update the transportation routes map in the Clackamas County Natural hazard Mitigation Plan with the evacuation routes data; and
- Integrate the evacuation routes data into the Clackamas County Emergency Operations Plan.

Coordinating Organization:	Clackamas County Emergency Management
Timeline:	2 years
Plan Goals Addressed:	Emergency Services

LT-EQ#1: Identify funding sources for structural and nonstructural retrofitting of structures that are identified as seismically vulnerable.

Ideas for Implementation

- Provide information for property owners, small businesses, and organizations on sources of funds (loans, grants, etc.); and
- Explore options for including seismic retrofitting in existing programs such as low-income housing, insurance reimbursements, and pre and post disaster repairs.

Coordinating Organization:	Hazard Mitigation Advisory Committee
Timeline:	ongoing
Plan Goals Addressed:	Partnerships and Implementation, Public Awareness

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LT-EQ#2: Encourage purchase of earthquake hazard insurance.

Ideas for Implementation

- Provide earthquake insurance information to Clackamas County residents; and
- Coordinate with insurance companies and organizations such as the Insurance Information Service of Oregon and Idaho to produce and distribute earthquake insurance information.

Coordinating Organization:	Hazard Mitigation Advisory Committee
Timeline:	ongoing
Plan Goals Addressed:	Protect Life and Property, Public Awareness

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LT-EQ#3: Encourage seismic strength evaluations of critical facilities in the county to identify vulnerabilities for mitigation of schools and universities, public 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;
- Encourage owners of non-retrofitted reservoirs to upgrade them to meet seismic standards; and
- Encourage all water providers to replace all old cast iron pipes with more ductile iron, and identify partnership opportunities with other agencies for pipe replacement.

Coordinating Organization: Hazard Mitigation Advisory Committee
Timeline: 5 years
Plan Goals Addressed: Protect Life and Property, Emergency Services

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LT-EQ#4: Encourage reduction of nonstructural and structural earthquake hazards in homes, schools, businesses, and government offices.

Ideas for Implementation

- Provide information 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 Damag*e;
- Encourage homeowners and renters to use *Is Your Home Protected from Earthquake Disaster? A Homeowner's Guide to Earthquake Retrofit* (IBHS) for economic and efficient mitigation techniques;
- Explore partnerships to provide retrofitting classes for homeowners, renters, building professionals, and contractors; and
- Target development located in potential fault zones or in unstable soils for intensive education and retrofitting resources.

Coordinating Organization: Hazard Mitigation Advisory Committee
Timeline: Ongoing
Plan Goals Addressed: Protect Life and Property, Public Awareness

Earthquake Resource Directory

State Resources

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

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, OR 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, OR 97309
Phone: (503) 378-4133
Fax: (503) 378-2322
Website: http://www.cbs.state.or.us/external

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." Each state and local agency and employer with 250 or more full-time employees shall maintain a file that documents the date the earthquake drill was conducted.

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.

Federal Resources

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, CO 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

Cascadia Region Earthquake Workgroup (CREW)

The Cascadia Region Earthquake Workgroup provides information on regional earthquake hazards, facts, and mitigation strategies for homes and businesses. 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

Western States Seismic Policy Council Earthquake Program Information Center (WSSPC)

WSSPC is a regional earthquake consortium funded mainly FEMA. 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

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 Clackamas 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

[1] Wang, Yumei and Clark, J.L. *Earthquake damage in Oregon: Preliminary estimates of future earthquake losses* (1999), DOGAMI, Special Paper 29.

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

[3] Preparing for Earthquakes in Oregon. Oregon Geology, Vol. 59. No. 2 March/April 1997.

[4] Bott, Jacqueline D.J. and Wong, Ivan G. *Historical earthquakes in and around Portland, Oregon. (*September 1993). Oregon Geology 55 (5). 116.

[5] Bott, Jacqueline D.J. and Wong, Ivan G. *Historical earthquakes in and around Portland, Oregon*. September (1993). Oregon Geology 55 (5). 116.

[6] http://earthquake.usgs.gov

[7] Madin, Ian P. and Zhenming Wang. *Relative Earthquake Hazard Maps Report.* (1999) DOGAMI.

[8] *Planning for Natural Hazards: The Oregon Technical Resource Guide,* Department of Land Conservation and Development (July 2000), Ch. 8, pp. 8.

[9] March 4, 2001. "A region at risk." The Oregonian.

[10] *Questions and Answers on Earthquakes in Washington and Oregon* (February 2001) www.geophys.washington.edu/seis/pnsn/info_general/faq.html.

[11] "A region at risk." March 4, 2001. The Oregonian.

[12] *Planning for Natural Hazards: The Oregon Technical Resource Guide,* Department of Land Conservation and Development (July 2000), Ch. 8, pp. 9.

[13] *Planning for Natural Hazards: The Oregon Technical Resource Guide,* Department of Land Conservation and Development (July 2000), Ch. 8, pp. 7.

[14] Ibid.

[15] Ibid.

[16] Ibid.

[17] *Planning for Natural Hazards: The Oregon Technical Resource Guide,* Department of Land Conservation and Development (July 2000), Ch. 8, pp. 11.

[18] *All Hazard Mitigation Plan Clackamas County, Oregon*. G&E Engineering Systems Report 32.07.01, Revision 0. September 23, 1998.

[19] Ibid

[20] Ibid

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

[22] FEMA HAZUS <http://www.fema.gov/hazus/hazus2.htm> (May 2001).

[23] *All Hazard Mitigation Plan Clackamas County, Oregon*. G&E Engineering Systems Report 32.07.01, Revision 0. September 23, 1998.

[24] Wang, Yumei and Clark, J.L. *Earthquake damage in Oregon: Preliminary estimates of future earthquake losses* (1999), DOGAMI, Special Paper 29.

[25] Personal Interview. April 12, 2002. Dave Conrad (Clackamas Couinty Roads Division)

[26] Wang, Yumei and Clark, J.L. *Earthquake damage in Oregon: Preliminary estimates of future earthquake losses* (1999), DOGAMI, Special Paper 29.

[27] DOGAMI Risk Perception Survey (1999)

[28]Institute for Business and Home Safety Resources (April 2001), http://www.ibhs.net/ibhsdocuments/pdf/earthquake.pdf.

Section 12:
Volcanic Eruption

Table of Contents

Why is Volcanic Eruption a Threat to Clackamas County?

The Pacific Northwest lies on the "Ring of Fire," an area of active volcanic activity surrounding the Pacific Basin. Volcanic eruptions occur 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 volcanic threat to lives and property in Clackamas County is from eruptions of Mount Hood that generate mud and debris flows that can sweep down river valleys for tens of miles, and from ash clouds that drift downwind to the county from near or distant eruptions.

History of Volcanic Eruption Events Affecting Clackamas County

Any eruption in the Cascades could have an effect on Clackamas County if the wind blows in the right direction. Only Mount Hood and Mount St. Helens are known to have had direct effects in the county in the past. However, any eruption in the Cascades that affects regional infrastructure, air traffic, bridges, or Interstates 5 and 84 will have a direct or indirect impact on the county.

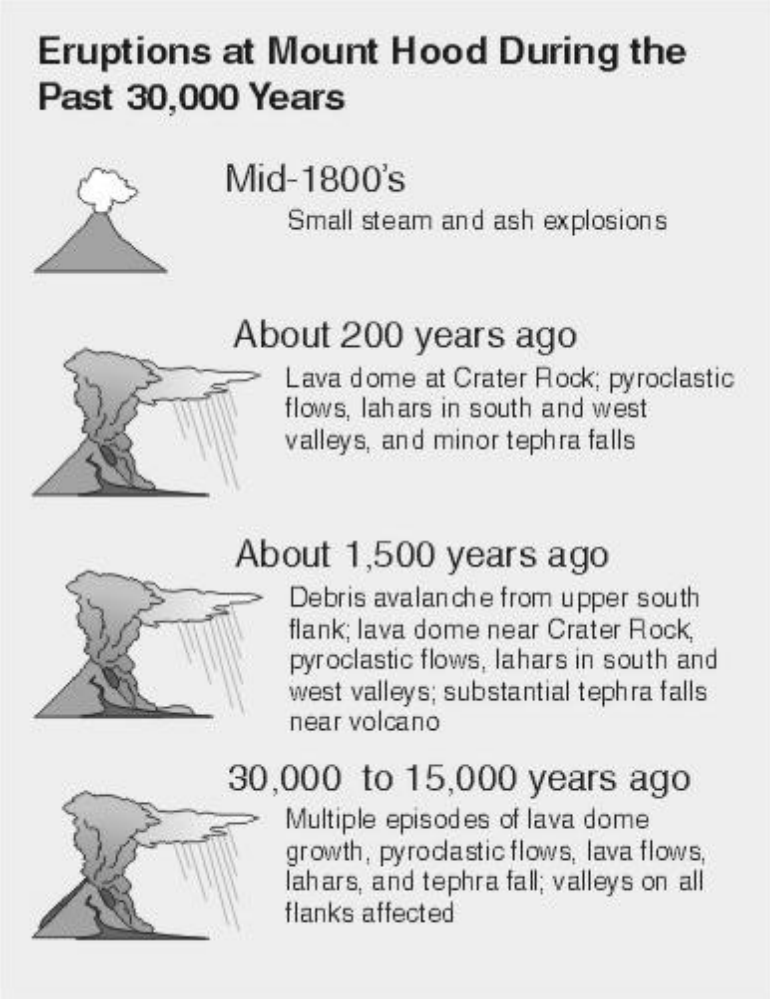
Mount Hood

Mount Hood is located on the eastern boundary of Clackamas County and has been recurrently active over the past 500,000 years. It has had two significant eruptive periods in recent times - one about 1,500 years ago and another about 200 years ago. Figure 12-1 shows the major geologic events in the Mount Hood Region during the past 30,000 years. In addition to these eruptive episodes, there is evidence of an-eruption occurring just before Lewis and Clark traversed the region (1804-1806). There is also evidence of several minor eruptions between about 1846 and 1865.[1]

Although Mount Hood does not have a history of violent explosive eruptions, there are significant hazards associated with this volcano. The flanks of the volcano were formed in part by lava flows, which flowed up to 8 miles from the summit. These slow-moving lava flows are destructive, but do not pose a serious threat to life and safety because people have ample time to evacuate. Lava erupting from Mount Hood is too viscous to flow and accumulates around vents to form steep-sided lava domes. Lava domes can collapse, forming fast moving pyroclastic flows, hot avalanches of lava blocks, ash, and hot gases. These pyroclastic flows can swiftly melt snow and ice to form lahars or volcanic mudflows that can continue far down river valleys. Mount

Hood has also generated lahars from landslides, or debris avalanches, of weakened, saturated masses of rock high on the volcano. Lahars are the most dangerous potential threat posed by the seemingly dormant volcano in eastern Clackamas County. While Mount Hood has shown no recent signs of volcanic activity, scientists predict the next eruption will consist of lava dome growth and collapse, which will generate pyroclastic flows, ash clouds, and lahars (mud and debris flows). Future eruptions from Mount Hood could seriously disrupt transportation, water supplies, and hydroelectric power generation and transmission in northwest Oregon and southwest Washington.

Figure 12-1. Eruption at Mount Hood



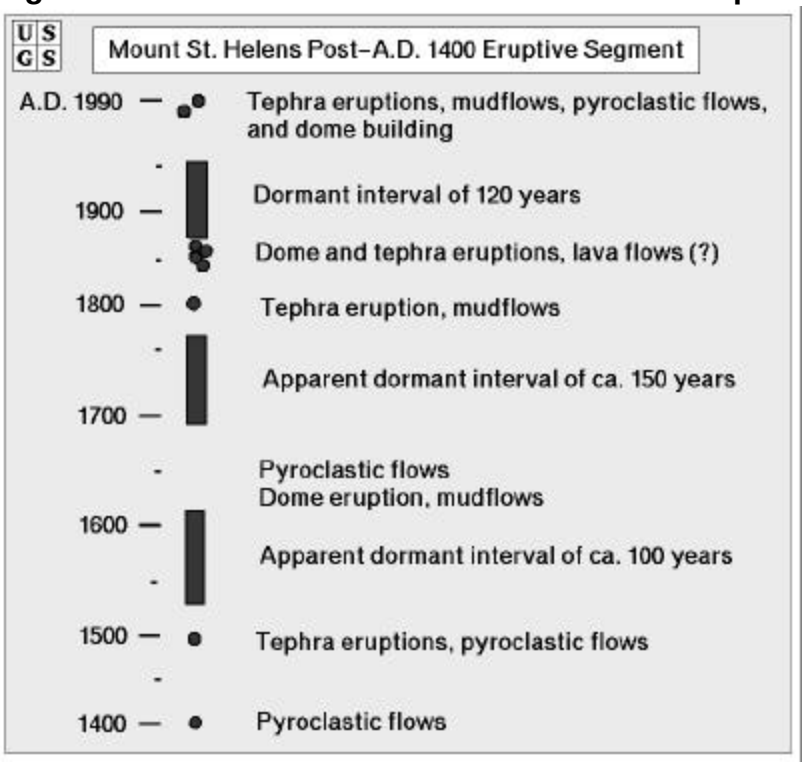
Source: United States Geologic Survey

Mount St. Helens

Mount St. Helens is a fifty thousand year old volcano, located in southwestern Washington about sixty miles northeast of Clackamas County. In the last 515 years, it is known to have produced 4 major explosive eruptions (each with at least 1 cubic kilometer of eruption

deposits) and dozens of lesser eruptions. Two of the major eruptions were separated by only 2 years. One of those, in 1480 A.D., was about 5 times larger than the May 18, 1980 eruption, and even larger eruptions are known to have occurred during Mount St. Helens' brief but very active 50,000-year lifetime. Figure 12-2 shows the major geologic events in the Mount St. Helens region during the past 600 years. Mount St. Helens remains an active and potentially dangerous volcano.

Figure 12-2. Mount St. Helens Post-1400 A.D. Eruptive Segment



Source: United States Geologic Survey

The 1980 eruptions of Mount St. Helens in southwestern Washington marked the re-awakening of the volcano that had been dormant since 1857. The May 18, 1980 eruption of Mount St. Helens was preceded by about two months of precursory activity, including numerous earthquakes, marked deformation of the volcano's north flank, and small steam explosions. The lateral blast, debris avalanche, and lahars associated with the eruption are thought to have occurred just before a Richter Magnitude 5.1 earthquake shook the mountain.

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. Lahars filled the Toutle and Cowlitz Rivers and ultimately flowed into the Columbia River at Longview, Washington. Sediment from the lahars 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. [2]

Following the eruption on May 18, 1980, there were 5 smaller explosive eruptions over a period of 5 months. Thereafter, a series of 16 dome-building eruptions through October 1986 constructed the new, 270-meter- (880 feet) high, lava dome in the crater formed by the May 18, 1980 eruption.

A few millimeters of ash fell onto Clackamas 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 and 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. 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.

Mount Rainier

Mount Rainier has produced at least four eruption periods and numerous lahars in the past 4,000 years. Mount Rainier is known to have erupted as recently as in the 1840s, and large eruptions took place as recently as about 1,000 and 2,300 years ago. Mount Rainier is capped by more glacier ice than the rest of the Cascades volcanoes combined, and parts of its steep slopes have been weakened by attack from hot, acidic volcanic gases and water. These factors make this volcano prone to landslide and lahars.

Mount Adams

Mount Adams stands astride the Cascade Crest some 50 kilometers due east of Mount St. Helens. This volcano has produced few eruptions during the past several thousand years. The most recent activity was a series of eruptions about 1,000 years ago. Mount Adams is also prone to landslides of weakened rock.

Mount Jefferson

Mount Jefferson has erupted repeatedly for hundreds of thousands of years, with its last eruptive episode during the last major glaciation,

which culminated about 15,000 years ago. Geologic evidence shows that Mount Jefferson is capable of large explosive eruptions. The largest such eruption occurred between 35,000 and 100,000 years ago, and caused ash to fall as far away as the present-day town of Arco in southeast Idaho. Although there has not been an eruption at Mount Jefferson for some time, experience at explosive volcanoes elsewhere suggests that Mount Jefferson cannot be regarded as extinct. If Mount Jefferson erupts again, areas close to the eruptive vent will be severely affected, and even areas tens of kilometers (tens of miles) downstream along river valleys or hundreds of kilometers (hundreds of miles) downwind may be at risk.[3]

Characteristics of Volcanic Eruptions

Volcanoes are mountains that are built by the accumulation of their own eruptive products – lava flows, lava domes, lava bombs (crusted over lava blobs), pyroclastic 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.

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.

Hazards Related to Volcanic Eruptions

Tephra

Tephra consists of sand-sized or finer particles of volcanic rock, sometimes called volcanic ash, 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. 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 large falling fragments, which is only a problem within a few miles of vents, 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.

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-sized boulders. Lahars can also form from landslides or debris avalanches of water-saturated material and from breaching of crater or debris-dammed lakes.

Lava Flows[5]

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.

Lava Domes[6]

Volcanic lava domes are mounds that form when viscous lava is erupted slowly and piles up over the vent, rather than moving away as a lava flow. The sides of most domes are very steep and composed of silica-rich lava, which may contain enough pressurized gas to cause explosions. Dome eruption can bury or disrupt the preexisting ground surface. Because of their high temperatures, domes may start fires if they are erupted in forested areas. Domes are extruded so slowly that people can avoid them, but they may endanger man-made structures that cannot be moved.

Earthquakes[7]

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

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. Directed blasts may affect only narrow sectors or spread out from a volcano to cover a sector as broad as 180 degrees. Because they carry rock debris at high speeds, lateral blasts can devastate areas of tens to hundreds of square miles within a few minutes, and can

destroy man-made structures and kill all living things by abrasion, impact, burial, and heat.

Pyroclastic Flows[8]

Pyroclastic flows are fluid mixtures of hot rock fragments, ash, and gases that sweep down the flanks of volcanoes. High-speed avalanches of hot ash, rock fragments, and gas move down the sides of a volcano during explosive eruptions or when the steep edge of a dome breaks apart and collapses. These pyroclastic flows, which can reach 1500° F and move at 100-150 miles per hour, are capable of knocking down and burning everything in their paths.

Volcanic Landslides

Landslides, or debris avalanches, are a rapid downhill movement of rocky material, snow, or ice.[9] Volcanic landslides are not always associated with eruptions; heavy rainfall or a large regional earthquake can trigger a landslide on steep slopes. Volcanoes are susceptible to landslides because they are composed of layers of weak, fragmented, volcanic rocks that tower above the surrounding terrain. Furthermore, some of these rocks have been altered to soft, slippery, clay minerals by hot, acidic ground water inside the volcano.[10]

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

Volcanic Eruption Hazard Assessment

Hazard Identification

The USGS/Cascades Volcano Observatory (CVO) produced a volcanic hazard zonation report for Mount Hood in 1997 and 2000. The report includes a description of potential hazards that may occur to immediate communities.

The hazard zones illustrated on Map 14 were determined based on the distance from the volcano, vent location, and type of hazardous events. Proximal Hazard Zones 1 and 2 are areas subject to rapidly moving debris avalanches, pyroclastic flows, and lahars that can reach the hazard boundary in less than 30 minutes, as well as slow-moving lava flows. Areas within proximal hazard zones should be evacuated before an eruption begins because there is little time to get people out of harm's way once an eruption starts. Most pyroclastic flows, lava flows, and debris avalanches will stop within the proximal hazard zone, but lahars can travel much farther.

Distal Hazards Zones 3 includes areas adjacent to rivers that are pathways for lahars. Estimated travel time for lahars to reach these zones is more than 30 minutes, which may allow individuals time to move to higher ground and greater safety if given notice. Lahars could affect transportation corridors by damaging or destroying roads, and can damage Bull Run pipelines that cross the Sandy River.

Vulnerability Assessment

While an assessment that describes the number of lives or amount of property exposed to the hazard has not yet been conducted for Clackamas County volcanic eruption events, there are many issues relating to what is in danger within a community that point to potential vulnerability.

Recent Activity at Mount Hood: In the period between July 6-9, 1980, four earthquakes measuring 3.2 and 3.3 were recorded as having their epicenter at, or near Mount Hood. Numerous smaller aftershocks also occurred following these earthquakes. Subsequently, a number of seismic activities ranging up to 3.2 have been recorded at the mountain, almost annually. There are earthquake swarms routinely, gas emissions from summit fumaroles, and, most importantly, numerous small debris flows generated by storms, landslides, and glacier outburst floods that affect areas around the volcano and sometimes affect highways. The latter events are real issues for the Forest Service and ODOT, primarily in Hood River County but also in Clackamas.

Future Activity at Mount Hood: While Mount Hood has shown no recent signs of volcanic activity, scientists predict the next eruption will consist of lava dome growth accompanied by small explosions, and lava-dome collapse generating pyroclastic flows, ash clouds, and lahars. Future eruptions from Mount Hood could seriously disrupt

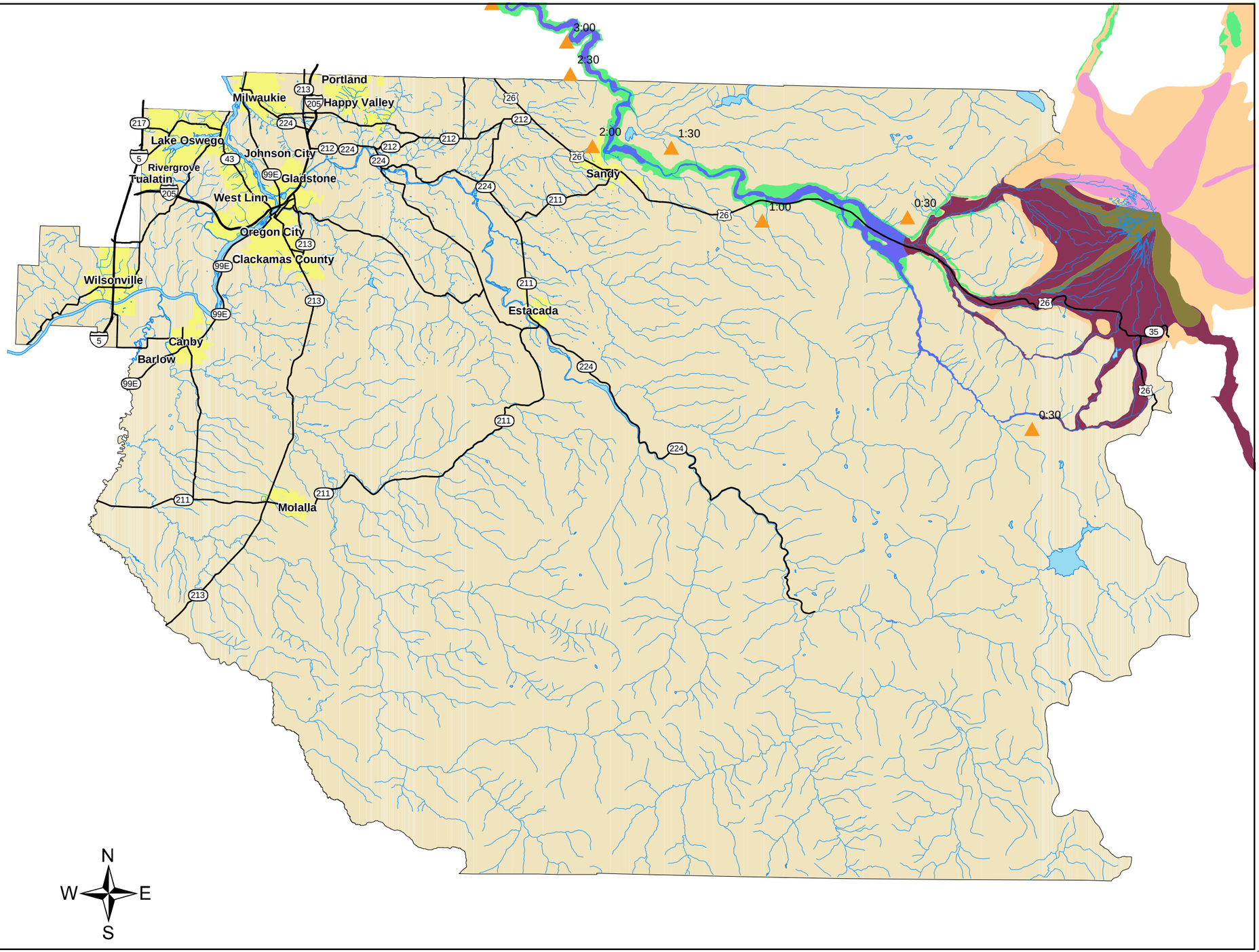
transportation, water supplies, and hydroelectric power generation and transmission in northwest Oregon and southwest Washington.

Ash fall generated by Mount Hood and other nearby volcanoes is a significant hazard that affects Clackamas County. 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 clogged, and the economy can be adversely impacted. Any future eruption of a nearby volcano (e.g., Hood, St. Helens, or Adams) occurring during a period of easterly or southern 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 were insufficient to conduct a risk analysis and the software needed to conduct this type of analysis was not available.

Map 14
Mt. Hood Hazards for Clackamas County



Proximal

Zone 1: Vent at or near Crater Rock, which is considered the most likely case during future eruptions.

Zone 2: Vent on east, north, or west flank, or the the summit. (A summit vent also would endanger zone 1)

Distal

Zone 3: Major valleys that pyroclastic flows and lahars would follow from lava-dome collapses on the upper flanks or summit. As an eruptive episode progresses, one or more of these valleys might become filled with debris, so that pyroclastic flows and lahars could spill into adjacent valleys and affect a broader sector of a zone one. Also includes areas that are affected frequently by small lahars and debris avalaches generated by storms and rapid snowmelt. (This area not shown on map.)

Area that may be affected by hazards as described above for zones 1 and 3.

Area that may be affected by hazards as described above for zones 2 and 3.

Areas along Sandy River and it tributaries and White River that are subject ot lahars generated by eruptions at vent located at or near Crater Rock and to debris avalanches and related lahars generated from steep upper flanks on west and south sides of Mount Hood.

Areas along Sandy and Hood Rivers subject to inudation by a debris avalanche and lahar of about 500 million cubic meters, which is considered to be among the largest magnitude events possible at Mouth Hood.

▲ Travel Time of Lahars Down River

Data Source: City Limits are maintained by Metro. The County Boundary, Hydrology, and Street layers are maintained by Clackamas County GIS Staff.

The Mt. Hood Hazard data was provided to Clackamas County by the USGS.

1 inch equals 5 miles

Miles

8 4 0 8

Clackamas County

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Community Volcanic Eruption Issues

What is Susceptible to Volcanic Eruptions?

Building and Infrastructure Damage

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.

During an eruption at Mount Hood, Bonneville Power Administration transmission lines may be severed. A number of high voltage lines are located in the immediate vicinity of Mount Hood. These lines provide a portion of the electrical power to Clackamas County, the Portland Metropolitan Area, and the rest of the Willamette Valley.

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. [11] Fine ash in water supplies will cause brief muddiness and chemical contamination. Ash suspended in the atmosphere is especially a concern for airports, where aircraft machinery could be damaged or clogged.

Ash fall also decreases visibility and disrupts daily activities. For example, some individuals may encounter eye irritation. 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.

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, cause rapid wear of machinery, clog air filters, block drains, creeks, and water intakes, and impact agriculture.[12] Removal and disposal of large volumes of deposited ash can also have significant impacts on government and business.

The interconnectedness of the region's economy can be disturbed after a volcanic eruption. Roads, railroads, and bridges can be damaged from lahars and mudflows. 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. However, the eruption did lead to the creation of a thriving tourist industry for decades following event.

Transportation of goods may also be halted. Subsequent airport closures can disrupt airline schedules for travelers. In addition, the movement of goods via the Columbia River and other major waterways can also be halted due to debris in the river, and tephra in the air. The Mount St. Helens event in May 1980 cost the trade and commerce industry an estimated $50 million in only two days, as ships were unable to navigate the Columbia.[13] 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.[14]

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

USGS and Pacific Northwest Seismograph Network at the University of Washington conduct seismic monitoring of all Cascade volcanoes in Washington and Oregon . 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. [15] 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 Clackamas 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. Emergency coordination and communication is necessary to reduce losses from potential volcanic eruptions in the Cascade region.

A Mount Hood Volcano Inter-Agency Coordination Plan was developed after the Mount St. Helens eruption in the early 1980s, and was last updated for Clackamas County in 1997. The purpose of this Plan is to identify the key steps and linkages necessary during a volcanic emergency at Mount Hood. The development of this Plan fostered many important partnerships, and resulted in the following: the development of a tactical operations center, appointment of an operations coordinator, an outline for logistical support during an emergency, and development of a public information center to disseminate emergency information to the media and general public. The Plan details specific roles and duties assigned to various state federal, and local agencies to be executed during a volcanic event. The Plan provides a centralized coordination system to ensure that issues, which affect more than one unit or agency, are coordinated for the common good.

Warning Systems[16]

The best warning of a volcanic eruption is one that specifies when and where an eruption is most likely to occur and what type and size eruption should be expected. Such accurate predictions are sometimes possible but still rare in volcanology. The most accurate warnings are those in which scientists indicate an eruption is probably only hours to days away based on significant changes in a volcano's earthquake activity, ground deformation, and gas emissions. Experience from around the world has shown that most eruptions are preceded by such changes over a period of days to weeks.

A volcano may begin to show signs of unrest several months to a few years before an eruption. In these cases, however, a warning that specifies when it might erupt months to years ahead of time are extremely rare. The strategy that the USGS-CVO uses to provide volcano warnings in the Cascade Range volcanoes in Washington and Oregon involves a series of alert levels that correspond generally to increasing levels of volcanic activity. As a volcano becomes increasingly active or as incoming data suggest that a given level of unrest is likely to lead to a significant eruption, the USGS-CVO declares a corresponding higher alert level. This alert level ranking thus offers the public and civil authorities a framework they can use to gauge and coordinate their response to a developing volcano emergency.

Notice of Volcanic Unrest Alert Level One

This alert level is declared by USGS-CVO when significant anomalous conditions are recognized that could be indicative of an eventual hazardous volcanic event. The most likely such anomalous condition would be sustained, elevated seismicity. A "notice of volcanic unrest" expresses concern about the potential for hazardous volcanic activity but does not imply imminent hazard. Among the possible outcomes are: (1) anomalous condition is determined not symptomatic of an eventual hazardous volcanic event, leading to cancellation of "notice of volcanic unrest;" (2) symptomatic activity wanes, leading to cancellation of the "notice of volcanic unrest;" (3) conditions evolve so as to indicate progress toward hazardous volcanic activity, leading to issuance of a "volcano advisory" or "volcano alert."

Volcano Advisory Alert Level Two

This alert level is declared by USGS-CVO when monitoring and evaluation indicate that processes are underway that have significant likelihood of culminating in hazardous volcanic activity but when the evidence does not indicate a life- or property-threatening event is imminent. This alert level is used to emphasize heightened concern about potential hazard. Among the possible outcomes are: (1) precursory activity wanes, leading either to cancellation of the "volcano advisory" or to a downgrade of alert level to "notice of volcanic unrest;" (2) conditions evolve so as to indicate that a life-threatening volcanic or hydrologic event is imminent or underway, leading to issuance of a "volcano alert." "Volcano advisory" statements, supplemented as appropriate by "updated volcano advisory" statements will clarify as fully as possible USGS-CVO understanding of the hazard implications.

Volcano Advisory Alert Level Three

This alert level is declared by USGS-CVO when monitoring and evaluation indicate that precursory events have escalated to the point where a volcanic event with attendant volcanic (?) or hydrologic hazards threatening to life and property appears imminent or is underway. Depending upon further developments, a "volcano alert" will be maintained, updated, downgraded to a "volcano advisory," or canceled. A "volcano alert" statement will indicate, in as much detail as possible, the time window, place, and expected impact of an anticipated hazardous event. "Updated volcano alert" statements will amplify hazard information as dictated by evolving conditions.

Education and Outreach

USGS Video Programs

The USGS has developed educational volcanic hazards videos (“Understanding Volcanic Hazards” and “Reducing Volcanic Risk”) that are designed to increase the public’s awareness. The USGS has also developed the video program “At Risk: Volcano Hazards from Mount Hood, Oregon,” which 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.

Volcanic Eruption Mitigation Action Items

The volcanic eruption mitigation action items provide direction on specific activities that cities, organizations, and residents in Clackamas County can undertake to reduce risk and prevent loss from volcanic eruption events. 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-VE#1: Work with the state and other impacted jurisdictions to revise the Mount Hood Inter-Agency Coordination Plan from 1997-2002.

Ideas for Implementation

- Coordinate with local and regional groups to conduct a plan evaluation and develop plan revisions.

Coordinating Organization:	Clackamas County Emergency Management
Timeline:	1-2 years
Plan Goals Addressed:	Public Awareness, Partnerships and Implementation, Emergency Services

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ST-VE#2: Collaborate with USGS-CVO and related agencies to develop ash fall models that are specific to Clackamas County.

Ideas for Implementation

- Determine critical activities that must be implemented for varying degrees of ash fall.

Coordinating Organization:	Clackamas County Emergency Management, Clackamas County Geographic Information Systems
Timeline:	2 years
Plan Goals Addressed:	Public Awareness, Partnerships and Implementation, Protect Life and Property

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LT-VE#1: Strengthen response and recovery programs, and develop and implement public education programs for volcanic eruption hazards.

Ideas for Implementation

- Develop basic public education materials that describe volcanic eruption hazards (pyroclastic surges, pyroclastic flows, lahars,

mudflows, landslides, ash fall), potential impacts, and appropriate response and mitigation activities; and

- Coordinate with the media for volcanic hazard education programs to reduce conveyance of misinformation.

Coordinating Organization:	Clackamas County Emergency Management
Timeline:	5 years
Plan Goals Addressed:	Protect Life and Property, Emergency Services Public Awareness, Partnerships and Implementation

Volcanic Eruption Resource Directory

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 volcano 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: 1300 SE Cardinal Court, Vancouver, WA 98683
Phone: (360) 993-8900
Fax: (360) 993-8980
Website: http://vulcan.wr.usgs.gov/CVO_Info/framework.html or http://volcanoes.usgs.gov

Additional Resources

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

Volcano Specialists
Contact: Wairakei Research Centre
Address: State Highway 1 Private Bag 2000 Taupo New Zealand
Phone: 64-7-374-8211
Fax: 64-7-374-8199
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, and includes valuable references and suggested reading.

Contact: USGS-CVO
Address: 1300 SE Cardinal Court, Vancouver, WA 98683
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: 1300 SE Cardinal Court, Vancouver, WA 98683
Phone: (360) 993-8900
Website: http://vulcan.wr.usgs.gov/Volcanoes/MSH/Hazards

Videotapes

"Reducing Volcanic Risk," USGS (24 minutes)

This videotape showcases how people can lower their risk from volcanic activity. Three steps can prevent volcanic eruptions from becoming volcanic disasters:

- Identify Hazard Areas
- Monitor Volcanoes
- Develop Emergency Plan

Video of volcanoes from around the world shows how these three steps saved lives when they were used. Reducing Volcanic Risk also describes the critical elements of emergency plans that made the difference between life and death for tens of thousands of people living in the shadows of active volcanoes. People must be informed of the hazards they face. Scientists and public officials must announce warnings clearly. And emergency plans must be tested and practiced ahead of time and used without hesitation when a volcano threatens to erupt.

"Understanding Volcanic Hazards," USGS (24 minutes)

This videotape features images of erupting volcanoes and graphically shows how volcanic activity can affect people, their property, and the land on which they live. The program focuses on seven types of volcanic hazards: ash falls, hot-ash flows (pyroclastic flows), lahars, landslides, tsunamis, lava flows, and volcanic gases.

"At Risk: Volcano Hazards from Mount Hood, Oregon," USGS

This video program describes and illustrates the types of volcano hazards posed by Mount Hood, Oregon, 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 volcano hazards from the volcano. Located about 80 km east of Portland, Oregon, Mount Hood's recent activity has included debris avalanches (landslides), lahars, pyroclastic flows, and eruption of viscous lava. The video includes dramatic images of eruptions from volcanoes in the Caribbean, Japan, and Hawaii.

Contact: Northwest Interpretive Association
Address: 3029 Spirit Lake Highway, Castle Rock, WA 98611
Phone: (360) 274-2127
Fax: (360) 274-2101
Website: http://volcanoes.usgs.gov

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]Harris, Stephen L. *Fire and Ice: The Cascade Volcanoes.*Pacific Search and The Mountaineers, Seattle, WA.

[2] *May 18, 1980 Eruption of Mount St. Helens Summary*, http://vulcan.wr.usgs.gov/Volcanoes (March 2001) USGS.

[3] http://vulcan.wr.usgs.gov/Volcanoes/Cascades

[4] *What is a Volcano?* (June 2001) USGS, vulcan.wr.usgs.gov/Outreach/AboutVolcanoes.

[5] *Volcanic Hazard Zonation for Mount St. Helens, Washington* (1995), USGS, Open-File-Report 95-497.

[6] http://vulcan.wr.usgs.gov

[7] Riley, Colleen M., *A Basic Guide to Volcanic Hazards* (March 2001), Michigan Technological University, www.geo.mtu.edu/volcanoes/hazards/primer.

[8]: *Volcanoes* (March 2001), FEMA, www.fema.gov/library/volcano.htm.

[9] Wright and Pierson, *Living With Volcanoes*, (1973, 1992) USGS Volcano Hazards Program Circular.

[10] http://vulcan.wr.usgs.gov

[11] *Volcano Hazards of the Lassen Volcanic National Park Area,* (March 2001), USGS.

[12] Ibid.

[13]Clackamas County Courier Newspaper. October, 1986.

[14] Personal Interview. Cashman, Kathy, University of Oregon Department of Volcanology, March 14, 2001.

[15] Volcano Hazards in the Mount Hood Region and Mount St. Helens, (April 2001), USGS, vulcan.wr.usgs.gov/Volcanoes/Hood/Hazards.

[16] http://volcanoes.usgs.gov/Products/Warn/WarnSchemes.html

Appendix A:
Resource Directory

Master Resource Directory

The Resource Directory provides contact information for local, regional, state, and federal programs that are currently involved in hazard mitigation activities. The Hazard Mitigation Advisory Committee may look to the organizations on the flowing pages for resources and technical assistance. The Resource Directory provides a foundation for potential partners in action item implementation.

The Hazard Mitigation Advisory Committee will continue to add contact information for organizations currently engaged in hazard mitigation activities. This section may also be used by various community members interested in hazard mitigation information and projects.

Master Resource Directory

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Earthquake	Cascadia Region Earthquake Workgroup (CREW)	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	State	The Cascadia Region Earthquake Workgroup provides information on regional earthquake hazards, facts, and mitigation strategies for homes and businesses. 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.
Earthquake	Building Seismic Safety Council (BSSC)	Address: 1090 Vermont Avenue NW, Suite 700 Washington, DC 20005 Phone: (202) 289-7800 Fax: (202) 289-109 Website:http://www.bssconline.org/	Federal	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.
Earthquake	Oregon Department of Consumer & Business Services-Building Codes Division	Contact: Building Codes Division Address: 1535 Edgewater St. NW P.O. Box 14470 Salem, OR 97309 Phone: (503) 378-4133 Fax: (503) 378-2322 Website: http://www.cbs.state.or.us/external	State	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.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Earthquake	Northwest GeoData Clearinghouse, Department of Geology – Portland State University	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	Regional	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.
Earthquake	Western States Seismic Policy Council Earthquake Program Information Center (WSSPC)	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	State	WSSPC is a regional earthquake consortium funded mainly FEMA. Its website is a great earthquake resource, with information clearly categorized - from policy to engineering to education.
Flood	Oregon Department of Fish and Wildlife (ODFW)	Contact:ODFW Address:2501 SW First Avenue PO Box 59 Portland, OR 97207 Phone:(503) 872-5268 Website:http://www.dfw.state.or.us/ Email:Odfw.Info@state.or.us	State	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	USGS Water Resources	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	Federal	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.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Flood	The Community Rating System (CRS)	Contact: CRS website: http://www.fema.gov/nfip/crs.htm.	Federal	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.
Flood	Office of Hydrology, National Weather Service	Contact:Office of Hydrology, National Weather Service Website:http://www.nws.noaa.gov/oh or http://www.nws.noaa.gov/oh/hic/	Federal	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.
Flood	Student Watershed Research Project (SWRP)	Contact: Student Watershed Research Project Address: 20000 NW Walker Road Beaverton, OR 97006 Fax: (503) 748-1388 Website: http://www.swrp.org	State	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.

Hazard	Agency	Contact Information	Level	Type of Assistance
Flood	Oregon Wetlands Joint Venture	Contact: Division of State Lands Website: http://wetlands.dfw.state.or.us/	State	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.
Flood	Oregon's Wetlands Protection Program	Contact: Division of State Lands Website: http://statelands.dsl.or.us/	State	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.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Flood	Watershed Councils	Willamette Riverkeepers Contact: Chair Address: 380 SE Spokane St. Suite 305 Portland, OR 97202 Phone: (503) 223-6418 Website: www.willamette-riverkeeper.org Email: info@willamette-riverkeeper.org Johnson Creek WS Council Contact: Chair Address: PO Box 82584 Portland, OR 97282 Phone: (503) 239-3932 Website: www.jcwc.org Email: kim@jcwc.org Hood River WS Council Contact: Chair Address: 3007 Experiment Station Road Hood River, OR 97031 Phone: (541) 386-2275 Email: hcoccoli@aol.com Clackamas River Basin Council Contact: Chair Address: PO Box 1869 Clackamas, Oregon 97015 Phone: (503) 650-1256 Website :http:// www.clackamas river.org Email: crbc@teleport.com Tualatin WS Council Contact: Chair Address: 1080 SW Baseline Building B, Suite B-2 Hillsboro, OR 97123 Phone: (503) 648-3174x116 Website: http://www.trwc.org/ Email: tualatinwc@yahoo.com Friends of Kellogg/ Mt. Scott Contact: Chair Address: PO Box 22373 Milwakie, OR 97222	Local	

Hazard	Agency	Contact Information	Level	Type of Assistance
		Phone: (503) 653-7875 Email: fourcreeks@aol.com		
Flood	Bureau of Reclamation	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	State	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.
Flood	Oregon Water Resources Department (WRD)	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	State	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.
Flood	FEMA List of Flood Related Websites	Contact:Federal Emergency Management Agency. Phone:(800) 480-2520 Website:http://www.fema.gov/nfip/related.htm		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.
Flood	Oregon Division of State Lands (DSL)	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	State	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.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Flood	Northwest Regional Floodplain Managers Association (NORFMA)	Contact:NORFMA Website:http://www.norfma.org/ Email:admin@floodplain.org		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 floodplair and fisheries management.
Flood	National Floodplain Insurance Program (NFIP)	Contact: NFIP Website: http://www.fema.gov/nfip/		Oregon has 256 flood-prone communities. Flood insurance is available to citizens in communities that adopt and implement NFIP 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.
Flood	The Floodplain Management Association	Contact:Floodplain Managers Association Website: http://www.floodplain.org Email: admin@floodplain.org		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 a catalog of Web links.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Flood	Oregon Water Resources	Contact: WRD Address:158 12th St. NE Salem, OR 973-1-4172 Phone:(202) 482-6090 Fax: (202) 482-3154	State	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 fromt eh central office in Salem.
Flood	The Association of State Floodplain Managers	Contact:The Association of State Floodplain Managers Address:2809 Fish Hatchery Road Madison, WI 53713 Phone:(608) 274-0123 Website:http://www.floods.org		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.
Landslide	Nature of the Northwest	Contact:The Nature of the Northwest Information Cente 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	State	The 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.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Landslide	US Geological Survey, National Landslide Information Center (NLIC)	Contact: National Landslide Information Center Phone: (800) 654-4966 Website: http://landslide.usgs.gov	Federal	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.
Landslide	Federal Emergency Management Agency, Landslide Fact Sheet	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	Federal	FEMA's website contains information on strategies to reduce risk and prevent loss from landslides and debris flows.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Multi-hazard	Local Radio Stations	KEX Radio Address: 4949 SW Macadam Portland, OR 9720 Phone: 503 225-1190 FAX: 503-224-3216 Email: bradford@1190kex.com KXL Radio Address: 0234 S.W. Bancroft Portland, OR 97201 Phone: 503 417-7630 FAX : 503-417-7661 Email: dougcarter@kxl.com KPAM Radio Address: 888 SW 5th #790 Portland, OR 97204 FAX: 503-226-3994 Phone: 503-226-3996 Email: news@ kpam.com KOPB Radio Address: 7140 SW Macadam Portland, OR 97219 Phone: 503-293-1905 FAX: 503-293-1919 Email: opbnews@opb.org Television KGW TV Address: 1501 SW Jefferson Portland, OR 97201 Phone: 503-226-5111 FAX: 503-226-5059 Email: newsdesk@kgw.com KOIN TV Address: 222 SW Columbia Portland, OR 97201 Phone: 503-464-0797 FAX: 503-464-0806 Email: koindesk@koin.com KATU TV	Local	

Hazard	Agency	Contact Information	Level	Type of Assistance
		Address: PO Box 2 Portland, OR 97207 Phone: 503-231-4260 FAX: 503-231-4263 Email: katu.com KPTV Address: PO Box 3401 Portland, OR 97208 Phone: 503-230-1200 FAX: 503-230-1065 Email: kptvnews@kptv.com KOPB Address: 7140 S.W. Macadam Portland, OR 97219 Phone: 503-226-1311 FAX: 503-224-7140 Email: opbnews@opb.org KPDX TV49 Address: 910 NE MLK Blvd. Portland, OR 97232 Phone: 503-548-4949 FAX: 503-548-6920 Email: kpdxdesk@kpdx.com		
Multi-hazard	Oregon Division of State Lands (DSL)	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	State	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.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Multi-hazard	Oregon Department of Consumer and Business Services	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	State	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.
Multi-hazard	Oregon Emergency Management (OEM)	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/ OEM Hazard Mitigation Officer: (503) 378-2911 xt. 247 Recovery and Mitigation Specialist: (503) 378-2911 xt. 240	State	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 involved in flood damage analysis 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.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Multi-hazard	Department of Land Conservation and Development (DLCD)	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 xt. 255	State	DLCD administers Oregon'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.
Multi-hazard	Regional Water Providers Consortium	Phone: 503-823-7528 Website: http://www.conserveh2o.org/about/aboutRWPC.html Email: RWPCinfo@water.ci.portland.or.us	Regional	The Consortium was formed in 1996 by Intergovernmental Agreement to coordinate the implementation of the Regional Water Supply Plan for the Portland Metropolitan Area. The Regional Water Supply Plan is the region's water supply strategy. The Consortium provides a forum for collaboration on water supply, resource management and conservation issues affecting the region. Currently, there are 22 water providers and Metro in the Consortium.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Multi-hazard	Portland Metropolitan Area Transportation Cooperative (PMAT)	Contact: PMAT Administrator Phone: (503) 780-8814	Regional	Established in 1996, the Portland Metropolitan Area Transportation Cooperative founding members are ODOT, Multnomah County, and the City of Gresham. The purpose was to share resources, personnel, and knowledge to improve transportation maintenance activities in East Multnomah County. Since its founding, the cooperative has expanded to include Clackamas County, the Cities of Portland and Wood Village, and Washington County. Informal cooperatives exist with several other local metropolitan cities. Working together to stretch the transportation dollar has helped to improve road maintenance activities, keep costs down and improve communications amongst the many member agencies.
Multi-hazard	Federal Emergency Management Agency (FEMA)	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	Federal	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.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Multi-hazard	Metro Regional Government	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	Regional	Metro is a coordinating agency 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 Mitigatior Policy and Planning Guide in 1999 to assist local governments in planning for future natural hazard events.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Multi-hazard	Local Newspapers	Canby Herald – Twice Weekly. Address: PO Box 1108 241 N. Grant St. Canby, OR 97013 Phone: 503-266-6831 FAX: 503-266-6836 Email: dhowell@eaglenewspapers.com Clackamas County News – Weekly. Address: PO Box 549 24 SW Zobrist Estacada, OR 97023 Phone: 503-630-3241 FAX: 503-630-5840 Email: email@clackamascountynews.com Clackamas Review/Oregon City News – Weekly. Address: 16207 SE McLoughlin Blvd. Bldg. A Milwaukie, OR 97267 Phone: 503-786-1996 FAX: 503-786-6977 Email: dstroup@clackamasreview.com Gresham Outlook - Twice weekly. Address: PO Box 747 1190 NE Division Gresham, OR 97030 Phone: 503-665-2181 Email: drhodes@theoutlookonline.com FAX: 503-665-2187 Lake Oswego Review – Weekly. Address: PO Box 548 111 A St. Lake Oswego, OR 97034 Phone: 503-635-8811 FAX: 503-635-8817 Email: reviewandtidings@yahoo.com Molalla Pioneer – Twice weekly. Address: PO Box 168 217 E. Main St. Molalla, OR 97038	Local	

Phone: 503-829-2301
FAX: 503-829-2317
Email: sst.amand@eaglenewspapers.com

The Mountain Times - Monthly on 1st.
Address: P.O. Box 1031
Welches, OR 97067
Phone: 503-622-3289
FAX: 503-622-5984
Email: editor@the-mountain-times.com

Oregonian/South Metro – Daily.
Address: PO Box 5029, 1678
S. Beavercreek Rd.
Oregon City, OR 97045
Phone: 503-656-0083
FAX: 503-656-2417
Email: daparker@news.oregonian.com

Oregonian/East Metro – Daily.
Address: PO Box 1398
295 NE Second
Gresham, OR 97030
Phone: 503-294-5932
FAX: 503-667-9973

Oregonian/West Metro – Daily.
Address: 10245 S.W. Parkway
Portland, OR 97225
Phone: 503-297-8861
FAX: 503-203-1813

Oregonian/SW Metro – Daily.
Address: 15495 SW Sequoia Parkway
Suite 190
Portland, OR 97224
Phone: 503-294-5966
FAX: 503-968-6061
Email: southwest@news.oregonian.com

Sandy Post – Weekly.
Address: PO Box 68, 17279 Bluff Road
Sandy, OR 97055
Phone: 503-668-5548

FAX: 503-668-0748
Email: govtlool@aol.com

Sandy Profile – Weekly.
Address: PO Box 850
38945 Proctor Blvd.
Sandy, OR 97055
Phone: 503-668-7447
FAX: 503-668-3423
Email: sandyprofile@earthlink.net

City Edition – Monthly.
Address: 39320 Evans St.
Sandy, OR 97055-7336
Phone: 503-668-0327
FAX: 503-771-4020
Email: gnn@northwest.com

Wilsonville Spokesman – Weekly.
Address: PO Box 878
Wilsonville, OR 97070
Phone: 503-682-3935
FAX: 503-682-6265
Email: ckipp@eaglenewspapers.com
Publisher: Bill Cassel

West Linn Tidings – Weekly.
Address: PO Box 548
111 "A" St.
Lake Oswego, OR 97034
Phone: 503-635-8811
FAX: 503-635-8817
Email: reviewandtidings@yahoo.com

The Villager – Monthly.
Address: P.O. Box 516
Wilsonville, OR 97070
Phone: 503-694-5516
FAX: 503-694-5783
Email: villagerkc@aol.com

Daily Journal Of Commerce - Daily.
Address: P.O. Box 10127
Portland, OR 97210

Phone: 503-226-1311
FAX: 503-224-7140
Email: newsroom@djc-or.com

The Asian Reporter - Weekly
Address: 922 N. Killingsworth #1-A
Portland, OR 97217
Phone: 503-283-4440
FAX: 503-283-4445
Email: asianreporter@juno.com

El Hispanic News - Weekly
Address: P.O. Box 306
Portland, OR 97207
Phone: 503-228-3139
FAX: 503-228-3384
Email: hispnews@hispnews.com

The Skanner Newspaper
Address: P.O. Box 5455
Portland, OR 97228,
FAX: 503-285-2900
Email: skphotos@earthlink.net

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Multi-hazard	Local Public Works	Estacada Public Works Contact: Estacada Public Works Address: PO Box 958 Estacda, OR 97023 Phone: (503) 630-8270 Fax: (503) 630-8280 Website: http://www.cityofestacada.org/public_works.htm Lake Oswego Public Works Contact: Lake Oswego Public Works Address: P.O. Box 369 Lake Oswego, OR 97034 Phone: (503) 635-0270 Fax: (503) 635-0269 Website: http://www.ci.oswego.or.us Molalla Public Works Contact: Molalla Public Wokrs Address: PO Box 248 Molalla, OR 97038 Phone: (503) 829-5408 Fax: (503) 829-3676 Website: http://www.molalla.net/comm.htm Sandy Public Works Contact: Sandy Public Works Address: 39250 Pioneer Blvd. Sandy, OR 97055 Phone: (503) 668-9190 Fax: (503)668-8714Oregon City Website: http://www.ci.sandy.or.us/ Oregon City Contact: Oregon City Address: 320 Warner Milne Road, PO Box 3040 Oregon City, Oregon 97045 Phone: (503) 657-0891 Fax: (503) 650-9590 Website: http://www.orcity.org/ West Linn Contact: West Linn Address: 4100 Norfolk St.	Local	

West Linn, OR 97068
Phone: 503-656-4211
Fax: 503-657-3237
Website: http://www.ci.west-linn.or.us

Canby Public Works
Contact: Canby Public Works
Address: 1470 NE Territorial Road
Canby, OR 97213
Phone: (503) 266-4021
Fax: (503) 266-7961
Website: http://www.ci.canby.or.us/

Gladstone Public Works
Contact: Gladstone Public Works
Address: 525 Portland Avenue
Gladstone, OR 97027
Phone: (503) 656-7957
Fax:(503) 722-9078

Milwakie Public Works
Contact: Milwakie Public Works
Address: 6101 SE Johnson Creek Blvd.
Milwaukie, OR 97206
Phone: (503) 786-7681
Fax: (503) 774-8326
Website: http://cityofmilwaukie.org/

Wilsonville Public Works
Contact: Wilsonville Public Works
Address: PO Box 220
Wilsonville, OR 97017
Phone: (503) 682-1011
Fax: (503) 682-1015
Website: http://www.ci.wilsonville.or.us/

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Multi-hazard	Waste Water Treatment Facilities	Oak Lodge Sanitary District Contact: Oak Lodge Sanitary District Address: 14496 SE River Road Milwakie, OR 97267 Phone: (503) 654-7765 Fax: (503) 653-1973 City of Canby Contact: City of Canby Address: 1470 NE Territorial Rd. Canby, 97013 Phone: (503) 266 4021 ext. 248 Fax: (503) 266-7623 Estacada Sewer District Contact: Estacada Sewer District Address: PO Box 958 Estacada, OR 97023 Phone: (503) 630-8274 Fax: (503) 630-8276 City of Sandy Contact: City of Sandy Address: 39250 Pioneer Blvd. Sandy, OR 97055 Phone: (503) 668-9190 Fax: (503)668-8714 City of Lake Oswego Contact: City of Lake Oswego Address: 5705 Jean Road, P.O. Box 369 Lake Oswego, OR 97034 Phone: (503) 635-0280 Fax: (503) 697-7411 City of Molalla Contact: City of Molalla Address: PO Box 248 Molalla, OR 97038 Phone: (503) 829-5408 Fax: (503) 829-3676 City of Milwaukie Johnson Creek	Local	

Hazard	Agency	Contact Information	Level	Type of Assistance
		Facility Contact: City of Milwakie Johnson Creek Facility Address: 6101 SE Johnson Creek Blvd. Milwaukie, OR 97206 Phone: 503 786 7622 Fax: (503) 774-8326 City of Wilsonville Contact: City of Wilsonville Address: 30000 SW Town Center Loop E Wilsonville, OR Phone: (503) 682-9772 Fax: (503) 682-8816		
Multi-hazard	Water Environment Services	Contact: Customer Services Coordinator Address: 9101 Sunnybrook Blvd. Clackamas, OR 97015 Phone: (503)-353-4576 Fax: 503-353-4565 Website: http://www.co.clackamas.or.us/wes/index.htm	Local	Water Environment Services (WES) was formed in the early 1970s as the Clackamas County Department of Utilities. WES provides wastewater management services to more than 150,000 people in two districts in Clackamas County: the Tri-City Service District (TCSD) and Clackamas County Service District No. 1 (CCSD No.1). Working very closely together, the Wastewater Maintenance Services and Wastewater Treatment Services division operate and maintain the infrastructure that helps to keep the waters of Clackamas County clean and pure. Water Environment Services (WES) is committed to protecting water resources and public health in Clackamas County. Treating wastewater is of primary importance at WES. WES provides sanitary sewer collection, wastewater treatment, and biosolids production for six cities, and several unincorporated areas in the County.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Multi-hazard	Water Providers serving more than 1,000 Clackamas County Residents	Alder Creek Barlow # 29 Contact: Alder Creek Barlow # 29 Address: PO Box 542 Sandy, OR 97055 Phone: (503) 622-4310 Fax: 503 668-4129 Boring Water District Contact: Boring Water Address: PO Box 66 Boring, OR 97009 Phone: (503) 663-4594 Fax: (503) 663-3343 Canby Utility Contact: Canby Utility Address: PO Box 1070 Canby, OR 97012 Phone: (503) 263-4324 Fax: (503) 266 2174 Clackamas River Water Contact: Clackamas River Water Address: 16770 SE 82nd Drive Clackamas, OR 97015 Phone: 503-722-9241 Fax: 503-6567086 Colton Water District Contact: Colton Water District Address: PO Box 171 Colton, OR 97017 Phone: (503) 824-2500 Fax: (503) 824-2546 Estacada Water District Contact: Estacada Water District Address: PO Box 958 Estacada, OR 97023 Phone: (503) 630-8274 Fax: (503) 630-8276 City of Gladstone Contact: City of Gladstone	Local	

Address: 525 Portland Avenue
Gladstone, OR 97027
Phone: (503) 656-7957
Fax:(503) 722-9078

Lake Grove Water District
Contact: Lake Grove Water Distrcit
Address: PO Box 1173
Lake Grove, OR 97035
Phone: (503) 636-1617
Fax: (503) 635-5066

Lake Oswego Municipal Water
Contact: Lake Oswego Municipal Water
Address: 4260 SW Kenthornpe Way
West Linn, OR 97068
Phone: (503) 635-0394
Fax: (503) 697-7424

City of Milwakie
Contact: City of Milwakie
Address: 6101 SE Johnson Creek Blvd.
Portland, OR 97206
Phone: (503) 786-7616
Fax: (503) 774-8326

City of Molalla
Contact: City of Molalla
Address: PO Box 248
Molalla, OR 97038
Phone: (503) 829-5408
Fax: (503) 829-3676

Oak Lodge Water
Contact: Oak Lodge Water
Address: 14496 SE River Road
Milwakie, OR 97267
Phone: (503) 654-7765
Fax: (503) 653-1973

Oregon City- South Fork Water Board
Contact: South Fork Water Board
Address: 15962 S. Hunter Ave.
Oregon City OR 97045

Phone: (503) 657-5030
Fax: (503) 656 9336

Rivergrove Water District
Contact: Rivergrove Water District
Address: 17661 Pilkington Rd
Lake Oswego, OR 97035
Phone: (503) 635-6041
Fax: (503) 699-9423

Salmon Valley Water Company
Contact: Salmon Valley Water Company
Address: 24525 East Welches Rd.
Welches, OR 97067
Phone: (503) 622-4083
Fax: (503) 622-3458

City of Sandy
Contact: City of Sandy
Address: 39250 Pioneer Blvd.
Sandy, OR 97055
Phone: (503) 668-9190
Fax: (503)668-8714

Sunrise Water Authority
Contact: Sunrise Water Authority
Address: 10602 SE 129th
Portland, OR 97236
Phone: (503) 761-0220
Fax: (503) 761-7406

City of West Linn
Contact: City of West Linn
Address: 4100 Norfolk St.
West Linn, OR 97068
Phone: (503) 656-6081
Fax: (503) 657 3237

City of Wilsonville
Contact: City of WIlsonville
Address: 30000 SW Town Center
Loop E
Wilsonville, OR
Phone: (503) 682-9772

Hazard	Agency	Contact Information	Level	Type of Assistance
		Fax: (503) 682-8816		
Multi-hazard	Clackamas Education Service District	Contact: Clackamas Education Service District Address: Marylhurst Campus Hwy 43 P.O. Box 216 Marylhurst, OR 97036-0216 Phone: (503) 675-4013 Fax: (503) 675-4200 Website: http://www.clackesd.k12.or.us/index.htm	Local	Clackamas Education Service District (ESD) is empowered by state law to provide services to local school districts and to promote equal educational opportunities. Clackamas ESD provides services that are best managed on a regional basis including those required by state statute, those approved by local school districtboard resolution, and those provided by contract, state and federal grants.
Multi-hazard	Clackamas County Soil and Water Conservation District (SWCD)	Contact: District Manager Address: 256 Warner-Milne Rd. Oregon City, OR 97045 Phone: (503) 656-3499 Fax: (503) 650-2367 Website: http://www.cc-swcd.org/	Local	The Clackamas County Soil and Water Conservation District is one of Oregon's 45 Districts assisting landowners in resource conservation. Clackamas County SWCD has worked to integrate economics and environmental health for the benefit of the people of Clackamas County. The District assists landowners with matters such as developing and implementing farm and woodland management systems that contribute to resource conservation and production efficiency.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Multi-hazard	Clackamas County Department of Transportation and Development	Zoning and Planning Contact: Zoning Information Public Service Representative Address:9101 SE Sunnybrook Blvd. Clackamas, OR 97015 Phone: (503) 353-4500 Fax: 503-353-4550 Website: http://www.co.clackamas.or.us/dtd/zoning/zone.html Email: Zoninginfo@co.clackamas.or.us Building Codes Contact: Building Codes Public Service Representativ Address:9101 SE Sunnybrook Blvd.Clackamas, OR 97015 Phone: 503-353-4739 Fax: 503-353-4741 Website: http://www.co.clackamas.or.us/dtd/bldg/build.html Email: BldService@co.clackamas.or.us Roads & Bridges Contact: Road Maintenance Supervisor Address: 902 Abernethy Road, Oregon City, Oregon 97045 Phone: (503) 650-3446 Fax: (503) 650-3992 Website: http://www.co.clackamas.or.us/dtd/trans/htmls/rd_cons html	Local	The Clackamas County Department of Transportation and Development (DTD) houses many county agencies that are responsible for overseeing development throughout the County. The various agencies within this department are also responsible for planning for future development, and maintaining the quality of infrastructure in the County.
Multi-hazard	Farm Services Agency, US Department of Agriculture Clackamas-Multnomah County FSA	Contact: County Executive Director Address: 256 Warner Milne Road Oregon City, Oregon 97045-4096 Phone: (503) 655-3144 Fax: (503) 656-3143 Website: http://www.fsa.usda.gov/pas/default.asp	Regional	Stabilizing farm income, helping farmers conserve land and water resources, providing credit to new or disadvantaged farmers and ranchers, and helping farm operations recover from the effects of disaster are the missions of the U.S. Department of Agriculture's Farm Service Agency (FSA).

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Multi-hazard	Oregon Department of Geology and Mineral Industries (DOGAMI)	Contacts: Deputy State Geologist, Seismic, Tsunami, and Coastal Hazards Team Leaders Address: 800 NE Oregon St. Suite 965 Portland, OR 97232 Phone: (503) 731-4100 Fax: (503) 731-4066 Website: http://sarvis.dogami.state.or.us/homepage	State	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.
Multi-hazard	National Resources Conservation Service (NRCS), US Department of Agriculture	Contact: Resource Conservationist Address: 256 Warner Milne Rd Oregon City, OR 97045-4014 Phone: (503) 655- 3144 xt. 108 Fax: (503) 656- 3143 Website: http://www.nrcs.usda.gov/	Federal	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 clear debris from clogged waterways, restore vegetation, and stabilizing riverbanks. The measures taken under EWP must be environmentally and economically sound and generally benefit more that one property.

Hazard	Agency	Contact Information	Level	Type of Assistance
Multi-hazard	Army Corps of Engineers	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/	Federal	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.
Multi-hazard	National Oceanic and Atmospheric Administration (NOAA)	Contact: National Oceanic and Atmospheric Administration Address: 14th Street & Constitution Ave NW Room 6013 Washington, DC 20230 Phone:(202) 482-6090 Fax: (202) 482-3154 Website:http://www.noaa.gov Email: answers@noaa.gov	Federal	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	Oregon Climate Service	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	State	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.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Multi-hazard	Clackamas County Office of Emergency Management	Contact: Emergency Management Coordinator Address:2200 Kaen Rd. Clackamas, OR 97045 Phone:(503)-655-8378 Fax: (503) 655-8531 Website: http://www.co.clackamas.or.us/emergency/index.html ckamas.or.us/emergency/index.html	State	Under the Oregon Revised Statutes Chapter 401, each county in the State is required to establish an emergency management agency and appoint an emergency program manager. It is the responsibility of the program manager to develop plans for response to major emergencies. Management plans must consider all the hazards the county faces, all jurisdictions within and neighboring the county, all disciplines (police, fire, medical, transportation, etc.) and all phases of an emergency. The County's Emergency Management system requires coordination of activities to mitigate, prepare for, respond to and recover from major emergencies or disasters. Clackamas County's Emergency Management program is administered by the Sheriff's Office with the Sheriff designated as the Director. The program is managed by a civilian Emergency Management Coordinator.
Multi-hazard	Oregon Department of Transportation (ODOT)	Contact:ODOT Transportation Building Address:355 Capitol St. NE Salem, OR 97310 Phone:(888) 275-6368 Website:http://www.odot.state.or.us	State	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.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Multi-hazard	National Weather Service, Portland Bureau	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_hydr/	Federal	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.
Multi-hazard	Oregon Department of Forestry (ODF)	Contact:Oregon Department of Forestry Address: 2600 State Street Salem, Oregon 97310 Phone: (503) 945-7200 Fax: (503) 945-7212 Website: http://www.odf.state.or.us/	State	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.
Multi-hazard	United States Geological Survey (USGS)	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	Federal	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.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Multi-hazard	Oregon Department of Consumer & Business Services - Building Codes Division	Contact: Building Codes Division Address: 1535 Edgewater St. NW P.O. Box 14470 Salem, OR 97309 Phone: (503) 378-4133 Fax: (503) 378-2322 Website: http://www.cbs.state.or.us/external	State	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.
Volcano	Institute of Geological & Nuclear Sciences Limited (GNS)	Institute of Geological & Nuclear Sciences Limited (GNS) Contact: Institute of Geological & Nuclear Sciences Address: 69 Gracefield Rd PO Box 30-368 Lower Hutt, New Zealand Phone:(+04) 570-1444 Volcano Specialists Contact:Wairakei Research Centre Address:State Highway 1 Private Bag 2000 Taupo New Zealand Phone:64-7-374-8211 Fax: 64-7-374-8199 E-mail:info@ibhs.org Website: http://www.gns.cri.nz/earthact/volcanoes/hazards/index.htm	Federal	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.
Volcano	USGS-David A. Johnston Cascades Volcano Observatory (CVO)	Contact: CVO Address: 1300 SE Cardinal Court Vancouver, WA 98683 Phone:(360) 993-8900 Fax: (360) 993-8980 Website: http://vulcan.wr.usgs.gov/CVO_Info/framework.html or http://volcanoes.usgs.gov	Federal	CVO provides accurate and timely information pertinent to assessment, warning, and mitigation of volcano 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.

Hazard	Agency	Contact Information	Level	Type of Assistance
Wildfire	Local Fire Departments	Boring Fire District Contact: Fire Chief Address: PO Box 85, 28655 SE Hwy 212 Boring, Oregon 97009-0085 Phone: (503) 663-4638 Fax: (503) 663-5792 Website: http://www.boringfire.com/ Canby Fire District Contact: Fire Chief Address: 221 South Pine Street Canby, Oregon 97013 Phone: (503) 266-5851 Fax: (503) 266-1320 Website: http://www.canbyfire.org/ Email: tkunze@canbyfire.org Clackamas Co. Fire District #1 Contact: Fire Chief Address: 11300 S.E. Fuller Road Milwaukie, Oregon 97222 Phone: (503) 655-8534 Fax: (503) 655-8538 Website: http://www.clackamasfire.com/ Email: randybru@ccfd1.com Colton Fire District Contact: Fire Chief Address: PO Box 71 Colton, OR 97017 Phone: (503) 824-2545 Fax: (503) 824-2546 Email: Crfpd70@colton.com Estacada Fire District Contact: Fire Chief Address: PO BOX 608 Estacada, OR 97023-0608 Phone: (503) 630-7712 Fax: (503) 630-7757 Email: llong@estacadafire.com Gladstone Fire Department	Local	

Contact: Fire Chief
Address: 555 PORTLAND AVE
GLADSTONE, OR 97027
Phone: (503) 656-4253
Fax: (503) 650-8938
Email: Glad@spiritone.com

Hoodland Fire District
Contact: Fire Chief
Address: 69634 E Hwy 26
Welches, Oregon USA 97067
Phone: (503) 622-3256
Fax: (503) 622-3125
Website: http://www.hoodlandfire.org/
Email: davidolson@hoodlandfire.org

Lake Oswego Fire Department
Contact: Fire Chief
Address: 300 B Avenue
P.O. Box 369
Lake Oswego, OR 97034
Phone: (503) 635-0275
Fax: (503) 635-0376
Website: http://www.ci.oswego.or.us/fire/fire.htm
Email: semrad@ci.oswego.or.us

Molalla Fire District
Contact: Fire Chief
Address: 320 N. MOLALLA AVE.
MOLALLA, OR
Phone: (503) 829-2200
Fax: (503) 829-5794
Website: http://www.molallafire.org/
Email: misso@molallafire.org

Monitor Rural Fire District
Contact: Fire Chief
Phone: (503) 634-2570
Fax: (503) 634-2600
Email: chief81@molalla.net

Sandy Fire District
Contact: Fire Chief
Address: 17460 SE Bruns

Hazard	Agency	Contact Information	Level	Type of Assistance
		Sandy, Oregon 97055 Phone: (503) 668-8093 Fax: (503) 668-7941 Website: http://www.sandyfire.com/ Email: gmcqueen@sandyfire.com Tualatin Valley Fire & Rescue Contact: Fire Chief Address: 20665 SW Blanton Street Aloha, Oregon 97007 Phone: (503) 649-8577 Fax: (503) 642-4814 Website: http://www.tvfr.com Email: johnsojd@tvfr.com Clackamas Fire Defense Board Contact: Fire Chief Phone: 503-655-8534 Fax: 503-266-1320 Email: tkunze@canbyfire.org		
Wildfire	Office of the State Fire Marshal (OSFM)	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	State	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.
Wildfire	Federal Wildland Fire Policy, Wildland/Urban Interface Protection	Website: http://www.fs.fed.us/land/wdfire7c.htm	Federal	This is a report describing federal policy and interface fire. Areas of needed improvement are identified and addressed through recommended goals and actions.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Wildfire	National Fire Protection Association (NFPA)	Contact: Public Fire Protection Division Address: 1 Battery March Park P.O. Box 9101 Quincy, MA 02269-9101 Phone : (617) 770-3000	Federal	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.
Wildfire	United States Fire Administration (USFA) of the Federal Emergency Management Agency (FEMA)	Contact: USFA, Planning Branch, Mitigation Directorat 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	Federal	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.
Wildfire	FireFree Program to Promote Home Safety	Contact: FireFree Address: 63377 Jamison St. Bend, OR 97701 Phone:(541) 318-0459 E-mail:dcrfpd2@dcrfpd2.com Website: http://www.firefree.org	State	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.

Hazard	*Agency*	*Contact Information*	*Level*	*Type of Assistance*
Wildfire	Firewise – The National Wildland/Urban Interface Fire Program	Contact: Firewise E-mail:firewise@firewise.org Website: http://www.firewise.org/	Federal	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.
Wildfire	National Interagency Fire Center (NIFC)	Website: http://www.nifc.gov/	Federal	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.

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 Clackamas County Natural Hazards Mitigation Plan integrates a cross-section of citizen input throughout the planning process. To accomplish this goal, the Resource Assistance for Rural Environments (RARE) participant, the Oregon Natural Hazards Workgroup, and the Clackamas County Hazard Mitigation Advisory Committee developed a public participation process through three components: (1) developing a project steering committee comprised of knowledgeable individuals representative of the community; (2) conducting stakeholder interviews to target the specialized knowledge of individuals working with populations or areas at risk from natural hazards; and (3) 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 during the development of the Clackamas County Natural Hazards Mitigation Plan has ultimately resulted in increased public awareness. Through citizen involvement, the mitigation plan reflects community issues, concerns, and new ideas and perspectives on mitigation opportunities and plan action items.

Steering Committee

In recent years, hazard mitigation in Clackamas County has been overseen by the Hazard Mitigation Advisory Committee, which consists of representatives from various county Departments. For the development of this plan, the Committee was broadened to represent private organizations and business in the county. 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 Clackamas County Natural Hazards Mitigation Plan Steering Committee.

Table B.1. Mitigation Plan Steering Committee

Name	Organization
Rebecca Ceniga	Clackamas County Building Services
Greg Jenks	Clackamas County Economic Development
Casey Marley	Clackamas County Emergency Management

Jeff Rubin	Clackamas Fire Defense Board
Marc Gonzales	Clackamas County Finance
Eric Bohard	Clackamas County GIS
Jon Skidmore	Clackamas County Planning
Steve Hanschka	Clackamas County Planning
Terri Poet	Clackamas County Project Impact
Ron Oberg	Clackamas County Public Information Officer
Richard Koskela	Clackamas County Roads Division
Molly Cunningham	Clackamas County Social Services
Ela Whelan	Clackamas County Water Environment Services
Jackie Tommas	Clackamas River Basin Council
Jon Hofmeister	Department of Geology and Mineral Industries
Andrew Hendrickson	Federal Emergency Management Agency
Judy Kolias	Eagle Creek/ Barton Community Planning Organization
Mark Darienzo	Oregon Emergency Management

Meeting #1: October 15, 2001

The Community Service Center (CSC) staff provided an overview to the steering committee about the resources and programs available to the county through the partnership with the University of Oregon. CSC described the programs, including RARE, the Oregon Natural Hazards Workgroup, and Community Planning Workshop, within the CSC that would provide assistance to the county during development of the Clackamas County Natural hazard Mitigation Plan.

The Clackamas County Emergency Manager introduced the RARE participant, Cindy Kolomechuk, to the steering committee. Each committee member described the department or organization that they represented and their role in addressing hazard mitigation. A discussion of current mitigation activities occurring in the county provided Cindy with a knowledge base of community issues.

Meeting #2 November 11, 2001

Cindy presented the project methodology and the draft framework for the Mitigation Plan. Steering Committee members were asked to provide input on key stakeholders to be included in the planning process. A brainstorming process was then conducted to develop the goals for the Plan. The Steering Committee was asked to identify goals for risk reduction, and potential outcomes for how the plan could be used in the future. Table B-2 lists the resulting goals and ideas.

Table B.2. Goal Areas and Ideas

Goal Area	Idea

Property Protection	• Reduce insurance losses and repetitive claims for chronic hazard events while promoting insurance coverage for catastrophic hazards. • Focus resources on activities involving property owners and that assist in protecting homes, structures, or property from natural hazards.
Natural Systems	• Evaluate and make recommendations for county guidelines, codes, and permitting processes in addressing natural hazard mitigation and development in vulnerable areas. • 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	• Develop and implement education programs that will increase property owners and developers awareness of natural hazards. • Develop and conduct outreach programs to increase the number of local, county, and regional activities implemented by public and private sector organizations.
Partnerships	• Strengthen communication and coordinate participation in and between public agencies, citizens, non-profit organizations, business, and industry. • Document the process and resources that will reduce the administrative burden on the requestors/recipients of grant funds. • Provoke congressional attention by identifying mitigation priorities.
Emergency Services	• Establish policy to encourage mitigation for critical facilities, services, and infrastructure. • Strengthen emergency operations by increasing collaboration and coordination among public agencies, non-profit organizations, business, and industry.
Implementation	• Promote leadership within public agencies to implement natural hazard mitigation activities. • Attain participation and funding to implement mitigation activities by creating a dynamic document, which is continually updated and revised.
Guide Development and Use of Vulnerable Areas	• Identify a clear process by which planners can identify and illustrate to potential developers the natural hazards that are present, the threat they pose, and how their development will be mitigated, regulated, and possibly limited. • Improve hazard identification, assessment and Summarize hazards data and possible mitigation strategies to address those hazards in a palatable format.

Source: Clackamas County Natural Hazards Steering Committee, 2002

Meeting #3: January 8, 2002

The steering committee used this meeting as a work session to revise the goals identified in the previous Steering Committee Meeting. The Committee worked through the structure of the plan, and agreed on the final organizational framework.

The committee also discussed strategies for advertising the upcoming public workshop to be held on February 26, 2002. Cindy presented a preliminary agenda and explained the role of the steering committee during the workshop.

Meeting #4: February 19, 2002

The steering committee began the meeting by finalizing the plan goals. The committee members then volunteered to review appropriate sections of the Plan.

Technical reviewers for each section were identified to ensure accuracy and readability.

Cindy explained the structure of the upcoming workshop, and the role of the steering committee, which included helping to facilitate the brainstorming sessions and providing information to the citizens.

Meeting #5: April 4, 2002

During this stage of plan development, the focus of the plan moved from goal development to development of action items. Using information from the public process, action items for the Multi-Hazard and Flood sections were created. The committee brainstormed potential action items for these two hazard sections and suggested potential partners and coordinating organizations for the implementation of the proposed action items.

Meeting #6: May 30, 2002

The steering committee began this meeting by discussing strategies to sustain the plan. The committee decided to include a plan maintenance section, which would document the adoption process by the Board of County Commissioners, identify a convener to facilitate future committee meetings, and describe the review and updating process.

The committee then identified mitigation action items for Landslides, Earthquakes, and Volcanoes. A discussion of the organization and presentation of potential partners followed. The committee agreed that the plan resource directory could serve as the list of potential partners for action item implementation.

Meeting #7: July 7, 2002

The committee discussed action items for the Wildfire, Severe Winter Storm, and Wind Sections. After using a snow card process to brainstorm about these action items, the Committee reviewed potential conveners, the organization or body responsible for convening the Hazard Mitigation Advisory Committee during plan implementation.. The committee suggested that the Convener position be held close to the Board of County Commissioners. Cindy agreed to meet with the County Executive Officer to discuss this issue.

The Steering Committee reviewed the agenda for the public workshop scheduled for July 23, 2002. They agreed to focus on facilitating groups to identify strategies for loss reduction during this workshop.

Meeting #8: August 28, 2002

This was the final steering committee meeting for the development of the Clackamas County Natural hazards Mitigation Plan. Committee members submitted final revisions for the plan during this meeting, and the number of copies to be available for public viewing was discussed. The committee discussed a preliminary agenda for the first Hazard Mitigation Advisory Committee Meeting to assist in the new convener in facilitating the meeting.

Stakeholders Interviews

Stakeholders interviewed for the mitigation plan represented agencies and organizations throughout the county. Cindy integrated information provided by stakeholders into the sections of the plan relating to current mitigation activities, new action items and in the resource directory. Table B.3 lists the stakeholders that Cindy interviewed during development of the mitigation plan.

Table B.3. Mitigation Plan Stakeholders

Name	Organization
Linda Belle	Clackamas County Tourism Development Council
Dave Benfield	Water Environment Services
Darrel Burnum	Clackamas County Roads Division
Dub Burnum	Water Environment Services
Rebecca Ceniga	Clackamas County Building Services
Dave Conrad	Clackamas County Roads Division
Gary DiCenzo	Clackamas County Community Development
Paul DeMarco	Clackamas Town Center
Carl Hanson	Canby Utility
Kris Homma	Natural Resources Conservation Service
Greg Jenks	Clackamas County Economic Development
Dave Johnson	Portland General Electric
Lyn Jones	Oak Grove Fire
Karla Keller	Oregon Department of Transportation
Clair Klock	Soil and Water Conservation District
Ken Kushman	Oregon Department of Fire
Nancy Kraushaar	Oregon City Engineer/Public Works director
Dave Olson	Hoodland Fire Chief
Amy Pfeiffer	Oregon Department of Transportation District
Gary Richter	North Clackamas School District Emergency Manager
Neil Robins	Water Environment Services
Kris Sayre	Water Environment Services
Bill Segwig	Clackamas County Roads Division
Larry Stevens	Clackamas River Water District
Dave Stokey	Kaiser Hospital

Public Meetings

Clackamas County coordinated two public workshops in the County to gather public ideas and opinions about the mitigation plan goals and activities.

First Public Workshop

The first public workshop provided information on the mitigation plan to workshop participants and garnered input on issues related to natural hazards in the community. The meeting was successful: approximately 16 citizens, 20 steering committee members, and 5 representatives from the University of Oregon attended t the workshop.

Invitation Process

The County Public Information Officer worked with Cindy to identify all possible public notice sources. A press release was submitted to most of the Chambers of Commerce organizations throughout the county, the Oregon City newsletter, the Citizen Newsletter, the Beavercreek Bulletin, the Oregonian, and the local newspapers. Additionally, Cindy sent letters of invitation to all Community Planning Organization Chair persons.

Results

Cindy began the presentation by providing an overview of workshop objectives to the participants. The citizens and steering committee members broke into two small groups. Each group began with introductions, and then discussed their thoughts on the plan goals. The groups then discussed some of the hazards or disasters they had personally experienced in the past and activities that might prevent damages from natural hazards in the future. The group process took approximately 45 minutes.

After another short break, the workshop attendees reconvened to wrap up the workshop. Clackamas County held a drawing to award one of the participants with a 72-hour kit, used to sustain a person for 72 hours after a natural disaster occurs. Clackamas County purchased the kit using Project Impact funds. The steering committee members closed the meeting by introducing themselves and fielding questions from participants. The meeting lasted from 7-9 pm, and was aired on Clackamas County cable access for approximately one month.

Second Public Workshop

Clackamas County held the second public workshop to gather public input on issues related to natural hazards in the county, as well as ideas for strategies to reduce risk. The workshop was successful in attaining public input, with 8 citizens, 9 steering committee members, and 3 representatives from the University of Oregon in attendance.

Invitation Process

The county Public Information Officer worked with Cindy to identify all possible public notice sources. A press release was submitted to most of the Chambers of Commerce throughout the county, the Oregon City newsletter, the Citizen Newsletter, the Beavercreek Bulletin, the Oregonian, and the local newspapers. Additionally, Cindy sent letters describing the workshop to all Community Planning Organization Chair persons.

Results

After Cindy presented the workshop objectives,, participants and steering committee members broke into two small groups. Each group began with introductions, followed by a discussion of the Multi Hazard action items to identify areas that participants felt could be improved or added to.. The groups then participated in a snow card process, in which they wrote their ideas for potential mitigation activities. The group process took approximately 60 minutes.

After another short break, the workshop attendees reconvened to wrap up the workshop. Clackamas County held a drawing to award one of the participants with a “day tripper”, used to sustain a person for 24 hours after a natural disaster occurs. The kit was donated by Safe-T-Tek. The steering committee members closed the meeting by introducing themselves and field questions from participants of the workshop.

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:

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.

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.

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

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Appendix D:
List of Acronyms

County and Regional

CREW	Cascadia Region Earthquake Workgroup
WES	Water Environment Services
CCSD #1	Clackamas County Service District One
SWMACC	Surface Water Management Agency of Clackamas County
IISOI	Insurance and Information Services of Oregon & Idaho
Metro	Metropolitan Regional Government
PGE	Portland General Electric
NN	Northwest Natural
TVFR	Tualatin Valley Fire and Rescue
CCEM	Clackamas County Office of Emergency Management
DTD	Clackamas County Department of Transportation & Development
CCFDB	Clackamas County Fire Defense Board

Oregon

AGC	Associated General Contractors
AOC	Association of Oregon Counties
BCD	Building Codes Division (Department of Consumer and Business Services)
BPA	Bonneville Power Administration
CPW	Community Planning Workshop (University of Oregon)
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 Office (State of Oregon)
LCDC	Land Conservation and Development Commission (State of Oregon)
LOC	League of Oregon Cities
OCS	Oregon Climate Service
ODA	Oregon Department of Agriculture
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
OEM	Office of Emergency Management (Oregon State Police)

OEMA	Oregon Emergency Management Association
OERS	Oregon Emergency Response System
OHIRA	Oregon Hazard Identification and Risk Assessment
ONHW	Oregon Natural Hazards Workshop (University of Oregon)
ORS	Oregon Revised Statutes
OSFM	Office of State Fire Marshal (Oregon State Police)
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 Association of State Highway and Transportation Officials
ATC	Applied Technology Council
b/ca	benefit/cost analysis
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	Cascade Volcano Observatory (USGS)
EDA	Economic Development Administration
EPA	Environmental Protection Agency
ER	Emergency Relief
EWP	Emergency Watershed Protection (NRCS Program)
FAS	Federal Aid System
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FMA	Flood Mitigation Assistance (FEMA Program)
FTE	Full Time Equivalent
GIS	Geographic Information System
GNS	Institute of Geological and Nuclear Sciences (International)
GSA	General Services Administration
HAZUS	Hazards U.S.
HMGP	Hazard Mitigation Grant Program
HMST	Hazard Mitigation Survey Team
HUD	Housing and Urban Development (United States, Department of)

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	Natural Hazard Mitigation Plan (also known as “409 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
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