Linn County
Natural Hazard Mitigation Plan

Produced By:

Linn County Planning and Building Department

With the Assistance of:

The Oregon Natural Hazards Workgroup

Through a Regional Partnership Funded by:

The Federal Emergency Management Agency

Pre-Disaster Mitigation Competitive Grant Program

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Linn County
Natural Hazard Mitigation Plan

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Regional Partners

Federal Emergency Management Agency Region 10
Oregon Emergency Management
Oregon Department of Geology and Mineral Industries
Oregon Natural Hazards Workgroup, University of Oregon Community Service Center
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Lane County
Linn County
Marion County
Polk County
Yamhill County
City of Albany
Mid-Willamette Valley Council of Governments

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Linn County
Natural Hazards Mitigation Plan
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Executive Summary

Why Develop this Mitigation Plan?

Linn County developed this Natural Hazard Mitigation Plan to protect life and property and reduce damages resulting from natural disasters by reducing vulnerability to natural hazard risks. Reducing potential damages improves public safety and economic stability. The mitigation plan identifies resources, information, and strategies to reduce risks from natural hazards, and guides the County's mitigation activities. Mitigation plan activities may be considered for funding through state and federal grant programs, including the Federal Emergency Management Agency's Hazard Mitigation Grant Program and Pre-Disaster Mitigation Competitive Grant Program, as funds are made available.

How is the Plan Funded?

Primary funding for this plan is from a grant through the federal Pre-Disaster Mitigation (PDM) Competitive Grant Program for pre-disaster mitigation planning and projects addressing natural hazards. The grant program is administered by the Federal Emergency Management Agency (FEMA). The County contributed additional matching funds of at least 25 percent.

How is the Plan Organized?

The Mitigation Plan is organized into three volumes. Volume I contains the executive summary plus five plan sections: Introduction; Community Profile; Risk Assessment; Goals and Action Items; and Plan Maintenance. These sections detail how the plan was developed and what action items are proposed. The five-year action plan matrix is included in the Executive Summary. Volume II contains the five natural hazard sections – Flood; Landslide; Wildfire; Severe Weather; and Earthquake – and a Multi-hazard section. The hazard-specific sections provide background information on each hazard, specific action items, and local, county, and state resources. The appendices in Volume III provide information on the plan development process and other technical resources.

What is the Plan's Mission?

The mission statement expresses the purpose and defines the primary function of the Mitigation Plan. The plan mission answers the following three questions: 1) Who does the plan serve? 2) What does the Plan do? 3) What can the plan accomplish? The Hazard Mitigation Steering Committee developed and adopted the following Plan Mission:

> *The mission of the Linn County Natural Hazard Mitigation Plan is to reduce the impact of natural hazards on the community through planning, communication, coordination and partnership development.*

Who Participated in Developing the Plan?

The Linn County Natural Hazards Mitigation Plan was developed under a collaborative process through the participation of Linn County citizens, private business representatives, public agencies, special districts and private organizations. The planning process was coordinated through the Linn County Planning and Building Department (Department). The Linn County Planning Commission served as the Mitigation Plan Steering Committee. The Steering Committee is comprised of a diverse group of Linn County citizens with extensive understanding of the geography, history and issues critical to guiding the development of the natural hazard mitigation plan. Additional public and agency participation through a stakeholder survey and open committee meetings played a key role in the development of goals and action items.

What are Plan Goals and Objectives?

The Mitigation Plan goals and objectives describe the steps that Linn County, public and private agencies, organizations, and citizens can take toward reducing risk from natural hazards. The Steering Committee, in conjunction with public and agency input, developed the following three plan goals and corresponding objectives.

Goal #1: Enhance coordination and communication among Linn County stakeholders to implement the Plan

- Objective 1.1: Establish and maintain methods to ensure plan implementation
- Objective 1.2: Provide leadership to promote, communicate, and support disaster safety messages and activities

Goal #2: Protect life, the built environment and natural systems through County policies, procedures and services

- Objective 2.1: Incorporate mitigation into planning and policy development
- Objective 2.2: Support the enhancement of County vulnerability assessment activities
- Objective 2.3: Ensure continuity of County emergency service functions
- Objective 2.4: Implement structural and non-structural mitigation of publicly owned facilities and infrastructure

Goal #3: Protect life, the built environment, the economy and natural resources through community-wide partnerships

- Objective 3.1: Increase citizen awareness and promote risk reduction activities through education and outreach
- Objective 3.2: Develop collaborative programs that encourage local businesses to plan for disasters
- Objective 3.3: Develop partnerships with external partners for hazard specific mitigation projects

How are the Action Items Organized?

The Linn County Natural Hazard Mitigation Plan Action Item Matrix displays the multi-hazard and hazard-specific action items adopted in the mitigation plan. The action items were developed through data collection, research and the public participation process. The matrix includes the following information for each action item.

Goals: The Action Plan lists three goals. All plan objectives are tied to one of the three goals.

Objectives: There are nine objectives listed within the plan. All action items fit within one of the nine objectives as well as being a part of the multi-hazard or hazard-specific sections.

Action Items: The mitigation plan identifies short-term and long-term action items. Action items address both multi-hazard (MH) and hazard specific issues for the hazards addressed in this plan. To facilitate implementation, each action item in the matrix includes the action item priority score, an estimated timeline, the lead organization, and a list of possible partner organizations. The action item proposal forms in ***Appendix B*** include the rationale for the proposed action item, critical issues addressed, ideas for implementation and other action item information.

Lead Organization: The lead organization is the public agency with regulatory responsibility to address the action item, or other public or private entity that is willing and able to champion the action item or otherwise organize resources and coordinate action item implementation.

Internal/External Partners: Internal and external partner organizations are public, private or nonprofit agencies that may be able to assist in the implementation of action items by providing relevant resources to the coordinating organization. External partner organizations can assist the county in implementing the action items in various functions and may include local, regional, state, or federal agencies, as well as local and regional public and private sector organizations. The internal and external partner organizations listed in the mitigation plan are potential partners recommended by the steering committee, but who were not necessarily contacted during the development of the plan.

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 may be implemented 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.

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

The plan implementation and maintenance section of this plan (Volume I, Section 5) details the formal process that will ensure that Linn County's 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 an updated plan every five years.

The plan maintenance section describes how the County will integrate public participation throughout the plan maintenance and implementation process. This section also includes an explanation of how the County intends to incorporate the mitigation strategies outlined in this Plan into existing planning mechanisms and programs such as the Linn County comprehensive land use planning process, capital improvement planning process, and building codes enforcement and implementation.

Plan Adoption

The Linn County Board of Commissioners will be responsible for adopting the Natural Hazards Mitigation Plan by resolution. The Board has the authority to promote sound public policy regarding natural hazards.

Coordinating Body

The Hazard Mitigation Steering Committee will be the coordinating body for the hazard mitigation plan. The Steering Committee is responsible for plan maintenance, coordinating the implementation of plan action items, and undertaking the formal review process. The Linn County Planning Commission will continue to serve as the Steering Committee with other stakeholders serving on working committees as needed.

Convener

The Linn County Emergency Management Coordinator and the Planning and Building Department Director, as co-conveners, will each have authority to convene the Steering Committee to address action items; to facilitate Steering Committee meetings; and to assign tasks such as updating the plan and making presentations to the committee.

Implementation through Existing Programs

Linn County addresses statewide planning goals and legislative requirements through its comprehensive land use plan, capital improvement plans, and building codes. To the extent possible, Linn County will work to incorporate the recommended mitigation action items into existing programs and procedures.

Economic Analysis of Mitigation Projects

The two FEMA-approved methods of identifying the costs and benefits associated with natural hazard mitigation measures or projects are: (1) benefit/cost analysis; and (2) cost-effectiveness analysis. Benefit/cost analysis is used to determine 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. The County will use FEMA-approved cost/benefit methodology to identify and prioritize action items when applying for federal mitigation funding. For other projects and funding sources, the County will use other approaches. Economic analysis methods are described in detail in ***Appendix C***.

Formal Review Process

Plan maintenance and review is a critical component of the natural hazard mitigation plan. Proper maintenance of the plan will ensure that this plan will benefit Linn County's efforts to reduce the risks posed by natural hazards. Linn County and its partners have developed a method to ensure that a regular review and update of the plan occurs.

The Steering Committee will maintain and update the plan through a series of meetings. The committee will meet annually to review updates on risk assessment data and local planning efforts and to evaluate program effectiveness. The committee will also evaluate and update the plan every five years in accordance with the Disaster Mitigation Act of 2000.

Continued Public Involvement

Linn County is dedicated to involving the public directly in the ongoing reshaping and updating of the Hazard Mitigation Plan. The Steering Committee will continue to solicit feedback and input from the general public and affected agencies during annual reviews and plan updates.

Copies of the plan will be catalogued and made available at the office of Linn County Emergency Management, the Planning and Building Department, the Linn County Commissioners, the County Recorder, and other appropriate county agencies. Copies of the plan and any proposed changes will also be posted on the Linn County and the Oregon Natural Hazard Workgroup (ONHW) web sites. These sites will contain the email address and phone number to which people can direct their comments and concerns.

The hazard mitigation action items may be made a part of many county documents that will be available for public review and comment. These include the budgeting process, capital improvement project reviews, Comprehensive Plan review and in goals and objectives developed by individuals departments.

All meetings where portions of the Mitigation Plan are discussed will provide the public a forum for which they can express concerns, opinions, or ideas about the plan and parts of it. Public meetings relating to plan maintenance and implementation will be publicized on the county web page and in local newspapers to ensure an opportunity for public input.

Linn County *Natural Hazard Mitigation Plan Action Item Matrix*

Goals & Objectives	Action Item:				
GOAL 1: Enhance coordination and communication among Linn County stakeholders to implement the Plan					
Objective 1.1. Establish and maintain methods to ensure plan implementation		Action Item Priority Score	Time Line	Lead Organization	Internal/External Partners
MH-ST	**Action 1.1.1.** Develop formal agreements with internal and external partners to work together on risk reduction efforts in the County	9	Ongoing	Board of County Commissioners	Emergency Management; COG; Cities; State Agencies; Non-profit Organizations; OSU Extension Service
MH-ST	**Action 1.1.2.** Explore funding opportunities with internal and external partners to implement the actions identified in the plan	9	Ongoing	Emergency Management	Oregon Emergency Management; DOGAMI; FEMA; ONHW
MH-LT	**Action 1.1.3.** Establish mitigation benchmarks to assist in evaluating and updating the plan	9	3-5 years	Steering Committee	Planning and Building Dept.; Linn County Emergency Management; State Agencies
Objective 1.2. Provide leadership to promote, communicate, and support disaster safety messages and activities		Action Item Priority Score	Time Line	Lead Organization	Internal/External Partners
MH-ST	**Action 1.2.1.** Encourage and support the development of local community plan supplements to the County Natural Hazard Mitigation Plan	9	Ongoing	Board of County Commissioners	Cities; Emergency Mngt; Planning and Building Dept; OEM; ONHW
MH-ST	**Action 1.2.2.** Develop County protocols and strategies for the dissemination of media messages that focus on individual responsibility for disaster safety and risk reduction.	9	1-3 years	Emergency Management	Planning and Building; Emergency Management; State Agencies; FEMA

MH-ST	**Action 1.2.3.** Develop public officials information kit that can be distributed to elected officials and community decision makers. The kit should include information regarding the Natural Hazard Mitigation Plan and Steering Committee and it's activities as well as facts and figures on the Natural Hazards the County is facing.	9	1-3 years	Emergency Management	Planning and Building; County Departments; State Agencies
MH-LT	**Action 1.2.4.** Develop and maintain a database of current action items	9	3-5 years	Emergency Management	Planning and Building

GOAL 2: Protect life, the built environment and natural systems through County policies, procedures and services

Objective 2.1. Incorporate mitigation into planning and policy development		Action Item Priority Score	Time Line	Lead Organization	Internal/External Partners
MH-ST	**Action 2.1.1.** Provide mitigation awareness training for county planning and public works staff, including GIS technicians	11	1-3 years	Emergency Management	Oregon Emergency Management; DOGAMI; FEMA; ONHW; Fire Marshall; Insurance Companies
MH-ST	**Action 2.1.2.** Develop a continuity of government plan that details how core governmental operations will be maintained in the event of an emergency	11	1-3 years	Linn County Administrative Officer	Emergency Management; Elected Officials; Board of Commissioners; County Departments
MH-LT	**Action 2.1.3.** Evaluate current zoning codes to incorporate mitigation principles	11	3-5 years	Planning & Building Department	Emergency Management; Planning Commission; Board of Commissioners;
FL-ST	**Action 2.1.4.** Explore participation in the National Flood Insurance Program's Community Rating System	6	Ongoing	Planning & Building Department	Building Official; Emergency Management; Board of Commissioners; FEMA; Insurance Companies; Cities
FL-LT	**Action 2.1.5.** Explore the development of management strategies to preserve the function of the floodplain	6	Ongoing	Planning & Building Department	Building Official; Cities; FEMA; DSL; ODFW; OWRD; Watershed Councils

Objective 2.2. Support the enhancement of County vulnerability assessment activities		Action Item Priority Score	Time Line	Lead Organization	Internal/External Partners
MH-ST	**Action 2.2.1.** Develop an inventory of county assets including replacement costs	11	1-3 years	General Services	Linn County Property Management; Treasurer; Assessor; GIS
EQ-ST	**Action 2.2.2.** Re-run DOGAMI HAZUS with local refined data	7	1-3 years	GIS Department	Emergency Management; Planning and Building; Assessor; DOGAMI; FEMA
FL-LT	**Action 2.2.3.** Update Flood Insurance Rate Maps (FIRM)	6	2-5 years	Planning & Building Department	Building Official; Emergency Management; Insurance Companies; Cities; FEMA; OEM
WS-ST	**Action 2.2.4.** Develop pre-storm strategies for coordinated debris removal following wind and winter storms	8	Ongoing	Road Department	Emergency Management; Sheriff; 911 Coordinator; Utility Companies, Cities
WS-LT	**Action 2.2.5.** Identify severe weather hazard areas and inventory vulnerable buildings, infrastructure and critical facilities.	8	2-5 years	Emergency Management	Road Dept; Planning & Building; Assessor; GIS; Emergency Services Providers; ODOT; OEM; FEMA; Insurance Companies; Utility Companies
LS-LT	**Action 2.2.6.** Use final DOF Debris Flow Hazard maps and improved development data to update the landslide vulnerability and risk analysis.	5	3-5 years	Emergency Management	GIS; Assessor; Road Department; Planning and Building; DOF; DOGAMI; OEM; FEMA
WF-ST	**Action 2.2.7.** Develop wildfire hazard maps and vulnerable asset inventories.	4	1-3 years	Emergency Management	GIS; Assessor; Road Department; Planning and Building; DOF; OEM; FEMA; State and Local Fire Marshalls; Local RFPDs, Insurance Companies

MH-LT	**Action 2.2.8.** Geo-code the location, type, occupancy, footprint and elevation data for buildings, infrastructure, and critical facilities in natural hazard areas.	11	3-5 years	GIS Department	Assessor; Planning & Building Dept.; Emergency Management; Road Dept.; FEMA; OEM; DOGAMI; Cities; Insurance Companies
Objective 2.3. Ensure continuity of County emergency service functions		Action Item Priority Score	Time Line	Lead Organization	Internal/External Partners
MH-ST	**Action 2.3.1.** Update the Emergency Operations Plan	11	1-3 years	Emergency Management	County Administrator; Sheriff; Road Dept; COG; Cities; 911 Coordinator; State Police; Utility Companies
MH-ST	**Action 2.3.2.** Consolidate the mitigation plan, Emergency Operations Plan, recovery plans, and continuity of government plans into a Unified Disaster Plan	11	1-3 years	Emergency Management	County Administrator; Sheriff; Road Dept; COG; Cities; 911 Coordinator; State Police; Utility Companies
MH-ST	**Action 2.3.3.** Identify and evaluate county-owned emergency transportation routes and determine which roads and bridges are critical to the transportation network	11	1-3 years	Road Department	Emergency Management; 911 Coordinator; Sheriff; State Police; OEM; Fire Marshall
Objective 2.4. Implement structural and non-structural mitigation of publicly owned facilities and infrastructure		Action Item Priority Score	Time Line	Lead Organization	Internal/External Partners
EQ-ST	**Action 2.4.1.** Develop a program to implement non-structural retrofit of County staff offices and workspaces	7	1-3 years	Safety Committee	General Services; County Insurance Carrier; OEM; OR-OSHA; BC
EQ-LT	**Action 2.4.2.** Complete a seismic vulnerability assessment of all County-owned structures and prioritize vulnerable publicly owned structures	7	3-5 years	County Engineer	General Services; Board of Commissioners; Building Official; OEM; Assessor; DOGAMI; Safety Committee
EQ-LT	**Action 2.4.3.** Complete a seismic vulnerability assessment of all County-owned bridges on lifeline routes and prioritize vulnerable bridges	7	3-5 years	Road Department	County Engineer; Board of Commissioners; DOGAMI; Fire Marshall; 911 Coordinator; OEM; ODOT; Sheriff
EQ-LT	**Action 2.4.4.** Implement structural mitigation projects for prioritized, vulnerable publicly owned structures and bridges identified in Action 2.4.2 and Action 2.4.3	7	3-5 years	County Engineer	General Services; Road Department; Board of Commissioners; FEMA; DOGAMI; OEM; ODOT; U.S. DOT

GOAL 3: Protect life, the built environment, the economy and natural resources through community-wide partnerships					
Objective 3.1. Increase citizen awareness and promote risk reduction activities through education and outreach		Action Item Priority Score	Time Line	Lead Organization	Internal/External Partners
MH-ST	**Action 3.1.1.** Develop public awareness campaigns aimed at homeowners, children, the elderly, and non-English speaking residents to make them aware of what they can do to prepare for natural hazard events.	10	1-3 years	Emergency Management	Red Cross; COG; Cities; Linn Benton ESD; United Way; State Agencies; Hospitals; Insurance Companies; Children and Families Commission
LS-ST	**Action 3.1.2.** Use and publicize the Oregon Department of Forestry's debris flow warning system	4	Ongoing	Emergency Management	Dept of Forestry; DOGAMI; OEM; ODOT; Road Department; Radio Stations
Objective 3.2. Develop collaborative programs that encourage local businesses to plan for disasters		Action Item Priority Score	Time Line	Lead Organization	Internal/External Partners
MH-LT	**Action 3.2.1.** Encourage small businesses to develop recovery plans in the event of a disaster and to implement non-structural mitigation	10	3-5 years	Chamber of Commerce	Emergency Management; Business Development Coordinator; COG; LBCC Business Development; Cities
Objective 3.3. Develop partnerships with external partners for hazard specific mitigation projects		Action Item Priority Score	Time Line	Lead Organization	Internal/External Partners
EQ-ST	**Action 3.3.1.** Assist K-12 schools, child care facilities and private schools to develop vulnerability assessment and mitigation projects to improve safety	6	1-3 years	Linn-Benton Educational Service District	Emergency Management; School Districts; Private Schools; American Red Cross; DOGAMI; OEM; Commission on Children and Families
FL-LT	**Action 3.3.2.** Support multi-objective stream and river enhancement projects that maximize flood mitigation	5	Ongoing	Board of County Commissioners	Emergency Management; Watershed Councils; Water Control Districts; DSL; ODFW; DOF; DEQ; FEMA; USCE; Cities
WF-LT	**Action 3.3.3.** Conduct community based fuel reduction demonstration projects in the interface	3	3-5 years	State Fire Marshall	Emergency Management; Department of Forestry; Fire Districts; Cities; OEM

WF-ST	**Action 3.3.4.** Develop a countywide Community Wildfire Protection Plan	3	1-3 years	Emergency Management	Department of Forestry; Fire Districts; Cities; Fire Marshall; OEM
WF-ST	**Action 3.3.5.** Partner with the Oregon Department of Forestry and Rural Fire Districts to promote home site assessment programs for the wildfire hazard	3	Ongoing	State Fire Marshall	Emergency Management; Department of Forestry; Fire Districts; Cities; Fire Marshall; OEM
WS-LT	**Action 3.3.6.** Develop partnerships to implement programs to keep trees from threatening lives, property, and public infrastructure during wind and winter storms	7	2-5 years	Emergency Management	Road Dept; Parks Dept; Utilities; Insurance Cos; OSU Extension Service; Timber Cos; DOF; Arbor Care Companies

Linn County
Natural Hazard Mitigation Plan
Maps

The Linn County Natural Hazard Mitigation Plan uses a number of mapped resources which were created by the Linn County Geographic Information Systems (GIS) Department. The following table is a reference guide to the types of information included in the maps that were used to create the plan. The maps in ***Appendix D*** were generated by the Oregon Department of Geology and Mineral Industries (DOGAMI) and used in the analysis of potential earthquake hazards.

Map #	Map Title	Featured Information	Relevant Plan Chapter
1	Linn County, Oregon	County boundary; Cities; Highways; Rivers; Water Bodies; Topography	Section 1: Introduction
2	Critical Infrastructure	Major roads; Bridges; Hospitals; Dams Schools; Emergency Facilities; Community Centers	Section 2: Community Profile Section 3: Risk Assessment
3	Lifeline Routes: Albany (West)	Priority lifeline routes	Section 2: Community Profile
4	Lifeline Routes: Albany (East)	Priority lifeline routes	Section 2: Community Profile
5	Lifeline Routes: Halsey	Priority lifeline routes	Section 2: Community Profile
6	Lifeline Routes: Lebanon	Priority lifeline routes	Section 2: Community Profile
7	Lifeline Routes: Scio (West)	Priority lifeline routes	Section 2: Community Profile
8	Lifeline Routes: Scio (East)	Priority lifeline routes	Section 2: Community Profile
9	Lifeline Routes: Sweet Home	Priority lifeline routes	Section 2: Community Profile
10	Precipitation	Annual Precipitation	Section 2: Community Profile Section 6: Floods
11	Watersheds	Fifth Field Watersheds	Section 2: Community Profile Section 6: Floods
12	FEMA Flood Plain	100-year Flood Zone	Section 6: Floods
13	Mass Movement Areas	Mass Movement; Vulnerable Structures and Roads	Section: 7: Landslide

14	Potential Debris Flow Areas	Debris Flow Hazards; Vulnerable Structures and Roads	Section 7: Landslide
15	Rural Fire Districts	Fire Districts	Section 2: Community Profile Section 8: Wildfire
16	Peak Ground Acceleration – Crustal	Peak Ground Acceleration from a Crustal Fault Earthquake (Appendix D)	Section 10: Earthquake Appendix D
17	Peak Ground Acceleration – Cascadia	Peak Ground Acceleration from a Cascadia Subduction Earthquake (Appendix D)	Section 10: Earthquake Appendix D
18	Ground Shaking Amplification	Relative Ground Shaking Amplification Susceptibility (Appendix D)	Section 10: Earthquake Appendix D
19	Liquefaction Susceptibility	Relative Liquefaction Susceptibility (Appendix D)	Section 10: Earthquake Appendix D
20	Earthquake Induced Susceptibility	Relative Earthquake Induced Landslide Susceptibility (Appendix D)	Section 10: Earthquake Appendix D
21	Landslide Areas	Identified Landslides (Appendix D)	Section 10: Earthquake Appendix D

Note: *The information on the maps in this plan was derived from the Linn County GIS and other sources. Care was taken in the creation of these maps, but is provided "as is". Linn County cannot accept any responsibility for any errors, omissions or positional accuracy, and therefore, there are no warranties that accompany these products (the maps). 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.*

Section 1:
Introduction

What Is Hazard Mitigation?

"Natural hazard mitigation" refers to developing and implementing actions designed to reduce or eliminate the impacts to life and property resulting from future natural hazard events. The key element in pre-disaster hazard mitigation is risk reduction. For new development, hazard mitigation might include applying specific design standards to minimize damages that may result from natural events such as earthquakes, landslides or floods; or identifying and avoiding certain high hazard areas prior to building site selection. For existing development, hazard mitigation might include elevating homes in repetitive flood loss areas above the 100-year flood level; and retrofitting public buildings and bridges to increase their ability to withstand earthquakes.

Why Develop a Mitigation Plan?

Linn County (the County) developed this Natural Hazard Mitigation Plan to protect life and property and reduce damages resulting from natural disasters by reducing vulnerability to natural hazard risks. Reducing potential damages improves public safety and economic stability. The mitigation plan identifies resources, information, and strategies to reduce risks from natural hazards, and guides the County's mitigation activities.

The federal Disaster Mitigation Act of 2000 (DMA 2000) and the implementing rules in 44 CFR Part 201.6 requires that the County complete a FEMA-approved natural hazard mitigation plan to be eligible for certain federal assistance programs. The mitigation plan is intended to: (1) identify and prioritize future mitigation activities; (2) establish a framework for coordination among agencies and the public; and (3) meet federal disaster mitigation planning requirements and qualify the County for certain pre-disaster and post-disaster assistance programs.

Primary funding for this plan is from a grant through the federal Pre-Disaster Mitigation Competitive Grant Program for pre-disaster mitigation planning and projects addressing natural hazards. The grant program is administered by the Federal Emergency Management Agency (FEMA). The County contributed additional matching funds.

Who Will Benefit From the Mitigation Plan?

The Linn County Natural Hazard Mitigation Plan (Mitigation Plan) presents strategies and resources to reduce hazard risks within unincorporated Linn County. The mitigation plan identifies and prioritizes a set of action items designed to reduce risks through public education, public improvement projects, and the enhancement of partnerships. Local governments, unincorporated communities, special districts, businesses and rural property owners can all benefit from the Mitigation Plan.

Policy Framework for Natural Hazard Planning in Oregon

Oregon's statewide planning program is founded on a set of 19 statewide planning goals. Statewide Planning Goal 7 provides planning guidelines in areas subject to natural disasters and hazards. The goals and implementing regulations are adopted as a set of administrative rules (Oregon Administrative Rules Chapter 660). The coordination and implementation of the statewide goals is achieved through local comprehensive planning.

Key state and federal agencies involved in developing risk reduction strategies and resources include: Oregon Emergency Management (OEM), Oregon Building Codes Division (BCD), Oregon Department of Forestry (DOF), Oregon Department of Geology and Mineral Industries (DOGAMI), the Department of Land Conservation and Development (DLCD), and the Federal Emergency Management Agency (FEMA).

The federal Disaster Mitigation Act of 2000 (DMA 2000) established a program for local pre-disaster hazard mitigation planning and new requirements for the national post-disaster Hazard Mitigation Grant Program (HMGP). The County must have a FEMA approved pre-disaster mitigation plan in place to qualify for mitigation project funding and to qualify to receive post-disaster HMGP funds.

Previous Natural Hazard Mitigation Planning Efforts

Statewide Planning Goal 7 is intended to protect life and property in areas subject to natural disasters and hazards. The Linn County Comprehensive Plan (Comprehensive Plan) was acknowledged in 1985. The Comprehensive Plan at LCC 903.200 through 903.280 includes an inventory of areas subject to certain natural and geologic hazards and a set of Plan policies to guide development within known hazard areas. Risk reduction measures in areas subject to natural disasters and hazards are implemented through application of the County's Land Development and Building Codes.

The Regional All Hazard Mitigation Master Plan for Benton, Lane, Lincoln, and Linn Counties was developed between 1998 and 2002. The Mitigation Master Plan is designed to help local communities gather the data necessary to compete for future FEMA funding of mitigation projects. The Mitigation Master Plan reviews the principles of mitigation planning and presents a seven-step process for conducting a detailed, quantitative evaluation of prospective mitigation projects. Phase One of the Mitigation Master Plan addressed planning for the hazards of flooding, severe winter storms, mud slides and landslides. Phase Two addressed earthquakes, wildland/urban interface fires and dam failures. Phase Three addressed hazardous materials.

Plan Process and Methodology

The Linn County Natural Hazards Mitigation Plan was created under a collaborative process through the participation of Linn County citizens, private business representatives, public agencies, special districts and private organizations. The planning process was coordinated through the Linn County Planning and Building Department (Department).

Steering Committee

The Linn County Planning Commission served as the Natural Hazards Mitigation Plan Steering Committee. The Steering Committee is comprised of a diverse group of Linn County citizens with extensive understanding of the geography, history and issues critical to guiding the development of the natural hazard mitigation plan.

The Steering Committee met a total of 10 times while developing the plan. The Steering Committee guided the development of the plan by setting plan goals, encouraging public participation, and identifying and prioritizing appropriate mitigation activities and action items. The steering committee will also assist in the implementation and monitoring of the plan.

Linn County Communities

The Department contacted each Linn County municipality and invited their participation in the County's mitigation planning process. Representatives from the City of Albany, the City of Lebanon and the City of Scio contributed to Linn County's hazard mitigation plan by actively participating in Steering Committee meetings and by providing written information. The city of Sweet Home has already completed its hazard mitigation plan. The city of Albany is developing its own hazard mitigation plan using the same process as the County. The city of Scio is developing a natural hazards mitigation plan that will be adopted as an annex to Linn County's plan. Additionally, department staff discussed the development of annex plans with officials from the cities of Brownsville, Harrisburg, Lyons, Mill City and Millersburg. While each of these cities expressed a desire to develop mitigation plans, none were able to do so at this time.

Public Participation

Public participation was sought throughout the process especially in the identification of hazard risks and the development of plan goals and mitigation action items. The public was notified of the mitigation planning project and the public meetings through published notices, press releases, and mailings to potential stakeholders and interested parties. The public was invited to participate in regularly scheduled Steering Committee meetings and public workshops. Identified stakeholders and interested parties were mailed a focus group survey. The Steering Committee also held an open public workshop to identify the natural hazard mitigation plan mission, objectives, goals and action plan for Linn County.

Stakeholder Survey

In December 2004 the Department sent out a natural hazard survey letter to 134 Linn County businesses, special districts, public agencies, local governments, governmental agencies, public utilities, emergency services providers, interested citizens and others. The survey questionnaire was also provided to interested parties upon request and at public meetings. The survey provided identified stakeholders and interested parties an opportunity to share knowledge about natural hazards in Linn County and opinions about preparing for and reducing natural disaster risks. The Steering Committee reviewed the compiled survey results to help identify issues, prioritize goals and identify action items. The survey and compiled responses are presented in ***Appendix A***.

Hazard Specific Research

The Linn County Planning and Building Department collected existing demographic, property development and natural hazard data for Linn County. The hazard research included information relating to flood, landslide, severe winter storm, windstorm, wildfire, earthquake, and volcanic hazards. Hazard specific research included materials from previously published plans and reports from the Linn County Planning and Building Department, Linn County Emergency Management, the Department of Geology and Mineral Industries (DOGAMI), the Federal Emergency Management Agency (FEMA), and other State and Federal agencies. Existing mitigation measures and resources are listed in each hazard-specific section.

Hazard Assessment

The Mitigation Plan compiles information for seven types of natural hazards in Linn County and establishes mitigation goals and action items for each hazard. The hazard assessment provides information on the location of the hazard, the land and property characteristics within the hazard area, and an assessment of risks to life and property that may result from a natural hazard event. The three elements of hazard assessment are:

1) ***Hazard Identification*** identifies the geographic extent of the hazard, the potential intensity of the hazard, and its probability of occurrence. This information is presented using hazard maps when available.

2) ***Vulnerability Assessment*** inventories existing and planned property development and populations that are located within a hazard area and are therefore exposed to that hazard.

3) ***Risk Analysis*** estimates the damage, injuries and economic losses that may be sustained within a hazard area over a given period of time. The risk analysis uses mathematical models based on the magnitude of the harm that may result and the likelihood of the harm occurring.

The hazard assessments are limited by the available hazard-specific data. Linn County has mapped geographic information system (GIS) data for FEMA floodplain information, DOGAMI mass movement (landslide) information, earthquake fault lines. The GIS data also includes location information for rural dwellings and public buildings.

The County conducted a flood hazard vulnerability assessment using GIS data to identify the extent of flood hazard areas and to assess the land, property and economic value at risk from flooding. The earthquake hazard vulnerability assessment is conducted using the FEMA HAZUS analysis model. There is insufficient data to conduct vulnerability assessments for the other natural hazards in the plan: landslide, severe winter storm, windstorm, wildfire, and volcanic eruption. Risk analyses were not conducted for any of the hazards in the plan due to insufficient data.

Plan Organization

The Linn County Natural Hazard Mitigation Plan is organized into three elements.

Volume I contains the executive summary plus five plan sections: Introduction; Community Profile; Risk Assessment; Goals and Action Items; and Plan Maintenance. These sections provide an overview of how the plan was developed and what action items are proposed.

Volume II contains five natural hazard sections. The hazard-specific sections provide background information on each hazard, specific action items, and local, county, and state resources.

Volume III includes five resource appendices. The appendices provide information on the plan development process and other resources and issues.

Volume I: Mitigation Plan

Executive Summary and Five-Year Action Plan

The Executive Summary provides an overview of the mitigation plan goals and action items. The action items address both multi-hazard issues and hazard-specific activities that can reduce risks and losses from future natural hazard events.

Section1: Introduction

The Introduction section describes the background of hazards in Linn County, the purpose of developing the hazard mitigation plan, and the planning process and methodology.

Section 2: Community Profile

The Community Profile section presents the history, geography, demographics and economic profile of Linn County. This section also provides an overview of natural hazard events in the county.

Section 3: Natural Hazards Risk Assessment

The Risk Assessment section provides information on hazard identification, vulnerability and risk associated with natural hazards in Linn County.

Section 4: Multi-Hazard Goals and Action Items

The Goals and Action Items section provides information on the process used to develop goals and action items for the seven natural hazards addressed in the mitigation plan.

Section 5: Plan Maintenance

The Plan Maintenance section provides information on plan implementation, monitoring and evaluation.

Volume II: Hazard-Specific Information

Five chronic hazards and one catastrophic hazard are addressed in this plan. Chronic hazards occur with regularity and may be predicted through historic evidence and statistical modeling. Catastrophic hazards do not occur with the frequency of chronic hazards and are less predictable, but can have devastating impacts on life and property.

Each of the five hazard-specific sections includes information on the history, causes and characteristics of the specific natural hazard. The hazard sections also include goals and action items; and local, state and national mitigation resources.

The five chronic hazards addressed in the plan are:

Section 6: Flood

Section 7: Landslide

Section 8: Wildfire

Section 9: Severe Weather

The catastrophic hazard addressed in the plan is:

Section 10: Earthquake

The plan also includes a section that lists the multi-hazard mitigation action items. Multi-hazard action items are action items that address two or more of the natural hazards addressed in the plan. The multi-hazard action items are identified in:

Section 11: Multi-hazard Mitigation Action Items

Volume III: Resources Appendices

The plan resource appendices include additional information to assist users of the Linn County Natural Hazards Mitigation Plan in understanding the development and contents of the plan. The appendices also include potential resources to assist with plan implementation.

Section 2:
Community Profile

Why Plan For Natural Hazards in Linn County?

Linn County is subject to impacts from natural hazard events including floods, severe winter storms, windstorms, landslides (mass movement), and wildfires. The impacts of past hazard events in Linn County have resulted in loss of life and property, economic losses, and damaged infrastructure.

Western Linn County is subject to stream flooding and ponding, such as occurred during the floods of 1964, 1974 and 1996. Linn County experienced severe damage during the Columbus Day wind storm in 1962, and parts of southern and western Linn County were severely impacted by a wind storm in February of 2002. Eastern Linn County is susceptible to landslides, winter storms and wildfire. Most recently, in January 2004 the county was impacted by a severe winter storm that resulted in damage and hazards related to snow and ice.

These types of chronic hazards will continue to impact the county in the future. The County may also be subject to impacts from future catastrophic hazards such as earthquakes and volcanoes. The risks from future natural disasters and the impacts of future disasters on the population, economy and infrastructure will increase as areas of risk become more heavily developed.

The federal Disaster Mitigation Act of 2000 (DMA 2000) requires local communities to develop a natural hazard mitigation plan. The purpose of natural hazard mitigation planning is to protect life and property and reduce damages resulting from natural disasters by reducing vulnerability to natural hazard risks. Reducing potential damages improves public safety and economic stability. The DMA 2000 implementing rules in 44 CFR Part 201.6 also require the County to complete a FEMA-approved plan to be eligible for certain federal disaster assistance programs.

Geography and the Environment

Linn County is located in the mid-Willamette Valley and covers an area of 2,297 square miles. The elevation ranges from 125 feet along the Willamette River in western Linn County to 10,497 feet at the peak of Mt. Jefferson in eastern Linn County.

Linn County's diverse landscape includes broad, fertile bottomlands and terraces throughout the valley floor in the west, the varied relief of the Cascade foothills, and the abundant forests and volcanic peaks of the Cascade Range in the east. These productive resource lands established Linn County's early settlement patterns and rural heritage. The farm and forest use of land continues to be of significant cultural and economic importance to the citizens of Linn County.

Productive floodplains, terraces and foothills inspired settlers to build homes and make a life in Linn County. As farming and forest activities shaped Linn County's economy, rural communities developed near cities and in unincorporated rural centers such as Holly, Lacomb, Jordan, Shedd, Crabtree, Peoria and Crawfordsville.

Climate

Western Linn County is characterized by a temperate climate. Summers are warm and dry, but extremely hot days are rare. Winters are cool and rainy, but snow and freezing temperatures are uncommon, except at higher foothill elevations. Eastern Linn County consists of the higher elevations of the Cascade Range. Winters are colder with much more precipitation, much of it in the form of snow. Summers in the mountains are mostly dry with warm days, cool nights, and occasional lightening storms.

Average annual precipitation on the valley floor is around 40 to 45 inches, occurring mostly (79 percent) between the months of October through March. Precipitation increases as the elevation rises east into the Cascade foothills. Annual precipitation at Foster is 54 inches, increasing to 62 inches at Cascadia, and 85 inches at the Santiam Pass. In the north county area, annual precipitation is 53 inches at Stayton (north of Scio) and 83 inches at Detroit. The lower valley elevations experience very little snowfall. Cascadia averages 10 inches of snowfall annually while the Santiam Pass averages 85 inches.[1]

The average minimum temperature in January is 45 degrees in Albany, 34 degrees in Foster, 31 degrees in Cascadia, and 20 degrees at the Santiam Pass. The average maximum temperature in July is 82 degrees in Albany, 80 degrees in Foster and Cascadia, and 73 degrees at the Santiam Pass.[2]

In most winters, one or two storms over the whole area bring strong and sometimes damaging winds. Heavy rains often result in localized flooding and ponding on the valley floor. In some years heavy rain storms cause serious flooding, which can become widespread and severe when combined with rapid snow melt in the mountains. Every few years, a large continental or polar air mass will invade the area for a few days causing abnormal temperatures well below freezing.

Mountain Ranges

While nearly all of Linn County's population lives in the Willamette Valley between the Willamette River and the Cascade foothills, fully one-half of the county is undeveloped forest lands of the Cascade Range. Most of this area is in the Willamette National Forest or is Bureau of Land Management lands. The Cascades were formed by volcanic activity resulting from the convergence of two tectonic plates. The visible landmarks created by past volcanic activity include Snow Peak, Mount Washington, Mount Jefferson, and Three Fingered Jack. The tallest peak in Linn County is Mount Jefferson, at 10,497 feet.

Although mostly uninhabited, the Cascades draw large numbers of visitors throughout the year. Popular recreational activities include camping, hiking, fishing, hunting, mushroom picking, horseback riding, mountain climbing, picnicking, boating, water and snow skiing, sledding, snowshoeing, gold panning, and others. The rugged, steep mountains are dry in the summer and are subject to lightening storms during the hot summer months. The Cascades are subject to a variety of natural events, including wildfire in the summer, severe storms during winter, and landslides in winter and spring.

Rivers

Linn County includes four major rivers and many smaller rivers, creeks and drainages. The largest river in the Willamette Valley is the Willamette River. The Willamette River establishes Linn County's western boundary and flows past the communities of Harrisburg, Peoria, and Albany. The North Santiam River establishes most of the county's northern boundary and flows past the communities of Idanha, Gates, Mill City and Lyons.

The South Santiam River and the Calapooia River watersheds are entirely within Linn County. The South Santiam River begins high in the Cascade Mountains and runs across the valley floor merging with the North Santiam River north of Albany. The South Santiam river flows through the communities of Cascadia, Sweet Home, Waterloo, and Lebanon. The Calapooia River runs from the Cascade foothills in southeast Linn County through the communities of Holley, Crawfordsville, and Brownsville before entering the Willamette River in Albany.

Other smaller drainages in Linn County include the Middle Fork of the Santiam River, Roaring River, Crabtree Creek, Thomas Creek, Hamilton Creek, McDowell Creek, Wiley Creek, Muddy Creek, Courtney Creek and others. Combined with the many sloughs and low-lying areas on the valley floor, the county is highly susceptible to flood hazards.

Soils and Other Geologic Features

On the broad flood plains along the Willamette River and the lower reaches of the Santiam River system the soils are well drained to excessively drained, except for the soils in remnant channels that have filled with sediment. The soils on terraces adjacent to the flood plains are well drained. Internal drainage problems within the terraces increase as they broaden and become nearly level to depressional.[3]

Between the broad Willamette Valley terraces to the west and the mountainous uplands of the Cascade Range to the east are low foothills that range in elevation from 300 to 1400 feet. The soils in these areas are well drained to poorly drained. The topography ranges from gently sloping areas on low plateaus to steep side slopes. These soils formed in material derived from igneous or sedimentary rock. The South Santiam and Calapooia Rivers dissect these low foothills forming major valleys that have both narrow flood plains and narrow stream terraces. Minor streams such as Thomas and Crabtree Creeks dissect the low foothills and form minor valleys characterized by narrow stream terraces of recent alluvium.[4]

The mountainous uplands of the western Cascade Range have elevations up to 5000 feet. The Cascades formed from volcanic material such as hard basalt and soft pyroclastic and sedimentary material. Volcanic ash covers much of the higher areas. The differences in the hardness of these materials accounts for the differing rates of dissection. The mountains are characterized by gently sloping soils on high plateaus and steep to very steep soils on canyon walls and side slopes. Steep headwalls and rolling slump blocks indicate slumping and landslide problems in some areas.

The Cascades are drained by tributaries of the Willamette River system. The upper valleys of the tributaries are narrow and have stream terraces of recent origin. The streams are characterized by waterfalls and numerous rapids until they reach the nearly level areas of the Willamette Valley.

The U.S. Army Corps of Engineers has built flood control dams on the North, South and Middle Forks of the Santiam River. These structures have controlled much of the historical flooding in the lower reaches of the valleys, especially those of the Willamette Valley. Many areas that were active flood plains in the past are no longer subject to periodic flooding.

Population and Demographics

In 2000 the Linn County population was 103,069, representing a 13 percent increase since 1990. The population of Linn County living in unincorporated areas was 39,014 or 38 percent of the total county population. **Table 2-1** shows the distribution of Linn County population in 2000.

Table 2-1
Linn County Population

Community	Population (Year 2000)	Percent of Total
Unincorporated Linn County	36,219	35.1%
Albany (Linn County Part)	35,748	34.6%
Lebanon	12,950	12.6%
Sweet Home	8,016	7.8%
Harrisburg	2,795	2.7%
Brownsville	1,449	1.4%
Mill City (Linn County Part)	1,225	1.2%
Lyons	1,008	1.0%
Tangent	933	0.9%
Halsey	724	0.7%
Scio	695	0.7%
Millersburg	651	0.6%
Sodaville	290	0.3%
Waterloo	239	0.2%
Idanha (Linn County Part)	85	0.1%
Gates (Linn County Part)	42	<0.1%
Total Linn County	103,069	100.0%

Source: U.S. Census Bureau, Census 2000 Population Data

The July 1, 2004 Linn County population estimate is 106,350 (Portland State University, Population Research Center). According to the Oregon Office of Economic Analysis, the population of the southern Willamette Valley region is projected to grow 15 percent at a rate of 1.9 percent per year over the next 20 years.

In terms of losses and the ability to recover from natural disasters, special needs groups such as minorities and the poor are disproportionately impacted compared to other population groups. Minorities comprise six percent of the Linn County population. In Linn County, 11 percent of the population is living below the federal poverty level, including 15 percent of children under 18 and seven percent of residents over age 65.[5] Changes in the rural Linn County growth pattern can increase the risks associated with hazards and will impact how the county prepares for natural hazard related emergencies

Housing and Development

Much of the housing outside of cities in Linn County is on small acreage home sites clustered together in rural residential exception areas and within the county's eight unincorporated rural communities. In 2002 there were an estimated 5,129 housing units within these types of rural communities in Linn County.[6]

The older a structure is, the greater the risk of damage from a natural disaster. Homes built before the late 1960s normally did not incorporate earthquake resistant designs. The Linn County Building Ordinance began recognizing the importance of developing outside flood prone areas in 1971. The County adopted a floodplain development code in 1980. The Federal Emergency Management Agency did not complete comprehensive floodplain mapping in Linn County until 1986.

The year-built date for homes and the housing unit type is important for assessing risk and developing mitigation strategies. **Table 2-2** shows housing by construction date. **Table 2-3** shows housing by housing unit type.

Table 2-2 shows that as of March 2000, 72 percent of housing units in Linn County were constructed prior to 1980. **Table 2-3** shows that in 2000, 16 percent of housing units in Linn County were mobile home units. A greater percentage of housing units in unincorporated areas are mobile home units compared to urban areas, while nearly all multi-family units are in incorporated places.

Table 2-2
Linn County Housing Units in 2000
by Year Structure Built

Year Structure Built	Housing Units	Percent of Total
Before 1960	13,716	32%
1960 to 1979	16,937	40%
1980 to March 2000	11,868	28%
Total	42,521	100%

Source: U.S. Bureau of the Census, Profile of Housing Characteristics 2000

Table 2-3
Linn County Housing Units in 2000
by Units in Structure

Housing Unit Type	Housing Units	Percent of Total
Single Family Units	28,351	66.7%
2 to 4 Units	3,141	7.4%
5 to 19 Units	2,289	5.4%
20 or more Units	1,656	3.9%
Mobile Homes	6,703	15.7%
Boat/RV/Van/other	381	0.9%
Total	42,521	100.0%

Source: U.S. Bureau of the Census, Profile of Housing Characteristics 2000

Employment and Industry

Linn County's economy has relied heavily on the lumber and wood products industry for a significant portion of its income and jobs. In 1973, lumber products accounted for almost one out of four non farm payroll jobs in the county. At that time, the county's unemployment rate was only slightly higher than the state's. By 2000, after years of layoffs and mill closures, lumber manufacturing accounted for less than one out of 10 non farm payroll jobs. Linn County's unemployment rate currently trends about two percentage points higher than the state's.[7]

Agriculture continues to be an important component in Linn County's economy. Crop sales in Linn County totaled $169.3 million in 2000, with grass and legume seed production accounted for 47 percent of total crop sales. Other significant components of the county's economy include rare metals manufacturing, manufactured home production, and retail sales. The Linn County economy benefits from its prime mid-Willamette Valley location. Interstate 5, U.S. Highway 20 and Highway 34 provide easy access to jobs in nearby Salem, Eugene and Corvallis. The proximity to other urban centers and major highways supports the development of regional retail centers and attracts firms looking to relocate or expand in the region.

The region's economy grew by 20 percent during the 1990s. Job growth is expected to slow due to a variety of reasons, including the slowing national economy and high tech industry, which has resulted in layoffs at Hewlett-Packard in Corvallis. Other factors include slowing population increases and improvements in the California economy compared to Oregon's economy. Rising fuel and fertilizer costs will create challenges for local agriculture. Local wood products manufacturers are facing reduced demand due to the slowing of the state and national economies, weak foreign markets, and competition from Canadian imports. Industry employment projections for the mid-Willamette Valley indicate that the region's economy will grow by 9.7 percent over the next decade, compared to the statewide forecast of 12.5 percent growth. Growth in the region is expected across all broad industry sectors, with the greatest growth in services, trade and government services.[8]

Median household income can be used to help gauge a community's economic stability. **Table 2-4** shows that the median household income in Linn County is below that of the nation, the state and the average of the median household incomes of the six-county southern Willamette Valley region.

Table 2-4
Median Household Income (1999)

Linn County	So. Willamette Valley Counties (Average)	Oregon	United States
$37,518	$40,516	$40,916	$41,994

Source: U.S. Bureau of the Census, Quick Facts and the Profile of Economic Characteristics 2000.

Transportation and Commuting Patterns

The communities of Linn County are linked together and to other regions of the state by Interstate 5, U.S. Highway 20, State Highway 34, State Highway 99E, and a well developed and maintained network of regional and local rural highways and county roads. Growth in the county will increase the number of vehicles on the roads. A high number of workers driving alone to work will increase traffic congestion and the risk of accidents. Increasing numbers of vehicles can place stress on roads, bridges and infrastructure in rural areas where traffic is confined to fewer transit roads.

According to the 2000 U.S. Census, 79 percent of Linn County workers drive to work alone, and the average commute time is 22 minutes each way. **Table 2-5** shows the commuting patterns for Linn County workers.

Table 2-5
Linn County Commuting Patterns by Transportation Type

Commute Type	Number	Percent
Drove Alone: Car, Truck or Van	35,991	79.3
Carpooled: Car, Truck or Van	5,373	11.8
Public Transportation	128	0.3
Walked	1,321	2.9
Other Means	511	1.1
Worked at Home	2,049	4.5
Total (Workers 16 years and over)	45,373	100
Mean Travel Time to Work (Minutes)	22.2	--

Source: U.S. Census Bureau, Census 2000 Profile of Selected Economic Characteristics

Most employed residents of the county remain in the area to work. **Table 2-6** shows that more Linn County workers commute from Linn County to counties outside the Linn/Benton/Lincoln County region to work than the number of workers who commute to Linn County from outside the county.

Table 2-6
Linn County Commuting Patterns by County of Origin

Percent of Linn County Residents That Work, Who Work:		
In Linn County	In Benton or Lincoln Counties	Outside Linn, Benton, or Lincoln Counties
73.6%	11.6%	14.8%
Percent of Linn County Jobs Held by Workers Living:		
In Linn County	In Benton or Lincoln Counties	Outside Linn, Benton, or Lincoln Counties
77.2%	11.2%	11.6%

Source: Oregon Employment Department, 2002 Regional Economic Profile

Hazards such as localized flooding can render roads unusable. A severe winter storm such as occurred in Linn County in January 2002 can disrupt the daily driving route of thousands of people or make driving prohibitively hazardous. A natural disaster or emergency that cuts off access on a rural road or highway can shut down the local or regional transit system, making evacuations difficult, increasing commuting time and distances, impacting the local or regional economy, and in some cases completely isolating a local area or economy.

Bridges and Highways

Bridges that are not seismically retrofitted that are in areas subject to earthquakes can create significant risks. Damaged bridges can disrupt or cut off traffic flow and lead to economic losses when commuters and consumers have difficulty reaching their destinations and when businesses are unable to deliver products and services to their clients.

Linn County currently owns 329 bridges. Inspection is provided by the Oregon State Highway Division. Bridges less than 20 feet in length are inspected by Linn County. All Linn County bridges are inspected at two year intervals. Bridges that are found to be in critical condition during an inspection are prioritized for immediate replacement. Continued repair, maintenance and widening of bridges will be necessary over the next 20 years. Linn County is working closely with the Oregon Department of Transportation to inventory and rank all the County's bridges with respect to earthquake response.[9]

Three bridges in the county are considered too narrow. These are the Brownsville Bridge, the Scio Bridge and the Mill City Bridge. Linn and Benton counties are separated by the Willamette River so there are no land connections between the two counties. There are only two bridge crossing points linking the two counties, comprising five total bridges. Two are on Highway 20 in Albany and three are on Highway 34 at Corvallis.

The Van Buren Street Bridge linking Linn County and the City of Corvallis on Highway 34 is in need of improvement or replacement. Damage to any of these crossings could impact the economies of the two counties. These inter-county routes may become strained with increased development and commuting traffic.

Table 2-7 shows the number of bridges in Linn County.

Table 2-7
Linn County Bridges

County	State	County	City	Historical Covered Bridges	Total
Linn County	219	329	32	6	586

Source: Oregon State Natural Hazard Risk Assessment, Region 3

A well developed network of local rural highways and county roads connects the Linn County communities to each other and to the region. Interstate 5 (I-5) is the major north-south freeway through Linn County and is the main route for vehicles traveling between Eugene and Portland and between Washington and California. Highway 99E runs parallel to I-5 and serves the communities of Harrisburg, Halsey, Shedd, Tangent, and Albany, as well as providing a backup route to the freeway. Other state highways the serve Linn County include:

- US Route 20 -- Runs from Newport at the Oregon Coast east through Corvallis, Albany, Lebanon, Sweet Home and then continues beyond eastern Oregon;
- State Highway 34 – Runs from Waldport at the Oregon Coast east through Corvallis, Albany and Lebanon;
- State Highway 226 – Runs from US Route 20 near Crabtree northeasterly through Scio and Lyons to Marion County; and
- State Highway 228 – Runs from Halsey east across I-5 to Brownsville and Sweet Home.

Lifeline Routes

Lifeline routes are critical transportation routes that are vital to continued pubic safety, mobility and commerce in the event of a natural disaster. The ODOT has identified state highways and important secondary lifeline routes in Linn County. The County designates the ODOT lifeline routes in Linn County as Priority 1 routes. Priority 1 routes receive the highest priority for emergency road maintenance in the event of road closures.

The Linn County Road Department is divided into five maintenance districts. The lifeline route priority maps are attached to the end of this section. The lifeline route maps are organized by maintenance district and show the emergency maintenance classification for Priority 1, Priority 2, and Priority 3 routes.

Critical Facilities and Infrastructure

Critical facilities are those facilities that are considered critical to government response and recovery activities, such as police and fire stations, public works facilities, sewer and water facilities, hospitals, bridges and roads. When redundancies occur not all such facilities are necessarily considered to be critical. Critical facilities in Linn County are shown on the critical facilities map at the end of this section.

Table 2-8 below is derived from a table of critical facilities identified in the Oregon State Natural Hazards Risk Assessment. Some of the State risk assessment data in the table are updated from County Assessor and Corps of Engineers data.

Table 2-8
Critical Facilities

County	Hospitals		Police Station	Fire & Rescue Station	School Dist. & Colleges	Power Plants	Dams (National Inventory of Dams)	
	# of Hospitals	#of Beds					#of Dams	High Hazard Potential
Linn County	2	131	12	15	12 Districts 1 Com Col	1 @ 93 MW	12	7

Source: Oregon State Natural Hazard Risk Assessment, Region 3; National Inventory of Dams, U.S. Army Corps of Engineers; Linn County Assessor's Office

In addition to the facilities listed in ***Table 2-8***, there are other critical and essential facilities that are vital to the continued delivery of key governmental services or that may significantly impact the public's ability to recover from emergencies. Some of these facilities, such as correctional institutions, public services buildings, law enforcement centers, courthouses, juvenile services buildings, schools and other public facilities should be detailed in future updates of the hazard mitigation plan.[10]

Emergency Facilities

Emergency facilities include law enforcement, fire and ambulance facilities, and emergency operations center (EOC) sites. The following tables list emergency facilities in Linn County. Emergency facilities are also shown on the critical facilities map at the end of this section.

Table 2-9
Law Enforcement Facilities

Facility Description	Facility Address
Linn County Sheriff's Office: Main office, Jail, 911/Dispatch Center, EOC	1115 Jackson St. SE, Albany
Civil Division Substation	300 4th Ave. SW, Albany
Sheriff's Brownsville Substation	255 N. Main St., Brownsville
Sheriff's Harrisburg Substation	354 Smith St., Harrisburg
Sheriff's Lyons Substation	242 Fifth St., Lyons
Sheriff's Mill City Substation	274 SW Cedar St., Lyons
Sheriff's Millersburg Substation	4310 NE Woods Rd., Albany
Sheriff's Scio Substation	38957 N. Main St., Scio
Sheriff's Sweet Home Substation	1951 Main St., Sweet Home
Sheriff's Sweet Home Substation	3225 Hwy. 20, Sweet Home
Albany Police Department: Also secondary PSAP & dispatch for police	1117 Jackson St. SE, Albany
Lebanon Police Department: Also secondary PSAP & dispatch for police	40 E. Maple St., Lebanon
Sweet Home Police Department: Also PSAP/Dispatch for police & fire	1950 Main St., Sweet Home
Oregon State Police: Albany state police barracks	3400 Spicer Dr., Albany

Source: Linn County Emergency Management; May 15, 2004

Table 2-10
Fire and Ambulance Facilities

Facility Description	Facility Address
Albany Fire Department	
Headquarters	333 Broadalbin, Albany
Station 11 – fire & ambulance	110 Sixth Ave SE
Station 12 – fire & ambulance	120 34th Ave. SE
Station 13 – fire & ambulance	1980 Three Lakes Rd. SE
Station 14 – fire & ambulance	1850 Gibson Hill NW

Brownsville Fire District	
Station 61	255 N. Main St. Brownsville
Halsey/Shedd/Peoria Fire District	
Halsey Fire Station 51	740 W. Second St., Halsey
Shedd Fire Station 52	31922 B St., Shedd
Peoria Fire Station 53	29399 Abraham Dr., Peoria
Oakville Fire Station 54	31919 Oakville Dr., Oakville
Harrisburg Fire District	
Station 41	500 Smith, Harrisburg
Jefferson Fire District	
Station 630	4310 NE Woods Rd., Albany
Lebanon Fire District	
Station 31 – fire & ambulance, joint w/City EOC	1050 W. Oak St., Lebanon
Station 32 – fire	34128 E. Lacomb Dr., Lacomb
Station 33 – fire	30570 Fairview Rd., Lebanon
Lyons Fire & Ambulance District	
Station 550 – fire & ambulance	1114 Main St., Lyons
Station 570 - fire	39079 Jordan Rd., Lyons
Mill City Fire District	
Station 790	400 S. First, Mill City
Scio Fire District	
Station 90, Admin., joint city/fire district EOC	38975 SW Sixth Ave.
Station 91	39023 Second Ave.
Station 92	37587 Crabtree Dr., Crabtree
Station 93	43042 Burmester Dr., Scio
Sweet Home Fire & Ambulance District	
Station 21 – fire & ambulance	1099 Long St., Sweet Home
Station 22	1390 47th Ave., Foster
Station 23	25995 First Ave., Crawfordsville
Station 24	Hwy. 20, Cascadia
Tangent Fire District	
Station 71	32053 Birdfoot Dr., Tangent

Source: Linn County Emergency Management; May 15, 2004

Table 2-11
Emergency Operations Center Sites

Facility Description	Facility Address
Linn County Courthouse: alternate EOC, principal seat of county government, critical site for county information technology & GIS, sheriff's substation for the civil division	300 4th Ave. SW, Albany
Albany City Hall: principal seat of city government/ city EOC	333 Broadalbin, Albany
Brownsville City Hall: principal seat of city government/ EOC	255 N. Main St., Brownsville
Halsey City Hall: principal seat of city government, city EOC	773 W. First St., Halsey
Harrisburg City Hall: principal seat of city government/ EOC	354 Smith St., Harrisburg
Lyons City Hall: principal seat of city government	449 Fifth St., Lyons
Lebanon City Hall: principal seat of city government	925 Main St., Lebanon
Mill City Hall: principal seat of city government	252 SW Cedar St., Mill City
Millersburg City Hall: principal seat of city government/ EOC	4222 Old Salem Rd, Albany
Scio City Hall: principal seat of city government, city EOC	38957 NW 1st Ave., Scio
Sodaville City Hall: principal seat of city government/ EOC	30723 Sodaville Rd., Sodaville
Sweet Home City Hall: principal seat of city government/ EOC	140 12th Ave., Sweet Home
Tangent City Hall: principal seat of city government, city EOC	32166 Old Oak Dr., Tangent

Source: Linn County Emergency Management; May 15, 2004

Dam Failure

Dam failures can occur unexpectedly but most result in minor damage and pose a low risk to life safety. Because the potential for severe damage and fatalities does exist, the U.S. Army Corps of Engineers (USACE) developed the National Inventory of Dams (NID), which includes a listing of High Hazard Potential dams for the nation.

There are 12 NID dams in Linn County. A dam is included in the NID if:

(1) It is a High or Significant hazard potential class dam; or

(2) It is a Low Hazard potential class dam that exceeds 25 feet in height and 15 acre-feet storage; or

(3) It is a Low Hazard potential class dam that exceeds 50 acre-feet storage and 6 feet height.

Dams assigned the High Hazard Potential classification are those where failure or operation error will probably cause loss of human life. The NID classifies seven Linn County dams as High Hazard Potential dams. These are:

- The Willamette National (Foster) Log Pond
- Big Cliff
- Detroit
- Green Peter
- Foster
- Trail Bridge
- Smith

Section 2 Endnotes

[1] Source: Western Regional Climate Center. www.wrcc.dri.edu Accessed 11/23/04

[2] Ibid.

[3] Source: USDA, Soil Conservation Service (SCS). Soil Survey of Linn County Area Oregon, Issued July 1987; pp. 2-3

[4] Ibid.

[5] Source: U.S. Bureau of the Census. quickfacts.census.gov Accessed 11/15/04

[6] Source: Linn County Rural Residential Buildable Lands Inventory, 2002

[7] Source: Oregon Employment Department, 2002 Regional Economic Profile

[8] Ibid.

[9] Source: Linn County Transportation Plan (LCC 907.360)

[10] Source: Oregon State Natural Hazard Risk Assessment (OR-SNHRA), Region 3 Profile

Section 3:
Risk Assessment

This Section describes the natural hazard risk assessment process. It provides general information on what a risk assessment entails and lists the hazard vulnerability maps that are included in the Mitigation Plan. Risk assessment information for each of the hazards identified in this plan can be found in the hazard specific sections listed below.

- Section 6: Flood
- Section 7: Landslide
- Section 8: Wildfire
- Section 9: Severe Weather (Ice/Snow/Wind Storm)
- Section 10: Earthquake

The Steering Committee determined that since many of the identified impacts and potential mitigation activities associated with severe winter storms (ice and snow) and windstorms are similar, those hazards would be combined into a single section. The Committee also determined that volcanic hazards present a low probability of impact to the community and therefore are not addressed at this time. The County will reevaluate the need to include volcanic hazards in the plan when the plan is updated in five years.

What is a Risk Assessment?

The risk assessment process identifies natural hazard threats and vulnerabilities that exist within the community. A risk assessment provides information on the location of hazards; the value of existing land and property in hazard locations; and an analysis of the risk to life, property, and the environment that may result from natural hazard events. The major elements of a risk assessment are as follows:

1. **Hazard Identification** describes the hazard's geographic extent, intensity, and probability of occurrence. Maps are used when available to display major hazards that consistently affect the geographic area. Linn County identified five major hazards that consistently affect the area. These hazards – Floods, Landslides, Wildfires, Winter Storms, and Wind Storms – were identified through the hazards analysis. Earthquakes, although infrequent in this area, were also determined to be a significant hazard due to their projected intensity and impact.

2. **Profiling Hazard Events** describes the causes and characteristics of each hazard; how it has affected the county in the past; and what elements of the county's population, infrastructure, and environment have historically been vulnerable to each specific hazard. Each hazard section of this plan includes a hazard profile. Please refer to the appropriate hazard section for a full description of the history of hazard specific events.

3. **Vulnerability Assessment/Asset Inventory** 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 they provide essential products and services to the public that are necessary to preserve the welfare and quality of life in the county. Critical facilities also fulfill important public safety, emergency response, and/or disaster recovery functions. Critical facilities such as hospitals, police stations, schools, major roads and bridges, have been identified and are shown on the map at the end of this section. The hazards sections also identify known vulnerability areas, including critical facilities and other public and private property.

4. **Risk Analysis/Potential Losses Estimate** 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. 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. The Community Profile section of this Plan provides a comprehensive description of the vital characteristics of Linn County. The community profile describes the geography and environment; population and demographics; land use and development; housing and community development; employment and industry; and transportation and commuting patterns within the county. Analyzing these characteristics helps in identifying potential problem areas and serves as a guide for incorporating goals and ideas contained in this mitigation plan into other community development plans.

Hazard Assessment

There are three phases of hazard assessment: 1) Hazard Identification; 2) Vulnerability Assessment; and 3) Risk Analysis. Hazard identification and 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 available data and information from county, state or federal agency sources.

Linn County conducted a vulnerability assessment for the flood hazard using FEMA and County Geographic Information System (GIS) data and tools to identify the geographic extent of the hazard and assess the land use and property value at risk from the flood hazard. Landslide hazards were estimated using available state landslide models and county GIS data. The vulnerability assessment for the earthquake hazard is derived in part from Department of Geology and Mineral Industries (DOGAMI) estimates using FEMA's HAZUS analysis model. Insufficient data exists to conduct vulnerability assessments and risk analyses for the other hazards addressed in the plan.

Even though hazard assessment information may be incomplete, 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 reduce disruption of 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 Risk Assessment Requirements

Federal regulations for hazard mitigation plans outlined in CFR Part 201 include a risk assessment requirement. The Federal criterion for risk assessment and information on how Linn County's Natural Hazard Mitigation Plan meets those criteria is outlined in **Table 3-1** below.

Table 3-1
Federal Criteria for Risk Assessment

Section 322 Requirement	**How is this addressed?**
Identifying Hazards	Each hazard section identifies hazard areas using the best available data. To the extent GIS data are available, the County developed maps identifying the location of the hazard. The Executive Summary and the Risk Assessment sections of the plan include a list of the hazard maps.
Profiling Hazards Events	Each hazard section includes documentation of the history, causes and characteristics of the hazard within the county.
Assessing Vulnerability: Identifying Assets	Where data is available, the vulnerability assessment for each hazard includes an inventory of publicly owned property within hazard areas. Each hazard section provides information on vulnerable areas in the Community Issues section. Each hazard section also identifies potential mitigation strategies.
Assessing Vulnerability: Estimating Potential Losses	The Risk Assessment Section of the mitigation plan includes a map of key critical facilities and lifelines in the county. Vulnerability assessments have been completed for the hazards addressed in the plan, and quantitative estimates were made for each hazard where data were available.
Assessing Vulnerability: Analyzing Development Trends	The Community Profile describes 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.

The risk assessment requirement is intended to provide information that will help communities identify and prioritize mitigation activities that will reduce losses from the identified hazards. There are six hazards profiled in five sections of this mitigation plan, including: floods, landslides, wildfire, severe winter storms, wind storms, and earthquakes.

Critical Facilities and Infrastructure

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 an emergency. These facilities include public services buildings such as the courthouse, jail, sheriff's office, community corrections center, and other public facilities such as schools. Critical and emergency facilities in Linn County are shown on the critical facilities map at the end of Section 2. Emergency facilities are listed in Table 2-9 in Section 2.

Facilities critical to government response and recovery activities (i.e., life, safety and property) include: emergency operations centers; police and fire stations; public works facilities; road department facilities; bridges and roads; sewer and water facilities; hospitals; and shelters. Facilities that, if damaged, could cause serious secondary impacts may also be considered "critical." A facility storing hazardous material is one example of this type of critical facility. The maps at the end of this section illustrate the critical facilities, essential facilities, public infrastructure, and critical transportation routes within the county.

Summary

Natural hazard mitigation strategies can reduce the impacts of natural hazard events on private property, public infrastructure, critical facilities, and vulnerable populations. Natural hazard mitigation by businesses, private groups and public agencies may include developing relationships with emergency management services before disaster strikes, and establishing joint mitigation strategies. Collaboration among the public and private sector to create mitigation plans and actions can reduce the impacts of natural hazards.

The County lacks sufficient information to estimate the number and type of buildings, infrastructure, and critical facilities located in all of the hazard areas within the county or to estimate the potential losses. The steering committee crafted action items and identified necessary resources to address this deficiency in the future.

Section 4:
Action Plan

This section provides information on the process used to develop the mission, goals and action items 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 four parts – Mission, Objectives, Goals and Action Items*:*

- *Mission* – The mission statement is a philosophical or value statement that answers the question "Why develop a plan?" In short, the mission states the purpose and defines the primary function of the Linn County Natural Hazards Mitigation plan. The mission is an action-oriented statement of the plan's reason to exist. It is broad enough that it need not change unless the community environment changes.
- *Objectives* – Objectives link goals and action items. Objectives are the direction, methods, processes or steps used to accomplish or achieve the goals.
- *Goals* – Goals are designed to drive actions and they are intended to represent the general end toward which the County effort is directed. Goals identify how the area intends to work toward mitigating risk from natural hazards. They should not specify how the community is to achieve the level of performance. The goals are guiding principles for the specific recommendations that are outlined in the action items.
- *Action Items* – The action items are detailed recommendations for activities that local departments, citizens and others could engage in to reduce risk (See Section 5 for information on the plan's action items).

The mission, goals, objectives and actions for the Linn County plan were developed over a series of two Steering Committee meetings held on April 12th and May 17th, 2005. The Steering Committee completed an exercise on community values and issue identification to help guide the development of the action plan. The Action Items were further refined during Steering Committee meetings held on June 14th and June 28th, 2005. The Oregon Natural Hazards Workgroup (ONHW) at the University of Oregon provided guidance on developing mission, goals, objectives and actions.

Natural Hazard Mitigation Plan Mission

In order to develop the mission statement for the plan, the Steering Committee reviewed sample mission statements from existing FEMA-approved plans and completed an exercise that answered the following three questions: 1) Who does the plan serve? 2) What does the Plan do? 3) What can the plan accomplish? The Steering Committee developed and adopted the following Plan Mission:

> *The mission of the Linn County Natural Hazard Mitigation Plan is to reduce the impact of natural hazards on the community through planning, communication, coordination and partnership development.*

Mitigation Plan Goals

To develop the Linn County plan goals, the Steering Committee reviewed sample goals from existing FEMA-approved mitigation plans and held a discussion of appropriate goals for the County. ONHW provided the Steering Committee with draft goals based on their discussions and their responses to the community values and issues identification exercises. Linn County's mitigation plan goals are:

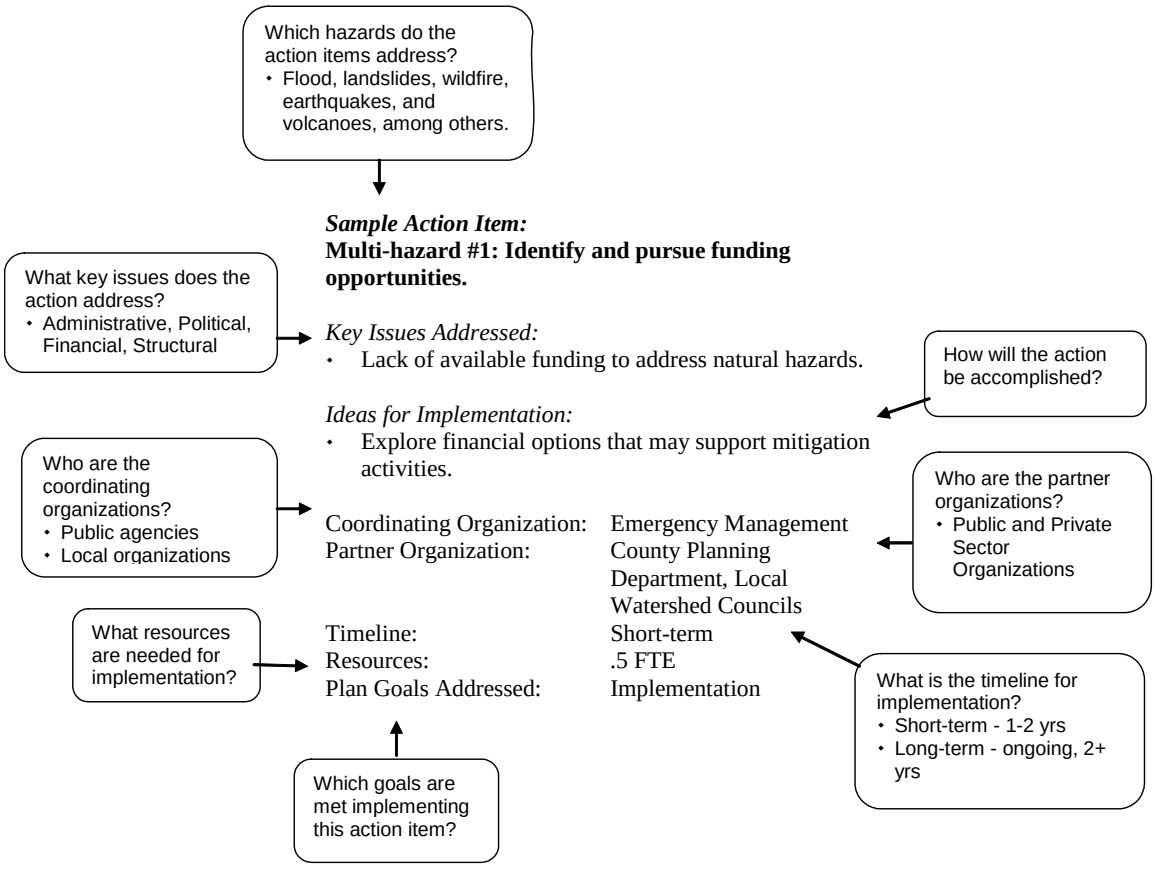
Goal #1: Enhance coordination and communication among Linn County stakeholders to implement the Plan

Goal #2: Protect life, the built environment and natural systems through County policies, procedures and services

Goal #3: Protect life, the built environment, the economy and natural resources through community-wide partnerships

Mitigation Plan Action Items

Figure 4-1
Sample Action Item Documentation



Source: Oregon Natural Hazards Workgroup 2004: Oregon Pre-Disaster Mitigation Program Training Manual

A sample action item is diagramed in **Figure 4-1** above. The mitigation plan identifies short-term and long-term action items developed through data collection and research. Mitigation plan activities may be considered for funding through state and federal grant programs, including the Federal Emergency Management Agency's Hazard Mitigation Grant Program and Pre-Disaster Mitigation Competitive Grant Program, as funds are made available. Action items address both multi-hazard (MH) and hazard specific issues for the hazards addressed in this plan. To facilitate implementation, each action item includes information on timeline, coordinating and partner organizations, key issues addressed, ideas for implementation, and plan goals addressed.

Key Issues Addressed:

Each action item includes a list of the key issues that the activity will address. Action items should be fact based and tied directly to issues or needs identified throughout the planning process. Action items can be developed from a number of sources including participants of the planning process, noted deficiencies in local capability, or issues identified through the risk assessment.

Ideas for Implementation:

Appendix B contains the final Action Item Proposal Forms. Each action item form includes ideas for implementation and potential resources. This information offers a transition from theory to practice. The ideas for implementation serve as a starting point for this plan. This component of the action items is dynamic as some ideas may not be feasible and new ideas can be added during the plan maintenance process. Section 5, Plan Maintenance provides more information on how the plan will be implemented and evaluated.

The action items are suggestions for ways to implement the plan goals only. Some of these items may prove to be unrealistic and other more refined ideas may be identified and added to the plan. Ideas for implementation include things such as collaboration with relevant organizations, grant programs, tax incentives, human resources, education and outreach, research, and physical manipulation of buildings and infrastructure. A list of potential resources outlines what organization or agency will be most qualified and capable to perform the implementation strategy. Potential resources often include utility companies, non-profits, schools, and other community organizations.

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.

Internal Partners:

Internal partner organizations are departments within the County that may be able to assist in the implementation of action items by providing relevant resources to the coordinating organization.

External Partners:

External partner organizations can assist the coordinating organization in implementing the action items in various functions and may include local, regional, state, or federal agencies, as well as local and regional public and private sector organizations. The internal and external partner organizations listed in the Mitigation Plan are potential partners recommended by the project steering committee, but not necessarily contacted during the development of the plan. The coordinating organization should contact the identified partner organizations to see if they are capable of and interested in participation. This initial contact is also to gain a commitment of time and or resources towards completion of the action items.

Plan Goals Addressed

The plan goals addressed by each action item are identified as a means for monitoring and evaluating how well the mitigation plan is achieving its goals following implementation.

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 may be implemented with existing resources and authorities within one to two years. Long-term action items (LT) may require new or additional resources and/or authorities, and may take between one and five years to implement.

Methodology for Prioritizing Plan Action Items

To prioritize the plan's action items Linn County utilized a multi-tiered approach. First the plan goals were prioritized. Second, the natural hazards identified in the County were prioritized based on the hazard risk assessments. Third, using the outcome of these two activities each action item was scored according to a point system to determine its relative priority in the plan.

The prioritized list of action items serves only as a starting point for the implementation of mitigation activities. Linn County has the option to implement any of the action items at any time. This allows the County to consider mitigation strategies as new opportunities arise, such as funding for action items that may not be of highest priority. The following is the method by which the Hazard Mitigation Steering Committee will prioritize the plan action items.

Step 1: Prioritizing Plan Goals

To accomplish this task the Hazard Mitigation Steering Committee examined and voted on the importance of each of the plan's three goals. The steering committee members used a "dot prioritization" exercise to determine the relative priority of each goal. Committee members were given three different colored adhesive "dots". Each "dot" had a number assigned to it ranging from 3 points to 1 point (three being the highest value). They were asked to place a single "dot" on each of the plan goals, thereby ranking the importance of each goal in making Linn County more disaster resilient. The steering committee members ranked the goals regardless of how easy

each goal would be to accomplish. After the vote their priorities, the "dots" and their associated points were tallied. The results are as follows:

Highest Priority (14 Points) – Goal 2: Protect Life, the Built Environment and Natural Systems Through County Policies, Procedures and Services

2nd Highest Priority (12 Points) – Goal 3: Protect Life, the Built Environment, the Economy and Natural Resources Through Community-Wide Partnerships

3rd Highest Priority (10 Points) – Goal 1: Enhance Coordination and Communication Among Linn County Stakeholders to Implement the Plan

Step 2: Prioritizing Community Hazards

The second step in prioritizing the plan's action items was to examine which hazards they are associated with and where these hazards rank in terms of community risk. The Steering Committee ranked the hazards based on the history of hazard events in the county and the hazard-specific risk assessments in Section 6 through Section 10 of the mitigation plan. In ranking the hazards, the Steering Committee considered the hazard impact, probability, speed of onset, and duration.

To rank the hazards, the Steering Committee again used the "dot prioritization" exercise to determine the relative priority of each of the natural hazards addressed in the plan. Committee members were given five different colored adhesive "dots". Each "dot" had a number assigned to it ranging from 5 points to 1 point (five being the highest value). They were asked to place a single "dot" next to each of the five plan hazards, thereby ranking the importance of each goal in making Linn County more disaster resilient. After the vote, their rankings and their associated points were tallied. According to this analysis, the hazards identified in the plan were ranked in the following order of priority: Severe Weather; Earthquake; Flood; Landslide; and Wildfire.

Step 3: Tallying the Priorities of Plan Goals and Hazards

A prioritized list of action items was developed based on how the goals and hazards were ranked in Steps 1 and 2. In the first step, action items were assigned the following number of points for addressing each goal.[i]

3 Points – Goal 2: Protect Life, the Built Environment and Natural Systems Through County Policies, Procedures and Services

2 Points – Goal 3: Protect Life, the Built Environment, the Economy and Natural Resources Through Community-Wide Partnerships

1 Point – Goal 1: Enhance Coordination and Communication Among Linn County Stakeholders to Implement the Plan

In the second step, the following point system was assigned to each hazard:

8 Points – Multi-Hazard

5 Points – Severe Weather Hazard

4 Points – Earthquake Hazard

3 Points – Flood Hazard

2 Points – Landslide Hazard

1 Point – Wildfire Hazard

Points were then assigned to each action item based on the ranking of the hazard they address. Multi-Hazard action items are assigned the most points because they address multiple hazards. The points assigned to each action item in the goal prioritization step were combined with the points assigned to each action item in the hazard prioritization step to arrive at the Action Item Priority Score. The Action Item Priority Score is noted in the Action Item Matrix included in the Executive Summary. Higher scores indicate higher priorities.

Step 4: Action Item Implementation

Linn County's Natural Hazards Mitigation Plan Steering Committee, with the assistance of Linn County Emergency Management and the Linn County Planning and Building Department will administer the implementation of action items with the overall guidance of the Linn County Board of Commissioners. In examining the feasibility of the plan's prioritized action items benefit-cost analysis will be encouraged for all structural mitigation projects. See ***Appendix C*** for more information on this process.

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[i] The Hazard Mitigation Plan Steering Committee had previously identified which goals were covered by which action items.

Section 5:
Plan Implementation and Maintenance

The plan implementation and maintenance section of this document details the formal process that will ensure that Linn County's 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 an updated plan every five years. This section also describes how the County will integrate public participation throughout the plan maintenance and implementation process. Finally, this section includes an explanation of how the County intends to incorporate the mitigation strategies outlined in this Plan into existing planning mechanisms and programs such as the Linn County comprehensive land use planning process, capital improvement planning process, and building codes enforcement and implementation.

The plan's format allows Linn County to review and update sections when new data become available. New data can be easily incorporated, resulting in a natural hazards mitigation plan that remains current and relevant to Linn County.

Monitoring and Implementing the Plan

The Linn County Board of Commissioners will adopt the Hazard Mitigation Plan via resolution. Once adopted, the Linn County Emergency Management Coordinator will be responsible for submitting it to the State Hazard Mitigation Officer at Oregon Emergency Management (OEM). Oregon Emergency Management will then submit the plan to the Federal Emergency Management Agency (FEMA–Region 10) for review. This review will address the federal criteria outlined in FEMA Interim Final Rule 44 CFR Part 201. Upon acceptance by FEMA, Linn County will gain eligibility for the Pre-Disaster Mitigation Grant Program, Hazard Mitigation Grant Program funds, and Flood Mitigation Assistance program funds.

Once the plan is adopted and approved, the Steering Committee will be charged with implementing and maintaining the plan. The Linn County Emergency Management Coordinator and the Linn County Planning and Building Department Director will act as co-conveners of the Steering Committee.

The effectiveness of Linn County's non-regulatory Natural Hazard Mitigation Plan will be contingent on the implementation of the plan and the incorporation of the outlined action items into existing county plans, policies, and programs. The Natural Hazard Mitigation Plan includes a range of action items that, if implemented, would reduce loss from hazard events in Linn County. Together, the action items in Linn County's Natural Hazard Mitigation Plan provide the framework for activities that county agencies can choose to implement over the next five years. The Hazard Mitigation Steering Committee has prioritized the plan's goals and identified actions. These will be implemented, as resources permit, through existing plans, policies, and programs.

Coordinating Body

The Hazard Mitigation Steering Committee will be the coordinating body for the hazard mitigation plan. The Steering Committee is responsible for plan maintenance, coordinating the implementation of plan action items, and undertaking the formal review process. The Linn County Planning Commission will continue to serve as the Steering Committee with other stakeholders serving on working committees as needed.

To make the coordination and review of Linn County's Hazard Mitigation Plan as broad and useful as possible, the Steering Committee will engage other stakeholders and relevant hazard mitigation organizations and agencies to implement the identified action items. The Steering Committee will meet annually to review the plan. In addition to the Planning Commission members, participating agencies and stakeholders in this process include:

Linn County Board of Commissioners
Linn County Building Official
Linn County Emergency Management
Linn County Planning and Building Department
Linn County Road Department
City of Albany
City of Lebanon
City of Scio
Oregon Natural Hazards Workgroup
Department of Geology and Mineral Industries
Oregon Emergency Management
Federal Emergency Management Agency
Oregon Department of Forestry
Linn County Citizens

Convener

The Linn County Emergency Management Coordinator and the Planning and Building Department Director, as co-conveners, will each have authority to convene the Steering Committee to address action items; to facilitate Steering Committee meetings; and to assign tasks such as updating the plan and making presentations to the committee. The Steering Committee members will share responsibility for plan implementation and evaluation.

Implementation through Existing Programs

The Natural Hazard Mitigation Plan includes a range of action items that, when implemented, will reduce loss from hazard events in Linn County. Within the framework of the plan, FEMA requires the identification of existing programs that might be used to implement these action items.

Linn County addresses statewide planning goals and legislative requirements through its comprehensive land use plan, capital improvement plans, and building codes. To the extent possible, Linn County will work to incorporate the recommended mitigation action items into existing programs and procedures. The following existing county resources will be used to assist in the implementation of hazards mitigation actions whenever possible.

Policies

Linn County Comprehensive Plan

Date of last revision: April, 2003

Plan Owner: Board of Commissioners

Plan Description: The function is to address a wide range of concerns such as the best use of air, land and water resources, as well as the delivery of public services.

Plan cycle: The comprehensive plan changes when the needs and desires of the public change, when development occurs at a different rate than predicted, and when corrections in a plan are needed, the plan needs to be revised. However, if this doesn't occur, then the plan is reviewed and updated three years after the initial adoption of the plan.

Relation to hazard mitigation: Action-items identified in a natural hazard mitigation plan, may assist in achieving the goals and policies outlined in the Comprehensive Plan. The mitigation plan may identify the need to update or revise policies and ordinances located in the Comprehensive Plan as well.

Functional Plans

Transportation Plan

Date of last revision: August, 2005

Plan Owner: Board of Commissioners

Plan Description: This is a 20 year plan focusing on linking transportation with land use planning. It contains a brief background description of facilities and issues followed by a complete list of County transportation policies. Sections of the plan list and prioritize transportation projects.

Plan cycle: There is no scheduled date of maintenance/update.

Relation to hazard mitigation: The mitigation plan may identify actions related to key transportation links that might be impacted by disasters. These actions can be cross-listed in the mitigation and transportation improvement plans.

Community Plans

Emergency Operations Plan

Date of last revision: October 1, 1997

Plan Owner: Sheriff's Office

Plan Description: To provide all the tasks necessary to provide support and maintain the ability of the emergency services system to prevent or reduce the impact of injuries.

Plan cycle: There is no scheduled plan maintenance/evaluation.

Relations to hazard mitigation: Both mitigation and response are components of the disaster cycle; however, any risk that is mitigated before a disaster occurs is one less incident that will need responding to. The mitigation plan helps to identify risk that can be mitigated before a disaster occurs.

Implementing Measures

Building Code

Date of last revision: April, 2005

Plan Owner: Planning and Building Department

Plan Description: Provide uniform performance standards providing reasonable safeguards protecting health, safety, welfare, comfort and security of the residents of this County who are occupants and users of the buildings.

Plan cycle: The code is revised every two years.

Relation to hazard mitigation: Action items initiated by the natural hazard mitigation plan that changes the building code must also be consistent with the goals of the city's Comprehensive Plan.

Land Development Code

Date of last revision: April, 2003

Plan Owner: Planning and Building Department

Plan Description: The Linn County Development Code implements the County's Comprehensive Plan.

Plan cycle: Every three years, unless the needs and desires of the community change, or when development is increased faster than expected.

Relation to hazard mitigation: The mitigation plan may identify potential changes to the land development code that would result in a reduction in the risk posed by certain hazards in the community.

Planning Maps

Comprehensive Plan Map

Date of last revision: April, 2003

Plan Owner: Board of Commissioners, Planning and Building Department, GIS Department

Plan Description: Although not a zoning map, these two maps should be closely related to each other. It is specifically used in the land use element of the comprehensive plan.

Plan cycle: Every three years the Comprehensive Map needs to be revised if the needs and desires of the public change, development occurs at a different rate than predicted or when corrections in a plan are needed.

Relation to hazard mitigation: Comprehensive plan maps can be a useful tool for directly development away from identified hazard areas. The mitigation plan may identify opportunities to revise the current comprehensive plan map(s) to reduce the impact of disasters on the community.

County Zoning Map

Date of last revision: April, 2003

Plan Owner: Board of Commissioners, Planning and Building Department, GIS Department

Plan Description: The zoning map is one of the most significant tools available to carry out the general, long range goals of the plan. Within the same plan designation, several zoning districts may be used.

Plan cycle: Every three years, unless the needs and desires of the community change, or when development is increased faster than expected.

Relation to hazard mitigation: Zoning can be a useful tool for directing development away from identified hazard areas. The mitigation plan may identify opportunities to revise current zoning to reduce the impact of disasters on the community.

Economic Analysis of Mitigation Projects

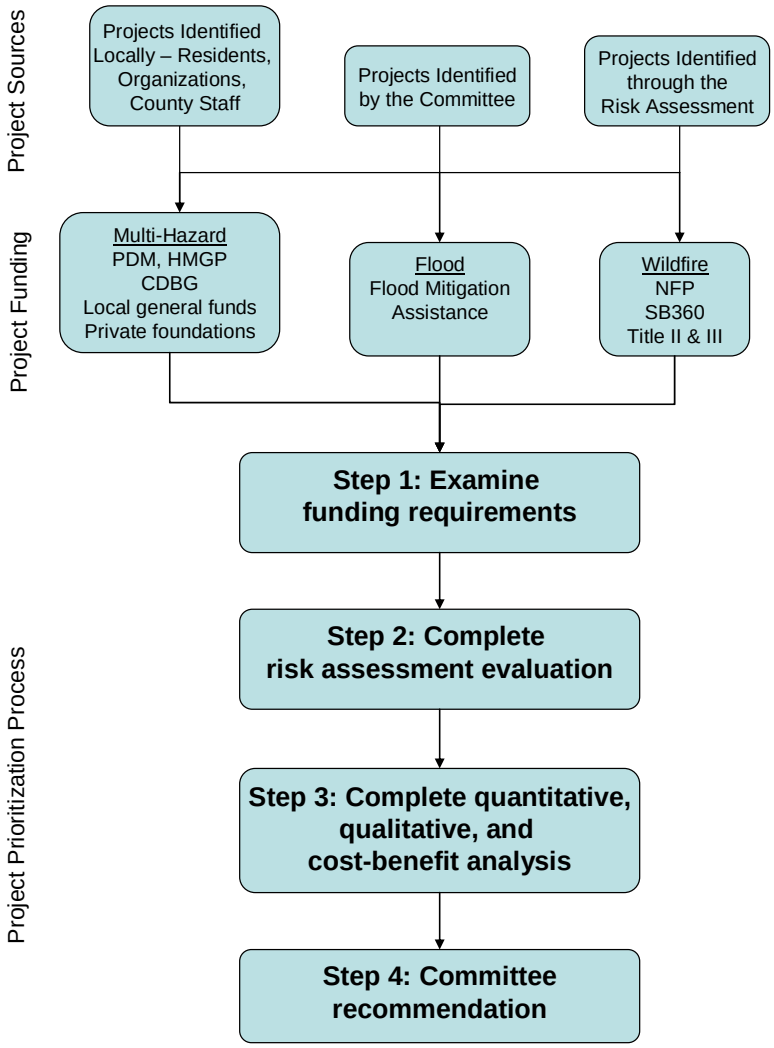
The FEMA's methods of identifying the costs and benefits associated with natural hazard mitigation strategies, measures, or projects fall into two general categories: (1) benefit/cost analysis; and (2) cost-effectiveness analysis. Conducting benefit/cost analysis for a mitigation activity can assist 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 provides decision-makers with an understanding of the potential benefits and costs of an activity, as well as a basis upon which to compare alternative projects.

The Hazard Mitigation Steering Committee and the Emergency Management Coordinator will use FEMA-approved cost benefit methodology as a tool for identifying and prioritizing mitigation action items when applying for federal mitigation funding. For other projects and funding sources, the Hazard Mitigation Steering Committee and the Emergency Management Coordinator 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***.

Methodology for Prioritizing Plan Action Items

Section 201.6(c)(3)*iii* of the Disaster Mitigation Act of 2000 requires that communities describe how the actions identified in the plan will be prioritized, implemented and administered. The following describes the process in which potential mitigation activities will be prioritized.

Figure 5.1
Project Prioritization Process Overview



Source: ONHW/CPW, 2005

Potential mitigation activities may come from a variety of sources; therefore the project prioritization process needs to be flexible. Projects and issues may be identified by committee members, residents, local government staff, risk assessments, or other methods.

Depending on a potential project's intent and implementation methods, several funding sources may be appropriate. Examples of mitigation activity funding sources include: the National Fire Plan (NFP), Title II funds, Title III funds, Pre-Disaster Mitigation (PDM) grants, Community Development Block Grants (CDBG), the Hazard Mitigation Grant Program (HMGP), and Senate Bill 360 funds. These examples are used in ***Figure 5-1*** above to illustrate the project prioritization process.

The prioritization process utilizes the countywide Risk Assessment to prioritize projects to help ensure that mitigation dollars are used effectively. The Steering Committee uses this methodology to initially prioritize the plan's action items in addition to maintaining the action list during annual review and update. The Steering Committee and community partners have the option to propose implementation of any of the action items at any time, regardless of the prioritization rank. This allows the committee to consider mitigation strategies as new opportunities arise, such as qualified funding for specific action items.

Step 1: Examine Funding Requirements

The Steering Committee will examine the funding stream's requirements to ensure that the mitigation activity would be eligible through the funding source. The Steering Committee may consult with the funding entity, Oregon Emergency Management, or other appropriate state or regional organization to determine the project's eligibility.

Step 2: Complete Risk Assessment Evaluation

The second step in prioritizing action items is to examine their associated hazards and where these hazards rank in terms of community risk. The Steering Committee will determine if the risk assessment supports implementing the proposed mitigation activity. This will be determined based on the location of the potential activity, the proximity to known hazard areas, historic hazard occurrence, and the probability of future occurrence documented in the plan. The risk assessment in the plan identified natural hazards from high to low risk as follows:

1. Severe Weather
2. Earthquake
3. Flood
4. Landslide
5. Wildfire

Each action item that is adopted into the plan addresses risk from one or more of these natural hazards.

Step 3: Complete Quantitative, Qualitative and Economic Analysis

Conducting a benefit/cost analysis for a mitigation activity can help the county determine whether a project is worth undertaking at the present time in order to avoid disaster-related impacts 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 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.

Depending on the type of project and the funding source, either a quantitative or qualitative assessment of cost effectiveness will be completed to assist in prioritizing potential actions. If the proposed activity is seeking federal funding for a structural project, the Committee will use a FEMA-approved cost-benefit analysis tool to evaluate the appropriateness of the activity. See ***Appendix C****: Economic Analysis of Natural Hazard Mitigation Projects* for a description of the FEMA-approved cost-benefit analysis. A project must have a benefit cost ratio of greater than one in order to be eligible for FEMA funding.

For FEMA-funded nonstructural projects or projects funded through entities other than FEMA, a qualitative assessment will be completed to determine the project's cost effectiveness. To prioritize these action items the Committee will use a multivariable assessment technique called STAPLE/E. The STAPLE/E technique evaluates the Social, Technical, Administrative, Political, Legal, Economic, and Environmental issues associated with the particular mitigation item. Assessing projects based upon these seven variables can help define the qualitative cost effectiveness of a project. The STAPLE/E technique has been tailored for natural hazard action item prioritization by the University of Oregon's Natural Hazards Workgroup. **See *Appendix C:*** *Economic Analysis of Natural Hazard Mitigation Projects* for a description of the STAPLE/E evaluation methodology.

Step 4: Committee Recommendation

Once the evaluations in the above steps are complete, the Committee will recommend whether or not the mitigation activity should move forward. If the Committee decides to move forward with the action, the coordinating organization designated for that activity will be responsible for taking further action and for documenting success upon project completion. The Committee will also review the issues surrounding grant applications and shared resources. This process will afford greater coordination and less competition for limited funds.

Plan Maintenance

Plan maintenance is a critical component of the natural hazard mitigation plan. Proper maintenance of the plan will ensure that this plan will benefit Linn County's efforts to reduce the risks posed by natural hazards. Linn County and its partners have developed a method to ensure that a regular review and update of the plan occurs.

The Committee will be responsible for maintaining and updating the plan through a series of meetings outlined in the maintenance schedule below.

Annual Meeting

The Committee will meet annually to:

- Review updates on local planning efforts;
- Review updates of the Risk Assessment data and findings;
- Discuss methods of continued public involvement; and
- Document successes and lessons learned based on actions that were accomplished during the previous year.

The convener will be responsible for documenting the outcomes of the annual meetings.

Five-Year Plan Review

The plan will be evaluated and updated every five years in accordance with the requirements of the Disaster Mitigation Act of 2000. During this plan update, the following questions should be asked to determine what actions are necessary to update the plan. The convener will be responsible for documenting the outcomes of the five-year plan review.

Table 5.2 provides a list of questions that can be used by the Committee to update the Hazard Mitigation Plan. The answers to these questions will help the committee determine what components of the mitigation plan need updating. The Committee will be responsible for updating any deficiencies found in the plan based on these questions.

Table 5.2
5-year Plan Review Questions

Introduction
Has the natural hazard framework at the local, state, or federal level changed?
Are there new local, regional, state or federal policies influencing natural hazards that should be addressed?
Have responsibilities of partner agencies changed?
Have recent hazard occurrences been accurately reflected in the plan?
Risk Assessment Data
Are there new studies or data available that would enhance the risk assessment?
Has the risk across the County changed?
Have there been changes in development patterns that could influence hazard risk?
Have new tools emerged to better evaluate the hazards?
Have activities been implemented that might change the County's overall risk?
Outreach Data
Are there new partners that should be brought to the table?

Action Plan Data
Are the Plan goals still applicable?
Do the goals, objectives and actions address current or expected conditions?
Have actions been effectively implemented?
Are there new funding sources available to mitigation the hazards?
Are there new actions that should be added to action plan matrix?
Plan Implementation Data
Are the structures and methods established for implementing the plan still relevant?
Have there been any lessons learned documented from recent events in other parts of the state that might be applicable to the community?
Has the community successfully implemented any mitigation activities since the plan was last updated?
What obstacles and challenges have arisen that have prevented or delayed implementation? Legal? Financial? Institutional?
What opportunities have arisen that could accelerate implementation?

Continued Public Involvement & Participation

Linn County is dedicated to involving the public directly in the ongoing reshaping and updating of the Plan. The Hazard Mitigation Steering Committee is responsible for monitoring and evaluating the progress of the mitigation strategy in the Mitigation Plan and for the annual review and update of the Plan. The members of the Steering Committee provide a wide range of public and professional experience. In addition to the Steering Committee members, the general public will continue to have the opportunity to provide feedback and input into the Plan.

Public participation has been incorporated into every stage of the plan development process. Copies of the plan will be catalogued and made available at the office of Linn County Emergency Management, the Planning and Building Department, the Linn County Commissioners, the County Recorder, and other appropriate county agencies. Copies of the plan and any proposed changes will also be posted on the Linn County and the Oregon Natural Hazard Workgroup (ONHW) web sites. These sites will contain the email address and phone number to which people can direct their comments and concerns.

The hazard mitigation action items may be made a part of many county documents that will be available for public review and comment. These include the budgeting process, capital improvement project reviews, Comprehensive Plan review and in goals and objectives developed by individuals departments.

All meetings where portions of the Mitigation Plan are discussed will provide the public a forum for which they can express concerns, opinions, or ideas about the plan and parts of it. Public meetings relating to plan maintenance and implementation will be publicized on the county web page and in local newspapers to ensure an opportunity for public input.

Section 6:
Flood

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Why Are Floods a Threat to Linn County?

Linn County has several large rivers and numerous smaller tributaries that are susceptible to flooding. Flooding poses a threat to life and safety and can cause severe damage to public and private property. It is necessary to evaluate past floods and the damages sustained from them in order to realize the potential impact of future floods.

Annual flooding occurs on all major and minor drainages in Linn County. Most flooding occurs during the months of December or January, although the actual flood season extends from October to April. During past floods, the worst flood damage occurred in the Tennessee District bottom lands; the Knox-Butte-Crabtree and Dever-Conner areas; and the Calapooia River drainage. The city of Scio is also vulnerable to severe flood impacts. Flood damage has occurred to commercial buildings in the cities of Albany, Lebanon and Sweet Home, however agricultural lands have suffered the most damage. The Soil Conservation Service has estimated that 140,000 acres are inundated during river and stream flooding each year in Linn County.[1]

History of Floods in Linn County

Linn County has a lengthy flood history. Most serious flooding in Linn County occurs in December and January. These events are often associated with La Nina conditions that result in prolonged rain and rapid snow melt on saturated or frozen ground. The resultant sudden impact of water swells rivers, causing tributary streams to back up and flood communities.

Spring snowmelt sometimes causes problematic flooding. Water flows more quickly over logged forestland, transmitting more rainwater into streams and rivers more quickly. Sheet flooding that originates from agricultural land that is far from a source river or stream may not be depicted on federal Flood Insurance Rate Maps.

Development also contributes to the severity of normal stream cycles. Urbanization and storm water runoff have had a significant impact on Willamette Valley flooding. Undersized culverts, bridge clearance, substandard dikes and levees, and debris dams also cause or exacerbate flooding problems.[2]

The principal riverine flood sources for Linn County are the Willamette River and its tributaries, especially[3]:

- The Calapooia River
- The North Santiam River
- The South Santiam River
- Thomas Creek
- Crabtree Creek
- Ames Creek
- Oak Creek
- Peavey Ditch
- Truax Creek

The most significant flooding to affect Linn County is related to the unregulated Calapooia River and creeks. Flood damage has occurred in the Scio area from Thomas Creek and the related drainage basin; from Crabtree Creek; in the area surrounding Oak Creek running between Albany and Lebanon; from Courtney Creek in the Brownsville-Halsey area; and from the Calapooia River, which extends from south central Linn County through Holley, Crawfordsville, Brownsville and the northwest corner of Albany, where it empties into the Willamette River. Property damage to homes and damage to crops and loss of livestock are the primary loss due to flooding in these areas. Transportation routes within the county can be disrupted from hours to days during a flood event. While technically not considered flooding, water from heavy rainfall ponding on farmland annually causes road closures as it flows across the roads.[4]

Table 6-1 below provides information on the previous occurrences of flooding in the mid-Willamette Valley region of Western Oregon.

Table 6-1
Significant Western Oregon Floods

Date	Location	Characteristics	Flood Type
Dec. 1861	Willamette Basin and Coastal Rivers	Proceeded by two weeks of heavy rain. Every town on the Willamette flooded or washed away.	Rain on snow; snow melt
Feb. 1890	Willamette basin and Coastal Rivers	Second largest known flood in the Willamette Basin. Almost every large bridge was washed downstream.	Rain on snow
Dec. 1937	Western Oregon	Flooding followed heavy rains. Considerable highway flooding; Landslides.	Rain on snow
Jan. 1953	Western Oregon	Widespread flooding in western Oregon accompanied by windstorm.	Rain on snow
Dec. 1964-Jan. 1965	Willamette Basin	Record flooding throughout Willamette Basin. Two intense storms. Near-record early season snow Depths. Largest flood in Oregon since dam construction on upper Willamette (1940s-50s).	Rain on snow
Jan. 1974	Western Oregon	Flooding followed heavy wet snow and freezing rain. Nine counties received Disaster Declaration	Rain on snow
Dec. 1978	Western Oregon	Intense heavy rain, snowmelt, saturated ground. 1 fatality in Region 3 (Benton County)	Rain on snow
Feb. 1986	Entire State	Severe statewide flooding. Rain and melting snow. Numerous homes flooded and highways closed.	Snowmelt
Feb. 1987	Western Oregon	Willamette River and tributaries. Mudslides; damaged highways and homes.	Rain on snow
Feb. 1996	Entire State	Deep snow pack, warm temperatures, record-breaking rains. Flooding, landslides, power-outages. (FEMA-1099-DR-OR)	Rain on snow
Nov. 1996	Entire State	Record-breaking precipitation; local flooding / landslides. (FEMA-1149-DR-OR)	Rain on snow

Source: Oregon Natural Hazards Plan, from Taylor, George and Raymond Hatton, 1999, *The Oregon Weather Book*, p.77-103.

The most recent significant floods in Linn County occurred in 1996, causing widespread damage in both rural and urban areas of the county and throughout the region. The February 1996 flood was caused by prolonged heavy precipitation that contributed to an early snowmelt. Many rivers and creeks throughout the Willamette River watershed rose to the mapped 100-year flood level inundating surrounding areas including cities. As the rivers and tributaries backed up, runoff from farm land also backed up causing flooding across the floor of the Willamette Valley, flooding farmland and rural communities. A Presidential Declaration of Emergency was declared and three lives were lost in Linn County as a direct result of the flood. Another major storm hit the area in November 1996, again causing urban and riverine flooding.

The two 1996 floods caused a combined $400 million in damages statewide, as 26 major rivers reached flood stage. More than 100 Red Cross and Salvation Army shelters were opened and 23,000 residents evacuated 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.[5]

The February 1996 flood resulted in property losses in Linn County of over $8 million. Most significantly, three residents of Linn County lost their lives in the flood, including an eight year old girl.[6]

Although the 1996 floods created a major disaster across the region, the floods of 1861, 1890 and 1964 were larger. The Christmas flood of 1964 caused over $157 million in damage statewide and twenty people lost their lives. The floods destroyed hundreds of homes and businesses, forced the evacuation of thousands of people, destroyed at least thirty bridges and washed out hundreds of miles of roads and highways.[7]

Causes and Characteristics of Flood Hazards

Flooding occurs when climate, geology and hydrology combine to create conditions where water flows outside of its usual course. Linn County's geography and climate combine to create chronic seasonal flooding conditions.

Precipitation

Linn County spans a wide range of climatic and geologic regions. The elevation in Linn County ranges from 125 feet above sea level along the Willamette River in western Linn County to 10,497 feet at the peak of Mt. Jefferson in eastern Linn County. The elevation changes cause significant differences in precipitation. Average annual precipitation ranges from 40 inches of rain on the valley floor to more than 85 inches of rain and snow at the Santiam Pass. Precipitation occurs primarily (79 percent) between the months of October through March, with very little precipitation falling between mid-June and mid-September.

Flooding is most common from November through March when Pacific storms bring intense rainfall to the area. The larger floods are more common between December and February when heavy rains lasting several days can combine with snowmelt and saturated soils from previous rains.

Geography and Geology

Approximately one-half of the land area and almost all of the population of Linn County lie within the Willamette River Basin, either on the valley floor or in the western Cascade foothills. The broad valley floodplain can be easily inundated by floodwaters from the Willamette River and its tributaries or by ponding and sheet flooding across the open farm fields. The valley floor consists of fine-grained deposits of Willamette silt, sand and gravel and includes many fine silts and clays of poor permeability.

According to the National Flood Insurance Program (NFIP), Oregon has 256 flood prone communities including all 36 counties. Flooding typically results from large-scale weather systems generating prolonged rainfall and from "rain on snow" events that cause large amounts of snowmelt. Other sources of flooding include flash floods associated with locally intense thunderstorms, ice jams, and dam failures.[8]

Many of Oregon's flood records were set in December 1964 and January 1965 during the "Christmas Flood." From December 20th through 24th, 1964, the most severe rainstorm to occur in Central Oregon and one of the most severe west of the Cascades left many areas with two-thirds their normal annual rainfall in five days. A similar flood event occurred in February 1996. Following an extended period of unseasonably cold weather and heavy snowfall in the Pacific Northwest, warming temperatures and rain began thawing the snowpack and frozen rivers throughout Oregon. On February 6, a strong subtropical jet stream or "pineapple express" reached Oregon. This warm, humid air mass brought record rainfall amounts, quickly melting the snow pack.[9]

Types of Flooding

There are three primary types of flooding in Linn County: riverine flooding, urban area flooding, and shallow area flooding or ponding. Some areas of Linn County within the western Cascades or possessing steep topography may also be subject to flash floods.

Riverine Floods

Riverine flooding is the most common flood hazard in Linn County. It is caused by the passage of a large quantity of water than cannot be contained within the normal stream channel. The increased stream flow is usually caused by extensive rainfall over a period of several days. The most severe flooding conditions generally occur when rainfall is augmented by snowmelt. If the ground is saturated or frozen, stream flow can be increased even more by the inability of the soil to absorb additional precipitation. Examples of riverine events are the flooding in February 1996 and December 1964 to January 1965.[10]

Riverine floods generally develop from large-scale weather systems that generate prolonged rainfall over a wide geographic area over a period of days, thus providing some level of advance warning. Riverine flooding occurs mainly during the winter months, with the onset of persistent, heavy rainfall, and during the spring, with the melting of snow in the Cascade range.

Flash Floods

Flash floods are a major cause of weather-related deaths in the United States. Flash flooding is caused by extremely intense rainfall over a short period of time, commonly within a single drainage. Flash floods can occur with little or no warning and can reach full peak runoff in only a few minutes. Flash floods are most common in arid and semi-arid areas where there is steep topography.[11]

Central and Eastern Oregon are the areas of the state that are most susceptible to flash flooding. Flash floods usually occur in the summer during the thunderstorm season. The key contributors to flash flooding are rainfall intensity and duration. Topography, soil conditions and ground cover also impact flooding. Flash floods, because of their intensity, often pick up large loads of sediment and other solid materials. In these situations, a flash flood may arrive as a fast moving wall of debris, mud and water. Linn County does not have any areas currently identified as being susceptible to flash floods.

Occasionally, floating debris or ice can accumulate at a natural or man-made obstruction and restrict the flow of water. Water held back by the ice jam or debris dam can cause flooding upstream. Subsequent flash flooding can occur downstream if the obstruction suddenly releases. Areas subject to flash floods are not as obvious as a typical riverine floodplain. However, flash floods may be associated with recognizable locations such as canyons or arroyos. The most notorious flash flood in Oregon is the June 1903 event in Heppner.[12]

Shallow Area Flooding

Some areas are characterized by FEMA as being subject to shallow flood hazards with flood depths of only one to three feet. These are areas inundated by the 100-year flood with flood depths of one to three feet. These floods are usually low velocity events characterized by "sheet flows" of water, and are common in some areas of the Willamette Valley floor.

Urban Flooding

As land is converted from fields or woodlands to roads and parking lots, it loses its ability to absorb rainfall. The transition from pervious surfaces to impervious surfaces results in more water running off instead of infiltrating into the ground. The water also runs off into watercourses more quickly. During periods of urban flooding, streets can become swift moving rivers, and basements can fill with water. Storm drains often back up with yard waste causing additional flooding.[13]

Dam Failure Flooding

There are 18 dams in Linn County of various sizes and function. The National Inventory of Dams (NID) identifies 12 Linn County dams in its inventory. The NID also identifies seven dams considered to be High Hazard Potential dams. A major failure to one of these High Hazard Potential dams would almost certainly cause loss of life, and may also cause damage to structures, roads, utilities and crops, and result in economic losses.

Because dam failure can have severe consequences, FEMA requires dam owners to develop Emergency Action Plans (EAP) for warning, evacuation, and post-flood actions. According to the Oregon Water Resources Department (WRD) three of Linn County's High Hazard Potential dams – Smith River, Trail Bridge, and the Willamette National Log Pond – do not have emergency action plans filed. These three are privately owned dams.

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. These areas, if left undisturbed, act to store excess flood water. The floodplain is made up of two sections: the floodway and the flood fringe.[14]

100-Year Flood

The "100-year" floodplain (or base flood) is that area where there is a 1% chance of a flood of that magnitude or greater in any given year. The 100-year floodplain is the area adjoining a river, stream, or watercourse covered by water during a 100-year flood event.

Floodway

A floodway is the channel of a river and the portion of the floodplain that carries most of the flood flow. Floodways are usually the area where water velocities and forces are the greatest and most destructive. The NFIP definition of floodway 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." NFIP regulations, adopted in local ordinances, require that the floodway be kept open so that flood flows are not obstructed or diverted onto other properties.[15]

Flood Fringe

The flood fringe refers to the outer portions of the floodplain, beginning at the edge of the floodway and continuing outward. The Linn County Floodplain Management Code (Linn County Code (LCC) 870.050(M)) defines the "flood fringe" as: "that portion of the floodplain that lies beyond the floodway and serves as a temporary storage area for flood waters during a flood."

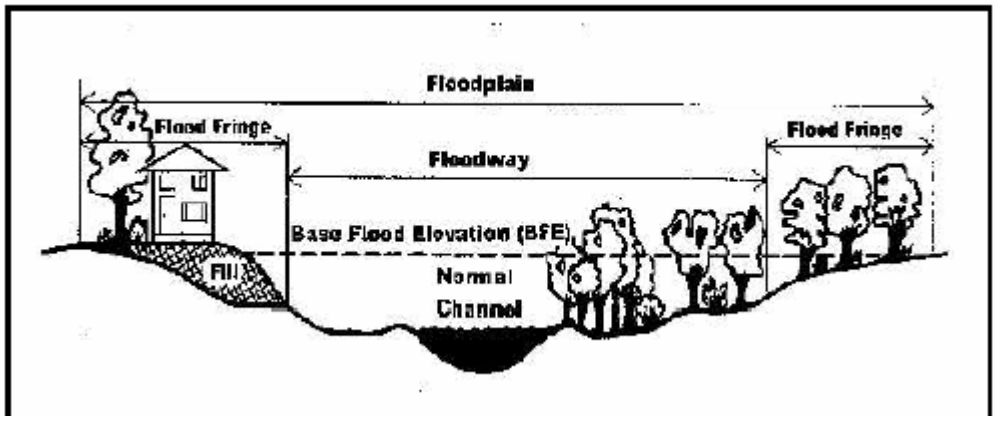
Base Flood Elevation (BFE)

The term "Base Flood Elevation" refers to the elevation (measured in feet above sea level) that the base flood (100-year flood) is expected to reach.

Development

The Linn County Floodplain Management Code (LCC 870.050(H)) defines "development" as: "any manmade change to improved or unimproved real estate including but not limited to buildings or other structures, partitioning or subdividing, mining, dredging, filling, grading, paving, excavation or drilling operations.

Figure 6-1
Flood Hazard Schematic



Source: Oregon State Natural Hazard Mitigation Plan, June 2000, FL-5

Probability and Flood Risk

Flood risk or probability is generally expressed by frequency of occurrence. It is measured as the average recurrence interval of a flood of a given size and is stated as the percent chance that a flood of a certain magnitude or greater will occur in any given year. The Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) is based on the risk associated with a "100-year" or base flood. This is a flood that has a 1% chance of occurring in any year or a 26% chance of occurring during the life of a 30-year home mortgage.[16]

Information regarding the probability of flooding at a given location is provided by Flood Insurance Studies (FIS) and Flood Insurance Rate Maps (FIRMs) produced for the NFIP. Many of the flood studies in Oregon were conducted in the late 1970s and early 1980s. The Linn County FIRMs were published on September 29, 1986.

These studies and maps represent flood risk at a point in time and don't reflect changing conditions in the watershed. For example, many urban areas, rural communities and rural residential areas have had significant population increases during the past twenty years. Increased development changes the hydrology of urban streams as increased impervious surface results in greater runoff volumes and velocities.

Although many communities rely exclusively on FEMA's flood insurance maps to characterize the risk of flooding in their area, some jurisdictions have developed their own flood hazard maps. For example, several jurisdictions in Oregon have used high water marks from the February 1996 flood events in conjunction with the FEMA maps to better reflect the true flood risk. Some communities have used aerial photos taken during the 1996 and 1997 floods to serve as a benchmark for predicting flood impacts.[17]

There is insufficient data to determine the probability of future flood occurrence and severity at specific locations across the county. However, based on past flood events and Linn County's flood history the probability is high that portions of the county will experience severe flooding at some point in the future.

Flood Warnings

The National Weather Service (NWS) of the National Oceanic and Atmospheric Administration is the federal agency in charge of weather forecasts and warnings for the nation, including flood forecasts and warnings. In Oregon, the NWS accomplishes this mission through the Northwest River Forecast Center and forecast offices located in Medford, Pendleton, and Portland, Oregon, and in Boise, Idaho.

Flood forecasts are developed using information from U.S. Geological Survey's (USGS) stream gauging stations, and from gauges operated by state Water Resources Department (WRD). USGS and WRD each have approximately 200 stream gauges in Oregon. Real time stream data is available on line for many of Oregon's larger river basins including the Willamette. Many of these gauges are available real time on the internet and most of the historical data can also be accessed via web sites. Flood warnings generally refer to flood levels that will be a number of feet above "flood stage." In general, flood stage is the water surface level at which water begins going over the banks.[18]

Community Rating System

Currently, fifteen Oregon communities participate in the Community Rating System. These communities have adopted floodplain development standards that are more protective than those required by the National Flood Insurance Program. They have also developed hazard mitigation plans, preserved land and open space for flood storage and to keep structures out of harm's way, and conducted public outreach on flood hazards. Residents in these communities benefit through reduced flood insurance rates.

Several communities that are not currently participating in the CRS are also implementing floodplain development standards that are more protective than the NFIP. These include Tillamook County, which requires the elevation of residential structures three feet above the base flood elevation; and Marion County, which requires elevation two feet above BFE, and applies its regulations to an area more extensive than those included on Flood Insurance Rate Maps (FIRM).[19]

Linn County does not participate in the CRS program. Within Linn County, the City of Albany participates in the CRS program, with a current rating of 8. The City of Scio also participates in the CRS program, with a current rating of 9.

Flood Hazard Assessment

The flood hazard assessment provides information on the location of flood hazards, the land and property characteristics within the hazard area, and an assessment of risks to life and property that may result from a flood hazard event. The three elements of hazard assessment are: (1) hazard identification; (2) vulnerability assessment; and (3) risk analysis.

Hazard Identification

The first phase of flood-hazard assessment is hazard identification. Hazard Identification identifies: (1) the geographic extent of areas subject to flooding, (2) the expected intensity of a flood event at different locations, and (3) the probability of occurrence of flood events.

Flood hazard information is depicted using floodplain maps. The County uses the detailed information on floodplain maps to help make policy and land-use decisions. The floodplain maps will help the project Steering Committee analyze vulnerability and risk and identify flood mitigation action items.

The Federal Emergency Management Agency (FEMA) mapped the 100-year and 500-year floodplains in Linn County through the Flood Insurance Study (FIS). Information regarding the probability of flooding at a given location is provided by the FEMA Flood Insurance Rate Maps (FIRMs) produced for the National Flood Insurance Program (NFIP). The Linn County FIRMs were published on September 29, 1986.

The FIRM floodplain information is incorporated into the county's Geographic Information System (GIS) data. Occasionally, individual property owners, in the course of developing their property, will request Letters of Map Amendments from FEMA to indicate that a specific area of their property is outside the 100-year floodplain. The County GIS also includes elevation contour data for western Linn County at five-foot intervals in rural areas and two-foot intervals in urban areas. Improved elevation contour information could be useful in the future in improving the accuracy of the local FIRM maps.

Flood Hazard Vulnerability Assessment

Section 201.6(c)(2)(ii)(A) of the Disaster Mitigation Act of 2000 requires that risk assessments include a description of the jurisdiction's vulnerability to the hazard. This description shall include an overall summary for the hazard and its impact on the community. Vulnerability is described later in this chapter in terms of the type and number of existing and future buildings, infrastructure, and critical facilities located in identified hazard areas.

Linn County Vulnerability Summary

Vulnerability assessment is the second phase in flood hazard assessment. Vulnerability assessment inventories property development and populations that are located within a flood hazard area and so are vulnerable to flooding. Locating and understanding the population, property and facilities that are exposed to flood hazards will assist in reducing risks and preventing losses from future flood events.

The amount of property within the floodplain and the value of those properties must be calculated to estimate potential flood losses. Calculating the county's vulnerability to flood events is difficult because site-specific inventory data, including inundation levels for a specific flood event (i.e. 10-year, 50-year, or 100-year) are not readily available.

Notwithstanding these data limitations, a regional risk assessment completed in 1998 estimated the area, number of tax lots, and road miles in the 100-year floodplain in Linn County, as shown in ***Table 6-2***.

Table 6-2
Flood Hazard Summary

Area in the 100-year Floodplain (Acres)	110,464 acres
Area in the 100-year Floodplain (Square Miles)	173 square miles
Roads in the 100-year Floodplain (Miles)	302.50 miles
Tax lots partially or completely within the 100-year Floodplain	7130

Source: Linn County GIS; and Regional All-Hazard Mitigation Master Plan July 27, 1998

The Regional All-Hazard Mitigation Master Plan, July 27, 1998, estimated the number of buildings and the total value of buildings within the 100-year floodplain in Linn County using a model based on census tract, floodplain, road mile, and aggregate building data. The building vulnerability information is shown in ***Table 6-3***.

Table 6-3
Flood Hazard Vulnerability by Building Type

Item	Residential	Commercial	Industrial	Agricultural	Public	Total
Buildings in 100-Year Floodplain	2694	47	32	10	8	2791
Square Footage in 100-Year Floodplain	4099	895	904	139	144	6180
Potential losses in 100-Year Floodplain (x$1000)	$87,218	$19,038	$19,230	$2,948	$3,064	$131,498

Source: Regional All-Hazard Mitigation Master Plan July 27, 1998

To update the 1998 hazard and vulnerability estimates of the types and number of buildings, infrastructure, and critical facilities in the flood hazard area, more detailed GIS studies need to be conducted. The County currently has insufficient data to complete this step of the vulnerability assessment. Additional inventory data needed might include:

- Updated FEMA Flood Insurance Rate Maps
- Geo-coded building location, type, occupancy, footprint and ground floor elevation data. A mechanism would be needed to collect this information.
- Inundation level at each building for a particular flood event. Elevations could be developed from flood survey data; using aerial surveys of flood photos to derive vertical elevation data at a building location; or using field survey data collected by utilities during the course of road construction, pipe burial or other facilities improvements.

Community Flood Impacts

The type of property damage caused by flood events depends on the depth and velocity of the floodwaters. Faster moving floodwaters can wash buildings off their foundations and sweep cars downstream. Pipelines, bridges, and other infrastructure can be damaged when high waters combine with flood debris. Extensive flood damage can be caused by basement flooding and landslide damage related to soil saturation from flood events. Surface water entering into crawlspaces, 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. Most flood damage is caused by water saturating materials susceptible to loss (e.g., wood, insulation, wallboard, fabric, furnishings, floor coverings, and appliances). Most of the losses in the 1996 floods were due to saturation damage.

Private property flood issues

All development within the floodplain must conform to the requirements of the Linn County Floodplain Management Code (LCC Chapter 870). The purpose of the Floodplain Management Code is to promote public safety and welfare and to reduce the potential for loss of life and property damage. This is achieved by requiring construction in a manner that will reduce flood impacts; managing the alteration of the floodplain, channels and natural barriers that accommodate or channel flood waters; and other planning measures. In 1996, flood damage to private property totaled one-third of damages statewide.[20] The Floodplain Management Code helps to reduce public costs for emergency operations, relief, evacuations and restorations and reduces flood insurance and development costs through floodplain management.

Homes

Housing losses accounted for the largest share of private property damage during the 1996 flood events.[21] In Linn County, FEMA awarded 312 Housing Assistance Grants totaling $686,576 and 98 Family Assistance Grants totaling $151,941. The Small Business Administration reported the approval of 78 loan applications for homes totaling $1,102,800.[22] Homes in frequently flooded areas can also suffer damage to septic systems and drain fields. Homes in rural floodplain areas often depend on private sewage treatment systems. Inundation of these systems may result in leakage of wastewater into surrounding areas. In many cases, flood damage to homes can render them unlivable.

Manufactured Homes

Statewide, the 1996 floods destroyed 156 housing units. Of those units, 61 percent were mobile homes and trailers.[23] Several older manufactured home parks in Linn County are located in floodplain areas. Manufactured homes have a lower level of structural stability than "stick-built" homes. A stick-built home's foundation and building frame are put together on site as opposed to manufactured homes which are pre-fabricated off site.[24] Manufactured homes in floodplain zones must be anchored to provide additional structural stability during flood events. Linn County enforces the manufactured home construction standards in LCC Chapter 870 for development in floodplains to reduce the severity of damages from flood events.

Business and Industry

Flood events impact businesses by damaging property and by interrupting commerce. Flood events can cut off customer access to a business as well as close a business for repairs. As a result of the 1996 floods, the Small Business Administration reported that it approved 21 loans for businesses in Linn County that were damaged in the flood, totaling $656, 300. It is estimated that the loans protected 41 jobs that otherwise would have been lost.[25]

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.

Public Infrastructure

Publicly owned facilities are a key component of daily life for all citizens of Linn 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, and to craft public policy that reduces risk to private property from flood events.

Buildings and Roads

In the wake of the 1996 floods, damage to public buildings statewide represented 34 percent of total public losses.[26] Of particular importance during flood events are facilities critical to government response and recovery activities that are located in flood hazard areas.

During natural hazard events, or any type of emergency or disaster, dependable road connections are critical for providing emergency services. The Linn County Road Department is the primary response agency in Linn County for maintaining roadways and bridges, maintaining culverts and roadside drainage systems to reduce flood impacts, monitoring roadway emergencies, closing flooded roadways, and taking necessary emergency maintenance measures to keep roadways functioning during flood events.

Bridges

Bridges are key points of concern during flood events for two primary reasons:

(1) They are often important links in road networks, crossing water courses or other significant natural features; and,

(2) They can be obstructions in watercourses, inhibiting the flow of water during flood events.

Damaged bridges can disrupt or cut off traffic flow and impede access to and by emergency services. They can also lead to economic losses when commuters and consumers have difficulty reaching their destinations and when businesses are unable to deliver products and services to their clients.

There are approximately 586 bridge crossings in Linn County, including state highways, county roads and urban areas. Linn and Benton counties are separated by the Willamette River and there are only two bridge crossing points linking the two counties, comprising five total bridges. Two are on Highway 20 in Albany and three are on Highway 34 at Corvallis. While these bridges are constructed out of the floodplain, numerous other low-lying state and county bridges are susceptible to flooding. Examples during the 1996 flood include bridges on Highway 226 south of Scio; Highway 228 west of Brownsville; and numerous culverts and smaller bridges on rural roads throughout the valley. Flooding at bridge crossings isolates small communities and rural home sites and impedes access to emergency services.

Floods and Natural Systems

Maintaining and restoring natural systems helps mitigate the impact of flood events on the built environment. Floods can change 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. Maintaining these natural flood reservoir areas reduces downstream flood levels and impacts.

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 willow and cottonwood trees. Healthy vegetation in riparian buffers can reduce streamside erosion.[27] During flood events, high water can cause significant erosion. Well-managed riparian areas can reduce the amount of erosion and help to protect water quality during flood events. To help protect these areas, the Linn County Land Development Code restricts development within a 50-foot riparian buffer around rivers, streams, lakes and wetlands.

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.[28]

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.[29]

Linn County coordinates with the Oregon Division of State lands to restrict development, fill or removal activities that may impact identified wetlands. The Linn County Land Development Code also restricts development within a 50-foot buffer area around inventoried wetlands.

Repetitive Flood Loss Areas

A Repetitive Loss Property is defined as any property with two or more losses in any 10-year rolling period. If there are two losses within 10 days of each other only one of those losses is counted. This is used only for purposes of selecting a property. In order for a loss to be considered for a repetitive loss file, it must have occurred on or after January 01, 1978, been closed, and have at least $1,000 in payments.

FEMA identifies five properties as repetitive flood loss properties within unincorporated Linn County. If incorporated properties were included, the number would be much larger. Four of the five properties received this classification due to impacts from the two 1996 floods. One property near Scio was impacted by the February 1996 event and again in December 1998. NFIP claims and loss data are protected by the Privacy Act and are for internal use only. NFIP data can be aggregated for use in the plan so that no particular property can be easily identified. The following five areas in ***Table 6-5*** are identified by FEMA as containing repetitive flood loss properties in Linn County.

Table 6-4
Repetitive Flood Loss Properties

Location	Occupancy	Flood Zone	Date of Loss
Millersburg Area, North of Albany	Single Family	C	11/19/1996 02/08/1996
Oakville Road, SW of Albany	Single Family	A	11/19/1996 02/06/1996
Peoria Road, SW of Corvallis	Single Family	A11	11/20/1996 02/08/1996
Stayton-Scio Road North of Scio	Single Family	A04	12/28/1998 02/08/1996
Waterloo Road, South of Lebanon	Single Family	C	11/19/1996 02/06/1996

Source: FEMA

Risk Analysis

Risk analysis is the third and most advanced phase of hazard assessment. Risk analysis builds on the hazard identification and vulnerability assessment to estimate the damage, injuries and economic losses that may be sustained within a hazard area over a given period of time. The risk analysis uses mathematical models based on the magnitude of the harm that may result and the likelihood of the harm occurring.

A flood risk analysis for Linn County would include at least two components: (1) the life and value of property that may incur losses from a defined flood event; and (2) the number and type of flood events expected to occur over time. A risk analysis would predict the severity of damage from a range of events.

Flow velocity models can be used to predict the amount of damage expected from different magnitudes of flood events using hydrological analysis of landscape features. It may be possible to use flow velocity models with the county's GIS to map the expected damage from flood events over the region and on specific property.

Currently there is insufficient data to conduct a detailed risk analysis for flood events in Linn County. The mitigation plan may include recommendations for improved data and partnerships that may lead to detailed flood risk analysis in the county.

Flood Hazard Mitigation Programs

Existing flood mitigation programs and strategies are principally the responsibility of the Department of Land Conservation and Development (DLCD), the state Building Codes Division (BCD), and the Office of Emergency Management (OEM). In addition to state programs, the National Flood Insurance Program (NFIP) of the Federal Emergency Management Agency (FEMA) is designed to help minimize flood losses through floodplain management. The NFIP relies on insurance, mortgage lending requirements, and floodplain development standards to reduce flood losses.

Goal 7 of the statewide planning goals, administered by DLCD, requires local governments to adopt flood protection policies and controls. The DLCD also administers the NFIP in Oregon, and every community with identified flood hazards is a member of this program. Thus, these local governments are required to adopt the NFIP's minimum requirements. The NFIP is comprised of a flood hazard mapping component, an enforcement component, technical assistance, and insurance which provides a financial safety net for owners of improved property. Together, all four components of the NFIP work together to reduce flood losses.

The state building code for one and two family dwellings and manufactured dwellings requires that the lowest living space in a dwelling be elevated at least one foot above the base flood elevation (BFE). Other buildings are also regulated and required to be elevated a minimum of one foot above base flood elevation or flood proofed.

OEM is involved in many programs which mitigate the effects of flooding including the Hazard Mitigation Grant Program, the Flood Mitigation Assistance Program, co-sponsoring and participating in training and workshops, and "Project Impact" - Building Disaster Resistant Communities. Also, as part of its warning responsibilities, OEM notifies local public safety agencies and keeps them informed of potential and actual flood conditions so prevention and mitigation actions can be taken.[30]

Linn County Programs

Comprehensive Plan

The Linn County Comprehensive Plan at LCC 903.200 through 903.280 includes an inventory of areas subject to natural hazards and a set of Plan policies to guide development within known hazard areas. The FEMA FIRM maps are adopted as the county's flood hazard inventory. Risk reduction measures in areas subject to natural disasters and hazards are implemented through application of the County's Land Development, Floodplain Management and Building Codes.

Land Development Code

The Land Development Code protects public safety and restricts development activities within inventoried natural hazard areas. The Development Code requires grading permits when needed, and requires compliance with the Oregon One and Two Family Dwelling Code (CABO), the Uniform Building Code (UBC), and the Linn County Floodplain Management Code. All development regulated by the Land Development Code must be located outside the mapped 100-year floodplain unless it is demonstrated that the use can be designed and engineered to comply with accepted hazard mitigation requirements.

Floodplain Management Code (LCC Chapter 870)

All development within the floodplain must conform to the requirements of the Linn County Floodplain Management Code (LCC Chapter 870). The purpose of the Floodplain Management Code is to promote public safety and welfare and to reduce the potential for loss of life and property damage. This is achieved by requiring construction in a manner that will reduce flood impacts; by managing the alteration of the floodplain, channels and natural barriers that accommodate or channel flood waters; and other planning and site development measures. The FIRM floodplain information is incorporated into the county's Geographic Information System (GIS) data. Grading permits and removal/fill regulations are also administered through the Floodplain Management Code.

Public Facilities

The Linn County Road Department maintains county roadways, bridges, culverts and roadside drainage systems to reduce flood impacts.

State Programs

State of Oregon Floodplain and Floodway Removal/Fill Law

The Oregon Removal/Fill Law, which is administered by the Oregon Division of State Lands, requires a permit for activities that would remove or fill 50 cubic yards or more of material in waters of the state (e.g., streams, lakes, wetlands). Linn County must comply with the removal/fill laws when designing and building facilities, and have related responsibilities when dealing with private development and other construction projects.[31]

Oregon's Wetlands Protection Program

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

Oregon Wetlands Joint Venture

The Oregon Wetlands Joint Venture is a coalition of private conservation, waterfowl, fisheries, and agriculture organizations working with government agencies to protect and restore important wetland habitats.[32]

Federal Programs

National Weather Service

The National Weather Service provides flood watches, warnings, and informational statements for rivers throughout Linn County.

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

NRCS provides a suite of federal programs designed to assist state and local governments and landowners in mitigating the impacts of flood events. The Watershed Surveys and Planning Program and the Small Watershed Program provide technical and financial assistance to help participants solve natural resource and related economic problems on a watershed basis.

The Wetlands Reserve Program and the Flood Risk Reduction Program provide financial incentives to landowners to put aside land that is either a wetland resource, or that experiences frequent flooding. The Emergency Watershed Protection Program (EWP) provides technical and financial assistance to clearing debris from clogged waterways, restoring vegetation, and stabilizing riverbanks. The measures taken under EWP must be environmentally and economically sound and generally benefit more that one property.

Federal Emergency Management Agency (FEMA) Programs

The Federal Emergency Management Agency (FEMA) resulted from the consolidation of five federal agencies that were dealing with different types of emergencies. Since then, many states and local jurisdictions have accepted this approach and changed the names of their organizations to include the words "emergency management." FEMA provides maps of flood hazard areas, various publications related to flood mitigation, funding for flood mitigation projects, and technical assistance.

National Flood Insurance Program (NFIP)

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

The Community Rating System (CRS)

The Community Rating System (CRS) recognizes community floodplain management efforts that go beyond the minimum requirements of the NFIP. The cities of Albany and Scio participate in the CRS program. At the current time, Linn County does not. If the County were to implement floodplain management practices that qualify for participation in the CRS program, property owners within the County could receive reduced NFIP flood insurance premiums.

Flood Mitigation Action Items

The flood mitigation action items provide direction on specific activities that organizations and residents in Linn County can undertake to reduce risk and prevent loss from flood events. There is one short-term flood hazard action item and there are three long-term flood hazard action items, described below.

Short-term Action Items

FL-ST #1: Action 2.1.4. Explore participation in the National Flood Insurance Program's Community Rating System

Coordinating Organization: Planning and Building Department
Internal Partners: Building Official; Emergency Management
External Partners: FEMA; Insurance Companies; Small Cities
Timeline: Ongoing
Plan Goals Addressed: Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective: Objective 2.1. Incorporate mitigation into planning and policy development.

Long-term Action Items

FL-LT #1: Action 2.1.5. Explore the development of management strategies to preserve the function of the floodplain

Coordinating Organization: Planning and Building Department
Internal Partners: Building Official; Board of Commissioners
External Partners: FEMA; DSL; ODFW; OWRD; Watershed Councils
Timeline: Ongoing
Plan Goals Addressed: Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective: Objective 2.1. Incorporate mitigation into planning and policy development.

FL-LT #2: Action 2.2.3. Update Flood Insurance Rate Maps

Coordinating Organization: Planning and Building Department
Internal Partners: Building Official; Emergency Management
External Partners: FEMA; OEM; Insurance Companies; Small Cities
Timeline: 2-5 years
Plan Goals Addressed: Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective: Objective 2.2. Support the enhancement of County vulnerability assessment activities.

FL-LT #3: Action 3.3.2. Support multi-objective stream and river enhancement projects that maximize flood mitigation

Coordinating Organization: Board of County Commissioners
Internal Partners: Emergency Management
External Partners: Water Control Districts; Watershed Councils; FEMA; DSL; ODFW; OWRD; DOF; DEQ; USCE; Cities
Timeline: Ongoing
Plan Goals Addressed: Goal 3. Protect life, the built environment, the economy and natural resources through community-wide partnerships.
Plan Objective: Objective 3.3. Develop partnerships with external partners for hazard specific mitigation projects.

Flood Hazard Endnotes

[1] Natural and Geologic Background Report, Linn County, 1980 pp. 4

[2] Oregon Natural Hazards Mitigation Plan, November 2003

[3] Federal Emergency Management Agency (FEMA), Linn County FIS, 09/29/86)

[4] Linn County Emergency Management, 2002 Hazard Analysis

[5] Oregon Emergency Management (OEM); State of Oregon Emergency Management Plan (June 2000)

[6] Cascades West Council of Governments, 1996 Regional Flood Recovery Plan (Dec. 11, 1996), pp. 100

[7] OEM; State of Oregon Emergency Management Plan (June 2000)

[8] Ibid.

[9] Ibid.

[10] Ibid.

[11] University of Oregon; Community Service Center; Oregon Natural Hazards Technical Resource Guide

[12] OEM; State of Oregon *Natural Hazards Mitigation Plan* (June 2000)

[13] Ibid.

[14] Ibid.

[15] Ibid.

[16] Ibid.

[17] Ibid.

[18] Ibid.

[19] Ibid.

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

[21] Ibid.

[22] 1996 Regional Flood Recovery Plan, Cascades West Council of Governments, pp. 100

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

[24] Personal Interview, Ed McMahon. June 24, 2003

[25] 1996 Regional Flood Recovery Plan, Cascades West Council of Governments, pp. 100

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

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

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

[29] Ibid.

[30] Ibid.

[31] *Surface Water Management Framework*. (January 2001). Clean Water Services (formerly Unified Sewerage Agency.)

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

Section 7:
Landslide

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Why are Landslides a Threat to Linn County?

Landslides are a serious geologic hazard in many states, including Oregon. Nationally, landslides cause 25 to 50 deaths each year and can pose a serious threat to human life.[1] The best estimates of the direct and indirect costs of landslide damage in the United States range between $1 billion to $2 billion annually.[2] Although not all landslides result in private property damage, many impact transportation corridors, fuel and energy conduits, and communication facilities.[3]

Landslides and debris flows have helped shape the landscape in much of Linn County. Development, road building and logging can cause or contribute to the severity of landslides. Landslides become hazardous when buildings and infrastructure are placed within their path. In general, slopes that are over 25 percent or have a history of landslides might signal a landslide problem. However, landslides can also occur in areas of generally low relief in the form of cut-and-fill failures, river bluff failures, lateral spreading landslides and mining slope failures.

Table 7-1 describes some of the major landslides that have occurred in Oregon over the last 75 years. The list is not all-inclusive, but focuses on slides that caused loss of life or significant damage. Although most of the listed events were outside of Linn County, all serve as indicators of the type of landslide events likely to occur in the region.

Table 7-1
Major Landslides in Oregon

February 1926	A landslide closed Roosevelt Highway between Coos Bay and Coquille, causing at least $25,000 in damage.
November 1928	A landslide killed two workmen working on a railroad tunnel near Baker.
August 1957	A rockslide killed two quarry workers near Westfir.
February 1961	A large section of Ecola State Park, including the parking lot, slid into the Pacific ocean near Cannon Beach.
March 1972	Three motorists were injured in a mud and rockslide on Interstate 5 near Portland.
January 1974	Nine employees working in a telephone company building were killed when the building was pushed by a mudslide into Canyon Creek near Canyonville.
October 1984	Two children were killed in a rockslide along Interstate 84 near Cascade Locks. The cost of stabilizing the slide area eventually reached $4 million.
September 1990	Four highway workers were injured in a landslide near Troutdale.
February 1996	Heavy rains and rapidly melting snow contributed to hundreds of landslides across the state, many occurring on clear cuts that damaged logging roads.
November 1996	Heavy rain triggered mudslides in Lane and Douglas Counties that resulted in eight fatalities.
February 1999	Two timber workers were killed in a mud and rockslide south of Florence.
January 2000	A landslide north of Florence closed Highway 101 for three months, resulting in major social and economic disruption to nearby communities.

Source: Department of Land Conservation and Development, Natural Hazards Program Website, http://www.lcd.state.or.us

There are several categories of landslides, based on configuration (slide mechanism), slide materials, and rate of movement. Some slides are ancient, deep-seated, and slow moving. Others move rapidly as a mass of rock, mud, and large woody debris. All can be hazardous when in the vicinity of buildings and infrastructure. Oregon counties with the highest percentage of reported landslides are: Lane (24%), Douglas (11%), Linn (10%), Tillamook (9%), Lincoln (8%), and Multnomah (7%).[4]

Landslides and debris flows usually accompany the major storm systems that impact western Oregon. Particularly noteworthy landslides accompanied storms in 1964, 1982, 1986, and 1996. Two major landslide producing winter storms occurred in Oregon during 1996. Intense rainfall triggered over 9,500 landslides and debris flows, some of which resulted directly or indirectly in eight fatalities. Highways were closed and a number of homes were lost statewide. The fatalities and losses resulting from the 1996 landslides led to the passage of Oregon Senate Bill 12, which authorized the mapping of areas subject to rapidly moving landslides and the development of model landslide ordinances.[5]

Mass Movement Topography[6]

Mass Movement topography is terrain for which prior landslide activity is inferred on the basis of topographic expression. Mass Movement topography is shown on ***Map 7-1***. Mass Movement topography in Linn County occurs primarily on the Little Butte terrain of the Cascades Formation and in places where landslides undercut Columbia River Basalt. On slopes of 15 percent to 50 percent, weathering and failure occur at depths great enough to leave visible evidence of mass movement. On steeper slopes, shallower types of mass movement occur.

In north central Linn County, massive slope failures are present on the sides of Hungry Hill, Rogers Mountain, McCully Mountain, and other high ridges leading eastward towards Detroit Dam. The slides typically develop in the Little Butte Formation and undercut the crests, forming pronounced head scarps. Depth of failure is great below the larger head scarps, and landslide features are well-developed in places. Landslides are occurring in the Cascades Formation on the lower flanks of Snow Peak. On the south side of the mountain along Crabtree Creek rapid down cutting is initiating a series of active slides. Numerous scattered patches of mass movement topography are mapped in the region bounded by Lebanon, Brownsville, and Sweet Home. Sliding is restricted to thick soils and tuffs of the Little Butte Formation. Most of these are underlain by basaltic intrusions and are generally stable.

Damage to structures may occur in areas of mass movement topography through continued slide movement, uneven settling, or a variety of related processes. Cuts, fills, and changes of the ground water budget through use of septic tanks or improper handling of runoff are common factors in reinitiated slide activity.

Several areas of mass movement topography in western Linn County are zoned for residential development. These include some of the slopes south of Lyons, the north side of Rogers Mountain, the Ward Butte area north of Brownsville, the slopes east of Lebanon, the valley areas of the Calapooia drainage, and the lower slopes of Mount Tom in southern Linn County. Without proper development considerations, considerable structural damage could occur in these areas in future years.

The major impacts of mass movement in areas of logging include road and cut-bank failure and the contribution of huge volumes of debris and sediment to streams. A good example is the repeated failures on the upper Crabtree Creek Road leading to Snow Peak Camp.

Steep Slope Failure[7]

Types of landslide on steep slopes (slopes greater than 50 percent) include rockfall, rockslide, and shallow earthflow or mudflow. Unlike deep failures, such as those involved in mass movement topography, failures on steep slopes do not penetrate to great depths. Slope maps may be used to define general areas especially prone to these forms of landslide.

In Linn County, failures on steep slopes are most common along the upper reaches of the Calapooia, Middle Santiam, and North Santiam Rivers and along major creeks such as Wiley Creek and Neal Creek. Steep-slope failures are concentrated along escarpments of Sardine Formation, Columbia River Basalt, and the Little Butte Formation.

Human-induced causes of steep slope failures include undercutting steep slopes; placing of excessive fill; indiscriminant blasting; improper handling of runoff in construction areas; removal of vegetation; and the diversion of streams against steep canyon walls that have poorly engineered valley-bottom roads.

Areas mapped by the Oregon Department of Geology and Mineral Industries (DOGAMI) as steep slopes where possible residential use is allowed include some of the slopes west of Lyons, a few lower valley areas near Cascadia, and part of West Point Hill in southern Linn County. On-site inspections and engineering reports should precede development in these areas.

Causes and Characteristics of Landslide Hazards

This section provides information about landslide types and causes. Much of the information was gathered from the Department of Land Conservation and Development (DLCD) Natural Hazards Program website; the United States Geologic Survey (USGS) Landslide Hazard Fact Sheet 2004-3072; Oregon Department of Geology and Mineral Industries (DOGAMI) Bulletin 84; the Oregon Natural Hazards Mitigation Plan (OR-SNHMP) Region 3 Hazards Assessment; and the Regional All Hazard Mitigation Plan for Benton, Lane and Linn Counties (RAHMP).

What is a landslide?

The term "landslide" is used to describe the down slope movement (sliding or falling) of slope-forming materials composed of rock, soil, artificial fill, or a combination of these. The materials may move by falling, toppling, sliding, spreading, or flowing. The term is also applied to the mass of soil or rock material that results from one of these events.[8]

The various types of landslides can be differentiated by the kinds of materials involved and the mode of movement. Although landslides are primarily associated with mountainous regions, they can also occur in areas of generally low relief.[9]

Landslides are natural processes, but can be triggered or accelerated by changes in groundwater levels, usually from intense rainfall or rapid snow melt; undercutting of a slope or cliff by erosion or excavation; shocks or vibrations from earthquakes or construction; vegetation removal; or the placing of fill on steep slopes.[10]

Landslide Types

Some of the processes that are referred to as landslides are shown in ***Figure 7-1*** and include:

- **Debris Flow**: Rapidly-moving landslides that can travel long distances, often within confined channels, and often involving significant amounts of water and mud. Debris flows (mudslides, mudflows, debris avalanches) are common and generally occur during intense rainfall on previously saturated ground. They usually begin on steep hillsides as slumps or slides that liquefy, accelerate to speeds as great as 35 mph, and flow down slopes and channels onto gently sloping ground.[11]

  The consistency of debris flows ranges from watery mud to thick, rocky, mud-like wet cement, dense enough to carry boulders, trees, and automobiles. Debris flows from different sources can combine in canyons and channels, where their destructive power is greatly increased.[12] Generally speaking, five conditions must be present for a debris flow to occur:

  1. Steep slopes;
  2. Loose rock and soil materials;
  3. Clay minerals;
  4. Saturated soils; and
  5. Rainfall or snow melt generated runoff of high intensity and duration.

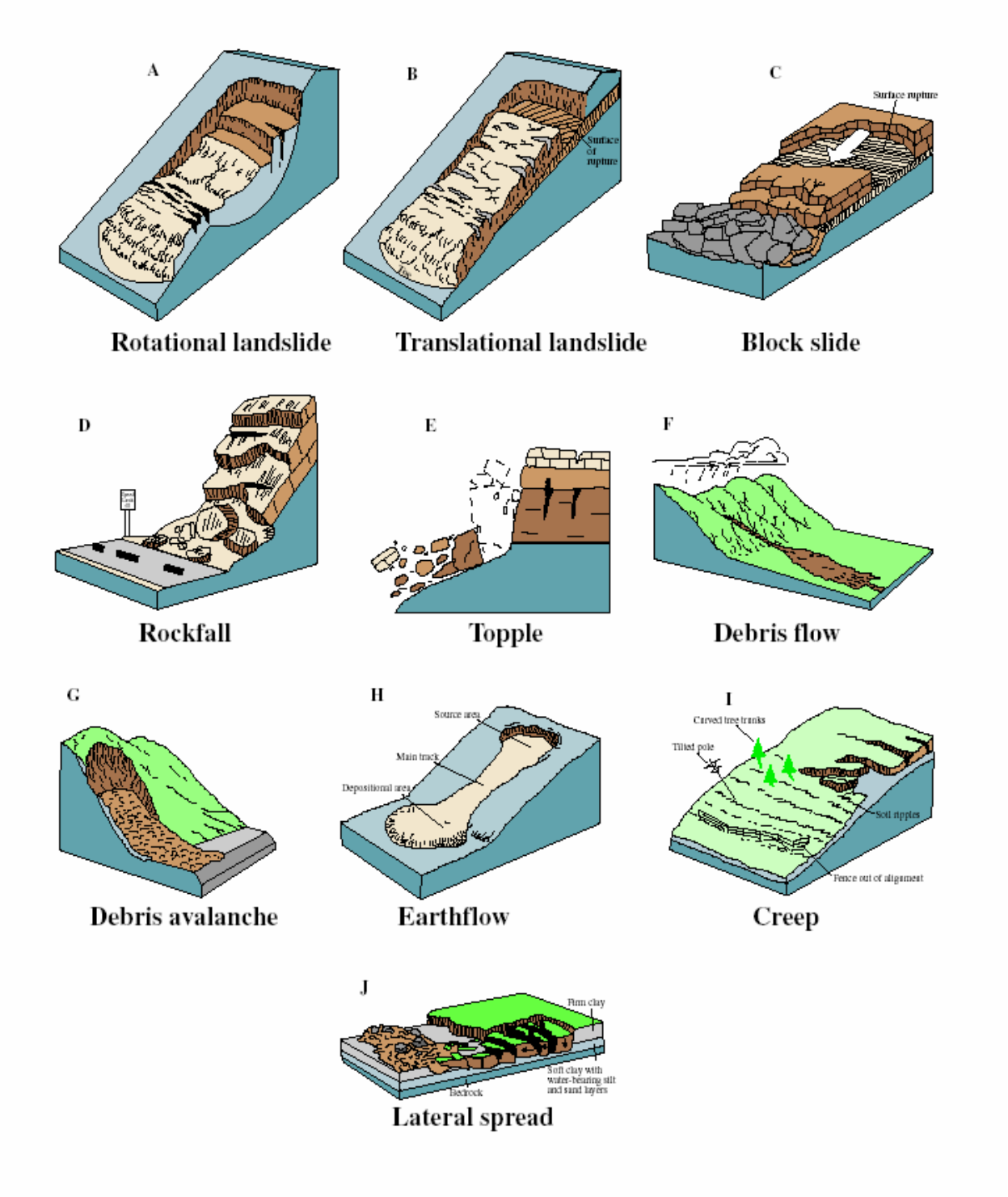
  Debris flow areas are associated with steep gullies. A **debris avalanche** is a type of very rapid to extremely rapid debris flow. A debris avalanche is generally long and narrow and often leaves a V-shaped scar tapering uphill at the head. A **mudflow** is an earth flow consisting of material that is wet enough to flow rapidly and contains at least 50 percent sand, silt and clay-sized particles.[13]

- **Rockfalls**: The abrupt movement of masses of geologic materials that become detached from steep slopes or cliffs. Separation occurs along fractures, joints, and bedding surfaces, and movement occurs by free-fall, bouncing, and rolling. Falls are strongly influenced by gravity, mechanical weathering, and the presence of interstitial water. Depending on the type of materials involved, the result is a rock fall, soil fall, debris fall, boulder fall and so on. All types of falls are promoted by undercutting, differential weathering, excavation or stream erosion. Rock falls are common along Oregon highways where roads are cut through bedrock.[14]

- **Rockslides**: The rapid down-slope movement of rock material along a plane of separation within the bedrock, which could be a fault surface, a fracture surface, or the depositional surfaces found in some sedimentary rocks. These slides can occur on relatively gentle slopes and cause serious damage.[15]

Figure 7-1 illustrates the major types of landslides described in this section.

Figure 7-1
Landslide Types



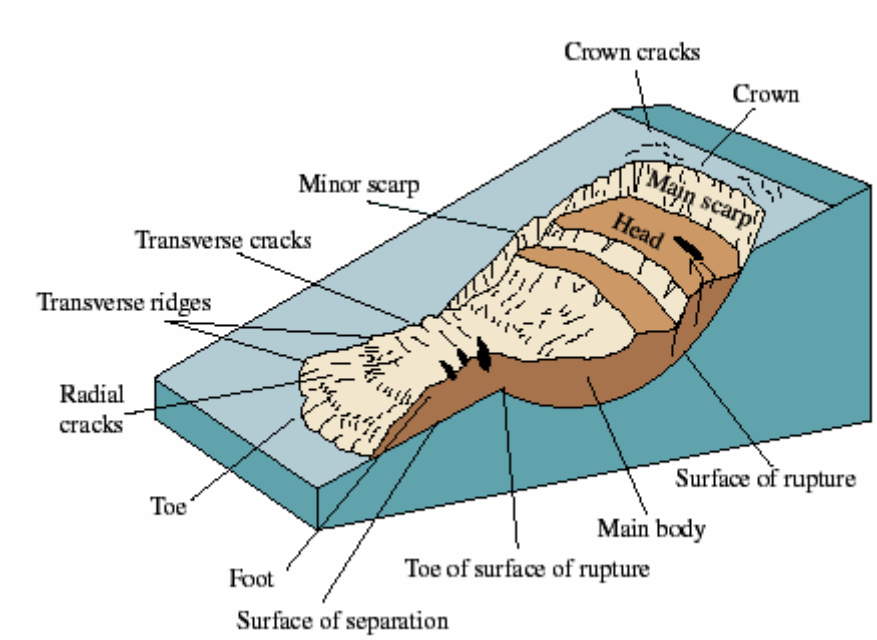
Source: USGS Landslide Hazard Fact Sheet 2004-3072

- **Rotational slides**: Slides in which the surface of the rupture is curved concavely upward and the slide movement is rotational about an axis that is parallel across the slope. The scarp formed at the head of the slope may be almost vertical. The toe usually bulges upward, but sometimes flows outward. **Slumps** are examples of small rotational slides.

  The head of a rotational slide can sometimes be located in the fill side of a road. The axis of the road would generally follow the contour of the hill. Many older hillside roads were built without proper design of the "fill" side of the road. The head of the slide would damage the fill side of the road; and the foot of the slide would damage any buildings located below the road surface, commonly for a distance of 20 to 80 feet below the road surface.[16]

  Figure 7-2 shows a graphic illustration of a rotational landslide, with the commonly accepted terminology describing its features.

Figure 7-2
Rotational Landslide Features



Source: USGS Landslide Hazard Fact Sheet 2004-3072

- **Translational Slides**: Slides in which the mass moves out, or down and out along a more or less planar surface and has little rotational or backward tilting. The mass commonly slides out on the original ground surface. Such a slide may progress over great areas if the conditions are right. The movement of translational slides is commonly controlled by surfaces of weakness such as faults, bedding planes, and variations in shear strength between layers of bedded deposits, or by contact between firm bedrock and overlying loose soils.[17]

Landslide Causes

Factors contributing to landslides and other mass movement include climate, rock type, slope, and natural or human caused changes to any of these factors. Linn County's moist, moderate climate promotes deep weathering which breaks down the rock, increases pore pressures, and decreases shear strength.[18]

Landslides are typically triggered by periods of heavy rainfall or rapid snowmelt. Earthquakes, volcanic activity, and erosion may also trigger landslides. Human activities, including excavation, locating development near steep slopes, and removing vegetation can increase susceptibility to landslide events. Grading for roads and construction can decrease the stability of a hill slope by adding weight to the top of the slope, removing support at the base of the slope, and increasing water content. Landslides on steep slopes are more dangerous because movements can be rapid.[19]

Certain geologic formations are more susceptible to landslides than others. Rocks which weather to clay-rich soils are the least stable and the most prone to failure. The Little Butte Formation, common in Linn County, is particularly high in ash, a component which weathers to clay.[20]

The primary causes of landslides are listed in ***Table 7-2***.

Table 7-2
Landslide Causes

Geological causes	Morphological causes	Human causes
Weak or sensitive materials	Tectonic or volcanic uplift	Excavation of slope or its toe
Weathered materials	Glacial rebound	Loading of slope or its crest
Sheared, jointed, or fissured materials	Fluvial, wave, or glacial erosion of slope toe or lateral margins	Drawdown (of reservoirs)
Discontinuous orientation of materials (unconformity, schistosity, layering, faults)	Subterranean erosion (solution, piping)	Deforestation
Contrast in permeability and/or stiffness of materials	Deposition loading on slope or its crest	Irrigation; Alterating ground water table
	Vegetation removal (fire, drought)	
	Thawing	
	Freeze-and-thaw weathering	
	Shrink-and-swell weathering	

(Source: USGS Landslide Hazard Fact Sheet 2004-3072)

Natural Causes

Natural processes can cause landslides or re-activate historical landslide sites. The undercutting of shoreline material along bodies of water by currents and waves causes many small slides each year. Seismic tremors can trigger landslides on slopes historically known to have landslide movement. Earthquakes can also cause lateral spreading on gentle slopes above steep streams and riverbanks. Landslides are particularly common along stream banks, reservoir shorelines, and large lakes. Steep, concave-shaped slopes with larger drainage areas appear to be more susceptible to landslides than other landforms of over one cubic mile of material. All soil types can be affected by natural landslide triggering conditions.[21]

Human Causes

Human impacts can affect the potential for landslide failures in Linn County. Proper planning can protect people, property and infrastructure. Three major human causes of landslides in Linn County are: (1) Excavation and grading; (2) Drainage and groundwater alterations; and (3) Changes in vegetation.

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.[22]

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. A high ground water table results in increased pore pressure and decreased shear strength of the soil, thus increasing the chance of slide movement. 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.

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.[23]

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. Areas that have experienced wildfire and land clearing for development may have long periods o 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.[24]

Major Landslide Hazards[25]

There are multiple types of causes of landslides. The three that cause most of the damaging landslides around the world are: (1) Water; (2) Seismic activity; and (3) Volcanic activity.

Landslides and Water

Slope saturation by water is a primary cause of landslides in Linn County. This effect can occur in the form of intense rainfall, snowmelt, changes in ground-water levels, and water-level changes along coastlines, earth dams, and the banks of lakes, reservoirs, canals, and rivers.

Landsliding and flooding are closely allied because both are related to precipitation, runoff, and the saturation of ground by water. In addition, debris flows and mudflows usually occur in small, steep stream channels and often are mistaken for floods; in fact, these two events often occur simultaneously in the same area.

Landslides can cause flooding by forming landslide dams that block valleys and stream channels, allowing large amounts of water to back up. This causes backwater flooding and, if the dam fails, subsequent downstream flooding. Also, solid landslide debris can "bulk" or add volume and density to otherwise normal streamflow or cause channel blockages and diversions creating flood conditions or localized erosion. Landslides can also cause overtopping of reservoirs and/or reduced capacity of reservoirs to store water.

Landslides and Seismic Activity

Many mountainous areas that are vulnerable to landslides have also experienced at least moderate rates of earthquake occurrence. The occurrence of earthquakes in steep landslide-prone areas greatly increases the likelihood that landslides will occur, due to ground shaking alone or shaking-caused dilation of soil materials, which allows rapid infiltration of water.

The 1964 Great Alaska Earthquake caused widespread landsliding and other ground failure, which caused most of the monetary loss due to the earthquake. Other areas of the United States, such as California and the Puget Sound region in Washington, have experienced slides, lateral spreading, and other types of ground failure due to moderate to large earthquakes. Widespread rockfalls also are caused by loosening of rocks as a result of ground shaking. Worldwide, landslides caused by earthquakes kill people and damage structures at higher rates than in the United States.

Landslides and Volcanic Activity

Landslides due to volcanic activity are some of the most devastating types. Volcanic lava may melt snow at a rapid rate, causing a deluge of rock, soil, ash, and water that accelerates rapidly on the steep slopes of volcanoes, devastating anything in its path. These volcanic debris flows (also known as lahars) reach great distances, once they leave the flanks of the volcano, and can damage structures in flat areas surrounding the volcanoes. The 1980 eruption of Mount St. Helens in Washington triggered a massive landslide on the north flank of the volcano, the largest landslide in recorded time.

Landslide Hazard Assessment

The landslide hazard assessment provides information on the location of landslide hazards, the land and property characteristics within the hazard area, and an assessment of risks to life and property that may result from a landslide event. The three elements of hazard assessment are: (1) Hazard identification; (2) Vulnerability assessment; and (3) Risk analysis.

Section 201.6(c)(2)(i) of the *Disaster Mitigation Act of 2000* (DMA-2000) requires that the risk assessment include a description of the location and extent of all natural hazard that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

Hazard Identification

The first essential step of landslide hazard assessment is hazard identification. Hazard identification identifies: (1) The geographic extent of areas that are known to be subject to landslides; (2) The characteristics of potential landslides at different locations; and (3) The probability of occurrence of landslide events.

Landslide Hazard Areas

Locations at risk from landslides or debris flows include areas with one or more of the following conditions[26]:

- On or close to steep hills;
- Steep road-cuts or excavations;
- Existing landslides or places of known historic landslides;
- 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.

Maps identifying the location of areas showing previous mass movement; potential debris flow areas; and areas of steep slope are included at the end of this chapter.

The Cascade Range is characterized by large, recently active volcanoes. The climate is sub-humid to very wet. The steep volcanic slopes are subject to mudflows, rock falls and snow and rock avalanches. Some older Tertiary rocks on the west flank of the Cascade Range are prone to land sliding. Debris slides from volcanic eruptions are not considered in this section.

Geologic Hazard Maps

The Department of Geology and Mineral Industries (DOGAMI) published *Bulletin 84, Environmental Geology of Linn County, Oregon* in 1974. *Bulletin 84* includes Geologic Hazards maps for western Linn County. The Linn County Comprehensive Plan at *LCC 903.260(B)(1)* establishes *Bulletin 84* as the official source for determining if a property is located within an area characterized by mass movement topography. ***Map 7-1*** at the end of this section shows identified geologic hazard/mass movement areas for Linn County.

Preliminary Debris Flow Hazard Maps

In response to the catastrophic landslides that occurred in Oregon in 1996, the state of Oregon adopted Senate Bill 12 in 1999 to address rapidly moving landslides (debris flows). Among other requirements, Senate Bill 12 directs DOGAMI to identify areas potentially prone to debris flows on "further review area" maps.

The Oregon Department of Forestry (ODF) has developed preliminary debris flow maps for western Oregon. ***Map 7-2*** shows the mapped debris flow areas in Linn County. While the debris flow maps are generally good for steep slope areas where landslides typically initiate, they are less accurate for identifying the down slope impacts of these landslides, and may not capture many areas that are of a public safety concern. They are not intended to be used as the final "further review areas" as defined by Senate Bill 12, but they are available to local governments to provide an initial indication of debris flow hazards. These maps can be used to show areas where further on-the-ground investigation is needed, but should not be used to determine the actual hazard at any specific location. The preliminary debris flow hazard maps can help analyze vulnerability and risk and identify landslide mitigation action items.[27]

Further Review Area Maps

DOGAMI is refining the ODF debris-flow maps to identify "further review areas" as required by Senate Bill 12. DOGAMI has performed preliminary field investigations throughout western Oregon to improve the delineation of the down-slope run-out areas – the most critical areas in terms of public safety. Findings from those field investigations are being used to develop and evaluate improved methods for GIS modeling of debris flow hazards. Several models have been identified and are currently being tested.[28]

DOGAMI is also inventorying and consolidating slope failure information from the three major storms of February 1996, November 1996, and December 1996/January 1997. The final inventory identified 9,582 known landslide locations. For each documented landslide, up to 15 descriptive items are reported. From this study, DOGAMI found that counties with the highest percentage of total landslides reported are Lane (24 %), Douglas (11 %), Linn (10 %), Clackamas (9 %), Tillamook (9 %), Lincoln (8 %), and Multnomah (7 %)."[29]

Vulnerability Assessment

Vulnerability assessment is the second phase in landslide hazard assessment. Vulnerability assessment inventories development and populations that are located within identified landslide hazard areas.

Section 201.6(c)(2)(ii)(A) of the DMA-2000 requires that the risk assessment include a description of the jurisdiction's vulnerability to the hazard. This description shall include an overall summary for the hazard and its impact on the community. If appropriate data is available, the vulnerability assessment should describe the type and number of existing and future buildings, infrastructure, and critical facilities located in identified hazard areas.

Landslides can impact important transportation routes, impeding commerce and blocking residents from reaching essential services, businesses and places of employment. Locating and understanding the population, property and facilities that are exposed to landslide and debris flow hazards will assist in reducing risks and preventing losses from future landslides.

Information on landslide-prone and debris flow-prone locations in the county can be used to assess the value of property and the population at risk from future landslides. The amount of property within landslide prone areas and the value of those properties can be calculated to estimate potential losses. Calculating a community's vulnerability to landslides is difficult because site-specific vulnerability data is difficult and costly to obtain.

A property-specific assessment of the number of lives or amount of property exposed to landslide hazards has not yet been conducted for Linn County. However, Phase I of the *Regional All Hazard Mitigation Master Plan (RAHMP) for Benton, Lane and Linn Counties* estimated vulnerability and losses due to winter storm induced landslides using small-scale landslide data available in 1998.[30] Unfortunately, the results of this study are not useful on a site-specific scale. An updated vulnerability analysis for landslides in Linn County could be developed using the debris flow hazard maps being prepared by DOF and DOGAMI.

Probability

Most of the Cascade Range in eastern Linn County is classified as having "moderate" landslide incidence and susceptibility. **Susceptibility** is defined as the probability of landslides. **Incidence** is defined as the observed rate of landslides. Parts of the Cascades east side of the Willamette Valley are considered to have "high" landslide incidence and susceptibility. Within the Willamette Valley, the landslide susceptibility and incidence is "low." This is not to say that no landslides can occur in this area; but that the incidence rate is less than 1.5 percent of the area.[31]

The Oregon Department of Forestry (ODF) estimates widespread landslide activity will occur about every 20 years. Landslides at a local level can be expected every two or three years. The probability of a rapidly moving landslide occurring depends on a number of factors. These include steepness of slope, slope materials, local geology, vegetative cover, human activity, and water. There is a strong correlation between intensive winter rainstorms and the occurrence of rapidly moving landslides (debris flows). Consequently, the ODF tracks storms during the rainy season, monitors rain gauges and snow melt, and issues warnings as conditions warrant.[32]

Given the correlation between precipitation and snow melt and rapidly moving landslides, it may be feasible to construct a probability curve. The installation of slope indicators or the use of more advanced measuring techniques could provide information on slower moving slides.[33]

Vulnerability

The probability that Linn County will experience landslides and the county's vulnerability to their effects are identified in the Oregon State Natural Hazard Mitigation Plan (OR-SNHMP) Region 3: Mid/Southern Willamette Valley Hazards Assessment. According to the OR-SNHMP, Linn County's probability score is "High" and its vulnerability score is "Low" for landslides.

The probability score addresses the likelihood of a future major emergency or disaster within a specific period of time, as follows:

High = One incident likely within a 10 to 35 year period.

Moderate = One incident likely within a 35 to 75 year period.

Low = One incident likely within a 75 to 100 year period.

The vulnerability score addresses the percentage of county population or assets likely to be affected by a major emergency or disaster, as follows:

High = More than 10% affected

Moderate = 1-10% affected

Low = Less than 1% affected

Existing Landslide Vulnerability Estimates

The 1998 RAHMP used national scale data to model winter storm induced landslide vulnerability and risk in Linn County. At that time there were no high resolution studies on landslide hazards and risks or detailed debris flow maps for the area. An updated vulnerability and risk analysis for landslides in Linn County could be developed using the debris flow hazard maps that are currently being prepared by DOF and DOGAMI.

Due to data limitations the RAHMP identified most of the hilly areas of the county as having a "high" potential for landslides. However, there is significant variation in actual landslide susceptibility. Local variation in slope, soil types, drainage conditions, rainfall intensity potential, historical landslide experience and manmade factors was not factored into the model.

The RAHMP landslide vulnerability estimates for Linn County are in ***Table 7-3***. The table does not include estimates for property vulnerable to debris-flow hazards. Because the RAHMP landslide hazard analysis was highly generalized, and developed at a scale of 1:7,500,000, it is unsuitable for local site selection determinations. A more detailed study utilizing large-scale hazard maps and accurate data on the location and types of development could be a useful mitigation item.

Table 7-3
Estimated Building and Road Inventory in Landslide Susceptible Areas

County	Wood Buildings	Steel Buildings	Concrete and Masonry Buildings	Roads and Highways (mi)
Linn County	685	4	16	152

RAHMP July 27, 1998 Page 30

Table 7-4 shows the area, number of tax lots, and road miles within the identified mass movement areas and the State modeled debris flow areas in Linn County. Note that some areas may be in both a Mass Movement area and within one of the Debris Flow hazard areas.

Table 7-4
Landslide Hazard Summary

Hazard	Vulnerability Area (Acres)	Roads and Highways (Miles)	Tax Lots	Residential Structures	Commercial and Industrial Structures	Critical Facilities
Mass Movement	94,338	20	2222	472	0	0
Debris Flow (Moderate)	386,126	35	2008	223	1	0
Debris Flow (High)	151,889	15	1140	3	0	0

Source: Linn County Geographic Information Systems, February 2005

In order to be able to identify the types and number of buildings, infrastructure, and critical facilities in the landslide hazard area, more detailed GIS studies need to be conducted. The County currently has insufficient data to complete this step of the vulnerability assessment.

Section 201.6(c)(2)(ii)(B) of the *Disaster Mitigation Act of 2000* (DMA-2000) requires that the risk assessment include an estimate of the potential dollar losses to vulnerable structures. There is insufficient development and vulnerability data available to estimate potential dollar losses to vulnerable structures and facilities at this time. The collection and analysis of appropriate data would serve as an important mitigation item to be completed in the future. Needed data includes the location and ranking of hazard areas; the location, types and numbers of buildings, infrastructure and critical facilities; and the location, construction, materials, and replacement value of buildings, infrastructure and critical facilities in hazard areas.

Risk Analysis

Risk analysis is the third and most advanced phase of hazard assessment. Risk analysis builds on the hazard identification and vulnerability assessment to estimate the damage, injuries and economic losses that may be sustained within a hazard area over a given period of time. The risk analysis uses mathematical models based on the magnitude of the harm that may result and the likelihood of the harm occurring.

Section 201.6(c)(2)(ii)(B) of the *Disaster Mitigation Act of 2000* (DMA-2000) requires that the risk assessment include an estimate of the potential dollar losses to vulnerable structures. A landslide risk analysis for Linn County would include at least two components: (1) The life and value of property and critical facilities that may incur losses from a landslide event; and (2) The number and type of landslide events expected to occur over time. A risk analysis would predict the severity of damage from a range of events and the probability of those events occurring at specific locations.

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.[34]

Phase I of the *Regional All Hazard Mitigation Master Plan (RAHMP) for Benton, Lane and Linn Counties* includes estimated landslide losses in Linn County. Although the RAHMP does not include detailed landslide data, the plan develops a loss estimate model for winter storm induced landslides using data available in 1998.

Minor amounts of landslide-induced ground movement is not normally life threatening. For example, settlements of 0.5 inches may occur due to landslide, and such settlements will generally cause some damage in buildings, but such damage is not likely to cause severe injury. Given that a site experiences some permanent ground movement, the extent of building damage depends on where the structure is located within the zone of permanent ground deformation (PGD). For example, if the structure straddles the area were the ground moves, to where the ground does not move, then the structure will experience major damage. On the other hand, if the structure is located within a large land mass which moves, more or less, as a unified mass, then the structure may experience very little or no damage (other than loss of buried utilities).

The experience of wood frame structures in Japan in past earthquakes suggests that in large lateral spreads (1 meter or more) perhaps 50 percent of the structures are extensively damaged or worse; whereas the other structures are only modestly damaged. Engineering judgment suggests that steel frame structures should be only modestly more susceptible to PGD-induced damage as compared to wood structures; and concrete structures should be the most susceptible.[35]

For roads, it is assumed that minor landslides are repaired by coning off the affected section, and repaving with asphalt. For major movements of 60 inches, it is assumed that the fill-side lane of a two lane road is rebuilt at about 70 percent of the cost of a new two lane road. For ground movements over 100 inches, it is assumed that the road is rebuilt.

The RAHMP developed fragility curves and damage state probabilities assuming that the slight damage state results in 5 percent loss; moderate damage 15 percent loss; extensive damage 50 percent loss; and total collapse 100 percent loss. Then, for the PGDs that correspond to areas that experience significant lateral spreads, the losses to buildings are shown in ***Table 7-5***:

Table 7-5
Building and Road Loss Ratios, Given Permanent Ground Deformation (PGD)

Rainfall Intensity in 24 hours	Expected PGD, Given that Site Slides (Inches)	Wood Buildings (Percent)	Steel Buildings (Percent)	Concrete Buildings (Percent)	Roads and Highways (Percent)
0 - 3 inches	0	0	0	0	0
3 - 4 inches	5	5	6	8	5
4 - 6 inches	10	10	12	18	15
6 - 10 inches	30	30	33	50	40
10 - 15 inches	60	50	55	70	70
15+ inches	100	75	80	90	100

Source: RAHMP July 27, 1998 Page 31

The RAHMP model assumed the average wood structure has replacement value of $150,000; the replacement value of concrete and steel structures is $1,000,000; and roads cost $750,000 per km to repair. Based on these average valuations, the estimated landslide losses in the county are listed in ***Table 7-6***. Based on this information, the largest losses from landslides will be to roads and highways. The estimates in ***Table 7-6*** are probable maximum losses, given the entire county is subjected to the 2, 25 or 100 year storm at the same time. However, no single storm is likely to produce the 100-year rainfall throughout the entire county. It is more likely that a single storm will produce the 100-year rainfall in about 25 percent of the area; the 25 year rainfall in about 50 percent of the area; and the 2 year rainfall in about 25 percent of the area. This suggests that the losses would be about one-half the estimated losses in the table.[36]

Table 7-6
Landslide Loss Estimates (Excludes Casualty and Indirect Losses)

Storm Event	Wood Buildings	Steel Buildings	Concrete and Masonry Buildings	Roads and Highways	Total Losses
2-year	$929,000	$42,000	$248,000	$2,281,000	$3,500,000
25-year	$3,995,000	$173,000	$998,000	$9,766,000	$14,932,000
100-year	$7,382,000	$315,000	$1,820,000	$17,731,000	$27,248,000

Source: RAHMP July 27, 1998 Page 32

The RAHMP does not include detailed maps showing areas prone to debris flows. Debris flows are not as damaging to roads and highways as are deep seated landslides. This is because the typical debris flow will generate debris atop the road, but not actually fail the road. While road closure still occurs, the cost to repair (remove the debris) the road usually includes dirt removal, off haul, and minor fence and signage repairs. More expensive repairs, including mitigation to prevent future debris flows, are usually not performed. Based on these factors, the losses due to debris flows is estimated to be about 20 percent of that from deep seated landslides, when measured on a dollar loss ratio.[37]

Currently there is insufficient data to conduct a detailed risk analysis for landslide events in Linn County. The mitigation plan may include recommendations for improved data and partnerships that may lead to a detailed landslide risk analysis. An updated risk analysis for landslides in Linn County could be developed using the debris flow hazard maps being prepared by DOF and DOGAMI along with site-specific development information contained in Linn County's Assessor and GIS databases and more specific footprint and site information not currently available.

Community Landslide Issues

What is Susceptible to Damage from a Landslide Event?

Landslides can affect utility services, transportation systems, and critical lifelines. In addition to the immediate damages and loss of service that communities may suffer, the 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 electricity are all essential to the community. Loss of electricity has the most widespread impact on the whole community and can even affect other utilities. For example, even landslide movements as small as an inch or two increase the potential for natural gas pipelines to break.[38]

Roads and Bridges

Roads are subject to closure during landslide events and constitute the largest losses incurred from landslide hazards in Linn County. The Linn County Road Department and the Oregon Department of Transportation (ODOT) are responsible for responding to slides that inhibit the flow of traffic and/or damage a road or bridge.

Since many Linn County residents are dependent on roads for commuting to work, delays and detours generated by a landslide event will likely have an economic impact on residents and businesses. Bridges are a critical part of road connections that may suffer extensive damage in landslide events. A transportation analysis should be conducted to determine which of Linn County's roads and bridges should be classified as critical to the transportation network.

It is not cost effective to mitigate for all slides, due to the fact that some historical slides are likely to become active again even after mitigation measures have been implemented. The Road Department can alleviate 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.

Lifelines and Critical Facilities

It is important to identify facilities determined to be critical to life and safety, such as hospitals, emergency services, and public utilities that are subject to direct impacts from landslides. Critical facilities may also be indirectly impacted by landslides. Lifelines and critical facilities must remain accessible during a natural hazard event. The impact of closed transportation arteries is increased if the closed road or bridge is the access to a hospital or other emergency facility, or if populations are cut off from emergency services or utilities. Therefore, inspection and repair of critical transportation facilities and routes is essential and should be a high priority. Loss of power and/or phone service is also potentially a consequence of landslide events. In hillside areas, soil erosion can be accelerated by heavy rains, resulting in loss of soil support beneath high voltage transmission towers.

Landslide Loss Potential

Landslides are a significant hazard to life and property. In some cases, it is cost effective to mitigate existing infrastructure against landslides. More often, the most cost effective approach to deal with landslides is by zoning regulations, whereby landslide hazard areas are identified prior to construction, and the planned facilities are either relocated or the landslide is mitigated prior to construction. If the cost to mitigate a landslide is high, and the risk of landslide loss is suitably small, in some cases it may be worthwhile to accept the risk and consequences from unmitigated landslides. Landslides should also be considered in the development of emergency response plans.[39]

How to Reduce the Effects of Landslides[40]

Vulnerability to landslide hazards is a function of location, type of human activity, use, and frequency of landslide events. The effects of landslides on people and structures can be lessened by total avoidance of landslide hazard areas or by restricting, prohibiting, or imposing conditions on hazard-zone activity. Local governments can reduce landslide effects through land-use policies and regulations. Individuals can reduce their exposure to hazards by educating themselves on the past hazard history of a site and by making inquiries to planning and engineering departments of local governments. They can also obtain the professional services of an engineering geologist, a geotechnical engineer, or a civil engineer, who can properly evaluate the hazard potential of a site, built or unbuilt.

The hazard from landslides can be reduced by avoiding construction on steep slopes and existing landslides, or by stabilizing the slopes. Stability increases when ground water is prevented from rising in the landslide mass by:

(1) Covering the landslide with an impermeable membrane;

(2) Directing surface water away from the landslide;

(3) Draining ground water away from the landslide; and

(4) Minimizing surface irrigation.

Slope stability is also increased when a retaining structure and/or the weight of a soil/rock berm are placed at the toe of the landslide or when mass is removed from the top of the slope.

Landslide Mitigation Programs

Linn County Codes

Statewide Planning Goal 7 seeks to "protect life and property" from natural disasters and hazards such as floods, landslides, and earthquakes. Linn County complies with Goal 7 by incorporating hazard inventories into the comprehensive plan and by adopting policies and ordinances to protect people and property from the identified hazard.

The Linn County Comprehensive Plan (Plan) in LCC Chapter 903 contains policies to address areas subject to natural and geologic hazards. The Plan identifies DOGAMI *Bulletin 84, Environmental Geology of Western Linn County, Oregon,* and subsequent amendments, as the official source for determining if a property is located within a mass movement area. *LCC 903.260(B)(10)* sets forth that:

> *If a development is proposed in an area known to have geologic or natural hazards, the county may require the applicant to submit a report which details the extent of the hazard. The county, before approving the proposal, must find that presence of a hazard will not be detrimental to the development.*

The Linn County Land Development Code in LCC 921.980(D)(2) states:

> *In an area containing mass movement topography as indicated in the Bulletin 84, Environmental Geology of Western Linn County, Oregon, no person may develop land unless the applicant provides a report from an Oregon Engineering Geologist to the Director before development permits may be issued. The report shall state that the land can be safely developed. If the report provides recommendations for development, those recommendations shall be incorporated into the site development.*

State Programs and Activities

Statewide Planning Goal 7[41]

Statewide Planning Goal 7 is one of the original 14 Statewide Planning Goals adopted by the Land Conservation and Development Commission in 1974. Goal 7 seeks to "protect life and property" from natural disasters and hazards such as floods, landslides, and earthquakes. To help accomplish this protection, the Goal requires that local plans be based on an inventory of known areas subject to natural hazards and disasters and advises that "developments subject to damage or that could result in loss of life shall not be planned nor located in known areas of natural disasters and hazards without appropriate safeguards."

Senate Bill 12[42]

In response to the catastrophic landslide events that occurred in Oregon in 1996, the state of Oregon adopted Senate Bill 12 in 1999 to address rapidly moving landslides (debris flows). Among other requirements, Senate Bill 12 requires local governments to:

> *Regulate through mitigation measures and site development standards the siting of dwellings and other structures designed for human occupancy in further review areas where there is evidence of substantial risk for rapidly moving landslides.*

In brief, Senate Bill 12 (Source: DLCD Natural Hazards Program website):

- Directs the Oregon Department of Geology and Mineral Industries (DOGAMI) to identify areas potentially prone to debris flows on "further review area" maps;
- Directs the Oregon Department of Land Conservation and Development (DLCD) to assist local governments in implementing the Bill;
- Requires the Oregon Board of Forestry to adopt regulations that reduce the risks associated with rapidly moving landslides;
- Requires the Oregon Department of Forestry (ODF) and DOGAMI to provide technical assistance to local governments;
- Requires the Oregon Department of Transportation (ODOT) to provide warnings to motorists during periods determined to be of the highest risk of rapidly moving landslides along areas of state highways with a history of being most vulnerable to rapidly moving landslides; and
- Directs the Office of Emergency Management of the Department of State Police to coordinate state resources for rapid and effective response to landslide-related emergencies.

Department of Geology and Mineral Industries (DOGAMI)

Senate Bill 12 requires DOGAMI to map "further review areas" in coordination with the Oregon Department of Forestry (ODF). The ODF and DOGAMI have worked together to develop landslide hazard identification maps in order to provide information to local governments that will allow for more informed mitigation decisions.

Department of Land Conservation and Development (DLCD)

The DLCD awarded a grant to Douglas County for the development of a model program to help in the mitigation of rapidly moving landslide hazards. Douglas County agreed to produce four main products: (1) A model landslide hazards ordinance; (2) Model documents to support implementation of Senate Bill 12; (3) A model Transfer of Development Rights program; and (4) Procedures to integrate DOGAMI's "further review area" maps into local tax parcel maps.

Oregon Department of Forestry (ODF)

Senate Bill 1211 and Senate Bill 12, passed in 1997 and 1999 respectively, contain provisions to be addressed by the ODF. These provisions include the interim prohibition of forest operations in certain areas and the development of certain forest practices requirements. The interim prohibitions authorized by Senate Bill 1211 will eventually be replaced by the forest practice rules to be adopted by the Oregon Board of Forestry as required by Senate Bill 12. (Source: DLCD Natural Hazards Program)

Interim Prohibitions[43]

Senate Bill 1211, a precursor to Senate Bill 12, authorized the ODF to prohibit forest operations on steep, landslide-prone sites above homes and busy roads in the interest of public safety. Specifically, the State Forester is authorized to prohibit operations if all of the following conditions exist:

- The operation location includes high-risk sites;
- Homes and other buildings where people are likely to be present during periods of intense rainfall or where county or state highways are in such close proximity to the potential path of a landslide or debris torrent that there is significant risk to human life; and
- The farthest expected extent of a potential landslide or debris torrent that might originate in the operation area, based on physical features of the landslide or debris torrent path, will reach the residences, buildings, or highways.

Forest Practices Requirements

Senate Bill 12 required the ODF to adopt and enforce forest practice rules to reduce the risk of serious bodily injury or death from rapidly moving landslides (Oregon Revised Statutes (ORS) 527.630)). ORS 527.710(11) sets forth the criteria the Board of Forestry should consider in adopting such rules, including the exposure of the public to these safety risks and appropriate practices to reduce the occurrence, timing, or effects of rapidly moving landslides.

Landslide Warnings

The Oregon Department of Geology and Mineral Industries (DOGAMI) is developing a slope failure database that it has used to study the relationship between rainfall events and debris flows. Records from the four major storms that hit western Oregon during 1996 and 1997 confirm that the occurrence of many landslides and debris flows can be related to rainfall intensity and duration. The relationships that have been shown between rainfall intensity and debris flows are useful in helping to determine areas where debris flow warning systems are appropriate. A debris-flow hazard warning system has been developed, and a current alert message can be found at the ODF.[44]

Oregon's landslide / debris flow warning system primarily involves three state and one federal agency: the ODF, DOGAMI, the Oregon Department of Transportation (ODOT), and the National Oceanic and Atmospheric Administration (NOAA). The warning system is triggered by rainfall and monitored in areas that have been determined to be hazardous.

As the lead agency, ODF is responsible for forecasting and measuring rainfall from storms that may trigger debris flows. Advisories and warnings are issued as appropriate. Information is broadcast over NOAA weather radio and on the Law Enforcement Data System. DOGAMI provides additional information on debris flows to the media. ODOT provides information concerning the location of landslides / debris flows and alternate transportation routes.[45]

Oregon State Building Code Standards

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

Both codes contain requirements for cut, fill, and sloping of a buildling lot in relationship to the location of the foundation. There are also building setback requirements from the top and bottom of slopes. The codes specify foundation design requirements to accommodate the type of soils, the soil bearing pressure, and the compaction and lateral loads from soil and ground water on sloped lots. The building official has the authority to require a soils analysis for any project where it appears the site conditions do not meet the requirements of the code, or that special design considerations must be taken. *ORS 455.447* and the Structural Code require a seismic site hazard report for projects that include essential facilities such as hospitals, fire and police stations, emergency response facilities, and special occupancy structures, such as large schools and prisons.[46]

Landslide Mitigation Action Items

Landslide mitigation action items provide direction on specific activities that communities, organizations, and residents in Linn County can undertake to reduce risk and prevent loss from landslide events. The Steering Committee identified one short-term and one long-term landslide hazard action item.

Short-term Action Items

LS-ST #1: Action 3.1.2. Use and publicize the Oregon Department of Forestry's debris flow warning system

Coordinating Organization: Linn County Emergency Management
Internal Partners: Road Department; Board of Commissioners
External Partners: DOF; DOGAMI; OEM; ODOT; Radio Stations
Timeline: Ongoing
Plan Goals Addressed: Goal 3. Protect life, the built environment, the economy and natural resources through community-wide partnerships.
Plan Objective: Objective 3.1. Increase citizen awareness and promote risk reduction activities through education and outreach.

Long-term Action Items

LS-LT #1: Action 2.2.6. Use final DOF Debris Flow Hazard maps and improved development data to update the landslide vulnerability and risk analysis.

Coordinating Organization: Linn County Emergency Management
Internal Partners: GIS; Assessor; Road Department; Planning & Building
External Partners: DOF; DOGAMI; OEM; FEMA
Timeline: 3-5 years
Plan Goals Addressed: Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective: Objective 2.2. Support the enhancement of County vulnerability assessment activities.

Landslide Endnotes

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

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

[3] Ibid.

[4] Oregon State Natural Hazard Mitigation Plan (OR-SNHMP) (Region 3) Mid/Southern Willamette Valley Hazards Assessment, Nov. 2003, pp R3-22

[5] Ibid.

[6] State of Oregon Department of Geology and Mineral Industries (DOGAMI) Bulletin 84 (1974), Environmental Geology of Western Linn County, Oregon, pp 62-66

[7] Ibid. pg 67

[8] Department of Land Conservation and Development (DLCD) Natural Hazards Program Website, http://www.lcd.state.or.us

[9] Regional All Hazard Mitigation Plan for Benton, Lane, Lincoln and Linn Counties (RAHMP) July 27, 1998, pg. 25

[10] DLCD Natural Hazards Program Website, http://www.lcd.state.or.us

[11] Ibid.

[12] Ibid.

[13] RAHMP, July 27, 1998, pg. 26

[14] Ibid. pg. 25

[15] Ibid.

[16] Ibid.

[17] Ibid.

[18] DOGAMI Bulletin 84 (1974), pg. 62

[19] Douglas County Natural Hazard Mitigation Plan (NHMP), 2003, pp. 105

[20] DOGAMI Bulletin 84 (1974), pg. 62

[21] Douglas County NHMP (2003), pp. 105

[22] Ibid. pg. 106

[23] Ibid. pg. 106

[24] Ibid. pg. 105

[25] USGS Landslide Hazard Fact Sheet 2004-3072 (July 2004)

[26] Douglas County NHMP (2003), pp. 105

[27]DLCD Natural Hazards Program Website, http://www.lcd.state.or.us

[28] Ibid.

[29] Ibid.

[30] RAHMP July 27, 1998, pg. 32

[31] RAHMP July 27, 1998, pp 29-30

[32] OR-SNHMP Region 3 Hazard Assessment, pp R3-23

[33] Ibid.

[34] Douglas County NHMP (2003), pp 107

[35] RAHMP July 27, 1998, pg. 30

[36] Ibid. pg. 32

[37] Ibid. pg. 33

[38] Regional All Hazard Mitigation Master Plan for Clackamas County (February 1998) Goettel & Associates.

[39] Source: RAHMP, July 27, 1998, Page 25

[40] USGS Landslide Hazard Fact Sheet 2004-3072 (July 2004)

[41] Source: DLCD Natural Hazards Program Website, http://www.lcd.state.or.us

[42] Ibid.

[43] Ibid.

[44] Ibid.

[45] OR-SNHMP Region 3 Hazard Assessment, pp R3-23

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

Section 8:
Wildfire

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Why is Wildfire a Threat to Linn County?

This report defines wildfire as an uncontrolled burning of wildlands (forest, brush or grassland). Although fire is a natural part of forest and grassland ecosystems in Linn County, wildfire can pose a significant risk to life and property in wildland/urban interface areas. The urban interface is the area at the urban-rural fringe where homes and other structures are built into a forested or natural landscape. If left unchecked, fires in these areas can threaten lives and property.

Over 900,000 acres, or nearly 65 percent of Linn County, is forested.[1] These forested lands play a critical role in the economic, environmental and social vitality of the county. Wildfire poses a serious threat to economic activity, recreation, life and property in forested areas. Because 35 percent of Linn County's population resides outside of cities, wildfire poses a threat to rural communities, rural residential areas and other rural home sites located throughout the county.

Linn County's climate is characterized by warm dry summers. During the summer fire season the danger of fire in the county's forests and grasslands increases as the trees, brush and grassland dries and increases the potential for a conflagration. The forest lands in eastern Linn County are subject to annual small to moderate fires caused by human and natural causes, such as lightening.[2]

Much of the Willamette Valley in western Linn County is dominated by grass seed fields. Beginning in 1948, Oregon's grass seed farmers began burning their fields to control disease and dispose of straw. In 1988, grass smoke from a controlled burn in a field adjacent to Interstate 5 between Albany and Highway 34 intruded across the interstate, causing a 24-car pile-up. Thirty-eight people were injured and seven people died. Since then legislation has been adopted restricting but not eliminating the burning of fields. Grass farmers have developed alternatives to burning and currently burn fewer acres than allowed by law. [3]

Burning of any kind is a potential threat to safety. Forest slash burns, grass field burns, and residential back yard burning in the wildland/urban interface all have the potential to ignite wildfire, threatening health, life and property.

Causes and Characteristics of Wildfire Hazards

The characteristics of fire are important to understand when trying to mitigate its negative effects on humans and structures. In order for fire to exist, the three components of the fire triangle must be present. The triangle consists of fuel, heat, and oxygen.[4]

Most naturally caused fires are initiated by lightning strikes. Human-caused fires, both accidental and deliberate, are produced in many ways, including campfires, chimneys, torches, matches, fireworks, cigarettes, vehicle fires, military ordnance, and smoldering slash piles.[5] Whether natural or human-caused, the ignition is started because the fire triangle exists. Fire occurring in natural ecosystems begins as a point of ignition, burns outward into circles and, if escalates, spreads in the direction toward which the wind is blowing.[6] Additionally, when burning occurs on uneven terrain, the fire spreads upslope to eventually form itself into broad ellipses.[7]

Effects of fire on ecosystem resources can represent damages, benefits, or some combination of both, depending largely on the characteristics of the fire site, the severity of the fire, the time period of valuation, and the values placed on the resources affected by the fire.[8] The ecosystems of most forests depend upon fire to maintain various functions. The use of fire for beneficial purposes is considered for reducing fuel loads, disposing of slash, preparing seedbeds, thinning overstocked stands, increasing forage plant production, improving wildlife habitats, changing hydrologic processes, and improving aesthetic environments.[9] However, despite its beneficial values to ecosystems, fire has been suppressed for years because of its perceived effects on timber harvest and threat to human life. In addition, new development continues to push its way into what is termed as the "wildland/urban interface."

The Interface

There are three categories of interface fire:[10]

- 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.

Unlike most other natural hazards, the wildland/urban interface is not designated by geography alone. Certain conditions must be present for significant interface fires to occur. The most common are hot, dry, and windy weather; the inability of fire protection forces to contain or suppress the fire; the occurrence of multiple fires that overwhelm committed resources; and a large fuel load (dense vegetation).[11]

Once a fire has started, several conditions influence its behavior, including fuel, topography, weather, drought, and development. These combined conditions are the key elements that add to increased wildfire risk. The severity of the wildfire is ultimately affected by the severity of these conditions. For example, if a steep slope is combined with extremely low humidity, high winds, and highly flammable vegetation, then a high–intensity wildfire may develop.

Since the 1970s, Oregon's growing population has expanded further and further into traditional resource lands such as forestland. The "interface" between urban and suburban areas and the resource lands created by this expansion has produced a significant increase in threats to life and property from fires, and has pushed existing fire protection systems beyond original or current design or capability.[12] Property owners in the interface are often unaware 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. Human activities also increase the incidence of fire ignition and potential damage.

The Oregon State Natural Hazards Mitigation Plan (OR-SNHMP) Region 3 Hazards Assessment identifies the following as Wildland/Urban Interface Communities in Linn County[13]:

- Albany
- Brownsville
- Clear Lake Resort
- Harrisburg
- Lebanon
- Marion Forks
- Mill City
- Idahna
- Scio
- Sweet Home East
- Sweet Home West

There are many other rural residential areas in Linn County that may be subject to wildfire hazards because of their location in forested areas or on steep dry slopes. Examples of such rural residential exception areas include: Bartel's Canyon Estates, Cascadia, Middle Ridge, Mountain Home Drive, Mt. Tom/Wildwood Estates, Northernwood Drive, Powell Hills, Rodger's Mountain, Washburn Heights, the Upper Calapooia, and others.

Fuel[14]

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 refers to the species of trees, shrubs, and grass that are present. Oregon, as a western state with prevalent conifer, brush, and rangeland fuel types, is subject to more frequent wildfires than other regions of the nation.

An important element in understanding the danger of wildfire is the availability of diverse fuels in the landscape, such as natural vegetation, manmade structures, and combustible materials. A house surrounded by brushy growth rather than cleared space allows for greater continuity of fuel and increases the fire's ability to spread. After decades of fire suppression, "dog-hair" thickets have accumulated. These enable high intensity fires to flare and spread rapidly.

Structures that are made of combustible material such as shake roofs and wood siding are especially susceptible to fire. Untrimmed bushes near these structures often serve as "ladder fuels," enabling a slow moving ground fire to climb onto rooftops and into the crowns of trees. A crown fire is significantly more difficult to suppress than a ground fire, and are much more threatening to structures in the interface.

Wildfire at the upper end of the wildfire intensity spectrum is likely to spread into the tops of the tallest trees in violent and discontinuous surges.[15] Fire that occurs at this severe end of the spectrum responds to its own convective winds, spreading rapidly as sparks from exploding trees ignite other fires many meters away.[16] 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[17]

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 often desirable as residential areas. This underscores the need for wildfire hazard mitigation and increased education and outreach to homeowners living in interface areas.

Linn County's geography is characterized by broad flat Willamette Valley terraces in the west and mountainous uplands and peaks of the Cascade Range to the east. The western Cascade uplands have elevations up to 5000 feet and are characterized by gentle slopes to very steep slopes on canyon walls and side slopes.

In between the valley floor and the Cascade uplands are low, sometimes steep foothills that range in elevation from 300 to 1400 feet. Most of the county's unincorporated rural population resides in residential areas developed in these western Cascade foothills and other low hills that rise up from the valley floor. Significant examples include the large Viewcrest and Scravel Hill residential areas northeast of Albany; the Tyler Heights, Agate Hills, Blueberry Hill, Butte Creek and Middle Ridge areas south of Lebanon; the Rowell Hill, Riggs Hill, Marks Ridge, Topview Acres, and Ames Creek residential areas around Sweet Home; Oakview Heights and Powell Hills north of Brownsville; the Mount Tom area east of Harrisburg; the Rodgers Mountain, Hungry Hill and Loma Drive areas near Scio; and others.

Weather[18]

Weather patterns combined with certain geographic locations can create a favorable climate for wildfire. Areas where annual precipitation is less than 30 inches per year are extremely fire susceptible.[19] 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. In addition, many high intensity fires produce their own wind, which aids in the spread of fire.

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.

Drought contributes to the frequency and intensity of fires. 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, other than grasses, require two or three years of drought before the fuel becomes dangerously dry.

All areas of Linn County receive an average of more than 40 inches of rainfall per year. However, the county usually receives very little rainfall during the warm summer months, commonly going long periods with no measurable precipitation. During the summer fire season the danger of fire in the forests and grasslands increases as the trees, brush and grassland dries and increases the potential for conflagration. The county is highly susceptible to lightening induced fires during late summer Cascade thunderstorms.

Development

Growth and development in forested areas is increasing the number of structures in the interface. Wildfire effects development, yet development can also influence wildfire. While wildfires have always been part of the ecosystem in Oregon, homes in the interface often lead to human ignition of fire. The increase in human development and activity in the interface combined with the high fuels content from years of fire suppression can create a lethal combination.

Homeowners often prefer lots that are private and have scenic views nestled in vegetation. 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. [20]

Wildfire Hazard Assessment

The wildfire hazard assessment provides information on the location of wildfire hazards, the land and property characteristics within the hazard area, and an assessment of risks to life and property that may result from a wildfire. The three elements of hazard assessment are: (1) hazard identification; (2) vulnerability assessment; and (3) risk analysis.

Section 201.6(c)(2)(i) of the *Disaster Mitigation Act of 2000* (DMA-2000) requires that the risk assessment include a description of the location and extent of all natural hazard that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

Hazard Identification

The first phase of wildfire-hazard assessment is hazard identification. Hazard Identification identifies: (1) the geographic extent of areas subject to wildfire, (2) the expected intensity of a wildfire event at different locations, and (3) the probability of occurrence of wildfire events.

Wildfire hazard areas are commonly identified in areas of wildland/urban interface. The level of wildfire hazard is determined by the ease of fire ignition, from natural or human causes, and the difficulty of fire suppression. Wildfire hazard can be magnified by several fire suppression and control factors, such as the fuel load, weather, topography, and property characteristics. Hazard identification rating systems are based on weighted factors of fuels, weather, and topography.[21]

To determine the "base hazard factor" of specific wildfire hazard sites and interface regions, several factors must be considered. Categories used to assess the base hazard factor include[22]:

- 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) tools and improved data can assist in fire hazard assessment, allowing further integration of fuels, weather, topography, and development data for fire behavior prediction, watershed evaluation, developing mitigation strategies, and hazard mapping.

Wildfire in the US

On average there are more than 100,000 wildfires in the United States each year, burning more than 4 million acres and hundreds of homes within wildland areas. In 2002 there were 6.9 million acres burned in the U.S. in 88,458 separate fires. Lightning causes approximately 15 percent of the fires, human negligence and arson are responsible for the remainder.[23] Wildland fire data for the U.S. during the 2002 fire season, along with recorded averages, is summarized in ***Table 8-1***.

Table 8-1
U.S. Wildland Fire Season
2002 Summary

Item	Summary
Number of Fires (2002 final)	88,458
10-year Average (1992-2001)	103,112
Acres Burned (2002 final)	6,937,584
10-year Average (1992-2001)	4,215,089
Structures Burned	2,381
Primary Residences	835
Commercial Buildings	46
Outbuildings	1500
Cost of Fire Suppression (2002 – Federal agencies only)	$1.66 billion
9-year average (1994-2002 – Federal agencies only)	$7.68 million

Source: National Interagency Fire Center, Boise Idaho, Wildland Fire Statistics.
Retrieved February 18, 2005 from: http://www.nifc.gov/stats/wildlandfirestats.html

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.[24] Many of these fires burned in wildland/urban interface areas and exceeded the fire suppression capabilities of those areas.

The magnitude of the year 2000 fires is the result of two primary factors: (1) severe drought, accompanied by a series of storms that produced 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.[25]

Wildfire in Oregon

Oregon has a very lengthy history of fire in the undeveloped wildlands and in the developing wildland/urban interface. There have been many fires in Oregon, named and unnamed.[26]

Table 8-2 lists some of the major fires that occurred in Oregon from 1848 to 2002.

Table 8-2
Historic Oregon Wildfires (1848-2002)

Year	Fire	Number 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
1987	Silver	970,000
1992	Lone Pine	31,000
1996	Skelton	17,000
2002	Biscuit	500,000

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. Department of Forestry, http://www.odf.state.or.us/DIVISIONS/protection/fire_protection/stats/histfire.asp?id=3070105 Oregon Emergency Management, State Hazard Risk Assessment, 2003.

In 1990, Bend's Awbrey Hall Fire destroyed 21 homes, causing approximately $9 million in damage and costing 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.[27] In 2002, the Biscuit Fire became one of Oregon's most destructive fires in recent history, impacting nearly 500,000 acres, destroying 4 homes, 9 outbuildings, 1 lookout, and numerous recreational structures. The costs of fighting this fire totaled $153 million and included over 7,000 firefighters and support personnel.[28]

The number of wildfires in Oregon varies from year to year. In 2004 Oregon had 918 wildfires that burned 5,940 acres. Over the past 10 years Oregon has averaged 1,098 wildfires a year burning an average of 24,236 acres. The cost of fire suppression varies accordingly, averaging $8.69 million annually over the past 16 years. Lightning accounts for approximately 30 percent of forest fires in Oregon, the remaining 70 percent are human caused.[29] Oregon wildfire data from the Oregon Department of Forestry (ODF) is summarized in ***Table 8-3***.

Table 8-3
Oregon Seasonal Fire Occurrence
State and Association Districts

Item	Summary
Number of Fires – All Causes (2004 season)	918
10-year Average – All Causes (1994-2003)	1,098
Number of Lightning Caused Fires Only (2004 season)	257
10-year Average (1994-2003)	336
Number of Human Caused Fires Only (2004 season)	661
10-year Average (1994-2003)	762
Acres Burned (2004 final)	5,940
10-year Average (1994-2003)	24,236
Average State Fire Suppression Costs* (1985-2000)	$8.69 million
Year 2000*	$5.75 million
Low year (1997)*	$1.21 million
High year (1987)*	$32.08 million

Source: Oregon Department of Forestry, November 26, 2004
Retrieved February 18, 2005 from: www.odf.state.or.us/DIVISIONS/protection/Fire_protection/stats

*Figures apply to the 15.8 million acres of state, private and federal forest lands protected by the Oregon Department of Forestry

In recent years, the cost of fire suppression has risen dramatically. A large number of homes have been threatened or burned, more fire fighters have been placed at risk, and fire protection in wildland areas has been reduced. These factors prompted the passage of Oregon Senate Bill (SB) 360 (Forestland / Urban Interface Protection Act, 1997).[30] SB 360:

(1) Establishes legislative policy for fire protection;

(2) Defines urban/wildland interface areas for regulatory purposes;

(3) Establishes standards for locating homes in the urban/wildland interface; and

(4) Provides a means for establishing an integrated fire protection system.

Wildfire in Linn County

The eastern two-thirds of the county are forested. The forest lands are owned by the US Forest Service, Bureau of Land Management, Oregon Department of Forestry and private owners. The Western one-third of the county is primarily grassland or moderate to steep Cascade foothills. During the summer fire season the danger of fire in the forests and grasslands increases as the trees, brush and grassland dries and increases wildfire potential.[31] Historical data on the date, location, acreage and costs of wildfire events in Linn County are not available.

In 1988, a controlled burn in a field adjacent to Interstate 5 between Albany and Highway 34 caused a multi-vehicle accident when the smoke drifted across the highway. The forest land in eastern Linn County are subject to annual small to moderate fires caused by human intervention and natural causes, such as lightning.[32]

Probability of Future Wildfire[33]

The natural ignition of forest fires is largely a function of weather and fuel. Human-caused fires add another dimension to the probability of wildfire. Dry and diseased forests can be mapped accurately and some statement can be made about the probability of lightening strikes. Each forest is different and consequently has different probability / recurrence estimates.

This document defines wildfire as an uncontrolled burning of forest, brush, or grassland. Wildfire always has been a part of these ecosystems and sometimes with devastating effects. Wildfire results from natural causes (e.g., lightening strikes), a mechanical failure (Oxbow Fire), or human-caused (unattended campfire, debris burning, or arson). The severe fire season of 1987 resulted in a record setting mobilization of fire fighting resources. Most wildfires can be linked to human carelessness.

The intensity and behavior of wildfire depends on a number of factors including fuel, topography, weather, and density of development. There are a number of often-discussed strategies to reduce the negative impacts of these phenomena. They include land-use regulations, management techniques, site standards, building codes, and the recently passed Oregon Forestland-Urban Interface Fire Protection Act (1997). All of these have a bearing on a community's ability to prevent, withstand, and recover from a wildfire event.

The State Office of Emergency Management estimates that the probability that Linn County will experience fires in interface areas is "High."

Vulnerability Assessment

Vulnerability assessment is the second phase in wildfire hazard assessment. Vulnerability assessment inventories property development and populations that are located within wildfire hazard areas. Locating and understanding the population, property and facilities that are exposed to wildfires will assist in reducing risks and preventing losses from future wildfire events.

Section 201.6(c)(2)(ii)(A) of the DMA-2000 requires that the risk assessment include a description of the jurisdiction's vulnerability to the hazard. This description shall include an overall summary for the hazard and its impact on the community. If appropriate data is available, the vulnerability assessment should describe the type and number of existing and future buildings, infrastructure, and critical facilities located in identified hazard areas.

An understanding of risk begins with the knowledge that wildfire is a natural part of forest and grassland ecosystems. Past forest practices included the suppression of all forest and grassland fires. This practice, coupled with areas of dry brush or trees weakened or killed through insect infestation, has fostered a dangerous situation. Present state and national forest practices include the reduction of understory vegetation through thinning and prescribed (controlled) burning. [34]

Each year a significant number of people build homes within or on the edge of the forest (wildland/urban interface), thereby increasing wildfire hazards. Many Linn County communities (incorporated and unincorporated) are within or abut areas subject to serious wildfire hazards. In Oregon, there are about 240,000 homes worth around $6.5 billion within the wildland/urban interface. Such development has greatly complicated firefighting efforts and significantly increased the cost of fire suppression. These communities have been designated "Interface Communities" and include those listed on ***page 8-4*** of this report.[35]

Risk Analysis

Risk analysis is the third and most advanced phase of hazard assessment. Risk analysis builds on the hazard identification and vulnerability assessment to estimate the damage, injuries and economic losses that may be sustained within a hazard area over a given period of time. The risk analysis uses mathematical models based on the magnitude of the harm that may result and the likelihood of the harm occurring.

The State Office of Emergency Management estimates that the **probability** that Linn County will experience fires in interface areas is "High." The county's **vulnerability** to the effects of interface fires is identified as "Moderate." These rankings are based on an analysis of risk conducted by county emergency program managers with the assistance of a team of local public safety officials.[36]

The **probability** scores address the likelihood of a future major emergency or disaster within a specific period of time, as follows:

High = One incident likely within a 10 to 35 year period.

Moderate = One incident likely within a 35 to 75 year period.

Low = One incident likely within a 75 to 100 year period.

The **vulnerability** scores address the percentage of population or region assets likely to be affected by a major emergency or disaster, as follows:

High = More than 10% affected

Moderate = 1-10% affected

Low = Less than 1% affected

Most of Linn County outside of urban areas is susceptible to wildland fires during the dry summer months. A detailed community inventory of factors that affect vulnerability is important in assessing risk and is currently beyond the scope and capabilities of this assessment. Determining and gathering the necessary community and hazard information would serve as an important mitigation item. Development of wildfire hazard maps would assist county fire districts and fire departments in developing fire mitigation plans to address the areas most vulnerable to wildfires in Linn County.

Key factors in assessing wildfire risk include ignition sources, building materials and design, community design, structural density, slope, vegetative fuel, fire occurrence, and weather, including 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. Information on wildfire hazard assessment is available at http://www.Firewise.org.[37]

When assessing the risks from natural hazards, established mitigation practices already provide benefits in reduced disaster losses. It is important to understand the benefits of past mitigation practices when assessing their risks, being mindful of opportunities to further reduce losses. Possible mitigation practices include[38]:

- Identify and map current hazardous forest conditions such as fuel, topography, etc.;
- Identify forest / urban interface communities (list of interface communities, Federal Register, 08/17/01. V. 66, N. 160);
- Identify and map Forest Protection Districts;
- Identify and map water sources;
- Implement effective addressing system in rural forested areas;
- Clearly mark evacuation routes;
- Identify and locate seasonal forest users. Initiate information program through schools, summer camps, forest camping grounds, lodges, etc;
- Identify and map bridges that can (and can not) support the weight of emergency vehicles. This is a basic requirement for fire suppression;
- Form committees to implement Oregon Senate Bill 360. This is required in Oregon Senate Bill 360; and
- Enforce existing county road standards in interface areas to reflect fire suppression needs. Roads must be wide enough for fire suppression vehicles to turn around. Road grades cannot be too steep for large, heavy vehicles.

Community Wildfire Issues

Growth and Development in the Interface

The forested hills where homes and structures are built are considered to be interface areas, as are residential developments surrounded by grasslands. The development of homes and other structures encroaching onto the forest wildland and other natural areas is expanding the wildland/urban interface. The interface areas are characterized by a diverse mixture of varying housing structures, development patterns, ornamental and natural vegetation, and natural fuels.

People living in or near wildland settings in Linn County are vulnerable to the threat of wildfire. The Linn County Rural Residential Buildable Lands Inventory (BLI-2002) shows there is a significant amount of built land in rural areas throughout western Linn County. Current zoning regulations limit the number of new homes that can be established on currently undeveloped land. However, unforeseen legislative changes to Oregon's land use system could result in the expansion of residential development on lands marginally suited for farm or forest use. These types of marginal lands often contain characteristics that increase risks to wildfire.

The vegetation in these interface areas consists of an assortment of grasses, shrubs, and deciduous and coniferous trees. Steep slopes may also be a consideration in determining wildfire prone areas. In the event of a wildfire, vegetation, structures, and other flammables can merge into unwieldy and unpredictable events. Factors germane to the fighting of such fires include access, firebreaks, proximity of water sources, distance from fire stations, and available firefighting personnel and equipment. Reviewing past wildland/urban interface fires shows that many structures are destroyed or damaged by wildfire for one or more of the following reasons:[39]

- 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. Of particular concern to firefighters are developments with narrow roadways and few routes of egress; routes with very limited accessibility; and houses without adequate turn-around space. Developments that do not allow rear access to homes can be a significant problem for firefighters and emergency services in defending the structure and ensuring the safety of its inhabitants.

To ensure adequate ingress and egress for emergency vehicles, the Linn County Land Development Code at LCC 935.200 includes a number of roadway improvement standards. The

Code requires that all access roadways and drives be constructed of an all-weather surface capable of supporting 50,000 pounds gross vehicle weight (GVW). Some rural fire protection districts may require a surface capable of supporting 80,000 pounds GVW. The roadway must be at least 12 feet in width and must be constructed of six-inches of crushed rock or gravel or six inches of quarry run rock topped with four inches of one-inch minus crushed gravel.

All roads and access drives must maintain an unobstructed vertical clearance of 13 feet six inches and a horizontal clearance of 20 feet along their entire length. Roadways below 20 feet in width must have at least one vehicle turnout for emergency vehicles every 500 feet and provide a turnaround at the end of the access road. Additional access safety requirements are contained in *LCC 935.200*.

Minimum Fuel Break Standards

To reduce fire risks associated with development in forested areas, the Linn County Land Development Code requires all dwellings in the Farm/Forest (F/F) and Forest Conservation and Management (FCM) zones to maintain a 30-foot wide primary fuel break around structures and a 100-foot wide secondary fuel break around the primary fuel break. The specific standards are described at *LCC 934.590(8).*

Fire Safety Construction Standards

In addition to the State Uniform Building Code (UBC) requirements for residential development, the Linn County Land Development Code contains additional fire safety construction requirements for dwellings in the F/F and FCM zones at LCC 934.590.

Water Supply

Water supply is a critical factor in the ability to fight wildland fires. Developments lacking an adequate water supply and hydrant taps create extra challenges for firefighting personnel. Another water supply issue is that of small diameter pipe water systems, which are inadequate to provide sustained fire-fighting flows.

The majority of rural development in wildfire prone areas is not connected to any sort of public water system and must rely on emergency services response, water trucks, and on site water sources in the event of a fire or wildfire. The Land Development Code requires that a dwelling shall be located within a fire protection district or shall be provided structural fire protection by contract. If this is not practical, then alternative means for protecting the structure from fire hazards may be provided such as an on-site water storage system, pond, stream or lake subject to standards in LCC 934.590(B)(6).

Rural Services

People moving from more urban areas to secluded rural developments may not realize they are living outside of a fire protection district, or that the services provided are not the same as in an urban area. The diversity and amount of equipment and the number of personnel can be substantially limited in rural areas, and the response time may be increased. Fire protection may rely more on the landowner's personal initiative to take measures to reduce fire risk and protect

their own property. Therefore, public education and awareness may play a greater role in rural or interface areas.[40]

Development in rural areas in Linn County influences the wildland/urban interface. Although structural losses from wildfires in Linn County have historically been relatively low, continued development, and along with it an increase in fuel loads, expands the public need for natural hazards mitigation planning in the county.

Vulnerable Assets – Estimating Potential Losses

Section 201.6(c)(2)(ii)(B) of the *Disaster Mitigation Act of 2000* (DMA-2000) requires that the risk assessment include an estimate of the potential dollar losses to vulnerable structures. There is insufficient development and vulnerability data available to estimate potential dollar losses to vulnerable structures and facilities at this time. The collection and analysis of appropriate data would serve as an important mitigation item to be completed in the future. Needed data includes the location and ranking of hazard areas; the types and numbers of buildings, infrastructure and critical facilities; and the location, construction, materials, and replacement value of buildings, infrastructure and critical facilities in hazard areas.

Wildfire Mitigation Programs

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

Local Programs

All development within Linn County must comply with the fire protection construction standards in the Uniform Building Code (UBC) and the Linn County Land Development Code, as well as additional standards set forth by the applicable rural fire protection districts. The Land Development Code contains development standards designed to mitigate wildland fire risks affecting access standards (LCC 935.200) and other county development standards relating to site design and preparation, construction materials, fuel loads and fuel breaks, water supply, and other safety concerns (LCC 934.900).

Linn County Forestland Development Handbook

Linn County has developed a guide for development in the Farm/Forest (F/F) and the Forest Conservation and Management (FCM) zones. The *Linn County Forestland Development Handbook* was published in June 2003 and was funded by Title III funds. The forestland development handbook is a free publication given to property owners when they request information or a development permit in the F/F or FCM zones. The handbook describes the forestland structural siting standards contained in the Land Development Code including property line setbacks, building material requirements, road and access design standards, firebreaks and water supply standards.

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:

1. Dwelling has a fire retardant roof;
2. Dwelling will not be sited on a slope of greater than 40 percent;
3. Evidence is provided that the domestic water supply is from a source authorized by the Water Resources Department and not from a Class II stream as designated by the State Board of Forestry;
4. Dwelling is located upon a parcel within a fire protection district or is provided with residential fire protection by contract;
5. If dwelling is not within a fire protection district, the applicant provides evidence that the applicant has asked to be included in the nearest such district;
6. If dwelling has a chimney or chimneys, each chimney has a spark arrester; and
7. Dwelling owner provides and maintains a primary fuel-free break and secondary break areas on land surrounding the dwelling that is owned or controlled by the owner.

If a governing body determines that meeting the fourth requirement is impractical, local officials can approve an alternative means for protecting the dwelling from fire hazards.

Oregon Revised Statute 477.015-061

Provisions in *ORS 477.015-061*, Urban Interface Fire Protection, were established through efforts of the Oregon Department of Forestry, the Office of the State Fire Marshal, fire service agencies from across the state, and the Commissioners of Deschutes, Jefferson, and Jackson Counties. It is innovative legislation designed to address the expanding interface wildfire problem within Oregon Department of Forestry Fire Protection Districts. Full implementation of the statute will occur on or after January 1, 2002. The statute does the following:

1. Directs the State Forester to establish a system of classifying forestland-urban interface areas;
2. Defines forestland-urban interface areas;
3. Provides education to property owners about fire hazards in forestland-urban interface areas. Allows for a forestland- urban interface county committee to establish classification standards;
4. Requires maps identifying classified areas to be made public;
5. Requires public hearings and mailings to affected property owners on proposed classifications;

6. Allows property owners appeal rights;
7. Directs the Board of Forestry to promulgate rules that set minimum acceptable standards to minimize and mitigate fire hazards within forestland-urban interface areas; and
8. Creates a certification system for property owners meeting acceptable standards. Establishes a $100,000 liability limit for cost of suppressing fires, if certification requirements are not met.

Senate Bill 360

Senate Bill 360, passed in 1997, is state legislation put in place to address the growing wildland/urban interface problem. The bill has three purposes:

1. To provide an interface fire protection system in Oregon to minimize cost and risk and maximize effectiveness and efficiency;
2. To promote and encourage property owners' efforts to minimize and mitigate fire hazards and risks; and
3. To promote and encourage involvement of all levels of government and the private sector in interface solutions.[41]

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 that inter agency 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

The Oregon Department of Forestry (ODF) is involved with local fire chiefs and local fire departments to provide training. Local firefighters can get a range of experience from exposure to wildland firefighting. Local firefighters can also obtain their red card (wildland fire training documentation), and attend extensive workshops combining elements of structural and wildland firefighting, defending homes, and operations experience. [42]
ODF has been involved with emergency managers to provide support during non-fire events and for years, ODF has worked with industrial partners (big timber companies) to share equipment in the case of extremely large fires. [43]

Federal Programs

The proposed role of the federal land managing agencies, such as the U.S. Forest Service and the Bureau of Land Management, in the wildland/urban interface is diverse. Their roles include: 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. [44]

Federal Emergency Management Agency Programs

The Federal Emergency Management Agency (FEMA) is directly responsible for providing fire suppression assistance grants and, in certain cases, major disaster assistance and hazard mitigation grants in response to fires. The role of FEMA in the wildland/urban interface is to encourage comprehensive disaster preparedness plans and programs, increase the capability of state and local governments, and provide for a greater understanding of FEMA's programs at the federal, state, and local levels.[45]

Fire Suppression Assistance Grants

Fire Suppression Assistance Grants may be provided to a state only if the state has 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. Once the federal grant money is provided to the State, it is then passed along to local jurisdictions. This money would ultimately be passed along to Linn County to be applied to projects. 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.[46]

Hazard Mitigation Grant Program

Following a major disaster declaration, the FEMA Hazard Mitigation Grant Program provides funding for long-term hazard mitigation projects and activities to reduce the possibility of damages from all future fire hazards and to reduce the costs to the nation for responding to and recovering from the disaster.

National Wildland/Urban Interface Fire Protection Program

Federal agencies can use the National Wildland/Urban Interface Fire Protection Program to focus on wildland/urban interface fire protection issues and actions. The Western Governors' Association (WGA) can act as a catalyst to involve state agencies, as well as local and private

stakeholders, with the objective of developing an implementation plan to achieve a uniform, integrated national approach to hazard and risk assessment and fire prevention and protection in the wildland/urban interface. The program helps states develop viable and comprehensive wildland fire mitigation plans and performance-based partnerships.

US Forest Service

The US Forest Service (USFS) implements a fuel-loading program to assess fuels and reduce hazardous buildup on US forestlands.

Other Mitigation Programs and Activities

Some areas of the country are facing wildland/urban issues collaboratively. These are model programs that include local solutions. One example of this is in Ashland, Oregon. Because of the highly flammable slopes above Ashland, homeowners in the wildland urban interface face a high risk of encountering a wildland fire. The City has partnered with local organizations to help coordinate mitigation strategies with homeowners in high-risk areas. Currently, more than 40 acres have been treated in the interface above Ashland.[47] Treatment has included thinning of tree stands, removing of highly flammable noxious weeds (i.e. Scotch broom), and the creation of fuel breaks along ridge tops most susceptible to wildland fire. The City has contributed approximately one-half million dollars towards cost shares with homeowners to help reduce fuels near their homes.[48]

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. Both 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. [49]

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.[50]

Firewise

Firewise is a program developed within the National Wildland/ Urban Interface Fire Protection Program, and it is the primary federal program addressing interface fire. It is administered through the National Wildfire Coordinating Group whose extensive list of participants includes a wide range of federal agencies. The program is intended to empower planners and decision makers at the local level. Through conferences and information dissemination, Firewise increases support for interface wildfire mitigation by educating professionals and the general public about hazard evaluation and policy implementation techniques.

Firewise offers online wildfire protection information and checklists, as well as listings of other publications, videos, and conferences. The interactive home page allows users to ask fire protection experts questions, and to register for new information as it becomes available.

For more information on the Firewise program, contact:

The Wildland/Urban Interface Fire Program
C/o The National Fire Protection Association
1 Batterymarch Park, Quincy, MA 02269 - http://www.firewise.org

FireFree Program

FireFree is a unique private/public program for interface wildfire mitigation involving partnerships between an insurance company and local government agencies. It is an example of an effective non-regulatory approach to hazard mitigation. Originating in Bend, the program was developed in response to the city's "Skeleton Fire" of 1996, which burned over 17,000 acres and damaged or destroyed 30 homes and structures.[51] Bend sought to create a new kind of public education initiative that emphasized local involvement. SAFECO Insurance Corporation was a willing collaborator in this effort. Bend's pilot program included:

- A short video production featuring local citizens as actors, made available at local video stores, libraries, and fire stations;
- Two city-wide yard debris removal events;
- A 30-minute program on a model FireFree home, aired on a local cable television station; and
- Distribution of brochures, featuring a property owner's evaluation checklist and a listing of fire-resistant indigenous plants.

The success of the program helped to secure $300,000 in Federal Emergency Management Agency (FEMA) "Project Impact" matching funds. By fostering local community involvement, FireFree also has the potential for building support for sound interface wildfire policy. For information on FireFree, contact:

SAFECO Plaza T-8,
Seattle, WA 98185, (206) 545-6188

Wildfire Mitigation Action Items

The wildfire mitigation action items provide direction on specific activities that organizations and residents in Linn County can undertake to reduce risk and prevent loss from wildfire events. There are three short-term and one long-term wildfire hazard action items described below.

Short-term Action Items

WF-ST #1: Action 2.2.7. Develop wildfire hazard maps and vulnerable asset inventories

Coordinating Organization: Linn County Emergency Management
Internal Partners: GIS; Assessor; Planning and Building; Road Dept
External Partners: DOF; Fire Districts; Fire Marshall; OEM; FEMA
Timeline: 1-3 years
Plan Goals Addressed: Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective: Objective 2.2. Support the enhancement of County vulnerability assessment activities.

WF-ST #2: Action 3.3.4. Develop a countywide Community Wildfire Protection Plan

Coordinating Organization: Linn County Emergency Management
Internal Partners: Planning and Building Department; Board of Commissioners
External Partners: DOF; Fire Districts; Fire Marshall; Cities; OEM
Timeline: 1-3 years
Plan Goals Addressed: Goal 3. Protect life, the built environment, the economy and natural resources through community-wide partnerships.
Plan Objective: Objective 3.3. Develop partnerships with external partners for hazard specific mitigation projects.

WF-ST #3: Action 3.3.5. Partner with the Oregon Department of Forestry and Rural Fire Districts to promote home site assessment programs for wildfire hazards

Coordinating Organization: State Fire Marshall
Internal Partners: Emergency Management; Board of Commissioners
External Partners: DOF; Fire Districts; Cities; OEM
Timeline: Ongoing
Plan Goals Addressed: Goal 3. Protect life, the built environment, the economy and natural resources through community-wide partnerships.
Plan Objective: Objective 3.3. Develop partnerships with external partners for hazard specific mitigation projects.

Long-term Action Items

WF-LT #1: Action 3.3.3. Conduct community based fuel reduction demonstration projects in the interface

Coordinating Organization: State Fire Marshall
Internal Partners: Emergency Management; Board of Commissioners
External Partners: DOF; Fires Districts; Cities; OEM
Timeline: 3-5 years
Plan Goals Addressed: Goal 3. Protect life, the built environment, the economy and natural resources through community-wide partnerships.
Plan Objective: Objective 3.3. Develop partnerships with external partners for hazard specific mitigation projects.

Wildfire Endnotes

[1] Linn County Comprehensive Plan, LCC 905.200(C), pp. 905-6

[2] Hazard Analysis 2004, Linn County Emergency Management Agency, March 31, 2004, pg. 9

[3]A Tale of Two Grass Industries, North Idaho Communities On-Line, Retrieved February 26, 2005 from: www.nicon.org/sos/oregon-willamette.html

[4] DeBano, Leonard; Neary, Daniel; Ffolliott, Peter, *Fire's Effects on Ecosystems*, 1998, pg. 21

[5] Ibid 22

[6] Ibid 22

[7] Ibid 49

[8] Ibid. pg. 304

[9] Ibid

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

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

[12] Introductory language in Senate Bill 360, (July 2001), ODF website, http://www.odf.state.or.us/fireprot/sb360.html.

[13] OR-SNHMP (Region 3) Mid/Southern Willamette Valley Hazards Assessment, Nov. 2003, pp R3-15

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

[15] DeBano, Leonard; Neary, Daniel; Ffolliott, Peter, *Fire's Effects on Ecosystems*, 1998, pg. 59.

[16] Ibid

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

[18] Ibid.

[19] Ibid.

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

[21] Douglas County Natural Hazard Mitigation Plan – Section 8: Wildfire (2003), pp. 86

[22] Ibid. pg. 87

[23] National Interagency Fire Center, Wildland Fire Statistics. Retrieved February 18, 2005 from: http://www.nifc.gov/stats/wildlandfirestats.html

[24] Wilkinson, Todd. "Prometheus Unbound," (May/June 2001), Nature Conservancy.

[25] National Interagency Fire Center, *National Register of Urban Wildland Interface Communities Within the Vicinity of Federal Lands that are at High Risk from Wildfire.* (May 2001) http://www.nifc.gov/fireplan/fedreg.html.

[26] OR-SNHMP, Region 3, Mid/Southern Willamette Valley Hazards Assessment, Nov. 2003, pp R3-12

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

[28] Biscuit Fire Recovery Facts (February 2005), Burn Area Emergency Rehabilitation Team website, http://www.biscuitfire.com/index.htm

[29] Oregon Department of Forestry, November 26, 2004; Retrieved February 18, 2005 from: www.odf.state.or.us/DIVISIONS/protection/Fire_protection/stats

[30] OR-SNHMP, Region 3, Mid/Southern Willamette Valley Hazards Assessment, Nov. 2003, pp R3-12

[31] Hazard Analysis 2004, Linn County Emergency Management Agency, March 31, 2004, pg. 9

[32] Ibid.

[33] OR-SNHMP, Region 3, Mid/Southern Willamette Valley Hazards Assessment, Nov. 2003, pp R3-12, R3-13

[34] Ibid. pg R3-13

[35] Ibid.

[36] Ibid. pg R3-14

[37] Douglas County Natural Hazard Mitigation Plan – Section 8: Wildfire (2003), pp. 88

[38] OR-SNHMP, Region 3, Mid/Southern Willamette Valley Hazards Assessment, Nov. 2003, pp R3-12, R3-13

[39] Colorado State Forest Service, (July 2001), http://205.169.13.227/depts/emmgmt/wildfireproblem.htm

[40] Douglas County Natural Hazard Mitigation Plan – Section 8: Wildfire (2003), pp. 89

[41] Oregon Department of Forestry, (1999) Oregon Forests Report.

[42] Personal Interview. Jim Wolf, Oregon Department of Forestry, February 28, 2001.

[43] Ibid.

[44] Federal Wildland Fire Policy, (July 2001), http://www.fs.fed.us/land/wdfire7c.htm.

[45] Ibid.

[46] Ibid.

[47] Personal Interview, Bill Fleeger, Regional Ecosystem Applied Learning (REAL) Corps, June 30, 2003.

[48] Ibid.

[49] Personal Interview. M.J. Harvey, United States Forest Service, March 1, 2001.

[50] Ibid.

[51] http://www.firewise.org/communities/ffoverview.pdf/ (Accessed 6/26/03)

Section 9:
Severe Weather

Table of Contents

This section is concerned with severe weather events and focuses on severe winter storms and windstorms. Flooding is not included in this chapter, as it has been covered separately in *Section 6: Floods*.

Why is Severe Weather a Threat to Linn County?

Severe weather events pose a significant threat to life, property, and the local economy in Linn County by creating conditions that disrupt essential regional services such as public utilities, telecommunications, and transportation routes. Such storms can produce rain, freezing rain, ice, snow, cold temperatures, and high winds. High winds and ice storms can destroy trees and power lines, potentially interrupting utility services.

Severe Weather Characteristics

Linn County Weather

Western Linn County has a temperate climate characterized by dry warm summers and wet cool winters. In the foothills of the Western Cascades more extreme conditions are prevalent. Willamette Valley temperatures vary between 20 and 100 degrees Fahrenheit during the year. Linn County's average annual precipitation is approximately 42 inches in the central part of the valley, increasing to approximately 52 inches at Sweet Home and more than 80 inches a year in the upper Cascades.[1]

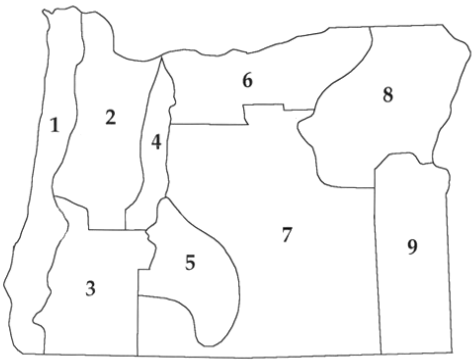
Severe winter weather in Linn County is characterized by extreme cold, snow, ice, and sleet. Although such conditions may be expected in the Cascade Mountains in eastern Linn County, they are considered to be unusual and result in more severe impacts in the Willamette Valley. Although outbreaks of very cold air occur with some degree of regularity, many communities are unprepared, financially and otherwise. Severe weather conditions typically do not last long in western Linn County, which may lead some jurisdictions to relegate winter-preparedness to a low priority.[2]

Severe storms affecting Linn County with snow and ice typically originate in the Gulf of Alaska or in the central Pacific Ocean. These storms are most common from October through March.[3] A majority of the destructive surface winds in Oregon, and specifically, in Linn County, are from the southwest.[4] Winds sometimes blow from the east, but most often do not carry the same destructive force as those from the Pacific Ocean.

The National Climatic Data Center has established climate zones in the US for areas that have similar temperature and precipitation characteristics. As shown in ***Figure 9-1***, most of Linn County is in Zone 2, while the Cascade Mountains in eastern Linn County are in Zone 4.

The climate in Zone 2, including all of the populated areas of Linn County, generally consists of wet, cool winters and warm, dry summers. The wettest months are November through March. Snowfall and freezing temperatures are uncommon on the lower elevations of the valley floor. Cascadia, in the lower Cascades, averages 10 inches of snowfall annually while the Santiam Pass averages 85 inches.[5]

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 Weather Book*, OSU Press (1999)

Historical weather and storm data for Linn County can be found at the following websites:

- NOAA National Climatic Data Center database - http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms
- National Weather Service - http://www.nws.noaa.gov/organization.php
- Oregon State University – Oregon Climate Service - http://www.ocs.oregonstate.edu/index.html
- Climate of Oregon Narrative, NWS - http://www.wrcc.dri.edu/narratives/OREGON.htm
- State of Oregon Natural Hazard Mitigation Plan - http://csc.uoregon.edu/pdr_website/projects/state/snhmp_web/index.htm

Snow

The lower valley elevations normally experience very little snowfall. Snowfall amounts increase as the elevation rises into the Cascades in eastern Linn County. Cascadia, east of Sweet Home, averages 10 inches of snowfall annually while the Santiam Pass averages 85 inches. During the last week of December 2003 and the first week of 2004, the Willamette Valley was blanketed with ice that was subsequently covered by an unusually heavy snow storm. The impacts were severe enough to damage the electrical power infrastructure and cause extremely hazardous travel conditions throughout the county for several days.[6]

Ice

Like snow storms, 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.[7]

While sleet and hail can create hazards for motorists when they accumulate, freezing rain can cause the most dangerous conditions within a community can be the most damaging of ice formations. Much of the damage from ice storms occurs when the ice thaws. Although some tree limbs fall from the weight of the ice, many broken tree limbs are held in place by the frozen ice structure. Water lines that have frozen in the storm will begin to leak as the ice melts. As a result, storm emergency periods often extend beyond the freeze to include the thaw.

The most difficult thing about comparing ice storms lies in the fact that ice is not an officially-measured weather parameter. Temperature, precipitation, winds and snowfall (among others) are routinely measured at stations statewide, but ice is not. To compare storms it is necessary to look at them subjectively using anecdotal information.[8]

Wind

A windstorm is generally a short duration event involving straight-line winds and/or gusts in excess of 50 mph. A majority of the destructive surface winds in Linn County are from the southwest. Strong southwesterly winds are associated with storms moving onto the coast from the Pacific Ocean. If the winds are from the west, they may be stronger on the coast than in the interior valleys because of the north-south orientation of the Coast Range, which obstruct and slow down the westerly surface winds. In Linn County, the most destructive winds are those which blow from the south, parallel to the major mountain ranges.[9]

Windstorms affect areas of Linn 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 valley are still high enough to knock down trees, bring down power lines, and cause other property damage. Linn County was severely impacted by the Columbus Day Storm of 1962.

> *The Columbus Day Storm of 1962 was a classic example of a southerly windstorm. The storm developed well off the coast of California and moved from the southwest, then turned and came directly from the south toward the Oregon Coast. Atmospheric pressure fell rapidly ahead of the storm center and rose rapidly once the storm center passed, creating very tight and sharp pressure gradients. When strong surface winds are further reinforced by upper airflow in the same direction (as was the case in the Columbus Day Storm), the surface wind speed is enhanced.*[10]

Severe Summer Heat Storms

Linn County occasionally experiences heat storms, defined as periods where the temperature exceeds 90 degrees Fahrenheit for more than three days.[11] The severity of the storm increases when high temperatures are accompanied by warm winds. These conditions cause the tissue in trees to shrink and contract. The wood in trees twists and cracks, causing limb failures that damage property, disable systems, and cause personal injuries. In addition to tree failures, extreme summer heat causes pressure on the electrical system as people increase their use of air conditioners. Water supply systems can also become stressed. Older citizens and others who are medically compromised can experience increased rates of heat exhaustion and stroke. Heat storms usually result in stagnant air and air quality alert days.

Severe Weather Risk Assessment

Hazard Identification

Section 201.6(c)(2)(*i*) of the Disaster Mitigation Act of 2000 requires that the risk assessment include a description of the location and extent of all natural hazard that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

Location and Extent of Severe Weather Events

Severe weather events consisting of snow, ice or wind storms occur throughout Linn County. Because severe weather events are atmospheric and not geologic, they generally affect the entire community.

Specific hazard events can sometimes be more destructive to a particular area. An extremely destructive wind storm on February 7, 2002 impacted the areas around Lebanon, Brownsville and Sweet Home much more severely than the areas around Albany and Scio. The ice and snow storms of December 2003-January 2004 impacted the entire county and most of western Oregon.

The Cascade Mountains in eastern Linn County annually experience levels of snow, ice and wind that can be devastating when those same weather characteristics occur in the populated portions of western Linn County.

History of Severe Weather in Linn County

Winter Storms[12]

Winter storms generally involve severe snow and ice storms which can result in power outages and disrupt transportation. This hazard is characterized by a variety of weather factors such as the amount of snow or rainfall, air temperature, wind velocity and temperature, and ground saturation or snow pack conditions.

During the last week of December 2003 and the first week of January 2004 snow and ice in Linn County was severe enough to damage the electrical power infrastructure and cause extremely hazardous travel conditions throughout the county. A presidential Disaster Declaration for public infrastructure was made.

Although such conditions are expected in the Cascade Mountains, they are considered to be unusual in the Willamette Valley. Outbreaks of very cold air occur in the valley with some regularity, but severe weather conditions do not last long. This causes most jurisdictions to relegate winter-preparedness to a low priority and most communities are unprepared for severe winter storms, financially and otherwise.

Table 9-1 identifies notable severe winter storms that have impacted Linn County.

TABLE 9-1
SEVERE WINTER STORMS

DATE	LOCATION	CHARACTERISTICS
Dec., 1861	Statewide	Snowfall varied between 1 and 3 feet. Did not leave Willamette Valley floor until late February
Dec., 1864	Willamette Valley & Columbia Basin	Heavy snowfall. Albany (Linn County) received 16 inches in 1 day.
Jan., 1916	Statewide	Two snow storms, each totaling 5 inches or more
Dec., 1919	Corvallis (Benton County)	Corvallis received 22 inches of snow and set an all-time low temperature record of 14 degrees F
Jan.- Feb., 1937	Statewide	Heavy snow throughout the Willamette Valley. Dallas (Polk Co.) had 24 inches; Salem (Marion County) had 25 inches
Jan., 1950	Statewide	Heaviest snowfall since 1890. Many highway closures. Considerable property damage.
Jan., 1956	Western Oregon	Packed snow became ice. Many automobile accidents throughout the region
Mar., 1960	Statewide	Snowfall: 3-12 inches, depending on location. More than 100 snow related accidents in Marion County
Jan., 1969	Statewide	Lane County surpassed old snowfall record. Eugene (Lane Co.) had a total snow depth of 47 inches. Three to $4 million in property damage
Jan., 1980	Statewide	A series of storms bringing snow, ice, wind, and freezing rain. Six fatalities.
Feb., 1985	Statewide	Western valleys received between 2-4 inches of snow; Massive power failures (tree limbs broke power lines)
Dec., 1985	Willamette Valley	Heavy snowfall throughout valley
Mar., 1988	Statewide	Strong winds and heavy snow
Feb., 1989	Statewide	Heavy snowfall and record low temperatures. Salem (Marion Co.) received 9 inches
Feb., 1990	Statewide	Average snowfall from one storm about 4 inches (Willamette Valley)
Dec., 1992	Western Oregon	Heavy snow. Interstate Highway closed.
Feb., 1993	Western Oregon	Record snowfall at Salem airport
Winter 1998-9	Statewide	Series of storms. One of the snowiest winters in Oregon history

Source: Taylor, George and Ray Hatton, 1999, *The Oregon Weather Book,* p.118-122.

Ice Storms

The “Oregon Weather Book" identifies a number of ice storms in Oregon. Some were confined to the area near the Columbia Gorge, but others were much more widespread, affecting the entire Willamette Valley or most of western Oregon. The following described ice storm events are similar to the storm that occurred the last week of December 2003 and the first week of January 2004:[13]

> **Jan. 5-7, 1942**. Moist, warm air from the south and southwest met cold air coming through the Columbia River Gorge. In some areas there was considerable sleet, followed by freezing rain. Throughout the middle and upper portions of the Willamette Valley the precipitation was mostly freezing rain, which resulted in heavy accumulations of ice on all exposed surfaces. Roads and streets became dangerous for travel, orchard and shade trees were damaged, and telephone, telegraph, and power wires and poles were broken down.
>
> **January 1950**. Severe blizzard conditions Jan. 13 and a heavy sleet and ice storm on Jan. 18-19 together caused several hundred thousand dollars' worth of damage (1950 dollars) and virtually halted traffic for two to three days. The Columbia River Highway was closed between Troutdale and The Dalles leaving large numbers of motorists stranded, removed to safety only by railway. Damage to orchard crops, timber, and power services was common, costing thousands in damages.
>
> **Jan. 30-31, 1963**. Substantial snowfall amplified by moderate to severe icing conditions produced hazardous highways. Large numbers of power lines were downed due to large amounts of ice or felled trees. Injuries, one reported death, and statewide school closures were due to the icy streets and highways.
>
> **Nov. 22-23, 1970**. Freezing rain caused severe glazing across western Oregon, especially in Corvallis, Albany, Salem, Independence, and Dallas. Ice accumulations up to a half inch thick broke thousands of tree limbs and in turn telephone lines. Hazardous traffic conditions, power and phone outages, and felled trees were common.
>
> **Jan. 11-12, 1973**. Rains glazed streets and highways, contributing to numerous auto, bus and truck accidents and persons injured in falls. Most hospitals reported "full house" conditions. Glaze of .25 to .5 inches was common in the Willamette Valley, with up to .75 inches of ice covering all surfaces in the West Hills of Portland.

Ice storms of comparable magnitude to the winter 2003-2004 event occur in Linn County on average about once every 10 years. The 2003-2004 ice storm, with the resulting school closures, downed and damaged trees, and power outages lasting several days in some areas, probably ranks in the top 10 such events in the last 100 years.[14]

Wind Storms

The Columbus Day Storm of 1962 was so devastating that it has become the benchmark from which other storms in Oregon and Linn County are measured.[15] Wind storms on December 10, 1995 and February 6, 2002 caused enough damage in Linn County to be included in Presidential Disaster Declarations. Other significant storms in Linn County include those listed in ***Table 9-2.***

TABLE 9-2
SIGNIFICANT WINDSTORMS[16]

DATE	AFFECTED AREA	CHARACTERISTICS
Apr., 1931	Western Oregon	Unofficial wind speeds reported at 78 mph. Damage to fruit orchards and timber.
Nov. 10-11, 1951	Statewide	Widespread damage; transmission and utility lines; Wind speed 40-60 mph; Gusts 75-80 mph
Dec., 1951	Statewide	Wind speed 60 mph in Willamette Valley. 75 mph gusts. Damage to buildings and utility lines.
Dec., 1955	Statewide	Wind speeds 55-65 mph with 69 mph gusts. Considerable damage to buildings and utility lines
Nov., 1958	Statewide	Wind speeds at 51 mph with 71 mph gusts. Every major highway blocked by fallen trees
Oct., 1962	Statewide	Columbus Day Storm; Oregon's most destructive storm to date. 116 mph winds in Willamette Valley. Estimated 84 houses destroyed, with 5,000 severely damaged. Total damage estimated at $170 million
Mar., 1971	Most of Oregon	Greatest damage in Willamette Valley. Homes and power lines destroyed by falling trees. Destruction to timber in Lane Co.
Nov., 1981	Most of Oregon	Highest winds since 10/62. Wind speed 71 mph in Salem. Marinas, airports and bridges severely damaged
Jan., 1990	Statewide	Heavy rain with winds exceeding 75 mph. Significant damage. One fatality
Dec., 1995	Statewide	Followed path of Columbus Day Storm. Wind speeds 62 mph in Willamette Valley. Damage to trees (saturated soil a factor) and homes. (FEMA-1107-DR-OR)
Nov., 1997	Western Oregon	Wind speed 52 mph in Willamette Valley. Trees uprooted. Considerable damage to small airports.
Feb., 2002	Western Oregon	Strongest storm to strike western Oregon in several years. Many downed power lines (trees); damage to buildings; water supply problems (lack of power). Estimated damage costs: $6.14 million. (FEMA-1405-DR-OR)

Source: Taylor, George H., and Ray Hatton, 1999, *The Oregon Weather Book*, p.151-157; and FEMA-1405-DR-OR: February 7, 2002, Hazard Mitigation Team Survey Report, Severe Windstorm in Western Oregon.

The February 6, 2002 windstorm damaged the electrical distribution infrastructure in six counties. A presidential Disaster Declaration was made for public infrastructure damage when over five million dollars damage was incurred to publicly held electrical power companies. Power company officials have reported that damage from the February 2002 event would have been far more severe if the company had not instituted a tree maintenance program after the December 1995 event.[17]

Damage to power lines and poles affected privately owned and publicly held electrical companies and agencies. While over 80 homes and businesses were damaged, insurance covered all but a few structures. Therefore, there was no Presidential disaster declaration for individual assistance.[18]

Observance of weather patterns in the northeastern Pacific Ocean depicted in enhanced satellite photos available on the Internet can provide advance notice of potential wind and rain storms. The Internet address for this is:

http://www.ocs.orst.edu/pub/weather/data/gifs/ir/goes_west/current.gif

Tornadoes[19]

Tornadoes do occasionally touch down in Linn County, causing light damage. These are classified as "cold core" tornadoes, and do not have as much energy as the more volatile "warm core" tornadoes that occur in the Mid-Western United States. These storms have occurred in all seasons. Observed tornadoes are listed in ***Table 9-3***.

TABLE 9-3
RECORDED TORNADOES[20]

DATE	COUNTY	RESULT
January, 1887	Lane	Fences damaged; Livestock losses; Trees up-rooted
November, 1925	Polk	Buildings, barns, and fruit trees damaged
February, 1926	Polk	House, and trees damaged
September, 1938	Linn	Observed in Brownsville. No damage.
December, 1951	Lane	Barn destroyed
January, 1953	Benton	Observed. No damage
March, 1960	Marion	Several farms damaged near Aumsville. Trees uprooted.
May, 1971	Yamhill	House and barn damaged near McMinnville
August, 1975	Lane	Metal building destroyed near Eugene.
August, 1978	Yamhill	Minor damage near Amity
April, 1984	Yamhill	Barn roof destroyed
May, 1984	Lane	Barn and shelter damaged near Junction City
November, 1989	Lane	Telephone poles and trees up-rooted near Eugene
November, 1991	Marion	Barn damaged near Silverton

Source: George Taylor and Ray Hatton, The Oregon Weather Book (1999), pp.130-137

Avalanches

Lightly populated and uninhabited areas along the western slope of the cascades are subject to risk from avalanches. However, there is usually little danger to life or structural property.

Probability of Future Severe Weather Events

Severe winter storms occur about every four years in Linn County.[21] The recurrence interval of a windstorm on the order of the 1962 Columbus Day Storm is about 100 years. A windstorm on the order of the February 7, 2002 event has a 10 to 12 year recurrence interval.[22]

Vulnerability Assessment

Section 201.6(c)(2)(*ii)*(A) of the Disaster Mitigation Act of 2000 requires that the risk assessment include a description of the jurisdiction's vulnerability to the hazard. This description shall include an overall summary for the hazard and its impact on the community. If best available data allows, vulnerability should be described in terms of the type and number of existing and future buildings, infrastructure, and critical facilities located in identified hazard areas.

Severe Winter Storm Vulnerability[23]

The probability that Linn County will experience severe winter storms and the region's vulnerability to their effects are depicted in ***Table 9-4*** below. These scores are established by Oregon Emergency Management based on an analysis of risk conducted by county emergency program managers, usually with the assistance of a team of local public safety officials.

The probability scores below address the likelihood of a future major emergency or disaster within a specific period of time, as follows:

High = One incident likely within a 10 to 35 year period.

Moderate = One incident likely within a 35 to 75 year period.

Low = One incident likely within a 75 to 100 year period.

The vulnerability scores address the percentage of population or region assets likely to be affected by a major emergency or disaster, as follows:

High = More than 10% affected

Moderate = 1-10% affected

Low = Less than 1% affected

Table 9-4
Vulnerability and Probability Assessment of Winter Storms

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	H	H	H	H	H	M
Probability	H	H	H	H	H	M

Source: Oregon Emergency Management, July 2003, County Hazard Analysis Scores.

Wind Storm Vulnerability[24]

Many buildings, utilities, and transportation systems within Linn County are vulnerable to wind damage. This is especially true in open areas, such as natural grasslands or farmlands. It also is true in forested areas, along tree-lined roads and electrical transmission lines, and on residential parcels where trees have been planted or left for aesthetic purposes. Structures most vulnerable to high winds include insufficiently anchored manufactured homes and older buildings in need of roof repair. The Oregon Department of Administrative Service's inventory of state-owned and operated buildings includes an assessment of roof conditions as well as the overall condition of the structure. Oregon Emergency Management has arranged this information by county.

Fallen trees are especially troublesome. They can block roads and rails for long periods, which can affect emergency operations. In addition, up-rooted or shattered trees can down power and utility lines and effectively bring local economic activity and other essential facilities to a standstill. Much of the problem may be attributed to a shallow or weakened root system in saturated ground. Many roofs have been destroyed by uprooted ancient trees growing next to a house. In some situations, strategic pruning may be the answer. Counties should work with utility companies in identifying problem areas and establishing a tree maintenance and removal program.

Bridges that may be closed during periods of high wind are an additional consideration. The probability that Linn County will experience windstorms and the region's vulnerability to their effects are depicted in ***Table 9-5*** below. These scores are established by Oregon Emergency Management based on an analysis of risk conducted by county emergency program managers, usually with the assistance of a team of local public safety officials.

The probability scores below address the likelihood of a future major emergency or disaster within a specific period of time, as follows:

High = One incident likely within a 10 to 35 year period.

Moderate = One incident likely within a 35 to 75 year period.

Low = One incident likely within a 75 to 100 year period.

The vulnerability scores address the percentage of population or region assets likely to be affected by a major emergency or disaster, as follows:

High = More than 10% affected

Moderate = 1-10% affected

Low = Less than 1% affected

TABLE 9-5
Vulnerability and Probability Assessment of Windstorms

	Benton	Lane	Linn	Marion	Polk	Yamhill
Vulnerability	H	H	H	H	H	M
Probability	H	H	H	H	H	M

Source: Oregon Emergency Management, July 2003, County Hazard Analysis Scores.

Community Impacts

Life and Property

Severe weather can be a deceptive killer. Storms—which bring snow, ice, and high winds—can have a significant impact on life and property. Many severe winter storm deaths occur as a result of traffic accidents on icy roads, heart attacks while shoveling snow, and hypothermia from prolonged exposure to the cold. Debris carried along by extreme winds can contribute directly to loss of life and indirectly through the failure of protective buildings, structures and infrastructure.

Property is at risk due to flooding (see ***Section 6***) and landslides (see ***Section 7***) that result from heavy rain and snowmelt. Additionally, ice, wind, and snow can affect the stability of trees, power lines, telephone lines, and television and radio antennas. Falling trees and limbs affected by these events and saturated soils can become hazards for houses, cars, utilities, and other property. These conditions can be major hindrances to emergency response and disaster recovery.

Windstorms have the ability to cause damage more than 100 miles from the center of storm activity. Wind pressure can create a direct 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. The forces applied by the wind to the building's protective envelope (doors, windows, and walls) can cause failure of some of the building's components and considerable structural damage. The effects of wind speed are shown in ***Table 9-6***.

Table 9-6
Effects of Wind Speed

WIND SPEED (MPH)	WIND EFFECTS
25-31	Large branches will be in motion.
32-38	Whole trees in motion; inconvenience felt
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

Infrastructure

Traffic

Severe weather can cause prolonged and extreme traffic disruptions. The importance of transportation is especially noticeable in situations where travel is difficult or dangerous. Both property damage and loss of life are risks to those who must drive. Economic concerns arise during storms that cause dangerous road conditions since many people choose to stay home in these situations. Additionally, traffic delays or blockages can seriously hinder the ability of emergency service providers.

Utilities

Falling trees are the major cause of power outages resulting in interruption of services and damaged property. The issue of weather related power outages must be addressed because many Linn County residents rely on electricity for heat, either directly or indirectly. Even homes using natural gas typically require electricity for system ignition and to operate and run circulation fans and thermostats. Natural gas distribution systems also rely to some degree on electrical service to keep the system operational and widespread power outages can interrupt that service. Power loss is also a concern economically as businesses may have to close during power outages.

Many overhead wires are at risk from snow and ice accumulations that are beyond their design specifications. High winds can create flying debris and down utility lines. For example, tree limbs breaking in winds of only 45 mph can be thrown more than 75 feet. As such, overhead power lines can be damaged even in relatively minor windstorm events.

Increasing population and new infrastructure in Linn County mean that more lives and property are exposed to risk. This situation creates a higher probability that damage will occur from severe weather events.

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 through the months of October, November, and December. In almost every severe winter storm previously described, broken pipes led to the closures of schools and businesses in Linn County.

During freezes, the broken mains not only result in lost water service to customers but also cause extensive property damage from spilled water. Severe weather can also affect the water system in other ways. Power interruptions at distribution pump stations, groundwater wells can have dramatic negative consequences to the water system. 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.

Vulnerable Assets

Section 201.6(c)(2)(ii)(B) of the *Disaster Mitigation Act of 2000* (DMA-2000) requires that the risk assessment include an estimate of the potential dollar losses to vulnerable structures. There is insufficient development and vulnerability data available to estimate potential dollar losses to vulnerable structures and facilities at this time. The collection and analysis of appropriate data would serve as an important mitigation item to be completed in the future. Needed data includes the location and ranking of hazard areas; the types and numbers of buildings, infrastructure and critical facilities; and the location, construction, materials, and replacement value of buildings, infrastructure and critical facilities in hazard areas.

Severe Weather Mitigation Programs

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

Local Programs

The Linn County Road Department maintenance crews implement the county's tree and limb maintenance program. The Road Department documents potentially hazardous vegetation along county road rights-of-way and conducts spraying, pruning and removal activities along roadways each year. Pacific Power also conducts a tree maintenance program along its overhead facilities.

The Oregon Department of Transportation (ODOT) has issued road clearing priority maps for state highways and alternate routes in Linn County. The Linn County Road Department has developed emergency road clearing and maintenance protocols and priorities that identify additional county roads as Priority 1, Priority 2, Priority 3, or non-priority roads. The Road Department is organized into five maintenance districts. In the event of a severe weather event or other natural hazard that precipitates road closures, each maintenance district uses the established road priority maps to determine emergency maintenance priorities. The priority maps are included at the end of this chapter. The Road Department deploys county-maintained road grading, sanding and snow plow equipment to improve public safety on county roads.

Federal Programs

National Weather Service

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

Severe Weather Mitigation Action Items

The severe weather event mitigation action items were identified and prioritized by the Mitigation Plan Steering Committee during open meetings with input from stakeholders and other interested members of the public. The action items provide direction on specific activities that the County and organizations and residents in Linn County can undertake to reduce risk and prevent loss from severe weather events. There is one short-term and there are two long-term severe weather hazard action items described below.

Short-term Action Items

WS-ST #1: Action 2.2.4 Develop pre-storm strategies for coordinated debris removal following wind and winter storms

Coordinating Organization:	Road Department
Internal Partners:	Emergency Management; Sheriff
External Partners:	911 Coordinator; Utility Companies; Cities
Timeline:	Ongoing
Plan Goals Addressed:	Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective:	Objective 2.2 Support the enhancement of County vulnerability assessment activities.

Long-term Action Items

WS-LT #1: Action 2.2.5 Identify severe weather hazard areas and inventory vulnerable buildings, infrastructure and critical facilities.

Coordinating Organization:	Emergency Management
Internal Partners:	Road Dept; Planning and Building; Assessor; GIS
External Partners:	Emergency Services Providers; ODOT; OEM; FEMA; Utility Companies; Insurance Companies
Timeline:	2-5 years
Plan Goals Addressed:	Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective:	Objective 2.2 Support the enhancement of County vulnerability assessment activities.

WS-LT #2: Action 3.3.6 Develop partnerships to implement programs to keep trees from threatening lives, property, and public infrastructure during wind and winter storms

Coordinating Organization:	Emergency Management
Internal Partners:	Road Dept; Parks Dept; Commissioners
External Partners:	Utility Companies; Insurance Companies; DOF; Timber Companies; Arbor Care Companies
Timeline:	2-5 years
Plan Goals Addressed:	Goal 3. Protect life, the built environment, the economy and natural resources through community-wide partnerships
Plan Objective:	Objective 3.3. Develop partnerships with external partners for hazard specific mitigation projects.

Severe Weather Endnotes

[1] Linn County Emergency Management Agency 2004 Hazard Analysis, pg. 3

[2] Oregon State Natural Hazard Mitigation Plan (OR-SNHMP) (Region 3) Mid/Southern Willamette Valley Hazards Assessment, Nov. 2003, pp R3-32

[3] Interagency Hazard Mitigation Team, *State Hazard Mitigation Plan* (2000) Oregon State Police - Office of Emergency Management

[4] National Weather Service Web-Page, http://www.wrh.noaa.gov/pqr/pdxclimate/index/php (Accessed 20 October 2004)

[5] Western Regional Climate Center

[6] Linn County Emergency Management Agency 2004 Hazard Analysis, pg. 4

[7] Taylor, George H. and Hannon, Chris, *The Oregon Weather Book,* (1999) Oregon State University Press

[8] Taylor, George, Oregon State Climatologist, Albany Democrat-Herald, January 17, 2004

[9] Taylor, George H. and Hannon, Chris, *The Oregon Weather Book,* (1999) Oregon State University Press

[10] Ibid.

[11] National Weather Service Web-Page, http://www.wrh.noaa.gov/pqr/pdxclimate/PG21.html (Accessed 20 October 2004)

[12] Linn County Emergency Management Agency 2004 Hazard Analysis, pg. 5

[13] Taylor, George, Oregon State Climatologist, Albany Democrat-Herald, January 17, 2004

[14] Ibid.

[15] Oregon State Natural Hazard Mitigation Plan (OR-SNHMP) (Region 3) Mid/Southern Willamette Valley Hazards Assessment, Nov. 2003, pp R3-28

[16] Ibid. pg. R3-29

[17] Linn County Emergency Management Agency 2004 Hazard Analysis, pg. 5

[18] Ibid.

[19] Ibid.

[20] Oregon State Natural Hazard Mitigation Plan (OR-SNHMP) (Region 3) Mid/Southern Willamette Valley Hazards Assessment, Nov. 2003, pp R3-30

[21] Ibid. pg. R3-34

[22] Ibid. pg. R3-30

[23] Ibid. pg. R3-34

[24] Ibid. pg. R3-30, R3-31

Section 10:
Earthquake

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Why are Earthquakes a threat to Linn County?

Oregon is rated third highest in the nation for potential loss due to earthquakes. This is partly due to the fact that until recently, Oregon was not considered to be an area of high seismicity, and the majority of its buildings and infrastructure were not designed for ground shaking at the magnitude now expected.

Recent studies of geological records show that Oregon has a history of seismic events, and that the Cascadia Subduction Zone is capable of producing magnitude 9.0 earthquakes. Projected losses in the Cascadia region could exceed $12 billion; 30,000 buildings could be destroyed and 8,000 lives lost in the event of a magnitude 8.5 Cascadia Subduction Zone earthquake.

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 Linn County.

The older a structure is the greater the risk of damage from earthquake. Seismic standards were not adopted into the state's building codes until 1973. Homes built before then normally did not incorporate earthquake resistant designs. As of March 2000, 72 percent of housing units in Linn County were constructed prior to 1980.[1]

Earthquake Characteristics

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 and occur at relatively shallow depths of 6-12 miles below the surface.[2] While most crustal fault earthquakes are smaller than magnitude 4.0 and generally create little or no damage, some can produce earthquakes of magnitudes 7.0 and higher and cause extensive damage. The county contains many areas of moderate to steep slopes where the soils are saturated for much of the year. A crustal fault quake could contribute to landslides in such areas.

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 magnitude 7.5.[3] 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 the Seattle-Tacoma International Airport caused seven deaths.[4]

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 and extends from British Columbia to northern California. Subduction zone earthquakes are caused by the abrupt release of slowly accumulated stress. Subduction zones similar to the Cascadia Subduction Zone have produced earthquakes with magnitudes (M) of 8.0 or larger. Historic subduction zone quakes include the 1960 Chile (M 9.5) and the 1964 southern Alaska (M 9.2) earthquakes. Geologic evidence shows that the Cascadia Subduction Zone has generated great earthquakes, most recently about 300 years ago. The largest is generally accepted to have been M 9.0 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.

The December 26, 2005 Sumatra quake is an example of a subduction zone earthquake. This was the fourth largest earthquake in the world since 1900 and is the largest since the 1964 Prince William Sound, Alaska earthquake. In total, more than 283,100 people were killed and 126,900 were displaced by the earthquake and subsequent tsunami in 10 countries in South Asia and East Africa. The earthquake was felt at Banda Aceh, at Meulaboh and at Medan, Sumatra and in parts of Bangladesh, India, Malaysia, Maldives, Myanmar, Singapore, Sri Lanka and Thailand. The tsunami caused more casualties than any other in recorded history and was recorded nearly world-wide on tide gauges in the Indian, Pacific and Atlantic Oceans. Surface water oscillations were observed in India and the United States. Subsidence and landslides were observed in Sumatra.[5]

Earthquake Risk Assessment

Hazard Identification

Section 201.6(c)(2)(*i*) of the Disaster Mitigation Act of 2000 requires that the risk assessment include a description of the location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

Location and Extent of Earthquake Hazard[6]

The geographical position of Linn County makes it susceptible to earthquakes from four sources: (1) the off-shore Cascadia Fault Zone; (2) deep intra-plate events within the subducting Juan de Fuca plate; (3) shallow crustal events within the North America Plate; and (4) earthquakes associated with renewed volcanic activity. All have some tie to the subducting or diving of the dense, oceanic Juan de Fuca Plate under the lighter, continental North America Plate. Stresses occur because of this movement and there appears to be a link between the subducting plate and the formation of volcanoes some distance inland from the off-shore fault zone.

When crustal faults slip, they can produce earthquakes with magnitudes (M) up to 7.0 and can cause extensive damage, which tends to be localized in the vicinity of the area of slippage. Deep intraplate earthquakes occur at depths between 30 and 100 kilometers below the earth's surface. They occur in the subducting oceanic plate and can approach M7.5. Subduction zone earthquakes pose the greatest hazard. They occur at the boundary between the descending oceanic Juan de Fuca Plate and the overriding North American Plate. This area of contact, which starts off the Oregon coast, is known as the Cascadia Subduction Zone (CSZ). The CSZ could produce an earthquake up to 9.0 or greater.

The Willamette Valley has experienced a few historic earthquakes centered in the region. The area has been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside the area. The most devastating future earthquakes will probably originate along shallow crustal faults in the region and along the Cascadia Fault Zone. Deep-seated intra-plate events, as occurred near Olympia, Washington in 1949 and 2001, could generate magnitudes as large as M7.5.

Earthquake associated hazards include severe ground shaking, liquefaction of fine-grained soils, and land sliding. The severity of these effects depend on several factors, including the distance from the earthquake source, the ability of soil and rock to conduct seismic energy and the degree (angle) and composition of slope materials. Earthquakes produced through volcanic activity could reach magnitudes of M5.2. However the Cascade volcanoes are some distance away from populated centers, which tends to lessen the risk.

While the DOGAMI earthquake data does not show active faults within Linn County, several active crustal faults are located nearby in Benton and Marion Counties. Earthquake risk in Linn County is reflected in the Uniform Building Code's (UBC) Earthquake Hazard maps (i.e., seismic zones 1-4). The higher the numerical designation, the more stringent the building standards become. Linn County is within UBC Seismic Zone 3.

Previous Occurrences of Earthquakes

Table 10-1 below contains information on previous Pacific Northwest earthquakes. Not all of the earthquakes in the table had significant impacts in Linn County. However, Linn County is vulnerable to the same tectonic forces and impacts.

February 28, 2001, Nisqually Earthquake -- Magnitude 6.8

The most recent large earthquake to be felt in the Northwest was the Nisqually earthquake, on February 28, 2001. This earthquake was centered northeast of Olympia, Washington, approximately 200 miles north of Linn County, and measured a magnitude of 6.8 on the Richter scale. In the Puget Sound area, this quake caused 400 injuries, one quake-related death, and about $2 billion dollars in damage.[7]

September 21, 1993, Klamath Falls Earthquakes – Magnitude 5.9

The most damaging far-inland earthquakes of the century in the California-Oregon border region. These earthquakes occurred along faults which are part of the northernmost Basin and Range geologic province. Significant damage occurred in older un-reinforced brick buildings in

the Klamath Falls area, approximately 200 miles south of Linn County. Rock falls caused the death of one motorist. This sequence illustrates that inland communities, although not as frequently hit as coastal regions, are also vulnerable to strong earthquakes.[8]

TABLE 10-1
SIGNIFICANT EARTHQUAKES

DATE	LOCATION	SIZE (M)	COMMENTS
Approximate Years 1400 BCE* 1050 BCE 600 BCE 400 750 900	Offshore, Cascadia Subduction Zone	Probably 8-9	Based on studies of earthquake and tsunami at Willapa Bay, Washington. These are the mid-points of the age ranges for these six events.
January, 1700	Offshore, Cascadia Subduction Zone	Approximately 9.0	Generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast
April, 1896	McMinnville	4	Also felt in Portland
July, 1930	Perrydale	4	Cracked plaster
April, 1949	Olympia, WA	7.1	Significant damage in Washington. Minor damage in NW Oregon. Intraplate
August, 1961	Albany (Linn County)	4.5	Minor damage in Albany
November, 1962	Portland area	5.5	Shaking lasted up to 30 seconds; chimneys cracked; windows broken; furniture moved
March, 1963	Salem	4.6	Minor damage in Salem
March, 1993	Scotts Mills, OR	5.6	On Mt. Angel-Gales Creek fault. $30 million damage (including Oregon State Capitol in Salem) (FEMA-985-DR-OR)
February, 2001	Nisqually, WA	6.8	Felt in the region, no damage reported

*BCE = Before Common Era

Sources: Ivan Wong and Jacqueline D.J. Bolt, 1995, "A Look Back at Oregon's Earthquake History, 1841-1994", *Oregon Geology*, pp. 125-139.

March 25, 1993, Scotts Mills Earthquake – Magnitude 5.7

In 1993, the Scotts Mills earthquake shook the northern Willamette Valley. It was a magnitude 5.7 on the Richter scale, and caused extensive damage primarily in the communities of Molalla, Woodburn, Newberg, McMinnville, and Salem.

November 5, 1962, Vancouver, Washington – Magnitude 5.2

Three and a half weeks after the devastating Columbus Day Storm, an earthquake that measured approximately 5.5 on the Richter scale shook Northwest Oregon. Centered approximately 60 miles north of Linn County, it was the largest quake to be generated by a fault under Portland and Vancouver.[9] This earthquake disappeared quickly from headlines, most likely because residents were still recovering from the Columbus Day Storm at the time of the earthquake.[10]

April 13, 1949, Olympia, Washington – Magnitude 7.1

On April 13, 1949, residents of Northwest Oregon felt an earthquake that was centered near Olympia, Washington, approximately 180 miles north of Linn County. In Washington, this quake caused 8 deaths and caused extensive damage to buildings and infrastructure.

Probability of Future Earthquake Events[11]

The Cascadia Subduction Zone generates an earthquake on average every 500-600 years. However, as with any natural process, the average time between events can be misleading. Some of the earthquakes may have been 150 years apart with some closer to 1,000 years apart (DOGAMI, 1999). Establishing a probability for crustal earthquakes is more difficult.

There have been 5 earthquakes above magnitude 4 (4M) centered in this region (see ***Table 10-1*** above), of which the 1993 Scotts Mills earthquake was the largest. Oregon's seismic record is short and the number of earthquakes above 4M centered in the Willamette Valley is small. Therefore, any kind of prediction would be questionable. Earthquakes generated by volcanic activity in Oregon's Cascade Range are possible, but likewise unpredictable.

Vulnerability to Future Earthquake Events[12]

The Willamette Valley is especially vulnerable to earthquake hazards because much of the area is susceptible to earthquake-induced landslides, liquefaction, and strong ground shaking. The Oregon Department of Geology and Mineral Industries (DOGAMI) has developed two earthquake loss models for Oregon based on the two most likely sources of seismic events: (1) the Cascadia Subduction Zone (CSZ); and (2) combined crustal events (500-year Model). Both models are based on HAZUS software currently used by the Federal Emergency Management Agency (FEMA) as a means of determining potential losses from earthquakes.

The CSZ event model is based on a potential 8.5 earthquake generated off the Oregon coast. The model does not take into account a tsunami, which probably would develop from the event. The 500-Year crustal event model does not look at a single earthquake (as in the CSZ model); it encompasses many faults, each with a 10 percent chance of producing an earthquake in the next 50 years. The model assumes that each fault will produce a single "average" earthquake during this time. Neither model takes un-reinforced masonry buildings into consideration.

The DOGAMI cautions that the models contain a high degree of uncertainty and should be used only for general planning purposes. Despite their limitations, the models provide some approximate estimates of damage. The results are shown in ***Table 10-2***, ***Table 10-3*** and ***Table 10-4*** below.

TABLE 10-2
ESTIMATED LOSSES FROM M8.5 CSZ AND 500-YEAR MODEL

REGION 3 COUNTIES	ECONOMIC BASE IN THOUSANDS (1999)	GREATEST ABSOLUTE LOSS IN THOUSANDS (1999) FROM AN 8.5 CSZ EVENT	GREATEST ABSOLUTE LOSS IN THOUSANDS (1999) FROM A 500-YEAR (CRUSTAL) EVENT
Benton	$3,963,000	$632,000	$1,073,000
Lane	$15,418,000	$1,614,000	$3,044,000
Linn	$4,724,000	$443,000	$998,000
Marion	$11,812,000	$776,000	$2,342,000

Source: DOGAMI, 1999, Special Publication 29: Earthquake Damage in Oregon

TABLE 10-3
ESTIMATED LOSSES ASSOCIATED WITH A MAGNITUDE 8.5 SUBDUCTION EVENT*

LOSS CATEGORY	Benton	Lane	Linn	Marion
Injuries	398	1,036	281	499
Deaths	8	19	5	9
Displaced Households	1,223	2,345	615	1,241
Economic Losses For Buildings	$652 million	$1.6 billion	$443 million	$776 million
Operational the Day After the Event				
Fire station	46%	49%	62%	68%
Police Station	38%	42%	60%	56%
Schools	40%	46%	53%	64%
Bridges	61%	76%	79%	81%
Economic Loss to Infrastructure				
Highways	$ 5 million	$39 million	$11 million	$13 million
Airports	$5 million	$11 million	$9 million	$5 million
Communications	$4 million	$11 million	$1 million	$2 million
Debris Generated (thousands of tons)	544	1,341	400	664

Source: DOGAMI, 1999, Special Paper 29: Earthquake Damage in Oregon

Notes: *The existence of many un-reinforced masonry buildings was not taken into account in the HAZUS run which produced these numbers

TABLE 10-4
ESTIMATED LOSSES ASSOCIATED WITH A 500-YEAR MODEL[1]

MITIGATION FACTORS	REGION 3 COUNTIES					
	Benton	**Lane**	**Linn**	**Marion**	**Polk**	**Yamhill**
INJURIES	682	2,254	736	1,951	266	427
DEATHS	15	45	15	41	6	9
DISPLACED HOUSEHOLDS	2,082	4,543	1,372	3,356	1,064	871
ECONOMIC LOSSES FOR BUILDINGS[2]	$1.1 billion	$3 billion	$1 billion	$2.3 billion	$529 million	$654 million
OPERATIONAL THE DAY AFTER THE EVENT						
Fire station	N/A[3]	N/A*	N/A*	N/A*	N/A*	N/A*
Police Station	N/A	N/A	N/A	N/A	N/A	N/A
Schools	N/A	N/A	N/A	N/A	N/A	N/A
Bridges	N/A	N/A	N/A	N/A	N/A	N/A
ECONOMIC LOSSES TO INFRASTRUCTURE						
Highways	$11 million	$74 million	$34 million	$59 million	$72 million	$11 million
Airports	$11 million	$20 million	$24 million	$23 million	$13 million	$20 million
Communications	$10 million	$20 million	$4 million	$8 million	$2 million	$3 million
DEBRIS GENERATED (in thousands of tons)	802	2,424	818	1,855	378	532

Source: DOGAMI, 1999, Special Paper 29.

Notes:

[1]Every part of Oregon is subject to earthquakes. The 500-year model is an attempt to quantify the risk across the state. The estimate does not represent a single earthquake. Instead, the 500-year model includes many faults, each with a 10% chance of producing an earthquake in the next 50 years. The model assumes that each fault will produce a single "average" earthquake during this time. More and higher magnitude earthquakes than used in this model may occur. (DOGAMI, 1999).

[2]There are numerous un-reinforced masonry structures (URMs) in Oregon, the currently available default building data does not include any URMs. Thus, the reported damage and loss estimates may seriously under-represent the actual threat" (page 126 – 1998, DOGAMI)

[3]Because the 500-year model includes several earthquakes, the number of facilities operational the "day after" can not be calculated

The DOGAMI has also mapped areas of severe ground shaking, liquefaction, and earthquake-induced landslides for all the counties in the Willamette Valley. These maps can be used for general planning purposes. The DOGAMI severe ground shaking, liquefaction, and earthquake-induced landslides maps for Linn County are included at the end of this chapter.

Probability and Vulnerability Scores

The probability that Willamette Valley counties will experience earthquakes and the region's vulnerability to their effects are depicted in ***Table 10-6*** below. These scores are based on an analysis of risk conducted by county emergency program managers, usually with the assistance of a team of local public safety officials.

The probability scores below address the likelihood of a future major emergency or disaster within a specific period of time, as follows:

High = One incident likely within a 10 to 35 year period.

Moderate = One incident likely within a 35 to 75 year period.

Low = One incident likely within a 75 to 100 year period.

The vulnerability scores address the percentage of population or region assets likely to be affected by a major emergency or disaster, as follows:

High = More than 10% affected

Moderate = 1-10% affected

Low = Less than 1% affected

TABLE 10-6
Vulnerability and Probability Assessment of Earthquake

	Benton	Lane (Inland)	Linn	Marion	Polk	Yamhill
Vulnerability	H	H	H	H	H	M
Probability	M	L	H	H	M	H

Source: Oregon Emergency Management, July 2003, County Hazard Analysis Scores.

Earthquake Hazard Vulnerability: Identifying Assets

Section 201.6(c)(2)(ii)(A) of the Disaster Mitigation Act of 2000 (DMA-2000) requires that the risk assessment describe the jurisdiction's vulnerability to the hazard. This description shall include an overall summary for the hazard and its impact on the community. If best available data allows, vulnerability should be described in terms of the type and number of existing and future buildings, infrastructure, and critical facilities located in identified hazard areas.

Linn County Vulnerability Summary[13]

Linn County is subject to the effects of two types of earthquakes: crustal fault earthquakes and subduction zone earthquakes. Both have approximately a 50 percent chance of occurring at any time within the next 50 years.

A crustal fault earthquake with an intensity of 5 to 7 on the Richter Scale could be expected to cause moderate to extensive damage to un-reinforced masonry structures in Linn County. Linn County is also vulnerable to a subduction zone earthquake off the Oregon Coast, where the Juan de Fuca Plate is subducting under the Oregon portion of the Continental Plate. This area is known as the Cascadia Subduction Zone, which extends under the Coast Range to the Willamette Valley.

An earthquake in the Cascadia Subduction Zone could be as high as 8 or 9 on the Richter Scale. Significant and severe damage could occur to even the most well constructed buildings in the county. Buildings constructed of un-reinforced masonry and buildings built before 1970 would be the most severely damaged. There are over 326 bridges and over 1139 miles of county roads in Linn County that would also be subjected to severe damage. Secondary hazards, such as hazardous materials releases, structure fires, power loss and dam failures could multiply the adverse effects of a subduction zone earthquake.

Earthquake Community Hazards and Impacts

Earthquake damage occurs because structures cannot withstand severe shaking and other geologic activities associated with earthquakes. Buildings, airports, schools, and lifelines including water, sewer, storm water and gas lines, transportation systems, electricity, and communication networks suffer damage in earthquakes and can cause death or injury to humans.

The welfare of homes, businesses, and public infrastructure is very important. Addressing the integrity of buildings, critical facilities, and infrastructure, and understanding the potential costs to government, businesses, and individuals as a result of an earthquake are challenges that Linn County must address.

Earthquake Related Hazards

Ground Shaking

Ground shaking is the motion felt on the earth's surface caused by seismic waves generated by an 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. The DOGAMI generated Relative Ground Shaking Amplification Susceptibility Map for Linn County is included at the end of this chapter.

Surface Fault Ruptures

Earthquakes are caused by the sudden movement, or rupture, of a fault. As the rupture zone progresses upward to the earth's surface it can cause surface fault ruptures. The result is often displacement or offset of the ground surface. Generally, the larger the earthquake, the greater the potential for surface fault rupture. It is generally considered impractical to design structures to withstand damage under the stress of surface fault rupture. Additionally, once a structure is located astride a fault, it is impossible to mitigate the surface fault rupture hazard unless the structure is relocated.[14]

Earthquake-Related Landslides

Earthquake-induced landslides are secondary earthquake hazards that occur from ground shaking. They can destroy roads, buildings, utilities, and other critical facilities necessary to respond to and recover from an earthquake. Many communities in Oregon, including Linn County, are likely to encounter such risks, especially in areas with steep slopes. As sloped lands to the northeast and southwest are developed, earthquake related landslides will begin to pose a bigger threat to homes and infrastructure. The DOGAMI generated Relative Slope Stability Susceptibility Map for Linn County, which shows earthquake induced landslide potential, is included at the end of this chapter.

Liquefaction

Liquefaction occurs when ground shaking causes wet granular soils to change from a solid to a liquid state. This causes a loss of soil strength and three potential types of ground failure: lateral spreading, flow failure, and loss of bearing strength. Buildings and their occupants are at risk when the ground can no longer support buildings and structures.[15] Areas of susceptibility to liquefaction include areas with high ground water tables and sandy soils.[16] The DOGAMI generated Relative Liquefaction Susceptibility Map for Linn County, which shows earthquake induced liquefaction potential, is included at the end of this chapter.

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. Amplification depends on the thickness of geologic materials and their physical properties. Buildings and structures built on soft and unconsolidated soils can face greater risk.[17] Amplification can also occur in areas with deep, sediment filled basins. The DOGAMI generated Relative Ground Shaking Amplification Susceptibility Map for Linn County is included at the end of this chapter.

Direct Earthquake Impacts

Buildings

The built environment is susceptible to damage from earthquakes. Buildings that collapse can trap and bury people, putting lives at risk and creating great costs to clean up the damages. In most Oregon communities, the majority of buildings were built before 1993 when building codes were not as strict, and many were built before 1973 when the state building codes did not include seismic standards.

Upgrading existing buildings to resist earthquake forces is more expensive than meeting code requirements for new construction. State code only requires seismic upgrades when there is significant structural alteration to the building or where there is a change in use that puts building occupants and the community at a greater risk. Therefore, the number of buildings at risk remains high. The lack of funding for such activity is a major issue.

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, power lines to fall, roads and railways to crack or move, and radio and telephone communication to cease. Transportation disruptions make it difficult to bring in supplies or services. All lifelines need to be usable after an earthquake to allow for rescue, recovery, and rebuilding efforts and to relay important information to the public.

Infrastructure and Communication

An earthquake can greatly damage bridges and roads, hampering the movement of people and goods. Damaged infrastructure strongly affects the economy of the community – it disconnects people from work, school, food, and leisure, and separates businesses from their employees, 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.

Linn County is bordered on the west by the Willamette River and on much of the north by the Santiam River system. Bridge crossings connect Linn County to Benton County at downtown Albany (U.S. Highway 20) and at Downtown Corvallis (State Highway 34). Another Willamette River crossing connects Linn County to Lane County at downtown Harrisburg. Important Santiam River system crossings connect Linn County to Marion County on Interstate 5, and at

the communities of Stayton, Lyons, Mill City and Gates. In all these cases connections to critical facilities such as hospitals, police and fire and rescue agencies will be impaired in the event of a bridge failure.

Disruption of Critical Services

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.

Indirect Earthquake Impacts

Businesses

Seismic activity can cause great loss to businesses - both large-scale corporations and small retail shops. When a company is forced to stop production for just a day, the economic loss can be tremendous, especially when its market is at a national or global level. Seismic activity can create economic loss that presents a burden to small shop owners who may have difficulty recovering from their losses. Most businesses could remain closed for only two days before suffering serious economic hardship.

Individual Preparedness

A 1999 DOGAMI survey shows that about 39 percent of respondents think an earthquake will occur in Oregon within the next 10 years. Only 28 percent of Oregon residents say they are prepared for an earthquake, and 22 percent have earthquake insurance. In addition, only 24 percent correctly identified what to do during an earthquake.[18]

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 insured for earthquake, are just a few steps individuals can take to prepare for an earthquake.

Death and Injury

Death and injury can occur both inside and outside of buildings due to falling equipment, furniture, debris, and structural materials. Downed power lines and broken water and gas lines can also endanger human life. Deaths can be prevented with proper building design and individual preparedness.

Debris

Following damage to 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.

Fire

Downed power lines or broken gas mains can trigger fires. When fire stations suffer structural or lifeline damage, quick response to suppress fires is less likely. Therefore, it is necessary for fire stations and critical facilities to be well protected from natural disasters. It is also necessary that the water system be well protected so that water for fire fighting will be available if needed. In the San Francisco earthquake of 1906, 85 percent of the total damage was caused by post-earthquake structural fires that could not be effectively fought because of earthquake damage to the water system.

Earthquake HAZUS

The Department of Geology and Mineral Industries (DOGAMI) has provided the county with its preliminary release of the Hazards US (HAZUS) global output reports and earthquake-induced hazard maps for Linn County. The final official publication is expected in the winter of 2005. The preliminary release information and maps are included in ***Appendix D*** of this plan. The official DOGAMI publication of the HAZUS earthquake models for Linn County will replace the preliminary information at a later date.

The preliminary HAZUS reports include separate models and data for two worst-case earthquake scenarios and their potential impacts on Linn County: (1) a magnitude 6.7 crustal earthquake on the Mill Creek Fault in northern Linn County/southern Marion County; and (2) a magnitude 9.0 earthquake of the Cascadia Subduction zone off the Oregon and Washington coast.

Vulnerable Assets

The HAZUS reports in ***Appendix D*** include information on the types and numbers of buildings, infrastructure, critical facilities, and lifeline facilities in Linn County. Each earthquake model also includes tables showing expected building damage by occupancy and type; expected damage to essential and transportation facilities; expected utility system facility and pipeline damage; and expected potable water and electric system performance.

Building Damage

The Mill Creek crustal fault earthquake model estimates that about 12,431 thousand buildings will be at least moderately damaged. This is over 34 percent of the total number of buildings in the region. There are an estimated 2,671 buildings that will be completely destroyed. Table 4 on page 20 of the HAZUS report in ***Appendix D*** summarizes the expected damage by general occupancy for the buildings in the region. Table 5 on page 20 of the HAZUS appendix summarizes the expected damage by general building type.

The Cascadia subduction earthquake model estimates that about 10,372 buildings will be at least moderately damaged. This is over 29 percent of the total number of buildings in the region. There are an estimated 2,470 buildings that will be completely destroyed. Table 4 on page 40 of the HAZUS appendix summaries the expected damage by general occupancy for the buildings in the region. Table 5 on page 40 of the HAZUS appendix summarizes the expected damage by general building type.

Essential Facility Damage

Currently, the region has 71 hospital beds available for use. The Mill Creek crustal fault earthquake model estimates that on the day of the earthquake, only 3 hospital beds (4 percent) will remain available for use by patients already in the hospital and those injured by the earthquake. After one week, 20 percent of the beds will be back in service. By 30 days, 62 percent will be operational. Table 6 on page 21 of the HAZUS appendix summarizes the expected damage to essential facilities.

The Cascadia subduction earthquake model estimates that on the day of the earthquake, 63 hospital beds (90 percent) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 90 percent of the beds will be back in service, and by 30 days, 90 percent will be operational. Table 6 on page 41 of the HAZUS appendix summarizes the expected damage to essential facilities.

Transportation and Utility Lifeline Damage

Transportation and utility lifeline damage estimates for the Mill Creek crustal fault earthquake model are shown in Table 7 through Table 10 on pages 22 and 23 of the HAZUS appendix. The model estimates that 12 of 122 bridges in the county will have at least moderate damage and that 119 of 122 bridges will be at least 50 percent functional after 7 days. The model shows that at day 7 utility system facilities will be at least 50 percent functional but that as many as 117 households may be without potable water and 3,254 households may be without electric power. The model shows that 776 households may still be without electric power at day 30.

Transportation and utility lifeline damage estimates for the Cascadia Subduction zone earthquake model are shown in Table 7 through Table 10 on pages 42 and 43 of the HAZUS appendix. The model estimates no significant damage to transportation systems and only minor damage to utility facility systems. The model shows that 259 household may still be without potable water at day 3 and none without water by day 7.

Vulnerability: Estimating Potential Losses

Section 201.6(c)(2)(*ii)*(B) of the Disaster Mitigation Act of 2000 (DMA 2000) requires that the risk assessment include an estimate of the potential dollar losses to vulnerable structures. The DOGAMI HAZUS earthquake models in ***Appendix D*** include potential building-related, transportation lifeline, utility lifeline, and utility system economic loss estimates.

The total economic loss estimated in Linn County for the Mill Creek crustal fault earthquake is $1,700,280,000. The total economic loss estimated for the Cascadia Subduction zone earthquake is $1,310,630,000. These estimates include building and lifeline related losses based on the region's available inventory.

Information about potential losses and the methodology used to estimate them is found in ***Appendix D,*** on pages 27-30 (Mill Creek crustal fault earthquake) and on pages 47-49 (Cascadia Subduction zone earthquake).

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

Mill Creek Crustal Earthquake Losses

The total building-related losses in the Mill Creek crustal fault earthquake model were $1,315,720,000. Ten percent of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 66 percent of the total loss. Table 12 on page 27 of ***Appendix D*** provides a summary of the losses associated with the building damage.

Cascadia Subduction Zone Earthquake Losses

The total building-related losses in the Cascadia Subduction zone earthquake model were $1,150,680,000. Thirteen percent of the estimated losses were related to the business interruption of the region. The largest loss was sustained by the residential occupancies which made up over 51 percent of the total loss. Table 12 on page 47 of ***Appendix D*** provides a summary of the losses associated with the building damage.

Casualties

HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows:

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum; the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum; and 5:00 PM represents peak commute time.

Mill Creek Crustal Earthquake Casualties

Table 11 on page 26 of ***Appendix D*** provides a summary of injury and casualty estimates for the Mill Creek crustal fault earthquake model. The greatest number of injuries and casualties are

expected with the 2:00 p.m. earthquake scenario. The least number of injuries and casualties is expected with the 2:00 a.m. scenario. Level 1 injury estimates range from 650 to 838. Level 2 injuries requiring hospitalization range from 156 to 248. Life-threatening Level 3 injury estimates range from 14 to 49 and casualty estimates range from 25 to 74.

Cascadia Subduction Zone Earthquake Casualties

Table 11 on page 46 of ***Appendix D*** provides a summary of injury and casualty estimates for the Cascadia Subduction zone earthquake model. The greatest number of injuries and casualties are expected with the 2:00 p.m. earthquake scenario. The least number of injuries and casualties is expected with the 2:00 a.m. scenario. Level 1 injury estimates range from 563 to 960. Level 2 injuries requiring hospitalization range from 139 to 290. Life-threatening Level 3 injury estimates range from 14 to 46 and casualty estimates range from 25 to 90.

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages.

Tables 13 and 14 on pages 28 and 29 of ***Appendix D*** provide a detailed breakdown of the expected lifeline losses resulting from the Mill Creek crustal fault earthquake model. Tables 13 and 14 on pages 48 and 49 of ***Appendix D*** provide a detailed breakdown of the expected lifeline losses resulting from the Cascadia Subduction zone earthquake model.

HAZUS estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 15 (***Appendix D*** page 30 and page 50) presents the results of the region for the given earthquake.

Existing Mitigation Programs

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

Local Programs

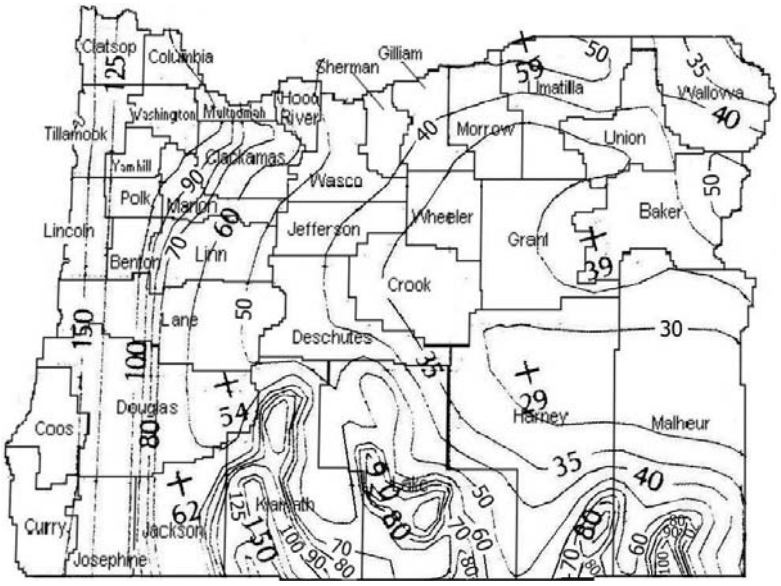
All building permit applications reviewed and issued by the Linn County Planning and Building Department must show compliance with the applicable standards in the state Uniform Building Code (UBC) and the Oregon Structural Specialty Code including engineering standards designed to protect against earthquake damage. Development permit applications for property within potential mass movement areas must also include a geo-technical report prepared by a registered engineer affirming site suitability and indicating landslide mitigation design standards, if necessary.

State Resources

State Building Codes[19]

The Oregon State Building Codes Division adopts statewide standards for building construction that are administered by the State, cities, and counties throughout Oregon. The codes apply to new construction and to the alteration of, addition to, or change of use of an existing structures. The One and Two Family Dwelling Code (effective April 1, 2005 *Oregon Residential Specialty Code*) and the Oregon Structural Specialty Code (both included in the State Building Code) prescribe seismic design requirements based on the seismology of the region. These codes are State of Oregon amended editions of national model codes from the International Code Council. These codes are based on maps that identify the various seismic parameters and classifications (seismic design category per ICC codes) for Oregon.

Figure 10-1
Seismic Zones in Oregon



Source: Oregon Building Codes Division

The Oregon Structural Specialty Code (OSSC) is based on the 2003 edition of the International Building Code (IBC) published by the International Code Council and amended by the State of Oregon. The IBC contains specific regulations for establishing seismic design category for buildings.[20] Within these standards are design and engineering specifications that are applied to areas according to the expected degree of ground motion and site conditions that a given area could experience during an earthquake (*ORS 455.447*).

The OSSC requires a site-specific seismic hazard report for buildings that are essential facilities (i.e. hospitals, fire and police stations, emergency response facilities), special occupancy structures (i.e. large schools, prisons), major occupancy structures (multi-storied buildings and parking structures) and hazardous facilities (i.e. structures containing toxics or explosives).

The seismic hazard report required by the OSSC must take into consideration factors such as the seismicity of the area, soil characteristics including amplification and liquefaction potential, any known faults, and potential landslides besides taking into account other local factors that can be seismically induced such as tsunami. The findings of the seismic hazard report must be considered in the design of the building. The Dwelling Code (Oregon Residential Specialty Code effective April 1, 2005) simply incorporates prescriptive requirements for the construction of various parts of a building including foundation reinforcement and framing connections[21]

The requirements for existing buildings vary depending on the type and size of the alteration and whether there is a change in the use of the building to house a more hazardous use. Oregon State Building Codes recognize the difficulty of meeting new construction standards in existing buildings and allow some exception to the general seismic standards. Upgrading existing buildings to resist earthquake forces is more expensive than meeting code requirements for new construction.

State code only requires seismic upgrades when there is significant structural alteration to the building or where there is a change in use that puts building occupants and the community at a greater risk. The local building official is responsible for enforcing these codes. Although there is no statewide building code for substandard structures, local communities have the option of adopting one to mitigate hazards in existing buildings. The State has adopted regulations to abate buildings damaged by an earthquake in Oregon Administrative Rules (OAR) 918- 470. *Oregon Revised Statutes (ORS) 455.020* and *ORS 455.390-400* also allow municipalities to create local programs to require seismic retrofitting of existing buildings within their communities. The building codes do not regulate public utilities and facilities constructed in public right-of-ways such as bridges that are regulated by the Department of Transportation.

Senate Bill 13 (2001): Seismic Event Preparation

Signed by Governor John Kitzhaber on June 14, 2001, Senate Bill 13 requires each state and local agency and persons employing 250 or more full-time employees to develop seismic preparation procedures and inform their employees about the procedures. Further, the Bill requires agencies to conduct drills in accordance with Office of Emergency Management guidelines. These drills must include "familiarization with routes and methods of exiting the building and methods of duck, cover, and hold during an earthquake."

Senate Bill 14 (2001): Seismic Surveys for School Buildings

Governor Kitzhaber 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 that 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. 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. (Plans are subject to available funding.) All seismic rehabilitation or other actions to reduce seismic risk must be completed before January 1, 2032.

DOGAMI and the Oregon University System joined to design a pilot program to begin the process to fulfill *ORS 455.400* (2001). Through university maintenance funds and FEMA Pre-Disaster Mitigation grants, they have initiated seismic safety surveys of university buildings and selected several particularly vulnerable buildings for seismic safety upgrades.

Senate Bill 15: Seismic Surveys for Hospital Buildings

Governor Kitzhaber 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. 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. (Again, plans are subject to available funding.) All seismic rehabilitations or other actions to reduce the risk must be completed before January 1, 2022.

Earthquake Awareness Month

April is Earthquake Awareness Month. During the month, the State Office of Emergency Management encourages individuals to strap down computers, heavy furniture, and bookshelves. In addition, the Oregon Natural Hazards Workgroup distributed a flyer with educational information about how to prepare for an earthquake.

Earthquake Education

Earthquake education in schools is ongoing in Oregon. Public schools are required to conduct periodic earthquake drills and educate students on how to respond when an earthquake event occurs (*ORS 455.447 and ORS 336.071*).

Federal Resources

National Earthquake Hazards Reduction Program (NEHRP)

The NEHRP's mission includes improved understanding, characterization, and prediction of hazards and vulnerabilities; improved model building codes and land use practices; risk reduction through post-earthquake investigations and education; development and improvement of design and construction techniques; improved mitigation capacity; and accelerated application of research results. The Act designates FEMA as the lead agency of the program and assigns several planning, coordinating, and reporting responsibilities.

National Earthquake Loss Reduction Program (NEP)

The NEP was formed as a result of the report "Strategy for National Earthquake Loss Reduction" prepared by the Office of Science and Technology Policy (OSTP) in April 1996. The NEP "aims to focus scarce research and development dollars on the most effective means for saving lives and property and limiting the social disruptions from earthquakes, coordinate federal earthquake mitigation research and development and emergency planning in a number of agencies beyond those in NEHRP to avoid duplication and ensure focus on priority goals, and cooperate with the private sector and with state and local jurisdictions to apply effective mitigation strategies and measures." The NEP does not replace NEHRP but encompasses a wider range of earthquake hazard reduction activities than those supported by the NEHRP agencies and provides a framework within which these activities can be more effectively coordinated.

The National Earthquake Technical Assistance Program (NETAP)

The NETAP is a technical assistance program created to provide ad hoc, short-term architectural and engineering support to state and local communities as they are related to earthquake mitigation. The program was designed to enhance state and local communities' ability to become more resistant to seismic hazards. This assistance cannot be used for actions that are covered under the State's and Territories Performance Partnership Agreement (PPA). This program assists in carrying out the statutory authorities of the National Earthquake Hazards Reduction Act of 1977, as amended.

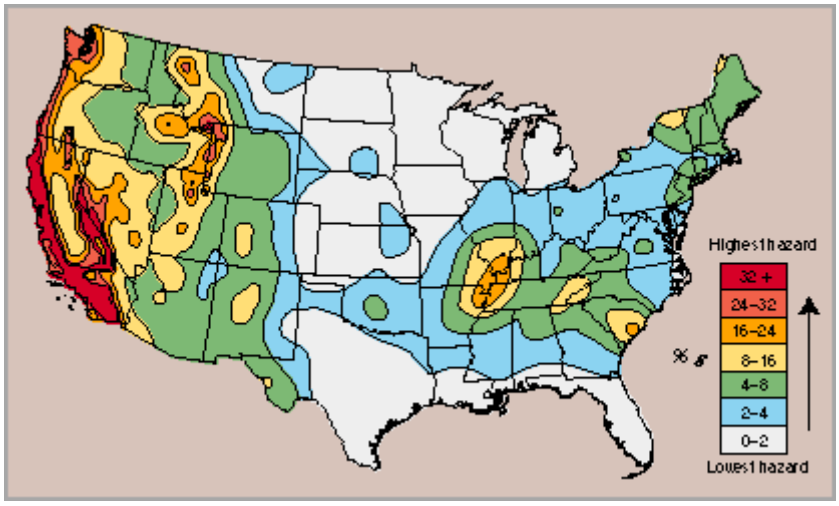
Technical assistance under the NETAP is available for use by the state/local communities within the 45 eligible and or participating seismic states and U.S. territories. This assistance is provided at no cost to the requesting local government. Examples of NETAP projects are seismic retrofit and evaluation training, evaluation of seismic hazards critical and essential facilities, post earthquake evaluations of buildings, and development of retrofit guidance for homeowners.

National Seismic Hazard Mapping Project

National maps of the earthquake shaking hazard in the United States have been produced since 1948. The 1996 U.S. Geological Survey shaking-hazard maps for the United States are based on current information about the rate at which earthquakes occur in different areas and on how far strong shaking extends from quake sources.

Scientists revise these maps as new earthquake studies improve their understanding of this hazard. After thorough review, professional organizations of engineers in turn update the seismic-risk maps and seismic design provisions contained in building codes. More than 20,000 cities, counties, and local government agencies use building codes, such as the International Building Code, to help establish the construction requirements necessary to preserve public health and safety in earthquakes.

The following national earthquake hazard map is found at:
http://quake.wr.usgs.gov/prepare/factsheets/RiskMaps/HazMap.gif



Earthquake Mitigation Action Items

The earthquake mitigation action items were identified and prioritized by the Mitigation Plan Steering Committee during open meetings with input from stakeholders and other interested members of the public. The action items provide direction on specific activities that organizations and residents in Linn County can undertake to reduce risk and prevent loss from severe weather events. There are three short-term and three long-term earthquake hazard action items described below.

Short-term Action Items

EQ-ST #1: Action 2.2.2. Rerun DOGAMI HAZUS model with local refined data

Coordinating Organization:	GIS Department
Internal Partners:	Emergency Management; Planning and Building; Assessor
External Partners:	DOGAMI; FEMA
Timeline:	1-3 years
Plan Goals Addressed:	Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective:	Objective 2.2. Support the enhancement of County vulnerability assessment activities.

EQ-ST #2: Action 2.4.1. Develop a program to implement non-structural retrofit of County staff offices and workspaces

Coordinating Organization: Safety Committee
Internal Partners: General Services; County Insurance Carrier; Board
External Partners: OR-OSHA
Timeline: 1-3 years
Plan Goals Addressed: Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective: Objective 2.4. Implement structural and non-structural mitigation of publicly owned facilities and infrastructure

EQ-ST #3: Action 3.3.1. Assist K-12 schools, child care facilities and private schools to develop vulnerability assessment and mitigation projects to improve safety

Coordinating Organization: Educational Service District
Internal Partners: Emergency Management
External Partners: School Districts; Private Schools; Red Cross; Commission on Children and Families; DOGAMI; OEM
Timeline: 1-3 years
Plan Goals Addressed: Goal 3. Protect life, the built environment, the economy and natural resources through community-wide partnerships
Plan Objective: Objective 3.3. Develop partnerships with external partners for hazard specific mitigation projects.

Long-term Action Items

EQ-LT #1: Action 2.4.2. Complete a seismic vulnerability assessment of all County-owned structures and prioritize vulnerable publicly owned structures

Coordinating Organization: County Engineer
Internal Partners: General Services; Board of Commissioners; Building Official; Assessor; Safety Committee
External Partners: DOGAMI; OEM
Timeline: 3-5 years
Plan Goals Addressed: Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective: Objective 2.4. Implement structural and non-structural mitigation of publicly owned facilities and infrastructure.

EQ-LT #2: Action 2.4.3. Complete a seismic vulnerability assessment of all County-owned bridges on lifeline routes and prioritize vulnerable bridges

Coordinating Organization:	Road Department
Internal Partners:	County Engineer; Board of Commissioners; Sheriff
External Partners:	DOGAMI; ODOT; OEM; 911 Coordinator; Fire Marshall
Timeline:	3-5 years
Plan Goals Addressed:	Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective:	Objective 2.4. Implement structural and non-structural mitigation of publicly owned facilities and infrastructure.

EQ-LT #3: Action 2.4.4. Implement structural mitigation projects for prioritized, vulnerable publicly owned structures and bridges identified in EQ-LT #1 and EQ-LT #2.

Coordinating Organization:	County Engineer
Internal Partners:	Road Department; General Services; Commissioners; Building Official; Assessor; Safety Committee
External Partners:	DOGAMI; ODOT; OEM; FEMA; US-DOT
Timeline:	3-5 years
Plan Goals Addressed:	Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective:	Objective 2.4. Implement structural and non-structural mitigation of publicly owned facilities and infrastructure.

Earthquake Hazard Endnotes

1 U.S. Bureau of Census, Profile of Housing Characteristics 2000

2 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.

3 Ibid.

4 Hill, Richard. "Geo Watch Warning Quake Shook Portland 40 Years Ago." The Oregonian, October 30, 2002

5 United States Geologic Survey, Earthquake Hazard Program. http://neic.usgs.gov/neis/eq_depot/2004/eq_041226/; March 21, 2005

6 Oregon State Natural Hazard Mitigation Plan (OR-SNHMP) (Region 3) Mid/Southern Willamette Valley Hazards Assessment, Nov. 2003, pp R3-5-6

7 Hill, Richard. "Geo Watch Warning Quake Shook Portland 40 Years Ago." The Oregonian, October 30, 2002

8 Humboldt State University;
http://sorrel.humboldt.edu/~geodept/earthquakes/shaky2_recent.html; March 21, 2005

9 . Richard."Geo Watch Warning Quake Shook Portland 40 Years Ago." The Oregonian, October 30, 2002

10 Ibid.

11 OR-SNHMP, Region 3 Hazards Assessment, pg. R3-6, R3-7

12 Ibid. pg. R3-7

13 Linn County Emergency Management Agency 2004 Hazard Analysis, pg. 5-6.

14 California Department of Conservation, California Geological Survey, 2002; Guidelines for Evaluating the Hazard of Surface Fault Rupture, Note 49.

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

16 City of Portland Natural Hazard Mitigation Plan, 2004

17 Ibid.

18 Community Planning Workshop, 2002

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

20 Washington County Natural Hazard Mitigation Plan, 2000.

21 United States Geological Survey, Geologic Division, Earthquake Information: reducing hazards, http://quake.wr.usgs.gov, October 19, 1999

Section 11:
Multi-Hazard

Table of Contents

Multi-Hazard Mitigation Action Items

Multi-hazard mitigation action items are action items that address two or more of the natural hazards addressed in this plan: flood, landslide, wildfire, severe weather, and earthquake.

The Multi-hazard action items were identified and prioritized by the Mitigation Plan Steering Committee during open meetings with input from stakeholders and other interested members of the public. The action items provide direction on specific activities that organizations and residents in Linn County can undertake to reduce risk and prevent loss from multiple types of hazard events.

There are 12 short-term and five long-term multi-hazard action items described below.

Short-term Action Items

MH-ST #1: Action 1.1.1. Develop formal agreements with internal and external partners to work together on risk reduction efforts in the County

Coordinating Organization:	Board of County Commissioners
Internal Partners:	Emergency Management
External Partners:	COG; Cities; State Agencies; Non-profit Organizations
Timeline:	Ongoing
Plan Goals Addressed:	Goal 1. Enhance coordination and communication among Linn County stakeholders to implement the Plan.
Plan Objective:	Objective 1.1. Establish and maintain methods to ensure plan implementation.

MH-ST #2: Action 1.1.2. Explore funding opportunities with internal and external partners to implement the actions identified in the plan

Coordinating Organization:	Emergency Management
Internal Partners:	Board of Commissioners
External Partners:	OEM; FEMA; ONHW; DOGAMI; COG
Timeline:	Ongoing
Plan Goals Addressed:	Goal 1. Enhance coordination and communication among Linn County stakeholders to implement the Plan
Plan Objective:	Objective 1.1. Establish and maintain methods to ensure plan implementation.

MH-ST #3: Action 1.2.1 Encourage and support the development of local community plan supplements to the County Natural Hazard Mitigation Plan

Coordinating Organization:	Board of County Commissioners
Internal Partners:	Emergency Management; Planning and Building Dept
External Partners:	Cities; OEM; DOGAMI; FEMA
Timeline:	Ongoing
Plan Goals Addressed:	Goal 1. Enhance coordination and communication among Linn County stakeholders to implement the Plan
Plan Objective:	Objective 1.2. Provide leadership to promote, communicate, and support disaster safety messages and activities.

MH-ST #4: Action 1.2.2. Develop County protocols and strategies for the dissemination of media messages that focus on individual responsibility for disaster safety and risk reduction

Coordinating Organization:	Emergency Management
Internal Partners:	Planning and Building Dept; Board of Commissioners
External Partners:	State Agencies; FEMA
Timeline:	1-3 years
Plan Goals Addressed:	Goal 1. Enhance coordination and communication among Linn County stakeholders to implement the Plan
Plan Objective:	Objective 1.2. Provide leadership to promote, communicate and support disaster safety messages and activities

MH-ST #5: Action 1.2.3. Develop public officials information kit that can be distributed to elected officials and community decision makers. The kit should include information regarding the Natural Hazard Mitigation Plan and Steering Committee and its activities as well as facts and figures on the Natural Hazards the County is facing

Coordinating Organization:	Emergency Management
Internal Partners:	County Departments
External Partners:	State Agencies; FEMA
Timeline:	1-3 years
Plan Goals Addressed:	Goal 1. Enhance coordination and communication among Linn County stakeholders to implement the Plan
Plan Objective:	Objective 1.2. Provide leadership to promote, communicate, and support disaster safety messages and activities

MH-ST #6: Action 2.1.1. Provide mitigation awareness training for county planning and public works staff, including GIS technicians

Coordinating Organization:	Emergency Management
Internal Partners:	County Departments
External Partners:	Oregon Emergency Management; State Agencies; FEMA; ONHW; Fire Marshall, Insurance Companies
Timeline:	1-3 years
Plan Goals Addressed:	Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective:	Objective 2.1. Incorporate mitigation into planning and policy development.

MH-ST #7: Action 2.1.2 Develop a continuity of government plan that details how core governmental operations will be maintained in the event of an emergency

Coordinating Organization:	Linn County Administrative Officer
Internal Partners:	Emergency Management; Elected Officials; County Departments
External Partners:	OEM; FEMA
Timeline:	1-3 years
Plan Goals Addressed:	Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective:	Objective 2.1. Incorporate mitigation into planning and policy development.

MH-ST #8: Action 2.2.1. Develop an inventory of county assets including replacement costs

Coordinating Organization:	General Services
Internal Partners:	Linn County Property Management; Treasurer; Assessor; GIS
External Partners:	OEM
Timeline:	1-3 years
Plan Goals Addressed:	Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective:	Objective 2.2. Support the enhancement of County vulnerability assessment activities.

MH-ST #9: Action 2.3.1. Update the Emergency Operations Plan

Coordinating Organization: Emergency Management
Internal Partners: County Administrator; Sheriff; Road Department; Elected Officials;
External Partners: Cities; COG; 911 Coordinator; State Police; Utility Companies; OEM
Timeline: 1-3 years
Plan Goals Addressed: Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective: Objective 2.3. Ensure continuity of County emergency service functions.

MH-ST #10: Action 2.3.2. Consolidate the mitigation plan, Emergency Operations Plan, recovery plans, and continuity of government plan into a Unified Disaster Plan

Coordinating Organization: Emergency Management
Internal Partners: County Administrator; Sheriff; Road Department; Elected Officials;
External Partners: Cities; COG; 911 Coordinator; State Police; Utility Companies; OEM
Timeline: 1-3 years
Plan Goals Addressed: Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective: Objective 2.3. Ensure continuity of County emergency service functions.

MH-ST #11: Action 2.3.3. Identify and evaluate county-owned emergency transportation routes and determine which roads and bridges are critical to the transportation network

Coordinating Organization: Road Department
Internal Partners: Emergency Management; Sheriff
External Partners: 911 Coordinator; State Police; OEM; Fire Marshall
Timeline: 1-3 years
Plan Goals Addressed: Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective: Objective 2.3. Ensure continuity of County emergency service functions.

MH-ST #12: Action 3.1.1. Develop public awareness campaigns aimed at homeowners, children, the elderly, and non-English speaking residents to make them aware of what they can do to prepare for natural hazard events

Coordinating Organization:	Emergency Management
Internal Partners:	Board of Commissioners
External Partners:	Red Cross; COG; Cities; LB-ESD; United Way; State Agencies; Hospitals; Insurance Companies; Children and Families Commission
Timeline:	1-3 years
Plan Goals Addressed:	Goal 3. Protect life, the built environment, the economy and natural resources through community-wide partnerships.
Plan Objective:	Objective 3.1. Increase citizen awareness and promote risk reduction activities through education and outreach.

Long-term Action Items

MH-LT #1: Action 1.1.3. Establish mitigation benchmarks to assist in evaluating and updating the plan

Coordinating Organization:	Steering Committee
Internal Partners:	Planning & Building Dept; Emergency Management
External Partners:	State Agencies
Timeline:	3-5 years
Plan Goals Addressed:	Goal 1. Enhance coordination and communication among Linn County stakeholders to implement the Plan.
Plan Objective:	Objective 1.1. Establish and maintain methods to ensure plan implementation.

MH-LT #2: Action 1.2.4. Develop and maintain a database of current action items.

Coordinating Organization:	Emergency Management
Internal Partners:	Planning & Building Department
External Partners:	OEM
Timeline:	3-5 years
Plan Goals Addressed:	Goal 1. Enhance coordination and communication among Linn County stakeholders to implement the Plan.
Plan Objective:	Objective 1.2. Provide leadership to promote, communicate, and support disaster safety messages and activities.

MH-LT #3: Action 2.1.3. Evaluate current zoning codes to incorporate mitigation principles

Coordinating Organization:	Planning & Building Department
Internal Partners:	Emergency Management; Planning Commission; Board of Commissioners
External Partners:	OEM
Timeline:	3-5 years
Plan Goals Addressed:	Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective:	Objective 2.1. Incorporate mitigation into planning and policy development.

MH-LT #4: Action 2.2.8. Geo-code the location, type, occupancy, footprint and elevation data for buildings, infrastructure, and critical facilities in natural hazard areas

Coordinating Organization:	GIS
Internal Partners:	Assessor; Planning & Building; Emergency Management; Road Department
External Partners:	FEMA; DOGAMI; OEM; Cities; Insurance Companies
Timeline:	3-5 years
Plan Goals Addressed:	Goal 2. Protect life, the built environment and natural systems through County policies, procedures and services.
Plan Objective:	Objective 2.2. Support the enhancement of County vulnerability assessment activities.

MH-LT #5: Action 3.2.1. Encourage small businesses to develop recovery plans in the event of a disaster and to implement non-structural mitigation

Coordinating Organization:	Chamber of Commerce
Internal Partners:	Emergency Management; Business Development Coordinator
External Partners:	COG; LBCC Business Development; Insurance Companies; Cities
Timeline:	3-5 years
Plan Goals Addressed:	Goal 3. Protect life, the built environment, the economy and natural resources through community-wide partnerships
Plan Objective:	Objective 3.2. Develop collaborative programs that encourage local businesses to plan for disasters.

Appendix A:
Public Participtation

Public participation is an important component in identifying hazard risks, impacts and hazard mitigation activities contained in this natural hazard Mitigation Plan. Public participation offers citizens the chance to voice their ideas, interests and opinions. Oregon's land use system addresses the need for public process in Statewide Land Use Planning Goal 1: Citizen Involvement. The citizen involvement goal ensures the opportunity for citizens to be involved in the planning process.

The Federal Emergency Management Agency's (FEMA) Disaster Mitigation Act of 2000 (DMA2000) includes requirements for involving the public in natural hazard mitigation planning. The DMA2000 states:

> *"An open public involvement process is essential to the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include:*
>
> *1. An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval.*
>
> *2. An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and no-profit interests to be involve in the planning process."*[1]

The public was notified and engaged in the process in three ways: (1) a nine-member steering committee was established comprised of the nine regular Planning Commission members; (2) a focus group survey was sent to 99 identified stakeholders, experts and interested parties; and (3) the public was invited to participate in all steering committee meetings and public workshops through the issuance of press releases and published public notices.

Steering Committee

The Hazard Mitigation Plan Steering Committee guided the development of the plan and participated in major decision-making including goal setting and identifying and prioritizing action items. The steering committee was comprised of the nine regular Planning Commission members, representing a broad cross-section of Linn County residents from various professions and regions of the county. The committee members' knowledge of community issues helped ensure the plan will be specific and relevant to the county.

The steering committee held a series of six planning meetings. Public and agency participation was solicited and encouraged at each planning meeting. To increase public awareness and participation, the county sent press releases and public notices soliciting public input to the 10 statewide, local and regional newspapers serving Linn County residents, and to individual citizens who requested inclusion in the mailing list.

The county established a list of 117 stakeholders and interested parties. The stakeholder list included representatives from state and other governmental agencies; each incorporated city in the county; the special taxing districts, including education, pubic safety and water districts; county department heads; private utility companies; other interested private businesses; various citizen groups and clubs; and other interested private citizens. The individuals identified on the stakeholder list were invited to participate in the steering committee meetings and were sent a short survey soliciting information on their experiences and understanding of natural hazards in Linn County; the effectiveness of current mitigation activities; and recommendations for future hazard mitigation policies and activities.

The Steering Committee members have a great deal of knowledge and familiarity with the history and impacts of natural hazard events throughout Linn County. The steering committee guided development of the plan by setting plan goals, identifying stakeholders, involving the public, and developing and prioritizing action items. Members of the steering committee were:

Name	Linn County Region: Profession	Years on Commission
Robert Bronson	Harrisburg: Insurance Agent	23 years
David Furtwangler	Lebanon: Forestry Consultant	2 years
Scott Mackie	Lacomb: Building Contractor	6 years
Jerome Magnuson	Albany: Farmer	10 years
John McKinney	Lebanon: Building Contractor	12 years
Gary Metts	Scio: Technology Coordinator	14 years
William Tucker	Lacomb: Real Estate Agent/Farmer	8 years
Mary VanAgtmael	Scio: Industrial Millwright Contractor	6 years
Ronald Walsh	Corvallis: Chemist -- Teledyne Wah Chang	23 years

The steering committee met on the following dates:

Steering Committee Meeting #1: November 9, 2004

Andre LeDuc of the Oregon Natural Hazards Workgroup (ONHW) and Bill Burns of the Oregon Department of Geology and Mineral Industries (DOGAMI) provided the Steering Committee with an overview of the Disaster Mitigation Act of 2000 (DMA2000) background, planning process and plan requirements. The Planning and Building Department mitigation plan project manager presented a staff report explaining the county's Pre-Disaster Mitigation (PDM) Grant; the mitigation plan scope of work; work program; project schedule; and the natural hazards questionnaire.

Steering Committee Meeting #2: January 11, 2005

The steering committee reviewed draft chapters covering plan Section 1: Introduction and Planning Process; Section 2: Community Profile; and Section 6: Flood hazards. The committee members reviewed flood, precipitation and watershed maps; discussed the issues and data in the plan chapters; provided feedback; and recommended chapter edits. The committee also discussed the ONHW risk assessment training.

Steering Committee Meeting #3: April 12, 2005

On March 3, 2005 the Steering Committee was sent drafts of Section 7: Landslide Hazards; and Section 8: Wildfire Hazards. The committee members reviewed these sections and prepared feedback and chapter edits for the April 12, 2005 meeting.

The Steering Committee developed the draft plan mission, goals, objectives and action items. Krista Mitchell of the ONHW facilitated the Goal Setting and Action Item Development Workshop. Participants included the Steering Committee and representatives from the cities of Albany, Lebanon, and Scio; the Oregon Department of Forestry; DOGAMI; the County Roadmaster; the County Building Official; the Planning and Building Department Director; the Linn County Emergency Management Coordinator; and other interested citizens.

Steering Committee Meeting #4: May 17, 2005

The Steering Committee reviewed the draft Section 9: Severe Weather Hazards and the responses to the Focus Group Survey. Krista Mitchell of the ONHW facilitated the follow-up goal and action item meeting. The Steering Committee approved the draft plan goals with minor amendments. The Committee approved the draft plan objectives with minor amendments. The Committee discussed each of the original 49 draft action items. The Committee approved, struck or revised many of the draft actions to develop a draft action item matrix.

Steering Committee Meeting #5: June 14, 2005

The Steering Committee reviewed the revised action item matrix and corresponding action item proposal forms. The committee modified several action items and adopted several new actions. The committee adopted action items, assigned the lead organizations, identified internal and external partners, and discussed implementation for one-half of the draft action items.

Steering Committee Meeting #6: June 28, 2005

The Steering Committee reviewed the revised action item matrix and corresponding action item proposal forms. The committee modified several action items and adopted several new actions. The committee adopted action items, assigned the lead organizations, identified internal and external partners, and discussed implementation measures.

Public Workshops

The public was encouraged to participate in all the steering committee meetings and public workshops. Time was set aside at each meeting for public participation. Public participation provided valuable inputs addressing experiences and concerns relating to natural hazard impacts in Linn County, possible mitigation strategies, and goal setting and action item priorities.

Focus Group Survey

A contact list of 117 possible stakeholders and interested parties was developed that included representatives from state and other governmental agencies; each incorporated city in the county; the special taxing districts, including education, pubic safety and water districts; county department heads; private utility companies; other interested private businesses; various citizen groups and clubs; and other interested private citizens.

The individuals identified on the stakeholder list were invited to participate in the steering committee meetings and were sent a short survey soliciting information on their experiences and understanding of natural hazards in Linn County; the effectiveness of current mitigation activities; and recommendations for future hazard mitigation policies and activities.

The survey was sent to 99 identified experts, stakeholders and interested citizens. Recipients were asked to respond to nine general natural hazard-related questions as they pertain to flood, storm, windstorm, landslide, wildfire, earthquake, volcanic, or other natural hazards in Linn County. A total of 14 identified stakeholders responded to the survey. The survey results were compiled to help formulate various sections of the plan, and were presented to the steering committee to help identify goals and hazard specific action items.

Survey Respondent Comments: Natural Hazard Mitigation Survey

Question 1: What types of natural hazards impact your residence, place of work, or local community?

- All the above (Lebanon Community School Dist.)
- Wind storms, heavy rain, snow melt (Mill City RFPD)
- Floods, windstorms (high winds/tornado), winter storms (snow, ice), volcanic ash, earthquake (City of Albany)
- Windstorms, severe winter storms, floods, landslides and wildfires have caused destruction of our power system, thereby causing a loss of power to our customers (Consumers Power)
- Windstorms, floods, snow and ice, wildfires, possible earthquake (Linn Co. Surveyor)
- Floods, storms, windstorms (Linn Co. Clerk)
- Floods, severe winter storms, windstorms, West Nile virus (Linn Co. Extension)
- Windstorms, wildfire, earthquake (City of Idanha)
- Floods, windstorm, ice (City of Harrisburg)
- Floods, windstorms, ice (Santiam Canyon School Dist.)
- Potentially all of them (City of Sweet Home)
- Wind, ice storms, and flooding impact my residence and community; downed trees cut power for days and block roads for hours (City of Sweet Home)
- Wildfire, debris torrents, landslides (Sweet Home Dept. of Forestry)
- All of the above (Linn Benton Lincoln ESD)

Question 2: How have you personally been impacted by natural hazard events in Linn County?

- Yes (Lebanon Community School Dist.)
- We get called to all events in and around our district (Mill City FRPD)
- The City of Albany has been impacted by floods, ice, snowstorms, and windstorms
- Yes, Consumers Power has experienced destruction of its electrical facilities in Linn County due to natural hazard events.
- Windstorms have blown trees on buildings and fences, knocked out power. Ice and snow have made travel to work or home difficult at times each winter. Heavy rains have washed out or flooded roads preventing travel (Linn Co. Surveyor)

- Windstorm damage to my house (falling tree limbs) and flooding (Linn Co. Clerk)
- During the flooding of 1996, highway 34 from Albany in Linn County to Corvallis was closed. Consequently, there was much additional traffic traveling on highway 20 to Corvallis and lengthy delays in travel. Many of our OSU Extension Service events scheduled during those weeks has to be cancelled due to the flooding conditions. There was an increase in requests for information on well water testing, purifying water, tree damage, etc. In January 0f 1996, we had an ice storm that caused hazardous travel conditions on our county highways. In 1004, West Nile virus spread to Linn County and resulted in many calls from customers seeking information. (Linn Co. Extension)
- Yes (City of Idanha)
- Yes, windstorm property damage (City of Harrisburg)
- Yes, a severe windstorm in February 2002 caused several thousand dollars worth of damage (Santiam Canyon School Dist.)
- Yes (City of Sweet Home)
- Yes, I have gone without power for days and been unable to leave my property during storms (City of Sweet Home)
- Responsible for wildfire suppression for Linn Forest Protective Association and resources within the South Cascade District, Sweet Home Unit (Sweet Home State Forestry)
- Winter storm damage, mainly to trees (Linn Benton Lincoln ESD)

Question 3: Please identify significant past natural disaster events, such as severe windstorms, ice storms, or flooding that have impacted Linn County?

- Windstorm of February 2002, winter snows (Lebanon Community School Dist.)
- In 1996, heavy snow melt caused severe high water, numerous high wind storms in the past 4-5 years, freezing rain/ice storms in 2003 (Mill City RFPD)
- 1996 – floods, 2004 – ice and snow, 1995-2003 – windstorms (City of Albany)
- In the February 2002 windstorm, 35 transmission poles plus dozens of distribution poles in the Harrisburg areas were blown down. In the December 29-31, 2003 snow storm and the January 5-7, 2004 ice storm many hundreds of service wires and wire spans between poles, plus many poles were downed by falling trees and branches (Consumers Power)
- 1962 – Columbus Day windstorm; 1964 – flooding around Christmas; 1969 – snowstorm in January; 1973 – freeze with snow; 1989 – snowstorm and freeze; December 1996 – wind and rainstorm, flooding, power outages; 2004 – winter storm with ice and snow (Linn Co. Surveyor)
- I cannot recall the specific dates (Linn Co. Clerk)
- 1962 – windstorm (Columbus Day storm); 1996 – flooding (Linn Co. Extension)
- Earthquake, flood, wildfire, windstorm (City of Idanha)
- February 2003 – windstorm; 1996 flooding (City of Harrisburg)
- Yes, a severe windstorm in February 2002 caused several thousand dollars worth of damage (Santiam Canyon School Dist.)
- Floods (1964, 1996, 1997); windstorm (1992), ice and snow (City of Sweet Home)
- January 2004 snow and ice storm; 1996 flood (City of Sweet Home)
- 1987 – Calapooia fire (2000 acres); 1998 – Thomas Creek fire (80 acres); 2001 – Island Inn fire (29 acres); 2003 – Overton Gap fire (40 acres); 1996 – floods; 2002 – February windstorm (Sweet Home Forestry Unit)

- In the 2 ½ years I have lived here, only one winter storm caused damage (Linn Benton Lincoln ESD)

Question 4: What current activities, actions or projects are beneficial in reducing risks and preventing losses from natural hazard events in Linn County?

- None that come to mind (Lebanon Community School District)
- Some trimming of trees around power lines (Mill City RFPD)
- Tree limb trimming by power companies, building regulations pertaining to 100 year flood zone, earthquake zone building code, drainage requirements, road requirements for urban fire (City of Albany)
- Placing power lines underground will reduce risk due to wind, ice and snow, but will increase the risk due to earthquake. However, the cost to place lines underground system wide is prohibitive. Risks can also be reduced by replacing small brittle copper wire with stronger aluminum wire and by a more aggressive tree trimming program. CPI is proactively working to identify and replace aging plans where sound engineering practices identify the cost effectiveness of doing so. (Consumers Power)
- Hazard free removal along roads and power lines, road improvements on culverts and bridges and shoulder widening, planning and design of roads and buildings in mountainous areas to prevent slides or washouts, planning for not building in flood prone areas. (Linn Co. Surveyor)
- NA (Linn Co. Clerk)
- In September 1004, OSU Extension agriculture program leader Bill Braunworth released an emergency response handbook/folder of 18 extension publications and 7 internal documents, a CD-ROM with the digital files and a copy of the FEMA publication "Are You Ready?" This emergency response handbook of reference materials is available for checkout by individuals or groups from the OSU Extension Service, Linn County office. Another important resource is the Linn County Emergency Management Director, Jim Howell, has been very involved in activities for emergency preparedness. For example, he hosted an emergency preparedness drill for Linn County employees. Linn County Citizen Corps and Linn-Benton Neighborhood Emergency Training, part of FEMA; Brownsville Area Emergency Management Advisory Commission. (Linn Co. Extension)
- Dealing with trees that may impact power and phone lines (City of Harrisburg)
- Monthly fire and earthquake drills, monthly safety committee meetings, crisis and emergency management plan in place, close communication with local rescue officials, radio and TV broadcast services; we also serve as a public shelter for certain emergencies. (Santiam Canyon School District)
- Sweet Home is improving small watershed's ability to handle flood waters; individual property protection from floods (City of Sweet Home)
- Trimming/cutting/transplanting trees in locations that affect power lines and roads. Work on Ames Creek (City of Sweet Home)
- We have recently concluded a $100,000 national fire plan grant for fuels reduction and community education extending from Brownsville south to Lane County line along the valley and foothills. Preparing to begin a $250,000 national fire plan grant for community education and fuels reduction starting at Brownsville and extending north along the foothills. (Sweet Home Forestry Dist.)
- I'm not aware of any (Linn Benton Lincoln ESD)

Question 5: What new activities, actions, or projects can reduce risks and prevent loss from future natural hazard events in Linn County?

- None that come to mind (Lebanon Community School Dist.)
- Cleaning of ditches and creeks would help on flooding. Taking out problem trees around electrical lines would help power outages. (Mill City RFPD)
- Tree limb trimming by power companies, building regulations pertaining to 100 year flood zone, earthquake zone building code, drainage requirements, road requirements for urban fire (City of Albany)
- Risks could be reduced by creating wider right-of-ways in utility corridors, but to do so taxes cooperation of landowners and special interest groups. (Consumers Power)
- More diligent removal of dangerous trees, and road improvement for better drainage. Better planning for slide and flood zone areas. (Linn Co. Surveyor)
- NA (Linn Co. Clerk)
- There is limited cell/radio service communications – no local news/weather broadcasts are available in this area (City of Idanha)
- Improve communications between agencies and share ideas and best practices; shut down the storms! (Santiam Canyon School Dist.)
- Reconnection of flood plains (City of Sweet Home)
- Continue work on waterways and drainage areas. Continue to work on trees at risk of causing damage. (City of Sweet Home)
- Continue to apply for national fire plan grants; enhance public education and involvement in fire protection and hazard fuels reductions adjacent to structures (Sweet Home Forestry Dept.)

Question 6: How can agencies, organizations, or individuals coordinate their efforts to reduce natural hazard risks in Linn County?

- Don't know (Lebanon Community School Dist.)
- Working together in rural areas to help small communities deal with these problems (Mill City RFPD)
- By developing a hazard mitigation plan for Linn County and cities, developing or using existing preparedness programs for citizens, get community organizations involved in preparedness programs (City of Albany)
- Improve communication between agencies, specifically providing a list of contacts and phone numbers that CPI can use to communicate with Linn County during such events (Consumers Power)
- Have a link on Linn County web site for input from the public to report possible hazards or risks (Linn Co. Surveyor)
- Better communication (Linn Co. Clerk)
- The public meetings are a good start. Have you considered a specialized Linn County web page for information dissemination. Consider an emergency preparedness summit meeting. (Linn Co. Extension)
- Coordinate putting utilities underground (City of Harrisburg)

- Someone needs to be responsible to take the lead and be accountable to make sure things are getting done (Santiam Canyon School Dist.)
- We all compete for the same funds, that makes it hard. More activities coordinated by Linn County Emergency Management. (City of Sweet Home)
- Be involved in citizen corp and other community groups and have multi-agency meetings on County wide issues. (City of Sweet Home)
- With our fire plan grants we involve landowners, fire districts, federal counterparts (BLM & USFS) (Sweet Home Forestry Dept.)
- Flow of information – if the county would provide information to help reduce risk, our agency could distribute to employees and their families (Linn Benton Lincoln ESD)

Question 7: Please list one or more important goals for pre-disaster natural hazard planning in Linn County.

- Don't know (Lebanon Community School Dist.)
- Preventative measures: cleaning ditches and creeks; cutting problem limbs and trees (Mill City RFPD)
- Integrate existing regulatory documents and programs; identify potential funding sources; improve collaborative programs between public, private, and community organizations (City of Albany)
- Public education is a very important goal. Vital services like electricity, water and telephone require right-of-ways that are accessible at all times and that can be maintained economically (Consumers Power)
- Weather warnings or road hazard signs with radio station information or phone numbers to call for updates placed on main roads throughout Linn County, like the State has on freeways (Linn Co. Surveyor)
- Better communication (Linn Co. Clerk)
- Develop a master list of local emergency contact information (including websites) specific to Linn County, including local chapter of the American Red Cross, city and county government officials, local shelters, food banks, hospitals, ambulance services, local media (radio stations, newspapers, and TV stations), key contact names including key volunteers (Linn County Extension)
- There is limited cell/radio service communications – no local news/weather broadcasts are available in this area (City of Idanha)
- To get by with as little loss as possible; to handle the disaster(s) with as little confusion as possible (Santiam Canyon School Dist.)
- Citizen preparedness (City of Sweet Home)
- Obtain others/citizens views and experiences as to where risks are and what would reduce the risk (City of Sweet Home)
- Prevent the catastrophic loss of homes and structures through education and fuels reduction when wildfires impinge upon the populated areas within our district (Sweet Home Dept. of Forestry)
- Transportation planning: assume a natural disaster occurred during a work day… where do people go and how do they get there? (Linn Benton Lincoln ESD)

Question 8: Would you like to be notified of scheduled hazard mitigation planning meetings?

- No thank you (Lebanon Community School Dist.)
- Yes (Mill City RFPD)
- Yes (City of Albany)
- Yes (Consumers Power)
- Yes (Linn Co. Surveyor)
- Like many, I now have little knowledge about this subject and end up reacting and coping with the effects of these kind of events. Many years ago, Linn County had a disaster planning team that included the elected officials. I believe the County Clerk's role was coordinating shelter activities in the event of a disaster (Linn Co. Clerk)
- Yes (Linn Co. Extension)
- Yes (City of Harrisburg)
- Yes (Santiam Canyon School Dist.
- Yes (City of Sweet Home)
- Yes (Sweet Home Dept. of Forestry)
- Yes (Linn Benton Lincoln ESD)

Question 9: Please provide names of anyone who you believe may be able to help identify or implement natural hazard mitigation strategies or activities in Linn County.

- Pacific Power and Light; City of Mill City (Mill City RFPD)
- Darrel Tedisch (City of Albany)
- Greg Nervino (451-6514), James Ramseyer (929-8531), Brad Kunda (929-8598) (Consumers Power)
- Darren Lane, Linn Co. Roadmaster; Linn County Commissioners; Dave Burright, Linn County Sheriff (Linn County Surveyor)
- Like many, I now have little knowledge about this subject and end up reacting and coping with the effects of these kind of events. Many years ago, Linn County had a disaster planning team that included the elected officials. I believe the County Clerk's role was coordinating shelter activities in the event of a disaster (Linn Co. Clerk)
- Jim Howell, Linn Co. Emergency Mgmt; Bill Braunworth, OSU Extension Agriculture Program Leader (541-737-1317) (Linn County Extension)
- Idanha City Council, Idanha/Detroit RFPD (City of Idanha)
- Tim Bunnell, Community Development Superintendent for Harrisburg (City of Harrisburg)
- Don Hoover, District Maintenance Mgr and member of the Mill City fire board (503-897-4057) (Santiam Canyon School Dist.)
- Ann Stein (466-5081) (City of Sweet Home)

Appendix A Endnotes

[1] Code of Federal Regulations. 44CFR201 and 44CFR206

Appendix B
Action Item Proposal Forms

Proposed Action Item Identification:		
ST: 1.1.1 Would be a Short Term Action proposed under Goal 1 Objective 1.1		
Proposed Action Title/Description:		
Develop formal agreements (such as Memorandums of Understanding, MOUs) with internal (departments) and external partners (e.g. non-profit organizations, cities, and state agencies) to work together on risk reduction efforts in the County.		
Rationale for Proposed Action Item:		
• In a self-completed hazard analysis, Linn County rated itself as having an above average or high risk to the majority of hazards addressed by the NHMP. Developing formal agreements with internal and external partners could assist the partners in collaborating and sharing the responsibility of natural hazard mitigation. Such actions to form collaborative partnerships and commitments to mitigation can assist the County in reducing its risk to the natural hazards addressed by the NHMP. • FEMA How-to-Guide #4 – *Bringing the Plan to Life* encourages communities to confirm and clarify responsibilities through formal agreements in order to implement the plan. • Mutual Aid Agreements are commonly used in the emergency management field to pre-arrange assistance with other agencies or jurisdictions in case of an event. This concept, under the term "Memorandum of Understanding" could be applied to pre-disaster mitigation to confirm collaboration on natural hazard mitigation activities.		
Ideas for Implementation:		
• Create a signature page for the Natural Hazard Mitigation Plan that must be signed by all County department heads indicating that they have received the plan and intent to assist in its implementation • Identify and pursue MOUs with potential external partners such as non-profit organizations or state and federal agencies that may be able to assist in implementing pre-disaster mitigation activities. • Renew MOUs for each calendar year so that they can be updated to reflect the changing needs and conditions of the community and internal and external partners; have both internal and external partners resign the updated MOUs each calendar year.		
Coordinating Organization:	**Linn County Board of Commissioners**	
Internal Partners:		**External Partners:**
Steering Committee Members		COG; Cities; State Agencies Non-profit Organizations OSU Extension Service
Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
6 Months – 1 Year		

Proposed Action Item Identification:

LT: 1.1.2 Would be a Short Term Action proposed under Goal 1 Objective 1.1

Proposed Action Title/Description:

Explore funding opportunities with partners (both internal & external) to implement the actions identified in the plan.

Rationale for Proposed Action Item:

- Linn County currently has limited local funding opportunities available to fund and implement natural hazard mitigation projects.
- In a self-completed hazard analysis, Linn County rated itself as having an above average or high risk to the majority of hazards addressed by the NHMP. Exploring funding opportunities could provide the County with resources to implement actions for hazard mitigation. Implementing such actions could assist the County in reducing its overall risk to hazards.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for, and vulnerability to, most hazards addressed by the NHMP as being high. Exploring funding opportunities could provide the County with resources to implement actions for hazard mitigation. Implementing such actions could assist the County in reducing its overall risk to hazards.

Ideas for Implementation:

- Convene a meeting of the Steering Committee annually to discuss potential funding sources.
- Maintain communication with external partners in an effort to identify upcoming fundings sources. Report findings at Steering Committee meetings.
- Collaborate with other communities to find funding sources on collaborative projects
- Identify existing funding sources for hazard mitigation projects

Coordinating Organization:	**Linn County Emergency Management**

Internal Partners:	**External Partners:**
Steering Committee Members	OEM DOGAMI FEMA ONHW

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
	Ongoing	

Proposed Action Item Identification:

LT: 1.1.3 Would be a Long Term Action proposed under Goal 1 Objective 1.1

Proposed Action Title/Description:

Establish mitigation benchmarks to assist in evaluating and updating the plan

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having an above average or high risk to the majority of hazards addressed by the NHMP. Establishing mitigation benchmarks can assist the County in more effectively and efficiently updating and evaluating its plan, helping the County reduce its risk to the hazards addressed by the NHMP.
- The ways in which natural hazards affect communities cannot be completely predicted and are subject to change. As risk assessment information changes or is updated, the predictions for how natural hazards will affect a community also change. Establishing benchmarks will provide an opportunity to incorporate new and updated risk assessment data into Linn County's NHMP, assisting the County in mitigating the affects of natural hazards addressed by the Plan.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for, and vulnerability to, most hazards addressed by the NHMP as being high. Establishing mitigation benchmarks can assist the County in more effectively and efficiently updating and evaluating its plan, helping the County reduce its risk to the hazards addressed by the NHMP.
- The Disaster Mitigation Act of 2000 requires that communities describe how they will monitor, evaluate and update their plans within a five-year cycle [201.6(c)(4)(*i*)]. Establishing benchmarks will assist the County in evaluating and updating its plan, and allow the County to easily identify what has been accomplished and what remains to be completed.

Ideas for Implementation:

- Research existing federal requirements for five-year cycle of plan monitoring, evaluation, and updating. Incorporate any appropriate requirements into Linn County's mitigation benchmarks.
- Identify and document potential mitigation benchmarks
- The Steering Committee will convene annually to evaluate existing benchamarks and identify any modifications or adjustments that need to be made to existing benchmarks.
- Partner with appropriate state agencies for assistance in developing appropriate benchmarks.
- Incorporate identified benchmarks into all Plan review and evaluation meetings.

Coordinating Organization:	**Steering Committee**

Internal Partners:	**External Partners:**
Planning and Building Departments Emergency Management	State Agencies OEM FEMA

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
	Ongoing	

Proposed Action Item Identification:

ST: 1.2.1 Would be a Short Term Action proposed under Goal 1 Objective 1.2

Proposed Action Title/Description:

Encourage and support the development of local community plan supplements to the County Natural Hazard Mitigation Plan

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having an above average or high risk to the majority of hazards addressed by the NHMP. Supporting the development of local community plans allows for better risk assessment data collection at the local level. Better local risk assessment data improves the county's risk assessment data. Improved county risk assessment data assists the county in better identifying at-risk areas and methods for mitigating those risks, helping the county reduce its overall risk to hazards.
- The Linn County plan only covers unincorporated Linn County and not incorporated communities. The City of Albany is currently developing a stand-alone mitigation plan. Supporting the development of such local city plans that will supplement the County plan and improve the data and coverage of the County NHMP. Such actions can assist the County in reducing its overall risk to hazards addressed by the NHMP.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for, and vulnerability to, hazards in general is high. Supporting the development of local community plans allows for better risk assessment data collection at the local level. Better local risk assessment data improves the county's risk assessment data. Improved county risk assessment data assists the county in better identifying at-risk areas and methods for mitigating those risks, helping the county reduce its overall risk to hazards.

Ideas for Implementation:

- Hold a forum to inform incorporated communities about the FEMA planning requirements.
- Assist communities with the mitigation planning process. Possible methods include:
  - Develop or acquire exisitng materials with information about the natural hazard mitigation planning process that could be distributed to project directors and emergency managers of city plans.
    - Provide links on the County's website for plan documents, and include an e-mail address and/or phone number that communities can contact for questions or assistance.
  - A County-hosted workshop to provide information and assistnace to project managers and emergency managers involved in city plans.

Coordinating Organization:	**Linn County Board of County Commissioners**

Internal Partners:	**External Partners:**
Steering Committee Members Planning and Building Departments	Local Cities FEMA ONHW OEM

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
1-2 Years		

Proposed Action Item Identification:

ST: 1.2.2 Would be a Short Term Action proposed under Goal 1 Objective 1.2

Proposed Action Title/Description:

Develop County protocols and communication strategies for the dissemination of media messages that focus on individual responsibility for disaster safety and risk reduction (e.g. IBHS homeowner guides, press releases for awareness campaigns, etc.)

Rationale for Proposed Action Item:

- The Steering Committee identified a lack of awareness of hazard risk among County residents. Developing communication strategies to inform the public about hazard mitigation would be a way to increase public awareness about hazards and encourage public participation in the County's efforts to mitigate its risks to the hazards addressed by the NHMP.
- In a self-completed hazard analysis, Linn County rated itself as having an above average or high risk to the majority of hazards addressed by the NHMP. Informing the public of their role in the County's risk mitigation efforts, not only increases the public's awareness of the county's hazard risks, but also helps the County reduce its risk to the hazards addressed by the NHMP.
- Mitigation is a shared responsibility between local, state, and federal government; citizens; businesses; non-profit organizations; and others. Informing the public of their role in the County's risk mitigation efforts, not only increases the public's awareness of the county's hazard risks, but also helps the County reduce its risk to the hazards addressed by the NHMP.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for, and vulnerability to, most hazards addressed by the NHMP as being high. Informing the public of their role in the County's risk mitigation efforts, not only increases the public's awareness of the county's hazard risks, but also helps the County reduce its risk to the hazards addressed by the NHMP.
- The Disaster Mitigation Act of 2000 requires that communities continue to involve the public beyond the original planning process [201.6(c)(4)(*ii*)]. Conducting outreach to educate the public on the shared responsibility of hazard mitigation would be a way to involve the public in the County's continued mitigation efforts.

Ideas for Implementation:

- Implement ONHW's homeowner survey of County residents to gain an understanding of current risk perception levels as well as preferred methods of receiving risk reduction information.
- Utilize the prefered methods of communication indicated by the household survey to develop communication strategies.
- Determine if materials or communication strategies already exist; utilize any existing materials and communication strategies.
- Develop targeted outreach campainges for specific hazards. Develop plans to run the campainges during the times of the year when the county has a greater risk to specific hazards (an example would be running a wildfire campaigne from mid-spring through the summer).

Coordinating Organization:	**Linn County Emergency Management**

Internal Partners:	**External Partners:**
Planning and Building Departments Emergency Management	State Agencies FEMA IBHS

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term (2-4 or more years)	
6 Months – 1 Year		

Proposed Action Item Identification:

ST: 1.2.3 Would be a Short Term Action proposed under Goal 1 Objective 1.2

Proposed Action Title/Description:

Develop public official information kit that can be distributed to elected officials and community decision makers. The kit should include pertinent information regarding the Natural Hazard Mitigation Plan and Steering Committee and its activities as well as facts and figures on the Natural Hazards the County is facing.

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having an above average or high risk to the majority of hazards addressed by the NHMP. Informing elected officials of their role in the County's risk mitigation efforts, not only increases officials' awareness of the county's hazard risks, but assists elected officials in making more informed decisions regarding hazards. More informed decisions regarding natural hazards assist the County in reducing its overall risk to the hazards addressed in the NHMP.
- Mitigation is a shared responsibility between local, state, and federal government; citizens; businesses; non-profit organizations; and others. Informing elected officials of their role in the County's risk mitigation efforts, not only increases the public's awareness of the county's hazard risks, but also helps the County reduce its risk to the hazards addressed by the NHMP.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for, and vulnerability to, most hazards addressed by the NHMP as being high. Informing elected officials of their role in the County's risk mitigation efforts, not only increases officials' awareness of the county's hazard risks, but assists elected officials in making better informed decisions regarding hazards. More informed decisions regarding natural hazards assist the County in reducing its overall risk to the hazards addressed in the NHMP.
- The Disaster Mitigation Act of 2000 requires communities to identify actions and projects that reduce the effects of hazards on the community [201.6(c)(3)(*ii*)]. Providing information to public officials about Linn County's risk to the hazards addressed in the NHMP would assist the elected officials in making more informed decisions regarding natural hazards. More informed decisions regarding natural hazards assist the County in reducing its overall risk to the hazards addressed in the NHMP.

Ideas for Implementation:

- Identify pertinent information to provide to and share with elected officials regarding the hazards addressed in the NHMP.
- Develop strategies for delivering the information to elected officials. Such methods could include:
  - Quick reference brouchers and factsheets.
  - Mailing such materials out to elected officials.
  - Informing elected officials of the existance of hazard related materials.
  - A County-sponsored seminar for elected officals regarding hazards.

Coordinating Organization:	**Linn County Emergency Management**

Internal Partners:	**External Partners:**
Planning and Building Departments County Departments	State Agencies

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
6 Months – 1 Year		

Proposed Action Item Identification:

LT: 1.2.4 Would be a Long Term Action proposed under Goal 1 Objective 1.2

Proposed Action Title/Description:

Develop and maintain a database of current action items

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having an above average or high risk to the majority of hazards addressed by the NHMP. Developing and maintaining a database or action items can allow the County to more quickly identify projects to submit for funding opportunities, making the County more competitive for potential funding opportunities. Being a more competitive candidate for funding opportunities can assist the county in reducing its overall risk to the natural hazards addressed in the NHMP.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for, and vulnerability to, most hazards addressed by the NHMP as being high. Developing and maintaining a database or action items can allow the County to more quickly identify projects to submit for funding opportunities, making the County more competitive for potential funding opportunities. Being a more competitive candidate for funding opportunities can assist the county in reducing its overall risk to the natural hazards addressed in the NHMP.
- The Disaster Mitigation Act of 2000 requires communities to identify actions and projects that reduce the effects of hazards on the community [201.6(c)(3)(*ii*)]. Developing and maintaining a database or action items can allow the County to more quickly identify projects to submit for funding opportunities, making the County more competitive for potential funding opportunities. Being a more competitive candidate for funding opportunities can assist the county in reducing its overall risk to the natural hazards addressed in the NHMP.

Ideas for Implementation:

- Develop a database for storing action items and relevant information regarding action items.
- Upon the Steering Committee's final approval, add all approved plan action items into the database.
- Develop methods for maintaining the database and keeping it up-to-date.
- Identify methods in which actions can be incorporated into other existing plans, programs, and policies.

Coordinating Organization:	**Linn County Emergency Management**

Internal Partners:	**External Partners:**
Planning and Building Departments	

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
	Ongoing	

Proposed Action Item Identification:

ST: 2.1.1 Would be a Short Term Action proposed under Goal 2 Objective 2.1

Proposed Action Title/Description:

Provide mitigation training to county planning and public works staff, including GIS technicians.

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having an above average or high risk to the majority of natural hazards addressed by the NHMP. Providing mitigation training for county planning, public works, and GIS staff increases their awareness and understanding of natural hazard mitigation planning. More informed staff can incorporate natural hazard mitigation into their daily work activities, make better decisions regarding natural hazard planning, and can assist the Steering Committee in implementing the Plan's identified action items. This can help the county reduce its overall risk to the natural hazards addressed by the NHMP.
- The Disaster Mitigation Act of 2000 requires communities to identify actions and projects that reduce the effects of hazards on the community [201.6(c)(3)(*ii*)]. Providing mitigation training for county planning, public works, and GIS staff increases their awareness and understanding of natural hazard mitigation planning. More informed staff can incorporate natural hazard mitigation into their daily work activities, make better decisions regarding natural hazard planning, and can assist the Steering Committee in implementing the Plan's identified action items. This can help the county reduce its overall risk to the natural hazards addressed by the NHMP.
- Have County staff members who understand the principles of mitigation will create the understanding needed to better incorporate mitigation into existing programs, which is a key requirement of the Disaster Mitigation Act of 2000.

Ideas for Implementation: (Optional)

- Identify desired areas of natural hazard mitigation training for county planning, public works, and GIS staff.
- Research existing regional, state, and federal natural hazard mitigation training programs, and contact agencies for information on possible training opportunities.
- Allow staff members to attend natural hazard mitigation trainings, or provide incentives for their attendance. Ensure that this is a continued, County-supported effort.

Coordinating Organization:	**Linn County Emergency Management**

Internal Partners:	**External Partners:**
	FEMA Fire Marshall OEM Insurance Companies DOGAMI ONHW

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	

Proposed Action Item Identification:

ST: 2.1.2 Would be a Short Term Action proposed under Goal 2 Objective 2.1

Proposed Action Title/Description:

Develop a continuity of government plan that details how core governmental operations will be maintained in the event of an emergency.

Rationale for Proposed Action Item:
(What critical issues will the action address?)

- **Commonwealth of Pennsylvania Human Resources and Management –** Continuity of government refers to the need to continue core governmental operations in the event of an emergency situation, including natural disasters. These plans detail how essential business functions will be maintained in the event of an emergency that disrupts normal operations.
- In a self-completed hazard analysis, Linn County rated itself as having an above average or high risk to the majority of natural hazards addressed by the NHMP. The County currently does not have a continuity of government plan. Developing a continuity plan will assist the County in planning how it will respond in the event of a natural disaster, helping the County mitigate the effects potential natural hazard events may have on the community.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for, and vulnerability to, most natural hazards addressed by the NHMP as being high. Developing a continuity plan will assist the County in planning how it will respond in the event of a natural disaster, helping the County mitigate the effects that potential natural hazard events may have on the community.

Ideas for Implementation: (Optional)

- Identify existing plans and policies within Linn County that deal with the County's response to natural hazard events and evaluate their methods for responding to a natural hazard event.
- Identify "core governmental opperations" necessary for Linn County and the departments and agencies responsbile for them.
- Develop a method for monitoring, evaluationg, and updating Linn County's continuity of government plan.
- When possible, integrate response, recovery, mitigation, and continuity plans to reflect the disaster cycle.

Coordinating Organization:	**Linn County Administrative Office**

Internal Partners:	**External Partners:**
Emergency Management County Departments	Elected Officials Board of County Commissioners

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
1-2 Years		

Proposed Action Item Identification:

LT: 2.1.3 Would be a Long Term Action proposed under Goal 2 Objective 2.1

Proposed Action Title/Description:

Evaluate current zoning codes to incorporate mitigation principles.

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having an above average or high risk to the majority of natural hazards addressed by the NHMP. Implementing mitigation principles through existing zoning codes allows the County to reduce the duplication of efforts.
- The Disaster Mitigation Act of 2000 requires communities to identify actions and projects that reduce the effects of hazards on both new and existing buildings [201.6(c)(3)(*ii*)]. Evaluating and enhancing zoning codes would address the future built environment and would also help further the objectives of Oregon Statewide Land Use Planning Goal 7 - Areas Subject to Natural Disasters and Hazards

Ideas for Implementation:

- Identify mitigation principles missing from existing zoning codes, or existing codes that mitigation principles could be added to.
- Research the possibilty for implementing mitigation principles them through zoning codes, and implement if possible.

Coordinating Organization:	**Linn County Planning & Building Department**

Internal Partners:	**External Partners:**
Emergency Management	Planning Commission Board of County Commissioners

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	

Proposed Action Item Identification:

ST: 2.1.4 Would be a Short Term Action proposed under Goal 2 Objective 2.1

Proposed Action Title/Description:

Explore participation in the National Flood Insurance Program's Community Rating System

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having a high flood risk rating of 220 out of 240. The County currently does not participate in the National Flood Insurance Program's Community Rating System (CRS). Participating in the CRS can help the County to better identify ways to reduce its flood risk and save money by earning reduced insurance premiums.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for a future flood event is high (that the county would be likely to have a major flooding event in the next 10-35 years) and the county's vulnerability to a future flood event is high. Participating in the CRS can help the County to better identify ways to reduce its flood risk and save money by earning reduced insurance premiums. Linn County was significantly impacted by the flooding events in 1996 and 1997, both of which were Presidentially Declared Disasters.
- The Disaster Mitigation Act of 2000 requires communities to identify actions and projects that reduce the effects of hazards on both new and existing buildings [201.6(c)(3)(*ii*)]. Participating in the CRS can help the County to better identify ways to reduce its flood risk and save money by earning reduced insurance premiums.

Ideas for Implementation:

- Determine CRS eligibility requirements
- Research and document current activities that Linn County is already conducting.
- Complete and submit CRS participation application
- Possible Ideas:
  - Update Linn County's code to reflect requirements of the CRS
  - Establish outreach projects to provide education flood hazards to Linn County Residents
  - Implement reasonable higher regulatory standards
  - Obtain digital floodplain maps.

Coordinating Organization:	**Linn County Planning & Building Department**

Internal Partners:	**External Partners:**
Building Official Emergency Management	Board of County Commissioners FEMA Insurance Companies Local Cities

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
3-6 Months		

Proposed Action Item Identification:

LT: 2.1.5 Would be a Long Term Action proposed under Goal 2 Objective 2.1

Proposed Action Title/Description:

Explore the development of management strategies to preserve the function of the floodplain

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having a high flood risk rating of 220 out of 240. Developing management strategies to preserve the function of the floodplain would affect the types of development, amount of development, and land use practices in the County's floodplain. Monitoring development and land use practices in the floodplain can assist the County in reducing its overall flood risk.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for a future flood event is high (that the county would be likely to have a major flooding event in the next 10-35 years) and the county's vulnerability to a future flood event is high. Developing management strategies to preserve the function of the floodplain would affect the types of development, amount of development, and land use practices in the County's floodplain. Monitoring development and land use practices in the floodplain can assist the County in reducing its overall flood risk.
- The Disaster Mitigation Act of 2000 requires communities to identify actions and projects that reduce the effects of hazards on both new and existing buildings [201.6(c)(3)(*ii*)]. Developing management strategies to preserve the function of the floodplain would affect the types of development, amount of development, and land use practices in the County's floodplain. Monitoring development and land use practices in the floodplain can assist the County in reducing its overall flood risk.

Ideas for Implementation:

- Identify the functions of the floodplain that are important to Linn County.
- Identify the departments and agencies responsible for maintaining and preserving those functions.
- Work with those departments and agencies to develop management strategies for preserving those functions.
- Develop methods for monitoring, evaluating, and updating those management strategies.

Coordinating Organization:	**Linn County Planning and Building Department**

Internal Partners:	**External Partners:**
Building Official	Local Cities FEMA DSL ODFW OWRD Watershed Councils

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
	2-3 Years	

Proposed Action Item Identification:

ST: 2.2.1 Would be a Short Term Action under Goal 2 Objective 2.2

Proposed Action Title/Description:

Develop an inventory of county assets including replacement costs

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having an above average or high risk to the majority of natural hazards addressed by the NHMP. Developing an inventory of county assets and replacement costs can assist the County in identifying what community assets are vulnerable to the natural hazards addressed in the NHMP. Assessing its vulnerability to hazards can help the County to better identify ways to reduce its risk to natural hazards.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for, and vulnerability to, most natural hazards addressed by the NHMP as being high. Developing an inventory of county assets and replacement costs can assist the County in identifying what community assets are vulnerability to the natural hazards addressed in the NHMP. Assessing its vulnerability to hazards can help the County to better identify ways to reduce its risk to natural hazards.
- The Disaster Mitigation Act of 2000 requires that communities identify their vulnerability to the hazards that affect the community, and how the community will be impacted [201.6(c)(2)(*ii*)(A)] and recommends estimating potential dollar losses [201.6(c)(2)(*ii*)(B)]. Developing an inventory of county assets and replacement costs can assist the County in identifying what community assets are vulnerability to the natural hazards addressed in the NHMP. Assessing its vulnerability to hazards can help the County to better identify ways to reduce its risk to natural hazards.

Ideas for Implementation:

- Identify assets that are important to the County to protect from the affects of natural hazards.
- Identify any existing inventories of important assets, including but not limited to: critical facilities and infrastructure, natural and cultural resources, historic sites and buildings, etc.
- Create a single server/location database for storing the inventory
- Develop methods for updating and maintaining the database and inventory.
- Make the outcome of this inventory available through the County's GIS system

Coordinating Organization:	**Linn County General Services**

Internal Partners:	**External Partners:**
GIS	Linn County Property Management Treasurer Assessor

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
1-2 Years		

Proposed Action Item Identification:

ST: 2.2.2 Would be a Short Term Action proposed under Goal 2 Objective 2.2

Proposed Action Title/Description:

Re-run DOGAMI HAZUS with local refined data for the earthquake hazard

Rationale for Proposed Action Item:

- HAZUS is a GIS mapping tool that can be used to estimate loss for potential natural hazard events such as earthquakes. HAZUS can assist communities determine in losses, allowing for emergency preparedness, response and recovery planning, and future risk reduction decisions. HAZUS is able to provide more accurate estimates when it has more refined data to work with. Adding better local data can allow Linn County to use the software to obtain more accurate estimates. Better estimates allow the County to better identify mitigation strategies that can assist it in reducing its risk to earthquakes.
- In a self-completed hazard analysis, Linn County rated itself as having a high earthquake risk rating of 223 out of 240. Re-running HAZUS with more refined local data can assist Linn County in obtaining better estimates for potential losses from earthquakes. Better estimates allow the County to better identify mitigation strategies that can assist it in reducing its risk to earthquakes.
- The Disaster Mitigation Act of 2000 requires that communities identify their vulnerability to the hazards that affect the community, and how the community will be impacted [201.6(c)(2)(*ii*)(A)]. Re-running HAZUS with more refined local data can assist Linn County in obtaining better estimates for potential losses from earthquakes, assisting the County in identifying its vulnerability to earthquakes. Better estimates of its vulnerability allow the County to better identify mitigation strategies that can assist the County in reducing its risk to earthquakes.

Ideas for Implementation:

- Obtain HAZUS training for appropriate County staff (GIS technicians, planners, etc…)
- Identify and collect local refined data.
- Obtain any new HAZUS updates.
- Ensure that any new HAZUS software updates are compatable with the County's existing servers, programs, and software.
- Re-run HAZUS with refined local data.

Coordinating Organization:	**Linn County GIS Department**

Internal Partners:	**External Partners:**
Emergency Management Planning and Building Departments	Assessor DOGAMI FEMA

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term (2-4 or more years)	
1 Year		

Proposed Action Item Identification:

LT: 2.2.3 Would be a Long Term Action proposed under Goal 2 Objective 2.2

Proposed Action Title/Description:

Update Flood Insurance Rate Maps (FIRM)

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having a high flood risk rating of 220 out of 240. Updated Flood Insurance Rate Maps can assist the County in more accurately predicting its risk to a future flooding event. Better predictions can assist the County to better identify mitigation strategies to reduce its flood risk.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for a future flood event is high (that the county would be likely to have a major flooding event in the next 10-35 years) and the county's vulnerability to a future flood event is high. Updated Flood Insurance Rate Maps can assist the County in more accurately predicting its risk to a future flooding event. Better predictions can assist the County to better identify mitigation strategies to reduce its flood risk.
- The Disaster Mitigation Act of 2000 requires communities to identify geographic extent of hazards known to impact the community [201.6(c)(2)(*i*)]. Updated Flood Insurance Rate Maps can assist the County better defining the flood hazard within the community given the development that has taken place since the current FIRMS were created.

Ideas for Implementation:

- Contact the State Floodplain Manager at DLCD to get more information on the Flood Map Modernization Program
- Determine whether or not the County has the capability to become a Cooperating Technical Partner in order to assist FEMA update the County's FIRMs.

Coordinating Organization:	**Linn County Planning and Building Department**

Internal Partners:	**External Partners:**
Emergency Management Building Official	Insurance Companies Local Cities FEMA OEM

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term (2-4 or more years)	

Proposed Action Item Identification:

ST: 2.2.4 Would be a Short Term Action proposed under Goal 2 Objective 2.2

Proposed Action Title/Description:

Develop pre-storm strategies for coordinated debris removal following wind and winter storms.

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having a high windstorm risk rating of 230 out of 240. Developing pre-storm response strategies for debris removal after wind and winter storms can assist the County in coordinating its response efforts. Coordinating resources assists the County in more efficiently and effectively using resources and responding when a wind or winter storm does happen.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for a future windstorm or winter storm is high (that the county would be likely to have a major windstorm or winter storm event in the next 10-35 years) and the county's vulnerability to a future windstorm or winter storm is high. Pre-planning to coordinate resources assists the County in more efficiently and effectively using resources and responding when a wind or winter storm does happen.

Ideas for Implementation:

- Identify and prioritize areas most likely to have debris to be removed following a wind or witner storm.
- Identify departmetns and agencies would could assist with debris removal.
- Work with departments, agencies and private organizations that can assist in developing coordinated strategies for removing debris after a wind or winter storm. Elements to include in strategies could include:
  - Tasks and responsibilities for each department and agency.
  - Routes to respond to prioritized areas.
  - Locations for depositing collected debris, or methods for dealing with collected debris.
  - Methods for responding to reports of debris caused by wind and winter storms.

Coordinating Organization:	**Linn County Roads Department**

Internal Partners:	**External Partners:**
Emergency Management	Sheriff 911 Coordinator Utility Companies Local Cities

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term (2-4 or more years)	
1 Year		

Proposed Action Item Identification:

ST: 2.3.1 Would be a Short Term Action proposed under Goal 2 Objective 2.3

Proposed Action Title/Description:

Update the Emergency Operations Plan.

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having an above average or high risk to the majority of natural hazards addressed by the NHMP. Updating the Emergency Operations Plan allows the County to update its ability to provide support and maintain the ability of the emergency services system in order to prevent or reduce the impact of injuries. This allows the County to improve its ability to mitigate the potential affects of the natural hazards addressed by the NHMP.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for, and vulnerability to, most natural hazards addressed by the NHMP as being high. Updating the Emergency Operations Plan allows the County to update its ability to provide support and maintain the ability of the emergency services system in order to prevent or reduce the impact of injuries. This allows the County to improve its ability to mitigate the potential affects of the natural hazards addressed by the NHMP.
- The Disaster Mitigation Act of 2000 requires communities to identify actions and projects that reduce the effects of hazards on the community [201.6(c)(3)(*ii*)]. Updating the Emergency Operations Plan allows the County to update its ability to provide support and maintain the ability of the emergency services system in order to prevent or reduce the impact of injuries. This allows the County to improve its ability to mitigate the potential affects of the natural hazards addressed by the NHMP.

Ideas for Implementation:

- Evaluate the current Emergency Operations Plan and identify areas that need to be updated or altered to reflect the current conditions and situation of the community.
- Ensure that links and references between the Emergency Operations Plan and the mitigation, recovery, and continuity of operations plans are made.
- Develop a method for scheduling updates and evaluations of the Emergency Operations Plan.

Coordinating Organization:	**Linn County Emergency Management**

Internal Partners:	**External Partners:**
County Administrator Road Department	Sheriff State Police COG Utility Companies Local Cities 911 Coordinator

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term (2-4 or more years)	
1 Year		

Proposed Action Item Identification:

ST: 2.3.2 Would be a Short Term Action proposed under Goal 2 Objective 2.3

Proposed Action Title/Description:

Consolidate mitigation plan, Emergency Operations Plan, recovery plans, and continuity of government plans into a Unified Disaster Plan.

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having an above average or high risk to the majority of natural hazards addressed by the NHMP. Consolidating the County's plans that address natural hazards improves the County's efficiency and effectiveness in mitigating, responding, and recovering from natural hazards. This can assist the County in reducing its overall risk to the natural hazards addressed by the NHMP.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for, and vulnerability to, most natural hazards addressed by the NHMP as being high. Consolidating the County's plans that address natural hazards improves the County's efficiency and effectiveness in mitigating, responding, and recovering from natural hazards. This can assist the County in reducing its overall risk to the natural hazards addressed by the NHMP.
- The Disaster Mitigation Act of 2000 requires communities to identify actions and projects that reduce the effects of hazards on the community [201.6(c)(3)(*ii*)]. Consolidating the County's plans that address natural hazards improves the County's efficiency and effectiveness in mitigating, responding, and recovering from natural hazards. This can assist the County in reducing its overall risk to the natural hazards addressed by the NHMP.

Ideas for Implementation:

- Research the plans to identify areas of overlap, areas that could be combined, and areas that are specific to only one plan.
- Ensure that links and references between the the mitigation, recovery, emergency operations, and continuity of operations plans are made.
- Schedule a Steering Committee meeting to address consolidating the mitigation plan, EOP, recovery plans, and continuity of governemnt plans. Develop a method for consolidating the plans.

Coordinating Organization:	**Linn County Emergency Management**

Internal Partners:	**External Partners:**
County Administrator Road Department	COG Utility Companies Local Cities 911 Coordinator State Police

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term (2-4 or more years)	
1-2 Years		

Proposed Action Item Identification:

ST: 2.4.1 Would be a Short Term Action proposed under Goal 2 Objective 2.4

Proposed Action Title/Description:

Develop a program to implement non-structural retrofit of County staff offices and workspaces

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having a high earthquake risk rating of 223 out of 240. Developing a program to implement non-structural retrofit projects in County staff offices will reduce the vulnerability of staff offices to earthquakes. This cannot only reduce the potential for injuries to staff that might be caused by a future earthquake, but can assist the county in reducing its risk to earthquakes.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for a future earthquake is high (that the county would be likely to have a major earthquake event in the next 10-35 years) and the county's vulnerability to earthquakes is high. Developing and implementing non-structural retrofit projects in County staff offices will reduce the vulnerability of staff offices to earthquakes, reducing the potential for earthquake-caused injuries. This can assist the County in reducing its overall earthquake risk.
- The Disaster Mitigation Act of 2000 requires communities to identify actions and projects that reduce the effects of hazards on the community, particularly to buildings and infrastructure [201.6(c)(3)(*ii*)]. Developing and implementing non-structural retrofit projects in County staff offices will reduce the vulnerability of staff offices to earthquakes, reducing the potential for earthquake-caused injuries. This can assist the County in reducing its overall earthquake risk.

Ideas for Implementation:

- Develop manuals, brochures, or hazard forms to help raise awareness of the need to mitigate non-structural hazards.
- Provide new employees, through new employee orientation, information on the hazards facing the county.
- Inventory County staff officies to determine needed non-structural retrofitting projects.
- Estimate costs of identified non-structural retrofit projects.
- Prioritize identified projects based on cost-benefit analysis.
- Identify resources and funding to complete retrofit projects.
- Develop a plan/schedule for completing retrofit projects.

Coordinating Organization:	**Linn County Safety Committee**

Internal Partners:	**External Partners:**
General Services	County Insurance Carrier OEM OR-OSHA BC

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term (2-4 or more years)	
1 Year		

Proposed Action Item Identification:

LT: 2.4.2 Would be a Long Term Action proposed under Goal 2 Objective 2.4

Proposed Action Title/Description:

Complete a seismic vulnerability assessment of all county-owned structures and prioritize vulnerable publicly owned structures

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having a high earthquake risk rating of 223 out of 240. Completing a seismic vulnerability assessment of all county-owned structures can assist the County in identifying its vulnerability to earthquakes. A better understanding of its vulnerability to earthquakes can assist the County to better identify mitigation strategies to reduce its overall earthquake risk.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for a future earthquake is high (that the county would be likely to have a major earthquake event in the next 10-35 years) and the county's vulnerability to earthquakes is high. Completing a seismic vulnerability assessment of all county-owned structures can assist the County in identifying its vulnerability to earthquakes. A better understanding of its vulnerability to earthquakes can assist the County to better identify mitigation strategies to reduce its overall earthquake risk.
- The Disaster Mitigation Act of 2000 requires communities to assess their vulnerability to natural hazards, particularly by identifying the types and number of buildings, infrastructure, and critical facilities that could be affected [201.6(c)(2)(*ii*)(A)]. Completing a seismic vulnerability assessment of all county-owned structures can assist the County in identifying its vulnerability to earthquakes. A better understanding of its vulnerability to earthquakes can assist the County to better identify mitigation strategies to reduce its overall earthquake risk.

Ideas for Implementation:

- Create list of all County-owned structures to assess.
- Develop a list of potential publicly owned structures to assess. Prioritize list based on a cost-benefit analysis for completing a structural vulnerability assessment.
- Research the possibility of completing *Rapid Visual Assessments* to determine vulnerability; research the possibility of hiring professionals to complete seismic vulnerability assessments.
- Determine which facilities have had their seismic vulnerability analyzed. For the facilities that have been assessed, find out when assessment was done to determine if a new assessment should be completed to address new seismic standards.
- For facilities that have had no seismic vulnerability analysis completed, work with facility operators to perform analysis.
- Prioritize facilities based on vulnerability.
- Ensure that data collected for the vulnerability assessment is captured in the County's GIS system
- Encourage County staff to attend state-sponsored *Rapid Visual Assessment* trainings.

Coordinating Organization:	**Linn County Engineer**

Internal Partners:	**External Partners:**	
General Services Building Official	Board of County Commissioners OEM Assessor	DOGAMI Safety Committee

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term (2-4 or more years)	
	5 Years	

Proposed Action Item Identification:

LT: 2.4.3 Would be a Long Term Action proposed under Goal 2 Objective 2.4

Proposed Action Title/Description:

Complete seismic vulnerability assessment of all County-owned bridges on lifeline routes and prioritize vulnerable bridges.

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having a high earthquake risk rating of 223 out of 240. Assessing the seismic vulnerability of all County-owned bridges can assist the County in understanding its vulnerability to potential earthquakes. Having an improved understanding of its earthquake vulnerability can assist the County in better identifying mitigation efforts and directing mitigation funding to prioritized projects.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates that Linn County's probability for a future earthquake is high (that the county would be likely to have a major earthquake event in the next 10-35 years) and the county's vulnerability to earthquakes is high. Assessing the seismic vulnerability of all County-owned bridges can assist the County in understanding its vulnerability to potential earthquakes. Having an improved understanding of its earthquake vulnerability can assist the County in better identifying mitigation efforts and directing mitigation funding to prioritized projects.
- The Disaster Mitigation Act of 2000 requires communities to assess their vulnerability to natural hazards, particularly by identifying the types and number of buildings, infrastructure, and critical facilities that could be affected [201.6(c)(2)(*ii*)(A)]. Assessing the seismic vulnerability of all County-owned bridges can assist the County in understanding its vulnerability to potential earthquakes. Having an improved understanding of its earthquake vulnerability can assist the County in better identifying mitigation efforts and directing mitigation funding to prioritized projects.

Ideas for Implementation:

- Create list of all County-owned bridges along lifeline routes to assess.
- Research the possibility of completing *Rapid Visual Assessments* to determine vulnerability; research the possibility of hiring professionals to complete seismic vulnerability assessments.
- Determine which bridges have already had their seismic vulnerability analyzed. For the bridges that have been assessed, find out when assessment was done to determine if a new assessment should be completed to address new seismic standards.
- For bridges that have had no seismic vulnerability analysis completed, perform analysis.
- Prioritize bridges based on the findings of the vulnerability assessments.

Coordinating Organization:	**Linn County Roads Department**

Internal Partners:	**External Partners:**	
County Engineer	Board of County Commissioners FEMA DOGAMI OEM ODOT	Fire Marshall 911 Coordinator Sheriff

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term (2-4 or more years)	
	5 Years	

Proposed Action Item Identification:

LT: 2.4.4 Would be a Long Term Action proposed under Goal 2 Objective 2.4

Proposed Action Title/Description:

Implement structural mitigation projects for prioritized, vulnerable publicly owned structures identified in Action 2.4.2 and 2.4.3.

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having a high earthquake risk rating of 223 out of 240. Implementing projects to reduce public facilities' seismic vulnerability can reduce the impact earthquakes will have on the facilities. Such actions help to reduce the County's overall risk to potential earthquakes.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates that Linn County's probability for a future earthquake is high (that the county would be likely to have a major earthquake event in the next 10-35 years) and the county's vulnerability to earthquakes is high. Implementing projects to reduce public facilities' seismic vulnerability can reduce the impact earthquakes will have on the facilities. Such actions help to reduce the County's overall risk to potential earthquakes.
- The Disaster Mitigation Act of 2000 requires communities to identify mitigation actions that are being considered by the community to reduce the effect that natural hazards will have on the community [201.6(c)(3)(*ii*)]. Developing and implementing projects to reduce public facilities' seismic vulnerability can reduce the impact earthquakes will have on the facilities. Such actions help to reduce the County's overall risk to potential earthquakes.

Ideas for Implementation:

- Use the seismic vulnerability assessments complted for publicly owned structures in Action Item 2.4.2, develop projects to reduce the seismic vulnerability of the highest prioritized structures.
- Identify funding sources to implement projects.

Coordinating Organization:	**Linn County Engineer**

Internal Partners:	**External Partners:**
General Services Road Department	Board of County Commissioners FEMA DOGAMI OEM ODOT U.S. Dot

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term (2-4 or more years)	
	5 Years	

Proposed Action Item Identification:

ST: 3.1.1 Would be a Short Term Action proposed under Goal 3 Objective 3.1

Proposed Action Title/Description:

Develop public awareness campaign aimed at homeowners, children, the elderly, and Spanish speaking residents to make them aware of what they can do to prepare for natural hazard events

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having a high risk to the majority of hazards addressed by the NHMP. Conducting outreach to educate the public and special needs groups on the importance of having emergency kits, supplies, and plans better prepares citizens for natural hazard events, helping reduce the county's overall risk to natural hazards.
- To increase natural hazard mitigation and emergency preparedness in Linn County, residents must be aware of the risk and know what they should do before and after the disaster occurs. Outreach and awareness campaigns need to be carefully organized and developed to ensure that residents receive critical information.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for, and vulnerability to, most hazards addressed by the NHMP as being high. Conducting outreach to educate the public on the importance of having emergency kits, supplies, and plans better prepares citizens for natural hazard events, helping reduce the county's overall risk to natural hazards.
- The Disaster Mitigation Act of 2000 requires that communities continue to involve the public beyond the original planning process [201.6(c)(4)(*ii*)]. Conducting outreach to educate the public on the importance of emergency kits, supplies, and plans would be a way to keep the public informed of, and involved in, the County's actions to mitigate hazards.

Ideas for Implementation:

- Encourage the development of 72-hour kits.
- Encourage elderly and special needs populations to make plans for emergency supplies and care before an event occurs.
- Develop education and outreach materials to make residents aware of the flood hazard and the availability of flood insurance.
- Develop education and outreach materials to make residents aware of the earthquake hazard and the availability of earthquake insurance.
- Develop awareness campaign that encourages residents to implement structural and non-structural mitigation for the earthquake hazard.
- Provide information to residents on landslide prevention (e.g. FEMA Homeowners Landslide Guide for Hillside Flooding, Debris Flow, Erosion and Landslide Control and Hillside Drainage).
- Partner with utility providers to make homeowners aware of the importance of tree and limb maintenance.
- Partner with insurance providers to provide insurance related information to homeowners and renters.

Coordinating Organization:	**Linn County Emergency Management**

Internal Partners:	**External Partners:**
Public Information Officer	Red Cross; COG; Local Cities; Linn Benton ESD; United Way; State Agencies; Hospitals; Insurance Companies; Children and Families Commission

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term (2-4 or more years)	
1-2 Years		

Proposed Action Item Identification:

ST: 3.1.2 Would be a Short Term Action proposed under Goal 3 Objective 3.1

Proposed Action Title/Description:

Use and publicize the Oregon Department of Forestry's debris flow warning system

Rationale for Proposed Action Item:

- The Oregon Department of Forestry's debris flow warning system is intended to alert people when certain areas become unsafe because of the danger of fast moving landslides. Linn County can use ODF's system to alert citizens who travel or live under steep slopes that are vulnerable to landslides.
- In a self-completed hazard analysis, Linn County rated itself as having an average risk rating to landslides of 125 out of 240. Utilizing ODF's debris flow warning system can assist Linn Count in protecting citizens from landslides, helping the County reduce its overall risk to landslides. The County was impacted during the 1996 flood and landslide events
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates that Linn County's probability for a future landslide is high (that the county would be likely to have a major earthquake event in the next 10-35 years) and the county's vulnerability to earthquakes is low. Utilizing ODF's warning system to alert citizens of a potential threatening landslide can assist the County in reducing its overall risk to landslides.
- The Disaster Mitigation Act of 2000 requires communities to identify mitigation actions that are being considered by the community to reduce the effect that natural hazards will have on the community [201.6(c)(3)(*ii*)]. Utilizing ODF's warning system to alert citizens of a potential threatening landslide can assist the county in reducing its overall risk to landslides.

Ideas for Implementation:

- Determine steps necessary to use ODF's debris warning system in Linn County.
- Identify areas in Linn County vulnerable to landslide that might need to be notified of potential threatening landslides; maintain a list of vulnerable areas.
- Develop partnerships with local media outlets to notify citizens of the warning system's existence.
- Develop partnerships with local media outlets (particularly television and radio) and develop methods for alerting systems when a landslide occurs.

Coordinating Organization:	**Emergency Management**

Internal Partners:	**External Partners:**
Road Department	ODF OEM DOGAMI ODOT

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term (2-4 or more years)	
	Ongoing	

Proposed Action Item Identification:

LT: 3.2.1 Would be a Long Term Action proposed under Goal 3 Objective 3.2

Proposed Action Title/Description:

Encourage small businesses to develop recovery plans and to implement non-structural mitigation.

Rationale for Proposed Action Item:

- Local economies can be severely impacted by disasters when local businesses have to close for extended periods of time due to physical and/or infrastructure damage. In a self-completed hazard analysis, Linn County rated itself as having a high risk to the majority of hazards addressed by the NHMP. Encouraging small businesses to develop recovery plans and implement non-structural mitigation can assist their recovery in the event of a natural hazard, mitigating the impact of natural hazards on the County's economic assets. Such mitigation efforts can assist the County in recovering more effectively and efficiently after the occurrence of a natural hazard.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for, and vulnerability to, most hazards addressed by the NHMP as being high. Encouraging businesses to develop recovery plans and implement non-structural mitigation activities can assist their recovery in the event of a natural hazard, mitigating the impact of natural hazards on the County's economic assets. Such mitigation efforts can assist the County in recovering more effectively and efficiently after the occurrence of a natural hazard.
- The Disaster Mitigation Act of 2000 requires communities to identify mitigation actions that are being considered by the community to reduce the effect that natural hazards will have on the community [201.6(c)(3)(*ii*)]. Encouraging businesses to develop recovery plans and implement non-structural mitigation activities can assist their recovery in the event of a natural hazard, mitigating the impact of natural hazards on the County's economic assets. Such mitigation efforts can assist the County in recovering more effectively and efficiently after the occurrence of a natural hazard.

Ideas for Implementation:

- Contact the Institute for Buisness and Home Saftey for information on their traning and software that can assist businesses in developing business continuity plans.
- Determine what materials and resources already exist to assist businesses in developing recovery plans and identify non-strucural mitigation techniques and activities.
- Develop methods to disseminate information and resources to small businesses. Possible methods could include:
  - Generating a list of small businesses and mailing information packets to those busienesses.
  - Staffing a booth with informaiton at County events.
  - Keeping packets of information at certain County agency offices and notifying small businesses of the existence of the packets.
  - Identify funding sources, if necessary, for any communication methods.
- Hold a County-sponsored small business symposium regarding the development of recovery plans and identifying non-strucutural mitigation activities.

Coordinating Organization:	**Linn County Chamber of Commerce**

Internal Partners:	**External Partners:**
Emergency Management Public Information Officer	Business Development Coordinator; COG; LBCC Business Development; Local Cities

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
	Ongoing	

Proposed Action Item Identification:

ST: 3.3.1 Would be a Short Term Action proposed under Goal 3 Objective 3.3

Proposed Action Title/Description:

Assist K-12 schools, childcare facilities and schools to develop vulnerability assessments and mitigation projects to improve safety

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having a high earthquake risk rating of 223 out of 240. Assisting schools and childcare facilities to develop vulnerability assessments and mitigation projects can improve the safety of citizens in Linn County and mitigate the affect that natural hazards have on the County's assets and critical infrastructure. Such activities can assist in reducing the County's overall earthquake risk.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates that Linn County's probability for a future earthquake is high (that the county would be likely to have a major earthquake event in the next 10-35 years) and the county's vulnerability to earthquakes is high. Assisting schools and childcare facilities to develop vulnerability assessments and mitigation projects can improve the safety of citizens in Linn County and mitigate the affect that natural hazards have on the County's assets and critical infrastructure. Such activities can assist in reducing the County's overall earthquake risk.
- The Disaster Mitigation Act of 2000 requires communities to identify mitigation actions that are being considered by the community to reduce the effect that natural hazards will have on the community [201.6(c)(3)(*ii*)]. Assisting schools and childcare facilities to develop vulnerability assessments and mitigation projects can improve the safety of citizens in Linn County and mitigate the affect that natural hazards have on the County's assets and critical infrastructure. Such activities can assist in reducing the County's overall earthquake risk.

Ideas for Implementation:

- Develop a list of all K-12 schools, childcare facilities, and other schools within Linn County.
- Determine if any schools have already had their seismic vulnerability analyzed. For the facilities that have been assessed, find out when assessment was done to determine if a new assessment should be completed to address new seismic standards.
- For facilities that have had no seismic vulnerability analysis completed, work with each facility to perform analysis.
- Use vulnerability assessments to identify mitigation projects.
- Create programs to cover the costs of the projects, or to cost-share the costs of the projects with facilities (for example, the County pays for 75% and the facility pays for 25% of identified projects).

Coordinating Organization:	**Linn-Benton Educational Service District**

Internal Partners:	**External Partners:**
Emergency Management	School Districts Private Schools American Red Cross DOGAMI OEM Commission on Children and Families

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
1-2 Years		

Proposed Action Item Identification:

LT: 3.3.2 Would be a Long Term Action proposed under Goal 3 Objective 3.3

Proposed Action Title/Description:

Encourage multi-objective stream and river enhancement projects that maximize flood mitigation

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having a high flood risk rating of 230 out of 240. Multi-objective stream and river enhancement projects can not only assist flood mitigation efforts, but can also reduce the duplication of efforts. Minimizing duplication allows the County to maximize its resources for natural hazard mitigation efforts, assisting the County in reducing its overall flood risk.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates that Linn County's probability for a future flood is high (that the county would be likely to have a major flooding event in the next 10-35 years) and the county's vulnerability to a future flood is high. Multi-objective stream and river enhancement projects can not only assist flood mitigation efforts, but can also reduce the duplication of efforts. Minimizing duplication allows the County to maximize its resources for natural hazard mitigation efforts, assisting the County in reducing its overall flood risk.
- The Disaster Mitigation Act of 2000 requires communities to identify mitigation actions that are being considered by the community to reduce the effect that natural hazards will have on the community [201.6(c)(3)(*ii*)]. Implementing multi-objective stream and river enhancement projects that maximize flood mitigation efforts assist the County in reducing its overall flood risk.

Ideas for Implementation:

- Identify stream and river enhancement projects, and locations of projects, that mitigate Linn County's flood risk.
- Identify any existing projects that are already scheduled for the same or close-by areas identified for mitigaiton projects.
- Contact the departments and/or agencies responsible for the already scheduled projects; discuss the potential for adding flood mitigation components to existing projects.
- Identify sources of funding for any potential cost of compensating or funding projects.
- Develop methods for external partners to submit proposals for multi-objective projects to the Board of County Commissioners or Steering Committee.
- Partner with community service organizations, such as Northwest Youth Corp to complete stream enhancement projects.

Coordinating Organization:	**Linn County Board of County Commissioners**

Internal Partners:	**External Partners:**	
Emergency Management	Watershed Councils	DEQ
	Water Control Districts	FEMA
	DSL	USCE
	ODFW	Local Cities
	DOF	

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
	Ongoing	

Proposed Action Item Identification:

LT: 3.3.3 Would be a Long Term Action proposed under Goal 3 Objective 3.3

Proposed Action Title/Description:

Conduct community based fuel reduction demonstration projects in the wildland-urban interface.

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County reported itself as having an above average wildland-urban interface fire (WUI) risk of 183 out of 240. Demonstrating fuel reduction projects to communities in the WUI can assist in showing residents how easy and aesthetically pleasing fuels reduction projects can be. Community residents may be more likely to share responsibility for mitigating the fire risk on their own properties and implement fuel reduction measures after viewing a demonstration. Such actions can assist the County in reducing its overall WUI fire risk.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates that Linn County's probability for a future WUI fire is high (that the county would be likely to have a major WUI fire event in the next 10-35 years) and the county's vulnerability to a future WUI fire is medium. Demonstrating fuel reduction projects to communities in the WUI can assist in showing residents how easy and aesthetically pleasing fuels reduction projects can be. Community residents may be more likely to share responsibility for mitigating the fire risk on their own properties and implement fuel reduction measures after viewing a demonstration. Such actions can assist the County in reducing its overall WUI fire risk.
- The Disaster Mitigation Act of 2000 requires that communities continue to involve the public beyond the original planning process [201.6(c)(4)(*ii*)]. Conducting demonstrations of fuel reduction projects in WUI communities is a way to involve residents in sharing the responsibility of mitigating the WUI fire risk, and demonstrate the ease of implementing fuel reduction projects. Such actions can not only continue to involve the public in the County's mitigation efforts, but can also assist the County in reducing its overall WUI fire risk.

Ideas for Implementation:

- Conduct public outreach to try to determine which fuels reduction methods Linn County WUI residents would be supportive of and likely to implement on their own properties.
- Identify target communities within the WUI where the County wants to conduct fuels reduction project demonstrations.
- Develop demonstration presentations and identify demonstration facilitators.
- Develop informational materials to disseminate to residents at the demonstrations.
- Identify funding sources to fund demonstrations and the production of informational materials.
- Develop methods for advertising the demonstrations to community residents, and methods for encouraging attendance.
- Encourage demonstration projects that highlight that fuel reduction projects can be aesthetically pleasing

Coordinating Organization:	**Emergency Management**

Internal Partners:	**External Partners:**
	State Fire Marshall ODF Fire Districts Local Cities OEM

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
	Ongoing	

Proposed Action Item Identification:		
ST: 3.3.4 Would be a Short Term Action under Goal 3 Objective 3.3		
Proposed Action Title/Description:		
Develop a countywide Community Wildfire Protection Plan		
Rationale for Proposed Action Item:		
• In a self-completed hazard analysis, Linn County reported itself as having an above average wildland-urban interface fire (WUI) risk of 183 out of 240. Developing a CWPP can assist Linn County in identifying mitigation partnerships, methods, and activities specifically for reducing its WUI fire risk. • The *State of Oregon's Natural Hazard Mitigation Plan* indicates that Linn County's probability for a future WUI fire is high (that the county would be likely to have a major WUI fire event in the next 10-35 years) and the county's vulnerability to a future WUI fire is medium. Developing a CWPP can assist Linn County in identifying mitigation partnerships, methods, and activities specifically for reducing its WUI fire risk. • The Healthy Forests Restoration Act of 2003 requires at-risk WUI communities to develop CWPPs in order to be eligible to receive certain federal funds for mitigation projects. Being eligible for federal funds can assist the County in funding WUI fire mitigation projects, assisting the County in reducing its overall WUI fire risk.		
Ideas for Implementation:		
• Research existing materials that provide assistance in developing a CWPP. • Research existing CWPPs and local, state, and federal regulations and requirements for WUI fire mitigation. • Identify key community stakeholders to involve in the mitigation planning process. • Create and convene a Linn County CWPP Steering Committee. • Using the background research that has been conducted, have the Steering Committee identify how to meet HFRA's requirments for a CWPP so that the needs, values, and situation of Linn County are addressed.		
Coordinating Organization:	**Linn County Emergency Management**	
Internal Partners:	**External Partners:**	
Land Management Public Works	ODF Fire Districts Local Cities State Fire Marshall OEM	BLM USFS Utilities Local WUI Property Owners
Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
1 Year		

Proposed Action Item Identification:

ST: 3.3.5 Would be a Short Term Action proposed under Goal 3 Objective 3.3

Proposed Action Title/Description:

Partner with the Oregon Department of Forestry and Rural Fire Districts to promote home site assessment programs for the wildfire hazard

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County reported itself as having an above average wildland-urban interface fire (WUI) risk of 183 out of 240. Promoting home site assessments for locations within Linn County's WUI can assist property owners in identifying their vulnerability to WUI fire and identifying mitigation activities. Assisting property owners with this may increase the likelihood that property owners would share responsibility for WUI fire mitigation on their properties and implement mitigation activities. Such actions can assist the County in reducing its overall WUI fire risk.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates that Linn County's probability for a future WUI fire is high (that the county would be likely to have a major WUI fire event in the next 10-35 years) and the county's vulnerability to a future WUI fire is medium. Promoting home site assessments for locations within Linn County's WUI can assist property owners in identifying their vulnerability to WUI fire and identifying mitigation activities. Assisting property owners with this may increase the likelihood that property owners would share responsibility for WUI fire mitigation on their properties and implement mitigation activities. Such actions can assist the County in reducing its overall WUI fire risk.
- The Disaster Mitigation Act of 2000 requires that communities continue to involve the public beyond the original planning process [201.6(c)(4)(*ii*)]. Promoting home site assessment programs would be a way to conduct outreach to inform homeowners of the county's risk to WUI fire and keep them involved in the County's efforts to mitigate that risk.

Ideas for Implementation:

- Determine if the home site asessments would be free for homeowners; free if they participate in a County survey, attend a community forum, etc.; or offered at a reduced cost to homeowners.
- Work with partners to identify at-risk communities to target for the program.
- Work with partners to develop home site assessment programs. Components of the program could include:
    - Determining what the assessments of home sites would include, and who would be responsible for conducting them.
    - Determining if there is a need to prioritize at-risk communities based on vulnerability, and begin the program in the most vulnerable, highest priority communities first.
    - Identifying and developing the most appropriate methods of communication to reach at-risk homeowners.
- Identify funding sources to fund the program.

Coordinating Organization:	**Linn County Emergency Management**

Internal Partners:	**External Partners:**
Land Management	ODF Local Cities Rural Fire Districts OEM State Fire Marshall

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
1-2 Years		

Proposed Action Item Identification:

LT: 3.3.6 Would be a Long Term Action proposed under Goal 3 Objective 3.3

Proposed Action Title/Description:

Develop partnerships to implement programs to keep trees from threatening lives, property, and public infrastructure during wind and winter storms

Rationale for Proposed Action Item:

- In a self-completed hazard analysis, Linn County rated itself as having a high windstorm risk rating of 230 out of 240. Wind and winter storms have the potential to down trees and cause injuries, and damage to property and infrastructure. Developing and implementing programs to reduce the potential for wind and winter storms to cause damage by downing trees can assist the County in mitigating its overall risk to wind and winter storms.
- The *State of Oregon's Natural Hazard Mitigation Plan* indicates Linn County's probability for a future windstorm or winter storm is high (that the county would be likely to have a major windstorm or winter storm event in the next 10-35 years) and the county's vulnerability to a future windstorm or winter storm is high. Wind and winter storms have the potential to down trees and cause injuries, and damage to property and infrastructure. Developing and implementing programs to reduce the potential for wind and winter storms to cause damage by downing trees can assist the County in mitigating its overall risk to wind and winter storms.
- The Disaster Mitigation Act of 2000 requires communities to identify mitigation actions that are being considered by the community to reduce the effect that natural hazards will have on the community [201.6(c)(3)(*ii*)]. Developing and implementing programs to reduce the potential for wind and winter storms to cause damage by downing trees can assist the County in mitigating its overall risk to wind and winter storms.

Ideas for Implementation:

- Determine if Linn County has a hazardous tree inventory. If not, consider the potential for creating one.
- Develop partnerships to create methods to reduce the vulnerability of the identified hazardous trees. Such methods could include:
  - Trimming trees away from buildings and infrastructure.
  - Removing trees that are very vulnerable to wind and winter storms.
  - Public outreach to inform citizens about how to reduce the potential for trees to be affected by wind and winter storms, and their potential to cause damage.
- Identify sources of funding to fund projects.
- Develop hazardous tree inventory
- Develop educational materials for County residents

Coordinating Organization:	**Linn County Emergency Management**

Internal Partners:	**External Partners:**	
Road Department Parks Department	Utilities Insurance Companies OSU Extension Service	ODF Arbor Care Companies Timber Companies

Timeline:		**If available, estimated cost:**
Short Term (0-2 years)	Long Term(2-4 or more years)	
	Ongoing	

Appendix C
Economic Analysis of Natural Hazard Mitigation Projects

This appendix outlines three 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 Mitigatio*n.

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 possible natural hazard mitigation activities 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 Evaluating Mitigation Strategies?

The approaches used to identify the costs and benefits associated with natural hazard mitigation strategies, measures, or projects fall into three general categories: benefit/cost analysis, cost-effectiveness analysis and the STAPLE/E approach. The distinction between the three methods is outlined below:

Benefit/Cost Analysis

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.

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. A project worth pursuing will have a benefit/cost ratio greater than 1 (i.e., the net benefits will exceed the net costs).

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 which 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 that is 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.

STAPLE/E Approach

Conducting detailed benefit/cost or cost-effectiveness analysis for every possible mitigation activity could be very time consuming and may not be practical. There are some alternate approaches for conducting a quick evaluation of the proposed mitigation activities which could be used to identify those mitigation activities that merit more detailed assessment. One of these methods is the STAPLE/E Approach.

Using STAPLE/E criteria, mitigation activities can be evaluated quickly by steering committees in a systematic fashion. This criteria requires the committee to assess the mitigation activities based on the Social, Technical, Administrative, Political, Legal, Economic, and Environmental (STAPLE/E) constraints and opportunities of implementing the particular mitigation item in your community. The second chapter in FEMA's April How-To Guide "Developing the Mitigation Plan – Identifying Mitigation Actions and Implementation Strategies" as well as the "State of Oregon's Local Natural Hazard Mitigation Plan: An Evaluation Process" outline some specific considerations in analyzing each aspect. The following are suggestions for how to examine each aspect of the STAPLE/E Approach from the "State of Oregon's Local Natural Hazard Mitigation Plan: An Evaluation Process".

Social: Community development staff, local non-profit organizations, or a local planning board can help answer these questions.

- Is the proposed action socially acceptable to the community?
- Are there equity issues involved that would mean that one segment of the community is treated unfairly?
- Will the action cause social disruption?

Technical: The city or county public works staff, and building department staff can help answer these questions.

- Will the proposed action work?
- Will it create more problems than it solves?
- Does it solve a problem or only a symptom?
- Is it the most useful action in light of other community goals?

Administrative: Elected officials or the city or county administrator, can help answer these questions.

- Can the community implement the action?
- Is there someone to coordinate and lead the effort?
- Is there sufficient funding, staff, and technical support available?
- Are there ongoing administrative requirements that need to be met?

Political: Consult the mayor, city council or county planning commission, city or county administrator, and local planning commissions to help answer these questions.

- Is the action politically acceptable?
- Is there public support both to implement and to maintain the project?

Legal: Include legal counsel, land use planners, risk managers, and city council or county planning commission members, among others, in this discussion.

- Is the community authorized to implement the proposed action? Is there a clear legal basis or precedent for this activity?
- Are there legal side effects? Could the activity be construed as a taking?
- Is the proposed action allowed by the comprehensive plan, or must the comprehensive plan be amended to allow the proposed action?
- Will the community be liable for action or lack of action?
- Will the activity be challenged?

Economic: Community economic development staff, civil engineers, building department staff, and the assessor's office can help answer these questions.

- What are the costs and benefits of this action?
- Do the benefits exceed the costs?
- Are initial, maintenance, and administrative costs taken into account?
- Has funding been secured for the proposed action? If not, what are the potential funding sources (public, non-profit, and private)?
- How will this action affect the fiscal capability of the community?
- What burden will this action place on the tax base or local economy?
- What are the budget and revenue effects of this activity?
- Does the action contribute to other community goals, such as capital improvements or economic development?
- What benefits will the action provide? (This can include dollar amount of damages prevented, number of homes protected, credit under the CRS, potential for funding under the HMGP or the FMA program, etc.)

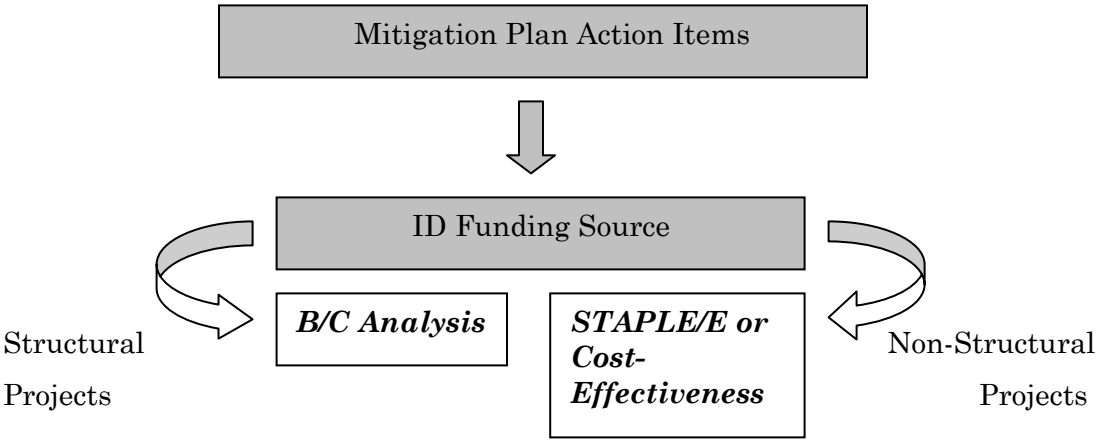
Environmental: Watershed councils, environmental groups, land use planners and natural resource managers can help answer these questions.

- How will the action impact the environment?
- Will the action need environmental regulatory approvals?
- Will it meet local and state regulatory requirements?
- Are endangered or threatened species likely to be affected?

The STAPLE/E approach is helpful for doing a quick analysis of mitigation projects. Most projects that seek federal funding and others often require more detailed Benefit/Cost Analyses.

When to use the Various Approaches

It is important to realize that various funding sources require different types of economic analyses. The following figure is to serve as a guideline for when to use the various approaches.



Implementing the Approaches

Benefit/cost analysis, cost-effectiveness analysis, and the STAPLE/E are important tools in evaluating whether or not to implement a mitigation activity. A framework for evaluating mitigation activities is outlined below. This framework should be used in further analyzing the feasibility of prioritized mitigation activities.

1. **Identify the Activities**

   Activities 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 activities. 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 benefit*s.** 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 Activities

Once costs and benefits have been quantified, economic analysis tools can rank the possible mitigation activities. Two methods for determining the best activities 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.

Economic Returns of Natural Hazard Mitigation

The estimation of economic returns, which accrue to building or landowner as a result of natural hazard mitigation, is difficult. Owners evaluating the economic feasibility of mitigation should consider reductions in physical damages and financial losses. A partial list follows:

- Building damages avoided
- Content damages avoided
- Inventory damages avoided
- Rental income losses avoided
- Relocation and disruption expenses avoided
- Proprietor's income losses avoided

These parameters can be estimated using observed prices, costs, and engineering data. The difficult part is to correctly determine the effectiveness of the hazard mitigation project and the resulting reduction in damages and losses. Equally as difficult is assessing the probability that an event will occur. The damages and losses should only include those that will be borne by the owner. The salvage value of the investment can be important in determining economic feasibility. Salvage value becomes more important as the time horizon of the owner declines. This is important because most businesses depreciate assets over a period of time.

Additional Costs from Natural Hazards

Property owners should also assess changes in a broader set of factors that can change as a result of a large natural disaster. These are usually termed "indirect" effects, but they can have a very direct effect on the economic value of the owner's building or land. They can be positive or negative, and include changes in the following:

- Commodity and resource prices
- Availability of resource supplies
- Commodity and resource demand changes
- Building and land values
- Capital availability and interest rates
- Availability of labor
- Economic structure
- Infrastructure
- Regional exports and imports
- Local, state, and national regulations and policies
- Insurance availability and rates

Changes in the resources and industries listed above are more difficult to estimate and require models that are structured to estimate total economic impacts. Total economic impacts are the sum of direct and indirect economic impacts. Total economic impact models are usually not combined with economic feasibility models. Many models exist to estimate total economic impacts of changes in an economy. Decision makers should understand the total economic impacts of natural disasters in order to calculate the benefits of a mitigation activity. This suggests that understanding the local economy is an important first step in being able to understand the potential impacts of a disaster, and the benefits of mitigation activities.

Additional Considerations

Conducting an economic analysis for potential mitigation activities can assist decision-makers in choosing the most appropriate strategy for their community to reduce risk and prevent loss from natural hazards. Economic analysis can also save time and resources from being spent on inappropriate or unfeasible projects. Several resources and models are listed on the following page that can assist in conducting an economic analysis for natural hazard mitigation activities.

Benefit/cost analysis is complicated, and the numbers may divert attention from other important issues. It is important to consider the qualitative factors of a project associated with mitigation that cannot be evaluated economically. There are alternative approaches to implementing mitigation projects. Many communities are looking towards developing multi-objective projects. With this in mind, opportunity rises to develop strategies that integrate natural hazard mitigation with projects related to watersheds, environmental planning, community economic development, and small business development, among others. Incorporating natural hazard mitigation with other community projects can increase the viability of project implementation.

Resources

CUREe Kajima Project, *Methodologies For Evaluating The Socio-Economic Consequences Of Large Earthquakes*, Task 7.2 Economic Impact Analysis, Prepared by University of California, Berkeley Team, Robert A. Olson, VSP Associates, Team Leader; John M. Eidinger, G&E Engineering Systems; Kenneth A. Goettel, Goettel and Associates Inc.; and Gerald L. Horner, Hazard Mitigation Economics Inc., 1997.

Federal Emergency Management Agency, *Benefit/Cost Analysis of Hazard Mitigation Projects*, Riverine Flood, Version 1.05, Hazard Mitigation Economics Inc., 1996.

Federal Emergency Management Agency *Report on Costs and Benefits of Natural Hazard Mitigation.* Publication 331, 1996.

Goettel & Horner Inc., *Earthquake Risk Analysis Volume III: The Economic Feasibility of Seismic Rehabilitation of Buildings in The City of Portland*, Submitted to the Bureau of Buildings, City of Portland, August 30, 1995.

Goettel & Horner Inc., *Benefit/Cost Analysis of Hazard Mitigation Projects* Volume V, Earthquakes, Prepared for FEMA's Hazard Mitigation Branch, October 25, 1995.

Horner, Gerald, *Benefit/Cost Methodologies for Use in Evaluating the Cost Effectiveness of Proposed Hazard Mitigation Measures*, Robert Olson Associates, Prepared for Oregon State Police, Office of Emergency Management, July 1999.

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

Risk Management Solutions, Inc., *Development of a Standardized Earthquake Loss Estimation Methodology*, National Institute of Building Sciences, Volume I and II, 1994.

VSP Associates, Inc., *A Benefit/Cost Model for the Seismic Rehabilitation of Buildings*, Volumes 1 & 2, Federal Emergency Management Agency, FEMA Publication Numbers 227 and 228, 1991.

VSP Associates, Inc., *Benefit/Cost Analysis of Hazard Mitigation Projects: Section 404 Hazard Mitigation Program and Section 406 Public Assistance Program, Volume 3: Seismic Hazard Mitigation Projects*, 1993.

VSP Associates, Inc., *Seismic Rehabilitation of Federal Buildings: A Benefit/Cost Model*, Volume 1, Federal Emergency Management Agency, FEMA Publication Number 255, 1994.

Appendix D

DOGAMI Earthquake HAZUS Models

APPENDIX D: Linn County

Earthquake Scenarios and

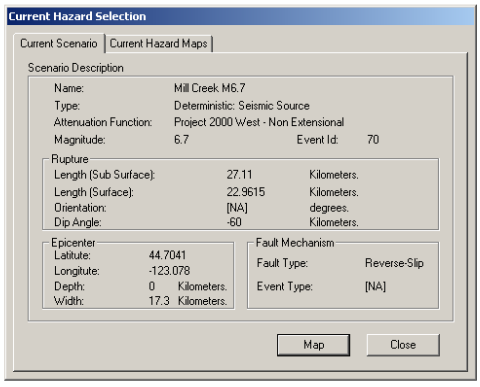
Ground Motion Maps

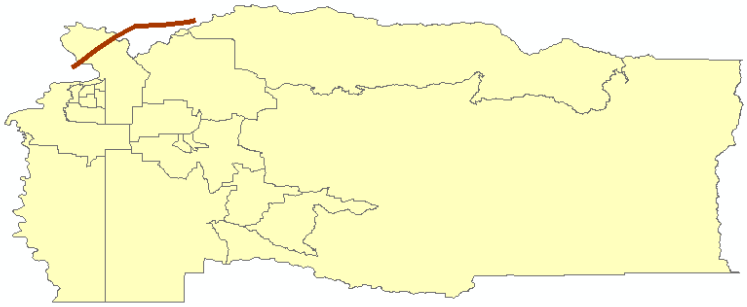
Crustal Earthquake Scenario Details

Crustal Earthquake Scenario: A magnitude 6.5 earthquake on the Corvallis Fault.

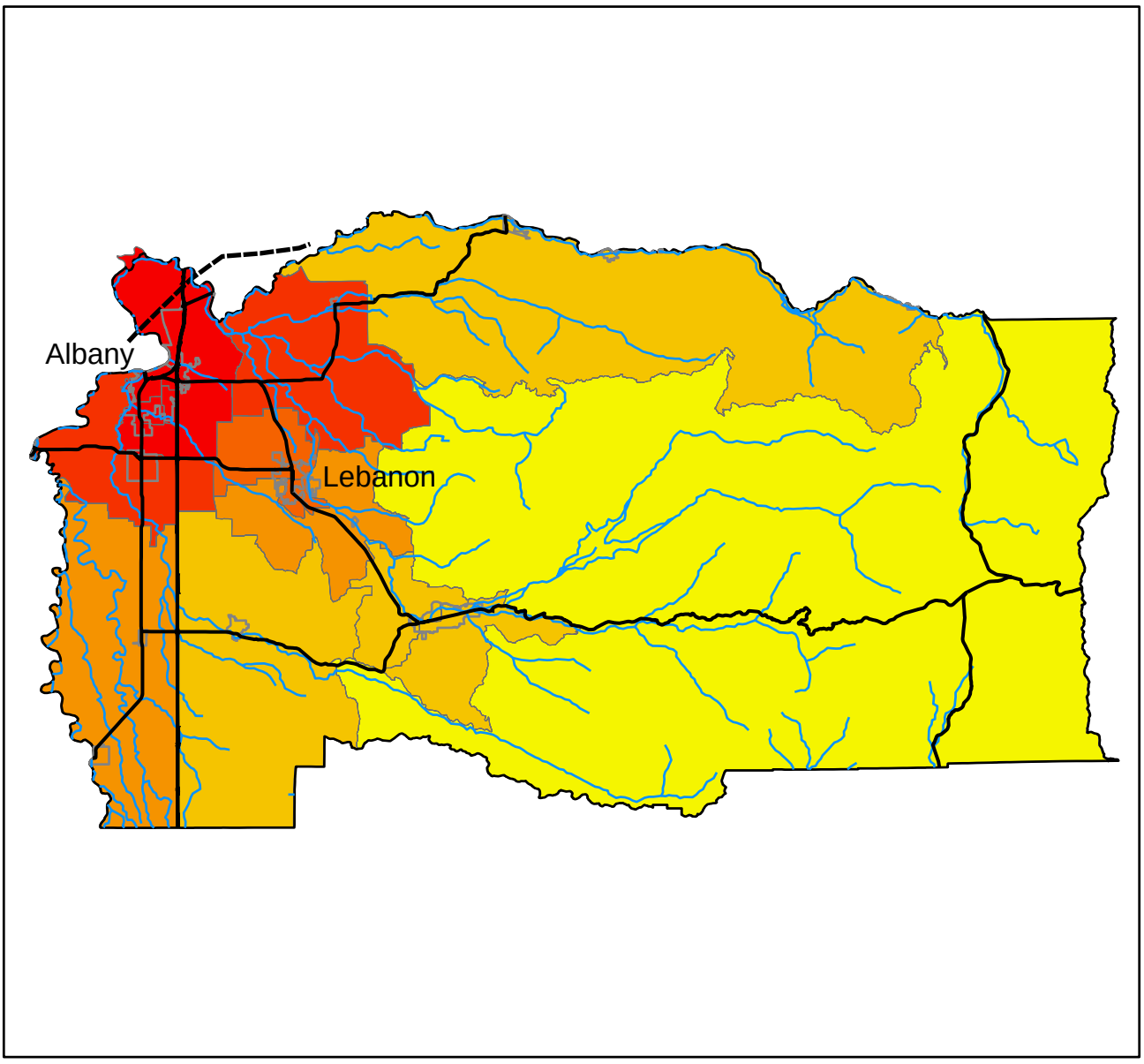
For the magnitude 6.7 earthquake on the Mill Creek Fault scenario, we defined the fault source using the "Deterministic Seismic Source" option within HAZUS (see figure below). The fault and earthquake event was chosen by examination of USGS data and data in the Geomatrix report (1995) titled *Seismic Design Mapping State of Oregon* prepared for the Oregon Department of Transportation. In general, a likely worst-case scenario was selected. In particular, this event was modeled after the scenario defined in the DOGAMI OFR 0-01-05 titled Preliminary Earthquake Hazard and Risk Assessment and Water-Induced Landslide Hazard in Benton County, Oregon. The figure below has the location of the fault, show as the dark brown line and the census tracks within Linn County.

Scenario Name	Mill Creek M6.7
Type of Earthquake	Source
Fault Name	Mill Creek Fault
Historical Epicenter ID #	70
Probabilistic Return Period	NA
Longitude of Epicenter	-123.015
Latitude of Epicenter	44.7428
Earthquake Magnitude	6.7
Depth (Km)	0.00
Rupture Length (Km)	27.11
Rupture Orientation (degrees)	0.00
Attenuation Function	Reverse-Slip





Peak Ground Acceleration (PGA) Map - Crustal
Linn County, Oregon



Highway or Interstate
Mill Creek Fault
River
PGA (g) by Census Tract
City Outline
0.0 - 0.1
County Outline
0.1 - 0.2
Census Tract Outline
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5+

N
W
E
S

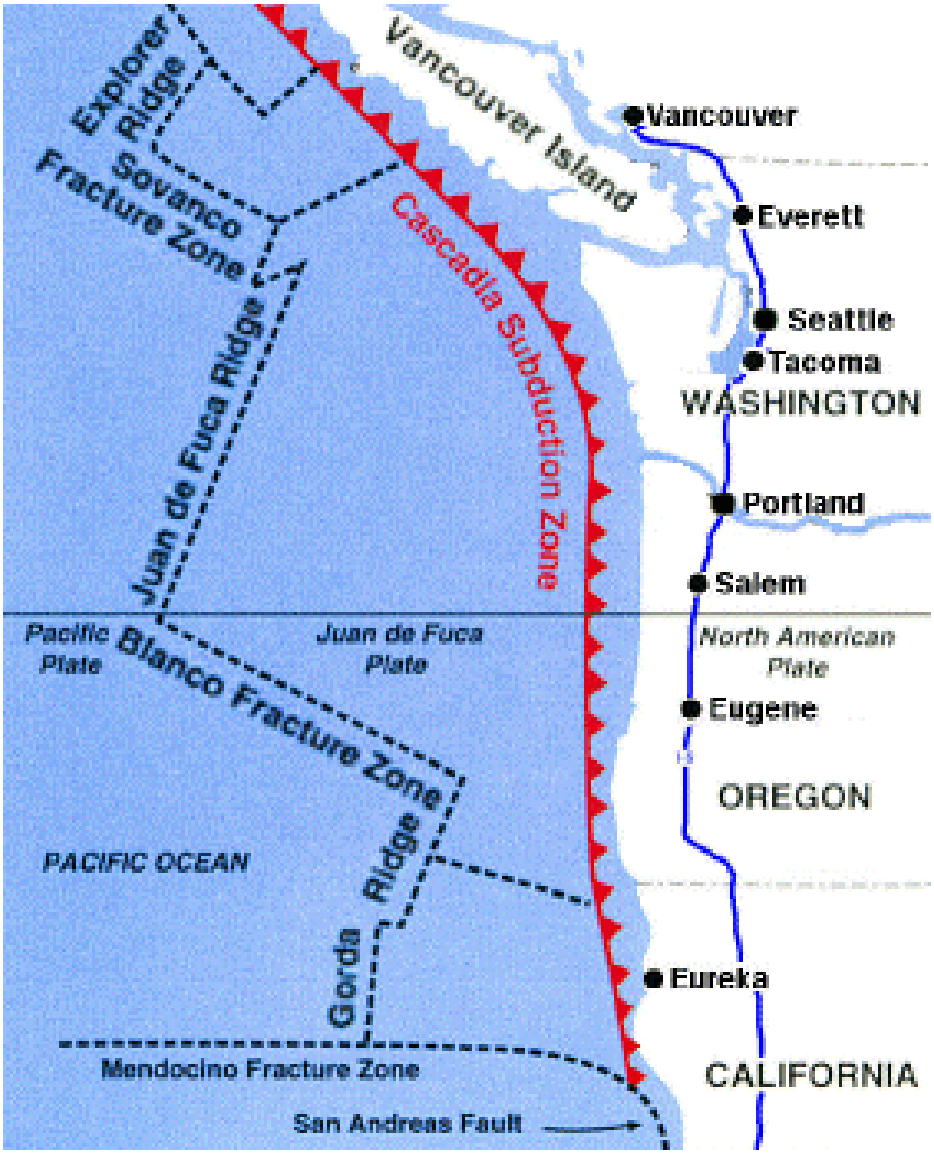
0 12,500 25,000 50,000 Meters

0 47,500 95,000 190,000 Feet

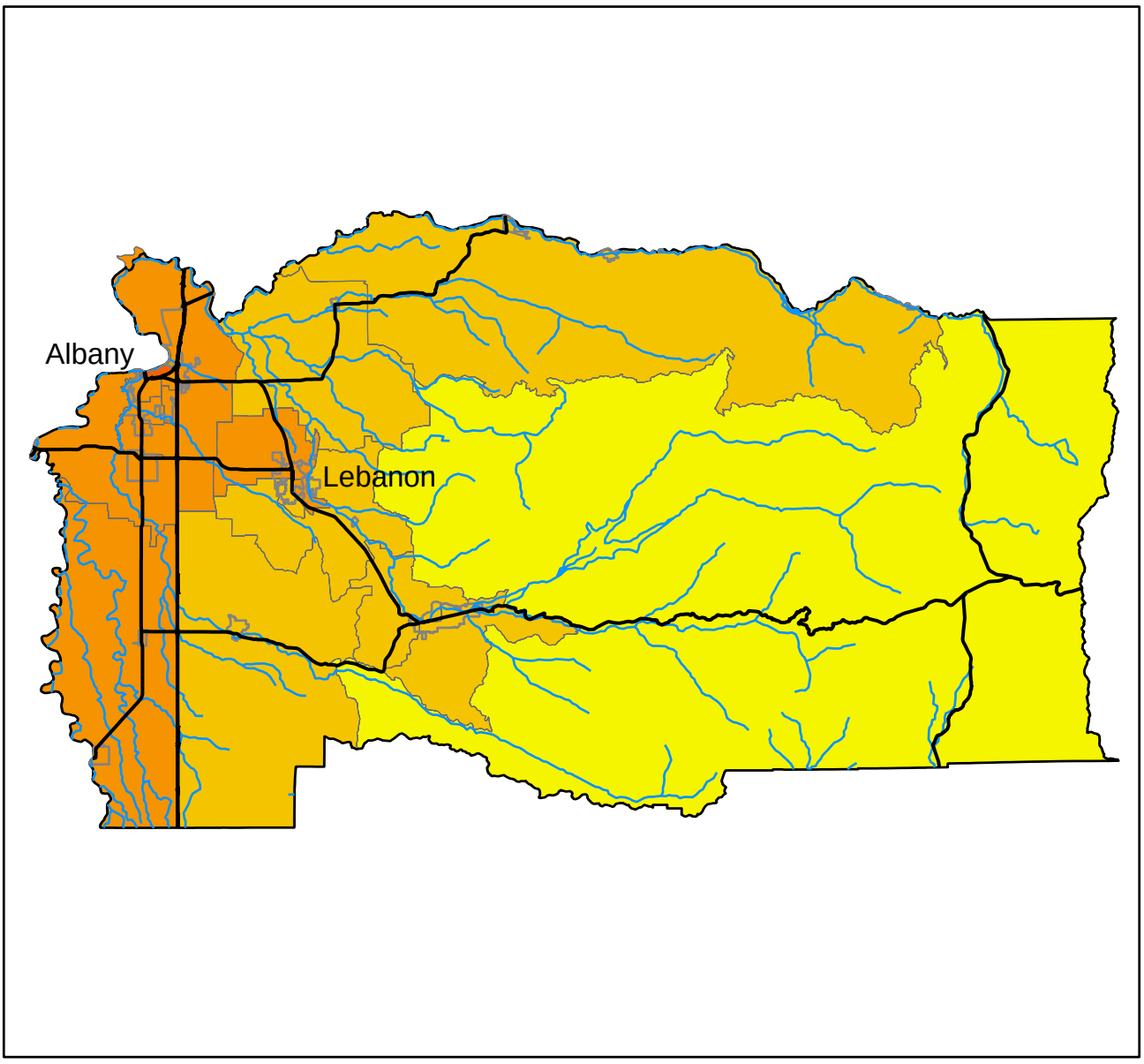
Subduction Zone Earthquake Scenario Details

Subduction Zone Scenario: A magnitude 9.0 earthquake on the Cascadia Subduction Zone was selected for the subduction zone earthquake scenario.

For the Cascadia Subduction Zone earthquake scenario, we used the "User-defined event" option within HAZUS to incorporate ground motion maps developed by CREW to model damage and loss from a magnitude 9.0 earthquake. The CREW maps were developed based on ground motion data provided by the U.S. Geological Survey. The CREW earthquake scenario required the input of four sets of GIS files that are included within the HAZUS study region including regional peak ground acceleration (pga), peak ground velocity (pgv), and the spectral velocity at 0.3 seconds and 1.0 seconds (CREW, 2003).



Peak Ground Acceleration (PGA) Map - Cascadia
Linn County, Oregon



Highway or Interstate
River
City Outline
County Outline
Census Tract Outline

PGA (g) by Census Tract
0.0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5+

N
W E
S

0 12,500 25,000 50,000
Meters

0 47,500 95,000 190,000
Feet

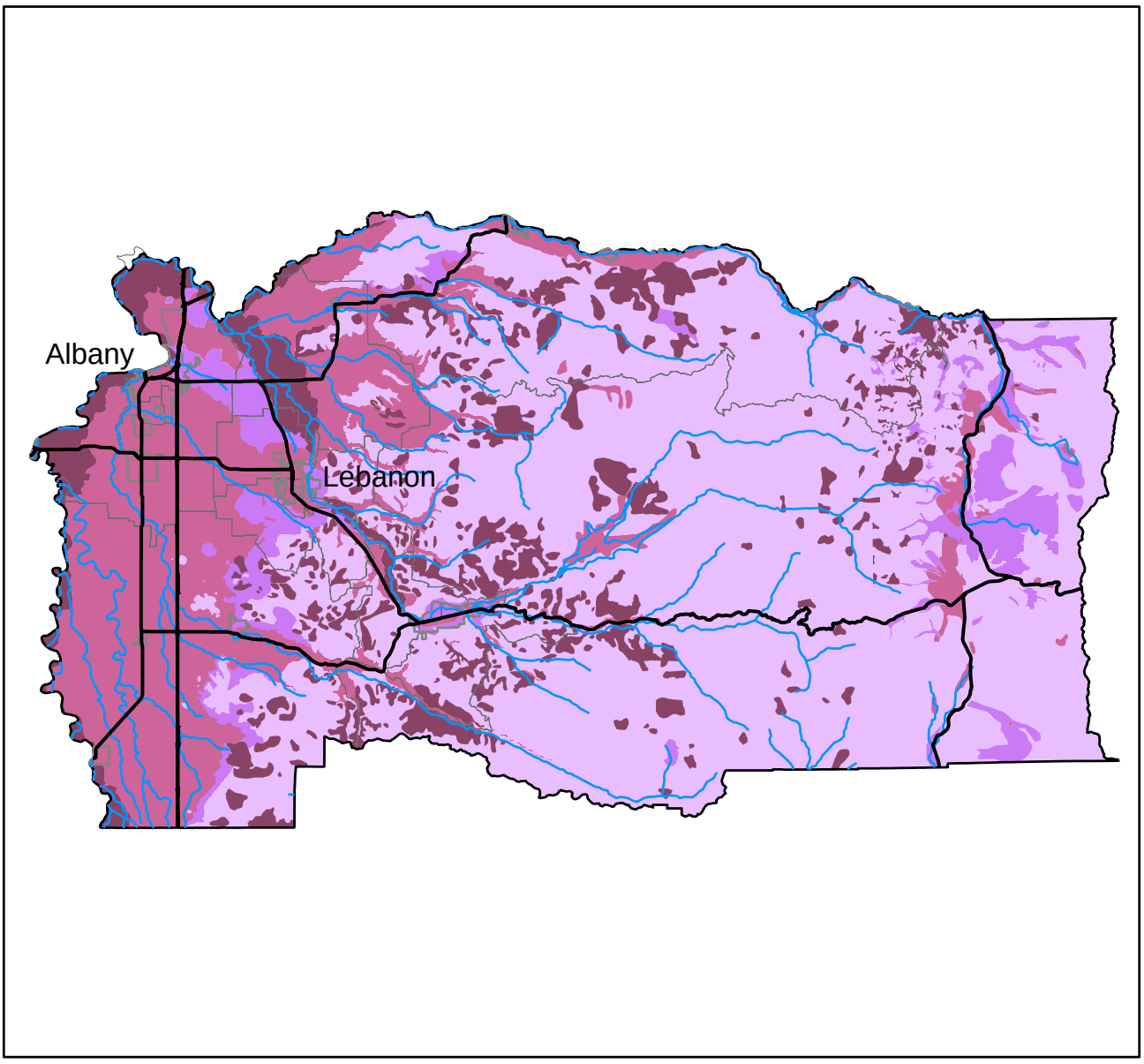
Ground Shaking Amplification Susceptibility Map,

Liquefaction Hazard Susceptibility Map,

Earthquake Induced Landslide Susceptibility Map,

and Identified Landslide Areas Map

Relative Ground Shaking Amplification Susceptibility Map
Linn County, Oregon



Highway or Interstate
River
City Outline
County Outline
Census Tract Outline

Ground Shaking Amplification (NEHRP Site Class)

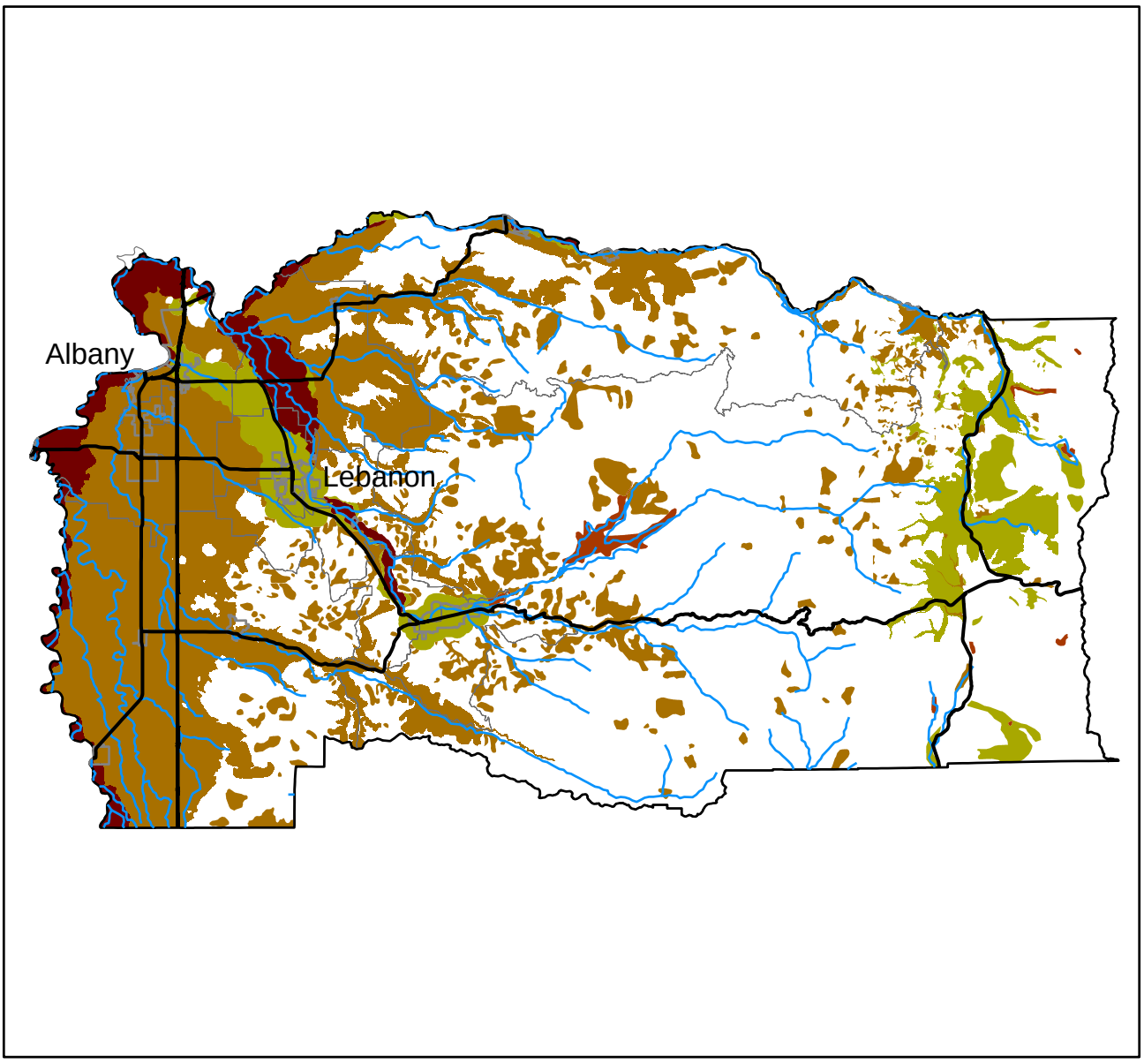
Very Low (A)
Low (B)
Moderate (C)
High (D)
Very High (E and F)

N
W E
S

0 11,250 22,500 45,000 Meters

0 40,500 81,000 162,000 Feet

Relative Liquefaction Susceptibility Map
Linn County, Oregon



Highway or Interstate
River
City Outline
County Outline
Census Tract Outline

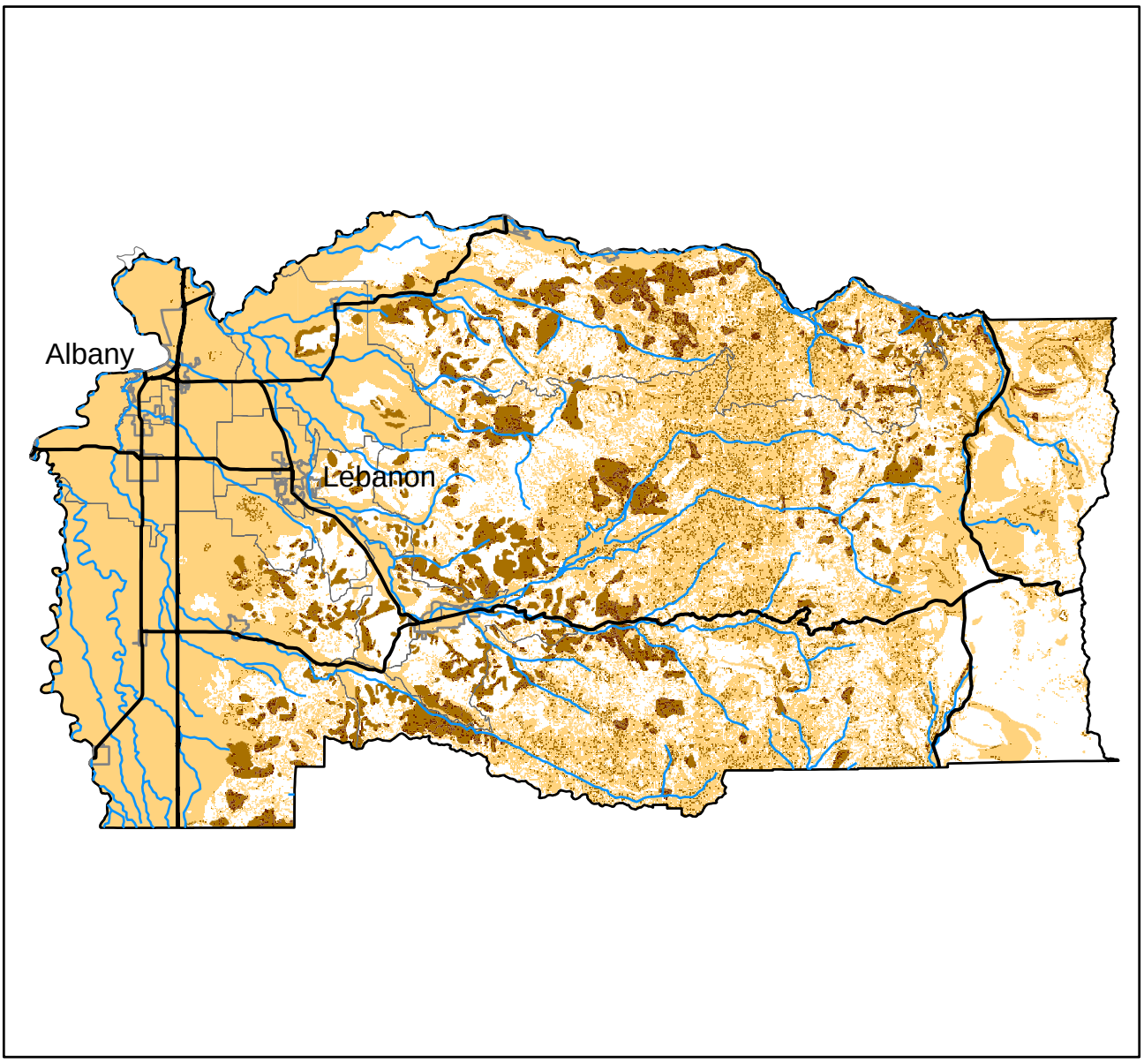
Liquefaction Susceptibility
Rare
Very Low
Low
Moderate
High
Very High

N
W E
S

0 11,250 22,500 45,000
Meters

0 40,500 81,000 162,000
Feet

Relative Earthquake Induced Susceptibility Map
Linn County, Oregon



Highway or Interstate
River
City Outline
County Outline
Census Tract Outline

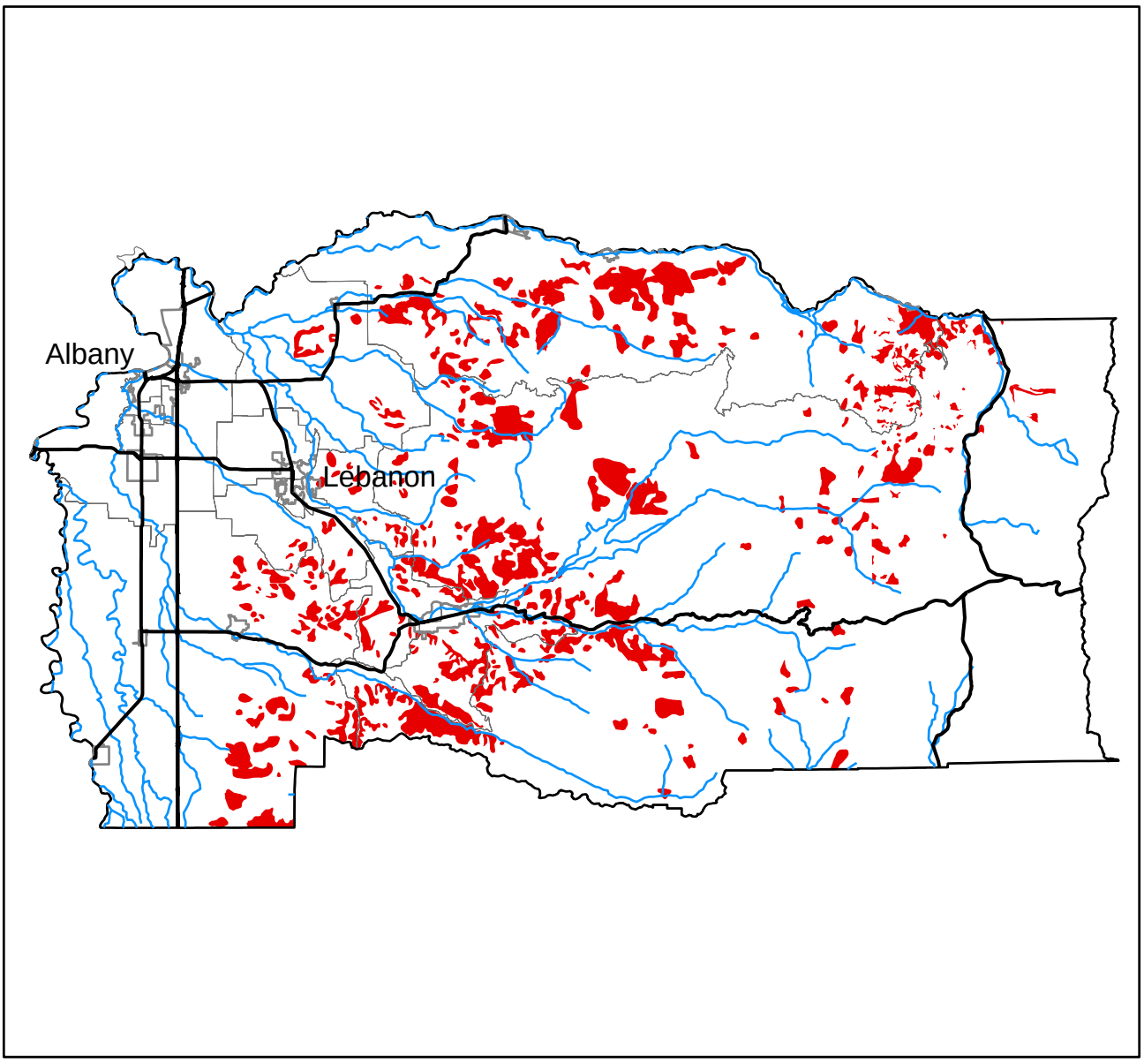
Landslide Susceptibility
Low
Moderate
High
Very High

N
W E
S

0 11,250 22,500 45,000
Meters

0 40,500 81,000 162,000
Feet

Identified Landslide Areas Map
Linn County, Oregon



Highway or Interstate
River
City Outline
County Outline
Census Tract Outline
Identified Landslides

N
W
E
S

0 11,250 22,500 45,000
Meters

0 40,500 81,000 162,000
Feet

HAZUS Global Reports for

Crustal and Subduction Zone Scenarios

HAZUS-MH: Earthquake Event Report

Region Name: ***Linn Crustal***

Earthquake Scenario: ***Mill Creek M6.7***

Print Date: ***March 18, 2005***

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

Table of Contents

General Description of the Region

HAZUS is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of HAZUS is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 1 county(ies) from the following state(s):

Oregon

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 2,304.63 square miles and contains 20 census tracts. There are over 39 thousand households in the region and has a total population of 103,069 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 36 thousand buildings in the region with a total building replacement value (excluding contents) of 5,669 (millions of dollars). Approximately 99.00 % of the buildings (and 85.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 4,440 and 1,278 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 36 thousand buildings in the region which have an aggregate total replacement value of 5,669 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 80% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

HAZUS breaks critical facilities into two (2) groups: essential facilities and high potential loss (HPL) facilities. Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 1 hospitals in the region with a total bed capacity of 71 beds. There are 64 schools, 13 fire stations, 5 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 11 dams identified within the region. Of these, 6 of the dams are classified as 'high hazard'. The inventory also includes 69 hazardous material sites, 0 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 2 and 3.

The total value of the lifeline inventory is over 5,718.00 (millions of dollars). This inventory includes over 400 kilometers of highways, 122 bridges, 19,117 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	122	1,732.10
	Segments	71	1,421.20
	Tunnels	0	0.00
		Subtotal	**3,153.30**
Railways	Bridges	0	0.00
	Facilities	1	2.50
	Segments	110	209.90
	Tunnels	0	0.00
		Subtotal	**212.40**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	1	1.20
		Subtotal	**1.20**
Ferry	Facilities	0	0.00
		Subtotal	**0.00**
Port	Facilities	0	0.00
		Subtotal	**0.00**
Airport	Facilities	26	160.10
	Runways	26	913.10
		Subtotal	**1,073.30**
		Total	**4,440.10**

Table 3: Utility System Lifeline inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	191.20
	Facilities	4	150.50
	Pipelines	0	0.00
		Subtotal	**341.70**
Waste Water	Distribution Lines	NA	114.70
	Facilities	10	752.60
	Pipelines	0	0.00
		Subtotal	**867.30**
Natural Gas	Distribution Lines	NA	76.50
	Facilities	1	1.20
	Pipelines	0	0.00
		Subtotal	**77.70**
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**0.00**
Electrical Power	Facilities	3	372.90
		Subtotal	**372.90**
Communication	Facilities	7	0.80
		Subtotal	**0.80**
		Total	**1,660.40**

Earthquake Scenario

HAZUS uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Scenario Name	Mill Creek M6.7
Type of Earthquake	Source
Fault Name	Mill Creek Fault
Historical Epicenter ID #	70
Probabilistic Return Period	NA
Longitude of Epicenter	-123.08
Latitude of Epicenter	44.70
Earthquake Magnitude	6.70
Depth (Km)	0.00
Rupture Length (Km)	22.96
Rupture Orientation (degrees)	0.00
Attenuation Function	Project 2000 West - Non Extensional

Building Damage

Building Damage

HAZUS estimates that about 12,431 thousand buildings will be at least moderately damaged. This is over 34.00 % of the total number of buildings in the region. There are an estimated 2,671 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 4 below summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries the expected damage by general building type.

Table 4: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	1	0.00	0	0.01	0	0.01	0	0.01	0	0.01
Commercial	46	0.28	27	0.39	52	0.77	52	1.72	63	2.35
Education	1	0.00	1	0.01	2	0.04	3	0.09	3	0.12
Government	4	0.02	1	0.01	1	0.02	1	0.03	1	0.04
Industrial	6	0.04	4	0.05	8	0.11	9	0.30	11	0.39
Other Residential	2,583	15.40	1,122	16.05	1,648	24.46	1,241	41.07	962	35.99
Religion	2	0.01	1	0.01	1	0.02	1	0.04	1	0.05
Single Family	14,124	84.24	5,832	83.46	5,026	74.58	1,714	56.74	1,631	61.04
Total	**16,767**		**6,988**		**6,739**		**3,021**		**2,672**	

Table 5: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	20	0.01	1	0.01	1	0.02	2	0.06	3	0.09
MH*	2,390	14.26	924	13.22	1,404	20.84	1,111	36.79	817	30.58
Precast	7	0.03	3	0.04	7	0.10	9	0.30	11	0.40
RM*	3	0.02	1	0.02	3	0.05	4	0.14	5	0.17
Steel	22	0.01	1	0.02	3	0.05	6	0.19	12	0.44
UM*	124	0.74	58	0.83	84	1.25	77	2.55	115	4.29
Wood	14,201	84.65	5973	85.48	5,177	76.82	1,747	57.85	1,638	61.32
Total	**16,767**		**6,988**		**6,739**		**3,021**		**2,672**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 71 hospital beds available for use. On the day of the earthquake, the model estimates that only 3 hospital beds (4.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 20.00% of the beds will be back in service. By 30 days, 62.00% will be operational.

Table 6: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		Least Moderate Damage > 50%	Complete Damage > 50%	# likely Functional on day 1
Hospitals	1	1	0	0
Schools	64	22	0	42
EOCs	0	0	0	0
PoliceStations	5	3	0	2
FireStations	13	3	0	10

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	71	0	0	71	71
	Bridges	122	12	0	111	119
	Tunnels	0	0	0	0	0
Railways	Segments	110	0	0	110	110
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	1	1	0	0	1
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	1	1	0	0	1
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	26	6	0	23	26
	Runways	26	0	0	26	26

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 8-10 provide information on the damage to the utility lifeline systems. Table 8 provides damage to the utility system facilities. Table 9 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis. Table 10 provides a summary of the system performance information.

Table 8 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	4	2	0	2	4
Waste Water	10	4	0	5	10
Natural Gas	1	0	0	1	1
Oil Systems	0	0	0	0	0
Electrical Power	3	1	0	2	3
Communication	7	2	0	6	7

Table 9 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	9,559	308	266
Waste Water	5,735	243	211
Natural Gas	3,824	260	225
Oil	0	0	0

Table 10: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	39,541	2,084	1,157	117	0	0
Electric Power		11,371	7,251	3,254	776	15

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 6 ignitions that will burn about 0.06 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 142 people and burn about 8 (millions of dollars) of building value.

Debris Generation

HAZUS estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 0 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 42.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 0 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Shelter Requirement

HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates (3,683 households to be displaced due to the earthquake. Of these, 927 people (out of a total population of 103,069 will seek temporary shelter in public shelters.

Casualties

HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 11 provides a summary of the casualties estimated for this earthquake

Table 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	8	2	0	1
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	3	1	0	0
	Industrial	12	4	1	1
	Other-Residential	281	72	8	14
	Single Family	344	77	5	8
	Total	**650**	**156**	**14**	**25**
2 PM	Commercial	518	159	26	52
	Commuting	1	1	1	0
	Educational	83	25	4	8
	Hotels	1	0	0	0
	Industrial	92	28	4	9
	Other-Residential	64	17	2	3
	Single Family	79	18	1	2
	Total	**838**	**248**	**39**	**74**
5 PM	Commercial	406	125	21	40
	Commuting	9	11	20	4
	Educational	10	3	1	1
	Hotels	1	0	0	0
	Industrial	58	17	3	5
	Other-Residential	107	28	3	6
	Single Family	138	31	2	3
	Total	**729**	**215**	**49**	**59**

Economic Loss

The total economic loss estimated for the earthquake is 1,700.28 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 1,315.72 (millions of dollars); 10 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 66 % of the total loss. Table 12 below provides a summary of the losses associated with the building damage.

Table 12: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Loses							
	Wage	0.00	3.04	32.06	1.43	2.72	39.25
	Capital-Related	0.00	1.29	28.26	1.10	1.06	31.71
	Rental	19.36	22.41	15.53	0.59	1.33	59.22
	Relocation	2.12	0.60	0.84	0.06	0.46	4.08
	Subtotal	**21.47**	**27.34**	**76.69**	**3.18**	**5.57**	**134.25**
Capital Stock Loses							
	Structural	101.77	34.82	43.94	10.49	7.52	198.54
	Non_Structural	382.11	164.12	123.22	40.72	32.04	742.22
	Content	96.57	34.58	57.77	26.76	17.12	232.79
	Inventory	0.00	0.00	2.64	5.08	0.20	7.92
	Subtotal	**580.45**	**233.52**	**227.57**	**83.06**	**56.88**	**1,181.47**
	Total	**601.92**	**260.86**	**304.26**	**86.24**	**62.44**	**1,315.72**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 13 & 14 provide a detailed breakdown in the expected lifeline losses.

HAZUS estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 15 presents the results of the region for the given earthquake.

Table 13: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	1,421.20	$12.85	0.90
	Bridges	1,732.06	$116.85	6.75
	Tunnels	0.00	$0.00	0.00
	Subtotal	**3153.30**	**129.70**	
Railways	Segments	209.93	$2.21	1.05
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	2.46	$1.15	46.70
	Subtotal	**212.40**	**3.40**	
Light Rail	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Bus	Facilities	1.23	$0.63	51.16
	Subtotal	**1.20**	**0.60**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Port	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Airport	Facilities	160.12	$36.02	22.49
	Runways	913.13	$2.25	0.25
	Subtotal	**1073.30**	**38.30**	
	Total	**4440.10**	**172.00**	

Table 14: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	150.50	$27.50	18.27
	Distribution Line	191.20	$6.55	3.43
	Subtotal	**341.69**	**$34.05**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	752.60	$112.79	14.99
	Distribution Line	114.70	$5.18	4.52
	Subtotal	**867.29**	**$117.98**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	1.20	$0.07	5.79
	Distribution Line	76.50	$5.54	7.25
	Subtotal	**77.70**	**$5.61**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Electrical Power	Facilities	372.90	$54.84	14.71
	Subtotal	**372.90**	**$54.84**	
Communication	Facilities	0.80	$0.11	13.44
	Subtotal	**0.79**	**$0.11**	
	Total	**1,660.38**	**$212.59**	

Table 15. Indirect Economic Impact with outside aid
(Employment as # of people and Income in millions of $)

	LOSS	Total	%
First Year			
	Employment Impact	0	0.00
	Income Impact	(67)	-7.10
Second Year			
	Employment Impact	0	0.00
	Income Impact	(91)	-9.63
Third Year			
	Employment Impact	0	0.00
	Income Impact	(100)	-10.69
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(100)	-10.69
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(100)	-10.69
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(100)	-10.69

Appendix A: County Listing for the Region

Linn, OR

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Oregon					
	Linn	103,069	4,821	847	5,669
Total State		**103,069**	**4,821**	**847**	**5,669**
Total Region		**103,069**	**4,821**	**847**	**5,669**

HAZUS-MH: Earthquake Event Report

Region Name: ***Linn Cascadia***

Earthquake Scenario: ***Cascadia M9.0***

Print Date: ***March 18, 2005***

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

Table of Contents

General Description of the Region

HAZUS is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of HAZUS is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 1 county(ies) from the following state(s):

Oregon

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 2,304.63 square miles and contains 20 census tracts. There are over 39 thousand households in the region and has a total population of 103,069 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 36 thousand buildings in the region with a total building replacement value (excluding contents) of 5,669 (millions of dollars). Approximately 99.00 % of the buildings (and 85.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 4,440 and 1,278 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 36 thousand buildings in the region which have an aggregate total replacement value of 5,669 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 80% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

HAZUS breaks critical facilities into two (2) groups: essential facilities and high potential loss (HPL) facilities. Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 1 hospitals in the region with a total bed capacity of 71 beds. There are 64 schools, 13 fire stations, 5 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 11 dams identified within the region. Of these, 6 of the dams are classified as 'high hazard'. The inventory also includes 69 hazardous material sites, 0 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 2 and 3.

The total value of the lifeline inventory is over 5,718.00 (millions of dollars). This inventory includes over 400 kilometers of highways, 122 bridges, 19,117 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	122	1,732.10
	Segments	71	1,421.20
	Tunnels	0	0.00
		Subtotal	**3,153.30**
Railways	Bridges	0	0.00
	Facilities	1	2.50
	Segments	110	209.90
	Tunnels	0	0.00
		Subtotal	**212.40**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	1	1.20
		Subtotal	**1.20**
Ferry	Facilities	0	0.00
		Subtotal	**0.00**
Port	Facilities	0	0.00
		Subtotal	**0.00**
Airport	Facilities	26	160.10
	Runways	26	913.10
		Subtotal	**1,073.30**
		Total	**4,440.10**

Table 3: Utility System Lifeline inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	191.20
	Facilities	4	150.50
	Pipelines	0	0.00
		Subtotal	**341.70**
Waste Water	Distribution Lines	NA	114.70
	Facilities	10	752.60
	Pipelines	0	0.00
		Subtotal	**867.30**
Natural Gas	Distribution Lines	NA	76.50
	Facilities	1	1.20
	Pipelines	0	0.00
		Subtotal	**77.70**
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**0.00**
Electrical Power	Facilities	3	372.90
		Subtotal	**372.90**
Communication	Facilities	7	0.80
		Subtotal	**0.80**
		Total	**1,660.40**

Earthquake Scenario

HAZUS uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Scenario Name	Cascadia M9.0
Type of Earthquake	User-defined
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	8.50
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Building Damage

HAZUS estimates that about 10,372 thousand buildings will be at least moderately damaged. This is over 29.00 % of the total number of buildings in the region. There are an estimated 2,470 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 4 below summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries the expected damage by general building type.

Table 4: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	0	0.00	0	0.00	0	0.01	0	0.01	0	0.02
Commercial	18	0.10	21	0.26	53	1.00	62	2.40	86	3.47
Education	1	0.00	1	0.01	2	0.04	3	0.11	3	0.13
Government	1	0.01	1	0.01	2	0.03	2	0.07	2	0.09
Industrial	2	0.01	2	0.03	7	0.13	10	0.40	16	0.64
Other Residential	1,161	6.66	1,039	12.41	1,942	36.65	1,950	74.89	1,463	59.20
Religion	1	0.01	1	0.01	1	0.02	1	0.05	2	0.08
Single Family	16,259	93.21	7,304	87.26	3,291	62.12	575	22.07	899	36.37
Total	**17,444**		**8,370**		**5,298**		**2,604**		**2,471**	

Table 5: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	7	0.00	0	0.00	1	0.02	2	0.09	4	0.16
MH*	860	4.93	813	9.71	1,779	33.59	1,870	71.80	1,324	53.60
Precast	2	0.01	1	0.02	6	0.11	10	0.38	16	0.64
RM*	1	0.01	1	0.01	3	0.06	5	0.19	6	0.26
Steel	5	0.00	0	0.00	2	0.04	5	0.19	17	0.67
UM*	83	0.47	66	0.78	103	1.95	90	3.45	116	4.71
Wood	16,486	94.50	7471	89.26	3,348	63.20	546	20.97	880	35.63
Total	**17,444**		**8,370**		**5,298**		**2,604**		**2,471**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 71 hospital beds available for use. On the day of the earthquake, the model estimates that only 63 hospital beds (90.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 90.00% of the beds will be back in service. By 30 days, 90.00% will be operational.

Table 6: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		Least Moderate Damage > 50%	Complete Damage > 50%	# likely Functional on day 1
Hospitals	1	0	0	1
Schools	64	0	0	64
EOCs	0	0	0	0
PoliceStations	5	0	0	5
FireStations	13	0	0	13

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	71	0	0	71	71
	Bridges	122	0	0	122	122
	Tunnels	0	0	0	0	0
Railways	Segments	110	0	0	110	110
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	1	0	0	1	1
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	1	0	0	1	1
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	26	0	0	26	26
	Runways	26	0	0	26	26

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 8-10 provide information on the damage to the utility lifeline systems. Table 8 provides damage to the utility system facilities. Table 9 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis. Table 10 provides a summary of the system performance information.

Table 8 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	4	1	0	3	4
Waste Water	10	2	0	2	10
Natural Gas	1	0	0	1	1
Oil Systems	0	0	0	0	0
Electrical Power	3	0	0	2	3
Communication	7	0	0	7	7

Table 9 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	9,559	451	191
Waste Water	5,735	357	151
Natural Gas	3,824	382	161
Oil	0	0	0

Table 10: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	39,541	777	259	0	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (millions of dollars) of building value.

Debris Generation

HAZUS estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 0 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 36.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 0 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Shelter Requirement

HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates (2,563 households to be displaced due to the earthquake. Of these, 653 people (out of a total population of 103,069 will seek temporary shelter in public shelters.

Casualties

HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 11 provides a summary of the casualties estimated for this earthquake

Table 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	9	3	0	1
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	4	1	0	0
	Industrial	16	5	1	2
	Other-Residential	340	87	9	17
	Single Family	194	43	3	5
	Total	**563**	**139**	**14**	**25**
2 PM	Commercial	619	193	32	63
	Commuting	0	0	0	0
	Educational	96	30	5	10
	Hotels	1	0	0	0
	Industrial	121	37	6	12
	Other-Residential	77	20	2	4
	Single Family	45	10	1	1
	Total	**960**	**290**	**46**	**90**
5 PM	Commercial	494	152	26	49
	Commuting	0	0	0	0
	Educational	10	3	1	1
	Hotels	1	0	0	0
	Industrial	76	23	4	7
	Other-Residential	127	33	4	7
	Single Family	77	17	1	2
	Total	**785**	**229**	**35**	**67**

Economic Loss

The total economic loss estimated for the earthquake is 1,310.63 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 1,150.68 (millions of dollars); 13 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 51 % of the total loss. Table 12 below provides a summary of the losses associated with the building damage.

Table 12: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Loses							
	Wage	0.00	2.45	43.02	2.09	3.16	50.72
	Capital-Related	0.00	1.04	37.44	1.53	1.16	41.17
	Rental	10.27	20.13	19.59	0.80	1.51	52.29
	Relocation	1.18	0.62	1.09	0.07	0.51	3.47
	Subtotal	**11.45**	**24.23**	**101.14**	**4.49**	**6.34**	**147.65**
Capital Stock Loses							
	Structural	54.39	39.13	57.54	14.03	9.68	174.77
	Non_Structural	209.37	160.93	155.67	51.51	35.46	612.94
	Content	55.41	31.54	68.41	32.40	17.48	205.23
	Inventory	0.00	0.00	3.15	6.65	0.29	10.09
	Subtotal	**319.16**	**231.60**	**284.77**	**104.59**	**62.91**	**1,003.03**
	Total	**330.61**	**255.83**	**385.92**	**109.07**	**69.25**	**1,150.68**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 13 & 14 provide a detailed breakdown in the expected lifeline losses.

HAZUS estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 15 presents the results of the region for the given earthquake.

Table 13: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	1,421.20	$4.44	0.31
	Bridges	1,732.06	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Subtotal	**3153.30**	**4.40**	
Railways	Segments	209.93	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	2.46	$0.65	26.32
	Subtotal	**212.40**	**0.60**	
Light Rail	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Bus	Facilities	1.23	$0.34	27.99
	Subtotal	**1.20**	**0.30**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Port	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Airport	Facilities	160.12	$22.00	13.74
	Runways	913.13	$1.09	0.12
	Subtotal	**1073.30**	**23.10**	
	Total	**4440.10**	**28.50**	

Table 14: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	150.50	$12.57	8.35
	Distribution Line	191.20	$5.62	2.94
	Subtotal	**341.69**	**$18.19**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	752.60	$83.55	11.10
	Distribution Line	114.70	$4.44	3.87
	Subtotal	**867.29**	**$88.00**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	1.20	$0.10	8.25
	Distribution Line	76.50	$4.75	6.21
	Subtotal	**77.70**	**$4.85**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Electrical Power	Facilities	372.90	$20.33	5.45
	Subtotal	**372.90**	**$20.33**	
Communication	Facilities	0.80	$0.07	8.32
	Subtotal	**0.79**	**$0.07**	
	Total	**1,660.38**	**$131.43**	

Table 15. Indirect Economic Impact with outside aid
(Employment as # of people and Income in millions of $)

	LOSS	Total	%
First Year			
	Employment Impact	0	0.00
	Income Impact	(65)	-6.90
Second Year			
	Employment Impact	0	0.00
	Income Impact	(85)	-9.04
Third Year			
	Employment Impact	0	0.00
	Income Impact	(93)	-9.92
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(93)	-9.92
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(93)	-9.92
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(93)	-9.92

Appendix A: County Listing for the Region

Linn, OR

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Oregon					
	Linn	103,069	4,821	847	5,669
Total State		**103,069**	**4,821**	**847**	**5,669**
Total Region		**103,069**	**4,821**	**847**	**5,669**

Appendix E
Natural Hazard Resource Directory

Landslide Mitigation Programs

Linn County Codes

Statewide Planning Goal 7 seeks to "protect life and property" from natural disasters and hazards such as floods, landslides, and earthquakes. Linn County complies with Goal 7 by incorporating hazard inventories into the comprehensive plan and by adopting policies and ordinances to protect people and property from the identified hazard.

The Linn County Comprehensive Plan (Plan) in LCC Chapter 903 contains policies to address areas subject to natural and geologic hazards. The Plan identifies DOGAMI *Bulletin 84, Environmental Geology of Western Linn County, Oregon*, and subsequent amendments, as the official source for determining if a property is located within a mass movement area. *LCC 903.260(B)(10)* sets forth that:

> *If a development is proposed in an area known to have geologic or natural hazards, the county may require the applicant to submit a report which details the extent of the hazard. The county, before approving the proposal, must find that presence of a hazard will not be detrimental to the development.*

The Linn County Land Development Code in LCC 921.980(D)(2) states:

> *In an area containing mass movement topography as indicated in the Bulletin 84, Environmental Geology of Western Linn County, Oregon, no person may develop land unless the applicant provides a report from an Oregon Engineering Geologist to the Director before development permits may be issued. The report shall state that the land can be safely developed. If the report provides recommendations for development, those recommendations shall be incorporated into the site development.*

State Programs and Activities

Statewide Planning Goal 7[1]

Statewide Planning Goal 7 is one of the original 14 Statewide Planning Goals adopted by the Land Conservation and Development Commission in 1974. Goal 7 seeks to "protect life and property" from natural disasters and hazards such as floods, landslides, and earthquakes. To help accomplish this protection, the Goal requires that local plans be based on an inventory of known areas subject to natural hazards and disasters and advises that "developments subject to damage or that could result in loss of life shall not be planned nor located in known areas of natural disasters and hazards without appropriate safeguards."

Senate Bill 12[2]

In response to the catastrophic landslide events that occurred in Oregon in 1996, the state of Oregon adopted Senate Bill 12 in 1999 to address rapidly moving landslides (debris flows). Among other requirements, Senate Bill 12 requires local governments to:

> *Regulate through mitigation measures and site development standards the siting of dwellings and other structures designed for human occupancy in further review areas where there is evidence of substantial risk for rapidly moving landslides.*

In brief, Senate Bill 12 (Source: DLCD Natural Hazards Program website):

- Directs the Oregon Department of Geology and Mineral Industries (DOGAMI) to identify areas potentially prone to debris flows on "further review area" maps;
- Directs the Oregon Department of Land Conservation and Development (DLCD) to assist local governments in implementing the Bill;
- Requires the Oregon Board of Forestry to adopt regulations that reduce the risks associated with rapidly moving landslides;
- Requires the Oregon Department of Forestry (ODF) and DOGAMI to provide technical assistance to local governments;
- Requires the Oregon Department of Transportation (ODOT) to provide warnings to motorists during periods determined to be of the highest risk of rapidly moving landslides along areas of state highways with a history of being most vulnerable to rapidly moving landslides; and
- Directs the Office of Emergency Management of the Department of State Police to coordinate state resources for rapid and effective response to landslide-related emergencies.

Department of Geology and Mineral Industries (DOGAMI)

Senate Bill 12 requires DOGAMI to map "further review areas" in coordination with the Oregon Department of Forestry (ODF). The ODF and DOGAMI have worked together to develop landslide hazard identification maps in order to provide information to local governments that will allow for more informed mitigation decisions.

Department of Land Conservation and Development (DLCD)

The DLCD awarded a grant to Douglas County for the development of a model program to help in the mitigation of rapidly moving landslide hazards. Douglas County agreed to produce four main products: (1) A model landslide hazards ordinance; (2) Model documents to support implementation of Senate Bill 12; (3) A model Transfer of Development Rights program; and (4) Procedures to integrate DOGAMI's "further review area" maps into local tax parcel maps.

Oregon Department of Forestry (ODF)

Senate Bill 1211 and Senate Bill 12, passed in 1997 and 1999 respectively, contain provisions to be addressed by the ODF. These provisions include the interim prohibition of forest operations in certain areas and the development of certain forest practices requirements. The interim prohibitions authorized by Senate Bill 1211 will eventually be replaced by the forest practice rules to be adopted by the Oregon Board of Forestry as required by Senate Bill 12. (Source: DLCD Natural Hazards Program)

Interim Prohibitions[3]

Senate Bill 1211, a precursor to Senate Bill 12, authorized the ODF to prohibit forest operations on steep, landslide-prone sites above homes and busy roads in the interest of public safety. Specifically, the State Forester is authorized to prohibit operations if all of the following conditions exist:

- The operation location includes high-risk sites;
- Residences and other buildings where people are likely to be present during periods of intense rainfall or where paved county or state highways are in such close proximity to the potential path of a landslide or debris torrent that there is significant risk to human life; and
- The farthest expected extent of a potential landslide or debris torrent that might originate in the operation area, based on physical features of the landslide or debris torrent path, will reach the residences, buildings, or highways.

Forest Practices Requirements

Senate Bill 12 required the ODF to adopt and enforce forest practice rules to reduce the risk of serious bodily injury or death from rapidly moving landslides (Oregon Revised Statutes (ORS) 527.630)). ORS 527.710(11) sets forth the criteria the Board of Forestry should consider in adopting such rules, including the exposure of the public to these safety risks and appropriate practices to reduce the occurrence, timing, or effects of rapidly moving landslides.

Landslide Warnings

The Oregon Department of Geology and Mineral Industries (DOGAMI) is developing a slope failure database that it has used to study the relationship between rainfall events and debris flows. Records from the four major storms that hit western Oregon during 1996 and 1997 confirm that the occurrence of many landslides and debris flows can be related to rainfall intensity and duration. The relationships that have been shown between rainfall intensity and debris flows are useful in helping to determine areas where debris flow warning systems are appropriate. A debris-flow hazard warning system has been developed, and a current alert message can be found at the ODF.[4]

Oregon's landslide / debris flow warning system primarily involves three state and one federal agency: the ODF, DOGAMI, the Oregon Department of Transportation (ODOT), and the

National Oceanic and Atmospheric Administration (NOAA). The warning system is triggered by rainfall and monitored in areas that have been determined to be hazardous. As the lead agency, ODF is responsible for forecasting and measuring rainfall from storms that may trigger debris flows. Advisories and warnings are issued as appropriate. Information is broadcast over NOAA weather radio and on the Law Enforcement Data System. DOGAMI provides additional information on debris flows to the media. ODOT provides information concerning the location of landslides / debris flows and alternate transportation routes. (Source: OR-SNHMP)

State Hazard Mitigation Resources

Department of Land Conservation and Development (DLCD)

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

Contact: Natural Hazards Program Manager, DLCD
Address: 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540
Phone: (503) 373-0050
Fax: (503) 378-6033
Website: http://www.lcd.state.or.us/hazards.html
Oregon Floodplain Coordinator: (503) 373-0050 ext. 255

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

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

Contact: Office of Emergency Management
Address: 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 Ext. 247
Recovery and Mitigation Specialist: (503) 378-2911 Ext. 240

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 in-stream 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 Hazard Mitigation Resources

Federal Emergency Management Agency (FEMA)

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

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

To obtain FEMA publications:
Phone: (800) 480-2520

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

United States Geological Survey (USGS)

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

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

Bureau of Reclamation

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. The Bureau of Reclamation owns Scoggins Dam in Washington County and prepares emergency action plans for events at the dam.

Contact: Bureau of Reclamation, Pacific Northwest Region
Address: 1150 N. Curtis Road, Boise, ID 83706

Phone: (208) 378-5012
Website: http://www.pn.usbr.gov/contact/index.shtml

Army Corps of Engineers

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

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

National Weather Service, Portland Bureau

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

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

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

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

Additional Resources

The National Flood Insurance Program

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

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

The Association of State Floodplain Managers

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

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

USGS Water Resources

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

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

Office of Hydrology, National Weather Service

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

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

The Floodplain Management Association

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

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

Northwest Regional Floodplain Managers Association (NORFMA)

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

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

FEMA's List of Flood Related Websites

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

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

Publications

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

Produced by the Community Planning Workshop for the Department of Land Conservation and Development (DLCD), this natural hazards planning and mitigation resource for Oregon cities and counties provides hazard-specific resources and plan evaluation tools. 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: flooding, wildfires, landslides, coastal hazards, and earthquakes. This document is available online. You can write, call, or fax to obtain this document:

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

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

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

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

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

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

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

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

This informative guide offers a ten-step process for successful flood hazard mitigation. Steps include: map hazards, determine potential damage areas, take an inventory of facilities in the flood zone, determine what is or is not being done about flooding, identify gaps in protection, brainstorm alternatives and actions, determine feasible actions, coordinate with others, prioritize actions, develop strategies for implementation, and adopt and monitor the plan.

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

Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials, (February 1987), FEMA-116.
This guidebook offers a table on actions that communities can take to reduce flood losses. It also offers a table with sources for floodplain mapping assistance for the various types of flooding hazards. There is information on various types of flood hazards with regard to existing mitigation efforts and options for action (policy and programs, mapping, regulatory, non-regulatory). Types of flooding which are covered include alluvial fan, areas behind levees, areas below unsafe dams, coastal flooding, flash floods, fluctuating lake level floods, ground failure triggered by earthquakes, ice jam flooding, and mudslides.

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

Oregon Model Flood Damage Prevention Ordinance, (January 1999), FEMA/DLCD.
This is an example of how to write an ordinance that complies with NFIP/FEMA standards. Communities can simply adopt this ordinance, word for word, filling in the blanks specific to their community or jurisdiction.

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

[1] Source: DLCD Natural Hazards Program Website, http://www.lcd.state.or.us

[2] Ibid.

[3] Ibid.

[4] Ibid.