RESOLUTION NO. 1153

A RESOLUTION APPROVING THE 2010 NATURAL HAZARD MITIGATION PLAN FOR CROOK COUNTY INCLUDING THE CITY OF PRINEVILLE ADDENDUM

WHEREAS, the City of Prineville ("City") approved the 2005 Natural Hazard Mitigation Plan ("NHMP") which covers the City, as well as Crook County; and

WHEREAS, without a current NHMP, neither Crook County nor the City will be eligible for FEMA grants; and

WHEREAS, FEMA requires the NHMP be reviewed and updated every five years to be current; and

WHEREAS, the 2010 NHMP includes an addendum addressing issues of particular concern to the City of Prineville; and

WHEREAS, the 2010 NHMP has been reviewed and updated by a steering committee of City and Crook County residents and professionals; and

WHEREAS, the City Council is required to approve the updated NHMP, including the City of Prineville Addendum to meet FEMA requirements;

NOW, THEREFORE,

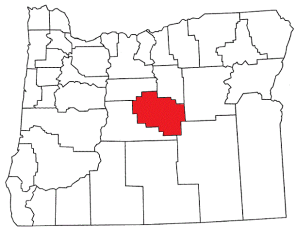
The City of Prineville Resolves that the 2010 Natural Hazard Mitigation Plan, including the City of Prineville Addendum to the 2010 Natural Hazard Mitigation Plan is hereby approved.

Passed by the City Council this 8th day of March 8th, 2011.

Betty J. Roppe, Mayor

ATTEST:

Lisa Morgan, City Recorder



Executive Summary

Crook County Natural Hazard Mitigation Plan 2010 Update

Executive Summary

What is in this Plan?
The Crook County Natural Hazards Mitigation (NHMP) Plan 2010 Update includes resources and information to assist county residents, public and private sector organizations, and others interested in participating in planning for natural hazards.

This Plan represents a mitigation plan for "All Natural Hazards" that may impact Crook County. The plan represents a collection of information and decision that is based on the data available at the time it was created. This Plan will be reviewed annually by the Crook County Office of Emergency Management to consider changes that may impact the performance of the Plan, and to monitor implementation of the Mitigation Action Items (see Section 4). The Plan will receive a complete review and update at least every five years. During the complete reviews, the Plan will be evaluated with respect to new requirements and action items.

The Plan provides a list of activities that may assist Crook County in reducing risk and preventing loss from future natural hazard events. The action items address multi-hazard issues, as well as activities for flood, fire, severe winter storm, windstorm, earthquake, landslide and volcanic eruption hazards.

What is the Plan Mission?
Through the implementation of the NHMP, Crook County will promote sound public policy designed to protect citizens, critical facilities, infrastructure, private property, and the environment from natural hazards. This can be achieved by increasing public awareness, documenting the resources for risk reduction and loss prevention, and identifying activities to guide the county towards building a safer, more sustainable community.

The Mission of the Crook County/Crook County Natural Hazards Mitigation Plan is:

> *To reduce risk, prevent loss and protect life, property and the environment from natural hazard events through coordination and cooperation among public and private partners.*

What are Plan Goals?
The NHMP Goals describe emergency management preparedness objectives and directions that Crook County governments, agencies, associations and citizens should strive to implement. These goals were evaluated and reprioritized through the Plan's 2010 update to be aligned more closely to the desire of the 2010 NHMP Steering Committee's interests in expanding natural hazard mitigation efforts throughout the County.

The NHMP Goals approved through the 2010 Update are as follows:

1. Partnership and Coordination
    a. Identify mitigation of risk reduction measures that address multiple areas (i.e. environment, transportation, and telecommunications).
    b. Coordinate public/private sector participation in planning and implementing mitigation projects throughout the county.
    c. Seek partnerships in funding and resources and resources for future mitigation efforts.
2. Emergency Services

    a. Minimize life safety issues.
    b. Promote, strengthen, and coordinate emergency response plans.
    c. Evaluate the performance of critical facilities during a natural hazard event.
3. Education and Outreach
    a. Further the public's awareness and understanding of natural hazards, potential risk, including economic vulnerability, and options available when natural hazard events occur.
    b. Provide public information and education to all residents of the county concerning natural hazard areas and mitigation efforts.
4. Prevention
    a. Reduce the threat of loss of life and property from natural hazards.
    b. Incorporate information on known hazards and provide incentives to make hazard mitigation planning in land use policies and decisions, which include plan implementation.
5. Property Protection
    a. Lesson impact from natural disaster on individual properties, businesses and public facilities.
    b. Increase awareness at the individual level and encourage activities that can prevent damage and loss of life from natural hazards.
6. Natural Resource Protection
    a. Preserve and rehabilitate natural systems to serve natural hazard mitigation functions (i.e. floodplains, wetlands, watersheds, and urban interface areas).
7. Structural Projects
    a. When applicable utilize structural mitigation activities to minimize risks associated with natural hazards.

Who Participated in Developing the Plan?

The Crook County Natural Hazards Mitigation Action Plan was first approved in 2005. The development of the Plan was completed through a collaborative effort between Crook County citizens, public agencies, non-profit organizations, the private sector, and regional and state organizations. Public participation played a key role in development of goals and action items. Interviews were conducted with stake holders throughout the county, and all of our workshops were open to the public to include our Sheriff's Town Hall Meetings. Several citizens were actively involved in our plan's development. The steering committee was comprised of representatives from:

- Crook County Citizens
- Crook County Sheriff's Office
- Crook County Court
- Crook County Fire and Rescue
- Crook County GIS
- Crook County Emergency Management
- Crook County Road Department
- Crook County Planning Department
- Ochoco Irrigation District
- Bureau of Reclamation
- Bureau of Land Management
- United States Forest Service

- Prineville City Administrators
- Prineville Public Works
- Prineville Police Department
- Oregon Department of Transportation
- Oregon Department of Forestry
- CDA Consulting Group Inc.
- Singe Tree Consulting Group

In 2010 Crook County and Prineville set out to update the 2005 Natural Hazard Mitigation Plan. FEMA requires that all local jurisdictions update their mitigation plans every five years to incorporate new hazard and risk information and to continue the ongoing public process to review and update the action items the NHMP.

Crook County contracted with CDA Consulting Group Inc to assist in completing the 2010 update process. The update of the plan was managed through the Crook County Emergency Management Office. This process focused on identifying new data (since 2005) that would improve or refine the County's understanding of risks and impacts associated with natural hazard disasters. The Crook County Emergency Planning Committee (CCEPC), which is a multi-disciplinary emergency management standing committee within the county, served as the Steering Committee for the 2010 update effort. The membership of the CCEPC was expanded to include additional disciplines and stakeholders to assist in the update effort. In total there were nearly 40 people, representing eleven discipline groups listed on the steering committee roster.

Public involvement was designed to be a cornerstone in the update process. In addition to targeted notices to state and federal departments and agencies, five public townhall meetings were scheduled to take input on the NHMP update.

Crook County believes that an open public process is essential to the development of an effective NHMP. This 2010 update of the Plan is the result of these efforts.

What are Mitigation Action Items and how are they Organized?
The mitigation action items are a listing of activities in which county governments, agencies, associations and citizens can work on to reduce the risks associated with Natural Hazards. Each action item includes an estimate of the timeline for implementation.

The action items include the following information for each action item:

- ✓ *Action Item Identifier.* Each identifier includes information on whether the action is considered to be a Short-Term action items (ST) or a Long-Term action items (LT). Short-term action items are activities that city or county agencies may implement with existing resources and authorities within one or two years. Long-term action items may require new or additional resources or authorities, and may take between one and five years to implement.

  Each action item identifier is also is numbered and categorized by type of hazard including; multi-hazard (MH), flood (FL), wildland fire (WF), sever winter storm (SWS), landslide (LS), earthquake (E) and Volcano (V). The numbering of action items are not prioritized. The 2010 NHMP Update Steering Committee determined that it was important that each action items

have equal weight (with the exception of being short-term or long term). The reasoning for this is that action items should be implemented as prudently as possible based upon the availability of staff and financial resources and match with programs that promote efficiencies through coordination and collaboration.

- ✓ *Ideas for Implementation.* Each action item includes ideas for implementation and potential resources, which may include grant programs or human resources. The ideas within the table below represent a summary of the action items listed in

- ✓ *Coordinating Organization.* The coordinating organization is the public agency with regulatory responsibility to address natural hazards, or that is willing and able to organize resources, find appropriate funding, or oversee activity implementation, monitoring, and evaluation. Coordinating organizations may include local, county, regional, agencies that are capable of or responsible for implementing activities and programs.

- ✓ *Partner Organizations*[1]*.* The Partner Organizations are listed as well as agencies or public/private sector organizations that may be able to assist in the implementation of action items by providing relevant resources to the coordinating organization. The partner organizations listed in the Resource Directory of the Crook County Natural Hazards Mitigation Plan (Appendix D) include other are potential partners that may be able to provide assistance.

- ✓ *Timeline*[2]*.* Action items include both short and long-term activities. Each action item includes an estimate of the timeline for implementation. Short-term action items (ST) are activities which county agencies are capable of implementing with existing resources and authorities within one to two years. Long-term action items (LT) may require new or additional resources or authorities, and may take between one and five years to complete. Some action items are listed as "ongoing", meaning that a continuous effort is anticipated throughout the life of the Plan.

- ✓ *Plan Goals Addressed.* The plan goals addressed by each action item are included as a way to monitor and evaluate how well the mitigation plan is achieving its goals once implementation begins. The plan goals are organized into the following areas:

    - Partnerships and Implementation
    - Emergency Services
    - Education and Outreach
    - Prevention
    - Property Protection
    - Natural Resource Protection
    - Structural Projects

- ✓ *Partner Organizations.* The Partner Organizations are listed as well as agencies or public/private sector organizations that may be able to assist in the implementation of action items by providing relevant resources to the coordinating organization. The partner organizations listed

[1] Omitted from the Executive Summary Action Item Table.
[2] Omitted from the Executive Summary Action Item Table.

in the Resource Directory of the Crook County Natural Hazards Mitigation Plan (Appendix D) include other are potential partners that may be able to provide assistance.

The action items are summarized within the following table, which lists all of the multi-hazard and hazard-specific action items included in the mitigation plan. The table also shows which goals are achieved and the coordinating organization that may lead the implementation effort associated with each action item. This table serves only as a summary. A more detailed listing of the action items is located in Section 4 of this Plan.

Summary of the Crook County NHMP Mitigation Action Items

Action Item Identifier	Mitigation Action Title	Coordinating Organization	Goal Implementation	Implementation Ideas Summary
Multi Hazard Action Items				
ST-MH-1	Sustain a public awareness campaign about natural hazards	Crook County Emergency Management	2, 3, 4	Inform and educate the public about potential natural hazards in Crook County, personnel preparedness, mitigation activities and opportunities, and options available when natural hazard events occur.
ST-MH-2	Develop public and private partnerships to foster natural hazard program coordination and collaboration in Crook County	Crook County Emergency Management	1, 3, 4	Coordination and implementation of county-wide and tri-county emergency management policies and procedures, training and exercises.
ST-MH-3	Maintain a GIS inventory of all critical facilities, large employers/public assembly areas, and lifelines, and use the GIS to evaluate their vulnerability by comparing them with hazard-prone areas.	Crook County GIS	2, 3, 4,	Expanding and maintaining data on the County GIS databases containing information about natural hazards, land development, community infrastructure, and demographics.
ST-MH-4	Promote natural hazards safety education.	School Districts, Facility Safety Personnel, Search and Rescue	1, 3,4	Natural Hazards Safety Education includes earthquake duck-and-cover drills, fire safety training, facility lock down drills, evacuations drills, hazardous materials training, and hug a tree presentations in many types of forums.
ST-MH-5	Establish partnerships to coordinate and collect geo-science and technical information for identifying potential areas of risk.	Crook County GIS, USFS GIS, BLM GIS, ODF GIS	1, 3, 4	Many public agencies in Crook County collect geo-science and technical for their own internal needs. County GIS could use this data to develop hazard maps for Emergency Management and mitigation purposes.
ST-MH-6	Maintain and enhance the systems that support populations with special needs. (e.g., elderly and disabled persons) during disaster.	Crook County Emergency Management	1, 2, 3, 4	Coordinate with public and private organizations to continue to identify vulnerable populations; establish and maintain protocols to update and maintain the database; and, develop plans and exercises to integrate vulnerable populations with disaster response.
ST-MH-7	Explore funding sources and grant opportunities for county-wide natural hazard mitigation activities.	Mitigation Plan Steering Committee	3, 4	Identify grants and appropriate loans for local governments, agencies, organizations and property owners to take a proactive role in hazards mitigation.
ST-MH-8	Evaluate security methods and processes to assess what types of data will have open public access versus restricted responder agency access.	Mitigation Plan Steering Committee	3, 4	Coordinate with local and state legal representatives to evaluate Oregon law; assess emergency management data to determine if it contains sensitive or critical information; develop protocols for access and distribution of sensitive data.

LT-MH-1	Review the Crook County Emergency Operations Plan and the Natural Hazards Mitigation Plan on an annual basis. Conduct a complete review of the plans and have them officially promulgated by the approving authorities every 5 years.	Crook County Emergency Management	2	Crook County Emergency Management will coordinate a plan review annually and a plan update at least every five years. During the complete reviews, the plans will be evaluated with respect to new requirements and action items.
LT-MH-2	Use hazard information as a basis for reviewing site-specific land use decisions.	Crook County GIS	4	Continually implement hazard mitigation policies and regulations.
LT-MH-3	Improve planning, notification, and training for volunteers.	Crook County Emergency Management	1, 2, 3	Identify, train and provide exercises for how volunteers can assist during different types of disaster
LT-MH-4	Promote hazard resistant utility and telecommunication construction and maintenance methods.	Crook County emergency Management, ARES	3, 4	Support and encourage utility and telecommunications companies to use construction and maintenance methods that are aligned with natural hazard preparedness practices.
LT-MH-5	Collect data for significant non-declared natural hazard events.	Crook County Emergency Management	1, 2, 3	Damage information should be collected and stored locally for significant non-declared natural disasters.
LT-MH-6	Develop a recovery plan for Crook County and Prineville from the effects of catastrophic hazards.	Crook County Emergency Management	1, 2	Develop a scenario based long-term recovery plan (Continuity of government plan) that identifies how Crook County and the City of Prineville will recover from a catastrophic event.
Flood Hazard Action Items				
ST-FL-1	Coordinate river gauge information.	NWS (Pendleton Office)	1	Crook County Emergency Management, National Weather Service, and all watershed councils, can benefit from coordinated river gauge information that is tied into National Weather Service flood forecasting activities.
ST-FL-2	Conduct a workshop for target audiences on National Flood Insurance Programs, mitigation activities, and potential assistance from FEMA's Flood Mitigation Assistance and Hazard Mitigation Grant Programs.	County Planning, County Emergency Management Agencies	1, 3, 4, 5	Present information on how other communities have addressed building in the floodplain to target audiences.
ST-FL-3	Update the Flood Insurance Rate (FIRM) Maps for Crook County using the 2010 FIRM maps.	Prineville Emergency Management, County Planning, County GIS	1, 4, 5	Work with FEMA to adopt the 2010 FIRM maps
LT-FL-1	Encourage private property owners to restore natural systems within the floodplain, and to manage riparian areas and wetlands for flood abatement.	Crook County/Prineville Emergency Management	5, 6	In addition to encouraging private property owners, managing publicly owned riparian and floodplain areas for conversion to open space/parkland/greenway is key to restoring natural floodwater absorption capacities.
LT-FL-2	Preserve water quality by using storm water best management practices.	County Roads, DEQ	6	Model standards could be the National Pollution Discharge Elimination System (NPDES).
LT-FL-3	Evaluate and asses the interest in County and City participation in the NFIP Community Rating System.	Crook County/Prineville Emergency Management, County Planning	1, 3, 4, 5	Participation in the NFIP Community Rating System could save residents considerable amounts money on insurance premiums.
LT-FL-4	Coordinate with Ochoco Irrigation District to evaluate the vulnerability of Ochoco Dam to natural hazards.	County Emergency Management, OID, Water Master	3, 4, 7	Share technical data as it becomes available and consider the impacts of earthquake, floods and other natural hazard.

Wildland Fire Hazard Action Items				
ST-WF-1	Continue to promote public awareness campaigns for individual property owners living in interface areas.	Crook County Emergency Management	1, 3, 4, 5	Focus on individual community outreach efforts.
ST-WF-2	Continue to reduce wildfire fuels.	County Planning, State Fire Marshal	3, 4, 5, 6	Identify and implement methods of disposal or utilization of fire fuels removed from individual properties.
Severe Winter Storm and Wind Storm Hazard Action Items				
ST-SWS-1	Coordinate with local and state agencies to collect and identify data that would assist in developing a vulnerability and risk assessment related to the possible effects of climate change, especially as it may be associated with draught and a reduction of the water table.	Crook County Emergency Management, NHMP Steering Committee	1, 3, 4	Expand the conversation of natural hazards to include discussions on climate change and draught; coordinate with local and state agencies and review data as it becomes available; and determine if sufficient data is available to conduct a vulnerability ad risk assessment.
Landslide Hazard Action Items				
LT-LS-1	Assess Crook County's and City of Prineville's Vulnerability to Landslides.	Crook County Emergency Management	4, 5	After sufficient data is compiled about the landslide hazard in Crook County a more detailed vulnerability assessment should be completed.
Earthquake Hazard Action Items				
ST-E-1	Develop in-depth studies to determine county and region's vulnerability to earthquake.	Crook County Emergency Management	1, 4	Work with agencies and expand existing studies to address scope of vulnerability; communicate study findings with key stakeholders and make policy and procedure changes that support study results that mitigate earthquake hazards.
ST-E-2	Promote building safety through nonstructural improvements.	Crook County Emergency Management	1, 4, 5	Publicize information on building safety and partner with Deschutes and Jefferson County Emergency Management to coordinate and promote non-structural strategies and mitigation information.
Volcano Hazard Action Items				
ST-V-1	Provide a Volcanic Ash Mitigation Guidebook on the County Website for Citizens and businesses.	Crook County Emergency Management	1, 3	Develop public awareness through workshops and publications and update the County web links include broader information related to volcanic ash mitigation.

SECTION 1 Introduction

Crook County Natural Hazard Mitigation Plan 2010 Update

S1.0 Introduction

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

Crook County is a mostly rural county with a 2009 population of 27,185[1] residents. Crook County is characterized by the unique and attractive desert landscape that connects the various communities in Central Oregon. However, the potential impacts of natural hazards associated with the terrain make the environment and population vulnerable to natural disaster situations. The county is subject to flooding, wildfires, sever winter storms, windstorms, earthquakes, landslides, and volcanic activity. It is impossible to predict when these disasters will occur, or the extent which they will effect the county. However, the careful planning and collaboration among public agencies, private sector organizations, and citizens within the community, it is possible to minimize the losses that can result from natural disasters.

Crook County most recently experienced large-scale destruction during the sever weather events in May 1998. The tiny Ochoco Creek that bisects Prineville and provides much of the Ochoco valley with needed irrigation water swelled way beyond the 100 year flood level, causing flooding in both rural and urban areas. Prolonged precipitation accompanied by an early snow melt caused Ochoco reservoir to over flow and release water over its spillway. This large volume of water destroyed several bridges and devastated an entire mobile home park located in the center of town.

The damages to Crook County residents and businesses were estimated to be about 17 million dollars. The county sought and received a Presidential Disaster Declaration to obtain federal assistance for its flood recovery effort. The Crook County Emergency Management Office estimated that the flood of 1998 directly or indirectly effected 63% of its 20,000 residents. Claims filed under the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program from Crook County residents and businesses accounted for a large portion of the entire claims throughout the State in 1998. In addition to federal disaster relief funds, Crook County sought and received disaster relief money from the Hazard Mitigation Grant Program. This program helps communities engage in mitigation activities designed to reduce losses from future natural hazard events.

Why Develop a Mitigation Plan?
The rising costs of natural disasters have led to a renewed interest in identifying affective ways to reduce vulnerability to disasters. Natural hazard mitigation plans assist communities in reducing risk from natural hazards by identifying resources, information, and strategies for risk reduction, while helping to guide and coordinate mitigation activities throughout the county.

The plan provides a set of action items to reduce risk from natural hazards through education and outreach programs, the development of partnerships, and implementation of preventative activities and mitigations steps.

[1] Center for Population Research and Census certified population estimate for 2009 http://www.pdx.edu/prc/

The resources and information within the Mitigation Plan: (1) establishes a foundation for continued coordination and collaboration among agencies and the public in Crook County related to natural hazards preparedness; (2) identify and prioritize future mitigation projects; and (3) assist in meeting the requirements of federal assistance programs. The Mitigation Plan works in conjunction with other county plans, including the County Comprehensive Land Use, Emergency Operations Plan, the Community Wildfire Plan and others.

Within the context of this plan, "Mitigation" is the development and implementation of activities designed to reduce or eliminate impacts resulting from natural hazards.

Who will benefit from this Mitigation Plan?

The resources and information described within the 2010 NHMP update pertain to all areas within the county and the recommendations can lay ground work for localized mitigation plans and partnerships. This plan provides a framework for planning for natural hazards for the entire Crook County. This Plan affects all properties and jurisdictions within the County, including the City of Prineville and all rural unincorporated communities.

Natural Hazard Land Use Policy in Oregon

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

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

In 1996, FEMA estimated that Oregon saves about 10 million a year in flood losses because of strong land-use planning. Statewide land use planning goal7: Planning for natural hazards, calls for local plans to include inventories, policies, and ordnances to guide development in hazard areas. Goal 7, along with other land-use planning goals, has helped to reduce losses from natural hazards.

State Support for Natural Hazard Mitigation

All mitigation occurs at the local level, and the primary responsibility for development and implementation of risk reduction strategies and policies lies with the local jurisdictions. Local jurisdictions, however, are not alone. Partners and resources exist at the state and federal levels. Numerous Oregon state agencies have a role in natural hazards and natural hazard mitigation. Some of the key agencies involved in natural hazards are:[2]

[2] Descriptions derived from Oregon Department of Geology and Minerals Industries, Special Paper 31 Mitigating Geologic Hazards in Oregon: A Technical Reference Manual, 1999.

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

Plan Methodology

Mitigation Plans form the foundation for a community's long-term strategy to reduce disaster losses and break the cycle of disaster damage, reconstruction, and repeated damage[3]. Mitigation strategies implemented before natural hazards occur can further reduce disruption to essential public and business services, reduce the risk to human life and alleviate damage to personal and public property and infrastructure.

Building a NHMP is a large endeavor and requires a significant effort to become an effective tool to reduce the risk associated with natural hazard disasters. Key elements that are needed to build, evaluate or update an effective plan include planning and public involvement processes that are intertwined to create a blueprint for reducing the potential losses identified in the risk assessment.

The mitigation plan is a framework for risk-based decision making to reduce damages to lives, property, and the economy from future disasters. It is created through a collaborative planning process that seeks out available information on hazards and risk, coupled with a community public involvement process.

During this process the various hazards are inventoried, the risks from each are evaluated along with an evaluation of possible losses that could be sustained. Understanding the risks and impacts that can be caused by natural disasters sets the stage to develop and evaluate concepts, actions and measures that can be used to increase community preparedness through mitigation efforts.

These mitigation efforts are prioritized and established through a public process. 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 for the 2010 update was designed to include:

[3] http://www.fema.gov/plan/mitplanning/index.shtm

(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 non-profit interests to be involved in the planning process; and
(3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

This approach seeks to obtain the greatest possible input in both the collection of important information and data; and the review of mitigation opportunities that are designed to reduce the risk of natural hazard disasters.

The following describes the development of the Crook County NHMP.

S1.1 The 2005 Natural Hazards Mitigation Plan (NHMP) –

The Seven Steps to a Successful Crook County NHMP

One of the results of the 1998 flood events was an increased awareness of natural hazards that pose a risk to Prineville/Crook County residents. Various county and city departments agreed to make natural hazard mitigation a priority and began convening as the Natural Hazard Mitigation Committee. This committee encouraged the development of the 2005 county-wide Natural Hazards Mitigation Plan. The plan identified the various hazard types that might impact county residents as well as mitigation steps that could be implemented to reduce the risk of and impacts caused by natural disasters.

Led by the Crook County Emergency Management office, NHMP Steering Committee set out to develop a 2005 process to complete the NHMP in a series of 7 steps.

Step 1 Organize and prepare the plan
Step 2 Community Involvement
Step 3 Describe Community and how mitigation is addressed
Step 4 Identify and characterize the natural hazards impacting Crook County
Step 5 Define our plan goals
Step 6 Develop Solutions
Step 7 Set the plan in motion

The committee played an integral role in developing the mission, goals, and action items for the mitigation plan. Information in the 2005 mitigation plan is based on research from a variety of sources. Data sources and contributors to the plan included:

- **Input from the steering committee**
  The steering committee played an integral role in developing the mission, goals, and action items for the Mitigation Plan. The 2005 steering committee was comprised of 23 people representing various agencies and organizations in Crook County and the City of Prineville.

- **Stakeholder interviews**

The Crook County Hazard Mitigation Team conducted 19 interviews with individuals, specialists, and organizations working in natural hazards planning. These interviews were avenues of participation for county stake holders not present on the steering committee. The interviews helped identify common concerns related to natural hazards and identified key short and long term activities to reduce risk from natural hazards in Crook County.

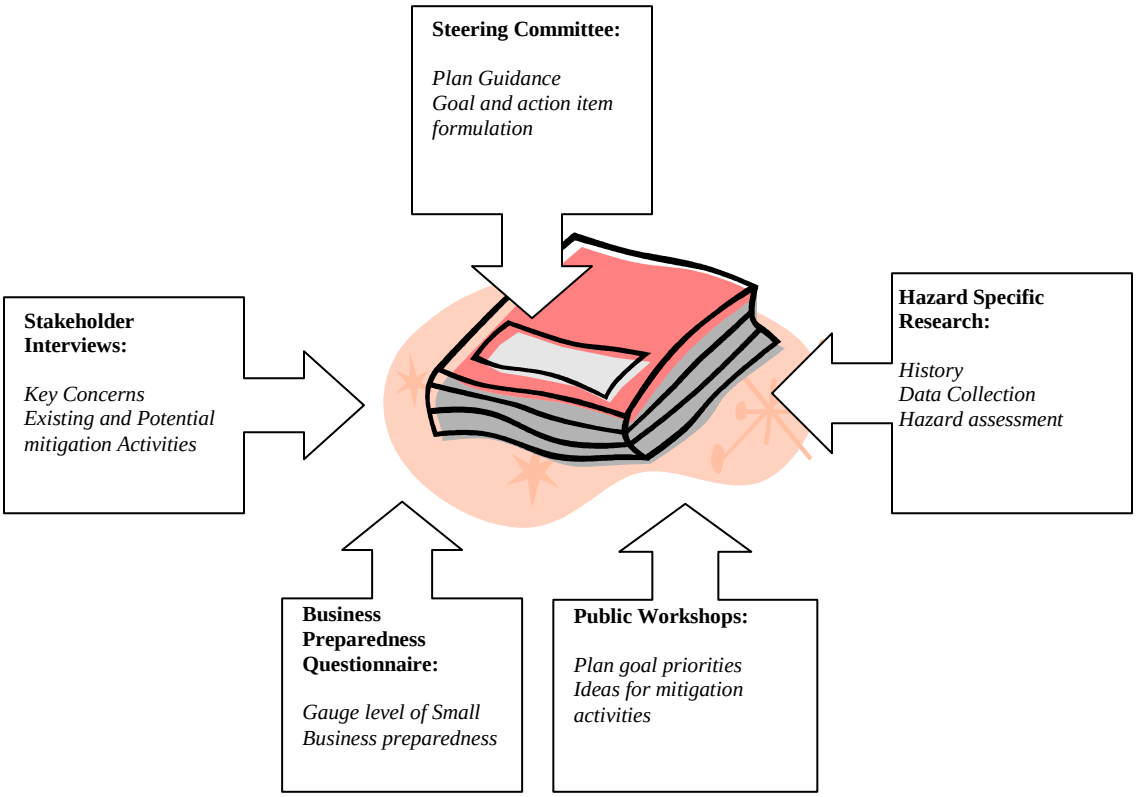
- **Statewide and National Plan Review**
  Crook County Hazard Mitigation Team reviewed natural hazard mitigation plans from around the country and looked at current FEMA planning standards, including the Community Rating System. Plans from Jackson County Oregon, Clackamas County Oregon, Deschutes County and the Planning for Natural Hazards: Oregon Technical Resource Guide, State of Oregon Natural Hazards Mitigation Plan, Central Oregon Natural Hazard Mitigation Plan, and Post Disaster Hazard Mitigation Planning Guidance for State and Local Governments helped identify reference materials and models for use in the development in the Crook County Mitigation Plan, and as a resource to communities within Crook County.

- **Business Preparedness Survey**
  Crook County Hazard Mitigation Team implemented a survey to gauge the level of preparedness of individual businesses in Crook County, and to assess information needs regarding mitigation activities, and local, state, and national resources and programs. The result of this survey identified potential strategies for reducing Crook County economic risk from natural hazards.

- **Hazard Specific Research**
  Crook County Hazard Mitigation Team collected data and compiled research on seven specific natural hazards, including, wildfire, flood, landslide, severe winter storm, wind storms, and earthquakes. Specific research material came from OEM, DOGAMI, ODF, NWS, Bowman Museum, pioneer citizen recollection, and the Central Oregonian.

- **Public Workshops**
  Crook County Hazard Mitigation Team facilitated six workshops to inform the public on Crook County Natural Hazards, and gather comments and ideas from the citizens of Crook County about mitigation planning. The public also prioritized goals that will help guide mitigation activities in reducing the risk from natural hazards.

2005 Crook County Hazard Mitigation Planning Process



These different components and inputs to the mitigation plan help insure a strong local perspective and identify strategies and activities to make Crook County more disaster resilient over time. The key outcomes from the different types of participation were essential to the formulating the 2005 five-year action plan.

S1.2 2010 NHMP Update

In 2010 Crook County and Prineville set out to update the 2005 Natural Hazard Mitigation Plan. FEMA requires that all local jurisdictions update their mitigation plans every five years to incorporate new hazard and risk information and to continue the ongoing public process to review and update the action items the NHMP.

Crook County contracted with CDA Consulting Group Inc to assist in completing the 2010 update process. The update of the plan was managed through the Crook County Emergency Management Office. CDA used direction from the Code of Federal Regulation Title 44 together with input from the Oregon Office of Emergency Management and the Federal Emergency Management Agency to design the 2010 update process. This process focused on identifying new data (since 2005) that would improve or refine the County's understanding of risks and impacts associated with natural hazard disasters. Appendix A provides details regarding the specific significant changes that have been incorporated into this update.

The Crook County Emergency Planning Committee (CCEPC), which is a multi-disciplinary emergency management standing committee within the county, served as the Steering Committee for the 2010 update effort. The membership of the CCEPC was expanded to include additional disciplines and stakeholders to assist in the update effort. In total there were nearly 40 people, representing eleven discipline groups listed on the steering committee roster. This included the following discipline groups:

- Communications
- Elected Officials
- Emergency Management
- Fire
- Law Enforcement
- Ochoco Irrigation District/Dams
- Private Sector/Business
- Public Administration/Planning
- Public Health/Environmental Health
- Public Works/Roads
- Schools

Public involvement was designed to be a cornerstone in the update process. In addition to targeted notices to state and federal departments and agencies, five public townhall meetings were scheduled to take input on the NHMP update. The meetings were set in different areas of the county to increase the opportunities for input. These meetings included four regional meetings located in the unincorporated communities of:

- Post Store
- Juniper Canyon fire station
- Powell Butte Community Hall
- Ochoco West Subdivision

In addition, a county-wide meeting was held on November 23, 2010 in the Crook County Fire and Rescue conference room to testimony and to allow comment on the 2010 update plan during the drafting stage and prior to plan approval.

In November a review of the process and draft plan were scheduled and heard as formal agenda items before the Crook County Court and the Prineville City Council. Final hearings and adoption of the 2010 Plan Update were initiated in December 2010.

S1.3 Hazard Assessment

The Prineville/Crook County Mitigation Plan compiles data for six natural hazards in the county, and establishes mitigation goals and activities that should be revised annually. Updating the action plan contents allows for the introduction of new data and technical resources, and maintains strong ties between cooperating agencies, organizations, non-profits, and governments. This continuous integration of new knowledge improves the assessment of each of the hazards in this plan, and improves Prineville and Crook County's ability to plan for, and withstand, the impacts of natural hazard events.

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

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

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

S1.4 Crook County NHMP Mission

The Crook County/Crook County Natural Hazards Mitigation Plan Mission is:

> *To reduce risk, prevent loss and protect life, property and the environment from natural hazard events through coordination and cooperation among public and private partners.*

The 2010 NHMP Steering Committee reviewed the mission statement and confirmed that it still accurately conveys the appropriate approach for prioritizing hazard mitigation within the County.

S1.5 Crook County NHMP Goals

The NHMP goals describe the overarching guiding principles for setting directions to mitigate risks from natural hazards. Through the 2010 Plan Update, the Steering Committee evaluated to 2005 NHMP goals.

As with the 2005 process, the 2010 Steering Committee agreed that public participation was a key aspect in developing plan goals. The goals were originally developed through meetings with the 2005 project steering committee, stake holder interviews, and public workshops which served as methods to obtain input and priorities in developing goals for reducing risk and preventing loss for natural hazards in Crook County.

Seven public workshops were held during the compilation of the 2005 mitigation plan and an additional five public workshops were held during the 2010 update. The purpose of these workshops was to inform the public about natural hazards that occur in Crook County, and identify community priorities, and potential strategies for achieving those priorities.

Crook County citizens established community priorities for the original 2005 plans goals through a voting process that asked each participant to choose three goal statements that are most important to them. After each participant made their choices, the outcomes were tallied and are represented in Table 3.1 of the 2005 NHMP. The 2010 NHMP Steering Committee reviewed and evaluated this section of the 2005 Plan and agreed that all of the plan goals are important.

2010 Natural Hazard Mitigation Goals

Goal	Goal Statement	Community Priority
#1. Partnership and Coordination	Identify mitigation of risk reduction measures that address multiple areas (i.e. environment, transportation, and telecommunications).	1
	Coordinate public/private sector participation in planning and implementing mitigation projects throughout the county.	
	Seek partnerships in funding and resources and resources for future mitigation efforts.	
#2. Emergency Services	Minimize life safety issues.	2
	Promote, strengthen, and coordinate emergency response plans.	
	Evaluate the performance of critical facilities during a natural hazard event.	
#3. Education and Outreach	Further the public's awareness and understanding of natural hazards, potential risk, including economic vulnerability, and options available when natural hazard events occur.	3
	Provide public information and education to all residents of the county concerning natural hazard areas and mitigation efforts.	
#4. Prevention	Reduce the threat of loss of life and property from natural hazards.	4
	Incorporate information on known hazards and provide incentives to make hazard mitigation planning in land use policies and decisions, which include plan implementation.	
#5. Property Protection	Lesson impact from natural disaster on individual properties, businesses and public facilities.	5
	Increase awareness at the individual level and encourage activities that can prevent damage and loss of life from natural hazards.	
#6. Natural Resource Protection	Preserve and rehabilitate natural systems to serve natural hazard mitigation functions (i.e. floodplains, wetlands, watersheds, and urban interface areas).	6
#7. Structural Projects	When applicable utilize structural mitigation activities to minimize risks associated with natural hazards.	7

The 2010 Steering Committee chose to accept the 2005 goals in the seven topic areas. The update Steering Committee reprioritized the goals, as seen above, to better represent the needs of County residents and businesses. This effort was conducted through a process that thoroughly deliberated each of the goals statements and concluded in a voting process to select goal priorities. The 2010 update Steering Committee agreed with the 2005 effort that using the "goals in establishing community

mitigation priorities does not negate or eliminate any goals"[4]. The goals provide assistance when making determinations which risk reducing action items to fund first, should funding become available.

S1.6 Plan Organization

The Mitigation Plan contains five Sections, eight appendices, an executive summary and additional information related to federal compliance labeled *Crosswalk Memo*.
The Plan has been reformatted to make the document more user friendly. Key changes in the format include:

- Grouping all of the mitigation action items into one section
- Combining all of the disaster risk and vulnerability information into one section
- Formatting the Hazard Identification and Risk Section so that each disaster types is formatted the same with a focus on risk and vulnerability information
- Moving supporting information and background data on disaster types to the appendix
- Removing unnecessary graphics

The Plan has been designed with the end users in mind. Noting that most people using the Plan will be involved in local emergency management issues, government or a chamber of commerce, the plan has been designed to get to the details quickly. The new format allows the reader to get information quickly by moving eh hazard identification, risks, action items and plan maintenance forward into the document. Those that need further background material can read these details in the appendices. Combined together the Plan is designed to implement its goals and mission to develop and execute activities designed to reduce or eliminate impacts resulting from natural hazards.

Each section of the NHMP is described below.

Executive Summary
The Executive Summary provides an overview of the major components of the Plan. It identifies the Plan's mission and goals, and summarizes key findings and conclusions related to hazard vulnerability and risk. This information sets the backdrop for understanding why mitigation is important, and connects these vulnerabilities to preparedness actions that will reduce risks.
Section 1: Introduction
The Introduction describes the concepts of a mitigation plan and includes information and methodology regarding how the 2005 plan was developed, the then updated in 2010. It also includes background information regarding the hazard mitigation planning process, hazard assessments and the state-wide setting for natural hazard planning.
Section 2: Tour of Crook County
This section provides a brief history of the chronic natural events that have occurred in Crook County. This section also identifies information related to the overall profile of Crook County, including geographic conditions, population, demographics and the economy.
Section 3: Natural Hazards Identification and Risk Assessment
This section describes the history of natural hazards in Crook County for two time periods: prior to 2005 (the date of the first County NHMP) and 2005-2010. It describes each of seven hazard types that Crook

[4] From Section 3 of the 2005 Prineville/Crook County Natural Hazard Mitigation Plan.

County may be susceptible to. This section includes information related to vulnerability and risk assessments for each hazard type. Additional background information for each hazard type in located in Appendix B of the Plan.

Section 4: Action Items and Implementation

This section reflects updated mitigation action items that were developed by the 2010 NHMP Update Steering Committee. The committee evaluated and assessed the progress made on each action item within the 2005 plan, and revised and developed new mitigation action items that are appropriate for possible and likely implementation through the 2010 Plan's implementation period. This section includes mitigation action items for each of the natural hazard types that are thought to impact Crook County.

Section 5: Plan Maintenance and Update

This section provides information about successes that have occurred since the development of the 2005 plan and sets a course for implementation of the 2010 plan through continued public involvement, agency coordination, mitigation implementation and program management. This includes expectations for updating the Plan in the future to meet continuing changes in the environment, funding, available information and capabilities to mitigate risk.

Plan Appendices

The appendices are designed to provide users of the Crook County NHMP with a second tier of information that expands on information within the main body of the Plan. This includes additional background material, changes that occurred through the 2010 update, resource information, connections to other plans and more.

Appendix A: Change Memo and Action Item Changes are two memos that identify the changes between the 2005 NHMP and this 2010 update. The Sections Change Memo describes general changes that have been made to the 2010 Plan on a section by section basis. The Mitigation Actions Changes memo documents changes that were made to each action item located in the 2005 plan that resulted in a process to create the 2010 Mitigation Action Items.

Appendix B: Hazard Background Information includes additional background material on each selected natural hazard type. This includes background information reproduced from the 2005 plan that was located in hazard chapter, together with new data and information that was collected through the 2010 update process.

Appendix C: Public Participation Processes explains and provides detail on the 2010 update process, steering committee work and the public outreach effort.

Appendix D: Resource Directory includes county, regional, state, and national resources information.

Appendix E: Approaches for Economic Analysis describes FEMA's requirements for benefit cost analysis in natural hazards mitigation, as well as various approaches for conducting economic analysis of proposed mitigation activities.

Appendix F: Terms and Acronyms provides a list of acronyms for county, regional, state, and federal agencies and organizations, and terms that may be referred to within the NHMP.

Appendix G: Crook County Community Wild Fire Protection Plan is included by reference to the Crook County NHMP 2010 update.

Appendix H: Preliminary FEMA Preliminary Flood Impact Study is included by reference to the Crook County NHMP 2010 update.

SECTION 2 A Tour of Crook County

Crook County Natural Hazard Mitigation Plan 2010 Update

S2.0 A Tour of Crook County

Why Plan for Natural Hazards in Crook County?
Across the United States, natural hazards cost communities billions of dollars, taking a toll on the built environment, human life, and the local economy. Crook County is no exception. Since its early settlement in the mid to late 1800s, the County and its residents have been subject to financial loss and property damage from flooding, landslides, wildfires, windstorms, and severe winter storms. Natural hazards will inevitably impact Crook County in the future. This fact illustrates the critical need for strategies to reduce risk from natural hazards.

Events such as flooding and wildfires are part of the natural process. They become natural disasters when they impact humans and development. Crook County's growing population places increased demands on the County's infrastructure and undeveloped areas. The number of people living in the rural areas of Crook County highlights this interface between people, property, and the natural environment, and places them at risk from natural hazard events now and in the future.

Chronic Natural Events
Chronic hazards occur with some degree of frequency and include flooding, landslides, windstorms, severe winter storms, and wildfires. These hazards impact communities with devastating economic consequences. During the last century, Crook County experienced at least 7 major floods.[1] The landmark event occurred in March of 1952. This flood completely covered the town of Prineville and caused significant damage to the economy and infrastructure. Shortly after Bowman Dam was constructed and regulated flows began in December of 1960.

Juniper Canyon Creek drains an area between Ochoco Creek and Crooked River drainages. In 1979 Juniper Canyon Creek over topped its banks washing out the Paulina Hwy and flooding most of the southern end of Prineville. In 1987 the Juniper Canyon flood control project was completed to convey water from Paulina Hwy to the crooked river. The Juniper Canyon flood control board is still active today.

In May of 1998, Crook County experienced another destructive event. A large storm system moved into central Oregon, releasing approximately 7 inches of rain in a 24 hour period. This amount was unusually high, as the average rainfall for Crook County is approximately 10.5 inches per year. To complicate matters, the Ochoco reservoir was full anticipating a long upcoming irrigation season. The high rainfall in combination of several other factors resulted in the overtopping of the reservoir's spillway with a discharge in the range of a 50-100 year storm event. This flood caused nearly 17 million dollars in damage to homes businesses and infrastructure in Crook County. More than 300 homes were affected by the flood and 50 were completely destroyed.[2] In June of 1998, President Clinton Declared Crook County eligible for disaster assistance due to damages resulting from this flood.

Crook County saw two devastating winter storms in 1919 with 30 inches of snowfall in 3 days and 1973 with 40 inches of snowfall in two days. These winter storms placed a huge burden on the infrastructure of Crook County and not only played havoc on residential plumbing, but also jammed traffic, cut power and took a heavy toll on the agricultural industry.

[1] Bowman Museum, Prineville, OR; also, Central Oregonian; and Interviews with Local Pioneers.
[2] City of Prineville Crook County Flood Mitigation Action Plan (1999)

Over the last century, Crook County has also experienced scores of major fire events resulting in millions of dollars in damage and suppression activities. Lightning is the primary cause of wildfire in the county. However, the potential risk for human caused fires increases as more people move into the urban Wildland interface. Human activities like running saws or other equipment, or burning debris piles can contribute to increased wildfire risk.

Catastrophic Natural Hazard Events
Catastrophic events do not occur with the same frequency as chronic hazards, but can have devastating consequences. Earthquakes and volcanoes are two types of catastrophic hazards. These types of natural hazards are difficult to predict, affect a wide geographic area, and can severely impact entire regions.

Crook County has been relatively unaffected by seismic activity since its settlement. Since 1982, there have been 11 small earthquakes epicentered within Crook County. These earthquakes have all registered lower than 3.0 in magnitude. Crook County sits on two inactive faults.[3] Eastern Oregon remains a very active seismic area. South of Crook County, in Klamath County, during the 1990s, they experienced a series of earthquakes that cost their community 7 million dollars in damages and complete destruction of their Klamath County Courthouse.

There have been no documented volcanic events affecting Crook County during Oregon's recorded history. However, Crook County sits down wind of the volcanically active Cascade Range. Depending on weather and wind patterns, Crook County is susceptible to eruptive ejecta from even 100 miles away meaning Mt. Hood, Mt. Jefferson, The Three Sisters, Mt. Bachelor and the other volcanoes in the area pose a distant threat.

Understanding the characteristics of hazards that affect Crook County helps define strategies to minimize the risk to personal safety and reduce potential damage to public and private property, the economy, and environment. Communities engaged in natural hazards mitigation also have access to federal resources, such as FEMA's Hazard Mitigation Grant Program that can be used in the wake of a variety of natural hazard events. These funds become available to communities after the President of the United States declares a particular region a disaster area, as in the May 1998 Flood.

S2.1 Geographic Conditions

The Crook County Landscape
Located in the very center of the State, Crook County occupies the very heart of Oregon covering 2,991 square miles. The area is rich in natural resources: forests, mountains, rivers, streams, lakes, and high desert dominate the landscape. Crook County's climate is pleasant and diverse. Consequently, the area's natural beauty has increased its popularity in recent decades. The growing population and increased development in Crook County increases its risk from natural hazards events by threatening loss of life, property, and long-term economic disruption.

Climate
Late October typically marks the beginning of the winter months in Crook County. The high desert helps moderate the area's annual rainfall, which averages 10.5 inches per year. This is a sharp contrast to the

[3] State of Oregon Department of Geology and Mineral Industries (2003)

37 to 50 inches normally seen in other parts of the Pacific Northwest. In most winters there are 1 to 4 snow storms that blow through leaving an average of 10 inches of snow each year. Summer precipitation is very low, and Crook County holds one of the State all time heat records of 114 degrees. These factors increase the risk of wildfire and requiring irrigation for crops.

Topography
Four major terrain features characterize Crook County Boundaries. The Ochoco Mountain Rang to the East/North East, The Maury Mountain Range to the South/South East, The Powell Buttes to the West, and the Grizzly, Grey Buttes to the North. The Crooked River and its tributaries cut through each of these regions on its journey to join the Deschutes River and Metolious River at the Round Butte Dam.

Crook County's terrain is typical to Central Oregon's High desert region. Because of a low yearly rainfall, and unique soil conditions, land slides are rare in Crook County and do not pose a significant risk to life and property.

Ochoco Mountains/Ochoco National Forest
With a total of almost 1,500 square miles, the Ochoco National Forest is endowed with vast natural resources, scenic grandeur, and tremendous recreation opportunities. People are drawn to the Ochoco for its majestic ponderosa pine stands, picturesque rim rock vantage points, deep canyons, unique geologic formations, abundant wildlife, and plentiful sunshine.
The Ochoco National Forest is divided into four ranger districts; Big Summit, Paulina, Prineville and Snow Mountain. The Crooked River National Grassland is also administered by the Ochoco and encompasses about 111,000 acres.

The Ochoco contains three designated Wilderness Areas. The largest of the three, the 17,000 acre Mill Creek Wilderness contains deep canyons, towering pinnacles and opportunities for solitude. The wilderness has meadows at 6,000 feet giving way to lower-elevation forests of dense pine and fir, dissected by Mill Creek and its tributaries. A unique feature of this wilderness is the pair of volcanic plugs called Twin Pillars. The Black Canyon Wilderness is 13,400 acres in size. It incorporates a variety of ecosystems ranging from dense forests to rugged canyons. Three sides of the canyon reach elevations to 6,000 feet, while waters in the gorge have downcut through lava basalt, and empty into the South Fork of the John Day River at 2,800 feet. The 5,400 acre Bridge Creek Wilderness is small but boasts some wonderful scenic vistas and solitude. There are no trails maintained in this wilderness but an old trail and a mile of old road exist. The Bridge Creek Wilderness is characterized by steep terrain, open meadows, forested slopes, and barren plateaus called scab flats. Bridge Creek flows through the heart of the wilderness. Most visitors to the Bridge Creek arrive for fall hunting seasons[4]

Near by volcanic neighbors include Mt. Bachelor, North, Middle and South Sisters, Mt. Jefferson, and Mt. Hood. While dramatic eruptions of the volcanoes have been absent during the last century, continued subduction and presence of numerous faults indicates that a significant seismic or volcanic event could occur at any time. Seismic activity can also trigger landslides and cause flash flood events due to breached dams, jeopardizing the safety of down stream Prineville.

Land Use
Due to the topography and climate described above, land is used most intensively by people in the valley below two major Dams Bowman and Ochoco. Development has followed the land use patterns of

[4] Ochoco National Forest, United States Forest Service

the early settlers; farmers located in the rich valley floors and miners and claimed the foothill and mountainous areas. [5] Agriculture, rural, suburban, urban, industrial, and rural service center land uses are concentrated in the fertile Prineville valley, whereas forest and open space and pockets of agriculture occur in surrounding mountainous and high desert plateau regions of the county. Subsequently, intense Prineville Valley development is subject to increase risk from associated flood hazards. Forested mountains and juniper covered land surrounding these valleys pose a significant risk to the entire region from urban forest interface wildfire events.

S2.2 Population and Demographics

A Historical Perspective

Crook County was established on October 24, 1882. It was created from the southern part of Wasco County and named after U.S. Army Major-General George Crook, a hero of the Snake Indian Wars.

Crook County is situated in the geographic center of Oregon. It has been reduced from its original size of 8,600 square miles to 2,986 square miles by the creation of Jefferson County in 1914 and Deschutes County in 1916. The current boundaries were established in 1927. Crook County is bounded by Jefferson and Wheeler Counties to the north, Grant and Harney Counties to the east, and Deschutes County to the south and west.

In 1882 the Legislative Assembly established Prineville as the county seat. The voters confirmed the choice of Prineville, the only incorporated town in the county, in the 1884 general election. Prineville was named in honor of the town's first merchant, Barney Prine.

The first courthouse was a one story wooden structure at the corner of West 5th and Main Streets. In 1885 a two story wooden structure was built for $5,474. By 1905 this building was considered unsafe to store the county's records, and a $16,526 bid was accepted to erect a new, brick and stone courthouse. The building was completed in 1909, at a cost $48,590, and remodeled in the early 1990s.

The government of Crook County consisted originally of a county judge, two county commissioners, clerk, treasurer, and sheriff. The position of school superintendent appeared by 1899. The county also added an assessor.

The first census in 1890 showed a population of 3,244 excluding the Indians. There has been a fluctuation in the population's growth.

Routes over the Cascades were difficult to find and traverse, thus delaying development in the area until access was more developed. The first effort was in 1862 when a supply train with cattle crossed the Scott Trail. This was also the first group of non-natives to spend the winter in central Oregon. The discovery and development of the Santiam Pass in the 1860s made development of the area much easier.

Demographics

Crook County is one of the most sparsely populated areas in the state, with 6.4 persons per square mile, compared to the state average of 35.6 persons per square mile and 74.2 persons per square mile

[5] United States Geological Survey/recollection of Pioneer Citizens of Crook County

nationally. Crook County is rural, with one incorporated city, Prineville, located in the geographical center of the state of Oregon. Prineville is the county seat and location for most services. Other distinct population areas include Post/Paulina, 54 miles from Prineville, Powell Butte, 15 miles from Prineville, and in the valleys south of Prineville, and area referred to as Juniper Canyon. To illustrate the remoteness of the county, there are no public transportation services and we are located 150 miles from the nearest international airport, train or metro bus service[6].

Crook County has experienced rapid population growth due mostly to high levels of in migration. Between 1990 and 2000, Crook County's population grew 35.94 percent, drastically higher than the State of Oregon's 20 percent growth Rate for the same period.[7] Rapid growth is expected to continue Crook County's population is projected to double in the next two decades.

Special needs in Crook County

Natural hazards do not discriminate, but impacts in terms of loss and the ability to recover vary greatly among groups. According to Peggy Stahl of the FEMA Preparedness, Training, and Exercise Directorate, 80% of the disaster burden falls on the public, and within that number, a disproportionate burden is placed on special needs groups: woman, children, minorities and the poor.[8]

It is estimated that as many as 16.2 percent of Crook County residents are living in poverty.[9] In 2003, 10.3 percent of Crook County's residents were unemployed.[10] Crook County also has a number of foster care facilities and nursing homes located with in our floodplains. Given these special needs populations, it is important to review hazard mitigation policies for all sectors and populations in a community.[11]

Education and outreach services can help all citizens of Crook County understand the risks from natural hazards and how to be prepared on an individual level for a natural hazard event. Another social issue related to natural hazards is the potential imbalance between the costs and benefits of natural hazards mitigation and recovery. The cost of natural hazard recovery can place unequal financial responsibility on the general population, when only a small proportion may benefit from government funds used to rebuild private structures.[12] Equity issues should be recognized during natural hazard planning and a key education and outreach goal of this mitigation plan is to "provide public information and education to all residents of the county concerning natural hazard areas and mitigation efforts." (See section 4 of this plan.) Crook County strives to ensure that all county requirements and restrictions are consistently applied. Crook County Emergency Management is working with the Oregon State Department of Human Resources, Senior and Disabled Services and other community service organizations to develop a system that serves people with physical and cognitive disabilities that impair their mobility, sight, or ability to independently respond to natural hazards.[13]

[6] Crook County Health Department

[7] U.S. Bureau of Census. (2000), population of Oregon and it's Counties and incorporated places, public Law 94-171 Redistricting Data. 1990-2000, prepared by Office of Economic Analysis, DAS State of Oregon

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

[9] United State Census Bureau

[10] "Where the Jobs Aren't" Employment Policies Institute, Washington D.C.

[11] Hazards Workshop Session Summary #16, Disasters Diversity and Equity.(July (2000). University of Colorado, Boulder., and the Crook County Emergency Operations Plan

[12] Olshansky,Robert B.,Rogers, David, J., Unstable Ground: *Landslide Policy in the United States,* Ecology Law Quarterly (Vol. 13:939, 1987) p 948

[13] Crook County Emergency Operations Plan, Section III, Annex Q, *Special Needs Population*

S2.3 Economy

During the 1990's the wood products industry in Crook County lost a significant portion of its jobs. Four major mills closed and left many of our residents commuting to Bend, Redmond and Madras for work. Because of a 35% increase in population, our construction industry has shown tremendous growth and has helped off set the jobs lost to the crash of the local wood products industry. The great majority of job growth in Crook County has been in the service and trade sectors. Economic growth in Crook County has come from service, trade, or information sectors rather than the traditional resource-based industries. Services are in greater demand, particularly government and health services. Les Schwab is the largest employer in Crook County. Recreational uses have grown in importance to the county, driving population growth and providing the basis for an increasingly important tourism sector of the economy. Beef production, grain, mint, and hay are the main products of Crook County's agricultural sector.

Crook County's economy might be vulnerable to natural hazard events if, for example, highways, streets, and railroads become impassible due to flooding, landslides, wildfires, earthquakes or other natural hazard events. Employees would be unable to get to work while products and business inventory, including perishable foods, would be stalled along the way. The county's tourism industry would be impacted. As business and industry recover from inventory damage, transportation delays, disruption of communications and utilities, and ultimately loss of customers in the wake of a natural hazard event, the entire community could suffer sever economic consequences.

As Crook County's population continues to grow, it becomes important that a broad spectrum of partnerships and collaboration exist to comprehensively address natural hazard mitigation, and reduce risk and prevent loss for Crook County residents.

SECTION 3 Natural Hazard Identification and Risk Assessment

Crook County Natural Hazard Mitigation Plan 2010 Update

S3.0 Natural Hazard Identification and Risk Assessment

Background and Overview

The 2005 Crook County NHMP includes information and mitigation action items for six natural hazards. These included flood, wildfire, severe winter storm, volcano, earthquake and landslide hazards. As part of the 2010 Plan update the NHMP Steering Committee reviewed these six hazard types as well as the other possible natural hazards and made a determination that the six hazard types identified in the 2005 NHMP are still the major hazards that impact Crook County.

Crook County conducted and completed a hazard analysis of the six natural hazards using hazard analysis methodology available through resources provided by the Oregon Office of Emergency Management (OEM)[1]. The document notes that:

> This hazard analysis methodology was first developed by FEMA circa 1983, and gradually refined by OEM over the years. During 1984, the predecessor agency to OEM (Emergency Management Division) conducted workshops around the State of Oregon that resulted in all of Oregon's 36 counties producing an analysis using this methodology. Since then, several cities have also conducted an analysis using this method.
>
> The methodology produces scores that range from 24 (lowest possible) to 240 (highest possible), one order of magnitude from lowest to highest. Vulnerability and probability are the two key components of the methodology. Vulnerability examines both typical and maximum credible events, and probability endeavors to reflect how physical changes in the jurisdiction and scientific research modify the historical record for each hazard. Vulnerability accounts for approximately 60% of the total score, and probability approximately 40%.
>
> For local governments, conducting the hazard analysis described in this document is a useful early step in planning for hazard mitigation, response, and recovery. This method provides the jurisdiction with a sense of hazard priorities, or relative risk. It doesn't predict the occurrence of a particular hazard, but it does "quantify" the risk of one hazard compared with another. By doing this analysis and planning can first be focused where the risk is greatest.
>
> Among other things, this hazard analysis can:
>
> - Help establish priorities for planning, capability development, and hazard mitigation;
> - Serve as a tool in the identification of hazard mitigation measures;
> - Be one tool in conducting a hazard-based needs analysis;
> - Serve to educate the public and public officials about hazards and vulnerabilities; and
> - Help communities make objective judgments about acceptable risk.

S3.1 Crook County Hazard Analysis

Using this analysis the six natural hazard types were scored with severity ratings and weighted factors to produce a numerical outcome. The outcomes were then used to prioritize the disasters by type the risk and vulnerability to Crook County residents and property.

[1] Oregon Emergency Management Hazard Analysis Methodology, updated May 2008
http://www.oregon.gov/OMD/OEM/docs/library/oem_hazard_analysis_methodology_5_08.pdf?ga=t

In this analysis, there are four categories used to consider the overall risk. These include:

1. History
2. Vulnerability
3. Maximum Threat
4. Probability

Using the State methodology, severity ratings (SR) are applied using the following values:

Low = choose the most appropriate number between 1 to 3 points
Medium = choose the most appropriate number between 4 to 7 points
HIGH = choose the most appropriate number between 8 to 10 points

The severity rating values are used to fill in the following categories as follows:

History (record of previous occurrences)

Low	0 - 1 event per 100 years
Medium	2 - 3 events per 100 years
High	4 + events per 100 years

Vulnerability (percentage of population and property likely to be affected)

Low	< 1 % affected
Medium	1 - 10% affected
High	> 10% affected

Maximum Threat (percentage of population and property that could be impacted under a worst-case scenario)

Low	< 5% affected
Medium	5 - 25% affected
High	> 25% affected

Probability (the likelihood of occurrence within a specified period of time)

Low	one incident likely within a 75 to 100 year period
Medium	one incident likely within a 35 to 75 year period
High	one incident likely within a 10 to 35 year period

Each of the four categories is then weighted to produce a score where vulnerability accounts for approximately 60% of the total score, and probability approximately 40%. The weighted factors are as follows:

1. History (SR X 2)
2. Vulnerability (SR X 5)
3. Maximum Threat (SR X 10)
4. Probability (SR X 7)

Although the analysis is blended with both factual data and opinioned factors, the outcome still produced an outcome where the hazard types can be compared against one another to prioritize overall hazard risk.

The following table shows the results of this analysis:

Crook County Hazard Analysis Matrix

Hazards	History WF=2	Vulnerability WF=5	Maximum Threat WF = 10	Probability WF=7	Total Score
Flood	10	9	9	10	**225**
Wildfire	10	5	7	10	**185**
Severe Winter Storm	10	4	6	10	**170**
Volcano	3	10	10	1	**163**
Earthquake	3	4	10	5	**161**
Landslide	2	2	9	4	**132**

As can be noted from this analysis, flood hazards scored as the highest overall risk score with 225 points out of a total 240 possible points. This is supported by the fact that there have been higher incidents of this hazard occurring together with high probability of reoccurrences within the next 10-35 year time period. Likewise, although the wildfire hazard has an equally high history as flood hazard, but its impact on population and property is lessened by the fact that wildfire occurs in less densely populated area, thus having lower vulnerability and maximum threat. Understanding the comparative risk of the other listed hazards will have a similar logic.

Filling in the category severity ratings required knowledge of the hazard identification, including history of occurrences, impacts to property and populations and indications of future probability. This is compared with information of

S3.2 Natural Hazard Identification

The results of this natural hazard risk assessment provide an analysis of the potential risk to life, property, and the environment that may result from natural hazard events. This assessment is supported and developed from data related to the identification of natural hazards. The identification of natural hazards provides information relating to the location, extent, previous occurrences, and future probability of natural hazards that can impact Crook County.

The outputs from this natural hazard planning effort are used to:

- Prioritize the hazards by their greatest risk to the County;
- Provide information that sets the background and basis for establishing mitigation strategies to reduce risk;
- As a tool to inform decisions makers regarding land use planning, urban growth management, and public safety regulation;
- Public education and awareness;
- Identifying natural hazard planning gaps that may require further study.

Natural Hazards

The following parts of this NHMP Section provide information on each hazard type and include hazard history prior to 2005, hazard history during the first planning period from2005-2010, data sources, vulnerability assessments and risk assessments. More extensive descriptions of each hazard background are provided in Appendix B of the Plan.

S3.3 Flood Hazard

(Hazard Analysis Score = 225)

Heavy rainfall on top of deep snow pack is the most common cause of flooding in Crook County. The winter typically hits the high desert late October through late April.

Crook County lies in the central part of Oregon along the Ochoco Mountains. It is wholly within Climate Division 7 (South Central Oregon) established by the National Climatic Data Center. Crook County typically receives approximately 10.5 inches of precipitation per year. About half of this precipitation is snow and the other half is rain. Rain falling on top of snow causes the snow to quickly melt and river and creek levels rise rapidly. The two most sever flood events in Crook County were the result of rain falling on snow pack.[2]

Figure: Mean Annual Precipitation[3]

[2] Interviews between Brandon Smith and the Crook County Historical Society (September 2003).
[3] http://www.ocs.oregonstate.edu/county_climate/fig2/crook.jpg

A climate table identifying precipitation in Crook County, as observed at long-term climate stations in Crook County, are included below[4].

Precipitation, Monthly and Annual Averages (1971-2000)

Name	Number	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Barnes Stn	501	1.44	1.1	1.24	1.05	1.42	1.04	0.79	0.86	0.68	0.86	1.62	1.62	13.72
Mitchell 17 SW Ochoco	6243	2.13	1.62	1.4	1.11	1.29	1.03	0.82	0.82	0.85	1.16	2.18	2.1	16.51
Prineville 4 NW	6883	1.14	1	0.95	0.8	1.06	0.84	0.58	0.45	0.41	0.76	1.3	1.2	10.49

The eastern, northern and southern boundaries of Crook County are mountainous, with a valley in the center of the county. These mountains collect rain and snow and deliver it to Crooked River and Ochoco Creek Valley. Slopes of the surrounding mountains are relatively steep and have shallow, rocky soils. These types of soils have low absorption properties and quickly transport the rainwater to the river system.

The type and relative amount of vegetation cover dramatically affect how quickly rainwater moves into waterways. Heavy vegetation cover slows the movement of rainwater into the river. When vegetation is removed or reduced, rainwater moves more rapidly into the river system, and contributes to higher water levels. Logging, clearing for development and agricultural practices can all contribute to rapid water level fluctuations in Crook County's rivers and creeks.

Crook County includes numerous areas where development has historically been located within the floodplain. Increased development within the floodplain increases the risk of flood damage to buildings and people. When structures or fill are placed in the floodplain, water is displaced. Development may cause floodwaters to rise higher than before the development was located in the hazard areas. This is particularly true if the development is located within the floodway. Impervious surfaces, including roads, parking areas and roof structures collect water rapidly and transport the water to storm water systems that may not be designed to mitigate heavy rainfall conditions, which will result in flooding.

Crook County Hazard History: prior to 2005

Flooding is a familiar occurrence in Crook County. Over the past 100 years, the county has experienced major flood events on a regular basis. Floods are the most common of all natural hazards and both Oregon and Crook County have an extensive history of flooding. The frequency of flooding combined with concentrated development along rivers and streams caused millions of dollars in damage to Crook County over the past several decades. The growing population and development activity in the floodplain can increase the risk of flood related damages.

The following timeline lists some of the major flood events that have occurred in Crook County.

Crook County Flood Timeline

- **August 04, 1904**- Crooked River floods, destroys crops, shuts down the Prineville Railway, washes away portions of a State Highway.
- **1918-** Flood downtown Prineville, Homes and Businesses damaged. Citizens displaced Both the Crooked River and Ochoco Creek Swell
- **December 1951, January 1952**- Prineville Floods, Crooked River runs well over its banks. Many business and homes damaged 300 People evacuated, 150 home evacuated.

[4] http://www.ocs.oregonstate.edu/county_climate/Crook_files/Crook.html

- **December 1955, January 1956-**Prineville floods. Citizens evacuated, homes and businesses damaged.
- **August 1991-** Rural Crook County, Near Post. What was described as the Aspen Valley Flood. Also described as Newsome Creek. Summer Super Cell dumped several inches of rain. Barns and houses demolished, one person killed, one person injured
- **May 1998-** Prineville floods, Ochoco Creek rises beyond flood levels. Federal Disaster Declaration.

The landmark flood event for Crook County in the last century was the flood of 1952. This flood set most of the record high-water marks for the region. The trigger for this flood was warm rain on a substantial snow pack. The rain quickly melted the snow, and caused Ochoco Creek and the Crooked River to overrun their banks. All subsequent floods have been compared to this event. The 1952 flood was characterized as a "100-year" flood event. A "100- year" flood has a 1%chance of occurring in any given year, or a 26% chance of occurring during the life of a 30-year home mortgage.

In May 1998, Crook County experienced another devastating flood. In the weeks preceding the flood, the county received abundant rain and snowfall. A warm and heavily moisture-laden storm front, typical to the Pacific El Nino pattern, followed the abundant snowfall. The warm rain quickly melted the snow pack, and county streams and rivers rapidly filled their channels and exceeded their banks. This particular flood event caused over $16 million in damages to Crook County homes, businesses and infrastructure, including damage to over 1000 properties and over 1000 residents were impacted by the flood.[5]

Hazard History: 2005-2010
Contacts were made to state and federal agencies to inquire about data relating to flood activity during this time period. No documented flood activity was noted by these agencies for this time period. In addition a steering committee made up of emergency managers, responder agencies, and local, state and federal administrators led the effort to update the Crook County Natural Hazard Mitigation Plan. The steering committee discovered no evidence of recorded flood activity during this time period.

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

The flood hazard for Crook County and City of Prineville was identified by FEMA in their Flood Insurance Rate Maps of the county. These maps were first completed in July 1989.The maps outline the extent of the 100-year, or base, floodplain. This is an outline of where floodwaters would extend if there were such a flood. These maps are used by FEMA to identify properties that need to purchase flood insurance and, if developed, need to meet floodplain development regulations.

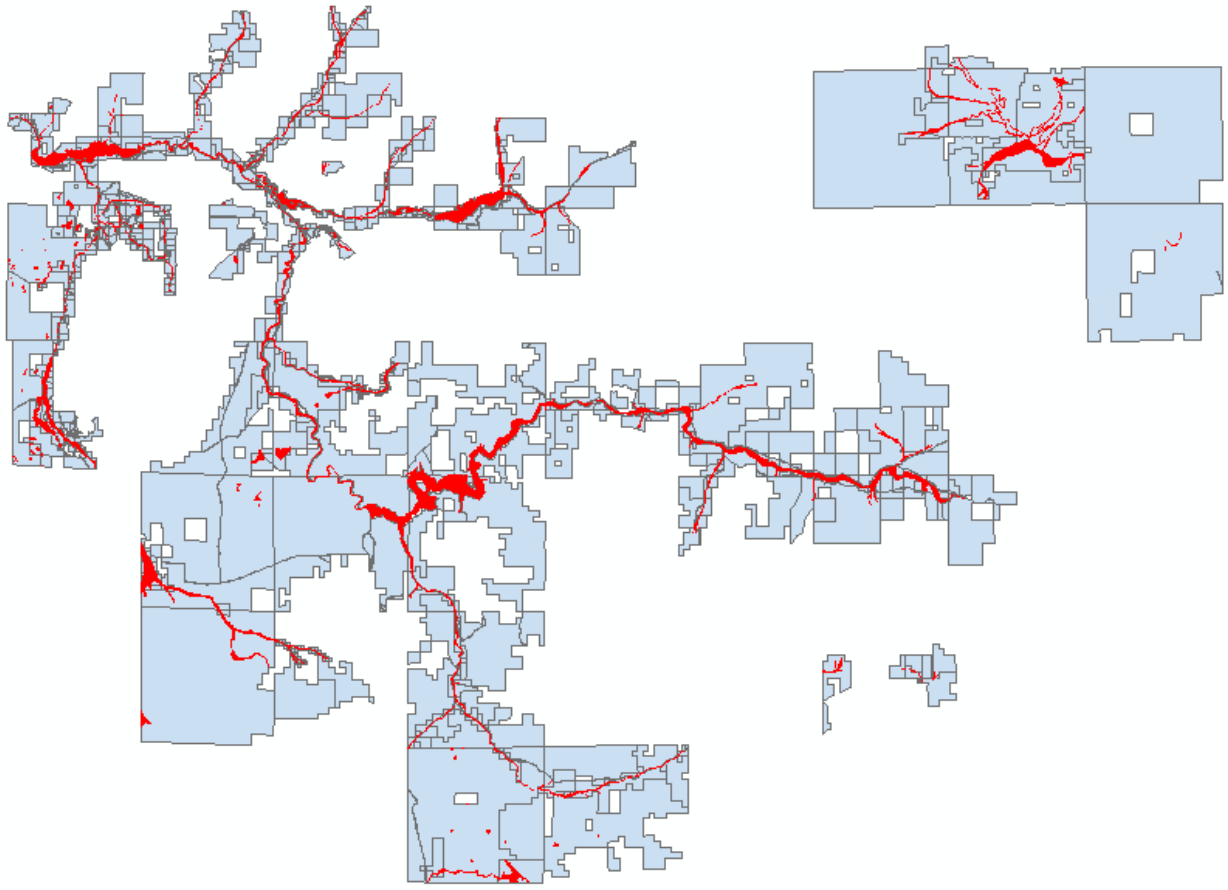
In 2010 new Flood Insurance Rate Maps became available. These maps were based upon updated information and technology that increased the accuracy of delineating the floodplain and floodway area along the Crooked River and Ochoco River. The maps are expected to be adopted soon after the update to this plan is completed. For the purposes of this update the 2010 NHMP update committee chose to use the new floodplain FIRM data provided within the draft maps.

[5] City of Prineville / Crook County Flood Mitigation Action Plan, Clay Moorhead, CDA Consulting Group Inc. (2000)

The Crook County Geographic Information System (GIS) Department has incorporated the 2010 FIRM data as overlay within their GIS database. A query was developed to combine the delineated boundaries of the 2010 FIRM maps with the 2010 certified tax roll (certified October 8, 2010) for properties within the County. Discrepancies were noted from information identified within the 2005 NHMP. Since the new FIRM data is based on updated topographical and hydraulic information, we relied on this new data to identify the flood hazard for the 2010 NHMP Update.

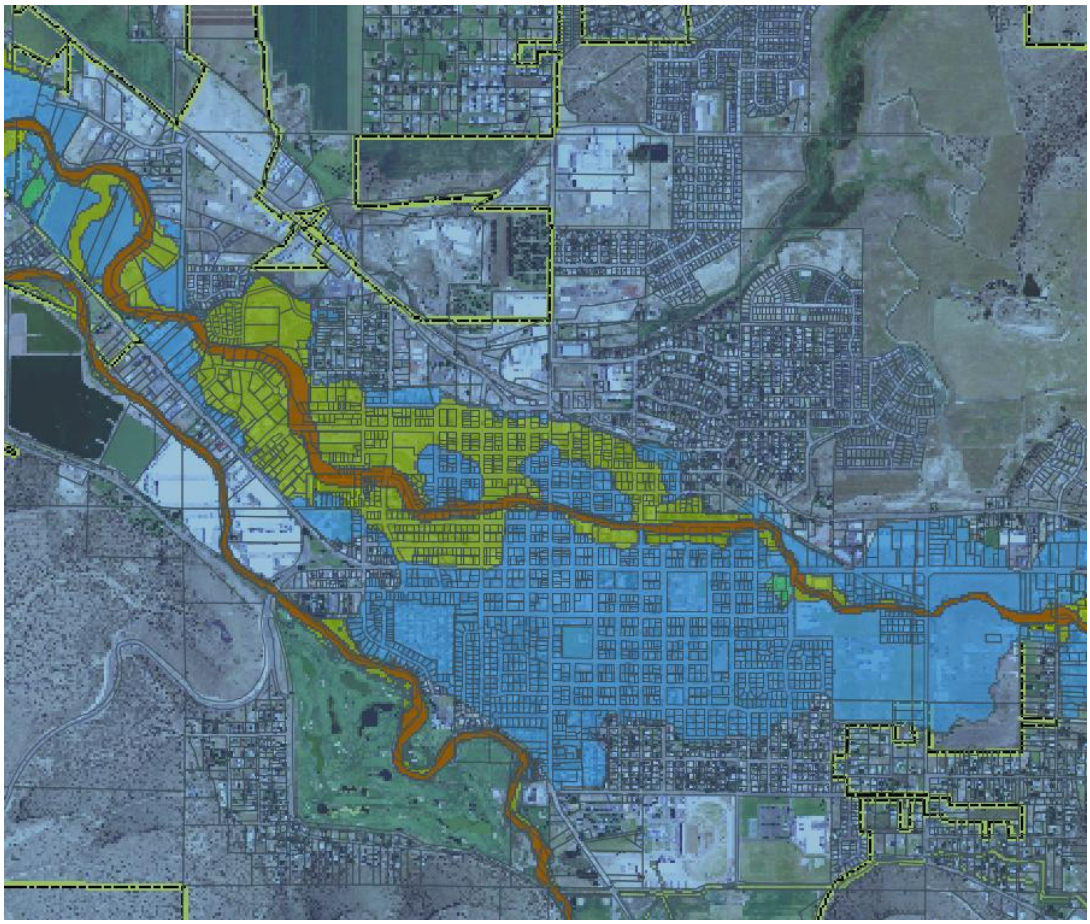
The following map shows flood areas as identified by the 2010 Flood Insurance Rate Map (FIRM) information. The official maps from this Flood Insurance Study have not yet been approved by Crook County. Crook County and Prineville are currently developing a process to review this information for approval in 2011. Once approved the new FIRM data will become the official mapped flood zoned for Crook County.

The new FIRM data has been plotted into the Crook County GIS system. Although the Countywide map shown below is too small to read, we use this to reference that data available through the County's GIS system.



When this information is plotted it can show more specifically where the flood zones are in relation to property and structures. The mapping capability provides detail on a property by property basis and is a significant tool that can be used for many purposes, most importantly compliance with the FEMA Floodplain regulations.

The following map is an example of a larger scale map showing flood zones within the central portions of the Prineville area. This map begins to show the capability of flood impact mapping. Although it was based upon 2010 revised Flood Insurance Study, it only serves as a graphical reference to the official maps that are expected to be adopted by Crook County.



Risk Assessment

The floodplains begin as very narrow strips adjacent to the upper tributaries of Ochoco Creek and the Crooked River, and steadily increase in width at lower elevations. The widest floodplains are in the center of Prineville and near the confluence of Ochoco Creek and the Crooked River. The Ochoco River bisects the City of Prineville and the floodplain locations include urban areas.

Within the past 5 years the city boundary has changed (expanded). As a result, the query was developed using the new corporate boundary lines. In addition, the query was used to select tax lot parcels that intersected the floodplain. This information was cross-referenced to the 2010 Real Marked Value (improvements component only) for five building types[6].

[6] Additional property classifications were used for internal purposes by the county (in brackets next to the class).

The first two tables below identify statistics for both Crook County and the City of Prineville as separated data. The third table reflects the combined information.

Flood Hazard Assessment Tables

Crook County		
Building Type	No. tax lots	Imp RMV
Single Family (101, 401 and 801)	272	$27,429,670
Multi Family (701)	0	$0
Mobile (019)	93	$4,841,010
Commercial (201)	12	$24,941,360
Industrial (301 and 303)	16	$1,993,030
Total	393	$59,205,070

City of Prineville	
No. tax lots	Imp RMV
397	$27,690,980
115	$3,462,030
177	$12,193,600
130	$27,764,990
41	$12,351,450
860	$83,463,050

Crook County Combined		
Building Type	No. tax lots	Imp RMV
Single Family (101, 401 and 801)	669	$27,429,670
Multi Family (701)	115	$3,462,030
Mobile (019)	270	$17,034,610
Commercial (201)	142	$52,706,350
Industrial (301 and 303)	57	$14,344,480
Total	1253	$114,977,140

Information from the County Assessor's office was combined with the Flood Insurance Rate Maps to estimate the improved property value that is at risk by a 100-year flood event. The Flood Hazard Tables above identify the number of tax lots and the real market value (RMV) for the Crook County flood hazard areas, and the maximum estimated losses caused by a flood disaster occurring along the Crooked and Ochoco Rivers. As of November 2010, there we 1,253 tax lots located within the 100-year flood plain, with an improved value of *$114,977,140.* Of the 1,253 lots, about 11.3 percent were manufactured homes, which are very susceptible to flood damage. These figures have increased since 2005 when the NHMP was first adopted due to the expansion of the city limits of the City of Prineville.

The County finds that, as can be noted from the Crook County Hazard Analysis Matrix found on page 3 of the Section, flood hazards scored as the highest overall risk score with 225 points out of a total 240 possible points. This is supported by the fact that there have been higher incidents of severe impacts of this hazard occurring. This is compounded by a high probability of a reoccurrence occurring within the next 10-35 year time period. Historically, significant development and urban populations have located within flood prone areas of Crook County. As such, the vulnerability and maximum threat from this natural hazard type is high.

S3.4 Wildland Fire Hazard (Hazard Analysis Score = 185)

Wildland fire plays a large, reoccurring and high impact role as a natural hazard in Central Oregon. While Crook County has experienced only three large wildland-urban-interface (WUI) fire within the last decade, it has also been the setting for several smaller interface fires with significant potential for major impact on interface areas and critical infrastructure. Neighboring counties have experienced numerous, high impact WUI fire incidents providing Crook County emergency managers insight into the complexities of such incidents. Crook County residential development is expanding further into sites traditionally covered by wildland vegetation bringing with it the potential for the wildland-urban interface scenarios envisioned by Congress when they passed the "Healthy Forest Restoration Act of 2003."[7]

The escalating size and intensity of these interface fires is the subject of continuing research in several scientific disciplines. These include the arenas of forest health, hazardous fuels treatment and community infrastructure protection as well as study of the impacts of climate change. These issues are likewise the subject of significant public discourse. Over the last two decades, community awareness has developed substantially regarding the interface fire threat as well as interest and involvement in issues of hazardous fuels treatment activities.

Central Oregon population growth has become a companion issue. Between 1990 and 2000, Crook County's population grew by nearly 36% to 19,182. This is a significant population gain, but is nothing compared to this last decade. Between the years 2000 to 2010 the County has grown now to 27,280[8], representing a 42% population increase in just one decade. This trend is predicted to continue with an additional doubling of population over the next 20 years. Population growth will have significant impacts on citizen exposure and infrastructure vulnerability to the effects of wildland fire.[9]

Wildfire hazard assessments have traditionally been conducted by individual jurisdictional agencies and organizations. In many cases these have been driven by local rural fire protection district boards of directors, county ordinance and for wildland agencies state or federal law, regulation, policy or directives.

In Deschutes County, hazard assessments in a variety of forms have been previously completed by individual fire districts. The outputs from these assessments have been incorporated into agency response plans. Pre-existing work will be validated and integrated into the Community Fire Plans as they are developed.

The Oregon Department of Forestry has identified Deschutes County as one of two pilot counties for implementation of the Oregon Forestland-Urban Interface Fire Protection Act of 1997, also known as Senate Bill 360 (SB 360).[10] The implementation process contains an extensive wildfire hazard identification component which has been embodied in Oregon Administrative Rule. This system will eventually be applicable throughout the state in "wildland-urban interface areas" as defined by the statute. SB360 has been implemented in Crook County. The mitigation treatment standards of the

[7] "Healthy Forests Restoration Act of 2003" (H.R. 1904); One Hundred Eighth Congress; Administrative implementation information available on the National Fire Plan website, www.fireplan.gov.
[8] Portland State University Population Research Center 2010 Preliminary County Population Estimates
[9] U.S. Bureau of Census, 2000. Population of Oregon and it's Counties and Incorporated Places, Public Law 94-171 Redistricting Data, prepared by the Office of Economic Analysis, Dept of Administrative Services, State of Oregon.
[10] ORS 477.015-477.061

Crook County Fire Ready program were derived from the SB360 standards so that there is now one defensible space treatment standard county-wide.

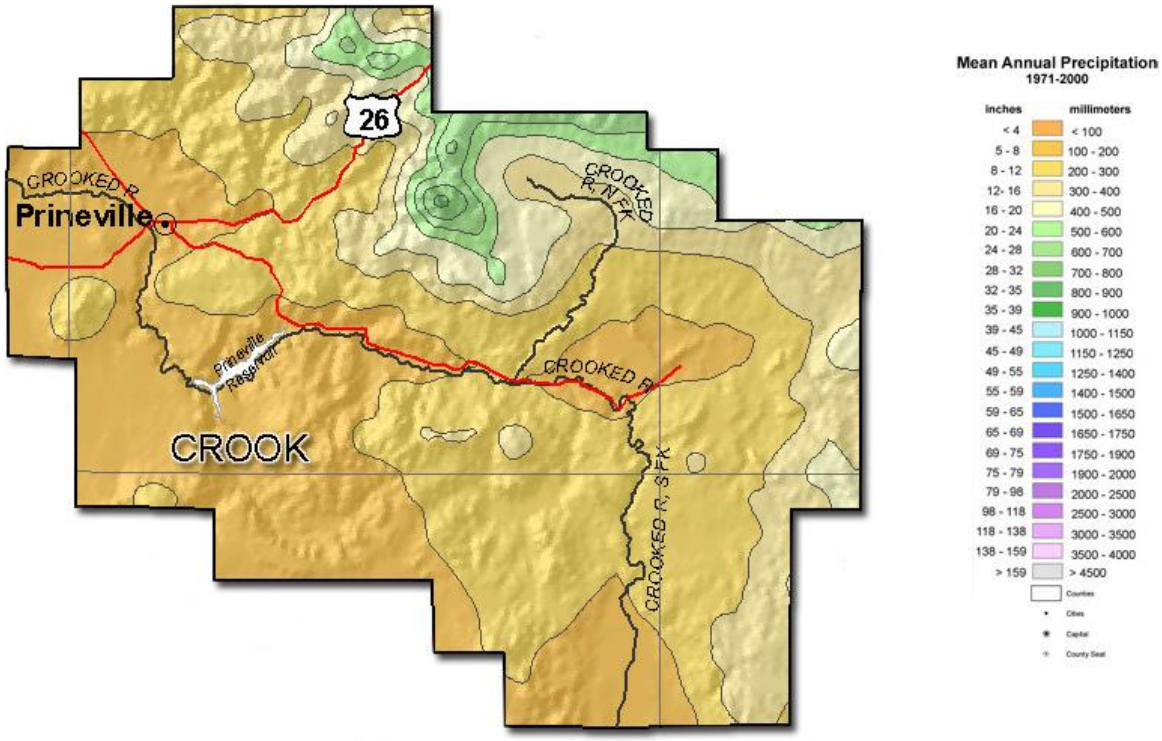
According to a report published by the National Interagency Coordination Center:

> *The forests and rangelands of central Oregon have evolved with wildland fire as a part of the landscape. Most observers agree that despite fire suppressions efforts, in recent years, wildland fires have been burning hotter, moving faster, and scorching more acres than the historical pattern. Six of the top 13 most destructive wildland-urban interface fires in Oregon's history have occurred in central Oregon.*[11]

This document goes on to state that that the acres burned in central Oregon between 2000 and 2004 exceeds the number of acres burned in the previous hundred years. This recent and dramatic increase in large fires has heightened community awareness and willingness to address fire safety.

The figure below illustrates Crook County precipitation patterns, the rain shadow effect from the Cascades Mountains and effect of the higher elevation of the Ochoco Mountains.

Figure: Mean Annual Precipitation[12]



A climate table identifying precipitation in Crook County, as observed at long-term climate stations in Crook County, are included below[13].

[11] Forest Log, National Interagency Coordination Center situation reports, as cited in Oregon Department of Forestry, http://egov.oregon.gov/ODF/FIRE/SB360/wui_history_table.shtml (accessed June 8, 2005). http://www.odf.state.or.us/AREAS/eastern/walkerrange/CWPP/Ch3.pdf

[12] http://www.ocs.oregonstate.edu/county_climate/fig2/crook.jpg

Precipitation, Monthly and Annual Averages (1971-2000)

Barnes Stn	501	1.44	1.1	1.24	1.05	1.42	1.04	0.79	0.86	0.68	0.86	1.62	1.62	13.72
Mitchell 17 SW Ochoco	6243	2.13	1.62	1.4	1.11	1.29	1.03	0.82	0.82	0.85	1.16	2.18	2.1	16.51
Prineville 4 NW	6883	1.14	1	0.95	0.8	1.06	0.84	0.58	0.45	0.41	0.76	1.3	1.2	10.49

Hazard History: prior to 2005

Figure 7-1 lists some of the larger wildland fires in the tri-county (Crook, Deschutes and Jefferson) area over the last decade requiring an emergency management response beyond that of the wildland fire and natural resource agencies. Since the 1990 Awbrey Hall fire, the local structural and wildland fire services have substantially refined the emergency response system for these types of destructive interface fires. Under the leadership of the Central Oregon Fire Chief's Association, the pre-planned interface fire mutual aid and task force system has effectively integrated the operational response process for structural and wildland fire fighting resources from all three counties. This response system is recognized as one of the most effective interagency efforts in the state.

Representative Interface Fires in Central Oregon Since 1990 - 2005[14]

Year	Fire Name	Size	Start Date	County	Conflagration Act Resources Mobilized	Unprotected Areas Involved	Remarks
1990	Awbrey Hall	3,032	7/5/1990	Deschutes	Yes		Destroyed 22 residences. 2800 Bend residents evacuated.
1996	Little Cabin	2,400	7/29/1996	Jefferson	Yes	Structural, Wildland	3 Rivers subdivision threatened. No structures lost.
1996	Ashwood-Donnybrook	100,000+	8/9/1996	Jefferson, Wasco	Yes	Structural, Wildland	Conflagration Act resources mobilized to protect the threatened community of Ashwood.
1996	Smith Rock	300	8/10/1996	Deschutes	Yes	Wildland	One residence destroyed.
1996	Skeleton-Evans West	22,000	8/23/1996	Deschutes	Yes		Destroyed 19 residences and 15 outbuildings.
1998	Elk Lake	252	9/2/1998	Deschutes			Thirty two recreational cabins adjacent to Elk Lake threatened. Several destroyed.
2000	Hash Rock	18,500	8/23/2000	Crook	Yes	Structural	Thirty residences and 32 commercial buildings threatened in Mill Creek and Marks Creek drainages. U.S. Hwy 26 traffic controlled with pilot car.
2002	Eyerly	23,573	7/9/2002	Jefferson	Yes	Structural, Wildland	Spread into 3 Rivers subdivision burning 18 residences & multiple outbuildings.
2002	Cache Mountain	3,894	7/23/2002	Deschutes, Jefferrson	Yes		Fire spread five miles to east, destroying two residences in

[13] http://www.ocs.oregonstate.edu/county_climate/Crook_files/Crook.html

[14] Figure 1 – Data derived from multiple Oregon State Fire Marshall, U.S. Forest Service, Oregon Department of Forestry and Bureau of Land Management sources.

							Black Butte Ranch.
2003	Davis	21,181	6/28/2010	Deschutes, Klamath		Structural	Early season, high intensity fire with high rates of spread. Spotting potential for south half of LaPine basin. Ash fallout reported 60 miles to NE at Prineville.
2003	Link	3,574	7/5/2010	Deschutes, Jefferson			Concern for potential spread to Black Butte Ranch.
2003	18 Road	3,800	7/23/2010	Deschutes			Threat of spread to residential areas on southwest side of Bend and High Desert Museum.
2003	B & B Complex	90,769	8/19/2003	Jefferson, Linn	Yes		Lightning wilderness fires spread east forcing evacuation of Camp Sherman (Jefferson Co.) and west threatening private land & residential development along Hwy 22 near Marion Forks. Santiam Pass Hwy closed. Black Butte Ranch was threatened as the fire moved south.

As is the case with the regional focus of table above, much of the Wildfire Chapter of this plan is presented with a regional focus on Crook, Deschutes and Jefferson counties. The scope and multi-jurisdictional nature of the local wildfire demand has driven development of a regional approach to pre-incident planning, training, initial and reinforced response, and recovery activities. The benefit of this type of coordinated approach is broadly acknowledged by fire service leadership as essential to meeting the local wildfire challenge.

Hazard History: 2005 – 2010

Year	Fire Name	Size	Start Date	County	Conflagration Act Resources Mobilized	Unprotected Areas Involved	Remarks
2007	GW	7,357	8/31/2007	Deschutes	Yes	Structural, Wildland	1221 dwelling structures saved, 50 threatened, zero destroyed
2007	Mile Post 8	120	9/27/2007	Crook		Structural, Wildland	1 dwelling structures saved, 1 threatened, zero destroyed
2008	S Summit Springs Complex	1,745	8/17/2008	Jefferson		Structural, Wildland	12 dwelling structure saved, 15 threatened, zero destroyed
2008	Juniper Butte	40	7/19/2008	Crook		Structural, Wildland	5 dwelling structures saved, 5 threatened, zero destroyed.
2010	Rooster Rock	6,037	8/2/2010	Deschutes	Yes	Structural, Wildland	14 dwelling structures saved, 20 threatened, zero destroyed

Vulnerability Assessment

The Crook County Community Wildfire Protection Plan (CWPP) was adopted in June 2005. The Plan was updated in 2007 and is currently going through a 2010 update. The Plan describes numerous areas where Crook County is vulnerable to wildfire. These areas are designated as having "high" or "extreme" hazard ratings.[15] The Plan states:

[15] Crook County Community Wildfire Protection Plan, 2005 as amended 2007.

> As is the case with much of central Oregon, Crook County is experiencing a period of rapid growth[16].
>
> There has been a corresponding growth in residential development, within the urban growth boundary, rural areas and in portions of the county traditionally occupied by natural vegetation. This trend is expanding Crook County's wildland-urban interface, exposing more residents to the potential impact of wildland fire.[17]

Vulnerability to fire is caused by numerous conditions. The Crook County CWPP states that most of the wildland-urban interface (WUI) areas occur in sites dominated by either Juniper/sage/grass or Ponderosa pine/dry fir. Climate and weather have a significant impact of wildfire vulnerability as does development within the wildland-urban interface (WUI). Additionally roads play a big impact on fire response, mitigation efforts and evacuation. Some of the communities that could be impacted by wildfire include:

- City of Prineville
- Powell Butte
- Paulina
- Rager Ranger Station
- Ochoco Reservoir
- Mill Creek
- Marks Creek
- McKay Creek
- Ochoco West
- Prineville Reservoir
- Juniper Acres

Risk Assessment

The information above illustrates not only the escalating size of large wildland fires in Central Oregon, but also the increasing impact on the citizens, values-at-risk and infrastructure of the counties. The fuels, weather and demographic conditions that have driven development of large, high impact, high intensity wildland interface fires in Deschutes and Jefferson counties are also present in Crook County. Work has begun on the next revision of the Fire Atlas to include the remainder of Central Oregon, including Crook County.

The County finds that there is an extensive history of wildland fires in and around Crook County. But because these fires are more prone to be in rural areas, the County has seen moderate impacts. With increases in population, especially within urban interface areas, these impacts may increase the County's vulnerability and maximum threat in future years. The overall probably that the County will be impacted by a significant wildland fire within the next ten to 35 years is high.

[16] U.S. Census Bureau data as quoted in *The Bulletin,* April 17, 2005
[17] Section 2.0 Crook County Community Profile.

Acres Burned by Decade in Large Fires

Acres Burned by Decade in Large Fires-Within the Upper Deschutes Fire Learning Network (UDBFLN) boundaries.[18]

More acres were burned by catastrophic wildfires within the boundaries of the project area in the past three years than in the previous century.

1900-1999 127,162 Acres
2000-2005 128,817 Acres

Structures Lost Since 1982 within UDBFLN Boundaries.[19]

Structures Lost

Since 1981, 82 homes have been consumed in nine wildfires within the Upper Deschutes Basin Fire Learning network Study Area.

- 2003 1 Structure
- 2002 20 Structures
- 2001 5 Structures
- 1996 30 Structures
- 1990 22 Structures
- 1981 5 Structures

One of the significant issues to reduce risk is the progress in hazardous vegetation treatment that Crook County has made with the assistance of FEMA PDM grants, Crook County-Fire Ready and the development of the Rangeland Fire Associations in the east county. These efforts have helped to address some of the unprotected lands issues.

The CWPP identifies six geographical risk assessment areas, each containing communities and multiple components of critical infrastructure. These are identified as:

1. Powell Butte
2. McKay
3. Juniper Canyon
4. Maurys
5. Paulina
6. Twelve Mile

The CWPP includes an assessment for each risk assessment areas. Hazard and protection priorities are identified for each area. The CWPP provides a numerical scoring for identified hazard locations to prioritize that have the higher vulnerability and risk.

[18] Central Oregon Fire Atlas- Presentation. The Nature Conservancy, Upper Deschutes Fire Learning Network Project, v2.0, February 9, 2004.
[19] Ibid.

S3.5 SEVERE WINTER STORM AND WINDSTORM HAZARD (Hazard Analysis Score = 170)

Crook County is threatened by hazards generated from weather conditions almost every year. Storms bring heavy rains, strong winds, and occasionally ice and snow. Flooding and landslides can also accompany severe storms. Damaging storms are most common from October through April. Severe storms can create conditions that disrupt essential regional systems such as public utilities, telecommunications, and transportation routes. Wind, snow, and ice associated with winter storms can knock down or otherwise damage trees, power lines, and utility services. Freezing winter temperatures can damage agricultural crops and utilities. Lightning poses a risk to life and can result in property damage. Weather hazards cause damage to private property and public infrastructure, and occasionally cause injury or death.

Storms affect all parts of Crook County. However, the varied elevations and topography of the County mean that the impact of a storm is variable depending on the location. The Ochoco Mountains, located within the center and eastern portions of the County, regularly receive the highest amounts of snowfall, and the strongest wind gusts in the County. The Cascade Mountain range to the west of the County blocks much of the potential rainfall in the area.

The most frequent weather related hazards in the Crook County are snow, wind, ice, and freezing temperatures. Occasionally, storms from the Pacific bring rain during the warmer months. However, most rainstorms in Crook County are from thunderstorms.

Hazard History: prior to 2005
The geographic extent of severe winter storm hazards covers every area in the County. Within the 2005 NHMP, there was no mapping data available that mapped extreme weather occurrences in Crook County. Though severe weather can be highly localized, the geographic extent of winter storm hazards includes all of Crook County. The nature of the hazard varies by location, with snow and ice creating more hazards at higher elevations, localized flooding more hazardous on the valley floors, and flash floods on the steep valley slopes.

The lower wind speeds typical in the lower valleys are still high enough to knock down trees, bring down power lines, and cause other property damage. Despite a lack of wind speed data for higher elevations, it is clear that the mountainous portions of the county experience much higher winds, under more varied conditions. A basic level of wind hazard can be assumed for every location in the County where trees can be found.

The damage sustained by a winter storm hazards is very dependent on types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas. Changes in vegetation, soil grading, storm water systems, the amount of impermeable surface, etc. can impact the likelihood and degree of winter storm hazards.

Hazard History: 2005 – 2010
Contacts were made to state and federal agencies to inquire about data relating to severe storm activity during this time period. No documented severe storm activity was noted by these agencies. Initial research was conducted on the internet to identify data or publications related to severe storm events or storm damage vulnerability. No data was identified.

In addition a steering committee made up of emergency managers, responder agencies, and local, state and federal administrators led the effort to update the Crook County Natural Hazard Mitigation Plan. The steering committee discovered no evidence of recorded severe storm activity during this time period.

Vulnerability Assessment

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

Severe Winter Storms

Crook County's has severe winter storms that occur with regularity, although none have been noted to be on the magnitude of a national disaster. Higher elevations have greater exposure to snow and ice, but may be less economically vulnerable, because they are sparsely populated. Roads may be closed longer in more isolated areas, and extreme snowfall or flash flood events may simply be more dangerous in the mountains. Outreach programs, emergency communications systems, and special emergency response plans may be the most effective ways to reduce vulnerability in outlying areas of the County.

Windstorms

Every location in the county is exposed to some level of windstorm-related hazards, and each location is vulnerable to the extent that trees are in close proximity to a structure, road, or power line. Because of Crook County's high elevation, many of its residents are often exposed to high winds, especially during the winter months and during summer thunderstorms. Certain properties or facilities are vulnerable because of an inherent susceptibility to wind damage, perhaps at certain critical times. As with severe winter storms, Crook County's higher elevations have greater exposure to high winds, but may be less economically vulnerable than other regions of the state because of its low population levels.

Risk Assessment

Crook County has a history of severe storms, but to date these storm have not cause severe impacts to Crook County populations or property. Based upon the experiences documented within this Plan, the County finds that there is moderate risk associated with the devastating impact of a severe winter storm hazard, and the vulnerability and maximum threat to property and populations within the County to also be moderate.

The Crook County Hazard Analysis Matrix on page 3 of this section describes the values placed on the overall risk associated with this natural hazard.

S3.6 VOLCANO HAZARD (Hazard Analysis Score = 163)

Volcanoes are present in Washington, Oregon, and California where volcanic activity is generated by continental plates moving against each other (Cascadia Subduction Zone movement). Because the population of the Pacific Northwest is rapidly expanding, volcanoes of the Cascades Range are now considered some of the most dangerous in the United States.

Crook County sits east of all of the Cascade Volcanoes. The terrain in between it's closest volcanic threats; Newberry, Bachelor, Broken Top, Three Sisters, Jefferson and Hood would eliminate the chance that a Lahar would affect Crook County.

Volcanic eruptions can send ash airborne, spreading the ash for hundreds or even thousands of miles. An erupting volcano can also trigger flash floods, earthquakes, rockfalls, and mudflows. Volcanic ash can contaminate water supplies, cause electrical storms, and collapse roofs.

The nature of volcanic eruptions is such that the immediate danger area covers approximately a 20-mile radius from the eruptive origin, but danger can also extend 100 miles or more from a volcano. Since Crook County falls outside of the 20 mile immediate threat area, our main hazard will be ash fall from Volcanoes as far North as Mount St. Helens to as far South as Mount Shasta.

Businesses and individuals can make plans to respond to volcano emergencies. Planning is prudent because once an emergency begins, public resources can often be overwhelmed, and citizens may need to provide for themselves and make informed decisions. Knowledge of volcano hazards can help citizens make a plan of action based on the relative safety of areas around home, school, and work.

Hazard History: prior to 2005
Although lava rock is relatively easy to find in Crook County, there have been no recent volcanic events in Crook County. The last volcanic eruption happened hundreds of thousands of years ago. This eruption created the basaltic rock that is seen in the Crook River canyon below Bowman Dam.

The closest recent eruption occurred at Mount St. Helens beginning on May 18, 1980. Following two months of earthquakes and minor eruptions and a century of dormancy, Mount St. Helens in Washington, exploded in one of the most devastating volcanic eruptions of the 20th century. Although less than 0.1 cubic mile of magma was erupted, 58 people died, and damage exceeded 1.2 billion dollars. Fortunately, most people in the area were able to evacuate safely before the eruption because the U.S. Geological Survey (USGS) and other scientists had alerted public officials to the danger. As early as 1975, USGS researchers had warned that Mount St. Helens might soon erupt. Coming more than 60 years after the last major eruption in the Cascades (Lassen Peak), the explosion of St. Helens was a spectacular reminder that the millions of residents of the Pacific Northwest share the region with live volcanoes.17

The eruption of Mount St. Helens caused heavy damage and disruption to businesses and other essential services throughout Washington and much of Oregon. If one of the central Cascade Volcanoes erupted the impacts to people and property would be severe.

Hazard History: 2005 – 2010
Contacts were made to state and federal agencies to inquire about data relating to severe storm activity during this time period. No documented volcanic activity was reported by these agencies for any

volcanic activity in proximity to Crook County for this time period. Initial research was also conducted on the internet to identify data or publications related to severe volcanic events. No data was identified from this search.

In addition a steering committee made up of emergency managers, responder agencies, and local, state and federal administrators led the effort to update the Crook County Natural Hazard Mitigation Plan. The steering committee discovered no evidence of recorded volcanic activity during this time period.

The United States Geological Survey-Cascades Volcano Observatory (CVO) produces publications on volcanic activity by volcano. A review of this data resource[20] identified no volcanic publication for the following volcanoes between 2005 and 2010:

- Adams
- Bachelor
- Broken Top
- Hood
- Jefferson
- Mount St. Helens
- Newberry
- South Sister
- Three Sisters

Vulnerability Assessment

Mount St. Helens is a tephra (ash) producing volcano. According to a USGS publication,[21] the most serious tephra hazards in the region are due to Mount St. Helens, the most prolific producer of tephra in the Cascades during the past few thousand years. The report exhibits a probability map that indentifies that Crook County has an annual probability of receiving an accumulation of 10 centimeters or more of tephra accumulation at 0.01 percent or less[22]. Data was not available at the time of this update to determine the specific vulnerability to the types and numbers of existing or future buildings, infrastructure and critical infrastructure.

According to a report prepared by John R. Labadie entitled *Volcanic Ash Effects and Mitigation*[23], "volcanic ash is abrasive, mildly corrosive, and conductive (especially when wet); it may also carry a high static charge for up to two days after being ejected from a volcano. The ash is easily entrained in the air by wind or vehicle movement and may remain suspended in the air for many minutes. Due to the combination of these qualities, volcanic ash is pervasive. It can penetrate all but the most tightly-sealed enclosures". Ash can have a significant impact on all forms of activity including public health, traffic, utilities, critical infrastructure, electronics, and others.

Risk Analysis

The likelihood or magnitude of a volcanic eruption cannot be forecast with confidence[24]. However, if an eruption of significant magnitude occurs, the volcanic ash cloud and fallout could be a high hazard for

[20] http://vulcan.wr.usgs.gov/Publications/publications_by_volcano.html
[21] *W.E. Scott, R.M. Iverson, J.W. Vallance, and W. Hildreth, 1995,*
Volcano Hazards in the Mount Adams Region, Washington: U.S. Geological Survey Open-File Report 95-492
[22] http://vulcan.wr.usgs.gov/Volcanoes/Cascades/Hazards/ash_accumulation_10cm.html
[23] The full report is included in the Hazard Background appendix
[24] John R. Labadie entitled *Volcanic Ash Effects and Mitigation*

Crook County, and the most likely risk appears to be from ash accumulation, with a chance of accumulation being less than 0.01 percent in any given year. Seismic activity (shown in the chapter on earthquake hazard) identifies numerous and regular earthquake activity within the Pacific Northwest. No specific earthquake data was identified for Crook County. As such it is concluded that Crook County faces no immediate and direct threat from a volcanic eruption and therefore has a low probability of threat. The County does have an indirect risk of ash accumulation that could have broad ranging impacts. Through the research and discovery phase of this update, there was insufficient data available to determine losses associated with a volcanic hazard event. This does not mean that such an eruption could not occur in any given year. Crook County must remain vigilant to the possibilities of a volcanic disaster.

S3.7 EARTHQUAKE HAZARD (Hazard Analysis Score = 161)

According to the Pacific Northwest Seismic Network[25] (PNSN):

> The seismology lab at the University of Washington records roughly 1,000 earthquakes per year in Washington and Oregon. Between one and two dozen of these cause enough ground shaking to be felt by residents. Most are in the Puget Sound region, and few cause any damage. However, based on the history of past damaging earthquakes and our understanding of the geologic history of the Pacific Northwest, we are certain that damaging earthquakes (magnitude 6 or greater) will recur in our area, although we have no way to predict whether this is more likely to be today or years from now.

The geographical position of Crook County makes it susceptible to earthquakes from four sources, though expert opinions vary regarding the degree of susceptibility from each. The four sources are:

1. The off-shore Cascadia Fault Zone,
2. Deep intraplate events within the sub-ducting Juan de Fuca Plate,
3. Shallow crustal events within the North American Plate, and
4. Earth quakes 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 American Plate. In the "Basin and Range" area in the southern part of the region (Klamath and Lake Counties) earthquakes are also associated with extension (pulling apart of the crust). Stresses occur because of these movements. There also appears to be a link between the sub-ducting 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 CZ=CSZ could produce a local earthquake along the coast up to 9.0 or greater.

Central Oregon includes portions of five physiographic provinces including High Cascades, Blue Mountains, Basin and Range, High Lava Plains, and Deschutes-Columbia Plateau. Consequently, its geology and earthquake susceptibility varies considerably. There have been several significant earthquakes in the region; however all have been located in Klamath and Lake Counties. Additionally, faults have been located in Klamath and Lake Counties. The region has also been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside the area as indicated in Figure 9.1. All considered, there is good reason to believe that the most devastating future earthquakes would probably originate along shallow crustal faults in the region.

[25] http://www.pnsn.org/INFO_GENERAL/eqhazards.html

Hazard History: prior to 2005

The most recent earthquake event in the area occurred in April 2004 with a two-day swarm of 100 to 200 small, unfelt earthquakes. The figure below charts recent events recorded in and around the Sisters Bulge.

Significant Earthquakes in the Central Oregon Region

Date	Location	Magnitude (M)	Remarks
Approx Yrs. 1400 BCE ,1050 BCE, 600 BCE, 400 CE , 750 CE, 900 CE	Offshore, Cascadia Subduction Zone	Probably 8-9	Based on Studies of earthquakes and tsunamis in Willapa Bay, Wa. These are the midpoints of the age ranges for these six events. BCE—Before the Common Era
Jan. 1700	Offshore, Cascadia, Subduction Zone	Approx. 9.0	Generated a tsunami that struck Or., Wa., Japan; destroyed Native Am. Coastal villiages
April 1906	North of Lakeview	V	Three felt aftershocks
April 1920	Crater Lake	V	One of three shocks
January 1923	Lakeview	VI	
March 1958	SE of Adel	4.5	
May-June 1968	Adel	4.7-5.1	Damage to homes. 20 earthquakes of M4. or greater were recorded between 5/28—6/24/68
September 1993	Klamath Falls	5.9 and 6.0	Series of earthquakes, the larges being M6. Damage to Klamath Falls—two related fatalities
Source: Wong, Ivan, Bolt, Jacqueline, 1995, A Look Back at Oregon's Earthquake History, 1841-1994, Ore. Geology, p.125-139			

Hazard History: 2005-2010

Contacts were made to state and federal agencies to inquire about data relating to flood activity during this time period. Representatives from Oregon Department of Geology and Mineral Industries (DOGAMI)[26] indicated that no specific hazard data was available through a search of their data catalog for the Prineville area, and a reference was provided for a new geological map that DOGAMI published in 2006. Link: http://www.naturenw.org/cgi-bin/quikstore.pl?store=maps&product=001447. DOGAMI also noted that Light Detection and Ranging (LDAR) was flown for the Crook County area but data will not be released until after the 2010 NHMP update is completed. LDAR is an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target.

[26] Email from Kaleena Hughes [mailto:kaleena.hughes@dogami.state.or.us] Monday, September 27, 2010 9:10 AM to Clay Moorhead, CDA Consulting Group Inc.

Another representative from DOGAMI[27] identified that they have several geologic publications that cover the parts of Crook County around Prineville. The following link identifies three field guides that cover the west part of Crook County. http://www.oregongeology.org/pubs/og/OGv69n01.pdf.

Although there have been no significant earthquake activity in Crook County during the past five years, notable earthquake activity continues to occur throughout the Pacific Northwest. Using a web search, data was discovered that identified earthquake data for the Pacific Northwest. Below is a listing of notable earthquakes that occurred from 2005-2010.

Notable Pacific Northwest Earthquakes since 2005 [28] (Most Recent First)

1. July 3, 2010 at 03:25:19.40 PM (PDT) -- Magnitude 3.1, W of Grants Pass, OR
2. June 17, 2010 at 07:23:24.47 AM (PDT) -- Magnitude 4.2, SSW of Yakima, Wa
3. May 25, 2010 at 05:21:0.62 AM (PDT) -- Magnitude 3.4, NW of Carnation, Wa
4. May 14, 2010 at 12:03:4.09 PM (PDT) -- Magnitude 3.0, WSW of Mt Hood, OR
5. March 29, 2010 at 02:27:12.12 PM (PDT) -- Magnitude 3.8, W of Ellensburg, WA
6. March 25, 2010 at 03:31:7.14 PM (PDT) -- Magnitude 3.2, NNW of Moses Lake, WA
7. March 25, 2010 at 03:31:7.29 PM (PDT) -- Magnitude 3.0, NNW of Moses Lake, WA
8. January 2, 2010 at 08:36:45.91 AM (PST) -- Magnitude 3.6, ESE of Maupin, OR
9. January 2, 2010 at 08:36:45.98 AM (PST) -- Magnitude 3.6, ESE of Maupin, OR
10. January 2, 2010 at 08:36:45.76 AM (PST) -- Magnitude 3.2, ESE of Maupin, OR
11. September 30, 2009 at 08:10:6.95 PM (PDT) -- Magnitude 3.4, NE of Satsop, WA
12. September 20, 2009 at 09:45:27.80 AM (PDT) -- Magnitude 2.3, NE of Mt Rainier, WA
13. July 2, 2009 at 03:40:10.55 PM (PDT) -- Magnitude 3.2, NNE of Poulsbo, WA
14. July 1, 2009 at 05:09:17.95 AM (PDT) -- Magnitude 3.7, SW of Mt Vernon, WA
15. May 4, 2009 at 03:47:42.59 AM (PDT) -- Magnitude 3.0, N of Richland, WA
16. April 20, 2009 at 02:41:52.38 PM (PDT) -- Magnitude 3.6, ESE of Maupin, OR
17. March 30, 2009 at 00:06:10.38 AM (PDT) -- Magnitude 3.6, SE of Mt Olympus, WA
18. March 20, 2009 at 03:44:50.77 PM (PDT) -- Magnitude 3.0, ESE of Maupin, OR
19. February 26, 2009 at 01:52:47.71 AM (PST) -- Magnitude 4.1, WNW of Grants Pass, OR
20. February 26, 2009 at 01:52:47.75 AM (PST) -- Magnitude 3.2, WNW of Grants Pass, OR
21. January 3, 2009 at 05:32:4.78 PM (PST) -- Magnitude 1.9, N of Richland, WA
22. January 30, 2009 at 05:25:3.99 AM (PST) -- Magnitude 4.5, ENE of Poulsbo, WA
23. December 27, 2008 at 03:32:35.74 PM (PST) -- Magnitude 3.6, ESE of Maupin, OR
24. November 16, 2008 at 07:54:30.65 AM (PST) -- Magnitude 3.4, ESE of Maupin, OR
25. October 18, 2008 at 10:22:21.08 PM (PDT) -- Magnitude 3.5, ESE of Maupin, OR
26. July 30, 2008 at 10:02:43.19 PM (PDT) -- Magnitude 3.6, SW of Mount Vernon, WA
27. July 23, 2008 at 08:36:42.42 AM (PDT) -- Magnitude 3.3, SW of Centralia, WA
28. July 14, 2008 at 11:45:55.08 AM (PDT) -- Magnitude 4.2, ESE of Maupin, OR
29. June 20, 2008 at 01:46:8.61 AM (PDT) -- Magnitude 3.2, ESE of Maupin, OR
30. June 1, 2008 at 09:46:28.17 AM (PDT) -- Magnitude 3.4, ESE of Maupin, OR
31. May 18, 2008 at 03:19:55.00 PM (PDT) -- Magnitude 3.7, ESE of Prosser, Wa
32. April 28, 2008 at 00:39:7.56 AM (PDT) -- Magnitude 3.1, ESE of Maupin, OR
33. April 21, 2008 at 11:40:40.06 AM (PDT) -- Magnitude 3.4, S of Darrington, WA
34. April 5, 2008 at 04:38:53.23 PM (PDT) -- Magnitude 3.6, ESE of Maupin, OR
35. March 20, 2008 at 01:03:58.77 PM (PDT) -- Magnitude 3.1, ESE of Maupin, OR
36. March 17, 2008 at 04:58:48.26 PM (PDT) -- Magnitude 3.3, E of Glacier Peak, WA
37. February 3, 2008 at 06:15:53.57 PM (PST) -- Magnitude 3.3, ESE of Maupin, OR
38. November 26, 2007 at 10:18:28.88 PM (PST) -- Magnitude 4.0, W of Poulsbo, WA

[27] Email from Jason McClaughry [mailto:jason.mcclaughry@dogami.state.or.us] Sent: Monday, September 27, 2010 10:03 AM to Clay Moorhead, CDA Consulting Group Inc.
[28] http://www.pnsn.org/SEIS/EQ_Special/pnwtectonics.html

39. November 21, 2007 at 07:02:6.63 AM (PST) -- Magnitude 3.3, ESE of Maupin, OR
40. November 12, 2007 at 08:05:14.76 AM (PST) -- Magnitude 3.1, SE of Diablo, WA
41. September 23, 2007 at 11:20:54.38 PM (PDT) -- Magnitude 3.6, WSW of Woodburn, OR
42. September 12, 2007 at 09:21:35.44 PM (PDT) -- Magnitude 3.0, SE of Friday Harbor, WA
43. July 11, 2007 at 08:53:21.01 PM (PDT) -- Magnitude 3.3, WSW of Canby, OR
44. June 14, 2007 at 02:57:56.94 PM (PDT) -- Magnitude 3.9, ESE of Maupin, OR
45. May 2, 2007 at 04:16:16.36 AM (PDT) -- Magnitude 3.3, ESE of Maupin, OR
46. April 8, 2007 at 02:40:41.22 AM (PDT) -- Magnitude 3.0, ESE of Maupin, OR
47. March 30, 2007 at 01:00:30.27 PM (PDT) -- Magnitude 3.0, SSE of Bellingham, WA
48. March 22, 2007 at 07:08:9.54 AM (PDT) -- Magnitude 2.9, SSW of Bremerton, WA
49. March 1, 2007 at 02:23:44.47 AM (PST) -- Magnitude 3.1, SE of Diablo, WA
50. March 1, 2007 at 02:07:31.97 AM (PST) -- Magnitude 3.6, ESE of Maupin, OR
51. January 26, 2007 at 01:23:49.30 AM (PST) -- Magnitude 3.2, WNW of Poulsbo, WA
52. January 20, 2007 at 00:12:41.16 AM (PST) -- Magnitude 3.0, ESE of Maupin, OR
53. December 20, 2006 at 01:43:26.16 AM (PST) -- Magnitude 3.3, WNW of Walla Walla, Wa
54. November 5, 2006 at 09:34:35.69 PM (PST) -- Magnitude 2.6, SW of Portland, OR
55. October 7, 2006 at 07:48:26.57 PM (PDT) -- Magnitude 4.5, E of Mt Rainier, WA
56. August 21, 2006 at 06:06:9.60 PM (PDT) -- Magnitude 3.0, ENE of Moses Lake, WA
57. August 3, 2006 at 01:39:18.70 AM (PDT) -- Magnitude 3.8, N of Portland, OR
58. July 24, 2006 at 11:13:37.88 PM (PDT) -- Magnitude 3.1, SSE of Entiat, WA
59. July 4, 2006 at 01:37:3.15 PM (PDT) -- Magnitude 3.6, SE of Victoria, BC
60. April 26, 2006 at 07:24:6.80 AM (PDT) -- Magnitude 3.0, ESE of Woodburn, OR
61. March 4, 2006 at 09:38:47.12 AM (PST) -- Magnitude 3.2, ENE of Newport, OR
62. February 2, 2006 at 05:47:46.73 PM (PST) -- Magnitude 3.3, WSW of Everett, WA
63. January 15, 2006 at 04:29:46.49 AM (PST) -- Magnitude 3.3, NW of Victoria, BC

Vulnerability Assessment

Although the region is vulnerable to earthquake induced landslides along side of volcanoes and strong ground shaking, little evidence is presented for these events specific to Crook County.

Prior to 2005, the 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. Both models are based on HAZUS, a computerized program, currently used by the Federal Emergency Management Agency (FEMA) as a means of determining potential losses from earthquakes. The CSZ event 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 model does not look at a single earthquake (as in the CSZ model); it encompasses many faults, each with a 10% change 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 unreinforced masonry building into consideration.

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning purposes. Despite their limitations, the models do indicate that damage would occur.

Risk Assessment

The Cascadia Subduction Zone generates a devastating earthquake on average every 500-600 years. However, as with any natural processes, 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. Smaller damaging earthquake occur more frequently and may happen at any time.

Establishing a probability for devastating or damaging earthquakes is difficult given the small number of historic events in the region. Earthquakes generated by volcanic activity in Oregon's Cascade Range are possible, but likewise unpredictable.

According to PNSN:

> Although scientists have tried for decades to predict earthquakes, no one has discovered a method which can be applied with regular success. For some areas with well-understood patterns of seismicity, it may be possible to forecast decades-long time windows when large earthquakes are likely to occur. However, the Pacific Northwest has only been monitored for a couple of decades; not long enough to allow us to see what patterns, if any, exist here. Seismologists are still trying to understand what types of earthquakes are possible here, and what kind of shaking we will experience from future earthquakes (depending on the earthquake location and size, and the site geology and topography). Earthquake hazards can be reduced by advance preparation; such as coordinating emergency communications and activities across jurisdictional lines, preparing personal emergency plans, and considering seismic hazards in land use plans, building codes, and planning for medical, utility, and emergency facilities.[29]

The County finds that there is significant history of devastating examples of volcano hazards in and around Crook County. With the exception of the impacts from Mount St. Helens, no other significant volcano event has impacted Crook County in the last century. The County vulnerability to a volcanic hazard is low; however if such an event were to occur, the maximum threat to the County is high due to the wide-spread damage that could occur. The overall probability of a severe impact in the next 35 – 100 years is currently anticipated to be low.

[29] http://www.pnsn.org/INFO_GENERAL/eqhazards.html

S3.8 LANDSLIDE HAZARD (Hazard Analysis Score = 132)

Landslides are defined as any detached mass of soil, rock, or debris that moves down a slope or a stream channel. Seldom if ever, can a landslide be attributed to a single cause. All landslides involve the failure of the earth under stress. Landslides are typically triggered by periods of heavy rainfall and/or rapid snowmelt. Earthquakes, volcanoes, and excavations may also trigger them.

Also, an intense wildfire may destroy vegetation and affect organic material so that with even normal rainfall, soil saturation may trigger a landslide. Locations with extremely steep slopes are most susceptible to landslides. Landslides on these slopes tend to move more rapidly and can be more dangerous than other landslides. Landslides are particularly common along stream banks, reservoir shorelines, and large lakes.

Although landslides are natural geologic processes, their incidence and impact on people and property can be exacerbated by human activities such as excavation and grading, drainage and groundwater alterations, and changes in vegetation.

Property damage from landslides throughout Oregon, including Crook County, continues to rise, in part due to increased development. Rapidly moving landslides present the greatest risk to human life, and persons living in or traveling through areas prone to rapidly moving landslides are at increased risk for serious injury. Rapidly moving landslides have also caused most of the recent landslide related injuries and deaths in Oregon.

Most of the landslides in Crook County associated with flood events have been rapidly moving debris flows. Identifying and mapping landslide-prone areas and planning for development are essential to help reduce the risks of landslide hazards to life and property in Crook County.

Hazard History: Prior to 2005
Landslides are a serious geologic hazard in almost every state in America. Landslides threaten transportation corridors, fuel and energy conduits, and communications facilities. While not all landslides result in property damage, many landslides impact roads and other infrastructure, and can pose a serious life-safety hazard. Growing population and an increase in housing demand has caused development to occur more frequently in hazard-prone areas.

No data source was referenced related to actual slide activity prior to 2005. This does not mean that landslides did not occur. There may have been numerous landslides that were not recorded, or where data did not exist to document the hazard activity. However, since devastating events would have been recorded, we assume that the history of impacts for landslides is low.

Hazard History: 2005 to 2010
Contacts were made to state and federal agencies to inquire about data relating to landslide activity during this time period. The Oregon Department of Transportation (ODOT) did identify work that is being developed by their agency on landslide prone areas within Crook County. More information regarding this data is located in Appendix B. The landslide prone areas that were identified by ODOT included areas that could potentially impact state highways. No other documented landslide activity was noted by these agencies. In addition a steering committee made up of emergency managers, responder agencies, and local, state and federal administrators led the effort to update the Crook

County Natural Hazard Mitigation Plan. The steering committee discovered no evidence of recorded landslide activity during this time period.

Vulnerability Assessment

The coordination effort to identify data related to significant landslide disaster activity in Crook County demonstrates a lack of vulnerability studies for locations other than the State's highway system. Although topographic and steep slope data is available, there are no correlation studies that pinpoint vulnerability locations that would impact buildings or people. Nonetheless, both the City of Prineville and Crook County have both implemented steep slope ordinances to regulate development in hazard-prone areas.

Landslides can affect services needed to support the Crook County population, including transportation systems, utilities, and property damage. The impacts from a devastating landslide could have a significant impact of maintaining critical lifelines to the area, and may cause economic damage to larger urban centers like the City of Prineville.

Risk Assessment

The Oregon Department of Transportation (ODOT) has completed mitigation planning with regard to landslide activities along the state highways system in Crook County. ODOT has identified information on landslides and rockfalls in Crook County. The information identifies the most problematic landslides and rockfalls will impact state highways. A comprehensive survey of highways 380 and 126 has not been completed by ODOT at this time.

Crook County finds that there is no significant history of devastating impacts from landslides. Although landslide could cause serious damage, the vulnerability of impacts to populations or property is low. However, if a serious landslide event were to occur, the maximum threat from this type of disaster would be high. The probability of a sever landslide event occurring within the next 35-100 year period is currently anticipated to be low.

SECTION 4 Action Items and Implementation

Crook County Natural Hazard Mitigation Plan 2010 Update

S4.0 General Introduction

The 2005 Crook County Natural Hazard Mitigation Action Plan (NHMP) included 42 short term and long term action items that could reduce the County's risk and vulnerability to natural disasters.

In 2010 the Crook County NHMP was updated through an extensive process that included numerous opportunities for public input. A steering committee was also established to assist in thoroughly reviewing the Plan's content and to update the action items. The committee found that they had completed many of the 2005 actions items and were continuing work on others. Some of the action items also fell within an "ongoing" category where continuous efforts were expected to occur. It was their opinion that these accomplishments had reduced Crook County's vulnerability and risk to natural disasters. They also noted that mitigation efforts need to continue, likely indefinitely. Through the review of the action items and the Plan's goals, the steering committee refined the actions that they believed provided the greatest benefit toward at enhancing the County's natural hazard preparedness. This included efforts to mitigate the vulnerabilities and risks of natural hazards.

A detailed list of changes to the actions included in the 2005 NHMP is provided in Appendix A: Memorandum of Action Item Changes.

This section lists the results of this effort and display the action items that are prioritized for work through the next Plan update cycle (2010-1015). The action items are intended to achieve compliance with national and state regulations and will aid in the reduction of effects of hazards on new, existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas.

S4.1 How Action Items Are Organized

The mitigation action items are a listing of activities in which county governments, agencies, associations and citizens can work on to reduce the risks associated with Natural Hazards. Each action item includes an estimate of the timeline for implementation.

The NHMP action items are grouped into seven hazard topics which include:

1. Multi-Hazard
2. Flood Hazard
3. Wildfire Hazard
4. Severe Winter Storm and Windstorm Hazard
5. Landslide Hazard
6. Earthquake Hazard
7. Volcano Hazard

Each section includes action items that are targeted to be addressed on either a short tem or long term basis. The action items include a description of the action step followed by implementation ideas, coordinating organizations, partner organizations, timeline, and Plan goals addressed.

Implementation ideas are identified as possible ways to successfully complete the action item. These steps are considered to be preliminary and may change as the action item is implemented. Coordinating organizations includes the public agency with regulatory responsibility to address natural hazards, or

that is capable of overseeing the implementation of the effort. Partner organizations include agencies or public/private sector organizations that may be able to assist with the implementation of action's efforts. The action items are intended to implement the overall goals of this Plan. So with each action item, one or more Plan goals are identified. This will aid the County in documenting the successes that are accomplished through each step of the way.

The components of each action item is as follows:

- ✓ *Action Item Identifier.* Each identifier includes information on whether the action is considered to be a Short-Term action items (ST) or a Long-Term action items (LT). Short-term action items are activities that city or county agencies may implement with existing resources and authorities within one or two years. Long-term action items may require new or additional resources or authorities, and may take between one and five years to implement.

  Each action item identifier is also is numbered and categorized by type of hazard including; multi-hazard (MH), flood (FL), wildland fire (WF), sever winter storm (SWS), landslide (LS), earthquake (E) and Volcano (V). The numbering of action items are not prioritized. The 2010 NHMP Update Steering Committee determined that it was important that each of the action items have equal weight (with the exception of being short-term or long term). The reasoning for this is that action items should be implemented as prudently as possible based upon the availability of staff and financial resources, and matched with programs that promote efficiencies through coordination and collaboration.

- ✓ *Ideas for Implementation.* Each action item includes ideas for implementation and potential resources, which may include grant programs or human resources.

- ✓ *Coordinating Organization.* The coordinating organization is the public agency with regulatory responsibility to address natural hazards, or that is willing and able to organize resources, find appropriate funding, or oversee activity implementation, monitoring, and evaluation. Coordinating organizations may include local, county, regional, agencies that are capable of or responsible for implementing activities and programs.

- ✓ *Partner Organizations.* The Partner Organizations are listed as well as agencies or public/private sector organizations that may be able to assist in the implementation of action items by providing relevant resources to the coordinating organization. The partner organizations listed in the Resource Directory of the Crook County Natural Hazards Mitigation Plan (Appendix D) include other are potential partners that may be able to provide assistance.

- ✓ *Timeline.* Action items include both short and long-term activities. Each action item includes an estimate of the timeline for implementation. Short-term action items (ST) are activities which county agencies are capable of implementing with existing resources and authorities within one to two years. Long-term action items (LT) may require new or additional resources or authorities, and may take between one and five years to complete. Some action items are listed as "ongoing", meaning that a continuous effort is anticipated throughout the life of the Plan.

- ✓ *Plan Goals Addressed.* The plan goals addressed by each action item are included as a way to monitor and evaluate how well the mitigation plan is achieving its goals once implementation begins. The plan goals are organized into the following areas:

    - Partnerships and Implementation
    - Emergency Services
    - Education and Outreach
    - Prevention
    - Property Protection
    - Natural Resource Protection
    - Structural Projects

The following includes the approved action items that were developed during the 2010 NHMP Update.

S4.2 Multi Hazard Action Items

ST-MH1: Sustain a public awareness campaign about natural hazards.
Implementation ideas: Inform and educate the public about potential natural hazards in Crook County, personnel preparedness, mitigation activities and opportunities, and options available when natural hazard events occur. The public awareness campaign may take many forms:

- Present hazard specific information at public workshops;
- Distribute preparedness and mitigation information at the Crook County Fair and other public functions;
- Disseminate the Crook County Emergency Operations Plan for families and county residents;
- Maintain a natural hazards display at the Bowman/Crook County Museum;
- Use Public Service Announcements to educate the public about emergency procedures;
- Survey the public to determine their level of preparedness and find out what deters them from taking preventative actions; and
- Develop a hazard information website that contains scientific facts about natural hazards, information on building codes, list of companies that provide insurance for specific hazards, and educational information on damage prevention.

Coordinating Organizations: Crook County Emergency Management
Partner Organizations: Bowman Museum, City of Prineville Planning/Crook County Planning, Crook County Fire, ODF, BLM, USFS
Timeline: Ongoing
Plan Goals Addressed: Education and Outreach, Prevention, Emergency Services

ST-MH-2: Develop public and private partnerships to foster natural hazard program coordination and collaboration in Crook County.
Implementation ideas:

- Coordination and implementation of county-wide and tri-county emergency management policies and procedures;
- Coordination of countywide emergency management training and exercises;
- Enhancing emergency operations preparedness, resources and facilities;
- Coordinating and collaborating available resources, grant opportunities, and other assistance;

- Disseminating information from Oregon Emergency Management and the Federal Emergency Management Agency.

Coordinating Organizations: Crook County Emergency Management
Partner Organizations: Prineville Emergency Management, Crook County Planning, Crook County Fire, ODF, BLM, USFS
Timeline: Ongoing
Plan Goals Addressed: Education and Outreach, Prevention, Partnership and Coordination

ST-MH-3: Maintain a GIS inventory of all critical facilities, large employers/public assembly areas, and lifelines, and use the GIS to evaluate their vulnerability by comparing them with hazard-prone areas.
Implementation ideas: Expanding and maintaining data on the County GIS databases containing information about natural hazards, land development, community infrastructure, and demographics. These data sets may be used to create hazard maps, assess risk and develop plans.
Coordinating Organizations: Crook County GIS
Partner Organizations: Prineville Emergency Management, Crook County Planning, Crook County Fire, ODF, BLM, USFS, Crook County Emergency Management, ARC, QWEST, Crook County Road, Prineville Public Works, Power Companies, OID
Timeline: Ongoing
Plan Goals Addressed: Education and Outreach, Prevention, Emergency Services

ST-MH-4: Promote natural hazards safety education.
***Implementation Ideas*:** Natural Hazards Safety Education includes earthquake duck-and-cover drills, fire safety training, facility lock down drills, evacuations drills, hazardous materials training, and hug a tree presentations. Natural hazards safety education may take place in schools, hospitals and businesses, as well as preparedness fairs and community events.
Coordinating Organizations: School Districts, Facility Safety Personnel, Search and Rescue
Partner Organizations: Prineville Emergency Management, Crook County Planning, Crook County Fire, ODF, BLM, USFS, OEM, FEMA, Association of Safety Engineers, Media, Utility and Telecommunications Companies
Timeline: Ongoing
Plan Goals Addressed: Education and Outreach, Prevention, Partnership and Coordination

ST-MH-5: Establish partnerships to coordinate and collect geo-science and technical information for identifying potential areas of risk.
***Implementation Ideas*:** Many public agencies in Crook County collect geo-science and technical for their own internal needs. Often these agencies contract with County GIS to work with their data and create specialized maps. With these agencies' permission, County GIS could use the data to develop hazard maps for Emergency Management and mitigation purposes. One key outcome would be the coordination of disparate vegetation mapping. This would allow wildland fire risk assessment to be done at large scale, rather than an individual parcel scale.
Coordinating Organizations: Crook County GIS, USFS GIS, BLM GIS, ODF GIS
Partner Organizations: Prineville Emergency Management, Crook County Planning, Crook County Fire, ODF, BLM, USFS, DOGAMI, USGS, NOAA, OEM, FEMA
Timeline: Ongoing
Plan Goals Addressed: Education and Outreach, Prevention, Partnership and Coordination

ST-MH-6: Maintain and enhance the systems that support populations with special needs. (e.g., elderly and disabled persons) during disaster.

***Implementation Ideas*:** Crook County and partner public and private organizations have developed a system that will serve people who have physical and cognitive disabilities that impair their mobility, sight, or ability to independently respond to disasters. The system currently includes an initial database available to 911 and Emergency Operations Center that shows the location of vulnerable populations. I will be important to:

- Coordinate with public and private organizations to continue to identify vulnerable populations;
- Establish and maintain protocols to update and maintain the database;
- Develop plans and exercises to integrate vulnerable populations with disaster response.

Coordinating Organizations: Crook County Emergency Management
Partner Organizations: Prineville Emergency Management, Crook County Health Department, County GIS, ARC
Timeline: 1-2 Years
Plan Goals Addressed: Education and Outreach, Prevention, Partnership and Coordination, Emergency Services.

ST-MH-7-Explore funding sources and grant opportunities for county-wide natural hazard mitigation activities.

***Implementation Ideas*:** Identify grants and appropriate loans for local governments, agencies, organizations and property owners to take a proactive role in hazards mitigation. There are different types of mitigation grant programs, for example, federal fire money for wildfire hazard mitigation, Hazard Mitigation Grant Program for various types of hazard mitigation, and flood mitigation assistance program.
Coordinating Organizations: Mitigation Plan Steering Committee
Partner Organizations: Prineville Emergency Management, Crook County Administration, OEM, FEMA
Timeline: Ongoing
Plan Goals Addressed: Education and Outreach, Prevention.

ST-MH-8: Evaluate security methods and processes to assess what types of data will have open public access versus restricted responder agency access. As an example should an inventory of critical facilities be available to the public or limited to use by emergency responder agencies.
***Implementation Ideas*:**

- Coordinate with local and state legal representatives to evaluate Oregon law;
- Assess emergency management data to determine if it contains sensitive or critical information;
- Develop protocols for access and distribution of sensitive data.

Coordinating Organizations: Mitigation Plan Steering Committee
Partner Organizations: Prineville Emergency Management, Crook County Administration, OEM, FEMA
Timeline: Ongoing
Plan Goals Addressed: Education and Outreach, Prevention.

LT-MH-1: Review the Crook County Emergency Operations Plan and the Natural Hazards Mitigation Plan on an annual basis. Conduct a complete review of the plans and have them officially promulgated by the approving authorities every 5 years.

***Implementation Ideas*:** Crook County Emergency Management will coordinate a plan review annually and a plan update at least every five years. During the complete reviews, the plans will be evaluated with respect to new requirements and action items.
Coordinating Organizations: Crook County Emergency Management
Partner Organizations: Prineville Emergency Management, Mitigation Plan Steering Committee, ARC, Law Enforcement Heads, Fire Heads, OSP, ODF, ODOT, ARNAG, ARES, OEM, FEMA
Timeline: Ongoing
Plan Goals Addressed: Emergency Services

LT-MH-2: Use hazard information as a basis for reviewing site-specific land use decisions.
***Implementation Ideas*:** Continually implement hazard mitigation policies and regulations.
Coordinating Organizations: Crook County Planning Department, Prineville Emergency Management
Partner Organizations: Crook County GIS
Timeline: Ongoing
Plan Goals Addressed: Prevention

LT-MH-3: Improve planning, notification, and training for volunteers.
***Implementation Ideas*:**

- Identify and prioritize how volunteers can assist during different types of disaster;
- Train volunteers about their roles and include them in community disaster exercises;
- Develop a notification process for volunteers that incorporates different thresholds of activation;
- Establish protocols for the registration and training of emergent volunteers;
- Evaluate the creation of a Community Emergency Response Team (CERT) countywide;
- Actively work to expand and encourage City and County government to expand community neighborhood watch programs.

Coordinating Organizations: Crook County Emergency Management
Partner Organizations: Crook County Administration, Prineville Emergency Management, Crook County SO, CERT, ARC, CCSO SAR, Crime Prevention
Timeline: 3-5 Years
Plan Goals Addressed: Education and Outreach, Partnership and Coordination, Emergency Services

LT-MH-4: Promote hazard resistant utility and telecommunication construction and maintenance methods.
***Implementation Ideas*:** Support and encourage utility and telecommunications companies to use construction and maintenance methods that are aligned with natural hazard preparedness practices.
Coordinating Organizations: Prineville Emergency Management, Crook County Planning
Partner Organizations: Crook County Emergency Management, ARES
Timeline: 3-5 Years
Plan Goals Addressed: Education Outreach, Prevention

LT-MH-5: Collect data for significant non-declared natural hazard events.
***Implementation Ideas*:** Damage information should be collected and stored locally for significant non-declared natural disasters. This information can include countywide damage totals for each event, with the idea that over time this data will show the geographic patterns of occurrence and vulnerability.
Coordinating Organizations: Crook County Emergency Management

Partner Organizations: Insurance Companies, OSU Extension, County GIS, County Building, County Planning
Timeline: Ongoing
Plan Goals Addressed: Education and Outreach, Partnerships and Coordination, Emergency Services

LT-MH-6: Develop a recovery plan for Crook County and Prineville from the effects of catastrophic hazards.
***Implementation Ideas*:** Develop a scenario based long-term recovery plan (Continuity of government plan) that identifies how Crook County and the City of Prineville will recover from a catastrophic event.
Coordinating Organizations: Crook County Emergency Management
Partner Organizations: Prineville Emergency Management, Crook County Administration, OEM
Timeline: 3-5 Years
Plan Goals Addressed: Partnership and Coordination, Emergency Services

S4.3 Flood Hazard Action Items

ST-FL-1: Coordinate river gauge information.
Implementation Ideas: Crook County Emergency Management, National Weather Service, and all watershed councils, can benefit from coordinated river gauge information that is tied into National Weather Service flood forecasting activities.
Coordinating Organization:NWS (Pendleton Office)
Partner Organizations: Watershed Councils, Cities, OSU Extension Service, USGS, WRD, USACE, BOR, private river gauges
Timeline: Ongoing
Plan Goals Addressed: Partnership and Coordination

ST-FL-2: Conduct a workshop for target audiences on National Flood Insurance Programs, mitigation activities, and potential assistance from FEMA's Flood Mitigation Assistance and Hazard Mitigation Grant Programs.
Implementation Ideas: Include information about the financial aspects of building (and rebuilding) in the floodplain. Present information on how other communities have addressed building in the floodplain. Selected target audiences can include: townhalls, realtors, lending institutions, surveyors, engineers, and government agencies.
Coordinating Organization: County Planning, County Emergency Management Agencies,
Partner Organizations: Watershed Councils, OEM, FEMA
Timeline: Annually
Plan Goals Addressed: Property Protection, Education and Outreach, Prevention, Partnership and Coordination

LT-FL-3: Update the Flood Insurance Rate (FIRM) Maps for Crook County using the 2010 FIRM maps.
Implementation Ideas: Work with FEMA to adopt the 2010 FIRM maps.
Coordinating Organization: Prineville Emergency Management, County Planning, County GIS
Partner Organizations: FEMA, DLCD
Timeline: 1 year
Plan Goals Addressed:Property Protection, Prevention, Partnership and Coordination

LT-FL-1: Encourage private property owners to restore natural systems within the floodplain, and to manage riparian areas and wetlands for flood abatement.
Implementation Ideas: In addition to encouraging private property owners, managing publicly owned riparian and floodplain areas for conversion to open space/parkland/greenway is key to restoring natural floodwater absorption capacities (i.e. Ochoco Creek Flood mitigation projects, Striker Field).
Coordinating Organization:Crook County/ Prineville Emergency Management
Partner Organizations:County Parks and Planning, FEMA, Watershed Councils, Cities, USACE, DSL
Timeline: Ongoing
Plan Goals Addressed:Property Protection, Natural Resource Protection

LT-FL-2: Preserve water quality by using storm water best management practices.

Implementation Ideas: Model standards could be the National Pollution Discharge Elimination System (NPDES).
Coordinating Organization:County Roads, DEQ
Partner Organizations: Watershed Councils, WRD, USACE,
Timeline: Ongoing
Plan Goals Addressed: Natural Resource Protection

LT-FL-3: Evaluate and asses the interest in County and City participation in the NFIP Community Rating System
Implementation Ideas: Participation in the NFIP Community Rating System could save residents considerable amounts money on insurance premiums.
Coordinating Organization: Prineville Emergency Management, County Planning, County Emergency Management Agencies
Partner Organizations: Watershed Councils, OEM, FEMA
Timeline: 3-5 Years
Plan Goals Addressed: Property Protection, Education and Outreach, Prevention, Partnership and Coordination

LT-FL-4: Coordinate with Ochoco Irrigation District to evaluate the vulnerability of Ochoco Dam to natural hazards.
Implementation Ideas:

- Share technical data as it becomes available;
- Consider the impacts of earthquake, floods and other natural hazards.

Coordinating Organization: County Emergency Management, OID, Water Master
Partner Organizations: Watershed Councils, USACE, BOR, WRD
Timeline: 3-5 years
Plan Goals Addressed: Education and Outreach, Prevention, Structural

S4.4 Wildland Fire Hazard Action Items

ST-WF-1: Continue to promote public awareness campaigns for individual property owners living in interface areas.

Implementation Ideas: Focus on individual community outreach efforts through:

- Working demonstrations of risk reduction measures (i.e. survivable space around structures; driveway, road and bridge specifications; and landscaping);
- Voluntary site visits by fire crews to consult with landowners about specific ways to reduce risk to their property and to identify properties that would not be saved if a wildfire event occurred;
- Mailings;
- Public service announcements in the media;
- Warn prospective buyers to ask about the level of fire protection available and fire insurance rating for properties in Crook County;
- Noxious weed abatement.

Coordinating Organization: Crook County Emergency Management
Partner Organization: Media, County Planning, OEM, FEMA,
Timeline: Ongoing
Plan Goals Addressed: Property Protection, Education and Outreach, Prevention, Partnership and Coordination

ST-WF-2: Continue to reduce wildfire fuels.

Implementation Ideas: Identify and implement methods of disposal or utilization of fire fuels removed from individual properties (i.e. prescribed fire application, fuel reduction through grass/timber/brush removal, small diameter forest product based industries, chipping etc.).
Coordinating Organization: Crook County Landfill, BLM, ODF, USFS
Partner Organization: County Planning, State Fire Marshal
Timeline: Ongoing
Plan Goals Addressed: Property Protection, Education and Outreach, Prevention, Natural Resource Protection

S4.5 Severe Winter Storm and Windstorm Hazard Action Items

ST-SWS-1: Coordinate with local and state agencies to collect and identify data that would assist in developing a vulnerability and risk assessment related to the possible effects of climate change, especially as it may be associated with draught and a reduction of the water table.

Implementation Ideas:

- Expand the conversation of natural hazards to include discussions on climate change and draught;
- Coordinate with local and state agencies and review data as it becomes available;
- Coordinate with the Oregon Water Master to review and evaluate historic water table data and compare to current conditions;
- Determine if sufficient data is available to conduct a vulnerability ad risk assessment.

Coordinating Organizations: Crook County Emergency Management, NHMP Steering Committee
Partner Organizations: Oregon Water Master, Prineville Emergency Management, Crook County Planning, Crook County Fire, ODF, BLM, USFS, DOGAMI, USGS, NOAA, OEM, FEMA, Crook County GIS.
Timeline: 1-3 years
Plan Goals Addressed: Education and Outreach, Prevention, Partnership and Coordination

S4.6 Landslide Hazard Action Items

LT-LS-1: Assess Crook County's and City of Prineville's Vulnerability to Landslides
Implementation Ideas: *After sufficient data is compiled about the landslide hazard in Crook County a more detailed vulnerability assessment should be completed.*
Coordinating Organization: County Emergency Management
Partner Organization: ODOT, DOGAMI, OEM, ODF, County Planning
Timeline: 1-2 years
Plan Goals Addressed: Property Protection, Prevention

S4.7 Earthquake Hazard Action Items

ST-E-1: Develop in-depth studies to determine county and region's vulnerability to earthquake.
Implementation Ideas:

- Work with OEM, DOGAMI, FEMA and USGS and expand existing studies to address scope of vulnerability;
- Communicate study findings with key stakeholders affiliated with public awareness, education, policy and mitigation strategies identified in study;
- If needed, make policy and procedure changes that support study results that mitigate earthquake hazards.

Coordinating Organization: County Emergency Management
Partner Organizations: OEM, DOGAMI, FEMA, USGS, Public Environmental Health
Timeline: 1-2 Years
Plan Goals Addressed: Prevention, Partnership and Coordination

ST-E-2: Promote building safety through nonstructural improvements.
Implementation Ideas:

- Publicize information on securing water heaters, book cases, filing cabinets, light fixtures and other items that can cause injuries and block exits;
- Work with local building supply outlets to feature checklists/retrofit kits for reducing nonstructural risk;
- Partner with Deschutes and Jefferson County Emergency Management to coordinate a booth at the Redmond Home Show to promote non-structural strategies and mitigation information.

Coordinating Organization: County Emergency Management
Partner Organizations: Local Business, Jefferson and Deschutes County Emergency Management
Timeline: 1-2 Years and ongoing. The Natural Hazard Mitigation update committee believes this is an important task that should continue to be developed as an ongoing effort.
Plan Goals Addressed: Prevention, Partnership and Coordination, Property Protection

S4.8 Volcano Hazard Action Items

ST-V-1: Provide a Volcanic Ash Mitigation Guidebook on the County Website for Citizens and businesses.

Implementation ideas:

- Develop public awareness through workshops and publications;
- Update the County web links include broader information related to volcanic ash mitigation.

Coordinating Organization: Crook County Emergency Management, USGS-CVO
Partner organization: DOGAMI
Timeline: 1-2 years
Plan Goals Addressed: Education and Outreach, Partnership and Coordination

SECTION 5 Plan Maintenance and Updating

Crook County Natural Hazard Mitigation Plan 2010 Update

Plan Maintenance and Updating

Regular Plan maintenance and updating allows this document to remain fresh and enables the County to advance its level of preparedness through the implementation of mitigation action items. Plan maintenance and updating is a process that combines open public involvement and the collection of new data to make informed decisions the assist in mitigating the disastrous effects on natural hazards, making the county more resilient to natural disasters.

Part of any successful plan is keeping the plan current through continuous maintenance. This Plan may be updated through a number of processes; including annual monitoring by the Crook County Office of Emergency Management, updating through the use of the NHMP Steering Committee, and a major update review during each 5-year Plan update cycle.

This Section of this document details the process that will ensure that the Prineville/Crook County Natural Hazards Mitigation Plan remains an active and relevant document. The plan maintenance process includes a schedule for monitoring and evaluating the Plan annually and producing a plan revision every five years. This section describes how the county will integrate public participation throughout the plan maintenance process.

Convener

Crook County Office of emergency Management

The Crook County Office of Emergency Management (CCOEM) will be the convener for the ongoing plan maintenance processes including:

- Annual review - The Prineville/Crook County Natural Hazards Mitigation Plan will be evaluated on an annual basis to determine the effectiveness of programs, and to reflect changes in land development or programs that may affect mitigation priorities;
- NHMP Steering Committee Plan implementation and updates – The CCOEM will lead the efforts to regularly involve the NHMP Steering Committee in ongoing activities;
- 5-year major review – The CCOEM will be responsible for compliance with FEMA's hazard mitigation planning requirements included in 44 CFR Part 201, including conducting a major review of the Crook County NHMP every five years.

The CCOEM is housed in the Sherriff's Department. CCOEM is the coordinating governmental office responsible for emergency preparedness, mitigation, response and recovery efforts for the Crook County.

Crook County Natural Hazard Mitigation Plan (NHMP) Steering Committee

The NHMP Steering Committee is a sub-committee of the Crook County Emergency Preparedness Committee (CCEPC). The CCEPC serves as the NHMP Steering Committee when conducting regular and routine activities associated with Plan implementation, maintenance, and amendments and updates to the NHMP. This committee is also responsible for continued public involvement and they involve additional key stakeholders and the general public in decision making processes involved with any amendments to the Plan.

The NHMP Steering Committee is made up of numerous responder disciplines, representatives of state agencies, local governmental agencies and the chamber of commerce. The committee meets on a monthly schedule and leads a multi-agency/multi-discipline effort to develop and implement

preparedness and response actions. The Prineville Emergency Management will be represented on the Committee.

Plan Adoption

The Crook County Court and City of Prineville Council will be responsible for adopting the Prineville/Crook County Natural Hazards Mitigation Plan and the City of Prineville Addendum to this Plan. These governing bodies have the authority to promote sound public policy regarding natural hazards. Once the NHMP has been adopted, the County Emergency Manager will be responsible for submitting it to the State Hazard Mitigation Officer at Oregon Emergency Management. Oregon Emergency Management will submit the updated NHMP to the Federal Emergency Management Agency (FEMA) for review. This review will address the federal criteria outlined in FEMA's Flood Mitigation Assistance program.

Ongoing Monitoring

The Crook County NHMP states that the County will review the Crook County Natural Hazards Mitigation Plan on an annual basis and conduct a complete review of the plans and have them officially promulgated by the approving authorities every 5 years[1]. Additional action items within the Plan are to sustain a public awareness campaign about natural hazards by informing and educating the public about potential natural hazards in Crook, and to develop public and private partnerships to foster natural hazard program coordination and collaboration in Crook County[2]. Achieving these actions will ensure that ongoing processes will occur to tracking and implement the Plan.

Topics that the Steering Committee could consider include:

- Ongoing prioritizing of action items and work plan
- Delegation of action item management and implementation
- Tracking and monitoring action item implementation
- Consideration of changes or appropriateness of action items
- Consideration of new information that could change assumptions, the risk assessment, or implementation actions of the Plan
- Natural hazard preparedness exercises

Ongoing Monitoring Steps include:

1. The CCOEM will be responsible for conducting and documenting progress made on the Crook County NHMP on an annual basis. The CCOEM will review each action item to track and document progress made.

2. Although the CCEPC meets monthly, the CCEPC should act as the NHMP Steering Committee and be convened once a year. The purpose of the annual review meeting will be to consider the annual review report prepared by the CCOEM, to determine the effectiveness of efforts made to implement the Plan, to promote public involvement and to consider new information, changing situations in the County, as well as changes in state or federal policies.

3. Document successes and any modification to the Plan's priorities or actions. If significant changes to the Plan are warranted, the Steering Committee shall forward a report identifying their conclusions to the Crook County Court for their review and consideration.

[1] Mitigation Action Item LT-MH-1
[2] Mitigation Action Items ST-MH1 and ST-MH-2

Crook County NHMP Review Schedule:

Year 1 (2011): Review risk assessment information and actions for implementation progress and prioritization. Document outcomes.

Year 2 (2012): Review risk assessment information and actions for implementation progress and prioritization. Document outcomes.

Year 3 (2013): Review risk assessment information and actions for implementation progress and prioritization. Document outcomes.

Year 4 (2014): Begin formal 5-year update of the NHMAP. Review Risk Assessment and actions to include new data if applicable.

Year 5 (2015): Formal Update of the NHMAP for FEMA review. During the five-year review, the Plan will be updated to meet current federal and state requirements through a public process that supports the mission of this Plan.

Implementation through Existing Programs

Crook County addresses statewide planning goals and legislative requirements through its Comprehensive Land Use Plan, capital improvement plans, and County building codes. The Natural Hazard Mitigation Plan provides a series of recommendations that are closely related to the goals and objectives of existing planning programs. Crook County will have the opportunity to implement recommended mitigation action items through existing programs and procedures.

Economic Analysis of Mitigation Projects

The Federal Emergency Management Agency's approaches to identify costs and benefits associated with natural hazard mitigation strategies or projects fall into two general categories: benefit/cost analysis and cost-effectiveness analysis. Conducting benefit/cost analysis for a mitigation activity can assist communities in determining whether a project is worth undertaking now, in order to avoid disaster-related damages later. Cost-effectiveness analysis evaluates how best to spend a given amount of money to achieve a specific goal. Determining the economic feasibility of mitigating natural hazards can provide decision-makers with an understanding of the potential benefits and costs of an activity, as well as a basis upon which to compare alternative projects.

Continued Public Involvement

The City of Prineville and Crook County are dedicated to involving the public directly in the continual review and updates of the Natural Hazard Mitigation Plan. Copies of the plan will be catalogued and kept at all of the public libraries in the County. The existence and locations of these copies will be publicized on the Crook County and City of Prineville website. This site will also contain contact information where questions or comments can be made. The plan also includes the address and the phone number to the Crook County Office of Emergency Management.

Appendix A Acronyms

Crook County Natural Hazard Mitigation Plan 2010 Update

A1.0 Acronyms

The following acronyms are used in the action plan and are provided here for clarification.

ARC	American Red Cross
ARES	Amateur Radio Emergency Services
BLM	Bureau of Land Management
CCFR	Crook County Fire and Rescue
CCSO	Crook County Sheriff's Office
CDBG	Community Development Block Grant
CERT	Community Emergency Response Team
CPW	Community Planning Workshop (University of Oregon)
CVO	Cascade Volcano Observatory (USGS)
DEQ	Department of Environmental Quality (State of Oregon)
DLCD	Department of Land Conservation & Development (State ofOregon)
DOGAMI	Department of Geology & Mineral Industries (State of Oregon)
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FMA	Flood Mitigation Assistance (FEMA Program)
FTE	Full Time Equivalent
GIS	Geographic Information System
HMGP	Hazard Mitigation Grant Program
HUD	Housing & Urban Development (United States)
IISOI	Insurance and Information Services of Oregon & Idaho
LEPC	Local Emergency Planning Committees
MCIC	Mass Casualty Incident Committee
NCDC	National Climate Data Service
NFIP	National Floodplain Insurance Program
NHMP	Natural Hazard Mitigation Plan
NOAA	National Oceanic & Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
ODF	Oregon Department of Forestry

ODOT	Oregon Department of Transportation
OEM	Office of Emergency Management (Oregon State Police)
OIT	Oregon Institute of Technology
ONHW	Oregon Natural Hazards Workshop (University of Oregon)
OSP	Oregon State Police
OSSPAC	Oregon Seismic Safety Policy Advisory Commission
PPD	Prineville Police Department
PP&L	Pacific Power & Light

Appendix B

Hazard Background Information

Crook County Natural Hazard Mitigation Plan 2010 Update

This appendix contains addition background information related to each of the hazards that shape Crook County's hazard mitigation programs.

Sections: Page

B1.0 FLOOD HAZARD

B1.1 Flood Impacts in Crook County

As floodwaters rise and overflow riverbanks, homes and other properties within and near the floodplain are impacted. Most urban and developed areas in Crook County are on valley floors, along rivers and streams, and most of the city of Prineville is built on a natural floodplain.

Fast moving water in the floodway can cause severe damage and dramatic change. Buildings in the way of fast moving water can be washed off their foundations and vehicles can float away. Meanwhile, other structures become vulnerable when fast moving water is combined with debris. Bridge support structures can be battered, destroying the bridge, or leaving it unsafe for use. Power lines and pipelines can also be damaged or lost to the debris carried in fast-moving water.

Prior to the 1998 flood event, most of the bridges that crossed the Ochoco Creek were built with a pier construction. These bridges had pier supports that were physically located in the river. During the May 1998 flood, swollen Ochoco Creek carried trees and debris into the City of Prineville. The debris was large enough to get caught up in the bridge piers causing the debris to pile up on bridges near the downtown area. The debris jams created a damming effect around the bridge structure that causing the flood waters to rise and move away from its natural water course. Bridges, roads, and utilities needed significant repairs resulting from this flood. As a result the flood, the City of Prineville and Crook County, together with financial support from state and federal programs have replaced four of the pier support bridges with free span bridge construction.

Shallow, slow moving water is less destructive, but often more costly, and accounts for most of the flooding damage in Crook County. Saturation damage occurs in basements and ground floors of houses that are inundated by floodwaters, soaking the contents of the houses, as well as the building materials. This type of flooding occurs not only within the floodplain, but also in areas where the land around the building is not able to drain the water faster than it can accumulate. Most of the losses Crook County residents suffered in the 1998 flood were due to saturation damage.[1]

Development raises the base-flood elevation by forcing the river to compensate for the flow space obstructed by the inserted structures. Over time, when structures or materials are added to the floodplain, and no fill is removed to compensate, serious problems can arise.

B1.2 Flood Causes and Characteristics

Many types of flooding occur in Crook County, including riverine, flash, shallow, and urban flooding. Following are descriptions of each type of flooding and their effects in Crook County.

Riverine Floods

Riverine floods, or over-bank flooding of rivers and streams, are the most common form of flooding. Most communities in Crook County have the potential to experience this riverine flooding after spring rains, heavy thunderstorms, or snowmelt. These floods can be slow or fast rising, but generally develop over a period of days. The most severe flooding conditions generally occur when direct rainfall is augmented by snowmelt, like the 1952 New Years Day flood and the May 1998 flood.

[1] City of Prineville/ Crook County Flood Mitigation Action Plan, Clay Moorhead, CDA Consulting Group Inc. (2000)

Flash Floods
Flash floods are a major cause of weather-related deaths in the United States. Flash floods usually result from intense storms dropping large amounts of rain within a brief period. Flash floods occur with little or no warning and rivers can rise in a manner of minutes. Flash floods are most common in arid and semi-arid areas where there is steep topography, little vegetation and intense but short-duration rainfall.

Crook County, located in a high desert region, is prone to this type of flooding. Steep topography combined with clearing of vegetation for development and timber production causes rapid runoff of rainwater. Flash floods occur in both urban and rural settings in Crook County, principally along smaller rivers and drainage ways. Covering land within cities with non-permeable surfaces and the construction of storm water drainage systems compound the effects of flash flooding. Storm water systems are designed to move the rainwater quickly out of the city, and into the local drainage way. This additional rapid infusion of water can push rivers over their banks, and literally create a wall of water moving downstream. In flash flood situations, waters rise rapidly, move at high velocities, and often contain large amounts of debris.

Occasionally, floating debris or ice can accumulate at a natural or man-made obstruction and restrict the flow of water. Water held back by ice jams or debris dams can cause flooding upstream. Subsequent flash flooding can occur downstream if the obstruction suddenly releases. Additionally, manmade structures like dams that retain water in reservoirs can fail and create flash flood downstream.

In August 1991 Crook County experienced a flash flood that was caused when a thunder storm dumped a large amount of water into the Newsome Creek drainage. Although Newsome Creek is located in a sparsely populated region of Crook County, the tragic flash flood cost the Crook County Community both human life and agriculture property damage.

Dams, or impoundments, can mitigate the effects of some types of flood events by storing runoff from large storms and releasing it slowly. Conversely, dams can cause flooding as well, by failing and releasing a flash flood down the river channel. The city of Prineville sits below two large reservoirs. The closest is the Ochoco dam located 6 miles east of Prineville. The Ochoco is a hydraulic fill structure that was constructed following WWI and rehabilitated by the Bureau of Reclamation in 1949 to increase the reservoir capacity.

Shallow Area Flooding
Shallow area flooding is a special type of riverine flooding. FEMA defines shallow flood hazards as areas that are inundated by the 100- year flood with water depths of one to three feet. Shallow area flooding is generally caused by broad, slow moving water on the floodplain.

Urban Flooding
As land is converted from fields or woodlands to paved surfaces, it loses its ability to absorb rainfall. This transition from permeable to impermeable surfaces results in more water running off instead of filtering into the ground. Thus, water moves faster to waterways, resulting in flow levels rising above historic, pre-development levels. 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, localized flooding.

Storm water systems are a benefit to urban areas, by quickly removing captured rainwater. However, they can be detrimental to areas downstream because they cause increased stream flows due to the rapid influx of captured storm water into the waterway. It is very important to evaluate storm water systems in conjunction with development in the floodplain to prevent unnecessary flooding to downstream properties.

Another cause of urban flooding is grading associated with development. Grading may cause changes in drainage direction from one property to another.

B1.3 Community Flood Issues

Human Life
Protection of human life is of primary importance. This issue is tied to several other community issues. Keeping homes safe from floodwaters will also help protect human life.

Critical Facilities/Lifelines
The City of Prineville is divided by the Ochoco Creek, and the major regional hospital is located on the north side of the river. If the Ochoco floods and blocks access across the valley, people on the south side of the valley will be cut off from the primary medical facilities in the county. Additionally, fire, Emergency Medical Services (EMS), and law enforcement response could be severely limited if roads and bridges were made impassable due to floodwaters.

B1.4 Private Property

Homes
Private homes that are built in flood prone areas are of particular concern. In 1996, flood damage to private property totaled one-third of damages statewide. Crook County had insurance claims that totaled nearly $1.5 million for the 1998 flood event.

Manufactured Homes
Statewide, the 1996 floods destroyed 156 housing units. Of those units, sixty-one percent were mobile homes and trailers. Numerous manufactured home parks are located along Ochoco Creek in Crook County. Many older manufactured home parks are located in floodplain areas. Manufactured homes have a lower level of structural stability compared to traditional lumber-built homes. Manufactured homes in floodplain zones should be anchored to provide additional structural stability during flood events. Crook County and Prineville regulate building codes for new construction and the placement of manufactured homes within the floodplain. These codes require methods and practices to minimize flood damage.

Businesses
The economic losses due to business closures often total more than the initial property losses that result from flood events. Business owners and their employees are significantly impacted by flood events. Direct damages from flooding are the most common impacts, but indirect damages, such as diminished clientele, can be just as debilitating to a business. Following the May 1998 flood, businesses in Prineville

suffered direct damage from high water, and reduced water service resulting from damage to the public water system.

B1.5 Public Infrastructure Flood Issues

Buildings and Roads
In 1996, Oregon and parts of Washington experienced a devastating flood event, in Oregon, damages to public buildings represented 34% of total public losses. Public buildings such as libraries, schools and government buildings are of concern to the county due to their potential utility in the event of a flood. These buildings house critical governmental services and can be used as temporary locations for medical and emergency housing services. Road systems are important to the local economy, and during hazard events, resilient road connections are critical for providing essential and emergency services. Roads are maintained by multiple jurisdictions. Federal, state, county, and city governments all have a stake in protecting roads from flood damage. Road networks in Crook County frequently cross floodplain and floodway areas.

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

1. Bridges are often important links in road networks, crossing watercourses or other significant natural features.
2. Bridges can be obstructions in the floodway, collecting debris and inhibiting the flow of water during flood events. This can cause water to back up and inundate areas upstream from the bridge that would not otherwise be affected.

A number of pier construction bridges that crossed Ochoco Creek obstructed the flow of water and began collecting trees and other debris flowing down the stream. During the flood, heavy equipment was used to remove debris as it floated downstream towards the bridges. After the flood event, the bridges required significant repair work. The Juniper Street, Main Street, Deer Street and Harwood Street bridges have all been replaced since the 1998 flood. The new bridges are all designed with open span construction, allowing debris to pass through with little impact to the stream. The Elm Street bridge is the only one left with pilings in the steam. As of the 2010 update, it was on the State ODOT list to be replaced in 2014. The City of Prineville is working to expedite the timing to reduce the flood hazard for the area.

Wastewater and Drinking Water Systems
Flood events significantly impact drinking water and waste water systems. When sewer systems are inundated with floodwaters, raw sewage can be flushed into the waterways, posing a significant health hazard. Additionally, drinking water supplies can be contaminated with flushed wastewater or high levels of solids (eroded soil for example), and made unsafe for consumption. Both water and sewage systems often require significant repair and maintenance work following a significant flood event. During the 1998 flood portions of Prineville's surface streets were underwater. As a result the sewer systems located within the street flooded. Although sewer can come out of a flooded manhole, no data is available to identify if contamination occurred during the flood event. However, floodwater rushing into the sewer system did cause problems to the waste water treatment facility. Records show that

flood water overwhelmed the treatment and holding capabilities of Prineville's waste water treatment facility.

Storm Water
Storm water systems collect and concentrate rainwater and rapidly deliver it into the local waterway. This infusion of water causes increased flows downstream. During large rainstorms and flood events, these systems are pushed past their capacity and storm water begins flowing over-ground, causing other infrastructure damage. Traditional storm water systems are a benefit to urban areas by quickly removing captured rainwater, however, they can be detrimental to areas downstream.

Other problems often develop where open ditches enter culverts or go underground. The filling of ditches and swales near buildings can inhibit or prevent the flow of water that can compound these problems. Inadequate maintenance, especially following leaf accumulation in the fall, can also contribute to the flood hazard in urban areas.

Parks and Open Space
Public parks and publicly owned openspace that are located in the flood hazard areas can provide a buffer between flood hazards and private property. Wetlands in public ownership can reduce flood impacts by absorbing floodwaters and buffering water level fluctuations.

Power Supply
Flooding also significantly impacts electrical supply systems. Floodwaters may cause electrical lines to short-out and cause transformers to fail. Additionally, debris transported by floodwaters can knock down power poles and put live, high-voltage lines in the water, posing a serious electrocution hazard to people.

Communications/Phone Lines
Telephone and cable lines are similarly susceptible to floodwaters and floating debris. Underground lines are more resistant to flood damage, but can be exposed and damaged by swift currents.

B1.6 Federal Programs

Anticipating and planning for flood events is an important activity for Crook County. Federal programs provide insurance and funding to communities engaging in flood hazard mitigation. The Federal Emergency Management Agency (FEMA) manages the National Flood Insurance Program (NFIP). The agency also administers grant programs through grants to reduce the risks of natural disasters and losses to property or people through projects and programs that mitigate the impacts natural disasters. These programs provide grant money to local governments for hazard mitigation efforts and owners of properties who have suffered losses from natural hazard events.

The National Flood Insurance Program (NFIP)
The NFIP is a federal program administered by the Federal Emergency Management Agency (FEMA). The function of the NFIP is to provide flood insurance to homes and businesses located in floodplains at a reasonable cost, and to encourage the location of new development away from the floodplain. The program maps flood risk areas, and requires local implementation to reduce the risk, primarily through restricting new development in floodplains. The maps are known as Flood Insurance Rate Maps (FIRM). Crook County's FIRM was last updated in July of 1989. New maps have recently been developed for the

Crooked River and Ochoco Creek. The new maps include advances in mapping for the area together with hydraulic modeling to increase the accuracy of the floodplain zones. The new maps are currently in the final stages of review and are anticipated to b e adopted immediately following this 2010 update.

Participation in the NFIP requires the adoption and enforcement of a local floodplain management ordinance that controls development in the floodplain. This type of ordinance is currently in effect in Crook County and the City of Prineville and Crook County and the City of Prineville are participating in the NFIP. The total claims from this program in Crook County since 1981 total over $1.6 million. No new claims have been identified during the 2005 to 2010 five-year update cycle.

Community Rating System (CRS)
Another program under the NFIP is the Community Rating System (CRS). This voluntary program recognizes and rewards efforts that go beyond the minimum standards of the NFIP. This recognition is in the form of reduced flood insurance premiums for communities that adopt such standards. CRS encourages voluntary community activities that reduce flood losses, facilitate accurate insurance rating, and promote flood insurance awareness.

Crook County and the City of Prineville do not yet participate in the CRS. If Crook County and the City of Prineville did participate, it may have a rating as high as 8, which would give the citizens of Crook County a 10% discount on flood insurance premiums. Crook County and City of Prineville will continue to weigh the costs and benefits of the program.

Hazard Mitigation Grant Program (HMGP)
The HMGP is administered by the Federal Emergency Management Agency (FEMA) and provides grants to state and local governments to implement long-term hazard mitigation measures after a federal disaster declaration. It is important to stress that the HMGP is available only after the president has issued a federal disaster declaration.

Following the flood event of 1998, Crook County and the City of Prineville received a presidential disaster declaration and applied to the HMGP program. The funding that Crook County received was applied to a variety of projects throughout the county. An example of the types of projects already completed is described below:

- **City of Prineville –** *Developed a ponding area West of Ochoco Creek Park*
- **City of Prineville –** *Replacement of several Ochoco Creek bridges damaged by the 1998 flood.*
- **City of Prineville –** *Acquired properties in the floodplain along Ochoco Creek and developed a Storm Water Management and Flood Mitigation Action Plan*
- **Crook County –** *Upgraded several bridges along Ochoco Creek*
- **Crook County** - *Home Elevation Projects along Ochoco Creek*
- **City of Prineville** - *Home Elevation Projects along Ochoco Creek*

B1.7 State Programs

State Land Use Planning Goals
There are 19 statewide planning goals that guide land use in the State of Oregon. One goal in particular focuses on land use planning and natural hazards:

Goal 7: Areas Subject to Natural Disasters and Hazards, requires local governments to shall adopt comprehensive plans (inventories, policies and implementing measures) to reduce risk to people and property from natural hazards. Natural hazards for purposes of this goal include floods, landslides, earthquakes and related hazards, tsunamis, coastal erosion, and wildfires. Local governments may identify and plan for other natural hazards.

B1.8 Local Programs

Local Governing Regulations

There are three primary local governments with that regulate and plan for lands with Crook County. These include Crook County, the City of Prineville and the Crook County Park and Recreation District.

Crook County Regulations

Crook County Comprehensive Plan Policies were adopted to set standards and guidance for development within the 100 year floodplain. The County policies that are in effect as of the 2010 update include:

FLOODPLAIN POLICIES

It shall be the policy of Crook County to recognize the 100-year floodplain areas as the minimum areas which could be inundated by flood, and to require strict controls for development near, or presently within them. The following shall be considered in relation to development in floodplain areas:

1. High density development shall occur as far from the floodplain as possible.
2. Building and engineering requirements such as drainage systems, minimum floor elevations, and diking as set forth by federal regulations shall be required within areas that could potentially have high water problems.
3. Construction standards established by the Federal Insurance Agency for Emergency Program Aid shall be observed; these include:
    a. Proper anchoring of structures.
    b. Use of construction materials that will minimize flood damage.
    c. Adequate drainage of new subdivisions.
    d. New or replacement utility systems are to be located and designed to preclude flood loss.
    e. All new construction or improved/repaired structures in flood hazard areas are to be elevated or flood-proofed to the 100-year elevation.

It shall be the policy of Crook County to identify and maintain floodways in their natural undeveloped condition in order to:

1. Minimize meander and bank erosion damage.
2. Provide an unobstructed channel for flood waters to provide conditions for minimum velocity and stream flow.
3. To reduce flood damage in areas not protected by flood control structures.
   The portion of the floodplain nearest the stream channel shall be considered best suited for:
    a. Grazing, hay and grain fields, orchards, truck gardens, nurseries, or other open space agriculture.

b. Parks, playgrounds, golf courses, ball fields, or other recreation not involving structures.
c. Locations of utility lines.
d. Storage during non-flood seasons.

The county Floodplain Overlay ordinance was first implemented in 1978 and was amended by Ordinance 18 in 2003. The Floodplain Overlay ordinance has been accepted by the Land Conservation and Development Commission as sufficient to comply with Statewide Goal 7 for flood hazards, and meets the minimum requirements for NFIP eligibility.

Prineville Regulations
Likewise the City of Prineville also has Comprehensive Plan policies related to the protection of the floodplain. These policies include:

The Prineville Comprehensive Plan states –

Chapter 3 Natural Environment
Goal # 1: Protect and enhance identified Goal 5 resources and other features of the natural environment using a variety of methods and strategies

Natural Environment Values and Policies

- Programs are needed to address the protection of the natural environment in a balanced and fair fashion given the urban development goals of the City. Prineville's limited protection program achieves an appropriate balance between urban development needs (employment, housing, schools, parks and institutions), conservation of significant natural resources, and protection of life and property from natural hazards.
- The creeks and rivers that traverse the community need special setback protection and corridor enhancement. Prineville has applied a three-tiered protection program that recognizes different levels of development that have occurred near Ochoco Creek, Crooked River, and the Hudspeth and Ryegrass Drainages.
- The Prineville community has long experience with damaging floods. Prineville will amend the floodplain ordinance to incorporate a "no net loss of flood storage capacity" standard. Significant riparian corridors and wetlands within the 100-year floodplain will have a high level of protection.
- Update and modify development regulations to provide protection of Goal 5 and other natural resources, reduce potential for flooding, and encourage private and/or public-private partnerships to protect and enhance sensitive natural areas.

In addition both the Crook County and the City of Prineville have specific development ordinances that set standards for all properties located within the floodplain.

Floodway development is currently regulated and Crook County (and FEMA[2]) requires engineering ("no rise") certification that the proposed developments will not cause the base flood (100 year flood) elevation to rise more than 1.0 foot. Displacement of a few inches of water can mean the difference between no structural damage occurring in a given flood event and the inundation of many homes, businesses, and other facilities. Careful attention must be paid to development that occurs within the

[2] Section 60.3 (d) (3) of *the National Flood Assistance Program Regulations*

floodplain and floodway of a river system to ensure that structures are prepared to withstand base flood events.

The City of Prineville has also adopted a flood regulation code in 1999 which is identified as Section 151 of the City's development regulations. The code is intended to comply with all state and federal requirements applicable at the time of its adoption.

The City has also adopted the Natural Features Overlay District (NFOD) & Slope Hazard Requirements (Chapter 155). The Purpose section of the NFOD states the "Chapter implements the Prineville Comprehensive Plan by protecting significant natural features and mitigating against potential natural hazards as mapped and described in the adopted Prineville Natural Features Inventory."

Crook County Park and Recreation District
Crook County Park and Recreation District has adopted a comprehensive plan that incorporates a Greenway Vision. The greenway vision is described in the District's key findings as follows:

> Key Findings:
> Based on input from the community, the following themes are important to the community and should be considered as high priorities for the District.
>
> River Greenways – The development of a river greenway concept along Ochoco and McKay Creeks and the Crooked River has extensive support in the community. (Key Finding #5)

The greenways are mapped on the Parks Vision map abutting the Crooked River and Ochoco Creek.

B2.0 WILDFIRE HAZARD

Introduction

Wildland fire plays a large, reoccurring and high impact role as a natural hazard in Central Oregon. While Crook County has experienced only one large wildland-urban-interface (WUI) fire within the last decade, it has also been the setting for several smaller interface fires with significant potential for major impact on interface areas and critical infrastructure. Neighboring counties have experienced numerous, high impact WUI fire incidents providing Crook County emergency managers insight into the complexities of such incidents. Crook County residential development is expanding further into sites traditionally covered by wildland vegetation bringing with it the potential for the wildland-urban interface scenarios envisioned by Congress when they passed the "Healthy Forest Restoration Act of 2003."

In 2005, Crook County completed its initial Community Wildfire Protection Plan. It was subsequently updated in 2007 and is currently being updated to reflect conditions through 2010. Beginning in 2007, Crook and Deschutes Counties have jointly been the recipients of two FEMA Pre-Disaster Mitigation Grants to treat hazardous vegetation in wildland-urban interface areas. With the support of these grant funds, *Crook County-Fire Ready*, a wildfire safety preparedness framework, has been initiated to provide community focus on mitigation activities.

Crook, Deschutes and Jefferson counties are often grouped into a single region for Wildland fire planning and mitigation efforts. Since 1990 there have been at least thirteen larger WUI fires within the tri-county area. Between 2005 and 2010 there were no large scale fires in Crook County. This is partly due to the mitigation efforts being conducted by local authorities to fuels. It has been noted that fuels are the real driving component of the WUI fire risk.

In Crook County on private land, there is no structural fire protection for areas outside of the Crook County Rural Fire Protection District and there is no wildland fire protection for private wildland areas outside of the Oregon Department of Forestry Central Oregon District boundary. Wildland fire protection on U.S. Forest Service and Bureau of Land Management managed public lands is provided by those agencies.

Attempts to develop a legislative solution to address this issue over the last decade have been unsuccessful. Because these types of areas have no protection organization and because of the light, flashy nature of the fuel types present in some areas, wildland fires have the potential to get quite large often spreading to the point where they become a threat to protected areas.

The Office of the Oregon State Fire Marshal and the Oregon Department of Forestry have recently renewed a policy level discussion Catastrophic Structural Fire Protection for unprotected areas within the state. A set of proposed principles have been developed to facilitate a review process of this issue.[3]

There are likewise substantial resource commitment and fiscal costs associated with emergency response to these incidents. As an example, this impact on local organizations in adjoining Deschutes and Jefferson Counties, was demonstrated by the multiple agency and organizational response in 2003 to the Davis Fire, Link Fire and the B & B Complex. The costs associated with multiple day mobilization

[3] "Catastrophic Structural Fire Protection-Unprotected Areas Policy Discussion, Proposed Principles"., Office of Oregon State Fire Marshal and Oregon Department of Forestry. April 2004.

of law enforcement, search and rescue and structural fire assets can quickly deplete these local agency budgets. Residential evacuation trigger American Red Cross mobilization and when major transportation routes are impacted, Oregon Department of Transportation and county Road Department personnel are also mobilized. Depending on the scope and specifics of an individual fire, additional agency and non-governmental support organizations may also be mobilized to help mitigate the impact on citizens and community infrastructure.

The rapid rates of spread and fire intensity observed in the recent past have raised the awareness level of the public and local public safety officials. Public safety and structural mobilization, at some level, occurs shortly after the initial smoke report for every wildland fire with urban interface threat potential. In these types of events, mobilization costs are incurred whether or not the fire directly impinges on population concentrations and structural development. Impacts on state highways from smoke, the fire front or the need to shut down a highway segment to facilitate an evacuation brings Oregon Department of Transportation and Oregon State Police into the picture. In a similar manner, even modest scale residential evacuations trigger sheltering and support activities from the American Red Cross.

The Davis and Link fires and the B&B Complex from 2003 (Deschutes, Jefferson and Klamath Counties) illustrate this potential impact.

The Davis Fire started in Klamath County just to the southwest of LaPine, ultimately burning about 21,000 acres. While this fire remained on the Deschutes National Forest, the threat to down-wind communities required a massive mobilization of law enforcement, search and rescue, ODOT and structural fire resources from both Klamath and Deschutes counties to address the potential spread. Ash fall from this incident was reported in Prineville, some 60 miles to the northeast of the fire.

The Link Fire started near Link Lake in Jefferson County to the northwest of Black Butte Ranch. In 2002, the nearby Cache Mountain Fire quickly spread over six miles from its point of origin into Black Butte Ranch leading to an expedited evacuation of the community and ultimately the destruction of two residences. While the 2003 Link Fire did not spread out of the wildland areas, the lessons learned from the Cache Fire experience triggered public safety concerns and preparation for another evacuation.

The B & B Complex, because of its size and duration, created a large scale impact on local government agencies, local community public safety and the regional economy in part due to the closure of Highway 20 access over Santiam Pass.

Much of the recent public policy discussion associated with the wildland-urban interface at federal, state and local levels and has been focused on resources and public safety issues. While that will continue to be an important component of future initiatives, these examples of rapidly moving, high intensity fires with long-range spotting demonstrate the need for coordinated fuels treatment strategies that address fire behavior issues for several miles beyond private land / public land boundary areas.

B2.1 Existing Situation, Strategies and Programs

Because of Crook County's geo-physical location, it sets astride the boundary of two general vegetative ecosystems: a) the "high desert" dominated by Western Juniper and a variety of sage brush and grass

species in the western and southern portions of the county and, b) a transition to dry-site Ponderosa pine and mixed conifer as elevation increases into the Ochoco Mountains in the northern and eastern areas of the county.[4] The boundary between these two general eco-types is driven for the most part by elevation, precipitation and soil moisture-holding capacity.

Central Oregon Fire Adapted Ecosystems

Most central Oregon ecosystems, particularly those at low and mid elevations adjacent to most community and residential development, are described as fire-adaptive. Vegetative species in these areas have evolved in and are dependent on relatively short fire return intervals.

Over the last 100-plus years, fire suppression and forest management activities have altered this natural fire return interval. This has created species shifts, increases in stand density and forest fuels. This change has increased susceptibility of the forest to insects, diseases and to wildfire.[5]

Recent inventory and analysis of this shift by the Ochoco National Forest stratifies the national forest and adjacent lands into one of four condition classes based on the number of "missed" fire entries.[6]

Vegetative Mapping for Fire Regime and Condition Class [7]

The Deschutes National Forest, Ochoco National Forest and the Prineville District of the Bureau of Land Management, working together as Central Oregon Fire Management Services (COFMS), completed the "Central Oregon Fire Management Plan 2003" (FMP). Included in that plan is an extensive Fire Regime and Condition Class analysis of the condition of the vegetation on those public lands managed by the agencies. The FMP analysis is broken out for each of sub-basin watersheds within the jurisdictions.

Because of the wide variability in vegetative types in central Oregon, the fire regime/condition class approach was selected as the best method to describe the range of conditions present on the ground. The approach is described in "Protecting People and Sustaining Resources in Fire-Adapted Ecosystems: A Cohesive Strategy, The Forest Service Management Response to the General Accounting Office Report GAO/RCED-99-65, April 13, 2000."

The table below, transcribed verbatim from the source document, describes the concept and the fire regime-condition class relationships.

Please see "Wildfire Hazard Assessment" section below for Fire Regime-Condition Class map.

Historic Natural Fire Regime Group	Condition Class I	Condition Class 2	Condition Class 3
Fire Regime I **0-35 yr return**	Surface fuel models 2,6,8,9	Surface fuel models 2,6,9,10,11	Surface fuel models 6,10,11,12,13

[4] Natural Vegetation of Oregon and Washington by Jerry F. Franklin and C.T. Dryness, 1973, Oregon State University Press, 452p. Chapter VII-Forest Zones of Eastern Oregon and Washington.

[5] Interview from Brandon Smith with Stephen Fitzgerald, OSU Extension Forester

[6] Central Oregon Fire Management Plan 2003, Central Oregon Fire Management Services, Chap 3-Scope of Fire Management.

[7] Ibid

interval **low severity** ***Dry forest types:*** **Ponderosa pine, interior Douglas-fir, pine-oak woodlands, and very dry grand fir type** **Large stand-replacing events can occur under certain weather conditions but are extremely rare events**	Expected 90th % flame length approx 2 feet Non-lethal fire effects ladder fuels infrequent Low crown fire potential Low expected smoke production Canopy closure <55% No missed disturbance cycles	Expected 90th % flame length 4 to 8 ft Mixed fire effects (between 20% and 80% mortality to dominants) common ladder fuels Moderate to high crown fire potential Smoke production greater than historic expected level Canopy closure 55% to 70% Missed one or two disturbances	Expected 90th % flame length>8 ft Lethal fire effects Ladder fuels common to abundant Crown fire potential very high to extreme High smoke production Disturbance deficit is evident in species composition, stand vigor Missed two or more disturbances
<u>Fire Regime II</u> 0-35 yr return interval lethal severity *Rangeland types:* grasslands and savannahs, mesic sagebrush and mountain shrub.	Surface fuel models 1,2, 3, 5, 6, 14-21 custom Surface vegetative cover 50%+ or near site potential Invasive juniper < 4ft	Surface fuel models 1, 14, 18, 21 Surface vegetative cover < 50% or somewhat below site potential Invasive juniper 4ft + tall	Surface fuel models 14,21 Surface vegetative cover < 25% or dramatically below site potential Non-native species trending towards dominance
<u>Fire Regime III</u> 35-100 yr return mixed severity *Mixed conifer types:* mesic Douglas-fir, grand fir, western hemlock, western redcedar heterogeneous landscape vegetative patterns	Surface fuel models 2,6,8,9 Crown fire potential low Low potential for non-native plant invasion Infrequent ladder fuels and high crown base heights (6 ft +)	Surface fuel models 2,6,9,10,11 Crown fire potential moderate to high Non-native species present and trending toward dominance Typical successional development unlikely due to past high grade cutting/insect & disease impacts/type conversion to shrub dominance	Surface fuel models 6,10,11,12,13 Crown fire potential very high to extreme Non-native species trending towards dominance Typical successional development unlikely due to past high grade cutting/insect & disease impacts/type conversion to shrub dominance
<u>Fire Regime IV</u> 35-100+ yr interval stand replacement severity *Lodgepole, dry shrub:* Seral communities that arise from	Surface fuel models 2,6,8,9 All crown fire potential categories Low potential for non-native plant invasion	Surface fuel models 2,6,9,10,11 All crown fire potential categories Non-native species present and trending toward dominance	Surface fuel models 6,10,11,12,13 All crown fire potential categories Non-native species trending towards dominance

infrequent stand replacement fires			
Fire Regime V >200 yr return stand replacement *Rarely burns, if ever*	Most fire regime V stands are within historic ranges, class 1	Undefined	Significant soil loss Vegetative type conversion (weed dominance)

Figure B-1. Fire Regime and Condition Class Description from Central Oregon Fire Management Plan, 2003.

While each of the fire regimes described exist in Crook County, Fire Regime 1 and Fire Regime 2 generally describe the forest condition that is present at the lower elevations adjacent to the more densely population areas of the county. The forest vegetative species shift cited in the paragraph above however is causing a greater presence of Fire Regime 3 at lower elevations with an increasing dominance of non-native species and increased fuels loading in those sites. This results in higher levels of fire intensity, crowning and spotting potential.

Fire Behavior

Wildland fire behavior is comprised of three components: fuels, topography and weather. While these three parameters individually define fire behavior, their interactive dynamics offer insight for effective mitigation approaches.[8]

Fuels

The fuels aspect of fire behavior takes into consideration loading, size and shape, compactness, horizontal and vertical continuity and chemical composition. Each of these parameters offers opportunities for effective hazardous fuels treatment mitigation actions. Due to the dry nature of most wildland-urban interface areas of Crook County, many of the brush species contain a significant amount of volatile, highly flammable oils and resins (e.g. bitterbrush). These relatively low profile fuels can generate very intense, high flame length fire behavior. This is similar to fires observed in the chaparral fires in southern California.

Topography

Topography takes into account elevation and slope position and steepness, aspect and shape of the country. Crook County's west boundary is located at about 3000 feet in an area of high desert vegetation. Elevation generally increases, up to about 6000 feet, as the terrain becomes more broken in the northern and eastern portions of the county, which are part of the Ochoco Mountains. The rain shadow effect of the Cascades that limits precipitation is still present in the lower western and southern parts of the county. The Cascades also contribute to gusty, turbulent, dry cold front passage that has historically contributed to high intensity fires with rapid rates of fire spread and medium to long range spotting particularly in the western half of the county. The increasing elevation of the Ochoco Mountains provide an additional lifting effect as weather events move through the area which can result in significant increases in precipitation.

Weather

[8] Fire in Oregon's Forests: Risks, Effects and Treatment Options, Chapter 12-Fire Behavior and Fire-Resilient Forests by James K. Agee. Oregon Forest Resource Institute, 2002

As mentioned above, central Oregon weather is strongly affected by the Cascade Mountains. While annual average precipitation in Prineville is about 10.5 inches, Ochoco Ranger Station in the western foothills of the Ochoco Mountains receives about 17 inches per year.[9] The relatively low precipitation, particularly at lower elevations adjacent to areas of community development, strong solar radiation and gusty wind patterns combine to generate a fairly dry environment.

There are some opportunities to compensate for the wildland interface fire exposure effects of local dry climatic conditions and weather patterns by consideration of topographic features during home construction and development planning. Overall, however, the greatest potential to impact fire behavior lies with hazardous fuels management, varying in scope from defensible space around individual homes and structures to well planned, landscape scale treatments, consistent with vegetative type present, to mimic the effects of periodic low intensity fire. In central Oregon, forests ecologically within the historical norm are also more fire tolerant and are less susceptible to high intensity, stand-replacement fires. Ultimately, fire behavior is related to the structure of the forest fuels. Hazardous fuels treatment strategies are the subject on on-going research efforts.[10]

The Wildland-Urban Interface of Crook County

Over the last 10 years, public recognition of the term "wildland-urban interface" (WUI) has become somewhat greater as large fires, the loss of residences to wildland fires, and highly visible smoke columns have become more common-place. The term "wildland-urban interface" helps to describe the boundary and inter-mixture of structural development adjacent to and within areas dominated by wildland vegetation. Likewise fire suppression tactics in interface areas, both structural and wildland, must be adapted significantly in many cases due to the close proximity of structures and wildland fuels.

There are however several additional "interface" situations that occur in the county. Many of these interface characteristics overlay and further complicate the development and implementation of hazardous fuels mitigation activities. In addition to residential/wildland boundaries, there are checkerboard ownership patterns between federal and private landowners. There is the boundary mixture between the lower elevation high desert ecotype and the Ponderosa pine type. There is a mix of long-term residents who have a greater understanding of how to successfully "live with fire" and nearly as many residents who have lived here 15 years or less. Likewise there is a mix of philosophies about how forests and other wildland areas should be managed. There is a general understanding by professional resource managers that publicly managed lands are typically managed to meet a certain set of objectives, while privately owned lands are often managed to meet different objectives. That concept is not universally understood by the public. The area is also transitioning from an economy based on agriculture and forest products to one based on tourism and recreation. Community perspectives are changing as well.

The Crook County Community Wildfire Protection Plan (CWPP) and the use of FEMA Pre-Disaster Mitigation grants have assisted in a greater level of public awareness and a higher level of mitigation in the WUI.

Climate Change

[9] Atlas of Oregon CD, University of Oregon Press

[10] Science Basis for Changing Forest Structure to Modify Wildfire Behavior and Severity by Russell T. Graham, Sarah McCaffrey and Theresa B. Jain. RMRS-GTR-120, U.S. Department of Agriculture Forest Service, 2004.

The potential for significant climate change has been a topic of discussion globally, particularly during the last decade. Lower elevation Crook County ecosystems appear to be particularly susceptible to the effects of such changes. As discussed earlier, the lower edge of the dry pine vegetative zone would be expected to show the impact of such long-term changes in available precipitation. The impact of the multiple-year drought is also being observed in Western Juniper stands.

Oregon State University has launched its Spatial Climate Analysis Service[11] and the University of Washington's Climate Impact Group[12] may be able to provide analysis support to mitigation planning if such climate shift should occur.

Structural and Wildland Fire Services Coordination

The fire services, both structural and wildland, provide a full spectrum of educational, prevention, pre-attack planning and incident response consistent with statutory, jurisdictional and regulatory responsibility and authority for private and public lands within Crook County.

The fire services in central Oregon have responded to expanding community development, increasing population and increasing wildland-urban interface fire load by developing one of the most well-coordinated structural/wildland response systems in the state. In addition to a joint pre-planned initial and extended attack system for the Oregon Department of Forestry, USFS and BLM, a tri-county pre-planned Interface Task Force system is in place for the structural fire departments. The wildland and structural resources are often blended at the fire scene to meet the specific demands of that interface fire situation. During the months of July and August in both 2002 and 2003, this system was activated to some degree on nearly a weekly basis.

The experiences of the late 1970s (Bridge Creek and Cold Springs/Tollgate fires) spawned the development of this progressive effort that undergoes annual re-evaluation and revision. Many improvements were in place for the 1990 Awbrey-Hall Fire near Bend. Lessons learned from that experience provided the foundation for further refinement of the response system. The 1996 fire season provided Central Oregon a challenging mix of interface (Little Cabin and Skeleton), wilderness (Park Meadow and Moolack) and unprotected lands wildfires (Ashwood-Donnybrook, Smith Rock and several smaller incidents) and multiple, high-saturation, dry lightning storm events.

In 2002, the Cache Mountain and Eyerly Fires and in 2003, the Davis, Link, 18 Road fires, the B and B Complex, and in 2010 the Rooster Rock fire just outside of Sisters, all resulted in extensive activation of these pre-planned systems during the initial and extended attack phases of the fires. The effectiveness of these systems continues to work well, in part, because of annual coordination and update processes and the strong interagency working relationships between all of the jurisdictional and supporting organizations.

Multi-Agency Coordination

Beginning in the mid 1980s, the Central Oregon fire services held periodic "disaster drills", both table-top and scaled field exercises. Initially these drills were developed around wildland interface fires. Later a variety of non-fire ("all-risk") components such as flood, loss of transportation routes, petroleum spills, etc were blended into the scenarios. These drills helped to identify components of the response process that were most subject to break-down. These components were re-engineered and integrated into the

[11] Available at www.ocs.oregonstate.edu/prism/
[12] Available at www.jisao.washington.edu/PNWimpacts/index.html

preplanned response system. These drills also became important to the on-going development of a more integrated, interagencycoordination, particularly for wildland and interface fires.

After the 1990 Awbrey-Hall Fire the fire services recognized that a more formalized, pre-planned multi-agency coordination (MAC) process was needed. A series of developmental planning meetings resulted in the establishment of a MAC Center at the City of Bend Public Works Building. This facility was used for both periodic exercises and for a variety of incidents.

In the mid 1990s, as the Deschutes County Sheriff's new facility was being developed, design accommodations were made in a large conference/training area for co-location of the MAC Center. This facility has been offered to support a Central Oregon-wide MAC Center, although Crook County is currently exploring options for a county MAC facility in Prineville.

Multi-agency coordination training and drills are now held in the Bend facility for a wide variety of agency personnel from throughout Central Oregon. The tri-county responder agencies have continued to utilize and integrate the MAC system in all of its regional exercises.

Reinforced Incident Response Capacity

Central Oregon is somewhat unique in its capacity to quickly provide expanded staffing to larger scale fire incidents. The U.S. Forest Service, Bureau of Land Management and the Oregon Department of Forestry have a large pool of personnel trained and certified to meet the requirements of all management positions within the Incident Command System.

The Central Oregon Interagency Incident Management Team (Type 2) was first organized in the late 1970s. Its initial purpose was to provide a local, pre-established team of personnel to manage developing interface fire incidents until further assistance could be mobilized to the area. At the time, typically an Oregon Department of Forestry or federal incident management team (IMT) would require at least 6 to 10 hours to mobilize and travel to central Oregon. Because of the significant number of local assignments over the last 20 years, the Central Oregon IMT developed its experience and level of expertise substantially.

The current interagency IMT dispatching process has identified four Type-2 IMTs within Oregon that are scheduled on a one week on/three weeks off rotation. With the large fire load now being experienced, there is high demand for these teams. Over the last few years they have been heavily mobilized to incidents throughout the western U.S. for a significant period each year.

Because fires behavior has intensified due to weather conditions and hazardous fuels build-up, the importance of ready availability of these pre-organized IMT teams is more important than ever. Mobilization of both ICS pool personnel and local IMTs are managed through the Central Oregon Interagency Dispatch Center (COIDC) in Prineville which provides integrated dispatching services for the Deschutes and Ochoco National Forests, Oregon Department of Forestry and the Prineville District of the Bureau of Land Management. COIDC also serves as a coordination point for mutual aid requests from the structural fire services in Crook, Deschutes and Jefferson counties and all surrounding wildland organizations and agencies.

Organizationally, there is the opportunity to utilize these ICS trained personnel for other than fire incidents. In September, 1999, "Fire and Ice: The roles of State and Federal Forestry Agencies in Disaster Management and Response" was published. This Task Force report, sponsored by the National

Association of State Foresters (NASF) in cooperation with the FEMA and USDA-Forest Service, focused on the value of Incident Command System (ICS)-trained wildland fire management personnel in support of multi-jurisdictional incident response.[13] There is however a fiscal limitation to using these wildland agency personnel in support of all-risk incidents.

The Central Oregon Cooperative Wildland Fire Agreement is signed by all fire service agencies, both structural and wildland. The wildland fire agencies are funded however to address wildland fire issues. There are statutory and agency-specific limitations to spending dedicated fire fighting funds for other types ("all risk") incidents if there has not been a governor's or federal declaration of emergency. In the absence of such a declaration or development of an expanded interagency mutual aid agreement, there may be a substantial delay in mobilizing these wildland personnel in, for example, logistical support roles. Examples of incidents where this situation could be critical include high-impact earthquakes, reservoir breach or any other incident where large scale impact to communities has occurred. This administrative/fiscal limitation may require legislative or additional administrative action. In this era of accelerated preparation for incident response, this potential barrier to timely dispatch of support personnel may delay mobilization and negate the benefits of pre-event preparedness planning.

Central Oregon Fire Chief's Association

The Central Oregon Fire Chief's Association (COFCA) provides the forum in Crook, Deschutes and Jefferson counties to integrate the refinements to the interface fire response system for individual structural and wildland agencies. COFCA also provides the leadership umbrella for a variety of local interagency prevention, investigation and training groups. One such example is the Central Oregon Fire Prevention Cooperative.

Fire Prevention

The central Oregon fire services, both structural and wildland, have a long tradition of effective organization-specific and cooperative programs. In dry, fire-prone regions such as central Oregon, a fire prevention program should conceptually address two facets of preventing destructive wildfires: a) ignition prevention and, b) large, catastrophic fire prevention.

An effective example of a cooperative ignition prevention effort is the Central Oregon Fire Prevention Cooperative (COFPC). This effort was organized in 1978 to provide a forum for coordination of common fire prevention needs between the state and federal wildland agencies and the dozen structural fire service agencies in Crook, Deschutes and Jefferson counties. This organization, the second of its kind in the state at the time, provided a mechanism to maximize effective use of staffing and fiscal resources from all of the cooperating agencies. Its purpose was to conduct a wide variety of ignition prevention, youth education, public service and public education initiatives. The Coop remains active today and has received state, regional and national recognition for its efforts.

The second facet of such a program is, in effect, a safety net to mitigate the adverse impact of fires that do occur. Current local examples focus on broad hazardous fuels treatment strategies to keep fires at more manageable levels and the development of defensible space around individual homes. There are a variety of local programs currently active and several more in the developmental stage throughout the county.

[13] "Fire and Ice: The Roles of State and Federal Forestry Agencies in Disaster Management and Response." National Association of State Foresters in cooperation with the Federal Emergency Management Agency and the USDA Forest Service, 21 pages, September, 1999

B2.2 Wildfire Mitigation Activities

Local fire prevention and hazardous fuels treatment efforts have been an integral component of the local interagency coordination picture since the early 1980s. The challenge of an expanding wildland-urban interface was recognized in Central Oregon two decades ago. The local fire service response system reflects that long period of interface fire experience and the recognized value of pre-incident mitigation activities.

More recently, several high visibility initiatives have demonstrated the effectiveness of mitigation efforts and have also demonstrated that local citizens are ready to help meet the wildland urban interface fire challenge.

"Fire Free! Get in the Zone" - One of the most recognized of these local efforts is the "Fire Free! Get in the Zone" campaign. This initiative got its start after the Skeleton Fire experience. SAFECO Insurance Company and the Bend Fire Department developed the concept and the program. This program has expanded with support from all of the fire services and has now become an annual event county-wide and in adjoining Crook and Jefferson counties. It has drawn national and international interest. A National Fire Plan grant coordinated through the Oregon Department of Forestry expanded the availability of the program for other communities with "starter packages" for program distribution other communities.[14]

The advent of the National Fire Plan and more recently, congressional passage of the Healthy Forest Restoration Act, has jump-started an elevated level of community interest in hazardous fuels treatment. The *Crook County Community Wildfire Protection Plan* was adopted in 2005 and had its first periodic update in 2007. The Plan is currently undergoing its second periodic review, expected to be completed in early 2011. This plan provides for a level of coordination between federal land managers, state agencies, local government and citizen groups to identify mitigation needs, set priorities and track results for each community area.

Since 2007, Crook County and Deschutes County have received grant funding support under FEMA's Pre-Disaster Mitigation program. Crook County has been addressing a variety of mitigation activities with the support of these funds. The Crook County-Fire Ready *Homeowners Guide* was adapted from a similar Oregon Department of Forestry publication and distributed widely through wildland-urban interface neighborhoods. Commercial chipper contractors supported by grant funds provide debris disposal support. Presentations on the role of hazardous fuels treatments to provide defensible space around building and along driveways and evacuation routes is provided at community and town hall meetings. The Crook County-Fire Ready program is intended to provide a public information framework for use by all jurisdictional agencies: fire agencies, Emergency Management evacuation route information, public utilities, etc. This program is designed to utilize disaster resistant efforts through the use of long-term wildfire mitigation strategies to reduce the overall risk to wildfire hazards. A significantly higher level of interest and knowledge is evident among neighborhoods that have participated in the program to date.

[14] State of Oregon Natural Hazards Mitigation Plan, Fire Chapter-Wildland-Urban Interface Loss Reduction Plan, page F-12. Information available at www.firefree.org.

Crook County continues to utilize mitigation grant funds to implement the CCCP. Of particular focus is a mitigation effort to reduce forest fuels within the WUI, especially in location that the CCCP has designated with a high hazard rating. This program usually begins with an outreach program that is used to notify individual landowners and homeowners associations and other groups of the fuels reduction projects. Private lands are assessed and a fuels reduction treatment plan is developed. Typically the costs of the treatment are shared between the property owner and the County. The mitigation grant is used to offset these costs

Wildfire Hazard Identification

The Oregon Forestland-Urban Interface Fire Protection Act of 1997 also known as Senate Bill 360 is being implemented in Crook County. "The Act recognizes that actions needed to address the wildland interface problem must include the active participation of local community leaders and, most importantly, individual landowners.

Senate Bill 360 establishes, for the first time in Oregon, a comprehensive statewide policy regarding fire protection and mitigation in wildland interface areas. It defines the wildland interface and sets in place a process to identify and classify these areas. The legislation also provides standards to help wildland interface owners more effectively manage and minimize hazards that could ignite or spread fire on their property.

According to the Oregon Department of Forestry:[15]

> The Oregon Forestland-Urban Interface Fire Protection Act, often referred to as Senate Bill 360, enlists the aid of property owners toward the goal of turning fire-vulnerable urban and suburban properties into less-volatile zones where firefighters may more safely and effectively defend homes from wildfires. Basically, the law requires property owners in identified forestland-urban interface areas to reduce excess vegetation, which may fuel a fire, around structures and along driveways. In some cases, it is also necessary to create fuel breaks along property lines and roadsides.

B2.3 Crook County Wildland Protection Plan

The Crook County Wildland Protection Plan (as amended) is incorporated into this appendix by reference.

[15] http://www.oregon.gov/ODF/FIRE/SB360/sb360.shtml

B3.0 SEVERE WINTER STORM AND WINDSTORM HAZARD

Climate

There are nine climate zones in Oregon. Crook County coincides with the western portion of Climate Zone 7. This overview of Crook County's climate is based in part on data for Zone 7, as well as weather data from local weather stations. Crook County's high altitude, rugged topography and its distance from the Pacific Ocean are the principal factors influencing the nature of its weather. The most populated portion of Crook County lies within Prineville, the County's only incorporated city. The Cascade Range effectively separates the region from the most severe impacts of the storm systems moving east from the Pacific. As indicated in Figure B.4, Prineville has an average annual precipitation of 10.7 inches per year. Average temperatures in Prineville range from 31.5 degrees Fahrenheit in January to 64.3 degrees in July. Average high temperatures in July are over 85.7 degrees Fahrenheit.

Because of Crook County's geographic location east of the Cascades and in the high desert, average precipitation levels are low, especially in comparison to the Willamette Valley. The majority of central Oregon's precipitation levels come from thunderstorms, which are more common than in western areas.' For this reason, central and eastern Oregon has more uniform precipitation levels throughout the year." Rain events in Crook County are most commonly ones of high precipitation levels despite lower rainfall amounts than in the Willamette Valley, snowfall averages in Crook County's valleys are much greater. The county's drier climate and higher altitudes result in colder winter temperatures, and annual snowfall totals are typically between twenty and thirty inches. Mountain locations receive far more snow than the valleys. Valley locations average around three storms annually that yield at least an inch of snow, while mountain locations may average thirty such storms per year." Because of Crook County's location east of the Rockies, it experiences much colder temperatures than the Willamette Valley. Often, arctic air moves west of the Rockies and makes its way into central Oregon.

Figure B-2 below illustrates Crook County precipitation patterns, the rain shadow effect from the Cascades Mountains and effect of the higher elevation of the Ochoco Mountains.

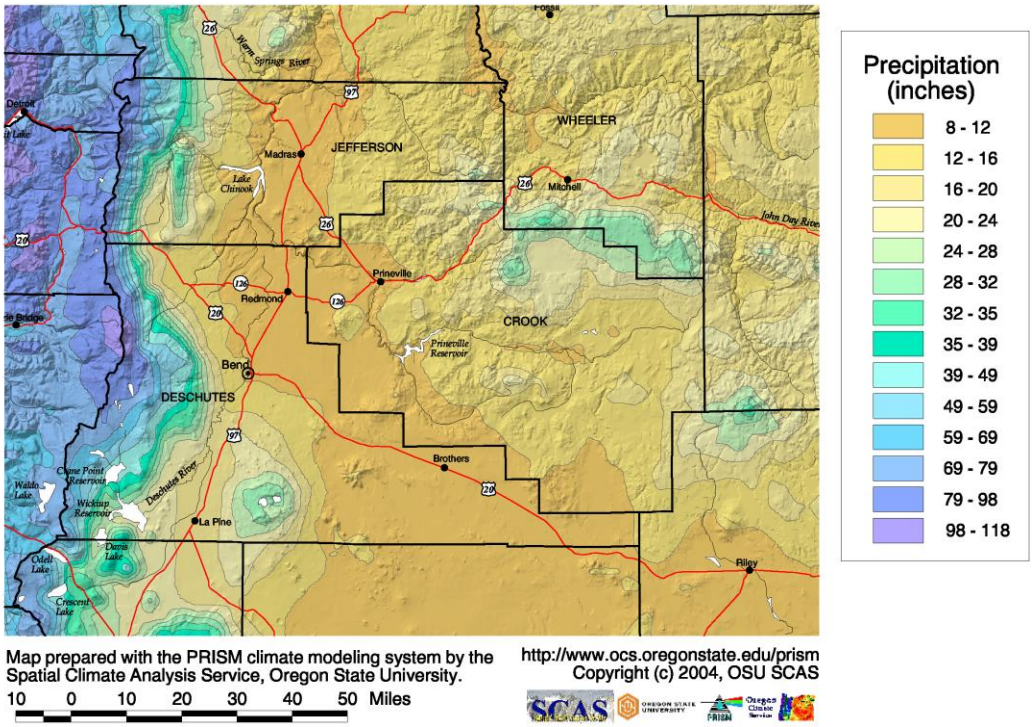


Figure B-2. Central Oregon Annual Average Precipitation Map (1961-1990).[16]

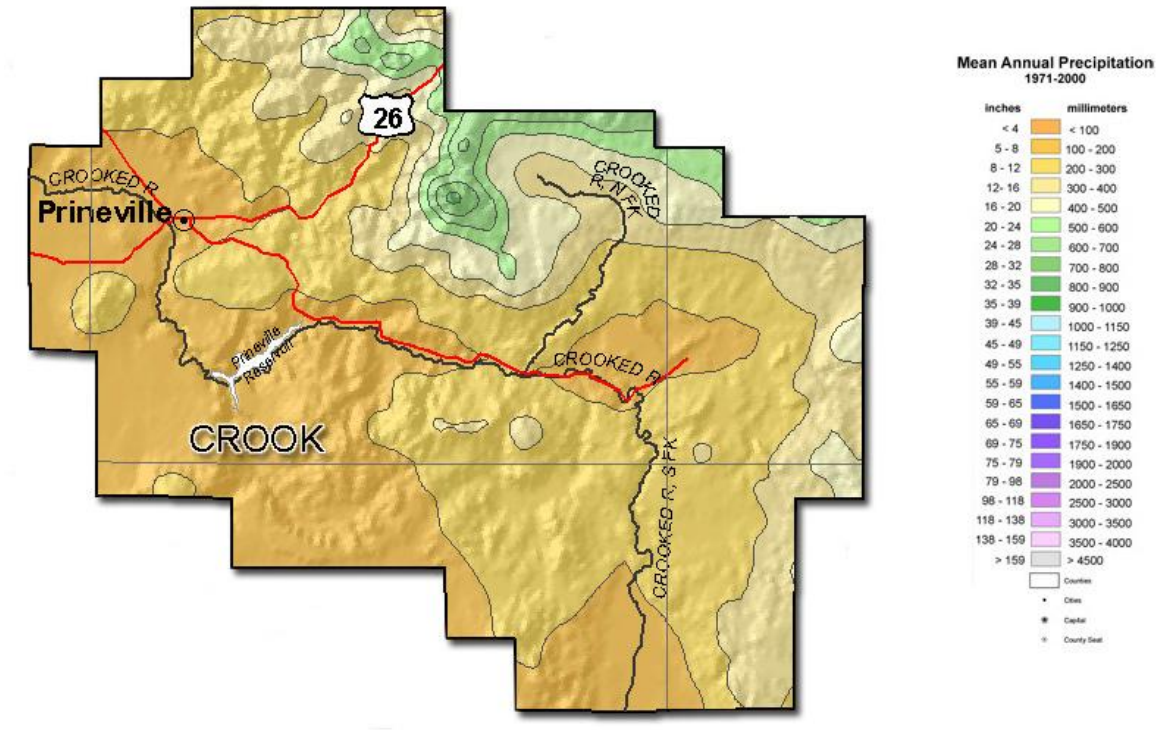


Figure B-3. Mean Annual Precipitation[17]

[16] Central Oregon Precipitation Map prepared for this plan by Oregon State University, Spatial Climate Analysis Service.
[17] http://www.ocs.oregonstate.edu/county_climate/fig2/crook.jpg

A climate table identifying precipitation in Crook County, as observed at long-term climate stations in Crook County, are included below[18].

Name	Number	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Barnes Stn	501	1.44	1.1	1.24	1.05	1.42	1.04	0.79	0.86	0.68	0.86	1.62	1.62	13.72
Mitchell 17 SW Ochoco	6243	2.13	1.62	1.4	1.11	1.29	1.03	0.82	0.82	0.85	1.16	2.18	2.1	16.51
Prineville 4 NW	6883	1.14	1	0.95	0.8	1.06	0.84	0.58	0.45	0.41	0.76	1.3	1.2	10.49

Figure B-4. Precipitation, Monthly and Annual Averages 1971-2000)

B3.1 Weather Patterns Marine Air Masses

Most of eastern Oregon is dominated by dry air masses. However, the Cascade Mountains protect Crook County from all but the most powerful movements of marine air.

Subtropical Air Masses

Subtropical air masses from the far southwest regions of the Pacific are most commonly associated with the wettest storms and with relatively warm temperatures of the Willamette Valley. Because of Crook County's location east of the Cascades, many subtropical air masses do not reach the high desert plateau.

Gulf of Alaska Air Masses

When Pacific low-pressure systems form at high latitudes, they may bring air that is moist and cold enough to cause snowstorms. Prineville's elevation of approximately 2,900 feet is particularly susceptible to snow generated by these air masses. These air masses can also be involved in certain kinds of fierce windstorms.

California Air Masses

South winds pass over California before coming into Oregon. These may arrive during the winter in advance of a storm system, when they bring warm, dry air from the Great Basin by way of California. During the summer, California air masses produce thunderstorms in the county when they bring moist Pacific air."

Severe Winter Storms

Each year the State of Oregon receives many "mid-latitude synoptic-scale cyclones" These systems approach from the Pacific, rotating counterclockwise around a low-pressure zone. Oregon's big winter storms share the following characteristics:

- They move in a general west-to-east direction, with occasional detours to the north or south.
- They form over the north Pacific.
- They produce both wind and rain. Much of Crook County's annual precipitation comes from these storms.
- They occur almost exclusively during the cool season, from October to March.

[18] http://www.ocs.oregonstate.edu/county_climate/Crook_files/Crook.html

- They move fairly rapidly, affecting an area for a day or less.
- Pacific storm systems generate predictable wind patterns.

Winds generally originate from the south-southeast. As the leading edge of the storm passes over the County, wind direction changes to blow from the south-southwest. These are the destructive winds, which constitute the storm's main wind hazard. A cold front defines the trailing edge of the storm, and winds shift once again to bring cold air from the west-northwest. Cold winds arriving at the end of a Pacific storm can cause violent windstorms affecting small areas in mountain valleys along the west side of Crook County.

Rain

In Crook County, rain is most common during summer thunderstorms. These thunderstorms occur much more frequently in Crook County than in most parts of western Oregon. Theses intense rain events often cause flooding because of the high volume of water that falls in a short amount of time. Precipitation that occurs during the winter months in Crook County often comes in the form of snow and ice.

Snow

Freezing temperatures and sufficiently moist air are required to produce a snowstorm. Crook County often receives heavier snowfall than the rest of western Oregon. Prineville, Crook County's only incorporated city, receives less snowfall amounts than other portions of the county due to its location in the Crooked River Valley. The northeastern portion of the County experiences the most significant snowfall levels, in the higher altitudes of the Ochoco Mountains. Unincorporated communities such as Powell Butte experience higher snowfall totals as well, due to their higher elevation than Prineville.

Windstorms

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

The more frequent and widespread strong winds from the southwest are associated with storms moving onto the coast from the Pacific Ocean. If the winds are from the west, they are often stronger on the coast than in the interior valleys due to the north-south orientation of the Coast Range and Cascades. The Coast Range and Cascade Range shelters Crook County from the majority of Pacific windstorms." The most destructive winds are those which blow from the south, parallel to the major mountain ranges. The Columbus Day Storm of 1962 was a classic example of a south wind storm. The storm developed off the coast of California, moved to the northeast, and then turned north and paralleled the Oregon coast.

High winds are common in the mountains of both the Ochoco Range within Crook County. Cold air from the northwest arriving behind Pacific storm fronts filters through mountain canyons into the basins and valleys of central Oregon. If the cold air is deep enough, it can spillover the mountain ridge. As the air funnels through canyons and over ridges, wind speeds may exceed 100 mph. Official wind observations in Oregon are all made at valley locations, but unofficial observations indicate that gusts over 100 mph occur several times a year across the higher ridges throughout Oregon." These very localized winds are unique to mountainous terrain. They are often intense, but of short duration and affect relatively small areas. High wind events in mountainous regions are probably underreported because of the lack of official weather stations there.

Damaging winds in Oregon are most often generated by Pacific windstorms. Records of major Pacific windstorms are documented by state agencies and weather stations throughout Oregon, including several official weather stations in Crook County's lower valleys. Many of the county's frequent localized windstorms go unrecorded.

One of Oregon's most powerful windstorms occurred in December of 1995. This storm caused massive damage throughout the state. The 113 mph gusts measured in Portland illustrate the force of the 1995 storm. The most powerful windstorm to hit Oregon statewide was the Columbus Day Storm of 1962. Statewide, an estimated $170 million of damage occurred with 23 deaths.

Thunderstorms
The National Climatic Data Center (NCDC) database for thunderstorms does not have recorded data for Crook County. Unfortunately, despite the numerous thunderstorms that occur, few are recorded. However, several severe weather events have been recorded by the NCDC of "bi-products" of thunderstorms, including heavy amounts of hail and rain. A thunderstorm in Powell Butte in 1997 sent a 2-foot wall of water through several homes and fields, causing significant damage."

Lightning is almost always an element of summer thunderstorms in Crook County, and is a direct hazard to human safety. More commonly, lightning damages property, primarily when it causes wildfires. Forested and grasslands are particularly vulnerable to thunderstorm lightning strikes during drought years. On July 28, 1997, a lightning strike touched off a one and one half acre fire in a residential area within Prineville."

Wind is a factor in most thunderstorms, and thunderstorm winds are sometimes very strong. A thunderstorm in 1998 created wind gusts of up to 45 mph, causing damage in the area. In August 2000, a lightning strike caused a 16,000 acre fire within the Mill Creek Wilderness area, east of Prineville." The fire threatened the community of Mark's Creek."

Community Severe Winter Storm & Windstorm Issues
Crook County residents face a number of difficult issues when dealing with storms and their aftermath. Residents are primarily concerned with protecting life, property, infrastructure, utilities, and transportation systems from storm damages.

B3.2 Property Protection

Severe Winter Storm Damages
Storm water drainage problems are one cause of property damage from severe winter storms. Insufficient or improperly maintained culverts or other elements of storm drainage systems cause localized flooding, and can lead to saturated soils and structural subsidence. Structural damage from subsidence can be very costly.

Property is also at risk due to flooding (see Flood Hazard section) and landslides (see Landslide section) resulting from heavy rainfall and snow melt. Trees, power lines, telephone lines, and television and radio antennas can be impacted by ice, wind, snow, and falling trees and limbs. Soil that is saturated can cause trees to lose their ability to stand and can be uprooted falling on houses, cars, utilities and other

property. Similarly, if streets are icy, it is difficult for emergency personnel to travel and may pose a secondary threat to life if police, fire, and medical personnel cannot respond to calls.

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

Windstorm Damages

Windstorms have the ability to cause damage over 100 miles from the center of storm activity. Isolated wind phenomena in the mountainous regions have more localized effects. Winds near the earth's surface and associated pressure effects on walls, doors, windows, and roofs, may cause structural components, the elements that provide the buildings structure, to fail. Wind pressure can create a direct and frontal assault on a structure, pushing walls, doors, and windows inward. Conversely, passing currents can create lift and suction forces that act to pull building components and surfaces outward. The effects of winds are magnified in the upper levels of multi-story structures. As positive and negative forces impact the buildings protective envelope (doors, windows, and walls), the result can be roof or building component failures and considerable structural damage.

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

Agricultural Damages

Strong winds can damage agricultural products. Following the Columbus Day Storm of 1962 pear producers throughout Oregon reported severe crop damage. Severe storms in October will consistently threaten late season agricultural products.

Utilities

Soil saturation as a result of heavy rainfall can destabilize tree root systems. When heavy rainfall is accompanied by high winds, trees can be easily blown down, potentially causing damage to power lines and other utility infrastructure. Saturate d soils are also much mo re sub je ct to landslides.

High winds near ground level can be very destructive. Storm winds indirect1ydamage buildings, power lines, the environment, and infrastructure by falling trees and branches. Historically, falling trees have been the major cause of power outages. According to Pacific Power & Light (PP&L), even 20 mph winds create a risk of falling trees. While the PP&L's tree hazard mitigation program has been successful, it only addresses trees that potentially threaten PP&L power lines. PP&L identified other areas besides power line easements that are at risk for tree-falls, including stands of trees left as visual screens adjacent to new timber cuts, and trees at the edges of new developments on the rural urban fringe. Trees in these kinds of locations are much more vulnerable to strong winds than are trees in areas of contiguous forest.

Transportation

Road closures from snow and ice can have severe consequences for commerce and public safety. Some roads in Crook County are regularly closed due to snow and ice hazards. Commerce and industry are especially dependent on the Highway 26 and Highway 126 corridor, which may be subject to closure during storms. Many smaller roads are subject to flash flood damage at creek crossings, and to localized flooding from overwhelmed drainage systems.

Roads blocked by fallen trees during a windstorm isolate people by cutting them off from their homes, jobs and essential services. Blocked roads also disrupt business services by preventing the transportation of goods. Falling trees often bring electric power lines down to the pavement, creating the possibility of lethal electric shock. Utility lines brought down by summer thunderstorms have also been known to cause wildfires, which can start in dry roadside vegetation.

Closed transportation corridors impact many Crook County industries, which engage in product exports, services for tourists, and other transportation-dependant activities. Additionally, power outages can have significant indirect impacts on commerce and industry through business closures and lost work time.

B3.3 Current Mitigation Activities

The following activities are currently being carried out by local, regional, state, and national organizations.

Farm Service Agency crop insurance

The Non-insured Crop Disaster Assistance Program (NAP) insures crops when other crop insurance is not available. It provides assistance for farmers who grow such crops, limiting their losses from natural disaster and helping to manage their overall business risk. Eligible crops include agricultural commodities that are: grown for food, planted and grown for livestock consumption, (including but not limited to grain and seeded and native forage crops), crops grown for fiber, except for trees; and specialty crops, such as aquaculture, floriculture, ornamental nursery, Christmas trees, turf for sod, industrial crops, and seed crops used to produce crops that are eligible for NAP.

Oregon Department of Transportation

The Oregon Department of Transportation (ODOT) has well-established programs to reduce the incidence of road closures from rain, snow, and ice, and windstorms. These include engineering standards for road construction as well as a tree removal program.

County and State Planning

Transformer substations are another aspect of public infrastructure subject to natural hazards. Statewide building and codes are in place to reduce vulnerability to windstorm hazards. The State Building Code already requires that buildings in Crook County be designed to resist wind speeds of 80 miles per hour. All utility facilities constructed on forestlands must submit to a conditional use process. The City of Prineville Code of Ordinances requires all new utility lines be placed underground.

Pacific Power and Light tree mitigation

Pacific Power and Light (PP&L) spends $4 million per year in Crook County on mitigating trees that are potentially hazardous to power lines during windstorms. The program involves pruning and tree removal, and the company has a fairly extensive outreach program. PP&L also operates a program through which the company subsidizes property owners to replace trees inappropriate for their location in or adjacent to utility easements. Power lines in high-wind zones are constructed according to different standards than areas with a lower wind hazard. These standards include stronger support wires, stronger connections, and different standards for poles and towers.

PP&L also provides outreach and education related to hazard mitigation. PP&L distributes numerous brochures from the International Society of Arboriculture on subjects such as Recognizing Tree Hazards, Avoiding Tree & Utility Conflicts, and many others on proper tree selection and care, especially in utility easements. PP&L's in-house forestry department has also put out their own publication on these subjects. PP&L distributes information from the U.S. Forest Service and the Washington State Department of Resources on landscaping for wildfire defense. For information about how to obtain these publications, contact PP&L

National Weather Service

The Pendleton 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.

B4.0 LANDSLIDE HAZARD

B4.1 Landslide Causes and Characteristics

Excavation and Grading
Slope excavation is generally needed in order to develop home sites or build roads on sloping terrain. Grading can result in slopes that are steeper than the pre-existing natural slopes. This increase in slope steepness as well as the added weight of fill placed on slopes can increase the potential for landslide hazards. Excavation practices, sometimes aggravated by drainage, can reduce the stability of otherwise stable slopes.

Drainage and Groundwater Alterations
Water flowing through the ground is often the factor that finally triggers many landslides. Any activity that increases the amount of water flowing into landslide-prone slopes can increase land slide hazards. Broken or leaking water or sewer lines can be problematic, as can water retention facilities that direct water onto slopes.

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 likelihood of landslides. Finally, development that results in an increase in impermeable surface will impair the ability of the land to absorb water and increases the risk of flooding as well as landslide hazards.

Changes in Vegetation
Removing vegetation from steep slopes can increase landslide hazards. Areas that have experienced wildfires and land clearing for development can have even longer periods of increased landslide hazards because forest recovery may take considerable time or may never occur. In addition, woody debris (both natural and logging slash) in stream channels may cause impacts from debris flows to be more severe.

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

Slides
Slides move in contact with the underlying surface. Slides include:

- Rockslides – the down slope movement of a rock mass along a plane surface
- Slumps – the sliding of material along a curved or flat surface.

Slumps are relatively intact landslides, generally made up of soil, which moves down slope at slow to moderate velocities. Slumps may occur without soil saturation.

Slumps occur when a slope is undercut or when the top of a slope is overloaded with increased weight, such as from buildings or roads. Types of slumps include *rotational* (movement along a curved surface) and *translational* (movement along a flat surface).

- Rotational slides occur when sliding material moves along a curved surface.
- Translational slides occur where movement occurs along a flat surface.

These slides are generally slow moving and can be deep. Slumps are small rotational slides that are generally shallow. Slow-moving landslides can occur on relatively gentle slopes and can cause significant property damage, but are far less likely to result in serious injuries than rapidly moving landslides.

Flows
Flows are primarily liquid movements in which mass (e.g., soil and rock) breaks up and flows during movement. It involves individual particles that move separately within a moving mass. They can occur in bedrock (less common) or in soils. Rock flows are generally a slow, deep, or shallow creep. Debris and mudflows tend to have higher water content than other landslides and often occur as a rapid movement. Debris flows usually occur on steep slopes and are often associated with prolonged rainfall, or rapid snowmelt that cause sharp changes in ground water levels. Debris flows were the most common type of landslide in Crook County during the 1998 flood event. Debris flows typically move rapidly and tend to increase in volume as they scour out a channel. They are complex and usually begin from slides in loose slope deposits on mountainsides. They are commonly composed of rock fragments, boulders, cobbles and gravel set in a matrix of sand with some clay content. Mudflows occur in wet sand or in silty-clays or clays that are so reworked with water or so liquefied by structural collapse that they adopt a flow mode.

Falls and Topples
In falls, material is detached from a steep slope or cliff and descends through the air by free fall or by bouncing or rolling down slope. Rock falls are common along Oregon highways where the roads are cut through bedrock. Earthquakes often trigger rock falls. Topples consist of the forward rotation of rocks or other materials about a pivot point on a hill slope. Topples generally create an end-over-end motion of rock down slope. The main step in planning for falls and topples is to produce suitable surveys created by engineering geologists or geomorphologists of likely hazard areas.

B4.2 Community Landslide Issues

Acres of property may be damaged and buildings and homes destroyed by landslides. Landslides can cause associated dangers such as broken electrical, water, gas, and sewage lines, and disrupt roadways and railways. Finally, landslides can result in injury and loss of life.

Property Damage
Landslides can cause significant commercial and residential property damage. Landslides occur as “on-site” hazards and “off-site” hazards. On-site hazards occur on or near development areas. In general, slower moving landslides cause most of the property damage in urban areas. Off-site hazards typically begin on steep slopes at a distance from homes or developments, and are often rapidly moving. These rapidly moving landslides have caused most of the property damage in rural areas.+

Utility Infrastructure Damage

Damage to water, gas, electrical and sewer lines are another important problem resulting from landslides. These damages include not only the costs of replacing and repairing damaged facilities, but also the costs associated with the disruption of the utilities.

Roads and Railway Damage
Much of the economic loss caused by landslides is borne by federal, state and local agencies. Highway construction is an area where mitigation practices could have a dramatic effect on reducing the economic loss associated with landslides. Many of the practices of excavation and grading used in road construction contribute to slope instability.

Death and Injury
Most of the death and injuries caused by landslides occur from rapidly moving landslides. Such landslides are impossible for people to outrun. The most common type of rapidly moving landslide is debris flow.

Current State-wide Mitigation Activities

Statewide LCDC Goal 7 and Senate Bill 12 serve as the foundation for local ordinances that regulate development in areas subject to landslide hazards, including landslides. Senate Bill 12 was adopted in 1999 in response to the catastrophic landslide events that occurred in Oregon in 1996.

In brief, Senate Bill 12[19]:

- 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.

Senate Bill 12 establishes responsibilities for local governments as well. The bill 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." Governments are limited in prohibiting development in high-risk areas unless they offer property owners an opportunity to participate in a Transfer of Development Rights program.

Local Governing Regulations

[19] http://www.oregon.gov/LCD/HAZ/landslidesstatbackgrnd.shtml

As part of the 2010 update, it was noted that Crook County's Comprehensive Plan includes the following policies:

NATURAL HAZARDS POLICIES

a. The county shall recognize the development limitations imposed by the carrying capacities of natural resources; i.e. surface and ground water capacities, soils, geology, etc.
b. Natural resource physical limitations shall be one of the primary evaluation factors for development approval. The carrying capacities thereof shall not be exceeded.
c. It shall be recognized that problem areas or hazards do not necessitate disapproval of development, but that higher development standards can be expected in order to minimize problems or hazards.
d. To maintain development costs at a minimum and to encourage the most efficient use of resources by guiding development to low hazard or physical limitation areas.
e. High density development shall be encouraged in areas having high carrying capacities and low physical limitations, and discouraged in areas having low carrying capacities and high or severe physical limitations. Thereof, the following criteria shall be considered:
    a. Slopes greater or less than 30%.
    b. Safe distance from rimrock scarps, talus debris and fractures.
    c. Sufficient quality and quantity of water.
    d. Location relative to floodplain channels, high ground water, unstable soils or geology, etc.
f. It shall be the developer/builder's burden of proof for determining the degree of hazard or physical resource carrying capacity.
g. Natural resource evaluations, hazard determinations, development effect and corrective measures shall be determined by a licensed bonded consultant at the expense of the developer for proposed developments located in recognized hazard areas or areas with severe physical limitations.

Likewise, the City of Prineville also completed effort to identify, protect and mitigate natural hazards by amending its comprehensive plan to include the following:

City of Prineville Comprehensive Plan-

Prineville's topography and small town charm are inseparably linked with natural floodplains and drainage ways, air quality issues, sensitive riparian areas, steep slopes, varied topography, historic flooding potential, urban flora and fauna, and high water tables. Thus, Prineville will need to adopt development regulations to protect critical areas (sensitive fish and wildlife habitat, frequently flooded areas, steep slopes, wetlands) and preserve air quality. Regulations should be balanced with other local values and in conformance with state law. Efforts to protect the natural environment should focus on maintaining a balance between the economy and ecology of the area while enhancing the aesthetic and livability ideals of the community.

Natural Environment Values and Policies

- Programs are needed to address the protection of the natural environment in a balanced and fair fashion given the urban development goals of the City. Prineville's limited protection program achieves an appropriate balance between urban development needs (employment, housing, schools, parks and institutions), conservation of significant natural resources, and protection of life and property from natural hazards.

- The cliffs and rimrock areas should be preserved and local regulations should be crafted to limit development intrusion into these areas. Prineville will continue to apply Crook County scenic setbacks along rimrock canyons as land is annexed to the City, and new local regulations will protect the rimrock face and talus slopes below.
- Barnes Butte provides the scenic backdrop and identity to Prineville, and is recognized as the community's defining scenic resource site. Prineville will allow for an appropriate residential development, while protecting Barnes Buttes and associated steep slopes, dry washes and raptor habitat through a three-tiered protection program.

Prineville's development code includes the Natural Features Overlay District (NFOD) & Slope Hazard Requirements (Chapter 155) which provides slope hazard regulations, but does not specifically call out landslides.

Oregon State Building Code Standards

The Oregon Building Codes Division adopts statewide standards for building construction that are administered by the state and local municipalities throughout Oregon. The One- and Two-Family Dwelling Code and the Structural Specialty Code contain provisions for lot grading and site preparation for the construction of building foundations. Both codes contain requirements for cut, fill and sloping of the lot in relationship to the location of the foundation. There are also building setback requirements from the top and bottom of slopes. The codes specify foundation design requirements to accommodate the type of soils, the soil bearing pressure, and the compaction and lateral loads from soil and ground water on sloped lots. The building official has the authority to require a soils analysis for any project where it appears the site conditions do not meet the requirements of the code, or that special design considerations must be taken. ORS 455.447 and the Structural Code require a seismic site hazard report for projects that include essential facilities such as hospitals, fire and police stations and emergency response facilities, and special occupancy structures, such as large schools and prisons. This report includes consideration of any potentially unstable soils and landslides.

Resource Information

Additional resources can be found at the Department of Geology and Mineral Industries. In 2006 the department published the *Oregon Geology Fact Sheet/ Landslide Hazards in Oregon*. The factsheet provides general information on common slide types, triggers and conditions and resources for getting additional information. The factsheet can be found on the web at:
http://www.oregongeology.org/sub/publications/landslide-factsheet.pdf

B5.0 EARTHQUAKE HAZARD

Volcanic earthquakes are commonly smaller than about magnitude 2.5, roughly the threshold for shaking felt by observers close to the event. Swarms of small earthquakes may persist for weeks to months before eruptions, but little or no damage would occur to buildings in surrounding communities. Some volcanic related swarms may include earthquakes as large as about magnitude 5. For the communities of Bend, La Pine, and Sunriver, shallow earthquakes in the magnitude 4-5 range that are located beneath Newberry volcano would cause walls to rattle or windows and dishes to vibrate.

Tectonic earthquakes occur periodically in south-central and southeast Oregon, and they are capable of exceeding the magnitude of volcanic earthquakes. Newberry volcano lies at the northwest margin of a broad geographic province known as the Basin and Range, an area whose land forms result from earthquake activity. Tectonic earthquakes as large as magnitude 7 may strike areas south and east of Newberry. Statistically speaking, central Oregon residents are far more likely to feel earthquake shaking than to witness an eruption in the area.

The Pacific Northwest Seismic Network (PNSN) operates seismograph stations and locates earthquakes in Washington and Oregon. They provide information on Pacific Northwest earthquake activity and hazards information through a website at http://www.pnsn.org/welcome.html. The PNSN is based at the University of Washington in the Department of Earth and Space Sciences and are operated jointly by several northwest institutions including the US Geological Survey(USGS) Earthquake Hazard Program, University of Oregon, Cascade Volcano Observatory and others. They are principally funded through the USGS, the Department of Energy, and the State of Washington.

According to the PNSN:

> The seismology lab at the University of Washington records roughly 1,000 earthquakes per year in Washington and Oregon. Between one and two dozen of these cause enough ground shaking to be felt by residents. Most are in the Puget Sound region, and few cause any damage. However, based on the history of past damaging earthquakes and our understanding of the geologic history of the Pacific Northwest, we are certain that damaging earthquakes (magnitude 6 or greater) will recur in our area, although we have no way to predict whether this is more likely to be today or years from now.

An earth quake scenario was developed in 2005 by the Cascade Region Earthquake Workgroup (CREW) to evaluate the impacts of a magnitude 9.0 Cascade Subduction Zone earthquake[20]. The scenario indicates that east of the Cascades "communities can expect a lower level of shaking. Even so, they will feel economic effects from the regional damage and will be important staging points for recovery efforts in Cascadia."

Existing Mitigation Activities

Existing mitigation activities include current mitigation programs and activities that are being implemented by county, regional, state, or federal agencies or organizations. Codes currently support buildings being constructed to meet certain earthquake standards. Training is provided to the public about mitigating structural earthquake damage.

[20] http://www.crew.org/papers/CREWCascadiaFinal.pdf

The Oregon Department of Geology and Mineral Industries (DOGAMI) also provides significant information and resources related to earthquake hazards. DOGAMI administers the 2005 Oregon Senate Bill 2 to develop a statewide seismic needs assessment that includes seismic safety surveys of K-12 public school buildings and community college buildings that have a capacity of 250 or more persons, hospital buildings with acute inpatient care facilities, fire stations, police stations, sheriffs' offices and other law enforcement agency buildings. The assessments provide rapid visual screenings (RVS) to categorize the likelihood of structural building failure in the event of an earthquake. According to DOGAMI, $1.2 billion will be appropriated to improve seismic safety statewide through structural rehabilitation grants. Based on the results of the RVS for Crook County[21], sixteen school, hospital and police buildings were rates as high or very high for collapse potential[22] due to seismic hazards.

[21] http://www.oregongeology.com/sub/projects/rvs/reports/Croo_hos01.pdf
[22] using the FEMA 154/March 2002 manual for RVS

B6.0 VOLCANO HAZARD

Volcanic Causes and Characteristics

Volcanoes are commonly conical hills or mountains built around a vent that connect with reservoirs of molten rock below the surface of the earth. Some younger volcanoes may connect directly with reservoirs of molten rock, while most volcanoes connect to empty chambers. Unlike most mountains, which are pushed up from below, volcanoes are built up by an accumulation of their own eruptive products: lava or ash flows and airborne ash and dust. When pressure from gases or molten rock becomes strong enough to cause an upsurge, eruptions occur. Gases and rocks are pushed through the opening and spill over, or fill the air with lava fragments. Figure B-5 diagrams the basic features of a volcano.

There are four principal types of volcanoes: cinder cones, composite, shield, and lava domes.

Shield Volcanoes

Shield volcanoes are built almost entirely of lava flows. In the south Cascades, lava oozes out in all directions from a central summit vent, or group of vents, building a dome-shape cone. These cones are small when compared to shield volcanoes in other parts of the world; many south Cascades volcanoes are less than ten miles long as opposed to 40 to 50 miles long. Cascade shield volcanoes can remain active for a few months, years, or even centuries. Lava commonly erupts from vents along fractures that develop on the flanks of the cone. Shield volcanoes tend to erupt non-explosively and pour out large volumes of lava. The North Sister, Mount Washington, Belknap, and Three Fingered Jack are all examples of Shield Volcanoes.

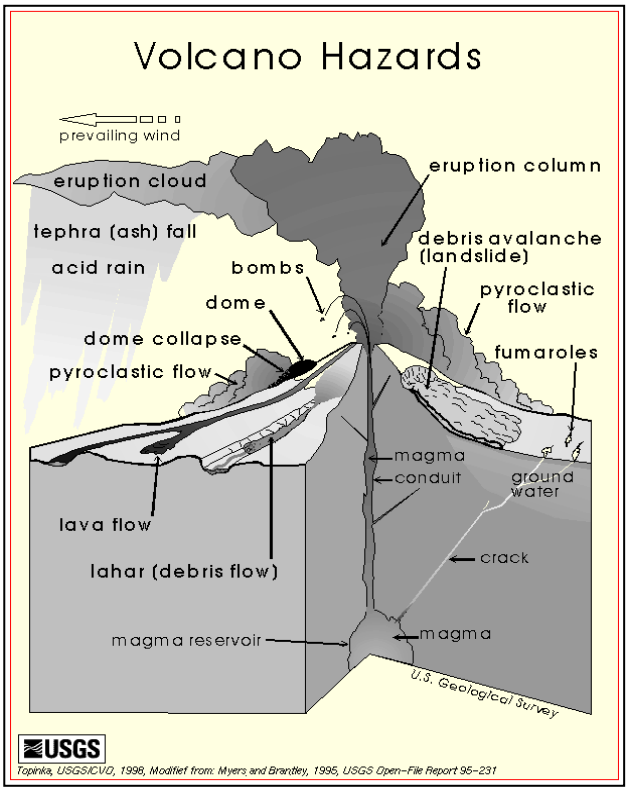


Figure B-5. Volcano Characteristics

Composite Volcanoes

Sometimes referred to as strato-volcanoes, most composite volcanoes have a crater at the summit that contains a central vent or a clustered group of vents. Lava either flows through breaks in the crater wall or from fissures on the flanks of the cone. Lava, solidified within the fissures, form dikes that greatly strengthen the cone. The essential feature of a composite volcano is a conduit system through which magma from a reservoir deep in the Earth's crust rises to the surface. The volcano is built up by the accumulation of material erupted through the conduit and increases in size as lava, cinders, and ash, are added to its slopes. Composite volcanoes are long-lived and are recurrently active over hundreds of thousands of years. Composite volcanoes tend to erupt explosively and pose considerable danger to nearby life and property through their tendency to produce pyroclastic flows and lahars.

The South and Middle Sisters and Broken Top are all major composite volcanoes. They are located about 40 miles to the West of Crook County. The South Sister is becoming more and more active over the years. In the spring of 2004 there was a swarm of earthquakes in the area of the South Sister. Scientists have been monitoring a small uplift of earth on its west slope.

Eruptions
Volcanic eruptions can be placed into two general categories: those that are explosive, such as the 1980 eruption of Mount St. Helens, and those that are effusive, such as the gentle lava flows, fountains, and spatter cones common in Hawaii. Many eruptions are explosive in nature. They produce fragmented rocks from erupting lava and surrounding parent rock. Some eruptions are highly explosive and produce fine volcanic ash that rises many kilometers into the atmosphere in enormous eruption columns. Explosive activity also causes widespread tephra fall, pyroclastic flows and surges, debris avalanches, landslides, lahars, earthquakes, and flash floods.

B6.1 Related Volcanic Hazards

Tephra
Tephra consists of volcanic ash (sand-sized or finer particles of volcanic rock) and larger fragments. During explosive eruptions, tephra together with a mixture of hot volcanic gas are ejected rapidly into the air from volcanic vents. Larger fragments fall down near the volcanic vent while finer particles drift downwind as a large cloud. When ash particles fall to the ground, they can form a blanket-like deposit, with finer grains carried further away from the volcano. In general, the thickness of ashfall deposits decreases in the downwind direction. Tephra hazards include impact of falling fragments, suspension of abrasive fine particles in the air and water, and burial of structures, transportation routes and vegetation.

Crater lake exhibits characteristics of tephra. 100 + miles to the south of Crook County is Crater Lake. Crater Lake is a composite volcano whose top collapsed and formed a huge depression, or *caldera,* that lays in the remains of Mount Mazama after a series of tremendous explosions occurred approximately 7,600 years ago – the largest known eruption from a Cascades Range volcano. In Crook County, there is evidence that nearly 1.5 feet of ash accumulated from the explosion on Mount Mazama.

Volcanic Landslides
Landslides – or debris avalanches – are a rapid downhill movement of rocky material, snow, and (or) ice. Volcanic landslides range in size from small movements of loose debris on the surface of a volcano to massive collapses of the entire summit or sides of a volcano. Steep volcanoes are susceptible to landslides because they are built up partly of layers of loose volcanic rock fragments. Landslides on volcano slopes are triggered not only by eruptions, but also by heavy rainfall or large earthquakes that can cause materials to break free and move downhill.

Earthquakes
Volcanic eruptions can be triggered by seismic activity and earthquakes can occur during or after a volcanic eruption. Earthquakes produced by stress changes are called *volcano-tectonic earthquakes*. These earthquakes, typically small to moderate in magnitude, occur as rock is moving to fill in spaces where magma is no longer present and can cause land to subside or produce large ground cracks. In addition to being generated after an eruption and magma withdrawal, these earthquakes also occur as

magma is intruding upward into a volcano, opening cracks and pressurizing systems. Volcano-tectonic earthquakes do not indicate that the volcano will be erupting.

Lahars and Flash Floods
Lahar is an Indonesian term that describes a hot or cold mixture of water and rock fragments flowing down the slopes of a volcano or river valley. Lahars typically begin when floods related to volcanism are produced by melting snow and ice during eruptions of ice-clad volcanoes like Mount Hood, Mount Jefferson and the Three Sisters. Floods can also be generated by eruption caused waves that could overtop dams or move down outlet streams from lakes.

Lahars react much like flash flood events in that a rapidly moving mass moves downstream, picking up more sediment and debris as it scours out a channel. This initial flow can also incorporate water from rivers, melting snow and ice. By eroding rock debris and incorporating additional water, lahars can easily grow to more than 10 times their initial size. But as a lahar moves farther away from a volcano, it will eventually begin to lose its heavy load of sediment and decrease in size.

Lahars often cause serious economic and environmental damage. The direct impact of a lahar's turbulent flow front or from the boulders and logs carried by the lahar can easily crush, abrade, or shear off at ground level just about anything in the path of a lahar. Even if not crushed or carried away by the force of a lahar, buildings and valuable land may become partially or completely buried by one or more cement-like layers of rock debris. By destroying bridges and key roads, lahars can also trap people in areas vulnerable to other hazardous volcanic activity, especially if the lahars leave deposits that are too deep, too soft, or too hot to cross.

B6.2 Volcanic Impacts

Building and Infrastructure Damage
Buildings and other property in the path of a flash flood, debris flow, or tephra fall can be damaged. Thick layers of ash can weaken roofs and cause collapse, especially if wet. Clouds of ash may cause electrical storms that start fires or damp ash can short-circuit electrical systems and disrupt radio communication.

Pollution and Visibility
Tephra fallout from an eruption column can blanket areas within a few miles of the vent with a thick layer of pumice. High-altitude winds may carry finer ash tens to hundreds of miles from the volcano, posing a hazard to flying aircraft, particularly those with jet engines. In an extreme situation, the Redmond and Crook County Airports would need to close to prevent the detrimental effect of fine ash on jet engines and for pilots to avoid total impaired visibility. Fine ash in water supplies will cause brief muddiness and chemical contamination.

Economic Impacts
Volcanic eruptions can disrupt the normal flow of commerce and daily human activity without causing severe physical harm or damage. Ash a few millimeters thick can halt traffic, possibly up to one week, and cause rapid wear of machinery, clog air filters, block drains and water intakes, and can kill or damage agriculture. Transportation of goods between Crook County and nearby communities and trade centers could be deterred or halted.

Crucial transit routes into Central Oregon could become impassible if a major volcanic event occurred. Hwy 26 would be affected by an eruption of Mount Hood. Hwy 126 could be threatened by an eruption of any of the Three Sisters or Mount Jefferson, and Hwy 97 could be threatened by an eruption of Mount Shasta.

Predicting Volcanic Eruptions

An important sign of an impending volcanic eruption is seismic activity beneath the volcanic area. The USGS and the Pacific Northwest Seismograph Network (PNSN) at the University of Washington continually monitor the Cascades for indications of volcanic activity. In many cases, seismologists can interpret subtle differences between earthquakes related to the rise of magma and the more familiar quakes caused by tectonic movement and fault slippage. Other warning signs of magma rising into the subsurface include increased release of volcanic gases from small openings called fumaroles and changes in the gas composition. Deformation of the ground surface in the vicinity of a volcano may also indicate that magma is approaching the surface. Typically, these warning signs appear a few weeks to months before an eruption, but can last for decades or even centuries without leading to an eruption. Government officials and the public must realize the limitations in forecasting eruptions and be prepared for such uncertainty. Airport closures can disrupt airline schedules for travelers. Fine ash can cause short circuits in electrical transformers, which in turn cause electrical blackouts. Volcanic activity can also force nearby recreation areas to close for safety precautions long before the activity ever culminates into an eruption. The interconnectedness of the region's economy could be disturbed after a volcanic eruption due to the interference of tephra fallout with transportation facilities such as Hwy26 and the railroad.

Death and Injury

Inhalation of volcanic ash can cause respiratory discomfort, damage or result in death for sensitive individuals miles away from the cone of a volcano. Likewise, emitted volcanic gases such as fluorine and sulfur dioxide can kill vegetation for livestock or cause a burning discomfort in the lungs.

Current Mitigation Activities

Communities, businesses, and citizens can plan ahead to mitigate the effects of possible volcanic eruptions. Long-term mitigation includes using information about volcano hazards when making decisions about land use and citing of critical facilities. When volcanoes erupt or threaten to erupt, appropriate emergency response is needed. Such response will be most effective if citizens and public officials have an understanding of volcano hazards and have planned the actions needed to protect communities.

Monitoring Volcanic Activity

The U. S. Geological Survey's Cascades Volcano Observatory (CVO) in Vancouver, Washington, monitors and assesses hazards from the volcanoes of the Cascade Range in Washington, Oregon, and California. Seismic monitoring is shared with the USGS center in Menlo Park, California, (for northern California) and the Pacific Northwest Seismograph Network (PNSN) at the University of Washington in Seattle (for Washington and Oregon).

Assessing Volcanic Threat

According to the USGS[23], "A National Volcano Early Warning System --NVEWS -- is being formulated by the Consortium of U.S. Volcano Observatories (CUSVO) to establish a proactive, fully integrated,

[23] http://pubs.usgs.gov/of/2005/1164/

national-scale monitoring effort that ensures the most threatening volcanoes in the United States are properly monitored in advance of the onset of unrest and at levels commensurate with the threats posed."[24] They note that over the past 25 years the United States has experienced a diverse range of the destructive phenomena that volcanoes can produce. They predict that hazardous volcanic activity will continue to occur, and -- because of increasing population, increasing development, and expanding national and international air traffic over volcanic regions -- the exposure of human life and enterprise to volcano hazards is increasing.

Because volcanoes exhibit seismic activity in advance of an eruption it is possible analyze this data. Significant advances in technology and monitoring have occurred since the cataclysmic eruption of Mount St. Helens. This advance in volcanology has led to the testing of models of volcanic behavior which are becoming more reliable in forecasting expected volcanic activity. Armed with this capability, it may be possible to anticipate an eruption. With this type of forecasting, communities at risk may be forewarned with reliable information in sufficient time to implement response plans and mitigation measures.

Resources

- Volcano- Section IA 6 of the Oregon State Emergency Operation Plan - http://www.oregon.gov/OMD/OEM/plans_train/docs/eop/eop_ia_6_volcano.pdf?ga=t
- USGS General Volcano Information - http://volcanoes.usgs.gov/publications/factsheets.php
- Cascade Range Volcano weekly activity update - http://volcanoes.usgs.gov/activity/archiveupdate.php?noticeid=5863
- Pacific Northwest Seismic Network, all about earthquakes and geologic hazards of the Pacific Northwest - http://www.pnsn.org/
- Oregon department of Geology and Mineral Industries - http://www.oregongeology.org/sub/default.htm
- Volcanic Ash Effects and Mitigation, by John R. Labadie adapted from a report prepared in 1983 for the Air Force Office of Scientific Research and the Defense Advanced Research Projects Agency
- *Paleogene calderas of central and eastern Oregon: Eruptive sources of widespread tuffs in the John Day and Clarno Formations* - The Geological Society of America Field Guide 15 2009
- Digital Data for Volcano Hazards of the Three Sisters Region, Oregon - *By* S.P. Schilling, S. Doelger, W.E. Scott, and R.M. Iverson - 2008 U.S. Geological Survey Open-File Report 2007-1221

B6.3 Central Oregon Volcanoes[25]

Newberry Caldera Volcano

Newberry volcano is a broad shield volcano located in central Oregon. It has been built by thousands of eruptions, beginning about 600,000 years ago. At least 25 vents on the flanks and summit have been active during several eruptive episodes of the past 10,000 years. The most recent eruption 1,300 years ago produced the Big Obsidian Flow. Thus, the volcano's long history and recent activity indicate that Newberry will erupt in the future. -- *Sherrod, et.al., 1997*

[24] http://pubs.usgs.gov/of/2005/1164/

[25] This section brought to you by the USGS

Newberry Caldera, Paulina Peak, Paulina and East Lakes
Newberry Volcano, centered about 20 miles southeast of Bend, Oregon, is among the largest Quaternary volcanoes in thee conterminous United States. It covers and area in excess of 500 square miles, and lavas from it extend northward many tens of miles beyond the volcano. The highest point on the volcano, Paulina Peak with an elevation of 7,984 feet, is about 4,000 feet higher than the terrain surrounding the volcano. The gently sloping flanks, embellished by more than 400 cinder cones, consist of basalt and basaltic andesite flows, andesitic to rhyolitic ash-flow and air-fall tuffs and other types of pyroclastic deposits, dacite to rhyolite domes and flows, and alluvial sediments produced during periods of erosion of the volcano. At Newberry's summit is a 4- to 5-mile-wide caldera that contains scenic Paulina and East Lakes. The caldera has been the site of numerous Holocene eruptions, mostly of rhyolitic composition, that occurred as recently as 1,400 years ago. ... Newberry lies 40 miles east of the crest of the Cascade Range ... -- *MacLeod, 1981*

Newberry Basaltic Eruptions
Basaltic eruptions are well known from observations elsewhere, such as at Hawaii, where spectacular fountains of spatter and cinders are associated with lava flows. At Newberry, basaltic eruptions have occurred repeatedly on the volcano's flanks and in the caldera. Typical products of a basaltic eruption are the 7,000-yr-old cinder cone of Lava Butte and its surrounding lava flows, located 10 kilometers (6 miles) south of Bend. Basaltic eruptions commonly begin with lava fountains that hurl cinders or spatter as far as 1 kilometers (0.6 miles) from the vent. Ejecta are thrown aloft for hundreds to a few thousand meters. Large fragments are expelled from the vent along ballistic trajectories, like artillery shells. Smaller particles are carried by wind and convective updrafts. The resulting deposits may be many meters thick near the vent and build a steep-sided cinder cone, but they generally thin to a few millimeters within 10 kilometers (6 miles) distance downwind. The chief hazard from ballistic ejection is direct impact. Some spatter will be hot upon impact and likely will start forest fires. -- *Sherrod, et.al., 1997*

Big Obsidian Flow
The eruptive sequence that culminated in the Big Obsidian Flow 1,300 years ago exemplifies several aspects of a typical rhyolitic eruptive sequence at Newberry volcano. The eruptions began with tephra showers that deposited pumice lumps and dense lava blocks as large as 1 meter (3 feet) within the caldera. ... As the eruption progressed, pyroclastic flows swept downslope from the Big Obsidian vent to Paulina Lake. The boat ramp at Little Crater Campground is excavated in these pyroclastic-flow deposits, as is the caldera road upslope from Paulina Lake. The flows entered Paulina Lake, perhaps causing secondary steam explosions and displacing water from the lake into Paulina Creek. The final stage of eruption produced the Big Obsidian Flow itself, a lava flow that moved slowly, probably advancing only a few meters or tens of meters per day as it oozed down an inner caldera wall and ponded on the caldera floor. The Big Obsidian Flow is about 1.8 kilometers (6,000 feet) long and locally thicker than 20 meters (65 feet). -- *Sherrod, et.al., 1997*

Three Sisters Region

Two Types of Volcanoes in the Region
Two types of volcanoes exist in the Three Sisters region and each poses distinct hazards to people and property. South Sister, Middle Sister, and Broken Top, major composite volcanoes clustered near the center of the region, have erupted repeatedly over tens of thousands of years and may erupt explosively in the future. In contrast, mafic volcanoes, which range from small cinder cones to large shield

volcanoes like North Sister and Belknap Crater, are typically short-lived (weeks to centuries) and erupt less explosively than do composite volcanoes. Hundreds of mafic volcanoes scattered through the Three Sisters region are part of a much longer zone along the High Cascades of Oregon in which birth of new mafic volcanoes is possible. -- *Scott, et.al., 2001*

The Three Sisters Volcanoes
The Three Sisters area contains 5 large cones of Quaternary age-- North Sister, Middle Sister, South Sister, Broken Top, and Mount Bachelor. North Sister and Broken Top are deeply dissected and probably have been inactive for at least 100,000 years. Middle Sister is younger than North Sister, and was active in late Pleistocene but not postglacial time. South Sister is the least dissected; its basaltic andesite summit cone has a well preserved crater. Most of South Sister predates late Wisconsin glaciation and is therefore older than 25,000 years; however, eruptions of rhyolite from flank vents have occurred as recently as 2,000 years ago. -- *Hoblitt, et.al., 1987*

Latest South Sister Activity
The latest eruptions on South Sister, which occurred in two closely spaced episodes about 2,000 years ago, illustrate a relatively modest scale of eruptive activity. Initial explosive eruptions produced small pyroclastic flows and tephra fallout from several aligned vents low on the south flank. Tephra fallout deposits more than 2 meters (7 feet) thick, composed of pumice, rock fragments, and ash, blanketed areas within 2 kilometers (1 mile) downwind of vents; at 13 kilometers (8 miles) about 10 centimeters (4 inches) fell. Less than one centimeter (0.5 inch) of ash fell at least as far as 40 kilometers (25 miles) south of the vents (at Cultus Lake) and east of the vents (at Bend). Following tephra eruptions, lava emerged from two vent areas, forming a large lava flow, Rock Mesa, and several small lava domes. Decades to a few centuries later, a similar eruptive sequence occurred along a zone of vents that extended from just north of Sparks Lake to high on the southeast flank of South Sister, as well as along a shorter zone on the north flank near Carver Lake. -- *Scott, et.al., 2001*

Mount Hood

Mount Hood Volcano
For the general public, Mount Hood is perhaps the most accessible and preeminent of Oregon's volcanoes, located only 75 kilometers east-southeast of Portland, Oregon. It is the highest peak in the state (3,426 meters - 11,239 feet) and one of the most often climbed peaks in the Pacific Northwest. In summer, Mount Hood's timberline wilderness is a pastoral garden for backpackers. In winter and spring the volcano's slopes host several downhill ski runs and cross-country tracks. -- *Sherrod, 1990, IN: Wood and Kienle*

Eruptive History
Mount Hood is also one of the major volcanoes of the Cascade Range, having erupted repeatedly for hundreds of thousands of years, most recently during two episodes in the past 1,500 years. The last episode ended shortly before the arrival of Lewis and Clark in 1805. When Mount Hood erupts again, it will severely affect areas on its flanks and far downstream in the major river valleys that head on the volcano. Volcanic ash may fall on areas up to several hundred kilometers downwind. -- *Scott, et.al., 1997*

Collapse of Lava Domes
Eruptive activity at Mount Hood during the past 30,000 years has been dominated by growth and collapse of lava domes. The last two episodes of eruptive activity occurred 1,500 and 200 years ago.

Repeated collapse of lava domes extruded near the site of Crater Rock, Mount Hood's youngest lava dome, generated pyroclastic flows and lahars and built much of the broad smooth fan on the south and southwest flank of the volcano. -- *Scott, et.al., 1997*

Quicksand River
In 1805, Meriwether Lewis and William Clark named a river on the south side of the Columbia River gorge the "Quicksand River." Their description of a wide, shallow river with a bed "formed entirely of quicksand," bears little resemblance to the narrow, moderately deep river we call today the Sandy River. What happened? The answer lay 50 miles away at Mount Hood. An eruption in the 1790's caused a tremendous amount of volcanic rock and sand to enter the Sandy River drainage. That sediment was still being flushed downstream when Lewis and Clark saw and named the river. Since 1806, the river has removed the excess sediment from its channel. The Toutle River in southwest Washington was similarly affected by the 1980 eruptions of Mount St. Helens. -- *Gardner, et.al., 2000*

Mount Bachelor

Mount Bachelor Volcanic Chain
The Mount Bachelor volcanic chain provides one example of the type and scale of eruptive activity that has produced most of the High Cascades platform, which consists chiefly of scoria cones and lava flows, shield volcanoes, and a few steep-sided cones of basalt and basaltic andesite. The chain is 25 kilometers long; its lava flows cover 250 square kilometers and constitute a total volume of 30-50 cubic kilometers. -- *Scott and Gardner, 1990*

Mount Bachelor Volcano
The Three Sisters area contains 5 large cones of Quaternary age-- North Sister, Middle Sister, South Sister, Broken Top, and Mount Bachelor. ... Mount Bachelor, which is between 11,000 and 15,000 years old, is the youngest of these volcanoes in the Cascades. -- *Hoblitt, et.al., 1987*

Mount Jefferson

Mount Jefferson Volcano
Mount Jefferson is a prominent feature of the landscape seen from highways east and west of the Cascades. Mount Jefferson (one of thirteen major volcanic centers in the Cascade Range) has erupted repeatedly for hundreds of thousands of years, with its last eruptive episode during the last major glaciation which culminated about 15,000 years ago. Geologic evidence shows that Mount Jefferson is capable of large explosive eruptions. The largest such eruption occurred between 35,000 and 100,000 years ago, and caused ash to fall as far away as the present-day town of Arco in southeast Idaho. Although there has not been an eruption at Mount Jefferson for some time, experience at explosive volcanoes elsewhere suggests that Mount Jefferson cannot be regarded as extinct. If Mount Jefferson erupts again, areas close to the eruptive vent will be severely affected, and even areas tens of kilometers (tens of miles) downstream along river valleys or hundreds of kilometers (hundreds of miles) downwind may be at risk. -- *Walder, et.al., 1999*

Upper Cone
Most of the cone (upper 1,000 meters) of Mount Jefferson is less than 100,000 years old, with much of it younger than the explosive event described above. The upper cone is composed largely of dacite lava flows and domes, many of which appear to have been emplaced when glaciers on the volcano were

much large than at present. It is likely that during growth of the domes, material was shed off to form pyroclastic flows and lahars, but if so, that record has been largely removed by glacial erosion. -- *Walder, et.al., 1999*

Youngest Lava Flows
The youngest lava flows in the Mount Jefferson area are basaltic lava flows from Forked Butte and an unnamed butte south of Bear Butte. Both of these flows postdate the large eruption of Mount Mazama (Crater Lake) of about 7,600 years. -- *Walder, et.al., 1999*

Localized Floods and Lahars
During the last few centuries, several small lakes were formed on the flanks of Mount Jefferson when small tributary valleys became dammed by glacial moraines (ridges of sediment left behind by glaciers). Several of these moraines have breached during the 20th century, producing local floods and small lahars. -- *Walder, et.al., 1999*

Belknap

Youngest Cascade Shield Volcano
Another type of *(Cascade)* basaltic activity is characterized by the concentration of many tephra and lava-flow eruptions at a central vent and several flank vents. This type of activity has built shield volcanoes typically 5-15 kilometers in diameter and several hundred meters to more than 1000 meters high. Many have summit cinder cones. Belknap in central Oregon is the youngest such shield volcano in the Cascades and has lava flows as young as 1,400 years. -- *Hoblitt, et.al., 1987*

Eruptive History
The Belknap shield volcano and its distal lava tongues cover 98 square kilometers of the crest of the central High Cascades in Oregon. Prior to 2,900 years before present, the first eruptive phase distributed basaltic cinders and ash over a broad area to the northeast and southeast, while basaltic lavas moved 10 kilometers eastward from a growing shield. A second phase, 2,883 years before present (carbon-14), produced an adventive shield of basaltic andesite on the east flank, known as "Little Belknap". The third phase was responsible for the bulk of modern Belknap volcano. It was constructed by effusion of basaltic andesite lavas from the central vent (Belknap Crater), 1,495 years before present (carbon-14), and from a vent 2 kilometers to the south (South Belknap cone), 1,775 years before present (carbon-14). The final eruptions from the northeast base of Belknap Crater sent lavas 15 kilometers westward into the valley of the McKenzie River. -- *Taylor, 1990, IN: Wood and Kienle*

Mount Washington

Mount Washington Volcano
Eruptions of relatively uniform basaltic andesite lavas produced a shield volcano, 5 kilometers in diameter, surmounted by a summit cone that probably reached an elevation of 2,600 meters, around 1,200 meters above the pre-existing basalt field. Mafic ash accumulated on the flanks of the shield and has been preserved as thick sections of palagonitic tuff on the southwest and northeast sides of the summit cone. The volcano was intruded by a micronorite plug which now forms the central pinnacle, 0.4 kilometers in diameter. Although no isotopic ages are available, all of the Mount Washington lavas and the underlying basalt appear to be of normal paleomagnetic polarity; the age of Mount Washington is probably no more than a few 100,000 years, similar to that of other central High Cascade

stratovolcanoes. During the late Pleistocene, cirques were excavated into the flanks of the summit cone by valley glaciers which extended more than 12 kilometers east and west. -- *Taylor, 1990, IN: Wood and Kienle*

Recent Spatter Cones
The is no evidence of recent reactivation of Mount Washington volcanism, but a series of aligned small basaltic andesite spatter cones erupted on the northeast flank approximately 1,330 years ago (carbon-14). -- *Taylor, 1990, IN: Wood and Kienle*

Broken Top

Broken Top - Complex Stratovolcano
Broken Top is a complex stratovolcano magnificently exposed by glacial erosion. Pleistocene eruptions of basaltic andesite lava produced a broad shield with a core of oxidized agglomerate invaded by dikes and sills. Subordinate silicic magmas were erupted intermittently; andesite, dacite, and rhyodacite lavas, intrusives, and pyroclastic flow deposits are associated with the predominant mafic lavas from the lower flanks to the summit of the volcano. The central crater of Broken Top was enlarged to a diameter of 0.8 kilometers, probably by subsidence. The resulting depression was filled by thick flows of basaltic andesite and eventually the summit cone was buried beneath a shroud of thin, vesicular lavas. After the central conduit had congealed to a plug of micronorite, the core of the volcano was subjected to hydrothermal alteration. Glacial cirques have been carved into three sides of the mountain, revealing internal structure. Holocene eruptive activity on the flanks has produced basaltic cones, flows, and ash deposits interbedded with Neoglacial moraines and outwash. -- *Taylor, 1990, IN: Wood and Kienle*

Lava Butte

This cinder cone rises 500 feet from the surrounding forest floor offering breathtaking views of the Cascades. At the 5000-foot summit is a fire lookout and visitor rest area with interpretive displays. Turn left from Lava Lands Visitor Center parking and follow signs to Lava Butte. The Butte is closed to trailers due to inadequate parking. -- *U.S. Forest Service Pamphlet, 1994*

The basaltic andesite flow derived from Lava Butte extends northward more than 5 miles and westward 3 miles to the Deschutes River. ... It is one of many basaltic andesite flows on Newberry that have carbon-14 ages of about 6,100 years. ... The lava flow emerges from the south side of the butte. -- *Hoblitt, et.al., 1987*

Pilot Butte

A cinder cone at the east city limits at Bend. Visible from its easily accessible top are the snow peaks of the Cascade Range (listed from the north): Mount Hood, 11,235 feet; Mount Jefferson, 10,495 feet; Three-Fingered Jack, 7,848 feet; Mount Washington, 7,802 feet; North Sister, 10,094 feet; Middle Sister, 10,053 feet; South Sister, 10,354 feet; Broken Top, 9, 165 feet; and Mount Bachelor Ski Resort Area, 9,600 feet. -- *Bend Chamber of Commerce, 1984*

Three Fingered Jack

Three Fingered Jack (2,390 meters) is the most distinctive volcano in this part of the range -- *(Central Oregon High Cascades south of Mount Jefferson to Santiam Pass)*. This deeply glaciated basaltic andesite shield volcano has around 800 meters of relief and is centered on a pyroclastic cone that underlies the summit of the mountain. The cone lacks a high-level conduit-filling plug, however, unlike other shield volcanoes such as nearby Mount Washington south of Santiam Pass. Three Fingered Jack is undated by radiometric methods, but its age probably lies between 0.50 and 0.25 million years ago (500,000 and 250,000 years ago), as inferred from its erosional state compared to other shield volcanoes in the High Cascades. -- *Sherrod, 1990, IN: Wood and Kienle*

Appendix C

Benefit Cost Analysis

Crook County Natural Hazard Mitigation Plan 2010 Update

Sections:

C1.0 Approaches for Economic Analysis (2005)

This appendix was developed in 2005 and included information by the Oregon Natural Hazards Workgroup of the University of Oregon's Community Service Center and the City of Portland Office of Emergency Management. The 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.

C1.1 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 there methods are 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 the exceed 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, 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.

C1.2 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. Mitigation Plan Action Items ID Funding Source

B/C Analysis STAPLE/E or Cost-Effectiveness
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.

C1.3 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.

C1.4 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.

C1.5 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.

C1.6 Resources[1]

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
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[1] This section adopted by Crook County/Prineville with permission from City of Portland Emergency Management

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Appendix D Resource Directory

Crook County Natural Hazard Mitigation Plan 2010 Update

D1.0 Resource Directory[1]

The following tables provide information on county, state and federal mitigation resources and programs. This resource directory is organized in five sections:

- County Resources and Programs
- State Resources and Programs
- Federal Resources and Programs
- Business Resources and programs
- Additional Organizations

[1] Taken from the 2005 Crook County NHMP

Additional Resources and Programs				
Program	**Hazard**	**Agency**	**Contact Information**	**Type of Assistance**
Minimizing Landslide Risk	Landslide	American Planning Association (APA)	122 S. Michigan Ave., Suite 1600, Chicago, Illinois 60603-6107 (312) 431-9100, http://www.planning.org/landslides, landslides@planning.org	The APA's research department embarked on a program to bring together solutions from multiple disciplines into a single source. It will help serve local planning efforts in identifying landslide hazards sufficiently early in the planning process so as to
Emergency prevention, preparedness, and response	Multi-hazard	American Red Cross	American Red Cross, Oregon Mountain River Chapter, 2680 NE Twin Knolls Bend, OR 97701, 1-888-895-1099, redcrossco@bendcable.com	The Oregon Mountain River Chapter was chartered as a Red Cross unit in 1917. The chapter serves the Oregon residents of Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla, Wallowa, Jefferson,Crook, Wheeler, Grant, and Harney County. Washington Counties, Skamania and Klickitat. The American Red Cross is a humanitarian organization, led by volunteers, t
Business Education and Resources	Multi-hazard	Institute for Business & Home Safety (IBHS)	IBHS, 1408 North Westshore Boulevard - Suite 208 - Tampa, FL 33607, (813) 286-3400, Info@ibhs.org, http://www.ibhs.org/ibhs2	IBHS was created as an initiative of the insurance industry to reduce damage and losses caused by natural disasters. This website provides educational resources and on-line publications for insurers, businesses, and homeowners who are interested in taking
Insurance Information	Multi-hazard	Insurance Information Service of Oregon and Idaho (IISOI)	5100 Macadam Avenue, Suite 350, Portland, OR 97201, (503) 241-1757, http://insuranceoregon.org/iisoicontents.htm	IISOI is a non-profit consumer education/communications organization supported by the property-casualty insurance industry in the Oregon & Idaho. Its primary purpose is to explain the function and services of the insurance industry, to inform the public o
Risk Management	Multi-hazard	Public Entity Risk Institute (PERI)	11350 Random Hills Road #210, Fairfax, VA 22030, (703) 352-1846, (703) 352-6339, www.riskinstitute.org	The Public Entity Risk Institute's mission is to serve public, private, and nonprofit organizations as a dynamic, forward thinking resource for the practical enhancement of risk management.

State Resources and Programs

Program	Hazard	Agency	Contact Information	Type of Assistance
Emergency Management and Mitigation Programs	Earthquake	Oregon State Police (OSP)-Office of Emergency Management (OEM)	Earthquake and Tsunami Program Coordinator (503) 378-2911 xt. 237	Earthquake: OEM coordinates the initial response to an earthquake including on-site inspectors providing damage assessment. OEM also holds a statewide emergency response exercise pertaining to a possible Cascadia subduction zone earthquake.
Geologic Information and Mapping Capabilities	Earthquake and Landslide	Oregon Department of Geology and Mineral Industries (DOGAMI)	DOGAMI 800 NE Oregon St., Suite 965, Portland, Oregon 97232, (503) 731-4100, Fax: (503) 731-4066, http://sarvis.dogami.state.or.us/homepage	DOGAMI's mission is to serve a broad public by providing a cost-effective source of geologic information for Oregonians and to use that information in partnership to reduce the future loss of life and property due to geologic hazards.
Research and Inventories	Earthquake and Landslide	Portland State University - Department of Geology	Portland State University, Department of Geology, 17 Cramer Hall; 1721 SW Broadway, PO Box 751, Portland, OR 97207, (503) 725-3389	Portland State University conducts research and prepares inventories and reports for communities throughout Oregon. Research and projects conducted through the Department of Geology at Portland State University includes earthquake research as well as an i
Emergency Management and Mitigation Programs	Flood	Oregon State Police (OSP)-Office of Emergency Management (OEM)	OEM Hazard Mitigation Officer (503) 378-2911 xt. 247 Recovery and Mitigation Specialist (503) 378-2911 xt. 240	OEM administers FEMA's Hazard Mitigation Grant Program, which provides monies for acquisition, elevation, relocation, and demolition of structures located in the floodplain. OEM also administers FEMA's Flood Mitigation Assistance Program as well as implem
Emergency Management and Mitigation Programs	Landslide	Oregon State Police (OSP)-Office of Emergency Management (OEM)	OEM Hazard Mitigation Officer (503) 378-2911 xt. 247	In relation to Senate Bill 12 and rapidly moving landslide hazards, OEM coordinates state resources for rapid and effective response to landslide-related emergencies.

State Resources and Programs

Program	Hazard	Agency	Contact Information	Type of Assistance
Landslide/Debris Flow Warnings and Fire Protection	Landslide and Wildfire	Oregon Department of Forestry (ODF)	3501 E 3rd Street Prineville,OR 97754, (541)-447-5658 www.odf.state.or.us or 2600 State Street, Salem, Oregon 97310, (503) 945-7446, http://www.odf.state.or.us/FIREPROT.HTM	The mission of the Oregon Department of Forestry is to serve the people of Oregon through the protection, management, and promotion of a healthy forest environment, which will enhance Oregon's livability and economy for today and tomorrow.
Emergency Management and Mitigation Programs	Multi-hazard	Oregon State Police (OSP)-Office of Emergency Management (OEM)	Office of Emergency Management, 595 Cottage Street NE, Salem, OR 97310, (503) 378-2911, http://www.osp.state.or.us/oem/	The purpose of OEM is to execute the Governor's responsibilities to maintain an emergency services system as prescribed in Oregon Revised Statutes Chapter 401 by planning, preparing and providing for the prevention, mitigation and management of emergencie
State Land Use Planning Program	Multi-hazard	Department of Land Conservation and Development (DLCD)	DLCD, 635 Capitol St. NE, Suite 200, Salem, OR 97301-2540, (503) 373-0050, http://www.lcd.state.or.us/hazards.html	DLCD administers the State's Land Use Planning Program. DLCD serves as Oregon's federally designated agency to coordinate floodplain management in Oregon. They also conduct various landslide related mitigation activities.
Hazard Related Publications	Multi-hazard	Nature of the Northwest Information Center (NNIC)	NNIC, 800 NE Oregon Street #5, Suite 177, Portland, Oregon 97232, (503) 872- 2750, www.naturenw.org, Nature.of.Northwest@state.or.us	The Nature of the Northwest Information Center is operated jointly by DOGAMI and the USDA Forest Service. It offers a selection of maps and publications from state, federal and private agencies.

State Resources and Programs				
Program	**Hazard**	**Agency**	**Contact Information**	**Type of Assistance**
Climate Information	Multi-hazard	Oregon Climate Service (OCS)	OCS, Oregon State University, Strand Ag Hall Room 316, Corvallis, OR 97331 (541) 737-5705, www.ocs.orst.edu, email: oregon@oce.orst.edu	The Oregon Climate Service collects, manages and maintains Oregon weather and climate data. OCS provides weather and climate information to those within and outside the state of Oregon and educates the citizens of Oregon on current and emerging climate issues. OCS also performs independent research related to weather and climate issues.
Building Codes	Multi-hazard	Oregon Department of Consumer and Business Services	1535 Edgewater St. NW, P.O. Box 14470, Salem, OR 97309 Phone:(503) 373-4133, www.cbs.state.or.us/external/bcd	The Building Codes Division of Oregon's Department of Consumer and Business Services is responsible for administering statewide building codes. Its responsibilities include adoption of statewide construction standards that help create disaster-resistant buildings, particularly for flood, wildfire, wind, foundation stability, and seismic hazards. Information about wildfire related building codes is found through this department.
Water Resources	Multi-hazard	Oregon Division of State Lands (DSL)	DSL, 775 Summer Street NE, Suite 100, Salem, OR 97301, (503) 378-3805, http://statelands.dsl.state.or.us/	DSL is a regulatory agency, responsible for administration of Oregon's Removal-Fill Law. This law is intended to protect, conserve and allow the best use of the state's water resources. It generally requires a permit from DSL to remove, fill or alter more than 50 cubic yards of material within the bed or banks of waters of the state. Exceptions are in State Scenic Waterways and areas designated essential salmon habitat, where a permit is required for all instream activity, regardless of size. These permits may be issued jointly by DSL and the U.S. Army Corps of Engineers.
Economic Development	Multi-hazard	Oregon Economic and Community Development Department (OECDD)	775 Summer Street, Suite 200, Salem, OR 97301-1280, 1-800-233-3306, www.econ.state.or.us/	Oregon's Economic and Community Development Department can assist business owners in numerous ways. The department collects economic data throughout the state by region and has specific activities geared toward business owner/operators; particularly the Governor's Small Business Council.
Fire Protection and Prevention	Wildfire	Office of the State Fire Marshal (OSFM)	OSFM, 4760 Portland Road NE, Salem, Oregon 97305-1760, (503) 378-3473	The Prevention Unit of Oregon's Office of the State Fire Marshal contains 19 Deputy State Fire Marshals located in various regions. The responsibilities of these Deputies include public education for local fire districts and inspection of businesses, public assemblies, schools, daycare centers, and adult foster homes.

Federal Resources and Programs

Program	Hazard	Agency	Contact Information	Type of Assistance
National Earthquake Hazards Reduction Program	Earthquake	FEMA, Department of Interior (DOI) - US Geological Survey (USGS), Office of Emergency Management (OEM)	Oregon Earthquake Program Coordinator (503) 378-2911 xt. 237	Training, planning and technical assistance under grants to States or local jurisdictions. Technical and planning assistance for activities associated with hazards mitigation.
National Earthquake Hazards Reduction Program	Earthquake	DOI-USGS, OEM	Oregon Earthquake Program Coordinator (503) 378-2911 xt. 237	Seismic mapping for US
Water Resources	Flood	US Army Corps of Engineers (USACE)	USACE-Portland District, Floodplain Information Branch, P.O. Box 2946, Portland, OR 97208-2946, (503) 808-4874, Fax: (503) 808-4875, http://www.nwp.usace.army.mil	USACE administers a permit program to ensure that the nation's waters are used in the public interest. In Oregon, joint permits may be issued with the Division of State Lands. The Corps is responsible for the protection and development of the nation's wat
Floodplain Management services	Flood	Department of Defense (DOD)-USACE	Northwestern Regional Office: (503) 808-3853	Technical and planning assistance at the local and regional or national level needed to support effective floodplains management
Aquatic ecosystem restoration	Flood	DOD-USACE	Chief of Planning, Northwestern Division (503) 808-3850	Direct support for carrying out aquatic ecosystem restoration projects that will improve the quality of the environment.
Beneficial uses of dredged materials	Flood	DOD-USACE	Chief of Planning, Northwestern Division (503) 808-3851	Direct assistance for projects that protect, restore, and create aquatic and ecologically-related habitats, including wetlands, in connection with dredging an authorized Federal navigation project.
Damaged Flood Control Works	Flood	DOD-USACE	Northwestern Regional Office: (503) 808-3853	Direct planning and construction grants for non-structural alternatives to the structural rehabilitation of flood control works damaged in floods.

Federal Resources and Programs				
Program	**Hazard**	**Agency**	**Contact Information**	**Type of Assistance**
Project modifications for improvement of the environment	Flood	DOD-USACE	Northwestern Regional Office: (503) 808-3853	Provides for ecosystem respiration by modifying structures and/or operations or water resources projects constructed by the USACE, or restoring areas where a USACE project contributed to the degradation of the area.
Stream gauging and flood monitoring network	Flood	Department of Energy (DOE)-USGS	USGS, Chief, Office of Surface Water, (703) 648-5303	Operation of a network of over 7,000 stream gauging stations that provide data on the flood characteristics of rivers.
Partners for Fish and Wildlife	Flood	DOI-Fish and Wildlife Service (FWS)	National Coordinator, Ecological Services: (703) 358-2201	Financial and technical assistance to private landowners interested in pursuing restoration projects affecting wetlands and riparian habitats.
North American Wetland Conservation Fund	Flood	DOI-FWS	North American Waterfowl and Wetlands Office (703) 358-1784	Cost-share grants to stimulate public/private partnerships for the protection, restoration and management of wetland habitats.
Mapping standards support	Flood	DOI-USGS	USGS - National Mapping Division (573) 308-3802	Expertise in mapping and digital data standards to support the National Flood Insurance Program.
NFIP: Technical Mapping Advisory Council	Flood	DOI-USGS	National Mapping Division (573) 308-3802	Technical guidance and advice to coordinate FEMA's map modernization efforts for the National Flood Insurance Program (NFIP).
Wetlands protection - development grants	Flood	Environmental Protection Agency (EPA)	EPA Wetlands Hotline: (800) 832-7828 or EPA Headquarters, Office of Water, Chief, Wetlands Strategies and State Programs (202) 260-6045	Grants to support the development and enhancement of State and tribal wetlands protection programs

Federal Resources and Programs

Program	Hazard	Agency	Contact Information	Type of Assistance
Clean Water Act	Flood	EPA	EPA, Office of Water, Chief, Non-Point Source Control Branch (202) 260-7088, 7100	Grants to States to implementation-point source programs, including support for non-structural watershed resource restoration activities.
NFIP	Flood	FEMA	Region X 130 228th Street, Southwest Bothell, WA 98021 www.fema.gov	Formula grants to States to assist communities to comply with NFIP floodplain management requirements (Community Assistance Program). Makes available flood insurance to residents of communities that adopt and enforce minimum floodplain management requirem
Flood Hazard Mapping	Flood	FEMA - Cooperative Technical Partners	http://www.fema.gov/mit/tsd/mm_ob13.htm	Tthe CTP initiative fosters partnerships with communities, states, and/or regional agencies to fully integrate them into FEMA's flood hazard mapping process. FEMA will maintain its national standards for NFIP mapping while building on local, state, and re
NFIP: Flood Mapping	Flood	FEMA	Region X 130 228th Street, Southwest Bothell, WA 98021 www.fema.gov	Flood Insurance Rate Maps and floodplain management maps for all NFIP communities.
Flood Mitigation Assistance	Flood	FEMA	Region X 130 228th Street, Southwest Bothell, WA 98021 www.fema.gov	Grants to States and communities for pre-disaster mitigation to help reduce or eliminate the long-term risk of flood damage to structures insurable under the National Flood Insurance Program.
Watershed Protection and Flood Prevention Program	Flood	USDA-Natural Resource Conservation Service (NRCS)	Watersheds and Wetlands Division (202) 720-3042 or (202) 690-4614 www.nrcs.usda.gov	Technical and financial assistance for installing works of improvement to protect, develop and utilize land or water resources in small watersheds under 250,000 acres
Watershed Surveys and Planning	Flood	USDA-NRCS	Watersheds and Wetlands Division (202) 720-4527 www.nrcs.usda.gov	Surveys and planning studies for appraising water and related resources, and formulating alternative plans for conservation use and development. Grants and advisory/counseling services to assist with planning and implementation improvement.
Wetlands Reserve Program	Flood	USDA-NRCS	National Policy Coordinator NRCS Watersheds and Wetlands Division: (202) 720-3042	Financial and technical assistance to protect and restore wetlands through easements and restoration agreements.

Federal Resources and Programs

Program	Hazard	Agency	Contact Information	Type of Assistance
National Dam Safety Program	Flood, Earthquake	FEMA	Region X 130 228th Street, Southwest Bothell, WA 98021	Technical assistance, training and grants to help improve State dam safety and programs.
Environmental Stewardship	Multi-hazard	National Oceanic and Atmospheric Administration (NOAA)	NOAA, 14th Street & Constitution Avenue, NW, Room 6013, Washington, DC 20230, (202) 482-6090, http://www.noaa.gov/, answers@noaa.gov	NOAA's historical role has been to predict environmental changes, protect life and property, provide decision makers with reliable scientific information, and foster global environmental stewardship.
Climate Information	Multi-hazard	The National Weather Service (NWS)	NWS, 5241 NE 122nd Ave, Portland, Oregon 97230, (503) 326-2340, http://nimbo.wrh.noaa.gov/Portland	NWS provides weather, hydrologic, and climate forecasts and warnings for the US, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. NWS data and products form a national i
Disaster Mitigation Planning	Multi-hazard	Department of Commerce, Economic Development Administration	EDA Disaster Recovery Coordinator (800) 345-1222, www.doc.gov/eda	Technical and planning assistance grants for capacity building and mitigation project activities focusing on creating disaster resistant jobs and workplaces
Post-Disaster Economic Recovery	Multi-hazard	DOC-EDA	EDA Headquarters Disaster Recovery Coordinator (202) 482-6225	Grant funding to assist with the long-term economic recovery of communities, industries, and firms adversely impacted by disasters.
Planning Assistance to States	Multi-hazard	DOD-USACE	Northwestern Regional Office: (503) 808-3853	Technical and planning assistance for the preparation of comprehensive plans for the development, utilitization and conservation of water and related land resources
Indian Housing Assistance (Housing Improvement Program)	Multi-hazard	DOI-Bureau of Indian Affairs (BIA)	Division of Housing Assistance Office of Tribal Services (202) 208-5427	Project grants and technical assistance to substantially eliminate sub-standard Indian Housing

Federal Resources and Programs				
Program	**Hazard**	**Agency**	**Contact Information**	**Type of Assistance**
Land Acquisition	Multi-hazard	DOI-FWS	Division of Realty, National Coordinator (703) 358-1713	Acquires or purchases easements on high-quality lands and waters for inclusion into the National Wildlife Refuge System
Federal Land Transfer/Federal Land to Parks Program	Multi-hazard	DOI-National Parks Service (NPS)	Federal Lands to Parks Leader, National Parks Office (202) 565-1184	Identifies, assesses, and transfers available Federal real property for acquisition for state and local parks and recreation, such as open space.
National Digital Orthophoto Program	Multi-hazard	DOI-USGS	National Mapping Division (573) 308-3802	Develops topographic quadrangles for use in mapping of flood and other hazards
Center for Integration of Natural Disaster Information	Multi-hazard	DOI-USGS	The Center for Integration of Natural Hazards Research: (703) 648-6059 hazinfo@usga.gov	Develops and evaluates technology for information integration and dissemination
Emergency Management/ Mitigation Training	Multi-hazard	FEMA	Region X 130 228th Street, Southwest Bothell, WA 98021 www.fema.gov	Training in disaster mitigation, preparedness, planning
Hazard Mitigation Grant Program	Multi-hazard	FEMA	Region X 130 228th Street, Southwest Bothell, WA 98021 www.fema.gov	Grants to states and communities for implementing long-term hazard mitigation measures following a major disaster declaration.
Public Assistance Program	Multi-hazard	FEMA	Region X 130 228th Street, Southwest Bothell, WA 98021 www.fema.gov	Grants to states and communities to repair damaged infrastructure and public facilities, and help restore government or government-related services. Mitigation funding is available for work related to damaged components of the eligible building or structu
Disaster Recovery Initiative	Multi-hazard	Department of Housing and Urban Development (HUD)	Community Planning and Development, Grant Programs, Office of Affordable Housing (800) 998-9999	Grants to fund gaps in available recovery assistance after disasters (including mitigation).

Federal Resources and Programs

Program	Hazard	Agency	Contact Information	Type of Assistance
Public Housing Modernization Reserve for Disasters and Emergencies	Multi-hazard	HUD	Director, Office of Capital Improvements: (202) 708-1640	Funding to public housing agencies for modernization needs resulting from natural disasters (including elevation, floodproofing, and retrofit.)
HOME Investments Partnerships Program	Multi-hazard	HUD	Community Planning and Development, Grant Programs, Office of Affordable Housing (800) 998-9999	Grants to States, local government and consortia for permanent and transitional housing (including support for property acquisition and rehabilitation) for low-income persons.
Community Development Block Grant	Multi-hazard	HUD, Oregon Economic Community Development Department (OECDD)	State or Small Cities Division, Office of Block Grant Assistance, HUD Headquarters (202) 708-3587 or OECCD	Grants to entitled cities and urban counties (e.g. housing, a suitable living environment, expanded economic opportunities) in non-entitled areas, for low-income and moderate-income persons.
Conservation	Multi-hazard	US Department of Agriculture (USDA) - Farm Service Agency (FSA)	Farm Loan Programs (202) 720-3467	Transfers title of certain inventory farm properties owned by FSA to federal and state agencies for conservation purposes (including the restoration of wetlands and floodplain areas to reduce future flood potential.)
Small Business Development	Multi-hazard	Small Business Administration (SBA)	Portland, OR District Office, 1515 SW 5th Avenue, Suite 1050, Portland, OR 97201-5494 (503) 326-2682	The Small Business Administration is broken down into districts. The Portland District assists business in the state of Oregon and includes information for new business owners and for those suffering in disaster situations.
Environmental Quality Incentives Program	Multi-hazard	USDA-NRCS	NRCS County Offices (202) 720-1834	Technical, educational, and limited financial assistance to encourage environmental enhancement
Soil survey/Erosion Control	Multi-hazard	USDA-NRCS	NRCS-Deputy Chief for Soil Science and Resource Assessment (202) 720-4630	Maintains soil surveys of counties or other areas to assist with farming, conservation, mitigation or related purposes.
Emergency Watershed Protection	Multi-hazard	USDA-NRCS	National Office (202) 690-0848	Provides technical and financial assistance for relief from imminent hazards in small watersheds, and to reduce vulnerability of life and property in small watershed areas damaged by severe natural hazards.

Federal Resources and Programs

Program	Hazard	Agency	Contact Information	Type of Assistance
Land Protection	Multi-hazard	USDA-NRCS	National Office (202) 720-4527	Technical Assistance for run-off retardation and soil erosion prevention to reduce hazards to life and property
Rural Development Assistance	Multi-hazard	USDA-Rural Housing service	Community Programs (202) 720-1502	Grants, loans, and technical assistance in addressing rehabilitation , health and safety needs in primarily low-income rural areas.
Rural Development Assistance	Multi-hazard	USDA-Rural utilities service	Program Support (202) 720-1382	Direct and guaranteed rural economic loans and business enterprise grants to address utility issues and development needs.
Natural Hazards Mitigation and Research	Multi-hazard	U.S. Geological Survey (USGS)	10615 S.E. Cherry Blossom Dr., Portland, OR 97216, (503) 251-3200, dc_or@usgs.gov, http://www.usgs.gov	The USGS conducts various researches on the conditions, issues, and problems of the natural resources in the nation. This information is useful for natural hazards mitigation and planning and is provided by USGS through its publications, maps, brochures a
Volcano Hazards	Volcano	DOI-USGS	Volcano Program: (703) 648-6708	Volcano hazard warnings and operation of four volcano observatories to monitor and assess volcano hazard risk
Wildfire Mitigation	Wildfire	United States Fire Administration (USFA)	Mitigation Directorate, 16825 S. Seton Ave., Emmitsburg, MD 21727, www.usfa.fema.gov	As an entity of the Federal Emergency Management Agency, the mission of the USFA is to reduce life and economic losses due to fire and related emergencies through leadership, advocacy, coordination, and support.
National Wildland/ Urban Interface Fire Protection	Wildfire	National Fire Protection Association (NFPA)	Public Fire Protection Division, 1 Battery March Park, P.O. Box 9101, Quincy, MA 02269-9101, (617) 770-3000	This is the principal federal agency involved in the National Wildland/Urban Interface Fire Protection Initiative. NFPA has information on the Initiative's programs and documents. Other members of the initiative include: the National Association of Stat

Business Resources and Programs

Program	Hazard	Agency	Contact Information	Type of Assistance
Business Education and Resources	Multi-hazard	Institute for Business & Home Safety (IBHS)	1408 North Westshore Boulevard - Suite 208 - Tampa, FL 33607, (813) 286-3400, www.ibhs.org/ibhs2	IBHS was created as an initiative of the insurance industry to reduce damage and losses caused by natural disasters. This website provides educational resources and on-line publications for insurers, businesses, and homeowners who are interested in taking
Insurance Information	Multi-hazard	Insurance Information Service of Oregon and Idaho (IISOI)	5100 Macadam Avenue, Suite 350, Portland, OR 97201, (503) 241-1757, http://insuranceoregon.org/iisoicontents.htm	IISOI is a non-profit consumer education/communications organization supported by the property-casualty insurance industry in the Oregon & Idaho. Its primary purpose is to explain the function and services of the insurance industry, to inform the public o
Risk Management	Multi-hazard	Public Entity Risk Institute (PERI)	11350 Random Hills Road #210, Fairfax, VA 22030, (703) 352-1846, www.riskinstitute.org	The Public Entity Risk Institute's mission is to serve public, private, and nonprofit organizations as a dynamic, forward thinking resource for the practical enhancement of risk management.
Contingency Planning	Multi-hazard	Association of Contingency Planners, (Business Emergency Planning)	http://www.acp-international.com/	The Association of Contingency Planners is a non-profit trade association dedicated to fostering continued professional growth and development in effective Contingency and Business Planning.
Small Business Development	Multi-hazard	Small Business Administration (SBA)	1515 SW 5th Avenue, Suite 1050, Portland, OR 97201-5494, (503) 326-2682, www.sba.gov/or/	The Small Business Administration is broken down into districts. The Portland District assists business in the state of Oregon and includes information for new business owners and for those suffering in disaster situations.
Post-Disaster Economic Recovery	Multi-hazard	Department of Commerce, Economic Development Administration	EDA Headquarters Disaster Recovery Coordinator (202) 482-6225	Grant funding to assist with the long-term economic recovery of communities, industries, and firms adversely impacted by disasters.
Mitigation Planning and Technical Assistance	Multi-hazard	Department of Commerce, Economic Development Administration	EDA Disaster Recovery Coordinator (800) 345-1222, www.doc.gov/eda	Technical and planning assistance grants for capacity building and mitigation project activities focusing on creating disaster resistant jobs and workplaces
Economic Development	Multi-hazard	Oregon Economic and Community Development Department (OECDD)	775 Summer Street, Suite 200, Salem, OR 97301, 1-800-233-3306, www.econ.state.or.us/	Oregon's Economic and Community Development Department can assist business owners in numerous ways. The department collects economic data throughout the state by region and has specific activities geared toward business owner/operators; particularly the G

Additional Resources and Programs				
Program	**Hazard**	**Agency**	**Contact Information**	**Type of Assistance**
Minimizing Landslide Risk	Landslide	American Planning Association (APA)	122 S. Michigan Ave., Suite 1600, Chicago, Illinois 60603-6107 (312) 431-9100, http://www.planning.org/landslides, landslides@planning.org	The APA's research department embarked on a program to bring together solutions from multiple disciplines into a single source. It will help serve local planning efforts in identifying landslide hazards sufficiently early in the planning process so as to
Emergency prevention, preparedness, and response	Multi-hazard	American Red Cross	American Red Cross, Oregon Mountain River Chapter, 2680 NE Twin Knolls Bend, OR 97701, 1-888-895-1099, redcrossco@bendcable.com	The Oregon Mountain River Chapter was chartered as a Red Cross unit in 1917. The chapter serves the Oregon residents of Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla, Wallowa, Jefferson,Crook, Wheeler, Grant, and Harney County. Washington Counties, Skamania and Klickitat. The American Red Cross is a humanitarian organization, led by volunteers, t
Business Education and Resources	Multi-hazard	Institute for Business & Home Safety (IBHS)	IBHS, 1408 North Westshore Boulevard - Suite 208 - Tampa, FL 33607, (813) 286-3400, info@ibhs.org, http://www.ibhs.org/ibhs2	IBHS was created as an initiative of the insurance industry to reduce damage and losses caused by natural disasters. This website provides educational resources and on-line publications for insurers, businesses, and homeowners who are interested in taking
Insurance Information	Multi-hazard	Insurance Information Service of Oregon and Idaho (IISOI)	5100 Macadam Avenue, Suite 350, Portland, OR 97201, (503) 241-1757, http://insuranceoregon.org/iisoicontents.htm	IISOI is a non-profit consumer education/communications organization supported by the property-casualty insurance industry in the Oregon & Idaho. Its primary purpose is to explain the function and services of the insurance industry, to inform the public o
Risk Management	Multi-hazard	Public Entity Risk Institute (PERI)	11350 Random Hills Road #210, Fairfax, VA 22030, (703) 352-1846, (703) 352-6339, www.riskinstitute.org	The Public Entity Risk Institute's mission is to serve public, private, and nonprofit organizations as a dynamic, forward thinking resource for the practical enhancement of risk management.

Additional Resources and Programs

Program	Hazard	Agency	Contact Information	Type of Assistance
Landslide Mitigation	Landslide	State of Washington, Department of Ecology	Department of Ecology, PO Box 47600, Olympia, WA 98504, http://www.ecy.wa.gov/programs/sea/landslides/	The Washington State Department of Ecology has a landslide website with tips for reducing risk, warning signs, and maps.
Planning for Natural Hazards: TRG	Multi-hazard	Department of Land Conservation and Development (DLCD)	635 Capitol St. NE, Suite 200, Salem, OR 97301-2540, (503) 373-0050, http://www.lcd.state.or.us/hazards.html	This is a natural hazards planning and mitigation resource for Oregon cities and counties. It provides hazard-specific resources and plan evaluation tools. The document was written for local staffs and officials. The Technical Resource Guide includes a na
Internet Resource	Multi-hazard	Association of Contingency Planners, International (Business Emergency Planning)	http://www.acp-international.com/	The Association of Contingency Planners is a non-profit trade association dedicated to fostering continued professional growth and development in effective Contingency and Business Planning.
Internet Resource	Multi-hazard	Department of Health and Human Services (DHHS), Office of Emergency Preparedness (OEP)	http://ndms.dhhs.gov/index.html	OEP is an office within the US Department of Health and Human Services and has the Departmental responsibility for managing and coordinating federal health, medical, and health related social services and recovery to major emergencies and federally declar
Internet Resource	Multi-hazard	International Association of Emergency Managers	http://www.iaem.com/	IAEM is a non-profit educational organization dedicated to promoting the goals of saving lives and protecting property during emergencies and disasters.
Internet Resource	Multi-hazard	The National Emergency Management Association	http://www.nemaweb.org/index.cfm	NEMA is the professional association of state, pacific, and Caribbean insular state emergency management directors.
Internet Resource	Multi-hazard	National Voluntary Organizations Active in Disasters (NVOAD)	http://www.nvoad.org/	NVOAD coordinates planning efforts by many voluntary organizations responding to disasters. Member organizations provide more effective and less duplication in service by getting together before disaster strikes,

Addendum

City of Prineville

City Addendum to the Crook County Natural Hazard Mitigation Plan 2010 Update
City of Prineville, Oregon

City Addendum to the Crook County Natural Hazard Mitigation Plan
City of Prineville, Oregon

1.0 Overview

The City of Prineville is the oldest city in Central Oregon, the county seat and the only incorporated City in Crook County. The City of Prineville's partnership with Crook County's Natural Hazard Mitigation Plan supports a mutual effort to increase County and the City of Prineville's resilience to natural hazards. This addendum focuses on the natural hazards that could affect City Of Prineville, Oregon, which include:

- Flood Hazard
- Wildland Fire
- Severe Winter Strom and Windstorm Hazard
- Volcano
- Earthquake
- Landslide

It is impossible to predict exactly when disasters may occur, or the extent to which they will affect the city. However, with careful planning and collaboration among public agencies, private sector organizations, and citizens within the community, it is possible to minimize the losses that can result from natural hazards.

The addendum supports mitigation actions that are found within the Crook County NHMP. The City's Natural Hazard Mitigation effort is nested within the overall Crook County NHMP. Prineville considers itself a partner in the implementation of the plan, its mission, goals and mitigation actions. This City's role in this partnership is to reduce the risks posed by natural hazards through education and outreach programs, the development of partnerships, and the implementation of preventative activities such as land use or watershed management programs.

As an example, Prineville and Crook County are both currently reviewing the recently updated FEMA Flood Insurance Rate Maps (FIRM). The City and County will cooperate in sharing this data on the County's geographic Information System (GIS). Both the City and County are currently involved in coordinating a process to adopt the updated information and to include the data into the development codes of both governments.

The actions described in the addendum are intended to be implemented through existing and new plans and programs within the City.

This addendum is comprised of the following sections: 1) Addendum Development Process; 2) Community Profile; 3) Risk Assessment; 4) Mission, Goals, and Actions; and 5) Plan Implementation and Maintenance.

Addendum Development Process

In summer of 2010, the City of Prineville partnered with Crook County to develop a Pre-Disaster Mitigation Planning Grant proposal to create natural hazards mitigation plan addenda to the Crook County NHMP for the City of Prineville. FEMA awarded the City and County a pre-disaster mitigation planning grant, and planning efforts were underway through the fall of 2010.

Representatives from the City of Prineville served on the joint steering committee for the Crook County NHMP. This included participation from the following:

- City Of Prineville Administration
- Police Department
- Planning Department
- Public Works Department

Additionally, the City was represented on the steering committee by the Chamber of Commerce, Red Cross and the Crook County Fire and Rescue District which serves both the City of Prineville and the County fire district.

The City participated in all meetings of the steering committee throughout the development of the NHMP update process. The City also provided data for the update process related to information that had changed between the time that Crook County NHMP's was adopted in 2005 through the update process in 2010. This included updated information on flood mapping, land use codes and other pertinent information.

The meeting location for the steering committee meetings was located at the conference room in the Crook County Fire and Rescue which is located at 500 NE Belknap Street in Prineville Oregon. This allowed easy access for steering committee representatives to attend the meeting as most City, County and state agency representative in Crook County are located within the City of Prineville.

Five County-wide twonhall meetings were used to encourage public participation in the planning effort to update the NHMP. One of these meetings was located within the City of Prineville. Notice of this townhall meeting was placed in both the Prineville Central Oregonian and the Bend Bulletin newspapers.

This townhall meeting was created to provide an open public involvement process. Prineville believes it is essential to include public involvement into the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the townhall meeting included:

- An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;
- An opportunity for, 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 non-profit interests to be involved in the planning process; and
- Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

The planning process used to create the City Addendum was designed to: (1) result in an addendum that is Disaster Mitigation Act 2000 compliant; (2) coordinate with the County's plan; and (3) build a partnership between the City and County that can play an active role in plan implementation.

The final adopted and approved addendum will be made a part of the Crook County NHMP and will be linked to the Crook County Office of Emergency Management Website and placed at the Crook County library and other locations.

P1.1 Community Profile

The following section describes the City of Prineville from a number of perspectives in order to help define and understand the city's sensitivity and resilience to natural hazards. Sensitivity factors can be defined as those community assets and characteristics that may be impacted by natural hazards, (e.g., special populations, economic factors, and historic and cultural resources). Community resilience factors can be defined as the community's ability to manage risk and adapt to hazard event impacts (e.g., governmental structure, agency missions and directives, and plans, policies, and programs). The information in this section represents a snapshot in time of the current sensitivity and resilience factors in the City Of Prineville when the plan was developed. The information documented here, along with the risk assessments located below, are used as the local level rationale for the risk reduction actions identified at the end of this addendum.

Geography & Climate
The City is located near the confluence of the Crooked River and Ochoco Creek and contains a total land area of 6.7 square miles[1]. The City was founded in 1877 and was named after the first merchant (Barney Prine) to locate in the City.

Population & Demographics
The City had a 2009 population of 10,370[2] and ranked 46th in size as compared to other Oregon cities. In 2009 Crook County had a population of 27,185. The City's population represented 38% of the total county population. Between 2000 and 2009 the City had a population increase of 39.9% while County had a population increase of 41.7%.

Disaster impacts disproportionately affect different population segments including, special needs groups, the elderly, the disabled, minorities, and low income persons. Of the City's total population, the population of those that were 65 years of age or older represented 15.5%. 8% of the population is a minority population. 35.8 percent of total households had children under the age of 18.

Employment & Economics
The City serves as the anchor for economic growth in Crook County with companies like Les Schwab tires, Facebook and public sector employment including County government and the Bureau of Land Management. Prineville serves as a center for both private and public sector jobs.

[1] US Census Bureau, as noted by Wikipedia
[2] 2009 Oregon Population Report, Portland State University Population Research Center

Median income can be used as an indicator of the strength of the region's economic stability. In 2000, the median household income in Prineville was 36,587 as compared to the national figure of $50,046. Percapita income was 14,163 for Prineville and 21,587 for the U.S[3].

Government Structure
Prineville has a City Manager form of Government with the City Manager acting as the Chief Executive Officer. Policy is set by a seven member city council. The Mayor presides at all meetings of the City Council and recommends measures he/she deems advisable. The Mayor has the power to appoint all members to city boards. The Mayor votes on all Council business and signs any ordinances passed by the Council.

Lane Use & Development
Growth issues are at the forefront of discussion amongst citizens in Prineville. As vacant lands within the Urban Growth Boundary (UGB) develop with new homes and businesses the City of Prineville staff are required to make sure that development is consistent with local and State law. The City's recently adopted Comprehensive Land Use Plan has many guidelines for development, which are intended to protect of the values of the City. The Plan serves as the controlling documenting for numerous development codes. Included in these protection codes are regulation related to steep slope, development in the floodplain and natural hazard protections.

The City of Prineville's Addendum to the Crook County Natural Hazard Mitigation Plan includes a range of recommended action items that, when implemented, will reduce the city's vulnerability to natural hazards. These recommendations are consistent with the goals and objectives of the City's comprehensive plan and implementing ordinances.

The following are some of the plans and policies already in place that support the NHMP.

- Prineville Comprehensive plan
- Land Use Code
- Flood Prevention Code
- Building Regulations
- Wastewater and Water Master Plans

Community Organizations and Programs
Social systems can be defined as community organizations and programs that provide social and community-based services, such as health care or housing assistance, to the public. Social systems can serve as partners in hazard mitigation through a number of methods including:

- Education and outreach – organization could partner with the community to educate the public or provide outreach assistance on natural hazard preparedness and mitigation.
- Information dissemination – organization could partner with the community to provide hazard-related information to target audiences.
- Plan/project implementation – organization may have plans and/or policies that may be used to implement mitigation activities or the organization could serve as the coordinating or partner organization to implement mitigation actions.

[3] http://www.americantowns.com/or/prineville-information

Social Services in Prineville include efforts supported by:

- The Pioneer Memorial Hospital;
- Red Cross;
- Chamber of Commerce;
- Oregon Department of Human Services;
- Crook County Department of Environmental Health;
- And others.

P1.2 Mission, Goals, and Action Items

Mission

The mission of the City Of Prineville's Addendum is:

> *To reduce risk, prevent loss and protect life, property and the environment from natural hazard events through coordination and cooperation among public and private partners.*

The 2010 NHMP Steering Committee reviewed the mission statement and confirmed that it still accurately conveys the appropriate approach for this Plan and Addendum. This mission statement conveys the cooperative relations between the City of Prineville and Crook County. Implementation will occur through implementation of the NHMP and through existing plans and programs such as the floodplain steep slope ordinances. .

Goals

The plan goals help guide the direction of future activities aimed at reducing risk and preventing loss from natural hazards. The goals listed here serve as checkpoints as agencies and organizations begin implementing mitigation action items. Through the 2010 Plan Update, the Steering Committee evaluated to 2005 NHMP goals.

As with the 2005 process, the 2010 Steering Committee agreed that public participation was a key aspect in developing plan goals. The goals were originally developed through meetings with the 2005 project steering committee, stake holder interviews, and public workshops which served as methods to obtain input and priorities in developing goals for reducing risk and preventing loss for natural hazards in Crook County.

Seven public workshops were held during the compilation of the 2005 mitigation plan and an additional five public workshops were held during the 2010 update. The purpose of these workshops was to inform the public about natural hazards that occur in Crook County, and identify community priorities, and potential strategies for achieving those priorities.

Crook County citizens established community priorities for the original 2005 plans goals through a voting process that asked each participant to choose three goal statements that are most important to them. After each participant made their choices, the outcomes were tallied and are represented in Table 3.1 of the 2005 NHMP. The 2010 NHMP Steering Committee, which included City of Prineville representatives, reviewed and evaluated this section of the 2005 Plan and agreed that all of the plan goals are important.

2010 Natural Hazard Mitigation Goals

Goal	Goal Statement	Community Priority
#1. Partnership and Coordination	Identify mitigation of risk reduction measures that address multiple areas (i.e. environment, transportation, and telecommunications).	1
	Coordinate public/private sector participation in planning and implementing mitigation projects throughout the county.	
	Seek partnerships in funding and resources and resources for future mitigation efforts.	
#2. Emergency Services	Minimize life safety issues.	2
	Promote, strengthen, and coordinate emergency response plans.	
	Evaluate the performance of critical facilities during a natural hazard event.	
#3. Education and Outreach	Further the public's awareness and understanding of natural hazards, potential risk, including economic vulnerability, and options available when natural hazard events occur.	3
	Provide public information and education to all residents of the county concerning natural hazard areas and mitigation efforts.	
#4. Prevention	Reduce the threat of loss of life and property from natural hazards.	4
	Incorporate information on known hazards and provide incentives to make hazard mitigation planning in land use policies and decisions, which include plan implementation.	
#5. Property Protection	Lesson impact from natural disaster on individual properties, businesses and public facilities.	5
	Increase awareness at the individual level and encourage activities that can prevent damage and loss of life from natural hazards.	
#6. Natural Resource Protection	Preserve and rehabilitate natural systems to serve natural hazard mitigation functions (i.e. floodplains, wetlands, watersheds, and urban interface areas).	6
#7. Structural Projects	When applicable utilize structural mitigation activities to minimize risks associated with natural hazards.	7

The 2010 Steering Committee chose to accept the 2005 goals in the seven topic areas. The update Steering Committee reprioritized the goals, as seen above, to better represent the needs of County residents and businesses. This effort was conducted through a process that thoroughly deliberated each of the goals statements and concluded in a voting process to select goal priorities. The 2010 update Steering Committee agreed with the 2005 effort that using the "goals in establishing community mitigation priorities does not negate or eliminate any goals"[4]. The goals provide assistance when making determinations which risk reducing action items to fund first, should funding become available.

Action Items and Implementation

The City of Prineville participated in the development of the Crook County NHMP Action Items and Implementation (refer to Section 4 of the Crook County NHMP). As an equal partner in the development and implementation of the Action Items, the City hereby incorporates Section 4 of the Crook County NHMP into this Addendum.

[4] From Section 3 of the 2005 Prineville/Crook County Natural Hazard Mitigation Plan.

P1.3 Risk Assessment

The following hazards have been addressed in the Crook County NHMP. The City of Prineville participated in the cooperative development of the County's plan on through the fall of 2010. During this time the City considered details of the Plan at two separate city council public meetings in November and December 2010. The City has reviewed the Plan and has assessed how its risks vary from the risks facing the entire planning area.

There are six natural hazard types which may impact the City of Prineville, these include:

1. Flood
2. Wildland Fire
3. Severe Winter Storm and Wind Storm
4. Volcano
5. Earthquake
6. Landslide

Prineville Hazard Analysis Matrix

The City of Prineville concurs with the hazard analysis Matrix for Crook County (found in Section 3 of this Plan. Although there may be differences on the scope and magnitude of various natural hazards impact on the City versus the County, the overall risk using the formula found in Section 3 are the same for both the City and the County. Below is the Prineville Hazard Analysis Matrix.

Hazards	History WF=2	Vulnerability WF=5	Maximum Threat WF = 10	Probability WF=7	Total Score
Flood	10	9	9	10	**225**
Wildfire	10	5	7	10	**185**
Severe Winter Storm	10	4	6	10	**170**
Volcano	3	10	10	1	**163**
Earthquake	3	4	10	5	**161**
Landslide	2	2	9	4	**132**

As can be seen from the matrix, floods pose the highest risk and threat to the City. Wildland fires and severe winter storms also pose high probability of frequency from impacts due to these natural disasters.

P1.4 Flood Hazard

(Hazard Analysis Score = 225)

Heavy rainfall on top of deep snow pack is the most common cause of flooding in Crook County. The winter typically hits the high desert late October through late April.

The City of Prineville is located in northwest Crook County, in the central part of Oregon along the Ochoco Mountains. It is wholly within Climate Division 7 (South Central Oregon) established by the

National Climatic Data Center. The City receives approximately 10.5 inches of precipitation per year. About half of this precipitation is snow and the other half is rain. Rain falling on top of snow causes the snow to quickly melt and river and creek levels rise rapidly. The two most sever flood events in Crook County were the result of rain falling on snow pack.[5]

A climate table identifying precipitation in Crook County, as observed at long-term climate stations in Crook County, are included below[6].

Precipitation, Monthly and Annual Averages (1971-2000)

Name	Number	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Prineville 4 NW	6883	1.14	1	0.95	0.8	1.06	0.84	0.58	0.45	0.41	0.76	1.3	1.2	**10.49**

The eastern, northern and southern boundaries of Crook County are mountainous, with a valley in the center of the county. These mountains collect rain and snow and deliver it to Crooked River and Ochoco Creek Valley. The City is located near the confluence of these two water bodies. Portions of the City are located with the flood zones as mapped by FEMA, and the City includes numerous areas where development has historically been located within the floodplain. This includes residential, commercial and industrial land uses.

Increased development within the floodplain increases the risk of flood damage to buildings and people. When structures or fill are placed in the floodplain, water is displaced. Development may cause floodwaters to rise higher than before the development was located in the hazard areas. This is particularly true if the development is located within the floodway. Impervious surfaces, including roads, parking areas and roof structures collect water rapidly and transport the water to storm water systems that may not be designed to mitigate heavy rainfall conditions, which will result in flooding.

Prineville Flood History: prior to 2005

- **August 04, 1904**- Crooked River floods, destroys crops, shuts down the Prineville Railway, washes away portions of a State Highway.
- **1918-** Flood downtown Prineville, Homes and Businesses damaged. Citizens displaced Both the Crooked River and Ochoco Creek Swell
- **December 1951, January 1952**- Prineville Floods, Crooked River runs well over its banks. Many business and homes damaged 300 People evacuated, 150 home evacuated.
- **December 1955, January 1956-**Prineville floods. Citizens evacuated, homes and businesses damaged.
- **May 1998-** Prineville floods, Ochoco Creek rises beyond flood levels. Federal Disaster Declaration.

The landmark flood event for Crook County in the last century was the flood of 1952. This flood set most of the record high-water marks for the region. The trigger for this flood was warm rain on a substantial snow pack. The rain quickly melted the snow, and caused Ochoco Creek and the Crooked River to overrun their banks. All subsequent floods have been compared to this event. The 1952 flood was

[5] Interviews between Brandon Smith and the Crook County Historical Society (September 2003).
[6] http://www.ocs.oregonstate.edu/county_climate/Crook_files/Crook.html

characterized as a "100-year" flood event. A "100- year" flood has a 1%chance of occurring in any given year, or a 26% chance of occurring during the life of a 30-year home mortgage.

In May 1998, Crook County experienced another devastating flood. In the weeks preceding the flood, the county received abundant rain and snowfall. A warm and heavily moisture-laden storm front, typical to the Pacific El Nino pattern, followed the abundant snowfall. The warm rain quickly melted the snow pack, and county streams and rivers rapidly filled their channels and exceeded their banks. This particular flood event caused over $16 million in damages to Crook County homes, businesses and infrastructure, including damage to over 1000 properties and over 1000 residents were impacted by the flood.[7]

Hazard History: 2005-2010

Contacts were made to state and federal agencies to inquire about data relating to flood activity during this time period. No documented flood activity was noted by these agencies for this time period. In addition a steering committee made up of emergency managers, responder agencies, and local, state and federal administrators led the effort to update the Crook County Natural Hazard Mitigation Plan. The steering committee discovered no evidence of recorded flood activity during this time period.

Vulnerability Assessment

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

The flood hazard for the City of Prineville was identified by FEMA in their Flood Insurance Rate Maps of the county. These maps were first completed in July 1989.The maps outline the extent of the 100-year, or base, floodplain. This is an outline of where floodwaters would extend if there were such a flood. These maps are used by FEMA to identify properties that need to purchase flood insurance and, if developed, need to meet floodplain development regulations.

In 2010 new Flood Insurance Rate Maps became available. These maps were based upon updated information and technology that increased the accuracy of delineating the floodplain and floodway area along the Crooked River and Ochoco River. The maps are expected to be adopted soon after the update to this plan is completed. For the purposes of this update the 2010 NHMP update committee chose to use the new floodplain FIRM data provided within the draft maps.

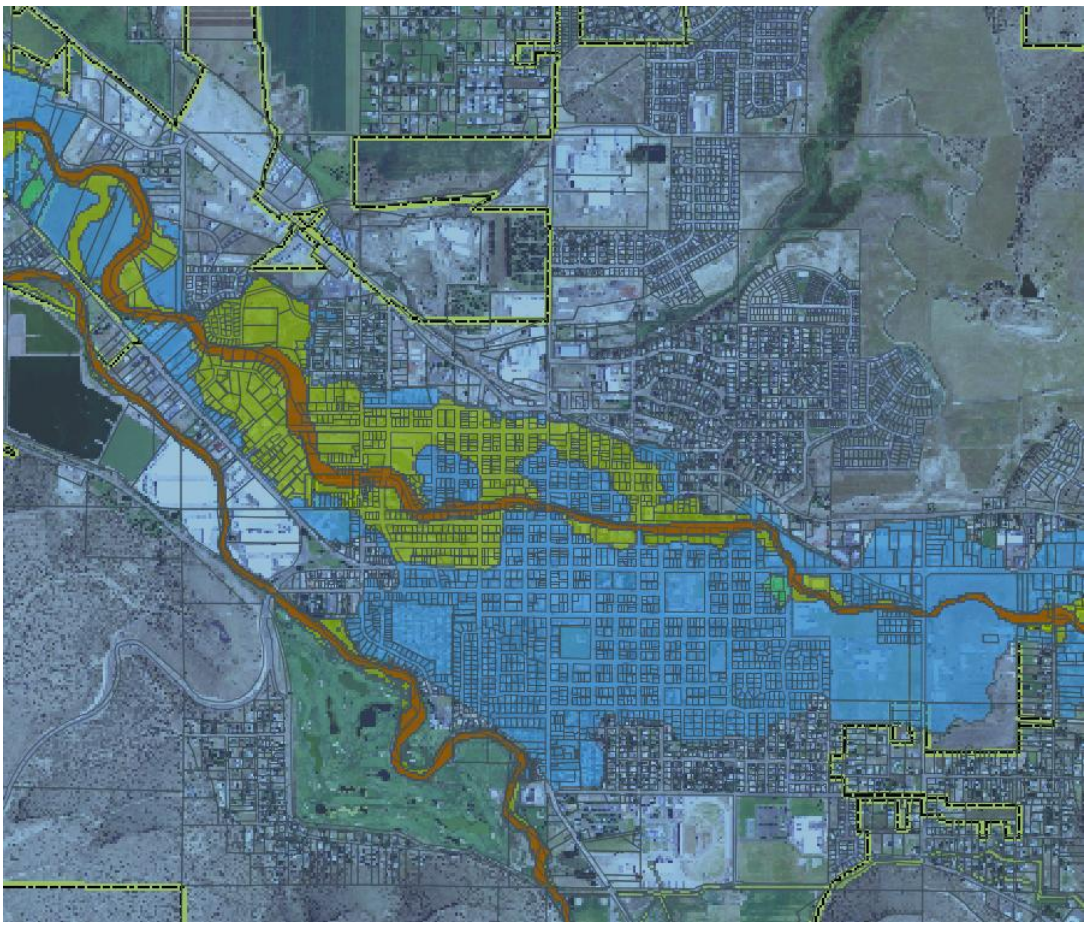
The Crook County Geographic Information System (GIS) Department has incorporated the 2010 FIRM data as overlay within their GIS database, including the mapping for the City of Prineville. A query was developed to combine the delineated boundaries of the 2010 FIRM maps with the 2010 certified tax roll (certified October 8, 2010) for properties within the City. Discrepancies were noted from information identified within the 2005 NHMP. Since the new FIRM data is based on updated topographical and hydraulic information, we relied on this new data to identify the flood hazard for the 2010 NHMP Update.

The following map shows an example of flood areas as identified by the 2010 Flood Insurance Rate Map (FIRM) information. The official maps from this Flood Insurance Study have not yet been approved by

[7] City of Prineville/Crook County Flood Mitigation Action Plan, Clay Moorhead, CDA Consulting Group Inc. (2000)

City. Crook County and Prineville are currently developing a process to review this information for approval in 2011. Once approved the new FIRM data will become the official mapped flood zoned for Crook County.

When this information is plotted it can show more specifically where the flood zones are in relation to property and structures. The mapping capability provides detail on a property by property basis and is a significant tool that can be used for many purposes, most importantly compliance with the FEMA Floodplain regulations. This map begins to show the capability of flood impact mapping[8].



Risk Assessment

The floodplains begin as very narrow strips adjacent to the upper tributaries of Ochoco Creek and the Crooked River, and steadily increase in width at lower elevations. The widest floodplains are in the center of Prineville and near the confluence of Ochoco Creek and the Crooked River. The Ochoco River bisects the City of Prineville and the floodplain locations include urban areas.

Information from the County Assessor's office was combined with the Flood Insurance Rate Maps to estimate the improved property value that is at risk by a 100-year flood event. As of November 2010, there we 1,831 tax lots located within the 100-year flood plain, with an improved value of

[8] Preliminary 2010 mapping as documented in the County GIS. For illustration purposes only.

$1,357,188,038.00. Of the 7,044 lots, about 12 percent were manufactured homes, which are very susceptible to flood damage.

Within the past 5 years the city boundary has changed (expanded). As a result, the query was developed using the new corporate boundary lines. In addition, the query was used to select tax lot parcels that intersected the floodplain. This information was cross-referenced to the 2010 Real Marked Value (improvements component only) for five building types[9].

The first two tables below identify statistics for both Crook County and the City of Prineville as separated data. The third table reflects the combined information.

Flood Hazard Assessment Tables

Crook County		
Building Type	No. tax lots	Imp RMV
Single Family (101, 401 and 801)	272	$27,429,670
Multi Family (701)	0	$0
Mobile (019)	93	$4,841,010
Commercial (201)	12	$24,941,360
Industrial (301 and 303)	16	$1,993,030
Total	393	$59,205,070

City of Prineville	
No. tax lots	Imp RMV
397	$27,690,980
115	$3,462,030
177	$12,193,600
130	$27,764,990
41	$12,351,450
860	$83,463,050

Crook County Combined		
Building Type	No. tax lots	Imp RMV
Single Family (101, 401 and 801)	669	$27,429,670
Multi Family (701)	115	$3,462,030
Mobile (019)	270	$17,034,610
Commercial (201)	142	$52,706,350
Industrial (301 and 303)	57	$14,344,480
Total	1253	$114,977,140

Information from the County Assessor's office was combined with the Flood Insurance Rate Maps to estimate the improved property value that is at risk by a 100-year flood event. The Flood Hazard Tables above identify the number of tax lots and the real market value (RMV) for the Crook County flood hazard areas, and the maximum estimated losses caused by a flood disaster occurring along the Crooked and Ochoco Rivers. As of November 2010, there we 1,253 tax lots located within the 100-year flood plain, with an improved value of *$114,977,140.* Of the 1,253 total lots county-wide, about 11.3 percent were manufactured homes, which are very susceptible to flood damage. Likewise of the total 860 lots within the City, 177 were manufactured homes representing 20.6%.

[9] Additional property classifications were used for internal purposes by the county (in brackets next to the class).

The City finds that, as can be noted from the Crook County Hazard Analysis Matrix found on page 6 of this addendum, flood hazards scored as the highest overall risk score with 225 points out of a total 240 possible points. This is supported by the fact that there have been higher incidents of severe impacts of this hazard occurring. This is compounded by a high probability of a reoccurrence occurring within the next 10-35 year time period. Historically, significant development and urban populations have located within flood prone areas of Prineville. As such, the vulnerability and maximum threat from this natural hazard type is high.

P1.5 Wildland Fire Hazard

(Hazard Analysis Score = 185)

Wildland fire plays a large, reoccurring and high impact role as a natural hazard in Central Oregon. While Crook County has experienced only three large wildland-urban-interface (WUI) fire within the last decade, it has also been the setting for several smaller interface fires with significant potential for major impact on interface areas and critical infrastructure. Neighboring counties have experienced numerous, high impact WUI fire incidents providing Crook County emergency managers insight into the complexities of such incidents.

The City of Prineville has not experienced a WUI fire within the City limits; however the City sees the potential impact of this hazard to be similar to Crook County. Prineville's residential development is expanding further into sites traditionally covered by wildland vegetation bringing with it the potential for the wildland-urban interface scenarios.

The escalating size and intensity of these interface fires is the subject of continuing research in several scientific disciplines. These include the arenas of forest health, hazardous fuels treatment and community infrastructure protection as well as study of the impacts of climate change. These issues are likewise the subject of significant public discourse. Over the last two decades, community awareness has developed substantially regarding the interface fire threat as well as interest and involvement in issues of hazardous fuels treatment activities.

Central Oregon population growth has become a companion issue. Between 1990 and 2000, Crook County's population grew by nearly 36% to 19,182. This is a significant population gain, but is nothing compared to this last decade. Between the years 2000 to 2010 the County has grown now to 27,280[10], representing a 42% population increase in just one decade.

The City of Prineville had a 2009 population of 10,370[11] and during this same year Crook County had a population of 27,185. The City's population represented 38% of the total county population. Between 2000 and 2009 the City had a population increase of 39.9%. This trend is predicted to continue. Population growth will have significant impacts on citizen exposure and infrastructure vulnerability to the effects of wildland fire.[12]

[10] Portland State University Population Research Center 2010 Preliminary County Population Estimates
[11] 2009 Oregon Population Report, Portland State University Population Research Center
[12] U.S. Bureau of Census, 2000. Population of Oregon and it's Counties and Incorporated Places, Public Law 94-171 Redistricting Data, prepared by the Office of Economic Analysis, Dept of Administrative Services, State of Oregon.

Wildfire hazard assessments have traditionally been conducted by individual jurisdictional agencies and organizations. In many cases these have been driven by local rural fire protection district boards of directors, county ordinance and for wildland agencies state or federal law, regulation, policy or directives.

The Oregon Department of Forestry has identified Deschutes County as one of two pilot counties for implementation of the Oregon Forestland-Urban Interface Fire Protection Act of 1997, also known as Senate Bill 360 (SB 360).[13] The implementation process contains an extensive wildfire hazard identification component which has been embodied in Oregon Administrative Rule. This system will eventually be applicable throughout the state in "wildland-urban interface areas" as defined by the statute. SB360 has been implemented in Crook County. The mitigation treatment standards of the Crook County Fire Ready program were derived from the SB360 standards so that there is now one defensible space treatment standard county-wide.

According to a report published by the National Interagency Coordination Center:

> *The forests and rangelands of central Oregon have evolved with wildland fire as a part of the landscape. Most observers agree that despite fire suppressions efforts, in recent years, wildland fires have been burning hotter, moving faster, and scorching more acres than the historical pattern. Six of the top 13 most destructive wildland-urban interface fires in Oregon's history have occurred in central Oregon.*[14]

This document goes on to state that that the acres burned in central Oregon between 2000 and 2004 exceeds the number of acres burned in the previous hundred years. This recent and dramatic increase in large fires has heightened community awareness and willingness to address fire safety.

As noted above, Prineville receives about 10.5 inches of precipitation per year.

Hazard History: prior to 2005

Figure 7-1 lists some of the larger wildland fires in the tri-county (Crook, Deschutes and Jefferson) area over the last decade requiring an emergency management response beyond that of the wildland fire and natural resource agencies. Since the 1990 Awbrey Hall fire, the local structural and wildland fire services have substantially refined the emergency response system for these types of destructive interface fires. Under the leadership of the Central Oregon Fire Chief's Association, the pre-planned interface fire mutual aid and task force system has effectively integrated the operational response process for structural and wildland fire fighting resources from all three counties. This response system is recognized as one of the most effective interagency efforts in the state.

[13] ORS 477.015-477.061

[14] Forest Log, National Interagency Coordination Center situation reports, as cited in Oregon Department of Forestry, http://egov.oregon.gov/ODF/FIRE/SB360/wui_history_table.shtml (accessed June 8, 2005).
http://www.odf.state.or.us/AREAS/eastern/walkerrange/CWPP/Ch3.pdf

Representative Interface Fires in Central Oregon since 1990 - 2005[15]

Year	Fire Name	Size	Start Date	County	Conflagration Act Resources Mobilized	Unprotected Areas Involved	Remarks
1990	Awbrey Hall	3,032	7/5/1990	Deschutes	Yes		Destroyed 22 residences. 2800 Bend residents evacuated.
1996	Little Cabin	2,400	7/29/1996	Jefferson	Yes	Structural, Wildland	3 Rivers subdivision threatened. No structures lost.
1996	Ashwood-Donnybrook	100,000+	8/9/1996	Jefferson, Wasco	Yes	Structural, Wildland	Conflagration Act resources mobilized to protect the threatened community of Ashwood.
1996	Smith Rock	300	8/10/1996	Deschutes	Yes	Wildland	One residence destroyed.
1996	Skeleton-Evans West	22,000	8/23/1996	Deschutes	Yes		Destroyed 19 residences and 15 outbuildings.
1998	Elk Lake	252	9/2/1998	Deschutes			Thirty two recreational cabins adjacent to Elk Lake threatened. Several destroyed.
2000	Hash Rock	18,500	8/23/2000	Crook	Yes	Structural	Thirty residences and 32 commercial buildings threatened in Mill Creek and Marks Creek drainages. U.S. Hwy 26 traffic controlled with pilot car.
2002	Eyerly	23,573	7/9/2002	Jefferson	Yes	Structural, Wildland	Spread into 3 Rivers subdivision burning 18 residences & multiple outbuildings.
2002	Cache Mountain	3,894	7/23/2002	Deschutes, Jefferrson	Yes		Fire spread five miles to east, destroying two residences in Black Butte Ranch.
2003	Davis	21,181	6/28/2010	Deschutes, Klamath		Structural	Early season, high intensity fire with high rates of spread. Spotting potential for south half of LaPine basin. Ash fallout reported 60 miles to NE at Prineville.
2003	Link	3,574	7/5/2010	Deschutes, Jefferson			Concern for potential spread to Black Butte Ranch.
2003	18 Road	3,800	7/23/2010	Deschutes			Threat of spread to residential areas on southwest side of Bend and High Desert Museum.
2003	B & B Complex	90,769	8/19/2003	Jefferson, Linn	Yes		Lightning wilderness fires spread east forcing evacuation of Camp Sherman (Jefferson Co.) and west threatening private land & residential development along Hwy 22 near Marion Forks. Santiam Pass Hwy closed. Black Butte Ranch was threatened as the fire moved south.

[15] Figure 1 – Data derived from multiple Oregon State Fire Marshall, U.S. Forest Service, Oregon Department of Forestry and Bureau of Land Management sources.

As is the case with the regional focus of table above, much of the Wildfire Chapter of this plan is presented with a regional focus on Crook, Deschutes and Jefferson counties. The scope and multi-jurisdictional nature of the local wildfire demand has driven development of a regional approach to pre-incident planning, training, initial and reinforced response, and recovery activities. The benefit of this type of coordinated approach is broadly acknowledged by fire service leadership as essential to meeting the local wildfire challenge.

Hazard History: 2005 – 2010

Year	Fire Name	Size	Start Date	County	Conflagration Act Resources Mobilized	Unprotected Areas Involved	Remarks
2007	GW	7,357	8/31/2007	Deschutes	Yes	Structural, Wildland	1221 dwelling structures saved, 50 threatened, zero destroyed
2007	Mile Post 8	120	9/27/2007	Crook		Structural, Wildland	1 dwelling structures saved, 1 threatened, zero destroyed
2008	S Summit Springs Complex	1,745	8/17/2008	Jefferson		Structural, Wildland	12 dwelling structure saved, 15 threatened, zero destroyed
2008	Juniper Butte	40	7/19/2008	Crook		Structural, Wildland	5 dwelling structures saved, 5 threatened, zero destroyed.
2010	Rooster Rock	6,037	8/2/2010	Deschutes	Yes	Structural, Wildland	14 dwelling structures saved, 20 threatened, zero destroyed

Vulnerability Assessment

The Crook County Community Wildfire Protection Plan (CWPP) was adopted in June 2005. The Plan was updated in 2007 and is currently going through a 2010 update. The Plan describes numerous areas where Crook County is vulnerable to wildfire. These areas are designated as having "high" or "extreme" hazard ratings.[16] The Plan states:

> As is the case with much of central Oregon, Crook County is experiencing a period of rapid growth[17].
>
> There has been a corresponding growth in residential development, within the urban growth boundary, rural areas and in portions of the county traditionally occupied by natural vegetation. This trend is expanding Crook County's wildland-urban interface, exposing more residents to the potential impact of wildland fire.[18]

Vulnerability to fire is caused by numerous conditions. The Crook County CWPP states that most of the wildland-urban interface (WUI) areas occur in sites dominated by either Juniper/sage/grass or Ponderosa pine/dry fir. Climate and weather have a significant impact of wildfire vulnerability as does development within the wildland-urban interface (WUI). Additionally roads play a big impact on fire response, mitigation efforts and evacuation. The Plan identifies Prineville as a community that could be impacted by wildfire.

[16] Crook County Community Wildfire Protection Plan, 2005 as amended 2007.
[17] U.S. Census Bureau data as quoted in *The Bulletin,* April 17, 2005
[18] Section 2.0 Crook County Community Profile.

Risk Assessment
The information above illustrates not only the escalating size of large wildland fires in Central Oregon, but also the increasing impact on the citizens, values-at-risk and infrastructure of the counties. The fuels, weather and demographic conditions that have driven development of large, high impact, high intensity wildland interface fires in Deschutes and Jefferson counties are also present in and around the City of Prineville.

The City finds that there is an extensive history of wildland fires in Central Oregon, including one near the City of Prineville. With increases in population, especially within urban interface areas, these impacts may increase the City's vulnerability and maximum threat in future years. The overall probably that the City will be impacted by a significant wildland fire within the next ten to 35 years is high.

P1.6 Severe Winter Storm and Wind Strom Hazard (Hazard Analysis Score = 170)

The City of Prineville is threatened by hazards generated from weather conditions almost every year. Storms bring heavy rains, strong winds, and occasionally ice and snow. Flooding and landslides can also accompany severe storms. Damaging storms are most common from October through April. Severe storms can create conditions that disrupt essential regional systems such as public utilities, telecommunications, and transportation routes. Wind, snow, and ice associated with winter storms can knock down or otherwise damage trees, power lines, and utility services. Freezing winter temperatures can damage utilities.

The most frequent weather related hazards in the City are snow, wind, ice, and freezing temperatures. Occasionally, storms from the Pacific bring rain during the warmer months. However, most rainstorms in Crook County are from thunderstorms.

Hazard History: prior to 2005
The geographic extent of severe winter storm hazards covers every area in the County. Within the 2005 NHMP, there was no mapping data available that mapped extreme weather occurrences in Crook County or the City of Prineville. Although recorded as a flood event, the weather conditions related an isolated storm event that initially caused flooding to occur in the 1998 Prineville Presidential Disaster. Severe weather can be highly localized and the nature of the hazard varies by location.

The City frequently is impacted by the effects of severe winter storms. Several non-recorded destructive winter storms have brought economic hardship and affected the life safety of City residents. Future windstorms may carry similar impacts. The damage sustained by a winter storm hazards is very dependent on types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas. The City is also impacted from severe winter storm elsewhere. Road closures on Mt. Hood stop commerce traffic and reduce the ability to obtain needed services and restrict the truck traffic that supplies Prineville's commercial and industrial businesses.

Hazard History: 2005 – 2010
Contacts were made to state and federal agencies to inquire about data relating to severe storm activity during this time period. No documented severe storm activity was noted by these agencies. Initial research was conducted on the internet to identify data or publications related to severe storm events or storm damage vulnerability. No data was identified.

In addition a steering committee made up of emergency managers, responder agencies, and local, state and federal administrators led the effort to update the Crook County Natural Hazard Mitigation Plan. The steering committee discovered no evidence of recorded severe storm activity during this time period.

Vulnerability Assessment
While a quantitative vulnerability assessment (an assessment that describes number of lives or amount of property exposed to the hazard) has not yet been conducted for winter storm events, there are many qualitative factors (issues relating to what is in danger within a community) that point to potential vulnerability. Windstorms and winter storm events can cause power outages, transportation and economic disruptions, significant property damage, and pose a high risk for injuries and loss of life. The event can also be typified by a need to shelter and care for individuals impacted by the event.

The City of Prineville is susceptible to direct and indirect impacts on infrastructure, property and business closures. Losses from interruptions in electric service can occur and road closures can cripple the community's ability to maintain transportation to vital services and commerce.
Builds and infrastructure within the City could be damaged or destroyed. Additionally, emergency response operations can be hampered when roads are blocked.

Risk Assessment
The City finds that, as can be noted from the Crook County Hazard Analysis Matrix found on page 6 of this addendum that there are a high number of winter storm events that impact the community. The community is resilient to the damaging impacts of minor storm events, but would be susceptible to damage from an intense storm event. Based upon the experiences documented within this Plan, the City finds that there is moderate risk associated with the devastating impact of a severe winter storm hazard, and the vulnerability and maximum threat to property and populations within the City is also considered to be moderate.

P1.7 Volcano Hazard (Hazard Analysis Score = 163)

Volcanoes are present in Washington, Oregon, and California where volcanic activity is generated by continental plates moving against each other (Cascadia Subduction Zone movement). Because the population of the Pacific Northwest is rapidly expanding, volcanoes of the Cascades Range are now considered some of the most dangerous in the United States.

Prineville sits east of all of the Cascade Volcanoes. The terrain in between its closest volcanic threats; Newberry, Bachelor, Broken Top, Three Sisters, Jefferson and Hood would eliminate the chance that a Lahar would affect Crook County.

Volcanic eruptions can send ash airborne, spreading the ash for hundreds or even thousands of miles. An erupting volcano can also trigger flash floods, earthquakes, rockfalls, and mudflows. Volcanic ash can contaminate water supplies, cause electrical storms, and collapse roofs.

The nature of volcanic eruptions is such that the immediate danger area covers approximately a 20-mile radius from the eruptive origin, but danger can also extend 100 miles or more from a volcano. Since the

City of Prineville falls outside of the 20 mile immediate threat area, our main hazard will be ash fall from Volcanoes as far North as Mount St. Helens to as far South as Mount Shasta.

Businesses and individuals can make plans to respond to volcano emergencies. Planning is prudent because once an emergency begins, public resources can often be overwhelmed, and citizens may need to provide for themselves and make informed decisions. Knowledge of volcano hazards can help citizens make a plan of action based on the relative safety of areas around home, school, and work.

Hazard History: prior to 2005
Although lava rock is relatively easy to find in and around the City, the closest recent eruption occurred at Mount St. Helens beginning on May 18, 1980. Following two months of earthquakes and minor eruptions and a century of dormancy, Mount St. Helens in Washington, exploded in one of the most devastating volcanic eruptions of the 20th century. Although less than 0.1 cubic mile of magma was erupted, 58 people died, and damage exceeded 1.2 billion dollars. Fortunately, most people in the area were able to evacuate safely before the eruption because the U.S. Geological Survey (USGS) and other scientists had alerted public officials to the danger. As early as 1975, USGS researchers had warned that Mount St. Helens might soon erupt. Coming more than 60 years after the last major eruption in the Cascades (Lassen Peak), the explosion of St. Helens was a spectacular reminder that the millions of residents of the Pacific Northwest share the region with live volcanoes.

The eruption of Mount St. Helens caused heavy damage and disruption to businesses and other essential services throughout Washington and much of Oregon. If one of the central Cascade Volcanoes erupted the impacts to people and property would be severe.

There have been no other recent volcanic events nearby. The last volcanic eruption happened hundreds of thousands of years ago. This eruption created the basaltic rock that is seen in the Crook River canyon below Bowman Dam.

Hazard History: 2005 – 2010
Contacts were made to state and federal agencies to inquire about data relating to severe storm activity during this time period. No documented volcanic activity was reported by these agencies for any volcanic activity in proximity to Crook County for this time period. Initial research was also conducted on the internet to identify data or publications related to severe volcanic events. No data was identified from this search.

In addition a steering committee made up of emergency managers, responder agencies, and local, state and federal administrators led the effort to update the Crook County Natural Hazard Mitigation Plan. The steering committee discovered no evidence of recorded volcanic activity during this time period.

The United States Geological Survey-Cascades Volcano Observatory (CVO) produces publications on volcanic activity by volcano. A review of this data resource[19] identified no volcanic publication for the following volcanoes between 2005 and 2010:

- Adams
- Bachelor
- Broken Top

[19] http://vulcan.wr.usgs.gov/Publications/publications_by_volcano.html

- Hood
- Jefferson
- Mount St. Helens
- Newberry
- South Sister
- Three Sisters

Vulnerability Assessment
Mount St. Helens is a tephra (ash) producing volcano. According to a USGS publication,[20] the most serious tephra hazards in the region are due to Mount St. Helens, the most prolific producer of tephra in the Cascades during the past few thousand years. The report exhibits a probability map that indentifies that the City of Prineville has an annual probability of receiving an accumulation of 10 centimeters or more of tephra accumulation at 0.01 percent or less[21]. Data was not available at the time of this update to determine the specific vulnerability to the types and numbers of existing or future buildings, infrastructure and critical infrastructure.

According to a report prepared by John R. Labadie entitled *Volcanic Ash Effects and Mitigation*[22], "volcanic ash is abrasive, mildly corrosive, and conductive (especially when wet); it may also carry a high static charge for up to two days after being ejected from a volcano. The ash is easily entrained in the air by wind or vehicle movement and may remain suspended in the air for many minutes. Due to the combination of these qualities, volcanic ash is pervasive. It can penetrate all but the most tightly-sealed enclosures". Ash can have a significant impact on all forms of activity including public health, traffic, utilities, critical infrastructure, electronics, and others.

Risk Analysis
The likelihood or magnitude of a volcanic eruption cannot be forecast with confidence[23]. However, if an eruption of significant magnitude occurs, the volcanic ash cloud and fallout could be a high hazard for the City, and the most likely risk appears to be from ash accumulation, with a chance of accumulation being less than 0.01 percent in any given year. Seismic activity (shown in the chapter on earthquake hazard) identifies numerous and regular earthquake activity within the Pacific Northwest. No specific earthquake data was identified for Prineville. As such it is concluded that the City faces no immediate and direct threat from a volcanic eruption and therefore has a low probability of threat. The City does have an indirect risk of ash accumulation that could have broad ranging impacts. Through the research and discovery phase of this update, there was insufficient data available to determine losses associated with a volcanic hazard event. This does not mean that such an eruption could not occur in any given year.

P1.8 Earthquake Hazard

(Hazard Analysis Score = 161)

According to the Pacific Northwest Seismic Network[24] (PNSN):

[20] *W.E. Scott, R.M. Iverson, J.W. Vallance, and W. Hildreth, 1995, Volcano Hazards in the Mount Adams Region, Washington: U.S. Geological Survey Open-File Report 95-492*
[21] http://vulcan.wr.usgs.gov/Volcanoes/Cascades/Hazards/ash_accumulation_10cm.html
[22] The full report is included in the Hazard Background appendix
[23] John R. Labadie entitled *Volcanic Ash Effects and Mitigation*
[24] http://www.pnsn.org/INFO_GENERAL/eqhazards.html

The seismology lab at the University of Washington records roughly 1,000 earthquakes per year in Washington and Oregon. Between one and two dozen of these cause enough ground shaking to be felt by residents. Most are in the Puget Sound region, and few cause any damage. However, based on the history of past damaging earthquakes and our understanding of the geologic history of the Pacific Northwest, we are certain that damaging earthquakes (magnitude 6 or greater) will recur in our area, although we have no way to predict whether this is more likely to be today or years from now.

The geographical position of the City of Prineville makes it susceptible to earthquakes from four sources, though expert opinions vary regarding the degree of susceptibility from each. The four sources are:

1. The off-shore Cascadia Fault Zone,
2. Deep intraplate events within the sub-ducting Juan de Fuca Plate,
3. Shallow crustal events within the North American Plate, and
4. Earth quakes 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 American Plate. In the "Basin and Range" area in the southern part of the region (Klamath and Lake Counties) earthquakes are also associated with extension (pulling apart of the crust). Stresses occur because of these movements. There also appears to be a link between the sub-ducting 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 CZ=CSZ could produce a local earthquake along the coast up to 9.0 or greater.

Central Oregon includes portions of five physiographic provinces including High Cascades, Blue Mountains, Basin and Range, High Lava Plains, and Deschutes-Columbia Plateau. Consequently, its geology and earthquake susceptibility varies considerably. There have been several significant earthquakes in the region; however all have been located in Klamath and Lake Counties. Additionally, faults have been located in Klamath and Lake Counties. The region has also been shaken historically by crustal and intraplate earthquakes and prehistorically by subduction zone earthquakes centered outside the area. All considered, there is good reason to believe that the most devastating future earthquakes would probably originate along shallow crustal faults in the region.

Hazard History: prior to 2005

An earthquake event occurred in the area occurred in April 2004 with a two-day swarm of 100 to 200 small, unfelt earthquakes. The figure below charts recent events recorded in and around the Sisters Bulge.

Significant Earthquakes in the Central Oregon Region

Date	Location	Magnitude (M)	Remarks
Approx Yrs. 1400 BCE ,1050 BCE, 600 BCE, 400 CE , 750 CE, 900 CE	Offshore, Cascadia Subduction Zone	Probably 8-9	Based on Studies of earthquakes and tsunamis in Willapa Bay, Wa. These are the midpoints of the age ranges for these six events. BCE—Before the Common Era
Jan. 1700	Offshore, Cascadia, Subduction Zone	Approx. 9.0	Generated a tsunami that struck Or., Wa., Japan; destroyed Native Am. Coastal villiages
April 1906	North of Lakeview	V	Three felt aftershocks
April 1920	Crater Lake	V	One of three shocks
January 1923	Lakeview	VI	
March 1958	SE of Adel	4.5	
May-June 1968	Adel	4.7-5.1	Damage to homes. 20 earthquakes of M4. or greater were recorded between 5/28—6/24/68
September 1993	Klamath Falls	5.9 and 6.0	Series of earthquakes, the larges being M6. Damage to Klamath Falls—two related fatalities
Source: Wong, Ivan, Bolt, Jacqueline, 1995, A Look Back at Oregon's Earthquake History, 1841-1994, Ore. Geology, p.125-139			

Hazard History: 2005-2010

Contacts were made to state and federal agencies to inquire about data relating to flood activity during this time period. Representatives from Oregon Department of Geology and Mineral Industries (DOGAMI)[25] indicated that no specific hazard data was available through a search of their data catalog for the Prineville area, and a reference was provided for a new geological map that DOGAMI published in 2006. Link: http://www.naturenw.org/cgi-bin/quikstore.pl?store=maps&product=001447. DOGAMI also noted that Light Detection and

[25] Email from Kaleena Hughes [mailto:kaleena.hughes@dogami.state.or.us] Monday, September 27, 2010 9:10 AM to Clay Moorhead, CDA Consulting Group Inc.

Ranging (LDAR) was flown for the Crook County area but data will not be released until after the 2010 NHMP update is completed. LDAR is an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target.

Another representative from DOGAMI[26] identified that they have several geologic publications that cover the parts of Crook County around Prineville. The following link identifies three field guides that cover the west part of Crook County. http://www.oregongeology.org/pubs/og/OGv69n01.pdf.

Although there have been no significant earthquake activity in the City of Prineville during the past five years, notable earthquake activity continues to occur throughout the Pacific Northwest. Using a web search, data was discovered that identified earthquake data for the Pacific Northwest. Below is a listing of notable earthquakes that occurred from 2005-2010.

Notable Pacific Northwest Earthquakes since 2005 [27] (Most Recent First)

1. July 3, 2010 at 03:25:19.40 PM (PDT) -- Magnitude 3.1, W of Grants Pass, OR
2. June 17, 2010 at 07:23:24.47 AM (PDT) -- Magnitude 4.2, SSW of Yakima, Wa
3. May 25, 2010 at 05:21:0.62 AM (PDT) -- Magnitude 3.4, NW of Carnation, Wa
4. May 14, 2010 at 12:03:4.09 PM (PDT) -- Magnitude 3.0, WSW of Mt Hood, OR
5. March 29, 2010 at 02:27:12.12 PM (PDT) -- Magnitude 3.8, W of Ellensburg, WA
6. March 25, 2010 at 03:31:7.14 PM (PDT) -- Magnitude 3.2, NNW of Moses Lake, WA
7. March 25, 2010 at 03:31:7.29 PM (PDT) -- Magnitude 3.0, NNW of Moses Lake, WA
8. January 2, 2010 at 08:36:45.91 AM (PST) -- Magnitude 3.6, ESE of Maupin, OR
9. January 2, 2010 at 08:36:45.98 AM (PST) -- Magnitude 3.6, ESE of Maupin, OR
10. January 2, 2010 at 08:36:45.76 AM (PST) -- Magnitude 3.2, ESE of Maupin, OR
11. September 30, 2009 at 08:10:6.95 PM (PDT) -- Magnitude 3.4, NE of Satsop, WA
12. September 20, 2009 at 09:45:27.80 AM (PDT) -- Magnitude 2.3, NE of Mt Rainier, WA
13. July 2, 2009 at 03:40:10.55 PM (PDT) -- Magnitude 3.2, NNE of Poulsbo, WA
14. July 1, 2009 at 05:09:17.95 AM (PDT) -- Magnitude 3.7, SW of Mt Vernon, WA
15. May 4, 2009 at 03:47:42.59 AM (PDT) -- Magnitude 3.0, N of Richland, WA
16. April 20, 2009 at 02:41:52.38 PM (PDT) -- Magnitude 3.6, ESE of Maupin, OR
17. March 30, 2009 at 00:06:10.38 AM (PDT) -- Magnitude 3.6, SE of Mt Olympus, WA
18. March 20, 2009 at 03:44:50.77 PM (PDT) -- Magnitude 3.0, ESE of Maupin, OR
19. February 26, 2009 at 01:52:47.71 AM (PST) -- Magnitude 4.1, WNW of Grants Pass, OR
20. February 26, 2009 at 01:52:47.75 AM (PST) -- Magnitude 3.2, WNW of Grants Pass, OR
21. January 3, 2009 at 05:32:4.78 PM (PST) -- Magnitude 1.9, N of Richland, WA
22. January 30, 2009 at 05:25:3.99 AM (PST) -- Magnitude 4.5, ENE of Poulsbo, WA
23. December 27, 2008 at 03:32:35.74 PM (PST) -- Magnitude 3.6, ESE of Maupin, OR
24. November 16, 2008 at 07:54:30.65 AM (PST) -- Magnitude 3.4, ESE of Maupin, OR
25. October 18, 2008 at 10:22:21.08 PM (PDT) -- Magnitude 3.5, ESE of Maupin, OR
26. July 30, 2008 at 10:02:43.19 PM (PDT) -- Magnitude 3.6, SW of Mount Vernon, WA
27. July 23, 2008 at 08:36:42.42 AM (PDT) -- Magnitude 3.3, SW of Centralia, WA
28. July 14, 2008 at 11:45:55.08 AM (PDT) -- Magnitude 4.2, ESE of Maupin, OR
29. June 20, 2008 at 01:46:8.61 AM (PDT) -- Magnitude 3.2, ESE of Maupin, OR
30. June 1, 2008 at 09:46:28.17 AM (PDT) -- Magnitude 3.4, ESE of Maupin, OR
31. May 18, 2008 at 03:19:55.00 PM (PDT) -- Magnitude 3.7, ESE of Prosser, Wa
32. April 28, 2008 at 00:39:7.56 AM (PDT) -- Magnitude 3.1, ESE of Maupin, OR

[26] Email from Jason McClaughry [mailto:jason.mcclaughry@dogami.state.or.us] Sent: Monday, September 27, 2010 10:03 AM to Clay Moorhead, CDA Consulting Group Inc.
[27] http://www.pnsn.org/SEIS/EQ_Special/pnwtectonics.html

33. April 21, 2008 at 11:40:40.06 AM (PDT) -- Magnitude 3.4, S of Darrington, WA
34. April 5, 2008 at 04:38:53.23 PM (PDT) -- Magnitude 3.6, ESE of Maupin, OR
35. March 20, 2008 at 01:03:58.77 PM (PDT) -- Magnitude 3.1, ESE of Maupin, OR
36. March 17, 2008 at 04:58:48.26 PM (PDT) -- Magnitude 3.3, E of Glacier Peak, WA
37. February 3, 2008 at 06:15:53.57 PM (PST) -- Magnitude 3.3, ESE of Maupin, OR
38. November 26, 2007 at 10:18:28.88 PM (PST) -- Magnitude 4.0, W of Poulsbo, WA
39. November 21, 2007 at 07:02:6.63 AM (PST) -- Magnitude 3.3, ESE of Maupin, OR
40. November 12, 2007 at 08:05:14.76 AM (PST) -- Magnitude 3.1, SE of Diablo, WA
41. September 23, 2007 at 11:20:54.38 PM (PDT) -- Magnitude 3.6, WSW of Woodburn, OR
42. September 12, 2007 at 09:21:35.44 PM (PDT) -- Magnitude 3.0, SE of Friday Harbor, WA
43. July 11, 2007 at 08:53:21.01 PM (PDT) -- Magnitude 3.3, WSW of Canby, OR
44. June 14, 2007 at 02:57:56.94 PM (PDT) -- Magnitude 3.9, ESE of Maupin, OR
45. May 2, 2007 at 04:16:16.36 AM (PDT) -- Magnitude 3.3, ESE of Maupin, OR
46. April 8, 2007 at 02:40:41.22 AM (PDT) -- Magnitude 3.0, ESE of Maupin, OR
47. March 30, 2007 at 01:00:30.27 PM (PDT) -- Magnitude 3.0, SSE of Bellingham, WA
48. March 22, 2007 at 07:08:9.54 AM (PDT) -- Magnitude 2.9, SSW of Bremerton, WA
49. March 1, 2007 at 02:23:44.47 AM (PST) -- Magnitude 3.1, SE of Diablo, WA
50. March 1, 2007 at 02:07:31.97 AM (PST) -- Magnitude 3.6, ESE of Maupin, OR
51. January 26, 2007 at 01:23:49.30 AM (PST) -- Magnitude 3.2, WNW of Poulsbo, WA
52. January 20, 2007 at 00:12:41.16 AM (PST) -- Magnitude 3.0, ESE of Maupin, OR
53. December 20, 2006 at 01:43:26.16 AM (PST) -- Magnitude 3.3, WNW of Walla Walla, Wa
54. November 5, 2006 at 09:34:35.69 PM (PST) -- Magnitude 2.6, SW of Portland, OR
55. October 7, 2006 at 07:48:26.57 PM (PDT) -- Magnitude 4.5, E of Mt Rainier, WA
56. August 21, 2006 at 06:06:9.60 PM (PDT) -- Magnitude 3.0, ENE of Moses Lake, WA
57. August 3, 2006 at 01:39:18.70 AM (PDT) -- Magnitude 3.8, N of Portland, OR
58. July 24, 2006 at 11:13:37.88 PM (PDT) -- Magnitude 3.1, SSE of Entiat, WA
59. July 4, 2006 at 01:37:3.15 PM (PDT) -- Magnitude 3.6, SE of Victoria, BC
60. April 26, 2006 at 07:24:6.80 AM (PDT) -- Magnitude 3.0, ESE of Woodburn, OR
61. March 4, 2006 at 09:38:47.12 AM (PST) -- Magnitude 3.2, ENE of Newport, OR
62. February 2, 2006 at 05:47:46.73 PM (PST) -- Magnitude 3.3, WSW of Everett, WA
63. January 15, 2006 at 04:29:46.49 AM (PST) -- Magnitude 3.3, NW of Victoria, BC

Vulnerability Assessment

Although the region is vulnerable to earthquake induced landslides along side of volcanoes and strong ground shaking, little evidence is presented for these events specific to the City of Prineville.

Prior to 2005, the 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. Both models are based on HAZUS, a computerized program, currently used by the Federal Emergency Management Agency (FEMA) as a means of determining potential losses from earthquakes. The CSZ event 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 model does not look at a single earthquake (as in the CSZ model); it encompasses many faults, each with a 10% change 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 unreinforced masonry building into consideration.

DOGAMI investigators caution that the models contain a high degree of uncertainty and should be used only for general planning purposes. Despite their limitations, the models do indicate that damage would occur.

Risk Assessment

The Cascadia Subduction Zone generates a devastating earthquake on average every 500-600 years. However, as with any natural processes, 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. Smaller damaging earthquake occur more frequently and may happen at any time.

Establishing a probability for devastating or damaging earthquakes is difficult given the small number of historic events in the region. Earthquakes generated by volcanic activity in Oregon's Cascade Range are possible, but likewise unpredictable.

According to PNSN:

> Although scientists have tried for decades to predict earthquakes, no one has discovered a method which can be applied with regular success[28].

The City finds that there is significant history of devastating examples of volcano hazards in and around Prineville. With the exception of the impacts from Mount St. Helens, no other significant volcano event has impacted the City in the last century. The City vulnerability to a volcanic hazard is low; however if such an event were to occur, the maximum threat to the City is high due to the wide-spread damage that could occur. The overall probability of a severe impact in the next 35 – 100 years is currently anticipated to be low.

P1.9 Landslide Hazard

(Hazard Analysis Score = 132)

Landslides are defined as any detached mass of soil, rock, or debris that moves down a slope or a stream channel. Seldom if ever, can a landslide be attributed to a single cause. All landslides involve the failure of the earth under stress. Landslides are typically triggered by periods of heavy rainfall and/or rapid snowmelt. Earthquakes, volcanoes, and excavations may also trigger them.

Also, an intense wildfire may destroy vegetation and affect organic material so that with even normal rainfall, soil saturation may trigger a landslide. Locations with extremely steep slopes are most susceptible to landslides. Landslides on these slopes tend to move more rapidly and can be more dangerous than other landslides. Landslides are particularly common along stream banks, reservoir shorelines, and large lakes.

Although landslides are natural geologic processes, their incidence and impact on people and property can be exacerbated by human activities such as excavation and grading, drainage and groundwater alterations, and changes in vegetation.

Most of the landslides in Crook County associated with flood events have been rapidly moving debris flows. Identifying and mapping landslide-prone areas and planning for development are essential to help reduce the risks of landslide hazards to life and property in the City of Prineville.

[28] http://www.pnsn.org/INFO_GENERAL/eqhazards.html

Hazard History: Prior to 2005
Landslides are a serious geologic hazard in almost every state in America. Landslides threaten transportation corridors, fuel and energy conduits, and communications facilities. While not all landslides result in property damage, many landslides impact roads and other infrastructure, and can pose a serious life-safety hazard. Growing population and an increase in housing demand has caused development to occur more frequently in hazard-prone areas.

No data source was referenced related to actual slide activity prior to 2005. This does not mean that landslides did not occur. There may have been numerous landslides that were not recorded, or where data did not exist to document the hazard activity. However, since devastating events would have been recorded, we assume that the history of impacts for landslides is low.

Hazard History: 2005 to 2010
Contacts were made to state and federal agencies to inquire about data relating to landslide activity during this time period. The Oregon Department of Transportation (ODOT) did identify work that is being developed by their agency on landslide prone areas within Crook County. More information regarding this data is located in Appendix B of the Crook County NHMP. The landslide prone areas that were identified by ODOT included areas that could potentially impact state highways. No other documented landslide activity was noted by these agencies. In addition a steering committee made up of emergency managers, responder agencies, and local, state and federal administrators led the effort to update the Crook County Natural Hazard Mitigation Plan. The steering committee discovered no evidence of recorded landslide activity during this time period.

Vulnerability Assessment
The coordination effort to identify data related to significant landslide disaster activity in near Prineville demonstrates a lack of vulnerability studies for locations other than the State's highway system. Although topographic and steep slope data is available, there are no correlation studies that pinpoint vulnerability locations that would impact buildings or people. Nonetheless, both the City of Prineville and Crook County have both implemented steep slope ordinances to regulate development in hazard-prone areas.

Landslides can affect services needed to support the Prineville's population, including transportation systems, utilities, and property damage. The impacts from a devastating landslide could have a significant impact of maintaining critical lifelines to the area, and may cause economic damage to larger urban centers like the City of Prineville.

Risk Assessment
The Oregon Department of Transportation (ODOT) has completed mitigation planning with regard to landslide activities along the state highways system in Crook County. ODOT has identified information on landslides and rockfalls in Crook County. The information identifies the most problematic landslides and rockfalls will impact state highways. A comprehensive survey of highways 380 and 126 has not been completed by ODOT at this time.

The City of Prineville finds that there is no significant history of devastating impacts from landslides. Although landslide could cause serious damage, the vulnerability of impacts to populations or property is low. However, if a serious landslide event were to occur, the maximum threat from this type of disaster would be high. The probability of a sever landslide event occurring within the next 35-100 year period is currently anticipated to be low.

P2.0 Plan Implementation and Maintenance

Regular Plan maintenance and updating allows this document to remain fresh and enables the City to advance its level of preparedness through the implementation of mitigation action items. Plan maintenance and updating is a process that combines open public involvement and the collection of new data to make informed decisions the assist in mitigating the disastrous effects on natural hazards, making the county more resilient to natural disasters.

Part of any successful plan is keeping the plan current through continuous maintenance. This Plan may be updated through a number of processes; including annual monitoring by the City Of Prineville Emergency Management, updating through the use of the NHMP Steering Committee, and a major update review during each 5-year Plan update cycle.

This Section of this document details the process that will ensure that the Prineville/Crook County Natural Hazards Mitigation Plan remains an active and relevant document. The plan maintenance process includes a schedule for monitoring and evaluating the Plan annually and producing a plan revision every five years. This section describes how the county will integrate public participation throughout the plan maintenance process.

Convener

City of Prineville Emergency Management

The City of Prineville will designate a staff member or members to serve the roles necessary to maintain, implement and update this Addendum to the Crook County NHMP. For the purpose of this Addendum, this role is called Prineville Emergency Management.

The City of Prineville through the Prineville Emergency Management will maintain, implement and update this Addendum, and will maintain the same Plan maintenance schedule as Crook County. Both local governments benefit from a coordinated simultaneous effort.

The Prineville Emergency Management will be the convener of the City of Prineville Addendum maintenance review and update. The Prineville Emergency Management will maintain regular coordination with the Crook County Office of Emergency Management and will participate in regular plan implementation efforts as a partner with Crook County. The City will participate with the Crook County NHMP Steering Committee to support the roles of the Committee and its effort to implement and update the Crook County NHMP.

Crook County Office of emergency Management

The Crook County Office of Emergency Management (CCOEM) will be the convener for the ongoing plan maintenance processes of the Crook County NHMP including:

- Annual review - The Prineville/Crook County Natural Hazards Mitigation Plan will be evaluated on an annual basis to determine the effectiveness of programs, and to reflect changes in land development or programs that may affect mitigation priorities;
- NHMP Steering Committee Plan implementation and updates – The CCOEM will lead the efforts to regularly involve the NHMP Steering Committee in ongoing activities;
- 5-year major review – The CCOEM will be responsible for compliance with FEMA's hazard mitigation planning requirements included in 44 CFR Part 201, including conducting a major review of the Crook County NHMP every five years.

The CCOEM is housed in the Sherriff's Department. CCOEM is the coordinating governmental office responsible for emergency preparedness, mitigation, response and recovery efforts for the Crook County.

Crook County Natural Hazard Mitigation Plan (NHMP) Steering Committee
The NHMP Steering Committee is a sub-committee of the Crook County Emergency Preparedness Committee (CCEPC). The CCEPC serves as the NHMP Steering Committee when conducting regular and routine activities associated with Plan implementation, maintenance, and amendments and updates to the NHMP. This committee is also responsible for continued public involvement and they involve additional key stakeholders and the general public in decision making processes involved with any amendments to the Plan.

The NHMP Steering Committee is made up of numerous responder disciplines, representatives of state agencies, local governmental agencies and the chamber of commerce. The committee meets on a monthly schedule and leads a multi-agency/multi-discipline effort to develop and implement preparedness and response actions. The Prineville Emergency Management will be represented on the Committee.

Plan Adoption
The Crook County Court and City of Prineville Council will be responsible for adopting the Prineville/Crook County Natural Hazards Mitigation Plan and the City of Prineville Addendum. These governing bodies have the authority to promote sound public policy regarding natural hazards. Once the NHMP has been adopted, the County Emergency Manager will be responsible for submitting it to the State Hazard Mitigation Officer at Oregon Emergency Management. Oregon Emergency Management will submit the updated NHMP to the Federal Emergency Management Agency (FEMA) for review. This review will address the federal criteria outlined in FEMA's Flood Mitigation Assistance program.

Ongoing Monitoring
This Addendum shall be reviewed by the Prineville Emergency Management on an annual basis and a complete review of the Addendum will occur every 5 years[29].

Topics that the Steering Committee could consider include:

- Ongoing prioritizing of action items and work plan
- Delegation of action item management and implementation
- Tracking and monitoring action item implementation
- Consideration of changes or appropriateness of action items
- Consideration of new information that could change assumptions, the risk assessment, or implementation actions of the Plan
- Natural hazard preparedness exercises

Ongoing Monitoring Steps include:

1. The CCOEM will be responsible for conducting and documenting progress made on the Crook County NHMP and the Prineville Addendum on an annual basis. The CCOEM will review each action item to track and document progress made.

[29] Mitigation Action Item LT-MH-1

2. Although the CCEPC meets monthly, the CCEPC should act as the NHMP Steering Committee and be convened once a year. The purpose of the annual review meeting will be to consider the annual review report prepared by the CCOEM, to determine the effectiveness of efforts made to implement the Plan, to promote public involvement and to consider new information, changing situations in the County, as well as changes in state or federal policies.

3. Document successes and any modification to the Plan's priorities or actions. If significant changes to the Plan are warranted, the Steering Committee shall forward a report identifying their conclusions to the Crook County Court for their review and consideration.

Crook County NHMP Review Schedule:

Year 1 (2011): Review risk assessment information and actions for implementation progress and prioritization. Document outcomes.
Year 2 (2012): Review risk assessment information and actions for implementation progress and prioritization. Document outcomes.
Year 3 (2013): Review risk assessment information and actions for implementation progress and prioritization. Document outcomes.
Year 4 (2014): Begin formal 5-year update of the NHMAP. Review Risk Assessment and actions to include new data if applicable.
Year 5 (2015): Formal Update of the NHMAP for FEMA review. During the five-year review, the Plan will be updated to meet current federal and state requirements through a public process that supports the mission of this Plan.

Five-Year Review of Addendum

This Plan will be updated every five years in conjunction with the Crook County NHMP. During this plan update, the following questions will be asked to determine what actions are necessary to update the plan. The convener will be responsible for convening the city's steering committee to address the questions outlined below.

- Are the plan's goals still applicable?
- Do the plan's priorities align with state priorities?
- Are there new partners that should be brought to the table?
- Are there new local, regional, state or federal policies influencing natural hazards that should be addressed?
- Has the community successfully implemented any mitigation activities since the plan was last updated?
- Have new issues or problems related to hazards been identified in the community?
- Do existing actions need to be reprioritized for implementation?
- Are the actions still appropriate, given current resources?
- Have there been any changes in development patterns that could influence the effects of hazards?
- Are there new studies or data available that would enhance the risk assessment?
- Has the community been affected by any disasters? Did the plan accurately address the impacts of this event?

The questions above will help the steering committee and the Prineville Emergency Management to determine what components of the mitigation plan need updating. The committee will be responsible for updating any deficiencies found in the plan based on the questions above.

Implementation through Existing Programs

The City of Prineville addresses statewide planning goals and legislative requirements through its Comprehensive Land Use Plan, capital improvement plans, and County building codes. The Natural Hazard Mitigation Plan and the City of Prineville Addendum provide a series of recommendations that are closely related to the goals and objectives of existing planning programs. Crook County will have the opportunity to implement recommended mitigation action items through existing programs and procedures.

Economic Analysis of Mitigation Projects

The Federal Emergency Management Agency's approaches to identify costs and benefits associated with natural hazard mitigation strategies or projects fall into two general categories: benefit/cost analysis and cost-effectiveness analysis. Conducting benefit/cost analysis for a mitigation activity can assist communities in determining whether a project is worth undertaking now, in order to avoid disaster-related damages later. Cost-effectiveness analysis evaluates how best to spend a given amount of money to achieve a specific goal. Determining the economic feasibility of mitigating natural hazards can provide decision-makers with an understanding of the potential benefits and costs of an activity, as well as a basis upon which to compare alternative projects.

Continued Public Involvement

The City of Prineville and Crook County are dedicated to involving the public directly in the continual review and updates of the Natural Hazard Mitigation Plan. Copies of the plan will be catalogued and kept at all of the public libraries in the County. The existence and locations of these copies will be publicized on the Crook County and City of Prineville website. This site will also contain contact information where questions or comments can be made. The plan also includes the address and the phone number to the Crook County Office of Emergency Management.