2010 Deschutes County Natural Hazards Mitigation Plan

Report for:
Deschutes County Emergency Management,
Oregon Emergency Management, and
Federal Emergency Management Agency (FEMA)

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Acknowledgements

The Deschutes County Natural Hazards Mitigation Committee acknowledges the special contributions made by a number of individuals, agencies and organizations in completing this plan:

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Central Oregon Fire Chiefs Association

Deschutes County Board of Commissioners

Project Wildfire

And the many individuals and groups with interests related to wildland fire, severe winter storm, flooding, earthquake and volcanic eruption.

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Executive Summary

INTRODUCTION

Historically, the residents of Deschutes County have experienced the effects of various natural hazards. The most prevalent natural hazard is wildland fire, occurring yearly and threatening lives, homes and natural resources in Central Oregon. Also occurring in Deschutes County are severe winter storms and some flooding. Lesser realized but potentially as hazardous are the threats of volcanic eruption and earthquake. As the population of the county has increased, so has the potential for exposure to these natural hazards, putting the area's residents at a greater risk than in the past.

In an effort to manage risk, contain costs, and promote sustainable communities, the federal government outlined new mitigation planning requirements for local governments in the Disaster Mitigation Act of 2000. Although it is difficult to predict when the next disaster will occur, or the extent of an event, collaborative planning between public entities, private sector organizations and the citizens of the region will help minimize or mitigate the resulting losses.

For purposes of this Plan, natural hazard mitigation is defined as development and implementation of activities designed to reduce or eliminate losses resulting from natural hazards.

First approved by FEMA in 2005, the Deschutes County Natural Hazards Mitigation Plan included resources and information to assist county residents, public and private sector organizations, agencies and businesses in planning and preparing for natural hazards. The 2005 Plan also provided a prioritized list of initial activities to assist Deschutes County in reducing risk and preventing loss from future natural hazard events.

The 2005 Plan has proved to be a useful tool in meeting the continued challenge to prevent losses from natural hazards and address natural hazard planning in other county planning efforts. Under the direction of this plan, much work has been completed to address the most significant threat to the County – high intensity wildland fires. Severe winter storm and flooding are also prompting mitigation planning in communities across the county. The 2005 Plan provided information and guidance for use in the updated Deschutes County Comprehensive Plan and in the development of Community Wildfire Protection Plans.

The Deschutes County Natural Hazard Mitigation Committee is responsible for the maintenance and evaluation of the Plan. The Mitigation Committee has convened multiple times over the past five years to review the original goals, objectives and actions of the Plan and discuss potential changes in priorities and mitigation initiatives for the 2010 Deschutes County Natural Hazards Mitigation Plan.

The result is this 2010 Deschutes County Natural Hazards Mitigation Plan which includes prioritized mitigation initiatives based on history and analysis of specific natural hazards

in Deschutes County. This Plan collectively provides information, resources, and shared courses of actions to continue to reduce risk and prevent loss from future natural hazard events in Deschutes County. The Plan is designed to be used by citizens, businesses, groups, agencies and organizations as they address their individual and collective responsibilities in mitigating natural hazards.

COLLABORATION

Both the 2005 Plan and this 2010 updated Plan are the result of a collaborative effort of representatives from private and public agencies, organizations, businesses and community groups. This Plan, as with the 2005 Plan, was developed by advancing existing mitigation strategies and actions through the collaboration of multiple stakeholders.

One of the favorable outcomes of living in a disaster prone environment is the willingness over time of people and agencies, both public and private, to work together with a shared mission and goals to reduce the potential for catastrophic losses from natural disasters. Collaboration is no longer just a buzz word in Deschutes County. Multiple agencies, private organizations and citizens of Deschutes County routinely collaborate to assess, prioritize and implement mitigation strategies to reduce the risks of catastrophic losses here.

The 2005 Natural Hazard Mitigation Plan provided a fresh opportunity for groups to merge common strategies and actions to address the potential natural hazards here. This 2010 Plan builds on those actions to produce an updated picture of the natural hazards relevant in Deschutes County.

The Deschutes County Natural Hazard Mitigation Committee is the primary review committee and convening body for the Plan. The Mitigation Committee is co-chaired by the Deschutes County Emergency Manager and the Deschutes County Forester and is comprised of partners from the following jurisdictions and organizations:

- Project Wildfire
- Deschutes County Board of Commissioners
- Deschutes County Emergency Management
- Deschutes County Community Development
- City of Sisters, Oregon
- City of Bend, Oregon
- City of La Pine, Oregon
- City of Redmond, Oregon
- Bend Fire & Rescue
- Deschutes County Rural Fire Protection District #2
- Sisters – Camp Sherman Rural Fire Protection District

- Oregon Department of Forestry
- Deschutes County Sheriff
- Oregon State University Extension
- Central Oregon Fire Chiefs Association
- USDA Forest Service, Deschutes National Forest
- USDI Bureau of Land Management, Prineville District

The Mitigation Committee meets a minimum of every two years. The purpose of the meeting is to review the current plan and its integration within other planning efforts, identify new and emerging issues, and update the plan on a five year cycle. Most recently, Committee members met in 2009 through individual meetings, phone conferences or via email to review the 2005 Plan and develop the 2010 Plan.

MISSION

The mission of the 2010 Deschutes County Natural Hazards Mitigation Plan is to promote sound public policy designed to protect citizens, critical facilities, infrastructure, private property, and the environment from natural hazards.

This can be achieved by increasing public awareness, documenting the resources for risk reduction and loss-prevention, and identifying activities to guide the county towards building a safer, more disaster resistant community.

PURPOSE

The 2010 Deschutes County Natural Hazards Mitigation Plan is intended to serve many purposes. These include the following:

- Provide a methodical approach to mitigation planning;
- Enhance public awareness and understanding of natural hazards;
- Create a decision-making tool for policy and decision makers;
- Promote compliance with state and federal program requirements;
- Assure coordination of mitigation-related programming;
- Create specific hazard mitigation initiatives that can be incorporated into Deschutes County's Comprehensive Plan Update (Plan 2030) to assist with implementation; and
- Document resources for risk reduction and loss prevention.

RISK ASSESSMENT

Hazard assessments for wildland fire, severe winter storm, flood, earthquake and volcanic eruption were originally performed to provide the factual basis for the mitigation initiatives proposed in the 2005 Plan. In the 2010 Plan, much of the factual information is still correct. Where it differentiates from the assessment information in the 2005 Plan, it is specifically noted in each section. The assessment information under hazard specific risk assessments are detailed under each hazard section.

The risk assessments include the following elements:

- An identification and description of the natural hazard.
- A profile of the hazard events describing the location and extent of the natural hazard, including information on previous occurrences.
- Information on the impact of the hazard on the community in terms of identifying assets and estimating potential losses.

GOALS

The Plan goals describe the overall direction that Deschutes County public and private sectors will take to mitigate risks from natural hazards.

The Deschutes County Natural Hazard Mitigation Committee reviewed the goals and assessed activities and actions taken since 2005 that have directly addressed mitigation of the five potential natural hazards in Deschutes County.

Departing from the format of the 2005 Plan goals, the Mitigation Committee agreed that a cleaner outline and description of goals and initiatives will assist in the planning, implementation and review process. The Committee further agreed that the concepts of the 2005 goals are still relevant, requiring only moderate refinement. The following five goals are the 2010 Mitigation Plan Goals that support the mission above.

1. **Involve Emergency Services**
    - Strengthen emergency operations by increasing collaboration among agencies, organizations, groups and businesses.
    - Establish policy to ensure mitigation projects for critical facilities, services and infrastructure.
    - When appropriate, systematically integrate mitigation actions with emergency operations plans and procedures.
2. **Enhance Natural Systems**
    - Preserve, rehabilitate and enhance natural systems to serve natural hazard mitigation functions.

- Integrate planning, management and land use with natural hazard mitigation strategies to protect life, property and the environment.

3. Enhance Partnerships

- Strengthen communication and coordinate participation among and within agencies, organizations, groups and individuals invested in mitigation implementation.
- Engage leadership to prioritize and implement county and regional mitigation activities.

4. Protect Life & Property

- Implement activities that assist in protecting lives by making facilities and other property more resistant to natural hazards.
- Reduce losses and repetitive damages for chronic hazard events while promoting insurance coverage for catastrophic losses from natural hazards.

5. Increase Public Awareness

- Develop and implement information and education outreach of risks, policies and strategies.

MITIGATION INITIATIVES

Mitigation initiatives are the core of the Deschutes County Natural Hazards Mitigation Plan. It is through the implementation of these initiatives that the communities in Deschutes County will become more disaster resistant.

The term "mitigation initiatives" is a relatively new addition to the lexicon of hazard management. For the purposes of this Plan, mitigation initiatives are defined as activities designed to reduce or eliminate losses resulting from natural hazards. These are the initiatives that the participating individuals, agencies and organizations will implement when resources are available to do so.

The mitigation initiatives reflect both multi-hazard and hazard specific strategies. Table 1 is a summary of the multi-hazard initiatives. Table 2 is a summary of the hazard specific initiatives.

Table 1 – Summary of Multi-Hazard Mitigation Initiatives

Multi Hazard Initiative	Description
One: Increase Public Awareness, Training and Education	Integrate training and education initiatives from the Plan into existing regulatory documents and programs where appropriate.
Two: Increase Coordination	Identify and pursue coordination of planning, fund development and mitigation initiatives.
Three: Support Research	Strengthen understanding of probability of natural hazards, particularly earthquake and volcano by continuing to support research specific to the region.

For each of the five specific natural hazards, mitigation initiatives are identified that meet one or more of the five goals. Additionally, they are prioritized. The following table provides an overview of the actions.

Table 2 – Summary of Prioritized Hazard Specific Mitigation Initiatives

Hazard	Mitigation Initiative	Priority	Goals Addressed
Wildland Fire	**One:** Continue/expand annual training to enhance effectiveness of local wildland fire mitigation, response and recovery actions.	**1**	Involve Emergency Services, Enhance Partnerships, Protect Life and Property
	Two: Develop reserve of non-traditional response resources to support local wildland fire response during draw-down situations.		Involve Emergency Services, Enhance Partnerships, Protect Life and Property
	Three: Expand public information/education initiatives in support of active hazardous fuels treatment.		Enhance Partnerships, Protect Life and Property, Increase Public Awareness
	Four: Review and upgrade existing building and land use Codes to address landscape, fuel amounts and structure detail that reduces the incidence or spread of wildland fire in urban/rural interface areas.		Protect Life and Property
	Five: Continue to prioritize and support fuels reduction projects on private lands utilizing FireFree and other programs; and identify and prioritize fuels reduction projects on public lands in the WUI.		Enhance Partnerships, Enhance Natural Systems, Protect Life and Property, Increase Public Awareness
Severe Winter Storm	**One:** Continue to coordinate mitigation activities to reduce risk to the public from severe winter storms.	**2**	Involve Emergency Services, Enhance Partnerships, Protect Life and Property, Increase Public Awareness
	Two: Continue public awareness of severe winter storm mitigation activities.		Involve Emergency Services, Enhance Partnerships, Protect Life and Property, Increase Public Awareness
	Three: Continue to enhance coordination maintenance and mitigation activities to reduce risk to public infrastructure from severe winter storms.		Involve Emergency Services, Enhance Partnerships, Protect Life and Property, Increase Public Awareness
Flooding	**One:** Continue to coordinate mitigation activities with appropriate agencies and home and business owners/groups that include an inventory of actions to or within the floodplain.	**3**	Enhance Natural Systems, Enhance Partnerships, Protect Life and Property
	Two: Maintain an inventory of all permitted dams in Deschutes County.		Enhance Natural Systems, Protect Life and Property
	Three: Comply with National Flood Insurance Program to maintain participation in program.		Protect Life & Property
	Four: Update the Flood Insurance Rate Maps for Deschutes County and revisit land use codes to determine if floodplain standards are still adequate.		Protect Life and Property, Enhance Partnerships
	Five: As federal funding become available, upgrade individual properties adjacent to or within the floodplain as appropriate.		Protect Life and Property
Volcanic Eruption	**One:** Continue to support on-going study of probability of volcanic eruption and potential impact.	**4**	Enhance Natural Systems
	Two: Review and upgrade existing building codes to address potential damage to structures from earthquake and volcanic eruption.		Protect Life and Property
Earthquake	**One:** Support in-depth studies to determine county and region's vulnerability to earthquake.	**5**	Enhance Natural Systems
	Two: Review and upgrade existing building codes to address potential damage to structures from earthquake and volcanic eruption.		Protect Life & Property

PLAN ADOPTION

Prior to formal adoption of the Plan locally, Oregon Emergency Management (OEM) and FEMA will review the final draft. This is in accordance with FEMA's *Local Multi-Hazard Mitigation Planning Guidance, July 1, 2008.*

Upon acceptance and approval of the 2010 Deschutes County Natural Hazards Mitigation Plan, the Deschutes County Board of Commissioners will formally adopt the Plan. This governing body has the authority and is charged with the responsibility to promote sound public policy regarding natural hazards.

Following approval from FEMA and adoption by the Deschutes County Board of Commissioners, this Plan will be distributed to all entity partners for use in their planning efforts.

PLAN IMPLEMENTATION

The Deschutes County Natural Hazards Mitigation Committee will oversee implementation of the Plan. Plan implementation will be a shared responsibility among all committee members.

This Plan seeks to coordinate and advance work accomplished by existing groups through communication, building partnerships and leveraging needed resources. Each governmental entity will be responsible for implementation of their individual mitigation initiatives based on funding availability and entity priorities. This implementation may include incorporating mitigation initiatives and activities into existing programs and activities. This may also include amending local comprehensive plans for policies and programs, and the development of regulations for building, zoning and subdivision code standards.

This Plan will serve as a resource as Deschutes County addresses statewide planning goals and legislative requirements through its Comprehensive Land Use Plan, Capital Improvement Plans, and County Building Codes. This Natural Hazard Mitigation Plan provides a series of recommendations that are closely related to the goals and objectives of these existing plans.

In addition to plans, programs and regulations, the entities may also incorporate the mitigation measures into their comprehensive emergency management plans (CEMPs) and capital facilities plans (CFPs). When CFPs and CEMPs are updated it is recommended that they include parts of this plan or be linked back to this document by reference.

PLAN MONITORING AND MAINTENANCE

The Plan Maintenance Section details the formal process for implementing, monitoring and keeping the Plan current. This section describes the Deschutes County Natural

Hazards Mitigation Committee that will serve as the "caretaker" of the Plan for implementation, monitoring and updating the Plan. This group will coordinate communication and various mitigation actions currently in place and advance actions described in this Plan.

CONTINUED PUBLIC INVOLVEMENT

The Deschutes County Natural Hazard Mitigation Committee along with all of the individuals, agencies and organizations that participated in this Plan, are committed to continued public involvement and education. The Mitigation Committee will continue to engage a wide cross section of Deschutes County citizens, groups, agencies and organizations representing both the private and public sectors. It will be important that natural hazards mitigation becomes integrated into existing programs and becomes part of the way jurisdictions make decisions about land use and facilities planning.

Planning

BACKGROUND

Over the last two centuries, residents of Deschutes County have experienced various natural hazards that have threatened lives, property and the environment. The emphasis to address these natural hazards is elevated now due to the extreme population growth in the region – an increase of 45% since 2000. The 2005 Mitigation Plan followed multiple ongoing efforts and results in the identification of new issues and infrastructure needed to improve existing mitigation efforts. The 2010 Plan will continue to engage the collaborative and individual efforts in the County that address natural hazards.

Deschutes County lies in the center of the state of Oregon, with the majority of the county within a large basin. While this location makes the county less vulnerable to natural disasters such as hurricanes and landslides, the county is at substantial risk of catastrophic loss from large wildland fires, severe winter storms, flooding, and potentially earthquakes and volcanic eruption.

In recent years, Deschutes County has experienced a number of large wildland fires that have impacted residents, the economy of the region and the health of the landscape. The County also routinely experiences severe winter storms and some flooding that have likewise impacted residents, the local economy and the health of the landscape. While these three natural hazards are given the most attention in this Plan, earthquakes and volcanic eruption are also examined as potential threats here.

One of the favorable outcomes of living in a disaster prone environment is the willingness over time of people and agencies, both public and private, to work together with a shared mission and goals to reduce the potential for catastrophic losses from natural disasters. Multiple agencies, private organizations and citizens of Deschutes County have collaborated to assess, prioritize and implement mitigation initiatives to reduce the risks of damage here.

THE 2005 DESCHUTES COUNTY NATURAL HAZARDS MITIGATION PLAN

In an effort to expand mitigation planning led by Deschutes County Community Development, application was made in 2003 to Federal Emergency Management Agency (FEMA) to develop a fully engaged mitigation plan that resulted in the approved 2005 Deschutes County Natural Hazard Mitigation Plan. This plan aimed to reduce the risk of loss from natural hazards by creating an ongoing community system of resources, information, and strategies to mitigate the impact of natural hazards.

The resources and information within the 2005 Mitigation Plan established a foundation for a community system of mitigation that included specific actions to be taken, integration of federal assistance programs, and integration with other private and public planning. Multiple groups and agencies have responded to the goals and objectives outlined in the 2005 Mitigation Plan.

UPDATE PROCESS

The Deschutes County Natural Hazards Mitigation Committee is the primary reviewing committee and convening body for the Plan. The Committee meets a minimum of every two years. The 2005 Plan outlined a review schedule of every year. However, the Mitigation Committee did not formally meet until 2009 to review actions against the initial 2005 objectives. By way of informal meetings including phone conferences, emails and brief assembly, the Mitigation Committee followed activities of various groups engaged in meeting the goals and objectives of the 2005 Plan.

The Mitigation Committee agreed that from this point forward, an official two-year rotation for formal review of the 2010 Plan will be appropriate. This will allow for greater resource development and implementation to occur, thus providing more opportunity to measure accomplishments aligned with the Plan.

The purpose of meeting is to review the current plan and its integration within other planning efforts, identify new and emerging issues, and update the plan on a five year cycle.

The primary focus of the reviews by the Mitigation Committee has been the areas of the plan that have had the most activity and attention since 2005. The wildland fire hazard has prompted the most activity with the development of Community Wildfire Protection Plans and numerous hazardous fuels treatment projects. Severe winter storm and flooding hazards have also initiated planning activities. Comprehensive details of this activity and any significant changes from the 2005 Plan are noted in their respective hazard sections.

There have been no significant activities, research or developments in the areas of Volcanic Eruption and Earthquake hazards since 2005; however updated data on these hazards are included under their respective sections.

Each section of the 2005 Plan was reviewed by the Hazard Mitigation Committee as part of the 2010 planning process. Furthermore, each section was revised as appropriate based on that review and any new information obtained. Any changes or departures from the 2005 Plan are detailed at the beginning of each hazard section.

THE 2010 DESCHUTES COUNTY NATURAL HAZARDS MITIGATION PLAN

Wildland fire still holds the top honor for the threat of catastrophic loss in Deschutes County. Since 2005, an additional 22,446 acres of forestland have been lost to wildland fire in the County.

As predicted in the 2005 Mitigation Plan, the condition of our forests has continued to get worse with overstocked trees and thick vegetation on forest floors. Insects and disease continue to plague our public and private lands. The conditions are now overripe for high intensity fires that destroy the forest landscape and threaten our communities.

Multiple stakeholder groups in wildland urban interface communities across Deschutes County participated in mapping WUI boundaries, assessing the wildland fire risks and making recommendations to reduce the threat of high intensity wildland fires on public and private lands.

The threat of damage from severe winter storms and flooding are somewhat related in Deschutes County as detailed in their respective sections. Severe winter storms and potential flooding are ongoing risks in central Oregon and stakeholder groups across Deschutes County have participated in discussions to receive and update information on both risks. The risk of flooding under this Plan has been upgraded to a higher priority for ongoing mitigation activities.

The 2005 Plan also addressed the potential for seismic and volcanic activity. Deschutes County is located along the east slope of the Cascade Range where documented seismic and volcanic activity occurs. The possibility of earthquake and volcanic events are of great concern. With a population increase of 45% in the last nine years, Deschutes County residents now experience higher risks associated with these hazards as more people move to the area. The Mitigation Committee includes updated information on these hazards in their respective sections.

NATURAL HAZARD LAND USE POLICY IN OREGON

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

This is particularly true in the case of planning for natural hazards where communities must balance development pressures with detailed information regarding 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.

Deschutes County Community Development has actively pursued the Comprehensive Plan Update 2030 over the last two years. Mitigation planning efforts, information and recommendations as a result of the guidance in the 2005 Natural Hazard Mitigation Plan have been included in the Update and led to changes in local land use planning. Details of this incorporation are found in the Mitigation Initiatives of this Plan.

Deschutes County has also moved forward with mitigation planning at the local level with new requirements for subdivision developments outside city limits. Again, mitigation planning efforts, information and recommendations as a result of the guidance in the 2005 Natural Hazard Mitigation Plan led to significant changes in local land use policy. Details of this incorporation are found in the Mitigation Initiatives of this Plan.

STATEWIDE JURISDICTIONAL SUPPORT

All mitigation is local, and the primary responsibility for development and implementation of risk reduction strategies and policies lies with local jurisdictions. Local jurisdictions however are not alone. Partners and resources exist at the state and federal levels. Numerous Oregon state agencies have a role in natural hazards and natural hazard mitigation. Key state agencies important in assisting Deschutes County include:

Oregon State Police & Homeland Security Office and Office of Emergency Management (OEM) are responsible for disaster mitigation, preparedness and response recovery at the state level and the administration of federal funds after a major disaster declaration.

Building Codes Division (BCD) and local Community Development Departments are responsible for building code 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 following an earthquake.

Oregon Department of Forestry (ODF) is responsible for all aspects of wildland fire protection on designated private and state forest lands. Private unprotected lands exist in central Oregon and are not designated for protection by ODF. ODF administers forest practice regulations, including landslide mitigation on non-federal lands;

USDA Forest Service and USDI Bureau of Land Management provide wildland fire protection on the federal lands within Deschutes County. Together, they are identified as the Central Oregon Fire Management Service (COFMS). COFMS includes the Deschutes National Forest, the Ochoco National Forest, the Crooked River National Grassland, and the Prineville District of the BLM. These four units are managed cooperatively under combined leadership.

Oregon Department of Geology and Mineral Industries (DOGAMI) is responsible for geological 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.

Department of Land Conservation and Development (DLCD) is responsible for planning-based hazard management including implementation of land use planning and Statewide Planning Goal 7 (natural hazards), with attention given to hazard assessments and hazard mitigation.

PLAN METHODOLOGY AND PUBLIC PARTICIPATION

Undoubtedly, wildland fire continues to be at the forefront of hazard mitigation issues in Deschutes County. Planning for the 2010 Deschutes County Natural Hazards Mitigation

Plan focused primarily upon the wildland fire risk and mitigation activities that have taken place in the County since the 2005 Plan. Updated information, goals and mitigation initiatives for each of the five natural hazards are in this Plan, along with recognition of whether initial goals and objectives were met, deferred or deleted.

The Mitigation Committee is co-chaired by the Deschutes County Emergency Manager and the Deschutes County Forester and is comprised of members from the following jurisdictions and organizations:

- Project Wildfire
- Deschutes County Board of Commissioners
- Deschutes County Emergency Management
- Deschutes County Community Development
- City of Sisters, Oregon
- City of Bend, Oregon
- City of La Pine, Oregon
- City of Redmond, Oregon
- Bend Fire & Rescue
- Deschutes County Rural Fire Protection District #2
- Oregon Department of Forestry
- Deschutes County Sheriff
- Oregon State University Extension
- Central Oregon Fire Chiefs Association
- USDA Forest Service, Deschutes National Forest
- USDI Bureau of Land Management, Prineville District

A variety of methods were used to encourage public participation in the planning process as well as educate the public about hazard mitigation efforts in their communities. Public media releases announcing meetings were sent to all media outlets in Central Oregon which resulted in numerous TV and radio interviews; and many newspaper articles.

Multiple public meetings where attendees could access information regarding the plan as well as hazard mitigation were held. In order to extend outreach to all portions of Deschutes County, community meetings were held across the county.

The following table summarizes planning meetings to address natural hazard planning in Deschutes County.

Table 3 – Natural Hazard Planning Meetings Summary

Date	# of meetings	Community	Discussion
4/21/05 thru 5/11/09	11	La Pine	Greater La Pine CWPP – original CWPP and follow up revisions in 2009. Mitigation priorities for wildland fire, evacuation & education.
1/15/05 thru 7/20/05	3	Sunriver	Sunriver CWPP – mitigation priorities for wildland fire.
7/15/06 thru 2/21/07	5	Upper Deschutes River Coalition	UDRC CWPP revisions to original 2004 plan. Mitigation priorities for wildland fire, evacuation & education.
6/1/05 thru 5/16/06	10	Bend	Greater Bend CWPP – mitigation priorities for wildland fire, evacuation, watershed issues & education.
6/13/06 thru 12/19/06	6	Redmond	Greater Redmond CWPP – mitigation priorities for wildland fire, evacuation & education.
12/19/07 thru 8-31-09	7	Sisters	Greater Sisters Country CWPP – revisions to original 2005 CWPP. Mitigation priorities for wildland fire, evacuation & education.
6/28/07 thru 9/27/07	7	Alfalfa, Brothers	East & West Deschutes County CWPP – mitigation priorities for wildland fire & education.
1/14/09 & 6/18/09	2	Deschutes County	Review of Severe Winter Storm, Flooding & Volcanic Eruption mitigation activities, goals and planning.
12/1//08 thru 6/30/09	5	City of Sisters	Under the City of Sisters Emergency Operations Plan, in depth mitigation planning for damage from breach of Carver Lake and resulting flooding of Whychus Creek.

These meetings resulted in determining mitigation goals and priorities. Electronic communication to all member organizations listed was provided and inputs incorporated in this Plan. Participants agreed to integrate the mitigation initiatives into their individual efforts when appropriate.

Stakeholders provided input and validation for the Deschutes County Natural Hazards Mitigation Plan from the following groups:

- City of Bend
- City of Sisters

- City of La Pine
- City of Redmond
- Oregon State University Extension Service
- Deschutes County Community Development
- Bend Fire & Rescue
- Deschutes County Rural Fire Protection District #2
- Central Oregon Fire Management Service
- Oregon Department of Forestry
- La Pine Rural Fire Protection District
- Sisters – Camp Sherman Rural Fire District
- Redmond Fire & Rescue
- Sunriver Fire Department
- Deschutes County Sheriff
- Federal Emergency Management Agency
- Oregon Department of Forestry
- Bureau of Land Management
- US Forest Service
- Oregon Department of Geological and Mineral Industries
- Oregon Department of Transportation
- Oregon Emergency Management
- Oregon State Police
- US Geological Survey
- Multiple homeowners associations and road district groups

In preparing the 2010 Deschutes County Natural Hazards Mitigation Plan, the Mitigation Committee reviewed the plans, standards and requirements for completing this Plan including:

- Local Multi-Hazard Mitigation Planning Guidance – 2008
- Central Oregon Hazards Assessment for Region 6 – 2009
- Deschutes County Comprehensive Plan – 2009
- Oregon Emergency Management Hazard Analysis Methodology – 2008
- FEMA State and Local Mitigation Planning – 2003
- Preparing a Community Wildfire Protection Plan – 2005
- State of Oregon Emergency Management Plan – 2003

County Profile

Deschutes County is threatened by a number of different types of natural hazards. These hazards endanger the health and safety of the county's population, jeopardize its economic vitality, and imperil the quality of the environment. Wildland fires, severe winter storms, flooding, volcanic eruption, and earthquakes have exposed Deschutes County residents and businesses to the financial and emotional costs of recovering after natural disasters. The risks associated with these natural hazards increase as more people move to the area.

The inevitability of natural hazards, and the growing population and activity within the County continues to create an urgent need to develop strategies, coordinate resources, and increase public awareness to reduce risk and prevent loss from future natural hazard events. Identifying risks posed by natural hazards and developing mitigation initiatives to reduce the impact of hazards will assist us in protecting life and property of citizens and communities.

The following county profile gives current, general information about Deschutes County and identifies information to be incorporated into natural hazards mitigation planning.

SIGNIFICANT CHANGES SINCE 2005 PLAN

The significant changes noted in this section pertain to the new incorporation of the city of La Pine; and the overall county population, which has increased 17% since 2005.

Also noted is the change from a booming economy described in the 2005 Plan to a now sluggish economy. In 2007, the Central Oregon region began to experience significant job losses as a result of the national economic downturn.

And, with the economic downturn, Deschutes County has also seen a significant dip in the median price of home sales in the last three years. In 2006, the median sales price of a home was approximately $325,000. That figure has dipped to less than $225,000 in 2009.

GEOGRAPHY AND TOPOGRAPHY

Located in Central Oregon, Deschutes County covers an area of 3,018 square miles. Approximately 78% of the land area in Deschutes County is publicly owned, predominantly managed by the USDA Forest Service. Deschutes County constitutes twenty-six percent (26%) of the Deschutes River Basin, a major watershed which covers 10,000 square miles in Central Oregon.[1] The Deschutes River is the major waterway draining the Basin. It flows north to the Columbia River which culminates its journey in the Pacific Ocean. Five sub-basins feed the main artery. Most of Deschutes County is contained by parts of three: the Upper Deschutes River Sub-basin, the Middle Deschutes River Sub-basin, and the Lower Crooked River Sub-basin. The remainder of the County

is located in the Upper Crooked River Sub-basin and in the Goose and Summer Lakes Basin. [2]

The greatest variation in relief is in the western part of the county, while towards the eastern and southern part, broad lava plains occur. Elevations range from 2,700 feet in the northern part of the county to a high of 10,358 feet at the peak of South Sister, which is along the Cascade Crest of the county's western boundary.[3] There are eight general landforms in Deschutes County: high mountains; rolling hills; isolated mountains, hills or buttes; plateaus; valleys or plains; shield volcano; lava flows; and canyons.

The Deschutes River Basin, from its headwaters to the Columbia River, encompasses 10,400 square miles of the north central part of the state.[4] Nearly 91% of Deschutes County lies within the Deschutes Basin. There are two features of the upper Deschutes River Basin which influence its characteristics - groundwater and recent volcanic activity. The most obvious is the dominance of groundwater inflow on stream flows. The complex geology of recent lava flows, pumice, and ash along with the glacial activity which has reworked much of the area, allows subsurface flows to travel in large quantities and at relatively rapid rates. The result is a very stable hydrologic regime in which daily, monthly, and even annual fluctuations in water flows are minimal compared to rivers dominated by surface runoff. [5]

The Deschutes River is a vital, multi-purpose waterway that touches the lives of thousands of people along its banks and throughout Central Oregon. An important historical, economic, and cultural resource, the Deschutes provides natural beauty, abundant wildlife, and varied recreational opportunities.

The Deschutes River received its name from early fur traders who called the river, *"Riviere des Chutes"* which means "River of the Falls."[6] Originating at Little Lava Lake, the river flows 87.4 miles through the Deschutes National Forest to the city of Bend. It joins the Columbia River upstream from The Dalles, Oregon. The river stretches for a total length of 252.2 miles. Most of the upper flow of the Deschutes River is through public land, although portions flow past private holdings. From Wickiup Reservoir to Benham Falls, the Deschutes River flows through sediments left by ancient lakes and streams.

The river has been dammed many times by lava flows and lava domes in the Benham Falls/Lava Butte area. The River now cuts through a lava dome at Benham Falls. Two sections of the River were added to the Federal Wild and Scenic River System in 1988.[7] Fifteen miles of Whychus Creek (formerly Squaw Creek), with its headwaters in the Three Sisters Wilderness, is also federally designated as Wild and Scenic.[8]

Other notable tributaries to the Deschutes River that originate or contain segments in the County include the Crooked River, Fall River, Indian Ford Creek, Little Deschutes River, Paulina Creek, and Tumalo Creek.[9] Stream flows in most of the upper Deschutes River Basin are controlled by the influence of reservoir regulation and irrigation diversions near Bend. Storage reservoirs were constructed by irrigators for the purpose of storing water

from the river during non-irrigation season to serve as a supplement to the natural flow of the river during irrigation season. Three reservoirs: Crane Prairie, Crescent Lake, and Wickiup were constructed by the Bureau of Reclamation in the 1920s and 1940s, financed by loans secured and repaid by the irrigation districts. The three reservoirs have a combined storage capacity of 347,550 acre-feet.[10]

Seven irrigation districts distribute water to productive parts of the County, however not all of these districts irrigate land completely within it. Summer release from the reservoirs provide instream benefits for wildlife, navigation, and water quality. Recreational use at many of the projects is also significant. The Deschutes River has generated economic growth and promoted quality of life for the past 100 years. It is a source of power, irrigation, forestry, agriculture, and recreation.

To achieve these benefits however; the structure and integrity of the river have been compromised, as population growth and development have strained the water and land. Problems with water quality associated with septic systems exist in the La Pine area.[11] The development of thousands of small lots in southern Deschutes County is superimposed upon highly permeable, rapidly draining soils and a high groundwater table with relatively cold water temperatures. An overwhelming majority of the lots are served by onsite sewage disposal systems (septic systems). Nitrates, a by-product of septic systems and an indicator of human pathogens, are poorly retained in the fast draining soils and do not easily break down due to the cool groundwater temperature.

In 1980-81 contamination of the aquifer from septic systems occurred in the La Pine core area. Deschutes County, Oregon Health Division, Oregon Department of Environmental Quality, U.S. Environmental Protection Agency, and the U.S. Geological Survey are presently involved with groundwater investigations and testing of innovative sewage treatment and disposal systems to reduce the impact on groundwater from nitrogen in household sewage. Recent measures implemented to address ground water pollution include the creation of a New Neighborhood between La Pine and Wickiup Junction, using a market driven transferable development credit program.[12]

CLIMATE

Generally, the weather of Deschutes County may be described as dry and sunny in the summer, and cold with significant amounts of snow in the winter.[13] The geographical climate for central Oregon is predominately high desert. Every community in central Oregon has its own variations of temperature and precipitation, relative to its elevation and proximity to the mountains. Summer temperatures range from an average high of 85°F to a low of 44°F. Winter's average highs are in the 40s with lows in the 20s. Annual precipitation ranges from 10.5" to 12" for the cities of Bend, Redmond, and Sisters.[14]

Because Deschutes County spans a wide range of physiographic regions, there is considerable variation in precipitation, with elevation as the largest factor in precipitation totals. Moving west from Bend at 3,623 ft. to the summit of the Cascades annual precipitation averages can range from nine inches to over 100 inches, respectively. [15] This change in elevation causes a significant increase in precipitation, both in the form of

rain and snow. Although the majority of the county enjoys a fairly mild winter with less than 39 inches of snow per year, the areas surrounding the Cascades are covered with snow for the majority of the winter months. Depending on the location, the frost-free season ranges from 0 to 90 days.[16]

POPULATION AND DEMOGRAPHICS

The pioneering history of Central Oregon is relatively recent. The earliest explorer arrived in 1825. Bend, the regional hub of Deschutes County, was not incorporated until 1904 with many of the most important factors to affect development in Deschutes County occurring by 1920, specifically a railroad connection to Bend, irrigation projects, and the construction of two large pine processing mills.[17] Deschutes County is bounded by Jefferson County to the north, Crook County to the east, Klamath and Lake Counties to the south, and Lane and Linn Counties to the west.

There are now four incorporated cities in Deschutes County:

- Bend – 2008 estimated population 80,995
- Redmond – 2008 estimated population 25,445
- Sisters – 2008 estimated population 1,875
- La Pine – 2008 estimated population 1,610. [18]

Deschutes County was the most rapidly growing county in the State between 1990 and 2000.[19] In 2000, Deschutes County had a population of 115,367, growing at an average annual rate of 4.25% and adding 24,333 persons. Deschutes County's share of Oregon's population increased from 2.4% in 1980 to 3.4% in 2000. During this time period, Deschutes County grew at a rate nearly 2.4 times faster than the state of Oregon. Eighty-one percent (81%) of Deschutes County's population growth between 1980 and 2000 was from in-migration. In fact, the rate of in-migration increased in the 1990s, accounting for 86% of population growth.

Since 2000, it is estimated by Portland State University's Population Research Center that the population has increased to 167,015 in the County. This population growth is projected to continue (as shown in the next table), according to the Deschutes County's Coordinated Population Forecast.[20]

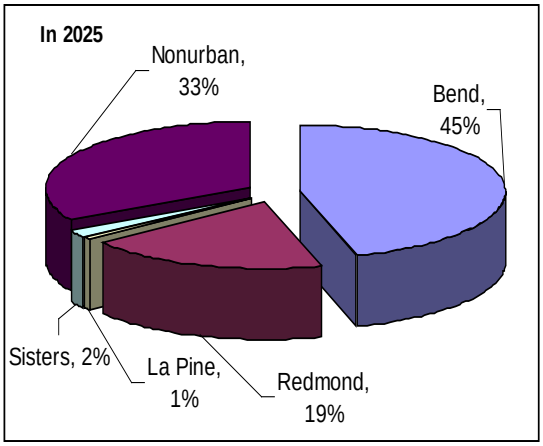
Table 4 – Historic and Projected Deschutes County Population

Deschutes County 2000-2025 Coordinated Population Forecast						
Year	Bend UGB	Redmond UGB	Sisters UGB	La Pine UGB	Non Urban	Total County
2000	52,800	15,505	975	NA	47,320	116,600
2005	69,004	19,249	1,768	NA	53,032	143,053
2010	81,242	23,897	2,306	1,697	57,430	166,572
2015	91,158	29,667	2,694	1,892	64,032	189,443
2020	100,646	36,831	3,166	2,110	71,392	214,145
2025	109,389	45,724	3,747	2,352	79,599	240,811

Source: Deschutes County's Coordinated Population Forecast 2000-2025.

Figure 1 shows the comparison of each jurisdiction's projected share of the county population in 2025.

Figure 1 – Projected Share of 2025 Population in Each Jurisdiction



Source: Deschutes County Coordinated Population Forecast 2000-2025

According to the Population Research Center at Portland State University, the largest cities in the county are Bend and Redmond, with 2008 estimated populations of 80,995 and 25,445, respectively. In 2006, the community of La Pine, Oregon incorporated forming a city with a population of 1,590. The 2008 estimated population of La Pine is 1,610. In 2000, the three incorporated communities within the county encompassed 58% of the population, leaving the remaining population in unincorporated areas. As shown in Figure 1 above, in 2008 the four incorporated cities in Deschutes County encompassed 67% of the county's population.

The increase of people living in Deschutes County creates more community exposure and changes how agencies prepare for and respond to natural hazards. For example, more

people living on the urban fringe can increase the risk of fire. Wildland fire has an increased chance of starting due to human activities in the wildland urban interface (WUI) and has the potential to injure more people and cause more property damage.

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

Vulnerable Populations

Natural hazards do not discriminate, but the impacts in terms of vulnerability and the ability to recover vary greatly among the population.[21] According to Peggy Stahl of the Federal Emergency Management Agency (FEMA) Preparedness, Training, and Exercise Directorate, 80% of the disaster burden falls on the public, and within that number, a disproportionate burden is placed upon special needs groups: women, children, minorities, and the poor.[22]

According to the US Census Bureau, 6.5% (10,856 persons) of Deschutes County's 2008 population is Hispanic or Latino. African Americans make up .7% (1,170 persons) of the population. The US Census also reports that 1.2% (2,005 persons) are American Indian, Alaskan Native, or of other ethnic descent and 1.1% (1,838 persons) of residents are Asian.[23]

In 2007, 8.2% of the population in Deschutes County was living in poverty. Approximately 9.1% of the people living in poverty at that time were under 18 years of age. Additionally, 7% of the age 65+ population and 15% of the disabled population also lived in poverty at that time.[24]

Vulnerable populations, including seniors, disabled citizens, women, and children, as well as those people living in poverty, may be disproportionately impacted by natural hazards. Examining the reach of hazard mitigation policies to special needs populations may assist in increasing access to services and programs.

FEMA's Office of Equal Rights addresses this need by suggesting that agencies and organizations planning for natural disasters identify special needs populations, make recovery centers more accessible, and review practices and procedures to remedy any discrimination in relief application or assistance. The cost of natural hazards recovery can place an unequal financial responsibility on the general population when only a small proportion may benefit from governmental funds used to rebuild private structures.[25]

Discussions about natural hazards that include local citizen groups, insurance companies, and other public and private sector organizations can help ensure that all members of the population are part of the decision-making processes.

EMPLOYMENT AND INDUSTRY

Deschutes County enjoys some economic advantages due to its location. In addition, the region's close proximity to the Cascade Mountains and the high desert terrain provide year-round sporting and tourism activities. The County continues to shift from a rural economy to one more characteristic of a growing urban area.

During the 1990's Deschutes County experienced the most rapid growth of any county in Oregon. Deschutes County's labor force in 2000 was 58,836, or about 3% of statewide employment.

In 2007, the Central Oregon region began to experience significant job losses as a result of the national economic downturn. In addition, industries that had once seen significant growth in the region saw large declines. These industries include leisure and hospitality, manufacturing, professional and business services, natural resources, mining, and construction. However, in Deschutes County industries such as educational and health services did see increases in employment in the region.[26]

In 2000 the median income for a household and a family was $42,712 and in 2007, the same mark in Deschutes County was nearly $56,000, well above the state median of $48,730.[27]

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

AGRICULTURE

Deschutes County has a short growing season based on the number of frost free days. The average frost free growing season for Bend and Redmond is forty-four days and eighty-four days respectively. The County's location east of the Cascades and proximity to the mountains creates special conditions that if not unique are certainly more predominant here than in any other county in the state. The climate determines the small amount of rainfall necessitating irrigation water, but even more importantly it sets the growing season. Without an adequate growing season, agricultural production is largely limited to grazing, pasture, and some marginal raising of cultivated crops.[28]

TRANSPORTATION AND COMMUTING PATTERNS

The County is bisected north to south by Highway 97 and east to west by Highway 20, and a railroad line travels north and south the length of the county carrying freight. Amtrak provides passenger rail service to Central Oregon through the Chemult station in Klamath County, sixty miles south of Bend on Highway 97.[29]

Deschutes County is responsible for maintaining approximately 943 miles of roadways within the County system, 750 miles which are paved. Of the 750 paved miles of public roads, many are controlled by the local jurisdictions within the four incorporated cities of Bend, Redmond, La Pine and Sisters.[30] U.S. Highways 97 and 20, both of which run though central Oregon, are two of Oregon's major trucking routes. The 17+ trucking companies that operate in central Oregon utilize Highway 97 to access Interstate 5 and Interstate 84, reaching the Northwest's metropolitan areas.

As daily transit rises, there is an increased risk that a natural hazard event will disrupt the travel plans of residents and business transportation across the region. For example, if a large wildland fire occurs which results in the closure of either Highway 20, 242 or 126, the economic loss to businesses in Sisters could exceed $500,000 per day, and on the larger impacted area of central Oregon the loss could exceed $3.5 million per day. The closure of Highway 20 for two weeks during the B&B Complex fire in 2003 resulted in the loss of $500,000 of daily commerce in Sisters which resulted in the activation of the FEMA Disaster Loan program.[31]

Localized flooding can also render roads unusable. A severe winter storm has the potential to disrupt the daily driving routine of thousands of people as does other natural hazards that can disrupt automobile traffic and shut down local transit systems.

Deschutes County is served by two airports with the Redmond Municipal Airport providing commercial service, air cargo, and general aviation to and from Crook, Deschutes, and Jefferson Counties.[32] The Bend Municipal Airport is classified as a General Aviation/Utility airport. A General Aviation/Utility airport is defined in the Oregon Aviation System Plan as an airport which "...accommodates all aircraft under 12,500 pounds. It usually has the capability for precision approach operations. General Utility airports are designed to serve aircraft with wingspans of less than 118' and approach speeds of less than 121 knots." For comparison, Redmond Airport is classified as a Primary Service/Transport airport, which means that it is intended to provide scheduled passenger service and generally accommodate larger and higher performance aircraft than Bend.[33]

There has been a 36% increase, in the number of people commuting to work from 1990 to 2000. Average travel time to work in 2008 was nineteen minutes.[34] In rural Deschutes County, the transportation choices are limited to mostly private automobiles traveling over state highways and county roads. The rural road system historically performed two basic functions: (1) providing general mobility for the residents in rural areas, and (2) accommodating the movements of agricultural and forest products to market. The rural transportation system was not designed to accommodate large volumes of traffic on a daily basis.

Urban Deschutes County meets its current transportation needs through a mixture of municipal road systems, county roads, and state highways. The County promotes alternative transportation through the Commute Options Central Oregon working group

and Central Oregon Rideshare Program. The Commute Options for Central Oregon vision is to "create a livable community by promoting transportation choices that encourage healthy individuals, a clean environment and a strong economy. Commute Options meets their mission by educating citizens, businesses, and government about the value of carpooling, vanpooling, walking, bicycling, teleworking, and riding the bus." [35]

LAND AND DEVELOPMENT

Over a period of eight years, beginning in 1845, three major immigrant wagon trains ventured through Central Oregon. None of these pioneers coming from the east lingered here to settle. Weather, terrain and other hardships pushed the travelers to the more gentle and fertile Willamette Valley.[36] The first twenty years of the Twentieth Century gradually brought an end to the untamed, untouched land of Deschutes County. This period marked the greatest rush for civilization, progress and settlement the region ever experienced. The three major cities, Sisters, Redmond, and Bend were platted; boundaries of the Deschutes National Forest were established; the railroad arrived; irrigation projects developed an agricultural landscape; and two major lumber mills began operation.[37]

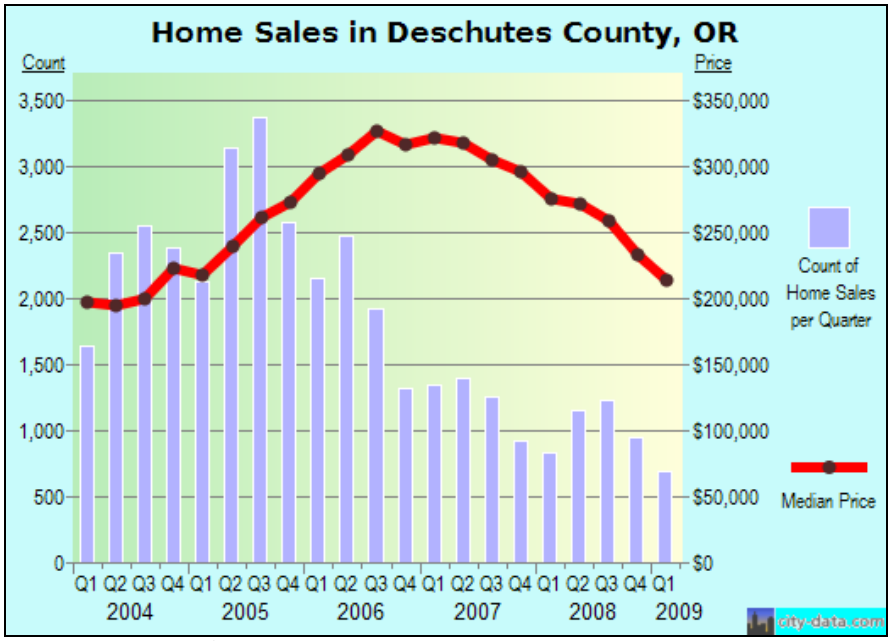
Throughout the years, the limitations of the resources in the county have created a heightened awareness of the importance of land use and development regulations. The dramatic growth and change in Deschutes County causes ever greater pressures on the land as well as the economic, governmental and social structures of the area. These pressures require many adjustments. To provide part of the answer, the comprehensive planning process has been developed for gathering information, reviewing alternatives and developing reasonable policies.[38] Important resources such as agriculture, wildlife and forest lands have been identified and marked for protection. Emphasis is also being placed on accommodating development in urban areas, while providing areas in and around rural service centers and on the urban fringes for those who wish to live in a rural area. By maintaining large open spaces and keeping development clustered together along transportation/energy corridors not only is sprawl reduced, but services may be provided more efficiently and air pollution may be kept at lower levels.[39]

HOUSING AND COMMUNITY DEVELOPMENT

Deschutes County with its rural settings, smaller cities, climate, recreational amenities, and health facilities has contributed a great deal to a strong real estate market until the recent economic downturn. Residential values increased from 2000 to 2003 and demand for low to medium priced homes continues to be strong. The median value for a home in 2000 was $148,800, compared to 1990's median value of $74,500. [40]

With the economic downturn, Deschutes County has seen a significant dip in the median price of home sales in the last three years. In 2006, the median sales price of a home was approximately $325,000. That figure has dipped to less than $225,000 in 2009. [41]

Figure 2 – Summary of Home Sales in Deschutes County 2004 - 2009



Source: City-Data.com for Deschutes County

Housing Works, formerly Central Oregon Regional Housing Authority, is a public corporation, organized under Housing Authority Law of the State of Oregon (ORS Chapter 456). Serving the combined populations of Crook, Deschutes and Jefferson Counties Housing Works provides affordable housing opportunities and services to lower income households.[42]

The Central Oregon Intergovernmental Council (COIC) is a Council of Government, as defined in Oregon Revised Statutes 190, providing educational, retraining, and economic development services in Crook, Deschutes, and Jefferson Counties. COIC provides grants and contract administration for Community Development Block Grants, Regional and Rural Investment Funds, and other funding programs.[43]

The Economic Development for Central Oregon (EDCO) is a private, non-profit organization dedicated to building a vibrant and thriving regional economy by attracting new investment and jobs through marketing, recruitment, and working with existing employers. The EDCO's mission is to assist the region in attracting new businesses, specifically primary job providers, in a variety of targeted industries through marketing and recruitment.[44]

County Profile Endnotes

[1] Monroe, William, Deschutes County Comprehensive Plan, Resource Element 1979

[2] Ibid.

[3] Ibid.

[4] Deschutes County/City of Bend River Study, April 1986

[5] Ibid.

[6] Oregon Historical County Records Guide, 2007 http://arcweb.sos.state.or.us/county/cpdeschuteshome.html

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

[8] http://www.rivers.gov/wsr-squaw.html

[9] Deschutes County Year 2000 Comprehensive Plan, adopted 1979.

[10] See note 1 above.

[11] See note 1 above.

[12] Deschutes County Comprehensive Plan, Chapter 23.44.010 Regional Problem Solving for South Deschutes County, April 2002

[13] See note 1 above.

[14] Economic Development for Central Oregon, *Central Oregon Area Profile*, 2004

[15] See note 1 above.

[16] See note 3 above.

[17] See note 1 above.

[18] Portland State University, Population Research Center, Population Estimates, 2008

[19] Deschutes County Coordinated Population Forecast 2000-2025, May 13, 2009.

[20] Ibid.

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

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

[23] http://quickfacts.census.gov/qfd/states/41/41017.html

[24] http://www.oregon.gov/OHCS/ISD/RA/docs/county_reports/08_Deschutes.pdf

[25] www.fema.gov

[26] Oregon Economic Forecast, September 2009 available at: www.oea.das.state.or.us/das/oea/docs/economic/executive.pdf

[27] http://www.oregon.gov/OHCS/ISD/RA/docs/county_reports/08_Deschutes.pdf

[28] Economic Development for Central Oregon, *Central Oregon Area Profile*, 2004

[29] Ibid.

[30] See note 9 above.

[31] Stein, Eileen, Sisters City Manager, interview, July 2009.

[32] http://www.flyrdm.com

[33] http://www.ci.bend.or.us/misc/airportQ&A.htm

[34] http://www.co.deschutes.or.us/go/living-here/transportation

[35] Ibid.

[36] Deschutes County Year 2000 Comprehensive Plan, adopted 1979.

[37] Ibid.

[38] Ibid.

[39] Ibid.

[40] http://quickfacts.census.gov/qfd/states/41/41017.html

[41] http://www.city-data.com/county/Deschutes_County-OR.html

[42] http://www.oregonhousingworks.org/ourorganization.php

[43] http://www.coic.org

[44] http://www.edcoinfo.com

Risk Assessment

The purpose of the Risk Assessment chapter is to provide the factual basis for the mitigation initiatives which are proposed in the next chapter. Hazard specific risk assessments are detailed under each hazard section. This chapter meets the following federal criteria for Risk Assessment:

1. **Hazard Identification** identifies the geographic extent and intensity of the hazard, and the probability of its occurrence. Five major natural hazards are identified that affect or could affect Deschutes County: wildland fire, severe winter storm, flooding, earthquake and volcanic eruption.

2. **Profiling Hazard Events** describes the causes and characteristics of each hazard, how it has affected Deschutes County in the past, and what part of the county's population, infrastructure, and environment has historically been vulnerable to each specific hard. A profile of each hazard discussed in his plan is provided in each hazard section.

3. **Vulnerability Assessment/Inventory Assets** combines hazard identification with an inventory of the existing (or planned) property and population exposed to a hazard. Critical facilities are of particular concern because these entities provide essential products and services to the general public that are necessary to preserve the welfare and quality of life in the county and fulfill important public safety, emergency response, and/or disaster recovery functions. A description of the critical facilities in the county is provided.

4. **Risk Analysis/Estimating Potential Losses** involves estimating the damage, injuries, and financial losses likely to be sustained in a geographic area over a given period of time. Two measures are used – magnitude of the harm that may result, and likelihood of the harm occurring.

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

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

Federal regulations for hazard mitigation plans outlined in 44 CFR Part 201 include a requirement for risk assessment. The following table outlines how this requirement is met in the 2010 Deschutes County Natural Hazard Mitigation Plan.

Table 5 – Federal Criteria for Risk Assessment

Requirement	Addressed in 2010 Deschutes County Natural Hazard Mitigation Plan
Identify Hazard	Each hazard section includes an inventory of the best available data sources that identify hazard areas.
Profile Hazard Events	Each hazard section includes documentation of the history, causes and characteristics of the hazard in the county.
Assessing Vulnerability: Identifying Assets	Where data are available, the vulnerability assessment for each hazard addressed includes an inventory of all publicly owned land with hazardous areas. Each hazard section provides information on vulnerable areas in the county.
Assess Vulnerability: Estimate Potential Losses	The Risk Assessment section of this plan identifies key critical facilities and lifelines in the county and includes a map of these facilities. Vulnerability assessments have been completed for each hazard addressed in the plan, and quantitative estimates were made for each hazard where data was available.
Assess Vulnerability: Analyze Development Trends	The Community Profile section of this plan provides a detailed description of the development trends in the county, including geography and environment, population and demographics, land use and development, housing and community development, employment and industry, and transportation and commuting patterns.

Hazard Identification Summary

The following table summarizes the five natural hazards, their probability of occurrence, vulnerability assessment and priority under this Plan.

Table 6 – Hazard Identification Summary

Hazard	Probability of occurrence	Vulnerability	Priority
Wildland Fire	High	High	1
Severe Winter Storm	Moderate	High	2
Flooding	Moderate	Moderate	3
Volcanic Eruption	Low	Low	4
Earthquake	Low	Low	

Critical and Essential Facilities and Infrastructure

Critical facilities and infrastructure are those that are vital to the continued delivery of key government services or that may significantly impact the public's ability to recover from an emergency. Essential facilities are those that if damaged, could cause serious secondary impacts. The following is a list of critical and essential facilities and infrastructure in Deschutes County.

Facilities critical to government response and recovery activities include:

- Hospitals
- Sheriff's office
- Police departments
- Fire stations
- Red Cross shelters

Infrastructures critical to government response and recovery activities include:

- Bridges
- Power substations
- Natural gas lines
- Railroads
- Gas transmission lines

Facilities essential to government response and recovery activities include:

- City halls
- County libraries
- Electric lines

The following maps illustrate the critical and essential facilities and infrastructure.

Figure 3 – Deschutes County Critical Facilities

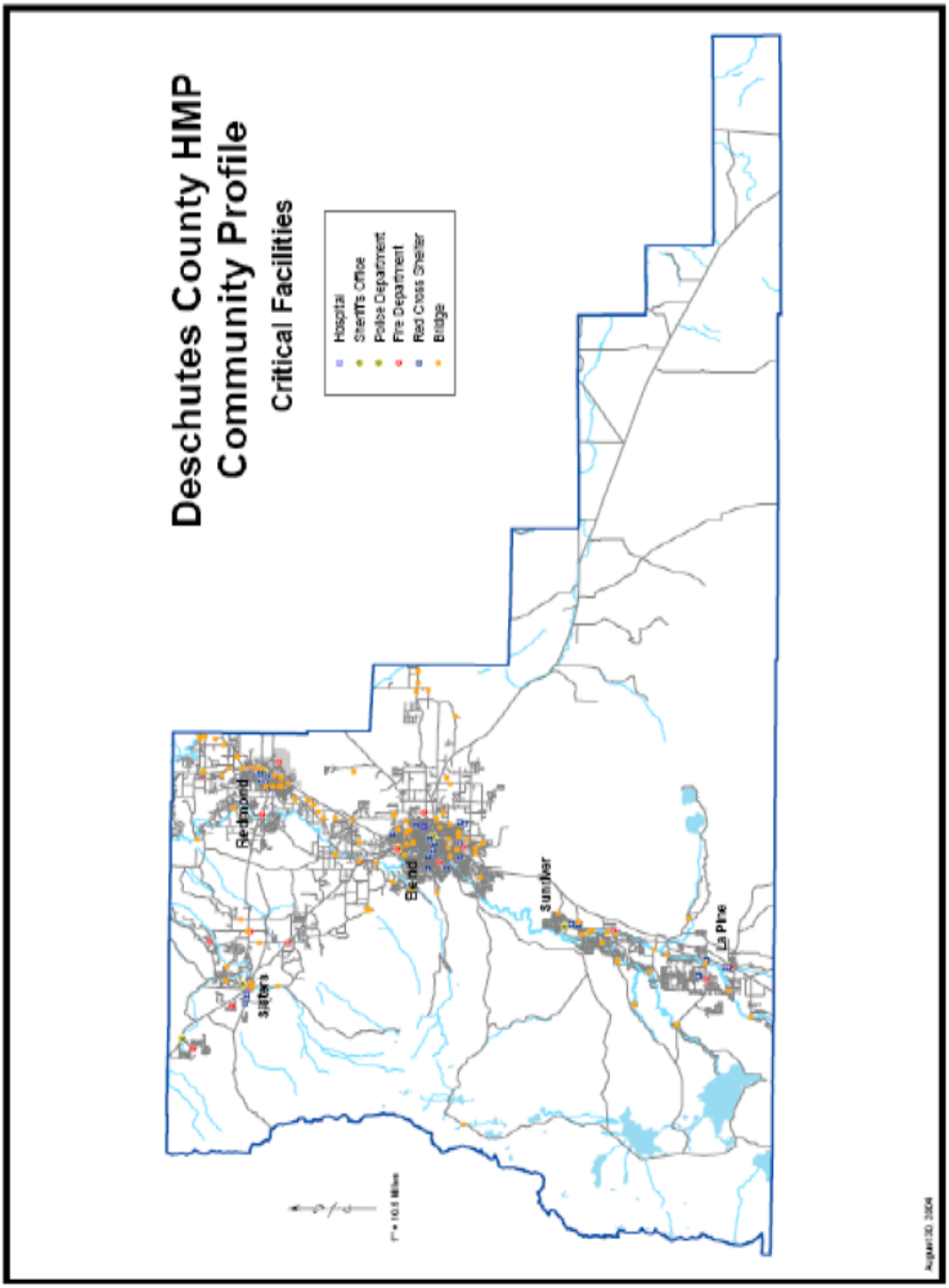


Figure 4 – Deschutes County Essential Facilities

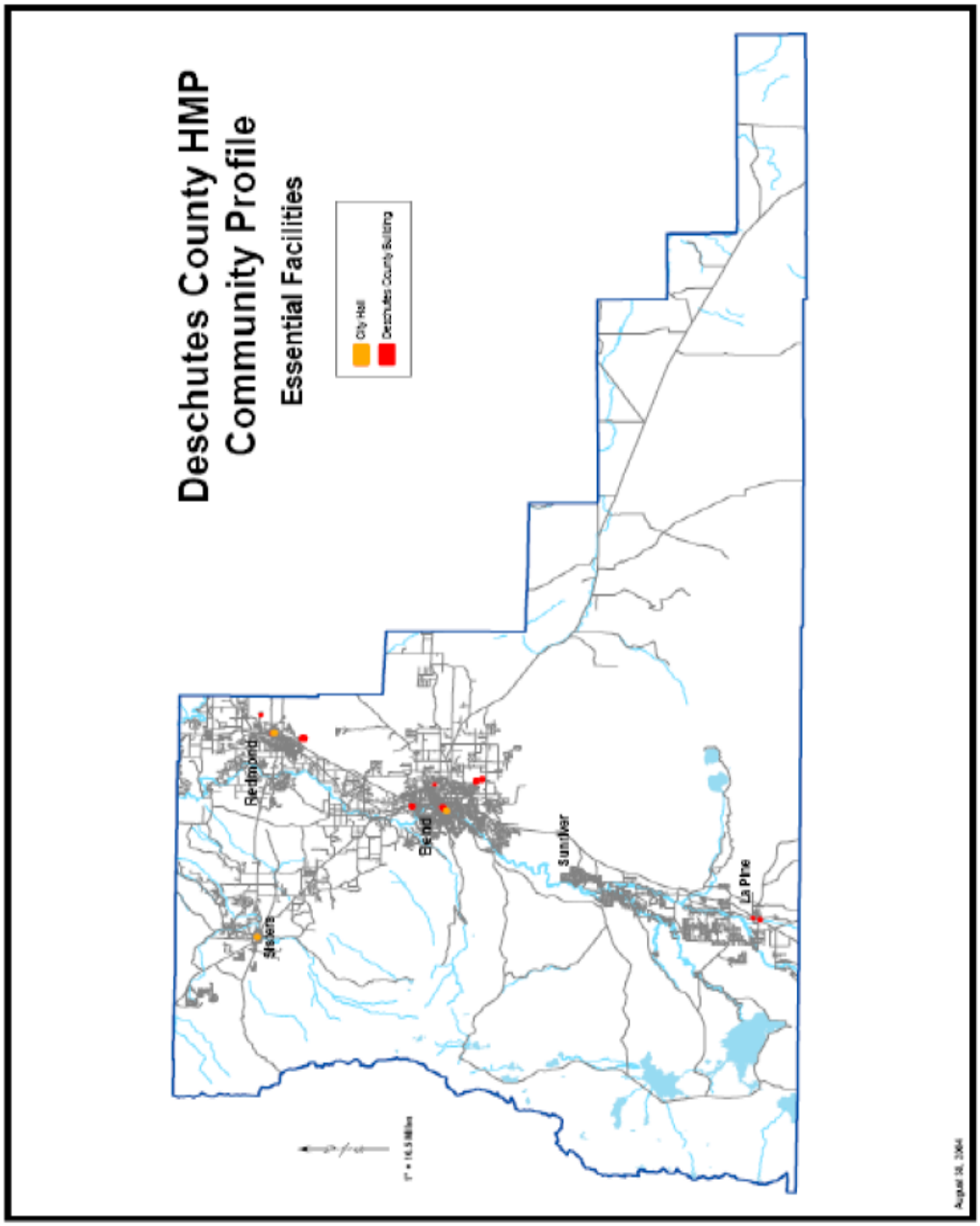
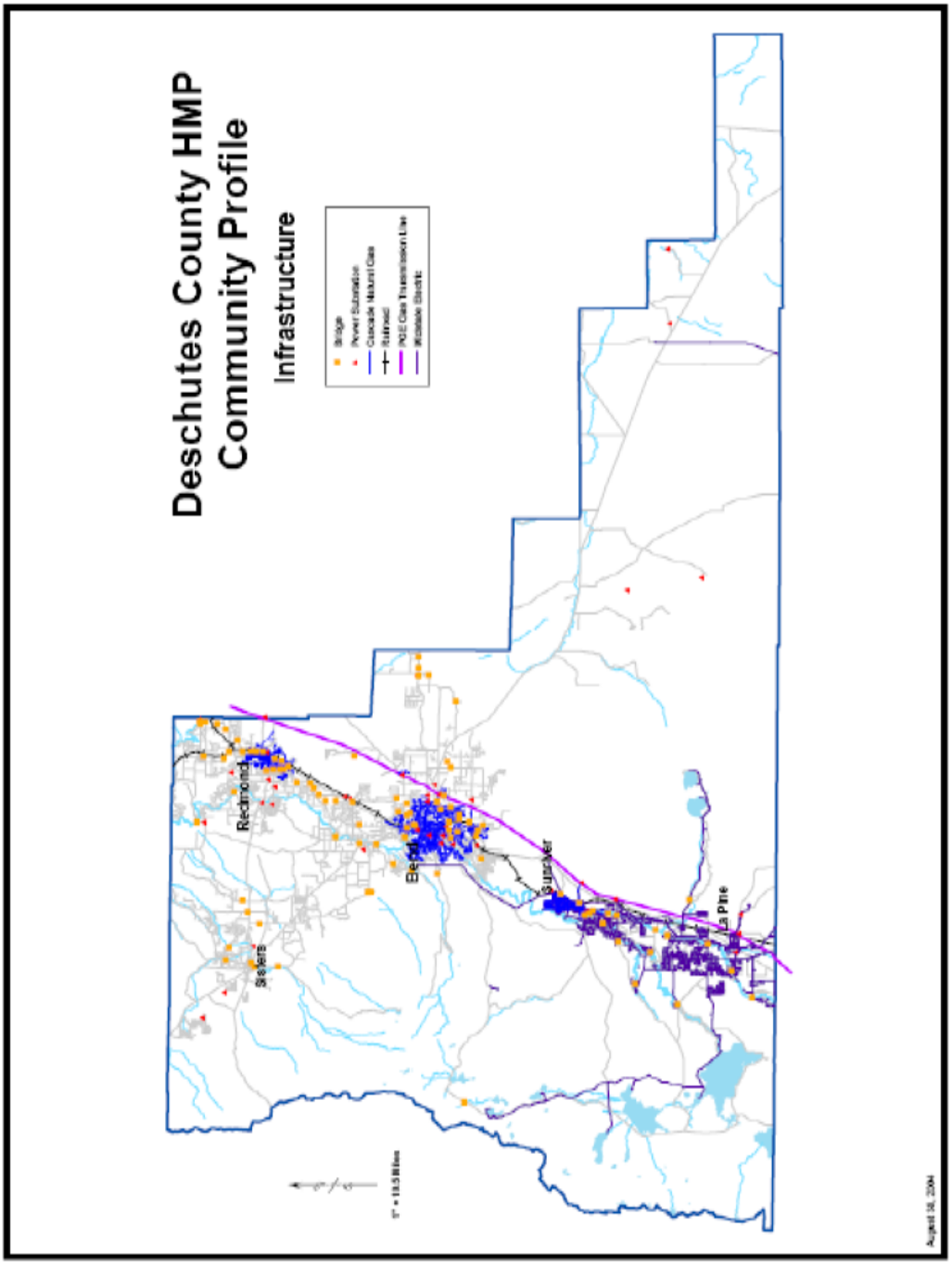


Figure 5 – Deschutes County Critical Infrastructure



Multi-Hazard Goals and Mitigation Initiatives

The Plan goals describe the overall direction that Deschutes County public and private sectors can take to work toward mitigating risks from natural hazards. The five goals outlined below support the mission of the Plan.

MISSION

The mission of the 2010 Deschutes County Natural Hazards Mitigation Plan is to promote sound public policy designed to protect citizens, critical facilities, infrastructure, private property, and the environment from natural hazards.

This can be achieved by increasing public awareness, documenting the resources for risk reduction and loss-prevention, and identifying activities to guide the county towards building a safer, more disaster resistant community.

GOALS

The Plan goals describe the overall direction that Deschutes County public and private sectors will take to mitigate risks from natural hazards.

The Deschutes County Natural Hazard Mitigation Committee reviewed the goals and assessed activities and actions taken since 2005 that have directly addressed mitigation of the five potential natural hazards in Deschutes County.

The Mitigation Committee agreed that the concepts of the 2005 goals and actions are still relevant, requiring only moderate refinement.

The 2005 Goals and Actions are summarized in the table below.

Table 7 – Summary of 2005 Multi-Hazard Mitigation Goals and Actions

Goals	Actions
Emergency Services	Coordination; Research; and Awareness, Training and Education for each natural hazard.
Natural Systems	
Partnerships	
Protect Life & Property	
Public Awareness	

Departing from the format of the 2005 Plan goals, the Mitigation Committee agreed that a cleaner outline and description of goals and initiatives will assist in the planning,

implementation and review process. The following goals are the 2010 Mitigation Plan Goals that support the mission above.

2010 MITIGATION PLAN GOALS

The goals listed serve as checkpoints as agencies and organizations begin implementing mitigation initiatives. Public participation, review of existing coordinated planning efforts and participation in mitigation plan training during development of the Mitigation Plan contributed to creating the goals. They are organized to provide an easy reference for planning, implementation and review over the next five years.

Table 8 – 2010 Natural Hazard Mitigation Goals

Goal	Actions
Involve Emergency Services	• Strengthen emergency operations by increasing collaboration among agencies, organizations, groups and businesses. • Establish policy to ensure mitigation projects for critical facilities, services and infrastructure. • When appropriate, systematically integrate mitigation actions with emergency operations plans and procedures.
Enhance Natural Systems	• Preserve, rehabilitate and enhance natural systems to serve natural hazard mitigation functions. • Integrate planning, management and land use with natural hazard mitigation strategies to protect life, property and the environment.
Enhance Partnerships	• Strengthen communication and coordinate participation among and within agencies, organizations, groups and individuals invested in mitigation implementation. • Engage leadership to prioritize and implement county and regional mitigation activities.
Protect Life & Property	• Implement activities that assist in protecting lives by making facilities and other property more resistant to natural hazards. • Reduce losses and repetitive damages for chronic hazard events while promoting insurance coverage for catastrophic losses from natural hazards.
Raise Public Awareness	• Develop and implement information and education outreach of risks, policies and strategies.

NATURAL HAZARD MITIGATION INITIATIVES

Mitigation initiatives are the core of the Deschutes County Natural Hazards Mitigation Plan. They are a listing of activities in which agencies, organizations, and individuals can be engaged to reduce the risk of loss from natural hazards. It is through the implementation of these initiatives that the communities in Deschutes County will meet

the Natural Hazard Mitigation Goals above and ultimately become more disaster resistant.

The term "mitigation initiatives" is a relatively new addition to the lexicon of hazard management and to the structure of this Plan. For the purposes of this Plan, mitigation initiatives are defined as activities designed to reduce or eliminate losses resulting from natural hazards. These are the initiatives that the participating individuals, agencies and organizations will implement when resources are available to do so.

Each of the five potential natural hazards is prioritized as shown in the following table. Prioritizing natural hazards and mitigation initiatives is based on the potential for the hazard to occur and the Deschutes County's vulnerability to it.

Table 9 – Summary of Mitigation Priorities

Hazard	Priority
Wildland Fire	1
Severe Winter Storm	2
Flooding	3
Volcanic Eruption	4
Earthquake	

The 2010 Natural Hazards Mitigation Plan identifies mitigation initiatives developed through data collection, research, and public participation; and through the implementation and review of the 2005 Plan.

Mitigation initiatives may be considered for funding though federal and state programs, and when other funds are available. Initiatives address multi-hazard and hazard specific issues. All initiatives are viewed as an "investment" in mitigation and therefore coordination and leveraging of all resources will be an important component to implementation.

The hazard-specific mitigation initiatives are listed under each hazard section along with comments from the Mitigation Committee regarding whether 2005 Plan Actions have been completed, deferred or deleted.

The following multi-hazard initiatives reflect the five overall goals of the 2010 Deschutes County Natural Hazards Mitigation Plan. The multi-hazard mitigation initiatives are summarized in Table 10.

❶ Multi-Hazard Mitigation Initiative One – Increase Public Awareness, Training and Education

Integrate training and education initiatives from the 2010 Deschutes County Natural Hazards Mitigation Plan into existing regulatory documents and programs where appropriate.

- Public education and training for staff should routinely be conducted. Resorts and other businesses related to tourism should be included.
- Distribute education materials to home and business owners that support initiatives to reduce the risk of loss from natural hazards.

Coordinating Organization: Deschutes County Natural Hazards Mitigation Committee

Timeline: Ongoing

Plan Goals Addressed: Involve Emergency Services, Enhance Natural Systems, Enhance Partnerships, Protect Life and Property, Increase Public Awareness

Benefits: The extreme population growth in the County and the region continues to bring people to the area who are not familiar with the climate, terrain, culture, etc. Additionally, this growth has placed new demands on the capacity of existing systems of support such as volunteer fire departments, city governments, and the service industry including hospitals, Red Cross and others.

It is critical that the majority of the population be informed and skilled in mitigation efforts, particularly related to wildland fire and severe winter storms. Efforts placed in public awareness, education and training will strengthen the County's capacity to address an event should it happen; heighten understanding and knowledge of how to prevent and mitigate impacts; and strengthen the culture and sense of responsibility for life, property and safety.

❷ Multi-Hazard Mitigation Initiative Two – Increase Coordination

Identify and pursue coordination of planning, fund development and mitigation initiatives.

- Establish a clear role for the Deschutes County Natural Hazards Mitigation Committee that results in a sustainable process for implementing, monitoring and evaluating mitigation activities.
- Integrate hazard mitigation initiatives into Deschutes County's Comprehensive Plan Update (Plan 2030).
- Integrate planning between cities and county where appropriate.
- Integrate other possible natural hazards not specifically included in this plan.

- Advance coordination of resource and fund development among cities and private land owners where appropriate mitigation plans mutually benefit.
- Advance coordination efforts among and with home and business owners and emergency management actions that result in reducing risk of loss from natural hazards.

Coordinating Organization: Deschutes County Natural Hazards Mitigation Committee

Timeline: Ongoing

Plan Goals Addressed: Involve Emergency Services, Enhance Natural Systems, Enhance Partnerships, Protect Life and Property, Increase Public Awareness

Benefits: The County has a good history of working together and building and sustaining systems of coordination. This is a result of facing events such as severe wildland fires and winter storms historically and recently. Stakeholders developing this plan concur that placing emphasis on coordinating efforts among public-private, geographic, and multi-interests is a sound investment in building capacity to mitigate hazards, using all resources to their greatest potential, and providing a basis for good communication among a wide range of individuals, groups, agencies and businesses.

❸ Multi-Hazard Mitigation Initiative Three – Support Research

Strengthen understanding of probability of natural hazards, particularly earthquake and volcano by continuing to support research specific to the region.

- Continue to work with the scientific community to review existing and emerging conditions related to earthquake and volcanic activity.
- Integrate research findings into county and local planning efforts.
- Integrate natural hazards not included in this plan that are identified by research.

Coordinating Organization: Deschutes County Natural Hazards Mitigation Committee

Timeline: Ongoing

Plan Goals Addressed: Involve Emergency Services, Enhance Natural Systems, Enhance Partnerships, Protect Life and Property, Increase Public Awareness

Benefits: While indicators of the potential for earthquake and volcanic eruption events are evident, the probability of these events occurring is low based on current studies. Scientists continue to study activities surrounding these hazards and document their findings. It will continue to be a priority for this research to continue in order to learn more about the vulnerability of the region, potential impact, and recommendations for additional mitigation actions.

Table 10 – Summary of 2010 Plan Multi-Hazard Mitigation Initiatives

Multi-Hazard Initiative	Description	Action
One: Increase Public Awareness, Training and Education	Integrate training and education initiatives from the Plan into existing regulatory documents and programs where appropriate.	• Public education and training for staff should routinely be conducted. Resorts and other businesses related to tourism should be included. • Distribute education materials to home and business owners that support initiatives to reduce the risk of loss from natural hazards.
Two: Increase Coordination	Identify and pursue coordination of planning, fund development and mitigation initiatives.	• Establish a clear role for the Deschutes County Natural Hazards Mitigation Committee that results in a sustainable process for implementing, monitoring and evaluating mitigation activities. • Integrate hazard mitigation initiatives into Deschutes County's Comprehensive Plan Update (Plan 2030). • Integrate planning between cities and county where appropriate. • Integrate other possible natural hazards not specifically included in this plan. • Advance coordination of resource and fund development among cities and private land owners where appropriate mitigation plans mutually benefit. • Advance coordination efforts among and with home and business owners and emergency management actions that result in reducing risk of loss from natural hazards.
Three: Support Research	Strengthen understanding of probability of natural hazards, particularly earthquake and volcano by continuing to support research specific to the region.	• Continue to work with the scientific community to review existing and emerging conditions related to earthquake and volcanic activity. • Integrate research findings into county and local planning efforts. • Integrate natural hazards not included in this plan that are identified by research.

Wildland Fire

THE THREAT OF WILDLAND FIRE IN DESCHUTES COUNTY

Wildland fire is a natural and necessary component of ecosystems across the country. Central Oregon is no exception. Historically, wildland fires have shaped the forests and wildlands valued by residents and visitors. These landscapes however, are now significantly altered due to fire prevention efforts, modern suppression activities and a general lack of large scale fires, resulting in overgrown forests with dense fuels that burn more intensely than in the past. In addition, the recent explosion in population has led to increased residential development into forested land, in the wildland urban interface (WUI).

SIGNIFICANT CHANGES SINCE 2005 PLAN

Wildland fire ranked as the number one priority under the 2005 Deschutes County Natural Hazard Mitigation Plan. An additional 22,446 acres have burned in the region since 2005. Under the 2010 Plan, wildland fire remains as the chief concern.

Due to the top priority of wildland fire and the amount of work completed in the last five years that directly meets the objectives and goals of the 2005 Plan, this entire hazard section is updated. Areas of the plan, including general information and specific initiatives, that have changed since the 2005 Plan will be addressed as they occur in this section.

HISTORY OF WILDLAND FIRE

Table 11 lists some of the larger wildland fires in the region including Crook, Deschutes and Jefferson counties over the last decade. These fires required a substantial emergency management response.

Table 11 – Summary of Large Fires

Year	Fire	Acres
2007	GW	7,357
2006	Lake George	5,550
	Black Crater	9,400
2005	Park	139
2003	Davis	21,181
	Link	3,574
	18 Road Fire	3,800
	B & B Complex	90,769
2002	Eyerly	23,573
	Cache Mountain	3,894
2001	Crane Complex	713

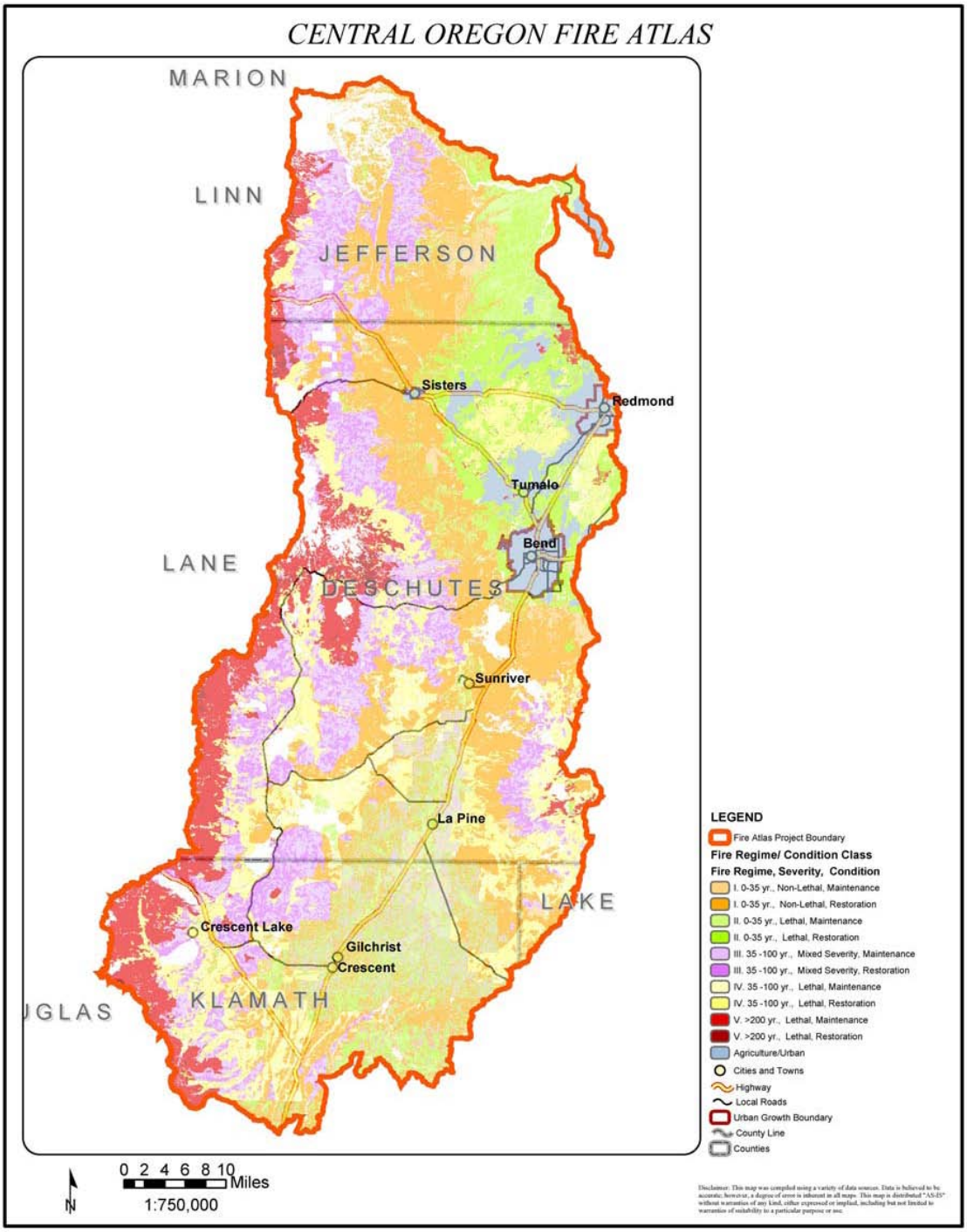
2000	Hash Rock	18,500
1998	Elk Lake	252
1996	Little Cabin	2,400
	Ashwood – Donnybrook	100,000+
	Smith Rock	300
	Skeleton	22,000
1990	Awbrey Hall	3,032

Source: Central Oregon Interagency Dispatch Records 2009

The local structural and wildland fire services have significantly refined the emergency response system for these types of destructive interface fires. Under the leadership of the Central Oregon Fire Chiefs 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. As is the case with the regional focus of Table 11, much of the wildland fire section of this plan is presented with a regional focus on Crook, Deschutes and Jefferson counties. The scope and multi-jurisdictional nature of local wildland fire 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.

Another measure of the scope and impact of the wildland fire issue, particularly in the wildland-urban interface (WUI) is illustrated by data developed in the Central Oregon Fire Atlas. The Fire Atlas was produced by The Nature Conservancy as a part of their Fire Learning Network initiative. In its current version, the Fire Atlas focuses on 2.05 million acres in Klamath, Deschutes and Jefferson counties.

Figure 6 – Central Oregon Fire Atlas[1]



Tables 11, 12 and 13 illustrate not only the escalating size of large wildland fires in Deschutes County, but also the increasing impact on the citizens, values-at-risk and infrastructure of the county.

Table 12 – Acres Burned by Decade

Summary:	
1900 – 1999 127,162 acres burned	
2000-present 188,450 acres burned	
Decade	**Acres Burned**
1900 – 1909	916
1910 - 1919	11,913
1920 – 1929	45,564
1930 – 1939	699
1940 – 1949	13,761
1950 – 1959	1,123
1960 – 1969	10,540
1970 – 1979	5,605
1980 – 1989	5,932
1990 – 1999	25,519
2000 – 2009	188,450

Source: Central Oregon Interagency Dispatch Records 2009

Although somewhat obvious, the significant story here is that central Oregon has experienced high intensity wildland fires on 48% more acreage in the last decade than in the previous 100 years combined.

The following table details the structures lost since 1981.

Table 13 – Structures Lost to Wildland Fire

Summary:	
From 1981 to present, 83 structures have been lost to wildland fire.	
Year	**Structures Lost**
2003	1
2002	20
2001	5
1996	30
1990	22
1981	5

Source: Central Oregon Interagency Dispatch Records 2009

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. In 1980, Deschutes County population was estimated to be 62,500. In 20 years, by 2000, it had nearly doubled to 116,600 and by 2002 it had increased another 8% to 126,500. The 2003 Oregon Office of Economic Analysis (OEA) has estimated the 2025 county population to be 209,919[2] while the Deschutes County Coordinated Forecast predicts a population of 240,811.[3] This trend of nearly an additional doubling of population in the next 25 years will have significant impacts on citizen exposure, infrastructure vulnerability and economic losses to the effects of wildland fire.

Unprotected lands are an issue of substantial importance in Deschutes County with 175,400 acres of unprotected lands. Throughout eastern Oregon approximately eight million acres of unprotected, privately owned wildland areas exist. In Deschutes County there are several examples of residential development that do not have structural or wildland fire protection. These include the Lower Bridge area east of Sisters, the Alfalfa community east of Bend and the Brothers and Hampton areas along Highway 20 on the eastern edge of the county. In addition, there are approximately 100,000 acres of privately owned rangeland east of Bend that do not have wildland fire protection.

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. In Deschutes County, an ordinance is currently being developed that will outline a system for landowners to respond to the wildland fire threat with defensible space and fire breaks on private property in the unprotected areas.

There are likewise substantial resource commitments and fiscal costs associated with emergency response to wildland fire incidents. This impact on local organizations was demonstrated by the multiple agency organizational response in 2003 to the Davis Fire, Link Fire and the B & B Complex Fire. The costs associated with multiple day mobilization of law enforcement, search and rescue and structural fire assets can quickly deplete local agency budgets. Residential evacuation triggers 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 higher 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 Deschutes County. In 2003, Deschutes County resources were mobilized on several occasions due to the threat to local communities from fires burning just outside of the County and in support of those adjoining counties. These 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 illustrate this impact. The Davis Fire started in Klamath County just to the southwest of La Pine, ultimately burning 21,181 acres. While this fire remained on the Deschutes National Forest, the threat to downwind communities required a massive mobilization of law enforcement, search and rescue, Oregon Department of Transportation and structural fire resources from both Klamath and Deschutes Counties to address the potential spread. Ashfall from this incident was reported as far away as Prineville in Crook County, 60 miles to the northeast.

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 area, 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 for two weeks during the peak of the tourist season. Economic losses suffered in Sisters, Camp Sherman and Black Butte Ranch triggered the declaration of an economic disaster and businesses in these communities were able to take advantage of FEMA's Economic Disaster Loan Program.

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 and public education efforts that address fire behavior issues for several miles beyond private and public land boundaries.

EXISTING SITUATION, STRATEGIES AND PROGRAMS

Deschutes County is generally considered within two vegetative ecosystems:

- the "high desert" dominated by Western juniper, sagebrush and a variety of grass species to the east and,
- to the west, a transition from dry-site ponderosa and lodgepole pine to mixed conifer to a sub-alpine mix of tree species near the crest of the Cascades.[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 adapted. Vegetative species in these areas have evolved in and are dependent on relatively short fire return intervals. Over the last 100+ years, fire suppression and forest management activities have altered this natural fire return interval. This has created species shifts and increases in stand density and forest fuels. This change has increased susceptibility of the forest to insects, diseases and to wildland fire.[5] Recent inventory and analysis of this shift by the Deschutes National Forest stratifies the national forest and adjacent lands into one of three Condition Classes based on the number of "missed" fire cycles.[6]

Vegetative Mapping for Fire Regime and Condition Class

Recently 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". Included in that plan is an extensive Fire Regime and Condition Class analysis of the condition of the vegetation on the public lands managed by the agencies.

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.

Fire Regime - Condition Class considers the type of vegetation and the departure from its natural fire behavior return interval. Five natural (historical) fire regimes are classified based on the average number of years between fires (fire frequency) combined with the severity of the fire on dominant overstory vegetation. Western juniper for example has a fire return interval of approximately 30 years with high potential for stand replacement fires. Therefore, it falls within Fire Regime II.

Table 14 summarizes Fire Regimes.

Table 14 – Fire Regimes

Fire Regime Group	Fire Frequency	Fire Severity	Plant Association Group
I	0 – 35 years	Low severity	Ponderosa pine, manzanita, bitterbrush
II	0 – 35 years	Stand replacement	Western juniper
III	35 – 100+ years	Mixed severity	Mixed conifer dry
IV	35 – 100+ years	Stand replacement	Lodgepole pine
V	> 200 years	Stand replacement	Western hemlock, mixed conifer wet

Condition Class categorizes a departure from the natural fire frequency based on ecosystem attributes. In Condition Class 1, the historical ecosystem attributes are largely intact and functioning as defined by the historical natural fire regime. In other words, the stand has not missed a fire cycle. In Condition Class 2, the historical ecosystem attributes have been moderately altered. Generally, at least one fire cycle has been missed. In Condition Class 3, historical ecosystem attributes have been significantly altered. Multiple fire cycles have been missed. The risk of losing key ecosystem components (e.g. native species, large trees, soil) is low for Class 1, moderate for Class 2, and high for Class 3.

Table 15 summarizes Condition Class.

Table 15 – Condition Class

Condition Class	Attributes
Condition Class 1	• Fire regimes are within or near an historical range. • The risk of losing key ecosystem components is low. • Fire frequencies have departed from historical frequencies (either increased or decreased) by no more than one return interval. • Vegetation attributes are intact and functioning within an historical range.
Condition Class 2	• Fire regimes have been moderately altered from their historical range. • The risk of losing key ecosystem components has increased to moderate. • Fire frequencies have departed (either increased or decreased) from historical frequencies by more than one return interval. This change results in moderate changes to one or more of the following: fire size, frequency, intensity, severity or landscape patterns. • Vegetation attributes have been moderately altered from their historic ranges.
Condition Class 3	• Fire regimes have been significantly altered from their historical range. • The risk of losing key ecosystem components is high. • Fire frequencies have departed (either increased or decreased) by multiple return intervals. This change results in dramatic changes to one or more of the following: fire size, frequency, intensity, severity, or landscape patterns. • Vegetation attributes have been significantly altered from their historic ranges.

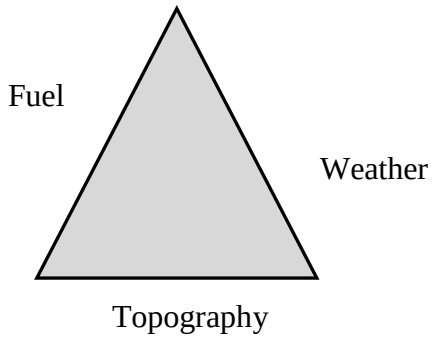
While each of the fire regimes described exist in Deschutes County, Fire Regime I and Fire Regime II generally describe the forest condition that is present at the lower elevations adjacent to the more densely population areas of the county. The forest vegetative species shift cited above however is causing a greater presence of Fire Regime III 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.

In Deschutes County, 1,899,750 acres or 64% of public lands are in Condition Class 2 or 3, having missed one or two (or more) fire return intervals. Ground vegetation and tree saplings have grown unchecked by natural fire contributing significantly to the potential for extreme fire behavior including crowning, torching and spotting.

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. The fire behavior triangle helps demonstrate the relationship between these three parameters.

Figure 7 – Fire Behavior Triangle

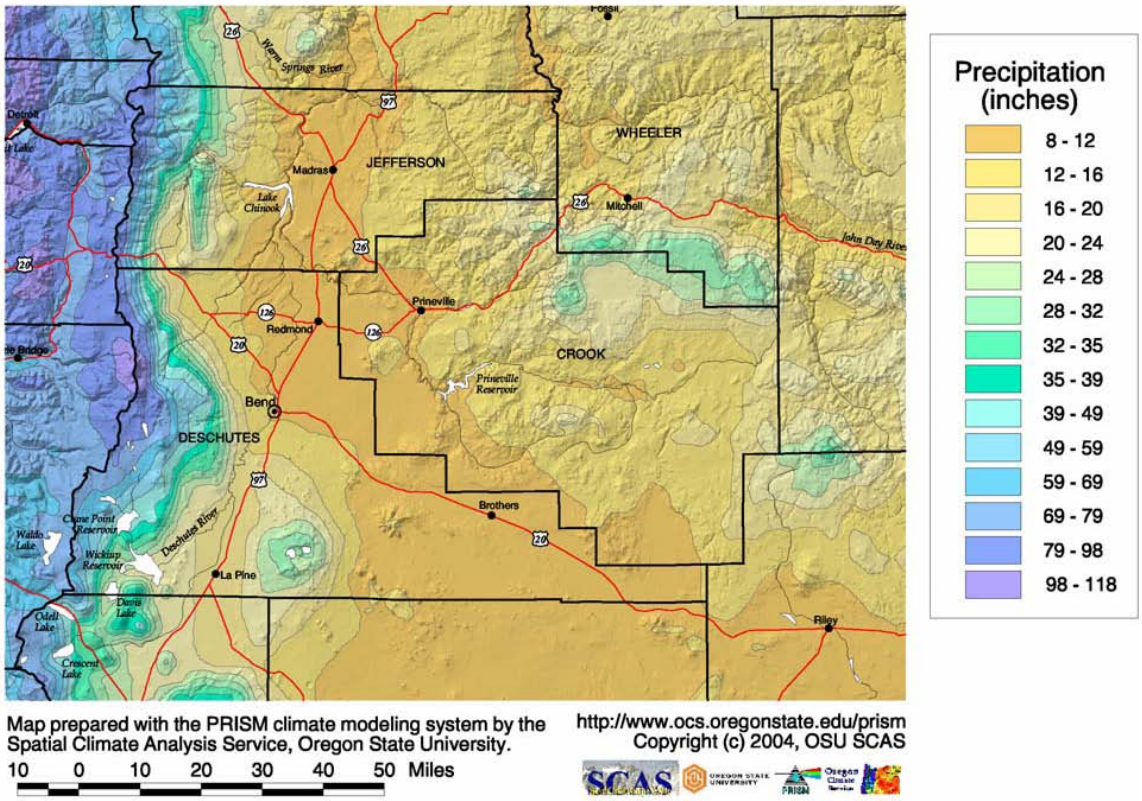


The **fuels** aspect of fire behavior takes into consideration loading, size and shape, compactness, horizontal and vertical continuity and chemical composition. Each of these parameters offers opportunities for effective hazardous fuels treatment mitigation actions. Due to the dry nature of most areas of Deschutes 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 takes into account elevation and slope position and steepness, aspect and shape of the country. Deschutes County's west boundary lies at the crest of the Cascade Mountains generally about 6,000 to 7,000 feet. The elevation falls off to the east, transitioning through the lower slopes and foothills of the Cascades, crossing the Deschutes River and progressing down to about 3,000 feet in the high desert. This generally gives the area an east and south aspect, which provides strong solar exposure throughout most of the day. The Cascades also act as a barrier to the prevailing westerly winds. This creates a rain shadow effect that limits precipitation on the east side of the mountains and contributes to gusty, turbulent, dry cold front passages that have historically contributed to high intensity fires with rapid rates of fire spread and medium to long range spotting.

As mentioned above, Central Oregon **weather** is strongly affected by the Cascade Mountains. The rain shadow effect is substantial with Bend only receiving about 12 inches of precipitation and Redmond receiving about 8.5 inches annually. Wickiup Reservoir in the Cascades near the southern edge of the county receives about 21 inches of annual precipitation.[7] 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.

Figure 8 – Precipitation Map of Central Oregon[8]



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 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 of on-going research efforts.[9]

The Wildland Urban Interface of Deschutes County

Over the last ten years, public recognition of the term "wildland urban interface" (WUI) has become greater with increased incidences of wildland fires, loss of residences, and highly visible smoke columns. The term "wildland urban interface" describes the boundary and intermixture of structural development adjacent to and within areas dominated by wildland fire vegetation. Fire suppression tactics in interface areas, both structural and wildland, must be adapted significantly.

Climate Change
The potential for significant climate change is evident globally, particularly during the last decade. Lower elevation pine ecosystems in Deschutes County are particularly susceptible to the effects of climate change. The lower edges of dry pine vegetative zones are expected to show impact of long-term changes in available precipitation early in the transition.

Wildland and Structural Fire Services Program Coordination
Both wildland and structural fire services provide a range of services including:

- educational and prevention services;
- pre-attack planning and incident response consistent with statutory, jurisdictional and regulatory responsibility; and
- fire response on private and public lands within Deschutes County.

Fire services in central Oregon have responded to expanding community development, increasing population and increasing wildland urban interface fire load by developing a well coordinated structural and wildland response system.

The structural agency Interface Task Force system and the interagency efforts of Oregon Department of Forestry, USFS, and BLM preplanned initial and extended attack system have been established for the three county region. The wildland and structural fire resources are routinely merged at the fire scene to meet specific demands of interface fire situations. During July and August in 2002 and 2003, the Interface Task Force system was activated on a weekly basis. These task forces are regularly utilized several times per year both in the tri-county area and in other portions of the state.

The effectiveness of these systems continues to work well because of annual coordination and update processes and the strong interagency working relationships between all of the jurisdictional and supporting organizations. The Bridge Creek and Cold Springs/Tollgate fires in the late 1970's initiated the refinement of the wildland preplanned system, coordination with structural resources and a culture of progressive coordination. The system undergoes annual evaluation and revision through the Central Oregon Fire Chiefs Association.

Multi-Agency Incident Coordination
In the mid 1980s, central Oregon fire services routinely held table-top and scaled field exercises or "disaster drills." Initially, these drills addressed wildland interface fires. Later, "all-risk" hazards including flood, loss of transportation routes, petroleum spills, etc., were merged into the drills. These drills helped identify components of the response process that were most subject to break-down. These components were re-engineered and integrated into the preplanned response system. The drills have become important to the ongoing development of a more integrated, interagency initial and reinforced response system, particularly for wildland urban interface fires.

The local Multi-Agency Coordination (MAC) system was created following the 1990 Awbrey Hall wildland fire. MAC, a formalized process for priority setting and coordination among jurisdictional agencies, was initially established in the City of Bend Public Works building. This facility was used for both periodic exercises and for a variety of incidents. In mid 1995 MAC was moved to the Deschutes County Sheriff Office, a new facility with accommodations that include a large conference/training area. Multi-agency coordination training and drills are now held in that facility for a wide variety of agency personnel.

Reinforced Incident Response Capacity

Central Oregon has a unique capacity to quickly provide expanded staffing to larger scale fire incidents. The US 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 organized in the late 1970's. Its 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, Oregon Department of Forestry or federal incident management teams (IMT) would require six to ten hours to mobilize and travel to central Oregon. Because of the Interagency Management Team in central Oregon a significant level of experience and capacity has been developed.

Today, central Oregon fire managers recognize the probability of the Type 2 Central Oregon IMT not having the capacity to function as originally intended. This is a result of the following:

1. With current large wildland fire loads nationally and regionally, high demand exists for both federal and state IMT services. They have been heavily mobilized to incidents throughout the western U.S. for a significant period each year and the Central Oregon Type 2 IMT may not be available.
2. Demand increases due to intensified fire behavior resulting from weather conditions and hazardous fuels build-up.

The current Oregon interagency IMT dispatching system has identified four Type 3 IMTs with personnel scheduled on a one week on and three weeks off rotation as a stopgap measure.

Mobilization of both ICS pool personnel and local IMTs are managed through the Central Oregon Interagency Dispatch Center (COIDC) in Prineville. COIDC 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 for wildland suppression resources in Crook, Deschutes and Jefferson counties and all surrounding wildland fire organizations and agencies.

Opportunity exists to leverage ICS trained personnel for incidents other than wildland fire. The National Association of State Foresters (NASF) published "Fire and Ice: The Roles of State and Federal Forestry Agencies in Disaster Management and Response" in 1999.[10] In cooperation with FEMA and USDA Forest Service the report focused on the value of Incident Command System (ICS) trained wildland fire management personnel in support of multijurisdictional incident response. With current budgets, fiscal limitations exist when using wildland fire agency personnel in support of all-risk incidents.

A formal Central Oregon Cooperative Wildland Fire Agreement exists among wildland and structural fire agencies. While wildland fire agencies are funded to address wildland fire issues there are statutory and agency-specific limitations to expending dedicated fire fighting funds for "all risk" incidents. During a Declaration of Emergency, wildland fire agencies can be partially reimbursed through the federal response framework.

Central Oregon Fire Chiefs Association

The Central Oregon Fire Chiefs 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.

Wildland Fire Prevention

Central Oregon wildland and structural fire services have a long tradition of effective organization-specific and cooperative programs. In dry, fire-prone regions such as central Oregon, fire prevention programs address two facets of preventing destructive wildfires: 1) ignition prevention, and 2) large, catastrophic fire prevention.

An 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 fire agencies and structural fire service agencies in Crook, Deschutes and Jefferson counties. COFPC provides a mechanism to maximize effective use of staffing and fiscal resources from all of the cooperating agencies. Its purpose is to conduct a wide variety of ignition prevention, youth education, public service and public education initiatives. COFPC remains active today and has received state, regional and national recognition for its efforts.

The second category includes activities intended to mitigate the impact of large fires. 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.

Project Wildfire is a successful example of a collaborative approach to large wildland fire mitigation. A national leader and model for wildland fire mitigation; Project Wildfire

takes advantage of public and private partnerships and collective resources to prevent deaths, injuries, property loss and environmental damage from wildland fire.

In the years since the 2005 Natural Hazard Mitigation Plan, Project Wildfire has become the facilitator and "caretaker" of seven Community Wildfire Protection Plans and the coordinator of the FireFree Program. Project Wildfire succeeds where an individual or one agency cannot. Project Wildfire is also committed to developing wildland fire prevention and education strategies and implementing hazardous fuels reduction programs across the County.

Federal Approach to Wildland Fire Mitigation

In 2002, President George Bush established the Healthy Forests Initiative (HFI) to improve regulatory processes to ensure more timely decisions, greater efficiency and better results in reducing the risk of high intensity wildfire. This initiative allowed forest management agencies for the first time, to expedite the environmental compliance process for the purpose of reducing hazardous fuels on public lands.

In 2003, the US Congress passed historical bi-partisan legislation: the Healthy Forests Restoration Act (HFRA). This legislation expands the initial effort under the Healthy Forests Initiative and directs federal agencies to collaborate with communities in developing a Community Wildfire Protection Plan (CWPP) which includes the identification and prioritization of areas needing hazardous fuels treatment. It further provides authorities to expedite the National Environmental Policy Act (NEPA) process for fuels reduction projects on federal lands. The act also requires that 50% of funding allocated to fuels projects be used in the wildland urban interface.[11]

At the time of compiling data, resources and information for the 2005 Natural Hazard Mitigation Plan, HFRA was new on the scene and the complete impact of its legislative reach was unknown.

As a result of the authorities under HFRA, communities in Deschutes County now have the opportunity to participate in advising where federal agencies place their fuels reduction efforts. With a Community Wildfire Protection Plan in place, community groups can apply for federal grants to treat hazardous fuels and address special concerns to reduce the risk of catastrophic loss as a result of wildland fire.

Although some of the authorities under the Healthy Forests Initiative have been subsequently challenged in federal courts, all have been successfully appealed and the original intent and authorities under each remain the same.

Community Wildfire Protection Plans

Central Oregon communities responded to a heightened awareness about wildland fire in the region and the new legislation and collaborated to produce seven CWPPs that address the specific wildland fire issues in each geographic area.

CWPPs had not been developed or produced at the time the 2005 Natural Hazard Plan was adopted. Their development and implementation is a significant change since the 2005 Plan.

CWPPs have led the way in providing consistent analysis of the existing fuels and WUI conditions along with recommendations and priorities for hazardous fuels reductions treatments on public and private lands. It is through these Community Wildfire Protection Plans that communities have set wildland urban interface (WUI) boundaries and conducted assessments on every community at risk. Further, each 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.

WILDLAND FIRE HAZARD IDENTIFICATION

Wildland Fire Hazard Zones

In part because of Deschutes County's 1990 Awbrey Hall Fire, the 1993 State Legislature initiated a process to identify wildfire hazard and declare wildfire hazard zones. The legislation provided a mechanism for counties to supersede local provisions requiring the use of flammable roofing materials such as wood shake. A second provision requires that addresses of structures be clearly identified. This process is complete in Deschutes County with the implementation of provisions in the Deschutes County Building Code. This is of particular significance because a combustible roof is the most vulnerable structure component to ember attack in interface wildfire situations.[12] By Deschutes County Ordinance, installation of combustible roofing materials is no longer allowed on new structures or replacement roof systems.

WILDLAND FIRE HAZARD ASSESSMENT

Prior to the inception of CWPPs in Deschutes County, wildland fire hazard assessments have been conducted by individual fire districts or agencies. The outputs from these assessments have been incorporated into agency response plans. With every acre of Deschutes County now included in a CWPP, consistent hazard assessment information is available to all agencies for response plans.

Community Wildfire Protection Plan Assessment

Each Community Wildfire Protection Plan utilized a variety of hazard assessment tools depending on the vegetation ecotypes of the Communities at Risk within each CWPP. At a minimum however, each CWPP utilized the Oregon Department of Forestry Assessment of Risk Factors which is based on five categories of evaluation that include a variety of information designed to identify and evaluate wildland fire risk across Oregon: risk of wildfire occurrence, hazard, protection capability, human and economic values protected and structural vulnerability.

Over the last five years, collaborative groups in each of seven CWPP areas met to conduct these assessments and determine priorities for fuels reduction activities on public and private lands.[13]

Based on the numerical outputs of this assessment, each of the Communities at Risk receives a score for each category and a total score. Utilizing the scores, the Communities at Risk can be ranked for prioritization. The following table details the priorities determined under each CWPP.

Table 16 – Summary of CWPP Priorities in Communities at Risk

CWPP Areas	Communities at Risk – Priorities
Sisters WUI	**Extreme Risk Priority Communities** Camp Sherman, Black Butte Ranch **Very High Risk Priority Communities** Tollgate, Indian Ford, Squaw Creek, Crossroads, Plainview, Sisters, Panoramic **High Risk Priority Communities** Suttle Lake, Sage Meadow, Forked Horn, Aspen Lakes, Cascade Meadow
Bend WUI	**Priority One** Deschutes River Woods, Southeast and Saddleback **Priority Two** West, West UGR and Skyliners **Priority Three** East UGR, North, Northeast and Tumalo
Redmond WUI	**Highest Priorities** Northwest, Southwest, Northeast, Southeast and Urban Northwest **High Priorities** Urban Northeast, Urban Southwest, Urban Southeast
Upper Deschutes River Coalition WUI	**Highest Priorities** Three Rivers, Little Deschutes Corridor, Big River, Foster Road Corridor **High Priorities** Wild River, Haner Park, Fall River
Sunriver WUI	**Highest priority** is treating public lands surrounding Sunriver and private lands inside Sunriver.
La Pine WUI	**Highest Priorities** 6th & Dorrance, Wickiup Acres, Day Road Corridor, Masten Road Area. **High Priorities** Huntington South, Little Deschutes River, Newberry Estates, Ponderosa Pines and Section 36.
East & West Deschutes County WUI	**Highest Priorities** Reservoirs, West Evacuation Routes, All West Lakes, Tumalo Falls, Paulina & East Lakes & their Evacuation Routes, Newberry Visitors Center and Lava River Cave, Alfalfa, Millican, Brothers, Pine Mountain, Hampton North and Glass Butte Road. **High Priorities** Edison Trailhead, Other West Trailheads, Round Mountain, Newberry Lava Cast Forest, Sugar Pine Butte, Fox Butte Rd, Millican/Brothers Evacuation Routes and Hampton South.

The Oregon Forestland-Urban Interface Fire Protection Act of 1997

Just barely put into practice at the time the 2005 Deschutes County Natural Hazard Mitigation Plan was the implementation of the Oregon Forestland-Urban Interface Fire Protection Act (also known as Senate Bill 360) in Deschutes County. Administered by the Oregon Department of Forestry (ODF), Senate Bill 360 enlists the aid of property owners toward the goal of turning wildland urban interface properties into less volatile zones where homes can survive and firefighters may more safely and effectively defend them against wildland fire. Senate Bill 360 applies only to interface areas on private land within the boundary of an Oregon State Department of Forestry District.

The law requires property owners in identified areas to reduce excess vegetation around structures and along driveways. In some cases, depending on the rating classification of the property, it is also necessary to create additional fuel breaks along property lines and roadsides.

The process of identifying wildland urban interface areas follows steps and definitions described in Oregon Administrative Rules. Briefly, the identification criteria include:

- Lands within the county that are also inside an Oregon Department of Forestry protection district.
- Lands that meet the state's definition of "forestland."
- Lands that meet the definition of "suburban" or "urban"; in some cases, "rural" lands may be included within a wildland urban interface area for the purpose of maintaining meaningful, contiguous boundaries.
- Lots that are developed, that are 10 acres in size or smaller, and which are grouped with other lots with similar characteristics in a minimum density of four structures per 40 acres.

Wildland urban interface areas were identified in each county by a classification committee. Once areas are identified, a committee applies fire risk classifications to the areas. The classifications range from "low" to "high density extreme," and the classification is used by a property owner to determine the size of a fuel break that needs to be established around a structure. The classification committee reconvenes every five years to review and recommend any changes to the classifications.[14]

During the summer of 2009, the Senate Bill 360 Reclassification Committee in Deschutes County met several times to review the original classifications and make recommendations based on new data, development and the new classification of previously unclassified areas. At the time this Natural Hazard Mitigation Plan was completed, the Reclassification Committee had only made recommendations. The final public input and approval process is scheduled for completion in early 2010.

The Oregon Department of Forestry is the agency steward of this program. It supplies information about the act's fuel reduction standards to property owners. ODF also mails each of these property owners a certification card, which may be signed and returned to

ODF after the fuel reduction standards have been met. Certification relieves a property owner from the act's fire cost recovery liability. This takes effect on properties that are within a wildland urban interface area and for which a certification card has not been received by the Department of Forestry. In these situations, the state of Oregon may seek to recover certain fire suppression costs from a property owner if a fire originates on the owner's property, the fuel reduction standards have not been met, and ODF incurs extraordinary suppression costs. The cost-recovery liability under the Oregon Forestland-Urban Interface Fire Protection Act is capped at $100,000.

In Deschutes County, Senate Bill 360 Ratings fall into High, Extreme and High-Density Extreme categories. The provisions of Senate Bill 360 also contain Optional Standards to accommodate a variety of circumstances and landowner preferences. Additional fuel breaks along property lines and roadsides are required for those properties that fall under the Extreme and High Density Extreme ratings.[15]

Each of the Community Wildfire Protection Plans incorporates Senate Bill 360 ratings where appropriate to provide additional risk assessment information. It also incorporates the Senate Bill 360 standards when listing recommendations for defensible space and fuel breaks on private property:

- A minimum 30-foot primary fuel break around structures for properties rated High. Up to an additional 70 feet of fuel breaks are required depending on rating and roof composition. A fuel break consists of: Removal of dead/dry/flammable brush around home, roof, chimney, decks and under nearby trees; removal of low hanging branches on trees; and reposition of wood piles at least 20 feet away from home during fire season.

- A minimum fuel break of 12 feet wide and 13.5 feet tall along driveways are also required if they are over 150 feet long.

Loss Estimates

The potential losses in Deschutes County extend beyond those to human life, homes, property and the landscape. The economic worth of infrastructure, property and business in Deschutes County is estimated at $13,349,475,700. [16] Two-thirds of this worth is located in and immediately around the city of Bend, Oregon.

These values at risk have been jeopardized recently. Local business economies are at substantial risk if a wildland fire necessitates the closure of any of the major transportation routes in Deschutes County. During the B & B Complex Fire in 2003, portions of State Highway 20 were closed for over two weeks. This resulted in an economic loss of $3.5 million per day in the County, with $500,000 per day lost in the community of Sisters.[17]

WILDLAND FIRE MITIGATION ACTIVITIES

Local fire prevention and hazardous fuels treatment efforts have been an integral component of the local interagency coordination picture since the early 1980's. The challenge of an expanding wildland urban interface was recognized in Deschutes County 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.

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

The FireFree program is a nationally recognized model for homeowner education and mitigation programs in the wildland urban interface. Created in 1997 following the devastating Skeleton Fire in Bend, FireFree creates awareness and educates residents about the risks of wildland fire to homes and property and the ten simple steps they can take to reduce those risks. FireFree encourages homeowners to take responsibility for risk mitigation by creating defensible space around their property and disposing of debris.

FireFree culminates in the spring and fall with FireFree Clean Up days which include the free disposal of debris at local recycling stations. In 2009, residents brought 42,000 cubic yards of debris to local collection sites.[18] FireFree is coordinated by Project Wildfire as a collaborative effort among local fire agencies, forestry departments, private businesses and the insurance industry.

Deschutes County was designated an Oregon Project Impact community in 1999. At the time, this national-level program was established "to reduce the human and economic costs of disasters through prevention, preparation and mitigation." Deschutes County was one of only a few areas across the nation identified to focus on wildland fire related mitigation activities. A steering committee was established by the Deschutes County Board of Commissioners to provide oversight and accountability for use of the funds. The original $300,000 grant allowed Project Impact to construct additional escape routes out of an at-risk community and fund additional activities for the next three years.

In 2002, a consultant and a sub-group of the steering committee began to explore development of a business plan for a follow-on organization to Project Impact. Project Wildfire was established. Based on the foundation of the Project Impact experience and as stated previously, Project Wildfire continues to provide coordination of a variety of wildland fire mitigation activities including the FireFree program, the facilitation of Community Wildfire Protection Plans, and serves as a source of information for local groups interested in obtaining grant funding to support mitigation activities.

Project Wildfire has established a web site (www.projectwildfire.org) to help showcase the wide variety of hazardous fuels treatment, prevention projects and public information and educational opportunities.[19]

Through the CWPP process, the overwhelmingly clear answer to the wildland fire mitigation question is to reduce the potential for extreme fire behavior by reducing the amount of hazardous fuels in high risk areas on both public and private lands. Since the inception of CWPPs, Deschutes County has secured approximately $6 million in funding under the National Fire Plan, Western States and FEMA grant programs to educate communities and treat hazardous fuels in and around communities at risk.

The wildland fire mitigation efforts in Deschutes County span a variety of agencies and groups. The County has facilitated treatment on over 2,000 acres of hazardous vegetation on private lands each year since 2005.[20] While this number does not sound significant on the surface, it is rather formidable when one considers that these fuels treatments were achieved on private properties ¼ to ½ acres at a time.

The CWPPs identified priority Communities at Risk and the US Forest Service has responded by treating 197,084 acres of national forest land in the WUI since 2005.

These successful projects however are also due in part to the level of collaboration experienced in Deschutes County. As stated earlier, Project Wildfire and the CWPP Committees and other groups such as the Nature Conservancy's Fire Learning Network and Central Oregon Intergovernmental Council routinely engage community members from all areas concerned about wildland fire. This includes representatives from the timber industry as well as environmental groups. It is not uncommon to see Timber Industry Consultants at the same planning table as Sierra Club members. This collaborative approach to fuels management on public lands includes all interested parties from the beginning. The results we continue to see in central Oregon are broadly accepted fuels treatment projects that proceed without litigation and protest.

WILDLAND FIRE MITIGATION INITIATIVES

The wildland fire mitigation initiatives provide hazard appropriate direction on specific activities that organizations and residents in Deschutes County and partners in the region can undertake to reduce risk and prevent loss from wildland fires. Each action item is followed by ideas for implementation, which can be used by the Mitigation Committee and local decision makers in pursuing strategies for implementation.

The first four initiatives for Wildland Fire Mitigation are identical to those in the 2005 Deschutes County Natural Hazard Mitigation Plan. For the 2010 Plan, the Mitigation Committee added a fifth initiative as outlined below. For each initiative, the Mitigation Committee notes whether action items were completed, deferred or deleted.

❶ Wildland Fire Mitigation Initiative One: Continue and expand annual training to enhance effectiveness of local wildland fire mitigation, response and recovery actions.

Implementation opportunities:	Actions taken since 2005:
• Expand the scope of annual Multi-Agency Coordination (MAC) drills.	Conducted yearly MAC drills with multiple involved agencies. **Completed.** Will continue.
• COFCA to consider establishment of a permanent training committee to sponsor/oversee the process. Offer training to all response organizations (fire, law enforcement, ODOT, Red Cross, etc.) in the tri-county (Deschutes, Crook and Jefferson) area.	Presented "ICS for Executives" class to multiple agency directors that could be involved in large scale incident. **Completed.** Will continue. Currently organizing a standing MAC Team. **Completed.** Will continue.
• Continue current practice of holding a "pre-season" planning and coordination meeting with all WUI response agencies/organizations.	COFCA and Project Wildfire host annual pre-season meetings. **Completed.** Will continue.
• Explore opportunities to blend "all-risk" components into all emergency drills and exercises throughout tri-county area.	Conducted yearly MAC drills with multiple involved agencies. **Completed.** Will continue.

Coordinating Organization: MAC

Timeline: 1-5 years

Plan Goals Addressed: Involve Emergency Services, Enhance Partnerships, Protect Life and Property

Potential Funding Sources: Establish MAC training fund; obtain federal & state grants for coordination and training, utilize current budgets for training from each agency.

❷ Wildland Fire Mitigation Initiative Two: Develop reserve of non-traditional response resources to support local wildland fire response during draw-down situations.

Implementation opportunities:	Actions taken since 2005:
• Refine and formalize current water tender support discussions/actions with ODOT/county road departments. Include activation of this process as practice during drills.	Opportunity **deferred** to 2010 Plan.

• Explore opportunities for similar solutions to potential shortages in fire-line building equipment, logistical support, etc.	Through COFCA, these discussions are ongoing. **Completed.** Will continue.
• Consider opportunities to use resources/processes in appropriate support roles for other types of incidents, e.g. severe winter storms, volcano, earthquake.	Currently organizing a standing MAC team. **Completed.** Will continue.

Coordinating Organization: Deschutes County Emergency Services

Timeline: 2- 4 years

Plan Goals Addressed: Involve Emergency Services, Enhance Partnerships, Protect Life and Property.

Potential Funding Sources: NA. These opportunities can be implemented utilizing little or no funding.

❸ Wildland Fire Mitigation Initiative Three: Expand public information/education initiatives in support of active hazardous fuels treatment.

Implementation opportunities:	Actions taken since 2005:
• Explore opportunities to expand the Project Wildfire mission addressing public awareness strategies.	Project Wildfire maintains regular public awareness programs - websites, FireFree, CWPPs, public education. **Completed.** Will continue. **Completed.** Will continue.
• Expand school enrichment education about fuels reduction and wildland fire prevention near home sites.	Regular participation in Team Teaching with COFPC in elementary school. Currently working with south county groups to supplement existing forest health and fire prevention initiatives at middle and high schools. County Forester worked with local community college to establish a Capstone Project for students to manage a 400 acre piece of land in the WUI. **Completed.** Will continue.

Coordinating Organization: Project Wildfire and Deschutes County Forester

Timeline: Ongoing.

Plan Goals Addressed: Enhance Partnerships, Protect Life and Property, Increase Public Awareness.

Potential Funding Sources: Obtain education funding through federal and state grants.

❹ **Wildland Fire Mitigation Initiative Four: Review and upgrade existing building and land use codes to address landscape, fuel amounts and structure detail that reduces the incidence or spread of wildland fire in urban/rural interface areas.**

In the 2005 Plan, this initiative did not include implementation opportunities. The Mitigation Committee clarifies them for this Plan.

Implementation opportunities:	**Actions taken since 2005:**
• Develop systems to regulate landscape, fuels and structure components for new construction.	Cities continue to require specific fire resistant components on new construction of subdivisions. County recently implemented similar system for subdivisions outside city limits. **Completed.** Will monitor and update.
• Develop and adopt countywide defensible space standards.	Deschutes County has embraced the same standards as Senate Bill 360. **Completed.** County to formally adopt standards. **Deferred** to 2010 Plan.
• Develop countywide classification system consistent with SB 360 to educate individual property owners and encourage compliance with defensible space standards.	**Completed** classification of all private property in Deschutes County.

Coordinating Organization: Deschutes County Community Development & County Forester.

Timeline: 1-2 years

Plan Goals Addressed: Protect Life and Property.

Potential Funding Sources: Funding will be necessary to notify/educate property owners of their classification and recommended standards for defensible space. Obtain grant funding from federal and state programs.

This initiative is new for the 2010 Deschutes County Natural Hazards Mitigation Plan.

❺ Wildland Fire Mitigation Initiative Five: Continue to prioritize and support fuels reduction projects on private lands utilizing FireFree and other programs; and identify and prioritize fuels reduction projects on public lands in the WUI.

Implementation opportunities:	**Actions taken since 2005:**
• Provide opportunities for defensible space and fuels reduction through FireFree and Sweat Equity Programs.	Annually provide opportunities for homeowner participation in fuels reduction projects and FireFree projects. **Completed.** Will continue.
• Continue to revisit CWPPs annually and update priorities for fuels reduction projects on private and public lands.	Annually revisit each CWPP. Conduct new risk assessments and revise priorities on a three year rotation. **Completed.** Will continue.

Coordinating Organization: Project Wildfire

Timeline: Ongoing

Plan Goals Addressed: Enhance Partnerships, Enhance Natural Systems, Protect Life and Property, Increase Public Awareness.

Potential Funding Sources: Obtain grants and cost share agreements with landowners to participate in Sweat Equity fuels reduction programs. Partner with collaborators to fund FireFree recycling days.

Wildland Fire Endnotes

[1] Central Oregon Fire Atlas, The Nature Conservancy. Upper Deschutes Fire Learning Network Project, v2.0, February 9, 2004.

[2] Oregon Office of Economic Forecast, www.oea.das.state.or.us/DAS/OEA/docs/economic/executive.pdf, September 2009.

[3] Deschutes County Coordinated Population Forecast 2000-2025, May 13, 2009.

[4] Franklin, Jerry and Dryness, C.T., Natural Vegetation of Oregon and Washington, Chapter VII – Forest Zones of Eastern Oregon and Washington, 1973.

[5] Fitzgerald, S., OSU Extension Wildland Forest Specialist, interview March 2004.

[6] Central Oregon Fire Management Plan 2003, Central Oregon Fire Management Service, Chapter 3 – Scope of Fire Management.

[7] Atlas of Oregon CD, University of Oregon Press.

[8] Central Oregon Precipitation Map prepared for this Plan by Oregon State University, Spatial Climate Analysis Service.

[9] 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, USDA Forest Service, 2004.

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

[11] "Healthy Forests Restoration Act of 2003" (H.R. 1904); One Hundred Eighth Congress; Administrative implementation information available at www.fireplan.gov.

[12] State of Oregon Natural Hazard Mitigation Plan, Fire Chapter – Wildland Urban Interface Fire Loss Reduction Plan, page F – 11.

[13] Deschutes County CWPPs – La Pine, Sunriver, UDRC, Bend, Sisters, Redmond and East & West, 2005-2009.

[14] www.oregon.gov/ODF/FIRE/SB360/docs/guide/guide_0106.pdf

[15] Ibid.

[16] Deschutes County tax assessed data, 2007.

[17] Stutler, J. Deschutes County Forester, informal survey, 2003.

[18] www.firefree.org

[19] Project Wildfire Business Plan, March 2003

[20] See note 17 above.

County Resources

Bend Fire & Rescue
Contact: Fire Chief
Address: 1212 S.W. Simpson
Bend, OR 97701
Phone: 541-322-6300
E-mail: lhuhn@ci.bend.or.us

Black Butte Ranch RFPD
Contact: Fire Chief
Address: P.O. Box 8190
Black Butte Ranch, OR 97759
Phone: 541-595-2288
E-mail: dtucker@bblackbutteranchfire.com

Cloverdale RFPD
Contact: Fire Chief
Address: 68787 George Cyrus Road
Sisters, OR 97759
Phone: 541-548-4815
E-mail: crfpd@outlawnet.com

Crooked River Ranch RFPD
Contact: Fire Chief
Address: 6730 SW Shad
Terrebonne, OR 97760
Phone: 541-923-6776
E-mail: crr_rfpd@msn.com

Deschutes County RFPD #2
Contact: Administrative Manager
Address: 63377 Jamison St.
Bend, OR 97701
Phone: 541-318-0459
E-mail: tfay@dcrfpd2.com

La Pine RFPD
Contact: Fire Chief
Address: P.O. Box 10
La Pine, OR 97739
Phone: 541-536-2935
E-mail: ACDaugherty@lapinefire.com

Redmond Fire & Rescue
Contact: Fire Chief
Address: 341 NW Dogwood
Redmond, OR 97756
Phone: 541-504-5000
E-mail: timm@redmond.or.us

Sisters-Camp Sherman RFPD
Contact: Fire Chief
Address: P.O. Box 1509
Sisters, OR 97759
Phone: 541-549-0771
Fax: 541-549-1343
E-mail: trobertson@sistersfire.com

Sunriver Fire Department
Contact: Fire Chief
Address: P.O. Box 3278
Sunriver, OR 97707
Phone: 541-593-8622

State Resources

Oregon Department of Forestry (ODF)
State Office, Fire Prevention Unit
Address: 2600 State St.
Salem, OR 97310
Phone: 503-945-7440
Website: http://www.odf.state.or.us/fireprot.htm

District Forester, ODF
Central Oregon District
Address: 3501 E. Third St
Prineville, OR 97754
Phone: 541-447-5658

Oregon State Fire Marshal (OSFM)
Oregon State Fire Marshal
Address: 4760 Portland Road NE
Salem, OR 97305-1760
Phone: 503-378-3473
E-mail: oregon.sfm@state.or.us

Deputy State Fire Marshal
Address 63319 Jamison
Bend, OR 97701
Phone: 541-388-6113
E-mail: Dave.Fields@state.or.us

Federal Resources

Deschutes National Forest
Fire Staff Officer
Address: 1645 Hwy. 20 East
Bend, OR 97701
Phone: 541-383-5300

Bureau of Land Management
Prineville District
Fire Staff Officer
Address: 3050 NE 3rd Street
Prineville, OR 97754
Phone: 541-416-6700

Severe Winter Storm

THE THREAT OF SEVERE WINTER STORM IN DESCHUTES COUNTY

Severe winter storms pose a significant risk to life and property in Deschutes County by creating conditions that disrupt essential regional systems including, but not limited to public utilities, telecommunications, and transportation routes. Severe winter storms can produce rain, freezing rain, ice, snow, cold temperatures, and wind. Severe winter storms involving heavy snow fall and cold temperatures occur more often than incidences of rain, freezing rain and ice storms.

SIGNIFICANT CHANGES SINCE 2005 PLAN

Increased population including new populations living in the high desert that are less familiar with cold snowy winters make Deschutes County more vulnerable to severe winter storms. Other than the population increase, there have been no significant changes in the threat of severe winter storm or in the mitigation initiatives since the adoption of the 2005 Deschutes County Natural Hazard Mitigation Plan.

HISTORY OF SEVERE WINTER STORM

Destructive storms producing heavy snow, ice and cold temperatures occurred throughout the County's history, most notably in 1916, 1920, 1937, 1950, 1985, 1986, 1988, 1990, 1992-93 and the winter of 1998-99. Records indicate storms occurring between 1916 and 1937 were marked by heavy snow drifts and cold temperatures. Records also indicate people and communities were generally prepared and equipped to cope with the extreme weather conditions.

The severe winter storm of 1950 impacted the entire state of Oregon. While many places experienced high winds, cold weather and snow, the impact in Deschutes County was high snow fall and drifts. Transportation of supplies imported to the Deschutes Basin was limited. In general, Deschutes County and the region are well prepared for severe winter storms thus reducing the impact of inclement weather.[1]

In recent years, the challenge facing the region is the significant increase in population and growth in tourism as a local industry. Both of these shifts have generally brought new population to the area, particularly with little or no experience with living and working in severe winter weather. This condition impacts shelter, access to medical services, transportation, utilities, fuel sources and telecommunication systems. In severe winter storm conditions, travelers must seek accommodations, sometimes in communities where lodging is limited or overextended. A significant amount of supplies including food and fuel are transported into the Deschutes Basin and in severe winter conditions, these necessities are often limited when road conditions are unfavorable. Likewise, unfavorable road conditions make emergency response operations more difficult to a more fragile population.

Recent shifts in climate patterns beginning in the 1960's has resulted in snowfall and cold weather shifts. While there have been record snowfalls, they are less frequent. The number of severe cold days has been fewer and less frequent. Fluctuating temperatures within storm events also creates the likelihood of ice dams.

Severe winter storms affecting the Deschutes Basin typically originate in the Gulf of Alaska and in the central Pacific Ocean. These storms are may occur from October through March.

SEVERE WINTER STORM HAZARD ASSESSMENT

Hazard Identification

A severe winter storm is generally a prolonged event involving snow and cold temperatures. The characteristics of severe winter storms are determined by the amount and extent of snow, air temperature, and event duration. Severe storms have various impacts in different parts of the county. There may be a 20 degree temperature difference from Terrebonne in the north part of the county and La Pine in the south part of the county. The National Weather Service Pendleton office monitors the stations and provides public warnings on storm, snow and cold temperature events as appropriate.

Probability

The recurrence interval for severe winter storms throughout Oregon is about every 13 years; however, there can be many localized storms between these periods. [2] The probability of severe winter storms is relatively high.

Vulnerability

The probability that Region 6 (Central Oregon), identified by the 2003 Oregon Natural Hazard Assessment Plan, will experience winter storms and the region's vulnerability to their effect are depicted in Table 17. These scores are based on an analysis of risk conducted by county emergency program managers, usually with the assistance of a team of local public safety officials.[3]

Table 17 - Vulnerability and Probability of Winter Storms in Deschutes County

	Deschutes County
Vulnerability Score addresses the percentage of population or region assets likely to be affected by a major emergency disaster. • High – More than 10% affected • Moderate – 1.0 to 10 % affected • Low – Less than 1.0% affected	**High**
Probability Score addresses the likelihood of a future major emergency or disaster within a specific period of time. • High – One incident likely within a 10-35 year period • Moderate – One incident likely within a 35-75 year period • Low – One incident likely within a 75-100 year period	**Moderate**

SEVERE WINTER STORM VALUES AT RISK

Life and Property

Severe winter storms contribute to threats on life and property. Injury and death are often associated with traffic accidents on snow and/or ice covered roads, physical exertion linked to shoveling snow and other activities involved in traveling through snow, and hypothermia from prolonged exposure to the cold. When streets and roads are affected by severe snow and ice, emergency vehicles including police, fire and medical may experience difficulty in reaching targeted destinations.

Roads

County, state, city and many private roads are routinely monitored for snow and ice. Jurisdictions and many private land owners in the rural-urban interface plow snow on a regular basis. Extreme snow fall and ice conditions usually place more demand on local jurisdictions, staff and budgets. Impassible roads hamper emergency response operations.

Power Lines

Extreme cold temperatures have caused power outages that interrupt services and damage property. Many outlying ranches and farms have generators and are generally self-sufficient in these events. However as the general population becomes more urban, fewer numbers of people have resources such as wood stoves, a traditional back up source for heat. Rising population growth and new infrastructure, particularly tourism related, create higher probability for damage to occur from severe winter storms as more life and property are exposed to risk.

Water Lines

The most frequent water system problems related to extreme cold weather are breaks in water mainlines. Breaks occur during severe cold event impacting residents and business.

Inadequate insulated potable water and fire sprinkler pipes can rupture and cause extensive damage to property. Aligned with the extreme population growth, Deschutes County has a significant number of new residential and commercial structures which have been built under current codes that recognize severe cold weather conditions.

Creek flooding within a single storm event, or between events and fluctuating temperatures may lead to the build up of ice dams in creeks. In the winter of 2003, an ice dam release on Whychus Creek caused ice and debris to build up and recede on the creek as it passed through Sisters. This release caused the creek level to rise to its high water mark, but broke loose before flooding homes.

The potential losses in Deschutes County extend beyond those to human life, homes, property and the landscape. The economic worth of infrastructure, property and business in Deschutes County is estimated at $13,349,475,700. [4] Two-thirds of this worth is located in and immediately around the city of Bend, Oregon.

EXISTING SEVERE WINTER STORM MITIGATION ACTIVITIES

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

County and Cities

County and municipal Public Works and Road Departments have plans in place to mitigate and respond to severe winter storms. The plans are updated annually and routinely implemented. Utility companies have existing restoration plans that include routine upgrade and repair, emergency restoration, and public education. Additionally, schools and employers of large scale businesses and agencies have "snow-day" plans. These schedules routinely plan a minimum of five to eight "snow-days" per year.

Federal

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

SEVERE WINTER STORM MITIGATION INITIATIVES

The severe winter storm mitigation initiatives provide direction on specific activities that organizations and residents in Deschutes County can undertake to reduce risk and prevent loss from such events. Each action item is followed by ideas for implementation, which can be used by the Mitigation Committee and local decision makers in pursuing strategies for implementation.

The Mitigation Initiatives for severe winter storm are identical to those in the 2005 Plan. For each initiative, the Mitigation Committee notes whether action items were completed, deferred or deleted.

❶ Severe Winter Storm Mitigation Initiative One: Continue to coordinate mitigation activities to reduce risk to the public from severe winter storms.

Implementation opportunities:

- Continue and expand partnerships with county, city, homeowner groups, businesses and other organizations on strategies that mitigate impact of snow, cold weather, ice and other events related to severe winter storms.

Actions taken since 2005:

No activities related to this initiative have occurred. **Deferred to the 2010 Plan.**

Coordinating Organization: Deschutes County Emergency Services

Timeline: 1-5 years

Plan Goals Addressed: Involve Emergency Services, Enhance Partnerships, Protect Life and Property, Increase Public Awareness.

Potential Funding Sources: Pursue grant and budgetary funding for educational outreach and partnership development.

❷ Severe Winter Storm Mitigation Initiative Two: Continue public awareness of severe winter storm mitigation activities.

Implementation opportunities:

- Target new residents and businesses; continue coordination and expansion of public awareness system providing education about protecting life, property, and the environment from severe winter storm events.

Actions taken since 2005:

Deferred to 2010 Plan.

- Distribute educational information about alternative heating sources, equipment and supplies to use during severe winter storm and power outage.

Deferred to 2010 Plan.

- Develop coordinated utility restoration plans with all utility sources.

Deferred to 2010 Plan.

- Develop coordinated plan for housing large numbers of residents and tourists.

Deferred to 2010 Plan.

Coordinating Organization: Deschutes County Emergency Services

Timeline: 1-5 years

Plan Goals Addressed: Involve Emergency Services, Enhance Partnerships, Protect Life and Property, Increase Public Awareness.

Potential Funding Sources: With department budgets at an all-time low, departmental funding is unlikely in the next five years. Pursue grant funding for educational materials and distribution.

❸ Severe Winter Storm Mitigation Initiative Three: Continue to enhance coordination maintenance and mitigation activities to reduce risk to public infrastructure from severe winter storms.

Implementation opportunities:

- Annually meet with county and city departments responsible for maintaining infrastructures including those addressing emergencies, roads, sewers, water etc. to address upgrades and improvements needed and needs of new and emerging neighborhoods.

Actions taken since 2005:

Annually meet with all departments to assess and consider upgrades and needs of new and emerging neighborhoods. **Completed.** Will continue.

Coordinating Organization: Deschutes County Emergency Services

Timeline: 1-5 years

Plan Goals Addressed: Involve Emergency Services, Enhance Partnerships, Protect Life and Property, Increase Public Awareness.

Potential Funding Sources: NA.

Severe Winter Storm Endnotes

[1] Taylor, George H. and Hannan, Chris, The Oregon Weather Book, (1999) Oregon State University Press.

[2] Oregon Natural Hazards Assessment Plan, Region 6, 2003.

[3] Ibid.

[4] Deschutes County tax assessed data, 2007.

Flood

THE THREAT OF FLOOD IN DESCHUTES COUNTY

Generally, river flooding has not historically been a serious problem in Deschutes County. This is mostly due to the porous nature of the underlying volcanic rock that has a large capacity for water storage, irrigation diversion canals and reservoir retention. Consequently, the discharge rate for the Deschutes River is very low considering the size of its basins.[1] Regular flooding events have occurred however near the headwaters of Tumalo Creek and in the Tumalo community. Along Whychus Creek, the city of Sisters frequently experiences flooding, with the most significant event occurring in 1964.

SIGNIFICANT CHANGES SINCE 2005 PLAN

The only significant flood event in the recent past was in December 2005. Deschutes and Crook Counties experienced flooding of local rivers and creeks that caused a combined $1,000,000 in damage.[2]

Although not a threat here, repetitive losses are now addressed as part of the 2010 Natural Hazards Mitigation Plan. Further, the 2010 Plan addresses actions for continued compliance with and participation in the National Flood Insurance Program (NFIP).

FLOOD HAZARD IDENTIFICATION

The principal flood sources in Deschutes County include: Deschutes River, Little Deschutes River, Paulina Creek, Whychus Creek and Spring River.[3]

The types of flooding that Central Oregon can experience however include:

- warm winter rain-on-snow events,
- flooding associated with dams breaching,
- ice-jam flooding,
- local flash flooding,
- spring run-off from melting snow, and
- intense warm rain during the winter months.

The most common of these potential flooding events in Deschutes County is a rain-on-snow event.[4] The weather pattern that produces these floods occurs during the winter months and has come to be associated with La Nina events, a three to seven year cycle of cool, wet weather. Brief, cool, moist weather conditions are followed by a system of warm, moist air from tropical latitudes. The intense warm rain associated with this system quickly melts foothill and mountain snow. Above-freezing temperatures may occur well above pass levels in the Cascade Mountains (4,000-5,000 feet). [5]

Another area of heightened concern focuses on the potential of flooding related to the failure of glacial moraine dams that impound high-altitude lakes around the Three Sisters and Broken Top. In the event of volcanic eruption, earthquake or a large avalanche of rock or ice into the lakes, these dams could release floods of water and debris whose major impact could inundate parts local areas.

Carver Lake, which lies in the headwaters of the South Fork of Whychus Creek is judged the most likely of lakes to generate future floods or debris flows large enough to affect areas beyond the immediate hazard zone. Lesser hazards include several small lakes at the headwaters of Whychus Creek and the basin (currently with no lake) below Collier Glacier at the head of White Branch.[6]

A third potential exists for sheet flooding occurring on frozen or impervious ground. These events are rare and generally found in localized areas and may occur during winter months and after significant rain.[7]

Mountain streams that begin in glacial lakes behind dams of ice or moraines can occasionally be emptied rapidly and result in flash floods with accompanying mud flows.

Flash flooding may occur in areas of moderate to steep slopes with sparse vegetation. With the occurrences of thunderstorms, these areas become susceptible to flooding and subsequent soil erosion. This situation would be typified by the eastern part of Deschutes County and areas without permanent streams such as the dry canyon west of Redmond.

FLOOD HAZARD ASSESSMENT

Probability

USGS scientists and US Army Corps of Engineers studies indicate the county is at a low level of risk for catastrophic flooding. USGS studies of Carver Lake estimate the probability of a lake flash flood to be approximately 1-5% annually.[8] Potentially, the Little Deschutes and Whychus Creek are most vulnerable, however greater risks are related to future volcanic eruptions (see Volcanic Eruption Hazard Assessment).

The Federal Emergency Management Agency (FEMA) has mapped the 10, 50, 100, and 500-year floodplains in the Region 6 counties. This corresponds to a 10%, 2%, 1% and 0.2% chance of a certain magnitude flood in any given year. In addition, FEMA has mapped the 100-year floodplain (i.e., 1% flood) in the incorporated cities. The 100-year flood is the benchmark upon which the National Flood Insurance Program (NFIP) is based.

Deschutes County is a participant in the National Flood Insurance Program with 190 policies in force totaling $52,814,600. Deschutes County's last Community Assistance Visit (CAV) was on July 22, 1994. At this time, there has only been one loss in the county with total payments amounting to $2,106.

Repetitive Losses

Repetitive losses must be addressed under Natural Hazard Mitigation Plans if there are any structures that are provided coverage for flood losses under the National Flood Insurance Program. A repetitive loss structure is an NFIP-insured structure that has had at least two paid flood losses of more than $1,000 each in any 10-year period since 1978.

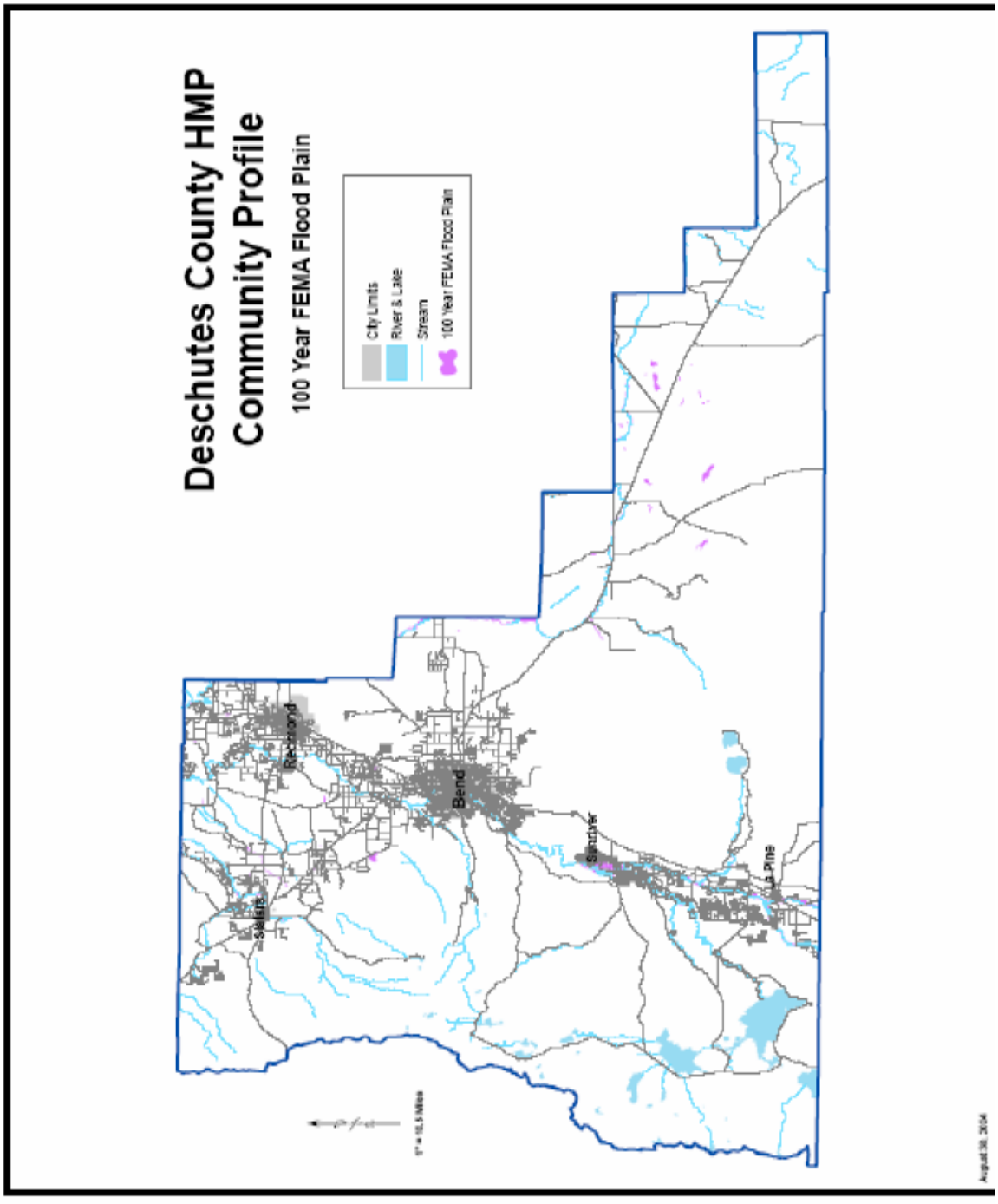
Deschutes County has no repetitive losses.

All of the Region 6 counties have Flood Insurance Rate Maps (FIRM); however, some of the maps are old and could be outdated. The FIRM maps for Deschutes County were issued on September 28, 2007 and are still being utilized today.[9]

The probability of a future flooding emergency in Deschutes County is high – with one incident likely within a 10-35 year period.[10]

The following map depicts the 100 year floodplain as determined by FEMA.

Figure 9 – Deschutes County 100 Year FEMA Floodplain



Vulnerability

Deschutes County's vulnerability to flooding is considered moderate which means 1-10% of the County's population is expected to be affected by a major emergency or disaster.[11]

Growth rates described in the Community Profile section of this Plan project a continued growth pattern that will place additional development, business and human life at risk.

Sisters is particularly vulnerable to economic loss in the event of road closures. According to USGS Open File Report 87-41, locally high velocities, damming, erosion and sediment deposit could cause considerable property damage and possible loss of life. The stream would be especially dangerous at road crossings where bridges may fail or sections could wash away.

EXISTING FLOOD MITIGATION ACTIVITIES

Current initiatives to mitigate the effects of potential flooding in Deschutes County are many. These actions are varied from projects initiated by homeowners and neighborhood associations to county policies and procedures aligned with the National Flood Insurance Program.

County Policies and Procedures – State Land Use Planning Goals

Deschutes County has adopted Goal 23.80.020 that prioritizes "protection of life and property from natural disasters and hazards."[12] This goals states:

> *"Natural hazard areas may be defined as areas subject to natural events that are known to result in death or to endanger works of man, such as stream flooding, wildfire, ground water, erosion and deposition, landslides, earthquakes, weak foundation soils and other hazards unique to local or regional areas."*[13]

This goal and subsequent actions align with Oregon State Land Use Planning Goals.

Deschutes County is fortunate to have only a few areas of geologic or topographic hazard. The major fault which runs through the County, the Brothers Fault, is believed by State geologists to be stable. Some potential for flash flooding exists near Millican and Brothers; however, little conflicting development is anticipated in those areas. Central Oregon is a semi-arid climate subject to many years without adequate precipitation. The State's goal is seen as appropriate for flooding in this area.

In order to accommodate the new population anticipated for Deschutes County in a safe and beneficial manner, a number of policies have been prepared for implementation.[14]

> **23.80.030. Policies.**
>
> 1. Review. Provision shall be made in County land use regulations to assure proposed developments will receive a review of potential natural hazards (stream flooding, flash flooding, landslides, wildfires, etc.) and that sufficient authority exists to modify or deny applications where such hazards exist.
>
> 2. Flooding.
>
> a. The flood hazard areas of Deschutes County are subject to periodic inundation which may result in loss of life and property,

health and safety hazards, disruption of commerce and governmental services, extraordinary public expenditures for flood protection and relief, and impairment of the tax base, all of which adversely affect the public health, safety and general welfare. Chapter 23.80 2 (01/2002)

b. These flood losses are caused by the cumulative effects of obstructions in areas of special flood hazards, which increase flood heights and velocities, and when in adequately flood roofed, elevated or otherwise protected from flood damage, also contribute to the flood loss.

c. In order to accomplish the purposes of this plan, the Zoning Ordinance shall provide for:

1. Restricting or prohibiting uses which are dangerous to health, safety and property due to water or erosion hazards, or which result in increased damage;

2. Controlling filling, grading, dredging and other development which may increase flood damage; and

3. Preventing or regulating the construction of flood barriers which will naturally divert floodwaters or may increase flood hazards in other areas.

d. No structures shall be allowed in areas except areas of shallow flooding. Fill should be allowed in the floodplain only to the extent that it is necessary to allow for utility facilities and stream bank stabilization which cannot be located outside of the floodplain. All uses which could have any effect upon the hazards set forth above shall be conditional uses and subject to rigorous review to insure that use of the floodplain is only a last resort to allow necessary facilities and some beneficial use of pre-existing lots of record.

e. No new parcels shall be created which would allow the construction of new dwelling units in the floodplain.

f. Only variances to dimensional standards of a lot or setback restrictions shall be considered. Use variance or variances to the minimum standards established by the Federal Emergency Management Agency shall be allowed.

g. The areas of special flood hazard identified by the Federal Insurance Administration in a scientific and engineering report entitled "The Flood Insurance Study for Deschutes County", with accompanying Flood Insurance Maps, is hereby adopted by reference and declared to be a part of this Ordinance. The Flood Insurance Study is on file at the Deschutes County Community Development Department Planning Division.

h. The Floodplain Zone shall include all areas designated as "Base Flood" areas by the Flood Insurance Study for Deschutes County. When Base Flood data has not been provided in accordance with the Flood Insurance Study for Deschutes County, the basis for establishing the Floodplain Zone shall be based upon any base flood information or floodway data reasonably available from a federal, state or other source.

Community and Individual Actions

Regardless of future investigative studies, some early warning, zoning, and planning studies are needed to prevent loss of life and property damage in areas downstream of Carver Lake. In Sisters, the potential breakout of Carver Lake represents several times the magnitude flood for which county and city governments presently plan. The flood could occur with little or no warning.[15]

The city of Sisters is currently engaged in discussions about potential flooding from the Carver Lake scenario described above and other flooding potential. The current belief by city planners is that a rain-on-snow event is more likely to occur than a breach at Carver Lake. Therefore, the City of Sisters will continue to pursue mitigation policies that address local flooding of Whychus Creek. [16]

Home and business owners and neighborhood associations in and around the County's floodplains continue to address mitigation activities for flooding. Riparian zones have been established to reduce erosion, review of building plans/codes and emergency strategies to mitigate damage from floods are being developed.

FLOOD MITIGATION INITIATIVES

The Flood Mitigation Initiatives provide guidance on activities that agencies, organizations and residents in Deschutes County can undertake to reduce the risk and percentage of loss from flooding. The initiatives also provide guidance to continue compliance with the National Flood Insurance Program.

The Mitigation Initiatives for flooding are identical to those in the 2005 Plan, with the exception of number three. For each initiative, the Mitigation Committee notes whether action items were completed, deferred or deleted.

❶ Flood Mitigation Initiative One: Continue to coordinate mitigation activities with appropriate agencies and home and business owners/groups that include an inventory of actions to or within the floodplain.

Implementation opportunities:

- Establish protocol to regularly update mitigation actions and activities within the floodplain.

Action taken since 2005:

Deferred to 2010 Plan.

Coordinating Organization: Deschutes County Community Development

Timeline: On-going

Plan Goal Addressed: Enhance Natural Systems, Enhance Partnerships, Protect Life and Property.

Potential Funding Sources: NA.

❷ Flood Mitigation Initiative Two: Maintain an inventory of all permitted dams in Deschutes County.

Implementation opportunities:	Actions taken since 2005:
• Update appropriate seismic criteria and procedures for evaluating performance of existing dams.	**Deferred** to 2010 Plan.

Coordinating Organization: Deschutes County Community Development

Timeline: 3years

Plan Goal Addressed: Enhance Natural Systems, Protect Life and Property.

Potential Funding Sources: NA.

The following initiative is new to the 2010 Plan and replaces the earlier initiative to "conduct workshops for targeted audiences about NFIP".

❸ Flood Mitigation Initiative Three: Comply with National Flood Insurance Program to maintain participation in program.

Implementation opportunities:	Actions taken since 2005:
• Work with NFIP liaison to identify additional actions to maintain compliance including assessment of potential staff resources, needed Community Assistance Visits, and updated Regulations.	**New to 2010 Plan.**
• Identify, map and update floodplains.	**New to 2010 Plan.**
• Work with NFIP to offer community assistance, education and outreach.	**New to 2010 Plan.**
• Work with NFIP to implement monitoring activities.	**New to 2010 Plan.**
• Track all community assistance, education and monitoring activities.	**New to 2010 Plan.**

Coordinating Organization: Deschutes County Community Development

Timeline: 4 years

Plan Goal Addressed: Protect Life and Property.

Potential Funding Sources: As budgets allow.

❹ Flood Mitigation Initiative Four: Update the Flood Insurance Rate Maps for Deschutes County and revisit land use codes to determine if floodplain standards are still adequate.

Implementation opportunities:	Actions taken since 2005:
• Work with appropriate agencies to update Flood Insurance Rate Maps.	**Deferred** to 2010 Plan.
• Revisit and update land use codes to determine is floodplain standards are adequate.	**Deferred** to 2010 Plan.

Coordinating Organization: Deschutes County Community Development

Timeline: 3-5 years

Plan Goal Addressed: Protect Life and Property, Enhance Partnerships.

Potential Funding Sources: As budgets allow.

❺ Flood Mitigation Initiative Five: As funding becomes available, upgrade individual properties adjacent to or within the floodplain as appropriate.

Implementation opportunities:	Actions taken since 2005:
• Assess individual properties for possible upgrades to prevent future flooding.	**Deferred** to 2010 Plan.
• Upgrade properties within the floodplain.	**Deferred** to 2010 Plan.

Coordinating Organization: Deschutes County Community Development

Timeline: 4-5 years

Plan Goal Addressed: Protect Life and Property

Potential Funding Sources: Pursue federal grant funding for projects.

Flood endnotes

[1] Monroe, William, Deschutes County Comprehensive Plan, Resource Element, 1979.

[2] Hazards & Vulnerability Research Institute (2007). The Spatial Hazard Events and Losses Database for the United States, Online **Significant Changes since 2005 Plan 68**

Database, Columbia, SC, University of South Carolina. http://www.sheldus.org

[3] FEMA, Deschutes County Flood Insurance Study,06/08/98;

[4] Collaborative meeting, Pajutee, Maret facilitator USGS, US Forest Service, Project Wildfire, Deschtues County Emergency Management, City of Sisters, January 14, 2009, Sisters, Oregon.

[5] George Taylor, 1999

[6] See note 2 above.

[7] Ibid.

[8] Hydrologic Hazards Along Whychus Creek From a Hypothetical Failure of the Glacial Moraine Impacting Carver Lake Nears Sisters, Oregon—USGS Open File Report 87-41.

[9] OR-SNHMP (Region 6), Central Oregon, January 2009, http://aaa.uoregon.edu/csc/onhw/downloads/pdf/ra/OR-SNHMP-Region6_profile_2009.pdf

[10] Deschutes County Hazard Analysis, Oregon Emergency Management, November 2008.

[11] Ibid.

[12] Deschutes County Ordinance - Chapter 23.80. NATURAL HAZARDS; 23.80.010. Natural hazards; 23.80.020. Goals; 23.80.030. Policies; 23.80.010. Natural hazards.

[13] Deschutes County Ordinance - Ord. 2002-005 1, 2002; Ord.2000-017 1, 200; Ord. 92-051, 1992;Ord. 88-031, 1988; PL-20, 1979.

[14] Deschutes County Ordinance - Ord. 2002-005 1, 2002; Ord. 2000-017 1, 200; Ord. 92-051, 1992; Ord. 88-031, 1988; PL-20, 1979.

[15] See note 4 above.

[16] See note 4 above.

Volcanic Eruption

THE THREAT OF VOLCANIC ERUPTION IN DESCHUTES COUNTY

Much of Deschutes County lies in the potentially active portion of the Cascade volcanic arc – a feature that is part of the "Ring of Fire" that surrounds the Pacific Ocean basin. Deschutes County and the region owe their scenic beauty to the landscape created by geologically recent eruptions.

Western Deschutes County is on the east slope of the Cascade Range. Volcanic activity in the Cascades will continue, but questions regarding how, to what extent, and when, remain. Many volcano-associated hazards affect local areas within 5 to 10 miles (e.g., explosions, lava flows, pyroclastic flows and debris avalanches). However, lahars, or volcanic mudflows can travel considerable distances downstream valleys and wind-borne tephra (ash) can blanket areas many miles from the source.

Deschutes County is therefore at risk from volcanic events and should consider the impact of volcano-related activity on communities, dams that create reservoirs, tourist destinations (e.g., Sunriver, Mt. Bachelor, Crater Lake), highways and railroads. Deschutes County should also consider probable impacts on the local economy should a volcano-related hazard occur.

Two long-lived volcanic centers, Three Sisters to the west and Newberry Volcano to the south, and many tens of smaller volcanoes have hosted numerous eruptions in geologically recent times that range widely in size and character. Some covered sizable, currently developed areas with lava flows or swiftly moving flows of searing ash and pumice. Others only managed to produce small volumes of ash that blew downwind and were barely detectable in the geologic record, or they produced lava flows in areas now protected as Wilderness. Similar eruptions will occur in the future and, depending on their location and scale, will have minor to catastrophic effects on the County. In addition, an eruption of any one of the major Cascade Range volcanoes could affect the county and the region with ashfall if the wind direction were favorable.

No eruptions have occurred in Deschutes County during the past 1,000 years, however the millennium before experienced numerous eruptions, including several at Three Sisters, and one eruption at Newberry Volcano. The most devastating effects of these events were restricted to Wilderness or largely undeveloped areas, but ashfalls from many probably deposited less than one-quarter inch to one-half inch of gritty ash in now densely settled areas.

SIGNIFICANT CHANGES SINCE 2005 PLAN

Since the adoption of the 2005 Deschutes County Natural Hazards Mitigation Plan, the US Geological Survey (USGS) has found that the Three Sisters Bulge is actually waning and is no longer a threat for volcanic eruption. While previously addressed in the 2005 Plan, it is not addressed in this 2010 version.

VOLCANIC ERUPTION HAZARD ASSESSMENT

Hazard Identification and Profile

The history of volcanic activity in the Cascade Range is contained in its geologic record, and shows that the major volcanic centers have been recurrently active for hundreds of thousands of years. In our lifetime, Mount St. Helens has hosted two eruptive episodes during the past 30 years.

Volcano Types

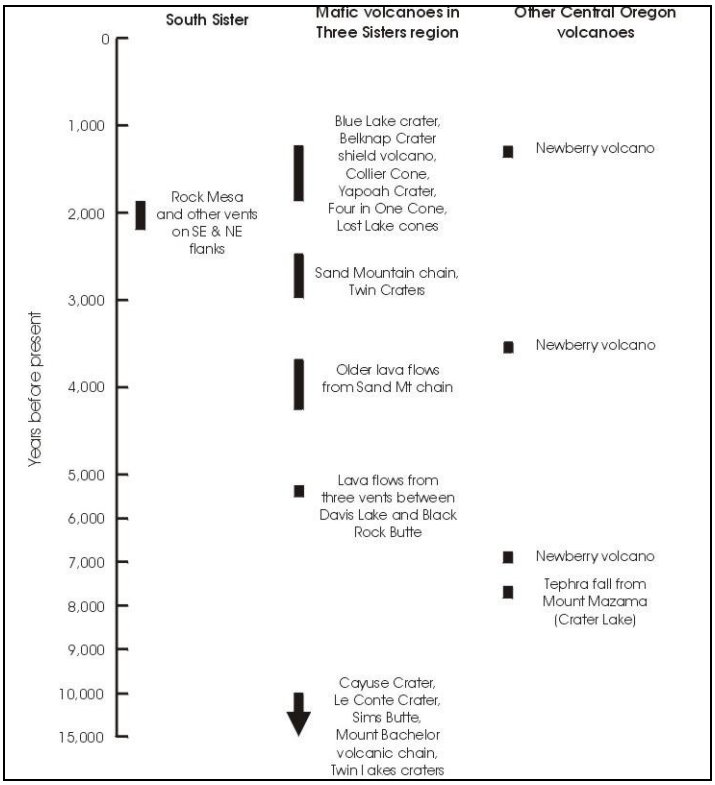
Two types of volcanoes exist in Deschutes County and each possesses distinct hazards to people and property. Major *composite volcanoes* have erupted repeatedly over tens of thousands of years and may erupt explosively in the future.[1] In contrast, *mafic volcanoes*, which range from small cinder cones to large volcanoes, erupt less explosively than composite volcanoes.

Table 18 – Key Volcanic Issues in Deschutes County [2]

Type of Volcano Hazard & Activity
• Non-eruptive hazard such as floods and debris flows from failure of moraine-dammed lakes; Carver Lake is of greatest concern with potential events affecting the city of Sisters.
• Explosive eruptions at South or Middle Sisters that swiftly melt ice and snow and send lahars down Whychus Creek.
• Eruptions from vents on the flanks Newberry Volcano that send lava flows into developed areas near La Pine.
• Large explosive eruption from Newberry Volcano that sends pyroclastic flows down the outer flanks of the volcano.
• Ash fallout in cities and towns from explosive eruptions at South or Middle Sister, Newberry Volcano or from a mafic volcano.

Figure 10 shows the chronology of volcanic events in Central Oregon.

Figure 10 – History of Volcanic Events in Central Oregon[3]



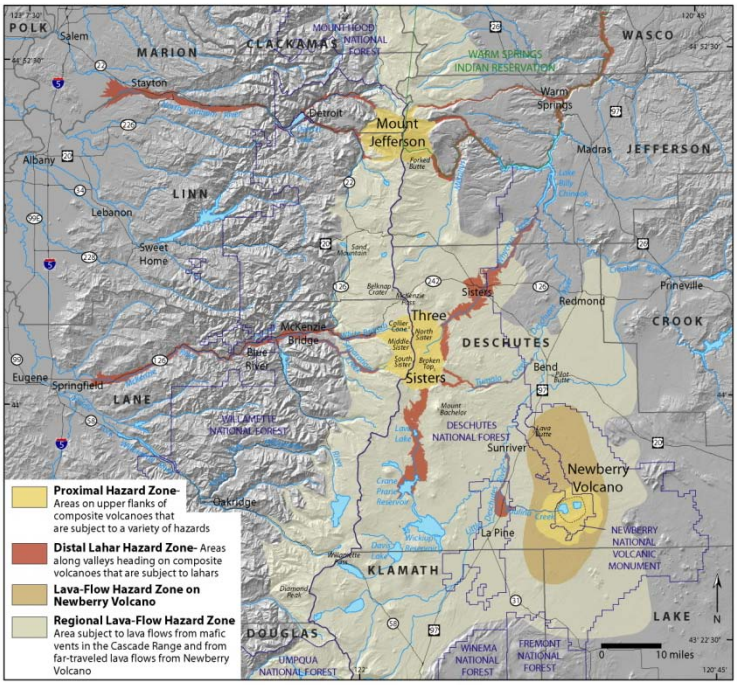
Much larger eruptions than those of the past few thousand years have occurred in the region in recent geologic time, but, although their hazards are potentially much more widespread and severe, they occur much less frequently than smaller eruptions. Such potential hazards include extensive lava flows from Newberry Volcano that pose a threat to Bend, or large-scale explosive eruptions of Newberry or Three Sisters that produce deposits of pumice and ash one foot or more thick in developed areas; or Three Sisters' eruptions that swiftly melt significant quantities of snow and ice to generate lahars that affect areas such as Whychus Creek and the City of Sisters.

One of the most notable eruptions to affect the region in past 10,000 years was the great eruption of ancient Mount Mazama about 7,600 years ago that formed Crater Lake. The eruption blanketed the southern part of the county with up to several feet of fine pumice and ash and the northern part with about one foot. Eruptions of such large scale are rare in the Cascades, but smaller-scale eruptions from other distant volcanoes such as Mount Hood or Mount St. Helens could affect the County with ashfall if wind conditions were favorable.

Volcanic Hazard Zones

A Volcanic Hazards Zonation Map (Figure 11) shows areas most likely to be affected by future hazardous geologic events in Deschutes County. Hazardous areas around composite volcanoes are divided into *proximal* and *distal* hazard zones depending on distance from the volcano.

Figure 11 – Volcano Hazard Zonation Map of Central Oregon[4]



Although the hazard map shows sharp boundaries for hazard zones, the degree of hazard does not change abruptly at these boundaries. Rather, the hazard decreases gradually as distance from the volcano increases and decreases more rapidly as elevation above valley floors increases. Areas immediately beyond outer hazard zones should not be regarded as hazard free, because the boundaries can only be located approximately, especially in areas of low relief. Too many uncertainties exist about the source, size, and mobility of future events to locate the boundaries of zero-hazard zones precisely.

The **proximal hazard zone** includes areas immediately surrounding the volcanoes. This zone, which extends outward from summits for as little as two to as many as 10 kilometers (six miles) depending on local topography, is subject to several types of rapidly moving, devastating flows including pyroclastic flows, debris avalanches, lahars, and dam-break floods. Slower moving lava flows could also affect these zones. [5]

The **distal hazard zone** lies beyond the proximal hazard zone and is concentrated in the surrounding valleys that head on the volcanoes. Debris avalanches and lahars will tend to

funnel into these valleys as they leave the slopes of the large volcanoes within the proximal hazard zone.

The **regional lava-flow hazard zone** outlines the area of the Three Sisters and Newberry Volcano region subject to lava flows from eruptions of mafic volcanoes. The zone is defined by the distribution of mafic volcanoes that erupted during roughly the past one million years. Hazards from thick tephra fall, ballistic projectiles, and pyroclastic flows would be restricted to within a few kilometers of vents, but lava flows could travel much farther. The hazard zone covers a broad area in Central Oregon, including Bend, Sisters, and areas on the lower flanks of Newberry Volcano in La Pine.

Hazardous Volcanic Events

Hazardous events related to volcanic eruption include lava flows, pyroclastic flows, tephra fallout, debris avalanches and lahars.[6]

Lava is molten rock that flows onto the earth's surface. **Lava flows** move downslope away from a vent and bury or burn everything in their paths.

Pyroclastic flows are high-speed avalanches of hot rock, gas, and ash that are formed by the collapse of lava domes or explosive eruptions. They can move up to 100 miles per hour and have temperatures up to 1500°F. They are lethal, burning, burying, or asphyxiating everything in their paths.

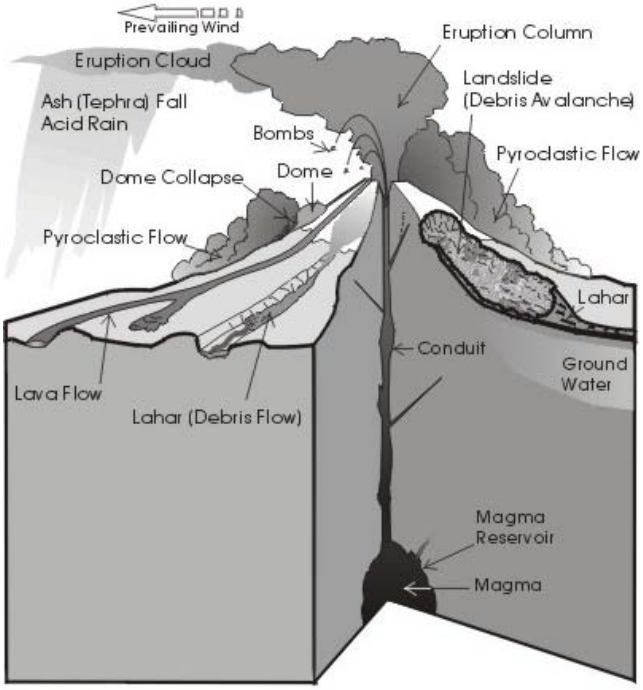
Tephra is lava fragments of all sizes ejected from a volcanic vent by an explosive eruption. Tephra can also be carried aloft in billowing ash clouds above pyroclastic flows. Large fragments fall to the ground close to the volcano, but smaller fragments (ash) can travel hundreds to thousands of miles downwind. Unless tephra blankets reach thicknesses great enough to collapse roofs, tephra falls offer little direct threat to life or structures, but tephra clouds can create tens of minutes to hours of darkness as they pass over a downwind area, even on sunny days, and reduce visibility on highways. Ash suspended in air can irritate eyes and respiratory systems, and prolonged inhalation of certain kinds of tephra can cause chronic lung disease. Deposits of tephra can topple or short-circuit electric transformers and power lines, especially if the tephra is wet, which makes it adhere to surfaces. Tephra ingested by vehicle engines can clog filters and increase wear. Tephra clouds commonly generate lightning that can interfere with electrical and communication systems and start fires. Finally, and perhaps most importantly, even small, dilute tephra clouds pose great hazards to aircraft that fly into them.

Debris avalanches are rapid landslides of rock, soil and overlying vegetation, snow or ice that can bury, move or smash anything in their path.

Lahars are fast-moving slurries of rock, mud, and water that move down river valley. Lahars form when pyroclastic flows melt snow or ice, or by the mobilization of loose debris on the flanks of volcanoes. Lahars can bury, move, or smash objects in their path.

All of the types of hazardous events depicted in Figure 12 below have occurred at local volcanoes in the past and could occur in the future. Most are driven by the eruption of molten rock, or *magma*, but some, like debris avalanches and some lahars, can occur even without eruptive activity. As magma nears the surface, gases dissolved in the magma are released. Rapid release can fragment the magma and propel it upward from the vent in a rush of expanding hot gas.

Figure 12 – Hazard Events at Composite Volcanoes[7]



Earthquakes

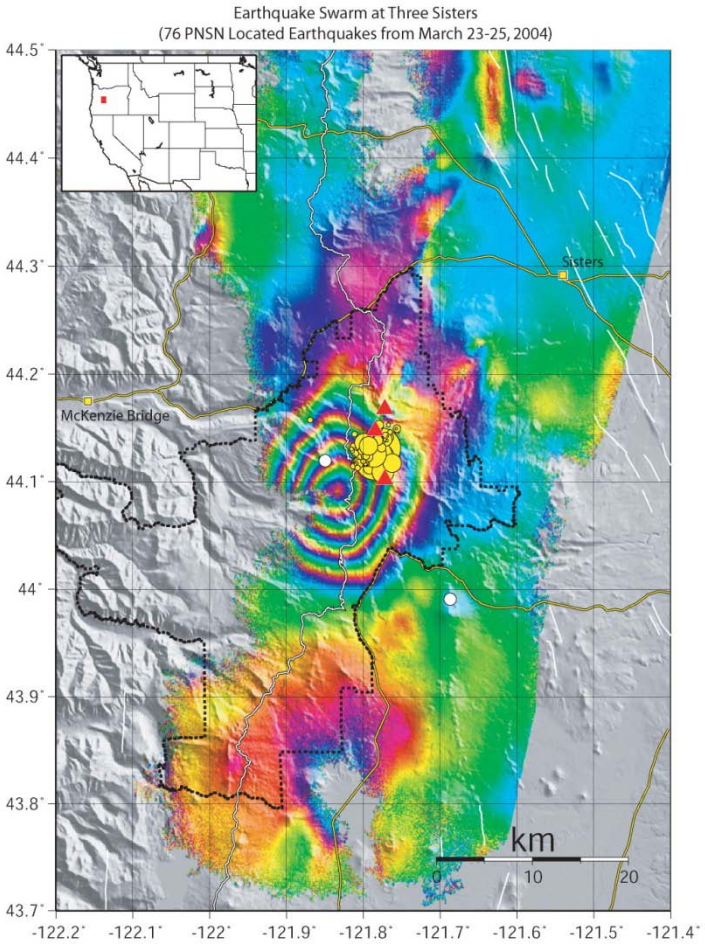
Earthquakes are another potentially hazardous event associated with volcanic eruptions. *Volcanic earthquakes* are commonly smaller than magnitude 2.5, roughly the threshold for felt shaking by observers close to the event. Swarms of small earthquakes may persist for weeks to months before eruptions, 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 landforms 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.

Figure 13 depicts the swarm of earthquakes at the Three Sisters over March 23-25, 2004.

Figure 13 – Earthquake Swarm at Three Sisters
March 23-25, 2004



Three Sisters Volcanoes

Large snow-covered volcanoes of the Three Sisters volcanic center dominate Central Oregon's landscape between Santiam Pass in the north and Willamette Pass in the south. Rapidly developing areas in Deschutes County occupy the eastern border of the region, and westward several small communities dot the McKenzie River valley along its course to the Eugene-Springfield metropolitan area.[8]

South Sister, Middle Sister and Broken Top are major composite volcanoes and may erupt explosively in the future. North Sister is considered a mafic volcano, with less explosive eruption potential.

The following photograph depicts an aerial view from southeast of Three Sisters volcanic center (South, Middle, and North Sister left of center; Broken Top right of center). Light colored areas on south flank of South Sister are 2,000 year old lava flows.

Photo by William E. Scott, USGS

On the basis of eruptive activity during the recent geologic past, Middle and South Sister are the most likely locations for explosive eruptions.

Whychus Creek and its tributaries drain the east flanks of North, Middle, and South Sister and the north flank of Broken Top. The broad fan of Whychus Creek around Sisters is of particular concern with regard to potential lahar inundation because Whychus Creek drains a large sector of the major volcanoes and the distance to Sisters is relatively short (about 30 kilometers or 20 miles). Typical flow velocities for lahars through terrain like that along Whychus Creek yield travel times to Sisters of as little as 30 minutes to one hour, depending on lahar size and point of origin.

South, Middle, and North Sister as well as Broken Top are high, steep-sided peaks that could also produce debris avalanches. Avalanches of modest volume (less than about 10 million cubic meters) are the most probable and would affect areas primarily within the proximal hazard zone. Nevertheless, even modest-sized avalanches that contain sufficient water could transform into lahars that travel well into distal hazard zones. Very large avalanches, those involving hundreds of millions of cubic meters of rock debris would likely be preceded by pronounced volcano deformation driven by intrusion of magma. Such activity would be detectable by seismometers and volcano surveys, and thus would elicit advance warning.

Tumalo Creek drains the area east of Broken Top and is unlikely to experience large lahars owing to lack of much volcano mass in its headwaters. Nevertheless, small lahars

might descend Tumalo Creek if rapid sedimentation in Crater Creek accompanied a large landslide or failure of the moraine dam on the east side of Broken Top and diverted debris over a low divide into Tumalo Creek.

Newberry Volcano

Newberry Volcano, part of which is designated as a National Volcanic Monument, managed by the U.S. Forest Service, is a broad shield volcano located in Deschutes County. 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.[9] Newberry volcano is presently quiet.

Three kinds of eruptions are expected to occur at Newberry volcano in the future. The most likely type involves explosive pyroclastic eruptions of rhyolitic magma in small to moderate volumes (0.01-1.0 km3; 13 million-1,300 million cubic yards) from vents in the caldera or just beyond the caldera rim. Presence of lakes and shallow ground water in the caldera increases the likelihood that eruptions from caldera vents will be explosive. The next most likely type of future eruption, and one of lesser potential hazard, is a basaltic eruption from vents on the flanks. These would likely produce lava flows and cinder deposits, also of small to moderate volume. The third type, and fortunately the least likely to occur, is a large explosive eruption from a vent in the caldera that discharges several cubic kilometers with substantial accumulations of tephra (10 cm to several meters, or 4 in. to more than 100 in.), but these sites have few permanent residents. Today, however, the volcano shows no signs of the volcanic buildup that would precede such a devastating eruption.

Any pyroclastic eruptions at Newberry would also produce tephra showers. The caldera and upper flanks are most likely to receive substantial accumulations of tephra (10 cm to several meters, or 4 in. to more than 100 in.), but these sites have few permanent residents. Downwind sites have more development at risk. Millican or Brothers are the nearest settlements most likely to be downwind during eruptions from caldera vents. However, they lie sufficiently far from the caldera (30-50 km, 20-30 mi) that tephra from most eruptions would likely accumulate less than a few centimeters (few inches), but could reach 25 cm (1 ft) thick during eruptions like those of 1,300 years ago. Similar thicknesses could fall in Bend or La Pine, but suitable wind directions occur infrequently.

VOLCANIC ERUPTION PROBABILITY AND RISK ANALYSIS

The annual probability of volcanic activity in or affecting Deschutes County can only be estimated with great uncertainty, but, depending on the type of eruption, ranges from roughly 1 in 1,000 to 1 in 10,000. However, as precursors of volcanic unrest begin the probability of eruption increases greatly. The precursors might include increased seismic activity, temperature and chemical changes in groundwater, ground deformation and release of volcanic gases.

The average annual probability of future mafic eruptions is roughly 1 in 1,500. Because most recent activity has been concentrated in the area between the North Sister and Santiam Pass, future activity is probably more likely there than in other parts of the lava-flow hazard zone to the south and east, which includes most of the settled areas in the region. Furthermore, because only a relatively small part of the entire lava-flow hazard zone is affected during one eruptive episode, the annual probability of any given point in the hazard zone being affected is considerably less than the average annual probability of 1 in 1,500. The US Geological Survey estimates the range of annual probabilities falls between 1 in 10,000, for some areas near the Cascade Crest around Three Sisters and on the upper flanks of Newberry Volcano, to 1 in 1,000,000 elsewhere. Because ashfall from such eruptions covers much larger areas than lava flows, the probability of ashfall affecting an area is greater.

With probability of volcanic events ranging from 1 in 1,500 to 1 in 1 million, the likelihood of repetitive losses is extremely low. Therefore the Hazard Mitigation Committee chose not to address the potential for repetitive losses under this hazard.

When a volcano erupts here again, areas close to the erupting vent will be severely affected. A proximal hazard zone roughly 20 kilometers (12 miles) in diameter surrounding the volcano could be affected within minutes of the onset of an eruption or large landslide. Distal hazard zones that follow river valleys downstream could be inundated by lahars (rapid flows of water-laden rock and mud) generated either by melting of snow and ice during eruption or by large landslides.[10]

On the basis of no prior events in the past 10,000 years, it is estimated that a lahar voluminous enough to inundate the largest of the distal hazard zones in any valley has an annual probability of less than 1 in 10,000. A lahar voluminous enough to inundate the smallest of the distal hazard zones in any valley has a greater annual probability, perhaps from 1 in 1,000 to 1 in 10,000. Still smaller lahars that result from phenomena such as moraine-dam failures are much more likely to occur (annual probability greater than 1 in 100 in potentially affected valleys), but are apt to inundate only parts of the smallest distal hazard zones immediately adjacent to streams.

The three major drainage systems that head in the Three Sisters area (Separation Creek, White Branch and Whychus Creek) are all potentially at risk from lahars during future eruptions. The location and size of lahars will depend on the site of the eruption and its character.

At least four times in the past 700,000 years, explosive eruptions that were probably sited near the present location of Broken Top and Three Sisters produced pyroclastic flows, a mobile, hot (hundreds of degrees) mixture of rock fragments, ash, and gas that swept over a broad area from Sisters to south of Bend. Such an event today would be catastrophic for Deschutes County, but fortunately, events of this magnitude are infrequent. Furthermore, there is no evidence that the large volume of magna necessary to drive such an eruption is present in the Three Sisters region today, nor would such a volume likely be generated in the near future.[11]

The annual probability of explosive eruptions at Newberry Volcano affecting the caldera and immediately adjacent areas is about 1 in 3,000 (four eruptive periods, one basaltic and three rhyolitic, in 12,000 years). The probability of such an eruption occurring in a 30-year period, the duration of many home mortgages or a human generation, is roughly 30 times the annual probability or 1 in 100.

The valley of Paulina Creek, which drains from Paulina Lake through the west rim of Newberry Crater, is the most likely drainage to carry damaging lahars and floods. In addition to lahars and floods caused by pyroclastic flows melting snow, a lahar could be generated along Paulina Creek by lake overflow. Pyroclastic flows entering the lake or explosive eruptions in the lake could displace water into Paulina Creek's canyon. Lahars or floods from Paulina Lake could reach the La Pine valley within 30 minutes.[12]

Where Paulina Creek leaves the confines of its canyon, it diminishes in gradient and forms a broad alluvial fan. Lahars could spread across Paulina Prairie and extend north along the floodplain of Paulina Creek to its confluence with the Little Deschutes River. The 100-year floodplain of the Little Deschutes River downstream from Paulina Creek is also included in the hazard zone for lahars and flooding in the event of volcanically induced surges of water from Paulina Lake.

The U.S. Geological Survey defines two lava-flow hazard zones for Newberry on the basis of likelihood of future lava flows within each zone. Lava-flow hazard zone LA encompasses the area more likely to be the site of flank vents or to be covered by lava, including the caldera. Zone LB includes two main areas: (1) areas on the lower flanks of Newberry that have relatively few flank vents and are chiefly covered by large lava flows from vents farther upslope and (2) lava flows from vents elsewhere in the Cascade Range or Basin and Range.

The outer boundary of lava-flow hazard zone LA is determined by encircling the part of the volcano with greatest density of vents as determined by geologic mapping. As shown on the hazard-zonation map, the outline of zone LA broadly defines the elongate shape of Newberry volcano itself, consistent with the idea that the volcano has grown by the repeated eruption of lava from vents preferentially located on the north and south flanks and in the summit region. The probability that a flank eruption will affect a given area in zone LA can be estimated only approximately because the frequency of such eruptions prior to the last ones about 7,000 years ago are so poorly known. The U.S. Geological Survey infers that the annual probability of a flank eruption occurring in zone LA is roughly 1 in 5,000 to 1 in 10,000.

Lava-flow hazard zone LB encompasses the entire hazard-map area beyond zone LA. Zone LB includes areas on the lower flanks and down slope from Newberry volcano and elsewhere in the region that have been affected by lava flows less frequently than areas in zone LA. The U.S. Geological Survey estimates that the annual probability of an eruption in this zone or of lava flows invading the zone from vents in zone LA is roughly 1 in

100,000, or less, on the basis of the frequency of lava-flow coverage in the past one million years and the few, widely scattered vents in the region.

VULNERABILITY TO VOLCANIC ERUPTION

Building and Infrastructure Damage

Ashfall of 0.4 inches is capable of creating serious although temporary disruptions of transportation, operations, sewage disposal and water systems. The history associated with the Mount St. Helens eruption in 1980 resulted in closed highways, airports and other transportation systems for several days to, in some cases, weeks.

Ash can cause substantial problems for internal-combustion engines and other mechanical and electrical equipment. Additionally, it can contaminate filters, oil systems and scratch surfaces. Fine ash can cause short circuits in electrical transformers, which in turn cause power outages. Specifically in Deschutes County, ash can cause problems for the hi-tech manufacturing industry represented here.

The potential losses in Deschutes County extend beyond those to human life, homes, property and the landscape. Lahars and flooding, resulting from eruptions that melt snow and ice can result in severe damage to roads, bridges, pipelines and buildings. Highway 20 in Sisters, gas pipelines and high-capacity power lines on the flanks of Newberry Volcano are especially vulnerable.

The economic worth of infrastructure, property and business in Deschutes County is estimated at $13,349,475,700. [13] Two-thirds of this worth is located in and immediately around the city of Bend, Oregon.

Local business economies are at substantial risk if fallout from a volcanic event necessitates the closure of any of the major transportation routes in Deschutes County. The estimated loss per day is $3.5 million.[14]

Earthquakes related to volcanic activity can cause significant damage to buildings and infrastructure as well as significant loss of life.

Pollution and Visibility

Ash fallout from an eruption column can blanket areas within a few miles of the vent with a thick layer of pumice and ash. High-altitude winds may carry finer ash from tens to hundreds of miles from the volcano, affecting downwind communities and posing a hazard to flying aircraft. Fine ash in water supplies will cause brief muddiness and chemical contamination. Ash suspended in the atmosphere is especially a concern for airports, where aircraft machinery could be damaged or clogged. Additionally, ashfall decreases visibility and disrupts daily activities.

Economy

Volcanic eruptions can disrupt the normal flow of commerce and daily human activity without causing severe physical harm or damage. Ash that is a few inches thick can halt traffic, cause rapid wear of machinery, clog air filters, block drains, waterways, and

severely impact tourism and agriculture as well as the economy of the region. The interconnectedness of the region's economy can be disturbed after a volcanic eruption. Infrastructure can be impacted, particularly in Sisters which is particularly vulnerable to lahars and flooding. Transportation of goods and services may be halted, closure of airports and recreation can severely impact local and regional economies.

EXISTING VOLCANIC ERUPTION MITIGATION ACTIVITIES

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

Volcano Monitoring

USGS and Pacific Northwest Seismic Network at the University of Washington conduct seismic monitoring of all Cascade volcanoes in Washington and Oregon. The US Forest Service serves as the primary dissemination agency for emergency information. As activity changes, USGS scientists provide update advisories and meet with local, state, and federal officials to discuss the hazards and appropriate levels of emergency response.[15]

Techniques for monitoring active or potentially active volcanoes focus on three areas—earthquakes (seismicity), ground deformation, and volcanic gases. Magma intruding a volcanic system breaks rock and causes slippage on faults, thereby creating earthquakes; it adds material at depth and heats and pressurizes ground water, thereby bowing up the ground surface; and it releases volcanic gases, mainly water vapor, carbon dioxide, and sulfur dioxide. Heat and volcanic gases from magma warm and add telltale chemicals to the ground water, which affects the composition of spring water throughout the area.

Some monitoring occurs in real-time or near real-time as data are telemetered from field sites to base stations; other monitoring is done on a periodic basis and requires visits to the field or gathering data from satellites.

Earthquakes in central Oregon are detected and located in real-time by the Pacific Northwest Seismic Network (PNSN) at the University of Washington, a cooperative undertaking of the university, USGS, and University of Oregon. Compared to areas that have frequent earthquakes, the station spacing in central Oregon is relatively large, so only earthquakes greater than magnitude (M) 1 or 2 are able to be located routinely. Six stations added in the Three Sisters area since ongoing uplift was recognized in 2001 have reduced the magnitude threshold for location there to about M 0.5 to 1, if all stations are operating. In addition, a cache of instruments at USGS Cascades Volcano Observatory is available to rapidly augment the existing network should conditions warrant.

Continuous Global Positioning System (CGPS) receivers are able to track ground deformation in real time for a single point on Earth's surface. At present CGPS receivers at Redmond, Mount Bachelor, and two near South Sister operate in real time. Such a sparse network is of limited use in understanding the complex nature of ground deformation in a volcanic environment. Additional instruments are planned.

Broader regional coverage is afforded by periodic USGS surveys (typically annual or every few years; more often if conditions warrant) of an array of benchmarks in the Three Sisters and Newberry areas by temporary deployment of GPS instruments. Both areas also have a system of precisely surveyed lines along roads or trails that are used for tiltleveling, a procedure that is capable of measuring slight crustal movements. Another technique called InSAR uses satellite radar data to detect crustal movements over broad areas.

USGS scientists measure output of volcanic gases by airborne surveys. Flights to central Oregon volcanoes are made every few years in order to develop baseline information; additional flights occur as conditions warrant. During times of increased concern, flights could occur as often as atmospheric conditions allow. Annual sampling and chemical and isotopic analysis of spring water from the area permit a broad regional view of how magmatic intrusion is affecting the chemical composition of shallow ground water.

By combining the results of these and other techniques and an understanding of a volcano's past behavior, the goal of volcano monitoring is to issue forecasts as accurately as possible about the state of a volcanic system and the probability for the onset of potentially hazardous conditions. Once an eruption has begun, monitoring information is used to forecast the character and expected outcome of the eruption, as well as its end.[16]

Emergency Coordination

During times of volcanic crisis, USGS scientists will monitor events closely and, together with PNSN and the Oregon Department of Geology and Mineral Industries, issue information statements, alert warnings, updates, and briefing as necessary to keep public officials, the media, and the public aware of potential hazards and other pertinent information. The USGS and the National Weather Service will work together to provide warnings about lahars, floods, and downwind ash-fall hazards.

Currently, agencies require information on hazards that affect nearby areas much like airlines and the Federal Aviation Administration require information on tephra plumes that can be hazardous to aircraft hundreds of miles from the source. The information required by these two groups is not always the same, and therefore the USGS in cooperation with various agencies, has developed two hierarchies of alert levels; one directed toward emergency response on the ground and the other towards ash hazards to aircraft.

The USGS issues statements of ground-based hazards which are transmitted as appropriate to state and federal agencies including FEMA, and National Weather Service. The counties receive information from Oregon Emergency Management then transmit the notifications as appropriate to local emergency management networks.[17]

Warning Systems

The best warning of a volcanic eruption is one that specifies when and where an eruption is most likely to occur and what type and size eruption should be expected. Such accurate predictions are sometimes possible but still warrant further research. The most accurate

warnings are those in which scientists indicate an eruption is probably hours to days away based on significant changes in a volcano's earthquake activity, ground deformation and gas emission. Experience from around the world has shown that most eruptions are preceded by such changes over a period of days to weeks.

A volcano may begin to show signs of unrest several months to a few years before an eruption. In these cases a warning that specifies when it might erupt months to years ahead of time are extremely rare. The strategy that the USGS uses to provide volcano warnings in the Cascade Range volcanoes in Washington and Oregon involves a series of alert levels that correspond generally to increasing levels of volcanic activity. As a volcano becomes increasingly active or as incoming data suggest that a given level of unrest is likely to lead to a significant eruption, the USGS declares a corresponding higher alert level. This alert level ranking thus offers the public and civil authorities a framework they can use to gauge and coordinate their response to a developing volcano emergency.

Education and Outreach
The USGS has developed educational volcanic hazards videos that are designed to increase public awareness. Education resources include: USGS Fact Sheets: http://pubs.usgs.gov/fs/fs027-00 and http://pubs.usgs.gov/fs/fs002-97.

VOLCANIC ERUPTION MITIGATION INITIATIVES

The volcanic eruption mitigation initiatives provide direction on the research needed to address investment of resources, including human, physical, and financial in mitigation strategies. Substantial evidence indicates that further research and study is needed to adequately address the vulnerability to the risk of volcanic eruption.

The Mitigation Initiatives for volcanic eruption are identical to those in the 2005 Plan. For each initiative, the Mitigation Committee notes whether action items were completed, deferred or deleted.

❶ Volcanic Eruption Mitigation Initiative One: Continue to support on-going study of probability of volcanic eruption and potential impact.

Implementation opportunities:	Actions taken since 2005:
• Continue to partner with federal and state organizations supporting studies and monitoring volcanic eruption indicators and activities.	Ongoing participation. **Completed.** Will continue.
• Participate in updating interagency communication plan for central Oregon volcanic activity.	Participates regularly in interagency communication update planning. **Completed.** Will continue.
• County Department of Community Development will conduct review and	**Deferred** to 2010 Plan.

inventory of masonry buildings and their vulnerability to volcanic eruption and earthquake events.	
• Develop cost analysis of county critical and essential infrastructures for upgrading to withstand earthquake and volcanic eruption events.	**Deferred** to 2010 Plan.

Coordinating Organization: Deschutes County Emergency Services

Timeline: On-going

Plan Goals Addressed: Enhance Natural Systems.

Potential Funding Sources: As budgets allow.

❷ Volcanic Eruption Mitigation Initiative Two: Review and upgrade existing Building Codes to address potential damage to structures from earthquake and volcanic eruption.

Actions taken since 2005: Deferred to 2010 Plan.

Coordinating Organization: Deschutes County Community Development

Timeline: 4-5 years

Plan Goals Addressed: Protect Life and Property

Potential Funding Sources: As budgets allow.

Volcanic Eruption Endnotes

[1] Scott, W.E., Iverson, R.M., Schilling, S.P., and Fisher, B.J., 1999, Volcano hazards in the Three Sisters region, Oregon: U.S. Geological Survey Open-File Report 99-437.

[2] See note 1 above.

[3] See note 1 above.

[4] Central Cascades Volcano Coordination Plan, Draft, January 30, 2007

[5] See note 1 above.

[6] U.S. Geological Survey Fact Sheet 002-97 http://pubs.usgs.gov/fs/fs002-97.

[7] Ibid.

[8] See note 1 above.

[9] Sherrod, David R., Mastin, Larry G., Scott, William E., Schilling, Steven P., Volcano Hazards at Newberry Volcano, Oregon, 1997. http://vulcan.wr.usgs.gov/Volcanoes/Newberry/Hazards/OFR97-513/OFR97-513.pdf

[10] See note 1 above.

[11] See note 5 above.

[12] See note 1 above.

[13] Deschutes County tax assessed data, 2007.

[14] Stutler, J. Informal survey during B & B Complex Fire, 2003.

[15] Central Cascades Volcano Coordination Plan, Draft, January 30, 2007

[16] The USGS-Cascade Volcano Observatory (CVO) website, http://vulcan.wr.usgs.gov.

[17] See note 12 above.

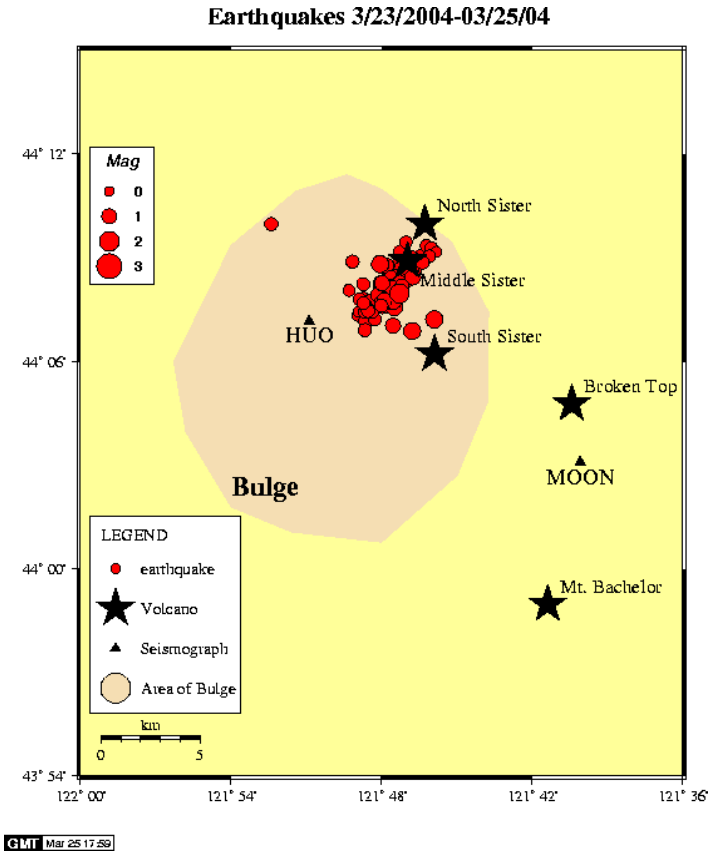
Earthquake

THE THREAT OF EARTHQUAKE IN DESCHUTES COUNTY

The most recent earthquake event in the area occurred in April 2004 with a two-day swarm of 100 to 200 small, unfelt earthquakes.[1]

Figure 14 charts recent events recorded in the Three Sisters volcanic range.

Figure 14 – Earthquakes 3/23/2004 – 3/25/2004



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

1. Events along the off-shore Cascadia Fault Zone,
2. Deep intraplate events within the subducting Juan de Fuca Plate,
3. Shallow crustal events within the North American Plate, and
4. Earthquakes associated with renewed volcanic activity.

All have some tie to the subducting or diving of the dense, oceanic Juan de Fuca Plate under the lighter, continental North 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 M 7.5.

Subduction zone earthquakes pose the greatest hazard. They occur at the boundary between the descending oceanic Juan de Fuca Plate and the overriding North American Plate. This area of contact, which starts off the Oregon coast, is known as the Cascadia Subduction Zone (CSZ). The CSZ could produce a local earthquake along the Oregon coast up to M 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 8. All considered, there is good reason to believe that the most devastating future earthquakes would probably originate along shallow crustal faults in the region.

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.

A summary of historical earthquakes is found in Table 19.

Table 19 – Significant Earthquakes in Central Oregon

Date	Location	Magnitude	Remarks
Approximate Years: 1400 BCE, 1050 BCE, 600 BCE, 400 BCE, 750 CE, 900 CE BCE = Before Common Era	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.
January 1700	Offshore, Cascadia Subduction Zone	Approximately 9.0	Generated a tsunami that struck Oregon, Washington & Japan. Destroyed Native American coastal villages.
April 1906	North of Lakeview, OR	5.0	Three felt aftershocks.
April 1920	Crater Lake	5.0	
January 1923	Lakeview, OR	6.0	
March 1958	Southeast of Adel, OR	4.5	
May – June 1968	Adel, OR	4.7 – 5.1	Damage to homes. 20 earthquakes of M4 or greater were recorded between 5/28/68 & 6/24/68.
September 1993	Klamath Falls, OR	5.9 and 6.0	Series of earthquakes, the largest at M6. Damage to city, 2 related fatalities.

Source: Wong, Ivan, Bolt, Jacqueline, 1995, A Look Back at Oregon's Earthquake History, 1841-1994

SIGNIFICANT CHANGES SINCE 2005 PLAN

The USGS states that there are no significant changes in the potential for earthquakes to occur in Deschutes County since 2005 and therefore, no significant changes in this section from the 2005 Plan.

EARTHQUAKE HAZARD ASSESSMENT

Probability[2]

The Cascadia Subduction Zone (CSZ) generates an 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 while some closer to 1,000 years apart.[3] Establishing a probability for crustal 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. Mitigation action calls for study of the probability of earthquake events.

With potential earthquake events ranging from 150 to 1,000 years apart, the likelihood of repetitive losses is extremely low. Therefore the Hazard Mitigation Committee chose not to address the potential for repetitive losses under this hazard.

Vulnerability[4]

Although the region is vulnerable to earthquake induced landslides alongside of volcanoes and strong ground shaking, little evidence is presented for these events specific to Deschutes County. The Oregon Department of Geology and Mineral Industries (DOGAMI) has developed two earthquake loss models for Oregon based on the two most likely sources of seismic events: 1) the 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% chance of producing an earthquake in the next 50 years. The model assumes that each fault will produce a single "average" earthquake during this time. Neither model takes 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 provide some approximate estimates of damage.

The probability that the region will experience earthquakes and the region's vulnerability to them is low – less than 15% chance in the next 50 years of experiencing a M9 earthquake.[5] These scores are based on an analysis of risk conducted by county emergency program managers, usually with the assistance of a team of local public safety officials. Further mention is made of potential for possible flooding in the event of earthquake in the area of the Sisters bulge. Current research being conducted of this area will determine potential impact and flooding potential.

Loss estimates

The potential losses from an earthquake in Deschutes County extend beyond those to human life, homes, property and the landscape. The economic worth of infrastructure, property and business in Deschutes County is estimated at $13,349,475,700.[6] Two-thirds of this worth is located in and immediately around the city of Bend, Oregon.

Local business economies are at substantial risk if an earthquake damages or otherwise necessitates the closure of any of the major transportation routes in Deschutes County. The economic loss to the region can exceed $3.5 million per day in the County.

EARTHQUAKE MITIGATION INITIATIVES

The earthquake mitigation initiatives provide guidance on activities that agencies, organizations, and residents in Deschutes County can undertake to reduce risk and percent loss form earthquake events.

The Mitigation Initiatives for earthquake are identical to those in the 2005 Plan. For each initiative, the Mitigation Committee notes whether action items were completed, deferred or deleted.

❶ Earthquake Mitigation Initiative One: Support development of in-depth studies to determine county and region's vulnerability to earthquake.

Implementation opportunities:	Actions taken since 2005:
• Work with OEM, DOGAMI, FEMA and USGS and expand existing studies to address scope of vulnerability.	**Deferred** to 2010 Plan.
• Communicate study findings with key stakeholders affiliated with public awareness, education, policy and mitigation strategies identified in study.	**Deferred** to 2010 Plan.
• If needed, make policy and procedures changes that support study results that mitigate earthquake hazards.	**Deferred** to 2010 Plan.
• Determine the impact that an event located outside the county will have on Deschutes County including west side evacuation to central Oregon.	**Deferred** to 2010 Plan.

Coordinating Organization: Deschutes County Emergency Services

Timeline: On-going

Plan Goal Addressed: Enhance Natural Systems.

Potential Funding Sources: As budgets allow.

❷ Earthquake Mitigation Initiative Two: Review and Upgrade existing Building Codes to address potential damage to structures from earthquake and volcanic eruption.

Implementation opportunities:	Actions taken since 2005:
• Conduct an inventory of buildings constructed prior to building codes supporting earthquake mitigation strategies and integrate upgrades.	**Deferred** to 2010 Plan.

Coordinating Organization: Deschutes County Community Development

Timeline: 3-5 years

Plan Goal Addressed: Protect Life and Property

Potential Funding Sources: As budgets allow.

Earthquake Endnotes

[1] Oregon State Natural Hazard Mitigation Plan, Region 6, Central Oregon, November 2003

[2] Ibid.

[3] DOGAMI Special Paper 29: Earthquake Damage in Oregon, p.3.

[4] Ibid.

[5] http://www.oregongeology.com

[6] Deschutes County tax assessed data, 2007.

Plan Maintenance

This section details the process that systematically integrates the Deschutes County Natural Hazards Mitigation Plan into the community. As a result of this integration, the plan will continue to be an active and relevant document with routine updates. The Plan Maintenance process includes a schedule for monitoring and evaluating the Plan every two years and producing a plan revision every five years. Further, this section describes how the county will integrate public participation and mitigation initiatives outlined into existing planning mechanisms.

MONITORING AND IMPLEMENTING THE PLAN

Plan Adoption

Prior to formal adoption of the Plan locally, Oregon Emergency Management (OEM) and FEMA will review the final draft. This is in accordance with FEMA's *Local Multi-Hazard Mitigation Planning Guidance, July 1, 2008*. Upon acceptance and approval of the 2010 Deschutes County Natural Hazards Mitigation Plan, the Deschutes County Board of Commissioners will formally adopt the Plan. This governing body has the authority and is charged with the responsibility to promote sound public policy regarding natural hazards.

Following approval from FEMA and adoption by the Deschutes County Board of Commissioners, this Plan will be reviewed every two years by the Deschutes County Natural Hazard Mitigation Committee. This process will address effectiveness of activities and reflect changes in the community that have an impact on advancing the Plan. The Mitigation Committee will continue to engage a wide cross section of Deschutes County citizens, groups, agencies and organizations representing both the private and public sectors.

This review will address the federal criteria outlined in FEMA Interim Final Rule 44 CFR 201. Upon acceptance by FEMA, Deschutes County will gain eligibility for Hazard Mitigation Grant Program Funds.

Coordinating Body

The Deschutes County Natural Hazards Mitigation Committee is the primary review committee and convening body for the Plan. The Mitigation Committee is co-chaired by the Deschutes County Emergency Manager and the Deschutes County Forester and is comprised of members from the following jurisdictions and organizations:

- Project Wildfire
- Deschutes County Board of Commissioners
- Deschutes County Emergency Management
- Deschutes County Community Development
- City of Sisters, Oregon
- City of Bend, Oregon

- City of La Pine, Oregon
- City of Redmond, Oregon
- Bend Fire & Rescue
- Deschutes County Rural Fire Protection District #2
- Oregon Department of Forestry
- Deschutes County Sheriff
- Oregon State University Extension
- Central Oregon Fire Chiefs Association
- USDA Forest Service, Deschutes National Forest
- USDI Bureau of Land Management, Prineville District

The Deschutes County Natural Hazards Mitigation Committee will oversee implementation of the Plan. Plan implementation will be a shared responsibility among all committee members.

This Plan seeks to coordinate and advance work accomplished by existing groups through communication, building partnerships and leveraging needed resources. Each governmental entity will be responsible for implementation of their individual mitigation initiatives based on funding availability and entity priorities. This implementation may include incorporating mitigation initiatives and activities into existing programs and activities. This would also include amending local comprehensive plans for policies and programs, and the development of regulations for building, zoning and subdivision code standards.

This Plan will serve as a resource as Deschutes County addresses statewide planning goals and legislative requirements through its Comprehensive Land Use Plan, Capital Improvement Plans, and County Building Codes. This Natural Hazard Mitigation Plan provides a series of recommendations that are closely related to the goals and objectives of these existing plans.

In addition to plans, programs and regulations, the entities may also incorporate the mitigation measures into their comprehensive emergency management plans (CEMPs) and capital facilities plans (CFPs). When CFPs and CEMPs are updated it is recommended that they include parts of this plan or be linked back to this document by reference.

The Mitigation Committee will meet a minimum of every two years. The purpose of the meeting will be to review the current plan and its integration within other planning efforts, identify new and emerging issues, and update the plan accordingly.

Implementation through Existing Programs
Deschutes County addresses statewide planning goals and legislative requirements through its Comprehensive Land Use Plan and County Building Codes. The Deschutes

County Natural Hazards Mitigation Plan provides a series of recommendations – many of which are closely related to the goals and objectives of existing planning programs. Deschutes County has ongoing opportunities to implement recommended mitigation initiatives through existing programs and procedures.

Upon adoption of this Mitigation Plan, the county will assist local municipalities in developing their natural hazard mitigation goals and action by providing the Plan as a baseline of information on natural hazards that potentially impact the county. These goals and mitigation initiatives will help local governments, as well as the Deschutes County Community Development address Statewide Land-Use Planning Goals.

Particular attention will be placed on goals relating to protecting life and property from natural disasters and hazards through planning strategies that restrict development in areas of known hazards. Local governments are required by state land use regulations to base development plans on inventories of known areas of natural disasters and hazards and that the intensity of the development should be limited by the degree to which the natural hazard occurs within the areas of proposed development. Local jurisdictions and the county can use periodic review as an avenue to update the elements of their comprehensive plan and to integrate mitigation into zoning and planning documents.

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

The recommendations listed will be incorporated into the process of existing planning mechanisms at the county level. The meetings of the Deschutes County Natural Hazards Mitigation Committee will provide an opportunity for committee members to report back on the progress made on the integration of mitigation planning elements into county planning documents and procedures.

Economic Analysis of Mitigation Projects

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

Given federal funding, the Deschutes County Natural Hazards Mitigation Committee will use FEMA-approved benefit/cost methodology as a tool for identifying and prioritizing mitigation action items when applying for federal mitigation funding. For other projects and funding sources, Emergency Management and Planning departments will use other approaches to understand the costs and benefits of each action item and develop a prioritized list. For more information regarding economic analysis of mitigation action items see Appendix A.

EVALUATING AND UPDATING THE PLAN

Review Process

The Deschutes County Natural Hazards Mitigation Plan will be evaluated every two years by the Mitigation Committee to determine the effectiveness of the Plan's action items and to reflect changes in land development or programs that may affect mitigation priorities. The review will yield a comprehensive update of this Plan on a five year cycle.

The evaluation process includes addressing timelines, lead responsibilities and participation teams. The Co-Chairs of the Deschutes County Natural Hazards Mitigation Committee will be responsible for contacting and communicating with committee members. Committee members will be responsible for monitoring and evaluating the progress of the mitigation initiatives.

The Mitigation Committee will review the goals and action items to determine their relevance to changing situations in the county and changes in State and Federal policy. The Committee will also review the risk assessment potion of the Plan to determine if this information should be updated or modified, given new data. The coordinating organizations responsible for the various action items will report on the status of their projects, the success of various implementation process, difficulties encountered, success of coordination efforts, and which initiatives should be revised.

The Co-Chairs of the Mitigation Committee will be responsible for updating the plan every five years and presenting the plan to the County Board of Commissioners. The Plan will be kept current electronically on the county website. Every five years the updated plan will be submitted to the State Hazard Mitigation Officer.

Continued Public Involvement

Deschutes County has a rich history of engaging the public in decision making and is dedicated in continuing this practice. The Mitigation Committee engages community participants from groups, organizations and business. The Committee is responsible for keeping the plan relevant. The public will have electronic access to the plan and opportunity to provide feedback about the Plan. In addition to electronic access, all appropriate county agencies will have copies of the Plan. The county public information officer will periodically provide public information stories related to the Plan. Additional opportunities for feedback will be provided during the meetings of the Mitigation Committee and any identified work sessions.

Appendix A

Economic Analysis of Natural Hazard Mitigation Projects

This appendix outlines three approaches for conducting economic analysis of natural hazard mitigation projects. It describes the importance of implementing mitigation activities, different approaches to economic analysis of mitigation strategies, and methods to calculate costs and benefits associated with mitigation strategies. Information in this section is derived in part from the *State Hazard Mitigation Plan created by the* Interagency Hazards Mitigation Team (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 appendix 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 raise benefit/cost analysis as an important issue, and to provide some background on how economic analysis can be used to evaluate mitigation projects.

EVALUATION OF MITIGATION ACTIVITIES

Mitigation activities reduce the cost of disasters by minimizing property damage, injuries, and the potential for loss of life; and reduce emergency response costs, which the county or other responsible entity would otherwise incur. Evaluating 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, influenced by many variables. Natural disasters affect entire communities – its individuals, businesses, and essential services such as fire, police, and utilities. While some of the direct and indirect costs of disaster damages are quantifiable, some costs are non-financial and difficult to quantify in dollars. Negative impacts of events with no true monetary value ripple throughout the community, increasing the disaster's social and economic consequences.

While not easily accomplished, assessing the positive and negative impacts from mitigation activities and obtaining an instructive benefit/cost comparison holds value from a public policy perspective. If such assessment and analysis were not completed, then it is more difficult to achieve an objective understanding of the reasons to pursue various mitigation options.

ECONOMIC ANALYSIS APPROACHES FOR EVALUATING MITIGATION INITIATIVES

The approaches used to identify the costs and benefits associated with natural hazards mitigation strategies, measures, or projects fall into three general categories: benefit/cost analysis, cost-effectiveness analysis and the STAPLE/E approach. The distinction between the three methods is how relative costs and benefits are measured. In addition, there are varying approaches to assess the value of mitigation for public sector and private sector activities.

Benefit/Cost Analysis

Benefit/cost analysis is a key mechanism used by Oregon Emergency Management (OEM), the Federal Emergency Management Agency (FEMA), and other state and federal agencies in evaluating hazard mitigation projects. In addition, the Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 93-288, as amended, also requires benefit/cost analysis.

Benefit/cost analysis is used in natural hazards mitigation to show whether 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 the value and timeliness of undertaking a project in order to avoid disaster-related damages. The basis of a benefit/cost analysis is calculating: 1) the frequency and severity of a hazard, 2) avoided future damages, and 3) risk.

Benefit/cost analyses evaluate all costs and benefits in terms of dollars, and compute a net benefit/cost ratio to determine the feasibility of implementing a project. A project worth pursuing would have a benefit/cost ratio greater than 1, i.e., the net benefits would 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 be organized according to the perspective of persons or entities with an economic interest in the outcome. Economic analysis methods are dealt with for both public and private sectors as follows.

Investing in public sector mitigation activities

Evaluating mitigation strategies in the public sector is complicated. It involves estimating all of the economic benefits and costs regardless of who realizes them, which potentially means the benefits and costs to a large number of people and economic entities. As previously stated, 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 nonmarket benefits.

Investing in private sector mitigation activities
Private sector mitigation projects tend to occur based on one of two approaches. The activity 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:

- Request cost sharing from public agencies;
- Dispose of the building or land either by sale or demolition;
- Change the designated use of the building or land and change the hazard mitigation compliance requirement; or
- 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. Real estate disclosure laws require sellers of real property to disclose to prospective purchasers known defects and deficiencies in the property, including structural weaknesses and hazards. Correcting deficiencies can be expensive and time consuming, but such deficiencies can prevent the sale of the property. The buyer and seller can negotiate conditions of the sale and price due to known defects and deficiencies in the property.

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 alternative approaches for conducting a swift evaluation of the proposed mitigation activities to identify mitigation activities that merit a more detailed assessment. One of these methods is the STAPLE/E Approach.

Using STAPLE/E criteria, steering committees can quickly and systematically evaluate mitigation activities. These criteria require the committee to assess the mitigation activities based on Social, Technical, Administrative, Political, Legal, Economic, and Environmental (STAPLE/E) constraints and opportunities of implementing the particular mitigation item in the community.

The second chapter in FEMA's how-to guide, "Developing the Mitigation Plan – Identifying Mitigation Actions and Implementation Strategies," as well as the "State of Oregon Local Natural Hazard Mitigation Plans: An Evaluation Process" outline some specific considerations in analyzing each aspect. The following are suggestions for how to examine each element of the STAPLE/E Approach from the "State of Oregon Local Natural Hazard Mitigation Plans: An Evaluation Process."

Social: Community development staff, local non-profit organizations, or a local planning board can help answer the following questions:

- Is the proposed action socially acceptable to the community?

- Are there equity issues involved that would result in one segment of the community being treated unfairly?
- Would the action cause social disruption?

Technical: The city or county public works staff and building department staff can help answer the following questions:

- Would the proposed action work?
- Would the proposed action create more problems than it solves?
- Does the proposed action solve a problem or only a symptom of the problem?
- Is the proposed action the most useful action in light of other community goals?

Administrative: Elected officials or the city or county administrator, can help answer the following questions:

- Could 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 on-going administrative requirements that must be met?

Political: Consult the city council or county board of commissioners, city or county administrator, and local planning commissions to help answer the following questions:

- Is the action politically acceptable?
- Is there public support to implement and to maintain the project?

Legal: Include legal counsel, land use planners, risk managers, and city council or county board of commission members, among others, in answering the following questions:

- 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 county assessor's office can help answer the following questions:

- What are the costs and benefits of this action?
- Do the benefits exceed the costs?
- Are initial, maintenance, and administrative costs considered?
- 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 the following questions:

- How would the action impact the environment?
- Would the action need environmental regulatory approvals?
- Would the action meet local and state regulatory requirements?
- Would endangered or threatened species likely to be affected?

The STAPLE/E approach is helpful for conducting a swift analysis of mitigation projects. Most projects that seek federal funding require more detailed benefit/cost analyses.

IMPLEMENTING THE APPROACHES

Benefit/cost analysis, cost-effectiveness analysis, and the STAPLE/E approach are important tools in evaluating whether or not to implement a mitigation activity. A framework for evaluating mitigation activities is set forth below. This framework should be used to further analyze the feasibility of prioritized mitigation initiatives.

1. Identify the Activities

Activities to reduce the risk from natural hazards include but are not limited to developing structural projects to enhance disaster resistance, creating education and outreach activities, and acquiring or demolition of exposed properties. Different mitigation projects can assist in minimizing risk from natural hazards, but accomplish this 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 activity. Potential economic criteria for evaluating activities include:

Determine the project cost. This may include initial project development costs and repair and operating costs of maintaining projects over time.

Estimate the benefits. Projecting the benefits resulting from a project can be difficult. Expected future returns from the mitigation effort depend on the correct specifications 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 would also provide guidance in selecting an appropriate salvage value. Future tax structures and rates must be projected. Financing alternatives must be researched, and they may include retained earnings, bond and stock issues, and commercial loans.

Consider costs and benefits to society and the environment. These are not easily measured, but can be assessed through a variety of economic tools including existence value or contingent value theories. These theories provide quantitative data on the value people attribute to physical or social environments. Even without hard data, 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 could include the risk-free cost of capital, but it may include the decision maker's time preference as well as a risk premium. Determining the discount rate includes consideration of inflation.

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 less 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.

CALCULATING BENEFITS OF MITIGATION

Economic Returns of Natural Hazard Mitigation

Estimating economic returns, which accrue to property owners 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 such as the following:

- Building damages avoided
- Content damages avoided
- Inventory damages avoided
- Rental income losses avoided
- Relocation and disruption expenses avoided
- Proprietor's income losses avoided

These factors 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 would occur. The damages and losses should only include those that would be borne by the owner. The salvage value of the investment could be important in determining economic feasibility. Salvage value becomes more important as the time horizon for the owner declines. This is important because most businesses depreciate assets over a period of time.

ADDITIONAL COSTS FROM NATURAL HAZARDS

Property owners should also assess changes in a broader set of factors that could change as a result of a large natural disaster. These are usually indirect effects, but they can have a very direct effect on the economic value of the owner's building or land. Effects can be positive or negative, and include changes in the following:

- Commodity and resource prices
- Availability of resource supplies
- Commodity and resource demand
- 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 assets listed above are difficult to estimate and require models structured to estimate total economic impacts. Total economic impacts are the sum total of direct and indirect economic impacts. Total economic impact models are usually not combined with economic feasibility models. Many models exist to estimate total economic impacts of changes in an economy. Decision makers should understand the total economic impacts of natural disasters in order to calculate the benefits of a mitigation activity. This suggests that understanding the local economy is an important first step in being able to understand the potential impacts of a disaster, and the benefits of mitigation activities.

ADDITIONAL CONSIDERATIONS

Conducting an economic analysis for potential mitigation activities can assist decision-makers in choosing the most appropriate strategy for their community to reduce risk and prevent loss from natural hazards. Economic analysis can also save time and resources from being spent on inappropriate or unfeasible projects. Several resources and models are listed on the following page that can assist in conducting an economic analysis for natural hazard mitigation activities.

Benefit/cost analysis is complicated, and the numbers may divert attention from other important issues. It is important to consider the qualitative factors of a project associated with mitigation that cannot be evaluated economically.

There are alternative approaches to implementing mitigation projects. Many communities are looking towards developing multi-objective projects. With this in mind, opportunity arises to develop strategies that integrate natural hazards mitigation with projects related to watersheds, environmental planning, community economic development, and small business development, among others. Incorporating natural hazards mitigation with other community projects increases the viability of project implementation.

Resources

Methodologies for Evaluating the Socio-Economic Consequences of Large Earthquakes, Task 7.2 Economic Impact Analysis, CUREe Kajima Project. Prepared by University of California, Berkeley Team, Robert A. Olson, VSP Associates, Team Leader; John M. Eidinger, G&E Engineering Systems; Kenneth A. Goettel, Goettel and Associates Inc.; and Gerald L. Horner, Hazard Mitigation Economics Inc., 1997.

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