MULTI-HAZARD MITIGATION PLAN

FOR

COLUMBIA COUNTY, OREGON

January 3, 2005

Prepared by:
Kenneth A. Goettel
Goettel & Associates Inc.
1732 Arena Drive
Davis, CA 95616
(530) 750-0440

Cover Photo:
City of Vernonia, Flood of February 1996

EXECUTIVE SUMMARY

This Multi-Hazard Mitigation Plan for Columbia County, Oregon covers each of the major natural and human-caused hazards that pose risks to the County. The primary objectives of this Mitigation plan are to reduce the negative impacts of future disasters on the community: to save lives and reduce injuries, minimize damage to buildings and infrastructure (especially critical facilities) and minimize economic losses. This Mitigation Plan is a planning document, not a regulatory document.

This mitigation plan meets FEMA's planning requirements by addressing hazards, vulnerability and risk. Hazard means the frequency and severity of disaster events. Vulnerability means the value, importance, and fragility of buildings and infrastructure. Risk means the threat to people, buildings and infrastructure, taking into account the probabilities of disaster events. Adoption of a mitigation plan is required for communities to remain eligible for future FEMA mitigation grant funds.

Review comments, suggestions, corrections and additions are enthusiastically encouraged from all interested parties. Please send comments to: Vicki Harguth, Columbia County Emergency Management Director, at:
HargutV@co.columbia.or.us

Overview and Context

Chapter 1: Introduction
Chapter 2: Community Profile
Chapter 3: Community Involvement and Public Process
Chapter 4: Mitigation Goals, Strategies and Action Items
Chapter 5: Plan Adoption, Implementation, and Maintenance

Hazards

Chapter 6: Floods
Chapter 7: Winter Storms
Chapter 8: Landslides
Chapter 9: Wildland/Urban Interface Fires
Chapter 10: Earthquakes
Chapter 11: Volcanic Hazards
Chapter 12: Dam Safety
Chapter 13: Disruption of Utility and Transportation Systems
Chapter 14: HAZMAT Incidents
Chapter 15: Terrorism

1.0 INTRODUCTION

1.1 What is a Mitigation Plan?

The communities of Columbia County are subject to a wide range of natural and human-caused hazards, including: floods, winter storms, landslides, wildland/urban interface fires, earthquakes, dam failures, hazardous material spills, and many others. The impact of a hazard event on a community may be minor - a few inches of water in a street - or it may be major - with damages reaching millions of dollars. There have been several recent disaster events in Columbia County with widespread damages and impacts on affected communities.

Mitigation simply means actions that reduce the potential for negative impacts from future disasters. That is, mitigation actions reduce future damages, losses and casualties.

This Mitigation Plan addresses all levels of natural hazard events and some human-caused hazards as well. The Plan includes minor events such as winter storms or localized storm water flooding that may happen in some locations almost every year and localized events such as landslides or mudslides. The plan also includes larger events such as major floods, earthquakes, or major wildland/urban interface fires that may affect large numbers of residents in Columbia County, with very high levels of damages and losses, albeit with much lower probabilities of occurrence.

The Columbia County mitigation plan has several key elements.

1. Each hazard that may impact Columbia County significantly is reviewed to determine the probability (frequency) and severity of likely hazard events.
2. The vulnerability of Columbia County to each hazard is evaluated to determine the likely extent of physical damages, casualties, and economic impacts.
3. A range of mitigation alternatives are evaluated to identify those with the greatest potential to reduce future damages and losses in Columbia County, to protect facilities deemed critical to the community's well being, and that are desirable from the community's political and economic perspectives.

1.2 Why is Mitigation Planning Important for Columbia County?

Effective mitigation planning will help the residents of Columbia County deal with natural and anthropogenic (human-caused) hazards realistically and rationally. That is, it will help identify specific locations in Columbia County where the level of risk from one or more hazards may be unacceptably high and then find cost effective ways to reduce such risk. Mitigation planning strikes a pragmatic middle ground between unwisely ignoring the potential for major hazard events on one hand and unnecessarily overreacting to the potential for disasters on the other hand.

Furthermore, the Federal Emergency Management Agency (FEMA) now requires each local government entity to adopt a multi-hazard mitigation plan to remain eligible for future pre- or post-disaster FEMA mitigation funding. Thus, an important objective in developing this plan is to maintain eligibility for FEMA funding and to enhance Columbia County's ability to attract future FEMA mitigation funding.

The Plan is specifically designed to help Columbia County gather the data necessary to compete successfully for future FEMA funding of mitigation projects. FEMA requires that all FEMA-funded hazard mitigation projects must be "cost-effective" (i.e., the benefits of a project must exceed the costs). Benefit-cost analysis is thus an important component of mitigation planning, not only to meet FEMA requirements, but also to help evaluate and prioritize potential hazard mitigation projects in Columbia County, regardless of whether funding is from FEMA, state or local government or from private sources.

Hazard mitigation planning is applicable to Columbia County as a whole, including the entire population and all of the built environment of buildings (residential, commercial, and public) and infrastructure (transportation and utility systems). However, for mitigation planning purposes and for implementation of mitigation actions, facilities designated as critical for the well being of residents of Columbia County are given a higher priority. A brief summary of the types of critical facilities in Columbia County is given below in Table 1.1

Table 1.1 Types of Critical Facilities in Columbia County

Category	Critical Functions	High Priority	Medium Priority
Emergency Services	Facilities critical for immediate emergency response, including life safety		
Fire Stations		YES	
Police Stations		YES	
Ambulance Services		YES	
Emergency Operations Centers		YES	
Emergency Shelters			YES
Medical Facilities	Facilities providing direct patient care, including hospitals, clinics, and nursing homes		
Hospitals and Urgent Care Facilities		YES	
Other Medical Facilities			YES
Special Needs Populations	Facilities housing people that may need assistance is evacuation from emergencies		
Elderly Housing		High occupancy facilities	Low occupancy facilities
Schools (K-12)		YES	
Schools (Higher Education)		YES	
Jails		YES	
Utilities			
Telecommunications	Facilities for transmission, switching and distribution of telephone traffic	PSAPs (911 centers) and Central Offices (switching)	Trunk lines
Electric Power	Facilities for generation, transmission and distribution of electric power	High voltage substations and transmission lines	Other substations and transmission lines, trunk distribution lines
Natural Gas	Facilities for transmission and distribution of natural gas		Transmission lines and compressor stations
Water	Facilities for treatment and distribution of potable and irrigation water	Major reservoirs, well fields, treatment plants and major pumping plants	Smaller reservoirs and pumping plants
Wastewater	Facilities for pumping and treatment of wastewater	Treatment plants and major pumping plants	
Dams	Facilities to impound water for flood control, power generation and water supply	Major dams upstream of population centers	Smaller dams and dams not upstream of population centers
Transportation Systems			
Roadways	Necessary for emergency response, public safety and disaster recovery	Major highways, arterials, and bridges on such roads	Secondary roads and bridges
Air, rail, and water transport	These transport modes are of secondary importance for Columbia County	Not at this time	Not at this time
Hazmat Facilities	Facilities that manufacture, store, use, or transport hazardous materials	Sites with large inventories of hazardous materials	Sites with smaller inventories of hazardous materials

The Columbia County Mitigation Plan

This Columbia County Mitigation Plan is built upon a quantitative assessment of each of the major hazards that may impact Columbia County, including their frequency, severity, and areas of the County likely to be affected. The hazards addressed include: floods, severe winter storms, landslides, wildland/urban interface fires, earthquakes, volcanic eruptions, dam failures, utility and transportation disruptions, hazmat incidents, and terrorism.

The Columbia County Mitigation plan includes a quantitative assessment of the vulnerability of buildings, infrastructure, and people to each of these hazards, to the extent possible with existing data. The plan also includes an evaluation of the likely magnitude of the impacts of future disasters on Columbia County.

These reviews of the hazards and the vulnerability of Columbia County to these hazards are the foundation of the mitigation plan. From these assessments, high hazard areas where buildings, infrastructure, and/or people may be at high risk are identified whenever possible. These high-risk situations then become priorities for future mitigation actions to reduce the negative impacts of future disasters on Columbia County.

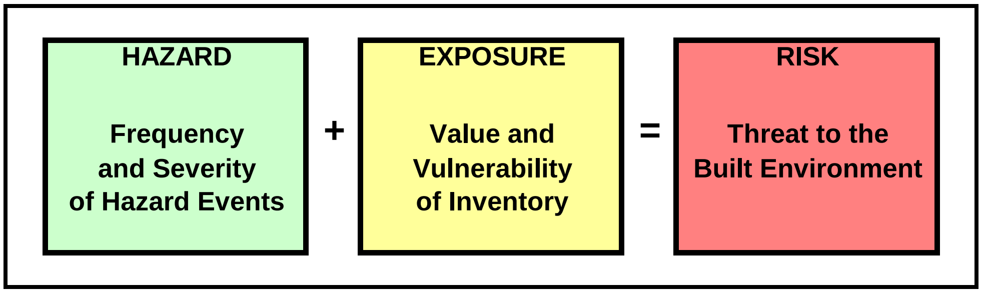
The Columbia County Mitigation Plan deals with hazards realistically and rationally and also strikes a balance between suggested physical mitigation measures to eliminate or reduce the negative impacts of future disasters and enhancements in land use planning to reduce the potential for negative impacts of disasters on new development. Finally, the plan suggests better emergency planning to help prepare the community to respond to and recover from disasters for which physical mitigation measures are not possible or not economically feasible.

1.3 Key Concepts and Definitions

The central concept of mitigation planning is that mitigation reduces risk. **Risk** is defined as the threat to the built environment posed by the hazards being considered. That is, risk is the potential for damages, losses and casualties arising from the impact of hazards on the built environment.

The extent of risk depends on the combination of **hazard** and **exposure** as shown in Figure 1.2 below.

Figure 1.2
Hazard and Exposure Combine to Produce Risk



Thus, there are four key concepts that govern hazard mitigation planning: hazard, exposure, risk and mitigation. Each of these key concepts is addressed in turn.

HAZARD refers to natural or anthropogenic events that potentially may cause damages, losses or casualties (e.g., floods, winter storms, landslides, earthquakes, hazardous material spills, etc.). Hazards are characterized by their frequency and severity and by the geographic area affected. Each hazard is characterized differently, with appropriate parameters for the specific hazard. For example, floods may be characterized by the frequency of flooding, along with flood depth and flood velocity. Winter storms may be characterized by the amount of rainfall in a 24-hour period, by the wind speed, by the amount of snow or ice associated with a storm. Earthquakes may be characterized by the severity and duration of ground motions and so on.

A hazard, by itself, may not result in any negative impacts on a community. For example, a highly flood-prone five acre parcel may typically experience several shallow floods per year, with several feet of water expected in a 50-year flood event and more than six feet of water expected in a 100-year flood event. However, the parcel may be wetlands adjacent to a tidal marsh that floods daily, with no development (structures or infrastructure) on the parcel. In this case, the frequent flooding does not have any negative impacts on the community. Indeed, in such circumstances, the very frequent flooding (i.e., high hazard) may be beneficial in providing wildlife habitat.

The important point here is that hazards do not produce risk, unless there is vulnerable inventory exposed to the hazard. In the context of mitigation planning, “inventory” means simply people, buildings, or infrastructure exposed to damages from one or more natural or manmade hazards.

EXPOSURE is the quantity, value and vulnerability of the built environment (inventory of buildings and infrastructure) in a particular location subject to one or more hazards. Inventory is described by the number, size, type, use, and occupancy of buildings and by the infrastructure present. Infrastructure includes roads and other transportation systems, utilities (potable water, wastewater, natural gas, electric power), telecommunications systems and so on.

Inventory varies markedly in its importance to a community and thus varies markedly in its importance for hazard mitigation planning. Some types of facilities, “critical facilities,” are especially important to a community, particularly during disaster situations. Examples of critical facilities include police and fire stations, hospitals, schools, emergency shelters, 911 centers, and other important buildings. Critical facilities may also include infrastructure elements that are important links or nodes in providing service to large numbers of people such as a potable water source, an electric power substation and so on. “Links” are elements such as water pipes, electric power lines, telephone cables that connect portions of a utility or transportation system. “Nodes” are locations with important functions, such as pumping plants, substations, or switching offices.

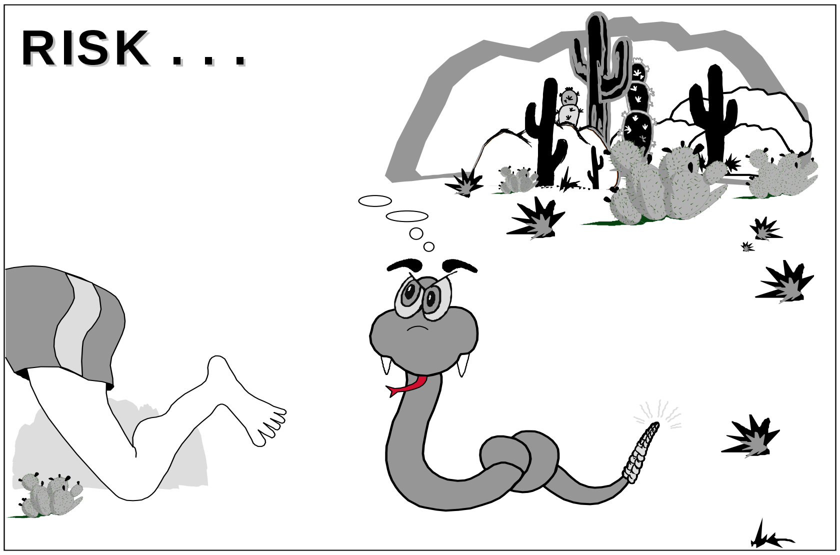
For hazard mitigation planning, inventory must be characterized not only by the quantity and value of buildings or infrastructure present but also by its vulnerability to each hazard under evaluation. For example, a given facility may be vulnerable to flood damages and earthquake damages or to flood damages only or to earthquake damages only. Depending on the hazard, different measures of vulnerability must be used.

RISK is the threat to the built environment (buildings and infrastructure) and people - the potential for damages, losses and casualties arising from hazards. Risk results from the combination of Hazard and Exposure. That is, when the geographic areas affected by one or more hazards contain people, buildings, and infrastructure vulnerable to damage from the hazard(s). For mitigation planning, evaluation of risk generally emphasizes the built environment and people. However, risk also includes the potential for environmental damage.

Risk is the potential for future damages, losses or casualties. A disaster event happens when a hazard event is combined with vulnerable inventory (that is when hazard event strikes vulnerability inventory exposed to the hazard). The highest risk in a community occurs in high hazard areas (frequent and/or severe hazard events) with large inventories of vulnerable buildings or infrastructure.

However, high risk can also occur with only moderately high hazard, if there is a large inventory of highly vulnerable inventory exposed to the hazard. For example, seismic hazard is lower in Oregon than in the seismically active areas of California. However, for some buildings, seismic risk in Oregon may be comparable to or even higher than seismic risk in California, due to the very recent adoption in Oregon of seismic design standards commensurate with current understanding of seismic hazards in Oregon. Much of the building inventory in Oregon is vulnerable to earthquake damages because older buildings were generally designed and built to much lower seismic standards than currently required in Oregon. Conversely, a high hazard area can have relatively low risk if the inventory is resistant to damages (e.g., elevated to protect against flooding or strengthened to minimize earthquake damages).

Figure 1.3
Risk Results from the Combination of Hazard and Exposure



MITIGATION means actions to reduce the risk due to hazards. Mitigation actions reduce the potential for damages, losses, and casualties in future disaster events. Repair of buildings or infrastructure damaged in a disaster is not mitigation because repair simply restores a facility to its pre-disaster condition and does not reduce the potential for future damages, losses, or casualties. Hazard mitigation projects may be initiated proactively - before a disaster, or after a disaster has already occurred. In either case, the objective of mitigation is always to reduce future damages, losses or casualties.

A few of the most common types of mitigation projects are shown below in Table 1.4.

Table 1.4
Common Mitigation Projects

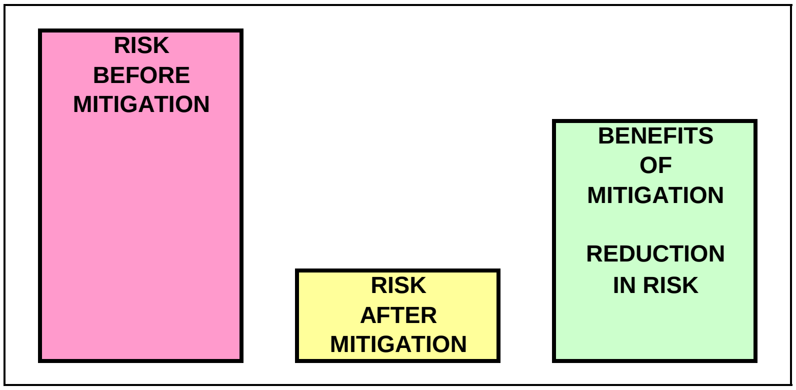
Hazard	Mitigation Project
Flood	Build or improve levees or flood walls
	Improve channels for flood control
	Improve drainage systems and culvert capacities
	Create detention ponds for storage
	Relocate, elevate or floodproof flood-prone structures
	Acquire and demolish highly flood-prone structures
Winter Storms	Add emergency generators for critical facilities
	Improve redundancy of utility systems
	Trim trees to reduce failures of utility lines
Earthquakes	Upgrade seismic performance of buildings
	Upgrade seismic performance of infrastructure
Landslides	Remediate slide conditions
	Relocate utility lines or structures
Wildland/Urban Interface Fires	Increase fire safe construction practices
	Vegetation (fuel load) control
General	Enhance emergency planning and mutual aid
	Expand public education programs

The mitigation project list above is not comprehensive and mitigation projects can encompass a broad range of other actions to reduce future damages, losses, and casualties.

1.4 The Mitigation Process

The key element for all hazard mitigation projects is that they reduce risk. The benefits of a mitigation project are the reduction in risk (i.e., the avoided damages, losses, and casualties attributable to the mitigation project). In other words, benefits are simply the difference in expected damages, losses, and casualties before mitigation (as-is conditions) and after mitigation. These important concepts are illustrated below in Figure 1-5.

Figure 1.5
Mitigation Projects Reduce Risk



Quantifying the benefits of a proposed mitigation project is an essential step in hazard mitigation planning and implementation. Only by quantifying benefits is it possible to compare the benefits and costs of mitigation to determine whether or not a particular project is worth doing (i.e., is economically feasible). Real world mitigation planning almost always involves choosing between a range of possible alternatives, often with varying costs and varying effectiveness in reducing risk.

Quantitative risk assessment is centrally important to hazard mitigation planning. When the level of risk is high, the expected levels of damages and losses are likely to be unacceptable and mitigation actions have a high priority. Thus, the greater the risk, the greater the urgency of undertaking mitigation actions.

Conversely, when risk is moderate both the urgency and the benefits of undertaking mitigation are reduced. It is neither technologically possible nor economically feasible to eliminate risk completely. Therefore, when levels of risk are low and/or the cost of mitigation is high relative to the level of risk, the risk may be deemed acceptable (or at least tolerable). Therefore, proposed mitigation projects that address low levels of risk or where the cost of the mitigation project is large relative to the level of risk are generally poor candidates for implementation.

The overall mitigation planning process is outlined in Figure 1.6 on the following page.

The flow chart below outlines the major steps in Hazard Mitigation Planning and Implementation for Columbia County.

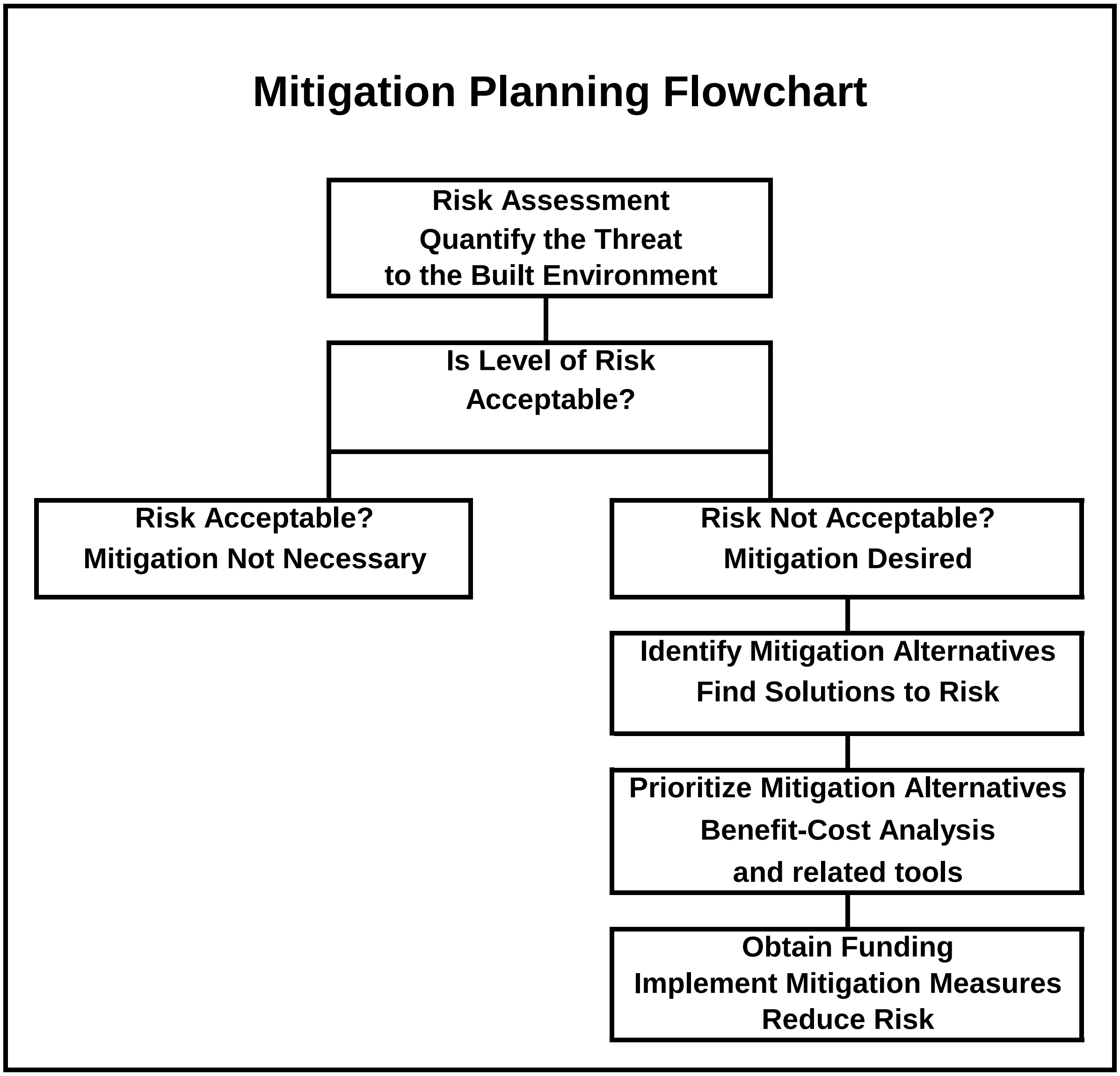
The first steps are quantitative evaluation of the hazards (frequency and severity) impacting Columbia County and of the inventory (people, buildings, infrastructure) exposed to these hazards. Together these hazard and exposure data determine the level of risk for specific locations, buildings or facilities in Columbia County.

The next key step is to determine whether or not the level of risk posed by each of the hazards impacting Columbia County is acceptable or tolerable. Only the residents of Columbia County can make this determination. If the level of risk is deemed acceptable or at least tolerable, then mitigation actions are not necessary or at least not a high priority.

On the other hand, if the level of risk is deemed not acceptable or tolerable, then mitigation actions are desired. In this case, the mitigation planning process moves on to more detailed evaluation of specific mitigation alternatives, prioritization, funding and implementation of mitigation measures. As with the determination of whether or not the level of risk posed by each hazard is acceptable or not, decisions about which mitigation projects to undertake can be made only by the residents of Columbia County.

For reference, a more detailed discussion of the overall mitigation planning process, including each step in the planning process flow chart shown in Figure 1.6.

Figure 1.6
The Mitigation Planning Process



Project prioritization and implementation take a variety of comprehensive as well as subjective measures to accomplish. It is important to use proven methods of analyzing data whenever possible. Analysis of Mitigation Projects using FEMA's methods of identifying the costs and benefits associated with natural hazard mitigation strategies, measures, or projects fall into two general categories: benefit/cost analysis and cost-effectiveness analysis. Conducting benefit/cost analysis for a mitigation activity can assist communities in determining whether a project is worth undertaking now, in order to avoid disaster-related damages later. Cost-effectiveness analysis evaluates how best to spend a given amount of money to achieve a specific goal. Determining the economic feasibility of mitigating natural hazards provides decision-makers with an understanding of the potential benefits and costs of an activity, as well as a basis upon which to compare alternative projects. The Hazard Mitigation Planning Committee and Columbia County Emergency Management will use FEMA-approved cost benefit methodology as a tool for identifying and prioritizing mitigation action items when applying for federal mitigation funding. For other projects and funding sources, the committee will use other approaches to understand the costs and benefits of each action item and develop a prioritized list.

All planning, mitigation or otherwise, needs to be done with the thought of being ready to implement projects when certain opportunities arise. These opportunities can be in the form of funding availability, land develop projects, or unforeseen disasters that open "windows of opportunities" for project implementation. It is important to keep the mitigation plan current and organized to take advantage of all opportunities.

1.5 The Role of Benefit-Cost Analysis in Mitigation Planning

Communities that are considering whether or not to undertake mitigation projects must answer questions that don't always have obvious answers, such as:

What is the nature of the hazard problem?

How frequent and how severe are hazard events?

Do we want to undertake mitigation measures?

What mitigation measures are feasible, appropriate, and affordable?

How do we prioritize between competing mitigation projects?

Are our mitigation projects likely to be eligible for FEMA funding?

Benefit-cost analysis is a powerful tool that can help communities provide solid, defensible answers to these difficult socio-political-economic-engineering questions. **Benefit-cost analysis is <u>required</u> for all FEMA-funded mitigation projects, under both pre-disaster and post-disaster mitigation programs. Thus, communities seeking FEMA funding must understand benefit-cost analysis.** However, regardless of whether or not FEMA funding is involved, benefit-cost analysis provides a sound basis for evaluating and prioritizing possible mitigation projects for any natural hazard.

Benefit-cost analysis software, technical manuals and a wide range of guidance documents are available from FEMA at no cost to communities. A Benefit-Cost Analysis Toolkit CD which contains all of the FEMA benefit-cost materials is available from FEMA. The publication ***What is a Benefit? Draft Guidance for Benefit-Cost Analysis*** is particularly recommended as a general reference for benefit-cost analysis. This publication includes categories of benefits to count for mitigation projects for various types of buildings, critical facilities, and infrastructure and has simple, standard methods to quantity the full range of benefits for most types of mitigation projects.

The principles of benefit-cost analysis are briefly summarized in the Annex at the end of this Chapter.

1.6 Hazard Synopsis

To set the overall context of hazard mitigation planning, we briefly review the major hazards that impact Columbia County. Different parts of Columbia County vary in topography, climate, population, development patterns and so on. Similarly, the impact of many hazards on communities in Columbia County varies with location within the County. Some hazards affect the entire County, while some hazards have only localized potential consequences.

Floods. Nearly every community in Columbia County is affected by flood hazards, to at least some extent. Most communities in Columbia County have areas of flood plains mapped by FEMA. These include areas along the Columbia, Clatskanie, and Nehalem Rivers, areas along Conyers, McNulty, Milton, Rock, Scappoose and North Scappoose Creeks, and areas near the Multnomah Channel. In addition, other portions of Columbia County, outside of the mapped floodplains, are also subject to significant, repetitive flooding from local storm water drainage or from creeks too small to be mapped by FEMA. County also has areas protected by flood dikes maintained by 15 separate dike districts. These areas are subject to flooding when dikes fail or are overtopped.

Winter Storms. All of Columbia County is subject to the effects of winter storms, including wind, rain, snow and ice, as well as secondary effects such as power outages. However, the severity of impacts and types of impacts vary with location and with elevation.

Landslides. Portions of the hilly areas of Columbia County, especially in the interior of the County, are subject to landslides or debris flows (mudslides), which may affect buildings, roads, and utilities. There are also several segments of Highway 30 subject to slide damage and road closures.

Wildland/Urban Interface Fires. Columbia County has large areas of forest and much of Columbia County is subject to the risk of wildland fires. As a result, many residential areas bordering or impinging into forested areas near the edges of the developed areas of Columbia County may have high levels of risk from wildland/urban interface fires. Every major community in Columbia County is listed in the Oregon State Hazard Mitigation Plan (Oregon Natural Hazards Risk Assessment, Region 2, Northern Willamette Valley/Portland Metro Hazards Assessment) as an “interface” community with risk of wildland/urban interface fires.

Earthquakes. All of Columbia County is subject to the impacts of earthquakes, including not only major earthquakes on the Cascadia Subduction Zone off the Oregon coast, but also smaller crustal earthquakes within western Oregon.

Volcanic Hazards. All of Columbia County is subjected, to some degree, to volcanic hazards from eruptions in the Cascades (e.g., Mt. St. Helens or Mount Hood,). For Columbia County, the impacts of volcanic events are likely to be only minor ash falls, with perhaps some impact on public water supplies from ash causing high turbidity in drinking water supplies.

Dam Failures. Portions of Columbia County along the Columbia River are in the inundation areas from dam failures. While dam failures are highly unlikely, the consequences of failure would be significant for affected areas.

Disruption of Utility and Transportation Systems. All of Columbia County is also subject to disruption of utility and transportation systems from winter storms and other natural hazards, as well as from anthropogenic causes.

Hazmat Incidents. Human-caused hazards, such as hazardous material releases, are possible nearby or downwind from fixed site concentrations (e.g., industrial sites) as well as along transportation corridors from truck or railroad accidents. All populated areas of Columbia County are subject to hazmat incidents.

Terrorism. The term "terrorism" is broadly inclusive of all deliberate malevolent actions intended to damage property or inflict casualties. Terrorism includes actions by outsiders (domestic or international groups or individuals,), insiders (e.g., employees), and cyber-terrorists (computer hackers). Any community in Columbia County could potentially be affected by terrorist actions. According to the FBI, acts of violence in protest of harm to animals or to the environment, are the United States' number one domestic terrorism threat.

In evaluating these natural or human-caused hazards, it is important to recognize that the risk to Columbia County (i.e., the potential for damages, economic losses, and casualties) varies markedly from one hazard to another. As discussed in more detail in Section 1.4, risk depends on the combination of the frequency and severity of hazard events and on the value and vulnerability of infrastructure, buildings, and people to each potential hazard. Risk is thus always probabilistic in nature. Some hazard events, such as winter storms, happen every year to at least some extent. Other hazard events, such as major earthquakes may happen only once every few hundred years. However, risk from earthquakes may not be low, even though the frequency of occurrence is low, because the consequences (damage, economic losses, and casualties) may be very high.

The relative risk posed to Columbia County by each of the 10 hazards covered in this mitigation plan is summarized below in Table 1.7.

Table 1.7
Relative Risk to Columbia County

Hazard	Risk
Flood	High
Earthquake	High
Wildland/Urban Interface Fires	Moderate
Disruption of Utility and Transportation Systems	Moderate
Winter storms (Severe weather)	Moderate
Landslides	Moderate
Hazmat Incidents	Low/Moderate
Terrorism	Low/Moderate
Dam Failure	Low
Volcanic Eruptions (Ash Falls)	Low

Another measure of the relative impacts of hazards on Columbia County is provided by survey results obtained at the August 3, 2004 meeting of CEPA (Columbia Emergency Planning Association). These results, shown below in Table 1.8 indicate which hazards were deemed most important to mitigate for Columbia County. In Table 1.8, the scores represent the average ranking; hazards with lower scores were deemed the highest priority. Thus, floods and earthquakes were deemed the highest and second highest priorities, respectively.

Table 1.8
Relative Ranking of Hazards as Priorities for Mitigation in Columbia County

Floods	1.91
Earthquakes	2.55
Severe Weather	4.32
Wildland/Urban Fires	4.68
Disruption of Utilities	5.67
Disruption of Transportation	5.71
Hazmat Incidents	6.50
Landslides	6.82
Dam Failure	7.27
Terrorism	9.09
Volcanic Eruption	10.05

In summary, there are many natural and human-caused hazards which affect all or large portions of Columbia County.

The remaining chapters of this mitigation plan include the following.

Chapter 2 provides a brief community profile for Columbia County.

Chapter 3 documents the community involvement and public process involved in developing this mitigation plan.

Chapter 4 outlines the mitigation plan goals, mitigation strategies, and action items.

Chapter 5 documents the formal process of plan adoption, implementation, and maintenance.

Chapters 6 through 15 cover each of the major hazards addressed in this mitigation plan, including: floods, winter storms, landslides, wildland/urban interface fires, earthquakes, volcanic hazards, dam safety, disruption of utility and transportation systems, hazmat incidents, and terrorism.

Chapter 1 Annex

Principles of Benefit-Cost Analysis

Benefit-cost analysis is the tool that provides answers to a central question for hazard mitigation projects: **"Is it worth it?"** If hazard mitigation were free, individuals and communities would undertake mitigation with robust enthusiasm and the risks from hazards would soon be greatly reduced. Unfortunately, mitigation is not free, but often rather expensive. For a given situation, is the investment in mitigation justified? Is the owner (public or private) better off economically to accept the risk or invest now in mitigation to reduce future damages? These are hard questions to answer! Benefit-cost analysis can help a community answer these difficult questions.

In the complicated real world of mitigation projects, there are many factors which determine whether or not a mitigation project is worth doing or which of two or more mitigation projects should have the highest priority. Consider a town which has two flood prone neighborhoods and each neighborhood desires a mitigation project. The two neighborhoods have different numbers of houses, different value of houses, different frequencies and severity of flooding. The first neighborhood proposes storm water drainage improvements at a cost of $3.0 million. The second neighborhood wants to elevate houses at a cost of $3.0 million. Which of these projects should be completed? Both? One or the Other? Neither? Which project should be completed first if there is only funding for one? Are there alternative mitigation projects which are more sensible or more cost-effective than the proposed projects?

Such complex socio-political-economic-engineering questions are nearly impossible to answer without completing the type of quantitative flood risk assessment and benefit-cost analysis discussed below.

In determining whether or not a given mitigation project is worth doing, the level of risk exposure without mitigation is critical. Consider a hypothetical $1,000,000 mitigation project. Whether or not the project is worth doing depends on the level of risk before mitigation and on the effectiveness of the project in reducing risk. For example, if the before mitigation risk is low (a subdivision street has a few inches of water on the street every couple of years or a soccer field in a city park floods every five years or so) the answer is different than if the before mitigation risk is high (100 or more houses are expected to have flooding above the first floor every 10 years or a critical facility is expected to be shut down because of flood damages once every five years).

All well-designed mitigation projects reduce risk (badly designed projects can increase risk or simply transfer risk from one community to another). However, just because a mitigation project reduces risk does not make it a good project. A $1,000,000 project that avoids an average of $100 per year in flood damages is not worth doing, while the same project that avoids an average of $200,000 per year in flood damages is worth doing.

The principles of benefit-cost analysis are briefly summarized here. The benefits of a hazard mitigation project are the reduction in future damages and losses, that is, the avoided damages and losses that are attributable to a mitigation project. To conduct benefit-cost analysis of a specific mitigation project the risk of damages and losses must be evaluated twice: before mitigation and after mitigation, with the benefits being the difference.

The benefits of a hazard mitigation project are thus simply future damages and losses which are avoided because a mitigation action was implemented.

Because the benefits of a hazard mitigation project accrue in the future, it is impossible to know exactly what they will be. For example, we do not know when future floods or other natural hazards will occur or how severe they will be. We do know, however, the probability of future floods or other natural hazards (if we have appropriate hazard data). Therefore, the benefits of mitigation projects must be evaluated probabilistically and expressed as the difference between annualized damages before and after mitigation. The following simplified example illustrates the principles of benefit-cost analysis; more details are given in the examples in the Appendices.

To illustrate the principles of benefit-cost analysis, we consider a hypothetical single family home in the town of Acorn, with the home located on the banks of Squirrel Creek. The home is a one-story house, about 1500 square feet on a post foundation, with a replacement value of $60/square foot (total $90,000). We have flood hazard data for Squirrel Creek (stream discharge and flood elevation data) and elevation data for the first floor of the house. Therefore, we can calculate the annual probability of flooding in one-foot increments, as shown below.

Table 1.10
Damages Before Mitigation

Flood Depth (feet)	Annual Probability of Flooding	Scenario Damages and Losses Per Flood Event	Annualized Flood Damages and Losses
0	0.2050	$6,400	$1,312
1	0.1234	$14,300	$1,765
2	0.0867	$24,500	$2,124
3	0.0223	$28,900	$673
4	0.0098	$32,100	$315
5	0.0036	$36,300	$123
Total Expected Annual (Annualized) Damages and Losses			$6,312

Flood depths shown above in Table 1.10 are in one-foot increments of water depth above the lowest floor elevation. Thus, a “3" foot flood means all floods between 2.5 feet and 3.5 feet of water depth above the floor. We note that a “0" foot flood has, on average, damages because this flood depth means water plus or minus 6" of the floor; even if the flood level is a few inches below the first floor, there may be damage to flooring and other building elements because of wicking of water.

The Scenario (per flood event) damages and losses include expected damages to the building, content, and displacement costs if occupants have to move to temporary quarters while flood damage is repaired.

The Annualized (expected annual) damages and losses are calculated as the product of the flood probability times the scenario damages. For example, a 4 foot flood has slightly less than a 1% chance per year of occurring. If it does occur, we expect about $32,100 in damages and losses. Averaged over a long time, 4 foot floods are thus expected to cause an average of about $315 per year in flood damages. Note that the smaller floods, which cause less damage per flood event, actually cause higher average annual damages because the probability of smaller floods is so much higher than that for larger floods. With these data, the house is expected to average $6312 per year in flood damages. This expected annual or “annualized” damage estimate does not mean that the house has this much damage every year. Rather, in most years there will be no floods, but over time the cumulative damages and losses from a mix of relatively frequent smaller floods and less frequent larger floods is calculated to average $6312 per year.

The calculated results in Table 1.10 are the flood risk assessment for this house for the as-is, before mitigation situation. The table shows the expected levels of damages and losses for scenario floods of various depths and also the annualized damages and losses.

The risk assessment shown in Table 1.10 shows a high flood risk, with frequent severe flooding which the owner deems unacceptable. Therefore he explores mitigation alternatives to reduce the risk: the example below is to elevate the house 4 feet.

Table 1.11
Damages After Mitigation

Flood Depth (feet)	Annual Probability of Flooding	Scenario Damages and Losses Per Flood Event	Annualized Flood Damages and Losses
0	0.2050	$0	$0
1	0.1234	$0	$0
2	0.0867	$0	$0
3	0.0223	$0	$0
4	0.0098	$6,400	$63
5	0.0036	$14,300	$49
			$112

By elevating the house 4 feet, the owner has reduced his expected annual (annualized) damages from $6312 to $112 (98% reduction) and greatly reduced the probability or frequency of flooding affecting his house. The annualized benefits are the difference in the annualized damages and losses before and after mitigation or $6312 - $112 = $6200.

Is this mitigation project worth doing? Common sense says yes, because the flood risk appears high: the annualized damages before mitigation are high ($6,312). To answer this question more quantitatively, we complete our benefit-cost analysis of this project. One key factor is the cost of mitigation. A mitigation project that is worth doing at one cost may not be worth doing at a higher cost. Let’s assume that the elevation costs $20,000. This $20,000 cost occurs once, up front, in the year that the elevation project is completed.

The benefits, however, accrue statistically over the lifetime of the mitigation project. Following FEMA convention, we assume that a residential mitigation project has a useful lifetime of 30 years. Money (benefits) received in the future has less value than money received today because of the time value of money. To take the time value of money into account, we need to do what is known as a “present value calculation.” We compare the present value of the anticipated stream of benefits over 30 years in the future to the up-front out-of-pocket cost of the mitigation project.

A present value calculation depends on the lifetime of the mitigation project and on what is known as the discount rate. The discount rate may be viewed simply as the interest rate you might earn on the cost of the project if you didn’t spend the money on the mitigation project. Let's assume that this mitigation project is to be funded by FEMA, which uses a 7% discount rate to evaluate hazard mitigation projects. With a 30-year lifetime and a 7% discount rate, the "present value coefficient" which is the value today of $1.00 per year in benefits over the lifetime of the mitigation project is 12.41. That is, each $1.00 per year in benefits over 30 years is worth $12.41 now. The benefit-cost results are now as follows.

Table 1.12
Benefit-Cost Results

Annualized Benefits	$6,200
Present Value Coefficient	12.41
Net Present Value of Future Benefits	$76,942
Mitigation Project Cost	$20,000
Benefit-Cost Ratio	3.85

These results indicate a benefit-cost ratio of 3.85. Thus, in FEMA's terms the mitigation project is cost-effective and eligible for FEMA funding. Taking into account the time value of money, which is essential for a correct economic calculation, results in lower benefits than if we simply multiplied the annual benefits times the 30-year project useful lifetime. Economically, simply multiplying the annual benefits times the lifetime would ignore the time value of money and thus gives an incorrect, spurious result.

The above discussion of benefit-cost analysis of a flood hazard mitigation project is intended to illustrate the basic concepts. Very similar principles apply to mitigation projects for earthquakes or any other natural hazards. The role of benefit-cost analysis in prioritizing and implementing mitigation projects in Columbia County is addressed in Chapter 4 (Plan Goals, Mitigation Strategies and Action Items).

CHAPTER TWO

2.0 COMMUNITY PROFILE: COLUMBIA COUNTY

2.1 Geography and Climate

Columbia County is located in northwestern Oregon and covers about 657 square miles. Columbia County is bordered by Clatsop County on the west and by Washington County and Multnomah County on the south. Columbia County's northern and eastern boundary is the Columbia River, with 62 miles of shoreline within the County.

For hazard mitigation planning, we consider two main physiographic regions within Columbia County,

The Columbia River Valley, which is characterized by low-elevation generally flat lands along the Columbia River, and

The interior of Columbia County, which is characterized by heavily forested hills with elevations up to 2033 feet (Cater Hill in southern Columbia County).

The geography, topography, climate, and other natural attributes such as vegetation vary somewhat with location in Columbia County. The geographic diversity of Columbia County is one factor to consider in mitigation planning for natural and human-caused hazards. The severity of potential impacts of most natural hazards varies significantly from location to location in Columbia County.

For example, portions of the Columbia River Valley part of Columbia County are protected from floods by dike districts, many of which provide less than optimum levels of flood protection. Furthermore, some of the dikes may be vulnerable to failure in earthquakes.

Other hazards such as floods, landslides and wildland/urban interface fires vary spatially within the County, depending on specific local elevation, topography, rainfall, and vegetation. Even the impacts of winter storms, which generally affect the entire County, vary in severity depending on local topography. Other hazards such as earthquakes vary more or less smoothly across Columbia County.

The climate for Columbia County is moderate. Mean daily temperatures range from highs in the 70s to 80s and lows in the 40s to 50s in July and August to highs in the 40s and lows of about 30 in December and January (sample data for Clatskanie, St. Helens, and Vernonia). The average annual rainfall varies from about 40 inches to about 60 inches depending on location. Average monthly precipitation varies from about 6 to 9 inches in November through January to about 0.5 inch to 1.0 inch in July. Average annual snowfall varies from about 2" along the Columbia River in southeastern Columbia County to about 10" in Clatskanie. At higher elevations in the hilly interior of Columbia County, temperatures are typically somewhat lower, with higher amounts of precipitation.

2.2 Population and Demographics

In 1805-1806, Lewis and Clark explored the area and camped along Columbia County's Columbia River shoreline. Very small early settlements were established by fur traders as early as 1810. However, immigration of non-native Americans began in earnest in the 1840s and 1850s, with most of the early population centers being along the Columbia River. Settlement occurred more slowly in the interior portion of the County. For example, Vernonia was founded in 1891 as a logging center.

Columbia County was created from the northern portion of Washington County in 1854. Milton was the first county seat until 1857 when St. Helens became the county seat.

Columbia County population (2000 Census) was 43,560. The 2003 population estimate was 46,261. Population data for Columbia County and for the incorporated cities in Columbia County are shown below in Table 2.1. Columbia County's current (October, 2004) population is approximately 47,000.

Table 2.1
Columbia County Population Data

Location	2000 Census	Estimate July 1, 2003
Columbia County	43,560	46,261
Incorporated Cities		
Clatskanie	1,528	1,608
Columbia City	1,571	1,644
Prescott	72	71
Rainier	1,687	1,787
St. Helens	10,019	11,209
Scappoose	4,976	5,506
Vernonia	2,228	2,244
Balance of Columbia County	21,479	22,192

The seven incorporated cities in Columbia County had just over 50% of the county's population in 2000, with the remaining 50% in rural areas. However, nearly 75% of the population growth between 2000 and 2003 has been in the larger cities.

Historical population data for Columbia County since 1900 are shown below in Table 2.2 (Census data). These long term data show the steady growth of population in Columbia County over the decades, from only about 6,000 in 1900 to the current population of about 47,000. From 1980 to 2003, the population of Columbia County grew at an annual rate of about 0.8%. From 2000 to 2003, the rate of annual population growth has accelerated to a little above 2.0%.

Table 2.2
Columbia County Historical Population Data

Census	Population
1900	6,237
1910	10,580
1920	13,960
1930	20,047
1940	20,917
1950	22,967
1960	22,379
1970	28,790
1980	35,646
1990	37,557
2000	43,560
2003	46,261

More detailed population and demographic data for Columbia County from the 2000 Census are shown below in Table 2.3, along with similar data for Oregon. The Age and Ethnicity categories in Table 2.3 below intentionally include overlapping subsets of categories for planning purposes.

Table 2.3
Population Demographics (2000 Census Data)

Demographic Data		Columbia County	Oregon
Age			
	Under 5 years	6.4%	6.5%
	Under 18 years	27.3%	24.7%
	18 years and over	72.7%	75.3%
	18 years to 65 years	61.1%	62.5%
	65 years and over	11.6%	12.8%
Ethnicity of Households			
	White	94.4%	86.6%
	Black or African Amerian	0.2%	1.6%
	American Indian and Alaska Native	1.3%	1.3%
	Asian	0.6%	3.0%
	Native Hawaiian and Pacific Islander	0.1%	0.2%
	Other or two or more races	3.3%	7.3%
	Hispanic or Latino (of any race)	2.5%	8.0%
Language Spoken at Home			
	English only	96.1%	87.9%
	Language other than English	3.9%	12.1%
	Speak English less than very well	1.3%	5.9%
	Spanish	1.9%	6.8%
	Other Indo-European languages	1.2%	2.6%
	Asian and Pacific Island languages	0.4%	2.4%

For emergency planning purposes, children, elderly adults, the disabled, and people whose primary language is not English are considered special needs populations. Based on these 2000 census data, Columbia County has a substantial population of children and elderly adults, along with about 4% of the population whose primary language is not English. As shown in Table 2.3 above, about 27% of the population are children less than 18 years old, while about 12% are adults over 65 years old.

The Census website (www.census.gov) has a vast amount of demographic data for Columbia County and for the individual cities within Columbia County. See the website for additional demographic data, including school enrollment, educational levels, disability status, and other categories of demographic data useful for planning purposes.

2.3 Employment and Economics

The primary industries of Columbia County are timber, fishing, water transportation, dairying, horticulture and recreation. The extensive stands of old growth timber, which had attracted many of the early settlers to Columbia County, were completely logged over by the 1950s. Second growth timber now provides the raw materials for the local lumber and pulp mills.

In the earliest years, the economy of Columbia County was largely agrarian; wheat

Selected economic data for Columbia County from the 2000 Census are summarized below in Table 2.4. Corresponding data for Oregon are also shown for reference.

Table 2.4
Selected Economic Data

Demographic Data		Columbia County	Oregon
Population 16 years and older		33,035	3,472,867
	In labor force	64.8%	65.2%
	Employed	60.7%	61.0%
	Unemployed	4.1%	4.2%
	Not in labor force	35.2%	34.8%
Commuting to work			
	Drove alone	78.7%	73.2%
	Carpooled	13.7%	12.2%
	Public transportation	0.2%	4.2%
	Walked	2.1%	3.6%
	Other means (includes bicycles)	1.0%	1.9%
	Worked at home	4.6%	5.0%
Housing Data			
	Homeownership rate	76.1%	64.3%
	Housing units in multi-unit structures	11.4%	23.1%
Incomes and poverty levels			
	Median household income	$45,797	$40,916
	Per capita money income	$20,078	$20,940
	Families below poverty level	6.7%	7.9
	with children under 18 years	10.4%	12.4
	with children under 5 years	14.6%	16.6

The Census website (www.census.gov) has a vast amount of other economic/ demographic data for Columbia County and for the individual cities within Columbia County. See the Census website for additional economic/demographic data, including employment breakdowns by occupation and industry, and detailed income data.

2.4 Housing in Columbia County

Housing demographic data for Columbia County from the 2000 Census are summarized below in Table 2.5.

Table 2.5
Housing Data

Demographic Data	Columbia County	Oregon
Total housing units	17,572	1,452,709
Occupied units	16,375	1,333,723
Vacant units	1,197	118,986
Vacany percentage	6.8%	8.2%
Owner-occupied units[1]	48.4%	53.5%
Renter-occupied units[1]	21.3%	38.2%

[1] Owner- and renter-occupied units do not total 100% because the remaing units are unspecified in census data.

For Columbia County, the percentage of owner-occupied units is slightly lower than for Oregon as a whole.

The age distribution of Columbia County's housing stock is shown below in Table 2.6. Age of the housing stock is relevant for mitigation planning purposes because older construction is much less likely to conform to current building code requirements for fire safety and earthquake safety and less likely to conform to current flood plain management regulations. For example, about 32% of Columbia County's housing stock was built before 1960, with 18% built before 1940.

Table 2.6
Columbia County Housing Stock by Year Built

Year Built	Percent
1990 - March 2000	23.5%
1980-1989	10.9%
1970-1979	23.1%
1960-1969	10.6%
1940-1959	14.0%
1939 or earlier	18.0%

2.5 Land and Development

The overall pattern of land use and development in Columbia County is shown below in Figure 2.7 (Land Development Division, November 2004).

The vast majority of Columbia County is forest, with much smaller areas of agricultural or agricultural/forest lands. Cities and rural residential areas are heavily concentrated along the Columbia River in the eastern and northern parts of the County and in the Vernonia area.

2.6 Regulatory Context: Overview

Oregon land use laws require land outside Urban Growth Boundaries (UGBs) to be protected for farm, forest, and aggregate resource values. For the most part, this law limits the amount of development in the rural areas. However, the land use designation can change from resource protection in one of two ways:

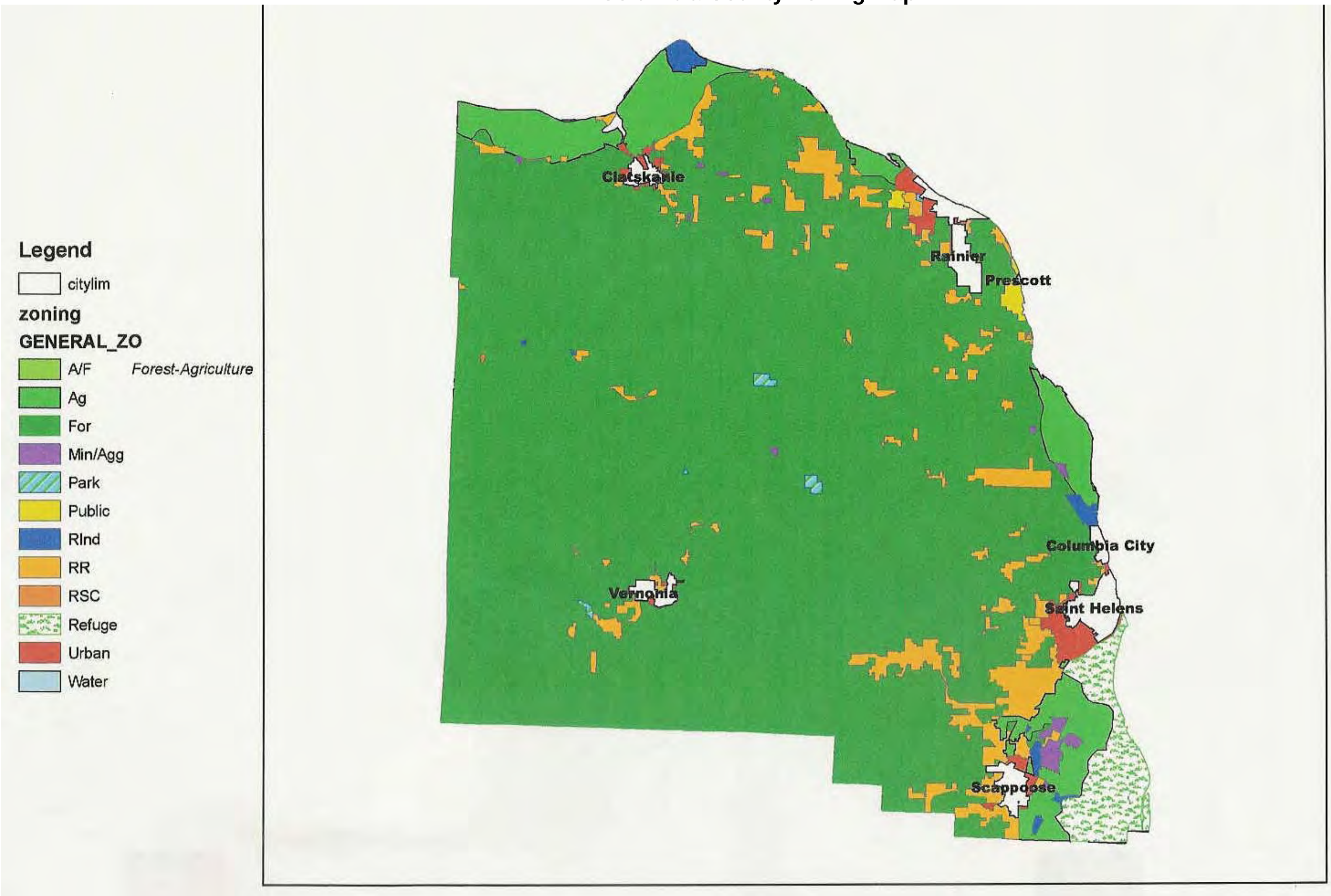
- The requested change could qualify as an exception to Statewide Planning Goals, in which case the county must demonstrate to the State that the change meets requirements for an *exception*. These lands, known as *exception lands,* are predominantly designated for residential use.
- Resource land can also be converted to non-resource use when it can be demonstrated to Columbia County that the land is no longer suitable for farm or forest production.

Local and state policies currently direct growth away from rural lands into UGBs and, to a lesser extent, into rural communities.

Over the next 50 years, emerging telecommunications services may affect the rural economy, enhancing the capacity of residents in rural areas to access information and deliver services from remote locations. Pressure for rural development may come from people seeking a rural lifestyle, especially workers in the information economy with remote service capacity and retirees who do not have commuting needs.

If development follows historical development trends, urban areas will expand their UGBs, rural unincorporated communities will continue to grow, and overall rural residential density will increase slightly with the bulk of rural lands kept in farm and forest use. The existing pattern of development in the rural areas, that of radiating out from the urban areas along rivers and streams is likely to continue. Most of the “easy to develop” land is already developed, in general leaving more constrained land such as land in the floodplains or on steep slopes to be developed in the future, perhaps increasing the rate at which development occurs in natural hazard areas.

Figure 2.7
Columbia County Zoning Map



2.7 Regulatory Context: Oregon Statewide Planning Goal 7

Oregon State Planning Overview

Since 1973, Oregon has maintained a strong statewide program for land use planning. The foundation of that program is a set of 19 statewide planning goals that express the state's policies on land use and on related topics, such as citizen involvement, land use planning, and natural resources.

Most of the goals are accompanied by "guidelines," which are suggestions about how a goal may be applied. Oregon's statewide goals are achieved through local comprehensive planning. State law requires each city and county to adopt a comprehensive plan and the zoning and land-division ordinances needed to put the plan into effect. The local comprehensive plans must be consistent with the statewide planning goals. Plans are reviewed for such consistency by the state's Land Conservation and Development Commission (LCDC). When LCDC officially approves a local government's plan, the plan is said to be "acknowledged." It then becomes the controlling document for land use in the area covered by that plan.

Goal 7

Goal 7: Areas Subject to Natural Disasters and Hazards has the overriding purpose to "protect people and property from natural hazards". Goal 7 requires local governments to adopt comprehensive plans (inventories, policies and implementing measures) to reduce risk to people and property from natural hazards. Natural hazards include floods, landslides, earthquakes, tsunamis, coastal erosion, and wildfires.

To comply with Goal 7, local governments are required to respond to new hazard inventory information from federal or state agencies. The local government must evaluate the hazard risk and assess the:

1. frequency, severity, and location of the hazard;
2. effects of the hazard on existing and future development;
3. potential for development in the hazard area to increase the frequency and severity of the hazard; and
4. types and intensities of land uses to be allowed in the hazard area.

Local governments must adopt or amend comprehensive plan policies and implementing measures to avoid development in hazard areas where the risk cannot be mitigated. In addition, the siting of essential facilities, major structures, hazardous facilities and special occupancy structures should be prohibited in hazard areas where the risk to public safety cannot be mitigated. The state recognizes compliance with Goal 7 for coastal and riverine flood hazards by adopting and implementing local floodplain regulations that meet the minimum National Flood Insurance Program (NFIP) requirements.

Goal 7 provides local jurisdictions with the following guidelines for planning and implementation:

Planning

1. Adopting plan policies and implementing measures for protection from natural hazards local governments should consider:
   a. the benefits of maintaining natural hazard areas as open space, recreation, and other low density uses;
   b. the beneficial effects that natural hazards can have on natural resources and the environment; and
   c. the effects of development and mitigation measures in identified hazard areas on the management of natural resources.
2. Local governments should coordinate their land use plans and decisions with emergency preparedness, response, recovery and mitigation programs. Given the numerous waterways and forested lands throughout Lane County, special attention should be given to problems associated with river bank erosion and potential for wild land/urban interface fires.

Implementation

1. Goal 7 guides local governments to give special attention to emergency access when considering development in identified hazard areas.
2. Consider programs to manage storm water runoff as a means to address flood and landslide hazards.
3. Consider non-regulatory approaches to help implement the goal.
4. When reviewing development requests in high hazard areas, require site specific reports, appropriate for the level and type of hazard. Reports should evaluate the risk to the site as well as the risk the proposed development may pose to other properties.
5. Consider measures exceeding the National Flood Insurance Program.

Columbia County Compliance With Goal 7

The County evaluates emergency access when considering development. For the most part (with few acceptations) developers are required to build dwellings near the roadway in part to provide easier access for emergency vehicles. Larger development proposals must include a storm water management plan for storm water discharge and development cannot alter an existing waterway. In conformance with NFIP regulations, the County requires that new development in mapped floodplains be at least one foot above the base flood elevation reducing the risk of flood damage.

The County could improve compliance with Goal 7 by participating in the Community Rating System (CRS) program (see Section 2.9) which exceeds the minimum measures required by the National Flood Insurance Program, including developing a program for storm water maintenance and management. The County could also establish limitations or standards for development in steep slope areas.

2.8 Community Rating System

Jurisdictions that regulate new development in their floodplains are able to join the National Flood Insurance Program (NFIP). In return, the NFIP provides federally backed flood insurance for properties in participating areas. Columbia County participates in the

NFIP program and over 600 flood insurance policies are held within Columbia County (including the cities).

The Community Rating System (CRS) is a part of the NFIP. The CRS reduces flood insurance premiums to reflect what a community does above and beyond the NFIP's minimum standards for floodplain regulation. The objective of the CRS is to reward communities for what they are doing, as well as to provide an incentive for new flood protection activities. The reduction in flood insurance premium rates is provided according to a jurisdiction's CRS classification, which is dependent upon the number of points awarded the jurisdictions for flood reduction activities implemented. To apply, a jurisdiction submits documentation that shows what it is doing and that its activities deserve at least 500 points. By participating in the CRS program, a jurisdiction not only reduces the risk of loss due to flood damage but policyholders gain up to a 45 percent reduction in flood insurance premiums. Community participation in the CRS is voluntary and Columbia County does not currently participate in this program.

There are 18 floodplain management activities credited by the CRS organized under four series:

1. Public Information,
2. Mapping and Regulations,
3. Flood Damage Reduction, and
4. Flood Preparedness.

All but two of the 18 management activities are optional. The two required activities for Columbia County to participate in the CRS program are the elevation certificate and repetitive loss requirements.

The CRS program could be "self-supporting" in the sense that the County could charge higher fees for initial construction in a flood zone area, paying for the cost of implementing the program. Although the initial cost to the property owner is higher, the property owner enjoys long-term savings from reduced insurance rates. The property owner and the county also gain long-term reduction in the risk associated with flood hazards.

Once the Columbia County Hazard Mitigation Plan is adopted, the County should:

- Apply for funding to complete a thorough assessment of the points the County qualifies for under the CRS,
- Develop a floodplain management plan for repetitive loss areas,
- Enhance existing programs to gain additional credits; and
- Proceed with the CRS program application.

2.9 Regulatory Context: Summary Comments

Sections 2.6 to 2.8 above reviewed regulatory programs and issues related to hazard mitigation planning. The state land use planning requirements, Goal 7, and the CRS regulations are all regulatory programs. That is, these programs impose legal requirements and restrictions on development that are intended to provide for public safety and to minimize the future impacts of disaster events on Columbia County.

In contrast, this Hazard Mitigation Plan is not a regulatory document. That is, a Hazard Mitigation Plan is intended to educate the public about hazards and to encourage prudent practices but it does not mandate practices or regulate development. However, a Hazard Mitigation Plan is closely related so some regulatory processes in the sense that greater awareness about and better data on hazards may subsequently lead to changes in regulations.

An important objective of developing a Hazard Mitigation Plan is to start the long term process of acquiring better data on hazards, vulnerability and risk in Columbia County. Acquiring better data may eventually lead to more regulation of identified high hazard areas. However, better data with higher spatial resolution may also result in reclassifying areas tentatively mapped as being in potential hazard areas as, in fact, not being in hazard areas. For example, the spatial resolution of mapping of potential landslide areas or areas subject to liquefaction in earthquakes is generally low. More refined mapped of such hazards is likely to reduce the areas designated as being potentially subject to these hazards.

CHAPTER THREE

PUBLIC PROCESS

3.0 PUBLIC PROCESS: COLUMBIA COUNTY

Public participation is a key component in all strategic planning processes. Citizen participation offers the public opportunity to voice their ideas, interests, and opinions. Oregon's land use planning system addresses the need for public process in Statewide Land Use Planning Goal 1(one): Citizen Involvement. This goal ensures the opportunity for citizens to be involved in the planning process. The Federal Emergency Management Agency also required public input during the development of the flood Hazard Mitigation plan completed in 1998.

The Columbia County Natural Hazards Mitigation Plan integrates a cross-section of citizen input throughout the planning process. To accomplish this goal, the county commissioners directed the Director of Emergency Manager to oversee the development of a new updated Hazard Mitigation Plan and to develop a public participation process using three components: (1) developing a project steering committee comprised of knowledgeable individuals representing the County, Cities, Special Districts, Businesses, Industry and the public, (2) Conduct public workshops to identify common concerns and ideas regarding hazard mitigation and to discuss specific goals and actions of the mitigation plan, (3) After development and approval of the Hazard Mitigation Plan, develop the Columbia County Hazard Mitigation Advisory Committee (HMAC) to oversee projects, prioritization, funding of projects and hold additional public meeting for input.

Integrating public participation, business and industry during the development of the Columbia County Natural Hazards Mitigation Plan has ultimately resulted in increased public awareness. Through citizen involvement, the mitigation plan reflects community issues, concerns, and new ideas and perspectives on mitigation opportunities. Citizens have also participated in the development of the hazard specific action items.

Steering Committee

The last hazard mitigation plan was completed in 1998 and was developed by a group of community members. In recent years, the Director of Emergency Management for Columbia County has overseen hazard mitigation in Columbia County. For the development of this plan, the committee was broadened from the normal county agencies to include city agencies, public safety agencies and representation from private organizations and business in the county. One such organization is the Columbia Emergency Planning Association (CEPA), which has representatives businesses, industry, non-profit organizations, county government, city government, public safety agencies and citizens. The steering committee members have an understanding of how the community is structured and how residents, businesses, and the environment may be affected by natural hazard events. The steering committee guided the development of the plan, and assisted in developing plan goals and action items and sharing local expertise to create a more comprehensive plan.

Table B.1 lists the various people and organizations that participated on the Columbia County Natural Hazards Mitigation Plan Steering Committee.

Table B.1. Mitigation Plan Steering Committee

Name	Organization
Tony Hyde	Columbia County Commissioner
Janet Wright/ Vicki Harguth	Columbia County Emergency Management
Dave Hill	Columbia County Road Department
Todd Dugdale	Columbia County Land Development Service
Robin Basset	City of Vernonia Public Works
Andre Le duc	ECO NW
Doug Greisen	City of Scappoose Police
Steve Salle	City of St. Helens Police
Brian Little	City of St. Helens
Terry Grice	Columbia River Fire & Rescue
Michael Greisen	Scappoose Fire District
Diane Dillard	**Boise Cascade & CEPA**
Mary Lou Busch	Mist-Birkenfeld Fire District
Lee Knowlton	Columbia 911 Communication District
Michael Walter	City of Scappoose
Dick Long	Clatskanie Fire District
Michael Simek	Oregon Department of Forestry
Ken Goettel	Consultant

Meeting #1

The first meeting was held with consultant Ken Goettel, who is overseeing the developed of the new Hazard Mitigation Plan. Introductions where made, with steering committee members giving information to Ken about each of their organizations. There was general discussion about the procedures used on the county's old Mitigation Plan. Ken provided a power point presentation on appropriate procedures used to develop the Hazard Mitigation Plans. The group discussed disasters, incidents, problems, damages and mitigation that have occurred in Columbia County over the years. During meeting one the group determined Mission Statement, Goals, hazards, vulnerability, and risk.

Meeting #2

The group agreed on a mission statement and the general chapters. They also agreed on the areas in the plan to cover the following disasters that the committee felt was important to have in a hazard mitigation plan, which could or has happened in Columbia County. It was agreed to have Earthquake, Volcano, Hazmat, Dams, Utility Transmission and Transportation, Terrorism, Flood, Winter Storms, Landslides and Fire as hazards that have potential to occur in the county and need to be addressed in the plan. Further discussion was held on the Earthquake, Volcano's and Flood hazards.

Meeting #3

The group discussed the chapters sent through e-mail correspondence that included Earthquakes, Volcano's and Flood and revised based on group consensus. Draft chapters were presented on Fire, Landslides, Dams and Winter Storms. E-mail is working well and is an excellent way for everyone to discuss opinions and develop overall consensus. It was agreed that email will continue to be the main group wide communication tool. The group agreed to start on the action items in the plan at the next meeting.

Meeting #4

Finalized changes to Earthquakes, Volcano's and Flooding chapters. Additional information on the Fire chapter is needed from the structural fire agencies; Oregon Department of Forestry added significant information addressing wildland urban interface wire hazards. Revisions were made to the chapters on Landslides, Dams and Winter Storms. Reviewed draft chapters on Utility Transmission, Terrorism and Hazmat. The group also reviewed Action Item drafts.

Meeting #5

Agreed on corrections made to all chapters. Reviewed and reprioritize action plans. Discussed and cleaned up additional questions and e-mails on hazard specific chapters.

Public Hearing

On February 17, 2005 a public hearing was held in Vernonia, Oregon. Approximately 15 people attended the 60-minute presentation and question/answer session. All three County Commissioners were in attendance. Vicki Harguth welcomed everyone and started the hearing with a brief explanation of the Pre-Disaster Mitigation Act of 2000 (PDM2K). Many citizens in the audience offered their perspective of the 1996 flood and some of the flood mitigation activities that have occurred in Vernonia and Clatskanie. The planning process was presented and followed by suggestion to continue the planning process so mitigation is always considered a priority. Vicki offered applications for membership in the Hazard Mitigation Advisory Committee (HMAC) as a way to be involved with the ongoing sustainability of the mitigation program in Columbia County.

Other Public Involvement

Throughout the plan development ongoing plan development progress reports were provide to the Citizens Emergency Preparedness Association (CEPA) monthly meetings in July 2004 through January 2005. CEPA is a group of citizens, businesses, local governments, and non-profit groups that are very strong emergency management advocates. CEPA currently has approximately 155 members with a monthly meeting attendance averaging 50.

Throughout the plan development process, ongoing progress reports were given to the Board of County Commissioners at Board Work Sessions between November 2004 and January 2005. The public is aware of these sessions and are encouraged to attend.

The hazard mitigation planning committee plans another public hearing as a kick off for the Hazard Mitigation Advisory Committee and ongoing project and planning process. This meeting is tentatively scheduled for April 2005 in Clatskanie, Oregon.

Once the plan is officially adopted, scheduled for March 2, 2005, the HMAC will begin a quarterly meeting schedule. The formalized plan will be put on the Columbia County Internet site for continuous public viewing and awareness. A process for ongoing public input will be available through County offices of Land Development Services, Road Department, and Emergency Management.

Applications are being accepted by the Board of County Commissioners through March 2005 for membership to the Columbia County Hazard Mitigation Advisory Committee (HMAC). The HMAC will be made up of a cross section of community members, business, industry and public agencies that will be appointed by the County Commissioners to serve on the advisory committee. The overall goal of the HMAC is to periodically monitor, evaluate and update the plan and search for mitigation funding sources. The County will continue to provide staffing to the committee through the Emergency Management Program and other agencies throughout the County.

CHAPTER FOUR

4.0 MISSION STATEMENT, GOALS, OBJECTIVES AND ACTION ITEMS

4.1 Overview

The overall purpose of the Columbia County Hazard Mitigation Plan is to reduce the impacts of future natural or human-caused disasters on the people and communities of Columbia County. That is, the purpose is to make Columbia County more disaster resistant and disaster resilient, by reducing the vulnerability to disasters and enhancing the capability to respond effectively to and recover quickly from future disasters.

Completely eliminating the risk of future disasters in Columbia County is neither technologically possible nor economically feasible. However, substantially reducing the negative impacts of future disasters is achievable with the adoption of this pragmatic Hazard Mitigation Plan and ongoing implementation of risk reducing action items. Incorporating risk reduction strategies and action items into the county's existing programs and decision making processes will facilitate moving Columbia County toward a safer and more disaster resistant future.

This mitigation plan provides the framework and guidance for both short- and long-term proactive steps that can be taken to:

- Protect life safety,
- Reduce property damage,
- Minimize economic losses and disruption, and
- Shorten the recovery period from future disasters.

In addition, the Columbia County Hazard Mitigation Plan is intended to meet or contribute towards meeting various regulatory requirements, including:

1. FEMA's (Federal Emergency Management Agency) mitigation planning requirements so that Columbia County remains eligible for pre- and post-disaster mitigation funding from FEMA,
2. FEMA's Flood Insurance Program's Community Rating System guidelines, to help minimize future flood insurance rates in Columbia County,
3. Oregon Emergency Management's mitigation planning evaluation criteria, and
4. Oregon's Goal 7 natural hazard planning guidelines.

Meeting these regulatory requirements is an essential step to facilitate implementation of mitigation measures and in making progress towards achieving the primary mission, goals and objectives summarized below.

The Columbia County Hazard Mitigation Plan is based on a four-step framework that is designed to help focus attention and action on successful mitigation strategies: Mission Statement, Goals, Objectives and Action Items.

- **Mission Statement.** The Mission Statement states the purpose and defines the primary function of the Columbia County Hazard Mitigation Plan. The Mission Statement is an action-oriented summary that answers the question "Why develop a hazard mitigation plan?"
- **Goals.** Goals identify priorities and specify how Columbia County intends to work toward reducing the risks from natural and human-caused hazards. The Goals

represent the guiding principles toward which the County's efforts are directed. Goals provide focus for the more specific issues, recommendations and actions addressed in Objectives and Action Items.

- **Objectives.** Each goal has objectives which specify the directions, methods, processes, or steps necessary to accomplish the plan's Goals. Objectives lead directly to specific Action Items.
- **Action Items.** Action items are specific well-defined activities or projects that work to reduce risk. That is, the Action Items represent the steps necessary to achieve the Mission Statement, Goals and Objectives.

4.2 Mission Statement

The mission of the Columbia County Hazard Mitigation Plan is to:

Proactively facilitate and support county-wide policies, practices, and programs that make Columbia County more disaster resistant and disaster resilient.

Making Columbia County more disaster resistant and disaster resilient means taking proactive steps and actions to:

- Protect life safety,
- Reduce property damage,
- Minimize economic losses and disruption, and
- Shorten the recovery period from future disasters.

4.3 Mitigation Plan Goals and Objectives

Mitigation plan goals and objectives guide the direction of future policies and activities aimed at reducing risk and preventing loss from disaster events. The goals and objectives listed here serve as guideposts and checklists as agencies, organizations, and individuals begin implementing mitigation action items in Columbia County.

Columbia County's mitigation plan goals and objectives are based on the goals established by the State of Oregon Natural Hazards Mitigation Plan. However, the specific priorities, emphasis and language are Columbia County's. These goals were developed with extensive input and priority setting by agencies, the mitigation plan steering committee, stakeholders and citizens from throughout Columbia County.

<u>Goal 1: Reduce the Threat to Life Safety</u>

<u>OBJECTIVE:</u>

- Enhance life safety by minimizing the potential for deaths and injuries in future disaster events.

<u>Goal 2: Protect Critical Facilities and Enhance Emergency and Essential Services</u>

<u>OBJECTIVES:</u>

- Implement activities or projects to protect critical facilities and infrastructure.
- Seek opportunities to enhance, protect, and integrate emergency and essential services.
- Strengthen emergency operations plans and procedures by increasing collaboration and coordination among public agencies, non-profit organizations, business, and industry.

<u>Goal 3: Reduce the Threat to Property</u>

<u>OBJECTIVES:</u>

- Seek opportunities to protect, enhance and integrate emergency and essential services.
- Strengthen emergency operations plans and procedures by increasing collaboration and coordination among public agencies, non-profit organizations, business, industry and the citizens of Columbia County.

<u>Goal 4: Create a Disaster Resistant and Disaster-Resilient Economy</u>

<u>OBJECTIVES:</u>

- Develop and implement activities to protect economic well-being and vitality while reducing economic hardship in post disaster situations.
- Reduce insurance losses and repetitive claims for chronic hazard events.
- Work with State and Federal Partners to reduce short-term and long-term recovery and reconstruction costs.
- Work with local organization, such as Columbia Emergency Planning Association (CEPA).
- Expedite pre-disaster and post-disaster grants and program funding.

Goal 5: Increase Public Awareness, Education, Outreach, and Partnerships

OBJECTIVES:

- Coordinate and collaborate, where possible, risk reduction outreach efforts with the Oregon Partners for Disaster Resistance & Resilience and other public and private organizations.
- Develop and implement risk reduction education programs to increase awareness among citizens, local, county, and regional agencies, non-profit organizations, business, and industry.
- Promote insurance coverage for catastrophic hazards
- Strengthen communication and coordinate participation in and between public agencies, citizens, nonprofit organizations, business, and industry.

4.3 Columbia County Hazard Mitigation Plan Action Items

The Mission Statement, Goals and Objectives for Columbia County, as outlined above, are achieved via implementation of specific mitigation action items. Action items may include refinement of policies, data collection to better characterize hazards or risk, education, outreach or partnership building activities, as well as specific engineering or construction measures to reduce risk from one or more hazards at specific locations within Columbia County.

Individual action items may address a single hazard (such as flood, earthquake, or wildland/urban interface fires) or they may address two or more hazards concurrently. Action items identified and prioritized during the development of the Columbia County Hazard Mitigation Plan are summarized in the following tables. The first group of action items is for multi-hazard items that address more than one hazard, followed by groups of action items for each of the ten hazards addressed in this plan (as addressed in Chapters 6 to 15

4.4 Mitigation Activity Evaluation and Prioritization

Columbia County HMAC will be the lead group for determining mitigation activity prioritization and project funding eligibility. The group has determined to begin the evaluation process using the STAPLE/E methodology described below. Once the HMAC has discussed mitigation projects and activities using STAPLE/E, the Columbia County Board of Commissioners will have the final say on project/activity approval.

STAPLE/E Approach

Using STAPLE/E criteria, mitigation activities can be evaluated quickly in a systematic fashion. This criterion requires the committee to assess the mitigation activities based on the Social, Technical, Administrative, Political, Legal, Economic, and Environmental (STAPLE/E) constraints and opportunities of implementing the particular mitigation item in the County. The STAPLE/E approach is helpful for doing a quick analysis of mitigation projects. Most projects that seek federal funding and others often require more detailed Benefit/Cost Analyses.

The following are suggestions for how to examine each aspect of the STAPLE/E Approach from the "State of Oregon's Local Natural Hazard Mitigation Plan: An Evaluation Process". The HMAC along with suggested organizations listed will consider these or similar questions.

Social: Community development staff, local non-profit organizations, or local planning groups can help answer these questions.

- Is the proposed action socially acceptable to the community?
- Are there equity issues involved that would mean that one segment of the community is treated unfairly?
- Will the action cause social disruption?

Technical: The County public works and building department can help answer these questions.

- Will the proposed action work?
- Will it create more problems than it solves?

- Does it solve a problem or only a symptom?
- Is it the most useful action in light of other goals?

Administrative: Elected officials from local government can help answer these questions.

- Is the action implementable?
- Is there someone to coordinate and lead the effort?
- Is there sufficient funding, staff, and technical support available?
- Are there ongoing administrative requirements that need to be met?

Political: Consult Board of Commissioners, local City Mayor's, and planning officials, to help answer these questions.

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

Legal: Include legal counsel, land use planners, and risk managers in this discussion.

- Who is 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 County be liable for action or lack of action?
- Will the activity be challenged?

Economic: County economic development staff, civil engineers, building department, and the assessor's office can help answer these questions.

- What are the costs and benefits of this action?
- Do the benefits exceed the costs?
- Are initial, maintenance, and administrative costs taken into account?
- Has funding been secured for the proposed action? If not, what are the potential funding sources (public, non-profit, and private)?
- How will this action affect the fiscal capability of the County?
- What burden will this action place on the tax base or economy?
- What are the budget and revenue effects of this activity?
- Does the action contribute to other 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: Environmental groups, land use planners, and natural resource managers can help answer these questions.

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

4.4.1 High Priority Projects Examples

Columbia County has been coordination mitigation activities across jurisdictional boundaries and disciplines since the flood of 1996 on a regular basis. Vernonia and Clatskanie were both isolated communities during that event causing increased awareness of mitigation activities for all hazards. The following is a list of Columbia County projects that are given a high priority to develop and implement. This is a partial list and will be developed further as more Cities and Special Districts join the Hazard Mitigation Advisory Committee and help determine projects and priorities. Project implementation will be considered as funds become available through mitigation grants, local budgets, State and Federal funds, strong benefit cost analysis data, and other sources.

Critical Facility Projects

County Sites

County Courthouse 230 Strand, St. Helens	Provide power backup throughout the building to ensure continuity of government and critical operations
Emergency Operations Center, 230 Strand, St. Helens	Move EOC to 911 Building at 58611 McNulty Way, St. Helens to ensure sustainability and critical operations.
County Road Dept. 1054 Oregon St.	Provide power backup throughout the building to ensure continuity of government and critical operations
County Courthouse 230 Strand, St. Helens	Seismically upgrade building and develop non-structural mitigation projects to ensure continuity of government and critical operations
County Road Dept. 1054 Oregon St.	Seismically upgrade building and develop non-structural mitigation projects to ensure continuity of government and critical operations

Other Critical Facilities

Fire Stations

Numerous Fire Stations need Seismic Upgrades.

Stations identified currently Include:

Scappoose
52751 Columbia River Hwy, Scappoose

Columbia River Fire and Rescue
105 South 12th Street, St. Helens
58798 Saulsler Rd., Warren
211 2nd Street, Rainier

Police Stations

Ambulance Stations

City Halls

Medical Facilities/Urgent Care Facilities

Special Population Facilities

Schools

Emergency Shelters

Other Critical Infrastructure Projects

Culvert - Major Roadway	Replace culvert on Scappoose-Vernonia Highway at milepost 9.3
Culvert - Major Roadway	Culvert replacement at Oak Ranch Creek on Apiary Road 1.8 miles from Hwy 47
Culvert – Major Roadway	Install culverts to improve drainage on Upper Apiary Rd., 11.2 and 11.4 miles from Apiary Rd. and Hwy 47

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed: Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Flood Mitigation Action Items: Within FEMA-Mapped Floodplains								
Short-Term #1	Complete inventory of critical facilities within 100-year and 500-year floodplains, with GIS mapping if possible	Columbia County (Land Development Services, Roads, Assessor), cities, special districts	Ongoing	X	X	X	X	
Short-Term #2	Complete inventory of residential and commercial buildings within 100-year and 500-year floodplains, with GIS mapping if possible	Columbia County (Land Development Services, Roads, Assessor), cities, special districts	Ongoing	X		X	X	
Short-Term #3	Consult with property owners and explore mitigation actions for any Columbia County properties on FEMA's national repetitive loss list	Columbia County Hazard Mitigation Advisory Committee	1 year	X		X	X	X
Long-Term #1	Survey elevation data for critical facilities, residential buildings and commercial buildings within the 100-year floodplain and establish flood mitigation priorities	Local emergency services, Columbia County Hazard Mitigation Advisory Committee	2-5 years	X	X	X	X	X
Long-Term #2	For critical facilities within the 100-year floodplain and for other structures deep within the 100-year floodplain explore mitigation options with property owners and implement mitigation measures	Local emergency services, Columbia County Hazard Mitigation Advisory Committee	2-10 years	X	X	X	X	X
Flood Mitigation Action Items: Outside of FEMA-Mapped Floodplains								
Short-Term #1	Complete the inventory of locations in Columbia County subject to frequent storm water flooding	Columbia County (Land Development Services, Roads, Assessor), cities, special districts	Ongoing	X	X	X	X	X
Long-Term #1	For locations with repetitive flooding and significant damages or road closures, determine and implement mitigation measures such as upsizing culverts or storm water drainage ditches	Columbia County (Land Development Services, Roads, Assessor), cities, special districts	Ongoing	X	X	X	X	X

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Winter Storms Mitigation Action Items								
Short-Term #1	Complete the inventory of locations in Columbia County subject to frequent storm water flooding	Columbia County Roads, cities	Ongoing	X	X	X	X	X
Short-Term #2	Enhance tree trimming efforts especially for transmission lines and trunk distribution lines.	BPA, West Oregon Electric Coop, local PUDs	Ongoing	X	X	X	X	X
Short-Term #3	Encourage prudent tree planting (avoid service lines) and safe, professional tree trimming where necessary	Columbia County Hazard Mitigation Advisory Committee	Ongoing	X		X	X	
Short-Term #4	Ensure that all critical facilities in Columbia County have backup power and emergency operations plans to deal with power outages	Local emergency services, Columbia County Hazard Mitigation Advisory Committee	1-2 Years	X	X			
Long-Term #1	For locations with repetitive flooding and significant damages or road closures, determine and implement mitigation measures such as upsizing culverts or storm water drainage ditches	Columbia County Roads, cities	Ongoing	X	X	X	X	X
Long-Term #2	Consider upgrading lines and poles to improve wind/ice loading, undergrounding critical lines, and adding interconnect switches to allow alternative feed paths and disconnect switches to minimize outage areas	BPA, West Oregon Electric Coop, local PUDs	5 Years	X	X	X	X	X
Long-Term #3	Encourage new developments to include underground power lines	Columbia County Land Development Services, cities	ongoing	X	X	X	X	X

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Landslide Mitigation Action Items								
Short-Term #1	Complete the inventory of locations where critical facilities, other buildings and infrastructure are subject to landslides	Columbia County Land Development Services, cities (public works)	1-2 Years	X	X	X	X	X
Long-Term #1	Consider landslide mitigation actions for slides seriously threatening critical facilities, other buildings or infrastructure	Columbia County Hazard Mitigation Advisory Committee	5 Years	X	X	X	X	X
Long-Term #2	Limit future development in high landslide potential areas	Columbia County Land Development Services, cities	Ongoing	X	X	X	X	X

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Wildland/Urban Interface Fire Mitigation Action Items								
Short-Term #1	Identify specific parts of Columbia County at high risk for urban/wildland urban interface fires because of fuel loading, topography and prevailing construction practices	County Fire Defense Board, fire agencies	1-2 Years	X	X	X	X	X
Short-Term #2	Identify evacuation routes and procedures for high risk areas and educate the public	County Fire Defense Board, fire agencies, law enforcement, County Roads, public works	Ongoing	X	X	X		X
Short-Term #3	Develop Community Wildand Fire Protection Plans for all at-risk communities	County, cities, fire agencies, ODF	1-2 Years	X	X	X	X	X
Long-Term #1	Encourage fire-safe construction practices for existing and new construction in high risk areas	County Land Development Services, city building departments, fire agencies	Ongoing	X	X	X	X	X
Long-Term #2	Enhance home landscape cleanup (defensible space) and debris disposal programs	County Land Development Services, city building departments, fire agencies	Ongoing	X	X	X	X	X
Long-Term #3	Identify potential fuel breaks and fuel reduction zones and implement mitigation actions	County Land Development Services, city building departments, fire agencies	Ongoing	X	X	X	X	X
Long-Term #4	Implement SB360 Wildland Urban Interface Act of 1997 in Columbia County	County Land Development Services, city building departments, fire agencies	5-10 years	X	X	X	X	X

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed: Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Earthquake Mitigation Action Items								
Short-Term #1	Complete inventory of public and commercial buildings that may be particularly vulnerable to earthquake damage	County, cities, special districts	1-2 Years	X	X	X	X	X
Short-Term #2	Complete inventory of wood-frame residential buildings that may be particularly vulnerable to earthquake damage, including pre-1940s homes and homes with cripple wall foundations.	County, cities	1-2 Years	X	X	X	X	X
Short-Term #3	Disseminate FEMA pamphlets to educate homeowners about structural and non-structural retrofitting of vulnerable homes and encourage retrofit	Columbia County Hazard Mitigation Advisory Committee	Ongoing	X		X	X	X
Short-Term #4	Complete seismic vulnerability analysis of important public facilities with significant seismic vulnerabilities	County, cities, special districts	1-2 Years	X	X	X	X	X
Long-Term #1	Obtain funding and retrofit important public facilities with significant seismic vulnerabilities	County, cities, special districts	10 years	X	X	X	X	X
Long-Term #2	Retrofit bridges that are not seismically adequate for lifeline transportation routes	ODOT, County, cities, roads		X	X	X	X	X
Volcanic Hazards Mitigation Action Items								
Short-Term #1	Update public emergency notification procedures for ash fall events	CEPA, CCOM, local emergency services agencies	1-2 Years	X	X			X
Short-Term #2	Update emergency response planning for ash fall events	CEPA, CCOM, local emergency services agencies	1-2 Years	X	X			X
Short-Term #3	Evaluate capability of water treatment plants to deal with high turbidity from ash falls and upgrade treatment facilities and emergency response plans to deal with ash falls	local water agencies	1-2 Years	X	X	X	X	X
Short-Term #4	Evaluate ash impact on storm water drainage system and develop mitigation actions if necessary	public works agencies	1-2 Years		X	X	X	X

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed: Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Dam Safety Mitigation Action Items								
Short-Term #1	Prepare high resolution maps of dam failure inundation areas and update emergency response plans, including public notification and evacuation routes	County Land Development Services, city building departments, local emergency service agencies	1-2 Years	X	X			X
Long-Term #2	Encourage the Corps of Engineers to complete seismic vulnerability assessments for dams upstream of heavily populated areas in Columbia County and to make seismic improvements as necessary	Columbia County Hazard Mitigation Advisory Committee, US Army Corps of Engineers	Ongoing	X	X	X	X	X
Long-Term #3	Evaluate the adequacy of dike systems for both floods and earthquakes and implement mitigation measures if necessary	Local Dike Districts, US Army Corps of Engineers	Ongoing	X	X	X	X	X
Utility and Transportation System Disruption Mitigation Action Items								
Short-Term #1	Educate and encourage residents to maintain several days of emergency supplies for power outages or road closures	Columbia County Hazard Mitigation Advisory Committee, CEPA	Ongoing	X	X			X
Short-Term #2	Review and update emergency response plans for disruptions of utilities or roads	local emergency service agencies, CEPA	1-2 Years	X	X			X
Short-Term #3	Ensure that all critical facilities in Columbia County have backup power and emergency operations plans to deal with power outages	local emergency service agencies, CEPA	1-2 Years	X	X			X

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Hazmat Incident Mitigation Action Items								
Short-Term #1	Ensure that first responders have readily available site-specific knowledge of hazardous chemical inventories in Columbia County	local fire and law enforcement agencies	1 year	X	X			X
Short-Term #2	Enhance emergency planning, emergency response training and equipment to address hazardous materials incidents.	local fire and law enforcement agencies	Ongoing	X	X			X
Short-Term #3	Evaluate existing security measures for sites with large quantities of hazardous materials or any quantities of extremely hazardous substances and enhance security as necessary	local facility managers	1 year	X	X	X	X	X
Short-Term #4	Evaluate seismic bracing/anchoring for sites with large quantities of hazardous materials or any quantities of extremely hazardous substances and upgrade as necessary	local facility managers	1-2 years	X	X	X	X	X

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Terrorism Mitigation Action Items								
Short-Term #1	Enhance emergency planning, emergency response training and equipment to address potential terrorism incidents.	local fire and law enforcement agencies, facility managers	Ongoing	X	X	X	X	X
Long-Term #1	Upgrade physical security detection and response capability for critical facilities, including water systems and for any high-profile facilities such as major timber industry facilities and sites with large quantities of hazardous materials	facility managers	5 Years	X	X	X	X	X

CHAPTER FIVE

5.0 PLAN ADOPTION, MAINTENANCE, AND IMPLEMENTATION

5.1 Overview

For a hazard mitigation plan to be effective, it has to be implemented gradually over time, as resources become available, continually evaluated and periodically updated. Only through developing a system which routinely incorporates logical thinking about hazards and cost-effective mitigation into ongoing public- and private-sector decision making will the mitigation action items in this document be accomplished effectively. The following sections depict how Columbia County has adopted and will implement and maintain the vitality of the Columbia County Hazard Mitigation Plan.

5.2 Plan Adoption

The Columbia County Hazard Mitigation Plan was adopted by the Columbia County Board of Commissioners on March 9, 2005, making it the effective date of the plan. The Final Draft of the plan was submitted to OEM and FEMA for review approval, with the stipulation that edits required for approval were included in the adoption motion.

FEMA approval of the Plan was received on March 9, 2005. FEMA approval means that Columbia County's Hazard Mitigation Plan meets national standards and that the County will continue to be eligible for hazard mitigation funding from FEMA's Hazard Mitigation Grant Program, the Pre-Disaster Mitigation Program and other programs.

Columbia County has the necessary human resources to ensure the Plan continues to be an actively used planning document. County staff has been active in the preparation of the plan, and have gained an understating of the process and the desire to integrate the plan into the Comprehensive Land Use Plan. Through this linkage, the plan will be kept active and be a working document. In 1996 and more recently, Columbia County has experienced several natural disaster events. These events have kept the interest in hazard mitigation planning and implementation alive at the Commissioner level, at the County staff level, in cities and special districts and among the citizens of Columbia County.

5.3 IMPLEMENTATION

Coordinating Body

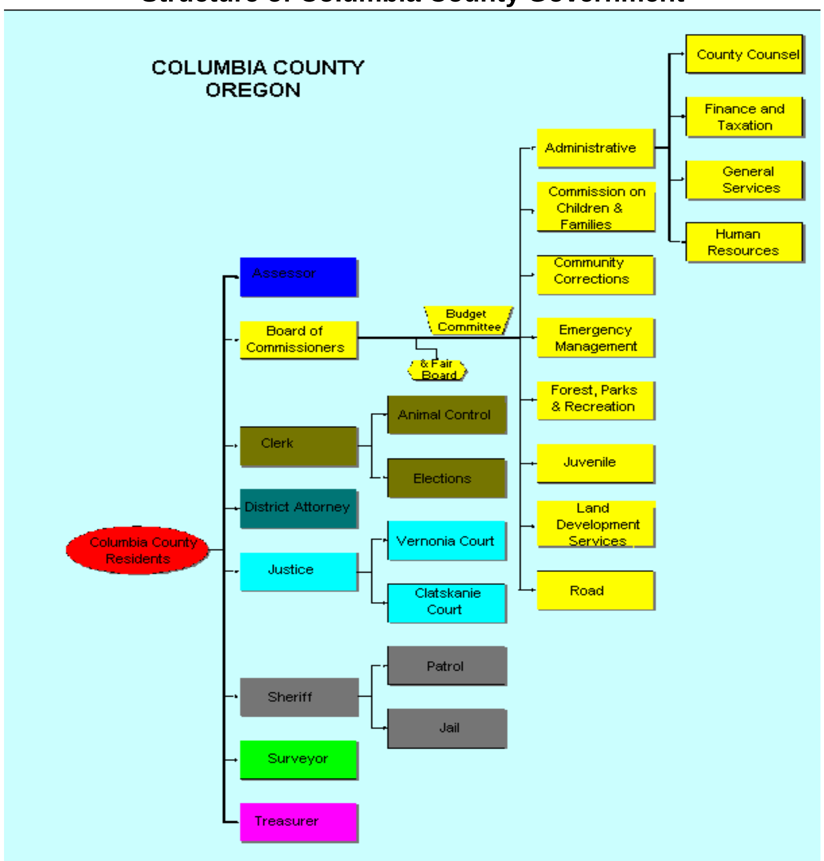
The Columbia County Hazard Mitigation Advisory Committee, convened by Commissioner Tony Hyde, will coordinate the implementation of the plan and be responsible for periodically monitoring, evaluating and updating the plan. The County will continue to provide staffing to the committee through the Emergency Management Program. Consistent staffing allows for well-organized meetings and will ensure that the right people are involved at the meetings. The existing active interest in mitigation and emergency planning that exists within Columbia County will help to ensure the successful implementation of the plan.

Integration of the Hazard Mitigation Plan Into Ongoing Programs, Policies, and Practices

The mission statement, objectives, goals and action items outlined in Chapter 4 of the Columbia County Hazard Mitigation Plan provide a strong framework and guidance for the identified mitigation priorities for Columbia County. However, the Mitigation Plan is a guidance document, not a regulatory document, and thus implementation of the objectives, goals and action items can be accomplished only by fully integrating this guidance into ongoing programs, policies and practices. Such integration is important not only at the county level, but also within cities and special districts as well.

The current Hazard Mitigation Advisory Committee has representatives from key departments of Columbia County government including: Emergency Management, Land Development Services, Forest, Parks and Recreation and Roads.

Figure 5.1
Structure of Columbia County Government



The County currently addresses statewide planning goals and legislative requirements through its comprehensive land use plan, capital improvement plans, and implementation of building codes. The Natural Hazard Mitigation Plan provides a series of action items – many of which are closely related to the objectives of these existing county programs. To the extent possible, Columbia County will work to incorporate the recommended mitigation action items into existing programs and procedures. These action items will help the County address various other statewide requirements, such as land-use planning Goal 7 which was developed to protect life and property from natural disasters and hazards through planning strategies that restrict development in areas of known hazards.

Goal 7 requires that local governments base development plans on inventories of known areas of natural disasters and hazards and that the intensity of development should be limited by the degree to which the natural hazard occurs within the areas of proposed development. The County's Land Development Services is responsible for land use reviews, and assuring compliance with the zoning codes. The department will be able to use the resources and actions identified in this plan as an avenue to update statewide land-use planning Goal 7: Natural Hazards element of the County's comprehensive plan and to integrate mitigation into existing zoning and planning documents when applicable.

Additionally, the County is also responsible for issuing building permits and promoting compliance with state adopted construction codes. After the adoption of the mitigation plan, they will work with the State Building Code Office to make sure that they enforce the minimum standards established in the new State Building Code. In addition, the Hazard Mitigation Advisory Council will promote safe building practices in an effort to have structures more resistant to the impacts of all hazards.

This integration of the Plan with ongoing activities will continue for other plans and projects within the County. As development plans come into the Community Development Department, reviewers will need to keep in mind potential hazard mitigation actions that may need to be implemented. The adopted building codes for the County include many standards that mitigate potential hazard damage. The County stays current in adoption of upgraded codes, ensuring that the new construction activities will meet the highest standard available for hazards such as floods and seismic.

Capital improvement planning that occurs in the future will also contribute to the goals in the Natural Hazard Mitigation Plan. Various County Departments, including Public Works and Roads, develop Capital Improvement Programs (CIPs) and review them on an annual basis. The Hazard Mitigation Advisory Council will work with these departments to identify any relevant action items from Natural Hazard Mitigation Plan and work to incorporate such actions into the appropriate sections of the County's CIPs.

Within six months of formal adoption of the County's Mitigation Plan, the procedures listed above will be incorporated into the process of existing planning mechanisms at the County level. The meetings of the Hazard Mitigation Advisory Council 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, policies, procedures, and programs.

Cost Effectiveness of Mitigation Projects

As Columbia County or the communities and special districts within the County consider whether or not to undertake specific mitigation projects or evaluate how to decide between competing mitigation projects, they must answer questions that don't always have obvious answers, such as:

- What is the nature of the hazard problem?
- How frequent and how severe are hazard events?
- Do we want to undertake mitigation measures?
- What mitigation measures are feasible, appropriate, and affordable?
- How do we prioritize between competing mitigation projects?
- Are our mitigation projects likely to be eligible for FEMA funding?

Columbia County recognizes that benefit-cost analysis is a powerful tool that can help communities provide solid, defensible answers to these difficult socio-political-economic-engineering questions. Benefit-cost analysis is required for all FEMA-funded mitigation projects, under both pre-disaster and post-disaster mitigation programs. Thus, communities seeking FEMA funding must understand benefit-cost analysis. However, regardless of whether or not FEMA funding is involved, benefit-cost analysis provides a sound basis for evaluating and prioritizing possible mitigation projects for any natural hazard. Thus, Columbia County will use benefit-cost analysis and related economic tools, such as cost-effectiveness evaluation, to the extent practicable in prioritizing and implementing mitigation actions.

5.4 Plan Maintenance

Periodic Monitoring, Evaluation and Updating

The Columbia County Hazard Mitigation Plan will be monitored and evaluated annually and updated at least every five years. As the community gradually implements the action items within the Plan, remaining action items may evolve or priorities may change. The hazards that exist in Columbia County will continue to exist, but the conditions within the community, such as the population and development patterns, will undoubtedly continue to change. As such changes occur gradually over time, the Plan will be regularly monitored, evaluated, and updated to ensure that it remains up to date and retains its vitality and relevance.

Local, state and federal agencies will conduct or refine studies that may lead to new or better information on specific hazards. For example, flood plan maps are periodically updated and new studies may better define landslide or debris flow areas or areas subject to liquefaction during earthquakes. The new information will need to be incorporated not only into the Hazard Mitigation Plan but also into other documents, such as the Comprehensive Plan.

Changes in the priorities of citizens of Columbia County may also affect the effectiveness of the Plan. Community values are regularly monitored through the Comprehensive Plan update process. As the Comprehensive Plan is implemented and updated, the Hazard Mitigation Plan will be reviewed as well.

The Hazard Mitigation Advisory Committee will meet at least annually to review and evaluate the Plan. This will be the opportunity to incorporate new information into the Plan and remove outdated items and completed actions. This will also be the time to recognize the success of the community in implementation of action items. All revisions of the Plan will be taken to the Board of Commissioners for formal acknowledgement as part of Columbia County's Plan maintenance and implementation program. The Committee will also have lead responsibility for the formal updates of the plan every five years.

Continued Public Involvement and Participation

Implementation of the mitigation actions identified in the Plan will engage the community. The participation that led to the Plan was result of existing community networks and this network will continue to participate as the community wide mitigation activities identified in the plan are begun. Some projects can be done at the volunteer level, and others will require technical expertise. The stakeholders in the planning process will become project partners as needed on specific items.

There are many organizations within the County that have common interests and concerns, including hazard mitigation. Organizations such as CEPA, the Oregon Department of Forestry, cities, special districts, and both large and small businesses will be important partners in the implementation of the Plan over time. Successful completion of high priority mitigation action items will require ongoing project planning with active participation from all stakeholders.

Columbia County has a proven history of involving and continues to involve multiple partners in planning and mitigation work. These partnerships with local, state, and federal partners have resulted in comprehensive plans and projects that could not have been completed by any agency alone. This cooperation is also demonstrated by the broad based makeup of the Hazard Mitigation Advisory Committee.

Columbia County is dedicated to involving the public directly in the ongoing monitoring, evaluating and updating of the Hazard Mitigation Plan. Copies of the Plan will be posted on the County website which will also contain an email address and phone number to which people can direct their comments and concerns about hazard mitigation issues and priorities.

Public meetings will also be held after each annual evaluation or when deemed necessary by the Hazard Mitigation Advisory Council. The meetings will provide the public a forum for which they can express their concerns, opinions, or ideas about the Plan. The County Emergency Management Office will maintain public involvement and advertise for the public meetings through existing community organizations such as CEPA. County Emergency Management will be responsible for using County resources to publicize the annual public meetings and maintain public involvement through local newspapers.

6.0 FLOOD HAZARDS

Columbia County is subject to flooding from several different types of flood sources, including:

1. over bank flooding from the Columbia River, the Multnomah Channel and smaller rivers including the Clatskanie River and the Nehalem River,
2. over bank flooding from smaller creeks such as Conyers Creek, McNulty Creek, Milton Creek, Rock Creek, Scappoose Creek, North Scappoose Creek, and others, and
3. local storm water drainage flooding.

The flood history of Columbia County indicates two distinct patterns for flooding: winter flooding from rainstorms affecting the streams and rivers within Columbia County and late spring flooding when snowmelt from the upper Columbia basin results in a gradual rise of the Columbia River along the northern and eastern border of Columbia County. Historically, the most severe floods have occurred in December, January and February, but damaging winter floods may occur anytime between October and April and spring runoff flooding along the Columbia River can occur between May and July.

Winter flooding on streams and rivers within Columbia County generally results from large winter storms from the Pacific Ocean which often result in simultaneous flooding on many rivers and streams in an affected area. However, because of geographic variations in rainfall amounts and differences in drainage areas, slopes, and other watershed characteristics, the severity of flooding in any given rainfall event often varies significantly from stream to stream and location to location.

6.1 Historical Floods in Columbia County

Historically, flooding has occurred in Columbia County throughout the recorded history of the area, ever since the first European settlers arrived in the area in the mid-1800s.

The FEMA Flood Insurance Study for Columbia County (August 16, 1988) has a brief history of major historical floods in Columbia County, over the 40 years preceding the Flood Insurance Study. Major floods occurred in 1948, 1964, 1972 and 1974. The 1948 flood inundated eight drainage districts, much of Clatskanie’s central business district and the industrial port area of St. Helens. However, flood impacts for much of the reach of the Columbia River through Columbia County are limited by the relatively high and steeply sloping banks of the river, which limit flooding to a narrow band along the river.

Winter flooding occurred in 1964, 1972, and 1974 on the Nehalem River, Scappoose Creek, North Scappoose Creek, Clatskanie River, Conyers Creek, and McNulty Creek. A major flood occurred on Scappoose Creek on February 1, 1987, flooding many homes in Scappoose.

Flooding in St. Helens arises principally from the Columbia River, Multnomah Channel, Milton Creek and McNulty Creek. Significant flooding on Milton and McNulty Creeks occurred in 1955 and 1974, respectively.

The largest floods on the Clatskanie River occurred in 1956, 1964, 1972, and 1974, although property damage was low.

Flooding on the Nehalem River has been more severe, with homes near Vernonia inundated by the 1964, 1972, and 1974 floods.

Flooding potential along the Columbia River and Multnomah Channel has been substantially reduced by upstream flood control storage reservoirs. There are 22 major reservoirs upstream on the Columbia (about 40 million acre feet of flood control storage), 11 major flood control reservoirs on the Willamette (1.7 million acre feet of flood control storage), and one reservoir on the Cowlitz River (360,000 acre feet of flood control storage). Therefore, the probability of flood events such as the 1948 Columbia River flood which flooded eight drainage districts and parts of Clatskanie and St. Helens is lower than in the past, but not zero.

Despite the reduction in flood potential from construction of the dams, portions of Columbia County continue to have a significant level of flood risk from the major rivers as well as from the numerous creeks running through Columbia County. The dams on the larger rivers have not reduced flood risk on these smaller streams.

6.2 The 1996 Flood

The most recent significant flood event in Columbia County occurred in February 1996. Unusually heavy rains over the four-day period from February 5th to February 8th 1996 resulted in significant flooding on numerous rivers and streams throughout western Oregon. In Columbia County, flood impacts continued for several days after the end of heavy rainfall.

There were widespread road closures in Columbia County, from a combination of landslides and high water, including Highway 30 and Highway 47 at several locations and the Scappoose-Vernonia Road. During the peak flood period, all major highways were closed and secondary roads were open for emergency vehicles only or closed. Clatskanie and Vernonia were isolated due to road closures.

The flooding in February 1996 affected many portions of Columbia County, with major flooding in Vernonia, Clatskanie, Rainier, and Mist and significant flooding in many other areas. Evacuations were necessary in much of Clatskanie and Vernonia as well as portions of Scappoose, St. Helens and Rainier and in several dike-protected areas along the Columbia River. The Columbia County Drainage District No. 1 and the Clatskanie Drainage Improvement Company Levees were breached during this flood.

A boil water alert was necessary for most of the county, due to high turbidity in drinking water. Telecommunications, including emergency communications in some areas, were disrupted.

FEMA funded repair and response costs for eligible public entities totaled over $5,000,000 and the Oregon Economic Development Department provided nearly $1,000,000 in Disaster Recovery Grants to Columbia County. Total damages to private property were undoubtedly much larger than $5,000,000.

The 1996 flood was significant for Columbia County, but certainly not the maximum possible flood event. Much larger floods are possible.

6.3 Flood Hazards and Flood Risk: Within Mapped Floodplains

6.3.1 Overview

FEMA Floodplain Maps show areas where the Federal Emergency Management Agency (FEMA) has determined that a flood hazard exists. Nearly all communities have at least some portion of the mapped hazard areas, or floodplains, within their jurisdiction. The FEMA-mapped floodplains in Columbia County are summarized below in Table 6.1 (FEMA Flood Insurance Study, August 16, 1988).

For the most part, the FEMA-mapped floodplains in Columbia County include only areas along the larger rivers and streams, which also have significant concentrations of development and population. Throughout Columbia County, there are many other localized areas that have significant flood risk but are not included in the FEMA mapped floodplains because the streams are too small and/or because the flood-prone population is too small. Thus, evaluation of flood hazards in Columbia County must consider not only the FEMA-mapped floodplains, but also the localized areas of repetitive flooding or high flood risk outside of the mapped floodplains.

Table 6.1
FEMA-Mapped Floodplains in Columbia County

Flood Source	Mapped Reach[1]
Columbia River	entire reach from Multnomah to Clatsop County lines
Clatskanie River	mouth to RM 3.2 at the Hazel Grove Road
Conyers Creek	mouth to RM 1.5 in Clatskanie
McNulty Creek	mouth to RM 2.3 at Ross Road near St. Helens
Milton Creek	mouth to RM 8.1 at Brinn Rd. in Yankton
Multnomah Channel	from confluence with Columbia River to Multnomah County Line
Nehalem River	from RM 88.2 to RM 91.2 near Vernonia
Rock Creek	from mouth to RM 1.1 at Vernonia
Scappoose Creek	from RM 4.2 near West Lane Road to RM 9.9 at Raymond Creek Road near Scappoose
North Scappoose Creek	from mouth to RM1.2 near Scappoose
North Scappoose Creek Overflow	from its confluence with Scappoose Creek to the divergence from North Scappoose Creek

[1] The term "reach" means distance along a river or stream. The term "RM" means river mile; river miles are measured upstream, starting from the mouth of the river or stream.

A synopsis of the flood-prone areas in Columbia County as shown on these FIRM maps is given below in Table 6.2.

Table 6.2
Synopsis of FEMA-Mapped Flood-Prone Areas in Columbia County

Flood Source	Geographic Area
Columbia River	Diked areas along Columbia from near Clatskanie to near Ranier, including portions of Webb Drainage District, Marshland Drainage District, Midland Drainage District, Magruder Drainage District, Beaver Drainage District, John Drainage District, Kerry Drainage District, Woodson Drainage District, Clatskanie Drainage District
Fish Hawk Creek and Nehalem River	Unincorporated areas west of Clatskanie
Clatskanie River, Conyers Creek, and Beaver Creek	Portions of City of Clatskanie, including approximately 10% of the streets in Clatskanie. Narrow bands along Conyers Creek and Beaver Creek in unincorporated areas near Clatskanie .
Columbia River, Beaver Creek, and Goble Creek	Portions of the City of Ranier, north and east of Highway 30, including less than 10% of streets in Ranier. Narrow bands along Beaver and Goble Creek in unincorporated areas near Ranier.
Nehalem River, Clatskanie River, Deep Creek and Rock Creek	Narrow bands along these flood sources in unincorporated areas in western and central Columbia County, including areas along Highway 47.
Tide Creek and Milton Creek	Narrow bands along these flood sources in unincorporated areas west of St. Helens.
Columbia River	Deer Island and surrounding areas north of Columbia City and east of Highway 30.
Nehalem River	Narrow bands along the river in unincorporated areas southwest of Vernonia
Nehalem River and Rock Creek	Large portions of Vernonia, including approximately 50% of the streets in the city.
Salmon Creek, Cox Creek, Milton Creek, North Scappoose Creek, South Scappoose Creek and Raymond Creek	Narrow bands along these flood sources in unincorporated areas in eastern Columbia County west of Scappoose.
Colombia River, Scappoose Creek and North Scappoose Creek	City of Scappoose, areas along the two creeks and area east of Highway 30 and north of the Burlington Northern Railroad line, including approximately 15% of the streets in Scappoose.
Columbia River	Diked areas along the Columbia from Ranier to Columbia City, St. Helens and Scappoose and southwards to the county line, including Scappoose Drainage District, Sauvie Island and other areas along the river.
McNulty Creek and Milton Creek	Narrow bands along the creeks in unincorporated areas west of St. Helens, continuing along the creeks into the city.

FEMA-mapped floodplains in Columbia County include:

1. a broad swath of the lowlands along the entire reach of the Columbia River in Columbia County, including the dike districts,
2. narrow bands along the Clatskanie and Nehalem Rivers and along numerous creeks in the County,
3. portions of the larger cities, including Clatskanie, Rainier, Columbia City, St. Helens, Scappoose, and Vernonia.

Of the larger cities, Vernonia appears to have the highest proportion of flood prone area and structures, with approximately 50% of the streets in the city within the 100-year flood plain.

FEMA Flood Insurance Rate Maps (FIRMs) for the above mapped areas show flood plain details such as the 100-year and 500-year flood plain boundaries. For Columbia County, there are several dozen FIRMs for cities and communities in unincorporated portions of the county.

An important caveat in interpreting the FEMA floodplain maps (and the synopsis above) is that there are additional areas of Columbia County, not within the mapped floodplains, that are also at flood risk. These flood-prone areas are discussed later in this chapter (Section 6.4).

6.3.2 Flood Hazard Data

For mapped floodplain areas, the flood hazard data included in the Flood Insurance Study (FIS) allow quantitative calculation of the frequency and severity of flooding for any property within the floodplain. Such calculations are very important for mitigation planning, because they allow the level of flood risk for any structure to be evaluated quantitatively. The example below illustrates these concepts.

For example, for the Nehalem River in Vernonia, downstream of the confluence with Rock Creek, the 1988 FEMA FIS includes the following data:

Table 6.3
Flood Hazard Data
Nehalem River in Vernonia, at Highway 47 (Bridge Street)

Flood Frequency (years)	Discharge (cfs)	Elevation (feet)
10	10,400	603.9
50	13,200	605.6
100	14,700	606.2
500	17,400	607.5

The stream discharge data shown above are from the table on page 19 of the FIS for Columbia County, for the Nehalem River, downstream from the confluence of Rock Creek. Stream discharge means the volume of water flowing down the river and is typically measured in cubic feet of water per second (cfs). The flood elevation data are from the Flood Profile Graph 22P in the FIS. Flood elevation data vary with location along the reach of the river and thus separate flood elevation data points must be read from the graph at each location along the river. The flood elevation data above are at Highway 47 (Bridge Street).

Quantitative flood hazard data, such as shown above, are very important for mitigation planning purposes because they allow quantitative determination of the frequency and severity (i.e., depth) of flooding for any building or other facility (e.g., road or water treatment plant) for which elevation data exist. For example, a building located in Vernonia near the Highway 47 bridge (cf. Table 6.3 above), with a first floor elevation of 604 feet is expected to flood about once very 10 years, on average. 50-year, 100-year, and 500-year flood events would result in about 1.6 feet, 2.2 feet and 3.5 feet of water above the first floor, respectively. Thus, such a structure is demonstrably at significantly high flood risk.

Such quantitative flood hazard data also facilitate detailed economic analysis (benefit-cost analysis) of mitigation projects to reduce the level of flood risk for a particular building or other facility. Further details and examples of how such data are used are given in the Appendix (Mitigation Project Examples).

6.3.3 Interpreting Flood Hazard Data for Mapped Floodplains

The level of flood hazard (frequency and severity of flooding) is not determined simply by whether the footprint of a given structure is or is not within the 100-year floodplain. A common error is to assume that structures within the 100-year floodplain are at risk of flooding while structures outside of the 100-year floodplain are not. Some importance guidance for interpreting flood hazard is given below.

a. Being in the 100-year floodplain does not mean that floods happen once every 100 years. Rather, a 100-year flood simply means that the probability of a flood to the 100-year level or greater has a 1% chance of happening every year.
b. Much flooding happens outside of the mapped 100-year floodplain. First, the 100-year flood is by no means the worst possible flood. For example, for flooding along the Nehalem River in Vernonia, the 500-year flood is 1.3 feet higher than the 100-year flood (cf. data in Table 6.3 above). Thus, floods greater than the 100-year event will flood many areas outside of the mapped 100-year floodplain. Second, many flood prone areas flood because of local storm water drainage conditions. Such flood prone areas have nothing to do with the 100-year floodplain boundaries.
c. The key determinant of flood hazard and flood risk for a structure or other facility is the relationship of the elevation of the structure or facility to the flood elevations for various flood events. Thus, homes with first floor elevations below or near the 10-year flood elevation have drastically higher levels of flood hazard and risk than other homes in the same neighborhood with first floor elevations near the 50-year or 100-year flood elevation.

The FEMA FIRM maps use a variety of nomenclature to describe different types of flood-prone area and flood plain classifications have changed over time. For reference, definitions of some important flood plain terms commonly used on FIRMs are given below.

The FEMA floodplain maps include the following types of flood-prone areas:

1. **Zone AE**, within the 100-year floodplain, with base flood elevation (100-year flood) and detailed flood hazard data,
2. **Zone A**, within 100-year flood plain, but without base flood elevation or detailed flood hazard data,
3. **Zone AH**, flood depths of 1 to 3 feet (usually areas of ponding), base flood elevations determined,
4. **Zone AO**, flood depths of 1 to 3 feet (usually sheet flow on sloping terrain),
5. **Zone A99**, to be protected from 100-year flood by Federal flood protection system under construction, no base flood elevations determined,
6. **Zone X (shaded)**, areas of 500-year flood, areas of 100-year flood with average depths less than 1 foot or with drainage areas less than 1 square mile, and areas protected by levees from 100-year flood,
7. **Zone X (unshaded)**, areas outside 500-year flood plain, and
8. **Zone D**, areas in which flood hazards are undetermined.

6.3.4 Caveats for Columbia County Flood Insurance Study

The Flood Insurance Study (FIS) for Columbia County was published in 1988. Flood hazard conditions often change with time as channels and watersheds evolve with increasing development and other changes. Overtime, the accuracy of a FIS typically diminishes with time and any FIS should be redone periodically to ensure that data are accurate and up to date for flood zoning and mitigation planning purposes.

Simply because an FIS is old, does not necessarily mean that a FIS is obsolete or inaccurate. However, the older a study is, the more likely it is that channel or watershed conditions have changed over time. Therefore, as time passes, care should be taken in interpreting and using data from the FIS, especially in reaches of rivers or streams where substantial channel changes are documented or flood control measures have been added.

6.4 Flood Hazards and Flood Risk: Outside of Mapped Floodplains

Section 6.3 above applies only to the limited portions of Columbia County that are within the FEMA-mapped floodplains of the major rivers and portions of some of the smaller streams. For mitigation planning purposes, it is very important to recognize that flood risk for a community is not limited only to areas of mapped floodplains. Other portions of Columbia County outside of the mapped floodplains may also at relatively high risk from over bank flooding from streams too small to be mapped by FEMA or from local storm water drainage. In Columbia County as a whole there are dozens of small creeks with unmapped floodplains.

Many areas of Columbia County outside of mapped floodplains are also subject to repetitive, damaging floods from local storm water drainage, separate from overbank flooding from creeks too small to be mapped. In many cases, local storm water drainage flooding occurs along unnamed gullies or simply in low spots. There are probably numerous such flood prone sites in Columbia County; many of these sites may have experienced repetitive flooding over many years. Unlike FEMA-mapped floodplains for larger rivers and creeks, areas subject to storm water drainage are not systematically mapped.

Storm water drainage systems vary markedly within Columbia County. In urban areas and some smaller communities, storm water drainage consists of drains and an underground pipe system. In lower population density areas, storm water drainage systems are generally open drainage ditches. In rural areas, storm water drainage systems are typically hit or miss, with culverts or other drainage infrastructure built only in limited locations with repetitive flooding episodes.

A complete inventory of Columbia County's storm water drainage system is beyond the scope of this mitigation plan. Individual communities can provide information about their specific local drainage system. In general, however, storm water drainage systems, including those in Columbia County, are almost always designed to handle only small to moderate size rainfall events. Storm water systems are sometimes designed to handle only 2-year or 5-year flood events, and are rarely designed to handle rainfall events greater than 10-year or 15-year events.

For local rainfall events that exceed the collection and conveyance capacities of the storm water drainage system, some level of flooding inevitably occurs. In many cases, local storm water drainage systems are designed to allow minor street flooding to carry off storm waters that exceed the capacity of the storm water drainage system. In larger rainfall events, flooding may extend beyond streets to include yards. In major rainfall events, local storm water drainage flooding can also flood buildings. In extreme cases, local storm water drainage flooding can sometimes result in several feet of water in buildings, with correspondingly high damage levels.

Columbia County's 1998 Hazard Mitigation Plan identified three high priority locations for storm water drainage improvements:

1. Culvert replacement on Scappoose-Vernonia Highway at milepost 9.3,
2. Culvert replacement at Oak Ranch Creek on Apiary Road, and
3. Drainage improvements/culverts on Apiary Rd.

These identified projects remain as high priorities for mitigation projects as resources become available. The County is continuously seeking funding sources for mitigation activities such as these.

6.5 Inventory Exposed to Flood Hazards in Columbia County

6.5.1 Overview

Critical facilities such as emergency communications, fire stations, police stations, medical care facilities are, by definition, particularly important to a community. Similarly, key transportation and utility infrastructure are also particularly important to a community. One important action item for the Columbia County Hazard Mitigation Plan is to compile an inventory of such critical facilities that are at high risk for each hazard, including floods. A preliminary list of critical facilities located within the FEMA-mapped 100-year or 500-year floodplains, or otherwise perceived to be at high flood risk is given below in Table 6.4.

To quantify the level of flood hazard for buildings, other facilities or infrastructure, within mapped floodplains, it is necessary to determine the elevations of these structures. Only by determining the elevation of each potentially flood-prone structure, can the level of flood hazard (frequency and severity of flooding) be calculated accurately. Similarly, acquiring elevation data for additional structures within the 500-year flood plain as well as for structures in other flood-prone areas outside of mapped floodplains would greatly increase the accuracy of hazard, inventory, and vulnerability assessments for floods in Columbia County. Compiling and interpreting such elevation data, especially for critical facilities is encouraged as a high priority action item.

The best structure elevations (first floor elevations) are those determined accurately by surveying. Flood insurance certificates generally include survey elevation data. Absent survey data, however, useful estimates of elevations for structures can often be made by reference to elevations of nearby structures or public infrastructure with surveyed elevation data.

In addition to elevation data, quantifying the level of risk faced by these structures requires basic data about each structure, including building data (square footage, number of stories, with or without basement), and information on the type and importance of function (residential, commercial, public).

Additional sites of repetitive flood problems outside of the mapped floodplains are also included below in Table 6.4.

As noted above, many localized areas of Columbia County, outside of the mapped floodplains, are also subject to relatively high levels of flood risk To quantify the level of flood risk posed by these areas, historical data should be systematically compiled to include documentation of the frequency and severity of flooding. Severity of flooding can include dollar estimates of past damages, if available, and/or simple narratives reporting whether the flooding in a given area is limited to minor street and yard flooding only, or whether flooding is severe enough to produce road damages, road closures, or damages to other infrastructure or buildings as well.

Table 6.4
Critical Facilities and Infrastructure Located within FEMA-Mapped Floodplains or Otherwise Perceived to be at High Flood Risk

Jurisdiction	Facility	Notes
Columbia 9-1-1 Communications District[1]	9-1-1 Facility	Within footprint of 100-year floodplain but floor level is approximately 2.5 to 3 feet above 100-year flood elevation
City of Scappoose[2]	Water treatment plants (2)	Within 100-year floodplain or otherwise perceived as being at flood risk
	Wastewater treatment plant	Within 100-year floodplain or otherwise perceived as being at flood risk
	Other water infrastructure	Within 100-year floodplain or otherwise perceived as being at flood risk
City of Vernonia[3]	Washington Elementary and Vernonia High Schools	Within 100-year floodplain or otherwise perceived as being at flood risk
	Vernonia and Columbia County Public Works	Within 100-year floodplain or otherwise perceived as being at flood risk
	Vernonia Water Treatment Plant and Water Station at Mist Dr. and Ivy St.	Within 100-year floodplain or otherwise perceived as being at flood risk
	Verizon Communications and Western Oregon Electric Facilities	Within 100-year floodplain or otherwise perceived as being at flood risk
	Providence Health Clinic	Within 100-year floodplain or otherwise perceived as being at flood risk
	Two bridges on Bridge Street	Within 100-year floodplain or otherwise perceived as being at flood risk
Mist-Birkenfeld Rural Fire Protection District[4]	Sections of Highways 47 and 202, as identified in 1998 Columbia County Hazard Mitigation Plan	Subject to closures due to flooding.

[1] Data from Sally Jones, 8/24/2004
[2] Data from Jon Hanken, 8/312004
[3] Data from Chief Matthew Workman, 8/23/2004
4 Data from Chief Dave Crawford, 8/23/04

The above list of flood prone facilities is only a sample of flood prone facilities in Columbia County. Most other cities and other population centers also have at least some critical buildings and infrastructure at flood risk. Some of such critical facilities being considered for flood mitigation measures are:

Action Item Short Term #1 and Long Term #1

Facility	Location	Water Body	Approximate Elevation
Fire Stations			
Clatskanie	280 Third St. SE Clatskanie	Clatskanie River	20
Columbia River Fire and Rescue	270 Col. Blvd. St Helens	McNulty Creek	60
Mist-Birkenfeld	12525 Hwy. 202 Mist	Nehalem River	540
Scappoose RFPD	52751 Col Riv. Hwy. Scappoose	Scappoose Creek	60
Police Stations			
Vernonia Police	1001 Bridge St. Vernonia	Nehalem River	620
Elderly Housing			
Vernonia Senior Center	446 Bridge St. Vernonia	Vernonia Lake	
Scappoose Assisted Living	33800SE Harder Scappoose	Jackson Creek	
Schools (K-12)			
Scappoose High	3358 High School Way, Scappoose	Scappoose Creek	60
Vernonia High and Elementary Schools	475 Bridge St. Vernonia	Nehalem River	
Rainier Elementary	PO Box 160 Rainier	Goble Creek	100

Electric Power			
West Oregon Electric	715 Maple St Vernonia	Nehalem River	600

6.5.2 Columbia County Dike Districts

There are 15 drainage improvement districts or companies which operate levees in Columbia County. In total these districts cover over 35,000 acres (about 56 square miles) with 98 miles of levees. Summary data on these districts or companies is given below in Table 6.5.

As shown in Table 6.5, all of these levee systems were originally constructed in the first half of the twentieth century, although all have undergone numerous rounds of repairs and improvements over the decades. The FEMA firm maps show large areas of some of these districts as Zone AE (within 100-year floodplain); only a few of these levees are certified to provide 100-year flood protection. The five levee systems certified to provide 100-year flood protection, according to Richard Gamble (US Army Corps of Engineers, August 2004) include:

Sauvie Island Drainage Improvement Company,

Scappoose Drainage Improvement Company,

Rainier Water Improvement Company,

Midland Drainage Improvement Company, and

Beaver Drainage Improvement Company.

The specific level of flood protection offered by each district's levee system depends on levee heights, condition, and maintenance.

All of these districts contain primarily agricultural lands, with many having low density rural development with a few residences. The level of flood risk posed to these residences varies from district to district.

Table 6.5
Drainage Improvement Districts or Companies

Drainage District	Acres	Levee Miles	Original Construction	Safe Water Level[2]	Development within Levees
Sauvie Island Drainage Improvement Company	12,000	18	1938 to 1942	4 feet above 100-year flood	agricultural lands, ponds
Scappoose Drainage Improvement Company	5,530	10	1922 to 1940	2.1 feet above 100-year flood	agricultural lands, with few residences
Ranier Water Improvement District	1,287	4.6	1920	1.8 feet above 100-year flood	agricultural lands, sloughs
Midland Drainage Improvement Company	1,330	6.7	1912	0.1 foot above 100-year flood	agricultural lands
Beaver Drainage Improvement Company	5,595	13	1915	0 foot above 100-year flood	mostly agricultural lands
Clatsop Drainage Improvement Company No. 15	233	2.1	1920	2.6 feet below 100-year flood	agricultural lands
Westland Drainage District Improvement Company	1,090	6.5	before 1930	2.9 feet below 100-year flood	agricultural lands
Woodson Drainage Districts	355	3.4	1915	3.1 feet below 100-year flood	agricultural lands
Marshland Drainage Improvement Company	1,145	4.8	1920	3.4 feet below 100-year flood	agricultural lands
Magruder Drainage Improvement Company	592	3	1911	3.9 feet below 100-year flood	agricultural lands
Clatskanie Drainage Improvement Company	325	2.2	1912	4.2 feet below 100-year flood	agricultural lands
Webb District Improvement Company	733	4.5	1921	4.4 feet below 100-year flood	agricultural lands
John Drainage District	147	1.7	1915	4.8 feet below 100-year flood	agricultural lands, residences
Columbia County Drainage District No. 1	1,559	9.3	1915	5.2 feet below 100-year flood	agricultural lands, wild fowl refuge, 20 acres of home sites
Deer Island Drainage Improvement Company	3,900	8.58	1942	5.2 feet below 100-year flood	agricultural lands, lakes and sloughs
Totals	35,821	98			

[1] Compilation of drainage district data obtained from US Army Corps of Engineers, Portland District publication "Columbia River and Tributaries Review Study CRT 69 - Lower Columbia River Flood Control Study - River Mile 0 to 145 - Summary Report Volume 2", January 1989.

[2] Values given for the safe water level represents the highest flood level for which reasonable assurance can be made that the levee system will not fail. This level is further defined as the river state at which only normal surveillance and minor remedial work would be required during normal flood periods and close surveillance of the system is required only during extended flood periods.

6.6 Flood Loss Estimates and Flood Risk

6.6.1 Flood Loss Estimates: Rough Estimates

Rough estimates of the magnitude of potential flood losses in Columbia County can be made from estimates of the number of buildings located within mapped-floodplains, as shown below in Tables 6.6, 6.7, 6.8, and 6.9. These estimates are rough, for planning purposes only (e.g., for comparison of the relative impact of various hazards on Columbia County) and should not be taken literally.

Based on census data, we estimate that there are roughly 20,000 buildings in Columbia County (Table 6.6). Based on review of the Columbia County FIRMs, we estimate than about 6% of these buildings may be in the 100-year floodplain, or otherwise flood-prone.

Table 6.6
Census Data and Estimated Number of Buildings

Demographic Category	Estimate
Population 2003 Estimate	46,261
Persons per Household	2.65
Households	17,457
Other buildings	2,543
Total buildings	20,000

Table 6.7
Estimated Number of Flood-Prone Buildings

Community	Total Population	Estimated to be in 100-Year Flood Plain		
		Percent	Population	Structures
Vernonia	2,243	50%	1,122	485
Scappoose	5,326	20%	1,065	461
Rest of County	38,692	2%	774	335
Total	46,261	6.40%	2,961	1,280

Estimated damages per flooded building are shown below in Table 6.8. These estimates are based on an average building replacement value of $100,000 ($66.67/sf for 1,500 sf), with an average contents value of $30,000 (typical FEMA assumption for benefit-cost analysis of residential flood mitigation projects). For an average flood water depth of 2 feet above the first floor, building and contents damage percentages are estimated as 22% and 33%, respectively of building replacement value and contents replacement value, based on typical FEMA values for one-story structures without basements (from nationwide flood insurance claims data). Other damages, including damages to yards, vehicles, and outbuildings are estimated roughly at $4,000 per structure. Displacement costs for temporary housing are estimated roughly at $2,000 per structure. With these input data/assumptions, estimated damages and losses total nearly $38,000 per flooded building.

Table 6.8
Estimated Damages per Flooded Building

Category	Estimate
Average Building Replacement Value	$100,000
Average Contents Value	$30,000
Building damage (22%)	$22,000
Contents damage (33%)	$9,900
Other damages	$4,000
Displacement costs	$2,000
Total Damages and Losses	$37,900

Total damages and losses for buildings and contents (and related losses) are estimated simply by multiplying the estimated damages and losses per building by the estimate number of flood-prone buildings. Then, damages to infrastructure and economic impacts of floods (lost business income, lost wages, etc.) are each estimated very roughly at 50% of total damages and losses for buildings and contents.

Table 6.9
Estimated Total Damages and Losses for Hypothetical County-Wide 100-Year Flood

Category	Estimate
Building and Contents etc.	$48,509,313
Infrastructure Damages	$24,254,656
Economic Losses	$24,254,656
Total Damages and Losses	$97,018,626

As acknowledged above, these estimated flood losses are very rough and should not be interpreted literally, but rather only as an order of magnitude estimate of potential flood losses. Furthermore, a 100-year flood (or any other flood event) would be highly unlikely to affect the entire county at one time. Nevertheless, these rough estimates seem approximately correct.

From these rough estimates, it appears that a moderately severe flood event such as the 1996 flood could easily result in $5,000,000 to $10,000,000 to $20,000,000 in flood damages and losses within Columbia County. Larger flood events, such as a 100-year event, could probably result in losses several times larger, perhaps approaching roughly $100,000,000 for Columbia County as a whole.

Somewhat more accurate flood damage and loss estimates can be made using more detailed data, using loss estimation calculation tools such as FEMA's HAZUS-MH loss estimation software. However, accurate flood loss estimates for specific communities requires much more detailed data as discussed below in the following section.

6.6.2 Techniques for More Accurate Flood Loss Estimates

More accurate flood loss estimates for specific areas of Columbia County can be made by obtaining more detailed inventory information, including elevations of flood prone structures. Then, the economic impacts of floods can be estimated more completely using the approaches outlined below.

For most residential structures and many similar commercial and public structures, the likely amount of building damage from floods of any given depth can be estimated approximately using FEMA depth-damage tables. These depth damage tables are derived from Federal Insurance Administration flood insurance claims data for several million properties and thus represent typical damage levels for typical structures. Although actual damages will vary somewhat from structure to structure, depending also on flood conditions such as duration, velocity, and degree of contamination, these typical values represent a good starting point to estimate flood damages for typical structures and thus to help quantify the level of flood risk. Current FEMA depth-damage data for typical structures are given in the Appendix – Example Mitigation Projects.

In estimating flood losses or evaluating flood risk (for a structure or a whole community) it is very important to recognize that the economic impact of floods includes not only damages to buildings and contents but other economic impacts as well, including:

1. damages to yards, vehicles, and outbuildings (not in depth damage data above),
2. displacement costs for temporary quarters while repairs are made,
3. loss of business income,
4. loss of public services.

In some cases, these economic impacts of floods can be a significant fraction of building and contents damages, or even larger, especially for critical facilities or critical infrastructure. FEMA's publication *What is a Benefit? Draft Guidance for Benefit-Cost Analysis* provides an excellent primer, along with typical values and simple economic methods, to place monetary values on the loss of function of buildings, critical facilities, roads and bridges, and utility systems.

6.7 Flood Insurance Data for Columbia County

The National Flood Insurance Program (NFIP) maintains a database of all flood insurance policies in the United States. NFIP data for Columbia County are summarized below in Table 6.10. As shown below, there are 626 flood insurance policies in place in Columbia County as a whole, with about 40% of these outside of the larger cities. Of the policies within the larger cities, most are in Vernonia and Scappoose, reflecting the significant fractions of these cities located within the mapped floodplains.

Table 6.10
NFIP Data for Columbia County

Jurisdiction	Flood Policies	Repetitive Loss
Clatskanie	23	0
Prescott	3	0
Ranier	3	0
Scappoose	144	0
St. Helens	45	0
Vernonia	156	0
Unincorporated Areas	252	1
Columbia County Total	626	1

The FEMA NFIP database indicates that 234 of these insured structures (37%) are post-FIRM structures and thus may have been built in accord with flood plain management regulations governing minimum first floor elevations vis-à-vis the base flood (100-year) elevation. However, 384 of these structures (61%) are pre-FIRM structures and likely to be lower, more flood-prone elevations. The data of construction and pre- or post-FIRM status of the remaining 8 structures is not known.

FEMA's repetitive loss list includes all insured properties that have experienced two or more insured losses of at least $1,000 for which the flood events were at least 10 days apart but not more than 10 years apart. The FEMA repetitive loss list provides one indication of properties that may be at high risk for future flooding. However, because these claims data do not consider the severity or frequency of the flood events causing the flood loss claims, the repetitive loss list is not mathematically rigorous. For example, some properties on the list may have simply been unlucky and have experienced two flood events with low probabilities (e.g., 100-year or greater events) within a short time period. Thus, the properties on the repetitive loss list may be at relatively high flood risk or they may not. Correspondingly, there are almost certainly other properties within Columbia County at equal or higher levels of flood risk that are not on the FEMA repetitive loss list. These properties may not have flood insurance or simply may have been lucky over the relatively short reporting period for the NFIP repetitive loss list (data since 1978).

Despite these limitations of FEMA's repetitive loss list, properties within Columbia County on the repetitive loss list may be good targets of opportunity for flood mitigation. Most of FEMA's mitigation programs list repetitive loss properties as high priorities for mitigation and thus obtaining FEMA funding for properties on the repetitive loss list may be more likely than for properties not on the list.

For reference, we note that the very approximate calculations presented above in Table 6.7estimated about 1,280 buildings with footprints within the 100-year floodplain. The actual number of flood insurance policies in Columbia County (cf. Table 6.10 above) is about 50% of this estimate. A 50% ratio of flood insurance policies to structures in the 100-year flood plain is more of less typical of many communities. The lower number of policies most likely results from a combination of factors, including homeowners who simply choose not to buy flood insurance, buildings not required to have flood insurance or not having insurance whether required or not as well as buildings whose footprint is in the 100-year flood plain but whose first floor elevation is above the 100-year flood elevation.

6.8 Summary of Flood Risk for Columbia County

The flood hazard, vulnerability and risk data, estimates and analyses presented above are summarized in the following table.

Table 6.11
Summary of Flood Risk for Columbia County

Question	Commentary
What is the source and type of the flood problem?	
a. overbank flooding from Columbia, Nehalem, and Clatskanie Rivers and numerous smaller streams	Affects portions of every community in Columbia County.
b. storm water drainage flooding	Affects portions of many communities and rural areas.
What is the geographic area affected by the flooding?	
a. FEMA-mapped floodplains	Every major community in Columbia County has portions of the community within FEMA-mapped floodplains. Vernonia and Scappoose have the largest percentage of flood-prone structures. All of the diked areas are subject to flooding in major flood events.
b. areas outside of FEMA-mapped floodplains	Numerous locations affected by storm water drainage and flooding on smaller, unmapped streams; complete inventory of flood prone sites not yet available
What inventory of buildings and infrastructure are at risk?	
a. Buildings	Complete inventory not yet available. Rough estimate is that about 1,000 to 1,500 buildings may be within footprint of 100-year flood plain.
b. Critical facilities	Complete inventory not yet available.
b. Roads and other infrastructure	As demonstrated by the 1996 flood, every major highway in Columbia County and many secondary roads are subject to closure during flood events.
How frequent is the flooding problem?	
a. roads	Road closures and road damages happen to some extent almost every year
b. buildings	Relatively few buildings appear to be at extremely high flood risk (10-year floodplain or lower), but many buildings are at risk from flooding in larger less frequent flood events
How serious is the flooding problem?	
a. frequent flooding (annual or every few years)	Very frequent flooding appears to impact primarily roads and relatively few buildings and other facilities
b major floods (25-year, 50-year, 100-year etc. events)	Increasingly major floods affect increasingly large fractions of the population, building stock and infrastructure of Columbia County. A widespread 100-year flood event could result in up to one hundred million dollars of damages and directly affect over one thousand buildings and several thousand people.

6.9 Common Flood Mitigation Projects

Potential mitigation projects to reduce the potential for future flood losses cover a wide range of possibilities.

For either major rivers or the creeks, it would be theoretically possible to reduce future flood losses by building levees or floodwalls. In practice, however, such projects are often very expensive and have a host of environmental and other regulatory hurdles.

For the smaller creeks, channel improvements to improve water conveyance capacity and removal of flow-restriction obstructions may be desirable. Another possibility for some of the smaller creeks would be to construct detention ponds upstream to temporarily store water during high rainfall periods. Detention ponds are basically leaky dams, designed to be dry during normal conditions. Detention ponds typically have restricted outlets with controlled flow rates. Thus, during periods of high inflow into the pond, water is stored temporarily and then gradually released. The effect of detention ponds is to lower peak discharge values and thus to lower peak flood elevations.

For areas of Columbia County subject to flooding from storm water drainage, various storm water drainage system improvements may be desirable. Typical improvements include upgrades to the size of drainage ditches or storm water drainage pipes and upgrades to pumping capacity (for pumped portions of drainage systems). Another possibility for some areas may be construction of local detention ponds.

For critical facilities at low elevations with high flood risk, such as the water and wastewater treatment plants, construction of berms or floodwalls to protect the facilities may be desirable.

For residential, commercial or public facilities at high flood risk, elevation of structures or, for structures at very high flood risk, acquisition and demolition are potential mitigation options. Elevation and acquisition (especially) are expensive mitigation options that are generally not cost-effective unless the levels of flood hazard and flood risk are rather high. That is, these mitigation options are most attractive for structures deep in the flood plain (i.e., with first floors below the 10-, or 20-, or 30-year flood elevations). For structures outside of mapped floodplains, elevation or acquisition would likely be cost-effective only for structures with a strong history of major, repetitive flood losses.

For structures near the fringe of the 100-year flood plain, near the 100-year flood level, or with some history of repetitive flood losses, various small-scale flood loss reduction measures such as elevation of furnaces and utilities may be desirable.

The following table contains flood mitigation action items from the master Action Item table in Chapter 4

Table 6.12
Flood Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Flood Mitigation Action Items: Within FEMA-Mapped Floodplains								
Short-Term #1	Complete inventory of critical facilities within 100-year and 500-year floodplains, with GIS mapping if possible	Columbia County (Land Development Services, Roads, Assessor), cities, special districts	Ongoing	X	X	X	X	
Short-Term #2	Complete inventory of residential and commercial buildings within 100-year and 500-year floodplains, with GIS mapping if possible	Columbia County (Land Development Services, Roads, Assessor), cities, special districts	Ongoing	X		X	X	
Short-Term #3	Consult with property owners and explore mitigation actions for any Columbia County properties on FEMA's national repetitive loss list	Columbia County Hazard Mitigation Advisory Committee	1 year	X		X	X	X
Long-Term #1	Survey elevation data for critical facilities, residential buildings and commercial buildings within the 100-year floodplain and establish flood mitigation priorities	Local emergency services, Columbia County Hazard Mitigation Advisory Committee	2-5 years	X	X	X	X	X
Long-Term #2	For critical facilities within the 100-year floodplain and for other structures deep within the 100-year floodplain explore mitigation options with property owners and implement mitigation measures	Local emergency services, Columbia County Hazard Mitigation Advisory Committee	2-10 years	X	X	X	X	X
Flood Mitigation Action Items: Outside of FEMA-Mapped Floodplains								
Short-Term #1	Complete the inventory of locations in Columbia County subject to frequent storm water flooding	Columbia County (Land Development Services, Roads, Assessor), cities, special districts	Ongoing	X	X	X	X	X
Long-Term #1	For locations with repetitive flooding and significant damages or road closures, determine and implement mitigation measures such as upsizing culverts or storm water drainage ditches	Columbia County (Land Development Services, Roads, Assessor), cities, special districts	Ongoing	X	X	X	X	X

CHAPTER SEVEN

7.0 WINTER STORMS

7.1 Overview

Winter storms affecting Columbia County are generally characterized by a combination of heavy rains and high winds throughout the County, sometimes with snowfall, especially at higher elevations. Heavy rains can result in localized or widespread flooding, as well as debris slides and landslides. High winds commonly result in tree falls which primarily affect the electric power system, but which may also affect roads, buildings and vehicles. This chapter deals primarily with the rain, wind, snow and ice effects of winter storms. Larger scale flooding is addressed in Chapter 6. Debris flows and landslides are addressed in Chapter 8.

For completeness, we also briefly address other severe weather events, including severe thunderstorms, hail, lightning strikes and tornadoes in Section 7.5. However, the frequency, severity, and impacts of such severe weather events are generally minor for Columbia County, compared to winter storm effects.

Winter storms can affect the area directly, with damage within Columbia County, or indirectly, with damage outside the area but affecting transportation to/from the area and/or utility services (especially electric power). Historically, the area has often been subject to both direct and indirect impacts of winter storms.

The winter storms that affect Columbia County are typically not local events affecting only small geographic areas. Rather, the winter storms are typically large cyclonic low pressure systems moving from the Pacific Ocean and that thus usually affect large areas of Oregon and/or the whole Pacific Northwest.

Historical winter storm data complied by the Portland Office of the National Weather Service (www.wrh.noaa.gov/Portland/windstorm.html) include the following major winter storm events with substantial wind damage in Oregon:

1. February 7, 2002
2. December 12, 1995
3. November 13-15, 1981
4. March 25-26, 1971
5. October 2, 1967
6. March 27, 1963
7. October 12, 1962
8. November 3, 1958
9. December 21-23, 1955
10. December 4, 1951
11. November 10-11, 1951
12. April 21-22, 1931
13. January 20, 1921
14. January 9, 1880.

The website referenced above has informative narrative summaries of each winter storm event, including wind speed data and damage reports. Similar compilations of historical windstorm data have been compiled by Wolf Read at Oregon State University (http://oregonstate.edu/~readw/). The OSU website has a vast archive of historical winter storm data for Oregon.

The specific severity and impacts of the major historical winter storm events listed above varied significantly with geographic location within Oregon. However, in terms of sustained wind speeds and damage levels, the 1880 and 1962 storms stand out as the most severe such events for Oregon.

7.2 Rain Hazard Data

Severe winter storms in Columbia County often include heavy rainfall. The potential impact of heavy rainfall depends on both the total inches of rain and the intensity of rainfall (inches per hour or inches per day). In the context of potential flooding, “rainfall” also includes the rainfall equivalent from snowmelt. Flash floods, which are produced by episodes of intense heavy rains (usually 6 hours or less) or dam breaks are rare in Columbia County (and western Oregon) but do represent a potential meteorological hazard. For Columbia County, sudden levee breaks could result in flash flooding of diked areas along the Columbia River.

Large drainage basins, such as that for the Columbia River typically have response times of several days: the total rainfall amounts (plus snow melt) over periods of several days or more are what determines the peak level of flooding along large rivers. Smaller rivers may have response times of several hours up to a day or so. Smaller, local drainage basins have even shorter response times and levels of peak flooding may be governed by rainfall totals over a period of an hour to a few hours.

However, for the Columbia River, there are numerous large multi-purpose dams and thus the usual natural correlation between rainfall events and flood levels does not apply. Rather, flooding along such rivers is predominantly affected by water release patterns from the dams. For the major rivers, dam operating characteristics and capacities are included in the flood modeling for FEMA-mapped floodplains (see Chapter 6).

Columbia County annual rainfall data are summarized in Table 7.1 below for three representative cities.

Table 7.1
Columbia County Rainfall Data

Location	Average Annual Precipitation (inches)	Lowest Annual Precipitation (inches)	Highest Annual Precipitation (inches)
Clatskanie	57.23	31.50 (1948)	75.96 (1950)
St. Helens	43.53	9.01 (1976)	64.39 (1995)
Vernonia	48.88	19.08 (1967)	71.16 (1996)

Data for Clatskanie, St. Helens RFD and Vernonia 2 weather stations from Western Regional Climate Center website:
www.wrcc.dri.edu

Average annual rainfall amounts are moderately high throughout Columbia County, with somewhat higher averages in western portions of the county. As shown above, there are also substantial variations in annual rainfall from year to year.

The rainfall data shown in Table 7.1 give general overview of the potential for winter storm flooding in Columbia County, but whether or not flooding occurs at specific sites depends heavily on specific local rainfall totals during individual storms and local drainage conditions. Whether or not localized flooding does occur depends on specific local drainage conditions. For example, 3" of rain in one area may cause no damage at all, while 3" of rain in a nearby area may cause road washouts and flooding of buildings.

For Columbia County, identification of specific sites subject to localized flooding during winter storms is based on historical occurrences of repetitive flooding events during past winter storm events. Most of these sites affect roads, rather than buildings.

An action-list of the some of the most problematic sites for roadway flooding in Columbia County is given below in Table 7.2.

Table 7.2
Sites with Repetitive Road Flooding Problems

Emergency Transportation Routes	Flood Problem Areas
Scappoose-Vernonia Road	18 locations between milepost 0.8 and milepost 20.0
Apiary Road	3 locations between milepost 8.4 and milepost 17.7

Other Repetitive Flood Problem Areas			
Address	**Community**	**Address**	**Community**
1102 Millard	St. Helens	2038 Meisner	Rainier
1011 Barger	St. Helens	? Calvin	Rainier
1128 Pittsburg	St. Helens	2100 Parkdale	Rainier
1015 Berg	St. Helens	2090 Neer City	Rainier
1140 Shaffer		2033 Doan	Rainier
1029 Cannan	Deer Island	1064 Gensman	Yankton
3064 Keasey	Columbia City	2060 Heath	Alston
3034 Fishhawk	Fishhawk	2076 Larson	Alston
4134 Mayger	Mayger	1001 Alder Creek	Chapman
4147 Beaver Falls	Mayger	2011 Barker	Beaver Homes
2087 Moiser	Mayger	2053 Gregory	Beaver Homes
3098 Bayers	Mist		

In addition, the following areas were identified as top candidates for drainage problem mitigation: Gensman Road (St. Helens), Barker Road (Beaver Homes), South Canaan Road (Trenholm) and Smith Road (west of Columbia City).

7.3 Wind Hazard Data

Wind speeds associated with winter storms vary depending on meteorological conditions, but also vary spatially depending on local topography. For Columbia County, the wind hazard levels are generally highest in the immediate vicinity of the Columbia River and then fairly uniform across most of the rest of the county. In the hilly areas, however, the level of wind hazard is strongly determined by local specific conditions of topography and vegetation cover.

A regional overview of wind hazards is shown by the data in Figures 7.3 and 7.4 which show contours of wind speed (in kilometers per hour) for western Oregon (Wantz and Sinclair, Distribution of Extreme Wind Speeds in the Bonneville Power Administration Service Area, Journal of Applied Meteorology, Volume 20, 1400-1411, 1981). These data are for the standard meteorological data height of 10 meters (about 39 feet) above ground level. Figures 7.3 and 7.4 show wind speed contours for recurrence intervals of 2-years and 50-years, respectively. These data are for sustained wind speeds. Peak gusts are commonly 30% or so higher than the sustained wind speeds. These wind-speed data are fairly old, but still representative of overall wind storm conditions in Oregon and in Columbia County.

Figure 7.3
Wind Speed Contours for 2-Year Recurrence Interval
(km/hour)

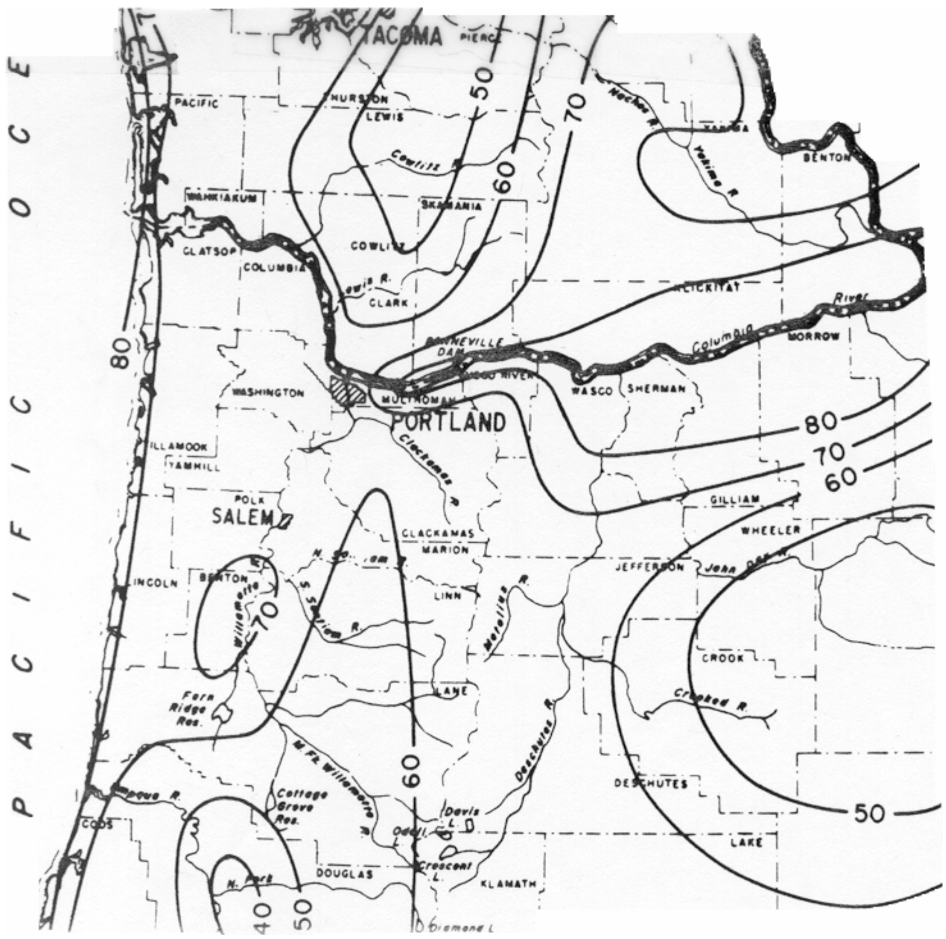
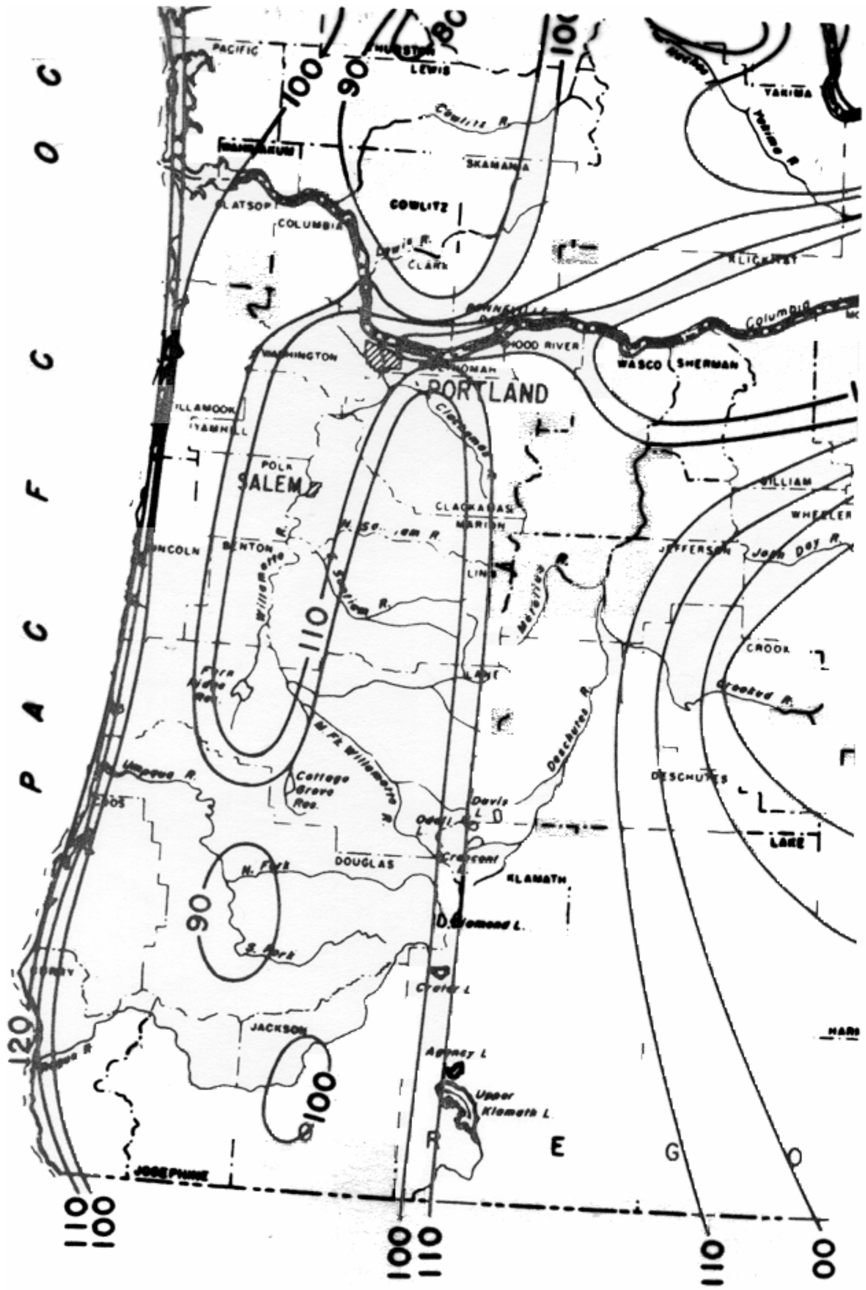


Figure 7.4
Wind Speed Contours for 50-Year Recurrence Interval
(km/hr)



Data from the maps above are summarized in Table 7.5.

Table 7.5
Wind Speed Data for Columbia County

Return Period	Sustained Wind Speeds (km/hr)	Sustained Wind Speeds (miles/hr)[1]
2-year	60 to 70	37 to 43
50-year	90 to 100	56 to 62

[1] Conversion from map contours in kilometers per hour is 0.6214 miles per kilometer

For Columbia County, the 2-year recurrence interval sustained wind speeds range from about 60 to 70 km/hour or about 37 to 43 miles per hour. These 2-year wind speeds are too low to cause widespread substantial wind damage. However, there may be significant local wind damage at sites where local wind speeds are higher or where there are especially exposed locations, such at the boundary between clear cut and forested areas.

For Columbia County, the 50-year recurrence interval wind speeds range from about 90 to 100 km/hour or about 56 to 62 miles per hour. These wind speeds are high enough to cause widespread wind damage. Damage may be severe at particularly exposed sites. Thus, for most regions of Columbia County winter storms with significant direct wind damage are not likely every year or every few years, but perhaps once every decade or so, on average, with major windstorm events happening at intervals averaging a few decades.

The maps shown above have limited spatial resolution for Columbia County, but suggest that the potential for damaging winds may be somewhat higher in eastern Columbia County along the Columbia River. Historically, areas along the Columbia River North and West of Rainier appear to be hardest hit from severe winds. Additional areas with frequent tree falls reported are shown below in Table 7.6.

Table 7.6

Repetitive Tree Fall Areas	
Road/Area	**Road/Area**
Sauvies Island area	Steward Creek
Scappoose Dike cottonwood tree farms	Shaffer Road
Scappoose-Vernonia Highway	Old Rainier Rd.
Cater Hill area	Chapman Rd.
Meserve	McDonald Rd.
Culver	Sweedtown Rd.
Cedar Grove	Fern Hill Rd.
Pellam Hill	Beaver Falls Rd.
Viewcrest Hill	Fishhawk Rd.
Pebble Creek	Keasey Rd.
Alder Grove	

7.4 Snow and Ice Hazard Data for Columbia County

Winter storms can also involve ice and snow, most commonly at the higher elevations in Columbia County, but sometimes along the Columbia River as well. The most likely impact of snow and ice events on Columbia County are road closures limiting access/egress to/from some areas, especially roads to higher elevations. Winter storms with heavy wet snow or high winds and ice storms may also result in power outages from downed transmission lines and/or poles.

Average annual snowfalls in Columbia County are generally low as shown below in Table 7.7.

Table 7.7
Snowfall Data for Selected Cities in Columbia County

Location	Average Annual Snowfall (inches)	Lowest Annual Snowfall (inches)	Highest Annual Snowfall (inches)	Period of Record
Clatskanie	10.40	0.00	72.0 (1949-50)	1948-2004
St. Helens	2.50	0.00	25.3 (1979-80)	1976-2004
Vernonia	9.50	0.00	47.4 (1968-9)	1967-2004

Data for Clatskanie, St. Helens RFD and Vernonia 2 weather
Western Regional Climate Center website: www.wrcc.dri.edu

However, there is considerable variation in historical snowfall data within Columbia County. Average annual snowfall for St. Helens is only about 25% of that for Clatskanie and Vernonia. Highest annual snowfall is also much higher at Clatskanie and Vernonia than at St. Helens. However, the highest annual snowfall data are affected by varying periods of weather records at these stations.

Including Vernonia data from the previous weather station location, the highest annual snowfall is 147.70 inches in (1949-50). Nevertheless, the general pattern is clear, with eastern Columbia County typically receiving lower snowfall amounts than western portions of the county.

The snowfall data in Table 7.8 below show dates of significant snow accumulations at these weather stations, with the Vernonia data being for the current weather station only. These snowfall data are from the same source as Table 7.7 above.

Table 7.8
Significant Snowfall Events for Selected Cities in Columbia County

Clatskanie			
Year	**Annual Snowfall (inches)**	**Peak Snowfall Month**	**Peak Monthly Snowfall (inches)**
1948-9	33.0	February	19.5
1949-50	72.0	January	68.5
1950-1	34.5	March	30.0
1951-2	23.5	January	15.0
1953-4	33.0	January	33.0
1955-6	40.5	January	13.5
1964-5	27.0	December	22.0
1968-9	31.5	January	18.5
1970-1	41.5	January	21.5
1979-80	22.5	January	16.0

St. Helens			
Year	**Annual Snowfall (inches)**	**Peak Snowfall Month**	**Peak Monthly Snowfall (inches)**
1977-8	5.3	November	5.3
1978-9	10.0	November	3.9
1979-80	25.3	December	24.3
1984-5	8.3	February	7.3
1985-6	10.5	November	6.0
1992-3	5.5	December	5.5

Vernonia			
Year	**Annual Snowfall (inches)**	**Peak Snowfall Month**	**Peak Monthly Snowfall (inches)**
1967-8	18.1	January	18.1
1968-9	47.6	January	22.6
1970-1	43.8	January	17.5
1972-3	13.0	December	14.5
1975-6	12.1	February	7.5
1978-9	26.2	January	11.0
1979-80	16.0	January	10.5
1981-2	20.3	January	11.8
1984-5	12.5	February	6.1
1985-6	25.3	November	16.2
1988-9	12.0	February	6.4
1989-90	23.9	February	23.7

In addition to snow events, Columbia County is also subject to ice storm and freezing rain events. For example, the winter storm in January 2004 had 8” to 12” of snow, followed by about ½” to ¾” of ice. This storm resulted in considerable disruption of traffic in many portions of Columbia County. Ice storms and freezing rain are fairly common, especially along the Columbia River when cold air near the ground coincides with warm moist air at higher altitudes.

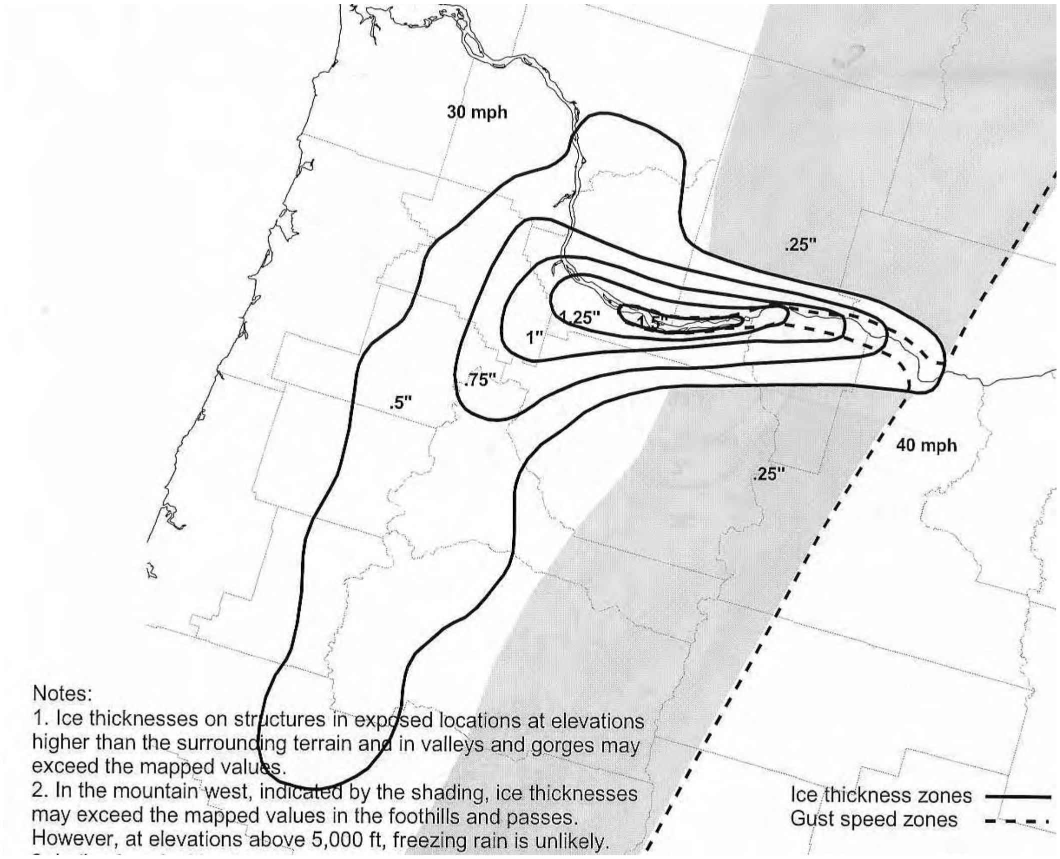
The National Climatic Data Center (NCDC) database shows eight ice storm or freezing rain events for Columbia County between 1993 and 2004. Most of these were relatively minor events with increased traffic accidents due to ice on the roads, with some tree falls and localized power outages. Website addresses for NCDC and the state and county storm event database are: www.ncdc.noaa.gov and http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms, respectively.

The most significant ice storm event occurred between December 26th and 29th in 1996, with up to 4 or 5 inches of ice in the Columbia Gorge. Interstate 84 was closed for 4 days. There were hundreds of downed trees and power lines, with widespread power outages in the greater Portland area, including portions of Columbia County.

Probabilistic ice storm data showing ice thicknesses with return periods from 50 years to 400 years are given in a recent draft report for FEMA and the National Institute of Building Sciences: Extreme Ice Thicknesses from Freezing Rain (Kathleen F. Jones, US Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, May 28, 2004). The 50-year return period ice thickness map (Figure 7.9 below) shows about 0.5” of ice for Columbia County, with maximum ice thicknesses in southeastern Columbia County and decreasing towards northwestern Columbia County. Typical 100-year and 400-year ice thicknesses for Columbia County are about 0.75” and 1.0”, respectively.

For Columbia County, ice thicknesses in 50-year or more severe events are high enough (0.5” or greater) to cause substantial damage, especially to trees and utility lines.

Figure 7.9
50-Year Ice Thickness from Freezing Rain



7.5 Other Severe Weather Events

The National Oceanic and Atmospheric Administration (NOAA), which includes the National Weather Service, also includes the National Climatic Data Center (NCDC). The NOAA and NCDC websites have a vast amount of historical information on severe weather events throughout the United States. These databases can also be searched by State and County to obtain more localized information. Website addresses are: www.noaa.gov and www.ncdc.noaa.gov, for NOAA and NCDC, respectively. The state and county storm event database can be found at:

http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms. Unless otherwise referenced, all of the storm event data below for Columbia County are from the state and county storm event database referenced above.

<u>Severe Thunderstorms and Hail Events</u>

The NCDC database lists 21 thunderstorm and high wind events in Columbia County since 1993, but all of these appear to be winter storm events rather than thunderstorm events. The thunderstorm events in Columbia County are typically too minor to be recorded as significant storm events. Nevertheless, thunderstorm events in Columbia County can occasionally cause locally high winds with tree falls which may affect roads, utility lines, and buildings.

The NCDD data base listed two hail events for Columbia County : July 15, 1955 and July 31, 1995, both of which were reported to have 1" hail. No damage reports were available.

Hail events certainly occur in Columbia County, generally during summer months. However, hail damage is generally minor and few practical mitigation alternatives are applicable to hail, other than taking shelter and moving vehicles to garages when possible.

Lightning

Nationwide, lightning is the number two weather related killer nationwide, second only to floods. NOAA data show that lightning causes about 90 deaths per year, with at least 230 injuries (NOAA Technical Memorandum NWS SR-193, 1997). Lightning injuries appear to be systematically underreported and thus the actual injury total is most likely significantly higher.

For Oregon, casualties from lightning are very low, with totals of only 7 deaths and 19 injuries reported over a 35 year period (NOAA). Thus, the level of risk posed by lightning strikes in Columbia County, while not zero, is very low. Public education about safe practices during electrical storms is the only available mitigation measure to reduce casualties from lightning. Lightning strike damage to buildings or infrastructure is generally relatively minor and few practical mitigation alternatives are applicable to lightning, other than installing lightning arrestors on critical facilities subject to lightning damage.

Tornadoes

Tornadoes also do occur occasionally in Oregon. However, Oregon is not among the 39 states with any reported tornado deaths since 1950. A compilation of historical tornadoes in Oregon by the National Weather Service includes two tornadoes in Columbia County (http://nimbo.wrh.noaa.gov/Portland/tornado.html). in August 28, 1978 a small tornado near Scappoose damaged a mobile home. On November 11, 1965, a small tornado in Rainier destroyed two buildings, with the tornado path being about one-half mile long and 15 to 20 yards wide. Several other tornadoes have occurred in nearby counties, including Clatsop and Multnomah.

Climate and weather conditions in Oregon and specifically in Columbia County make the occurrence of major tornadoes unlikely. The most practical mitigation actions for tornadoes are public warnings and taking shelter to minimize the potential for deaths and injuries.

7.6 Winter Storm Risk Assessment

Winter storm flooding and wind impacts may affect both infrastructure and buildings. Localized flooding from winter storms very commonly affects the transportation system, especially roads. Severe winter storms will result in numerous road closures due either to washouts or due to depth of water on road surfaces. Such localized flooding also affects buildings located in the flooded areas. Additional road closures are likely in some events from landslides/mudslides as well as from snow/ice storms.

Wind impacts from winter storms arise primarily from tree falls, which may affect vehicles and buildings, to some extent, but whose primary impact is often on utility lines, especially electric power lines. Widespread wind damages may result in widespread downing of trees or tree limbs with resulting widespread downage of utility lines. Such tree-fall induced power outages affect primarily the local electric distribution system, because transmission system cables are generally less prone to tree fall damage because of design and better tree-trimming maintenance. In severe wind storms, direct wind damage or wind driven debris impacts on buildings cause building damages, especially for more vulnerable types of construction such as mobile homes.

As discussed above in Section 7.1, both winter storm flood hazards and winter storm wind hazards have highly localized impacts. The location and severity of such impacts depend very strongly on specific local conditions. Therefore, it is difficult to make regional risk assessment or loss estimates from mapping the hazards and overlaying the inventory: such a risk assessment simply requires too much detailed data which are not available.

An alternative approach is to document the severity and locations of winter storm flood and wind damage from the pattern of historical events. This approach is illustrated by the brief narratives above for selected winter storm events in Columbia County.

For more quantitative risk assessment of localized flooding and wind damages arising from winter storms, the best approach is to systematically gather data on sites of repetitive damages due to localized flooding or wind damages. By documenting (and mapping using GIS) the sites of repetitive damage events, along with documentation of the type and cost of damages and losses, the most seriously impacted sites can be clearly identified. Clearly, such repetitive loss sites with significant damages are likely candidates for mitigation actions.

The probable impacts of winter storms on Columbia County are summarized below in Table 7.10.

Table 7.10
Probable Impacts of Winter Storms on Columbia County[1]

Inventory	Probable Impacts
Portion of Columbia County affected	Entire County may be affected by road closures or loss of electric power; otherwise direct damages to buildings and infrastructure are likely to be localized and relatively minor
Buildings	Isolated minor damage from tree falls, some buildings affected by flood damage in major storms, especially in the storm water drainage problem areas identified in Section 6.3
Streets within communities	Minor road closures due to tree falls and flooding; limited impact because of short detour routes within communities
Roads within and to/from Columbia County	Potential closures of some roads and major highways due to snow, debris flows or landslides, localized flooding and tree falls
Electric power	Loss of electric power may be localized due to tree falls on local distribution lines or affect larger areas if tree falls affect transmission lines
Other Utilities	Generally minor or no impacts on other utilities from winter storms
Casualties	Small potential for casualties (deaths and injuries) from tree falls or contact with downed power lines

[1] These winter storm impacts include localized flooding and the effects of wind, snow, and ice.

Critical Facilities that are needed during an emergency event must have reliable back-up power to ensure public safety. The following buildings have no backup power currently. The County encourages property owners to consider generators either manually or automatic start for these specific locations:

Building Type	Location	Jurisdiction
Fire Stations	76015 Atkins Road	Clatskanie
	80694 Mayger Hill Road	Clatskanie
	797 Quincy-Mayger Road	Clatskanie
	400 G Street	Columbia City
	19260 NW Cleetwood	Portland/Scappoose
Police Stations	195 S.E. 2nd Street	Clatskanie
	33568 E. Columbia Ave	Scappoose
City Halls/County Gov.	33568 E. Columbia Ave	Scappoose
	265 Strand Street	St. Helens
	260 Strand Street	St. Helens

7.7 Mitigation of Winter Storm Impacts

Potential mitigation projects for winter storms may address any of the aspects of such storms, including floods, winds, and landslides (see Chapter 8). See also Chapter 13 for additional discussion of the disruptions to utility and transportation systems.

For winter storm flooding, the mitigation measures discussed in Chapter 6 (Floods) for local storm water drainage flooding are exactly the mitigation measures for the flood aspects of winter storms. Common mitigation projects include: upgrading storm water drainage systems, construction of detention basins, and structure-specific mitigation measures (acquisition, elevation, flood proofing) for flood-prone buildings. For roads subject to frequent winter storm flooding, possible mitigation actions include elevation of the road surface and improved local drainage. For utilities subject to frequent winter storm flooding, possible mitigation actions include improved local drainage, elevation or relocation of the vulnerable utility elements to non-flood prone areas nearby.

For wind effects of winter storms, the most common and most effective mitigation action is to increase tree trimming effects, because a high percentage of wind damage to utilities, buildings, vehicles, and people arises from tree falls. Trimming of trees subject to falling on utilities, buildings, vehicles, and people is an effective mitigation measure. However, economic, political and esthetic realities place limits on tree trimming as a mitigation action. Future wind storm damage in Columbia County could be almost eliminated by cutting down all large trees along roads or in populated areas. Obviously, such an extreme mitigation measure is neither practical nor desirable for many reasons.

Effective tree trimming mitigation programs focus on limited areas where tree falls have a high potential to result in major damages and economic losses. High priority areas include examples such as the following:

1. Transmission lines providing electric power to the area,
2. Major trunk lines providing the backbone of the electric power distribution system within the area
3. Distribution lines for electric power to critical facilities in the area,
4. Specific circumstances where falling of large trees poses an obvious threat to damage buildings and/or people or close major transportation arteries.

Mitigation measures for snow and ice are limited, although tree trimming efforts, discussed above under wind, also reduce the impact of snow and ice on trees, roads, and utility lines. For the most part, dealing with snow and ice storms are primarily issues of emergency planning, along with response and recovery actions.

Similarly, few mitigation measures appear practical for Columbia County for other types of severe weather, including severe thunderstorms, hail, lightning, and tornadoes. For such weather events, public education about safe practices and emergency planning, response and recover appear to be the most useful pragmatic actions.

The following table contains winter storm mitigation action items from the master Action Item table in Chapter 4.

Table 7.10
Winter Storm Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed: Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Winter Storms Mitigation Action Items								
Short-Term #1	Complete the inventory of locations in Columbia County subject to frequent storm water flooding	Columbia County Roads, cities	Ongoing	X	X	X	X	X
Short-Term #2	Enhance tree trimming efforts especially for transmission lines and trunk distribution lines.	BPA, West Oregon Electric Coop, local PUDs	Ongoing	X	X	X	X	X
Short-Term #3	Encourage prudent tree planting (avoid service lines) and safe, professional tree trimming where necessary	Columbia County Hazard Mitigation Advisory Committee	Ongoing	X		X	X	
Short-Term #4	Ensure that all critical facilities in Columbia County have backup power and emergency operations plans to deal with power outages	Local emergency services, Columbia County Hazard Mitigation Advisory Committee	1-2 Years	X	X			
Long-Term #1	For locations with repetitive flooding and significant damages or road closures, determine and implement mitigation measures such as upsizing culverts or storm water drainage ditches	Columbia County Roads, cities	Ongoing	X	X	X	X	X
Long-Term #2	Consider upgrading lines and poles to improve wind/ice loading, undergrounding critical lines, and adding interconnect switches to allow alternative feed paths and disconnect switches to minimize outage areas	BPA, West Oregon Electric Coop, local PUDs	5 Years	X	X	X	X	X
Long-Term #3	Encourage new developments to include underground power lines	Columbia County Land Development Services, cities	ongoing	X	X	X	X	X

CHAPTER EIGHT

8.0 LANDSLIDES

8.1 Landslide Overview and Definitions

The term “landslide” refers to a variety of slope instabilities that result in the downward and outward movement of slope-forming materials, including rocks, soils and artificial fill. Four types of landslides are distinguished based on the types of materials involved and on the mode of movement. These types of landslides are illustrated in Figures 8.1 to 8.4 and described below.

Rockfalls are abrupt movements of masses of geologic materials (rocks and soils) that become detached from steep slopes or cliffs. Movement occurs by free-fall, bouncing and rolling. Falls are strongly influenced by gravity, weathering, undercutting or erosion.

Rotational Slides are those in which the rupture surface is curved concavely upwards and the slide movement is rotational about an axis parallel to the slope. Rotational slides usually have a steep scarp at the upslope end and a bulging “toe” of the slid material at the bottom of the slide. Rotational slides may creep slowly or move large distances suddenly.

Translational Slides are those in which the moving material slides along a more or less planar surface. Translational slides occur on surfaces of weaknesses, such as faults and bedding planes or at the contact between firm rock and overlying loose soils. Translational slides may creep slowly or move large distances rather suddenly.

Debris Flows (also called debris torrents) are surficial movements in which loose soils, rocks and organic matter combine with entrained water to form slurries that flow rapidly downslope or within a stream channel. They may travel hundreds to thousands of feet.

All of these types of landslides may cause road blockages by dumping debris on road surfaces or road damages if the road surface itself slides downhill. Utility lines and pipes are prone to breakage in slide areas. Buildings impacted by slides may suffer minor damage from small settlements or may be completely destroyed by large ground displacements or by burial in slide debris. Also, as evidenced by 1996 winter storms in Oregon, landslides may also result in injuries or fatalities.

There are three main factors that determine susceptibility (potential) for landslides:

1. slope steepness,
2. soil/rock characteristics or landform shape, and
3. subsurface water.

Loose, weak rock or soil is more prone to landslides than is more competent rock or dense, firm soils. For landslides, the term competent rock means solid, coherent rock with good bearing strength that is less prone to landslides. Finally, water saturated soils or rock with a high water table are much more prone to landslides because the water pore pressure decreases the shear strength of the soil and thus increases the probability of sliding.

Figures 8.1 to 8.4
Major Types of Landslides

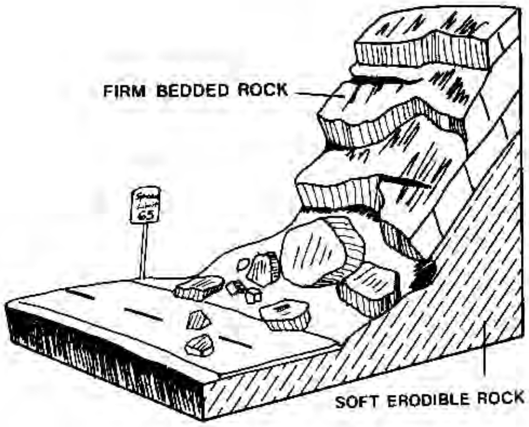


Fig. 8-1. Rockfall

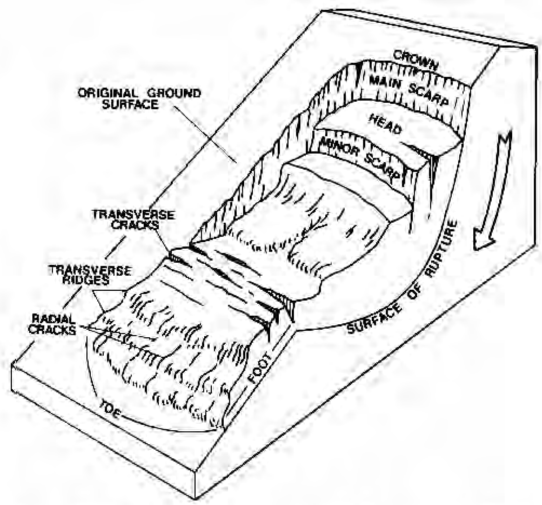


Fig. 8-2. Rotational Landslide

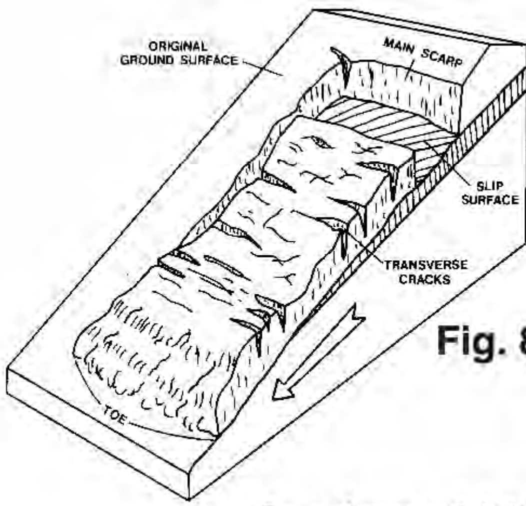


Fig. 8-3. Translational Landslide

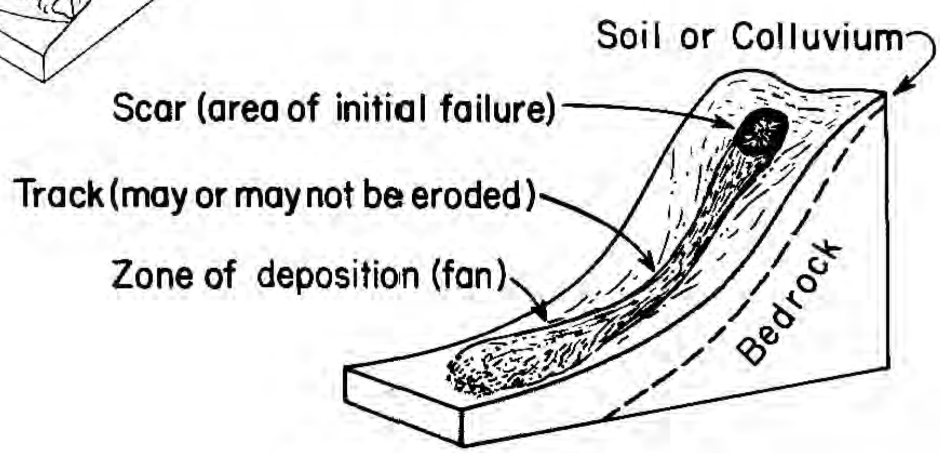


Fig. 8-4. Debris Flow

The water content of soils/rock is a major factor in determining the likelihood of sliding for any given slide-prone location. Thus, the vast majority of landslides happen during rainy months, when soils are saturated with water.

Landslides may happen at any time of the year. In addition to landslides triggered by a combination of slope stability and water content, landslides may also be triggered by earthquakes. Areas prone to seismically triggered landslides are generally the same as those prone to ordinary (i.e., non-seismic) landslides. As with ordinary landslides, seismically triggered landslides are more likely for earthquakes that occur when soils are saturated with water.

Debris flows and landslides are a very common occurrence in hilly areas of Oregon, including Columbia County. Many landslides occur in undeveloped areas and thus may go unnoticed or unreported. For example, the Oregon Department of Geology and Mineral Industries (DOGAMI) conducted a statewide survey of landslides from four winter storms in 1996 and 1997 and found 9,582 documented landslides, with the actual number of landslides estimated to be many times the documented number. For the most part, landslides become a problem only when they impact developed areas and have the potential to damage buildings, roads, or utilities.

8.2 Landslide Hazard Assessment for Columbia County

The February 1996 winter storm contributed to landslides throughout western Oregon, including Columbia County. The February storm was an intense, long duration rainfall event that was preceded by long periods of winter rainfall and a heavy snowfall in the mountains. A tropical jet stream flow brought intense warm rain that melted the snow, which contributed to the timing and runoff from the already wet soil. This resulted in numerous slope failures on slopes that were already slide-prone.

Some of the significant slides in Columbia County that affected roads during this 1996 event are listed below in Table 8.5. Other identified slide problem areas in Columbia County are shown in Table 8.6.

Table 8.5
Slide Problem Areas for February 1996 Winter Storm

1996 Slide Locations[1]
north side of Highway 30 just east of Clatskanie
west side of Highway 30 near Prescott
west side of Highway 30 at two location just south of Goble
west side of Highway 30 near Tide Creek Road
south side of Colvin Road near Marshland
Johnson Road and Olson Road south of Clatskanie
Rainier Road, west of Rainier
Neer City Road just east and south of Rainier
Nicolai Road and Nicolai Cutoff Road west of Goble
Tide Creek Road west of Deer Island
Pittsburg Road west of Columbia City
Meissner Road west of Shiloh Basin
Canyon Road and Mtn. View Road west of Scappoose
Scappoose-Vernonia Road just east of Pittsburg
Scappoose-Vernonia Road west of Chapman
Scappoose-Vernonia Road east of Walker Road

[1] Hand drawn map provided by John Clouse, former Columbia County Emergency Management Director.

Table 8.6
Other Slide Problem Areas

Emergency Transportation Routes	Slide Problem Areas
Scappoose-Vernonia Road	19 locations between milepost 1.9 and milepost 16.6
Apiary Road	4 locations between milepost 8.0 and milepost 16.2

Other Slide Problem Locations
Vernonia[1]
Bridge St. between California Ave. and Texas Ave.
Corey Hill: towers for radio, cable, cellular
Tide Creek Road. Mileposts 0.3 and 2.8
Nicolai Road, Milepost 1.4
Nicolai Cutoff Road, Milepost 0.5
Colvin Road, Milepost 0.1 to 3.0
Near City Road, Milepost 9.0
Meissner Road, Milepost 3.6
Oester Road, Milepost 0.5
Mustola Road, Milepost 0.25

[1] Chief Workman, August 23, 2004
Other data from Columbia County Roads, November 2004

ODF Study of 1996 Winter Storm Landslides

The Oregon Department of Forestry conducted a 3-year study of the impacts and landslides for two 1996 winter storms (ODF, Storm Impacts and Landslides of 1996: Final Report, June, 1999). This highly technical study is primarily focused on identifying specific slope and forest characteristics that relate to probabilities and severities of landslides. The ODF study included eight study areas, one of which was in Columbia County, a 3.4 square mile area near Vernonia. The Vernonia study area included 19 slides, 3 on roads and 16 in non-road areas. This ODF study provides important technical data on landslides, but does not provide a detailed inventory of landslide prone areas in Columbia County, outside of the very small study area. This study is thus of limited use for mitigation planning purposes.

General conclusions drawn from the ODF study include the following. The highest hazard for shallow rapid landslides in western Oregon occurs on slopes of over 70% to 80% steepness (depending on landform and geology). There is a moderate risk of these landslides on slopes between 50% to 70%. Landslides that entered stream channels during the storms of 1996 typically occurred in very steep landscapes, or adjacent to stream channels. Even landslides that initiate as relatively small debris slides can mobilize into debris flows that mobilize large volumes of material and move long distances. Landslide characteristics vary greatly according to local landscape and geologic factors. Debris flows that were not initiated by up-slope landslides were uncommon. A debris flow occurs when landslides move downslope, scouring or partially scouring soils from the slope along its path.

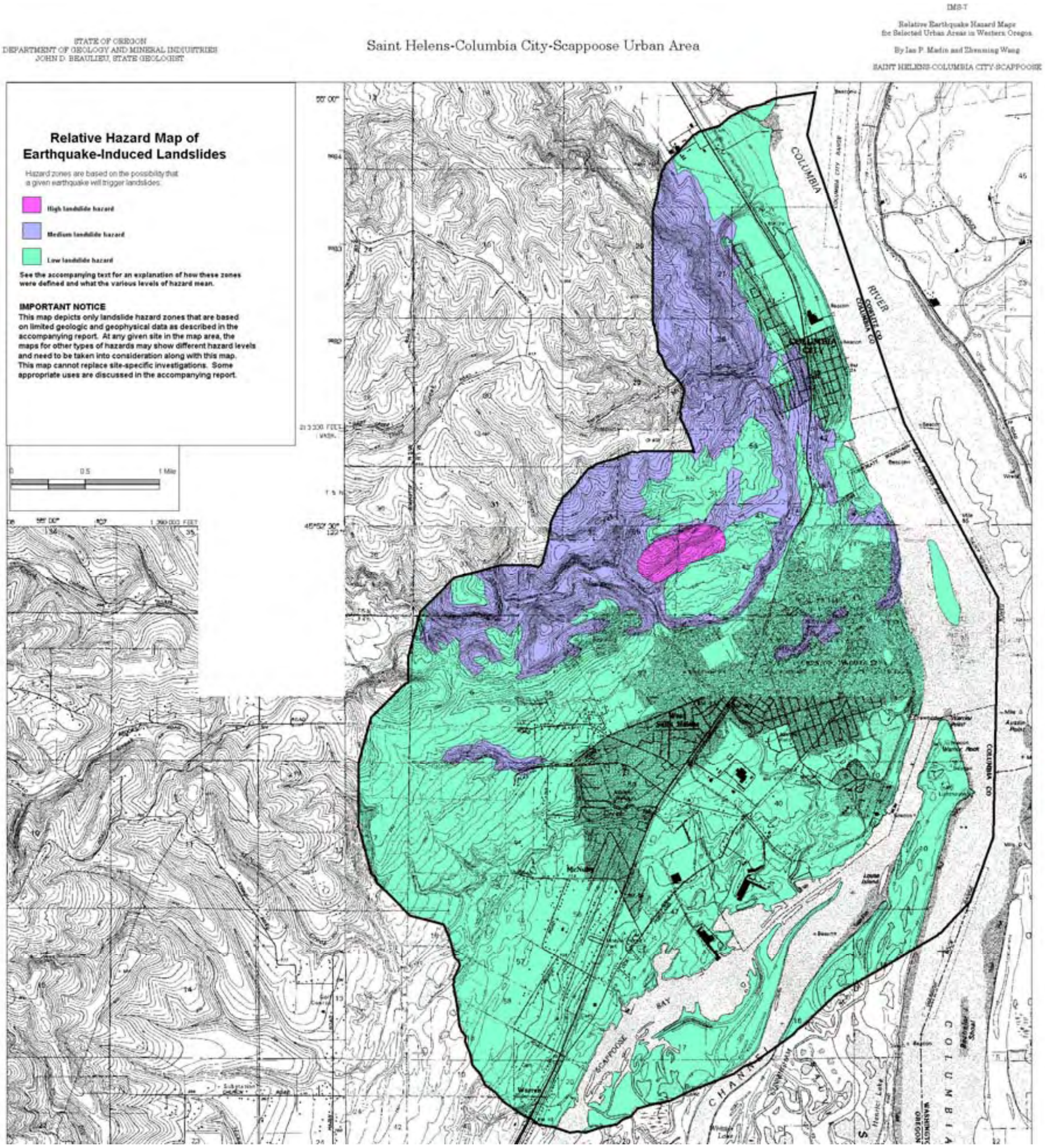
DOGAMI Earthquake–Induced Landslide Maps

For Columbia County, the Oregon Department of Geology and Mineral Industries (DOGAMI) has produced hazard maps for earthquake-induced landslides for three communities in Columbia County: Columbia City, St. Helens and Scappoose (Relative Earthquake Hazard Maps for Selected Urban Areas in Western Oregon, IMS-7, 1999). Areas prone to earthquake induced landslides are generally also prone to non-earthquake induced landslides as well. However, these DOGAMI maps have low spatial resolution, with large areas of significant slope characterized as moderate or high landslide potential. These maps do not identify specific locations of active slides.

These DOGAMI landslide maps are shown as Figures 8.7 and 8.8.

It is also important to note that while an earthquake may trigger numerous landslides, the return interval of major earthquake-induced landslides may be several hundred years, while the return interval for major storm-induced landslides may be only about 10 years. Therefore, for Columbia County the probability of occurrence for major storm-induced landslides greatly exceeds that for earthquake-induced landslides.

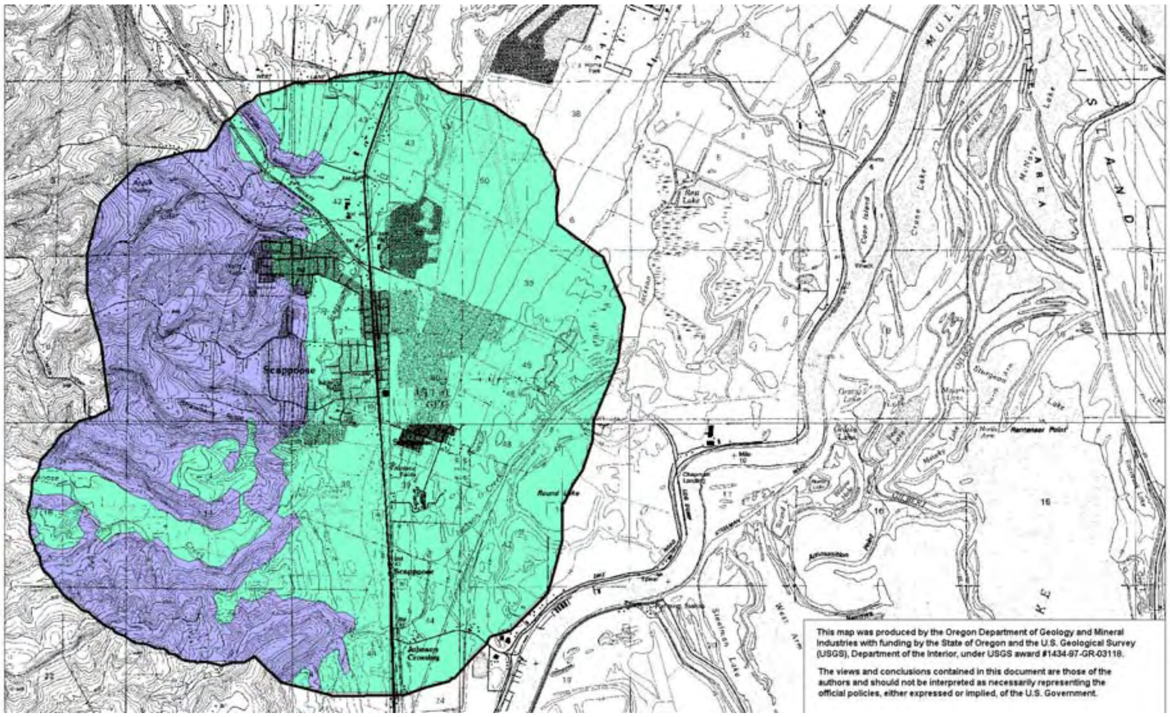
Figure 8.7
DOGAMI Landslide Hazard Map for St. Helens and Columbia City



For St. Helens and Columbia City, there is one small area mapped as high landslide potential and significant areas mapped as medium landslide potential. These maps are based on available data and should not be over interpreted to represent exact locations of landslides. Not all areas within given categories of landslide potential may be as classified: some areas may have higher potential and some areas may have lower potential.

Detailed site-specific geotechnical studies are necessary to determine the level of landslide hazard at any specific location. More detailed landslide hazard assessment at specific locations requires a site-specific analysis of the slope, soil/rock and groundwater characteristics at a specific site. Such assessments are often conducted prior to major development projects in areas with moderate to high landslide potential, to evaluate the specific hazard at the development site.

Figure 8.8
DOGAMI Landslide Hazard Map for Scappoose



The Scappoose landslide maps shows significant portions of the hilly areas in the western portion of Scappoose as being in medium landslide potential areas. The caveats noted above for the St. Helens map also apply to the Scappoose map. Both maps are from DOGAMI's publication Relative Earthquake Hazard Maps for Selected Urban Areas in Western Oregon (IMS-7, 1999).

NOAA/Oregon Climate Service Debris Flow Maps

NOAA and the Oregon Climate Service have prepared debris flow maps for all counties in western Oregon. These maps show numerous areas within Columbia County subject to debris flows.

Columbia County Landslide Hazard Map

Ideally, a county-wide landslide hazard map for all types of landslides could be developed for Columbia County, using the existing maps described above, slope data, rainfall data, soil/rock data, as well as historical data on active slide areas. However, such a county-wide map does not currently exist.

8.3 Landslide Risk Assessment for Columbia County

In this section, we review a methodology for estimating landslide losses due to winter storm induced landslides. Winter storms with intense rainfalls are the most common trigger for landslides in Oregon, including landslides within Columbia County. Major storms with intense rainfall can result in numerous landslides in slide-prone areas.

Of course, at any given slide-prone location, landslides can occur with or without winter storms, but such occurrences are isolated and not likely to result in the type of fairly widespread landslide impacts that are possible during winter storms. Widespread landslides can also be triggered by earthquakes, especially if the earthquake occurs during the rainy season when soils are saturated. However, since the probability of storm-induced landslides is greater than that for earthquake-induced landslides, it makes sense to focus mitigation efforts on storm related landslide hazards. See Chapter 10 (Earthquakes) for further commentary on earthquake-triggered landslides.

As with any risk assessment, a quantitative landslide hazard assessment requires overlay of landslide hazard (frequency and severity of landslides) with the inventory exposed to the hazard (value and vulnerability) by considering:

1. Extent of landslide susceptible areas,
2. Inventory of buildings and infrastructure in landslide susceptible areas,
3. Severity of winter storm event (inches of rainfall in 24 hours),
4. Percentage of landslide susceptible areas that will move and the range of movements (displacements) likely, and
5. Vulnerability (amount of damage for various ranges of movement).

For Columbia County, many high landslide potential areas are in hilly forested areas owned by timber companies. Landslides in these areas may damage or destroy some timber and impact logging roads.

Many of the major highways in Columbia County are at risk for landslides at one or more locations with a high potential for road closures and damage to utility lines. Especially in the interior portions of Columbia County, with a limited redundancy of the road network, such road closures may isolate some communities. In addition to direct landslide damages to roads and highways, affected communities are also subject to the economic impacts of road closures due to landslides, which may disrupt access/egress to/from communities.

In addition, portions of most communities in Columbia County are in moderate or high landslide potential areas (cf. DOGAMI maps referenced above). In these areas, landslides may damage homes, utilities and roads in the area, and pose some level of life safety risk for residents.

For debris flows, Oregon has a warning system developed by the Department of Forestry (ODF), the Department of Geology and Mineral Industries (DOGAMI), the Office of Emergency Management (OEM), and the Department of Transportation (ODOT). Throughout the rainy season, ODF meteorologists will forecast storms and monitor rainfall at several locations in western Oregon. The warning system will be activated during expected and actual periods of intense rainfall that may trigger debris flows.

Debris flow *advisories* alert people to the possibility of intense rainfall that could trigger debris flows. Debris flow *warnings* are issued when a rainfall threshold is reached or nearly reached, particularly at night, when debris flows are more difficult to detect.

The potential impact of debris flows and landslides on Columbia County are summarized below in Table 8.9.

Table 8.9
Potential Impacts of Debris Flows and Landslides on Columbia County

Inventory	Probable Impacts
Portion of Columbia County affected	Landslides and debris flows are possible in any of the higher slope portions of Columbia County, including much of the interior of the county.
Buildings	Buildings at high risk include those situated below steep slopes or at the mouth of drainage basins. Most buildings in landslide potential areas are residential; the inventory of landslide prone buildings (including critical facilities) in Columbia County is not yet determined.
Streets within communities	Minor road closures possible from landslides; limited impact because of short detour routes within communities.
Roads within and to/from Columbia Cour	Potential closures of major highways due to landsides, including Highway 30 in several locations and most of the interior highways. Potential to isolate communites, especially in the interior portions of the county.
Electric power	Potential for localized loss of electric power due to landslides affecting power lines in or near Columbia County
Other Utilities	Potential outages of water, wastewater and natural gas from pipe breaks from landslides. Probable impacts are very localized.
Casualties	Landslides that impact buildings or roads could result in a small number of casualties (deaths and injuries)

8.4 Mitigation of Landslide Risk

In terms of public safety there are two broad types of landslides to be concerned about: 1) those that can sometimes be solved by engineering methods (such as road fill failures and slow moving landslides, and 2) those that can typically only be solved through prudent location of buildings, roads, and utilities (debris flows, debris torrents). It is important to make this distinction to understand that some landslide problems do not lend themselves to engineering solutions.

Mitigation of landslide risks is often quite expensive. In some cases, slope stability can be improved by addition of subsurface drainage to reduce pore water pressure, by construction of appropriate debris dams, retaining walls or by other types of geotechnical remediation. In some cases, buildings can be hardened to reduce damages. An alternative mitigation strategy for already built buildings or infrastructure with high potential for landslide losses is to relocate the facilities outside of known slide areas.

Mitigation of landslide risk can also be accomplished by effective land use planning to minimize development in slide-prone areas. Generally, such land use planning requires rather detailed geotechnical mapping of slide potential so that high hazard areas can be demarcated without unnecessarily including other areas of low slide potential.

The impacts of slide damage on road systems can also be partially addressed by identifying areas of high slide potential or of repetitive past slide damages so that alternative routes for emergency response can be pre-determined.

The following table contains landslide mitigation action items from the master Action Items table in Chapter 4.

Table 8.10
Landslide Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed: Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Landslide Mitigation Action Items								
Short-Term #1	Complete the inventory of locations where critical facilities, other buildings and infrastructure are subject to landslides	Columbia County Land Development Services, cities (public works)	1-2 Years	X	X	X	X	X
Long-Term #1	Consider landslide mitigation actions for slides seriously threatening critical facilities, other buildings or infrastructure	Columbia County Hazard Mitigation Advisory Committee	5 Years	X	X	X	X	X
Long-Term #2	Limit future development in high landslide potential areas	Columbia County Land Development Services, cities	Ongoing	X	X	X	X	X

CHAPTER NINE

9.0 WILDLAND/URBAN INTERFACE FIRES

Fire has posed a threat to mankind since the dawn of civilization. Fires may cause significant damage to property and may also result in deaths and injuries. For the purposes of mitigation planning, we consider three types of fires: structure fires, wildland fires, and wildland/urban interface fires.

Structure fires are fires in urban, suburban or rural areas where structures (and contents) are the primary fire fuel. Structure fires predominantly affect residential and other ordinary buildings. However, structure fires may also affect other types of structures, including bulk fuel storage or hazmat facilities. Fires affecting these types of facilities may be particularly hazardous to both firefighters and nearby residents.

> Fires on pipelines and transportation fires (road, rail, air) generally have similar characteristics to fires at hazmat sites or structures.
>
> Wildland fires are fires where vegetation (grass, brush, trees) is the primary fire fuel.
>
> Wildland/urban interface fires are fires where the fire fuel includes both structures and vegetation.

This chapter considers all types of fires. However, the emphasis is on wildland/urban interface fires because such fires are analogous to natural disasters in that they may affect large developed areas and large numbers of people. Thus, wildland/urban interface fires are of special concern for mitigation planning. Most structure fires are limited to one structure. Structure fires involving bulk fuel, hazardous materials, pipelines, and transportation fires have many similarities in response strategies and impacts to the more general discussion of Hazmat Incidents, as discussed in Chapter 14. Wildland fires, by definition, affect wildland with generally limited impacts on developed areas.

In 1999, according to National Fire Protection Association (NFPA) data there were over 30,000 fire agencies in the United States. Nearly 90% of these are all volunteer or mostly volunteer fire districts with only about 11% being career or mostly career fire fighting agencies. However, the career fire agencies tend to serve large communities. Thus, about 60% of the total population in the United States is served by career agencies, while about 40% is served by volunteer fire districts.

In Oregon, historical fire statistical data are generally good because each local fire agency is required to file reports of every fire incident with the State Fire Marshal's Office. National fire statistics are available through the National Fire Incident Reporting System (NFIRS) that is maintained by the U.S. Fire Administration (USFA). National fire data are published by the USFA and by the National Fire Protection Association (NFPA), a private association. THE NFIRS database contains incident reports from 49 states and over 11,000 fire agencies and includes about one-third of all reported fires that occur annually in the United States.

Columbia County includes a mix of forest, brush, grasslands, and agricultural land, as well as developed land. Vegetation patterns for lands surrounding population centers in Columbia County vary, but all of the cities and all of the smaller rural communities have forested areas in close proximity to developed areas.

The following 17 communities in Columbia County have been designated as "Interface Communities" that are within or adjacent to areas subject to serious wildfire hazards and are in the vicinity of Federal lands.

Table 9.1
Interface Communities in Columbia County[1]

Interface Communities	
Alston	Rainier
Clatskanie	St. Helens
Columbia City	Scappoose
Deer Island	Spitzenburg
Goble	Swedetown
Mist-Birkenfeld	Vernonia
Pittsburg	Warren
Prescott	Yankton
Quincy	

[1] Federal Register, Volume 66, pp. 43383-43435. August 21, 2001

9.1 Fire Primer

For this section of the multi-hazard mitigation plan, the focus is on wildland/urban interface fires. However, to provide a context for the discussion of wildland/urban interface fires, we first briefly review the characteristics of all three types of fires.

9.1.1 Structure Fires

Structure fires are fires in urban, suburban or rural areas where structures (and contents) are the primary fire fuel. Ever since the first volunteer fire agency was established in the United States in 1648, the primary focus of most fire agencies has been to reduce the risk of structure fires. Historically, structure fires have posed the greatest threat to both property and life safety.

In dealing with structure fires, fire agencies have three primary objectives: first, minimize casualties; second, prevent a single structure fire from spreading to other structures; and third, minimize damage to the structure and contents.

In recent decades, the rate of structure fires (number of fires per year per 1,000 structures) and the total number of structure fires have declined sharply even though the number of structures has increased with increasing population. This decrease in structure fires is attributed to a number of factors, most importantly better building codes that have reduced both the numbers of ignitions and the likelihood that a small fire will quickly spread. Building code improvements include better wiring, smoke detectors, better design of furnaces, reduced use of portable heating devices, and the widespread use of fire resistant materials such as sheet rock and non-flammable roofs.

In addition to the building code improvements, fire suppression capabilities have also improved over the decades. Improved water systems provide greater and more reliable water flows for fire suppression efforts. Improved fixed fire protection systems including notification systems, sprinklers, and fire barriers along with better training, better communication equipment, better fire fighting equipment and apparatus have also all contributed to improved fire suppression capabilities. Widespread use of smoke detectors has also reduced the number of casualties by providing occupants more warning time for evacuation. In recent decades, a decline in the percentage of smokers in the United States has also had a beneficial impact on the rate of accidental ignitions from careless handling of smoking materials.

The decrease in the number of structure fires in recent decades has been accompanied by a corresponding decrease in the numbers of deaths from structure fires as shown below in Table 9.2.

Table 9.2
Recent History of Fire Deaths in the United States

Year	Fire Deaths[1]	
	U.S.	**Oregon**
1980	5,809	50
1990	4,162	33
2000	4,045	42
2002	3,380	45

1 Fire deaths are as estimated by the National Fire Protection Association (www.nfpa.org), with 2000 and 2002 Oregon data from Oregon Office of State Fire Marshal.

Despite the dramatic reductions over the decades, structure fires still cause a great deal of damage and many casualties. NFPA estimates for 2002 are that structure fires caused about 3,380 deaths and $10 billion in property damage.

In addition to dealing with structure fires, urban, suburban and rural fire agencies also deal with other common types of fires including vehicle fires, trash fires, and small debris or vegetation fires. For 2002, NFPA estimates for total fire agency responses to fires are as summarized below in Table 9.3.

Table 9.3
2002 NFPA Fire Statistics

Type of Fire	Fire Agency Responses
Structure Fires	519,000
Vehicle Fires	329,500
Fires Outside Structures	71,000
Rubbish Fires	204,000
Wildland Fires	399,000
All Other Fires	165,000
TOTAL	1,687,500

The complete NFPA fire statistics estimates are given in their report "Fire Loss in the United States During 2002," that is downloadable from their website (www.nfpa.org). Additional data are available at the USFA website (www.usfa.fema.gov).

9.1.2 Wildland Fires

Wildland fires are fires where vegetation (grass, brush, or trees) is the primary fire fuel. Wildland fires in Oregon typically occur in national or state forests and parks or in forest tracts of private land that may be owned by forest industries or by other private owners. By definition, wildland fires generally involve few or no structures. Fires that involve a mixture of vegetation and structures are considered wildland/urban interface fires and are discussed below in Section 9.1.3.

Fire suppression strategy for wildland fires is significantly different than for structure fires. For wildland fires, the most common suppression strategy is to contain the fire at its boundaries, to stop the spread of the fire and then to let the fire burn itself out. Fire containment typically relies heavily on natural or manmade fire breaks. Water and chemical fire suppressants are used primarily to help make or defend a fire break, rather than to put out an entire fire, as would be the case with a structure fire.

Fires that are purely wildland fires, without threatening structures, nevertheless cause timber resource losses and environmental and ecological damage. Wildland fires kill wildlife and damage habitat. Areas that have burned are also subject to erosion and landslides due to loss of ground cover. These effects also may negatively impact water quality by increasing turbidity. Wildland fires also may result in large fire suppression costs, with a potential for casualties among firefighting personnel. Historically, fire suppression strategy for wildland fires has generally been to try to minimize the acreage burned in each wildland fire, by applying the maximum available fire suppression resources and trying to contain each fire as quickly as possible.

In recent years, however, fire suppression strategy for wildland fires in federal forests has evolved substantially in two important aspects. First, to a greater extent than previously, wildland fires are being recognized as part of the natural ecology and natural life cycles of wildlands. Fires create open spaces with different habitats for both plants and animals than existed previously. Second, the emphasis on maximum suppression of wildland fires has resulted in many fires being smaller than would naturally occur. Because of the reduction in frequent, smaller fires, many wildland areas have developed extraordinarily high fuel loads. Thus, the potential for very large, catastrophic wildland fires may actually be increased by the effective suppression of smaller fires. In recent years, evolving strategies for dealing with wildland fires have focused more attention on fuel management. Strategies include more controlled burns and greater tolerance for allowing smaller fires to burn, with the objective of reducing fuel loads of smaller vegetation and thus reducing the potential for larger fires.

The above fire strategies are most applicable to lands managed as wilderness of natural areas. Fire protection strategies for commercial forest lands focus more on the value of wood fiber and thus fire protection for such areas is intended to minimize acreage burned and therefore to minimize value lost. The value protected is both the market value of the standing timber and the lost opportunity if a stand of timber is lost.

Wildfires may be started by natural causes, such as lightning strikes. US Forest Service data for the United States indicate that about 13% of wildfires are started by lightning. About 25% of wildfires are arson, while the rest are due to a variety of manmade causes including debris burns, discarded smoking materials, sparks from vehicles, sparks from power lines and so on. In Columbia County, because of local weather conditions, the proportion of wildfires started by lightning is significantly lower than the national data referenced above and the proportion of fires due to arson is also lower.

Wildfire hazard depends on three main factors: vegetative fuel load, weather, and topography.

There are several parameters that define the fire potential of vegetation. Vegetative fuel loads are typically expressed as tons per acre. The greater the amount of fuel loading the greater the amount of energy that will be released in a fire. Vegetative fuels are also classified by burn index, which is a measure of the amount of energy per pound of fuel. Fuels may also be classified by potential duration of burning. For example, wildfires fueled by grass may spread very quickly, but grass contains relatively little fuel energy and tends to burn out quickly. Wildfires fueled by larger vegetation may spread more slowly, but larger vegetation contains more fuel energy and tends to burn for a longer duration.

Moisture content of vegetative fuels is also a major determinant of wildland fire potential. The lower the moisture content the greater the fire potential. Moisture content at any given time depends on antecedent (before the given time) weather conditions. The moisture content of larger fuels (e.g., trees) depends on previous weather conditions over periods of several weeks or even months. The moisture content of smaller fuels (brush) depends on previous weather conditions over several days or a week or two. The moisture content of very small fuels (e.g., grasses) depends largely on previous weather conditions over a few hours or a day or two.

The fire hazard posed by vegetative fuel loads also depends on fuel continuity, both horizontally and vertically. Horizontal continuity, the distribution of fuels over the landscape, strongly affects the spread and containment of wildfires in a given geographic area. Vertical continuity of fuels, the linkage between fuels at ground level and tree crowns, also affects the fire potential. Forests with strong ladder fuels (understory growth between ground fuels and tree crowns) are more likely to have major fires involving tree crowns. Forests with limited ground fuels and little or no ladder fuels are much more likely to experience minor ground fires without a fire involving tree crowns.

Weather also has a profound impact on wildland fire potential. Weather conditions of high temperatures, low humidity, and high winds may greatly accelerate the spread of a wildland fire and make containment difficult or impossible. Changes in weather conditions can greatly accelerate a fire’s spreading rate. Many casualties have occurred when firefighting personnel are trapped by sudden bursts of fire spread in response to changes in wind conditions. For many larger fires, containment is possible only with a little help from mother nature via lower temperatures, reduced winds or significant rainfall.

Local topography is also a major factor in the spread of wildfires. Fires burn much more quickly up slope than they do down slope. Doubling a slope approximately doubles the rate of fire spread. Canyons, gulches and other local topographic effect can act as chimneys, intensifying fires in certain areas. Fires tend to slow at ridge tops and thus ridge tops are often chosen as locations for fire breaks.

Suppression of wildland fires depends on the three main factors - vegetative fuel load, weather, and topography - that, in combination, govern fire potential. High fuel loads, hot, dry, windy weather and steep slopes increase fire potential and make fire suppression much more difficult. Conversely, low fuel loads, cool, moist weather with low winds, and gentle slopes make fire suppression easier.

In addition, however, fire suppression also depends on two other important factors: availability of fire suppression resources and access. Fire suppression resources include firefighting personnel, equipment and apparatus, as well as water and chemical fire suppressants. The greater the availability of fire suppression resources, the more likely it is that a given fire will be contained quickly. Fire suppression also depends on access. Fires in remote areas without ground access via roads are more difficult to fight and thus harder to contain than are fires with better access for fire suppression crews and apparatus. Access and therefore effective response is partially a function of land management objectives. Lands managed for natural conditions (wilderness) where roads have not been built or the existing roads have been vacated, tend to have a much poorer fire suppression response than commercial forest lands where road systems are maintained.

In the 1930s, wildfires consumed an average of 40 to 50 million acres per year in the contiguous United States, according to US Forest Service estimates (US Forest Service, Managing the Impact of Wildfires on Communities and the Environment, September 8, 2000). By the 1970s, the average acreage burned had been reduced to about 5 million acres per year. Over this time period, fire suppression efforts were dramatically increased and firefighting tactics and equipment became more sophisticated and effective. For the 11 Western states, the average acreage burned per year since 1970 remained relatively constant at about 3.5 million acres per year.

However, because of this pattern of more effective suppression of wildland fires, the patterns and characteristics of wildland fires are changing. Vegetation species that would have normally been minimized by frequent fires became more dominant. Over time, many species have become susceptible to disease and insects, leading to an increase in dead and dying trees. The resulting accumulation of debris has created the types of fuels than promote intense, rapidly spreading fires. In many areas introduction of non-native species has also added to the fuel load. Decades old patterns of logging and fire suppression have also changed the characteristics of forests. Older forests were typically less dense, with smaller numbers of larger, more fire-resistant trees. Newer forests are denser with larger numbers of smaller less fire-resistant trees. Younger trees have thinner bark and are more susceptible to fire injury and thus may also sustain more economic damage than an older stand. In combination these effects over the last several decades have resulted in many recent wildland fires that are hotter, faster, and larger than those experienced in the past.

9.1.3 Wildland/Urban Interface Fires

Wildland/urban interface fires are fires where the fuel load consists of both vegetation and structures. In Oregon, as elsewhere in the United States, recent patterns of development have lead to increasing numbers of homes built in areas subject to wildland fires. Development in areas subject to wildland fires may pose high levels of life safety risk for occupants as well as high levels of fire risk for homes and other structures.

Urban or suburban areas may have a significant amount of landscaping and other vegetation. However, in such areas the fuel load of flammable vegetation is not continuous, but rather is broken by paved areas, open space and areas of mowed, often irrigated, grassy areas with low fuel loads. In these areas, the vast preponderance of all significant fires are single structure fires. The combination of separations between buildings, various types of fire breaks, and generally low total vegetative fuel loads make the risk of fire spreading much lower than in wildland areas. Furthermore, most developed areas in urban and suburban areas have water systems with good capacities to provide water for fire suppression and organized fire agencies who typically respond quickly to fires, with sufficient personnel and apparatus to control fires effectively. Thus, in such areas the risk of a single structure fire spreading to involve multiple structures is generally quite low.

Areas subject to wildland/urban interface fires have very different fire hazard characteristics. The defining characteristic of the wildland/urban interface area is that structures are built in areas with essentially continuous (and often high) vegetative fuel loads. In other words, structures are built in areas subject to wildland fires. When wildland fires occur in such areas, they tend to spread quickly and structures in these areas may, unfortunately, become little more than additional fuel sources for wildland fires. The siting of homes has also changed over time. Historically pioneering families built their homes in low lands, close to water and the fields they intended to work, while during the last 30 years or so, rural homes have increasingly been built in locations chosen because of the view or other amenities. Thus, many newer homes are in locations more difficult to defend against wildland fires.

The fire risk to structures and occupants in wildland/urban interface areas is high not only because of the high vegetative fuel loads but also because fire suppression resources are typically much lower than in urban or suburban areas. Homes in wildland/urban interface areas are most commonly on wells rather than on municipal water supplies. Thus, the availability of water for fire suppression is often severely limited. Less availability of water resources makes it more likely that a small wildland fire or a single structure fire in an urban/wildland interface area will spread before it can be extinguished.

Furthermore, because many developments in interface areas have relatively low populations and are some distance from population centers, the availability of firefighting personnel and apparatus is generally lower than in more populated areas and response times are typically much longer. The longer typical response times arise in part because of greater travel distances and, thus, greater travel times, but also because most fire agencies in lower population density areas are entirely or largely composed of volunteer staff. Response times from volunteer staff fire agencies are typically longer than response times for career staff agencies, where fire stations are commonly staffed continuously. In some cases, narrow winding roads also impede access by fire fighting apparatus. As with water supplies, the lower availability of fire fighting personnel and apparatus and the longer response times increase the probability that a small wildland fire or a single structure fire in an urban/wildland interface area will spread before it can be extinguished. It is important to note however, that fire agencies in wildland/urban interface areas are often more experienced in dealing with such fires than are urban fire agencies. Furthermore, because of local placement, they are often closer to wildland/urban interface incidents than are the Oregon Department of Forestry or the U.S. Forest Service and Bureau of Land Management.

Developments in urban/wildland interface areas often face high fire risk from a combination of high fire hazard (high vegetative fuel loads) and limited fire suppression capabilities. Unfortunately, occupants in many wildland/urban interface areas also face high life safety risk. High life safety risk arises from the high fire risk, especially from large fires that may spread quickly and block evacuation. Life safety risk in interface areas is often exacerbated by limited roads (in the worst case only one access road) that are often narrow and winding and subject to blockage by a wildland fire.

Life safety risk in interface areas is also often exacerbated by homeowners' reluctance to evacuate homes quickly. Instead, homeowners often try to protect their homes with whatever fire suppression resources are available. Such efforts generally have very little effectiveness. For example, the water flow from a garden hose is too small to meaningfully impact even a single structure fire (once the structure is significantly engulfed by flames) and is profoundly too small to have any impact on a wildland fire. Unfortunately, home owners who delay evacuation in well meant but misguided attempts to save their homes often place their lives in grave jeopardy by delaying evacuation until it may be impossible.

Major fires in the urban/wildland interface have the potential for enormous destruction and very high casualties. For example, the October 20, 1991 East Bay Fire in Oakland California burned 1,600 acres with 25 fatalities, 150 injuries, and over 3300 single-family homes and 450 apartment units destroyed. Total damages were over $1.5 billion. This fire was fueled by very high vegetative fuel loads and occurred on an unusually hot, dry, windy day. The fire spread extremely quickly, with over 800 homes engulfed by fire within the first hour, and completely overwhelmed initial fire suppression efforts.

In October 1991, rural counties near Spokane Washington experienced 92 separate fires that burned about 35,000 acres and 114 homes. Between October 25 and November 3, 1993, 21 major wildland fires broke out in California. These fires burned over 189,000 acres and destroyed over 1,100 structures with 3 fatalities and hundreds of injuries. The worst wildland/urban interface fire in United States history as far as casualties are concerned occurred in 1871 in Peshtigo, Wisconsin. This fire burned over 1.2 million acres and killed over 1,200 people. In 2003, a series of wildland/urban interface fires in southern California (San Bernardino area) burned over 750,000 acres and destroyed over 3,000 homes. These few examples dramatically illustrate the potential for disasters in the urban/wildland interface area.

9.2 Measures of the Level of Fire Hazard

There are several quantitative and semi-quantitative measures of the level of fire hazard. Most of these measures have been developed by the United States Forest Service in cooperation with other fire agencies. National maps of these fire hazard measures are available at the Forest Service website (www.fs.fed.us). These maps are updated very frequently, in some cases daily. All of the Forest Service Fire Danger maps and related technical maps are viewable at the website by going to the INDEX category, then to Fire, Wildland Fire Assessment System.

The spatial resolution of the web-published maps is relatively low. For example, the Oregon data are based on about 90 reporting stations scattered across the state. Thus, these maps are intended to show regional differences in the level of fire hazard, rather than detailed local differences. However, as a regional guide to fire hazard levels, these maps are enormously useful and readily accessible. The ODF web site (www.odf.state.or.us) has local fire danger information for Columbia County, as well as any fire restrictions currently in effect. In addition, regulated use signs are also posted to inform the public and rural residents of fire restrictions due to fire danger. Local ODF offices also maintain and post local fire danger levels, using ODF's four level fire danger classification described below.

The most useful major fire danger measures are briefly reviewed below. For reference, we note that the Forest Service website also has an extensive glossary of fire-related terms, which may be helpful for those unfamiliar with fire terminology and nomenclature.

Observed Fire Danger Class Maps

The USFS fire danger class is a five level fire danger classification scheme that is based largely on moisture content in fuels and weather conditions (temperature, humidity, wind). Daily nationwide maps are viewable and printable from the Forest Service website (www.fs.fed.us). This fire danger classification is widely used for purposes such as restricting campfires and outdoor burning and is widely reported in the media. The formal definitions of the five levels of danger are given below.

USFS Fire Danger Classification (with Color Codes)

LOW (dark green). Fuels do not ignite readily from small firebrands, although a more intense heat source, such as lightning, may start many fires in duff or punky wood. Fires in open cured grassland may burn freely a few hours after rain, but woods fires spread slowly by creeping or smoldering, and burn in irregular fingers. There is little danger of spotting.

MEDIUM (light green or blue). Fires can start from most accidental causes, but with the exception of lightning fires in some areas, the number of starts is generally low. Fires in open-cured grassland will burn briskly and spread rapidly on windy days. Timber fires spread slowly to moderately fast. The average fire is of moderate intensity, although heavy concentrations of fuel, especially draped fuel, may burn hot. Short-distance spotting may occur, but is not persistent. Fires are not likely to become serious, and control is relatively easy.

HIGH (yellow). All fine dead fuels ignite readily and fires start easily from most causes. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High-intensity burning may develop on slopes, or in concentrations of fine fuels. Fire may become serious and their control difficult, unless they are attacked successfully while small.

VERY HIGH (orange). Fires start easily from all causes and, immediately after ignition, spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high intensity characteristics such as long-distance spotting and fire whirlwinds when they burn into heavier fuels.

EXTREME (red). Fires under extreme conditions start quickly, spread furiously, and burn intensely. All fires are potentially serious. Development into high-intensity burning will usually be faster and occur from smaller fires than in the very high danger class. Direct attack is rarely possible, and may be dangerous, except immediately after ignition. Fires that develop headway in heavy slash or in conifer stands may be unmanageable while the extreme burning condition lasts. Under these conditions, the only effective and safe control action is on the flanks until the weather changes or the fuel supply lessens.

In Oregon, the Oregon Department of Forestry's four level fire danger classification is widely used. These four levels are similar to the USFS levels described above, except for the omission of the Very High classification level:

LOW (green)

MODERATE (blue)

HIGH (yellow), and

EXTREME (red).

Fire Potential Index Map

This experimental product portrays a more quantitative measure of fire danger than the Fire Danger Classification map discussed above. This map is primarily of interest for fire service professionals and fire researchers.

<u>Other Maps</u>

The Forest Service website also provides several other types of technical maps which are intended for fire service professionals and fire researches. These maps and all of the more common maps summarized above can also be found at the FDR (Fire Danger Rating) web page which can be accessed via the search button on the Forest Service Home Page referenced above.

9.3 Historical Data for Wildland Fires in Oregon

The Oregon Department of Forestry website (www.odf.state.or.us) has a table of the most important historical fires in Oregon over the past 150 years. Of the 12 major fires, the five largest fires all occurred between 1848 and 1868. The two largest fires, the 1868 Coos Bay fire and the 1849 Siletz fire consumed 988,000 and 800,000 acres of wildland, respectively. The next four largest fires occurred between 1933 and 1945, with each fire consuming between 240,000 and 180,000 acres. The most recent fire listed, the 1987 Silver Fire burned 97,000 acres. More recent major fires include the 2002 Biscuit Fire that burned nearly 500,000 total acres (with about 471,000 acres in Oregon and nearly 29,000 acres in California) and the 2003 B&B Complex fire that burned 90,769 acres. However, none of these major fires occurred in Columbia County.

The Oregon Department of Forestry website (www.odf.state.or.us) has several categories of wildland fire data listed, including: numbers of forest fires and numbers of acres burned in Oregon forest lands for 1986 to 2003. However, these ODF data are <u>only</u> for ODF-responsibility lands and do not include forest lands where primary fire suppression responsibility is federal or local. These data, which will presumably be updated from time to time, provide one measure of wildland fire data for Oregon. For ODF responsibility lands in Oregon as a whole, the 10-year average number of wildland fires is 1,062. Since 1986, the largest number of acres burned in one year was 99,060 in 2002, while the lowest number of ODF-responsibility acres burned in one year was 1,410 in 1997. For the entire state of Oregon, both the number of fires and the acres burned are higher than these ODF data alone.

The United States Forest Service (Department of Agriculture), in cooperation with several agencies from the Department of the Interior, has recently published a report identifying wildland/urban interface communities within the vicinity of Federal lands that are a high risk from wildfire. As shown above in Table 9.1, every community in Columbia County is included on this at-risk list.

The Oregon Department of Forestry website (www.odf.state.or.us) has an excellent map showing forest coverage and forest type throughout Oregon. Oregon Department of Forestry data on forest ownership areas are shown below in Table 9-4 for Oregon.

Table 9.4
Forest Land Ownership in Oregon

Ownership	Acres	Percent of Total
Federal	15,968,000	57.51%
State	885,000	3.19%
Other Public Lands	123,000	0.44%
Tribal	414,000	1.49%
Forest Industry	5,870,000	21.14%
Other Private	4,506,000	16.23%
Total	27,766,000	100.00%

For Oregon as a whole, about 61% of the forest lands are public, 1.5% are tribal, with the remainder being privately owned. Of the privately owned forest land, about 57% is owned by the forest industry. Statewide, the Oregon Department of Forestry has responsibility for about 15.8 million acres of forest land, or about 57% of the total forests in Oregon.

However, the overall forest ownership pattern for Columbia County is much different than the statewide pattern shown above in Table 9.4. Overall, Columbia County is approximately 90% forested (Atlas of Oregon, Vegetation Map, University of Oregon Press, 2002). Essentially the entire interior of the county is forested, along with much of the area along the Columbia River, except for the relatively small developed areas and relatively small areas of agricultural lands. This vegetation map is shown on the following page.

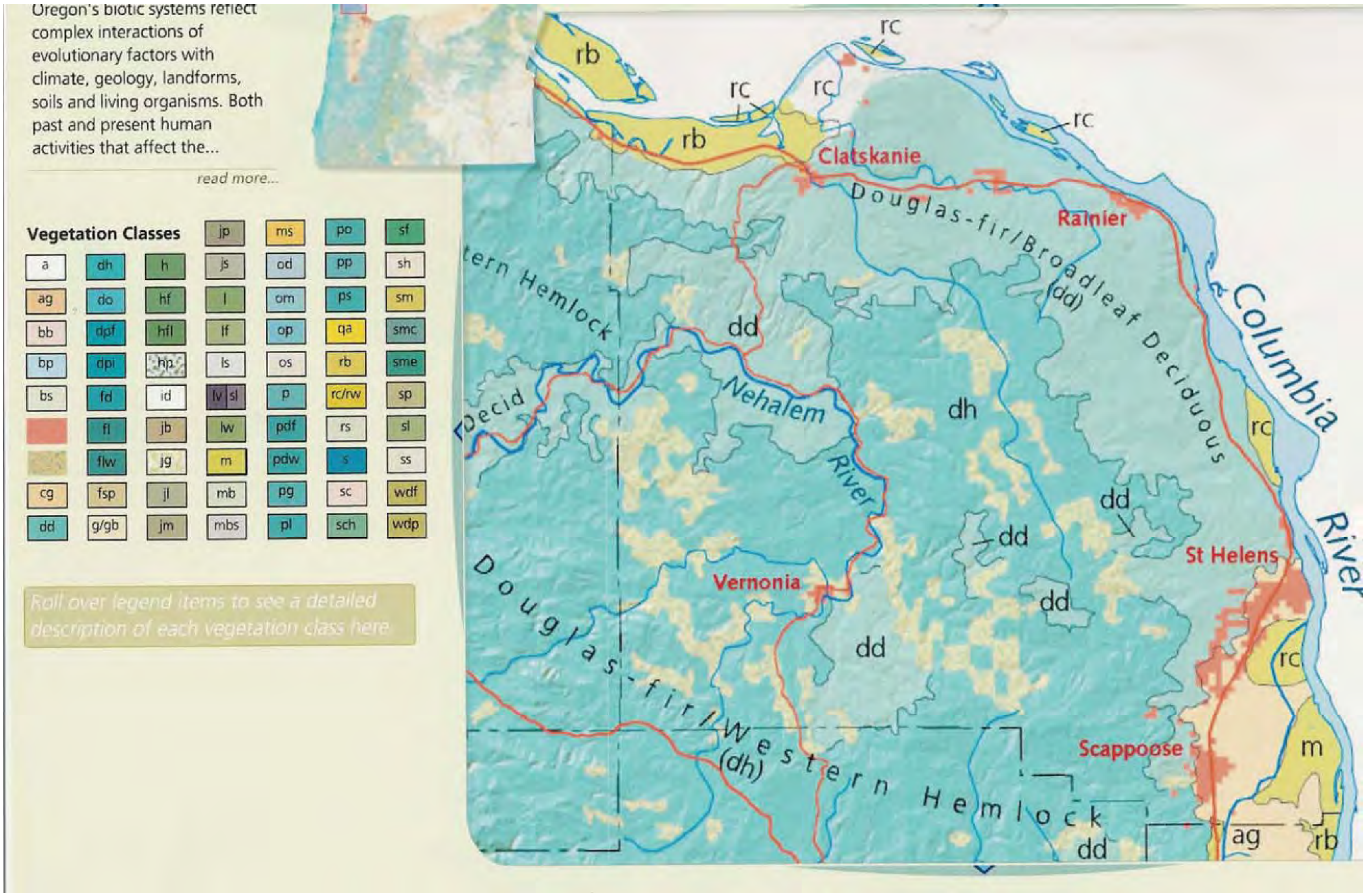
Most of the vegetated areas in Columbia County are classified as Douglas Fir – Broadleaf Deciduous, with areas of Douglas Fir – Western Hemlock. Along the Columbia River Valley there are areas of Cottonwood-Willow Riparian, and Pasture Riparian Bottomland, with these classifications being as per the Atlas of Oregon.

Vegetation Codes for Columbia County Include:

- dd Douglas fir – broadleaf deciduous
- dh Douglas fir – western hemlock
- rc Cottonwood – willow riparian
- rb Pasture – riparian bottomland
- ag agricultural

The portion of Clatsop State Forest in Columbia County covers about 6,400 acres in about a half dozen non-connected blocks of land. The remaining forest lands are predominantly privately owned, mostly by timber companies.

Vegetation Cover in Columbia County (Atlas of Oregon)



9.4 Urban/Wildland Interface Fire Hazards for Columbia County

As discussed above (Section 9.1) portions of every community in Columbia County are subject to risk from wildland/urban interface fires.

Overview and Background Information

As discussed above in Section 9.1, wildland/urban interface fires are wildland fires in areas where structures provide additional fuel load. Thus, the fire hazard for wildland/urban interface fires is essentially the same as the fire hazard for wildland fires. In this context, fire hazard means the probability and severity of fires. Fire risk, the threat to people and the built environment, depends on the level of fire hazard and on the extent of development in fire-prone areas.

The three primary factors governing the level of hazard for wildland fires or wildland/ urban interface fires are: fuels (type and load) weather and topography. For many communities in Columbia County, the fuel load in the nearby forested areas is generally high and relatively continuous across large geographic areas. Because of historical logging activities, much of the forest is composed of relatively young trees, with a high density of trees per acre.

However, for Columbia County, a high percentage of forest lands are actively managed for timber. Such actively managed forest lands typically have lower fire risk because they are relatively free of dead and downed material that would pose higher fuel loading fire hazards. Intensively managed stands are healthy young stands that are marketed in shorter rotations. Harvest scheduling often includes multiple entries including thinning and salvage and final harvest operations of these stands have less breakage and efficient utilization. This results in minimal accumulation of heavy fuel load. In addition, forests within Columbia County are relatively free of major insect and disease problems which often plague other forests in Oregon. Stand replacement fires (high intensity timber fires) are rare within Columbia County.

However, the harvest of timber does create a temporary dead fuel load (slash accumulations) that can pose an extreme fire risk for fire starts and fire spread. In particular, areas where logging occurs within the urban-interface may present higher potential for a large fire for a period following harvesting. Harvest units are usually scarified in windrows or piles to allow planting and reduce fire hazard. Some owners reduce hazard by prescribed fire but this is often problematic in the interface. Such areas are commonly scarified into piles and not burned. The most common fuel types that carry fire are grass, brush, recently harvested sites with logging slash, replanted units and reproduction to about 15 years of age and timber understory vegetation.

Topography contributes to fire hazard because fires spread much more quickly up steep slopes. Weather is very important in governing the level of fire hazard. Rainfall amounts and patterns contribute to the level of fuel load and also to moisture levels in vegetation. During fires, temperature, humidity and wind speed are major factors governing the rate of spread of wildland fires and thus major factors governing the ease or difficulty with which a given fire is likely to be contained.

Typical annual rainfall amounts for Columbia County are moderately high to high, with annual rainfalls ranging from about 40 inches to 60 inches. Wildland/urban fire hazards in Columbia County would be highest during prolonged periods of drought, especially after periods of normal to above normal rainfall, which would result in a combination of high fuel loads and unusually dry conditions.

Historical Fire Data

The Oregon Department of Forestry (Jim Wolf) provided records for all wildland fires in ODF responsibility lands in Columbia County from 1970 to 2003. These records provide an useful resource to evaluate both the historical frequency and severity of wildland fires in Columbia County For this 34-year period, the ODF records show a total of 689 wildland fires for ODF responsibility lands in Columbia County, or an average of about 20 fires per year. These ODF data are summarized below in Table 9.5.

Table 9.5
ODF Fire Data for Columbia County

ODF Fire Responsibility for Columbia County	
Columbia County Total (acres)	420,480
ODF Responsibility (acres) [1]	334,091
ODF Responsibility (% of county)	79.45%

ODF Fire Statistics (1970-2003)	
Total ODF Fires	689
Fires Less than 1 acre	540
Fires 1 to 9 acres	134
Fires 10 acres or more	15
Largest fire (acres)	93
ODF Fires Per Year	20
Total Acres Burned	789
Average Acres Burned Per Year	23

[1] Michael Simek, ODF, Sept. 21, 2004.

In interpreting these data, it is important to keep in mind that these data are for ODF responsibility areas, along with ODF joint responses to fires in areas where the primary responsibility is provided by local fire agencies. However, for Columbia County, ODF responsibility lands include nearly 80% of the entire county and since these ODF data include the joint responses these data probably represent most of the wildland and wildland/urban interface fires in Columbia County.

The ODF data show 689 fires over the 34-year time period, or an average of 20 fires per year. The total acres burned were only 789 or about 23 acres per year. Most of these fires were less than one acre (540), with 134 fires between 1 and 9 acres. Only 15 fires were10 acres or more. The largest fire reported consumed 93 acres.

Ideally, historical fire data should suffice to estimate the annual probably for fires in the wildland/urban interface areas of Columbia County. However, current data do not appear adequate to make credible calculations because the data for local, state, and federal responsibility areas are not commensurate and are not sortable by type of location (wildland, interface, developed areas). Nevertheless, the data reviewed above provide a general picture of the level of wildland/urban interface fire risk for Columbia County overall.

However, there are several reasons why the fire risk may be higher than suggested above, especially in developing wildland/urban interface areas.

1. Large fires may occur infrequently, but statistically they will occur. One large fire could significantly change the statistics. In other words, 34 years of historical data may be too short to capture large, infrequent wildland fire events. A seismic analogy is the Cascadia Subduction Zone earthquake

discussed in Chapter 10. This event has not occurred in the past 30 years and probably has not occurred since 1700. Nevertheless, large earthquakes have occurred in the past and are likely in the future. Thus, a 34-year record does not completely reflect the hazard from large earthquakes or large wildland fires.

2. The level of fire hazard depends profoundly on weather patterns. A several year drought period would substantially increase the probability of large wildland fires in Columbia County. For smaller vegetation areas, with grass, brush and small trees, a much shorter drought period of a few months or less would substantially increase the fire hazard.

3. The level of fire hazard in wildland/urban interface areas, with the greatest risk for life safety and property, is likely significantly higher than for wildland areas as a whole. The probability of fires starting in interface areas is much higher than in wildland areas because of the much higher population density in interface areas. Most wildland or interface fires have human sources of ignition - arson, sparks from vehicles or electric lines, discarded smoking materials, or trash or debris fires that get out control, and so on. Thus, the probability of a given acre burning is probably higher in interface areas than for the wildland areas of Columbia County as a whole.

Developments in wildland/urban interface areas face a range of levels of fire risk, depending on a number of factors. Developments that have all of most of the following attributes are at the highest level of risk:

1. High vegetative fuel loads, with a high degree on continuity of fuel load (i.e., few significant firebreaks). Risk may be particularly high if the fuel load is grass, brush and smaller trees, subject to being at very low moisture levels in short duration drought periods.

2. Higher slopes, which cause fires to spread more rapidly than in flatter terrain.

3. Limited fire suppression capacity, including limited water supply capacity for fire suppression purposes, limited fire fighting personnel and apparatus, and typically long response times for fire alarms.

4. Limited access for fire fighting apparatus and limited evacuation routes for residents at risk.

5. Construction of structures to less than fully fire-safe practices, and

6. Lack of maintenance of firebreaks and defensible zones around structures.

Overall, the threat of wildland fire and/or wildland/urban interface fires appears moderate to moderately high for Columbia County, in large part because of the typically high levels of rainfall.

However, for portions of Columbia County, depending on specific conditions in developments in wildland/urban interface areas, the threat may be moderate to high, especially during periods of drought. The specific level of risk for each development depends on the risk factors as summarized above. A comprehensive evaluation of the level of risk for developments in wildland/urban interface areas requires a specific evaluation of the risk attributes listed above for each development area.

9.5 Fire Protection Service Providers and Areas with High Potential for Wildland/Urban Interface Fires

Fire protection services within the developed areas of Columbia County are provided by ODF and five local agencies:

Oregon Department of Forestry

Clatskanie Rural Fire Protection District

Columbia River Fire and Rescue

Mist-Birkenfeld Rural Fire Protection District

Scappoose Rural Fire Protection District

Vernonia Rural Fire Protection District

Each of the fire protection service providers in Columbia County was surveyed to determine areas of special concern with high potential for wildland/urban interface fires. Many of these identified areas of special concern are likely to be high priority areas for mitigation actions to reduce fire risks. These survey results are summarized below in Table 9.6.

Table 9.6
Areas of Special Concern for Wildand/Urban Interface Fires

Community	Areas of Special Concern [1]
Clatskanie	Conyers Creek drainage area, area NE of Clatskanie and populated areas in the interface adjoining natural cover and wildland fuels.
Mist-Birkenfeld	Fishhawk Lake area and other rural areas in the interface adjoining natural cover and wildland fuels.
Rainier	Populated areas of the interface adjoining natural cover and wildland areas.
Scappoose	Chapman, Alder Creek, JP West, Mt. View, Callahan, Bonneville, and Wilkinson Roads. Dutch Canyon, Pamarama Terrace and Raymond Creek subdivisions.[2] Populated areas of the interface adjoining natural cover and wildland areas.
St. Helens	Gray Cliffs and surrounding greater St. Helens area. Areas involving oak, brush, and grass fuel types. Populated areas of the interface adjoining natural cover and wildland areas.
Vernonia	Populated areas of the interface adjoining natural cover and wildland areas.

[1] Michael Simek, ODF, Sept. 21, 2004.

[2] Scappoose RFD, November, 2004

The potential impacts of wildland/urban interface fires on Columbia County are summarized below in Table 9.7.

Table 9.7
Potential Impacts of Wildland/Urban Interface Fires On Columbia County

Inventory	Probable Impacts
Portion of Columbia County affected	Highest risk areas are residential areas bordering heavily vegetated wildland areas. These areas include many of the smaller communities in Columbia County and portions of the larger communities (See Tables 9.1 and 9.6 above).
Buildings	Small wildland/urban interface fires could affect a few residential buildings. Larger fires could effect entire neighborhoods and extreme events (cf. Oakland Hills 1991 fire) could affect hundreds of buildings
Streets within communities	Minor road closures possible from fires; limited impact because of short detour routes within communities.
Roads within and to/from Columbia County	Potential closures of major highways due to fires, especially roads in the interior of Columbia County.
Electric power	Potential for localized loss of electric power due to fires affecting power lines in or near Columbia County
Other Utilities	Generally minor or no impacts on other utilities from fires, except for possible loss of telephone service due to fires affecting phone poles/lines.
Casualties	Potential for deaths and injuries in major wildland/urban interface fires, especially if evacuations are not completed expeditiously

9.6 Mitigation Strategies

9.6.1 General Strategies

This section outlines suggested strategies for reducing the level of risk to both property and life safety in wildland/urban interface development areas that may be at high risk from wildland/urban interface fires. The suggested mitigation strategy has four elements:

1. reduce the probability of fire ignitions,
2 reduce the probability that small fires will spread,
3 minimize property damage, and
4. minimize the life safety risk.

Reduce the probability of fire ignitions

Efforts to reduce the probability of fire ignitions should focus on manmade causes of ignition through a combination of fire prevention education, enforcement, and other actions. Fire prevention education actions could include efforts to heighten public awareness of fire dangers, especially during high danger time periods and better education about fire safe practices, such as careful disposal of smoking materials, and adhering to restrictions on burning of rubbish and debris. Fire prevention enforcement action could include strict enforcement of burning restrictions and vigorous investigation and prosecution of arson cases. An important physical action to reduce the probability of ignitions is to maintain or upgrade tree-trimming operations around power lines to minimize fires starting by sparking from lines to vegetative fuels.

Reduce the probability that small fires will spread.

Possible mitigation actions to reduce the probability that small fires will spread include enhancement of water supply and fire suppression capabilities for high risk areas, expansion of existing firebreaks, creation of new firebreaks and expanding defensible spaces around structures in wildland/urban interface areas. Geographical area specific pre-emergency planning by jurisdiction should also be conducted to help optimize fire response strategies.

Minimize Property Damage

The education and action items discussed above may help to reduce future property damages by reducing the number of fire ignitions and by reducing the probability that a small fire will spread. In addition, specific fire safe building practices should be implemented (if not yet implemented) or enforced vigorously (if not yet vigorously enforced). Fire safe building practices have two main elements: first, design of structures, and second, creation of defensible spaces around structures.

The USFA (www.usfa.fema.gov) and other organizations have many sources of information about fire safe practices in the wildland/urban interface. For example, the National Fire Protection Association (NFPA) has an excellent "Firewise" communities program with an excellent, highly informative website (www.firewise.org). The firewise website can also be reached from the main NFPA website (www.nfpa.org). The Firewise website has very informative publications and videos for local officials and homeowners to help understand, evaluate, and improve the fire safety of structures at risk from wildland/urban interface fires. Similar information is also available at the FireFree site by the Safeco Insurance Company: (www.safeco.com/safeco/about/giving/firefree.asp)

The NFPA Firewise construction and firewise landscaping checklists are particularly recommended as concise summaries of the primary fire-safe designs and practices for homeowners at risk from wildland/urban interface fires. The NFPA's Firewise Construction Checklist, makes the following main recommendations (among others):

1. site homes on as level terrain as possible, at least 30 feet back from cliffs or ridge lines,
2. build homes with fire-resistant roofing materials, such as Class-A asphalt shingles, slate or clay tiles, concrete or cement products, or metal.
3. build homes with fire-resistant exterior wall cladding, such as masonry or stucco,
4. consider the size and materials for windows; smaller panes hold up better than larger ones, double pane and tempered glass windows are more fire resistant than single pane windows; plastic skylights can melt and allow access for burning embers,
5. prevent sparks and embers from entering vents by covering vents with wire mesh no larger than 1/8", box eaves, and minimize places to trap embers on decks and other attached structures, and
6. keep roofs, eaves, and gutters free of flammable debris.

The NFPA's Firewise Landscaping Checklist includes the following main recommendations (among others), based on a four-zone planning concept around the house:

1. Zone 1 should be well irrigated area of closely mowed grass or non-flammable landscaping materials such as decorative stone, <u>at least</u> 30' in all directions around the home,
2. Zone 2 should be a further irrigated buffer zone with only a limited number of low-growing, fire-resistant plants,
3. Zone 3, further from the house, can include low growing plants and well-spaced, well-pruned trees, keeping the total vegetative fuel load as low as possible, and
4. Zone 4 is the natural area around the above three landscaped zones. This area should be thinned selectively, with removal of highly flammable vegetation and removal of ladder fuels that can spread a grass fire upwards into tree tops.

Minimize Life Safety Risk

The mitigation actions above may help to minimize life safety risk by helping to reduce the number of ignitions, by reducing the probability that small fires will spread, and by encouraging more fire-safe practices of building construction and fire-safe landscaping. These practices are meritorious for reducing the fire hazards to structures. However, they may also give homeowners a false sense of life safety security. A false sense of security may encourage people to stay in homes at risk during wildfires, rather than evacuating immediately at the first fire warning.

The most important action to minimize life safety risk during wildland/urban interface fires is immediate evacuation. However, evacuations must be directed by the responsible fire agencies to ensure both egress for residents <u>and</u> access for fire apparatus and personnel.

Uncontrolled evacuations can sometimes block access and thus potentially increase fire spread. Thus, reducing life safety risk requires public education and emergency planning to encourage and expedite warnings and evacuations (voluntary or mandatory).

Life safety risk during wildland/urban interface fires is exacerbated by limited evacuation routes. Improving evacuation roads (widening, straightening) and, most importantly, providing as many alternate evacuation routes as possible can significantly reduce evacuation times and lower the probability that residents seeking to evacuate may be trapped by fire-blocked routes.

Further information on fire safety measures for homeowners living in or near the wildand urban interface is available from local offices of the Oregon Department of Forestry and from local fire agencies.

9.6.2 Community Wildfire Protection Plans

The incentives for communities subject to wildland/urban interface fires to engage in comprehensive forest planning and prioritization was given new impetus with the enactment of the Healthy Forest Restoration Action (HFRA) in 2003. To be eligible for federal funding for future risk reduction measures, communities must complete a Community Wildfire Protection Plan (CWPP).

Community Wildfire Protection Plans may address issues such as wildfire response, hazard mitigation, community preparedness or structure protection. The minimum requirements for a CWPP include:

- A CWPP must be collaboratively developed by local and state government representatives, in consultation with federal agencies and other interested parties.
- A CWPP must identify and prioritize areas for hazardous fuel reduction treatments and recommend the types and methods of treatment that will protect one or more at-risk communities and essential infrastructure.
- A CWPP must recommend measures that homeowners and communities can take to reduce the ignitability of structures throughout the area addressed by the plan.

The following table contains wildland/urban interface fire mitigation action items from the master Action Item table in Chapter 4.

Table 9.8
Wildland/Urban Interface Fire Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Wildland/Urban Interface Fire Mitigation Action Items								
Short-Term #1	Identify specific parts of Columbia County at high risk for urban/wildland urban interface fires because of fuel loading, topography and prevailing construction practices	County Fire Defense Board, fire agencies	1-2 Years	X	X	X	X	X
Short-Term #2	Identify evacuation routes and procedures for high risk areas and educate the public	County Fire Defense Board, fire agencies, law enforcement, County Roads, public works	Ongoing	X	X	X		X
Short-Term #3	Develop Community Wildand Fire Protection Plans for all at-risk communities	County, cities, fire agencies, ODF	1-2 Years	X	X	X	X	X
Long-Term #1	Encourage fire-safe construction practices for existing and new construction in high risk areas	County Land Development Services, city building departments, fire agencies	Ongoing	X	X	X	X	X
Long-Term #2	Enhance home landscape cleanup (defensible space) and debris disposal programs	County Land Development Services, city building departments, fire agencies	Ongoing	X	X	X	X	X
Long-Term #3	Identify potential fuel breaks and fuel reduction zones and implement mitigation actions	County Land Development Services, city building departments, fire agencies	Ongoing	X	X	X	X	X
Long-Term #4	Implement SB360 Wildland Urban Interface Act of 1997 in Columbia County	County Land Development Services, city building departments, fire agencies	5-10 years	X	X	X	X	X

CHAPTER TEN

10.0 EARTHQUAKES

Historically, awareness of seismic risk in Oregon has generally been low, among both the public at large and public officials. This low level of awareness reflected the low level of seismic activity in Oregon, at least in recent historical time. However, over the past several years, awareness of seismic risk in Oregon has significantly increased. Factors in this increased awareness include the 1993 Scotts Mills earthquake in Clackamas County and the February 28, 2001 Nisqually earthquake in Pierce County, Washington. There has been an increase in widespread publicity about possible large magnitude earthquakes on the Cascadia Subduction Zone with projected losses possibly exceeding $12 billion, with over 30,000 destroyed building and 8,000 lives lost in the event of a magnitude 8.5. Also, Oregon has recently changed the Seismic Zonation in the Oregon Building Code which increased seismic design levels for new construction in western Oregon.

Before reviewing the levels of seismic hazard and seismic risk in Columbia County, we first present a brief earthquake “primer” that reviews some basic earthquake concepts and terms.

10.1 Earthquake Primer

In the popular press, earthquakes are most often described by their Richter Magnitude (M). Richter Magnitude is a measure of the total energy released by an earthquake. In addition to Richter magnitude, there are several other measures of earthquake magnitude used by seismologists, but such technical details are beyond the scope of this discussion. The Scotts Mills (Oregon) earthquake was M = 5.6, while the Northridge (California) earthquake was about M = 6.7. Great earthquakes, for example, on the San Andreas Fault or on the Cascadia Subduction Zone, may have magnitudes of 8 or greater.

It is important to recognize that the Richter scale is not linear, but rather logarithmic. A M8 earthquake is not twice as powerful as a M4, but rather thousands of times more powerful. A M7 earthquake releases about 30 times more energy than a M6, while a M8 releases about 30 times more energy than a M7 and so on. Thus, great M8 earthquakes may release thousands of times as much energy as do moderate earthquakes in the M5 or M6 range.

The public often assumes that the larger the magnitude of an earthquake the “worse” the earthquake. Thus, the “big one” is the M8 earthquake and smaller earthquakes (M6 or M7) are not the “big one”. However, this is true only in very general terms. Larger magnitude earthquakes affect larger geographic areas, with much more widespread damage than smaller magnitude earthquakes. However, for a given site, the magnitude of an earthquake is NOT a good measure of the severity of the earthquake at that site. Rather, the intensity of ground shaking at the site depends on the magnitude of the earthquake and on the distance from the site to the earthquake. An earthquake is located by its epicenter - the location on the earth’s surface directly above the point of origin of the earthquake. Earthquake ground shaking diminishes (attenuates) with distance from the epicenter. Thus, any given earthquake will produce the strongest ground motions near the earthquake with the intensity of ground motions diminishing with increasing distance from the epicenter.

Thus, for a given site, a smaller earthquake (such as a M6.5) which is very close to the site could cause greater damage than a much larger earthquake (such as a M8) which is quite far away from the particular site.

However, earthquakes at or below M5 are not likely to cause significant damage, even locally very near the epicenter. Earthquakes between about M5 and M6 are likely to cause some damage very near the epicenter, with the extent of damage typically being relatively minor (e.g., the 1993 Scotts Mills earthquake). Earthquakes of about M6.5 or greater can cause major damage (e.g., the Northridge earthquake), with damage usually concentrated fairly near the epicenter. Larger earthquakes of M7+ cause damage over increasingly wider geographic areas with the potential for very high levels of damage near the epicenter. Great earthquakes with M8+ can cause major damage over wide geographic areas. For example, a M8+ on the Cascadia Subduction Zone could affect the entire Pacific Northwest from British Columbia, through Washington and Oregon, and as far south as Northern California.

The intensity of ground shaking varies not only as a function of M and distance but also depends on soil types. Soft soils may amplify ground motions and increase the level of damage. Thus, for any given earthquake there will be contours of varying intensity of ground shaking. The intensity will generally decrease with distance from the earthquake, but often in an irregular pattern, reflecting soil conditions (amplification) and possible directionality in the dispersion of earthquake energy.

There are many measures of the severity or intensity of earthquake ground motions. A very old, but commonly used, scale is the Modified Mercalli Intensity scale (MMI), which is a descriptive, qualitative scale that relates severity of ground motions to types of damage experienced. MMIs range from I to XII.

More useful, modern intensity scales use terms that can be physically measured with seismometers, such as the acceleration, velocity, or displacement (movement) of the ground. The most common physical measure, and the one used in this Mitigation Plan, is Peak Ground Acceleration or PGA. PGA is a measure of the intensity of shaking, relative to the acceleration of gravity (g). For example, 1.0 g PGA in an earthquake (an extremely strong ground motion) means that objects accelerate sideways at the same rate as if they had been dropped from the ceiling. 10% g PGA means that the ground acceleration is 10% that of gravity and so on.

Damage levels experienced in an earthquake vary with the intensity of ground shaking and with the seismic capacity of structures. Ground motions of only 1 or 2% g are widely felt by people; hanging plants and lamps swing strongly, but damage levels, if any, are usually very low. Ground motions below about 10% g usually cause only slight damage. Ground motions between about 10% g and 30% g may cause minor to moderate damage in well-designed buildings, with higher levels of damage in poorly designed buildings. At this level of ground shaking, only unusually poor buildings would be subject to potential collapse. Ground motions above about 30% g may cause significant damage in well-designed buildings and very high levels of damage (including collapse) in poorly designed buildings. Ground motions above about 50% g may cause high levels of damage in many buildings, even those designed to resist seismic forces.

10.2 Seismic Hazards for Columbia County

Earthquakes in Western Oregon, and throughout the world, occur predominantly because of plate tectonics - the relative movement of plates of oceanic and continental rocks that make up the rocky surface of the earth. Earthquakes can also occur because of volcanic activity and due to other geologic processes.

The Cascadia Subduction Zone is a geologically complex area off the Pacific Northwest coast from Northern California to British Columbia. In simple terms, several pieces of oceanic crust (the Juan de Fuca Plate, Gorda Plate and other smaller pieces) are being subducted (pushed under) the crust of North America. This subduction process is responsible for most of the earthquakes in the Pacific Northwest as well as for creating the volcanoes in the Cascades. Figure 10.1 shows the geologic (plate-tectonic) setting for Oregon.

There are three source regions for earthquakes that can affect Columbia County:

1. "interface" or "subduction zone" earthquakes on the boundary between the subducting oceanic plates and the North American plate,
2. "intraslab" or "intraplate" earthquakes within the subducting oceanic plates, which are also known as "Benioff Zone" or deep zone earthquakes, and
3. "crustal" earthquakes within the North American Plate.

The geographic and geometric relationships of these earthquake source zones are shown in Figure 10.2

The "interface" earthquakes on the Cascadia Subduction Zone may have magnitudes of 8 or greater, with probable recurrence intervals of 500 to 800 years. The last major earthquake in this source region probably occurred in the year 1700, based on current interpretations of Japanese tsunami records. Such earthquakes are the great Cascadia Subduction Zone earthquake events that have received attention in the popular press. These earthquakes typically occur about 20 to 60 kilometers (12 to 40 miles) offshore from the Pacific Ocean coastline. Ground shaking from such earthquakes would be very strong near the coast and moderately strong ground shaking would be felt throughout Columbia County, with the level of shaking decreasing somewhat towards eastern Columbia County.

Figure 10.2
Earthquake Source Zones

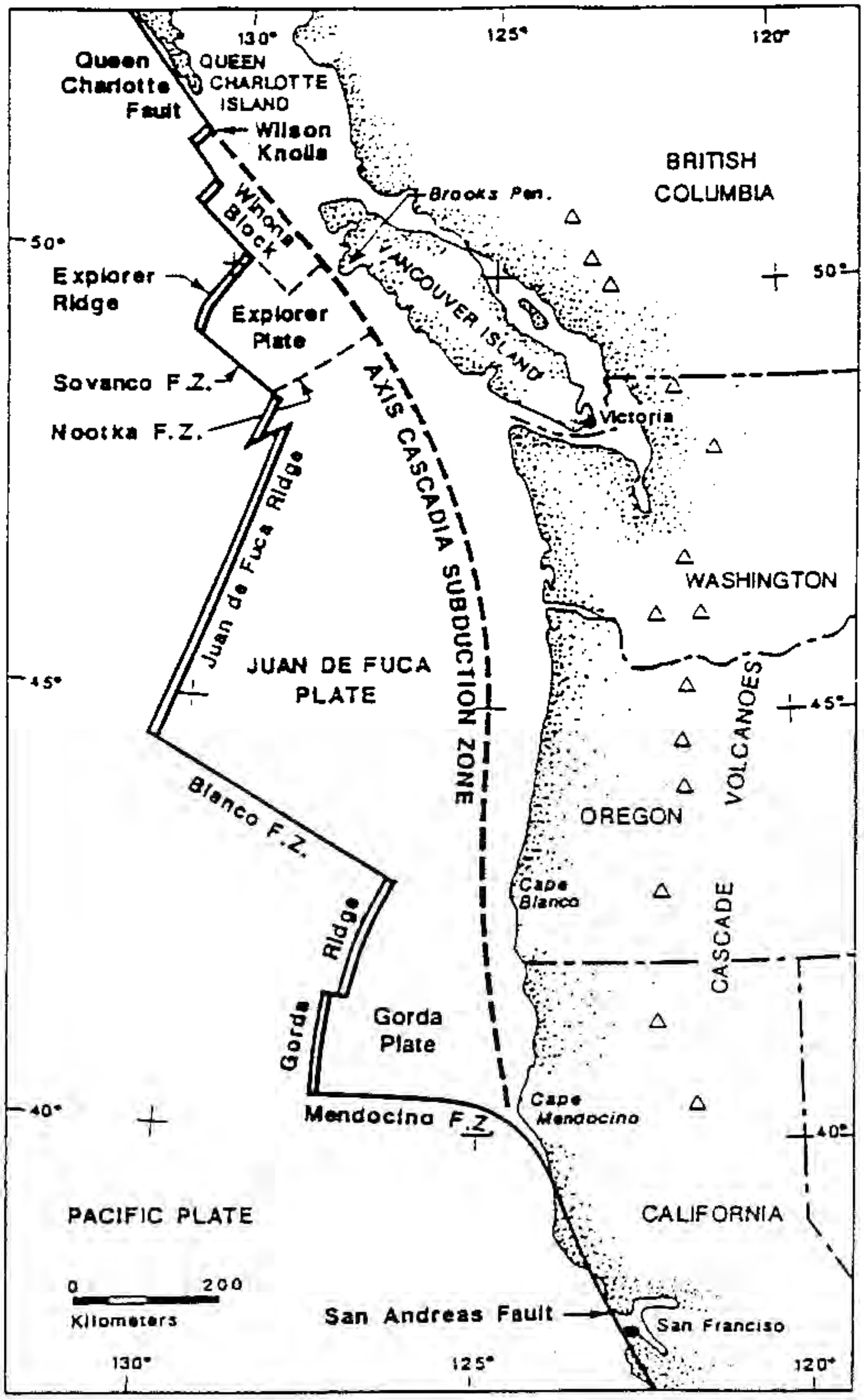
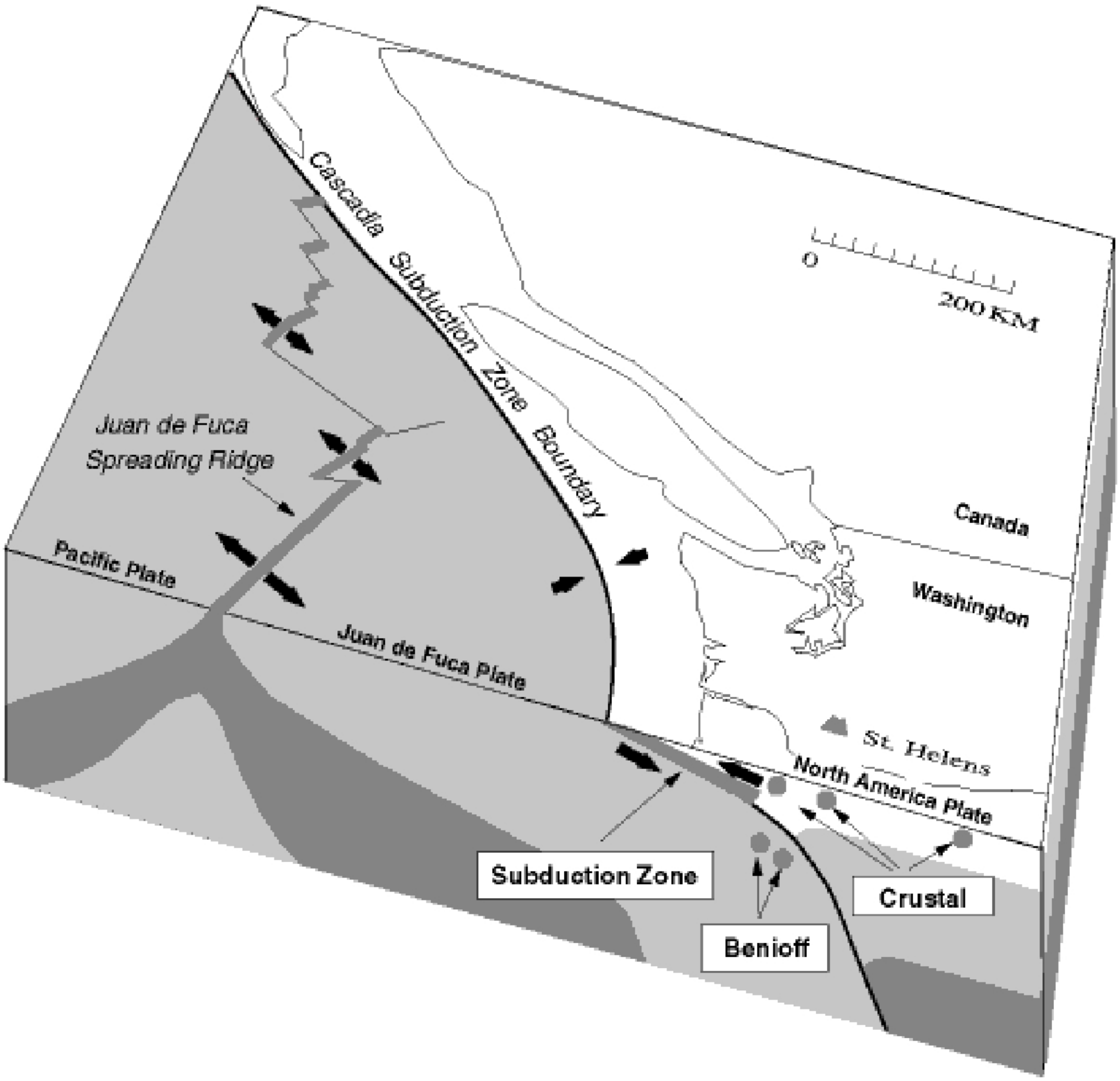


Figure 10-1. Cascadia Subduction Zone



The “intraslab” earthquakes, which are also called “intraplate” or “Benioff Zone” earthquakes, occur within the subducting oceanic plate. These earthquakes may have magnitudes up to about 7.5, with probable recurrence intervals of about 500 to 1000 years (recurrence intervals are poorly determined by current geologic data). These earthquakes occur quite deep in the earth, about 30 or 40 kilometers (18 to 25 miles) below the surface with epicenters that would likely range from near the Pacific Ocean coast to about 50 kilometers (30 miles) inland. Epicenters from these types of earthquakes could be located in Clatsop County or perhaps western Columbia County. Ground shaking from such earthquakes would be very strong near the epicenter and moderately strong ground shaking would be felt throughout all of Columbia County, with the level of shaking decreasing towards eastern Columbia County.

“Crustal” earthquakes within the North American plate are possible on faults mapped as active or potentially active as well as on unmapped (unknown) faults. Historically observed crustal earthquakes in Oregon from 1841 to 2002 are shown in Figure 10-3 (DOGAMI, Map of Selected Earthquakes for Oregon, 1841 through 2002, Open-File Report 03-02, 2003).

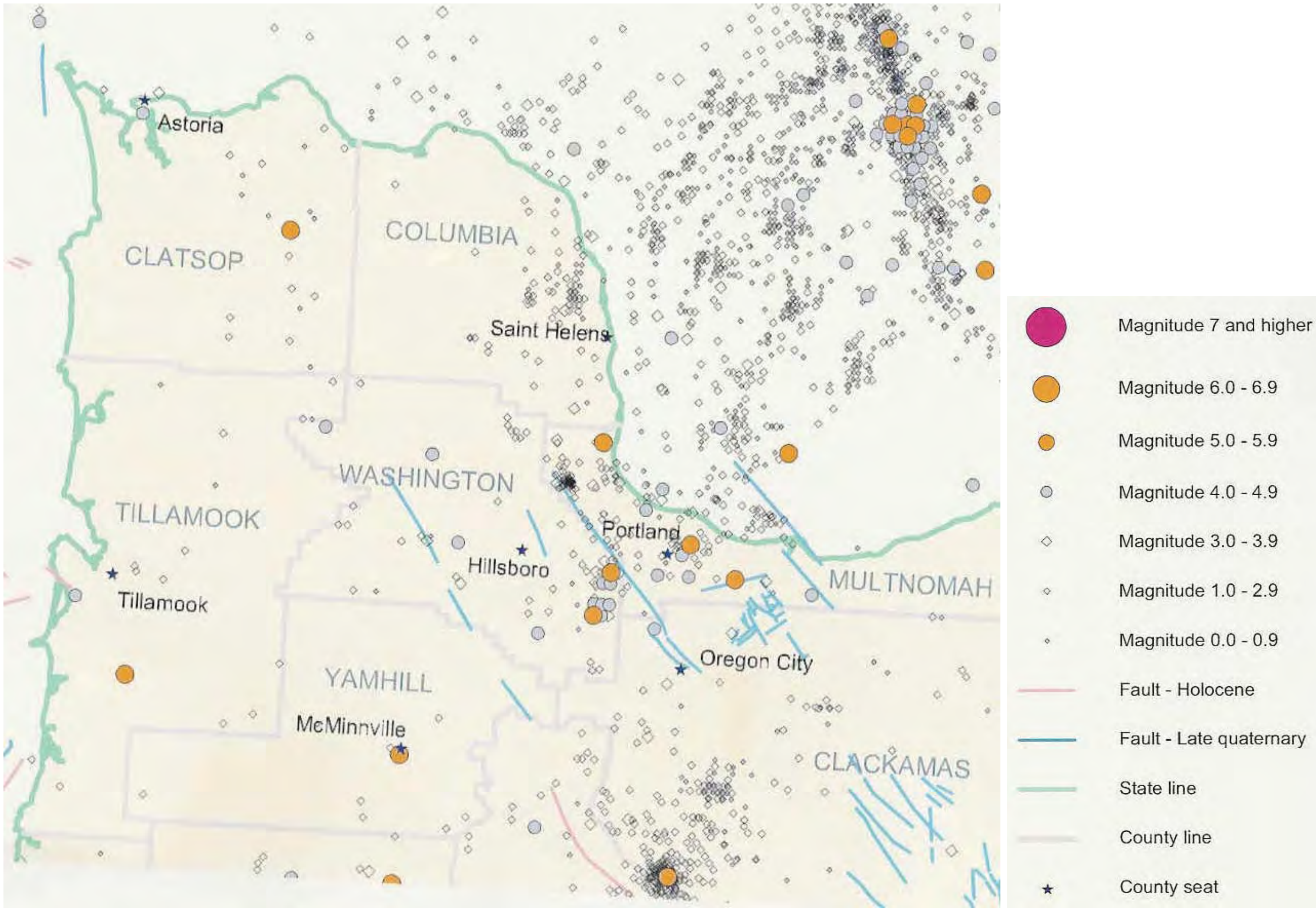
During this time period, several dozen, mostly small, earthquakes have occurred in Columbia County as shown on Figure 10.3. Larger earthquakes in Multnomah, Washington, and Clackamas County are also shown, along with a large number of earthquakes associated with volcanic activity at Mount St. Helens. There are no mapped active crustal faults in Columbia County, although several active crustal faults are shown in nearby counties.

The nearest large crustal fault is the Portland Hills Fault. Geologic studies of this fault suggest that one or two large (perhaps M6.5) earthquakes have occurred in the past 12,000 to 15,000. Thus, the recurrence interval for such events is likely to be very long, in the range of 5,000 to 10,000 years. A major earthquake on the Portland Hills Fault would have significant impacts on Columbia County, albeit with a low probability of occurrence.

Furthermore, based on the historical seismicity in Western Oregon and on analogies to other geologically similar areas, small to moderate earthquakes up to M5 or M5.5 are possible almost anyplace in Western Oregon, including in Columbia County. Such earthquakes would be mostly much smaller than the Scotts Mills earthquake up to about the magnitude of that 1993 earthquake. The possibility of larger crustal earthquakes in the M6+ range cannot be ruled out. However, in the absence of known, mapped faults, the probability of such events is likely to be very low.

Because the probability of large crustal earthquakes (M6 or greater) affecting Columbia County is so low and because any damage in smaller crustal earthquakes is likely to be minor and very localized, crustal earthquakes are not considered significant for hazard mitigation planning purposes. Therefore, our analysis focuses on the larger, much more damaging earthquakes arising from the Cascadia Subduction Zone.

Figure 10-3
Earthquake Epicenters from 1841 to 2002



The characteristics of the subduction zone earthquakes affecting Columbia County are summarized in Table 10.4 below. The maximum magnitudes are estimated from the length and width of the mapped fault plane or from similar earthquakes elsewhere in the Pacific Northwest (for the intraslab earthquakes). Recurrence intervals are based on current best estimates.

Table 10.4
Seismic Sources Affecting Columbia County

Fault	Maximum Magnitud e	Probable Recurrence Interval (years)
Cascadia Subduction Zone (interface earthquake)	8.5	500 to 800
Cascadia Subduction Zone (intraslab earthquake)	7.5	500 to 1000

10.3 Other Aspects of Seismic Hazards in Columbia County

Most of the damage in earthquakes occurs directly because of ground shaking which affects buildings and infrastructure. However, there are several other aspects of earthquakes that can result in very high levels of damage in localized sites: liquefaction, landslides, dam failures and tsunamis.

10.3.1 Soil Effects

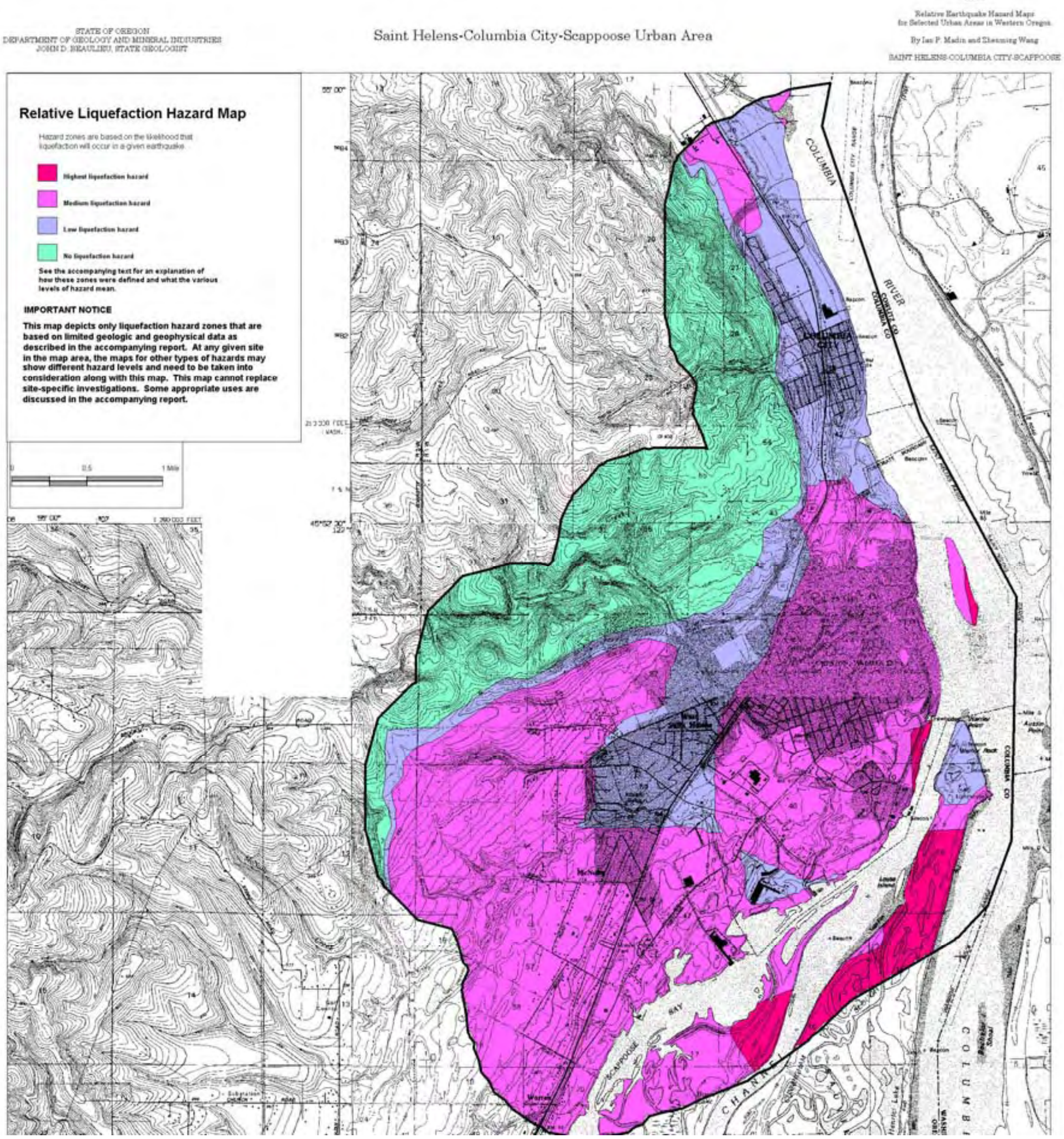
Liquefaction is a process where loose, wet sediments lose strength during an earthquake and behave similarly to a liquid. Once a soil liquefies, it will tend to settle and/or spread laterally. With even very slight slopes, liquefied soils tend to move sideways downhill (lateral spreading). Settling or lateral spreading can cause major damage to buildings and to buried infrastructure such as pipes and cables.

In general, areas of high liquefaction potential largely follow river and stream drainage channels, marshy areas and areas near lakes. In addition, similar soil conditions may occur in areas where lakes or streams existed in the past but have now been filled in by natural or human-caused processes.

In earthquakes, liquefaction, settling or lateral spreading does not occur in all such areas or in all earthquakes. However, in larger earthquakes with strong ground shaking and long duration shaking, liquefaction is likely in many of these high liquefaction potential areas. Settlements of a few inches or more and lateral spreads of a few inches to several feet are possible. Even a few inches of settlement or lateral spreading is likely to cause significant to major damage to buildings or infrastructure.

For Columbia County, county-wide maps of areas known or likely to be affected by these soils effects do not yet exist. DOGAMI Maps of relative liquefaction potential for St. Helens and Scappoose are shown below as Figures 10-5 and 10-6.

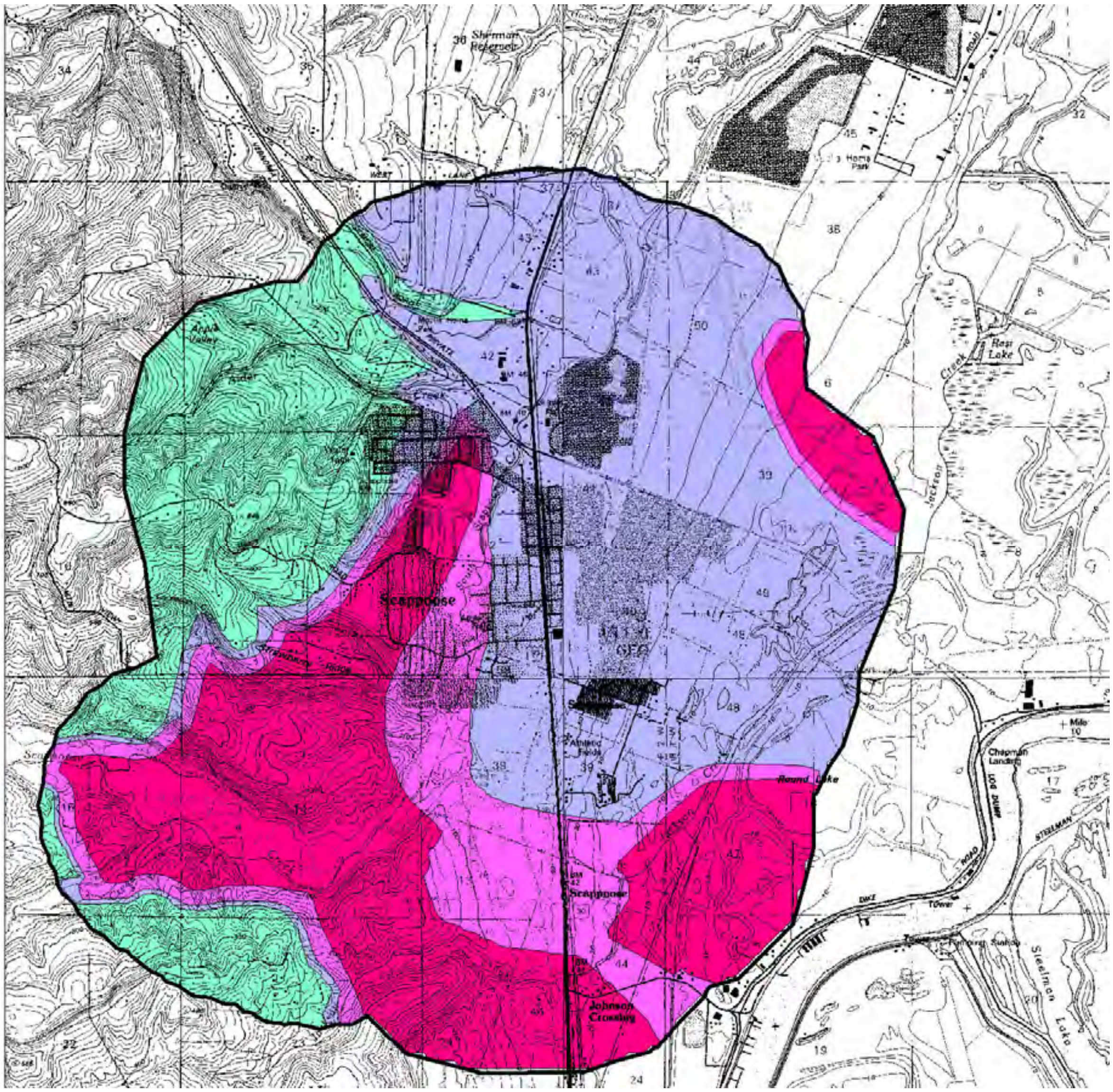
Figure 10-5
Relative Liquefaction Potential for St. Helens



For St. Helens, large areas are shown as “medium” liquefaction potential, with several small areas near the Columbia River shown as “high” liquefaction potential.

These maps are based on available data and should not be over interpreted to represent exact locations of soils subject to liquefaction. Not all areas within given categories of liquefaction potential may be as classified: some areas may have higher potential and some areas may have lower potential. Detailed site-specific geotechnical studies are necessary to determine the level of liquefaction, settlement or lateral spread hazard at any specific location.

Figure 10-6
Relative Liquefaction Potential for Scappoose



For Scappoose, large areas are shown as having “high” or “medium” liquefaction potential (same color codes as Figure 10-4 above). The caveats noted above for the St. Helens map also apply to the Scappoose map. Both maps are from DOGAMI’s publication Relative Earthquake Hazard Maps for Selected Urban Areas in Western Oregon (IMS-7, 1999).

10.3.2 Landslides

Earthquakes can also induce landslides, especially if an earthquake occurs during the rainy season and soils are saturated with water. The areas prone to earthquake-induced landslides are largely the same as those areas prone to landslides in general. As with all landslides, areas of steep slopes with loose rock or soils are most prone to earthquake-induced landslides.

Figures 8.7 and 8.8 (Chapter 8) show areas of St. Helens, Columbia City and Scappoose subject to earthquake-induced (and other) landslides. To date, relatively limited development has occurred in most of these high landslide potential areas although some portions have been developed as residential areas. See Chapter 8 for further discussion of landslide hazards.

10.3.3 Dam Failures

Earthquakes can also cause dam failures in several ways. The most common mode of earthquake-induced dam failure is slumping or settlement of earthfill dams where the fill has not been properly compacted. If the slumping occurs when the dam is full, then overtopping of the dam, with rapid erosion leading to dam failure is possible. Dam failure is also possible if strong ground motions heavily damage concrete dams. In a few cases, earthquake-induced landslides into reservoirs have caused dam failures.

Earthquake-induced dam failures are addressed in more detail in Chapter 12 which covers dam failures that could affect Columbia County.

10.3.4 Tsunamis and Seiches

Tsunamis, which are often incorrectly referred to as “tidal waves,” result from earthquakes which cause a sudden rise or fall of part of the ocean floor. Such movements may produce tsunami waves, which have nothing to do with the ordinary ocean tides. In the open ocean, far from land, in deep water, tsunami waves may be only a few inches high and thus be virtually undetectable, except by special monitoring instruments. These waves travel across the ocean at speeds of several hundred miles per hour. When such waves reach shallow water near the coastline, they slow down and can gain great heights.

Tsunamis affecting the Oregon coast can be produced from very distant earthquakes off the coast of Alaska or elsewhere in the Pacific Ocean. For such tsunamis, the warning time for the Oregon coast would be at least several hours. However, interface earthquakes on the Cascadia Subduction Zone can also produce tsunamis. For such earthquakes the warning times would be very short, only a few minutes. Because of this extremely short warning time, emergency planning and public education are essential before such an event occurs.

For Columbia County, the impact of possible tsunamis would be limited to minor increases in water level in the tidal reach of the lower Columbia River.

Another earthquake phenomenon is “seiches” which are waves from sloshing of inland bodies of water. Seiches have caused damages to shorefront structures and to dams. However, for Columbia County, the potential for seiches of sufficient magnitude to cause significant damage to upstream dams appears low.

10.4 Risk Assessment for Scenario Earthquakes

For regional planning purposes, FEMA’s HAZUS-MH (Hazards U.S. Multi-Hazard) software has been used to make estimates of county-wide damages in Columbia County from a major earthquake on the Cascadia Subduction Zone. HAZUS is an extensively peer-reviewed nationally-applicable loss estimation methodology which draws heavily on census and other nationally-available data on buildings and infrastructure.

The scenario earthquake considered was a M9.0 Cascadia Subduction Zone Interface Earthquake. A smaller M7.5 Cascadia Subduction Zone Intraplate (Benioff Zone) Earthquake would have similar impacts on Columbia County because although the earthquake magnitude is smaller, the epicenter would be closer to Columbia County.

Summary results from HAZUS-MH include the following:

Buildings: more than 50% of the approximately 16,000 buildings in Columbia County will have some earthquake damage, with about 28% having at least moderate damage. Nearly 600 buildings are estimated to be a complete loss. Total building and contents losses are estimated at about $274 million.

Emergency Shelter Needs: at least 4,000 people are likely to require emergency shelter, based on an estimated 1,800 buildings (predominantly residential) with extensive or complete damage. Based on experience in major earthquakes elsewhere in the United States, approximately 1/3 of displaced people will need public emergency shelter, with the rest finding shelter with relatives, friends, or in commercial lodgings.

Casualty estimates are shown below in Table 10.7. These estimates should not be interpreted literally, but rather as statistical calculations of the approximate level of expected casualties for Columbia County. Deaths and injuries are lower for a night time earthquake because more people are in wood frame residential buildings at night than during the day time.

Table 10.7
Casualty Estimates

Casualties	2 PM	2 AM
Minor Injuries[1]	198	128
Major Injuries[2]	64	29
Deaths	17	4

[1] requiring medical attention
[2] requiring hospitalization

Water Systems: loss of service to about 3,600 households, with about 750 pipe leaks and 190 pipe breaks.

Wastewater Systems: about 600 pipe beaks and 150 pipe breaks.

Natural Gas Systems: about 640 pipe leaks and 160 pipe breaks.

Electric Power: minor damage but probably only very limited or no loss of service.

Total damages to utilities and transportation infrastructure are estimated to be about $28 million, with an additional $77 million in economic impacts of temporary loss of service.

10.5 Probable Impacts of Major Earthquakes on Columbia County

The potential impacts of major earthquakes on Columbia County are summarized below in Table 10.8.

Table 10.8
Potential Impacts of Major Earthquakes on Columbia County

Inventory	Probable Impacts
Portion of Columbia County affected	Entire County and surrounding region, highest levels of ground shaking and damage percentages likely in western Columbia County
Buildings	Many buildings will have no damage or light to moderate damage, with heavy damage concentrated in vulnerable buildings (wood frame buildings with cripple walls, unreinforced masonry, etc.). Total building damage estimated to be about $274 million.
Streets within Columbia County	Minor road damage possible in areas of soft soils. Many bridges may have significant damage, 3% to 5% may be in complete damage state.
Roads to/from Columbia County	Minor road damage possible in areas of soft soils. Many bridges may have significant damage, 3% to 5% may be in complete damage state.
Electric power	Minor outages possible for a few hours after the earthquake.
Water utilities	Loss of water service for about 25% of the population of Columbia County, with most service restored in about 7 days.
Other Utilities	Natural gas system damages and outages similar to water systems. Phone systems (land and cellular) will have system overload for about 72 hours, then most customers will have normal service.
Emergency Shelter Needs	About 4000 people may need emergency shelter.
Casualties	About 17deaths for daytime earthquake or 4 deaths for nighttime earthquake. Daytime injuries about 260; nighttime injuries about 160.

The above summary of potential impacts is for major earthquakes on the Cascadia Subduction Zone, as shown above in Tables 10.7 and 10.8. Smaller earthquakes would have substantially smaller impacts on Columbia County than shown above.

In addition, there is a low probability that a major earthquake could result in substantial damage or failure of the major dams upstream of Columbia County. If dam failure were to occur, however, the impact on Columbia County is likely to be relatively minor (cf. Chapter 12 Dams).

10.6 Earthquake Risk Assessment: Technical Guidance

For planning purposes, it is sometimes useful to consider three levels of earthquake risk assessment.

A *Level One Risk* Assessment means that nationally available data are used. For example, FEMA's HAZUS loss estimation software uses national data and HAZUS risk assessments for a community are Level One. The risk assessments presented in the previous section were Level One Assessments using HAZUS.

A *Level Two Risk* Assessment is a more refined evaluation using local data such as soil maps, assessor's records, local building code history and so on to more accurately reflect local conditions than when using only national data. Level Two Assessments are generally more accurate than Level One

Assessments, but still rely on generalized, typical data, rather than building specific data.

A *Level Three Risk* Assessment is building- or facility-specific, using detailed data for each facility. A Level Three Risk Assessment cannot be done for an entire community, but rather is typically done for a single building or a few buildings or other facilities that may be particularly vulnerable or for which mitigation of seismic hazards is a high priority.

10.6.1 Level Two Risk Assessment

The Level One earthquake loss estimates presented above are based on census-tract level data. For a given community, a more accurate loss estimate could be obtained by incorporating Level Two local data into the loss calculations. Such data could include:

1. better inventory data,
2. spatial distribution of inventory within census tracts,
3. overlay of soils information with inventory to identify areas subject to amplification, liquefaction, settling and displacements, and
4. refinement of building fragility curves to reflect local inventory.

Such Level Two loss estimates would be more accurate than the Level One assessments presented above. However, the Level One estimates probably provide accurate enough estimates of the approximate magnitude of losses for emergency planning purposes. Furthermore, conducting a Level Two loss estimate would require very intensive data collection and processing efforts, without providing enough detail for specific mitigation projects. Therefore, Level Two risk assessments may not be as useful for Columbia County as the Level Three Assessments suggested below.

10.6.2 Level Three Risk Assessment

The potential damages and losses from earthquakes affecting Columbia County are very high. However, the probability of such earthquakes is relatively low and many types of buildings, such as wood frame homes, are generally expected to perform reasonably well in earthquakes. Therefore, widespread mitigation of seismic hazards is probably not called for in the case of most ordinary or typical buildings. That is, seismic mitigation actions are probably necessary only for a small percentage of the total building stock in Columbia County.

Furthermore, buildings constructed since the early 1990s generally meet current seismic design requirements and will generally perform fairly well in future earthquakes. Similarly, new buildings will be built in accordance with current Seismic Zone 3 requirements and thus the seismic capacity of the building stock in Columbia County will gradually improve over time as the existing stock is gradually replaced and/or upgraded.

However, for some types of buildings which are more vulnerable or more important than typical buildings, seismic retrofit may be highly desirable. Prime candidates for possible seismic retrofits include:

- any buildings that are substantially more vulnerable than typical buildings (e.g., unreinforced masonry buildings),
- buildings on soft soil sites, and

- essential service facilities such as major medical facilities, police and fire stations, schools, and emergency shelters.

Specific buildings may be substantially more vulnerable than typical buildings because of their structural system. Examples of vulnerable building types include: unreinforced masonry, precast concrete frame, concrete or steel frame with unreinforced masonry infill walls, concrete moment resisting frame, and precast concrete tiltup walls.

Buildings may also be substantially more vulnerable than typical buildings because of their design characteristics. Examples include buildings with soft first stories (taller than other stories and/or with large expanses of windows without shear walls) and buildings with major configurational irregularities, as well as wood frame buildings with cripple wall foundations or with sill plates not bolted to the foundation. Thus, we suggest that Level Three risk assessments focus primarily on such buildings, especially for essential service facilities.

A *Level Three* assessment provides a building-specific evaluation, more accurate than generic assessments based on typical buildings. Ideally, a Level Three assessment would include a site specific seismic hazard analysis, taking into account soil conditions, and a building-specific evaluation of the seismic vulnerability of each building under evaluation.

In addition to buildings, there are other critical facilities which may be vulnerable to seismic damage, including utility and transportation system infrastructure. Minimizing earthquake damage to such facilities is particularly important to a community because loss of function of critical utility or transportation system infrastructure may have a very large economic impact on the community. Facilities that should have a high priority for Level Three Risk Assessments include: electric power substations (especially high voltage substations), water and waste-water treatment plants, water reservoirs, bulk fuel storage tanks and hazmat storage tanks, dams and bridges. For utilities in general, non-structural mitigation measures are often very cost-effective and should have a high priority.

For buildings, utilities and other important facilities, the seven-step Mitigation Planning methodology outlined in Chapter 1 is appropriate. For prioritizing between mitigation projects, the principles of benefit-cost analysis apply to mitigation projects for all hazards, including seismic hazard mitigation. FEMA has software available to conduct such analyses of prospective earthquake hazard mitigation projects.

10.7 Other Earthquake Risk Comments for Columbia County

A “windshield” survey means a quick, preliminary seismic risk evaluation of a building or other facility, based on readily observable external attributes. A windshield survey may literally be done from a vehicle, but more commonly includes a quick walk around inspection. Conclusions drawn from such preliminary evaluations must be interpreted carefully as giving only a general indication of the probable level of seismic risk posed by the building or facility.

The following comments are based on a very limited windshield type survey of Columbia County’s population centers.

Overall, a majority of the building inventory in Columbia County is residential, with most residential structures being wood frame buildings. In general, wood frame buildings perform well in earthquakes, with a few notable exceptions. Wood frame buildings with the following characteristics are generally substantially vulnerable to major seismic damage:

1. sill plates not bolted to foundation,
2. cripple wall perimeter systems, and
3. buildings on steep slopes, partially supported on “stilts.”

Cripple wall perimeter systems are short wooden walls which raise the first floor elevation above grade by typically about 2 to 4 feet. Unbolted sill plates and cripple wall construction are common in pre-WW2 construction. Visual inspection and the general vintage of building stock in Columbia County suggest that there are likely significant numbers of buildings in Columbia County with cripple wall foundations or with unbolted sill plates.

Unreinforced masonry buildings are also subject to major damage in earthquakes. Columbia County has at least several dozen masonry buildings (most commercial or industrial in the older central business districts of most communities) which may be unreinforced or reinforced masonry. Some of these buildings may be highly vulnerable to earthquake damage and thus should have a high priority for detailed evaluation, especially those buildings with high occupancies or important functions.

A detailed inventory of wood frame buildings with the above noted seismic deficiencies and inventory of unreinforced masonry buildings would be useful to further quantify the level of risk posed by such structures in Columbia County.

10.7.1 Existing Earthquake Mitigation Activities

Columbia County encourages employers and individuals to meet the requirements of:

Senate Bill 13: Seismic Event Preparation Signed by Governor Kitzhaber on June 14, 2001, requiring each state and local agency and persons employing 250 or more full-time employees to develop seismic preparation procedures and inform their employees about the procedures. Further, the bill requires agencies to conduct drills in accordance with the State Office of Emergency Management guidelines. These drills must include “familiarization with routes and methods of exiting the building and methods of duck, cover, and hold during an earthquake.

Senate Bill 14: Seismic Surveys for School buildings Signed by the Governor on July 19, 2001, requiring the State Board of Higher Education to provide for seismic safety surveys of buildings that have a capacity of 250 or more persons and are routinely used for student activities.

Senate Bill 15: Seismic Surveys for Hospital Buildings Signed by the Governor on July 19, 2001 requiring the Health Division to provide for seismic safety surveys of hospital building that contain an acute in-patient care facility. Seismic surveys shall also be conducted on fire stations, police stations, sheriffs’ offices, and similar facilities subject to available funding. Surveys should be completed by January 1, 2007.

Columbia County plans on integrating HAZUS multi-hazard data sets into the new GIS program once it goes live in 2005.

Incorporate the Regional Emergency Management Groups post earthquake Emergency Transportation Routes plan in all appropriate planning documents.

Encourage property owners to purchase earthquake hazard insurance and consider non-structural and structural mitigation activities for their homes and businesses.

10.8 Earthquake Hazard Mitigation Projects: General Examples

There are a wide variety of possible hazard mitigation projects for earthquakes. The most common projects include: structural retrofit of buildings, non-structural bracing and anchoring of equipment and contents, and strengthening of bridges and other infrastructure components.

The seismic hazard (frequency and severity of earthquakes) is moderate in Columbia County. However, the risk (potential for damages and casualties) may be fairly high because some buildings and infrastructure may be highly vulnerable to earthquake damages. The risk assessment methodology outlined above for earthquakes provides the basis for identifying the high risk facilities that then become the primary targets for mitigation.

Structural retrofit of buildings should not focus on typical buildings, but rather on buildings that are most vulnerable to seismic damage. Priorities should include buildings on soft soil sites subject to amplification of ground motion and/or liquefaction and especially on critical service facilities such as hospitals, fire and police stations, emergency shelters, and schools.

Non-structural bracing of equipment and contents is often the most cost-effective type of seismic mitigation project. Inexpensive bracing and anchoring may protect very expensive equipment and/or equipment whose function is critical such as medical diagnostic equipment in hospitals, computers, and communication equipment for police and fire services and so on. For utilities, bracing of control equipment, pumps, generators, battery racks and other critical components can be powerfully effective in reducing the impact of earthquakes on system performance. Such measures should almost always be undertaken before considering large-scale structural mitigation projects.

The strategy for strengthening bridges and other infrastructure follows the same principles as discussed above for buildings. The targets for mitigation should not be typical infrastructure but rather specific infrastructure elements that have been identified as being unusually vulnerable and/or are critical links in the lifeline system. For example, vulnerable overpasses on major highways would have a much higher priority than overpasses on lightly traveled rural routes.

The following is a list of critical facilities that need seismic upgrades. These buildings will be prioritized for funding of seismic mitigation projects working through the Hazard Mitigation Advisory Committee, the County, Cities, and Special Service Districts.

EMERGENCY SERVICES		YEAR BUILT	Type of CONST	Need Seismic UPGRADE
	COLUMBIA COUNTY			
Emergency Operations Centers	Courthouse, 230 Strand, St. Helens	1800's	URM	No
Columbia 911 Dispatch Center	58611 McNulty Way	1999	wood	Yes
County Courthouse	230 Strand St.	1800's	URM	No
	CLATSKANIE			
Fire Stations	280 S.E. 3rd St.	1973	Wood	No
	Alston, 76015 Atkins Rd.	1953	wd/block	No
	Mayger Fill, 80694 Mayger Hill Rd.	1940's	wd/block	No
	Quincy, 79704 Quincy-Mayger Rd.	1960's	wd/block	No
Police Stations	195 S.E. 2nd St.	1970's	wood	No
Ambulance Services	CFD, 280 S.E. 3rd St.	1973	Wood	No
City Hall	95 S. Nehalem St.	No	wood	No
	COLUMBIA CITY			
Fire Stations	400 G St.		Wood	No
Police Stations	1840 2nd St. #1	50-60	Wood	No
City Hall	1840 2nd St. #2	50-60	Wood	No
	MIST-BIRKENFELD			
Fire Stations	12525 Hwy 202	1999	Steel	Yes
	Fishawk, 71288 Northshore Drive	1989	wood	No
Ambulance Services	MBFD 12525 Hwy 202	1999	Steel	yes
Emergency Operations Centers	MBFD 12525 Hwy 202	1999	Steel	yes
	RAINIER			
Fire Stations	211 2nd St.			No
	Fernhill, 73153 Doan Rd.			No
	Goble, 69321 Nicolai Rd.			No
Police Stations	106 B St. #1			No
Ambulance Services	CRFR, 211 2nd St.			No
City Hall	106 B St. #2			No
	SCAPPOOSE			
Fire Stations	52751 Columbia River Hwy	1986	wd/block	No
	19260 NW Cleetwood, Portland	1988	wood	No
	27713 Chapman Rd	1970	wd/steel	No
Police Stations	33568 E Columbia	1950/60	block	No
Ambulance Services	52751 Columbia River Hwy	1986	wd/block	No
Emergency Operations Centers	52751 Columbia River Hwy	1986	Wd/block	No
Emergency Shelters	Scappoose. High School 33700 S.E. High School Way.	1971	block	No
City Hall	33568 E. Columbia Ave.	1950/60	block	No

		VERNONIA		
Fire Stations	555 Bridge St. #1		wood/steel	no
Police Stations	1001 Bridge St. #1		Wood/blk	yes
City Hall	1001 Bridge St. #2		Wood/blk	yes
Police Stations	1001 Bridge St. #1		Wood/blk	yes
City Hall	1001 Bridge St. #2		Wood/blk	yes
	CRFR, 58798 Saulser Rd.			No
		ST HELENS		
Fire Stations	Admin, 270 Columbia Blvd.			No
	105 S. 12th St.	1930-60		No
	Deer Island, 33710 Canaan Rd.	1973		No
	Fairgrounds, 58798 Saulser Rd.	1973		No
	Maint. Facility, 58555 McNulty Wy.	1993	Steel	
Police Stations	150 S. 13th St.			No
Ambulance Services	CRFR, 105 S. 12th St.			No
	CRFR, 58798 Saulser Rd.			No
City Hall	265 Strand St.		URM	no

The following table contains earthquake mitigation action items from the master Action Item table in Chapter 4.

Table 10.10
Earthquake Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Earthquake Mitigation Action Items								
Short-Term #1	Complete inventory of public and commercial buildings that may be particularly vulnerable to earthquake damage	County, cities, special districts	1-2 Years	X	X	X	X	X
Short-Term #2	Complete inventory of wood-frame residential buildings that may be particularly vulnerable to earthquake damage, including pre-1940s homes and homes with cripple wall foundations.	County, cities	1-2 Years	X	X	X	X	X
Short-Term #3	Disseminate FEMA pamphlets to educate homeowners about structural and non-structural retrofitting of vulnerable homes and encourage retrofit	Columbia County Hazard Mitigation Advisory Committee	Ongoing	X		X	X	X
Short-Term #4	Complete seismic vulnerability analysis of important public facilities with significant seismic vulnerabilities	County, cities, special districts	1-2 Years	X	X	X	X	X
Long-Term #1	Obtain funding and retrofit important public facilities with significant seismic vulnerabilities	County, cities, special districts	10 years	X	X	X	X	X
Long-Term #2	Retrofit bridges that are not seismically adequate for lifeline transportation routes	ODOT, County, cities, roads		X	X	X	X	X

CHAPTER ELEVEN

11.0 VOLCANIC HAZARDS

11.1 Overview

The Cascades, which run from British Columbia through Washington and Oregon into northern California, contain more than a dozen major volcanoes and hundreds of smaller volcanic features. In the past 200 years, seven of the Cascade volcanoes in the United States have erupted, including: Mt. Baker, Glacier Peak, Mt. Rainier, Mount St. Helens, Mt. Hood, Mt. Shasta, and Mt. Lassen.

Over the past 4,000 years (a geologically very short time period) there have been three eruptions of Mt. Hood, four eruptions in the Three Sisters area, and two eruptions in the Newberry Volcano area and minor eruptions near Mt. Jefferson, at Blue Lake Crater, in the Sand Mountain Field (Santiam Pass), near Mt. Washington, and near Belknap Crater. During this time period, the most active volcano in the Cascades has been Mount St. Helens with about 14 major eruptions and many smaller eruptions.

Many other volcanoes are deemed active or potentially active. The Smithsonian Institution's Global Volcanism Project lists 20 active volcanoes in Oregon and 7 in Washington. These volcanoes are listed below in Tables 11.1 and 11.2

Table 11.1
Active Volcanoes in Oregon

Volcano	Type	Last Eruption
Mt. Hood	Stratovolcano	1866
Mt. Jefferson	Stratovolcano	950 main volcano inactive for >10,000 years
Blue Lake Crater	Crater	1490 BC
Sand Mountain Field	Cinder cones	1040 BC?
Mt. Washington	Shield volcano	620 main volcano inactive
Belknap Field	Shield volcanoes	460?
North Sister Field	Complex volcano	350
South Sister	Complex volcano	50 BC?
Mt. Bachelor	Stratovolcano	5800 BC
Davis Lake	Volcanic field	2790 BC?
Newberry Volcano	Shield volcano	620 crater formation 300,000 to 500,000 years ago
Devils Garden	Volcanic field	unknown
Squaw Ridge Lava Field	Volcanic field	unknown
Four Craters Lava Field	Volcanic field	unknown
Cinnamon Butte	Cinder cones	unknown
Crater Lake	Caldera	2290 BC Crater formation about 7,700 years ago
Diamond Craters	Volcanic field	unknown
Saddle Butte	Volcanic field	unknown
Jordan Craters	Volcanic field	1250 BC
Jackies Butte	Volcanic field	unknown

Table 11.2
Active Volcanoes in Washington

Volcano	Type	Last Eruption
Mt. Baker	Stratovolcano	1880
Glacier Peak	Stratovolcano	1700 ± 100
Mt. Rainier	Stratovolcano	1825 (?)
Mt. Adams	Stratovolcano	950 AD (?)
Mount St. Helens	Stratovolcano	1991 (eruptions started in 1980)
West Crater	Volcanic field	5760 BC (?)
Indian Heaven	Shield volcanoes	6250 BC ± 100

On a longer geological time scale, volcanic activity in the Cascades has been very widespread. A DOGAMI report on prehistoric and historic volcanic eruptions in Oregon (see website below) notes that, in the Cascades as a whole, over 3,000 large and small volcanoes have erupted over the past five million years. Within historical times, between 1843 and 1860 there were a series of 21 eruptions in the Cascades and there is some scientific speculation that the Northwest may be entering another period of volcanic activity.

A great deal of general background information on Oregon and Washington volcanoes and on volcanoes in general is available on several websites, including the following.

Table 11.3
Volcano Websites

Institution	Website
Smithsonian Institution (Global Volcanism Project)	www.volcano.si.edu/gvp
United States Geological Survey (USGS) - general site	www.usgs.gov
USGS Cascades Volcano Observatory (Vancouver, WA)	http://vulcan.wr.usgs.gov
DOGAMI	www.oregongeology.com

The numerous volcanoes of the Cascades differ markedly in their geological characteristics. The largest volcanoes are generally what geologists call composite or stratovolcanoes. These volcanoes may be active for tens of thousands of years to hundreds of thousands of years. In some cases, these large volcanoes may have explosive eruptions such as Mount St.. Helens in 1980 or Crater Lake about 7,700 years ago. The much more numerous sites of volcanic activity are generally what geologists call mafic volcanoes. This type of volcano is typically active for much shorter time periods, up to a few hundred years, and generally forms small craters or cones. Mafic volcanoes are not subject to large explosive events.

11.2 Volcanic Hazard Types

In Oregon, awareness of the potential for volcanic eruptions was greatly increased by the May 18, 1980 eruption of nearby Mount St. Helens in Washington which killed 57 people.

In this eruption, lateral blast effects covered 230 square miles and reached 17 miles northwest of the crater, pyroclastic flows covered six square miles and reached 5 miles north of the crater, and landslides covered 23 square miles. Ash accumulations were about 10 inches at 10 miles downwind, 1 inch at 60 miles downwind, and ½ inch at 300 miles downwind. Lahars (mudflows) affected the North and South Forks of the Toutle River, the Green River, and ultimately the Columbia River as far as 70 miles from the volcano. Damage and reconstruction costs exceeded $1 billion.

Volcanic eruptions often involve several distinct types of hazards to people and property, as well evidenced by the Mount St. Helens eruption. Major volcanic hazards include: lava flows, blast effects, pyroclastic flows, ash flows, lahars, and landslides or debris flows. Some of these hazards (e.g., lava flows) only affect areas very near the volcano. Other hazards may affect areas 10 or 20 miles away from the volcano, while ash falls may affect areas many miles downwind of the eruption site.

Lava flows are eruptions of molten rock. Lava flows for the major Cascades volcanoes tend to be thick and viscous, forming cones and thus typically affecting areas only very near the eruption vent. However, flows from the smaller mafic volcanoes may be less viscous flows that spread out over wider areas. Lava flows obviously destroy everything in their path.

Blast effects may occur with violent eruptions, such as Mount St. Helens in 1980. Most volcanic blasts are largely upwards. However, the Mount St. Helens blast was lateral, with impacts 17 miles from the volcano. Similar or larger blast zones are possible in future eruptions of any of the major Cascades volcanoes.

Pyroclastic flows are high-speed avalanches of hot ash, rock fragments and gases. Pyroclastic flows can be as hot as 1500^{o}F and move downslope at 100 to 150 miles per hour. Pyroclastic flows are extremely deadly for anyone caught in their path.

Ash falls result when explosive eruptions blast rock fragments into the air. Such blasts may include tephra (solid and molten rock fragments). The largest rock fragments (sometimes called “bombs”) generally fall within two miles of the eruption vent. Smaller ash fragments (less than about 0.1”) typically rise into the area forming a huge eruption column. In very large eruptions, ash falls may total many feet in depth near the vent and extent for hundreds or even thousands of miles downwind.

Lahars or mudflows are common during eruptions of volcanoes with heavy loading of ice and snow. These flows of mud, rock and water can rush down channels at 20 to 40 miles an hour and can extend for more than 50 miles. For some volcanoes, lahars are a major hazard because highly populated areas are built on lahar flows from previous eruptions.

Landslides or debris flows are the rapid downslope movement of rocky material, snow and/or ice. Volcano landslides can range from small movements of loose debris to massive collapses of the entire summit or sides of a volcano. Landslides on volcanic slopes may be triggered by eruptions or by earthquakes or simply by heavy rainfall.

11.3 Volcanic Hazards for Columbia County

Several of the active volcanoes in Oregon and Washington (See Tables 11.1 and 11.2) are located relatively near Columbia County, including Mount St. Helens and Mt. Hood. Approximate distances from St. Helens to four relatively nearby volcanoes are shown below in Table 11.4.

Table 11.4
Distances from St. Helens

Volcano	Distance (miles)
Mount St. Helens	38
Mt. Hood	63
Mt. Adams	70
Mt. Rainier	86

Among these relatively nearby volcanoes, Mount St. Helens is the most active. Mt. Hood and Mt. Rainier are definitely active and Mt. Adams is potentially active.

Columbia County is approximately 40 miles from Mount St. Helens, and further away from the other volcanoes. We review the volcanic hazards posed by Mount St. Helens, the nearest, most active volcano that may affect Columbia County.

The USGS analysis of Volcano Hazard Zonation for Mount St. Helens, Washington was published in 1995 (Open-File Report 95-497). The USGS study of volcano hazards in the vicinity of Mount St. Helens includes three hazard zones, shown on the map which accompanies the USGS report:

> **Flowage Hazard Zone 1 (proximal hazard zone)** is limited to the immediate area around the Mount St. Helens including all areas within about 5 miles of the volcano summit and some areas extending to about 10 miles away. The proximal hazard area is the area subject to the most intense volcanic hazards including lava flows, tephra flows, pyroclastic flows, landslides and debris flows and lahars. Fortunately, this area is predominantly wilderness with very low population.
>
> **Flowage Hazard Zone 2 (distal hazard zones)** are river valleys extending away from the proximal hazard zone that are subject to pyroclastic flows and lahars. Areas subjected to these hazards include a ring around Zone 1, extending downstream along the North and South Forks of the Toutle River and along the Kalama River.
>
> **Flowage Hazard Zone 3** includes the intermediate and lower reaches of river valleys that could be inundated by lahars, including the North and South Forks of the Toutle River and along the Kalama River, extending downstream to the Cowlitz River and to the Columbia River.

Of these Mount St. Helens volcanic hazards zones, only Zone 3 affects significant population centers (in Washington State). None of these volcanic hazard zones of Mount St. Helens affect Columbia County directly.

However, to a much lower extent, volcanic activity at Mount St. Helens could affect Columbia County in several ways:

1. Debris flows, landslides, and lahars into the river valleys near Mount St. Helens will affect the Columbia River at Longview and further downstream. In severe events, navigation in the Columbia River may be affected and dredging may be required to maintain channel depths.

Depending on the volume of volcanic ash ejected by an eruption and on prevailing wind directions at the time of eruption, various thicknesses of ash falls may affect Columbia County. Possible impacts of ash falls include:

a. Clean-up and debris removal,
d. Possible respiratory problems for at-risk population such as elderly, young children or others with respiratory problems,
e. Possible impacts on public water supplies drawn from surface waters, including degradation of water quality (high turbidity) and possible increased maintenance requirements at water treatment plants, and
f. Possible electric power outages from ash-induced short circuits in distribution lines, transmission lines, and substations.

Thus, the extent of volcanic hazards for most of Columbia County appears limited to the possibility of minor ash falls from eruptions from Mount St. Helens (or lesser ash falls from more distant volcanoes), along with possible impacts on navigation in the Lower Columbia River. In all but the most extreme events, ash falls for most communities are likely to be very minor with an inch or less of ash likely. In the 1980 Mount St. Helens eruption, Columbia County received about 1” to 1.5” of ash.

The following maps show probabilistic data on ash fall in western Oregon, taking into account all of the active volcanoes (USGS Open File Report 9-437, Plate 1, 1999). Interpolating between the map contours of Figure 11.5, the annual probability of 1 centimeter (about 0.4 inch) or more of volcanic ash ranges from about 1/3000 in eastern Columbia County to about 1/6000 in western Columbia County. In other words the return period for such ash falls are about 3,000 to 6,000 years for various locations within Columbia County.

Figure 11.5
Annual Probability of 1 Centimeter (about 0.4 inch) or More of Volcanic Ash

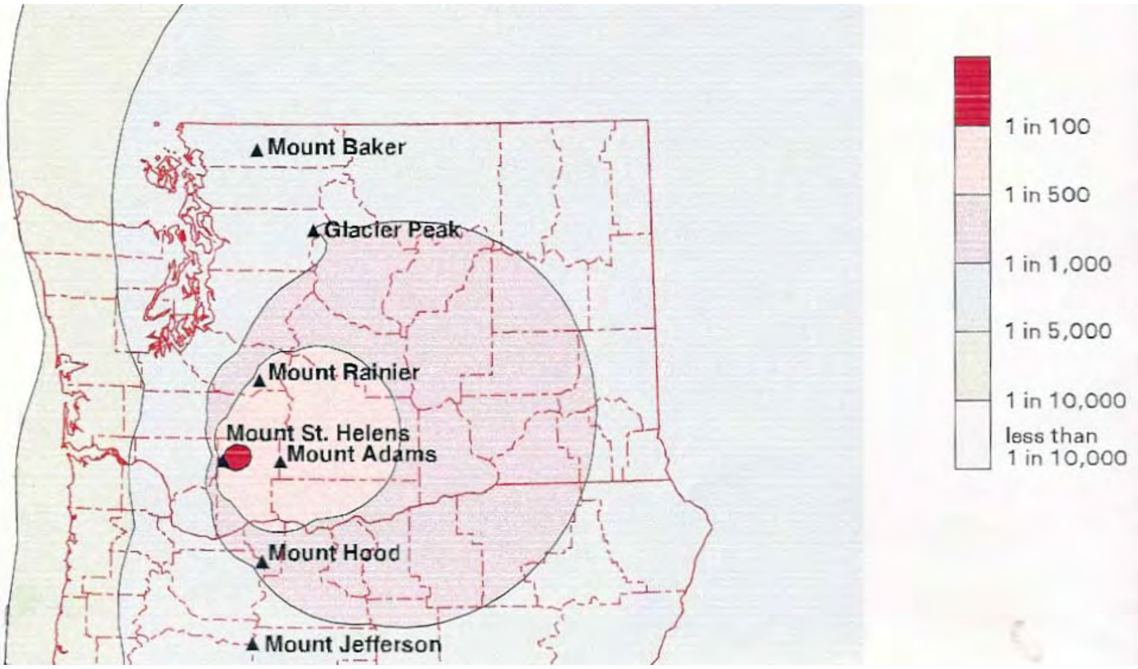
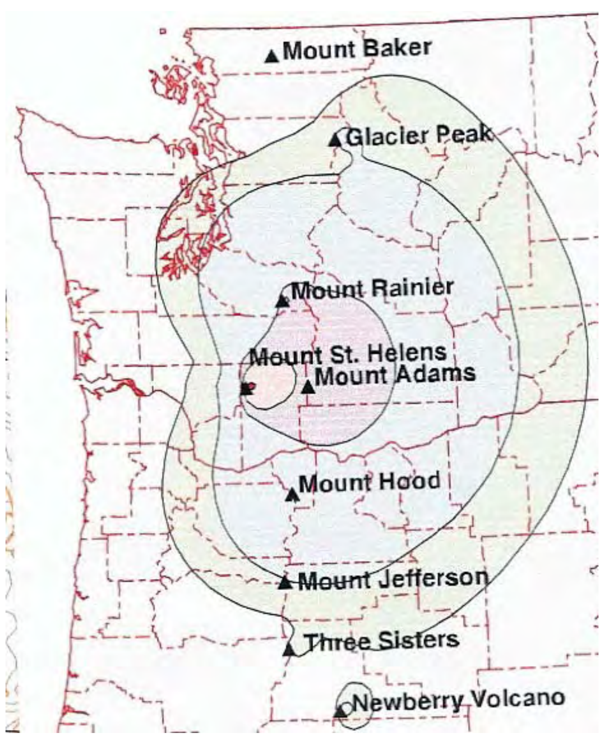


Figure 11.6
Annual Probability of 10 Centimeters (about 4 inches) or More of Volcanic Ash
(same scale as Figure 11.5 above)



Interpolating between the map contours of Figure 11.6, the annual probability of 10 centimeters (about 4 inches) or more of volcanic ash ranges from about 1/7500 in eastern Columbia County to about 1/15000 in western Columbia County. In other words the return period for such ash falls are about 7,500 to 15,000 years for various locations within Columbia County.

The low probabilities of significant ash falls (i.e., long return periods) arise because ash falls in Columbia County require volcanic eruptions producing ash <u>and</u> wind directions that deposit ash westward from the volcanoes.

The probable impacts of potential volcanic eruptions on Columbia County are summarized below in Table 11.7.

Table 11.7
Probable Impacts of Potential Volcanic Eruptions on Columbia County

Inventory	Probable Impacts
Portion of Columbia County Affected	Entire County and surrounding region may be affected by ash falls from some eruptions.
Buildings	Negligible impact, other than minor cleanup required
Streets within Columbia County	Negligible impact, other than minor cleanup required
Roads to/from Columbia County	Negligible impact, other than minor cleanup required
Electric Power	Temporary power outages likely from short circuits caused by ash falls
Other Utilities	Negligible impact, other than minor cleanup required for most utilities. Potential to impact water treatment plants which may require additional maintenance to deal with high turbidity water
Columbia River Navigation	Potential sedimentation in Columbia River from large eruptions, especially of Mt. St. Helens and Mt. Hood, could impact river traffic and require dredging to restore channel depths.
Casualties	Some potential for health impacts, especially for frail people with respiratory problems.

11.4 Mitigation of Volcanic Hazards

Mitigation of volcanic hazards is predominantly in the areas of monitoring volcanic activity, warnings and evacuation, and emergency response. That is, there are few, if any, practical physical measures to mitigate the direct impacts of volcanic activity.

The USGS actively monitors volcanic activity in the Cascades via networks of seismic sensors (which can detect earthquakes related to magma movements) as well as very accurate ground surface measurements, such as that which has detected the very small bulge on South Sister. The USGS also has a volcanic warning system with several levels of alert as a potential eruption becomes more likely and more imminent.

For the Cascades, the USGS volcano warning system (www.usgs.gov) has three levels. Level One (Volcanic Unrest) means anomalous conditions that could be indicative of an eventual volcanic eruption. Level Two (Volcanic Advisory) means that processes are underway that have a significant likelihood of culminating in hazardous volcanic activity, but when the evidence does not indicate that a life- or property-threatening event is imminent. Level Three (Volcano Alert) means that monitoring or evaluation indicate that precursory events have escalated to the point where a volcanic event with attendant volcanologic or hydrologic hazards threatening to life and property appears imminent or is underway.

For most of Columbia County, which is located well outside of any of the likely direct hazard zones for any Cascades volcanic events, mitigation for volcanic activity is likely a low priority. In the event of a minor ash flow, public warnings directing people (especially those with respiratory problems) to remain indoors, and minor cleanup are most likely the only necessary responses for most volcanic effects impacting Columbia County. In addition, water treatment plants should be evaluated to ensure that they can handle possible high turbidity events from volcanic ash falls into water supplies.

The following table includes the volcanic hazards mitigation action items from the master Action Items table in Chapter 4.

Table 11.8
Volcanic Hazards Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed: Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Volcanic Hazards Mitigation Action Items								
Short-Term #1	Update public emergency notification procedures for ash fall events	CEPA, CCOM, local emergency services agencies	1-2 Years	X	X			X
Short-Term #2	Update emergency response planning for ash fall events	CEPA, CCOM, local emergency services agencies	1-2 Years	X	X			X
Short-Term #3	Evaluate capability of water treatment plants to deal with high turbidity from ash falls and upgrade treatment facilities and emergency response plans to deal with ash falls	local water agencies	1-2 Years	X	X	X	X	X
Short-Term #4	Evaluate ash impact on storm water drainage system and develop mitigation actions if necessary	public works agencies	1-2 Years		X	X	X	X

CHAPTER TWELVE

12.0 DAM SAFETY

12.1 Overview of Dams

Dams are manmade structures built to impound water. Dams are built for many purposes including water storage for potable water supply, livestock water supply, irrigation, or fire suppression. Other dams are built for flood control, recreation, navigation, hydroelectric power or to contain mine tailings. Dams may also be multifunction, serving two or more of these purposes.

The National Inventory of Dams, NID, which is maintained by the United States Army Corps of Engineers, is a database of approximately 76,000 dams in the United States. The NID does not include all dams in the United States. Rather, the NID includes dams that are deemed to have a high or significant hazard potential and dams deemed to pose a low hazard if they meet inclusion criteria based on dam height and storage volume. Low hazard potential dams are included if they meet either of the following selection criteria: 1) exceed 25 feet in height and 15 acre-feet of storage, or 2) exceed 6 feet in height and 50-acre feet of storage. There are many thousands of dams too small to meet the NID selection criteria. However, these small dams are generally too small to have significant impacts if they fail and thus are generally not considered for purposes of risk assessment or mitigation planning.

This NID potential hazard classification is solely a measure of the probable impacts if a dam fails. Thus, a dam classified as High Potential Hazard does not mean that the dam is unsafe or likely to fail. The level of risk (probability of failure) of a given dam is not even considered in this classification scheme. Rather, the High Potential Hazard classification simply means that there are people at risk downstream from the dam in the inundation area, if the dam were to fail. The NID potential hazard classification system for dams is as summarized below in Table 12.1.

Table 12.1
NID Hazard Potential Classification for Dams[1]

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, or Lifeline Losses
Low	None expected	Low and generally limited to dam owner
Significant	None expected	Yes
High	Probable, one or more expected	Yes, but not necessary for this classification.

Dams assigned the low hazard potential classification are those where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the dam owner's property.

Dams assigned to the significant hazard potential classification are those where failure or mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, or disruption of lifeline facilities. Significant hazard potential dams are often located in predominantly rural or agricultural areas.

Dams assigned to the high hazard potential classification are those where failure or mis-operation will probably cause loss of human life. Failure of dams in the high classification will generally also result in economic, environmental or lifeline losses, but the classification is based solely on probable loss of life.

Of the dams in the NID, nearly 60% are privately owned. In addition to the dams in the NID, there are many thousands of dams too small to meet the selection criteria for the NID. Most of these small dams are also privately owned.

The NID is available online through several links at FEMA and the United States Army Corps of Engineers. However, since September 11, 2001, access is somewhat restricted. Basic NID information and links to the database are available at http://crunch.tec.army.mil/nid/webpages/nid.cfm

12.2 Dam Primer

In the simplest terms, dams are impervious structures that block the flow of water in a river or stream and thereby impound water behind the dam. Dams have been built for thousands of years from a wide range of materials, including earth, stone, masonry, wood, and concrete. Large modern dams are almost always embankment dams (built primarily from soil, rock, or mixtures) or concrete dams.

Large modern dams almost always have control mechanisms such as gated spillways or outlet pipes for releasing water in a controlled fashion. Typically, dams are operated to smooth natural variations in water flow. During high water flow periods, water is stored behind a dam, while in low water flow periods, water is released to increase flows. Controlled releases typically result in lower peak (flood) flows and higher minimum flows than in uncontrolled streams. The specific patterns of water storage and release vary from dam to dam, depending on the primary purpose(s) of the dam and on a wide variety of economic, regulatory and environmental considerations.

12.2.1 Dam Nomenclature and Types of Dams

Modern dams, whether embankment dams or concrete dams, are typically constructed on a foundation, which may be concrete, natural rock or soils, or compacted soils. Dams are usually constructed along a constricted part of a river valley to minimize cost. Dams are also connected to the surrounding natural valley walls, which become the abutments of the dam structure itself.

Embankment dams are commonly termed earthfill or rockfill dams, depending on the primary material used in their construction. Historically, a wide range of earth and rock materials have been used to construct embankment dams, with various construction techniques including hydraulic fill and compaction. Embankment dams are broad flat structures, typically at least twice as wide at the base as their height. In cross section, embankment dams are typically trapezoidal, with a wide flat base, sloping slides and a narrower flat top.

Depending on the permeability of the materials used in an embankment dam, impervious layers may be added to the upstream side of the structure or in the center core of the structure. Embankment dams are subject to erosion by running water. Thus, modern embankment dams always have erosion-resistant materials used in the water release and control mechanisms of the dam. Typically, concrete spillways with concrete or steel gates are used to control releases. Many dams also have outlet pipe systems with concrete or steel pipes as part of the water release control system.

Modern concrete dams fall into two major classes: gravity dams and arch dams. Concrete gravity dams are designed on principles similar to embankment dams. Concrete gravity dams are broad structures, generally triangular in shape with a flat base, a narrow top, a flat upstream side and a broad sloping downstream side. Much of these dams' capacity to impound water arises from the weight of the dam. Typically, gravity dams are keyed into bedrock foundations and abutments to increase the stability of the dam.

Concrete arch dams rely primarily on the strength of concrete to impound water. Concrete arch dams are much thinner in cross section than concrete gravity dams and are always convex on the upstream side and concave on the downstream side because concrete is much stronger in compression than in tension. With this arch design, the pressure of impounded water compresses the concrete and makes the dam stronger. Like concrete gravity dams, concrete arch dams are also keyed into bedrock foundations and abutments to provide stability. A less common variation of a concrete arch dam is a concrete buttress dam. Buttress dams are arched or straight dams with additional strength provided by buttresses perpendicular to the long axis of the dam.

An excellent introduction to dam nomenclature and descriptions of types of dams is given in the FEMA publication: Dam Safety: An Owner's Guidance Manual.[3] For further details, the reader is referred to this publication and the references therein.

12.2.2 Dam Failure Modes

Dam failures can occur at any time in a dam's life; however, failures are most common when water storage for the dam is at or near design capacity. At high water levels, the water force on the dam is higher and several of the most common failure modes are more likely to occur. Correspondingly, for any dam, the probability of failure is much lower when water levels are substantially below the design capacity for the reservoir.

For embankment dams, the most common failure mode is erosion of the dam during prolonged periods of rainfall and flooding. When dams are full and water inflow rates exceed the capacity of the controlled release mechanisms (spillways and outlet pipes), overtopping may occur. When overtopping occurs, scour and erosion of either the dam itself and/or of the abutments may lead to partial or complete failure of the dam. Especially for embankment dams, internal erosion, piping or seepage through the dam, foundation, or abutments can also lead to failure. For smaller dams, erosion and weakening of dam structures by growth of vegetation and burrowing animals is a common cause of failure.

For embankment dams, earthquake ground motions may cause dams to settle or spread laterally. Such settlement does not generally lead, by itself, to immediate failure. However, if the dam is full, relatively minor amounts of settling may cause overtopping to occur, with resulting scour and erosion that may progress to failure.

For any dam, improper design or construction or inadequate preparation of foundations and abutments can also cause failures. Improper operation of a dam, such as failure to open gates or valves during high flow periods can also trigger dam failure. For any dam, unusual hydrodynamic (water) forces can also initiate failure. Landslides into the reservoir, which may occur on their own or be triggered by earthquakes, may lead to surge waves which overtop dams or hydrodynamic forces which cause dams to fail under the unexpected load. Earthquakes can also cause seiches (waves) in reservoirs that may overtop or overload dam structures. In rare cases, high winds may also cause waves that overtop or overload dam structures.

Concrete dams are also subject to failure due to seepage of water through foundations or abutments. Dams of any construction type are also subject to deliberate damage via sabotage or terrorism. For waterways with a series of dams, downstream dams are also subject to failure induced by the failure of an upstream dam. If an upstream dam fails, then downstream dams also fail due to overtopping or due to hydrodynamic forces.

An excellent review of the common mechanisms for dam failures is given in the FEMA publication: Dam Safety: An Owner's Guidance Manual.[3] For further details, the reader is referred to this publication and the references therein.

A National Research Council study[4] of dam failures in the United States and Western Europe from 1900 to 1969 compiled historical data on the observed probability of failure as a function of type of dam. Dam failures are quite common in the United States. For example, FEMA data from Tropical Storm Alberto (1994) show 230 dam failures in the State of Georgia from this single event.[5] Fortunately, most dam failures are of small dams where the failure poses little or no risk to life safety and only minor, localized property damage. Most failures are of dams that are too small to be included in the NID database or dams in the NID Low Hazard Potential Category.

However, in the United States between 1960 and 1997 there were 23 dam failures that caused at least one death, with total fatalities from these 23 failures estimated at 318 people.[5] Since 1874, there have been six dam failures in the United States which killed over 100 people.[2] The worst dam failure, in terms of casualties, was the 1889 Johnstown Pennsylvania dam failure which killed over 2,200 people. Three of the high fatality dam failures occurred in the 1970s: Black Hills, South Dakota, Big Thompson River, Colorado, and Buffalo Creek, West Virginia. These three failures alone resulted in an estimated 514 deaths.[2] (Note: the published death statistics in this paragraph from these two FEMA sources are inconsistent, but these differences are not significant for the present purposes).

12.3 Oregon Dam Data

The National Inventory of Dams (NID) lists 812 dams in Oregon and 675 dams in Washington. Of these NID dams, 5 are in Columbia County and there is one dam in Clatsop County which is located upstream of Birkenfeld. The statistical breakdown of these dams by NID Potential Hazard Categories is shown below in Table 12.2.

Table 12.2
Numbers of Dams by NID Potential Hazard Categories

NID Hazard	Oregon	Columbia County[1]
High	128	0
Significant	151	2
Low	521	4
Undetermined	12	0
Total	812	6

[1] Includes one dam In Clatsop County

For Oregon, there are 128 dams in the High Potential Hazard Category. In Columbia County, there are no dams in the High Potential Hazard Category. The 6 dams in Columbia County (including one in Clatsop County) are listed individually in Table 12.3 below.

Table 12.3
NID Dams

Dam Name	River	Downstream City	Owner	Dam Type	Year	Storage (acre feet)	Hazard	EAP
Fish Hawk Lake[1]	Fishhawk Creek	Birkenfeld	Fishhawk Lake Rec. Club	RE	1969	1650	S	N
Vernonia Log Pond	Nehalem River	Vernonia	ODFW	RE/ER	1924	170	S	N
Fisher Reservoir	Sly Creek, Trib to	None	Betsy Johnson	RE	1971	36	L	N
Petes Slough Reservoir	Petes Slough	None	State Highway Division	RE	1980	2000	L	N
Salmonberry Reservoir	Salmon Creek	Trenholm	City of St. Helens	RE	1960	61	S	N
Sherman Stock Reservoir	Sly Creek, Trib to	Warren	Jeff and Beverly Heller	RE	1952	36	S	N

[1] Clatsop County

The NID dam type classification includes the following types of dams:

RE rockfill/earthfill embankment dams, primarily rockfill (fill >3” size)

ER rockfill/earthfill embankment dams, primarily earthfill (fill <3” size)

RE/ER combination of the above two types.

NID Hazard levels are High (H), Significant (S), and Low (L) as summarized in Table 12.1 above. The EAP column in Table 12.3 indicates whether or not the dam has an emergency action plan, which is required for large dams, but is not required for smaller dams such as those listed above.

None of these dams in Columbia County or affecting Columbia County are in the NID High Potential Hazard classification. All are relatively small dams, with relatively limited impacts downstream if they were to fail. Dams in the significant and low potential hazard categories do not pose a life safety threat and the risk of property damage is minimal or low.

12.4 Dam Failure Hazard Assessment: Columbia County

As noted above, the local dams in Columbia County (and Clatsop County) pose only limited risk to the residents of Columbia County. However, in addition to these small, local dams, there are numerous large dams upstream on the Columbia River and on the major tributaries of the Columbia, including the Willamette River, the Snake River and others.

Most of the dam failure risk for Columbia County comes from potential failures of these large dams upstream on the Columbia River and/or tributaries. For example, there are 22 major dams on the Columbia River (about 40 million acre feet of flood control storage) and 11 major dams on the Willamette River (about 1.7 million acre feet of flood control storage), as well as other dams on other tributaries.

As an example, Table 12.5 shows dam data for some of the major dams on the Willamette River and its tributaries. These dams are included here, as examples of upstream dams whose failure would affect downstream areas, including Columbia County to at least some extent.

Table 12.5
Sample Data on NID High Hazard Potential Dams Upstream of Columbia County

County	Dam Name	River	Storage (acre feet)	Date Built	Dam Type	EAP	Owner
Lane	Cottage Grove	Coast Fork Willamette	50,000	1942	RE	Y	Corps
Lane	Dexter	Middle Fork Willamette	29,900	1955	RE	Y	Corps
Lane	Fall Creek	Fall Creek	125,000	1965	ER	Y	Corps
Lane	Dorena	Row River	131,000	1949	RE	Y	Corps
Lane	Lookout Point	Middle Fork Willamette	477,700	1953	RE	Y	Corps
Lane	Blue River Dam	Blue River	89,000	1968	RE	Y	Corps
Lane	Hills Creek	Middle Fork Willamette	356,000	1962	RE	Y	Corps
Lane	Cougar	South Fork McKenzie	219,000	1964	ER	Y	Corps
Lane	Fern Ridge	Long Tom	121,000	1941	RE	Y	Corps

Terms used in Table 12.5 are identical to those defined above for Table 12.4.

These dams were completed between 1941 and 1968. All dams are rockfill/earthfill embankment dams, except Cougar which is an earthfill/rockfill embankment dam. All dams are operated by the US Army Corps of Engineers and all have emergency operations plans in place. All Corps dams are maintained on a regular schedule and undergo regular inspections, with major re-inspections every five years. Furthermore, the Corps is highly experienced in the construction, operation, and maintenance of dams.

On the Columbia River and other tributaries, the major dams are all classified as NID High Potential hazard. As noted previously, the NID classification as High Potential Hazard means only that there is probable loss of life if one of these dams fails. The NID classification contains no information whatsoever about the safety or lack of safety of a given dam and no information about the probability of failure. The Columbia River Dams are primarily concrete gravity dams and most were built from the 1930s to 1960s.

For embankment dams, as discussed above**,** the most common failure modes are overtopping, foundation failures, and seepage through the dam. For concrete dams, the most common failure modes are overtopping and foundation failures. Under normal or flood conditions, failure of the Corps operated dams appears highly unlikely. Failure is perhaps possible, however, in extreme flood events well above the design basis, especially if the reservoirs were close to full at the onset of flooding. The spillway capacities could be exceeded with a potential for overtopping failures.

There are, however, two other circumstances that may pose significant threats to any of these dams: landslides and earthquakes.

A major landslide into a reservoir, whether triggered by seismic activity or not, could result in a large surge wave that could result in dam failure from a combination of overtopping and hydrodynamic forces.

A major earthquake, either a Cascadia Subduction Zone earthquake, or a smaller, interplate or intraplate earthquake in Western Oregon, could cause sufficient damage to these dams to pose a risk of failure.

12.5 Risk Assessment

Most of the major dams which pose a potential life safety hazard for Columbia County are operated by the United States Army Corps of Engineers. The Portland District of the Corps, Geotechnical Engineer Branch, Concrete and Dam Safety Section has safety responsibilities for these dams. A variety of dam safety related information is available on the Portland District's web site at www.nwp.usace.army.mil. Under the Corps normal dam operating practices, dams are inspected annually, with a more complete evaluation every five years on a rotating schedule.

12.5.1 Flood Damage to Dams

All of the Corps dams were designed and built with specific flood capacities. Current dam designs are based on Standard Project Floods. Standard Project Floods, as defined in the Corps Engineer Manual 1110-2-1411 (March 1, 1965) are floods resulting from the Standard Project Storm. In turn, the Standard Project Storm is defined, somewhat imprecisely, as the most severe flood-producing rainfall-snowmelt, depth-area-duration event that is considered “reasonably characteristic” of the drainage basin. Discussions with Corps staff in the Portland District Office indicated that the Standard Project Flood is approximately a 500-year flood event.

The Corp dams' discharge design levels include the combination of spillway discharge capacity and reservoir outlet pipe discharge capacity. As an example, for the Hills Creek Dam, the Standard Project Flood is 64,500 cubic feet per second. The maximum controlled discharge capacity of the dam is 151,760 cubic feet per second, or nearly two and one-half times the Standard Project Flood discharge. These data are included on the Hills Creek Project, Emergency Response Flowchart[7]. At discharges beyond the maximum controlled discharge capacity of the dam, the dam would be overtopped, discharges would be uncontrolled, and there would be a high probability of damage to the dam, with some potential for dam failure. The large margin of safety in the discharge capacity of the dam suggests that the Hills Creek Dam likely has the capacity to withstand floods at least as large as a 1,000 year flood event without expected damage. The other Corps dams located upstream of Columbia County have similar margins of flood design safety.

12.5.2 Earthquake Damage to Dams

Most of these major dams on the Columbia River and its tributaries were designed and built in the 1930s to 1960s. Seismic design considerations were thus significantly lower than current seismic design considerations. As an example, a summary tabulation of the seismic design basis and inspection history of the major Willamette River dams is given below in Table 12.6 (Corps of Engineers, Portland District Office, March, 2001).

Table 12.6
Seismic Design, Evaluation and Inspection Data
Corps of Engineers Dams

Dam	Date of Last Seismic Evaluation	Seismic Design Basis		Date of Last Periodic Inspection
		Original	Current	
Cottage Grove	1981	None	0.21 g	1997
Dexter	1981	0.10 g	0.21 g	1996
Fall Creek	1981	0.10 g	0.21 g	1999
Dorena	1981	none	0.21 g	1997
Lookout Point	1981	0.10 g	0.21 g	1999
Blue River	1994	0.10 g	0.24 g	1996
Hills Creek	2000	0.10 g	0.22 g	1999
Cougar	1994	0.10 g	0.24 g	1997
Fern Ridge	2001	none	0.35 g	2000

As shown in Table 12.6, the Corps has conducted at least preliminary seismic evaluations of all of these dams. However, some of these evaluations were conducted in the 1980s and thus do not reflect current understanding of the seismic hazard in Oregon or current state-of-the-art seismic evaluation engineering principles. The Corps has an ongoing regular inspection program and an ongoing seismic evaluation program. Presumably, updated seismic evaluations of these dams will be completed over the next few years.

Seismic considerations were completely absent in the design of two of these dams: Dorena and Fern Ridge. The others were explicitly designed or probably designed to ground shaking levels of 0.10 g, which is the maximum seismic design level for any of the Corps dams in western Oregon. In contrast, the current Corps seismic design levels for dams at these sites (i.e., if new dams were to be built today) would be 0.21 g to 0.24g for the dams in eastern Lane County and 0.35 g for Fern Ridge . Thus, current seismic design requirements are for levels of ground shaking about two times higher than the probable design levels for most of these dams and about three times higher for Fern Ridge.

The many other major dams upstream of Columbia County, on the Columbia River and its tributaries have seismic design levels similar to the dams on the Willamette River, and similar potential seismic shortcomings.

Seismic evaluations of dam safety are a highly technical, highly specialized art. Separate evaluations must be done for each dam. The evaluation requires a detailed analysis of the design and construction of the dam, an analysis of the current condition of materials and components, geotechnical analysis of the foundation and site, and a site-specific seismic hazard analysis. For emergency planning purposes, a seismic evaluation should include the probabilities of failure for a scenario earthquake such as a large magnitude event on the Cascadia Subduction Zone.

The probability of catastrophic failure of these dams is impossible to estimate with any accuracy, from present data. Most likely, the probability is less than 0.1% per year (less than once in 1,000 years, on average) and perhaps substantially less. However, the consequences of failure are so high that careful evaluation is certainly warranted.

12.5.3 Dam Failure Inundation Maps

The USACE inundation maps for the lower Columbia River show inundation areas with a spillway design flood and with a spillway design flood plus dam failure. Spillway design floods are generally based on what the USACE determines to be the Probable Maximum Precipitation and the corresponding Probable Maximum Flood conditions. No frequency is explicitly attached the these probable maximum values, but such flood events would typically be roughly 5,000 or 10,000 year flood events (Bruce Duffe, USACE, August 16, 2004).

Inundation data from the USACE report "Guidelines for Flood Emergency Plans with Inundation Maps, Bonneville Dam, Columbia River, Oregon and Washington" (USACE Portland District, 1989) are summarized in Table 12.7 below. This table also includes flood elevation data from the FEMA Flood Insurance Study for Columbia County (FEMA, August 16, 1988). The USACE data includes the effects of upstream dams as well as the Bonneville Dam. The data shown below are for Mile 87, just east of St. Helens, with numerical values interpolated from data in the USACE report and from the FEMA flood profile graph for the Columbia River.

As shown in Table 12.7, dam failure alone results in flood elevations on the lower Columbia, under normal reservoir conditions, that are below the 10-year flood elevation. The spillway design flood is a truly extreme event, with flood elevations about 24 feet higher than the 500-year flood. The spillway design flood with dam failure is only about 0.2 feet higher than the spillway design flood alone.

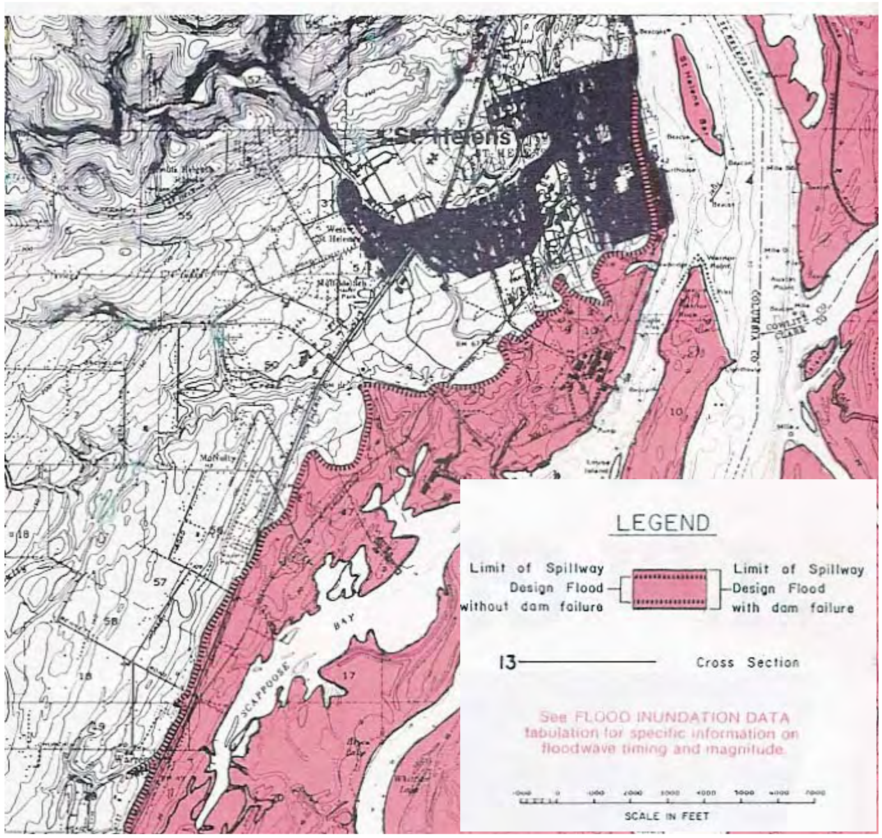
For Columbia County, inundation areas for the spillway design flood only and the spillway design flood with dam failure are shown on Plates 21 to 27 in the USACE report for Bonneville dam, referenced above. Inundation areas for the spillway design flood and dam failure are almost indistinguishable from the inundation areas with spillway design flood only. Either of these truly extreme flood events would inundate much of the low lying areas along the Columbia, as shown in Plates 21 to 27. For reference, a portion of Plate 22 near St. Helens is shown below as Figure 12.8.

Table 12.7
Columbia River Flood Data at Mile 87

Flood Event	River Flood Elevation (feet)
10-year flood[1]	18.6
50-year flood[1]	21.8
100-year flood[1]	23.2
500-year flood[1]	25.6
Dam failure[2,3]	13.2
Spillway design flood[3]	49.8
Spillway design flood and dam failure[3]	50.0

[1] FEMA FIS for Columbia County
[2] Dam failure at normal full pool
[3] Flood inundation data below Bonneville Dam, US Army Corps of Engineers, Guidelines for Flood Emergency Plans, Bonneville Dam, Portland District, 1989.

Figure 12.8
USACE Inundation Map for Lower Columbia River near St. Helens



The potential impacts of dam failures on communities in Columbia County are summarized below in Table 12.9.

Table 12.9
Probable Impacts of Potential Dam Failures on Columbia County

Inventory	Probable Impacts
Portion of Columbia County affected	Direct impacts limited to mapped inundation areas for very unlikely complete dam failures at the same time as extreme flood events.
Buildings	Heavy damage in inundation areas, if the above scenario occurs.
Streets within Columbia County	Damage and closures in inundation areas, if the above scenario occurs.
Roads to/from Columbia County	Damage and closures in inundation areas, if the above scenario occurs.
Electric power	Damage and loss of service in inundation areas, if the above scenario occurs.
Other Utilities	Damage and loss of service in inundation areas, if the above scenario occurs.. Potential for major damage to water and wastewater treatment plants in extreme events
Casualties	Potential for casualties (deaths and injuries) in extremely unlikely major dam failures concurrent with extreme floods, depending on warning time available and effectiveness of evacuations

In interpreting the above potential impacts of dam failure on Columbia County, it is essential to remember that dam failures alone, even of the major dams on the Columbia River, would have only very minor impacts. Only if dam failures occur concurrently with extreme flood events (such as 5,000 or 10,000 year) events are the full areas shown on the USACE dam failure inundation maps likely to be flooded.

12.6 Mitigation Strategies

Possible dam failures affecting Columbia County are very low probability events, but the potential casualties and economic impacts are high for truly extreme events with dam failures concurrent with extreme floods. The combination of low probability but large impacts makes analysis of such situations difficult from both a technical and a public policy perspective. The evaluation is difficult technically because it requires detailed engineering analysis of each dam and careful probabilistic risk analysis. As always, communication with the public must be non-alarmist, but factual, realistic and informative.

Recommendations

1. The first step in mitigation planning for dam safety is emergency planning. Emergency planners in Columbia County should obtain copies of the inundation maps for each of the major dams to familiarize themselves with the areas of potential flooding. For emergency planning, the estimated flood depths and the time periods from dam failure are particularly important. Flood depths and flood times both vary markedly with distance downstream from the dam locations. For emergency planning, key elements include community emergency notification procedures and evacuation planning (routes and traffic control). Because of the very large

numbers of potential evacuees, training seminars and scenario exercises are strongly recommended.

2. All dams have Emergency Action Plans. These plans should be reviewed to ensure that they are complete and up to date. Emergency planning officials in each county should be fully informed of the detailed consequences of the potential failure of each dam. Public notification and evacuation plans should be updated and tested. For some types of dam failures, for example, those due to extreme floods, there may be some warning time. Decision making procedures, protocols, and procedures for issuing watches, warnings, and evacuation notices should be reviewed and updated and coordinated among all responsible federal, state, and local agencies.

3. Because of the age of these dams, the seismic design basis is significantly below current seismic design requirements. Preliminary seismic evaluations have been done but without sufficient detail to evaluate the probabilities of dam failures. Because of the extreme consequences of potential failure of one or more of these dams, we recommend that detailed seismic evaluations be conducted for all of these dams.

The table on the following page contains dam safety mitigation action items from the master Action Items table in Chapter 4.

References

1. FEMA, Federal Guidelines for Dam Safety: Hazard Potential Classification Systems for Dams, FEMA 333, October 1998.
2. FEMA, Multihazard Identification and Risk Assessment, A Cornerstone of the National Mitigation Strategy, Chapter 20, Dam Failures, 1997.
3. FEMA, Dam Safety: An Owner’s Guidance Manual, FEMA 145, August 1987.
4. National Research Council, Safety of Existing Dams, Evaluation and Improvement, National Academy Press, 1983.
5. FEMA website (www.fema.gov), National Dam Safety Program webpage.
6. Oregon Emergency Management Division, Dam/Levee Failure, Statewide Hazard Analysis, March, 1987.
7. Hills Creek Lake Project, Emergency Response Flowchart, Distributed January 2000, United States Army Corps of Engineers, Portland District, 5 pages.

Table 12.10
Dam Safety Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed: Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Dam Safety Mitigation Action Items								
Short-Term #1	Prepare high resolution maps of dam failure inundation areas and update emergency response plans, including public notification and evacuation routes	County Land Development Services, city building departments, local emergency service agencies	1-2 Years	X	X			X
Long-Term #2	Encourage the Corps of Engineers to complete seismic vulnerability assessments for dams upstream of heavily populated areas in Columbia County and to make seismic improvements as necessary	Columbia County Hazard Mitigation Advisory Committee, US Army Corps of Engineers	Ongoing	X	X	X	X	X
Long-Term #3	Evaluate the adequacy of dike systems for both floods and earthquakes and implement mitigation measures if necessary	Local Dike Districts, US Army Corps of Engineers	Ongoing	X	X	X	X	X

CHAPTER THIRTEEN

13.0 DISRUPTION OF UTILITY AND TRANSPORTATION SYSTEMS

The previous chapters dealt with each of the major natural hazards impacting Columbia County including floods, winter storms, landslides, wildland/ urban interface fires, earthquakes and volcanic hazards. These chapters evaluated each of the hazards and the risk arising from the hazards as they impact the buildings, infrastructure and people of Columbia County.

Each of these hazards may result in not only damage to buildings but also damage to and disruption of utility and transportation systems. Mitigation projects may be implemented to reduce or avoid such damage and disruptions and a few examples were discussed in the previous chapters. In this sense, evaluating the potential damage and disruption of utility and transportation systems from each hazard is part of the risk assessment for each locality affected by a natural hazard.

However, disruption of utility and transportation systems may have impacts on the affected community which are far broader than the direct damage and corresponding direct loss of service. In this sense, disruption of utility and transportation systems may be viewed almost as a hazard. As for other hazards, the probability, duration, and extent of such outages can be assessed and the impacts (risk) associated with such outages can be quantified. Among the major utilities, loss of electric power generally has the most widespread impact on other utilities and on the community as a whole. Therefore, this chapter deals with electric power outages in more detail than for the other utility and transportation systems.

13.1 Transportation Systems

Streets, roads, and highways are subject to closure during flood events because of high water levels on road surfaces. This type of closure may occur during either a major flood event on the larger rivers and streams in Columbia County and surrounding areas or during win included most of the major routes in the interior of the county and numerous secondary roads.

For Columbia County, Chapter 7 (Winter Storms) identified some of the most problematic areas where major arteries and other roads have been repeatedly affected by winter storms (primarily localized flooding).

Some sites of road closures are difficult to mitigate without large scale flood control projects. However, mitigation is possible at many locations with high potential for road closures. Common measures include raising the road surface to reduce the probability of water overtopping the road or improving local drainage (e.g., culvert upsizings).

Risk assessments for road closures must include a measure of the importance of the road for transportation as well as an evaluation of the direct physical damages to the road. In many cases, the disruption of transportation has a larger economic impact that the direct physical damages.

To evaluate and prioritize hazard mitigation projects for roads, we suggest three measures of the relative importance of a road:

1. number of vehicle trips per day,
2. detour time around a road closure, and
3. road use as primary access/egress, including emergency vehicles.

The number of vehicle trips per day is an obvious measure of the importance of a road. All other factors being equal, a road with 500 trips per day is more important than a road with 50 trips per day and thus should have a higher priority for mitigation projects. However, a better measure of the importance of a road is obtained if the detour time is also considered. If traffic loads were equal, a mitigation project on a road where a closure required a one-hour detour would have a higher priority than a road where a closure only required a five minute detour. More accurately, it is the combination of traffic load and detour time that provides a measure of the impact of road closure. The product of number of trips per day and the detour time gives a measure of the number of vehicle-hours of delay that result from a closure. Consider the following example:

Table 13.1
Calculation of Vehicle-Hours of Delay from Road Closures

Road	Trips per Day	Detour Time (hours)	Vehicle-Hours of Delay per day of Closure
A	500	0.10	50
B	100	1.00	100

In this example, Road A has fives times the traffic of Road B, but because the detour time is much longer for a closure on B than on A, the number of vehicle-hours of delay is greater on Road B than on Road A. On this basis, mitigation of the hazard causing the closure would have a higher priority on Road B than on Road A.

The number of vehicle hours of delay is a proxy for the economic impact of the closure. The current FEMA value (for benefit-cost analysis purposes) for the economic impact of lost time due to road closures is $32.23 per vehicle hour of delay (What is a Benefit?, FEMA 2001). This value is based on national average wage and benefits level and national average vehicle occupancy data, along with the assumption that an hour of leisure time is worth the same to a person as an hour of work (a common economic assumption). Then, for example, 100 vehicle hours of delay per day has an estimated economic impact of $3,223 and so on. For the vast majority of roads, with “typical” traffic loads, using an economic value of $32.23 per vehicle per hour of delay provides a reasonable measure of the economic impact of road closures. Everything else being more or less equal, roads which serve as primary access/egress routes and/or serve many emergency vehicles may be given a higher priority for mitigation.

For completeness, we note that roads are networked systems and a more accurate analysis of the relative priority of mitigation projects to reduce road closures should consider the network characteristics of a local road system. However, network analysis is complex, requires specialized expertise and is expensive. Network analysis may be justified for very expensive projects, such as a multi-million dollar relocation of a bridge to reduce the potential for flood washouts. However, the simple three parameter prioritization methodology suggested above is probably sufficient for evaluation of most small to medium sized mitigation projects.

Rail systems are subject to the same sorts of closures as are road systems. Evaluation and prioritization of mitigation projects for rail systems would follow a methodology closely analogous to that discussed above for road systems, with economic impact parameters appropriate for a rail system.

Other transportation systems (air, ports, ferry) are also subject to disruption due to the impacts of hazards. The analysis of such systems is roughly similar to that discussed above, but mitigation projects for such systems are encountered far less frequently than are mitigation projects for roads. Moreover, most such projects are not directly applicable to or a low priority for Columbia County and are thus not considered further.

13.2 Utility Systems - Overview

Evaluation of hazard mitigation projects for utility systems have some commonalities between systems that we briefly review before addressing each major utility system in turn.

Utility systems such as potable water, wastewater, natural gas, telecommunications, and electric power are all networked systems. That is, they consist of nodes and links. Nodes are centers where something happens - such as a pumping plant, a treatment plant, a substation, a switching office and the like. Links are the connections (pipes or lines) between nodes.

Risk assessments for utility systems are similar to risk assessments for buildings, in that the inventory of utility components is overlaid on the hazard map and the vulnerability of utility components is evaluated for the hazards impacting the utility. A major difference arises, however, because of the networked nature of utilities. As a simple example, consider an electric utility which suffers damage to 10% of its transmission lines. The extent of service outage might be essentially zero if there are redundant lines with sufficient capacity to handle the demand for electric power. Or, the extent of service outage might be 100% if the damaged lines provide the sole power feed for a community. Thus, the operating characteristics and network characteristics (especially the amount of redundancy) must be considered.

In conducting risk assessments or evaluating hazard mitigation projects for utility systems, the networked nature of such systems must be considered. The extent or lack of redundancy for particular elements in a system profoundly affects the extent to which a given level of damage results in system outages.

The general procedure for conducting a risk assessment or evaluating a hazard mitigation project for a networked utility system is outlined below in six steps.

1. Overlay utility system components with hazard maps,
2. Estimate the vulnerability of each component to impacts from each hazard,
3. From the estimated amount of damage to the system and the system's network operating characteristics, estimate the extent and duration of service outage,
4. From the damage estimates and the resources available, estimate the restoration time,
5. From the service outage (number of customers and duration) estimate the economic impacts of such loss of service, and
6. If a mitigation project is being evaluated estimate the reduction in direct damages and the reduction in service interruption attributable to mitigation project.

An important caveat for conducting risk assessments or evaluation of hazard mitigation projects for networked utility systems is that specialized expertise is often required. The analyst must thoroughly understand the operating characteristics of utility system components and their vulnerability to each hazard as well as thoroughly understand the network operating characteristics of the system as a whole. In the absence of sufficient experience and expertise risk assessments or evaluation of hazard mitigation projects may produce inaccurate and misleading results.

CAVEAT: conducting risk assessments or evaluation of hazard mitigation projects of networked utility systems often requires specialized expertise to produce meaningful results.

For reference, a detailed discussion of how to evaluate seismic hazard mitigation projects for water systems is given in the American Society of Civil Engineers monograph "***Guidelines for the Seismic Upgrade of Existing Water Transmission Facilities***," (J. M. Eidinger, editor, 1999; chapter by K. A. Goettel "Seismic Upgrades of Water Transmission Systems: When Is It Worth It?"). Very similar principles apply to evaluating hazard mitigation projects for other utility systems for any type of hazard.

The following sections briefly review utility systems with emphasis on identifying the system components which are most vulnerable to damage and loss of service from hazards covered in this Mitigation Plan: flooding, winter storms, landslides and earthquakes. Such components are thus logical targets for high priority mitigation projects whenever important components are subject to the hazards.

13.3 Potable Water Systems

Water treatment plants, including those in Columbia County, are often located in flood prone areas and are subject to inundation when raw water enters the filters, sedimentation or flocculation basins, resulting in loss of capability to treat incoming raw water properly. Water system control buildings and pump stations may also be subject to flood damages. Public or private water systems with wells as the water source are subject to outages when flood waters contaminate well heads; this is a common problem for smaller water systems.

Water transmission or distribution pipes are rarely damaged by flood waters, unless there are soil settlements or major erosion, because the lines are sufficiently pressurized (for water quality) to prevent intrusion of flood waters. Water transmission or distribution pipes are, however, subject to breakage when they cross landslide areas or in earthquakes. Water treatment plants are also subject to earthquake damages to the building and to process and control equipment.

Water systems, including Columbia County's water systems, are also highly vulnerable to electric power outages. Many water systems include pumped storage systems where water is pumped to storage tanks which are typically located 60 to 200 feet above the elevation of water system customers. Such tanks generally contain no more than 1 or 2 days of storage beyond typical daily usage (for reasons of water quality). Thus, electric power outages of more than 1 or 2 days may result in loss of potable water due to the inability of pumping plants to pump water. The most logical mitigation projects to minimize such outages are to provide back-up generators at key pumping plants or to provide quick connects so that portable generators (if available) can be quickly installed. Water treatment plants are also subject to outages due to loss of electric power.

Common mitigation projects for water systems include flood protection for treatment plants, providing back-up power, moving pipes from active landslide areas, and seismic upgrades for treatment plants.

13.4 Wastewater Systems

Wastewater systems are often highly vulnerable to flood impacts. Rising water may cause collection pipes to backup and overflow. Intrusion of storm water into collection systems may result in flows that exceed treatment plant capacities, resulting in release of untreated or only partially treated flows. Treatment plants are often located in flood plains, at low elevations, to facilitate gravity flow. However, such locations also facilitate flood damages. Wastewater treatment plans may be inundated, resulting in full or partial plant shutdown or plant bypass with corresponding release of untreated or only partially treated flows.

Lift stations and treatment plants are also subject to loss of function due to electric power outages, with resulting overflows or releases. Collection pipes are also subject to breakage due to landslides. However, such impacts are not particularly common, since most wastewater collection systems are in more urbanized areas with only selected areas subject to slides. Wastewater pipes are, however, subject to breakage in earthquakes. Wastewater treatment plants are also subject to earthquake damages to the building and to process and control equipment.

Common mitigation projects for wastewater systems include flood protection for wastewater treatment plants, providing back-up power for nodes such as lift stations, moving collection pipes from active landslide areas, and seismic upgrades for treatment plants.

13.5 Natural Gas Systems

Natural gas transmission and distribution pipes are not usually affected by flooding, because the pipes are pressurized. However, compressor stations may be subject to inundation damage or loss of electrical power to run electrical and mechanical equipment.

Transmission and distribution pipes are also subject to rupture in slide areas. Buried utility pipes are very subject to failure in small ground movements. Movements as small as an inch or two are often sufficient to break the relatively brittle pipe materials. Possible mitigation projects for natural gas systems include providing back-up power for important nodes (e.g., compressor stations) and moving pipes from active landslide areas.

The potential for fire or explosions from failure of natural gas lines is addressed in Chapter 14 Hazmat.

13.6 Telecommunications Systems

Telephone (land lines and cellular) systems, broadcast radio and TV systems, and cable TV systems may all be vulnerable to damages and services outages from hazards. However, in general, such systems have proved to be somewhat less vulnerable to service outages than other utility systems. System nodes (broadcast studios, switching offices and such) are subject to flooding if located in flood-prone areas. However, because of the importance of such facilities, few are located in highly flood-prone sites.

Similarly, few such facilities are likely to be located in landslide prone areas. Cellular towers in hilly areas, however, may be more subject to landslide hazards.

Buried communications (copper and fiber optic) and cable television cables are usually flexible enough to accommodate several feet of ground movement before failure. Thus, while major landslides may rupture such cables, minor settlements or small slides are not nearly as likely to impact such cables as they are to break buried gas or water pipes.

Above ground communications and cable television cables are subject to wind-induced failures from tree falls and pole failures. However, such failures are about ten times less common than failures of electric power lines. The better performance of communications cables arises in part because the electrical cables are always highest on the poles, thus a falling branch is usually first resisted by the power cables. Also, because the voltage levels in communications cables are much lower than those in power cables, the communication cables are not subject to “burn down” or shorting if wind-swayed cables touch each other or get too close.

Some telecommunications facilities are subject to failure as a result of loss of electric power. However, key facilities almost always have backup battery power and/or generators. Therefore, telecommunications facilities are generally much less vulnerable to outages from loss of electric power than are water or wastewater systems.

Possible mitigation projects for telecommunications systems include flood proofing of important nodes, adding back-up power, relocating facilities out of active slide areas and seismic retrofits.

13.7 Electric Power Systems

The electric power system is central to the functioning of a modern society. The impacts of loss of electric power are large: residential, commercial and public customers are all heavily dependent on electric power for normal functioning. Furthermore, as discussed above, other utility systems, especially water systems, are heavily dependent on electric power for normal operations. Loss of electric power, therefore, may have large impacts on affected communities, especially if outages are prolonged.

Electric power for Columbia County is distributed by Portland General Electric, the West Oregon Electric Co-Op, the Columbia River PUD, and the Clatskanie PUD.

Electric power systems have somewhat complex operating characteristics, which are briefly summarized here. Electric power systems have three main parts: generation, transmission, and distribution.

Generation is the production of electric power. Generating plans can be hydroelectric, fossil fuel (oil, gas, or coal), nuclear, or various renewable fuels (wind, solar, biomass, etc.). Most of the electric power consumed within Columbia County is produced elsewhere and transmitted via high-voltage transmission lines into the county. The Bonneville Power Administration (BPA) is the primary source of power for Columbia County. BPA’s power comes from hydroelectric facilities (57%) operated by the Corps of Engineers or the Bureau of Reclamation, from a nuclear plant (3%), from interchanges and wheeling (37%) of power transmitted by BPA but not owned by BPA and from other sources (3%). Through the Pacific Interties (high voltage AC or DC transmission lines) power is moved back and forth between California, the Pacific Northwest and western Canada.

There is only one small (530 megawatt output) generating plant within Columbia County near Clatskanie. This plant is owned by the Port of St Helens, but is leased to and operated by Portland General Electric. The plan operates on either natural gas or diesel fuel. Power from this generating plant is transmitted by 230 KV above ground lines that feed into the BPA transmission system at a substation west of Rainier.

The transmission system is a network of high voltage lines (500 kV and 230 kV) and substations which transmit power between generation plants and the local distribution system. The distribution system is a network of lower voltage lines and substations which carries power from transmission system substations to neighborhoods and eventually to individual customers.

Power outages in Columbia County are most likely to result from disruption of the transmission lines carrying power from outside Columbia County or within Columbia County, or damage to the local distribution lines within Columbia County. The generating plant system has sufficient redundancy so that failures of one or more plants do not usually lead to significant power outages. However, because of the limited generation capacity within Columbia County, major disruptions in the transmission system would result in substantial curtailment of available power. A major ice storm in the Columbia River area could conceivably fail all of the 500 kV transmission lines feeding Columbia County from the east.

However, a severe ice storm with 2 to 4" of ice over much of Columbia County could result in failure of most 500 kV and 230 kV transmission lines to and within Columbia County. Such a failure, which is unlikely, but certainly not impossible, would probably entail widespread power outages for 2 to 5 days.

The most frequent power outages, however, are due to failure of the local subtransmission or distribution system lines. Winter storms are the most frequent cause of significant electric power outages, with wind being the primary culprit. Electric distribution lines, the low voltage lines that deliver power to neighborhoods, are the most vulnerable electric system component in winter storms. Failures most commonly result from tree falls or from “burn downs” when wind-swayed cables touch or get too close to each other and short circuit. Distribution system failures may also be due to utility pole failures. Distribution lines may also fail due to ice loading in excess of design specifications or from landslides or debris flows or flooding which knock out utility poles.

Failures of distribution system lines are thus the most common failure mode for electric power systems. Power system outages are more common and of longer duration in rural areas compared to urban or suburban areas. Rural areas are more prone to electric outages because they have a higher percentage of above-ground lines and are more likely to have hilly areas with high concentrations of trees and higher wind speeds than in flatter terrain. In rural areas, with lower population density, there is also a higher ratio of length of distribution lines per customer. With a longer length of exposed line, the probability of an outage is higher for a rural customer than for an urban customer.

Once a portion of a power distribution circuit fails, all customers in that part of the circuit lose power. The duration of the power outage depends on the number of outages and the number of repair crews available for repairs. A typical power utility repair crew (2 or 3 people with a cherry picker) can restore power to a distribution circuit with common types of damage in 1 or 2 hours after arriving at the damage site.

Electric transmission lines (110 kV and higher) are less vulnerable to winter storm damage because of more robust design specifications. Also, such lines are usually higher above the ground and much less prone to tree branches falling on lines. Furthermore, because of the higher voltage (compared to distribution lines), power utilities must diligently pursue tree trimming programs to avoid flashovers from lines being too close to trees. Nevertheless, transmission lines do sometimes fail due to large tree falls, rapid growth of trees near lines, unusually high winds or heavy ice loads.

Columbia County is subject to outages of electric power primarily due to line failures. One possible failure mode would be the transmission lines that feed Columbia County from the east. More common failure modes would be failures of the trunk distribution lines within Columbia County and failures of distribution circuits or service drops from distribution lines to individual buildings. The local failures are most likely due to tree falls during wind storm events.

Mitigation projects to reduce the frequency and duration of electric power systems include: augmenting tree trimming programs and hardening lines and poles in locations where ice loading or wind effects result in repeated outages. In some cases, adding connections to improve redundancy of power feed paths and adding disconnect switches to minimize areas affected by any given failure are also worthwhile. In addition to such “hard” mitigation possibilities, there are also “soft” or planning mitigation projects. For example, enhancing mutual aid agreements with nearby utilities can reduce the duration of major outages by increasing the number of crews and equipment for making repairs. Other planning/logistics measures such as ensuring that adequate supplies of parts and equipment are available may also reduce the duration of future outages.

For Columbia County, augmenting tree trimming programs, especially for the transmission lines and the trunk distribution lines is probably the most effective mitigation measure. In selected locations upgrading lines and poles to better withstand loads from trees, wind and ice may also be appropriate. If there are key links in the systems that are highly prone to repetitive failures, undergrounding of limited portions of such links may also be appropriate.

13.8 Impacts on Columbia County and Mitigation Action Items

The probable impacts of disruption of transportation and utility systems on Columbia County, which were summarized above, are also covered in each of the other hazard Chapters (6 -12, 14, 15). Each of these chapters includes an impacts table which summarizes probable impacts on roads, bridges, and utility systems. A generalized summary of the probable impacts of utility disruptions and road closures on Columbia Count is given in Table 13.2 below.

Table 13.2
Probable Impacts of Utility Disruptions and Road Closures

Inventory	Probable Impacts
Portion of Columbia County affected	Impacts may be localized for damage to local utility distribution systems or street closures, or effect the entire County for damage to transmission lines or closures of major highways to/from Columbia County
Buildings	Negligible impacts to buildings, but loss of utilities may substantially affect function of buildings
Streets within Columbia County	Some incidents may include temporary street closures
Roads to/from Columbia County	Some incidents may include temporary road closures
Electric power	Some incidents may include temporary loss of electric power in localized parts of Columbia County or for the entire County. Duration of disruptions can range from an hour to up to a probable maximum outage of 1 or 2 days.
Other Utilities	Some incidents may include temporary loss of utilities in localized parts of Columbia County or for the entire County. Duration of disruptions can range from an hour to up to a probable maximum outage of 1 or 2 days.
Casualties	Low potential for direct casualties, but some incidents such as loss of electric power during cold weather may require evacuations and displacement of people (especially fragile or special needs population) to temporary shelters.

Within Columbia County, all of the dike districts rely heavily on pumping to keep dike areas dry, especially during flood periods and periods of heavy rainfall. Power outages longer than a few hours may have significant impacts on many of these dike districts, which generally have limited back-up power capabilities for the pumps.

The following table contains action items for mitigation of disruptions of utility and transportation systems, from the master Action Items table in Chapter 4. See also the mitigation action items for Winter Storms (Chapter 7) which includes action items related to tree trimming efforts to reduce storm effects on the electrical distribution systems within Columbia County.

Table 13.3
Mitigation Action Items for Disruption of Utility and Transportation Systems

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed: Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Utility and Transportation System Disruption Mitigation Action Items								
Short-Term #1	Educate and encourage residents to maintain several days of emergency supplies for power outages or road closures	Columbia County Hazard Mitigation Advisory Committee, CEPA	Ongoing	X	X		X	X
Short-Term #2	Review and update emergency response plans for disruptions of utilities or roads	local emergency service agencies, CEPA	1-2 Years	X	X		X	X
Short-Term #3	Ensure that all critical facilities in Columbia County have backup power and emergency operations plans to deal with power outages	local emergency service agencies, CEPA	1-2 Years	X	X		X	X

CHAPTER FOURTEEN

14.0 HAZARDOUS MATERIALS

14.1 Introduction

For mitigation planning, hazardous materials may be defined simply as any materials that may have negative impacts on human health, animal health, or the environment. That is, exposure to hazardous materials may result in injury, illness, or death. The impacts of a hazardous materials exposure may be short-term with negative effects immediately or in a few seconds, minutes or hours or long-term with negative effects in days, weeks, or in some cases years after exposure.

Hazardous materials vary widely in their toxicity to humans. Some hazardous materials are highly toxic so that even brief exposures to minute amounts may be dangerous or even fatal. Other hazardous materials are much less toxic and negative effects may occur only after a significant exposure to large quantities of a substance, or exposure to smaller quantities for a prolonged period of time. The technical term "toxic," or "toxicity," which is widely used to describe hazardous materials, is simply a synonym for the more common terms "poison" or "poisonous." A toxic is thus defined as any substance that causes injury, illness, or death to living tissue by chemical activity.

Hazardous chemicals are widely used in heavy industry, manufacturing, agriculture, mining, the oil and gas industry, high tech industries, forestry, and transportation as well as in medical facilities and commercial, public and residential buildings. There are literally hundreds of thousands of chemicals that may be hazardous to human health, at least to some extent. A typical single family home may contain dozens of potentially hazardous materials including fuels, paints, solvents, cleaning chemicals, pesticides, herbicides, medicines and others.

However, for mitigation planning purposes, small quantities of slightly or moderately hazardous materials being used by end users are rarely the focus of interest. Rather, interest is focused primarily on larger quantities of hazardous materials in industrial use and on hazardous materials being transported, where the potential for accidental spills or releases is high. Situations involving extremely hazardous materials or large quantities of hazardous materials in locations where accidents may result in significant public health risk are of special concern for planning purposes.

For mitigation planning purposes, the toxicity of particular hazardous materials is an important measure of the potential impact of hazardous materials on affected communities, but not the only important measure. Other characteristics of hazardous materials, especially the quantity of material and the ease of dispersal of the material may be as important as or more important than toxicity in governing the level of potential threat to a community. For example, a small quantity of a very toxic solid hazardous material used in a research laboratory may pose a much smaller level of risk for a community than a large quantity of a less toxic gaseous material in an industrial site located upwind from a populated area.

The severity of any hazardous material spill or release incident for an affected community depends on several factors, including:

a. the toxicity of the hazardous material,

b. the quantity of the hazardous material spilled or released,

c. the dispersal characteristics of the hazardous material,

d. the local conditions such as wind direction and topography, and

e. the location of the spill or release in proximity to sensitive environmental areas such as a watershed that provides a community's drinking water, and

f. the efficacy of response and recovery actions.

14.2 Effects of Hazardous Materials on Humans

The principal modes of human exposure to hazardous materials include:

a. Inhalation of gaseous or particulate materials via the respiratory (breathing) process,

b. Ingestion of hazardous materials via contaminated food or water,

c. Direct contact with skin or eyes.

Exposure to hazardous materials can result in a wide range of negative health effects on humans and animals. Hazardous materials are generally classified by their health effects. The most common types of hazardous materials are summarized below.

Flammable materials are substances where fire is the primary threat, although explosions and chemical effects listed below may also occur. Common examples include gasoline, diesel fuel, and propane.

Explosives are materials where explosion is the primary threat, although fires and chemical effects listed below may also occur. Common examples include dynamite and other explosives used in construction or demolition.

Irritants are substances that cause inflammation or chemical burns of the eyes, nose, throat, lungs, skin or other tissues of the body in which they come in contact. Examples of irritants are strong acids such as sulfuric or nitric acid.

Asphyxiants are substances that interfere with breathing. Simple asphyxiants cause injury or death by displacing the oxygen necessary for life. Nitrogen is a good example. Nitrogen is a normally harmless gas that constitutes about 78% of the atmosphere. However, nitrogen releases in a confined space may result in asphyxiation by displacing oxygen. Chemical asphyxiants are substances that prevent the body from using oxygen or otherwise interfere with the breathing process. Common examples are carbon monoxide and cyanides.

Anesthetics and Narcotics are substances which act on the body by depressing the central nervous system. Symptoms include drowsiness, weakness, fatigue, and incoordination, which may lead to unconsciousness, paralysis of the respiratory system and death. Examples include numerous hydrocarbon and organic compounds.

Hazardous materials may also have a wide variety of more specialized impacts on human health. Other types of toxic effects are briefly summarized in Table 14.1.

Table 14.1
Other Types of Hazardous Materials

Type of Hazardous Material	Effects on Humans
Hepatotoxin	Liver damage
Nephrotoxin	Kidney damage
Neurotoxin	Neurological (nerve) damage
Carcinogen	May result in cancer
Mutagen	May produce changes in the genetic material of cells
Teratogen	May have adverse affects on sperm, ova, or fetal tissue
Radioactive materials	May result directly in radiation sickness at high exposure levels or act as carcinogen, mutagen, or teratogen
Infectious substances	Biological materials such as bacteria or viruses that may cause illness or death

Much of the information above was summarized from Chapter Six of the **Handbook of Chemical Hazard Analysis Procedures**[1]. The first few chapters of this handbook contain a concise summary of many of the technical aspects of hazardous materials. These chapters may be useful to readers seeking a more technical introduction to the nomenclature and science of hazardous materials.

14.3 Classification System and Emergency Response Protocols

A standardized system is used to classify and identify hazardous materials. The 2004 Emergency Response Guidebook (A Guidebook for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Material Incident)[2] outlines the classification system. The 2004 Emergency Response Guidebook is an extremely useful reference book that provides standardized first response protocols and detailed reference sheets for the most common classes of hazardous materials.

Hazardous material releases are predominantly accidental results of traffic accidents, equipment failures or human errors. In rare cases, hazardous material releases may result from deliberate actions of sabotage or terrorism.

First responders for hazardous material incidents are generally public safety personnel (police or fire). The standard protocols for first responders are briefly summarized below, following guidance in the 2004 Emergency Response Guidebook.

The primary guidance for first responders is to:

a. resist rushing in,
b. approach the incident site from upwind, uphill or upstream, and
c. stay clear of all spills, vapors, fumes and smoke.

Upon approaching the incident site, a three-step procedure is recommended:

a. identify the material,
b. find the materials three digit guide number, and
c. read the numbered guide carefully and respond accordingly.

Identification of hazardous materials is by finding any one of the following:

a. the four-digit ID number on a placard or orange panel,

b. the four-digit ID number on a shipping document or package, or

c. the name of the material on a placard, shipping document or package.

Once identified by ID number or name, the material's three-digit guide number is looked up in either the ID number index or the name index. Then, the procedures and precautions outlined in the guide for the identified class of material are carefully followed. For each class of material, the guides have critical information on potential hazards, suggested evacuation distances for small and large spills, and recommended emergency response actions, including first aid. For further technical details see the 2004 Emergency Response Guidebook.

In Oregon, the Office of State Fire Marshal has defined standard response protocols for hazardous materials incidents in a series of Standard Operating Guidelines[3]. This series of about a dozen standard operating guidelines covers every main aspect of emergency response and recovery, including decisions to respond, levels of response, general response guidelines, mitigation methods, decontamination procedures, personal protective equipment, and others.

In Oregon, there is a three-level response plan for hazardous material incidents involving first responders and specialized emergency response teams.

First responders are local staff, generally public safety staff (police and fire) that are trained in basic procedures for the initial (first) response to hazardous materials incidents. The responsibilities of first responders including securing the incident scene and making a preliminary assessment of the potential severity of the hazardous material incident and the level of threat, if any, to persons at and outside of the immediate incident area. In Columbia County, most fire service first responders are trained to either the "Awareness" Level or "Operations" Level.

Emergency response teams are specialized teams, composed primarily of public safety staff, with higher-level training and more specialized equipment for dealing with hazardous materials incidents than first responders. State of Oregon Hazardous Materials Team members are trained to the "Technician" Level or higher. Statewide, these emergency response teams respond to about 350 hazardous material incidents per year, or about one per day, on average (Standard Operating Guidelines, Team Background[3]). In Oregon, there are fourteen emergency response teams, generally with 18 members each. Each response team has a defined geographic area of primary responsibility. For Columbia County, the Hazardous Materials Response Team with primary responsibility is the HM06 Portland Team which covers Columbia and Multnomah Counties.

The three-level response plan for hazardous materials incidents is characterized as Level I Response, Level II Response and Level III response. The distinction between Levels I, II, and III depends on:

a. class of hazardous material

b. size of container

c. fire/explosion potential

d. leak severity and container integrity, and

e. threat to life safety.

Level I Responses are those incidents readily controlled or stabilized by first responders. The HazMat Emergency Response Team personnel may provide technical assistance via telephone or on-site assistance, but full response by an Emergency Response Team is not required.

Level II Responses are those incidents that require response from a HazMat Emergency Response Team for control or stabilization of the spill. The Emergency Response Team response level may be 2-4 personnel for identification of the material and guidance on appropriate response actions or the response level may be a small team response of 6-8 personnel.

Level III Responses are those incidents that require special resources, including one or more full Emergency Response Teams and possibly other outside agencies for support.

Further technical details of the Level I, II, and III responses are given in the State of Oregon Standard Operating Guidelines, Levels of Response to Hazardous Materials Incidents, T-003.[3] A very useful glossary of technical terms used for hazardous materials incidents is given in the State SOG Glossary of Terms (Standard Operating Guidelines, Glossary of Terms, SOG-T-002.[3])

14.4 Statutory and Regulatory Context

The manufacture, storage, use, transportation, and disposal of hazardous materials are subject to a myriad of federal, state, and local regulations. In the context of mitigation planning and emergency response, we focus on reporting requirements for chemicals subject to mandatory risk management planning and extremely hazardous substances subject to additional reporting and planning requirements.

Oregon statutes governing hazardous materials are included in the following sections of the Oregon Revised Statutes:

ORS Chapter 453, 453.001 to 453.185 and 453.605 to 453.807

ORS Chapter 465, Hazardous Waste, Haz. Mat. I

ORS Chapter 466, Hazardous Waste, Haz. Mat. II

ORS Chapter 475, 475.405 to 475.495, Illegal Drug Clean-up

ORS Chapter 480, Explosives, flammable materials, pressure vessels.

Section 112(r) of the Clean Air Act Amendments was designed to prevent accidental releases of hazardous substances. The rule establishes a list of chemicals and threshold quantities that identify facilities subject to subsequent accident prevention regulations. The listed substances have the greatest potential to pose the greatest hazard to public health and the environment in the event of an accidental release.

The full list of Section 112(r) chemicals, including planning threshold quantities (TPQ) is given in the Office of State Fire Marshal's Hazardous Substance Information System database (available on CD from OSFM).

Hazardous materials may be released to the environment either routinely during manufacturing and other ongoing processes or accidentally. Certain types of businesses are required to report such releases annually for a specified list of chemicals. The paragraph below, quoted from the Office of State Fire Marshal, Hazardous Substance Information System (HSIS)[4], summarizes the intent and content of the regulatory requirements for substances covered under the Toxic Release Inventory regulations.

> "The Toxics Release Inventory (TRI) Program was established by section 113 of the Emergency Planning and Community Right to Know Act (EPCRA) of 1986. Under this program certain businesses are required to submit reports each year on the amounts of toxic chemicals their facilities release into the environment, either routinely or as a result of accidents."

There are additional reporting and planning requirements for materials deemed to be extremely hazardous. The paragraphs below, quoted from the Office of State Fire Marshal, Hazardous Substance Information System (HSIS)[4], summarize the intent and content of the regulatory requirements for extremely hazardous materials.

> "SARA Title III, section 302 requires owners and operators to notify the State Emergency Response Commission (SERC) regarding the presence of Extremely Hazardous Substances (EHS) at their facilities. Section 303 requires facilities that possess a threshold planning quantity (TPQ) of an EHS to develop a contingency plan in case of an accidental release, and assist emergency planners and emergency response organizations in developing a plan to protect the community from possible injury from a release of dangerous chemicals."

The full list of substances designated as Extremely Hazardous Substances (EHS) is given in the Office of State Fire Marshal's Hazardous Substance Information System database (available on CD from OSFM).

14.5 FIXED SITE HAZARDOUS MATERIALS LOCATIONS IN COLUMBIA COUNTY

Hazardous materials at fixed sites are generally identified by a NFPA (National Fire Protection Association) placard, commonly referred to as the NFPA hazard diamond. These hazard placards contain standardized information on the fire hazards and health hazards of the hazardous materials. Technical details about these hazard placards are given in the publication NFPA 704: Standard for the Identification of the Fire Hazards of Materials for Emergency Response (1996).

The Oregon Office of State Fire Marshal maintains a comprehensive listing of hazardous materials locations in Oregon[4]. Key data for Columbia County are shown below in Table 14.2.

Table 14.2
Summary of Hazardous Substance Information System (HSIS) Data

County	Total Reports	Reportable Quantities	112(r)[1] Chemicals	313 (TRI)[2] Chemicals	EHS[3] Chemicals
Columbia	610	256	124	32	28 [4]

[1] Chemicals reportable under Section 112(r)

[2] Chemicals reportable under Section 313, Toxics Release Inventory

[3] Extremely hazardous substances

[4] HSIS database appears incomplete, see text.

For Columbia County, the HSIS database has hazardous materials reports for 610 companies and other entities such as cities that have hazardous materials. Of these reporting locations, 256 or about 42%, have reportable quantities of hazardous materials.

As shown in Table 14.2, Columbia County also has 124 sites with Section 112(r) chemicals, 32 sites with Section 313 Toxics Release Inventory chemicals, and 28 sites with Extremely Hazardous Substances.

For mitigation planning purposes, Extremely Hazardous Substances are of special concern. The HSIS database for EHS in Columbia County appears possibly incomplete. For example, the EHS Facility list does not include 3 facilities which are on the EHS Pure Substance inventory list. Furthermore, there are only two water treatment plants listed; additional water or wastewater treatment plants in Columbia County may have chlorine or other EHS on site.

More detailed information about hazardous materials can be found online in the State Fire Marshal's Community Right-to-Know (CR2K) Hazardous Substance Information Program. Members of the public have the responsibility for informing themselves, getting involved with the planning and emergency response exercises and knowing the potential risks.

Hazardous Substance Information System (HSIS)

The Hazardous Substance Information System identifies hazardous substances that are used, stored, manufactured and/or disposed of at business sites in Oregon. The Office of State Fire Marshal (OSFM) annually surveys businesses and requires them to provide demographic information and report hazardous substances at or above reportable quantities. Businesses possessing reportable quantities of hazardous substances are required to report specific information including the chemical name, maximum amount and storage location. These businesses are also required to notify the OSFM within 30 days of any substantive changes that occur at the facility.

Environmental Protection Agency Tier II Chemical Inventory Reporting

By submitting the Office of State Fire Marshal Hazardous Substance Information Survey, Oregon businesses are complying with the EPA Tier II Chemical Inventory reporting requirements. To comply with Oregon reporting requirements, businesses must submit their chemical inventory information on a Hazardous Substance Information Survey. Tier II forms are not accepted.

How to Access the Hazardous Substance Information Database

The Office of State Fire Marshal's Hazardous Substance Information database is available online at http://www.sfm.state.or.us/CR2K/cr2k.htm. Scroll down to the "Community Right To Know" and click on the desired item. It is then possible to establish information parameters and run queries of our database and obtain the information. The database will be searched and the information will be displayed on the user's computer, and then either print or save the data to their system.

Limited Access Notification

Due to potential security issues, information on hazardous substances that have hazard classes listed below is not provided by individual facility. This information can be requested by contacting the Office of State Fire Marshal's, Community Right to Know Unit at SFM.CR2K@state.or.us.

Class	Description	Class	Description
1.1	Class A Explosives	1.5	Insensitive Explosives
1.2	Class B Explosives	2.3	Poison Gases
1.3	Class C Explosives	6.2	Etiologic Materials[1]
1.4	Blasting Agents	7.3	Radioactive Materials

[1] Etiologic means disease causing

14.6 Commentary on Inventory of Extremely Hazardous Substances (EHS)

There are a total of at least 27 sites in Columbia County with reportable quantities of extremely hazardous substances (EHS). Data on the geographic distribution of EHS sites in Columbia County are summarized below in Table 14.3

Table 14.3
Geographic Distribution of Extremely Hazardous Substances (EHS) Sites in Columbia County

Community	Number of Locations with EHS
St. Helens	10
Clatskanie	7
Rainier	4
Scappoose	3
Vernonia	2
Goble	1

Of these 28 sites with EHS chemicals in Columbia County, 13 are telephone company sites which presumably contain small quantities of cleaning solvents. There are two forest product company sites and a PGE site which contain sulfuric acid and other chemicals, along with several commercial/industrial sites that appear likely to contain only small quantities of EHS.

The Dyno Nobel Inc. facility in St. Helens appears to be the only facility in Columbia County which contains substantial quantities of EHS. The Company Report for this facility in the HSIS database lists a total of 58 chemicals, of which only six, anhydrous ammonia and ammonium hydroxide, ammonium nitrate, nitric acid, urea fertilizer, and urea ammonium nitrate solution appear to be present in large quantities. Of these six chemicals, only anhydrous ammonia and nitric acid are classified as EHS.

As noted above in Section 14.1, the toxicity of particular hazardous materials is an important measure of the potential impact of hazardous materials on affected communities, but not the only important measure. Other characteristics of hazardous materials, especially the quantity of material and the ease of dispersal of the material may be as important, or more important, in governing the level of potential threat to a community.

A full review of the potential public health impacts of accidents or deliberate acts at each of the above 28 sites is beyond the scope of this mitigation plan. For planning purposes, however, the Dyno Nobel Inc. site may warrant further evaluation, because of the combination of toxicity, quantity, and potential dispersal characteristics of chemicals at this site. In any case, first responders should be well informed about the proper response protocols for the chemicals present at this site in large quantities and emergency response plans should include evacuation plans in case of accidental releases.

14.7 HAZARDOUS MATERIALS TRANSPORT: TRUCK SHIPMENTS, RAIL SHIPMENTS AND PIPELINES

14.7.1 Overview and Truck Shipments

Hazardous materials may be transported once or many times during their “life cycle” of raw materials, manufacturing, incorporation in other products, wholesale and retail trade, use, waste disposal, and recycling. The transport of hazardous materials may be local within a single city or across a state, across the country or internationally.

For Columbia County, a general perspective on hazardous materials incidents is provided by annual statistics of hazardous materials incidents[5], prepared by the Office of State Fire Marshal. These incident reports include all reported hazardous material incidents, at fixed sites and during transportation, except generally excluding:

a. motor fuels which are spilled in quantities less than 42 gallons,

b. sewage overflows,

c. structure fires or other emergencies where hazardous substances are involved as exposures, if the quantities exposed are less than 42 gallons.

Statewide incident data for 2000-2003 are summarized in Table 14.4 below from the OSFM Annual Incident Reports. For these four years, statewide incidents have ranged from 399 to 248 per year. Of the total hazmat incidents, an average of about 31% occurred on public roads in Oregon. The decreasing trend over these four years may reflect improved safety, or changes in reporting, or may just be a statistical fluctuation. Over this four year period there were a total of 1284 reported hazmat incidents, of which only 10 were in Columbia County (about 0.8% of the statewide total incidents). Incident data for Columbia County are shown below in Table 14.5.

Table 14.4
Hazmat Incidents Reported Statewide in Oregon

Year	Hazmat Incidents[1]	Percent on Roads
2000	399	35.09%
2001	377	29.71%
2002	260	27.69%
2003	248	31.85%
average	321	31.39%

[1] reported incidents as per OSFM annual incident reports

Table 14.5
Hazmat Incidents Reported in Columbia County

Year	Hazmat Incidents[1]	Chemicals Involved
2000	2	Drug lab chemicals, propane
2001	4	Gasoline, unknown (2), inert powder
2002	3	Motor oil, sand, no chemical involved
2003	1	Ammonia
average	2.5	

Most of the reported hazmat incidents involve a relatively small number of hazardous materials, as shown below in Table 14.6. These statewide data present a very useful overview of hazardous material incidents in Oregon. For Columbia County, the general pattern of hazardous materials is likely to be similar to the statewide pattern below. Most hazardous materials incidents in Columbia County are likely to be the most commonly involved materials as shown below (i.e., drug lab chemicals, fuels, and motor vehicle fluids).

Table 14.6
Hazardous Materials Incidents in 2000-2003[5]
Reported Categories of Hazardous Materials

	Number of Incidents					
Chemical	**2000**	**2001**	**2002**	**2003**	**Total**	**Percent**
Drug lab chemicals	66	50	20	35	171	13.32%
Diesel, gasoline, fuel oil	99	73	43	45	260	20.25%
Antifreeze, motor oil, hydraulic fluid, transmission fluid	29	16	8	6	59	4.60%
Natural gas	45	35	19	14	113	8.80%
Propane	14	7	10	4	35	2.73%
Unknown chemical	44	55	36	20	155	12.07%
No chemical involved	10	26	15	27	78	6.07%
Other chemicals	92	115	109	97	413	32.17%
Total	399	377	260	248	1284	100.00%

The low number of hazmat incidents for Columbia County reflects the relatively low population of the county (corresponding too few shipments of fuels and other hazardous commodities relative to a more populated county). Another contributing factor may be the fact that there are no major interstate highways or major through roads between major population centers passing through Columbia County.

For Columbia County, the most likely road/highway hazmat incidents involve the common chemicals shown above in Table 14.6. In addition, chemicals necessary for the forest products and fertilizer industry facilities in the county may also be involved in hazmat incidents, along with outgoing shipments of fertilizer products. Road/highway hazmat incidents are most likely along Highway 30 which connects most of the population centers in the county and most of the major industrial facilities using or shipping potentially hazardous materials.

14.7.2 Rail Shipments

There are 22 freight railroads currently operating in Oregon, according to 2004 data from the Oregon Department of Transportation website (www.odot.state.or). Addresses and contact information for all of these railroads are given on the above referenced website, as are website addresses for several of the larger railroads.

The only freight railroad serving Columbia County is the Portland & Western line which runs from Astoria through Columbia County along the Highway 30 corridor to Portland. Specific data on hazmat shipments for this rail line were not available for this mitigation plan. However, the most likely chemicals for potential spills are probably generally similar to those noted above for road shipments within Columbia County.

14.7.3 Pipelines

There are two types of major fuel pipeline systems in Columbia County:

1. the natural gas transmission lines which runs from gas fields in the Mist-Birkenfeld area
2. natural gas distribution systems run by utilities in the larger cities, along with the transmission lines feeding these local gas systems.

Natural gas transmission pipelines run from Mist-Birkenfeld towards the southeast to connect to transmission lines in the greater Portland area and north to connect to a transmission line running along the Highway 30 corridor.

Each of the larger cities in Columbia County (including Scappoose, St. Helens, Columbia City, Rainier, Clatskanie, and Vernonia) and many smaller communities have local natural gas distribution systems connecting to transmission lines.

The United States Department of Transportation Office of Pipeline Safety regulates interstate pipelines. USDOT imposes a broad range of standards and inspection requirements for pipeline design, material specifications, construction standards, maintenance and testing requirements. For the United States as a whole, a network of about 300,000 miles of natural gas transmission lines serve about 1.5 million miles of distribution system lines which serve about 160 million customers. Overall, the safety record of natural gas transmission pipelines is good with relatively few significant accidents.

Columbia County also has a natural gas distribution system operated by Northwest Natural Gas. The natural gas pipeline systems of local gas utilities, including the systems in Columbia County, almost always follow road and street patterns because of established utility rights of way and because of the need to connect with each building served. Thus, for areas served by natural gas, the local street network is essentially identical to the natural gas distribution pipe network.

Overall, the safety record of natural gas distribution pipelines is good with relatively few significant accidents. Natural gas is not toxic (i.e., not poisonous). However, natural gas can be an asphyxiant if it displaces oxygen in an enclosed space. Natural gas burns readily when ignited, but only when gas concentrations are between 4% and 15% in air. In its pure state, natural gas is both colorless and odorless. The strong odor normally associated with natural gas is an odorant deliberately introduced at low concentrations to serve as a warning of the presence of natural gas. The strong odorant is generally added to natural gas at the local distribution level, by local gas utilities, and is readily detectible in concentrations well below the explosive range.

Fires and/or explosions from natural gas leaks in pipelines are rare. In part, the rarity of fires and/or explosions is due to the fact that natural gas is about 1/3rd less dense than ordinary air. Thus, leaking natural gas does not accumulate near the ground or "pond" in low-lying areas (as heavier gases such as liquefied natural gas or gasoline fumes may do). Instead, leaking natural gas rises rapidly and is dissipated by dilution in the atmosphere. The fires and /or explosions that do occur from natural gas leaks are generally in buildings where the confined space allows leaking gas to accumulate until ignited. Between 2000 and 2003 annual statistics of hazardous materials incidents[5], prepared by the Office of State Fire Marshal, show a total of only 113 natural gas incidents statewide in Oregon. Most of these incidents were minor without casualties or significant damage.

Pipeline breaks due to natural causes may occur due to landslides or earthquakes. Earthquake induced pipe breaks for natural gas transmission lines are most likely to occur in areas of soft soils subject to liquefaction and/or lateral spreading which cause significant pipe displacements. The most likely locations for such breaks during an earthquake are on slopes of soft ground near where pipelines cross rivers or streams.

The most common man-made cause of pipeline breaks is pipeline rupture due to pipes breaking when heavy construction equipment is used to excavate for construction projects. Most such breaks occur in local distribution lines. Pipeline breaks can also be caused by deliberate actions of sabotage or terrorism. Although pipelines are not symbolic targets with political, historical, and cultural significance, they are potential targets for terrorist actions. Major pipeline breaks could disrupt gas service over wide areas with resulting significant economic impacts.

Natural gas utilities and local emergency responders are generally well prepared to deal with natural gas breaks, because such incidents occur frequently enough to have well-standardized response procedures. Evacuations for natural gas distribution system pipeline ruptures are generally limited to the immediate area of the break.

14.8 Reference Information for Hazardous Materials Incidents Emergency Response

This section provides references to the appropriate Guide Number in the 2004 Emergency Response Guidebook, along with the corresponding initial isolation distances and protective action distances for a few common industrial chemicals. Initial isolation distances are given for both large and small spills. Protective action distances are given for both small and large spills and for day and night conditions. See Table 14.7 below; all of this information is from the 2004Emergency Response Guidebook.

As per the 2004 Emergency Response Guidebook, small spills are defined as one that involves a single small package (e.g., a drum containing up to approximately 200 liters), a small cylinder or a small leak from a large package. A large spill is one that involves a spill from a large package or multiple spills from many small packages. For very large spills, that involve more than one tank car, cargo tank, portable tank or large cylinder, the large spill distances may need to be increased.

As per the 2004 Emergency Response Guidebook, protective distances are defined in the downwind direction from the spill site. The width of the protective distance is equal to 50% of the downwind protect distance on each side of the wind direction. In other words, the total protect area is a square with sides equal to the defined protect distance. See Figure 14.8 below from the 2004 Emergency Response Guidebook.

Figure 14.8
Initial Isolation Zone and Protective Action Zones for Hazardous Material Spills

The shape of the area in which protective actions should be taken (the Protective Action Zone) is shown in this figure. The spill is located at the center of the small circle. The larger circle represents the INITIAL ISOLATION zone around the spill.

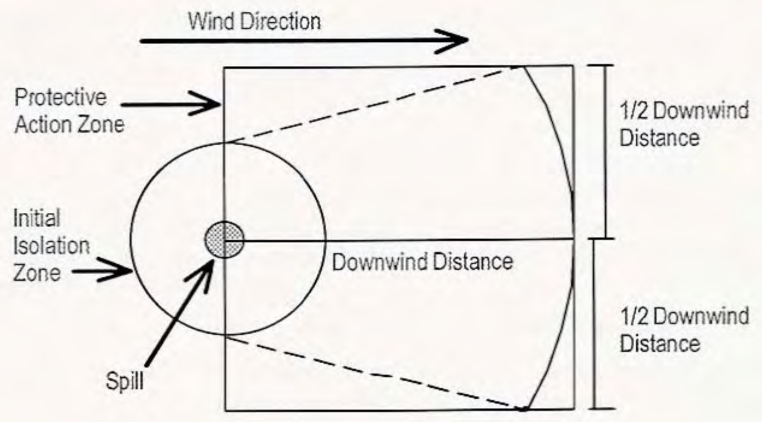


Table 14.7
Extremely Hazardous Substances: Reference Data from 2000 Emergency Response Guide

Most Hazardous Ingredient	Guide Number	Guide Category	Small Spills			Large Spills		
			Isolation Distance (m)	Day Protect Distance (km)	Night Protect Distance (km)	Isolation Distance (m)	Day Protect Distance (km)	Night Protect Distance (km)
Ammonia	125	Gases - corrosive	30	0.2	0.2	60	0.5	1.1
Chlorine	124	Gases – toxic and/or corrosive - oxidizing	30	0.3	1.1	275	2.7	6.8
Hydrochloric acid1	157	Substances – toxic and/or corrosive (non-combustible/water-sensitive)	30	0.2	0.6	185	1.6	4.3
Hydrofluoric acid`	157	Substances – toxic and/or corrosive (non-combustible/water-sensitive)	30	0.2	0.6	125	1.1	2.9
Sulfur dioxide	125	Gases – corrosive	30	0.3	1.1	185	3.1	7.2
Sulfuric acid	137	Substances – water reactive - corrosive	60	0.3	1.1	305	2.1	5.6

[1] For hydrochloric acid and hydrofluoric acid, the isolation and protect distances are for hydrogen chloride anhydrous and hydrogen fluoride anhydrous, respectively, because the 2000 ERG did not have specific listing for these acids.

See the 2004 Emergency Response Guide section on Introduction to the Table of Initial Isolation and Protective Action Distances (Page 311) for factors which may increase or decrease Protective Action Distances

The 2004 Emergency Response Guidebook has excellent general guidance on the decision factors that govern protective actions appropriate for a given incident. This guidance is given below verbatim.

The protective action distances given above in Table 14.7 are for general guidance only. For each specific hazardous material incident, the local jurisdiction Incident Commander, in consultation with the HazMat Response Team Branch Leader, makes incident specific decisions based on the specific conditions of each incident.

PROTECTIVE ACTION DECISION FACTORS TO CONSIDER

"The choice of protective actions for a given situation depends on a number of factors. For some cases, evacuation may be the best option; in others, sheltering in-place may be the best course. Sometimes, these two actions may be used in combination. In any emergency, officials need to quickly give the public instructions. The public will need continuing information and instructions while being evacuated or sheltered-in-place.

Proper evaluation of the factors below will determine the effectiveness of evacuation or in-place protection. The importance of these factors can vary with emergency conditions. In specific emergencies, other factors may need to be identified and considered as well. This list indicates what type of information may be needed to make the initial decision.

The Dangerous Goods

- Degree of health hazard
- Amount involved
- Containment/control of release
- Rate of vapor movement

The Population Threatened

- Location
- Number of people
- Time available to evacuate or shelter in-place
- Ability to control evacuation or shelter in-place
- Building types and availability
- Special institutions or population, e.g., nursing homes, hospitals, prisons

Weather Conditions

- Effect on vapor and cloud movement
- Potential for change
- Effect on evacuation or shelter-in-place"

Evacuate means to move all people within the protective distance area to a safer place. To evacuate, there must be enough time for people to be warned, to get ready, and to leave the area. If there is enough time, evacuation is usually the best protective action. Evacuations are usually progressive with the first evacuees being people closest to the incident location.

Shelter in-place means that people within the protective distance area are advised to seek shelter inside a building and remain inside until the danger passes. Sheltering in-place is used when evacuation would cause greater risk than staying put, or when an evacuation cannot be performed. For shelter in-place, occupants are advised to close all doors and windows and to shut off all ventilating, heating and cooling systems. Shelter in-place may not be appropriate if: a) vapors are flammable, b) it will take a long time for the hazardous material to clear the area, c) if buildings cannot be closed tightly or d) the hazardous material incident may increase in severity (such as an ongoing fire that might result in release of additional quantities of the hazardous material) .

14.9 Vulnerability and Risk Assessments

As reviewed above in Sections 14.5 to 14.7, there are many fixed locations in Columbia County with inventories of hazardous materials and a considerable volume of hazardous materials being transported to, from, within, or through Columbia County. For both fixed and in transit hazardous materials, there is a wide variety of types and quantities of materials.

Historically, the safety record for hazardous materials has been good, with relatively few, mostly minor hazmat incidents. Nevertheless, there is a potential for larger hazmat incidents in Columbia County. A brief synopsis of the probable impacts of hazmat incidents on Columbia County is given below in Table 14.9.

Table 14.9
Probable Impacts of Hazmat Incidents on Columbia County

Inventory	Probable Impacts
Portion of Columbia County affected	Most hazmat incident impacts would be localized near source of spill, but major spills could have extensive evacuation zones and affect a significant portion of a community in Columbia County
Buildings	Negligible impact, except for explosion incidents very near buildings
Streets within Columbia County	Temporary street closures likely
Roads to/from Columbia County	Temporary road closures likely
Electric power	Generally minor impacts, except for explosion incidents very near infrastructure
Other Utilities	Generally minor impacts, except for explosion incidents very near infrastructure or spills which release hazardous materials into rivers or reservoirs providing public water supply
Casualties	Potential for casualties (deaths and injuries), depending on location and identify of hazardous material(s) involved, time of day and effectiveness of evacuations

14.10 SUMMARY AND MITIGATION STRATEGIES

14.10.1 Planning and Response

Hazardous materials vary dramatically in their degree of toxicity to humans. The impact of a hazardous material release incident on an affected community depends on several factors including:

a. the toxicity of the hazardous material,
b. the quantity of the hazardous material released,
c. the dispersal characteristics of the hazardous material,
d. the local conditions such as wind direction and topography, and
e. the efficacy of response and recovery actions.

Effective mitigation planning and effective emergency response planning can help reduce the number or frequency of hazardous materials incidents and also reduce the severity of incidents that do occur. In combination, these benefits can significantly reduce the negative impacts of hazardous materials incidents on affected communities. The general principles of mitigation planning, emergency response planning (and training) are well standardized and practiced by Columbia County.

Perhaps the single most critical factor in enhancing both mitigation planning and emergency response planning is specific inventory awareness for major hazardous materials sites within each jurisdiction. Specific inventory awareness means detailed knowledge of the types of hazardous materials, quantities of hazardous materials and locations of every location in a jurisdiction with significant quantities of hazardous materials. In this context, what constitutes a significant quantity varies depending on the toxicity of the material, the dispersal characteristics and the nature and population of nearby areas likely to be affected by hazardous materials incidents.

The Office of State Fire Marshall's Hazardous Substance Information System (HSIS) database contains a vast amount of information on the inventories of hazardous materials at fixed locations in Columbia County. This detailed inventory information along with data on hazardous materials being transported within or through Columbia County, provides the basic data for specific inventory awareness. In combination, with the chemical data and emergency response information provided in the 2004 Emergency Response Guide and in other sources, these are the basic data necessary for effective planning and effective emergency response.

The complexity and overload of information is compounded by numerous labeling, placarding, and classification systems for hazardous materials, with countless cross references to guide numbers, material safety reports and so on. Because of this vast amount of complex information, effective mitigation planning and emergency response planning must occur before an incident occurs, not after. During an incident, the most effective response is precluded and impossible to achieve if emergency personnel are thumbing through databases trying to figure out what hazardous materials are at a given location and what the appropriate response precautions and protocols are for the specific materials involved in a hazardous materials incident.

Specific inventory awareness means that for every site with hazardous materials of sufficient toxicity, dispersal characteristics and quantities to pose a significant life safety risk to on-site employees and nearby residents must be identified in advance. Ideally, Columbia County should have detailed specific inventory awareness of every significant fixed site in its jurisdiction. Similarly, each jurisdiction should have specific inventory awareness of the most toxic, most common, large volume shipments of hazardous materials within and through the jurisdiction. For each hazardous material deemed to pose a significant life safety threat, the necessary chemical data, response protocols, initial isolation distances, protection distances for small and large spills, and all other data necessary for safe and effective response should be compiled and readily available before incidents occur.

14.10.2 Mitigation Measures

Specific inventory awareness is one cornerstone of reducing the potential for negative impacts from hazardous materials incidents by helping to optimize emergency planning and response planning. The other cornerstone is pro-active mitigation actions to reduce the number and severity of hazardous materials incidents.

The most common mitigation measures for reducing the potential of damaging hazardous materials incidents are briefly summarized below.

14.10.2.1 Physical Safety Measures

The tanks, other storage containers and transfer systems (valves, pipes etc.) for hazardous materials are frequently subject to damage in earthquakes, with a correspondingly high potential for accidental releases. Proper seismic design, bracing and anchoring of storage systems for hazardous materials can greatly reduce the potential of accidental releases during earthquakes. Bracing and anchoring measures for storage containers and transfer systems (e.g., piping) are often relatively inexpensive, with a large improvement in seismic performance. For small quantities of materials stored in bottles or jugs on shelving, bracing shelving and restraining containers so that they do not fall in earthquakes are particularly important.

Over time, the storage containers and other material handling elements for hazardous materials may be changed many times. In some cases, later modifications may not be designed to the same seismic standards as the original installation or later modifications may compromise the seismic stability of the original installation. Therefore, periodic review and inspections of seismic design, bracing and anchoring are highly recommended for all hazardous material facilities.

For facilities located in mapped flood plains or other areas subject to floodwaters there are two important physical safety measures. First, any containers subject to floating should be properly restrained. In many floods, improperly restrained tanks break free and float downstream, with high potential for negative impacts, including fires from tanks containing flammable materials as well as accidental releases of hazardous materials. Second, special precautions should be taken with water-reactive materials. Such materials should never be stored in low-elevation areas subject to flooding or in locations subject to water from storm water drainage or plumbing failures in a facility.

14.10.2.2 Standard Operating Procedures

Standard operating procedures for storing, transporting, and handling hazardous materials should be strictly enforced at all facilities. Appropriate training for all staff, with review courses and appropriate protective gear are essential for safety. Rigorous inspection and enforcement of hazardous materials regulations (federal, state, and local) are an important part of the overall process of ensuring safety.

14.10.2.3 Mitigation and Emergency Response Planning

Effective pre-event mitigation planning and emergency response planning can help reduce the severity of hazardous material incidents. From the mitigation planning perspective, specific inventory awareness of the types and quantities of hazardous materials present at each facility is particularly important for emergency response. Local fire departments and other responders should be thoroughly familiar with the specific inventory at each facility containing hazardous materials and with the appropriate response protocols for each hazardous material. First responders and emergency response teams must both have the full range of protective gear and equipment necessary for their respective roles in responding to hazardous materials incidents.

Emergency response planning should include thorough training in all aspects of hazardous materials response, including appropriate response protocols (procedures, protective gear and equipment). Frequent refresher training and frequent exercises (both tabletop and full field exercises) are essential for safe and effective emergency response. Training exercises should include both first responders and emergency response teams, to help ensure appropriate coordination of efforts during actual hazardous materials incidents.

The table on the following page has hazmat mitigation action items from the master Action Items table in Chapter 4.

Table 14.10
Hazmat Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Hazmat Incident Mitigation Action Items								
Short-Term #1	Ensure that first responders have readily available site-specific knowledge of hazardous chemical inventories in Columbia County	local fire and law enforcement agencies	1 year	X	X			X
Short-Term #2	Enhance emergency planning, emergency response training and equipment to address hazardous materials incidents.	local fire and law enforcement agencies	Ongoing	X	X			X
Short-Term #3	Evaluate existing security measures for sites with large quantities of hazardous materials or any quantities of extremely hazardous substances and enhance security as necessary	local facility managers	1 year	X	X	X	X	X
Short-Term #4	Evaluate seismic bracing/anchoring for sites with large quantities of hazardous materials or any quantities of extremely hazardous substances and upgrade as necessary	local facility managers	1-2 years	X	X	X	X	X

References

1. **Handbook of Chemical Analysis Procedures**, Federal Emergency Management Agency, U.S. Department of Transportation, and U.S. Environmental Protection Agency, U.S. Government Printing Office, 1988.
2. **2000 Emergency Response Guidebook** (A Guidebook for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Material Incident), developed jointly by the U.S. Department of Transportation, Transport Canada, and the Secretariat of Transport and Communications of Mexico, 2000.
3. **Hazardous Materials Emergency Response Teams Standard Operating Guidelines**, May 7, 2001 Office of State Fire Marshal (Oregon). This series of about a dozen standard operating guidelines covers every main aspect of emergency response and recovery, including decisions to respond, levels of response, general response guidelines, mitigation methods, decontamination procedures, personal protective equipment, and others.
4. **Hazardous Substance Information System** (HSIS), Office of State Fire Marshall, Version 2.0P, August, 2004. Microsoft Access Database on CD-ROM.
5. **Annual Report of Hazardous Materials Incidents in Oregon** as Reported by Oregon Fire Service, Office of State Fire Marshal (Oregon), 2003 and earlier years.

CHAPTER FIFTEEN

15.0 TERRORISM

15.1 Overview

For mitigation planning, terrorism is broadly inclusive of a wide range of deliberate malevolent acts intended to damage buildings or infrastructure or to result in deaths and injuries. The possibility of international terrorist organizations targeting Columbia County, is not zero, but is most likely small. However, Columbia County is certainly subject to deliberate malevolent acts from many sources including vandals, mentally disturbed individuals, domestic terrorist groups (e.g., eco-terrorists), as well as by disgruntled residents, and past or present employees.

The range of possible malevolent actions includes vandalism, arson, explosions and armed attacks, as well as use of chemical, biological, radiological or nuclear materials. Chemical attacks include deliberate release of on-site chemicals as well as deliberate dispersal of transported hazardous materials. Biological attacks include deliberate dispersal of biologically active materials (e.g., anthrax) capable of causing sickness or death. Radiological attacks include deliberate dispersal of radioactive materials, via dirty bombs (conventional explosives laced with radioactive materials) or other methods. Nuclear attacks include explosion of nuclear devices and the radioactive fallout from such explosions.

The range of possible malevolent actions also includes cyber-terrorism, or deliberate disruption/damage of computer systems and data. Especially for utility systems, cyber-terrorism can also result in loss of service due to disruption/damage to automated SCADA (Supervisory Control and Data Acquisition) systems widely used by utilities.

15.2 Threat Spectrum

For purposes of mitigation planning, we consider three sources of terrorist (malevolent) actions: outsiders, insiders, and hackers. In each case, we consider three levels of attack, with the levels reflecting the numbers of individuals involved, the level of technical knowledge or expertise, and the level of equipment or tools available. This threat spectrum is summarized below in Table 15.1.

In Table 15.1, outsider means anyone who is not an employee of the facility under potential terrorist attack. Outsiders could be vandals, disturbed individuals, or members of domestic or international organized groups. For Columbia County, the most likely terrorist or malevolent acts are minor vandalism or actions by disturbed individuals or employees. Deliberate terrorist actions are most likely from domestic groups, including eco-terrorists, and are less likely to be from international organizations.

In Table 15.1, insider means anyone who is an employee of the target under potential attack. Acts of vandalism, theft and other relatively minor actions are common. Larger scale malevolent acts are less common but still occur with some frequency. Such acts include larger scale damage, arson, explosives, and actions such as deliberate contamination of water supplies.

In Table 15.1, computer hacker means individuals or groups using remote access to explore, vandalize, or destroy websites, computer databases and such. For utility systems, hackers can also impact SCADA systems and may affect system operations directly.

Table 15.1
Threat Spectrum for Terrorist Actions

Adversary	Number of Adversaries	Level of Knowledge	Equipment Tools	Weapons	Objectives
Outsider: high level	1 to small group	Extensive knowledge of security systems, facilities and modes of attack	hand tools, power tools, vehicles	handguns or automatic weapons, incendiary devices, explosives, contaminants	Extensive damage to critical facilities, widespread damage or casualties
Outsider: medium level	1 to 3	Limited knowledge of security systems, facilities and modes of attack	hand tools, power tools, vehicle	handguns, incendiary devices, explosives, contaminants	Damage or casualties
Outsider: low level	1 or 2	Minimal knowledge of security systems, facilities and modes of attack	hand tools	None	Vandalism, damage or casualties
Insider: high level	1	Extensive knowledge of security systems, facilities, operations, policies and procedures	On site tools, chemicals, equipment, vehicles	handguns or automatic weapons, incendiary devices, explosives, contaminants	Damage or casualties
Insider: mediujm level	1	Moderate knowledge of security systems, facilities, operations, policies and procedures	On site tools, chemicals, equipment, vehicles	handguns, incendiary devices, explosives, contaminants	Damage or casualties
Insider: low level	1	Limited knowledge of security systems, facilities, operations, policies and procedures	On site tools, chemicals, equipment, vehicles	handgun or none	Vandalism, damage or casualties
Hacker: high level	1 to small group	Full knowledge of IT intrastructure, security systems, SCADA systems	Sophisticated hacker tools and methods	N/A	Destruction of data and systems, business operations
Hacker: medium level	1 or 2	Moderate knowledge of IT intrastructure, security systems, SCADA systems	Moderately sophisticated hacker tools and methods	N/A	Denial of servcie or disruption of some business services
Hacker: low level	1	Limited knowledge of IT intrastructure, security systems, SCADA systems	N/A	N/A	Minor cyber-vandalism to non-critical business areas

The probable impacts of terrorist events on Columbia County are summarized below in Table 15.2. For Columbia County, the most likely terrorist (or other malevolent) events are small scale events such as:

1. vandalism
2. minor damage by insiders (disgruntled employees)
3. minor damage by outsiders (extremist groups, mentally disturbed individuals),
4. computer hacking events, and
5. eco-terrorist actions.

Larger scale events by domestic or international groups are possible, but appear relatively unlikely for Columbia County, because there do not appear to be many targets of national significance in Columbia County. However, facilities with higher than usual concern for potential terrorism attacks include the following:

- Boise Cascade. A large employer in St. Helens with various quantities of hazardous materials.
- Point Westward industrial area, which includes industrial facilities and a power generation facility. Beaver Creek power generation plant is part of the Bonneville Power Grid.
- Columbia Meadows where summary concerts attracting up to 30,000 or 40,000 people are held. This location is also next to a large chemical industrial facility.
- Trojan Nuclear Plant – decommissioned
- Lewis and Clark Bridge between Rainier, Oregon and Longview, Washington.
- Natural Gas field and pipeline in Mist, Oregon

The potential impacts of terrorism incidents on Columbia County are summarized in Table 15.2 below.

Table 15.2
Probable Impacts of Terrorist Incidents on Columbia County

Inventory	Probable Impacts
Portion of Columbia County affected	Localized impacts for minor incidents, large portions or the entire County for extremely unlikely major incidents
Buildings	Localized impacts to a single building or a few nearby buildings, except for extremely unlikely major incidents
Streets within Columbia County	Some incidents may include temporary street closures
Roads to/from Columbia County	Some incidents may include temporary road closures
Electric power	Some incidents may include temporary loss of electric power in localized parts of Columbia County or for the entire County
Other Utilities	Some incidents may include temporary loss of utilities in localized parts of Columbia County or for the entire County. Major damage to water or wastewater treatment plants could result in full or partial loss of service for extended time periods
Casualties	Small scale incidents may have no casualties or a small number of casualties. Possible, but unlikely, major events may result in significant casualties (deaths and injuries)

15.3 Mitigation Actions

Evaluation of the threat of terrorist or other malevolent actions generally includes several steps:

1. determine critical facilities,
2. identify the specific adverse consequences to be avoided,
3. review the likelihood of malevolent actions,
4. evaluate existing countermeasures, and
5. implement a prioritized risk reduction plan.

For Columbia County, critical facilities include key elements of the water systems, electric power substations, facilities with large quantities of hazardous materials or any quantities of extremely hazardous materials (cf. Chapter 14) and important public facilities such as police and fire stations. Potential targets for eco-terrorists include any major timber industry facilities.

The most likely adverse consequences are vandalism and minor destructive actions by outsiders, insiders, or hackers. The evaluation of existing countermeasures should include:

1. Physical security measures, such as fencing, locks and key control, structural integrity of critical assets, and detection capabilities such as intrusion detection systems, alarms, operational alarms for utility systems, and general security/access issues,
2. Cyber security measures, such as protection measures for business/operational computer systems and SCADA systems, including fire walls, access, security policies and protocols, including vendor access and system diagnostics, and
3. Security procedures and polices, such as personnel security, physical security, key and badge control, system control and operational data, chemical and other vendor deliveries, as well as security and emergency response training, exercises and drills.

For Columbia County vigilance and modest upgrades to existing physical security, cyber security, and security procedures and policies are probably all that are reasonably required. For the highest profile buildings or facilities, barriers to restrict vehicles reaching close proximity to the building or facility, to the extent practical, might also warrant consideration.

The potential impacts of terrorism or other malevolent deliberate actions in Columbia County can also be mitigated by improving emergency response capabilities. Some types of actions, such as fires or explosions, are self-evident and emergency responders are well trained for dealing with such situations.

Other types of actions such as release of radiological materials, bioterrorism, or contamination of water or food supplies may not be immediately recognized. For such types of actions, close cooperation with public health officials and awareness of the possibility of deliberate actions are important. Such situations also commonly require specialized expertise and equipment to detect and identify the radiological, biological or chemical materials used in an attack. Emergency response plans should be updated and expanded, as necessary, to cover such situations, including protocols for public notifications and information about appropriate public responses such as shelter in place or evacuation.

The following table contains terrorism mitigation action items from the master Action Items table in Chapter 4.

Table 15.3
Terrorism Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed: Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Terrorism Mitigation Action Items								
Short-Term #1	Enhance emergency planning, emergency response training and equipment to address potential terrorism incidents.	local fire and law enforcement agencies, facility managers	Ongoing	X	X	X	X	X
Long-Term #1	Upgrade physical security detection and response capability for critical facilities, including water systems and for any high-profile facilities such as major timber industry facilities and sites with large quantities of hazardous materials	facility managers	5 Years	X	X	X	X	X

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Flood Mitigation Action Items: Within FEMA-Mapped Floodplains								
Short-Term #1	Complete inventory of critical facilities within 100-year and 500-year floodplains, with GIS mapping if possible	Columbia County (Land Development Services, Roads, Assessor), cities, special districts	Ongoing	X	X	X	X	
Short-Term #2	Complete inventory of residential and commercial buildings within 100-year and 500-year floodplains, with GIS mapping if possible	Columbia County (Land Development Services, Roads, Assessor), cities, special districts	Ongoing	X		X	X	
Short-Term #3	Consult with property owners and explore mitigation actions for any Columbia County properties on FEMA's national repetitive loss list	Columbia County Hazard Mitigation Advisory Committee	1 year	X		X	X	X
Long-Term #1	Survey elevation data for critical facilities, residential buildings and commercial buildings within the 100-year floodplain and establish flood mitigation priorities	Local emergency services, Columbia County Hazard Mitigation Advisory Committee	2-5 years	X	X	X	X	X
Long-Term #2	For critical facilities within the 100-year floodplain and for other structures deep within the 100-year floodplain explore mitigation options with property owners and implement mitigation measures	Local emergency services, Columbia County Hazard Mitigation Advisory Committee	2-10 years	X	X	X	X	X
Flood Mitigation Action Items: Outside of FEMA-Mapped Floodplains								
Short-Term #1	Complete the inventory of locations in Columbia County subject to frequent storm water flooding	Columbia County (Land Development Services, Roads, Assessor), cities, special districts	Ongoing	X	X	X	X	X
Long-Term #1	For locations with repetitive flooding and significant damages or road closures, determine and implement mitigation measures such as upsizing culverts or storm water drainage ditches	Columbia County (Land Development Services, Roads, Assessor), cities, special districts	Ongoing	X	X	X	X	X

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Earthquake Mitigation Action Items								
Short-Term #1	Complete inventory of public and commercial buildings that may be particularly vulnerable to earthquake damage	County, cities, special districts	1-2 Years	X	X	X	X	X
Short-Term #2	Complete inventory of wood-frame residential buildings that may be particularly vulnerable to earthquake damage, including pre-1940s homes and homes with cripple wall foundations.	County, cities	1-2 Years	X	X	X	X	X
Short-Term #3	Disseminate FEMA pamphlets to educate homeowners about structural and non-structural retrofitting of vulnerable homes and encourage retrofit	Columbia County Hazard Mitigation Advisory Committee	Ongoing	X		X	X	X
Short-Term #4	Complete seismic vulnerability analysis of important public facilities with significant seismic vulnerabilities	County, cities, special districts	1-2 Years	X	X	X	X	X
Long-Term #1	Obtain funding and retrofit important public facilities with significant seismic vulnerabilities	County, cities, special districts	10 years	X	X	X	X	X
Long-Term #2	Retrofit bridges that are not seismically adequate for lifeline transportation routes	ODOT, County, cities, roads		X	X	X	X	X

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Landslide Mitigation Action Items								
Short-Term #1	Complete the inventory of locations where critical facilities, other buildings and infrastructure are subject to landslides	Columbia County Land Development Services, cities (public works)	1-2 Years	X	X	X	X	X
Long-Term #1	Consider landslide mitigation actions for slides seriously threatening critical facilities, other buildings or infrastructure	Columbia County Hazard Mitigation Advisory Committee	5 Years	X	X	X	X	X
Long-Term #2	Limit future development in high landslide potential areas	Columbia County Land Development Services, cities	Ongoing	X	X	X	X	X

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Utility and Transportation System Disruption Mitigation Action Items								
Short-Term #1	Educate and encourage residents to maintain several days of emergency supplies for power outages or road closures	Columbia County Hazard Mitigation Advisory Committee, CEPA	Ongoing	X	X		X	X
Short-Term #2	Review and update emergency response plans for disruptions of utilities or roads	local emergency service agencies, CEPA	1-2 Years	X	X		X	X
Short-Term #3	Ensure that all critical facilities in Columbia County have backup power and emergency operations plans to deal with power outages	local emergency service agencies, CEPA	1-2 Years	X	X		X	X

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Wildland/Urban Interface Fire Mitigation Action Items								
Short-Term #1	Identify specific parts of Columbia County at high risk for urban/wildland urban interface fires because of fuel loading, topography and prevailing construction practices	County Fire Defense Board, fire agencies	1-2 Years	X	X	X	X	X
Short-Term #2	Identify evacuation routes and procedures for high risk areas and educate the public	County Fire Defense Board, fire agencies, law enforcement, County Roads, public works	Ongoing	X	X	X		X
Short-Term #3	Develop Community Wildand Fire Protection Plans for all at-risk communities	County, cities, fire agencies, ODF	1-2 Years	X	X	X	X	X
Long-Term #1	Encourage fire-safe construction practices for existing and new construction in high risk areas	County Land Development Services, city building departments, fire agencies	Ongoing	X	X	X	X	X
Long-Term #2	Enhance home landscape cleanup (defensible space) and debris disposal programs	County Land Development Services, city building departments, fire agencies	Ongoing	X	X	X	X	X
Long-Term #3	Identify potential fuel breaks and fuel reduction zones and implement mitigation actions	County Land Development Services, city building departments, fire agencies	Ongoing	X	X	X	X	X
Long-Term #4	Implement SB360 Wildland Urban Interface Act of 1997 in Columbia County	County Land Development Services, city building departments, fire agencies	5-10 years	X	X	X	X	X

Hazard	Action Item	Coordinating Organizations	Timeline	Mitigation Plan Goals Addressed				
				Life Safety	Critical Facilities and Emergency Services	Protect Property	Disaster Resilient Economy	Public Education, Outreach, Partnerships
Winter Storms Mitigation Action Items								
Short-Term #1	Complete the inventory of locations in Columbia County subject to frequent storm water flooding	Columbia County Roads, cities	Ongoing	X	X	X	X	X
Short-Term #2	Enhance tree trimming efforts especially for transmission lines and trunk distribution lines.	BPA, West Oregon Electric Coop, local PUDs	Ongoing	X	X	X	X	X
Short-Term #3	Encourage prudent tree planting (avoid service lines) and safe, professional tree trimming where necessary	Columbia County Hazard Mitigation Advisory Committee	Ongoing	X		X	X	
Short-Term #4	Ensure that all critical facilities in Columbia County have backup power and emergency operations plans to deal with power outages	Local emergency services, Columbia County Hazard Mitigation Advisory Committee	1-2 Years	X	X			
Long-Term #1	For locations with repetitive flooding and significant damages or road closures, determine and implement mitigation measures such as upsizing culverts or storm water drainage ditches	Columbia County Roads, cities	Ongoing	X	X	X	X	X
Long-Term #2	Consider upgrading lines and poles to improve wind/ice loading, undergrounding critical lines, and adding interconnect switches to allow alternative feed paths and disconnect switches to minimize outage areas	BPA, West Oregon Electric Coop, local PUDs	5 Years	X	X	X	X	X
Long-Term #3	Encourage new developments to include underground power lines	Columbia County Land Development Services, cities	ongoing	X	X	X	X	X