Multnomah County, Oregon

NATURAL HAZARDS MITIGATION PLAN

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Prepared by:

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The 2012 Multnomah County Natural Hazards Mitigation Plan is a living document which will be reviewed and updated periodically.

Comments, suggestions, corrections and additions are enthusiastically encouraged from all interested parties.

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EXECUTIVE SUMMARY

This 2012 Multnomah County Natural Hazards Mitigation Plan covers each of the major natural hazards that pose risks to the County. The 2012 Mitigation Plan is an update and enhancement of the 2006 Natural Hazards Mitigation Plan.

The primary objective of the mitigation plan is to reduce the negative impacts of future disasters on Multnomah County: to save lives and reduce injuries, minimize damage to buildings and infrastructure (especially critical facilities) and minimize economic losses. This mitigation plan is an educational and 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.

This Hazard Mitigation Plan includes the following chapter

Chapter 1: Introduction

Chapter 2: Community Profile: Multnomah County

Chapter 3: Planning Process

Chapter 4: Mission Statement, Goals, Objectives and Action Items

Chapter 5: Plan Adoption, Implementation, and Maintenance

Chapter 6: Earthquakes

Chapter 7: Wildland/Urban Interface Fires

Chapter 8: Landslides

Chapter 9: Floods

Chapter 10: Severe Weather

Chapter 11: Volcanic Hazards

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1.0 INTRODUCTION

Multnomah County is subject to a wide range of natural hazards including: earthquakes, wildland/urban interface fires, landslides, floods, windstorms and others. The impact of potential future hazard events on Multnomah County may be minor - a few inches of water in a street - or it may be major - with damages and economic losses reaching millions of dollars, with substantial numbers of injuries and deaths.

Some hazard events, such as earthquakes or windstorms may affect the entire county. Most of the other hazards, including wildland/urban interface fires, landslides and floods will affect only portions of the county. The Multnomah County Natural Hazards Mitigation Plan addresses each of the natural hazards that pose significant risk to the people, buildings and infrastructure of Multnomah County.

The impacts of major disasters on a community can be devastating: the total damages, economic losses, casualties, disruption, hardships and suffering are often far greater than the physical damages alone. Furthermore, recovery from major disasters often takes many years and some heavily impacted communities may never fully recover. Completely eliminating the risk of future disasters in Multnomah County is neither technologically possible nor economically feasible. However, substantially reducing the negative impacts of future disasters is achievable with the implementation of a pragmatic Natural Hazards Mitigation Plan.

1.1 What is a Natural Hazards Mitigation Plan?

The hazard mitigation plan addresses hazards such as wind storms and localized storm water drainage flooding that may occur in some locations almost every year. The plan also addresses less frequent hazard events including earthquakes, wildland/urban interface fires, landslides and major floods. These types of hazard events may not occur frequently but still pose a substantial threat to Multnomah County because of the potentially severe consequences when they do occur.

The Multnomah County Natural Hazards Mitigation Plan has three key elements.

1. Each hazard that may impact Multnomah County significantly is reviewed to estimate the probability (frequency) and severity of likely hazard events.

2. The vulnerability of Multnomah County to each hazard is evaluated to estimate 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 Multnomah County, to protect facilities deemed critical to the community's well being, and that are desirable from the community's social and economic perspectives.

The Multnomah County Natural Hazards Mitigation Plan covers the entire county. However, the emphasis is on the unincorporated rural parts of the county and on Multnomah County government facilities and services, especially with respect to identifying mitigation priorities and actions. The incorporated cities within Multnomah County all have their own hazard mitigation plans (except for Maywood Park) which address their mitigation planning in more detail than can be included in the county-wide plan.

1.2 Why is Hazard Mitigation Planning Important for Multnomah County?

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

Effective hazard mitigation planning will help the residents of Multnomah County deal with natural and manmade hazards realistically and rationally. This planning will identify specific locations in Multnomah County where the level of risk from one or more hazards may be unacceptably high and help the County 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 hazard mitigation plan and to update the plan every five years in order to remain eligible for future pre- or post-disaster FEMA mitigation grant funding. Thus, an important objective in creating the Multnomah County Natural Hazards Mitigation Plan is to achieve eligibility for FEMA funding and enhance Multnomah County's ability to attract future FEMA mitigation funding.

Updating the mitigation plan every five years is also important to ensure that the mitigation plan stays relevant and current as the natural and built environments evolve over time and as community perspectives and demographics change.

The Plan is specifically designed to help Multnomah 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). Therefore, benefit-

cost analysis is an important component of hazard mitigation planning, not only to meet FEMA requirements, but also to help evaluate and prioritize potential hazard mitigation projects in Multnomah County, regardless of whether funding is from FEMA, state or local government or from private sources.

1.3 The 2012 Update of the Multnomah County Natural Hazards Mitigation Plan

The initial Multnomah County Natural Hazards Mitigation Plan was adopted in 2006.

The 2012 update of the Multnomah County Natural Hazards Mitigation Plan includes the following significant enhancements:

- Update the hazard information for each of the major natural hazards,
- Refine the vulnerability and risk assessments for each of the major natural hazards,
- Redefine critical facilities with more specificity,
- Refocus and reprioritize hazard mitigation goals, objectives, and action items to emphasize pragmatic, implementable measures that address the highest risk situations in Multnomah County and that will significantly reduce risk.
- Identify specific mitigation projects with the best likelihood of garnering FEMA mitigation project grants for implementation, and
- Improve the usability of the plan for both non-technical and technical readers by striving to ensure that the content is clear and understandable and by re-organizing the Multnomah County Natural Hazards Mitigation Plan to address each natural hazard in a separate chapter and by removing materials not essential for mitigation planning.

1.4 The 2012 Multnomah County Natural Hazards Mitigation Plan

This Multnomah County Natural Hazards Mitigation Plan is built upon quantitative assessments, to the extent that data allows, of each of the significant natural hazards that may impact Multnomah County, including their frequency, severity, and areas of the county likely to be affected.

The Multnomah County Natural Hazards Mitigation Plan also includes a qualitative or quantitative assessment of the vulnerability of buildings, infrastructure, and people for each of these hazards. Reviews of the hazards and the vulnerability of Multnomah County to these hazards are the foundation of the mitigation plan. From these assessments, specific locations where buildings, infrastructure, and/or people may be at high risk may be identified. These high risk situations then

become priorities for future mitigation actions to reduce the negative impacts of future disasters on Multnomah County.

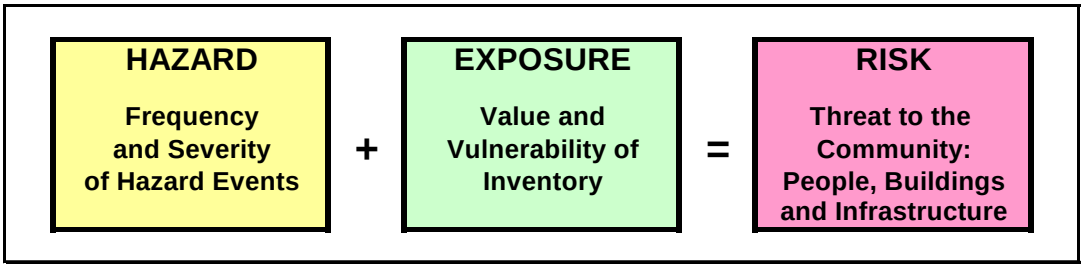
The Multnomah County Natural Hazards Mitigation Plan deals with hazards realistically and rationally while striking a balance between suggested physical mitigation measures to eliminate or reduce the negative impacts of future disasters and planning measures which better prepare the community to respond to and recover from disasters for which physical mitigation measures are not possible or not economically feasible. Mitigation measures may also include temporary measures, such as enhanced flood fighting capabilities, until permanent mitigation measures are implemented. In this context, mitigation planning is complementary to ongoing emergency and preparedness planning efforts.

1.5 Key Concepts and Definitions

The central concept of hazard mitigation planning is that mitigation reduces risk. **Risk** is defined as the threat to people and the built environment posed by the hazards being considered. Risk is the potential for damages, losses and casualties arising from the impact of hazards on the built environment. The essence of hazard mitigation planning is to identify high risk locations/situations in Multnomah County and to evaluate ways to mitigate (reduce) the impacts of future disasters on these high risk locations/situations.

The level of risk at a given location, building or facility depends on the combination of **hazard** and **exposure** as shown in Figure 1.1 below.

Figure 1.1
Hazard and Exposure Combine to Produce Risk



Risk is generally expressed in dollars (estimates of potential damages and other economic losses) and in terms of casualties (numbers of deaths and injuries).

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 manmade events that 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, or 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 event, by itself, may not result in any negative impacts on a community. For example, a 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. However, if the parcel is wetlands, with no structures or infrastructure, then there is no risk. That is, there is no threat to people or the built environment and the frequent flooding of this parcel does not have any negative impacts on the community. Indeed, in this case, the very frequent flooding (i.e., the high hazard) may be beneficial environmentally by providing wildlife habitat and recreational opportunities.

The important point here is that hazards do not produce risk to people and property, unless there is vulnerable inventory exposed to the hazard. Risk to people, buildings and/or infrastructure results only when hazards are combined with exposure.

EXPOSURE is the quantity, value and vulnerability of the built environment (inventory of people, 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, and 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 or may not be particularly vulnerable to flood damages or earthquake damages depending on the

details of its design and construction. Depending on the hazard, different measures of the vulnerability of buildings and infrastructure are often used.

RISK is the threat to people and the built environment - the potential for damages, losses and casualties arising from hazards. Risk results only from the combination of Hazard and Exposure as discussed above.

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 a hazard event strikes vulnerable 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. 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).

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 objectives of mitigation are always to reduce future damages, losses or casualties.

A few of the common types of mitigation projects are shown below in Table 1.1.

Table 1.1
Common Mitigation Projects

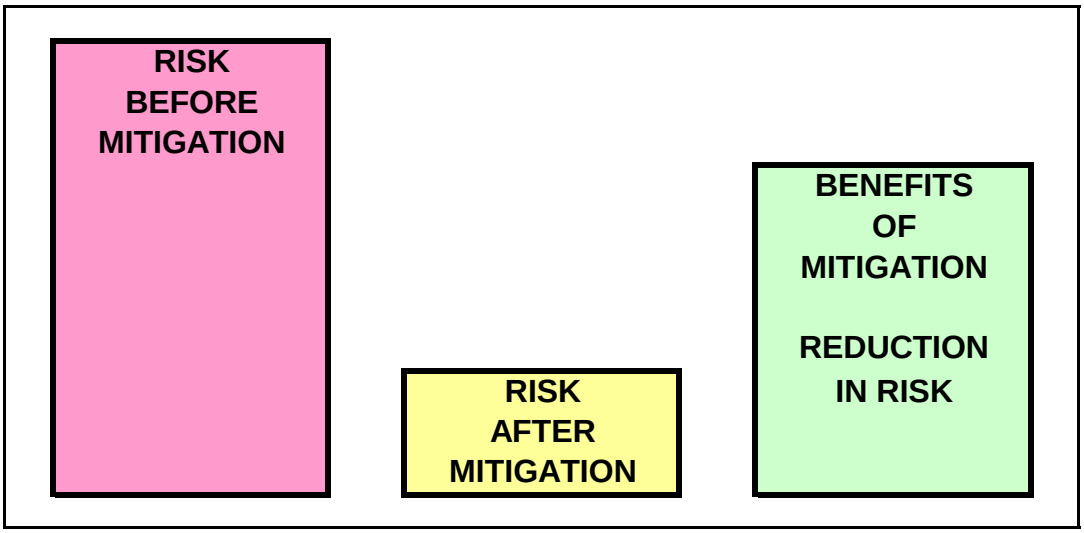
Hazard	Common Mitigation Projects
Earthquakes	Structural retrofits for buildings
	Nonstructural retrofits for contents and equipment
	Seismic upgrades for utility infrastructure
	Seismic retrofits for bridges
Wildland/Urban Interface Fires	Vegetation management - fuel reduction
	Enhance fire safe construction practices
Landslides	Remediate slide conditions
	Construct debris basins
	Relocate utility lines or critical facilities
Floods	Improve levees or channels
	Improve storm water drainage systems
	Elevate or acquire highly-flood prone structures
Windstorms	Enhance tree trimming efforts
	Add emergency generators for critical facilities
General	Increase public education programs for hazards
	Enhance emergency planning and mutual aid

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

1.6 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 condition) and after mitigation. These important concepts are illustrated below in Figure 1.2.

Figure 1.2
Mitigation Projects Reduce Risk



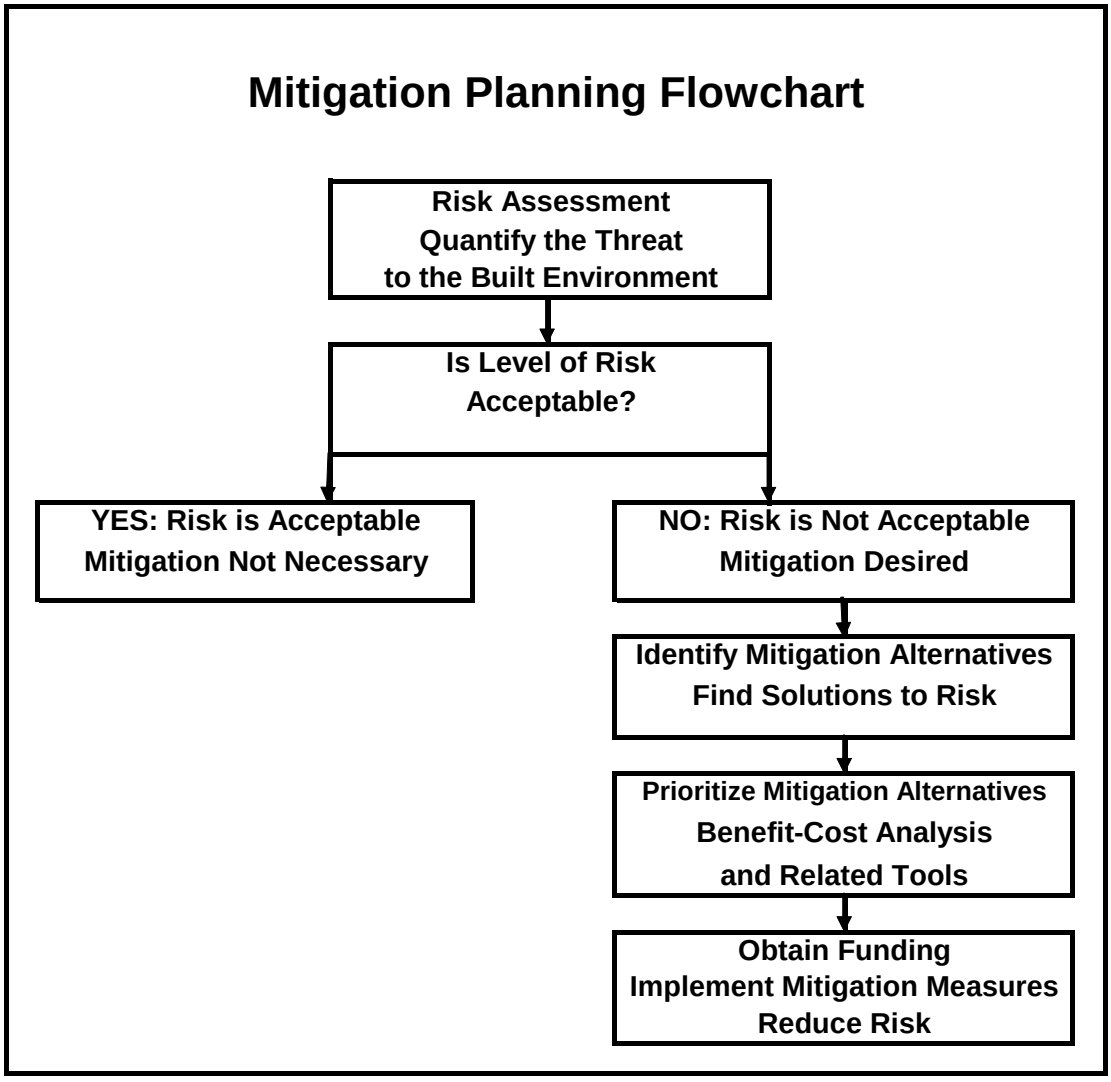
Quantifying the benefits of a proposed mitigation project is an essential step in hazard mitigation planning and implementation. Only by quantifying benefits is it possible to compare the benefits and costs of mitigation to determine whether or not a particular project is worth doing (i.e., is economically feasible). Real world hazard 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. Simply stated, the greater the risk, the greater the urgency of undertaking mitigation.

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. 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). Furthermore, 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 hazard mitigation planning process is outlined in Figure 1.3 below.

Figure 1.3
The Hazard Mitigation Planning Process



The flow chart above outlines the major steps in hazard mitigation planning and implementation for Multnomah County.

The first steps are quantitative evaluation (frequency and severity) of the hazards impacting Multnomah County. The first steps also include evaluation 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 Multnomah County.

The next key step is to determine whether or not the level of risk posed by each of the hazards at a given location is acceptable or tolerable. Only the residents of Multnomah 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 hazard mitigation planning process progresses to a 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 County, other local government entities and the residents of Multnomah County.

1.7 The Role of Benefit-Cost Analysis in Hazard Mitigation Planning

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.

Communities, such as Multnomah County, 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?

Detailed information about FEMA's mitigation grant programs is available online:

http://www.fema.gov/government/grant/hma/grant_resources.shtm

FEMA's benefit-cost analysis software, detailed guidance on benefit-cost analysis, reference publications, and training courses is available online at:

http://www.bcahelpline.com

The following FEMA publications are recommended as general references for benefit-cost analysis:

"*What is a Benefit? Guidance for Benefit-Cost Analysis"*

"*BCA Reference Guide"* and

"Supplement to the Benefit-Cost Reference Guide."

These publications include guidance on the categories of benefits to count for mitigation projects for various types of buildings, critical facilities, and infrastructure and provide simple, FEMA-standard methods to quantify the full range of benefits for most types of mitigation projects. The FEMA standard values in the BCA Reference Guide and the Supplement are the current values and should be used for benefit-cost analyses.

1.8 Synopsis of Hazards Affecting Multnomah County

To set the overall context of hazard mitigation planning, major hazards that impact Multnomah County are briefly reviewed. Some of these hazards affect the entire county, while others pose risk only to portions of the county.

Multnomah County has many areas mapped by FEMA as being within the 100-year regulatory flood plain or within the 500-year floodplain. These floodplains include areas adjacent to the Columbia River, the Willamette River and many smaller rivers and streams. Other parts of Multnomah County are subject to flooding during extreme events larger than the 500-year flood. Other areas outside of the mapped floodplains are also subject flooding from local storm water drainage.

All of Multnomah County is subject to severe weather including wind, snow and ice storms. Wind, snow and ice storms most commonly affect above ground utility lines with disruption of electric power but may also result in some damage to buildings and vehicles, especially from tree falls. The primary impacts of snow and ice storms include disruption of transportation systems as well as damage to above ground power lines and disruption of electric power.

Areas of Multnomah County with steep slopes and unstable rock or soils are subject to landslides and/or debris flows

All of Multnomah County is subject to the impacts of earthquakes from numerous active nearby faults. Earthquake damage will be concentrated in especially vulnerable (mostly older) buildings and infrastructure and in soft soil areas which amplify earthquake ground motions and/or may be subject to liquefaction or lateral spreading.

The portions of Multnomah County that are within, adjacent to or relatively close to hilly wildland areas are at risk from wildland/urban interface fires.

All of Multnomah County could be affected by ash falls from major volcanic eruptions. Portions of the county are at high risk from lahars from Mount Hood.

An important consideration for mitigation planning for natural hazards is that a given disaster event may involve multiple hazards. For example, severe weather may include damage from wind, snow or ice, flooding and landslides or an earthquake may result in flooding from failures of levees or dams and/or tsunami damage.

Although unlikely, it is also possible that more than one hazard event may occur concurrently. For example, a major earthquake could occur at the same time as a major flood, resulting in multiple sources of damages, with a substantial increase in the magnitude of necessary response and recovery actions. Such "perfect storm" multi-disaster events could be especially damaging if they were to occur.

The approximate level of risk posed to Multnomah County by each of the hazards covered in this mitigation plan is summarized below in Table 1.3. This ranking is based on quantitative/qualitative judgment about the likely long-term average annual damages and losses from each hazard, taking into account the probability of hazard events and the severity of damages and losses when such events occur.

Table 1.3
Relative Risk to Multnomah County from Hazards

Natural Hazard	Relative Risk to Multnomah County	Frequency
Earthquakes	High	Low
Floods	Moderate-High	Moderate-High
Volcanic Hazards	Moderate-High	Low
Wildland/Urban Interface Fires	Moderate	Low-Moderate
Severe Weather	Low-Moderate	High
Landslides/Mudslides	Low-Moderate	High

The relative risk terms in Table 1.3 are defined as follows:

High: Potential impacts include all or large portions of Multnomah County, or may be very severe in localized areas, with significant risk of loss of life and with property damages exceeding $10 million.

Moderate: Little or no risk of loss of life and property damages typically below $10 million.

Low: Potential for loss of life is very low and property damage typically below $1 million.

Very Low: Potential impacts are almost negligible.

The hazard event frequency terms are semi-quantitative, with definitions as follows:

> High Frequency: Hazard events occur every year or several times per year, with larger events having longer return periods.
>
> Moderate Frequency: Hazard events happen roughly every 5 to 25 years, with larger events having longer return periods.
>
> Low Frequency: Significant events happen roughly every 50 years or longer, with large evens having longer return periods.

An important note is that low frequency events don't necessarily mean low risk. An infrequent event such as a major earthquake or major eruption of Mount Hood may pose a high level of risk because the consequences (casualties, damages, economic losses) may be very high. Conversely, frequent events such as severe weather may pose relatively low risk because the consequences are usually not severe.

The relative risk and frequency rankings in Table 1.3 are based on the hazard data, vulnerability assessments and risk assessments in Chapters 6 through 11 which address the six major natural hazards listed in this table.

The remaining chapters of the Multnomah County Hazard Mitigation Plan include the following:

- Chapter 2 provides a brief community profile for Multnomah County.
- Chapter 3 documents the community involvement and public process involved in developing this hazard mitigation plan.
- Chapter 4 outlines the hazard mitigation plan goals, mitigation strategies and action items.
- Chapter 5 documents the formal process of plan adoption, implementation and maintenance.
- Chapters 6 through 11 cover each of the major hazards addressed in this hazard mitigation plan, including:
    - Chapter 6 Earthquakes,
    - Chapter 7 Wildland/Urban Interface Fires,
    - Chapter 8 Landslide ,
    - Chapter 9 Floods,
    - Chapter 10 Severe Weather, and

    - Chapter 11 Volcanic Hazards.

- Chapter 12 briefly addresses natural hazards which pose only minor or negligible threats to Multnomah County and human-caused hazards. Human-caused hazards are addressed only briefly in this mitigation plan which focuses on natural hazards. Human-caused hazards are addressed by emergency planning, emergency responders, law enforcement and other agencies.

The Appendices include:

- Appendix 1: Summary of FEMA and Oregon Mitigation Grant Programs.

- Appendix 2: Summary of benefit-cost analysis of mitigation projects. Benefit-cost analysis is required for almost all FEMA hazard mitigation grants.
- Appendix 3: Supplemental documentation of the public participation process during development of the Multnomah County Natural Hazards Mitigation Plan.

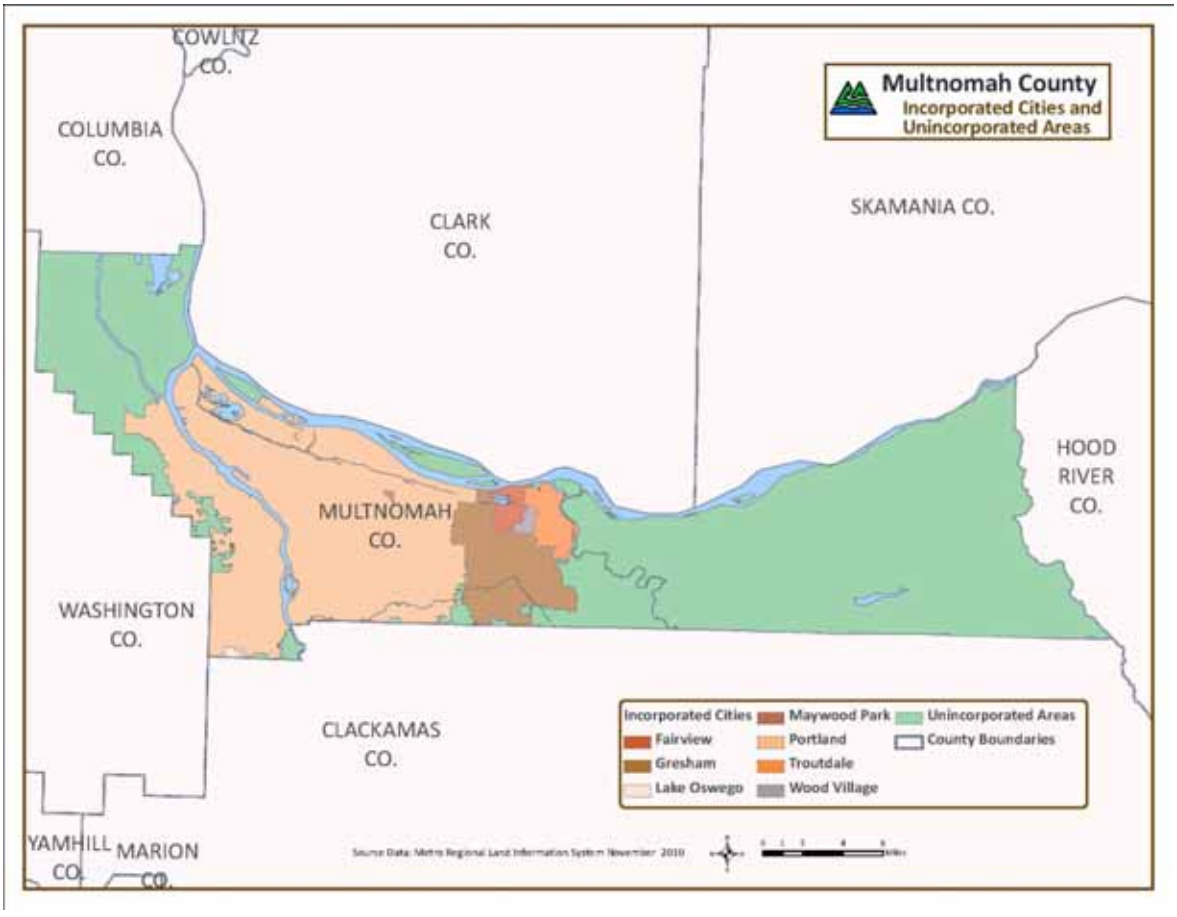
2.0 COMMUNITY PROFILE: MULTNOMAH COUNTY

2.1 Overview

Multnomah County was created on December 24, 1854 from the eastern part of Washington County and the northern part of Clackamas County. Multnomah County is bordered by Columbia County and the Columbia River on the north, Hood River County on the east, Clackamas County on the south, and Washington County on the west. Multnomah County is the smallest county in Oregon, with a total area of 466 square miles.

Multnomah County contains six incorporated cities (Portland, Gresham, Maywood Park, Fairview, Wood Village and Troutdale) and part of a seventh city, Lake Oswego which is predominantly in Clackamas County. The county also contains large unincorporated areas in the northwest and eastern parts of the county. The following figure shows the cities and the unincorporated portions of the county which are divided into Rural Plan areas.

Figure 2.1
Multnomah County Incorporated Cities and Unincorporated Areas



2.2 Geology, Geography and Climate

Multnomah County is located in a geologically active area. There are several active earthquake faults within the county and many other faults near the county, including the Cascadia Subduction Zone. The county is also close to active volcanoes, including Mount Hood in Clackamas County. Earthquake and volcanic hazards are addressed in Chapters 6 and 11 of this plan.

The topography of Multnomah County varies from flat to gently hilly terrain along the Willamette River and along the lower reaches of the Columbia River, to hilly in the west Portland Hills. Much of eastern Multnomah County from the Sandy River watershed eastward is hilly to mountainous. The highest location in Multnomah County is Buck's Peak with an elevation of 4,751 feet.

The two major rivers in Multnomah County are the Columbia River which forms much of the northern boundary of the county and the Willamette River which runs through Portland. The Sandy River, a tributary of the Columbia is another significant river in the county. There are FEMA-mapped floodplains along these three rivers as well as along many smaller streams.

Multnomah County has several small lakes, including Sturgeon, Bybee and Smith Lakes which are remnants of old channels of the Columbia River.

Temperatures and precipitation vary significantly within the county, depending on elevation. Average annual precipitation ranges from about 40 inches in the vicinity of the Portland Airport to about 70 inches in parts of the west hills to about 150 inches at high elevations in eastern Multnomah County. The data below are for the weather station at the Portland Airport.

The climate for Multnomah County is moderate. Mean daily temperatures range from highs of about 81^{o} and lows of about 54^{o} in July and August to highs of about 45^{o} and lows of about 34^{o} in December and January. The average annual precipitation is about 40". Average monthly precipitation varies from about 6 to 7 inches in November through January to about 0.75 inches in July. Average annual snowfall is about 5 inches, although many years have had no measurable snowfall.

Table 2.1
Multnomah County Precipitation Data

Location	Average Annual Precipitation (inches)	Lowest Annual Precipitation (inches)	Highest Annual Precipitation (inches)	Period of Record
Portland Airport	36.84	22.48 (1985)	63.20 (1996)	1941-2010

Western Regional Climate Center website: www.wrcc.dri.edu

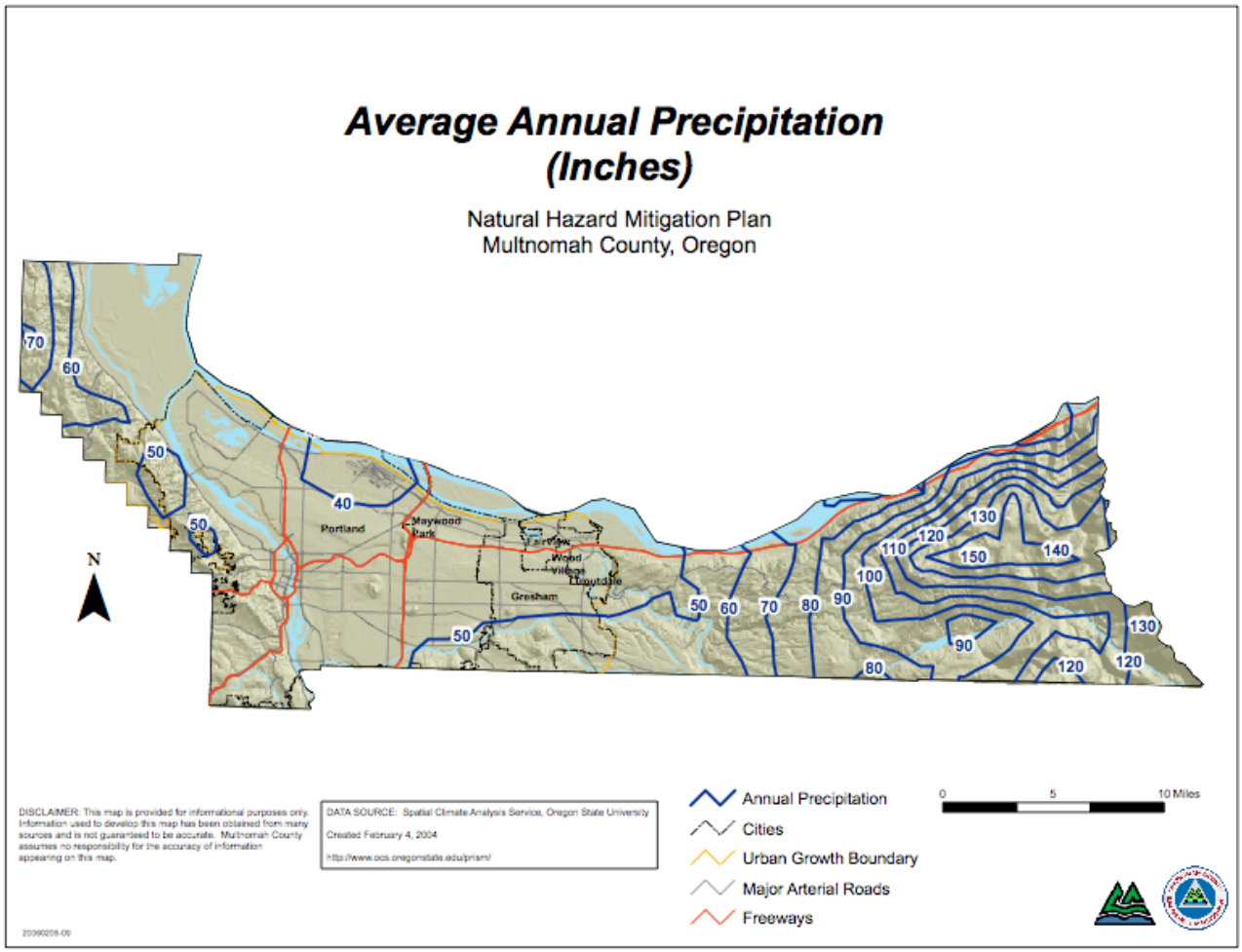
Table 2.2
Multnomah County Snowfall Data

Location	Average Annual Snowfall (inches)	Lowest Annual Snowfall (inches)	Highest Annual Snowfall (inches)	Period of Record
Portland Airport	2.80	0.00 (many years)	34.0 (1968-1969)	1941-2010

Western Regional Climate Center website: www.wrcc.dri.edu

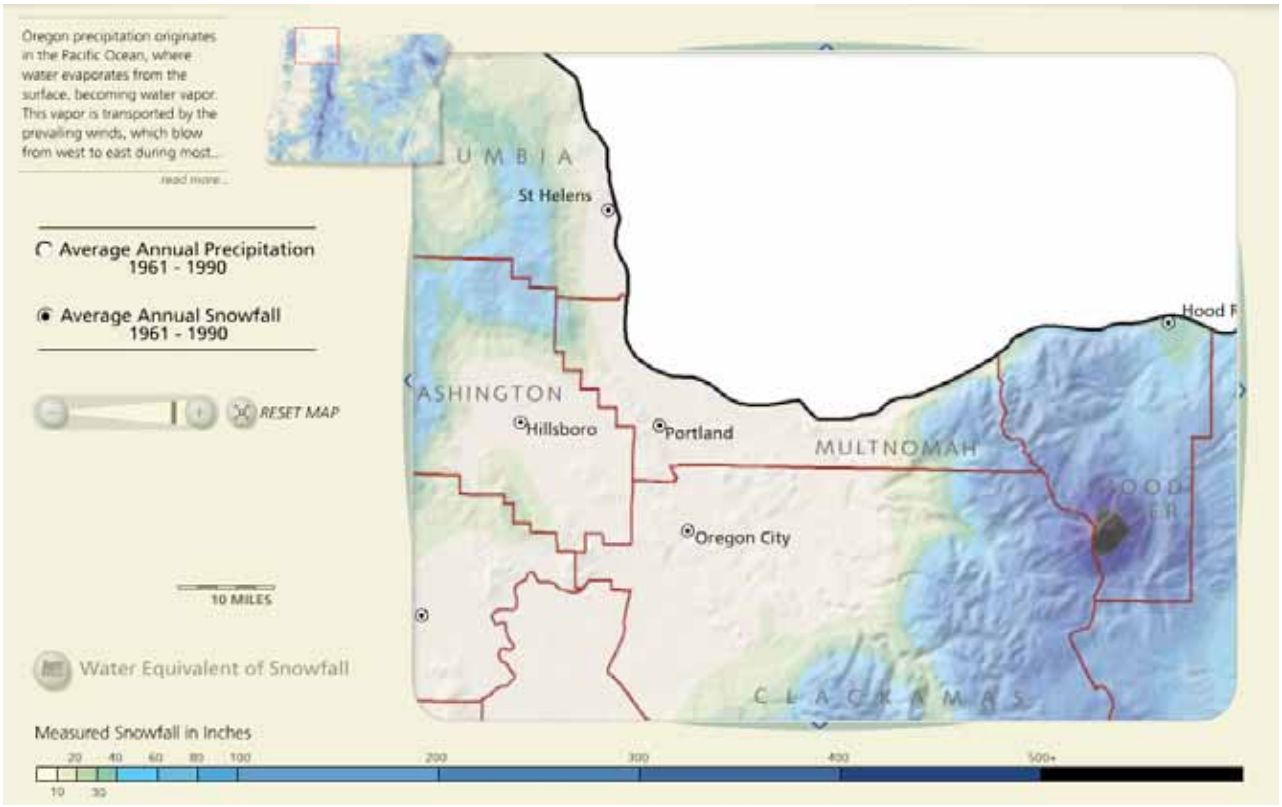
Multnomah County's climate and precipitation amounts vary significantly with elevation within the county. Higher elevations have lower temperatures and substantially higher precipitation.

Figure 2.2
Multnomah County Precipitation Patterns



As shown above, precipitation is significantly higher in the west Portland Hills and much higher in the high elevation areas in eastern Multnomah County than in the lower elevation areas within the Willamette and Columbia River valleys.

Figure 2.3
Multnomah County Snowfall Patterns



Atlas of Oregon CD ROM, 2002, University of Oregon Press.

As shown above, snowfall is significantly higher in the west Portland Hills and much higher in the high elevation areas in eastern Multnomah County than in the lower elevation areas within the Willamette and Columbia River valleys.

2.3 Population and Demographics

U.S. Census population data for Multnomah County for 1990, 2000 and 2010 are summarized in Table 2.3.

Table 2.3
Multnomah County Population Data

Entity	Population		
	2010	2000	1990
Multnomah County	735,334	660,486	583,887
Incorporated	721,211	644,439	521,224
Unincorporated	14,123	16,047	62,663
Fairview	8,920	7,561	2,391
Gresham	105,594	90,205	68,235
Lake Oswego[1]	2,329	2,274	2,253
Maywood Park	752	777	781
Portland[2]	583,776	526,986	436,898
Troutdale	15,962	13,776	7,852
Wood Village	3,878	2,860	2,814

[1] Only the part of Lake Oswego in Multnomah County

[2] A small part of Portland, with about 800 people, is in Clackamas County

The population of Multnomah County has grown substantially over the past two decades. However, the population of the unincorporated area has dropped markedly, about 75%, over this time period. This population loss in the unincorporated area is predominantly due to annexation of formerly unincorporated areas by the cities in the county, rather than because of migration.

2.3 Demographics

Selected demographic data for Multnomah County from the US Census Bureau are shown in Table 2.4. The age and ethnicity categories in Table 2.4 intentionally include overlapping subsets for planning purposes.

For emergency planning purposes, children, elderly adults, the disabled, people whose primary language is not English and low income residents are often considered special needs population groups. The numbers of people in these groups may also be a factor in mitigation planning, including community

participation efforts and in developing and prioritizing mitigation goals, objectives and action items.

Table 2.4
Multnomah County Demographic Characteristics
U.S. Census Bureau, American Community Survey, 1-Year Estimate, 2010

Demographic Data		
Age		
	Under 5 years	6.3%
	Under 18 years	20.5%
	18 years and over	79.5%
	18 years to 65 years	68.9%
	65 years and over	10.6%
Population with Disability		
	Age: Under 18	4.0%
	Age: 21 to 64 years	17.3%
	Age: 65 years and older	40.5%
Ethnicity of Households		
	White	77.0%
	Black or African American	6.0%
	American Indian and Alaska Native	0.9%
	Asian	6.8%
	Native Hawaiian and Pacific Islander	50.0%
	Other or two or more races	7.8%
	Hispanic or Latino (of any race)	10.9%
Language Spoken at Home		
	English only	80.3%
	Language other than English	19.7%
	Speak English less than very well	9.2%
	Spanish	8.5%
	Other Indo-European languages	4.8%
	Asian and Pacific Island languages	5.8%
	Other languages	0.7%
Country of Birth		
	United States	85.8%
	Foreign-born	14.2%
	Naturalized citizen	41.0%
	Not a U.S. citizen	59.0%
Income and Poverty Data		
	Median family income	$48,043
	Families with income below $10,000	7.0%
	Families with income below $25,000	18.9%
	Below poverty level	
	People	18.2%
	Families	13.6%
	Families with children	21.8%
	Children	25.4%
	People 65 years and older	17.2%

Multnomah County has a substantial population of children and elderly adults. As shown in Table 2.4 above, about 21% of the population is children less than 18 years old, while about 11% are adults over 65 years old. 4% of the children under 18 years old is classified as having a disability, as are about 17% of adults between 21 and 64 years old and about 41% of adults over 65 years old.

About 18% of the people, 14% of families, 22% of families with children, 25% of children and 17% of people over 65 years old are below the poverty level. 7% of families have incomes below $10,000 and 19% of families have incomes below $25,000.

About 20% of Multnomah County's residents speak a language other than English at home and 9% speak English less than very well. The people speaking a language other than English at home include: 8.5% who speak Spanish, 4.8% who speak other Indo-European languages and 6.5% who speak Asian, Pacific Island and other languages. About 14% of the population was born outside of the United States.

The US Census website (www.census.gov) has a vast amount of additional demographic data for Multnomah County which may be useful for planning purposes.

2.4 Housing

Selected housing data for Multnomah County from the U.S. Census Bureau are shown in Table 2.5.

The 2010 Census estimates for Multnomah indicate that about 54% of housing units are owner-occupied while 46% are owner-occupied. The overall vacancy rate was 7%. However, in 2010, given the housing crisis that has evolved over the last couple of years, including record number of foreclosures, the current vacancy rate and percentage of renter-occupied housing units may be somewhat higher than the 2010 Census estimates.

The proportion of owner- and renter-occupied housing units is significant for mitigation planning because mitigation actions for earthquakes or other hazards are predominantly undertaken by owners. The mitigation perspectives of owners for owner-occupied and renter-occupied housing units may differ.

The date of construction of housing units is also significant for mitigation planning because building codes for seismic and fire provisions have changed markedly over the decades. Less than 24% of Multnomah County's housing stock is post-1990 and thus built to recent codes with generally similar provisions to the current codes.

69% of the housing stock is pre-1980 and thus was built to codes with significantly different seismic and fire provisions than the current codes. Many pre-1940 single family and small multi-family housing units were built with cripple wall foundations (short walls typically two or three feet high, between the foundation and the main floor of the home) or with sill plates that are not bolted to the foundations. Homes with these structural characteristics have substantially greater vulnerability to earthquake damage than later structural types.

Relatively few of these pre-1940 homes have subsequently been voluntarily retrofitted to mitigate these seismic deficiencies. However, the majority such homes have not yet been retrofitted. Heavy damage to these structures in an earthquake would result in high levels of damages and casualties as well as very high demand for temporary housing.

Table 2.5
Multnomah County Housing Data
U.S. Census Bureau, American Community Survey, 1-Year Estimate, 2010

Housing Data		
	Number	**Percentage**
Total Housing Units	324,927	100.0%
Occupied Housing Units	302,182	93.0%
Vacant Housing Units	22,745	7.0%
Owner-Occupied	164,019	54.3%
Renter-Occupied	138,041	45.7%
Housing Type		
Single Family, Detached	183,909	56.6%
Single Family, Attached	12,997	4.0%
Apartments (2 to 9 units)	49,064	15.1%
Apartments (10 or more units)	70,509	21.7%
Mobile Home	7,798	2.4%
Other - boat, RV, van etc.	325	0.1%
Year Structure Built		
2000 or later	39,316	12.1%
1990s	37,692	11.6%
1980s	24,370	7.5%
1970s	45,490	14.0%
1960s	32,493	10.0%
1950s	39,966	12.3%
1940s	24,045	7.4%
Before 1940	81,882	25.2%

2.5 Transportation

Multnomah County is served by an extensive network of interstate highways, state highways and local roads and streets. The major interstates include I-5 which runs north-south through the county and is the major route connecting Oregon with

Washington and California. I-84 is the major route from Multnomah County eastward to Idaho, other Rocky Mountain States and to the central and eastern United States. I-205 is a bypass highway east of Portland that connects with I-5 south of Portland in Clackamas County and north of Portland in Washington State. I-405 is a short bypass highway off I-5 that connects to State Highway 26.

Major state highways in Multnomah County include Highway 26 which runs through the county, westward to the Oregon Coast and eastward to central and eastern Oregon. Highway 30 connects Multnomah County to Columbia County on the northwest and runs eastward generally parallel to I-84. Highway 99 runs north-south from I-5 near the Columbia River south to Clackamas County near Milwaukie. NW Cornelius Pass Road, which connects Highways 26 and 30 through the west Portland Hills, is also an important commuter route.

Multnomah County contains 504 bridges, including:

- 333 state highway bridges,
- 44 County highway bridges
- 126 municipal bridges, and
- 1 historic covered bridge.

Some of the bridges have vulnerabilities for earthquakes, floods and lahars. Evaluation of these bridges is important for both mitigation planning and emergency planning purposes.

Surface transportation in Multnomah County and adjacent counties also includes the MAX light rail lines, Westside Express Service commuter rail, and the extensive bus network operated by Tri-Met as well as the bus network operated by Interstate Bus.

Passenger rail service to/from Portland is operated by Amtrak which operates three routes through Portland:

- Amtrak Cascades between Vancouver BC and Eugene,
- Coast Starlight between Seattle, Portland and Los Angeles, and
- Empire Builder between Portland and Chicago.

Freight rail service in Multnomah County is provided by two long-haul railroads: BNSF and Union Pacific. BNSF provides service north to Seattle, south to California and east via Spokane. UP provides service south to California and east via Boise. In addition there are two short line railroads serving Multnomah County. Portland & Western provides service from Astoria to Portland and the Portland Terminal Railroad provides connections from Portland's marine terminals to other carriers.

Marine and air transport to/from Multnomah County is provided by facilities operated by the Port of Portland. The Port operates four marine terminals (one on the Columbia River and three on the Willamette River near the confluence with the Columbia River, which provide service via ocean-going ships and barges. The Port also operates the Portland International Airport (PDX), the main commercial airport for northwest Oregon and vicinity. The Port also operates three much smaller commercial airports, including Troutdale Airport in Multnomah County, Hillsboro Airport in Washington County and Mulino Airport in Clackamas County. The Port also owns and operates the dredge "Oregon" to help maintain the shipping channel on the lower Columbia River. The Port oversees five industrial/business parks and is the Portland area's largest owner of industrial land.

2.6 Land Use and Development

2.6.1 Overview

The overall pattern of land use and development in Multnomah County varies from the large urban areas, Portland and Gresham to the smaller incorporated cities of Maywood Park, Fairview, Wood Village, Troutdale and Lake Oswego (a small part of which is in Multnomah County).

The unincorporated parts of Multnomah County cover about half of the county by area, but only contain about 2% of the county's population. The unincorporated areas range from lightly developed areas in or near the urban growth boundaries of the cities, to very small unincorporated communities in rural areas and rural areas with farms or isolated homes.

The areas within incorporated cities' urban growth boundaries and the rural areas outside of the urban growth boundaries are shown below in Figure 2.4. Zoning for Multnomah County is shown in Figures 2.5 and 2.6 on the following pages.

Figure 2.4
Multnomah County Planning Areas


Sauvie Island
Rural Plan
Area
West
Hills
Rural
Plan
Area
Interlachen
Urban Plan Area
Maywood
Park
Portland
Troutdale
Fairview
Wood
Village
Gresham
Columbia River Gorge National Scenic Area
East of the Sandy River
Rural Plan Area
West
of the
Sandy River
Rural Plan Area
Pleasant Valley
Urban Plan Area
Lake
Oswego

Figure 2.5
Zoning: Western Multnomah County

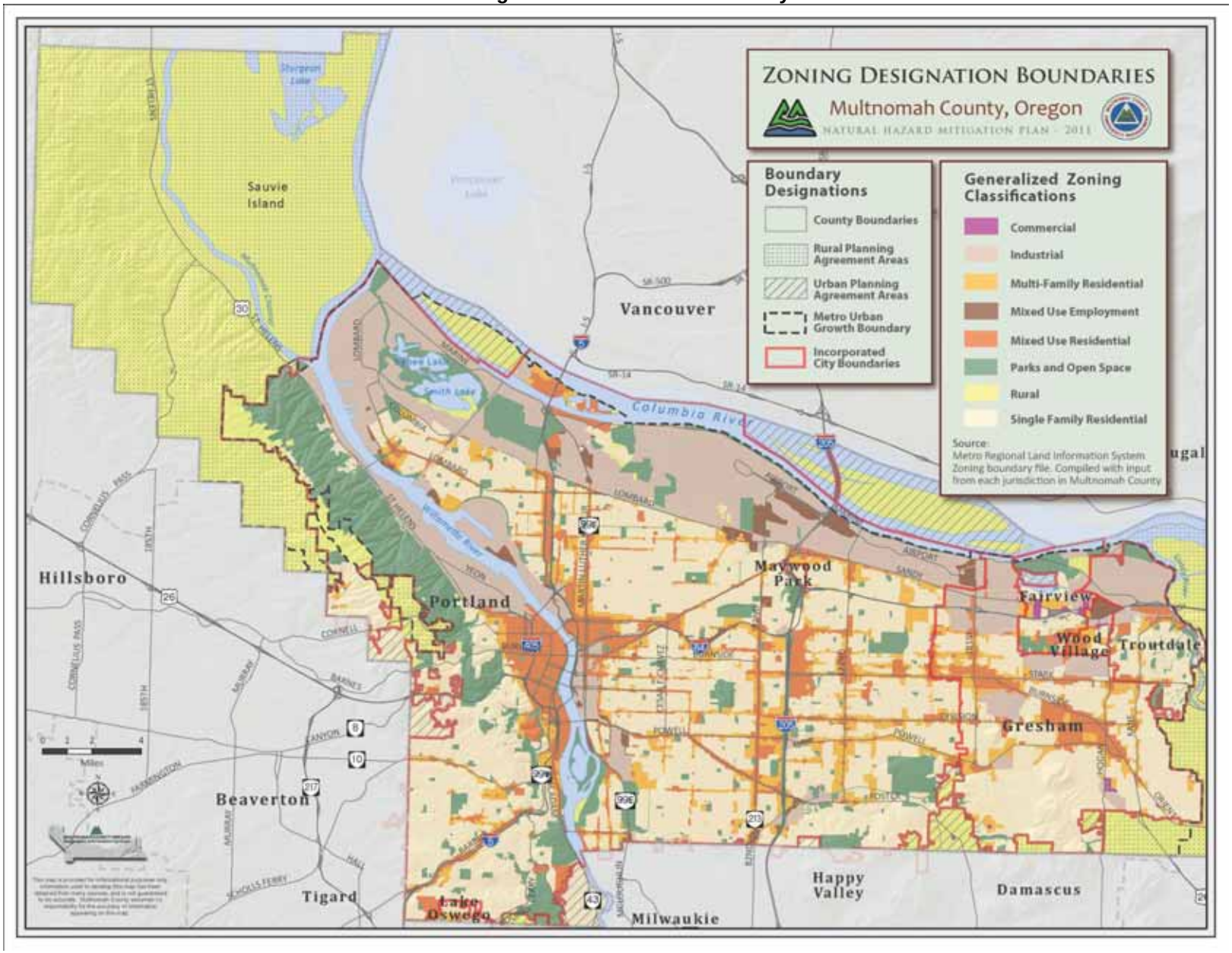
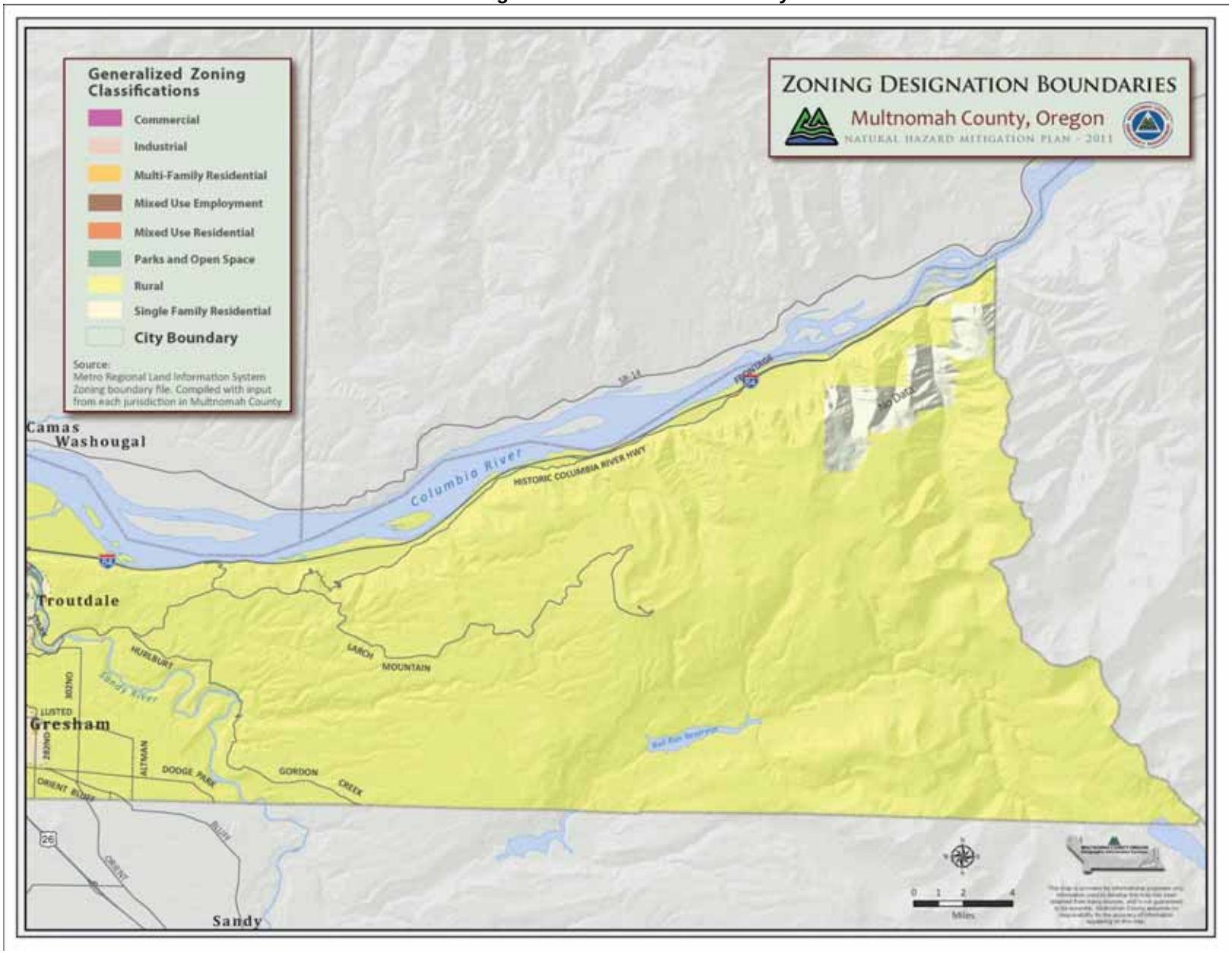
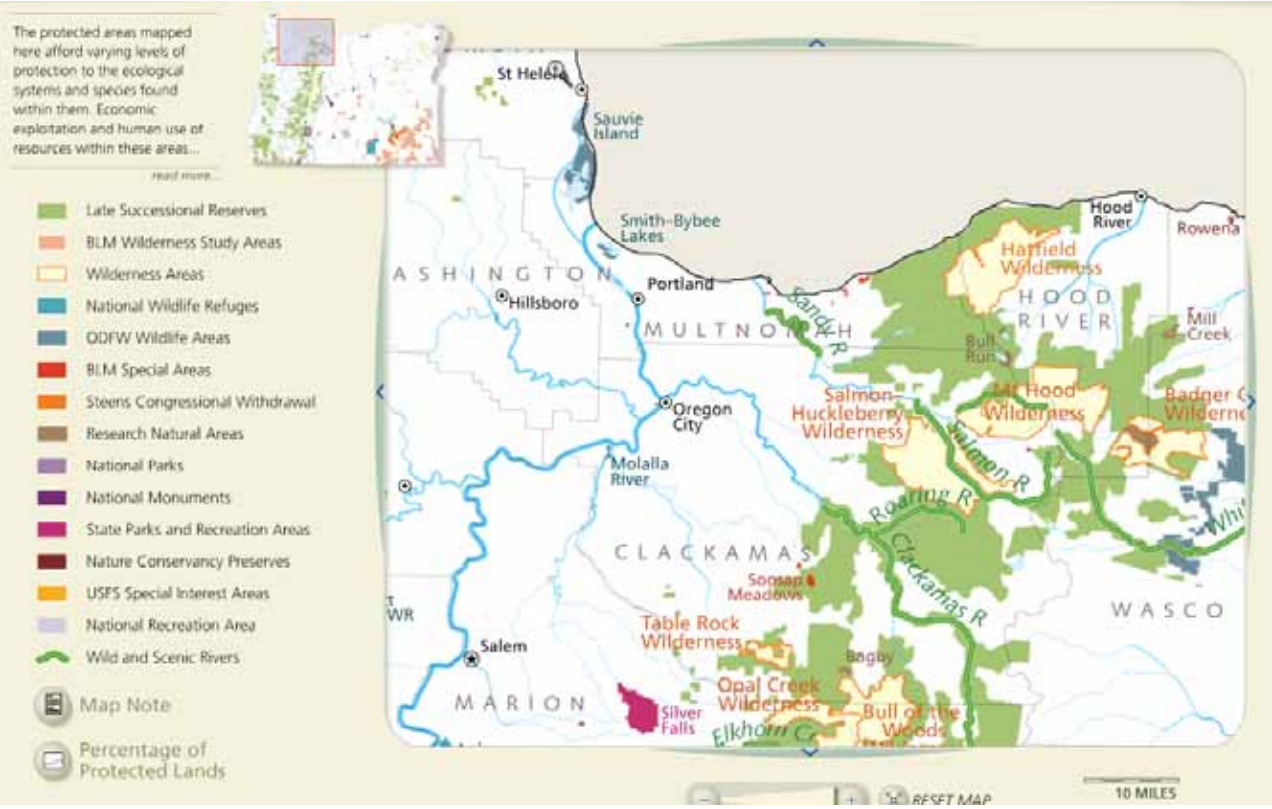


Figure 2.6
Zoning: Eastern Multnomah County



Eastern Multnomah County includes large forested areas which include both privately owned lands and National Forest lands as well as the Columbia River Gorge National Scenic Area. Protected areas in and near Multnomah County are shown in Figure 2.5.

Figure 2.5
Protected Areas



2.6.2 Development Trends Since 2006

Under Oregon's system of land-use management new development happens almost exclusively within the urban growth boundaries of the state's jurisdictions. This policy assures that new development will have access to urban services including sewer, water, roads, electricity and emergency services. Rural lots outside of the urban growth boundaries are typically large and not zoned for new development. Thus, the supply of developable land outside of the urban growth boundary is very limited.

The majority of the development in Multnomah County occurs within the Urban Growth Boundary and is nearly all subject to hazard mitigation plans of jurisdictions other than Multnomah County. Development in rural Multnomah County is limited by the county large minimum parcel size regulations intended to maintain those areas as sparsely settled farm, forest, and rural residential areas.

Land Use permit records contain twelve permits on parcels that have flood protection designations between 2007 and 2011. One of those permits was for a new dwelling. The other projects were replacement of existing structures, including the Interstate 84 bridges over the Sandy River, or bank stability/habitat projects.

2.6.3 Future Development Trends

Perhaps the best indicator of future development trends in rural Multnomah County can be found by considering the number of new land parcels expected. This is a useful measure because rural zoning allows just one dwelling on a lot. Data collected by the county land use planning division found 33 lots were created, 15 of which constituted a net increase of parcels, in the ten years from 1999 to 2009. This stable land supply indicates that very low levels of new development are expected in unincorporated areas of Multnomah County within the foreseeable future.

3.0 MITIGATION PLANNING PROCESS

3.1 Multnomah County's 2006 Natural Hazard Mitigation Plan

Multnomah County's 2006 Natural Hazard Mitigation Plan was not the first mitigation effort Multnomah County had carried out to reduce risk and exposure to natural hazards. The County's previous efforts include:

- Post 1996 flood activities, including bank hardening and levy repair and upgrades
- Project Impact and other educational outreach programs
- Retrofits to bridges and overpasses
- Updates in building code to restrict development in floodplains and include requirements for seismic retrofits.

Community involvement was an important part of creating the 2006 Natural Hazard Mitigation Plan. Stakeholders provided input in a number of ways throughout the process including a Steering Committee to oversee the plan development process; stakeholder interviews to receive in-depth information about vulnerabilities and risk reduction activities; a stakeholder forum to identify community vulnerability issues and devise actions to address them; and posting of the draft Natural Hazard Mitigation Plan on the County's website for review and comment before the Plan was finalized. The Steering Committee met four times between November 2005 and March 2006.

The natural hazards addressed in the 2006 Multnomah County Natural Hazard Mitigation Plan include drought, earthquakes, floods, landslides/debris flows, volcanic events, wildfires, and severe weather. For each of these hazards, the Plan identified:

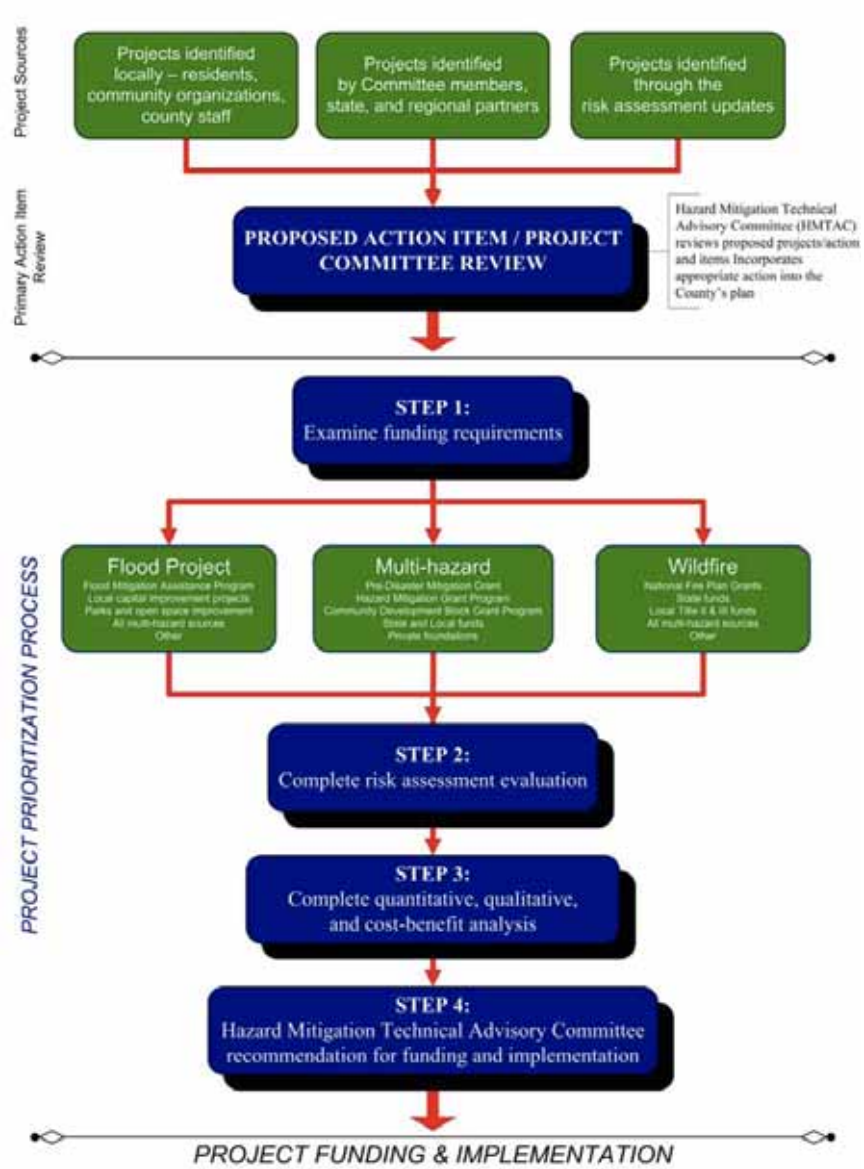
- The location of the hazard (What area is likely to be affected)
- The extent of the hazard at that location (How many people and how much infrastructure could be impacted by the hazard?)
- Previous occurrences of hazard events
- Risk, probability, and vulnerability estimates, and
- Previous mitigation efforts.

Map of areas most likely to experience a particular hazard were also included for most hazards.

The mission, goals, and action items highlighted in the 2006 Natural Hazard Mitigation Plan supported many of Multnomah County's other plans and programs, including the Comprehensive Plan, Capital Improvement Plan, and state building codes. Additionally, the goals and action items were aligned with the County's FY 2006 priority-based budgeting approach.

A mitigation project development and prioritization process (see below) was developed for prioritizing potential actions identified as part of the planning process as well as for actions/projects that will be identified in the future. Thirty-five action items were included in the 2006 Natural Hazard Mitigation Plan to address the Plan's five (5) goals: maintain a comprehensive, countywide risk assessment; reduce risk to people, property and environment; support a disaster resilient economy; promote public education, awareness, and understanding of risk; and develop and maintain collaborative partnerships and funding strategies for implementing the mitigation plan.

Figure 3.1
Mitigation Planning Process



3.2 Multnomah County Hazard Mitigation Plan – 2012 Update

The 2012 update of the Multnomah County Natural Hazard Mitigation Plan began in June 2009 with the convening of the Hazard Mitigation Planning Committee. In January 2011 the name of the committee was changed to the Natural Hazard Mitigation Plan (NHMP) Committee.

The members of the committee are Multnomah County personnel and key stakeholders that possess the knowledge and understanding to be a subject matter contributor to the mitigation plan update. The committee includes representatives from each County Department with a significant role in hazard mitigation planning and/or disaster response and recovery. The members of the committee (April, 2011) are shown in Table 3.2 below.

The hazard mitigation planning effort also includes consultants under contract to Multnomah County beginning in January 2011. The consultants are Kenneth A. Goettel of Goettel & Associates Inc. and Sandra Davis of ECO Resource Group. These consultants have served as adjunct members of the Committee in addition to supporting Multnomah County staff during the 2012 Natural Hazard Mitigation Plan update process.

Table 3.2
NHMP Committee Members

Organization	Title	Participant
Army Corps of Engineers	Flood Preparedness Program Manager	Les Miller
City of Gresham	Emergency Manager	Todd Felix
Facilities Management	Facilities Specialist	Mike McBride
MC Citizen Involvement Committee	CIC Member	Amy Anderson
MC Citizen Involvement Committee	CIC Member	Robb Wolfson
MC Emergency Management	Project Manager	Luis Hernandez
MC Emergency Management	Project Sponsor	Joe Partridge
MC GIS	GIS Analyst	Benjamin Harper
MC Land Use and Transportation	Senior Planner	Charles Beasley
MC Risk Management	Risk Manager	Marc Anderson
MC Transportation	Transportation Division Director	Kim Peoples
Multnomah County Drainage District #1	District Engineer II	Byron Woltersdorf
Port of Portland	Emergency Planner	Kori Olson
Portland Office of Emergency Management (POEM)	Planning and Mitigation Program Manager	Patty Rueter
Sauvie Island Drainage District	District Manager	Tim Couch
Oregon Emergency Management (State Oversight)	State Hazard Mitigation Specialist	Dennis Sigrist

Suggested improvements to the Multnomah County NHMP included:

- Update hazard, vulnerability and risk assessments with the latest data and more quantitative analysis/estimates
- Update, refocus, prioritize mitigation action items
    - Identify and prioritize specific actions to reduce risk, especially for high risk situations and critical facilities
    - Identify the best opportunities for FEMA and other mitigation grants
    - Make the action items more pragmatic/achievable
- Make the Plan understandable and accessible to the public and stakeholders

The major roles and responsibilities of the NHMP Committee, with technical support from the consultants, are to complete the 2012 update of the Multnomah County Natural Hazard Mitigation Plan, including:

- Provide Multnomah County specific data
- Identify critical facilities
- Provide synopses of historical disaster events
- Provide GIS maps and overlays of hazard areas with assessor's building data
- Provide thoughtful inputs into mitigation priorities and action items
- Provide detailed review comments on draft materials
- Meet FEMA's current requirements for mitigation plan approval
- Encourage and facilitate continued public involvement throughout the mitigation planning process
- Encourage and monitor the implementation of mitigation action items identified in the mitigation plan

After FEMA approval of the 2012 update of the Multnomah County Natural Hazard Mitigation Plan, the NHMP Committee's continuing role and responsibilities will include:

- Holding periodic meetings, at least annually, to review the Mitigation Plan and revise as necessary.
- Continuing to encourage and facilitate public involvement in the mitigation planning process.
- Continuing to encourage and monitor the implementation of mitigation action items identified in the mitigation plan.

- Initiating the FEMA-required 2017 update of the Multnomah County Natural Hazard Mitigation Plan by mid-2015.

The Multnomah County Natural Hazard Mitigation Plan NHMP Committee aggressively sought input from all County departments with a significant role in hazard mitigation and/or disaster response and recovery as well as from the broader community. Public participation is a key component of the mitigation planning process and offers citizens and stakeholders the opportunity to express their ideas and priorities for hazard mitigation activities.

The 2012 update of Multnomah County's Natural Hazard Mitigation Plan includes a seven phase public participation process:

- Developing the NHMP Committee composed of knowledgeable individuals from the County and the community and holding numerous committee meetings,
- Creating a Google website for communicating with and receiving input from the NHMP Committee, as well as posting information about the Multnomah County Natural Hazard Mitigation Plan update process on the County's website,
- Distributing a public questionnaire and posting it on the County's website to gather public opinions about known hazards, previous events and priorities,
- Providing information about the current hazard mitigation planning process to a broader list of stakeholders within the Multnomah County region with an interest in the County's hazard mitigation and disaster planning,
- Coordinating public outreach and education efforts with other hazard mitigation planning efforts within the region to the greatest extent possible,
- Conducting two public workshops to identify common concerns about hazards and to discuss specific goals and action items in the mitigation plan, and
- Ongoing public outreach activities to better educate the public about hazards, risks and mitigation priorities.

The following sections provide a synopsis of the major elements in the mitigation planning process. Supplemental documentation of the planning process is provided in Appendix 3.

3.2.1 Hazard Mitigation Planning Committee Meetings

For the 2012 update of Multnomah County Natural Hazard Mitigation Plan update process, the Hazard Mitigation Plan or the NHMP Committee met on the following dates:

- June 15, 2009
- July 20, 2009
- August 24, 2009
- September 24, 2009
- October 15, 2009
- November 19, 2009
- January 21, 2010
- February 18, 2010
- March 18, 2010
- April 15, 2010
- May 20, 2010
- June 17, 2010
- July 15, 2010
- January 18, 2011
- May 25, 2011
- August 10, 2011
- November 17, 2011

Agendas for the above meetings, are included in Appendix 3.

The gap between the July 15, 2010 and January 18, 2011 meetings corresponds to the time period when Multnomah County was going through the procurement process for consultant assistance.

The 2012 Multnomah County Natural Hazard Mitigation Plan addresses each of the natural hazards posing risk to the County, with emphasis on the hazards which pose the greatest risk (earthquakes and floods), moderate risk (wildland/urban interface fires and volcanic hazards), low-moderate risk (severe weather and landslides/mudslides).

The 2012 update of the Multnomah County Natural Hazard Mitigation Plan includes the following significant enhancements:

- Updating the hazard information for each of the major natural hazards,

- Refining the vulnerability and risk assessments for each of the major natural hazards,
- Redefining and identifying critical facilities with more specificity,
- Refocusing and reprioritizing hazard mitigation goals, objectives, and action items to emphasize pragmatic, implementable measures that address the highest risk situations in Multnomah County and that will significantly reduce risk.
- Identifying specific mitigation projects with the best likelihood of garnering FEMA mitigation project grants for implementation, and
- Improving the usability and accessibility of the Multnomah County Natural Hazard Mitigation Plan by re-organizing the plan and providing more

3.2.2 Public Inputs and Questionnaires

Public inputs for the 2012 update of the Multnomah County Natural Hazard Mitigation Plan were solicited via the County's website, by the NHMP Committee and Multnomah County staff, and as part of presentations throughout the planning process.

The public notice about the public questionnaires, which was posted on the Multnomah County website on February 28, 2011, is shown on the following page.

Public inputs were also solicited via a survey questionnaire posted on Multnomah County's website within both English and Spanish. In addition, hard copies were available at a variety of Mulntomah County Emergency Manangement sponsored events attended by the public. Copies of these questionnaires are included in Appendix 3.

The following sections provide synopses of the main trends in the responses.

90% of respondents were concerned about natural hazards, and approximately half of the survey respondents had experienced injury, damage or economic loss from a natural hazard. Of this half, the largest proportion experienced impacts from severe weather (snow, wind or ice) (92%) followed by floods (28%).

90% of all respondents were worried about future occurrences of disasters, with earthquakes, severe weather, floods and landslides being of most concern. These hazards were also considered the greatest threats to family, homes and place of work over the next 20 years.

About two-thirds of the respondents considered the possible occurrence of natural hazards when they bought or moved into their home. Those who didn't consider

the occurrence of a natural hazard threat for their home either didn't think it would affect them or it never occurred to them to consider the threat in their housing

Figure 3.2
Multnomah County Website Notice: Public Questionnaires for Mitigation Plan Update

Emergency Management seeks public input about natural hazards and community priorities

Monday, 2/28/11 - 2:16 pm

Jocelyn Augustino/FEMA Photo Library

Multnomah County is vulnerable to many different types of natural hazards, from earthquakes to landslides and floods. The county's Emergency Management staff are in the process of updating a plan for how to address the risk people, buildings and infrastructure face in the event of a disaster. Multnomah County's Natural Hazard Mitigation Plan was first adopted in 2006 and this year the plan is being updated to incorporate several important enhancements, including improving the usability and accessibility of the plan.

"Mitigation" is the term used for measures taken that reduce the potential for negative effects from future disasters, like physical damage, economic loss, and casualties. Mitigation planning attempts to find the middle ground between ignoring and overreacting to potential disaster events in a given area.

The 2011 revision of the Multnomah County Natural Hazard Mitigation Plan includes updating hazard information for major natural hazards, like earthquakes and floods; maintaining eligibility for FEMA mitigation grants; and prioritizing mitigation actions based on high risk situations identified in Multnomah County.

The plan update also aims to include community concerns about natural hazards and public preferences about how to reduce risk and loss from such disasters. Multnomah County has set up a short questionnaire in order to collect public input about priorities for the updated Natural Hazard Mitigation Plan. Questions touch on topics like past experience with natural hazards to perceived threat levels of different hazards over the next 20 years.

County residents are encouraged to share their thoughts about natural hazards by taking the online questionnaire.

decision. The main hazard considered in home selection was flooding, followed by severe weather and earthquakes.

The relative ranking of hazards for future threats and consideration when buying a home were generally very similar. However, earthquakes were seen as the greatest future threat, but ranked third in consideration when related to homes.

Table 3.2
Hazards: Future Threats and Consideration in Home Buying

Hazards seen as greatest future threat	Hazards considered when buying home
Earthquakes	Floods
Severe Weather	Severe weather
Floods	Earthquakes
Landslides	Landslides
Urban/Wildland Interface Fires	Urban/Wildland Interface Fires
Volcanic Events	Volcanic Events

The vast majority of respondents were interested in taking actions to protect their home, business or community from natural hazards. Given $10,000 to make their home, business or community less vulnerable, most of the respondents focused on their home or community.

About half of them specifically mentioned earthquakes, and others mentioned floods, wildfire, and wind, but many spoke generally about solutions that would reduce vulnerability for "various" hazards. The following table lists some solutions proposed for reducing vulnerability:

Table 3.3
Suggested Actions to Reduce Risks

Imagine that someone gave you $10,000 to make your home, business or community less vulnerable to natural hazards. What would you spend it on?			
Hazard	**Physical changes**	**Preparation and Planning**	**Power Supply**
Earthquake	• General retrofitting • Structural analysis • Bolt (tie down) house to foundation • Reinforce foundation and chimney • Reinforce foundation and chimney structure • Soil stabilization around house • Strengthen walls • Geological study of static sheer stress potential • Seismic remediation of all schools and hazmat tanks along Willamette River • Coat windows to make them shatterproof • Replace old windows • Anchor bookcase to wall	• Neighborhood outreach via neighborhood associations • Food & water storage, other supplies • Survival kit/preparedness • Education re: shelter location, community plan • Make a plan for living after the disaster. • Stock up on food/water • Preparedness supplies • Insurance	• Consider eliminating natural gas for heat source
Fire	• Fire resistant roofs to homes, outbuildings/barns	• Wildfire prevention/mitigation • Clear trees from near house • Water tanks for firefighting/ water storage capacity	• Developing community utility for power
Flood	• Dike management and repair • Additional drainage to street	• Insurance	• Generator • Fuel for Generator
Severe Weather	• Prepare roof for snow load • Snow shovel attachment for truck • Replace roof (wind)		• Solar panels

Various	• Shelter in place supplies at office • Improve home driveway for easy access for emergency vehicles • Community shelter supplied w/ food & water • Restore creeks and natural forest, Restricting human development	• Food and water storage for neighborhood • Emergency Response Leadership training for community members • Public information/training on how to form neighborhood support plans during disaster • Provide home survival kits	• Alternate heat source • Solar Power

The highest ranking mitigation priorities to reduce loss of life, property damage, and economic loss from future disasters were:

- reducing deaths and injuries,
- reducing damage to hospitals, fire and police stations, and schools
- reducing damage to electric power, gas, water and sewer systems,
- preventing future development in high hazard areas,
- reducing damage to roads and bridges,

When asked how they felt in terms of agreement or disagreement with strategies to reduce risk and losses from natural disasters, there was generally strong agreement with the strategies. The highest percentage of respondents agreed or strongly agreed that they would be willing to invest $500 to make their home more disaster resistant. However, the lowest percentage of agreement – and one where there was also the highest percentage of disagreement and neutrality – was for spending $5,000 on mitigation for their home. These results suggest a cap on personal investment in mitigation. There was strong support to limit development in hazardous areas, and in using tax dollars to reduce risks and losses. Voluntary and non-regulatory approaches had lower percentages of agreement.

When asked to describe past experience with natural hazards while living in Multnomah County, approximately half the total respondents to the survey listed various experiences. Most respondents list one event, but 18 described two events and 4 described three 3 events that they had experienced. Most of the experiences were with severe weather and flooding, a few with earthquakes, several with fires, and one with volcanic eruption.

Overall, the public responses show considerable concordance with the hazard analyses and mitigation priorities presented in the subsequent chapters of this plan. However, there are also some discordances with hazard data which emphasize the importance of continuing education and outreach activities to better inform the public about natural hazards affecting Multnomah County.

3.2.3 Public Workshops

The NHMP Committee held two public workshops in September 2011 and November 2011 to present a draft version of the updated Multnomah County Natural Hazard Mitigation Plan and solicit inputs from the public and stakeholders. The first meeting was held in Troutdale in eastern Multnomah County on September 29th at the Springdale Job Corps site. The second meeting was held in western Multnomah County on November 16th in Portland at the Linnton Community Center. The meeting sites in eastern and western Multnomah County were selected to maximize participation from residents in the unincorporated parts of the county.

The September 29th workshop was attended by 28 residents and representatives of local agencies, along with 6 Multnomah County staff and county's planning consultant. Local agencies who attended included the Northeast Multnomah County Neighborhood Association, Corbett Water, Multnomah County Fire District #14, Sauvie Island Drainage District and Sauvie Island Fire District.

Workshop activities included the following:

- Open house period with tables set up with hazard maps and other mitigation planning materials, with Multnomah County staff to answer questions,
- PowerPoint presentation outlining the basic elements of mitigation planning, review of hazards, and summary of mitigation priorities and action items.
- Question and answer period

The November 16th workshop was attended by 2 representatives of local agencies, Sauvie Island Drainage District and Sauvie Island Fire District, and by 5 Multnomah County staff. Workshop activities were similar to those summarized above.

Flyers for these two public workshops are included in on the following pages.

Figure 3.3
Public Workshop Flyer – September 29, 2011 Workshop

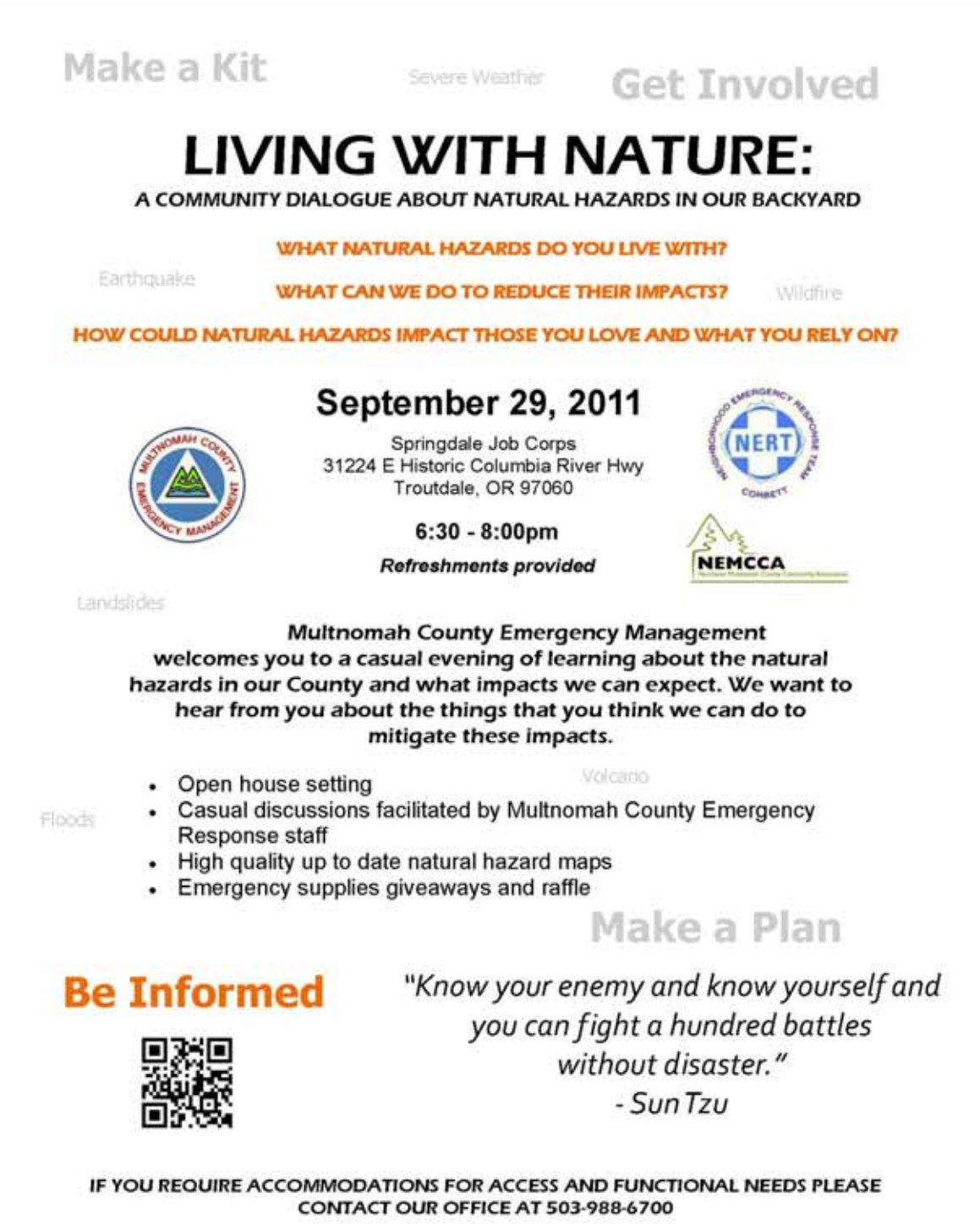
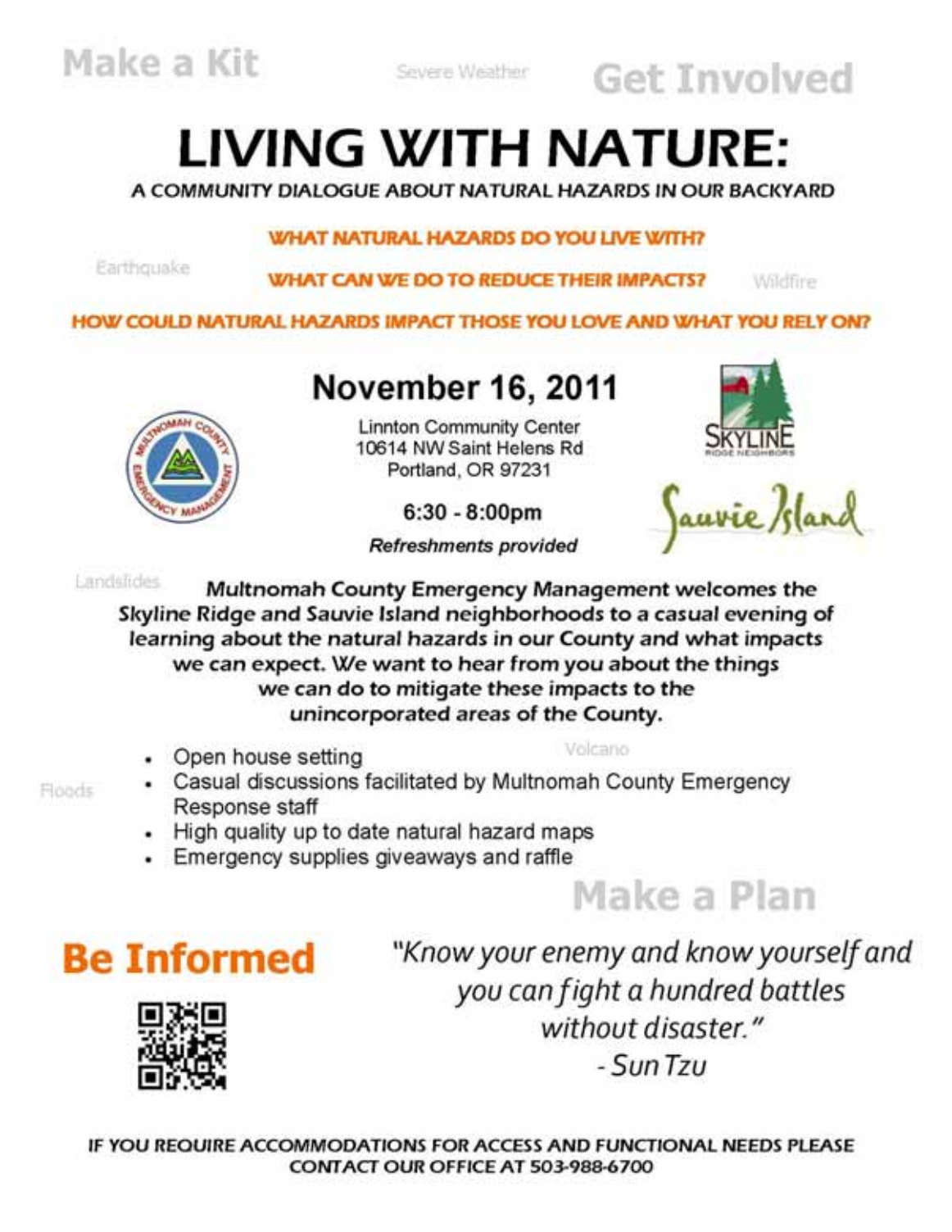


Figure 3.4
Public Workshop Flyer – November 16, 2011 Workshop



3.2.4 Stakeholder Interviews

Stakeholder interviews were conducted with the following key stakeholders to collect information regarding their knowledge of past disaster events, critical infrastructure and information needed to complete the 2012 update of the Multnomah County Natural Hazard Mitigation Plan:

- Mike McBride (Multnomah County Facilities Management),
- Chuck Beasley (Multnomah County Land Use and Transportation),
- Tim Couch (Sauvie island Drainage District),
- Kori Olson and Donna Tyner (Port of Portland),
- Marc Anderson (Multnomah County Risk Management),
- Ben Harper (Multnomah County GIS),
- Byron Woltersdorf (Multnomah County Drainage District #1), and
- Les Miller (US Army Corps of Engineers).

3.2.5 Outreach Efforts for Other Stakeholders

The list of other public and private stakeholders to whom periodic notices about the 2012 update of the Multnomah County Natural Hazard Mitigation Plan and invitations to comment on draft materials or otherwise participate in the planning process is shown below.

Table 3.4
Stakeholder List for Mitigation Plan Notices

Names	Organization
County	
Amy Esnard	Multnomah County Geographical Information Systems (GIS)
Kai Snyder	Multnomah County Geographical Information Systems (GIS)
Tom Hansell	Multnomah County Roads and Bridges
Garret R. Lang	Multnomah County Bridges/Amateur Radio Emergency Services (ARES)
Tim Moore	Multnomah County Sheriff
Chris Wirth	Vector Nuisance Control Manager (Environmental Health in Health Department)
Kat West	Multnomah County Office of Sustainability
Jon Schrotzberger	Multnomah County Facilities Program Manager
Jim Spitzer	Multnomah County Health Department
Mary Li	Health and Human Services
Mike Oswald	Multnomah County Animal Services

Chief Deputy Jason Gates	Multnomah County Sheriff's Office
Captain Monte Reiser	Multnomah County Sheriff's Office
Mike Pullen	Multnomah County Public Affairs
Roy Iwai	Multnomah County Water Quality Program
Adam Barber	Multnomah County Land Use and Transportation Planning, Senior Planner
Colleges	
Bryant Haley	Portland State University, Emergency Manager
Robert Costanza, Ph.D	Portland State University
Staci Huffaker	Risk Manager Mt Hood Community College
Gary Granger	REED College
Federal Agencies	
Roland Rose	Forest Service
State Agencies	
Geoffrey Bowyer	Oregon Department of Transportation
Jon Johnson	Oregon Department of Transportation Rail
Kevin Price	State Parks
Chris Babcock	Oregon Department of Forestry
Cindy Kolomechuk	Oregon Department of Forestry
K-12 schools	
Barbara Jorgenson	School Emergency Response/Recovery Alliance (SERRA)
Don Hicks	Multnomah Education Service District
Kari Skinner	Portland Public Schools
Dennis Tune	Portland Public Schools-Security Director
Chuck Cooper	Reynolds School District-Facilities Director
Mary Larson	Parkrose School District-Business Director
Rick Larson	Centennial School District-Business Director
Brook MacNamara	Riverdale School District-Superintendent
Dan McCue	David Douglas School District-Special Projects Director
Randy Trani	Corbett School District-Superintendent
Sam Olson	Sauvie Island School
Terry Taylor	Gresham-Barlow School District-Facilities Director
Cities	
Laureen Paulsen	Portland Office of Emergency Management
Kathie Condon	City of Portland, Bureau of Emergency Communications
Art Hendricks	Portland Parks and Recreation
David Harrington	Portland Bureau of Transportation
Steve Richards	Fairview
Todd Felix	Gresham
Allen Barry	Fairview
Randy Jones	Wood Village
Charlie Warren	Troutdale

Mark Hardie	Maywood Park
Special Districts	
Mike McGuire	Tri-Met
Angie Brewer, Planner	Columbia River Gorge Commission
Jennifer Kaden	Columbia River Gorge Commission
Corky Collier	Columbia Corridor Association
Jane Vandyke	Columbia Slough Water Shed Council
Jean	East Multnomah County Soil and Water Conservation District
Dick Springer	West Multnomah County Soil and Water Conservation District
Steve Wise	Sandy River Basin Watershed Council-Executive Director
Matt Clark	Johnson Creek Watershed Council-Executive Director
	Tualatin River Watershed Council
Jerry Uba	METRO
Donna Tyner	Port of Portland, Risk Manager
Business	
Debbie Guerra	Pacific Power
Brock Nelson	Union Pacific Railroad
Andrew Johnson	Burlington Northern Santa Fe (BNSF) Railway Company
Robbie Roberts	NW Natural Gas
David Ford	Portland General Electric
Marilyn Nikolas	Continuity Planners
Andrew Frazier	Small Business Advisory Council
Heather Hoell	Alliance of Portland Business Association
	Corbett Water District
	Reliance Connects
Community/Neighborhood Associations	
Charles Ormby	Birds Hill
Lora Creswick	Sauvie
Miles Merwin	Skyline
Karen Garber	Skyline
Robert Leeb	Engelwood
Leslie Goss	Riverdale
Carnetta Boyd	Notheast Multnomah County Community Organization (NEMMCA)
Kay Finney	Notheast Multnomah County Community Organization (NEMMCA)
Bob Sallinger	Audubon Society
Liesl Wendt	211 Info
Ron Carley	Coalition for a Livable Future
Stephen Hatfiled	Forest Park Conservancy
Nicholas Brown	Metro Exposition and Recreation Commission
Eric Corliss	American Red Cross. OR trail chapter
	Corbett Safety Action Committee

John Klosterman	Oregon Food Bank
Technical Experts	
Bill Burns	Dogami
Fire Districts	
Tom Layton	Multnomah County Rural Fire Protection District (MCRFPD) #14
Scott Lewis	Gresham Fire Department
Jim Klum	Portland Fire and Rescue
Norvin Collins	Sauvie Island Fire Department
CERTs	
Kathleen Reiter	Corbett Emergency Prep Coordinator
Contractors	
Ken Goettel	Goettel & Associates Inc.
Sandra Davis	ECO Resource Group
State Oversight	
Dennis Sigrist	State Hazard Mitigation Specialist

3.2.6 Board Staff Presentation

On February 21, 2012 the plan was presented at a Board Staff meeting. The presentation included a brief synopsis of the planning process; an overview of the hazards addressed and a discussion focused on Multnomah County Courthouse, maintenance of the NHMP and integration of action items into other plans within the County. Review and comments were facilitated using the planning project website over a one week period.

4.0 MISSION STATEMENT, GOALS, OBJECTIVES AND ACTION ITEMS

4.1 Overview

The overall purpose of the Multnomah County Hazard Mitigation Plan is to reduce the impacts of future natural disasters on Multnomah County. That is, the purpose is to make Multnomah County more disaster resistant and disaster resilient, by reducing the vulnerability to disasters and enhancing the capability of the County and its citizens to respond effectively to and recover quickly from future disasters.

Completely eliminating the risk of future disasters in Multnomah 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 Multnomah County's existing programs and decision making processes will facilitate moving Multnomah 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 Multnomah County Hazard Mitigation Plan is intended to meet FEMA's (Federal Emergency Management Agency) mitigation planning requirements so that Multnomah County remains eligible for pre- and post-disaster mitigation grant funding from FEMA.

The Multnomah 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 Multnomah 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 Multnomah County intends to work toward reducing the risks from natural and human-caused hazards.

The Goals represent the guiding principles toward which the community'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 then 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 Multnomah County Hazard Mitigation Plan is to:

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

The Multnomah County Hazard Mitigation Plan documents Multnomah County's commitment to promote sound public policies designed to protect citizens, critical facilities, infrastructure, private property and the environment from natural hazards by increasing public awareness, identifying resources for risk assessment, risk reduction and loss reduction, and identifying specific activities to help make Multnomah County more disaster resistant and disaster resilient.

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 the cities, other agencies, businesses and individuals begin implementing mitigation action items within Multnomah County.

Multnomah County's mitigation plan goals and objectives are based broadly, on and consistent with, the goals established by the State of Oregon Hazard Mitigation Plan. However, the specific priorities, emphasis and language are Multnomah County's. These goals were developed with extensive input and priority setting by the Multnomah County Natural Hazard Mitigation Plan (NHMP) Committee and the other stakeholders and citizens of Multnomah County.

Goal 1: Protect Life Safety

Objectives:

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

B. Enhance life safety by improving public awareness of earthquakes and other natural hazards posing life safety risk to the Multnomah County community.

Goal 2: Protect Multnomah County Buildings and Infrastructure

Objectives:

A. Identify buildings and infrastructure at high risk from one or more hazards addressed in the Multnomah County Hazard Mitigation Plan.

B. Conduct risk assessments for critical buildings, facilities and infrastructure at high risk to determine cost effective mitigation actions to eliminate or reduce risk.

C. Implement mitigation measures for buildings, facilities and infrastructure which pose an unacceptable level of risk.

D. Ensure that new buildings and infrastructure in Multnomah County are adequately designed and located to minimize damages in future disaster events.

Goal 3: Enhance Emergency Management Capability, Emergency Planning and Post-Disaster Recovery

Objectives:

A. Ensure that critical facilities and critical infrastructure are capable of withstanding disaster events with minimal damages and loss of function.

B. Enhance emergency planning to facilitate effective response and recovery from future disaster events.

C. Increase collaboration and coordination between Multnomah County, nearby communities, utilities, businesses and citizens to ensure the availability of adequate emergency and essential services for the Multnomah County community during and after disaster events.

Goal 4: Increase Public Awareness of Natural Hazards and Enhance Education, Outreach and Partnership Efforts

Objectives:

A. Develop and implement education and outreach programs to increase public awareness of the risks from natural hazards.

B. Provide information on resources, tools, partnership opportunities and funding resource sources to assist the community in implementing mitigation activities.

C. Strengthen communication and coordinate participation among and within public agencies, non-profit organizations, business, industry and the public to encourage and facilitate mitigation actions.

Goal 5: Environmental Stewardship

Objectives:

A. Balance and coordinate natural resource management, land use planning and natural hazard mitigation to protect life, property and the environment.

B. Preserve, rehabilitate and enhance natural systems to both enhance habitats and serve natural hazard mitigation functions.

C. Build and reinforce alliances with sustainability and climate adaptation initiatives that promote community resilience.

4.4 Critical and Essential Facilities

Many of the high priority action items focus on facilities which are critical or essential for Multnomah County. Critical facilities are facilities defined as those necessary for emergency response and recovery activities, especially public safety facilities and hospitals. Critical facilities also include:

- Public works facilities that are essential for disaster response, repairs, debris removal and recovery operations.
- Emergency Shelters
- Essential utility services such as water, wastewater, electric power, natural gas and telecommunications are also extremely important to communities, especially after a disaster. Such utilities are often characterized as “lifeline” utilities because they are so important to a community for life safety (e.g., services to hospitals) and for the economic recovery after a disaster.
- Key transportation system elements that are important for evacuation, emergency response and recovery.
- Major flood control infrastructure, including dams and the levee systems along the Columbia River and Willamette River.

Schools are not critical facilities, per the definition above. However, Multnomah County considers life safety for schools, especially for earthquakes, to be a very high priority because most schools have high occupancies and our community considers ensuring the safety of school children to be among our most important commitments. In this context, schools are essential facilities.

This plan focuses primarily on the following critical and essential facilities because they lie within the geographical unincorporated areas or house County services and they do not fall under the hazard mitigation planning scope of another jurisdiction's plan. While some facilities like fire stations and water towers may be located in the unincorporated areas, it is assumed that for the sake of this plan, their governing authority has adequately addressed hazard mitigation activities related to their vulnerabilities.

County Assets: County assets are located throughout the County in both incorporated and unincorporated areas. All major county assets are included in the scope of this plan, including:

- County Buildings, owned and leased,
- County Roads, especially major arteries and designated evacuation routes, and
- County Bridges, especially those on major arteries or designated evacuation routes.

Multnomah County's priorities for restoration of services for County buildings after disasters are summarized in Appendix 4.

Fire Stations: All fire stations within Multnomah County are essential for emergency response during disasters. The fire agencies within the unincorporated areas that are not covered by another jurisdiction's hazard mitigation plan include:

- Multnomah County Rural Fire Protection District (MCRFPD) #14
- Sauvie Island Fire Department (SIVFD) #30

Law Enforcement Assets: All law enforcement assets within Multnomah County are essential for emergency response during disasters. Law enforcement agencies within the county that are not covered by another jurisdiction's hazard mitigation plan include:

- Multnomah County Sheriff's Office

Emergency Services: Emergency services within the County that are not currently addressed in another jurisdiction's hazard mitigation plan.

- Multnomah Building County Emergency Coordination Center (ECC)
- Juvenile Justice Center County ECC
- Amateur Radio Emergency Services (ARES) repeaters

Medical services facilities: All citizens in the unincorporated areas are served by hospitals and medical facilities in the incorporated areas of the County which are covered by another jurisdiction's hazard mitigation plans.

Emergency Shelters: There are no pre-designated emergency shelters located in the unincorporated areas of the County.

Schools: The following are schools in the unincorporated areas.

Table 4.1
School Districts in Unincorporated Multnomah County

School	Address	District
West Orient Middle	29805 SE Orient Dr	Gresham-Barlow
East Orient Elementary	7431 SE 302nd Ave	Gresham-Barlow
Pleasant Valley Elementary	17625 SE Foster Rd	Centennial
Riverdale Grade	11733 SW Breyman Ave	Riverdale
Corbett Elementary	35800 E Historic Columbia River Hwy	Corbett
Terra Nova High School	10351 NW Thompson Rd	Beaverton
Springdale Job Corps Center	31224 E Historic Columbia River Hwy	Not Applicable
Skyline Elementary	11536 NW Skyline Blvd	Portland
Sauvie Island Elementary	14445 NW Charlton Rd	Scappoose
Corbett High	35800 E Historic Columbia River Hwy	Corbett
Corbett Middle	35800 E Historic Columbia River Hwy	Corbett
Sam Barlow High	5105 SE 302nd Ave	Gresham-Barlow

Lifeline Utility Systems

Potable Water

Table 4.2
Potable Water Supplies in Unincorporated Multnomah County

Potable water supply in unincorporated Multnomah County and County facilities is provided by several public water agencies, including**:**

Corbett Water District
Springdale Water District
Lusted Water District
Burlington Water District
Plainview Water District
Pleasant Home Water District
West Slope Water District
Portland Water Bureau

These agencies rely on both surface water and groundwater supplies. For water systems, the most critical components are raw water sources, pumping plants, treatment plants and transmission mains. Local distribution systems, while important, are less important than the components listed above because damage to distributions systems results in outages to fewer customers and is often easier and quicker to repair than damage to the major system components.

In addition, many residents in unincorporated areas rely on individual wells.

Wastewater

Wastewater collection and treatment in unincorporated Multnomah County and County facilities is provided by two wastewater agencies.

Table 4.3
Wastewater Agencies Serving Unincorporated Multnomah County

Portland Environmental Services
Sauvie Island Moorage along Multnomah Channel for floating homes

In addition, many residents in the more rural areas of the county rely on individual septic systems. For wastewater systems, the most critical components are the treatment plants, large pump stations and large diameter collection pipes. Local distribution systems, while important, are less important than the major components for the same reasons given above.

Electric Power

Electric power in Multnomah County is provided by Portland General Electric and PacifiCorp, both of which are private, investor owned utilities. Wholesale power to both Portland General Electric and PacifiCorp is provided by the Bonneville Power Administration, a federal agency. For electric power utilities, the most critical components are generation facilities (hydroelectric dams, fossil fuel power plants, and others), transmission lines and high voltage substations. Local distribution systems, including distribution lines and low-voltage substations, while important, are less important than the major components for the same reasons given above.

Natural Gas

Natural gas in Multnomah County is provided by Northwest Natural Gas, a private, investor-owned utility. For the natural gas system, the most critical components are large, high-pressure transmission mains. Local distribution systems, while important, are less important than the major components for the same reasons given above.

Telecommunications

Telecommunications, including voice, data and internet services, within Multnomah County are provided by several private investor-owned companies.

Table 4.4
Telecommunications Company Serving Unincorporated Multnomah County

Quest
Century Link
Comcast
Frontier
Cascade
Reliance Connects

For telecommunications, the most critical system components are the central offices which contain the switch gear necessary to connect telephone calls. For data and internet services, the most critical system components are high capacity fiber-optic links and peering facilities which transfer traffic between carriers.

Transportation Systems

Surface Transport Systems

The most critical highways within and to/from Multnomah County as a whole, and especially for the unincorporated areas, include I-5, I-84 and I-45, State Highway 26, State Highway 30, Historical Columbia Gorge Highway, and NW Cornelius Pass Road (which connects Highways 26 and 30 in the west Portland hills). The major bridges on the Interstates and State Highways, especially the bridges across the Columbia, Willamette and Sandy Rivers are also critically important.

Other important surface transportation systems include Trimet's MAX light rail and bus networks, Interstate Bus' system, the Amtrak passenger rail service and the freight rail systems, especially BNSF and Union Pacific.

Marine, Riverine and Air Transport Systems

The Port of Portland is charged with promoting aviation, maritime, commercial and industrial interests within Clackamas, Multnomah and Washington counties (including the city of Portland). It is a special district that is directed by a nine-member commission, whose members are appointed by the governor of the state of Oregon and confirmed by the Oregon Senate.

The Port most critical facilities are the four marine terminals (T6 on the Columbia River and T2,T4, & T5 on the Willamette River) and Oregon's primary commercial airport (Portland International Airport or PDX). The Port also operates three general aviation airports (Troutdale, Hillsboro and Mulino).

Drainage Districts

The Multnomah County Drainage District No. 1 (MCDD) provides flood protection for people, property and the environment within a 25 square mile managed floodplain along the Columbia River in Northeast Portland, Gresham and Fairview. The District also manages and controls three other drainage districts in the managed floodplain- Peninsula Drainage District #1 (PEN1), Peninsula Drainage District #2 (PEN2), and the Sandy Drainage Improvement Company (SDIC). The Portland International Airport (PDX), the Troutdale Airport, and Marine Terminals 2, 4, 5 & 6 are located within this consortium of floodplain districts (part of the Columbia River Basin).

The Sauvie Island Drainage Improvement Company manages the levee and canal system on the southern half of Sauvie Island. The levee protects 11,200 acres from flooding and is surrounded by the Columbia and Willamette Rivers as well as the Multnomah Channel and Sturgeon Lake. The levee is approximate 18 miles in length and divided into four segments. The elevation of the levee ranges from 33 to 36 feet.

Education Special Districts

The following special districts have critical or essential facilities:

- Multnomah County Education Service District, and
- The School Districts listed in Table 4.1.

4.5 Progress Report: 2006 Multnomah County Natural Hazard Mitigation Plan

4.5.1 Goals

The 2006 Multnomah County Natural Hazard Mitigation Plan had five main long-term goals:

Goal 1: Maintain a comprehensive, countywide risk assessment.

Goal 2: Reduce risk to people, property and environment.

Goal 3: Support a disaster resistant economy.

Goal 4: Promote public education, awareness and understanding of risk.

Goal 5: Develop and maintain collaborative partnerships and funding strategies for implementing the mitigation plan.

Multnomah County has made significant progress on many of these goals from 2006 to 2012, as evidenced by the full or partial completion of a number of action items. This progress is documented in the following section.

4.5.2 Action Items

The 2006 Multnomah County Natural Hazard Mitigation Plan had a total of 35 action items. These items are listed in Table 4.5, along with information whether the action item has been completed, has been partially completed, or has not yet been completed.

Of the 35 action items in the 2006 Multnomah County Natural Hazard Mitigation Plan, 25 actions have been completed or partially completed, while 10 actions have not been completed due to lack of funding availability or staff resources or because the item has been deleted upon further consideration.

Table 4.5
Progress Report:
Action Items from 2006 Multnomah County Natural Hazard Mitigation Plan

Goals Short Term (ST) Long Term (LT)	Action Item	Comments/Notes	Coordinating Organization / Internal Partners	Status			
				Completed	Partially Completed	No Action	Reason for No Action
Goal 1 (Risk Assessment) Action Items							
ST 1.1	Acquire LIDAR data (Airborne Light Detection and Ranging) to improve hazard mapping in Multnomah County.	The county is acquiring LIDAR data as it becomes available during FEMA map modernization work	Multnomah County Emergency Management / Land Use Transportation Division, Information Technology / GIS	x			
ST 1.2	Develop and implement inundation modeling for the urban managed floodplain managed by the combined Drainage Districts.		Multnomah County Emergency Management, Multnomah County Drainage District #1		x		
ST 1.3	Update Hillside Development Overlay Zone maps to identify areas of recurring loss.	Updated maps in 2012 mitigation plan	Multnomah County Community Services Department / Multnomah County Emergency Management		x		
ST 1.4	Partner with the Oregon Department of Forestry and Rural Fire Districts to promote home site assessment programs for the wildlife hazard.	This work was accomplished as part of the development and adoption of the Multnomah Community Wildfire Protection Plan (MCWPP)	Land Use and Transportation Division / Multnomah County Emergency Management			x	Lack of resources
ST 1.5	Acquire heat intensity imaging of levees.	Multnomah County Facilities Department has acquired the necessary equipment to conduct heat intensity imaging when required and in coordination with appropriate responding partners.	Multnomah County Emergency Management	x			
LT 1.1	Update Flood Insurance Rate Maps (FIRMs) and participate in FEMA's map modernization process.	Flood Insurance Study and FIRM maps updated in 2009	Land Use and Transportation Division / Multnomah County Emergency Management	x			
LT 1.2	Update and maintain the County's risk assessment.	The County's Hazard Identification and Analysis was conducted in 2008.	Multnomah County Emergency Management and the Hazard Mitigation Technical Advisory Committee	x			

Goals Short Term (ST) Long Term (LT)	Action Item	Comments/Notes	Coordinating Organization / Internal Partners	Status			
				Completed	Partially Completed	No Action	Reason for No Action
Goal 2 (Reduce Risk) Action Items							
ST 2.1	Complete seismic upgrades for Mt. Hood Community College gymnasium and Main Academic Center (shelter sites).	Seismic upgrades were completed for the Horticulture/Fisheries building. The actual grant award resulted in a smaller project than initially proposed.	Multnomah County Emergency Management		x		
ST 2.2	Upgrade Multnomah County Drainage District Command Center.	The command center was upgraded with real time monitoring and alarm capabilities.	Multnomah County Emergency Management	x			
ST 2.3	Develop a funding strategy to reduce the risk of loss to the critical infrastructure of the Willamette River bridges managed by Multnomah County from seismic and landslide hazards.	The new Sauvie Island Bridge was completed and the Sellwood Bridge is currently in design phase.	Multnomah County Emergency Management / Board of Commissioners	x			
ST 2.4	Seismic upgrades Multnomah County Courthouse.	SERA architects completed a feasibility study on possible strategies for completing seismic upgrades while maintaining routine operations.	Multnomah County Facilities & Property Management County Sheriff, District Attorney, Board of County Commissioners		x		
ST 2.5	Analyze each repetitive loss property to identify viable mitigation options.	Analysis done, properties being annexed by Gresham	Land Use and Transportation Division	x			
LT 2.1	Evaluate current zoning codes to incorporate mitigation principles related to flood and landslide.	An assessment was completed and provided to the Planning Commission in March of 2011.	Land Use and Transportation Division	x			
LT 2.2	Explore the development of management strategies to preserve the function of the floodplain.	Ordinance 1120 (2008) added regulatory requirements to preserve floodplain function	Land Use and Transportation Division	x			
LT 2.3	Qualify Multnomah County for the FEMA Community Rating System (CRS) program.		Multnomah County Emergency Management / Land Use Planning and Transportation Division			x	Deleted, too few NFIP polices in unincorporated areas
LT 2.4	Assess, design, and repair County waterways that are in danger of failure due to high water.		Multnomah County Emergency Management		x		
LT 2.5	Develop a food distribution contingency plan.	Accomplished via the adoption of the Multnomah County Food Action Plan.	Multnomah County Emergency Management / Departments of Planning and Transportation		x		
LT 2.6	Create mechanisms and incentives for home retrofit, including grants and tax incentives.		Multnomah County Emergency Management / Multnomah County Commissioners			x	Lack of staff resources
LT 2.7	Develop acquisition and management strategies to preserve parks, trails, and open space in the floodplain.		Environmental Services Division			x	Migrated to Portland's Hazard Mitigation Plan
LT 2.8	Develop and implement programs to keep trees from threatening lives, property, and public infrastructure from severe weather events.		Multnomah County Emergency Management			x	Lack of staff resources

Goals Short Term (ST) Long Term (LT)	Action Item	Comments/Notes	Coordinating Organization / Internal Partners	Status			
				Completed	Partially Completed	No Action	Reason for No Action
Goal 3 (Disaster Resilient Economy) Action Items							
ST 3.1	Develop and implement the Multnomah County Information Technology Disaster Recovery Plan.	County IT has hired a Sr. Disaster Recovery Coordinator to begin the development of a county-wide IT disaster recovery plan to address Continuity of Operations Plan (COOP).	Multnomah County Information Technology Infrastructure Group / County Business Units	x			
ST 3.2	Encourage small businesses to undertake business continuity planning.	Multnomah County Emergency Management participates in Oregon Continuity Planners Association, a local business continuity forum for private business.	Multnomah County Emergency Management	x			
ST 3.3	Install fiber optic communications network to fill 7,000 foot gap in existing conduit path for emergency communications and transportation	Project was completed in 2007 by the City of Gresham.	Multnomah County Emergency Management	x			
LT 3.1	Provide secondary power grids to flood protection storm water pump stations.		Multnomah County Emergency Management			x	Lack of staff resources
LT 3.2	Create a back-up river crossing system that uses barges or ferries to assure that people and goods can cross the rivers if the bridges are down.		Multnomah County Emergency Management / Multnomah County Land Use and Transportation			x	Lack of staff resources
LT 3.3	Assess the condition of and, if necessary, replace or repair the stormwater infrastructure under major County transportation routes, such as I-84 and Marine Drive.	A 48 inch culvert was installed across Marine Drive in 2007 for Arcata Creek.	Multnomah County Emergency Management		x		
Goal 4 (Education and Awareness) Action Items							
ST 4.1	Develop public official information kit that can be distributed to elected officials and community decision makers. The kit should include pertinent information regarding the Natural Hazard Mitigation Plan as well as the risk the County faces.		Multnomah County Emergency Management / Hazard Mitigation Technical Advisory Committee			x	Lack of staff resources
ST 4.2	Develop and distribute Natural Hazard Community Resource Maps and risk reduction tips that include instructions about how to prepare and reduce risks posed by natural hazards.	Multnomah County Emergency Management hired a full time program manger that oversees community outreach, education and private/public partner relationship development.	Multnomah County Emergency Management / Land Use and Transportation Division and GIS		x		
ST 4.3	Conduct earthquake awareness and mitigation outreach assistance.		Multnomah County Emergency Management	x			
ST 4.4	Research ways to create and disseminate a message that will cause people to act to reduce individual risk. Target education and outreach actions to reach marginalized populations.		Multnomah County Emergency Management / Public Affairs Office	x			
ST 4.5	Involve the public in updating the Natural Hazard Mitigation Plan.	The public has been involved in the renewal of this plan. See Chapter 3.	Multnomah County Emergency Management / Hazard Mitigation Technical Advisory Committee	x			

Goals Short Term (ST) Long Term (LT)	Action Item	Comments/Notes	Coordinating Organization / Internal Partners	Status			
				Completed	Partially Completed	No Action	Reason for No Action
Goal 5 (Plan Implementation) Action Items							
ST 5.1	Develop formal agreements (such as Memoranda of Understanding) with internal (departments) and external partners (non-profits, cities, and state agencies) to work together on risk reduction efforts in the County.		Multnomah County Commissioners and Hazard Mitigation Technical Advisory Committee / Multnomah County Emergency Management and Land Use and Transportation Division			x	Action item deleted upon further analysis.
ST 5.2	Encourage and support the development of local community plan addenda to the County Natural Hazard Mitigation Plan.	The cities of Wood Village, Fairview and Troutdale have completed individual hazard mitigation plans.	Hazard Mitigation Technical Advisory Committee / Land Use and Transportation Division	x			
ST 5.3	Develop a web-based or other electronic communication tool for the Hazard Mitigation Technical Advisory Committee and for the public to comment on the plan.	Two online tools have been developed. An internal collaboration site is used for coordinating the Hazard Mitigation Plan Committee and a web page on the County's public site serves as an interface where the public is able to review plan status and provide comment.	Multnomah County Emergency Management / Hazard Mitigation Technical Advisory Committee	x			
ST 5.4	Establish mitigation benchmarks to assist in evaluating and updating the plan.		Land Use and Transportation Division / Hazard Mitigation Technical Advisory Committee			x	Lack of staff resources

4.6 Multnomah County 2012 Hazard Mitigation Plan Action Items

The Mission Statement, Goals and Objectives for Multnomah 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 to specific buildings, facilities, or infrastructure within the Multnomah County community.

Action items identified and prioritized during the development of the Multnomah County Hazard Mitigation Plan are summarized in the tables on the following pages. Individual action items may address a single hazard (such as floods, or earthquakes) or they may address two or more hazards concurrently. The first group of action items is for multi-hazard items that address more than one hazard. The remaining action items address each of the hazards considered in this plan, for which significant vulnerabilities were identified, as addressed in Chapters 6 to 12.

Table 4.6
Multnomah County Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Plan Goals Addressed				
				Life Safety	Protect Property and Infrastructure	Emergency Management Capabilities	Public Awareness and Education	Environmental Stewardship
Multi-Hazard Mitigation Action Items								
Short-Term #1	Integrate the Mitigation Plan findings into planning and regulatory documents and programs.	Emergency Management Leadership Team	Ongoing		x	x	X	X
Short-Term #2	Collaborate with municipalities within Multnomah County on a unified approach to community outreach and education.	Multnomah County Emergency Management	Ongoing			X	X	
Short-Term #3	Explore a multi-jurisdictional unified strategy for developing a Threat and Hazard Identification and Risk Assessment (THIRA).	Multnomah County Emergency Management	1-2 Years			X	X	
Short-Term #4	Explore the desirability and feasibility of developing a County multi-jurisdictional plan that integrates the Local Hazard Mitigation Plans of Portland, Gresham, Wood Village, Troutdale and Fairview.	Multnomah County Emergency Management	1-2 Years			X	X	
Short-Term #5	Integrate 2011 DOGAMI Hazard Assessment data into the plan.	GIS	1 Year			X	X	
Short-Term #6	Collaborate with libraries, historical information groups and neighboring jurisdictions to develop a community workshop that uses storytelling and historical anecdotal experience to share natural hazard information.	Multnomah County Emergency Management	1-2 Years			X	X	
Short-Term #7	Develop and implement a community outreach and training portfolio that includes all hazards and hazard specific education.	Multnomah County Emergency Management	3 Years	X		X	X	
Short-Term #8	Publish the plan and natural hazard maps on the emergency management website along with basic information surrounding each hazard.	Multnomah County Emergency Management	1 Year			X	X	
Long-Term #1	Identify and pursue funding opportunities to implement mitigation actions.	Multnomah County Emergency Management	Ongoing	X	X	X	X	X

Hazard	Action Item	Coordinating Organizations	Timeline	Plan Goals Addressed				
				Life Safety	Protect Property and Infrastructure	Emergency Management Capabilities	Public Awareness and Education	Environmental Stewardship
Earthquake Mitigation Action Items								
Short-Term #1	Evaluate the structural vulnerability of critical county buildings and retrofit or replace when necessary.	Facilities	Ongoing	X	X	X		X
Short-Term #2	Encourage school districts, fire agencies and private building owners to evaluate the structural vulnerability of buildings and retrofit or replace when necessary. Example: grant workshops.	Multnomah County Emergency Management	Annually	X	X	X	X	
Short-Term #3	Evaluate the nonstructural vulnerabilities in county buildings and implement mitigation measures where necessary, including: automatic seismic shut off values on gas lines, flexible connections to gas-fueled equipment, bracing of fire sprinklers, bracing of contents and others.	Facilities	1-2 Years	X	X	X		X
Short-Term #4	Obtain and update earthquake map data as it becomes available through DOGAMI and other partners.	GIS	Ongoing			X	X	
Short-Term #5	Complete and maintain an inventory of critical facilities and lifelines that are susceptible to severe disruption due to earthquake hazards.	Multnomah County Emergency Management	Ongoing		X	X	X	
Short-Term #6	Enhance Multnomah County's staff earthquake expertise by attending training classes on nonstructural mitigation, post-earthquake seismic evaluations of buildings, and FEMA mitigation grants.	Multnomah County Emergency Management	Ongoing	X	X	X	X	
Long-Term #1	Retrofit suspended ceilings including light fixtures as replacement becomes necessary.	Facilities	Ongoing	X	X			
Long-Term #2	Retrofit or replace key bridges with substantial seismic vulnerabilities.	Transportation	Ongoing	X	X	X	X	X
Long-Term #3	Seismic upgrades Multnomah County Courthouse	Facilities	5 Years	X	X			

Hazard	Action Item	Coordinating Organizations	Timeline	Plan Goals Addressed				
				Life Safety	Protect Property and Infrastructure	Emergency Management Capabilities	Public Awareness and Education	Environmental Stewardship
Wildland/Urban Interface Fire Mitigation Action Items*								
Short-Term #1	Track and report progress of action items in the Community Wildfire Protection Plan.	Multnomah County Emergency Management	Annually	X	X	X	X	X
Short-Term #2	Review and amend as necessary planning and development regulations to incorporate mitigation strategies for urban/wildland interface fires considering the recommendations in the 2011 Multnomah County Community Wildfire Protection Plan.	Multnomah County Land Use Planning	3 Years	X	X	X	X	X
Short-Term #3	Consider how Multnomah County Land Use Planning should coordinate with fire agencies' planning for wildland/urban interface fires.	Planning	1-2 Years	X	X	X	X	X

Hazard	Action Item	Coordinating Organizations	Timeline	Plan Goals Addressed				
				Life Safety	Protect Property and Infrastructure	Emergency Management Capabilities	Public Awareness and Education	Environmental Stewardship
Landslide Mitigation Action Items								
Short-Term #1	Inventory utility and communication infrastructure in areas with a history of landslides or which are within mapped landslide hazard areas.	GIS	1-2 Years		X	X	X	
Short-Term #2	Compile inventory of county road segments with a history of landslides or which are within mapped landslide hazard areas.	Transportation	3 Years		X	X		
Short-Term #3	Review the Hillside Development ordinance to consider amendments that address areas at risk from landslides for areas not already identified on the County Slope Hazard Map or otherwise subject to the Hillside Development zoning code.	Planning	3 Years	X	X		X	X
Short-Term #4	Obtain completed detailed lidar-based inventory of historical and active landslides and areas with high landslide risk to update the County's slope hazard maps.	GIS	Ongoing		X	X	X	
Long-Term #1	Encourage the relocation of identified critical or essential facilities and high occupancy facilities in high landslide hazard areas or mitigation of the landslide hazard if feasible.	Multnomah County Emergency Management	Ongoing	X	X	X	X	

Hazard	Action Item	Coordinating Organizations	Timeline	Plan Goals Addressed				
				Life Safety	Protect Property and Infrastructure	Emergency Management Capabilities	Public Awareness and Education	Environmental Stewardship
Flood Mitigation Action Items: Within FEMA-Mapped Floodplains								
Short-Term #1	Complete an inventory and GIS mapping of structures, critical facilities and important transportation or utility system components within mapped floodplains and/or within areas subject to flood in the event of levee or dam failures, including elevation data.	GIS	1-2 Years			X	X	
Short-Term #2	Facilitate an identification and prioritization process for the purpose of defining a candidate list of localized inundation scenarios related to levee failures that result from different hazard events.	Multnomah County Emergency Management	1-2 Years	X	X	X		
Short-Term #3	Conduct a targeted risk assessment for all areas within the county containing public facilities, private industry and/or residential facilities which were previously flooded or flood prone.	Multnomah County Emergency Management	3 Years	X	X	X	X	
Short-Term #4	Use targeted flood risk assessments to educate stakeholders on need to take mitigation and/or preparedness actions in order to reduce flood hazard impacts.	Multnomah County Emergency Management	5 Years	X	X	X	X	
Short-Term #5	Encourage local jurisdictions to post high water marks around the county to aid citizens and first responders in visually assessing flood hazards.	Multnomah County Emergency Management	1-2 Years	X		X	X	
Long-Term #1	Implement mitigation actions for identified high risk buildings or infrastructure as funding becomes available.	Multnomah County Emergency Management	Ongoing	X	X	X	X	
Flood Mitigation Action Items: Outside of FEMA-Mapped Floodplains								
Short-Term #1	Complete an inventory and GIS Mapping of structures, critical facilities and important transportation or utility system components in locations with a history of severe or repetitive flooding.	GIS	1-2 Years	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 capacity.	Transportation	Ongoing	X	X	X		X

Hazard	Action Item	Coordinating Organizations	Timeline	Plan Goals Addressed				
				Life Safety	Protect Property and Infrastructure	Emergency Management Capabilities	Public Awareness and Education	Environmental Stewardship
Severe Weather Mitigation Action Items								
Short-Term #1	Ensure that all critical facilities in Multnomah County have backup power and/or coordination of operations plans in place to withstand loss of grid power.	Facilities	5 Years	X	X	X		
Short-Term #2	Conduct tree trimming activities on county roads where County Transportation has jurisdictional responsibility.	Transportation	Ongoing	X	X			X
Short-Term #3	Develop a strategy that encourages property owners to trim trees that could impact life safety and damage property.	Multnomah County Emergency Management	1-2 Years	X	X		X	X
Short-Term #4	Work with stakeholder groups to identify common criteria for defining extreme heat and cold events for the sake of determining proper mitigation, protection or preparedness strategies.	Multnomah County Emergency Management	1 Year	X		X	X	X
Long-Term #1	Encourage utilities to upgrade 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.	Multnomah County Emergency Management	5 Years	X	X	X	X	
Volcanic Hazards Mitigation Action Items								
Short-Term #1	Develop emergency evacuation protocols for lahar events and conduct exercises to test the protocols.	Multnomah County Emergency Management	3 Years	X		X	X	
Short-Term #2	Update public education, emergency notification procedures and emergency planning for ash fall and lahar events.	Multnomah County Emergency Management	1-2 Years	X		X	X	

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 measures into ongoing public- and private-sector decision making will the mitigation action items in this document be accomplished effectively. The following sections depict how Multnomah County has adopted and will implement and maintain the vitality of the Multnomah County Natural Hazard Mitigation Plan.

5.2 Plan Adoption

FEMA approval of the 2012 Multnomah County Hazard Mitigation Plan was received on **….TBD…..** FEMA approval means that Multnomah County's Hazard Mitigation Plan meets national standards and that the County will continue to be eligible for hazard mitigation funding from FEMA's mitigation grant programs.

The Multnomah County Hazard Mitigation Plan was adopted by the Multnomah County on ….**TBD……**, making this the effective date of the plan. The adoption resolution is included in the appendix at the end of this chapter.

Multnomah County has the necessary human resources to ensure the Plan continues to be an active planning document. County staff members from many departments have been active in the preparation of the plan and have gained an understanding of the process and the desire to keep it up to date and useful.

Recent major high-profile disasters and the growing understanding of the threats posed to Multnomah County from natural hazards, have kept the interest in hazard mitigation planning and implementation alive at the County Commissioner level, at the County staff level, among private sector entities and among the citizens of Multnomah County.

5.3 Implementation

5.3.1 Coordinating Body

The Multnomah County Emergency Management Leadership Team will coordinate the implementation of the plan and be responsible for periodic monitoring, evaluating and updating the plan. The County will continue to provide staffing to accomplish the mitigation plan monitoring, evaluating, and updating. The existing active interest in mitigation and emergency planning that exists within Multnomah

County will help to ensure the successful implementation of the plan over the coming years.

5.3.2 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 Multnomah County Hazard Mitigation Plan provide a strong framework and guidance for the identified mitigation priorities for Multnomah 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 most effectively by fully integrating this guidance into ongoing county-wide programs, policies and practices.

The updated hazard, vulnerability and risk assessments and the updated and re-prioritized mitigation action items in the 2012 Multnomah County Hazard Mitigation Plan provide a solid foundation for incorporating mitigation planning and implementation into ongoing programs, policies and practices, as listed below with the responsible Multnomah County Departments:

- Capital Improvement Program
- Multnomah County Community Wildfire Protection Plan (CWPP)
- Climate Action Plan
- Climate Adaptation Plan
- Facilities Maintenance plan
- Multnomah County Emergency Management Strategic Plan
- Multnomah County Emergency Operations Plan
- Multnomah County Recovery Plan (under development)
- Land Use Planning

All of the above ongoing programs, policies and practice mesh with and support the Hazard Mitigation Plan's primary goals of protecting life and property from natural disasters. An important contribution from the 2012 update of the Multnomah County Hazard Mitigation Plan is the updated hazard information, which will be incorporated into the plans referenced above to provide a more accurate basis for emergency planning, post-disaster recovery planning, the Multnomah County Safety Program, and Multnomah County's other related planning efforts.

Information in the above plans was incorporated into the 2012 update of the Multnomah County Hazard Mitigation Plan, including:

- CWPP Fire Severity Zone
- FEMA-mapped floodplains,

- Seismic report data in the Facilities Maintenance plan,
- Land use planning and zoning, and
- Capital improvement planning for many departments.

5.3.3 Cost Effectiveness of Mitigation Projects

As Multnomah County and other entities, public or private, 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?

Multnomah 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, Multnomah 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. See Appendix 2 Principles of Benefit-Cost Analysis for further details on the benefit-cost analysis process.

Multnomah County has used and will continue to use benefit-cost analysis in two important ways:

- To help prioritize mitigation actions, once specific projects are defined in sufficient detail, including at least conceptual designs and preliminary cost estimates.
- To support applications for FEMA mitigation grants.

5.3. 4 STAPLE/E Approach

Multnomah County has used and will continue to use the STAPLE/E approach to help evaluate potential mitigation actions. Using STAPLE/E criteria, mitigation activities can be evaluated quickly in a systematic fashion based on the Social,

Technical, Administrative, Political, Legal, Economic, and Environmental (STAPLE/E) considerations and opportunities for implementing particular mitigation action items in Multnomah County. The STAPLE/E approach is very helpful for assessing the viability of mitigation projects and supplements the risk and economic results from benefit-cost analyses.

The following synopsis outlines each of the elements of the STAPLE/E Approach

Social:

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

Technical:

- 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:

- 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:

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

Legal:

- 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:

- 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 City?
- 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:

- 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?

5.4 Prioritization of Mitigation Actions

Implementation of any of the mitigation actions listed in the 2012 Multnomah County Hazard Mitigation Plan is contingent upon resource availability, including both staff and financial resources. Thus, it is impossible to prioritize the mitigation action items exactly. The following multi-faceted approach has been used to prioritize the mitigation action items:

- The highest priority action items address the highest priority goals – including Protect Life Safety and Protect Multnomah County Buildings and Infrastructure.
- The highest priority action items thus are for the hazards which pose the greatest threats to Multnomah County: earthquakes, volcanic events (lahars), floods, wildland/urban interface fire and landslides/mudslides.
- Within the groups of action items – multi-hazard and hazard-specific, the relative priority has been determined by consensus of the Hazard Mitigation Planning Team, including the STAPLE/E approach and benefit-cost analysis as noted below.

- The STAPLE/E approach was used as a screening tool to ensure that each proposed mitigation action item was feasible for each of the STAPLE/E criteria.
- Multnomah County recognizes the importance of benefit-cost analysis not only for FEMA grant applications, but also to help prioritize between competing mitigation projects regardless of the funding source. Benefit-cost analysis is predominantly applicable to physical mitigation measures such as seismic retrofits, flood mitigation projects, fuel reduction measures for wildland/urban interface fires and so on. Benefit-cost analysis is generally not applicable to mapping, risk assessments, code enhancement and other types of measures. The importance of benefit-cost analysis is recognized not only in this section but also elsewhere in the 2012 Multnomah County Hazard Mitigation Plan including:
    - Chapter 1, Section 1.7 – The Role of Benefit-Cost Analysis in Mitigation Planning,
    - Chapter 5, Section 5.3.3 – Cost Effectiveness of Mitigation Projects, and
    - Appendix 2 – Principles of Benefit-Cost Analysis.

The above multi-faceted approach to prioritize mitigation action items is a good faith effort to establish priorities. However, the principal constraint for the implementation of each of these action items is the availability of resources – both staff time and financial resources – as necessary for implementation. Thus, Multnomah County's prioritization of action items is necessarily flexible. If resources become available for a lower priority mitigation item before funds are available for a higher priority action item, then the lower priority mitigation item will be implemented.

This realistic, flexible approach is necessary to achieve the paramount reason for mitigation planning - to gradually reduce risk in Multnomah County over time as resources to implement mitigation actions become available.

5.5 Plan Maintenance

5.5.1 Periodic Monitoring, Evaluation and Updating

Multnomah County has developed a process for regularly reviewing and updating the Natural Hazard Mitigation Plan. The Emergency Management Leadership Team will review the plan every six months from the date that the 2012 plan is effective as well as after significant disaster events affecting Multnomah County. The Emergency Management Leadership Team will be responsible for tracking the progress of the mitigation actions in the Plan. These reviews will provide opportunities 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.

The Emergency Management Leadership Team will assess whether and to what extent:

1. Do the plans goals, objectives and action items still address current and future expected conditions?
2. Do the mitigation action items accurately reflect Multnomah County's current conditions and mitigation priorities?
3. Have the technical hazard, vulnerability and risk data been updated or changed?
4. Are current resources adequate for implementing Multnomah County's Hazard Mitigation Plan? If not, are there other resources that may be available?
5. Are there any problems or impediments to implementation? If so, what are the solutions?
6. Have other agencies, partners, and the public participated as anticipated? If no, what measures can be taken to facilitate participation?
7. Have there been changes in federal and/or state laws pertaining to hazard mitigation in Multnomah County?
8. Have the FEMA requirements for the maintenance and updating of hazard mitigation plans changed?
9. What can Multnomah County learn from declared federal and/or state hazard events in communities that share similar characteristics to Multnomah County, such as population, geographical area, land use mix, and hazard vulnerability?
10. How have previously implemented mitigation measures performed in recent hazard events? This may include assessment of mitigation action items similar to those contained in this Plan, but where hazard events occurred outside of Multnomah County.

The Emergency Management Leadership Team will review the results of these Natural Hazard Mitigation Plan assessments, identify corrective actions and make recommendations, if necessary, to the County Commissioners for actions that may be necessary to bring the Mitigation Plan back into conformance with the stated goals and objectives.

The Multnomah County Emergency Management Office will have lead responsibility for the formal updates of the plan every five years. The formal update process will be initiated at least two years before the five-year anniversary of FEMA approval of the Multnomah County Mitigation Plan, to allow ample time for robust participation by stakeholders and the public and for updating data, maps, goals, objectives and action items. Revisions to the Plan will be reviewed with the County Commissioners for acknowledgement as part of Multnomah County's Plan maintenance and implementation program.

5.5.2 Continued Public Involvement and Participation

Implementation of the mitigation actions identified in the Plan must continue to engage not only County staff but also the entire community. Multnomah County is committed to involving the public directly in the ongoing review and updating of the Natural Hazard Mitigation Plan.

This public involvement process will include public participation in the monitoring, evaluation and updated processes outlined in the previous section and intensify as the 2017 update process is begun and completed.

The 2012 Multnomah County Hazard Mitigation Plan will be available on the County's website and hard copies will be available in the Multnomah County Emergency Management office. The County's website will provide an opportunity to share direct comments, suggestions and concerns with the Emergency Management Leadership Team.

A press release requesting public comments will be issued after each major update and also whenever additional public inputs are deemed necessary. The press release will direct people to the website and other locations where the public can review proposed updated versions of the plan. This process will provide the public with accessible and effective means to express their concerns, opinions, ideas about any updates/changes that are proposed to the mitigation plan.

The Multnomah County Emergency Management office will ensure that the resources are available to publicize the press releases and maintain public participation through web pages, public access channels and newspapers as deemed appropriate.

APPENDIX

Multnomah County Mitigation Plan: Adoption Resolution – INSERT scan of adoption resolution when available (after FEMA's Final Approval).

6.0 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, beginning in the early 1990s, awareness of seismic risk in Oregon has increased significantly. Factors in this increased awareness include the 1993 Scotts Mills earthquake in Clackamas County, the 1990s changes in seismic zones in the Oregon Building Code which increased seismic design levels for new construction in western Oregon and widespread publicity about the occurrence of large magnitude earthquakes on the Cascadia Subduction Zone.

Awareness of seismic risk in Oregon has also increased because of the devastating earthquakes and tsunamis in Indonesia in 2004 and Japan in 2011. The geologic settings for the Indonesia and Japan earthquakes are virtually identical to the Cascadia Subduction Zone.

Before reviewing the levels of seismic hazards and risk in Multnomah County, we first present a brief earthquake "primer" to review earthquake concepts and terms.

6.1 Earthquake Primer

Earthquakes are most often described by their magnitude (M), which is a measure of the total energy released by an earthquake. The most common magnitude is the "moment magnitude" which is calculated by seismologists from the amount of slip (movement) on the fault causing the earthquake and the area of the fault surface which breaks during the earthquake. Moment magnitudes are similar to the Richter magnitude, which was used for many decades but has now been replaced by the moment magnitude.

Moment magnitudes use a numerical scale which ranges from 0 to 9+. The magnitudes for the four largest earthquakes recorded worldwide and selected Oregon earthquakes are shown below in Table 6.1.

Table 6.1
Earthquake Magnitudes: Examples

Earthquake	Magnitude
Largest Earthquakes Worldwide	
1960 Chile	9.5
1964 Prince William Sound, Alaska	9.2
2004 Sumatra, Indonesia	9.1
2011 Japan	9.0
Selected Oregon Earthquakes	
1700 Cascadia Subduction Zone	9.0
1993 Klamath Falls	6.0
1993 Scotts Mills	5.6
2001 Nisqually (Washington)	6.8

In evaluating earthquakes, it is important to recognize that the earthquake magnitude scale is not linear, but rather logarithmic. Each one step increase in magnitude, for example from M7 to M8, corresponds to an increase of about a factor of 30 in the amount of energy released by the earthquake, because of the mathematics of the magnitude scale.

Thus, 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, a great M9 earthquake releases nearly 1,000 times more energy than a large earthquake of M7 and nearly 30,000 times more energy than a M6 earthquake.

The public often assumes that the larger the magnitude of an earthquake, the "worse" the earthquake. Thus, the "big one" is the M9 earthquake and smaller earthquakes such as 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 <u>not</u> a good measure of the severity of the earthquake at that site.

Rather, for any earthquake, the intensity of ground shaking at a given site depends on four main factors:

- Earthquake magnitude,
- Earthquake epicenter, which is the location on the earth's surface directly above the point of origin of an earthquake,
- Earthquake depth, and
- Soil or rock conditions at the site, which may amplify or deamplify earthquake ground motions.

An earthquake will generally produce the strongest ground motions near the earthquake with the intensity of ground motions diminishing with increasing distance from the epicenter.

For Multnomah County, a great magnitude 9.0 earthquake on the Cascadia Subduction Zone would result in widespread damage. However, this earthquake is not the worst case scenario for Multnomah County. Rather, a smaller, nearby earthquake such as a M7.1 on the Portland Hills Fault would result in higher levels of ground shaking and damage than a M9.0 Cascadia Subduction Zone earthquake.

In general, 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 relatively minor to moderate damage near the epicenter. Earthquakes of about M6.5 or greater (e.g., the 2001 Nisqually earthquake in Washington) can cause major damage, 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. A M9 earthquake 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 significant damage in most buildings, even those designed to resist seismic forces.

6.2 Oregon Earthquakes

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 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 6.1 shows the geologic (plate-tectonic) setting of the Cascadia Subduction Zone.

There are three source regions for earthquakes that can affect the Multnomah County area:

1) “interface” earthquakes on the boundary between the subducting oceanic plates and the North American plate,

2) “intraplate” earthquakes within the subducting oceanic plates, and

3) “crustal” earthquakes within the North American Plate.

The geographic and geometric relationships of these earthquake source zones are shown in Figures 6.2 and 6.3.

The “interface” earthquakes on the Cascadia Subduction Zone may have magnitudes of up to 9.0 or perhaps 9.2, with probable recurrence intervals of 500 to 800 years. The last major earthquake in this source region 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 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 Multnomah County, with the level of shaking decreasing towards eastern Multnomah County.

Figure 6.1
Cascadia Subduction Zone
(Cascadia Region Earthquake Working Group (2005): Cascadia Subduction Zone Earthquakes: A Magnitude 9.0 Earthquake Scenario)

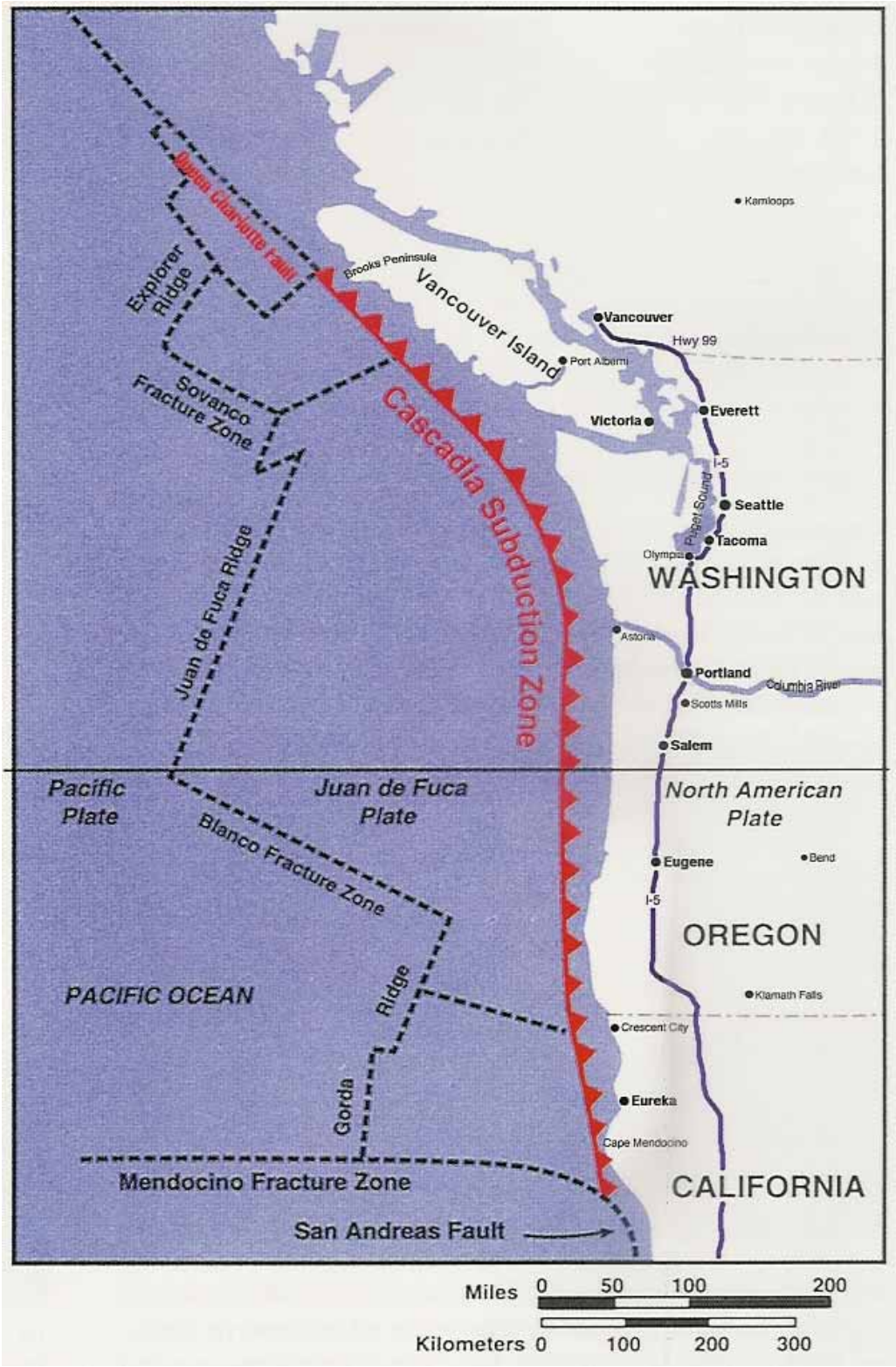
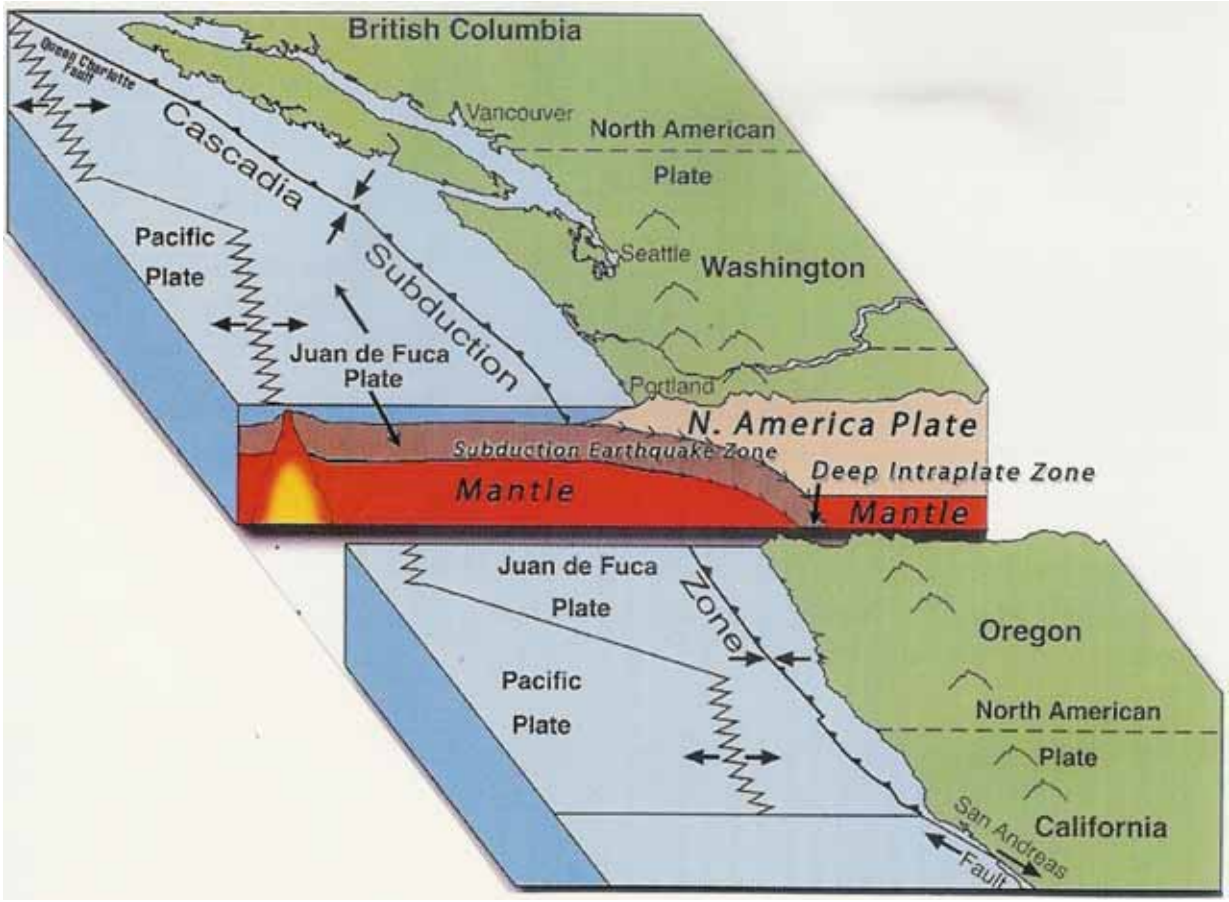


Figure 6.2
Cascadia Subduction Zone: Cross Section
(Cascadia Region Earthquake Working Group (2005): Cascadia Subduction Zone Earthquakes: A Magnitude 9.0 Earthquake Scenario)

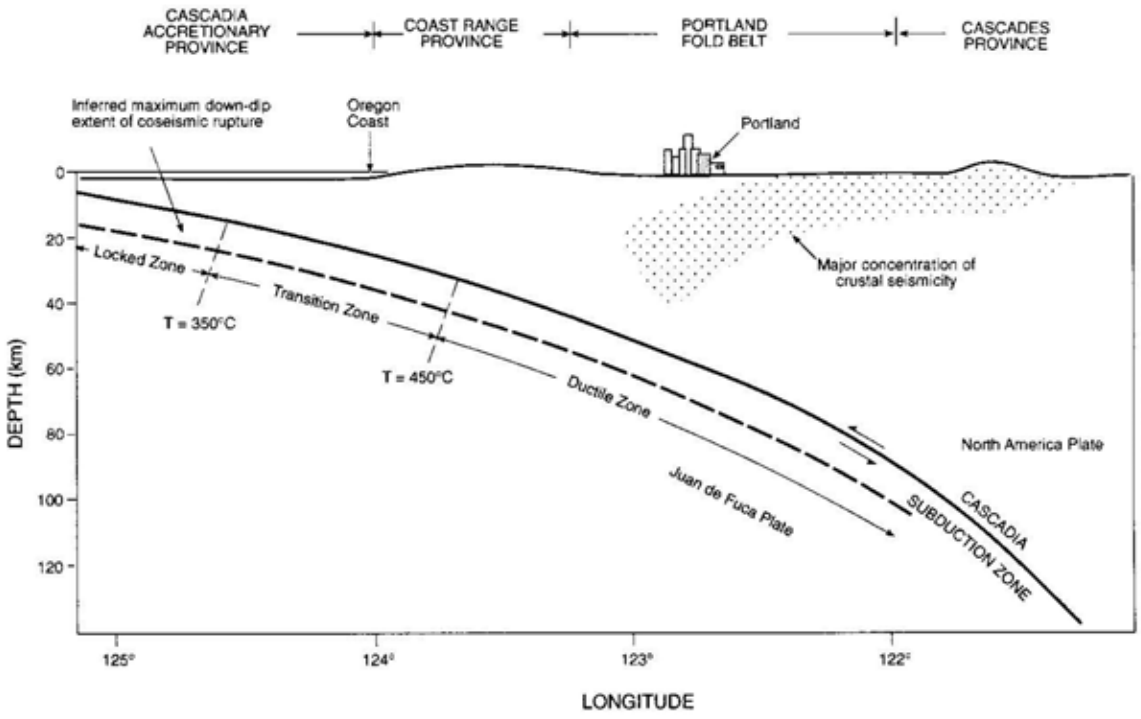


Interface earthquakes occur on the boundary between the subducting plate and the North American plate.

The "intraplate" 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. Thus, epicenters from these types of earthquakes could be located west of Portland. Ground shaking from such earthquakes would be very strong near the epicenter and strong ground shaking would be felt throughout all of Multnomah County, with the level of shaking decreasing towards eastern Multnomah County.

Crustal earthquakes occur within the North American plate, above the subducting plate, as shown in Figure 6.3 on the following page.

Figure 6.3
Cascadia Subduction Zone: Cross Section (Portland Area) –
Showing Crustal Earthquake Locations
(Wong et al. (1993), Strong Ground Shaking in the Portland, Oregon, Metropolitan Area, Oregon Geology, Volume 55, Number 6)



"Crustal" earthquakes within the North American plate are possible on faults mapped as active or potentially active as well as on unmapped (unknown) faults. The relationship between the subducting plate and crustal earthquakes in the greater Portland area is shown above in Figure 6.3.

Historical earthquake epicenters in northwest Oregon and portions of Washington are shown below in Figure 6.4. There have been dozens of mostly small earthquakes recorded in or near Multnomah County. A summary of the more significant historical earthquakes in Oregon is provided in Table 6.2.

Figure 6.4
Earthquake Epicenters in Northwest Oregon from 1841 to 2002

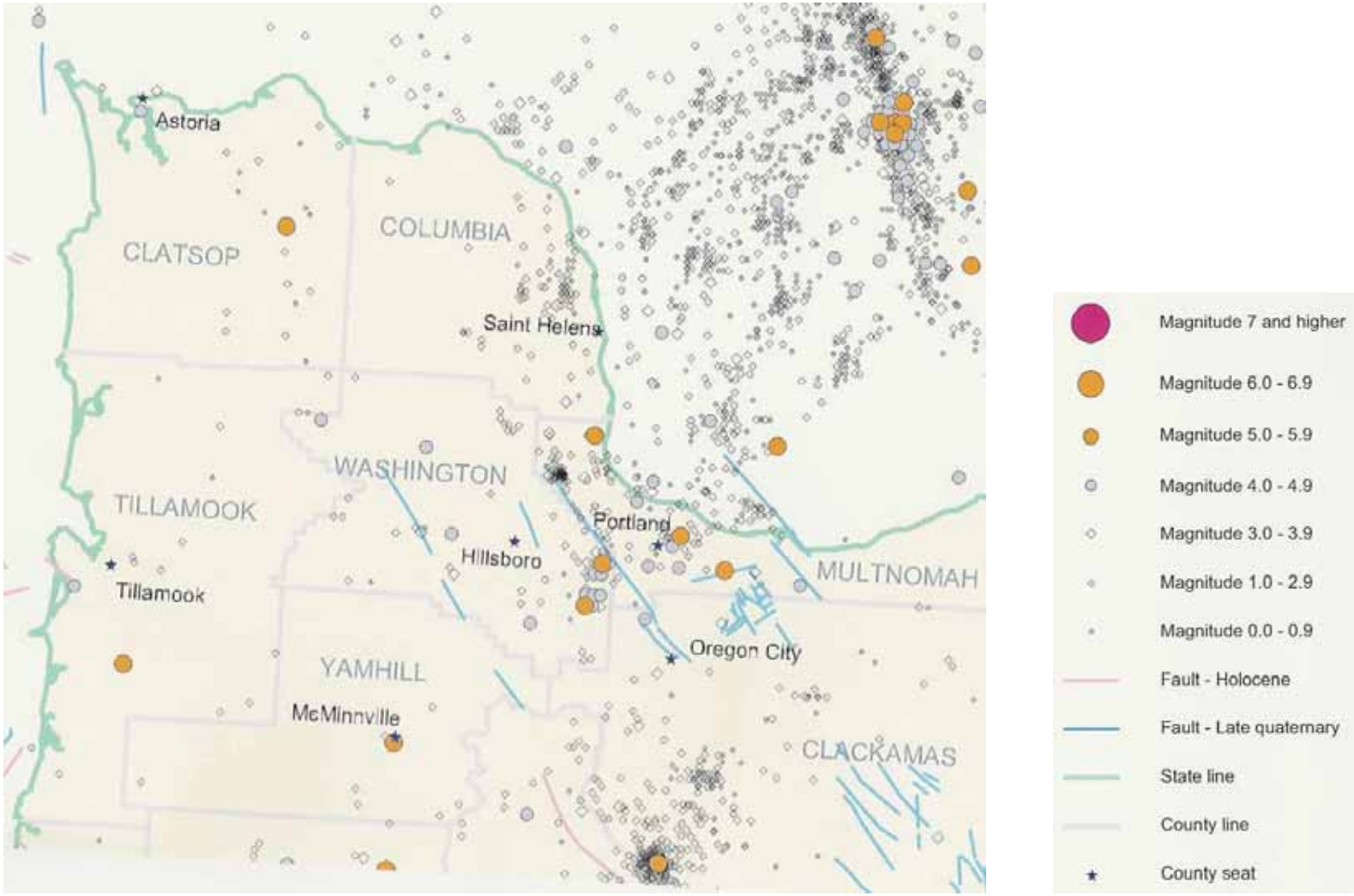


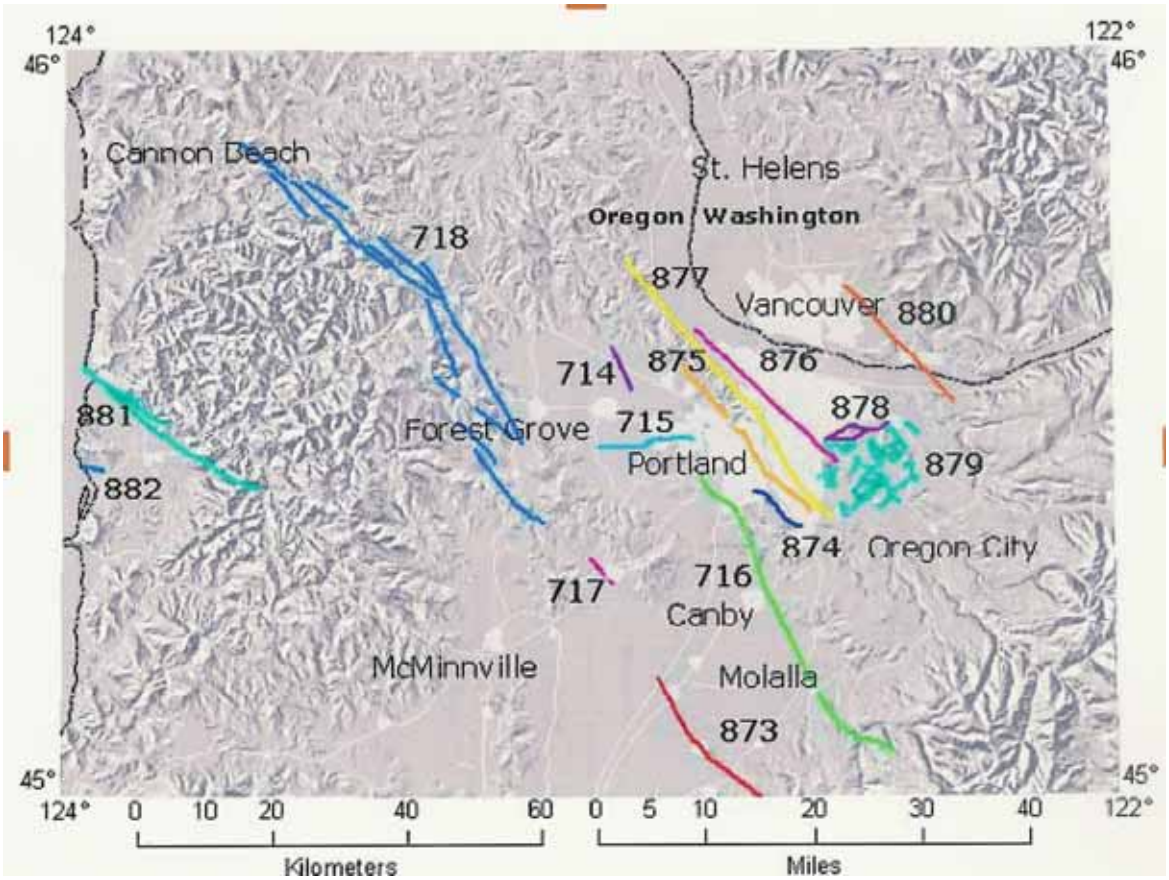
Table 6.2
Significant Historical Earthquakes Affecting Northwest Oregon

DATE	LOCATION	SIZE (M)	COMMENTS
Approximate Years 1400 BCE*, 1050 BCE, 600 BCE, 400, 750, 900	Offshore, Cascadia Subduction Zone (CSZ)	Probably 8.0 –9.0	Based on studies of earthquake and tsunami at Willapa Bay, Washington. These are the mid-points of the age ranges for these six events. * BCE: Before the Common Era
January, 1700	CSZ	Approx. 9.0	Generated a tsunami that struck Oregon, Washington, and Japan; destroyed Native American villages along the coast
October, 1877	Portland area	5.2	Two events were reported that day. The estimated felt area was approximately 41,000 square kilometers. Chimney damage reported
February, 1892	Portland area	5.0	No major damage occurred
December, 1941	Portland area	4.5	Felt by most Portland residents. Shattered windows and cracked plaster in Hillsboro and Sherwood.
April, 1949	Olympia, WA	7.1	Significant damage in Washington. Minor damage in NW Oregon
December, 1953	Portland area	4.5	Cracked plaster and caused objects to fall in Portland.
November, 1961	Portland area	5.0	Principal damage from cracked plaster
November, 1962	Portland area	5.5	Shaking lasted up to 30 seconds; chimneys cracked; windows broken; furniture moved
December, 1963	Portland area	4.5	Books and pictures fell in Plains
March 25, 1993	Scotts Mills	5.6	On Mt. Angel-Gales Creek fault. $30 million damage (including Oregon Capitol Building in Salem) (FEMA-985-DR-OR)
February, 2001	Nisqually, WA	6.8	Felt in the region, no damage reported

Source: Wong, Ivan and Jacqueline Bolt, November 1995, A Look Back at Oregon's Earthquake History, 1841-1994, *Oregon Geology* pp. 125-139.

Identified crustal earthquake faults in the vicinity of Multnomah County are shown in Figure 6.5.

Figure 6.5
USGS Mapped Crustal Faults Near Multnomah County
(USGS Earthquake Hazards Program – Quaternary Fault and Fold Database)



The faults numbered in Figure 6.5 above, include the following faults relatively close to Multnomah County:

- Oatfield Fault (875)
- East Bank Fault (876)
- Portland Hills fault (877),
- Grant Butte Fault (878),
- Damascas – Tickle Creek Fault Zone (879), and
- Lacamas Lake Fault (880).

The above faults are all listed as “Class A” faults by the USGS, which means that there is solid geological evidence for fault movements during the Quaternary

geologic period – that is, within the past 1.6 million years. The estimated slip rate on all of these faults is less than 0.2 mm per year. Return periods for earthquakes on these faults are not well known, but are probably at least several thousand years and perhaps 10,000 years or more.

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 Multnomah County. Such earthquakes would be mostly smaller than the 1993 Scotts Mills earthquake (M5.6). There is also a possibility of larger crustal earthquakes in the M6+ range, albeit, in the absence of known, mapped faults, the probability of such events is likely to be low.

6.3 Seismic Hazards for Multnomah County

The current scientific understanding of earthquakes is incapable of predicting exactly where and when the next earthquake will occur. However, the long term probability of earthquakes is well enough understood to make useful estimates of the probability of various levels of earthquake ground motions at a given location.

The current consensus estimates for earthquake hazards in the United States are incorporated into the 2008 USGS National Seismic Hazard Maps. These maps are the basis of building code design requirements for new construction. For Multnomah County, the level of seismic hazards varies significantly with location within the county, generally decreasing towards the east. 2008 USGS seismic hazard data for three locations within the county are shown below in Table 6.3.

Table 6.3
2008 USGS Seismic Hazard Data for Multnomah County
(Approximate Values for Firm Soil Sites)

Probabilistic Ground Motion	PGA (% of g)		
Location	Portland[1]	Troutdale[2]	Bonneville[3]
Longitude	122.857	122.386	121.947
10% in 50 years	30.3%	28.0%	20.7%
2/3rds of 2% in 50 years	32.2%	34.8%	23.0%
2% in 50 years	48.3%	42.7%	34.5%

[1] Near Skyline Elementary School

[2] Near Troutdale Elementary School

[3] Near Bonneville Dam

The ground shaking values in Table 6.3 are expressed as a percentage of g, the acceleration of gravity. For example, the 10% in 50 year PGA value means that over the next 50 years there is a 10% probability of this level of ground shaking or higher. Any of these levels of ground shaking are high enough to cause significant to substantial damage in vulnerable buildings. The 2/3rds of the 2% in 50 year

ground motion is the level of ground motion required for the design of new buildings in the International Building Code.

The 2008 USGS seismic hazard data for the area are also shown graphically in Figure 6.6, which shows the level of seismic hazard generally decreasing eastward. The values shown on these maps are lower than those shown above in Table 6.2 because the map contours are for rock sites. Ground motions on soil sites will generally be significantly higher than for rock sites.

Figure 6.6a
USGS Seismic Hazard Map
PGA value (%g) with a 10% Chance of Exceedance in 50 years

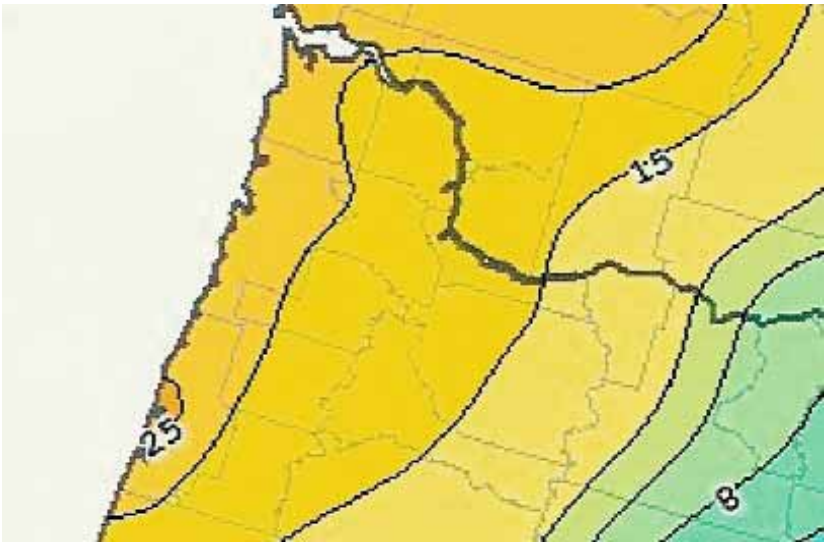
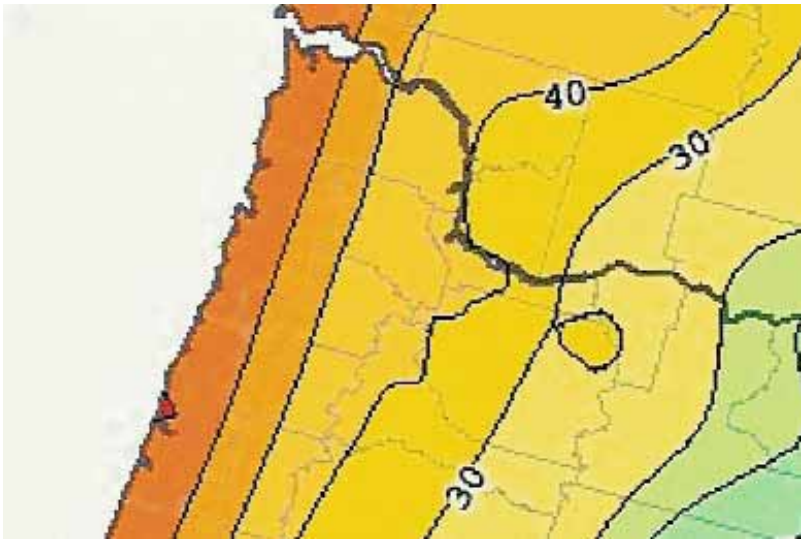


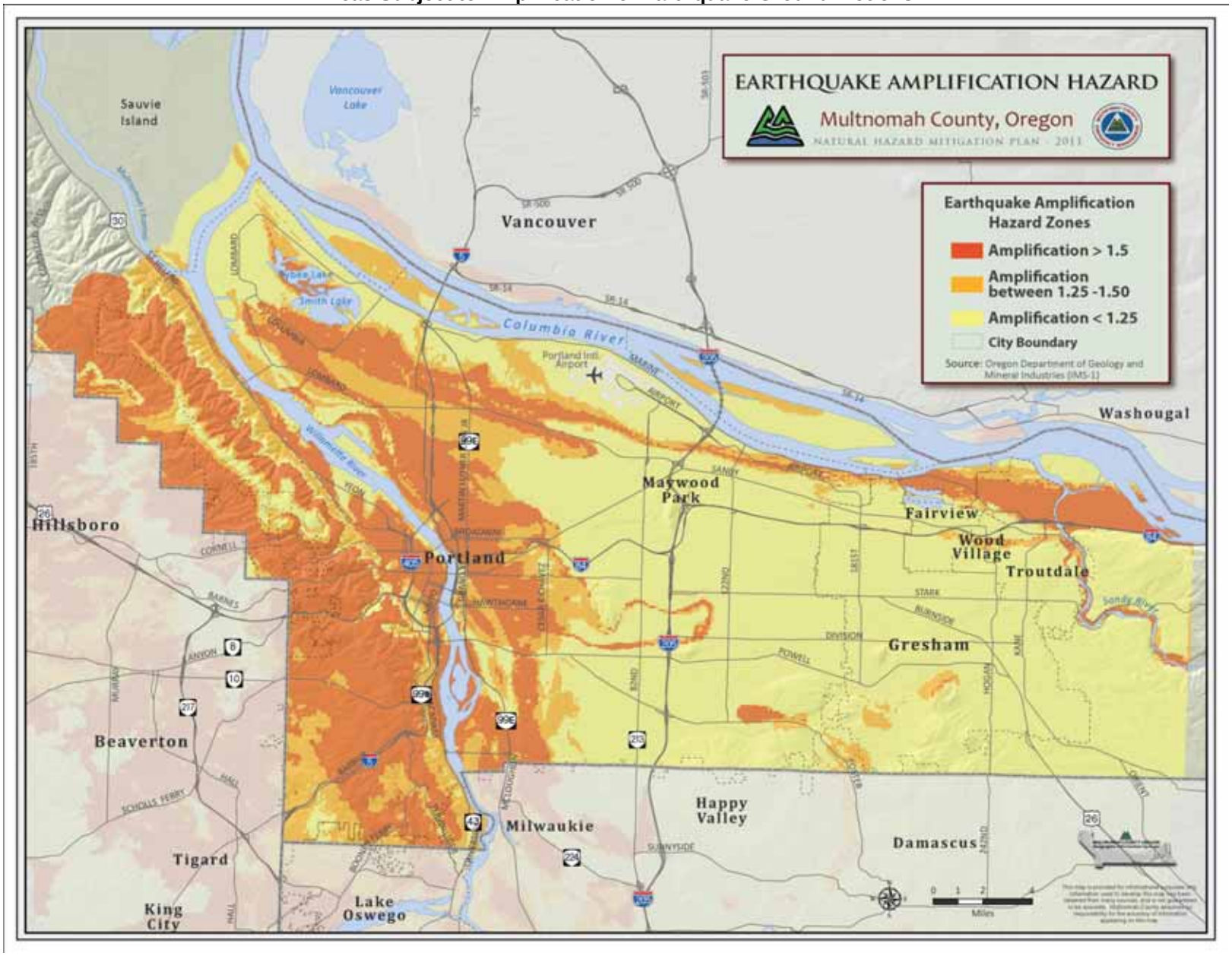
Figure 6.6b
USGS Seismic Hazard Map
PGA value (%g) with a 2% Chance of Exceedance in 50 years



The hazard maps shown above are probabilistic earthquake ground motions for rock sites. Earthquake ground motions may be significantly higher for soil sites, which may amplify ground motions. Figure 6.7 on the following page shows areas within Multnomah County subject to amplification of ground motions. Buildings and infrastructure in these areas will generally suffer more damage in any given earthquake than similar buildings and infrastructure located in areas not subject to amplification of earthquake ground motions.

Areas shown in dark red-orange have the highest levels of amplification, with the light orange areas having less amplification and the yellow areas having minor or no amplification of earthquake ground motions.

Figure 6.7
Areas Subject to Amplification of Earthquake Ground Motions



The level of seismic hazard for locations within Multnomah County can also be expressed as a "seismic hazard curve." A seismic hazard curve shows the annual probability of exceeding the full range of possible earthquake ground motions.

For Multnomah County, the example seismic hazard curve in Figure 6.8 below shows that there is about a 1% (0.01) annual chance of ground motions of 10% g or higher, and about a 0.2% (0.002) annual chance of ground motions of about 30% g or higher. This example is for Troutdale: as discussed previously, earthquake ground motions within Multnomah County will generally be higher to the west and lower to the east.

Figure 6.8
Multnomah County: Example Seismic Hazard Curve

Seismic Hazard Data by Latitude - Longitude

OREGON

Version 2.0 July 02, 2009

Project Name:	**Troutdale Elementary School**	**Date:**	**April 1, 2011**
Address:	**648 SE Harlow**	**User Name:**	**KA. Goettel**
City, State, Zip:	**Troutdale, OR**		

Enter Site Latitude-Longitude in degrees-minutes-seconds OR in decimal degrees

	Degrees	Minutes	Seconds	Decimal
Latitude:	45.53632			45.536320
Longitude:	122.38599			122.385990

Enter Project Site Soil/Rock Type: **D** **Soil/Rock entries must match letter codes exactly.**

Soil Rock Choices:

Rock	**AB**
Very Dense Soil	**C**
Firm Soil	**D**
Soft Soil	**E**
Very Soft Soil	**F**

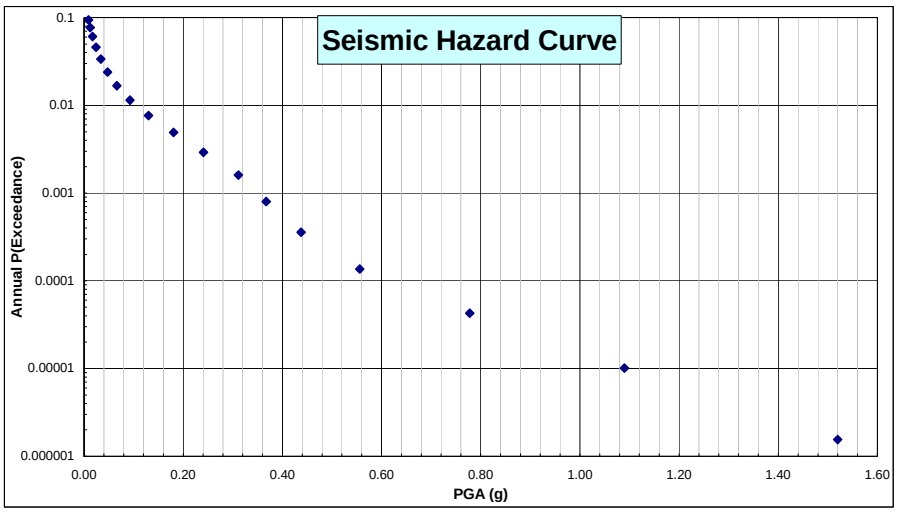
Soil/Rock types and definitions as per IBC 2003 (2006).

If soil/rock unknown, use Firm Soil D as default.

Site specific geotechnical analysis encouraged for Soil F

Site Hazard Data

PGA	Annual P
0.008800	9.404E-02
0.012320	7.725E-02
0.017248	6.080E-02
0.024112	4.605E-02
0.033792	3.364E-02
0.047344	2.395E-02
0.066176	1.676E-02
0.092752	1.148E-02
0.129888	7.659E-03
0.180600	4.918E-03
0.240845	2.922E-03
0.311280	1.609E-03
0.367382	8.031E-04
0.437891	3.571E-04
0.556000	1.359E-04
0.778000	4.266E-05
1.090000	1.012E-05
1.520000	1.549E-06
2.130000	1.551E-07



2/3rds of 2% in 50 year PGA value: **0.285**

Reference PGA values:	g	% g
10% in 50 years:	**0.280**	**28.0%**
5% in 50 years:	**0.348**	**34.8%**
2% in 50 years:	**0.427**	**42.7%**

PGA values are shown as fractions of g, the acceleration of gravity. Thus, for example, 0.500 means 0.5 g or 50% of g.

6.4 Other Aspects of Seismic Hazards in Multnomah County

Much of the damage in earthquakes occurs from ground shaking which affects buildings and infrastructure. However, there are several other consequences of earthquakes that can result in very high levels of damage in some locations, including: liquefaction, settlement, lateral spreading, landslides, dam failures and tsunamis.

6.4.1 Liquefaction, Settlement and Lateral Spreading

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 vertically 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.

Figure 6.9 shows areas with Multnomah County with high liquefaction potential. Even in areas mapped as high liquefaction potential, liquefaction 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 the 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 may cause significant damage to affected buildings or infrastructure.

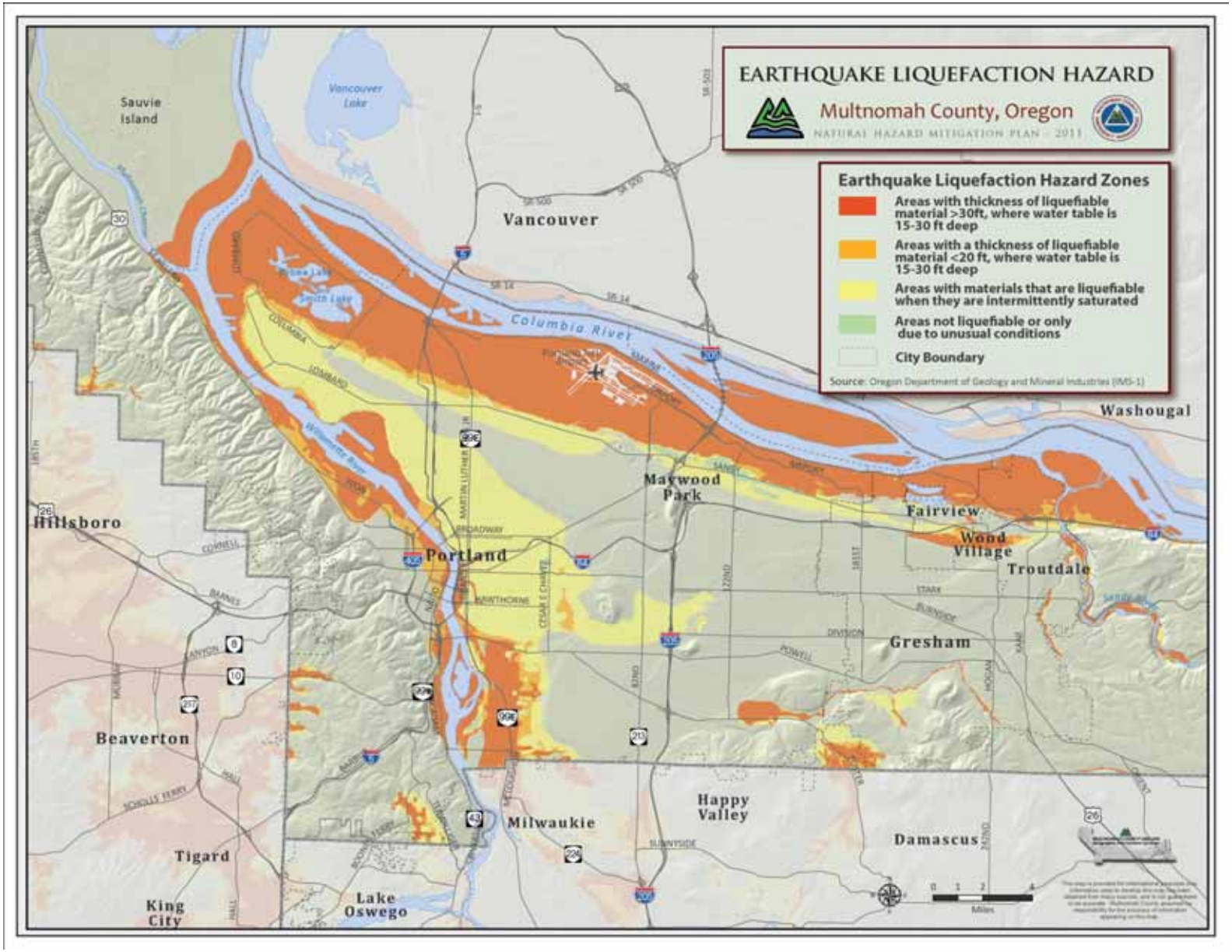
In Figure 6.9, the darkest red-orange areas have very high liquefaction potential, while the light orange and yellow areas have high and moderate liquefaction potential, respectively. The green areas have low or nil liquefaction potential.

The very high and high liquefaction areas include broad areas along the Columbia River, significant areas along both the Willamette and Sandy Rivers and smaller areas along several streams. These areas include Portland International Airport, significant portions of the cities of Portland, Troutdale and Wood Village. Within unincorporated Multnomah County, areas at risk of liquefaction include parts of Sauvie Island, areas along the Columbia River east of Troutdale and areas along the Sandy River and several streams.

6.4.2 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**.** See Chapter 8 Landslides for a more detailed discussion of landslides.

Figure 6.9
Areas with High Liquefaction Potential



6.4.3 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. Earthquake induced landslides into reservoirs have also caused dam failures.

Earthquake-induced dam failures are addressed in more detail in Chapter 6 Floods, which includes a section on dam failures that could affect Multnomah County.

6.4.4 Tsunamis and Seiches

Tsunamis, which are sometimes 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.

Multnomah County, while not located on the coast, would not be directly affected by tsunamis on the Oregon Coast. A tsunami surge could extend up the Columbia River, perhaps as far inland as Multnomah County. However, because of the considerable distance from the coast, the effects would be very minimal or nil. That is, the increase in water level would be immeasurable or perhaps just a few inches, with no damage.

Another similar earthquake phenomenon is “seiches” which are waves from sloshing of inland bodies of waters such as lakes, reservoirs, or rivers. Seiches may result in damages to docks and other shorefront structures and to dams. For Multnomah County, seiches could also cause localized damages to reservoirs or tanks.

6.5 Scenario Earthquake Loss Estimates for Multnomah County

6.5.1 Summary Results

There are a wide range of possible earthquakes that may affect Multnomah County, including not only Cascadia Subduction Zone earthquakes and crustal earthquakes on known faults but also crustal earthquakes on as yet unknown faults. The USGS national seismic hazard maps (cf. Figure 6.6) include contributions from unknown faults, which are statistically possible anywhere in Multnomah County and vicinity. Most likely earthquakes on as yet unknown faults would be relative small, most likely with magnitudes less than M6. However, earthquakes as large as M6 or M6.5 on unknown faults are also possible.

The range of possible earthquakes affecting Multnomah County was explored using FEMA's HAZUS loss estimation software: HAZUS-MH-MR5, Version 10.0.0. HAZUS loss estimates for specified scenario earthquakes are intended for regional planning purposes and provide general indications of the extent of damages, economic losses and casualties.

For Multnomah County, we evaluate four scenario earthquakes:

- M9.0 earthquake on the Cascadia Subduction Zone,
- M7.05 earthquake on the Portland Hills Fault,
- M6.0 earthquake on the Portland Hills Fault, and
- M6.8 earthquake on the Mount Angel Fault.

The HAZUS results presented below are based on the "level one" data built into the HAZUS software. The national inventory data used by HAZUS are estimates for each census tract. In some cases, these data may be incomplete or inaccurate. The results should not be interpreted as indicating the exact damages, losses or casualties for each scenario earthquake – the exact levels of damages, losses and casualties cannot be predicted before an earthquake occurs. Rather, the results illustrate the relative severity of consequences for Multnomah County for each of the four earthquake scenarios and the approximate levels of damages and casualties expected.

Summary HAZUS loss estimates for the four scenario earthquakes listed above are given in Table 6.4. The Cascadia M9.0 HAZUS run was made using the USGS shakemap ground motions for Cascadia M9.0 earthquake. The other scenarios were run using the UGSS-based earthquake hazard data and ground motion attenuation relationships in HAZUS.

Table 6.4
Summary Impacts for Multnomah County
Four Scenario Earthquakes

Category	Cascadia M9.0	Portland Hills M7.05	Portland Hills M6.0	Mount Angel M6.8
Damages and Losses				
Number of Damaged Buildings - Total	203,516	456,165	180,035	65,711
Number of Damaged Buildings - Slight Damage	126,601	198,628	139,249	57,867
Number of Damaged Buildings - Moderate Damage	54,450	149,973	33,640	7,140
Number of Damaged Buildings - Extensive Damage	20,714	62,256	6,338	660
Number of Damaged Buildings - Complete Damage	1,751	45,308	808	44
Building-Related Damages and Economic Losses	$7,979,000,000	$47,345,000,000	$6,667,000,000	$2,274,000,000
Transportation Systems Damages	$597,000,000	$4,064,000,000	$816,000,000	$180,600,000
Utility Systems Damages[1]	$23,000,000	$84,000,000	$18,290,000	$9,680,000
Total Damages and Losses	$8,599,000,000	$51,493,000,000	$7,501,290,000	$2,464,280,000
Casualties				
Injuries (2 pm)	3,448	45,414	2,612	881
Injuries (2 am)	1,104	12,074	691	418
Deaths (2 pm)	91	3,417	100	24
Deaths (2 am)	15	626	12	7

[1] Utility systems damages are for potable water only.

The estimated deaths and injuries are significantly lower during nighttime hours than during daytime hours, because more people are in wood frame residential buildings, which generally perform reasonably well in earthquakes.

The damage, loss and casualties estimates differ substantially for the four scenario earthquakes because of the combination of two factors:

- Magnitude of the earthquake, and
- Location of the earthquake vis-à-vis Multnomah County.

The M9.0 earthquake on the Cascadia Subduction Zone is the most likely great earthquake to affect Multnomah County, with an estimated return period of about 300 to 500 years. However, the worst case scenario earthquake is not the M9.0 on the Cascadia Subduction Zone but rather the M7.05 on the Portland Hills Fault. Because the Portland Hills Fault is located within Multnomah County the levels of ground shaking and thus, damages, losses and casualties are much higher than for the larger, but further away M9.0 on the Cascadia Subduction Zone.

The damage, loss and casualty estimates shown above in Table 6.4 are for all of Multnomah County. The vast majority of these losses are expected within the incorporated cities, with only a very small fraction expected for the unincorporated areas. Per the 2010 Census data shown in Chapter 2, the population of the unincorporated areas is only about 2% of the County's population. However, the fraction of the County's building stock and infrastructure within the unincorporated areas is less than 2% because the rural areas are predominantly residential.

Furthermore, the majority of the building stock in the unincorporated areas consists of small wood-frame homes, which have less earthquake vulnerability than unreinforced masonry and several other building types which are concentrated in the older sections of the incorporated cities. Given these considerations, the fraction of total earthquake damages and losses expected in the unincorporated areas from any of the scenario earthquakes is likely to be significantly less than 2%, with the fraction of deaths and injuries likely to be much less than 2%.

Current estimates for the return periods of these four scenario earthquakes are summarized in Table 6.5.

Table 6.5
Estimated Return Periods for Scenario Earthquakes

Scenario Earthquake	Return Period (Years)	Probability in 50 Years	Last Event
M9.0 Cascadia	300 to 500	10% to 15%[1]	January 1700
M7.05 Portland Hills	14,000	0.35%	Unknown
M6.0 Portland Hills	1,500	3.50%	Unknown
M6.8 Mount Angel	14,500	0.34%	Unknown

[1] Long-term average. Probability over the next 50 years may be substantially higher.

For the Cascadia M9.0 earthquake, 10% to 15% probability over the next 50 years represents the long-term average. However, because the last such earthquake occurred in 1700, the probability over the next 50 years may be substantially higher. Earthquake faults have "memory." That is, immediately after the M9.0 earthquake in 1700, the probability of another M9.0 earthquake was very low, almost nil. With increasing time, the stress gradually builds up on the fault and the probability gradually increases over time. The longer the time period since the last great earthquake, the higher the probability that the next great earthquake will occur.

Furthermore, the M9.0 earthquake corresponds to fault rupture over the entire fault zone. There is also paleoseismic evidence for partial ruptures of the northern and southern segments of the Cascadia Fault Zone with earthquake magnitudes greater than 8.0.

Recent research by Professor Goldfinger at Oregon State University has identified 41 very large earthquakes, M8.2 or higher, on the Cascadia Subduction Zone over the past 10,000 years. Many of these earthquakes occurred on the southern segment of the fault, from Newport south to Northern California. Considering the time interval since the last M9.0 earthquake and the likelihood of M8+ earthquakes, the total probability of large Cascadia earthquakes over the next 50 years may be substantially higher than 10% to 15%.

The return periods shown in Table 6.5 for the M7.05 Portland Hills and M6.8 Mount Angel scenarios are the 2008 USGS estimates. The return period for the smaller M6.0 Portland Hills scenario is estimated roughly as being about ten times less than that for the M7.05 scenario.

6.5.2 Earthquake Ground Motions for Scenario Earthquakes

The following maps show the variation in estimated earthquake ground motions for the four scenario earthquakes. The ground shaking maps for the Cascadia M9.0 and Portland Hills M6.0 scenarios are USGS shake maps which include the best available soil/rock data for the affected areas. The ground shaking maps for the Portland Hills M7.05 and Mount Angel M6.8 scenarios are based on HAZUS data, which is likely of lower spatial resolution than the USGS shakemaps.

Figure 6.10
Cascadia M9.0 Earthquake: Ground Motion

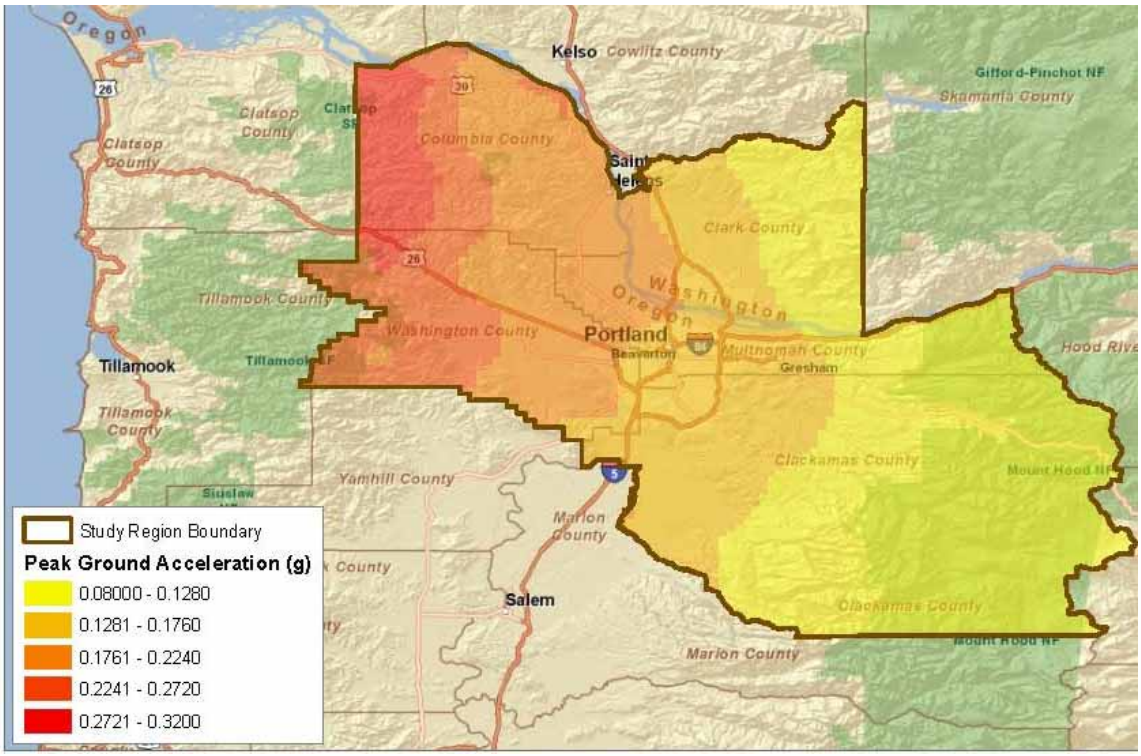


Figure 6.11
Portland Hills M7.05: Ground Motion

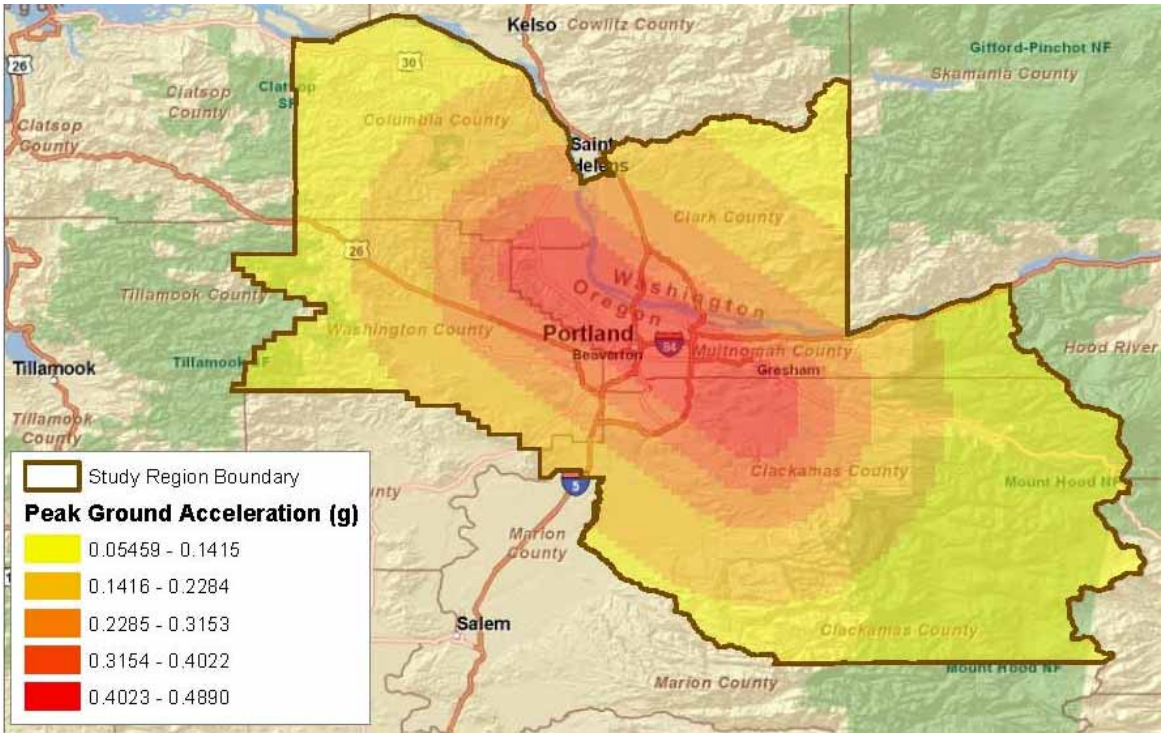


Figure 6.12
Portland Hills M6.0: Ground Motion

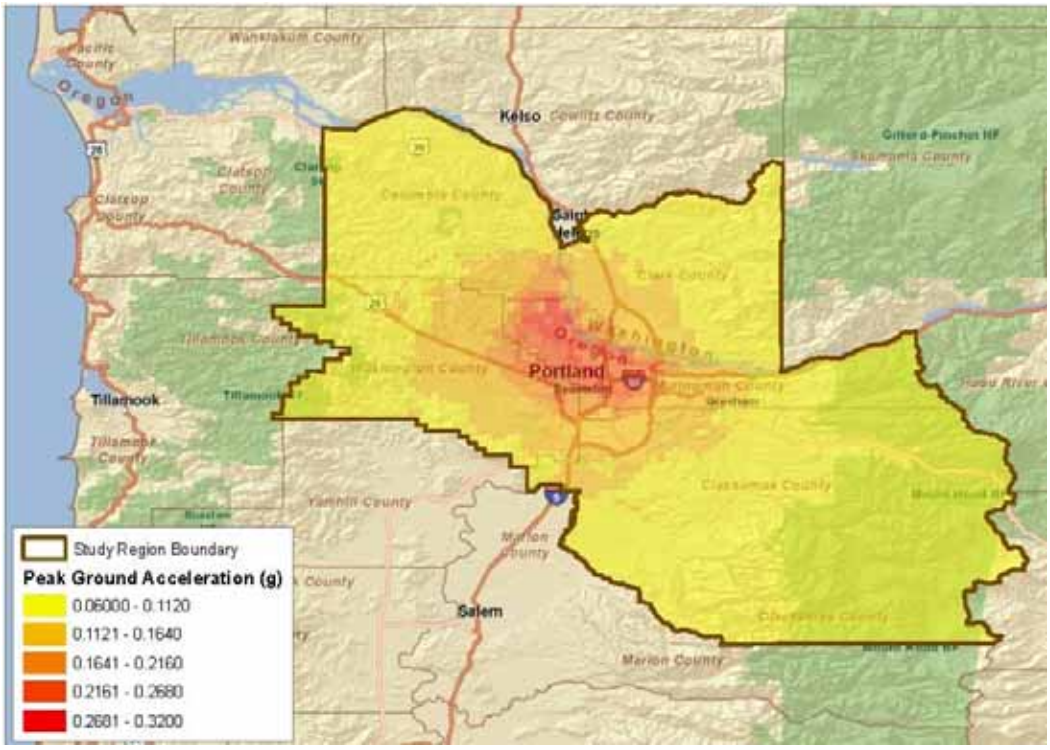
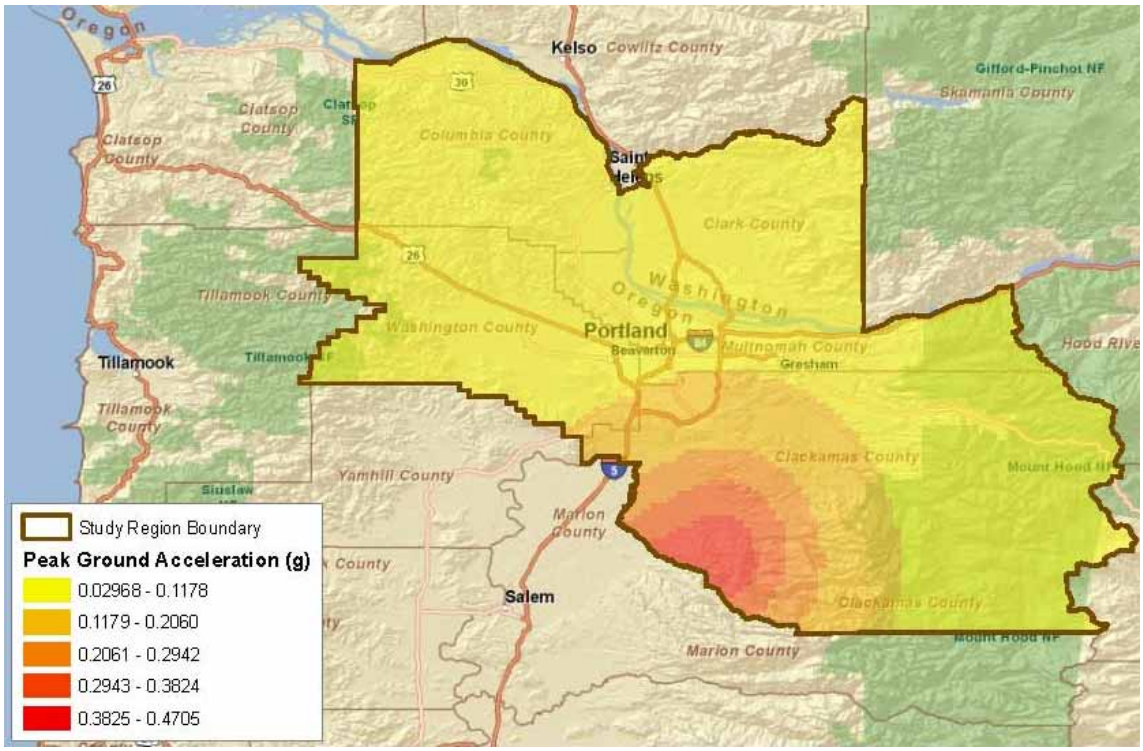


Figure 6.13
Mount Angel M6.8: Ground Motion



6.5.3 HAZUS Results: Commentary and Caveats

Summary HAZUS loss estimates for the four scenario earthquakes listed were shown previously Table 6.3.

HAZUS results illustrate the relative severity of consequences for Multnomah County for each of the four earthquake scenarios and the approximate levels of damages and casualties expected. The numerical results should not be over-interpreted.

In addition to the results shown in Table 6.3 and the tables in the appendix, HAZUS generates many more detailed output reports. However, the detailed information in these output reports should be interpreted very cautiously because the results are based on limited data, which may be incomplete and/or inaccurate.

For reference, some of the detailed HAZUS results (which are not included in the summary information in this chapter) appear significantly inaccurate, including the following information which is included in the HAZUS output reports:

- The expected damage and functionality estimates for essential facilities (hospitals, schools, EOCs, police stations and fire stations) appear incomplete and possibly inaccurate.

- The expected damage and functionality estimates for transportation systems appear incomplete and possibly inaccurate.
- The expected damage and functionality estimates for utility systems are incomplete and possibly inaccurate. Damage estimates are provided for potable water only. The reported zero leaks/breaks for the potable water system, even for the M7.05 Portland Hills scenario and the estimated zero households without water or electric service appear completely unrealistic. Especially for this scenario, but also for the other scenarios, damage and outages are likely for all of the utility systems.

6.5.4 Qualitative Loss Estimates for Other Earthquakes

In addition to the four scenario earthquakes summarized above, there are numerous other earthquakes which could result in significant damage in Multnomah County. Qualitative loss estimates for several of these earthquakes are provided below.

As discussed in Section 6.2, earthquakes on the Cascadia Subduction Zone include deep intraplate earthquakes as well as the interface earthquake presented above. Deep intraplate earthquakes might have magnitudes ranging from the high M6 range to as much as M7.5. An example of such an earthquake is the Nisqually earthquake in Washington State.

Levels of ground shaking and damages, economic losses and casualties in Multnomah County from deep intraplate earthquakes would vary significantly depending on the location and depth of the epicenter and the magnitude of the earthquake. However, damage levels could be roughly comparable to those for the further-away M9.0 interplate Cascadia Subduction Zone earthquake discussed above.

There are also numerous mapped crustal faults near Multnomah County (cf. Figure 6.5) as well as a likelihood of other not yet known faults. A large earthquake M6+ could result in significant damages. The severity of damages, losses and casualties would vary markedly depending on the magnitude and location of such earthquakes. The damages, losses and casualties for such earthquakes would be significantly lower than those for the M6.0 Portland Hills scenario, for earthquakes that occurred in less heavily developed portions of Multnomah County.

6.6 Earthquake Hazard Mitigation Projects

6.6.1 Overview

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, utility systems and other infrastructure components.

Structural retrofit of buildings should not focus on typical buildings, but rather on buildings that are most vulnerable to seismic damage. For example, let's assume that there are 100 reinforced masonry buildings built well before current seismic requirements. A logical retrofit prioritization may consider several factors, including:

- Which of these 100 buildings have the most severe seismic deficiencies?
- Among the buildings with most severe seismic deficiencies, which ones have the highest occupancy and/or are critical service facilities such as hospitals, fire and police stations, and emergency shelter? Many jurisdictions also consider school buildings as high priorities for retrofits.
- Which buildings are located in higher seismic hazard areas, including areas subject to soil amplification, liquefaction or lateral spreading?
- Which of these buildings pose the greatest risk (which may be evaluated quantitatively as part of a benefit-cost analysis) considering the vulnerability, occupancy and importance of each building?
- Which possible seismic retrofits have the highest benefit-cost ratio?

Considerations such as those outlined above help jurisdictions determine their own priorities for seismic retrofits.

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, 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 higher priority than overpasses on lightly traveled rural routes.

6.6.2 Mitigation Action Items for Earthquakes

Multnomah County's mitigation priorities for earthquake focus primarily on the unincorporated areas of the County and on County-owned buildings and infrastructure. The incorporated cities within the County have the primary responsibilities for buildings and infrastructure within their jurisdictions.

The action items in Table 6.6 on the following page, reflects these priorities. The action items include seismic evaluations and structural and nonstructural retrofits for County-owned buildings, with priorities generally similar to the post-disaster restoration priorities for County buildings shown in Appendix 4.

Similarly, for bridges with substantial seismic vulnerabilities, the County's priority is for County-owned bridges, especially those bridges essential for emergency access and egress.

Earthquake mitigation priorities also include the critical and essential buildings and infrastructure discussed in Chapter 4 and the other mitigation action items in Table 6.6.

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

Table 6.6
Earthquake Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Plan Goals Addressed				
				Life Safety	Protect Property and Infrastructure	Emergency Management Capabilities	Public Awareness and Education	Environmental Stewardship
Earthquake Mitigation Action Items								
Short-Term #1	Evaluate the structural vulnerability of critical county buildings and retrofit or replace when necessary.	Facilities	Ongoing	X	X	X		X
Short-Term #2	Encourage school districts, fire agencies and private building owners to evaluate the structural vulnerability of buildings and retrofit or replace when necessary. Example: grant workshops.	Multnomah County Emergency Management	Annually	X	X	X	X	
Short-Term #3	Evaluate the nonstructural vulnerabilities in county buildings and implement mitigation measures where necessary, including: automatic seismic shut off values on gas lines, flexible connections to gas-fueled equipment, bracing of fire sprinklers, bracing of contents and others.	Facilities	1-2 Years	X	X	X		X
Short-Term #4	Obtain and update earthquake map data as it becomes available through DOGAMI and other partners.	GIS	Ongoing			X	X	
Short-Term #5	Complete and maintain an inventory of critical facilities and lifelines that are susceptible to severe disruption due to earthquake hazards.	Multnomah County Emergency Management	Ongoing		X	X	X	
Short-Term #6	Enhance Multnomah County's staff earthquake expertise by attending training classes on nonstructural mitigation, post-earthquake seismic evaluations of buildings, and FEMA mitigation grants.	Multnomah County Emergency Management	Ongoing	X	X	X	X	
Long-Term #1	Retrofit suspended ceilings including light fixtures as replacement becomes necessary.	Facilities	Ongoing	X	X			
Long-Term #2	Retrofit or replace key bridges with substantial seismic vulnerabilities.	Transportation	Ongoing	X	X	X	X	X
Long-Term #3	Seismic upgrades Multnomah County Courthouse	Facilities	5 Years	X	X			

7.0 WILDLAND/URBAN INTERFACE FIRES

7.1 Overview

Fire has posed a threat to mankind since the dawn of civilization. Fires often cause substantial damage to property and also result in deaths and injuries. For the purposes of mitigation planning, we define three types of fires:

- Structure fires and other localized fires,
- Wildland fires, and
- Wildland/urban interface fires.

Structure fires are fires where structures and contents are the primary fire fuel. In dealing with structure fires, fire departments typically 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. Structure fires and the other common types of fire are most often confined to a single structure or location, although in some cases they may spread to adjacent structures.

Wildland fires are fires where vegetation (grass, brush, trees) is the primary fire fuel and thus involve few or no structures. 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. For wildland fires, fire suppression responsibility is shared by local and state fire agencies.

Wildland/urban interface fires are fires where the fire fuel includes both structures and vegetation. The defining characteristic of the wildland/urban interface area is that structures are built in or immediately adjacent to areas with essentially continuous vegetative fuel loads When wildland fires occur in such areas, they often spread quickly and structures in these areas may, unfortunately, become little more than additional fuel sources for wildland fires. Fire suppression efforts for wildland/urban interface fires focus on savings lives and on protecting structures to the extent possible.

This chapter focuses on wildland/urban interface fires which pose a substantial threat to parts of Multnomah County, especially in the unincorporated areas.

In Multnomah County, as elsewhere in Oregon, recent patterns of development have led to increasing numbers of homes being built in areas subject to wildland/urban interface fires. Fires in these areas pose high levels of life safety risk for occupants as well as high levels of fire risk for homes and other structures.

7.2 Wildland/Urban Interface Fires

Many urban or suburban areas have a significant amount of landscaping and other vegetation. However, in most areas the fuel load of flammable vegetation is not continuous, but rather is broken by paved areas, open space and areas of mowed grassy areas with low fuel loads. In these areas, most fires are single structure fires. The combination of separations between buildings, 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 fire departments that respond quickly to fires, with sufficient personnel and apparatus to control fires effectively. Thus, 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 which are very similar to those for wildland fires. The level of fire hazard for wildland/urban interface fires depends on:

- Vegetative fuel load,
- Weather,
- Topography,
- Fire suppression resources and
- Fire-safe construction and defensible space practices.

The level of fire hazard in wildland/urban interface areas is often high not only because of high vegetative fuel loads, but also because of topography. Many of these areas are hilly or mountainous and steeper slopes exacerbate fire spreading and impede fire suppression efforts. Water resources for fire suppression are typically lower in these areas which are predominantly residential and served by pumped pressure zones. Fire department response times may also be longer because of distance and/or narrow streets. These reduced fire suppression resources make 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.

Another important factor in the level of risk for individual structures or neighborhoods is the extent to which fire-safe construction practices and vegetation management practices such as weed abatement and maintenance of defensible space around structures are or are not implemented. Effective implementation of fire-safe construction practices and defensible space around structures substantially reduces the risk of a fire destroying structures when a fire occurs.

The level of fire hazard in areas prone to wildland/urban interface fires is also greatly increased during periods when 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

Life safety risk in interface areas is 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/urban interface fire. Unfortunately, home owners who delay evacuation in well meant but misguided attempts to save their homes may place their lives in jeopardy by delaying evacuation until it may be impossible.

Major fires in the urban/wildland interface have the potential for enormous destruction and high casualties. For example, the October 20, 1991 East Bay Fire in Oakland California burned about 1,600 acres with 25 fatalities, 150 injuries, and over 3,300 single-family homes and 450 apartment units destroyed. Total property damages were over $1.5 billion. This fire was fueled by 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 the rapid fire spreading completely overwhelmed initial fire suppression efforts.

7.3 Fire Agencies in Multnomah County

The responsibility for fire suppression and fire prevention in Multnomah County is shared by many fire agencies, including:

Portland Fire Bureau

Gresham Fire Department

Lake Oswego Fire Department

Sandy Fire

Clackamas Fire District #1

Multnomah County Rural Fire Protection District #10

Multnomah County Rural Fire Protection District #14

Riverdale Rural Fire Protection District #60

Sauvie Island Rural Fire Protection District #30

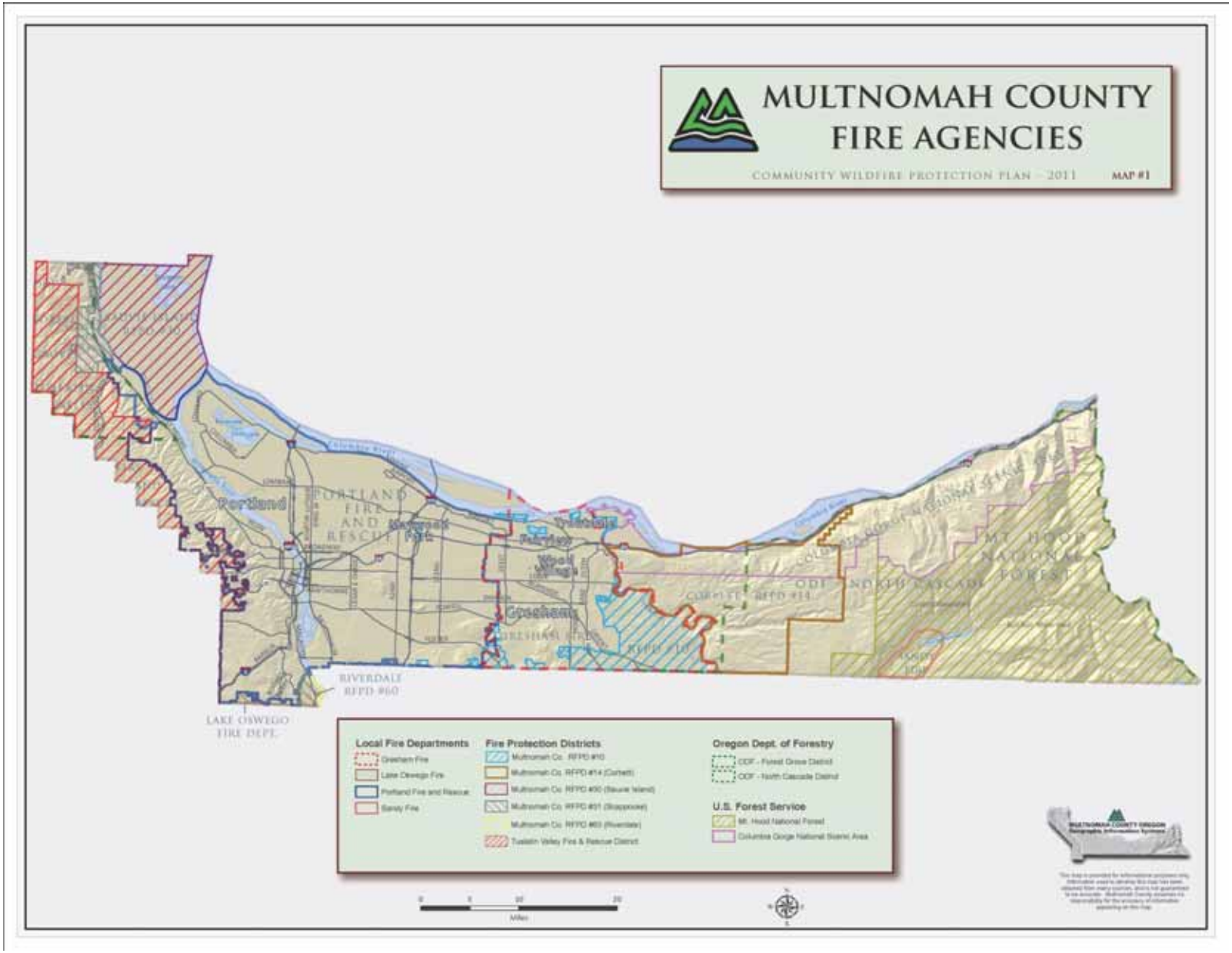
Scappoose Rural Fire Protection District #31

Tualatin Valley Fire & Rescue District

Oregon Department of Forestry

Figure 7.1 on the following page shows the fire protection service areas for the fire agencies above. Fire protection responsibility is shared between the Oregon Department of Forestry and local fire agencies for a large area in eastern Multnomah County and a smaller area in the northwest part of the County.

Figure 7.1
Fire Protection Service Areas in Multnomah County



7.4 Historical Data for Wildland and Wildland/Urban Interface Fires in Oregon and Multnomah County

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. Many of the largest fires occurred before 1945. The two largest fires, the 1868 Coos Bay fire and the 1849 Siletz fire consumed 988,000 and 800,000 acres, respectively. The next four largest fires occurred between 1933 and 1945, with each fire consuming between 240,000 and 180,000 acres. The 1987 Silver Fire, burned 97,000 acres. More recent major fires in Oregon include the 2002 Biscuit Fire that burned nearly about 471,000 acres in Oregon and the 2003 B&B Complex fire that burned 90,769 acres. None of these major fires occurred in Multnomah 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. However, these ODF data are only for ODF-responsibility lands, about 16 million acres, and do not include forest lands where primary fire suppression responsibility is federal or local. These data 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. For Multnomah County, the average number of wildland fires in ODF responsibility areas is about 3 to 4 fires per year.

ODF data for the 51 year period from 1960 to 2011 indicate a total of only about 1,600 acres burned in ODF responsibility areas. These data indicate an average of only about 30 acres burned per year. However, about 90% of the total acreage burned occurred in 1990, with zero or nearly zero acres burned in many years.

7.4 Wildland/Urban Interface Fire Hazards for Multnomah County

The Oregon Department of Forestry's latest Oregon's Communities at Risk Assessment (2006) classifies 14 communities in Multnomah County for wildland/urban interface fire risk. These classifications are based on the combination of ignition risk, hazard level, fire protection capability and values at risk.

The following communities are rated as "moderate" risk: Fairview, Gresham, Lake Oswego, Portland, Troutdale, Wood Village and Multnomah County overall. The service areas of the following fire agencies are also rated as moderate risk: Multnomah County Fire District #10, Riverdale Rural Fire Protection District, Sauvie Island Rural Fire Protection District, Scappoose Rural Fire Protection District, and Tualatin Valley Fire and Rescue. Maywood Park is rated as "low" risk.

ODF uses a five-tiered methodology to assess wildfire or wildland/urban interface fire risk throughout Oregon. The five ranking factors include the following:

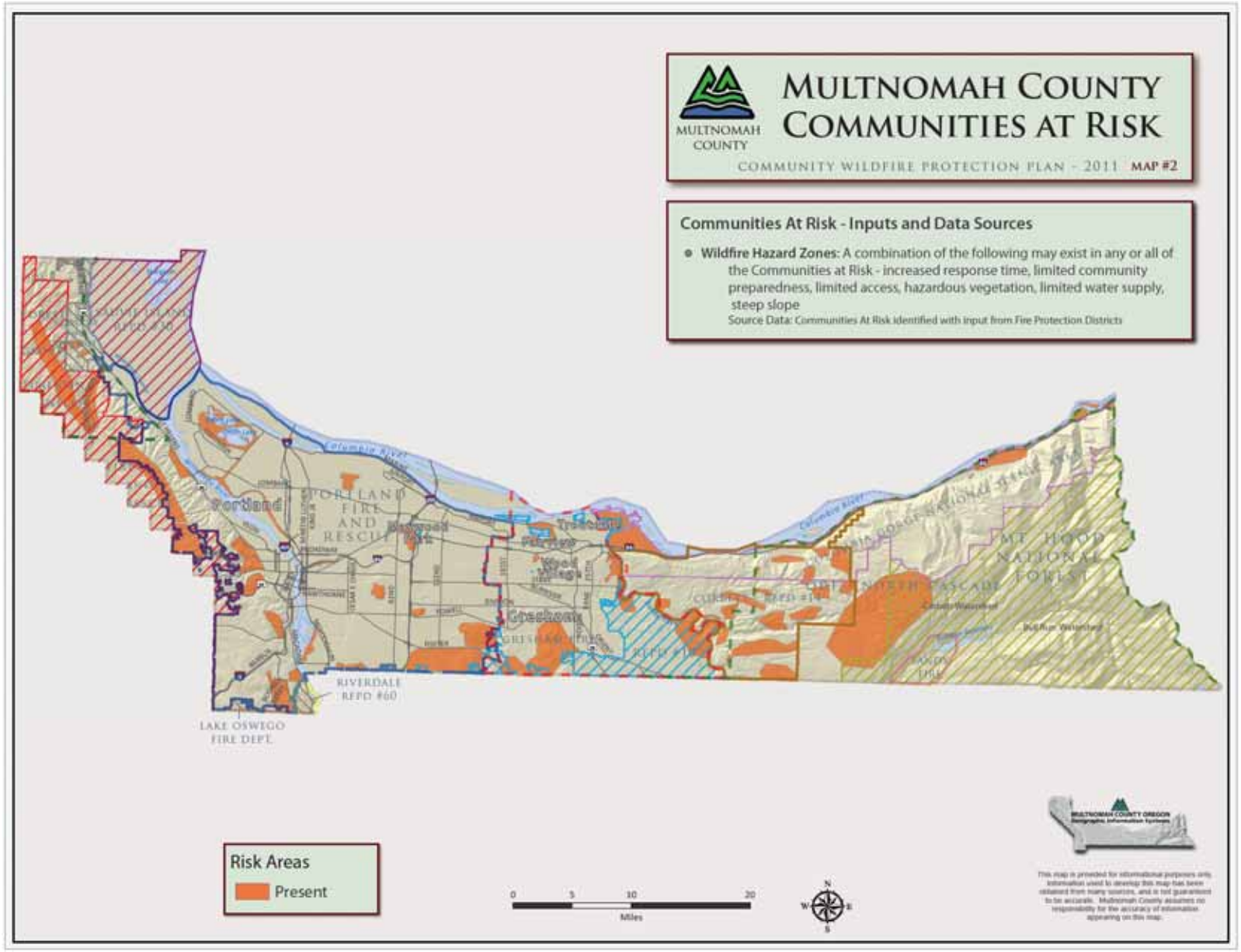
- **Hazard**: vegetation, topography and climate
- **Risk**: historical fire occurrence and ignition sources
- **Values**: community values, watersheds, critical facilities and infrastructure
- **Protection Capabilities**: Fire district response time
- **Structural Vulnerability**: wildland/urban interface

The communities/areas within Multnomah County with the highest risk from wildland/urban interface fires are shown as the red-orange shaded areas in Figure 7.2 on the following page.

The risk from wildland/urban interface fires arises from the combination of the five ranking factors listed above. That is, these areas have all or most of the following attributes:

- High vegetative fuel loads,
- Steep topography,
- Relative high rates of historical fire occurrence and or ignition sources, especially human-caused ignition sources
- High values of buildings, watersheds, or critical facilities and infrastructure
- Limited protection capabilities: response time, fire department resources, water supplies
- Structural vulnerability of buildings: extent of fire-safe construction and defensible space.

Figure 7.2
Communities at Risk in Multnomah County



The numbers of structures in the communities at risk areas shown in Figure 7.2 are shown below in Table 7.1.

Table 7.1
Numbers of Structures in Communities at Risk Areas

Unincorporated	Industrial	Commercial	Multi-Family Residential	Parks - Open Space	Mixed Use Residential	Single-Family Residential	Mixed Use Employment	Rural	**Total**
Wildfire, All Buildings									
	4	0	0	0	0	263	1	1366	1634
Wildfire, County Buildings									
	0	0	0	0	0	0	0	0	0
Incorporated	Industrial	Commercial	Multi-Family Residential	Parks - Open Space	Mixed Use Residential	Single-Family Residential	Mixed Use Employment	Rural	**Total**
Wildfire, All Buildings									
	127	0	769	263	220	11027	34	360	12800
Wildfire, County Buildings									
	0	0	0	1	1	0	0	0	2

As shown above, there are over 1,600 buildings in communities at risk areas (Figure 7.2) in the unincorporated areas of Multnomah County. These buildings are predominantly single-family residential or rural buildings, along with four industrial buildings. In the incorporated areas of Multnomah County, there are 12,800 buildings which are mostly residential, but with a mix of other uses as well, including 127 industrial buildings.

7.5 Wildland/Urban Fire: Potential Loss Estimates.

The identified high risk areas for wildland/urban interface fires have high risk because of the many factors discussed above.

Potential losses from wildland/urban fires impacting Multnomah County vary over a very wide range. Fires may result only minor damage to a few structures or result in the destruction of a few structures, a few dozen structures or hundreds of structures. In extreme events, such as the 1991 Oakland Hills fire in California, loss of several thousand structures is possible.

The following table has rough estimates of the order of magnitude of potential losses to structures and infrastructure, based on the following parameters per structure:

- Average structure replacement value: $250,000,
- Average contents replacement value: $75,000,

- Landscaping damages: $5,000
- Displacement costs for temporary quarters: $20,000,
- Other damages, including vehicles and infrastructure: $50,000
- Total damages per structure burned: $400,000

Table 7.2
Potential Losses from Wildland/Urban Interface Fires in Burbank

Structures Burned	Approximate Losses
1	$400,000
10	$4,000,000
100	$40,000,000
1000	$400,000,000

In addition to the potential for property damage, wildland/urban interface fires in Multnomah County pose substantial risk of deaths and injuries to both residents and firefighters. For a major wildland/urban interface fire in Multnomah County the number of deaths could be none or as high as several dozen or more, with several times as many injuries as deaths. Furthermore, high levels of smoke from major fires pose health risks, especially for vulnerable populations, including: individuals with asthma and other respiratory diseases or cardiovascular disease, the elderly, and children.

The above estimates and commentary notwithstanding, the likelihood of major wildland/urban interface fires destroying many dozens, hundreds or thousands of structures in Multnomah County appears rather low, given the wildland fire history over recent decades.

7.6 Multnomah County Ordinances for Wildland/Urban Interface Fires

Multnomah County relies on the regulations implemented by the rural fire protection districts to address fire flow and access for property in the rural plan areas. These regulations are based on the Oregon Fire Code.

The Multnomah County Code Volume 2: Land Use Ordinances has forest practices setbacks and fire safety zones for the West Hills Rural Plan Area and has Commercial Forest Use Zone regulations for all of the rural plan areas. The Commercial Forest Use Zones embrace the hazard mitigation planning strategy to reduce risk by:

- Requiring that the Primary Fire Safety zone be appropriate to the downhill slopes surrounding the development site. Primary Fire Safety zones are 20 feet for slopes less than 10% and increase to 80 feet, 105 feet, and 130 feet for slopes from 10% to 19%, 20% to 24%, and 25% to 39%, respectively.
- Reducing the amount of fuel available within the Primary Fire Safety Zone by requiring the distance between tree crowns to be at least 15 feet,

trimming low-hanging branches to eight feet above ground as the trees mature and limiting all other vegetation to less than two feet in height.

- Requiring a Secondary Fire Safety Zone to reduce the amount of fuel available to feed a fire in the forest. The reduction in fuel helps to keep a fire out of the tree crowns and to keep a fire from over-running the Primary Fire Safety Zone.
- Dwellings and structures must have a fire retardant roof and a spark arrestor on each chimney.

7.7 Mitigation Strategies for Wildland/Urban Interface Fires

7.7.1 Synopsis of Common Strategies

This section summarizes common strategies for reducing the level of fire risk to both property and life safety in wildland/urban interface areas. The common strategies have 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 focus on manmade causes of ignition through a combination of fire prevention education, enforcement and other actions. Fire prevention education actions 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 actions include strict enforcement of burning restrictions and vigorous investigation and prosecution of arson cases. One 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 as well as vigorous enforcement of overgrown vegetation and tall grass ordinances.

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.

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 can be implemented (if not yet implemented) or enforced vigorously (if not yet vigorously enforced). Fire safe building practices have two main elements:

- Fire safe design and construction of structures, and
- Maintenance of defensible spaces around structures.

The National Fire Protection Association (NFPA) has an excellent "Firewise" communities program with a 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. The 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, at least 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. Thus, reducing life safety risk requires public education and emergency planning to encourage and expedite warnings and evacuations (voluntary or mandatory).

7.7.2 FEMA Mitigation Actions for Wildland/Urban Interface Fires

The various FEMA mitigation grant programs (see: Appendix 1) include mitigation projects to reduce the risks from wildland/urban interface fires. Mitigation measures that FEMA commonly funds include:

- Defensible space activities,
- Hazardous fuel reduction activities, and
- Ignition resistant construction activities.

FEMA mitigation grants may also be available for some other wildand/urban interface fire mitigation activities. However, FEMA mitigation grants do not typically fund water system capacity enhancements, equipment or apparatus purchases or emergency planning activities.

7.7.3 Mitigation Action Items for Wildland/Urban Interface Fires

The following table contains wildland/urban interface fire mitigation action items

from the master Action Items table in Chapter 4.

Table 7.3
Wildland/Urban Interface Fire Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Plan Goals Addressed				
				Life Safety	Protect Property and Infrastructure	Emergency Management Capabilities	Public Awareness and Education	Environmental Stewardship
Wildland/Urban Interface Fire Mitigation Action Items*								
Short-Term #1	Track and report progress of action items in the Community Wildfire Protection Plan.	Multnomah County Emergency Management	Annually	X	X	X	X	X
Short-Term #2	Review and amend as necessary planning and development regulations to incorporate mitigation strategies for urban/wildland interface fires considering the recommendations in the 2011 Multnomah County Community Wildfire Protection Plan.	Multnomah County Land Use Planning	3 Years	X	X	X	X	X
Short-Term #3	Consider how Multnomah County Land Use Planning should coordinate with fire agencies' planning for wildland/urban interface fires.	Planning	1-2 Years	X	X	X	X	X

* See Multnomah County CWWP for a long list of potential action items.

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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 the mode of movement. These four types of landslides are illustrated in Figures 8.1 to 8.4 on the following page.

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. Roads constructed by cut and fill along the side of a slope are prone to slumping on the fill side of the road. 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 flat surface at some depth within the ground. Translational slides occur on surfaces of weaknesses, such as faults and bedding planes or at the contact surface between firm rock and overlying loose soils. Translational slides can either creep slowly or move large distances rather suddenly.

Debris Flows (mudflows) are movements in which loose soils, rocks and organic matter combine with entrained water to form slurries that flow rapidly downslope.

All of these types of landslides may cause road blockages by depositing debris on road surfaces or road damage 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 be completely destroyed by large ground displacements or by burial in slide debris. Landslides may also result in casualties, as evidenced by 1997 winter storms in Oregon.

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

1) slope,
2) soil/rock characteristics, and
3) water content.

Steeper slopes are more prone to all types of landslides. Loose, weak rock or soil is more prone to landslides than is more competent rock or dense, firm soils. 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

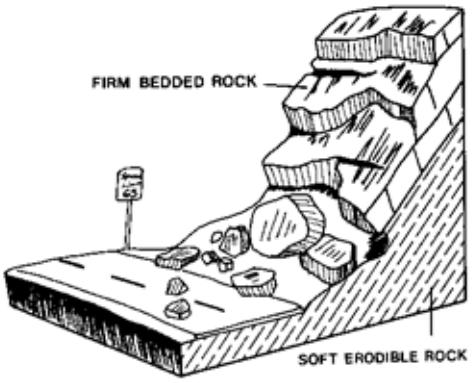


Fig. 8-1. Rockfall

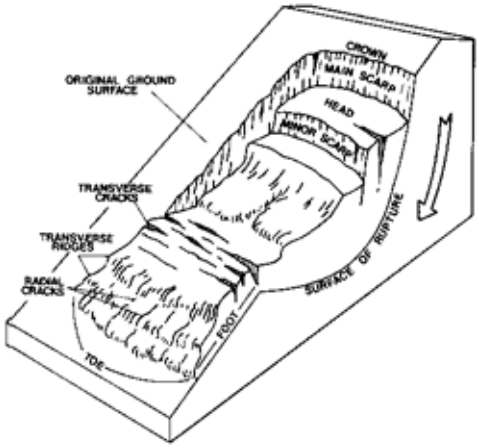


Fig. 8-2. Rotational Landslide

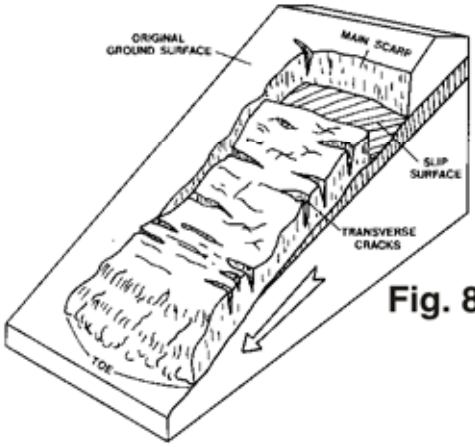


Fig. 8-3. Translational Landslide

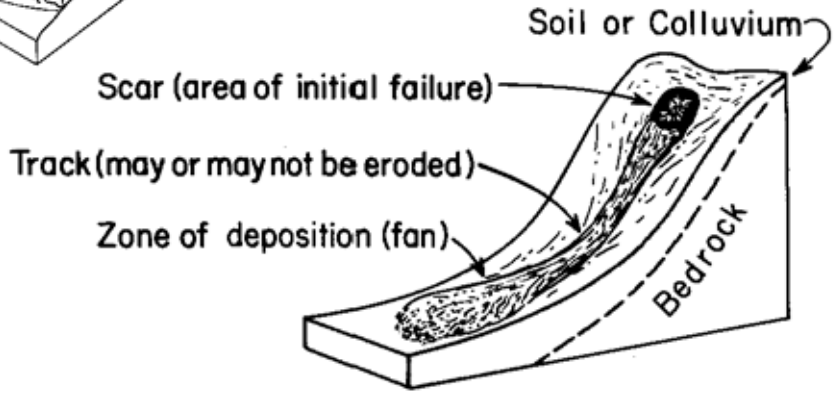


Fig. 8-4. Debris Flow

As noted above, the water content of soils/rock is a major factor in determining the likelihood of sliding for any given slide-prone location. Thus, most landslides happen during rainy months when soils are saturated with water. However, 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 exactly the same as those prone to ordinary (i.e., non-seismic) landslides. As with ordinary landslides, seismically triggered landslides are more likely from earthquakes that occur when soils are saturated with water.

8.2 Landslide Hazard Assessment for Multnomah County

Areas with potential landslide hazards within Multnomah County are shown in Figures 8.5 to 8.8. Landslide hazard areas are locations where landslides have occurred in the past or appear likely to occur in the future. These mapped areas include both developed and undeveloped areas.

Figures 8.5 and 8.6 are DOGAMI mapped potential landslide areas. Figures 8.7 to 8.8 are DOGAMI mapped historical landslide areas.

As shown in these figures, there are two areas of most concern for landslides:

- The west Portland Hills area, including U.S. Highway 30 and the adjacent rail line, and
- The area along Interstate 84 and the Historic Columbia River Highway from Troutdale east to the Multnomah County border.

In addition to these areas, large landslide hazard areas also exist in the hilly eastern portion of Multnomah County. However, this area is lightly developed. As shown on the figures, there are also smaller areas of landslide hazards scattered throughout Multnomah County

More detailed landslide hazard assessment requires a site-specific analysis of the slope, soil/rock and groundwater characteristics at specific sites. Such assessments are often conducted prior to development projects in areas with moderate to high landslide potential, to evaluate the specific hazard at the development site.

Figure 8.5
Landslide Hazard Areas: West

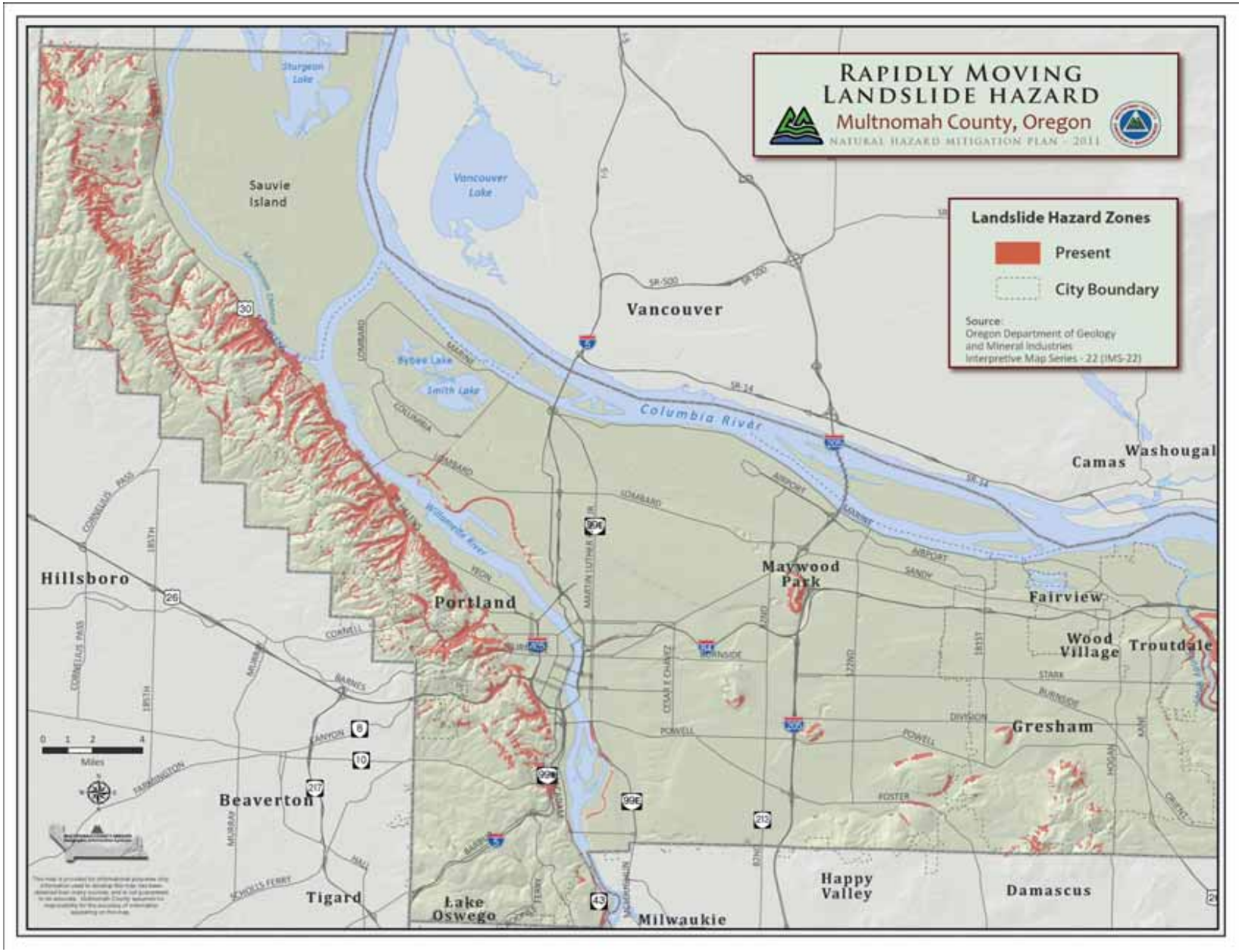


Figure 8.6
Landslide Hazard Areas: East

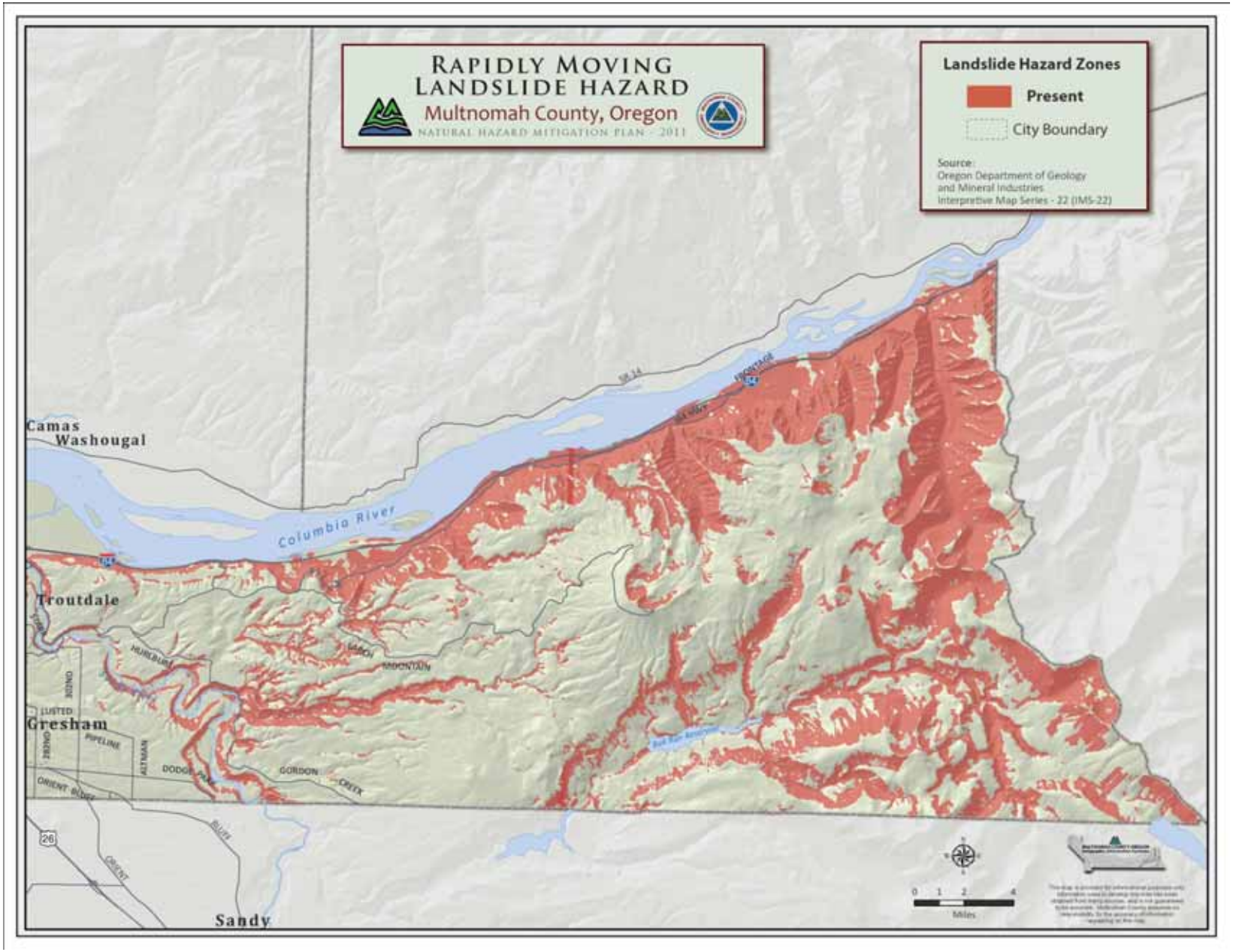


Figure 8.7
DOGAMI Mapped Historical Landslide Areas: West

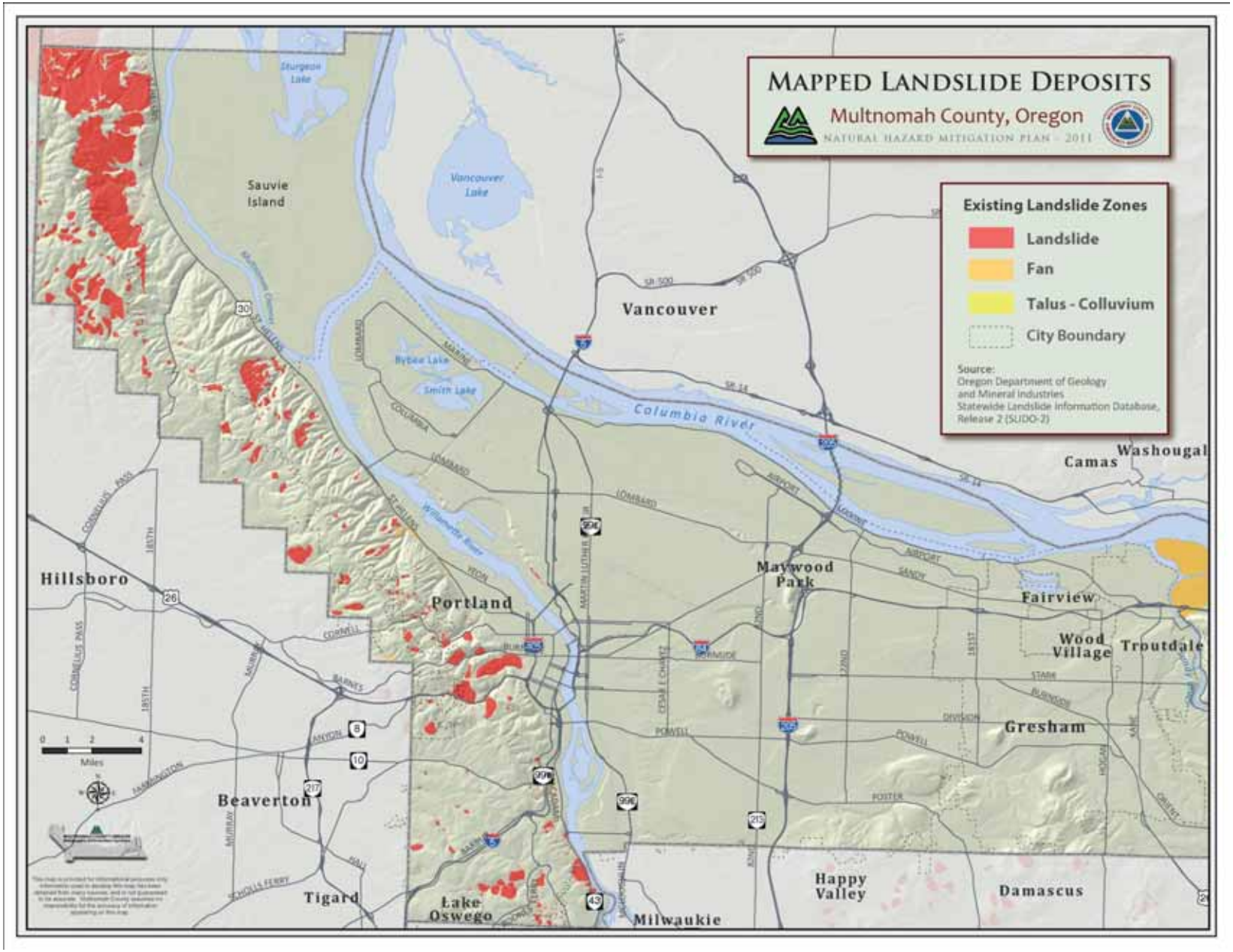
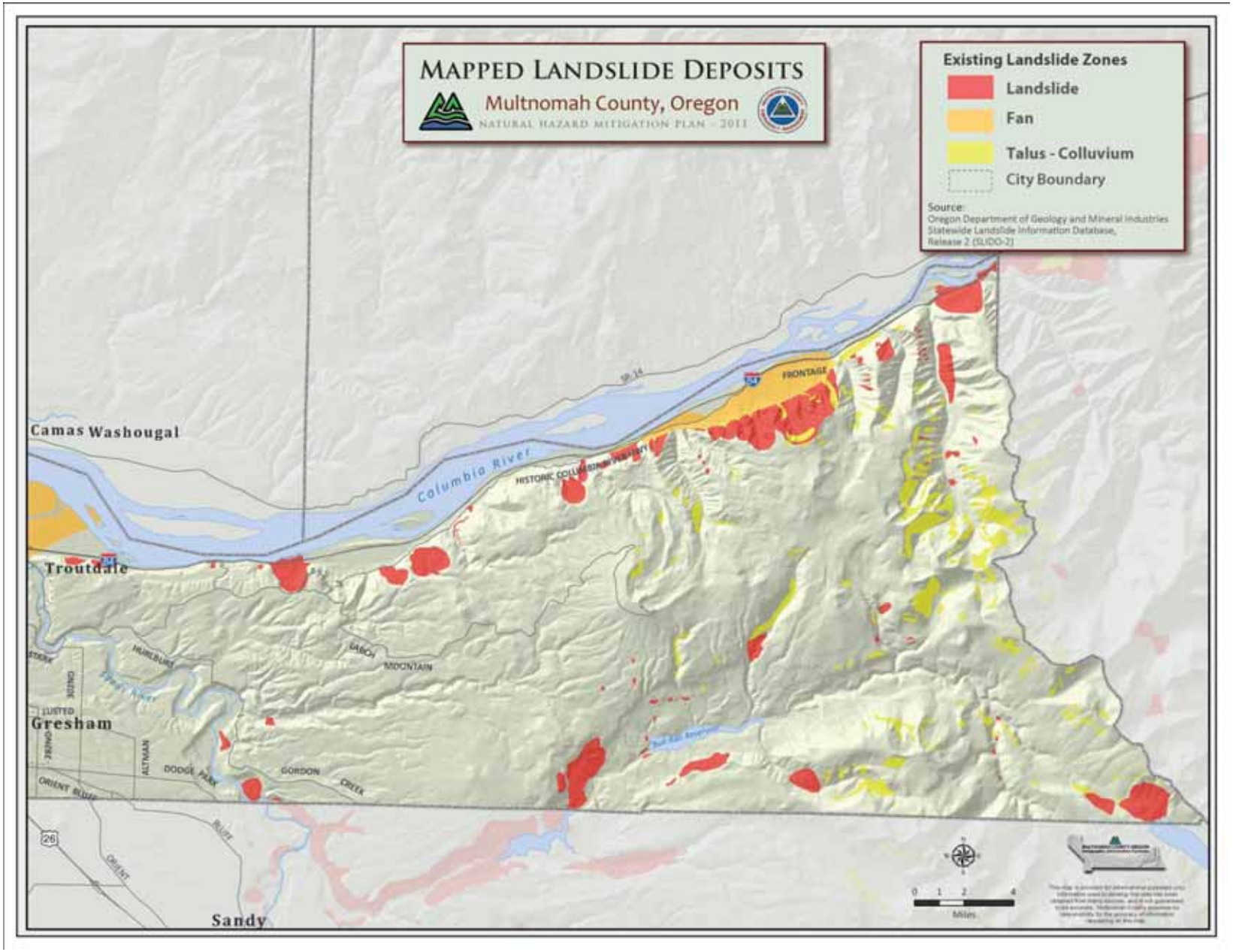


Figure 8.8
DOGAMI Mapped Historical Landslide Areas: East



8.3 Landslide Risk Assessment for Multnomah County

A fully quantitative risk assessment for landslides in Multnomah County, including estimates of the probabilities or return periods of landslides in specific locations, requires far more detailed data than is currently available. Therefore, we address landslide risks only in semi-quantitative terms.

High risk areas for landslides are locations where landslides have occurred in the past or appear likely to occur in the future and there are buildings or infrastructure in these areas. The overlap of landslide hazard areas with developed areas is what results in risk – threats to buildings and infrastructure.

The maps in Figures 8.5, 8.6, 8.7 and 8.8 show that many areas within Multnomah County are likely subject to landslides, including developed areas in the west Portland Hills and important transportation routes (Interstate 84 and the Historic Columbia River Highway in eastern Multnomah County). Significant parts of these areas are within the jurisdictions of incorporated cities and thus not within the County's area of jurisdiction.

There are also landslide hazard areas in undeveloped or very lightly developed areas. Many of these areas are federally owned, including Mt. Hood National Forest and portions of the Columbia River Gorge National Scenic Area.

The tables below show the numbers of buildings within the mapped landslide hazard areas.

Table 8.1
Mapped Landslide Hazard Areas

Landslide Hazard Areas: Unincorporated Portions of Multnomah County									
Data Set	**Indust**	**Commer**	**MultiFamRes**	**ParksOpenSpc**	**MixUseRes**	**SingleFamRes**	**MixUseEmpl**	**Rural**	**Total**
Buildings	0	0	0	0	0	104	0	375	479
County Buildings	0	0	0	0	0	0	0	0	0
Landslide Hazard Area: Incorporated Cities									
Data Set	**Indust**	**Commer**	**MultiFamRes**	**ParksOpenSpc**	**MixUseRes**	**SingleFamRes**	**MixUseEmpl**	**Rural**	**Total**
Buildings	225	0	247	24	165	1,279	26	2	1,968
County Buildings	0	0	0	0	0	0	0	0	0

The potential landslide risk areas within Multnomah County include nearly 500 single family and rural buildings in the unincorporated portions of the county and nearly 2,000 buildings in the incorporated cities. As shown above, there are no county buildings located in mapped landslide hazard areas.

In addition to posing risks for buildings, landslides also pose risks for roads, rail lines and utility systems. Underground utilities such as water, wastewater and natural gas pipes are particularly prone to damage from landslides. Even very small ground displacements of a few inches often result in pipe failures. The

consequences of landslides also include the economic impacts of road closures and utility outages.

Landslides also pose life safety risks. Occupants of buildings or vehicles may be injured or killed by landslides.

The 1996 winter storms resulted in many landslides in Oregon. Areas within Multnomah County where landslides occurred included areas west of the Sandy River: Wilson Road south of Kerslake Road and SE Stark Road about ½ mile west of the Sandy River. There were also several landslides, mostly rockfalls on very steep slopes, along the Historic Columbia River Highway. A debris flow area approximately 3 miles long occurred in the Dodson and Warrendale areas on February 7 and 8, 1996. Interstate 84 and the Union Pacific Railroad were closed for several days, and several residences were destroyed.

The potential impacts of landslides on Multnomah County are summarized in Table 8.2 below.

Table 8.2
Potential Impacts of Landslides on Multnomah County

Inventory	Probable Impacts
Portion of Multnomah County affected	Landslides or debris flows are possible in any of the mapped landslide hazard areas shown in Figures 8.5 to 8.8.
Buildings	In the unincorporated parts of the county, most buildings at risk are residential buildings.
Streets within communities	Street closures possible, but impacts generally limited because of short detour routes.
Roads within and to/from Multnomah County	Potential closures of major highways due to landsides, including Highway 30 and Interstate 84 and many secondary roads.
Rail transportation	Disruptions of rail service possible along the Highway 30 and Interstate 84 corridors.
Electric power	Potential for localized loss of electric power due to landslides affecting power lines in or near Multnomah County.
Other Utilities	Potential outages of water, wastewater and natural gas from pipe breaks from landslides. Probable impacts are localized.
Casualties	Landslides that impact buildings or roads could result in a small number of casualties (deaths and injuries).

The damages and economic losses from landslides are generally low to moderate, with damages and losses ranging from a few thousand dollars to hundreds of thousands of dollars. Damages and losses are generally low because the geographic areas affected are usually small. However, large landslides that affect dozens of homes could result in damages in the range of several million dollars.

Similarly, damages to roads and utilities are generally limited to small areas, often in residential areas, with low to moderate damages and economic losses. However, as with building damages, larger landslides or landslides which affect major roads or highways, including bridges, overpasses and viaducts, or major utility lines could have significantly larger economic impacts.

8.4 Mitigation of Landslide Risk

Mitigation of landslide risks is often quite expensive. In some cases, slope stability can be improved by addition of drainage to reduce pore water pressure, by construction of appropriate 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. Relocation outside of landslide hazard areas is especially important for high occupancy buildings and critical facilities.

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.

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 Multnomah County Hillside Development and Erosion Control Ordinance contains provisions that are intended to minimize loss due to earth movement hazards in rural areas shown on the County's adopted "Slope Hazard Maps" shown on figures 8.9 and 8.10. This mapping was developed based on an engineering study of the county that was completed in 1978. The County mapping was supplemented based on a 1996 engineering study of the Dodson-Warrendale area after debris flow losses there in that year.

New construction on land located in mapped hazard areas or with an average slope of 25% or more requires a Hillside Development Permit. However, there are several exemptions that can allow development to proceed without review. One example is a situation where a parcel having slopes less than 25% but which is located immediately downhill from a steep slope subject to failure (or even downhill from an active landslide) is exempt from review.

Multnomah County's regulatory role for landslides in areas within the Urban Growth Boundary is limited by the Urban Planning Area Agreement (UPAA) between the county and cities, which gives the cities' planning authority within the UPAA. The only unincorporated area that is not covered by city zoning under the UPAA is part of Pleasant Valley along Foster Road. This area is not within the mapped landslide hazard areas.

The table on page 8-13 includes landslide mitigation action items from the master Action Items table in Chapter 4.

Table 8-9
Regulatory Landslide Hazard Map: West

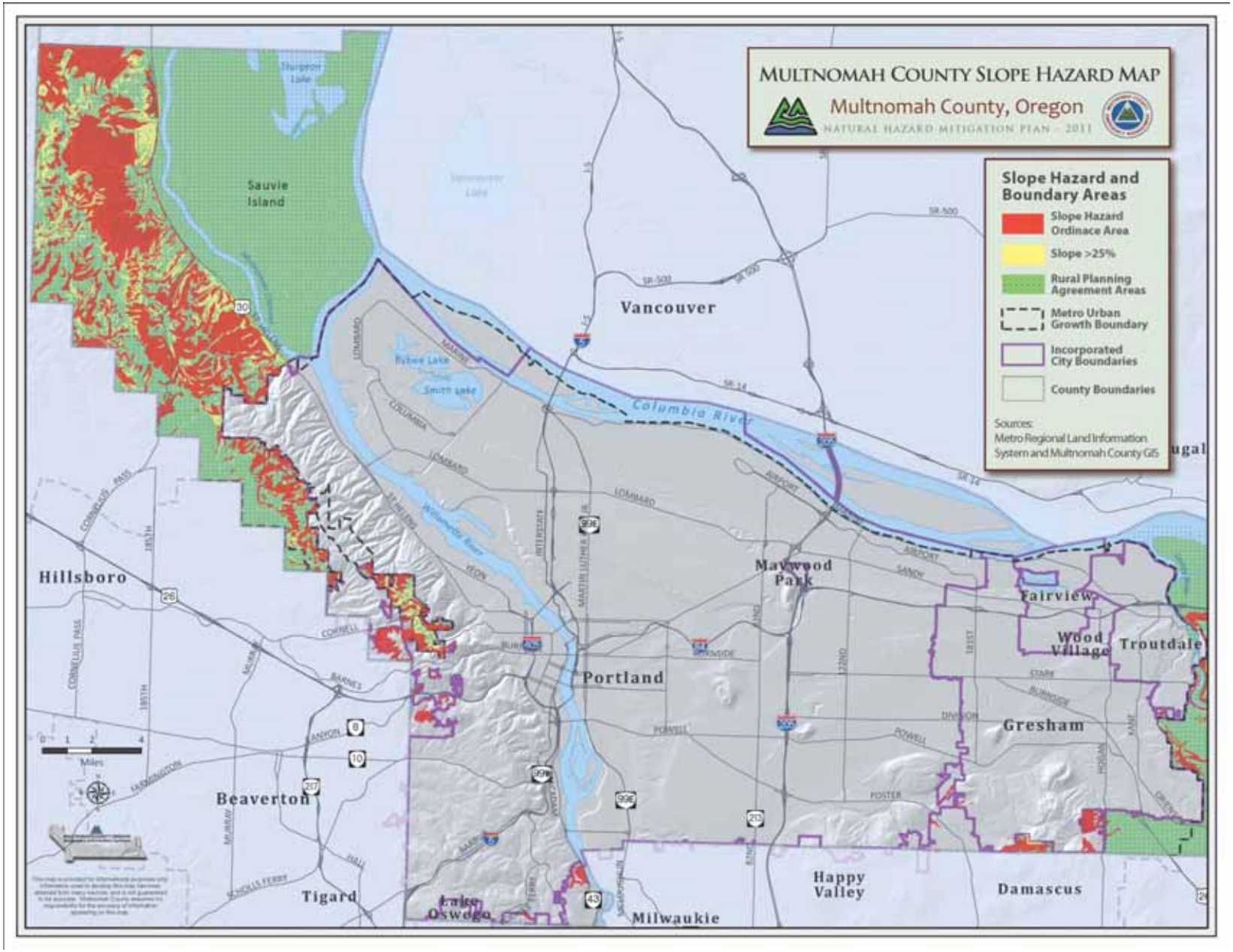


Figure 8-10
Regulatory Landslide Hazard Map: East

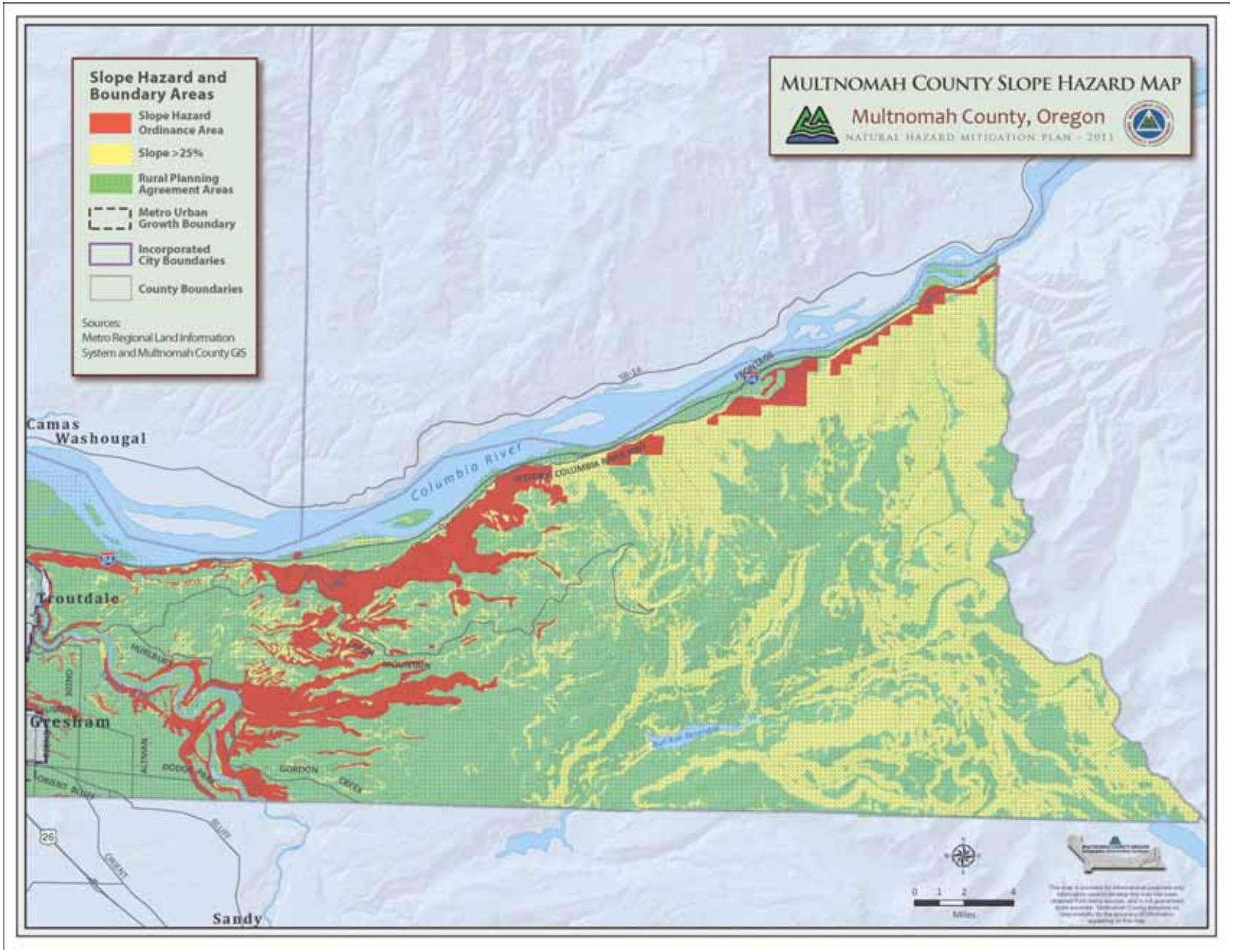


Table 8.3
Landslide Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Plan Goals Addressed				
				Life Safety	Protect Property and Infrastructure	Emergency Management Capabilities	Public Awareness and Education	Environmental Stewardship
Landslide Mitigation Action Items								
Short-Term #1	Inventory utility and communication infrastructure in areas with a history of landslides or which are within mapped landslide hazard areas.	GIS	1-2 Years		X	X	X	
Short-Term #2	Compile inventory of county road segments with a history of landslides or which are within mapped landslide hazard areas.	Transportation	3 Years		X	X		
Short-Term #3	Review the Hillside Development ordinance to consider amendments that address areas at risk from landslides for areas not already identified on the County Slope Hazard Map or otherwise subject to the Hillside Development zoning code.	Planning	3 Years	X	X		X	X
Short-Term #4	Obtain completed detailed lidar-based inventory of historical and active landslides and areas with high landslide risk to update the County's slope hazard maps.	GIS	Ongoing		X	X	X	
Long-Term #1	Encourage the relocation of identified critical or essential facilities and high occupancy facilities in high landslide hazard areas or mitigation of the landslide hazard if feasible.	Multnomah County Emergency Management	Ongoing	X	X	X	X	

9.0 FLOODS

Multnomah County is subject to flooding from several distinct flood sources, including:

1) overbank flooding from the Columbia River, Willamette River and Sandy River,
2) overbank flooding from the numerous smaller streams in Multnomah County,
3) potential floods from dam failures, and
4) local storm water drainage flooding.

Flooding events from the above possible flood sources have very different characteristics.

Floods on the Columbia River may occur from late fall through June, but are most common in late spring (May and June) when large contributions from snowmelt increase flows. Because the drainage area is very large, about 240,000 square miles, flood events are governed by the total rainfall and snowmelt over periods of a week or more. Multnomah County is protected from Columbia River floods by levees maintained by the Multnomah Drainage District #1, Sandy Drainage Improvement Company, Columbia Drainage District and the Sauvie Island Drainage District. The probability of levee failures is generally low, based on the construction and height of the levees, but extreme flood events could result in overtopping of the levees and/or levee failures. See Section 9.3 for further discussion of these levees.

Floods on the Willamette River may also occur from late fall through spring, with flooding most common in late fall and winter months. Floods on the Willamette arise from extended periods of rainfall, typically with contributions from snowmelt. Because the drainage area, about 11,000 square miles, is much smaller than that of the Columbia River, floods on the Willamette River are governed by total rainfall and snowmelt over shorter time periods, from a few days to a week or so. Parts of Multnomah County are protected from flooding on the Willamette River by levees and floodwalls maintained by the Port of Portland.

Flooding events on the Columbia River and Willamette River often occur at the same time, although the severity of flooding may differ.

Floods along the Sandy River and the small creeks in Multnomah County typically occurs from late fall or winter storms with intense rainfall, with flooding sometimes exacerbated by snow-melt runoff. Because the drainage areas are small, the streams' response time to rainfall is rapid and flood events tend to be governed by the amount of rainfall in relatively short periods of a few hours to a day or two. None of these smaller waterways have levees or flood walls. Flooding these

smaller waterways often occurs without flooding on the Columbia River and Willamette River, although flood events may also coincide. See Section 9.2 for further discussion of overbank flooding from these sources.

Flooding from failures of one or more dams along the Columbia River or the Willamette River and their tributaries is relatively unlikely because the dams are generally well-designed and well-maintained. However, the fact that a dam failure is possible, it cannot be ignored. See Section 9.5 for further discussion of possible dam failures.

In addition to overbank flooding from the above waterways, portions of Multnomah County are also subject to localized storm water drainage. Storm water drainage flooding occurs when inflows of storm water exceed the conveyance capacity of the local storm water drainage system. See Section 9.5 for further discussion of localized storm water drainage flooding.

9.1 Historical Floods in Multnomah County

Historically, flooding has occurred in the Multnomah County area throughout the recorded history. Flooding from the Columbia River was frequent in the 19th century and early 20th century, but has been greatly mitigated by the construction of extensive levee systems. Flooding has also occurred along the Sandy River and along the numerous smaller local creeks in Multnomah County.

Significant floods occurred on the Columbia River and Multnomah River in 1861, 1880, 1881, 1909, 1913, 1927, 1928, 1942, 1946, 1948, 1961, 1964/1965, 1996 and 2007. The construction of flood control infrastructure on the Columbia River and Willamette River has reduced, but not eliminated, the potential for major flood events on these rivers.

Notable historical flood events affecting Multnomah County include:

- 1948. Memorial Day flood on the Columbia River. This flood destroyed the town of Vanport, a community of 18,000 people. Lower elevations in Multnomah County, including portions of the Columbia River Highway, and especially the Sandy River delta area also experienced substantial flood damages.
- 1964. Christmas Day flood on the Sandy River. This flood damaged or destroyed about 750 homes along the Sandy River. In Multnomah County, the Columbia River Highway was washed out at the east end of the Beaver Creek Bridge.
- 1996. Major flooding occurred throughout almost the entire state in February from a combination of warm temperatures, heavy snowpack and four days of record breaking rain. Flooding was extensive in Multnomah County with widespread closures of major highways and secondary roads.

- 1999. Widespread flooding occurred on smaller rivers and streams which arose from heavy snowfalls in late January followed by warm temperatures and heavy rains in February. In addition to flood damage, there were numerous landslides and mudslides. The Historic Columbia River Highway east of the Sandy River Bridge was covered with slides coming from the cliffs above. One such mudslide pushed an entire house into the Sandy River resulting in the death of one person.
- 2007. Severe storms with flooding, winds, mudslides and landslides occurred between December 1st and December 17th. Many roads were closed and there were significant damages to public infrastructure, homes and businesses.
- 2009. On January 1st, Portland received 3.04 inches of rain from a warm tropical storm ("Pineapple Express") which combined with extensive snowmelt from heavy snowfall in December. Flood elevations in Johnson Creek were the second highest recorded and flooding also occurred on other streams in Multnomah County.

Figure 9.1
Vanport Flood of 1948

9.2 Flood Hazards and Flood Risk: Within Mapped Floodplains

9.2.1 Overview

The FEMA Flood Insurance Rate Maps (FIRMs) delineate the regulatory (100-year) floodplain areas. The maps for Multnomah County were updated on December 18, 2009.

FEMA floodplain maps typically include the following types of areas:

1. **Zone AE**: Areas with a 1% annual chance of flooding with detailed flood hazard data, including base flood elevations (the elevation of the 100-year flood).

2. **Zone A**: Unnumbered A-Zones, within 100-year flood plain, but without detailed flood hazard data (no base flood elevations).

3. **Zone AH**: Flood depths of 1 to 3 feet (usually areas of ponding), including base flood elevations.

4. **Zone X (Shaded)**: Areas of 0.2% annual chance flood (500-year flood), areas of 1% annual chance flood (100-year flood) with average depths of less than 1 foot, or with drainage areas of less than 1 square mile and areas protected by levees from the 1% annual chance flood.

5. **Zone X (Unshaded)**: Areas determined to be outside of the 0.2% annual chance flood (500-year flood).

The FEMA mapped floodplains (2009 Map) within Multnomah County are shown as Figures 9.2 and 9.3 on the following pages.

The FEMA floodplain maps delineate the 100-year floodplain boundaries and other potentially flood-prone areas as defined above. The 100-year flood is the flood with a 1% chance of being exceeded in any given year. A 1% annual chance of flooding corresponds to about a 26% chance of flooding in a 30-year time period. Detailed floodplain boundaries are shown on the Flood Insurance Rate Maps.

The FEMA Flood Insurance Study and Flood Insurance Rate Maps include a large number of terms of art and acronyms. A good summary of the terms used in flood hazard mapping is available on the FEMA website at:

http://www.fema.gov/pdf/floodplain/nfip_sg_appendix_d.pdf

Figure 9.2
FEMA-Mapped Floodplains within Multnomah County – West

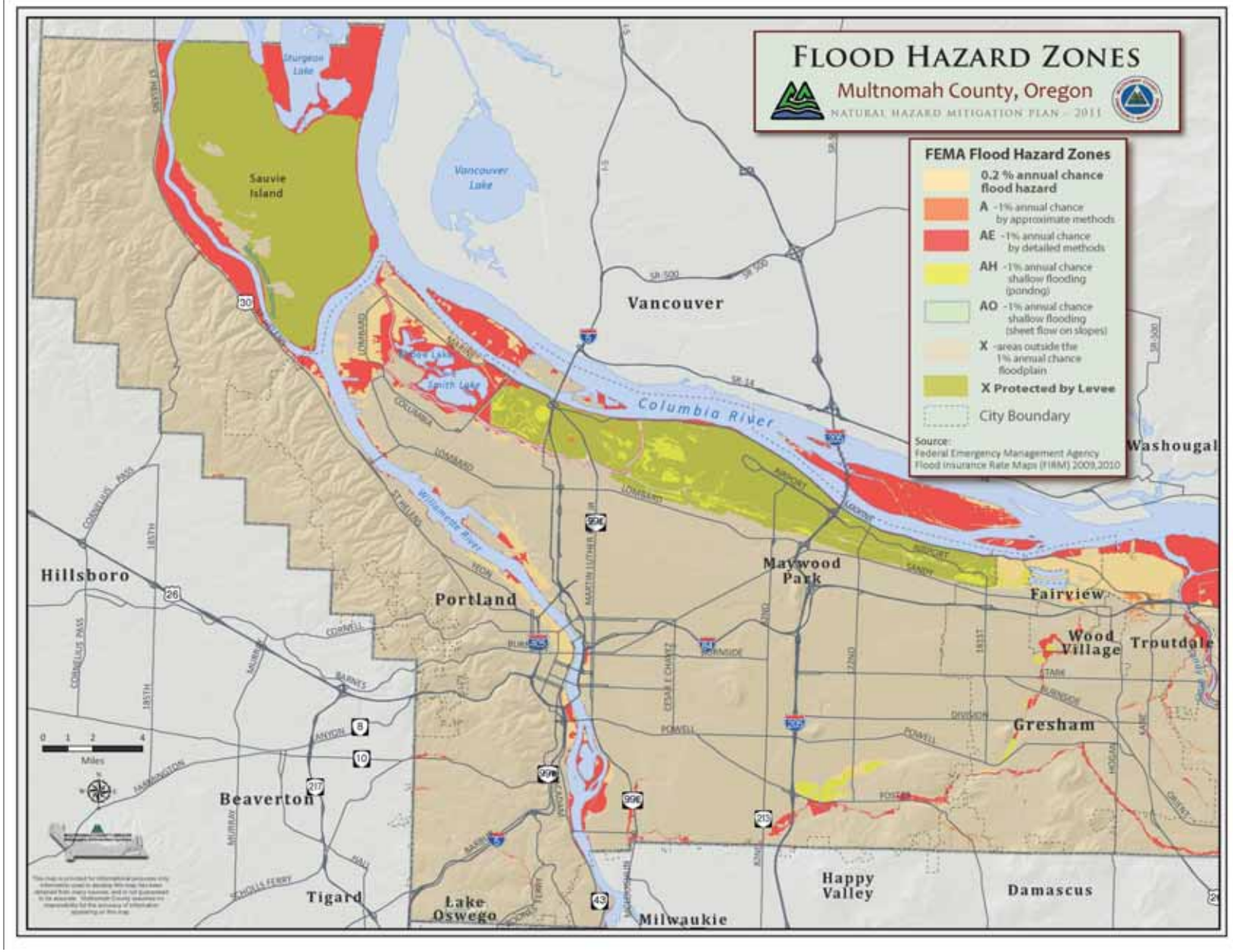


Figure 9.3
FEMA-Mapped Floodplains within Multnomah County - East

As shown in the preceding figures, there are many areas within Multnomah County within the FEMA-mapped floodplains or protected by levees. The majority of these at-risk areas are located along the Columbia River, with significant at-risk areas along the Willamette River and the Multnomah Channel, which separates Sauvie Island from the western part of Multnomah County. There are also smaller FEMA-mapped floodplains along the Sandy River and numerous smaller streams.

However, an important caveat on the interpretation of the FEMA Maps shown in Figures 9.2 and 9.3, is that some of the large areas, including a large area that includes Portland International Airport and much of Sauvie Island are classified as Zone X. These areas are protected by levees and thus subject to flooding only in extreme flood events or unanticipated levee failures.

9.2.2 Flood Hazard Data

For mapped 100-year floodplain areas (AE Zones), 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.

Table 9.1
Flood Hazard Data
Sandy River: At Columbia River Highway

Flood Frequency (years)	Discharge (cfs)	Elevation (feet)
10	48,000	35.8
50	72,000	39.2
100	82,800	40.6
500	129,200	45.0

The stream discharge data shown above for the Sandy River is from Table 6 on page 22 of the December 18, 2009 Flood Insurance Study for Multnomah County. 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 52P in the Flood Insurance Study. 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 data shown above are for Cross Section H, at the East Columbia Highway Bridge.

Quantitative flood hazard data such as shown above, are 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. Such quantitative flood hazard data are also necessary for benefit-cost analysis of mitigation projects to reduce the level of flood risk for a particular building or other facility.

For a given location, the level of flood risk varies dramatically depending on the first floor elevation of each building or other facility. For example, in the area near the Columbia River Highway Bridge, a building with a first floor elevation of 33 feet is expected to experience flooding above the first floor more frequently than every 10 years on average. However, a nearby building, with a first floor elevation of 41 feet would be expected to experience flooding above the first floor only about once every 100 years on average.

9.6.3 Caveats for the Multnomah County Flood Insurance Study

The Flood Insurance Study (FIS) for Multnomah County and vicinity was current as of 2009. Over time, flood hazards may gradually change because of increasing development upstream, changes in stream channels, improvements (or degradation) of flood protection measures over time and other changes, including climate change. Therefore, Flood Insurance Studies which are 10 or 20 years old are more likely to be inaccurate than more recent studies. The older a study is, the more likely it is that channel or watershed conditions have changed over time.

Another caveat is that flood studies are inevitably less than perfect, due to incomplete data and modeling uncertainties. Thus, in some cases, mapped floodplain boundaries may underestimate or overestimate the actual level of flood risk at a given location.

9.2.4 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. This simplistic view is simply not true. Some important guidance for interpreting flood hazards 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. Within or near the 100-year floodplain, the key determinant of flood hazard for a building or other facility is the relationship of the elevation of the structure or facility to the flood elevations for various flood events. Thus, for example, homes with first floor elevations below or near the 10-year flood elevation have drastically higher levels of flood hazard than other homes with first floor elevations near the 50-year or 100-year flood elevations or at higher elevations.

C. Much flooding happens outside of the mapped 100-year floodplain.

   a. The 100-year flood is not the worst possible flood. Floods greater than the 100-year event will flood many areas outside of the mapped 100-year floodplain.

   b. Areas protected by levees may flood if the levees fail.

   c. Some flood prone areas flood because of local storm water drainage conditions which are unrelated to the 100-year floodplain boundaries (see Section 9.5 below).

9.3 Levee Systems Protecting Multnomah County

9.3.1 Eastern Multnomah County

The low portions of Multnomah County south of the Columbia River are protected from Columbia River flooding by a substantial system of levees. The Columbia River levees were first built between 1915 and 1920, with extensions eastwards to the Sandy River completed in 1939. Over the ensuing years, the levees have been raised and strengthened several times.

There are four drainage districts which own the levees extending from west of Interstate 5 to the Sandy River on the east as shown in Figure 9.4 on the following page.

The four drainage districts shown above in Figure 9.4 from west to east are:

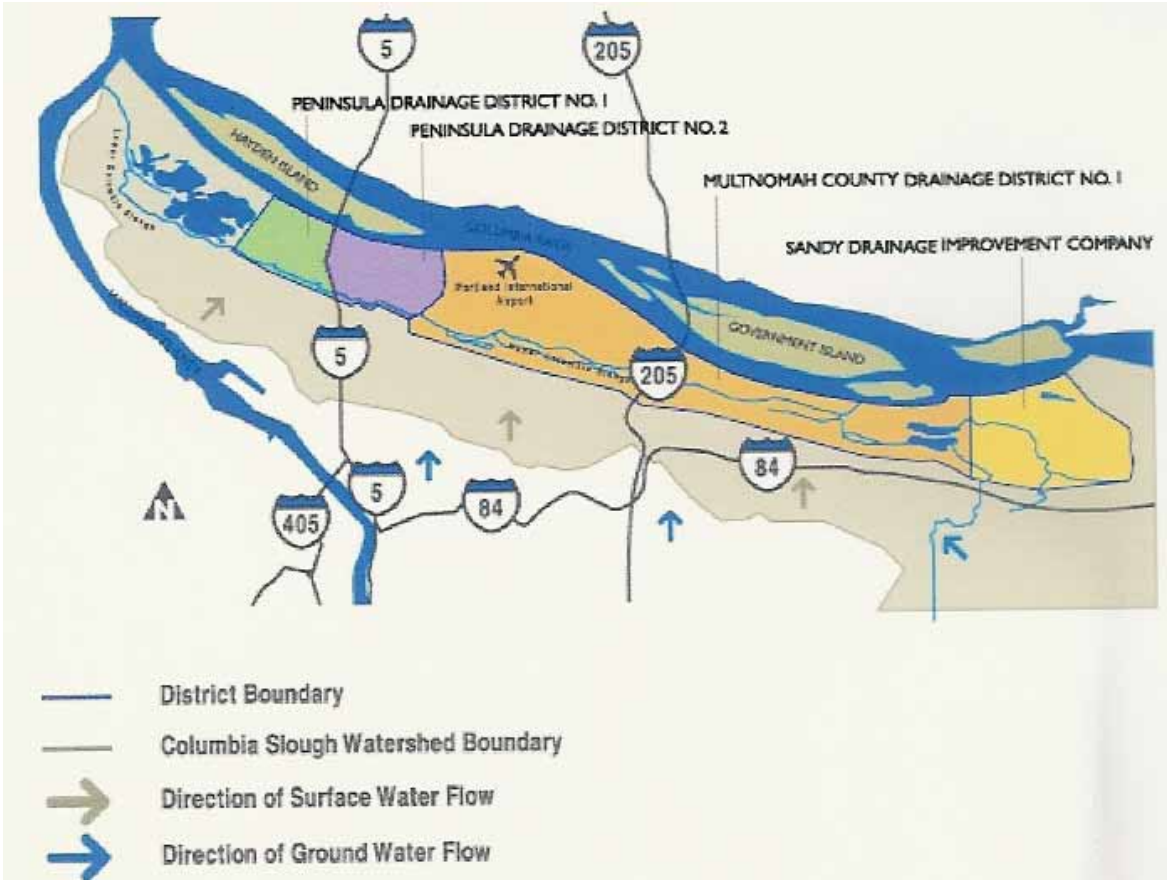
- Peninsula Drainage District No. 1, formed in 1917.
- Peninsula Drainage District No. 2, formed in 1917.
- Multnomah County Drainage District No. 1, formed in 1917.
- Sandy Drainage Improvement Company, formed in 1915.

Although there are four separate drainage districts, the Multnomah County Drainage District No.1 manages and operates all four systems, with contracts from the other three drainage districts.

The main components of this levee system include:

- Approximately 28 miles of levees along the Columbia River,
- Six cross levees between the Columbia River levees and high ground on the south side of the districts,
- An extensive drainage and pumping system behind the Columbia River levees.

Figure 9.4
Columbia River Drainage Districts



The main levees along the Columbia River provide the primary flood protection. Elevations of the levee tops range from about 41 to 44 feet. These levees have substantial overbuild beyond the minimum required elevations to provide 100-year flood protection. In the vicinity of Multnomah County, the 100-year and 500-year flood elevations are approximately 30.5 to 31 feet and 33.8 to 34.5 feet, respectively.

The cross levees provide important flood protection by limiting the extent of flooding if the main levees are breached.

The drainage and pumping system removes water from levee toe drains, rainfall, and streamflow into the protected area behind the levees.

9.3.2 Western Multnomah County

Sauvie Island, which is bordered by the Columbia River, Willamette River and the Multnomah Channel, is located partly in Multnomah County and

partly in Columbia County. Sauvie Island is protected by levees owned and operated by the Sauvie Island Drainage Improvement Company.

The Sauvie Island Drainage Improvement Company manages the levee and canal system on the southern half of Sauvie Island. The levee protects 11,200 acres from flooding and is surrounded by the Columbia and Willamette Rivers as well as the Multnomah Channel and Sturgeon Lake. The levee is approximate 18 miles in length and divided into four segments. The elevation of the levee ranges from 33 to 36 feet. Levee construction began in the late 1930's and is constructed of material dredged from the Colombia River and pits and canals dug on the island. The main Pump House was constructed in 1941 and houses four pumps capable of evacuating 125,000 gallons-per-minute of water at varying river levels. The interior of the drainage system consists of over 30 miles of canals and ditches to convey rain, seepage and spring water from the interior of the levee to the Multnomah Channel.

9.4 Flood Hazards and Flood Risk: Outside of Mapped Floodplains

Sections 9.2, 9.3 and 9.4 above apply only to the areas of Multnomah County that are within the FEMA-mapped floodplains and/or within areas of potential flooding due to levee or dam failures. In addition, other areas of Multnomah County may also be at relatively high risk from over bank flooding along streams too small to be mapped by FEMA or in localized stormwater drainage problem areas.

Many areas of the United States outside of mapped floodplains are subject to repetitive, damaging floods from local stormwater drainage. Nationwide, more than 25% of flood damage occurs outside of FEMA-mapped floodplains.

In most locations, stormwater drainage systems are designed to handle only small to moderate size rainfall events. Stormwater 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 stormwater 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 stormwater that exceeds the capacity of the stormwater drainage system. In larger rainfall events, flooding may extend beyond streets to include yards. In major rainfall events, local stormwater drainage flooding can also flood buildings. In extreme cases, local stormwater drainage flooding can sometimes result in several feet of water in buildings, with correspondingly high damage levels.

For Multnomah County, stormwater drainage problems have been minor, with no locations known to have significant flooding problems within the unincorporated areas. Storm water drainage problems within the incorporated cities are

addressed in their mitigation plans and are not included here. The County's current regulations for new storm water drainage systems require control of the 10-year 24-hour storm; however, many older drainage systems are built to lower standards.

9.5 Dam Failures

9.5.1 Columbia River Watershed

There are about 75 large dams and numerous smaller dams on the Columbia River and its tributaries which provide hydroelectric power, water for many purposes and flood control. A full analysis of the design and safety levels vis-à-vis floods, earthquakes and other hazards for all of these dams is beyond the scope of this mitigation planning effort. For reference, Figure 9.5 below shows some of the major dams.

The dams within the Columbia River drainage area are operated by federal agencies, state, provincial or local governments, public utilities and private owners. The four large dams on the Columbia River within Oregon are: Bonneville Dam, The Dalles Dam, John Day Dam and McNary Dam. These dams are maintained and operated by the US Army Corps of Engineers.

Figure 9.5
Dams in the Columbia River Watershed

In the very unlikely, but not impossible, failure of one or more of these dams, severe flooding could occur along the Columbia River. Worst case scenario flood events are shown by dam failure inundation maps with dam failure at the spillway design flood. These inundation maps are worst case scenarios, designed for emergency planning purposes only, and do not indicate that any of these dams are unsafe.

An excerpt from the maximum inundation map for Multnomah County in the event of failures of the McNary, John Day, The Dalles or Bonneville Dam is shown below in Figure 9.6 (USACE, Guidelines for Flood Emergency Plans with Inundation Maps, Bonneville Dam, Columbia River, Oregon and Washington, December 1989).

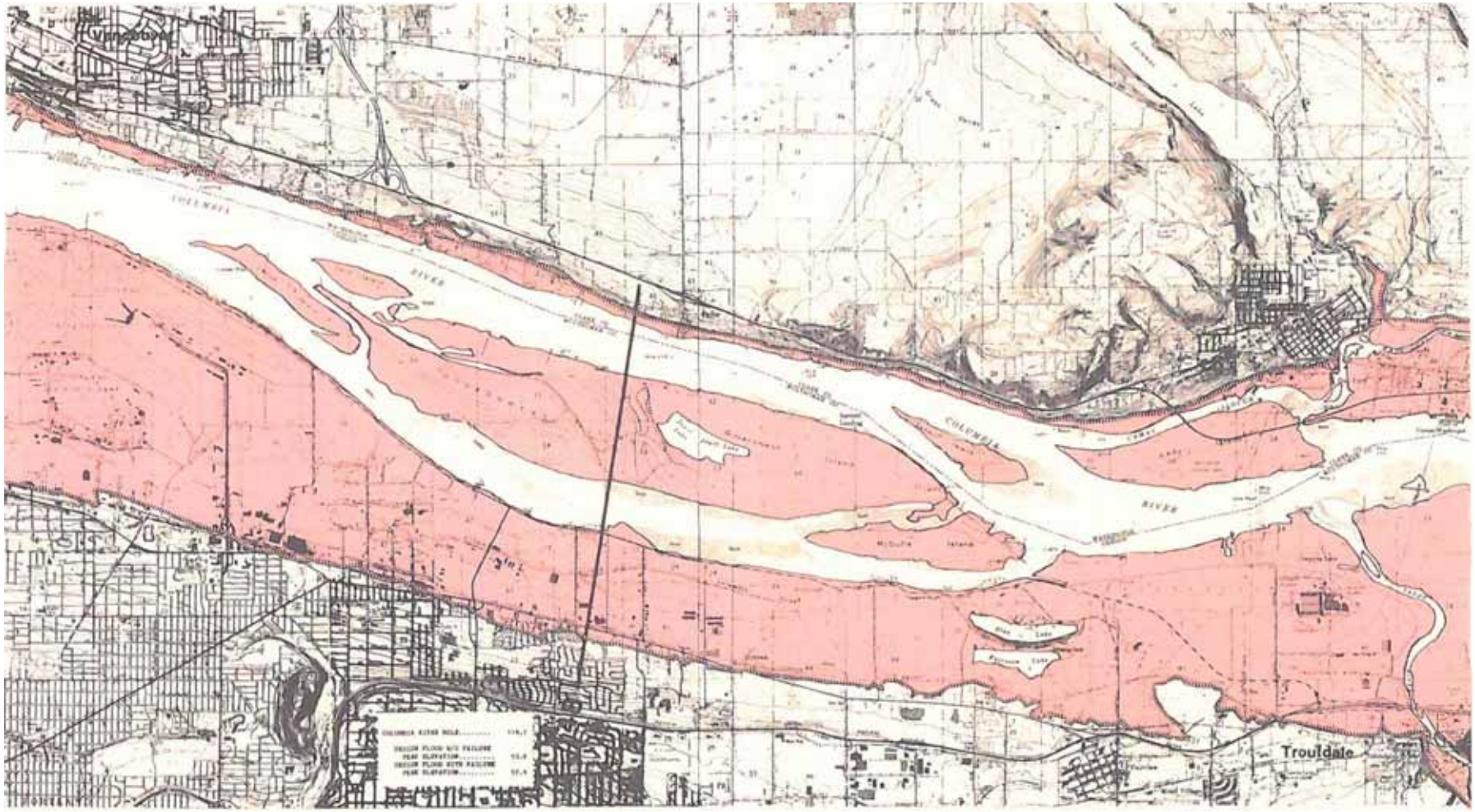
The pink-shaded area shows the inundation area for the spillway design flood without dam failure. The narrow hatched border shows the additional inundation area for the spillway design flood with dam failure. These are worst-case scenarios with a full reservoir pool coincident with dam failures and a spillway design flood.

As shown in Figure 9.6, substantial portions of Multnomah County along the Columbia River would be inundated in the worst case scenario of a spillway design flood event with or without dam failure. For the spillway design flood, the increase in inundated areas is minor.

It is important to recognize that dam failures at normal full pool would result in markedly smaller flood events. For example, for the John Day Dam, the flood elevation would be about 24 feet lower than the worst case scenario summarized above, resulting in no inundation behind the existing levees.

Thus, dam failures pose relatively little risk except for the truly worst case scenario of dam failures coincident with a spillway design flood.

Figure 9.6
Maximum Dam Failure Inundation Map for
McNary, John Day, The Dalles and Bonneville Dams



9.5.2 Multnomah County Watersheds and Willamette River Watershed

Figure 9.7 and 9.8 show dams within Multnomah County and dams in the Willamette watershed upstream of the County.

Failures of any of the dams within Multnomah County would result in localized flooding within watersheds downstream of the dam. Two example inundation maps are shown in Figure 9.9 and 9.10 for the Bull Run Dam and Mt. Tabor Reservoirs, respectively.

Failure of the Bull Run Dam would result in major flooding along Bull Run and the Sandy River downstream of the confluence with Bull Run. The possible inundation area includes large portions of Troutdale and the large area behind the Columbia River levees, including the Portland International Airport.

Failure of the Mt. Tabor Reservoirs would result in localized flooding within the City of Portland between Mt. Tabor and the Willamette River.

Failure of any one or more of the major dams upstream on the Willamette River could result in substantial flooding along the lower Willamette River. However, the extent of flooding would depend strongly on river levels at the time of dam failure, the amount of available storage in dams downstream of a dam which failed and whether or not progressive failure of downstream dams were to occur.

Figure 9.7
Dams Within Multnomah County

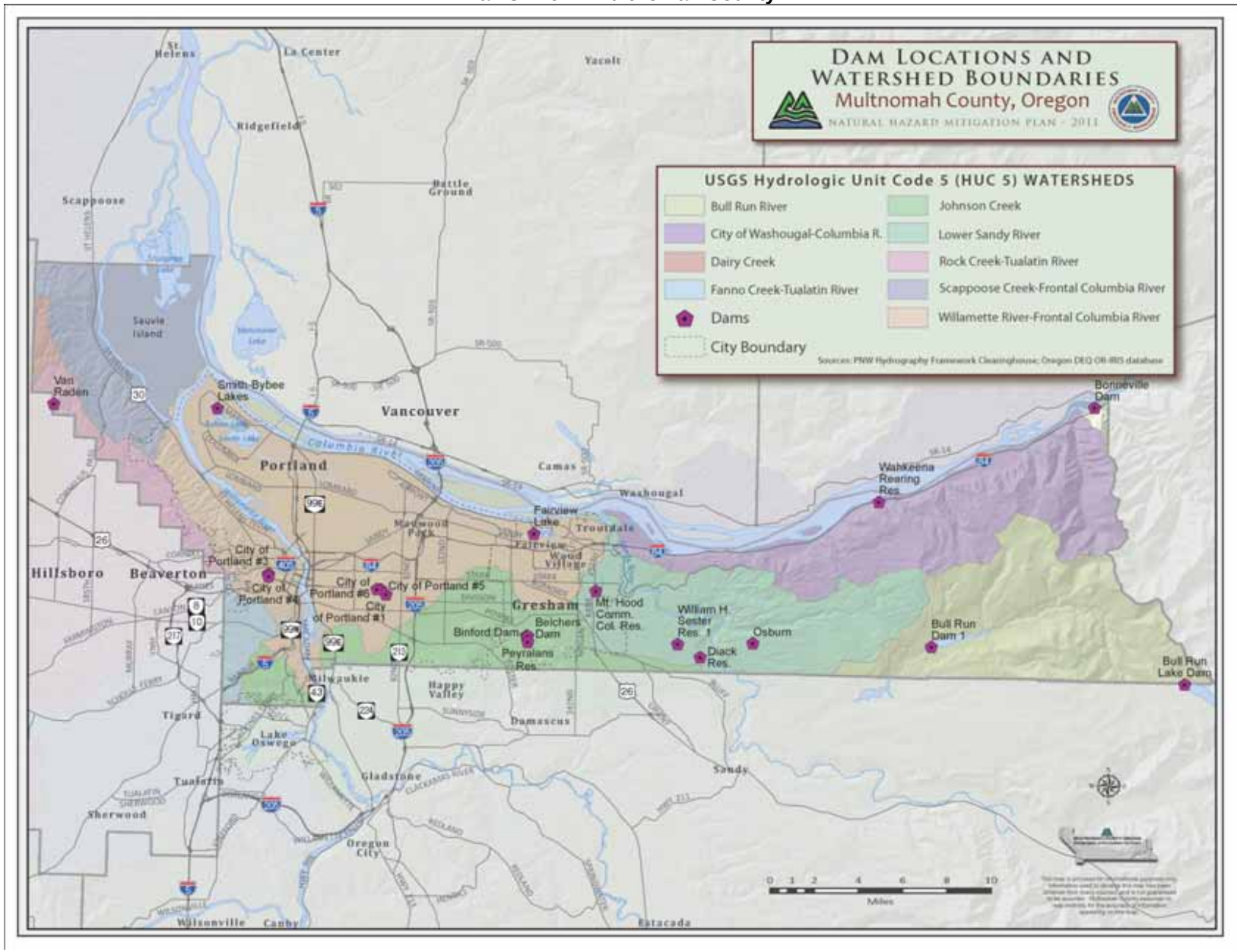


Figure 9.8
Willamette River Watershed: Major Dams Upstream of Multnomah County

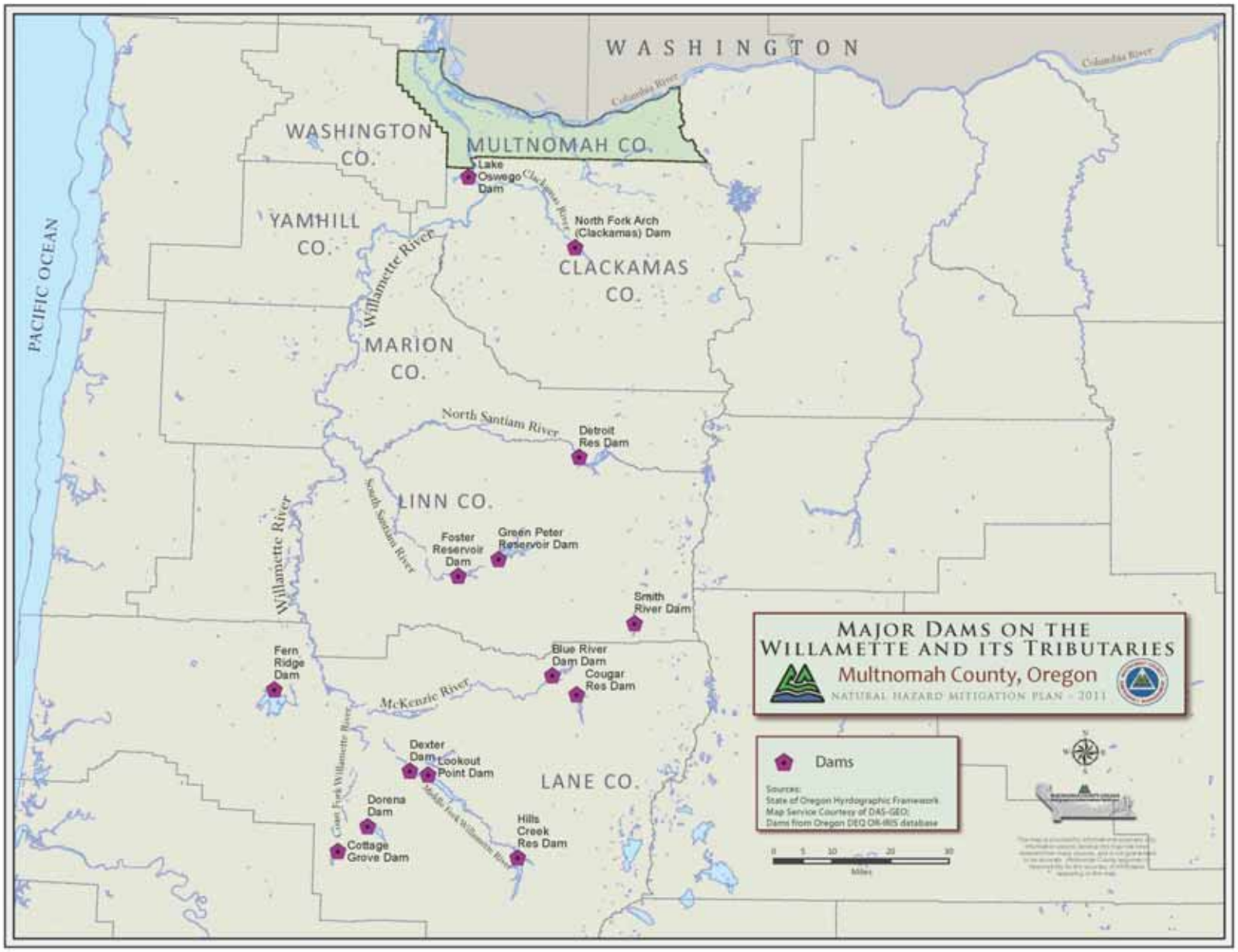


Figure 9.9
Inundation Map: Bull Run Reservoir

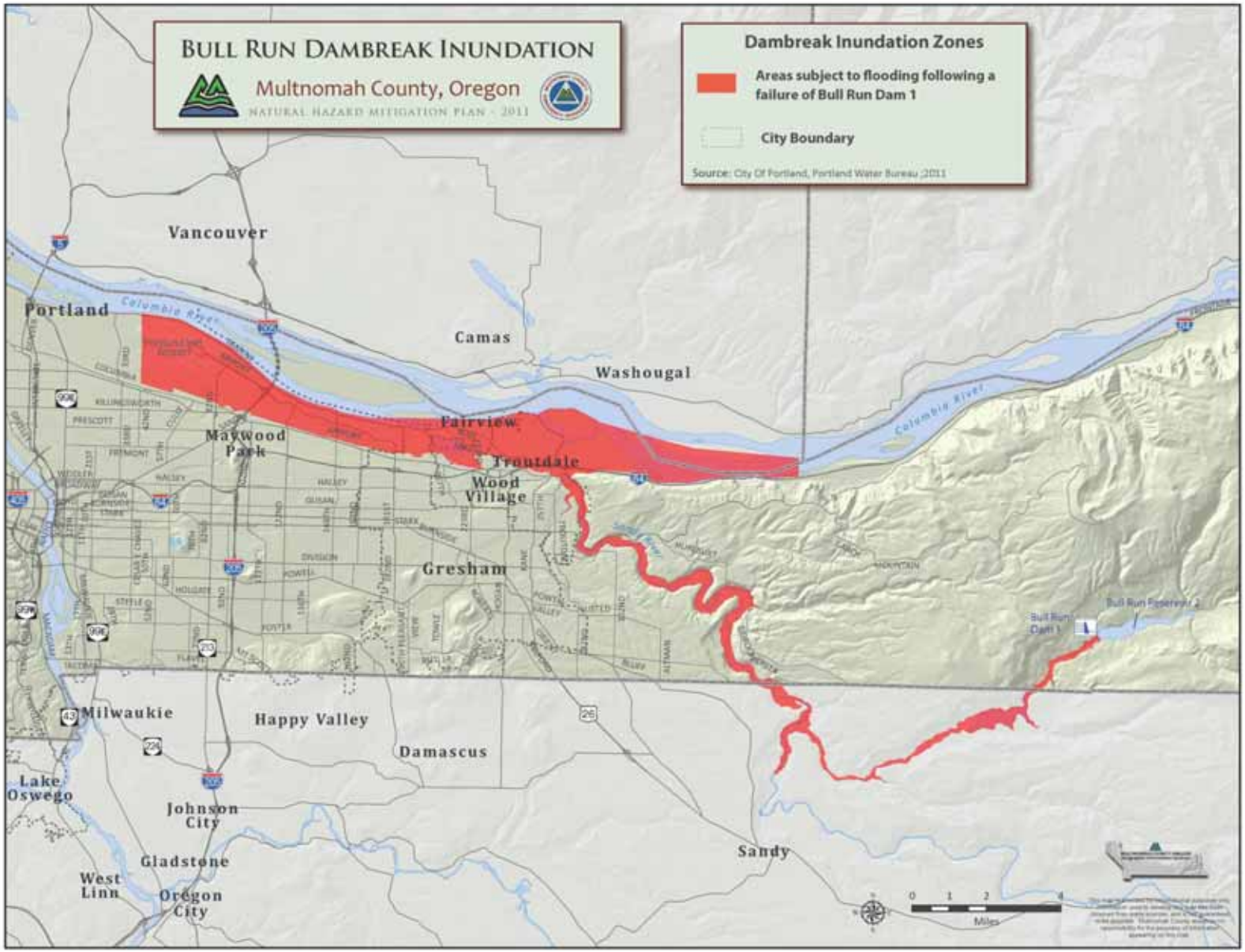
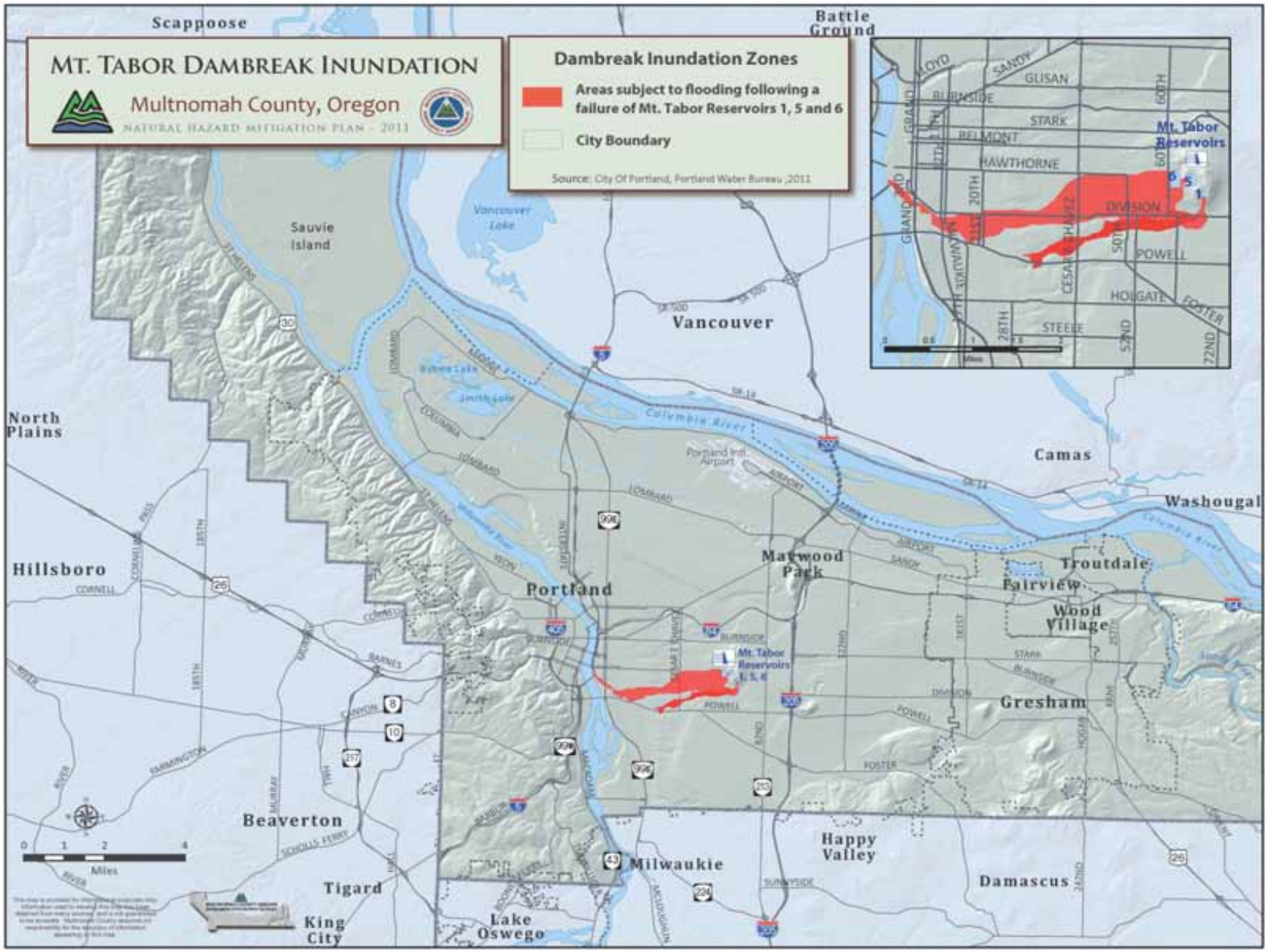


Figure 9.10
Inundation Map: Mt. Tabor



Reservoirs

9.6 Inventory Exposed to Flood Hazards in Multnomah County

The inventory of buildings within Multnomah County's FEMA mapped floodplains has been evaluated by overlaying the mapped floodplains Data are drawn from assesor's records and the 2009 Flood Insurance Rate Maps for Multnomah County.

Table 9.2
Multnomah County: All Buildings
Incorporated and Unincorporated Areas (Entire County)

Data Set	Industrial	Commercial	Multi-Family Residential	Parks - Open Space	Mixed Use Residential	Single-Family Residential	Mixed Use Employment	Rural	**Total**
Buildings	7,233	93	39,300	761	23,935	210,160	1,104	9,478	**292,064**
County Bldgs	32	0	5	9	68	16	2	7	**139**
Population	9,420	851	141,226	19,497	105,535	441,325	4,476	13,004	**735,334**

Table 9.3
Multnomah County: All Buildings
Unincorporated Areas Only

Data Set	Industrial	Commercial	Multi-Family Residential	Parks - Open Space	Mixed Use Residential	Single-Family Residential	Mixed Use Employment	Rural	**Total**
Buildings	30	0	15	0	0	2,061	4	8,731	**10,841**
County Bldgs	0	0	0	0	0	0	0	7	**7**
Population	2	0	272	0	0	4,144	0	11,781	**16,199**

Table 9.4
FEMA-Mapped Floodplains: All Buildings
Unincorporated Areas

Data Set	Industrial	Commercial	Multi-Family Residential	Parks - Open Space	Mixed Use Residential	Single-Family Residential	Mixed Use Employment	Rural	**Total**
0.2 %annual chance	4	0	0	0	0	177	0	48	**229**
A 1% annual chance	0		0	0	0	0	0	3	**3**
AE 1% annual chance	13	0	0	0	0	18	0	293	**324**
AH 1% annual chance	0	0	0	0	0	4	0	0	**4**
AO 1% annual chance	0	0	0	0	0	0	0	0	**0**
X outside 1% annual chance	13	0	15	0	0	1,860	4	8,039	**9,931**
X protected by levee	0	0	0	0	0	0	0	347	**347**
Total									**10,838**

Table 9.5
FEMA Mapped Floodplains: County Buildings Only
Unincorporated Areas

Data Set	Industrial	Commercial	Multi-Family Residential	Parks - Open Space	Mixed Use Residential	Single-Family Residential	Mixed Use Employment	Rural	**Total**
0.2 %annual chance	0	0	0	0	0	0	0	0	**0**
A 1% annual chance	0	0	0	0	0	0	0	0	**0**
AE 1% annual chance	0	0	0	0	0	0	0	0	**0**
AH 1% annual chance	0	0	0	0	0	0	0	0	**0**
AO 1% annual chance	0	0	0	0	0	0	0	0	**0**
X outside 1% annual chance	0	0	0	0	0	0	0	7	**7**
X protected by levee	0	0	0	0	0	0	0	0	**0**
Total									**7**

Table 9.6
FEMA Mapped Floodplains: All Buildings
Incorporated Areas

Data Set	Industrial	Commercial	Multi-Family Residential	Parks - Open Space	Mixed Use Residential	Single-Family Residential	Mixed Use Employment	Rural	**Total**
0.2 %annual chance	799	1	335	59	1,247	1,046	18	3	**3,508**
A 1% annual chance	27	0	0	0	7	17	0	0	**51**
AE 1% annual chance	682	0	241	39	840	419	21	161	**2,403**
AH 1% annual chance	79	0	150	2	8	583	9	2	**833**
AO 1% annual chance	6	0	0	1	0	0	0	0	**7**
X outside 1% annual chance	4,318	86	38,658	534	21,555	205,366	704	494	**271,715**
X protected by levee	1,354	0	0	51	284	536	355	79	**2,659**
Total									**281,176**

Table 9.7
FEMA Mapped Floodplains: County Buildings Only
Incorporated Areas

Data Set	Industrial	Commercial	Multi-Family Residential	Parks - Open Space	Mixed Use Residential	Single-Family Residential	Mixed Use Employment	Rural	**Total**
0.2 %annual chance	4	0	0	0	7	0	0	0	**11**
A 1% annual chance	0	0	0	0	0	0	0	0	**0**
AE 1% annual chance	0	0	0	7	1	0	0	0	**8**
AH 1% annual chance	0	0	0	0	0	0	0	0	**0**
AO 1% annual chance	0	0	0	0	0	0	0	0	**0**
X outside 1% annual chance	21	0	5	2	57	15	1	0	**101**
X protected by levee	3	0	0	0	0	0	0	0	**3**
Total									**123**

As shown in Table 9.4, there are 331 buildings within the 100-year floodplains in the unincorporated parts of Multnomah County, along with an additional 229 buildings within the 500-year floodplains.

Tables 9.6 and 9.7 contain buildings within the mapped floodplains in the incorporated areas of Multnomah County. The incorporated cities have primary responsibility for these areas. The data are shown above for reference and because the Multnomah County has primary responsibility for county-owned buildings in the incorporated areas. As shown in Table 9.7, there are a total of 123 county-owned buildings in the incorporated areas. Of these 11 are in the 0.2 % annual chance areas (500-year floodplain), 11 are within the 1% annual chance areas (100-year floodplain) and 104 are in Zone X. The definitions of these flood zones were given previously on Page 9-4.

9.7 National Flood Insurance Program Compliance

This section and the data presented below is only for the unincorporated areas of Multnomah County. The incorporated cities have responsibility for NFIP compliance within their jurisdictions.

FEMA's National Flood Insurance Program (NFIP) maintains nationwide databases of flood insurance policies and repetitive loss properties.

9.7.1 Insurance Summary

NFIP's 2011 data shows the following policy information for unincorporated Multnomah County:

- Number of polices: 252 of which 103 are in the A-Zones,
- Insurance in force: $65,823,800
- NFIP claims paid:850,
- Total claims amount: $1,148,575 which is an average of about $13,500 per claim, and
- Number of repetitive loss buildings: 0.
- Number of structures within mapped floodplains were shown previously in Tables 9.4 to 9.7.

Previous NFIP data indicated 2 homes on the repetitive loss list; both homes have been mitigated and both are now within an area annexed by the City of Gresham.

NFIP insured properties are often given high priority for flood mitigation actions such as elevation or acquisitions (which always voluntary at the discretion of the owner).

9.7.2 Staff Resources

- At present, Multnomah County does not have a certified floodplain manager on staff.
- Multnomah County Land Use Planning staff provides floodplain review for building permits and our contract building departments carry out inspections. Our staff provide information to the public and work with the public to identify structures on digital FIRM maps.
- There are no known barriers to effective floodplain management. Mulnomah County has an effective floodplain management program, with a low density of development within the limited areas of mapped floodplains in the unincorporated parts of the County.

9.7.3 Compliance History

- Multnomah County is in good standing with the NFIP.
- Current violations: NONE
- Last Community Assistance Visit: August 3, 2006.
- A follow up Community Assistance Visit does not appear necessary at this time.

9.7.4 Regulation

- Multnomah County entered the NFIP in 1982. The Community Number is 410179.
- The effective date of the first FIS and FIRMs was June 15, 1982..
- The latest revised FIS and FIRMs were adopted by the County and became effective on November 30, 2009.
- The 2009 FIRMs are digital.
- Multnomah County's floodplain ordinance, which is included in Multnomah County's Building Regulations Chapter 29, exceeds FEMA's minimum requirements. This ordinance was amended in response to the 2006 Community Assistance Visit and became effective in October of 2008. Flood Management Area which met NFIP standards when adopted. It exceeds NFIP standards in at least two areas: balanced cut and fill is required in the floodplain and dwellings must have at least one foot of freeboard.
- The County issues floodplain development permits for structural and non-structural development in the floodplain. Notices of watercourse alterations are provided to DLCD as the state coordinating agency. County works with permit applicants to ensure complete application information, and issues a floodplain

development permit including any conditions necessary for compliance. Applicant is then required to obtain a building permit for projects that include structures. The county provides a zoning stamp of compliance on building plans, which the applicant then takes to the appropriate city for issuance of building permits. The county has formal written agreements with the cities that provide building permit and inspection services.

9.7.5 Community Rating System (CRS)

- Multnomah County does not yet participate in the Community Rating System, because of the low number of buildings in the unincorporated areas that are within the FEMA-mapped 100-year floodplain.
- The decision to not participate in the CRS will be reviewed periodically.

9.7.6 NFIP Continued Compliance Actions

Staff Resources

- Staffing levels and training are adequate for the program at this time.

Compliance

- A Community Assistance Visit is not needed at this point..

Regulation

- The County's flood hazard program has been updated by several efforts in recent years that together meet the county's flood plain management needs. These updates include the levee certification process in 2007, revisions of the Flood Hazard ordinance in 2008 and completion of the FEMA map modernization process in 2009.

Flood Risk Maps

- The County FIRMs were recently updated in 2009 and included new Lidar data for areas along the Columbia River.
- We are not aware of any areas that need new flood studies. However, as additional Lidar data become available it may be desirable to update the flood studies.

Community Outreach Activities

- The Multnomah County Land Use Planning website contains a link to the FIRMs for our jurisdiction along with a description of the map coverage and purposes. Addition additional web resources include::
    - FEMA Floodplain Elevation Certificate,
    - FEMA Floodproofing Certificate,
    - County Flood Plain Development Permit**,** and
    - Link to Multnomah County Code Chapter 29 Flood Hazard regulations.
- The planning division provides applications and individualized service an information at the planning counter.

9.8 Flood Mitigation Projects

Potential mitigation projects to reduce the potential for future flood losses cover a wide range of possibilities, which include:

- Levee improvements,
- Interior drainage and pumping improvements,
- Channel improvements
- Storm water drainage improvements
- Elevation or acquisition/demolition of high risk structures, deep within mapped floodplains or with a history of repetitive losses,
- Floodproofing measures, and
- Others.

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

Table 9.8
Flood Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Plan Goals Addressed				
				Life Safety	Protect Property and Infrastructure	Emergency Management Capabilities	Public Awareness and Education	Environmental Stewardship
Flood Mitigation Action Items: Within FEMA-Mapped Floodplains								
Short-Term #1	Complete an inventory and GIS mapping of structures, critical facilities and important transportation or utility system components within mapped floodplains and/or within areas subject to flood in the event of levee or dam failures, including elevation data.	GIS	1-2 Years			X	X	
Short-Term #2	Facilitate an identification and prioritization process for the purpose of defining a candidate list of localized inundation scenarios related to levee failures that result from different hazard events.	Multnomah County Emergency Management	1-2 Years	X	X	X		
Short-Term #3	Conduct a targeted risk assessment for all areas within the county containing public facilities, private industry and/or residential facilities which were previously flooded or flood prone.	Multnomah County Emergency Management	3 Years	X	X	X	X	
Short-Term #4	Use targeted flood risk assessments to educate stakeholders on need to take mitigation and/or preparedness actions in order to reduce flood hazard impacts.	Multnomah County Emergency Management	5 Years	X	X	X	X	
Short-Term #5	Encourage local jurisdictions to post high water marks around the county to aid citizens and first responders in visually assessing flood hazards.	Multnomah County Emergency Management	1-2 Years	X		X	X	
Long-Term #1	Implement mitigation actions for identified high risk buildings or infrastructure as funding becomes available.	Multnomah County Emergency Management	Ongoing	X	X	X	X	
Flood Mitigation Action Items: Outside of FEMA-Mapped Floodplains								
Short-Term #1	Complete an inventory and GIS Mapping of structures, critical facilities and important transportation or utility system components in locations with a history of severe or repetitive flooding.	GIS	1-2 Years	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 capacity.	Transportation	Ongoing	X	X	X		X

10.0 SEVERE WEATHER

10.1 Overview

Winter storms affecting Multnomah 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. Winter storms may also result in significant ice accumulations, which primarily affect the electric power system and transportation. This chapter deals primarily with the rain, wind, snow and ice effects of winter storms. Larger scale flooding is addressed in Chapter 9.

For completeness, we also briefly address other severe weather events, including severe thunderstorms, hail, lightning strikes and tornadoes in Section 10.5. However, the frequency, severity, and impacts of such severe weather events are generally minor for Multnomah County, compared to winter storm effects.

Winter storms can affect the area directly, with damage within Multnomah County, or indirectly, with damage outside the area but affecting transportation to/from the area and/or utility services (especially electric power). Historically, Multnomah County has often been subject to both direct and indirect impacts of winter storms. The winter storms that affect Multnomah 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 compiled by the Portland Office of the National Weather Service include the following major winter storm events in western Oregon:

1. January 9, 2009
2. December 14-15, 2008
3. December 1-3, 2007
4. December 14, 2006
5. February 7, 2002
6. February 6, 1996
7. December 12, 1995
8. November 13-15, 1981
9. March 25-26, 1971
10. October 2, 1967
11. March 27, 1963
12. October 12, 1962
13. November 3, 1958
14. December 21-23, 1955
15. December 4, 1951
16. November 10-11, 1951
17. April 21-22, 1931
18. January 20, 1921.

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 1962 Columbus Day windstorm stands out as the most severe such event for western Oregon.

The highest sustained wind speed recorded at the Portland Airport was 88 mph during the 1962 Columbus Day windstorm. The peak gust recorded during this storm was 104 mph before the wind equipment was damaged; thus the actual peak gust was likely higher than 104 mph.

10.2 Rain Hazard Data

Severe winter storms in Multnomah 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 snow melt. Flash floods, which are produced by episodes of intense heavy rains (usually 6 hours or less) or dam failures, are rare in western Oregon but do represent a potential meteorological hazard.

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

Multnomah County annual precipitation data are summarized in Table 10.1 below. These data are for the Portland airport site.

Table 10.1
Multnomah County Rainfall Data

Location	Average Annual Precipitation (inches)	Lowest Annual Precipitation (inches)	Highest Annual Precipitation (inches)	Period of Record
Portland Airport	36.84	22.48 (1985)	63.20 (1996)	1941-2010

Western Regional Climate Center website: www.wrcc.dri.edu

Average annual precipitation amounts are moderately high in Multnomah County, about 37 inches per year. As shown above, there are also substantial variations in annual rainfall from year to year. However, precipitation varies significantly within Multnomah County, with much higher precipitation at higher elevations, especially on the slopes of Mount Hood. For example, average annual precipitation at Government Camp (Clackamas County) is over 87 inches; similar values occur elsewhere at similar elevations.

The rainfall data shown in Table 10.1 give general overview of the potential for winter storm flooding in Multnomah County, but whether or not flooding occurs at specific sites depends heavily on specific local rainfall totals during individual storms and local drainage conditions. For example, 2" of rain in one area may

cause no damage at all, while 2" of rain in a nearby area may cause road washouts and flooding of buildings.

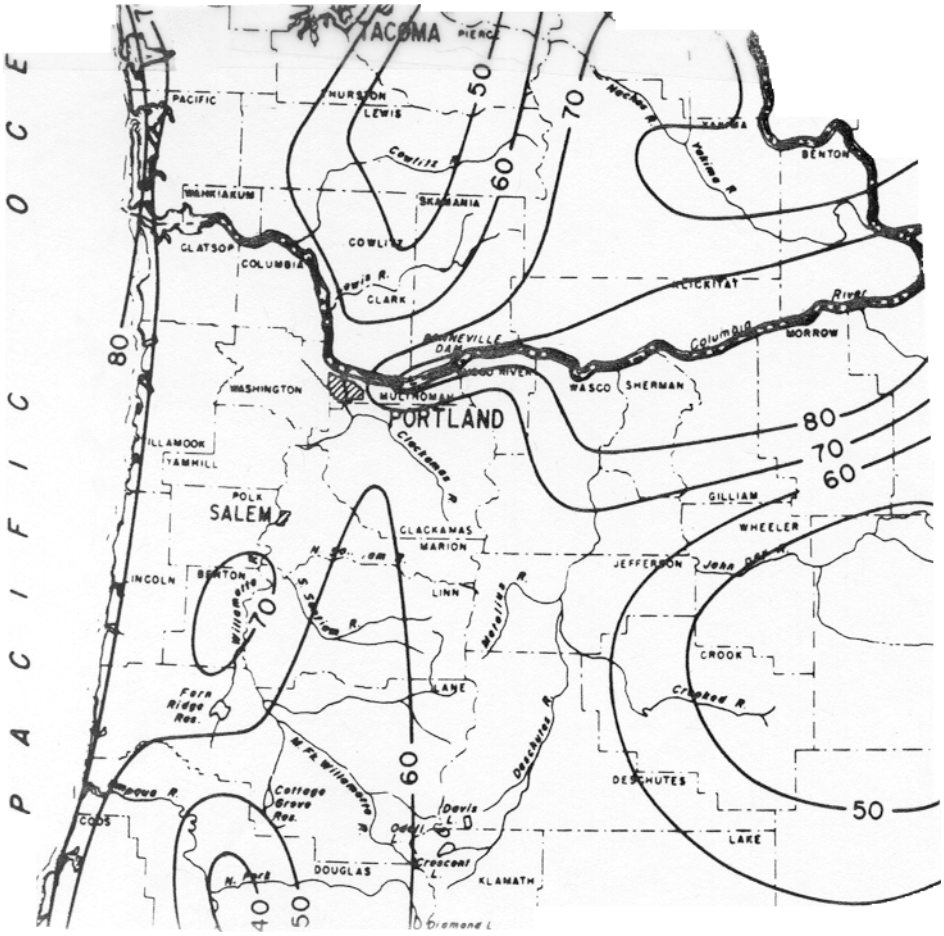
For Multnomah County, identification of specific sites subject to localized flooding during winter storms is based on historical occurrences of repetitive flooding events during past winter storm events. Most of these sites affect roads, rather than buildings. Flood data, including both overbank flooding from rivers and streams as well as localized flooding from stormwater drainage are addressed in Chapter 9.

10.3 Wind Hazard Data

Wind speeds associated with winter storms vary depending on meteorological conditions, but also vary spatially depending on local topography. For Multnomah County, high winds occur most commonly in eastern Multnomah County, along the Columbia River gorge and on Mount Hood.

The regional pattern wind hazards is shown by the contours in Figure 10.1, 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. 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 Multnomah County.

Figure 10.1
Wind Speed Contours for 2-Year Recurrence Interval
(km/hour)

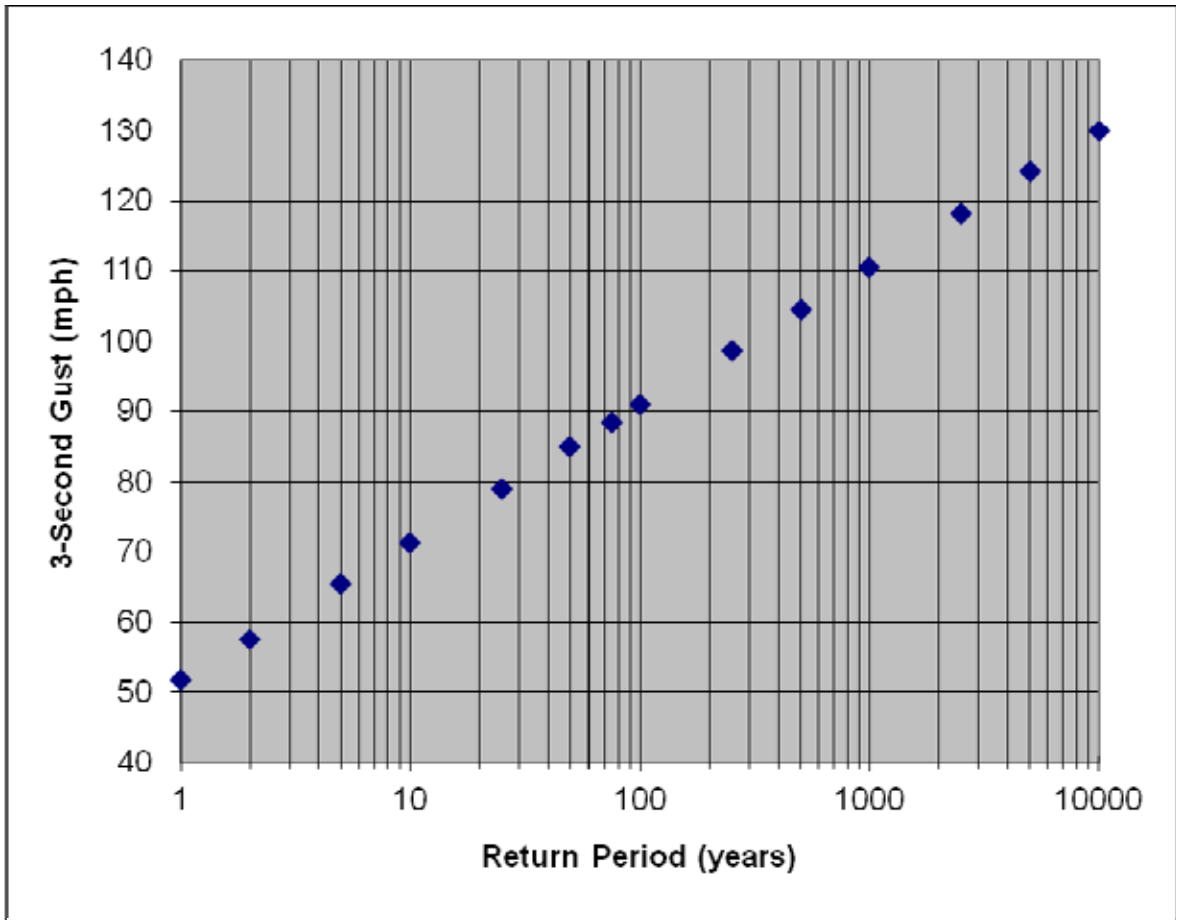


The level of wind hazard in much of Multnomah County is higher than many locations in western Oregon, other than the immediate coast, because of the unusually high winds common in the Columbia Gorge.

Design wind speeds for new construction are determined per the maps in ASCE 7-10, Minimum Design Loads for Buildings and Other Structures, as referenced in the building code. The standard wind design load is for an 85 mph 3 second gust. Higher wind design loads apply in special wind regions, but there are no such special wind regions within Multnomah County. There is a special wind hazard area in the Columbia Gorge Area, just east of Multnomah County.

The wind hazard curves for Multnomah County, based on the consensus ASCE 7-10 probability relationships for standard wind design locations is shown below in Figure 10.2

Figure 10.2
Wind Hazard Curves for Multnomah County



In Multnomah County, the 10-year and 100-year return periods are approximately 71 mph and 91 mph, respectively. These winds speeds are three-second gusts which are typically about 30% higher than sustained wind speeds. Thus, for example, a three-second gust of 91 mph corresponds to a sustained wind speed of about 70 mph. Higher elevations, such as on Mount Hood, have higher levels of wind hazards, but there is relatively little development in such areas.

For new construction, the Multnomah County relies on the applicable building code wind speed design requirements, as established by Portland and Gresham.

10.4 Snow and Ice Hazard Data for Multnomah County

Winter storms can also involve ice and snow in Multnomah County. The most likely impact of snow and ice events on Multnomah 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 Multnomah County are generally low as shown below in Table 10.2.

Table 10.2
Snowfall Data for Multnomah County

Location	Average Annual Snowfall (inches)	Lowest Annual Snowfall (inches)	Highest Annual Snowfall (inches)	Period of Record
Portland Airport	2.80	0.00 (many years)	34.0 (1968-1969)	1941-2010

Western Regional Climate Center website: www.wrcc.dri.edu

Average snowfall in Multnomah County, at the Portland Airport is low, only about 3 inches, with many years in which no snowfall has been recorded. However, the maximum annual snowfall was 34 inches in 1968-69. During the period of record, there have been ten years with snowfall above 10 inches.

Snowfalls vary markedly within Multnomah County, especially with altitude. Higher elevations receive much higher snowfalls than areas at lower elevations. For example, the mean annual snowfall at Government Camp (Clackamas County) is 270 inches per year. Locations in Multnomah County on the slopes of Mount Hood receive similar amounts of snow.

The most recent major snow storm event affecting Multnomah County occurred in December 2008. This storm event, which began on December 14th dumped more than a foot of snow and ice on the area. The major effects were road closures, with Interstate 84 closed through the Columbia River Gorge for two days. There were many road closures on hilly streets and localized power outages.

In addition to snow events, Multnomah County is also subject to ice storm and freezing rain events. The National Climatic Data Center (NCDC) database inexplicably shows zero significant snow, ice storm or freezing rain events for Multnomah County between 1950 and 2011, even though major such events have occurred. For example, the database shows 78 snow/ice events for Columbia County.

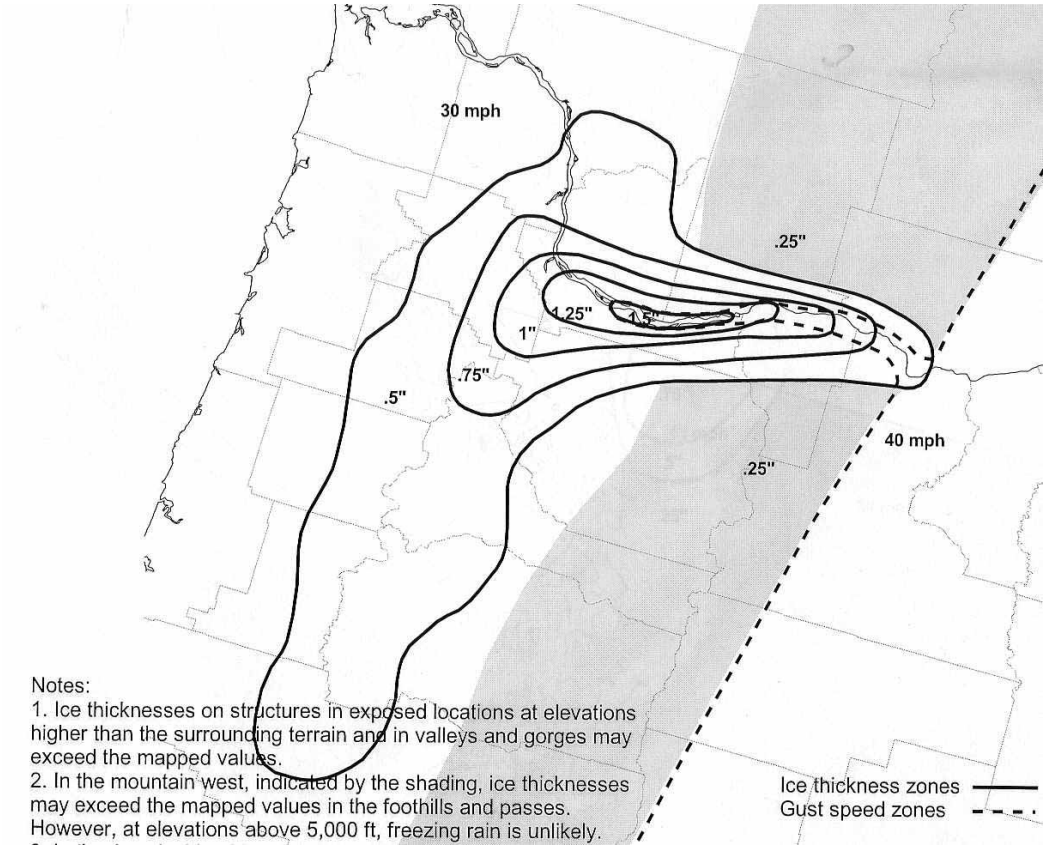
Website addresses for NCDC and the state and county storm event database are:

- www.ncdc.noaa.gov and
- http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms, respectively.

Nevertheless, the level of hazard for snow/ice storms is relatively high for Multnomah County, especially for ice storms. As illustrated by the ice thickness contour map below, Figure 10.3, the risk of ice storms in western Oregon is highest along the Columbia River, especially along the Columbia Gorge portion. This area has the highest level of ice storm hazard in the entire United States.

Probabilistic ice storm data showing ice thicknesses with return periods from 50 years to 400 years are given in a recent American Lifelines Alliance report: Extreme Ice Thicknesses from Freezing Rain (2004). The 50-year return period ice thickness map (Figure 10.3 below) shows about 1.5" of ice for Multnomah County. Typical 100-year and 400-year ice thicknesses for Multnomah County are about 1.75" and about 2.5", respectively.

Figure 10.3
50-Year Ice Thickness from Freezing Rain



For Multnomah County, ice thicknesses in 50-year or more severe events are high enough (about 1.5") to cause widespread substantial damage, especially to trees

and utility lines. Using typical ice thickness scaling relationships, ice thicknesses for 25-year and 10-year ice storms in Multnomah County would be about 1.2" and about 0.75" inches, respectively. Such events are also severe enough to result in significant damage to trees and utility lines.

Ice storms along the Columbia Gorge may also affect Multnomah County indirectly, potentially resulting in loss of electric power, because much of Multnomah County's power is transmitted from Bonneville Power Authority sites along the Columbia River. Closures of Interstate 84 outside of Multnomah County may also affect transportation to/from the county

The most significant recent 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 Multnomah County.

Ice storms have affected Multnomah County throughout its history. Figure 10.3 shows downtown Troutdale after the ice storm of November 18, 1921.

Figure 10.3
Downtown Troutdale – Ice Storm of November 18, 1921

10.5 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 Multnomah County are from the state and county storm event database referenced above.

Severe Thunderstorms and Hail Events

The NCDC database lists 10 thunderstorm events in Multnomah County from 1950 to 2010. Only two of these events included a damage amount which totaled only $7,000.

Thus, the thunderstorm events in Multnomah County are typically too minor to be recorded as significant storm events. Nevertheless, thunderstorm events in Multnomah County may occasionally cause locally high winds with tree falls which may affect roads, utility lines, and buildings.

The NCDC database lists seven hail events for Multnomah County from 1950 to 2011. Two of these events included damage amounts which were total only $10,000. However, all of the listed events occurred from 1991 to 2010; thus, the database is likely incomplete for earlier years. Hail damage is generally very localized to areas affected by strong thunderstorm cells which produce large diameter hail. Six of the seven listed hail events had hail diameters of 0.5” to 1.5” which is large enough to cause some damage.

Hail events may occur in Multnomah 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 a significant weather related killer. 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, however, casualties from lightning are very low, with totals of only 7 deaths and 19 injuries reported over a 35 year period (NOAA).

The NCDC data base lists seven severe lightning events for Multnomah County. Three of these events included reported damages:

- Gresham June 6, 1995 - $115,000 in damage.
- Gresham June 19, 2005 - $50,000 in damage.
- Fairview July 3, 2008 - $2,000 in damage.

Thus, the level of risk posed by lightning strikes in Multnomah County, while not zero, is 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 where lightning strikes might damage critical electronic equipment, such as IT or communications equipment.

Tornadoes

Tornadoes also do occur occasionally in Oregon. However, Oregon is not among the 39 states with any reported tornado deaths since 1950. NOAA's National Climatic Data Center's website lists a total of 101 recorded tornadoes in Oregon. These events are characterized on the Fujita Scale which ranges from F0 to F5, with F5 being the most severe. Of these, nearly all are small F0 or F1 tornadoes, with only three F2 and one F3 tornadoes. Cumulatively, these records indicate only 5 injuries and about $31 million in damages. The majority of the reported damages occurred in the 1968 Wallowa tornado (F3, $25 million), the 1975 Tillamook tornado (F2, $2.5 million) and the 2010 Aumsville tornado (F2, $1.2 million).

The most recent significant tornado in Oregon at Aumsville in 2010 was characterized as an EF2 on the Enhanced Fujita Scale, which has replaced the Fujita Scale with revisions to the estimated wind speeds for each class of tornado. This tornado had a total path length of about 5 miles, although the tornado was apparently off the ground for about the middle third of this path length. The average width was about 150 yards. Damage was reported to about 50 structures, mostly in the downtown area with more than 30 large trees uprooted or snapped in two.

An important caveat on historical reports of tornadoes, especially older events and those for small tornadoes, is that some events previously reported as tornadoes are now more accurately understood as downbursts or microbursts associated with thunderstorms and not actually tornadoes.

Climate and weather conditions in Oregon overall, and specifically in Multnomah County, make the occurrence of major tornadoes unlikely, but not impossible as demonstrated by the 1972 tornado event. The most practical mitigation actions

for tornadoes are public warnings and taking shelter to minimize the potential for deaths and injuries.

A compilation of historical tornadoes in Oregon by the National Weather Service includes four tornadoes and one cyclonic storm in Multnomah County. These tornadoes are summarized in Table 10.3 below.

Table 10.3
Historical Tornadoes in Multnomah County

Date	Location	Notes
November 12, 1991	near Troutdale	Small tornado damaged fencing with minor damage to one building
April 9, 1991	near Gresham	Very small weak tornado touched down with very slight damage.
August 16, 1978	near Gresham	Small tornado touched ground briefly with some damage to buildings and crops.
April 5, 1972	Portland area	F3 tornado, the most violent tornado in Oregon's recorded history. About $250K damages in Oregon. About $5,000,000 damages, 6 deaths, and 300 injuries in Vancouver WA.
March 19, 1904	East Portland	"cyclonic storm" damaged the Lewis and Clark Fairgrounds, several shacks and a large warehouse.

Source: http://www.wrh.noaa.gov/pqr/paststorms/tornado.php

Although relatively rare in Oregon, the 2010 Aumsville tornado and the 1972 tornado which caused relatively minor damage in Multnomah County but approximately $6 million in damage in Vancouver Washington demonstrate that the risk from tornadoes is not zero.

10.6 Winter Storm Risk Assessments

Winter storm flooding, snow, ice and wind events may affect both infrastructure and buildings. Localized flooding from winter storms very commonly affects the transportation system, especially roads. Severe winter storms may 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.

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.

Snow and/or ice events typically disrupt transportation, with more severe events also damaging above-ground utilities. Utility outages may be widespread and of long duration in major events, as occurred in the December 1996 ice storm event.

The location and severity of winter storm 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 would require very detailed data which are generally not available.

An alternative approach is to document the severity and locations of winter storm flood wind, snow and ice damage from the pattern of historical events. Fortunately, however, Multnomah County has suffered only relatively minor impacts from winter storms in recent years.

The probable impacts of winter storms on Multnomah County are summarized qualitatively below in Table 10.4.

Table 10.4
Probable Impacts of Winter Storms on Multnomah County[1]

Inventory	Probable Impacts
Portion of Multnomah County Affected	Severe winter storms may affect all of Multnomah County, although the severity if impacts typically varies significantly with location within the county.
Buildings	Isolated damage from tree falls, wind, heavy snow loads, landslides and localized flooding.
Streets and Roads Within Multnomah County	Road closures due to snow or ice, tree falls, landslides or flooding.
Highways to/from Multnomah County	Road closures may also affect major highways to/from Multnomah County, especially Interstate 84 through the Columbia Gorge.
Airports	Severe weather may result in temporary closures of PDX and smaller airports in Multnomah County.
Electric Power	Loss of electric power may be localized or widespread due to effects of wind, snow, ice and tree falls on local distribution lines or very widespread if transmission lines fail.
Other Utilities	Generally minor impacts on other utilities from winter storms, except for possible effects of loss of electric power; however, telephone and other telecommunications systems with above ground lines may also experience outages.
Casualties	Potential for casualties (deaths and injuries) from tree falls or contact with downed power lines or from traffic accidents.

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

For more quantitative risk assessment of localized flooding, snow, ice, wind and landslide damages arising from winter storms, the best approach is to systematically gather data on sites of repetitive damages. By documenting and mapping such sites 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. Then, such identified repetitive loss sites with significant damages would be likely candidates for future mitigation actions.

10.7 Mitigation of Winter Storm Impacts

Potential mitigation projects for winter storms may address any of the aspects of such storms, including floods, winds, and snow/ice.

For winter storm flooding, the mitigation measures discussed in Chapter 9 (Floods) for local storm water drainage flooding are the mitigation measures for the localized 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, snow and ice 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. However, economic, political and esthetic realities place limits on tree trimming as a mitigation action.

Effective tree trimming mitigation programs often 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, 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 Multnomah 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 recovery 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 10.5
Severe Weather Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Plan Goals Addressed				
				Life Safety	Protect Property and Infrastructure	Emergency Management Capabilities	Public Awareness and Education	Environmental Stewardship
Severe Weather Mitigation Action Items								
Short-Term #1	Ensure that all critical facilities in Multnomah County have backup power and/or coordination of operations plans in place to withstand loss of grid power.	Facilities	5 Years	X	X	X		
Short-Term #2	Conduct tree trimming activities on county roads where County Transportation has jurisdictional responsibility.	Transportation	Ongoing	X	X			X
Short-Term #3	Develop a strategy that encourages property owners to trim trees that could impact life safety and damage property.	Multnomah County Emergency Management	1-2 Years	X	X		X	X
Short-Term #4	Work with stakeholder groups to identify common criteria for defining extreme heat and cold events for the sake of determining proper mitigation, protection or preparedness strategies.	Multnomah County Emergency Management	1 Year	X		X	X	X
Long-Term #1	Encourage utilities to upgrade 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.	Multnomah County Emergency Management	5 Years	X	X	X	X	

11.0 VOLCANIC HAZARDS

11.1 Overview

The Cascades, which run from British Columbia 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 short time period) in Oregon there have been three eruptions of Mt. Hood, four eruptions in the Three Sisters area, two eruptions in the Newberry Volcano area and minor eruptions near Mt. Jefferson, at Blue Lake Crater, in the Sand Mountain Field, near Mt. Washington, and near Belknap Crater. During this time period, the most active volcano in the Cascades has been Mount St. Helens in Washington State with about 14 eruptions.

Many other volcanoes in Oregon and Washington 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

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
Devis 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	1980 - 2008
West Crater	Volcanic Field	5760 BC (?)
Indian Heaven	Shield Volcanoes	6250 ± 100 BC

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 3000 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 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
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 Mt. 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 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.

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 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 extend 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 be eruptions or by earthquakes or simply by heavy rainfall.

11.3 Volcanic Hazards for Multnomah County

11.3.1 Ashfalls

Of the active volcanoes in Oregon and nearby, the two which pose the most significant risk for Multnomah County are Mt. Hood because of its proximity and Mount St. Helens because of its high level of volcanic activity. Mt. Hood is located near the boundary of Clackamas County and Hood River County, about 10 miles from the southeast corner of Multnomah County. Mount St. Helens is approximately 50 miles from downtown Portland.

For Multnomah County, volcanic hazards from Mount St. Helens are limited to ash falls. USGS estimates of return periods for ashfalls are shown in Figures 11.1 and 11.2 on the following page. Interpolating between the map contours of Figures 11.1 and 11.2, return periods for 1 centimeter (about 0.4 inch) or more and 10 centimeters (about 4 inches) or more of volcanic ash are about 1,000 years and about 4,000 years, respectively. The corresponding annual probabilities are about 0.1% and about 0.025%, respectively. These ashfall maps predominantly reflect volcanic eruptions at Mount St. Helens, because this volcano is much more active than the other volcanoes in the Cascades.

The relatively low probabilities of significant ash falls (i.e., long return periods) for Multnomah County arise because ash falls in the County would require volcanic eruptions to produce ash and wind directions carrying ash towards Multnomah County, such as winds that deposit ash southward from Mount St. Helens or north-westward from Mt. Hood. These wind directions do occur, but are much less common than the prevailing westerly winds.

Figure 11.1
Annual Probability of 1 Centimeter (about 0.4 inch) or More of Volcanic Ash

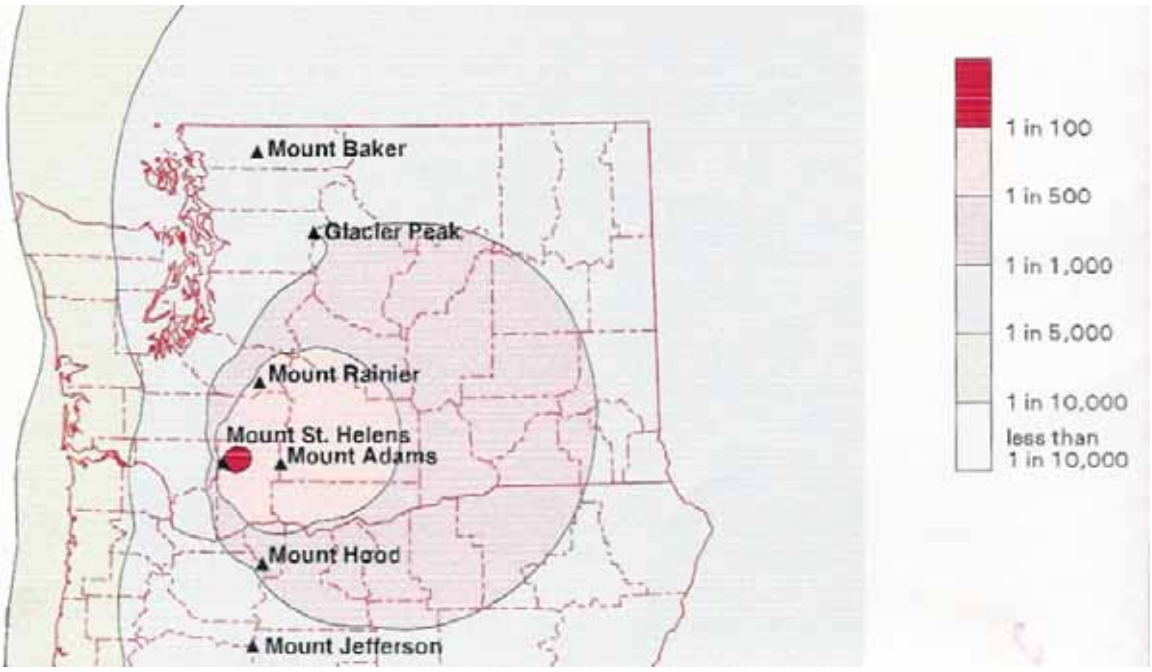
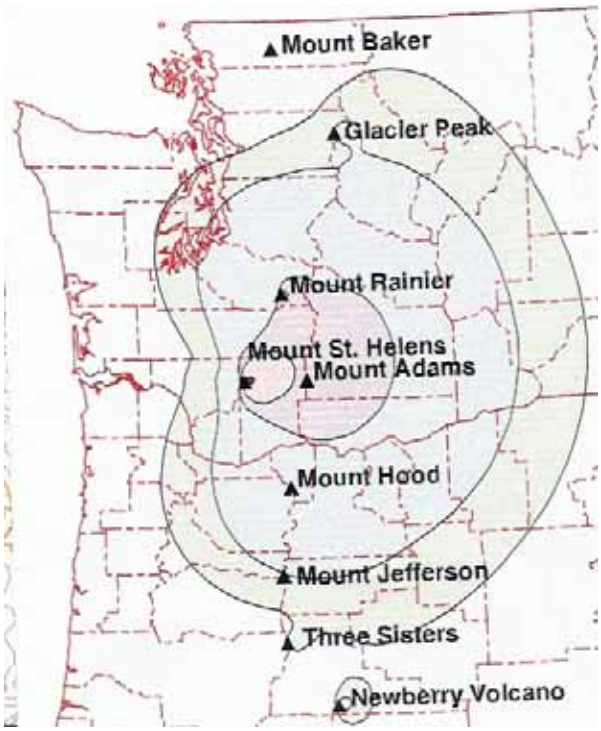


Figure 11.2
Annual Probability of 10 Centimeters (about 4 inches) or More of Volcanic Ash
(same scale as Figure 11.1 above)



11.3.2 Volcanic Hazards from Mt. Hood

The history of volcanic activity of Mt. Hood and analyses of volcanic hazard zones around Mt. Hood are summarized in the 1997 USGS Open File Report 97-89: Volcano Hazards in the Mount Hood Region, Oregon and in the accompanying map.

As documented in the above USGS report, the proximal (nearby) hazard zone for Mount Hood includes areas subject to lava flows, blast effects and pyroclastic flows. This extreme hazard area includes portions of Clackamas, Hood River and Wasco Counties, including several small communities. However, none of these hazard zones extend to Multnomah County.

Multnomah County, which is subject to ash falls from Mount Hood and other active volcanoes, is also subject to lahars or debris flows down the Sandy River. Figures 11.3 and 11.4, excerpted from the USGS Mount Hood map, show the hazard areas within Multnomah County. Figure 11.5 shows an overlay of the lahar maps for Troutdale with parcels and structures. Troutdale is the largest developed area in Multnomah County with high risk from lahars. However, portions of Wood Village and Fairview are also at risk, as well as small communities along the Sandy River between Troutdale and Mount Hood.

As shown on the Figure 11.4, the arrival time in Multnomah County for a lahar down the Sandy River ranges from about 2 hours and 30 minutes near the southern border of the county to about 3 hours and 30 minutes in Troutdale.

Figures 11.3, 11.4 and 11.5 show the expected inundation area for two sizes of lahars: a large lahar with a 30-year probability of approximately of 1 in 15 to 1 in 30 and a worst-case (largest possible) lahar with a 30-year probability of less than 1 in 3,000. The return periods for these lahars are approximately 450 to 900 years for the large lahar and about 10,000 years for the worst-case lahar.

The large lahar inundation area (shown in pink on Figures 11.3 and 11.4 and in beige on Figure 11.5) includes a large portion of Troutdale, including:

- The developed areas along the Sandy River and the lower reach of Beaver Creek, and
- Nearly all of Troutdale north of Interstate-84.

The worst-case lahar (shown in violet in Figures 11.3, 11.4 and 11.5) inundates even larger areas. Within these inundation areas the damage level would be extreme, with complete destruction of almost all structures.

Figure 11.3
Lahar Hazard Areas[1]

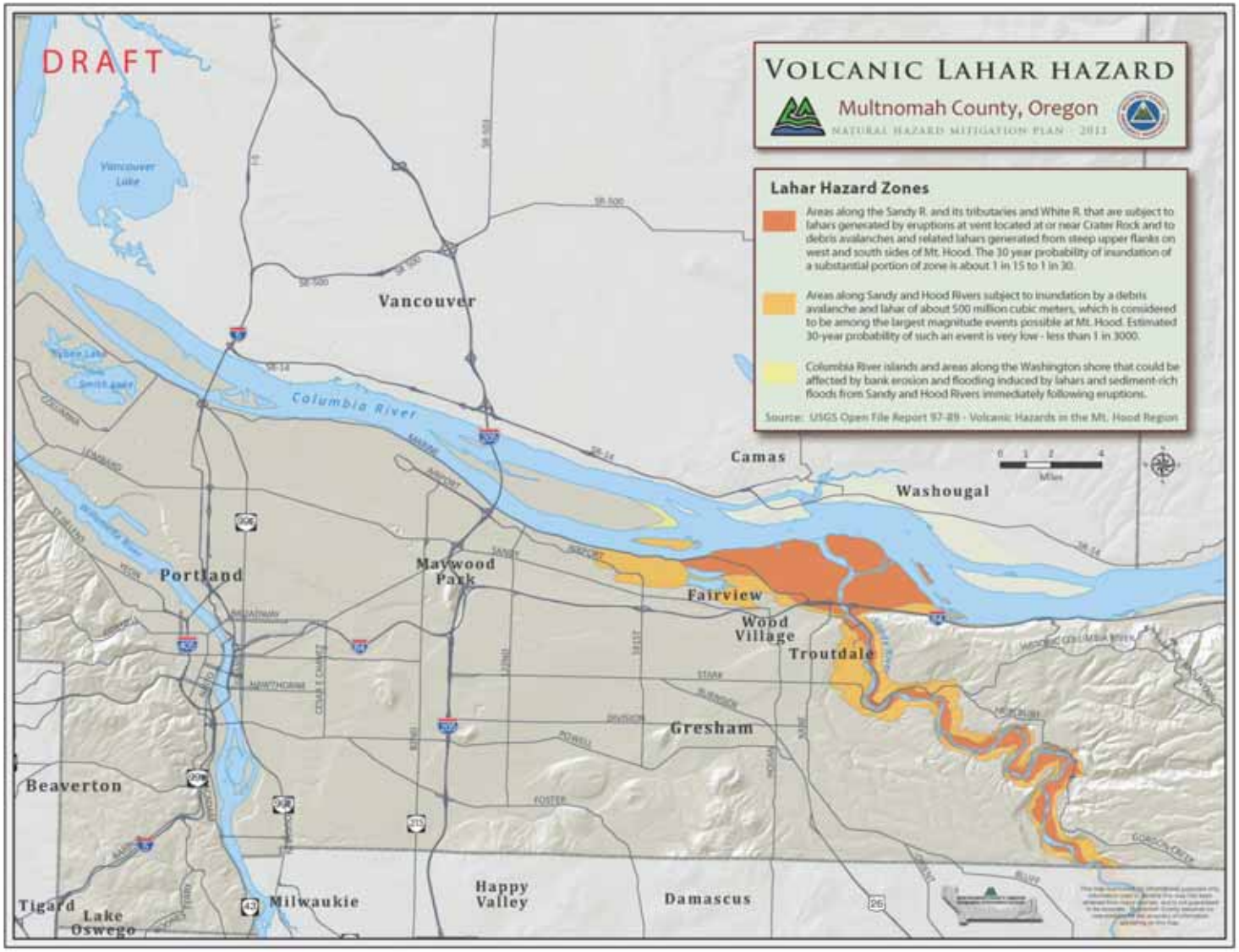
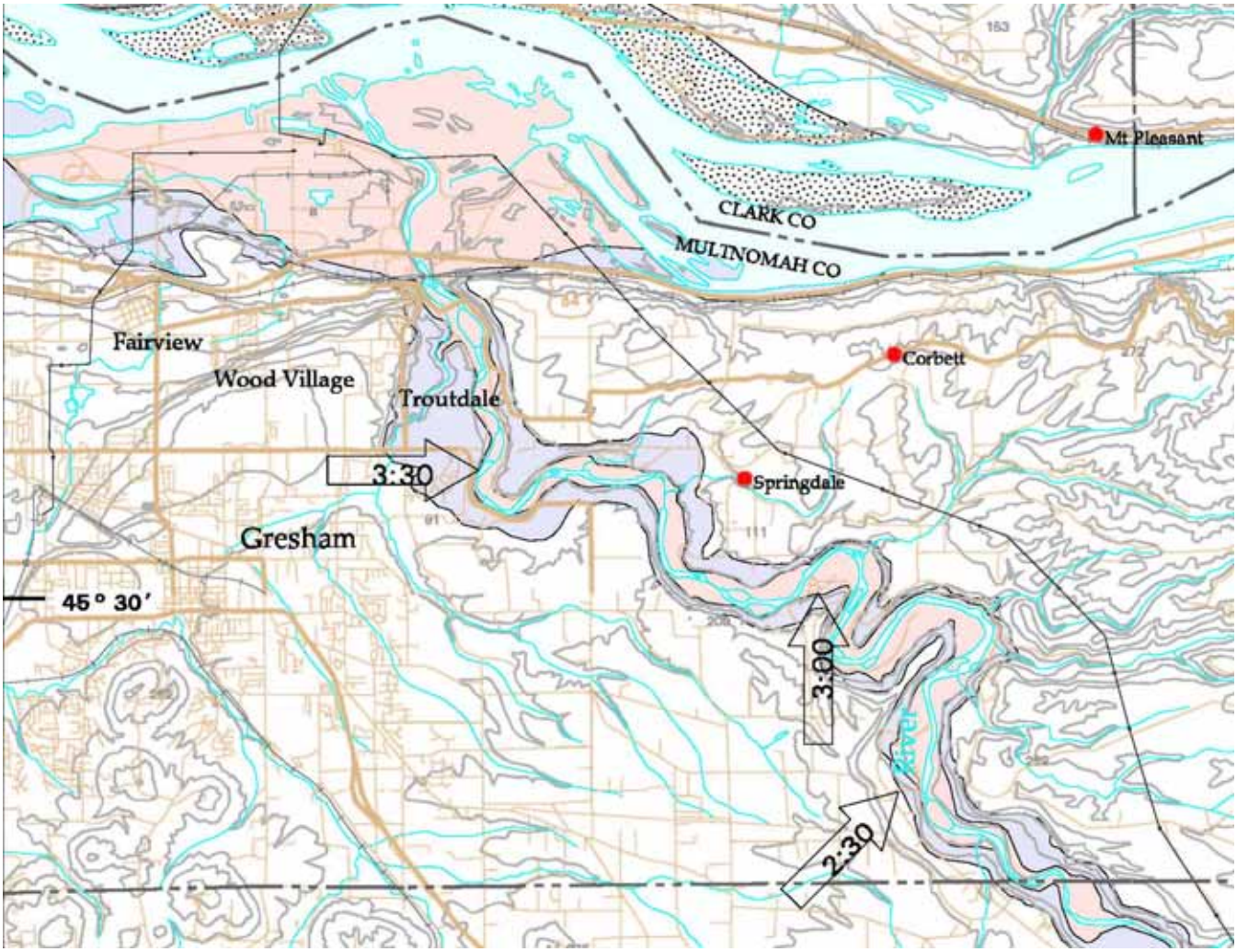


Figure 11.4
USGS Mount Hood Hazard Map (Excerpt) from OFR 97-89
Showing Arrival Times from the Time of Eruption

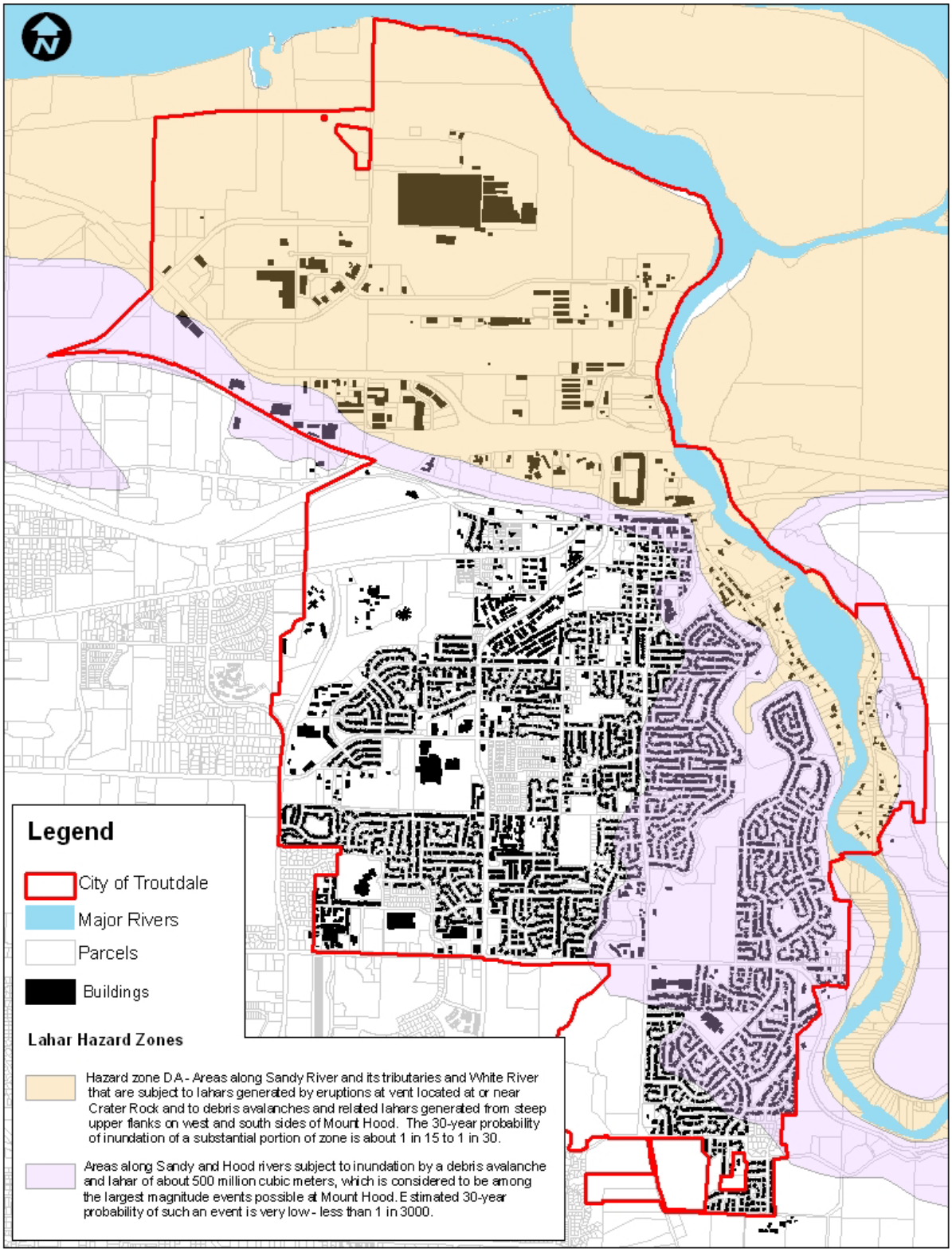


The USGS definitions of the lahar hazard zones shown above and in Figure 11.4 are:

Hazard zone DA — Areas along Sandy River and its tributaries and White River that are subject to lahars generated by eruptions at vent located at or near Crater Rock and to debris avalanches and related lahars generated from steep upper flanks on west and south sides of Mount Hood. The 30−year probability of inundation of a substantial portion of zone is about 1 in 15 to 1 in 30

Areas along Sandy and Hood Rivers subject to inundation by a debris avalanche and lahar of about 500 million cubic meters, which is considered to be among the largest magnitude events possible at Mount Hood [9]. Estimated 30−year probability of such an event is very low—less than 1 in 3000

Figure 11.5
Overlay of Lahar Hazard Map with Troutdale Parcels and Structures



11.4 Probable Consequences of Volcanic Events

The probable impacts of potential volcanic eruptions on Multnomah County include ash falls and lahars.

Ash Falls

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 Multnomah County. The impacts of ash falls on Multnomah County include:

a) Respiratory problems for at-risk population such as elderly, young children or people with respiratory problems,

b) Impacts on public water supplies drawn from surface waters, including degradation of water quality (high turbidity) and increased maintenance requirements at water treatment plants,

c) Possible electric power outages from ash-induced short circuits in distribution lines, transmission lines, and substations,

d) Disruptions of air traffic from the Portland Airport, other Multnomah County airports and/or other airports in the Pacific Northwest,

e) Clogging of filters and possible severe damage to vehicle engines, furnaces, heat pumps, air conditioners, commercial and public building combined HVAC systems (heating, ventilation and air conditioning) and other engines and mechanical equipment, and

f) Clean-up and ash removal from roofs, gutters, sidewalks, roads vehicles, HVAC systems and ductwork, engines and mechanical equipment.

In all but the most extreme events, ash falls for Multnomah County are likely to be very minor with an inch or less of ash likely. However, even minor amounts of ash fall can result in significant impacts, as noted above.

Lahars

Lahars down the Sandy River pose a greater threat to Multnomah County. As shown in Figures 11.3, 11.4 and 11.5 large lahars could inundate developed areas near the river. The consequences would be extreme levels of damage in the inundated areas and a high potential for casualties unless complete evacuations

were carried out before the lahar reached populated areas. The moderately large and worst case lahar events have 30-year probabilities estimated by the USGS to be about 1 in 15 to 1 in 30 for the moderately large lahars and less than 1 in 2,000 for the worst-case lahar events, respectively. The moderately large lahar events are shown in dark orange in Figure 11.3 and in tan in Figures 11.4 and 11.5. The worst case lahar events are shown in light orange in Figure 11.3 and in violet in Figures 11.4 and 11.5

Lahar events could also profoundly disrupt transportation to/from Multnomah County if the Interstate-84 bridge and other bridges across the Sandy River were to fail. In the event of bridge failures, the time to construct new bridges would likely be at least six months or longer.

The number of buildings located in the major and extreme lahars, defined as in the previous figures, are shown below in Table 11.4.

Table 11.4
Numbers of Buildings in Lahar Zones

Building Type:	Industrial	Commercial	Multi-Family Residential	Parks - Open Space	Mixed Use Residential	Single Family Residential	Mixed Use Other	Rural	**Total**
Unincorporated Multnomah County									
Major Lahar	8	0	0	0	0	51	0	149	**208**
Extreme Lahar[1]	0	0	0	0	0	130	0	218	**348**
Extreme Lahar (total)	8	0	0	0	0	181	0	367	**556**
Incorporated Multnomah County									
Major Lahar	139	0	6	58	48	143	0	3	**397**
Extreme Lahar[1]	135	8	105	5	33	2,073	10	7	**2,376**
Extreme Lahar (total)	274	8	111	63	81	2,216	10	10	**2,773**
Multnomah County (Entire)									
Major Lahar	147	0	6	58	48	194	0	152	**605**
Extreme Lahar[1]	135	8	105	5	33	2,203	10	225	**2,724**
Extreme Lahar (total)	282	8	111	63	81	2,397	10	377	**3,329**

[1] Numbers of buildings in Extreme Lahar rows is the additional number of buildings inundated beyond those inundated in the Major Lahar event.

As shown above, a major lahar event with a return period of about 450 to 900 years would inundate, and completely destroy, about 600 buildings in Multnomah County. For the extreme lahar event, with a return period of about 10,000 years, a total of about 3,300 buildings would be inundated and completely destroyed.

11.5 Mitigation of Volcanic Hazards

There are no practical physical mitigation measures possible to protect at risk areas from lahars that are feasible from an engineering perspective or an economic perspective. Therefore, the primary means of addressing lahar risk are warning systems, public education and evacuation planning.

11.5.1 USGS Volcano Monitoring and Warning

The USGS 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. The USGS also has a volcanic warning system with several levels of alert as a potential eruption becomes more likely and more imminent. The USGS volcanic warning system has parallel warnings for people on the ground and for air traffic: U.S. Geological Survey's Alert Notification System for Volcanic Activity (USGS Fact Sheet 2006-3139.

Figure 11.6
Volcanic Alert Levels for People on the Ground

Volcano Alert Levels Used by USGS Volcano Observatories

Alert Levels are intended to inform people on the ground about a volcano's status and are issued in conjunction with the Aviation Color Code. Notifications are issued for both increasing and decreasing volcanic activity and are accompanied by text with details (as known) about the nature of the unrest or eruption and about potential or current hazards and likely outcomes.

Term	Description
NORMAL	Volcano is in typical background, noneruptive state or, *after a change from a higher level,* volcanic activity has ceased and volcano has returned to noneruptive background state.
ADVISORY	Volcano is exhibiting signs of elevated unrest above known background level or, *after a change from a higher level,* volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase.
WATCH	Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain, **OR** eruption is underway but poses limited hazards.
WARNING	Hazardous eruption is imminent, underway, or suspected.

Figure 11.7
Volcanic Alert Levels for Air Traffic

Aviation Color Code Used by USGS Volcano Observatories

Color codes, which are in accordance with recommended International Civil Aviation Organization (ICAO) procedures, are intended to inform the aviation sector about a volcano's status and are issued in conjunction with an Alert Level. Notifications are issued for both increasing and decreasing volcanic activity and are accompanied by text with details (as known) about the nature of the unrest or eruption, especially in regard to ash-plume information and likely outcomes.

Color	Description
GREEN	Volcano is in typical background, noneruptive state or, *after a change from a higher level,* volcanic activity has ceased and volcano has returned to noneruptive background state.
YELLOW	Volcano is exhibiting signs of elevated unrest above known background level or, *after a change from a higher level,* volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase.
ORANGE	Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain, **OR** eruption is underway with no or minor volcanic-ash emissions [ash-plume height specified, if possible].
RED	Eruption is imminent with significant emission of volcanic ash into the atmosphere likely **OR** eruption is underway or suspected with significant emission of volcanic ash into the atmosphere [ash-plume height specified, if possible].

11.5.2 Multnomah County Volcanic Event Warning, Notification and Evacuation Planning

Multnomah County's emergency planning includes warning, notification and evacuation protocols for volcanic events.

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

Table 11-5
Volcanic Hazards Mitigation Action Items

Hazard	Action Item	Coordinating Organizations	Timeline	Plan Goals Addressed				
				Life Safety	Protect Property and Infrastructure	Emergency Management Capabilities	Public Awareness and Education	Environmental Stewardship
Volcanic Hazards Mitigation Action Items								
Short-Term #1	Develop emergency evacuation protocols for lahar events and conduct exercises to test the protocols.	Multnomah County Emergency Management	3 Years	X		X	X	
Short-Term #2	Update public education, emergency notification procedures and emergency planning for ash fall and lahar events.	Multnomah County Emergency Management	1-2 Years	X		X	X	

12.0 OTHER HAZARDS – NATURAL AND HUMAN-CAUSED

The previous six chapters addressed the natural hazards which pose the greatest risks for Multnomah County: earthquakes, wildland/urban interface fires, landslides, floods, severe weather and volcanic events.

This chapter briefly addresses the many other types of natural hazards which could also pose risk to Multnomah County. However, the level of risk posed by these other hazards is much lower than for the five major hazards and in most cases the level of risk is nearly negligible.

This chapter also briefly addresses the major human-caused hazards. Although some of the human-caused hazards are significant, most actions to reduce risks are entirely or predominantly in the bailiwick of emergency response planning or law enforcement. Such activities are deemed almost entirely outside the scope of Multnomah County's hazard mitigation planning.

12.1 Other Natural Hazards

12.1.1 Drought

Drought is a significant concern in many communities in the Western United States and climate change over future decades may exacerbate drought areas in some states.

However, for Multnomah County the risks posed by droughts, even considering the possible effects of future climate change, appear minimal. Available water supplies from the rivers and streams in Multnomah County and from ground water wells are far above the water usage levels in Multnomah County. Thus, the risk posed by drought appears nearly negligible.

12.1.2 Subsidence

The term "subsidence" refers to lowering of ground elevations, which typically occurs from ground water pumping or petroleum extraction. Subsidence can result in substantial damage to buildings, especially foundations, and to buried utility infrastructure. Subsidence damage may be severe, especially at soil type boundaries where there are discontinuities in the rate of subsidence.

In Multnomah County, there are no known areas where significant damage due to subsidence has or is occurring. Thus, subsidence risk in Multnomah County appears negligible**.**

12.1.3 Expansive Soils

The term “expansive soils” refers to soils, typically clay-rich, that undergo significant expansion and contraction cycles from seasonal variations in water content. Such cyclic changes can result in substantial damage to buildings, especially foundations, and to buried utility infrastructure.

In Multnomah County, there are no known areas where significant damage due to expansive soils has or is occurring. Thus, expansive soils risk in Multnomah County appears negligible**.**

12.1.4 Extreme Temperatures

Prolong periods of extreme temperatures – either unusually cold or unusually hot – can pose life safety risks, particularly for elderly and other at risk populations, especially if power outages are concurrent with extreme temperatures. The greatest risk is to lower income residents without air conditioning or those who have lost air conditioning due to power outages.

Extreme temperatures can also result in property damage, especially to cold-sensitive crops. Extreme cold may also result in freezing and rupturing of water pipes, including irrigation systems and pipes within buildings with inadequate insulation.

Multnomah County’s climate is generally mild; below freezing temperatures are not common but do occur. Average low temperatures range from 34^{o} in December to 57^{o} in July and August. The record low temperature in Multnomah County is -3^{o} which occurred on February 28, 1998. Extreme cold with temperatures well below zero have never occurred in Multnomah County. Unusually cold weather in Multnomah County would result in some damage to cold sensitive landscaping, with the possibility of water damages from pipe breakages. However, extreme cold does not pose a significant risk.

There are no obvious mitigation action items to reduce the impacts of extreme cold on the residents of Multnomah County.

Average high temperatures range from 45^{o} in January to 80^{o} in July and August. On average there are only about 12 days per year with daily high temperatures at or above 90^{o}. Temperatures at or above 100^{o} have occurred between May and September, but are not common. The record high temperature for Multnomah County is 107^{o} which was recorded on July 30, 1965 and August 8, 1981. Prolonged periods with extreme high temperature rarely, if ever, occur in Multnomah County.

Extreme heat often results in localized power outages. Demand for electricity may exceed capacity resulting in brownouts or blackouts. The combination of very high demand and high temperatures results in an increased number of equipment failures (especially lines and transformers), which increase the number of service outages.

Multnomah County is subject to occasional periods of high temperatures. However, public response to extreme heat situations is for emergency responders and public health staff. There are no obvious mitigation action items to reduce the impacts of extreme heat on the residents of Multnomah County.

Overall, the level of risk posed to Multnomah County by extreme temperatures is low.

Mitigation measures considered under previous hazard chapters to ensure back-up power supplies for critical facilities under disaster or other emergency conditions would also be beneficial during extreme heat conditions, which often include localized or widespread power outages.

12.2 Human-Caused Hazards

12.2.1 Overview

There are many human-caused hazards which pose risks for Multnomah County, including:

- Epidemics,
- Weapons of mass destruction,
- Terrorist or other malevolent actions,
- Structure fires,
- Explosions,
- Civil unrest,
- Transportation accidents (road, rail, air or sea/river),
- Hazardous material incidents,
- Sinkholes (from failures of water or wastewater systems), and
- Others.

All of the above types of human-caused events have the potential for damages, economic losses, and/or deaths and injuries. Thus, while all of these hazards do pose some level of risk to Multnomah County, addressing such hazards is well outside the typical scope of FEMA local hazard mitigation planning. Rather, addressing such hazards typically falls into the domains of:

- Emergency response planning,
- Emergency responders (fire, police and medical),
- Law enforcement,
- Other agencies, including:
    - The Federal Aviation Administration,
    - Environmental agencies for hazardous material incidents, and
    - Public health agencies for public health/epidemics.

Furthermore, consideration of human-caused hazards is not required by FEMA's guidance and requirements for local hazard mitigation plans.

Given these considerations, and the limited local resources to focus on hazard mitigation for natural hazards, the consensus decision of the mitigation planning team developing the 2011 Multnomah County Hazard Mitigation plan was to focus entirely on natural hazards.

This decision does not diminish the importance of planning for human-caused hazards, but rather simply recognizes that such planning is best accomplished separately from the 2011 Multnomah County Hazard Mitigation Plan.

12.2.2 Climate Change

There is a very strong consensus within the scientific community that human actions are resulting in global climate change. As average temperatures continue to increase over the rest of the 21st century, global impacts will include droughts and flooding, rising sea levels, increased vectors and invasive species, and many other significant disruptions to our natural cycles.

For Multnomah County, the most significant impacts of climate change will likely be: increased average temperatures and frequency and magnitude of extreme heat events; the amount and timing of precipitation, with increased flooding and impacts on water supplies; and higher intensity and frequency of wildfires.

Multnomah County's response to climate change is organized under the Climate Action Plan. However, it is important to recognize that anticipated changes to our climate will impact future hazard mitigation planning efforts.

12.3 Mitigation Strategies and Action Items

There are no mitigation strategies or action items included in this mitigation plan for the other natural hazards considered above because the level of risk is very low and/or there are no feasible mitigation measures. However, to some extent, mitigation measures for more important hazards, such as enhancing back-up

power for critical facilities, will also help reduce losses for some of the other hazards briefly noted in this chapter.

Similarly, there are no mitigation strategies or action items included in this mitigation plan for the human-caused hazards considered above. Planning for and responding to such events are best accomplished separately from the 2011 Multnomah County Hazard Mitigation Plan.