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 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.

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.

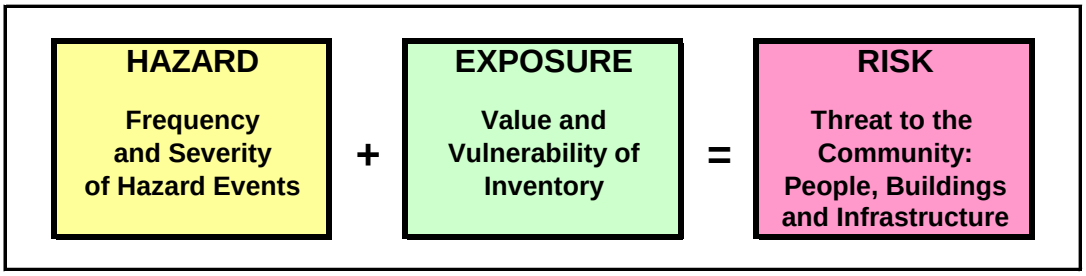
The Multnomah County Natural Hazards Mitigation Plan deals with hazards realistically and rationally while striking a balance between suggested physical mitigation measures to eliminate or reduce the negative impacts of future disasters and planning measures which better prepare the community to respond 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.

1.4 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

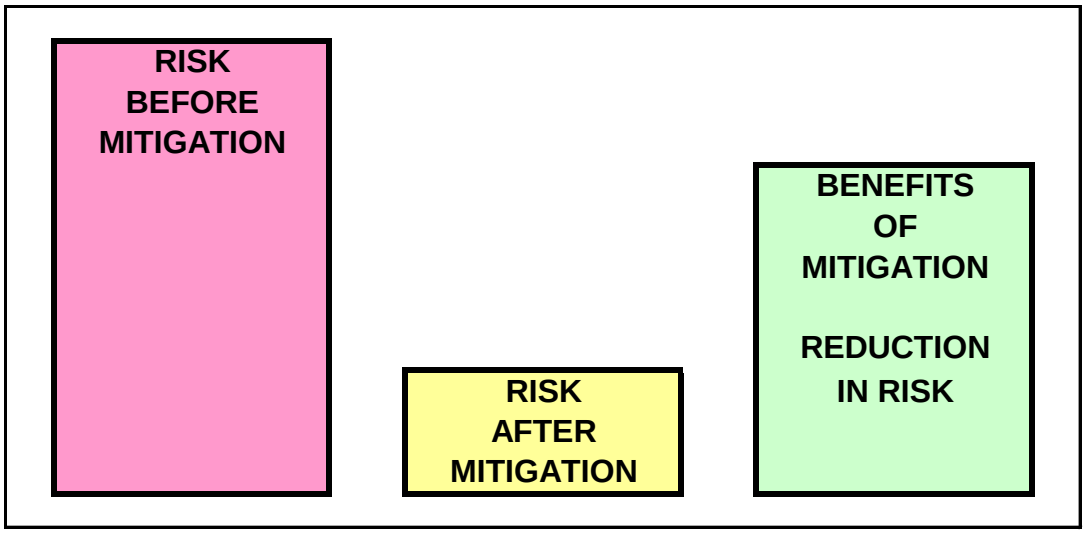
Hazard	Common Mitigation Projects
Earthquakes	Structural retrofits for buildings
	Nonstructural retrofits for contents and equipment
	Seismic upgrades for utility infrastructure
	Seismic retrofits for bridges
Wildland/Urban Interface Fires	Vegetation management - fuel reduction
	Enhance fire safe construction 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.

1.5 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



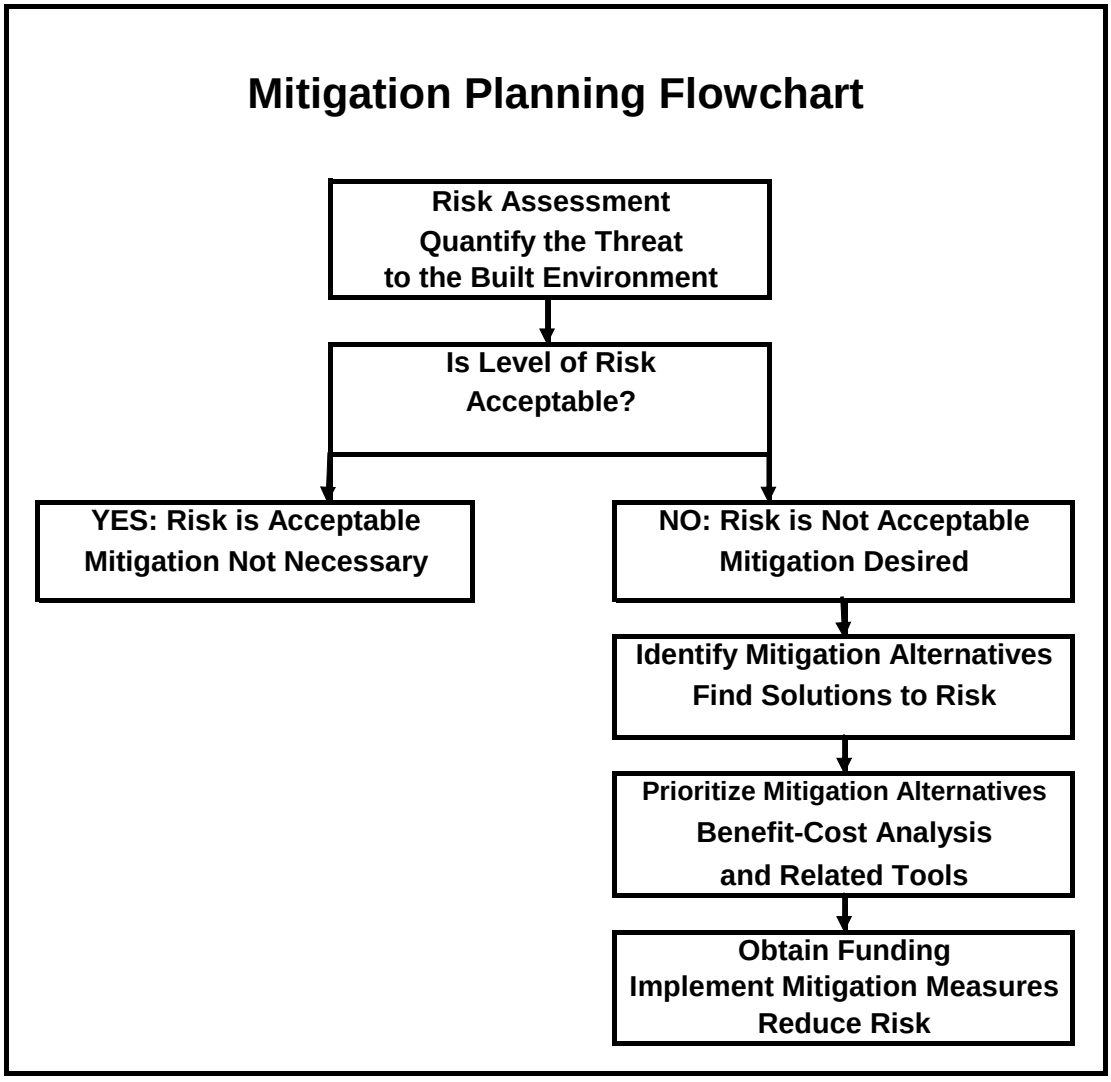
Quantifying the benefits of a proposed mitigation project is an essential step in hazard mitigation planning and implementation. Only by quantifying benefits is it possible to compare the benefits and costs of mitigation to determine whether or not a particular project is worth doing (i.e., is economically 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.

1.6 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://ww.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 quantity 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.

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

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

Very Low Risk: 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 the County of 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.
- Appendix 4: Multnomah County Buildings – Priorities for Post-Disaster Restoration of Services.