The 2018 Oregon State University 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 stakeholders and interested parties.

Please send comments and suggestions to:

Oregon State University
Emergency Manager
601 SW 17th Street
Corvallis, OR  97331

e-Mail address:  emergency@oregonstate.edu
EXECUTIVE SUMMARY

The Oregon State University Natural Hazards Mitigation Plan covers each of the major natural hazards that pose significant threats to the university.

The mission statement of the Oregon State University Hazard Mitigation Plan is to:

Proactively facilitate and support district-wide policies, practices, and programs that make the Oregon State University more disaster resistant and disaster resilient.

Making Oregon State University more disaster resistant and disaster resilient means taking proactive steps and actions to protect life safety, reduce property damage, minimize economic losses and disruption, and shorten the recovery period from future disasters. This plan is an educational and planning document that is intended to raise awareness and understanding of the potential impacts of natural hazard disasters and to help the Oregon State University address natural hazards in a pragmatic and cost-effective manner.

Completely eliminating the impacts of future disasters on Oregon State University is neither technologically possible nor economically feasible. However, substantially reducing the negative consequences of future disasters is achievable with the implementation of a pragmatic Hazard Mitigation Plan.

Mitigation simply means actions that reduce the potential for negative consequences from future disasters. That is, mitigation actions reduce future damages, losses, and casualties. Effective mitigation planning will help the Oregon State University address natural hazards realistically and rationally. That is, to identify where the level of risk from one or more hazards may be unacceptably high and then to find cost effective ways to reduce such risk. Mitigation planning strikes a pragmatic middle ground between unwisely ignoring the potential for major hazard incidents on one hand and unnecessarily overreacting to the potential for disasters on the other hand.

This mitigation plan focuses on the hazards that pose the greatest threats to the facilities and people: earthquakes, tsunamis, floods, and wildland/urban interface fires. Other natural hazards that pose lesser threats to the Oregon State University are addressed briefly.
Table of Contents

1.0 INTRODUCTION ................................................................................................ 1-1
  1.1 What is a Hazard Mitigation Plan? ................................................................. 1-1
  1.2 Why is Mitigation Planning Important for OSU? .......................................... 1-2
  1.3 The OSU Natural Hazard Mitigation Plan ..................................................... 1-2
  1.4 Key Concepts and Definitions ..................................................................... 1-3
  1.5 The Mitigation Process ............................................................................... 1-7
  1.6 Incorporating Hazard Data, Risk Data and Mitigation Planning into Ongoing Programs, Policies and Activities .................................................. 1-9
  1.7 The Role of Benefit-Cost Analysis in Mitigation Planning ......................... 1-9
  1.8 Hazard Synopsis ...................................................................................... 1-10

2.0 OREGON STATE UNIVERSITY PROFILE ....................................................... 2-1
  2.1 Overview .................................................................................................... 2-1
  2.2 OSU Facilities ............................................................................................ 2-2
  2.3 Historic Preservation .................................................................................. 2-4
  2.4 OSU Demographic Information .................................................................. 2-6

3.0 MITIGATION PLANNING PROCESS ................................................................ 3-1
  3.1 Overview .................................................................................................... 3-1
  3.2 Mitigation Planning Team ........................................................................... 3-1
  3.3 Mitigation Planning Meetings ..................................................................... 3-2
  3.4 Public Outreach Efforts During the Mitigation Planning Process ............... 3-5
  3.5 Review and Incorporation of Existing Plans, Studies, Reports and Technical Information ................................................................. 3-6

4.0 GOALS, OBJECTIVES, and ACTION ITEMS ................................................... 4-1
  4.1 Overview .................................................................................................... 4-1
  4.2 Mission Statement ...................................................................................... 4-2
  4.3 Mitigation Plan Goals and Objectives ....................................................... 4-2
  4.4 OSU Natural Hazards Mitigation Plan Action Items .................................. 4-3

5.0 MITIGATION PLAN ADOPTION, IMPLEMENTATION and MAINTENANCE... 5-1
  5.1 Overview .................................................................................................... 5-1
  5.2 Plan Adoption ............................................................................................. 5-1
  Resolution Adopting the Oregon State University ............................................ 5-2
  5.3 Implementation ........................................................................................... 5-3
    5.3.1 Existing Authorities, Policies, Programs, Resources and Capabilities ..... 5-3
8.3 Volcanic Hazard and Risk Assessment ........................................................... 8-5
8.4 Volcano Monitoring and Volcano Activity Alerts ........................................... 8-6
8.5 Volcanic Hazard Mitigation Measures ........................................................... 8-7
8.6 References .................................................................................................... 8-10

9.0 FLOOD ......................................................................................................... 9-1

9.1 Introduction .................................................................................................. 9-1
9.2 Flood Hazard Assessments: Within FEMA-Mapped Floodplains .................... 9-3
9.3 Flood Hazard Assessments: Outside FEMA-Mapped Floodplains ................ 9-7
9.4 National Flood Insurance Program Insured Structures ................................... 9-8
9.5 OSU Flood Risk Assessment ......................................................................... 9-8
  9.5.1 Overview ................................................................................................ 9-8
  9.5.2 Flood Loss Estimates ............................................................................. 9-9
9.6 Flood Mitigation Action Items ....................................................................... 9-10
9.5 References .................................................................................................. 9-13

10.0 Wildland/Urban Interface Fires ................................................................. 10-1

10.1 Overview .................................................................................................... 10-1
10.2 Wildland/Urban Interface Fires .................................................................. 10-2
10.3 Wildland and Wildland/Urban Fire Hazard Mapping and Hazard Assessment ................................................................................................................. 10-3
10.4 Wildland/Urban Interface Fire Hazard and Risk Assessments .................... 10-5
10.5 Mitigation for Wildland/Urban Interface Fires ............................................. 10-6

11.0 OTHER NATURAL HAZARDS .................................................................. 11-1

11.1 High Winds ............................................................................................... 11-1
11.2 Tornadoes ................................................................................................. 11-1
11.3 Snow and Ice Storms ............................................................................... 11-2
11.4 Thunderstorms and Hail Storms ................................................................. 11-3
11.5 Extreme Temperatures .............................................................................. 11-3
11.6 Drought ..................................................................................................... 11-4
11.7 Climate Change ........................................................................................ 11-4
11.8 Landslides .............................................................................................. 11-4
11.9 References: ............................................................................................... 11-6

Appendix 1: FEMA Mitigation Grant Programs .................................................. A1-1
  Overview ....................................................................................................... A1-2
  FEMA Public Assistance Programs ............................................................... A1-2
  FEMA Mitigation Grant Programs ................................................................. A1-4
Hazard Mitigation Grant Program (HMGP) ................................................................. A1-5
Annual Pre-Disaster Grant Programs ..................................................................... A1-6
Pre-Disaster Mitigation Grant Program (PDM) .................................................... A1-6
Flood Mitigation Assistance Grant Program (FMA) .............................................. A1-7
General Guidance for FEMA Grant Applications .............................................. A1-7

Appendix 2: Principles of Benefit Cost Analysis .................................................... A2-1
Introduction ............................................................................................................ A2-2
What are Benefits? ............................................................................................... A2-3
FEMA Benefit-Cost Analysis Software ............................................................... A2-4
Benefit-Cost Analysis: Use and Interpretation .................................................... A2-5
Benefit-Cost Analysis Example .......................................................................... A2-6

Appendix 3: MITIGATION PLANNING PUBLIC PROCESS DOCUMENTATION ....
Initiation of Mitigation Planning Effort October 26, 2015 .................................. A3-2
December 2015: Mitigation Planning Kick-Off Meetings .................................. A3-4
May 17, 2016 - Steering Committee Mitigation Planning Meeting .................. A3-7
September 7, 2017 Steering Committee, Work Group Planning Team and Public Meeting .......................................................... A3-11
Announcement of Mitigation Planning and Invitation to September 7, 2017 Meeting ........................................................................................................ A3-17
April 23, 2018 – Steering Committee Planning Meeting ................................... A3-23
April 23, 2018 2nd Public Planning Meeting ..................................................... A3-26
This Page Left Blank
1.0 INTRODUCTION

1.1 What is a Hazard Mitigation Plan?

The Oregon State University (OSU) Natural Hazard Mitigation Plan covers each of the major natural hazards that pose significant risk to the University.

The effects of potential future disaster incidents may be minor - a few inches of water in a street - or may be major - with widespread damages, deaths and injuries, and economic losses reaching millions of dollars. The effects of major disasters on OSU can be devastating: the total damages, injury and/or loss of life, economic losses, and disruption of services may be far greater than the physical damages alone.

The mission statement of the OSU Natural Hazard Mitigation Plan is to:

Proactively facilitate and support district-wide policies, practices and programs that make OSU more disaster resistant and disaster resilient.

Making OSU more disaster resistant and disaster resilient means taking proactive steps and actions to protect life safety, reduce property damage, minimize economic losses and disruption, and shorten the recovery period from future disasters.

This plan is an educational and planning document that is intended to raise awareness and understanding of the potential impacts of natural hazard incidents and to help OSU mitigate against these natural hazards in a pragmatic and cost-effective manner. It is important to recognize that the Natural Hazard Mitigation Plan is not a regulatory document and does not change existing OSU policies or zoning, building codes or other ordinances that apply to OSU.

Completely eliminating the risk of future disasters affecting OSU is neither technologically possible nor economically feasible. However, substantially reducing the negative consequences of future disasters is achievable with the implementation of a pragmatic Natural Hazard Mitigation Plan.

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

The OSU mitigation plan has several key elements:

1. Each hazard that may significantly affect OSU’s facilities is reviewed to estimate the probability (frequency) and severity of future hazard incidents.
2. The vulnerability of OSU to each hazard is evaluated to determine the likely severity of physical damages, casualties, and economic consequences.

3. A range of mitigation actions are evaluated to identify those with the greatest potential to reduce future damages and losses to OSU and that are desirable from the university’s perspective.

1.2 Why is Mitigation Planning Important for OSU?

Effective mitigation planning will help OSU deal with natural hazards realistically and rationally. That is, to identify where the level of risk from one or more hazards may be unacceptably high and then to find cost effective ways to reduce such risk. Mitigation planning strikes a pragmatic middle ground between unwisely ignoring the potential for major hazard incidents 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 state and local government entity to adopt a multi-hazard mitigation plan to remain eligible for future pre- or post-disaster FEMA mitigation funding. Thus, an important objective in developing this plan is to maintain eligibility for FEMA funding and to enhance OSU’s ability to garner future FEMA mitigation funding.

Further information about FEMA mitigation grant programs is given in Appendix 1: FEMA Mitigation Grant Programs.

1.3 The OSU Natural Hazard Mitigation Plan

This OSU Natural Hazard Mitigation Plan is built is upon a quantitative assessment of each of the major hazards that may significantly affect OSU, including their frequency, severity, and the campuses most likely to be affected.

These reviews of the hazards and the vulnerability of OSU to these hazards are the foundation of OSU’s mitigation plan. From these assessments, the greatest threats to OSU’s facilities are identified. These high risk situations then become priorities for future mitigation actions to reduce the negative consequences of future disasters affecting OSU.

The OSU Natural Hazard Mitigation Plan addresses hazards realistically and rationally and also strikes a balance between suggested physical mitigation actions to eliminate or reduce the negative consequences of future disasters and planning measures which better prepare the community to respond to and recover from disasters for which physical mitigation actions are not possible or not economically feasible.
1.4 Key Concepts and Definitions

The central concept of 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. That is, risk is the potential for damages, losses and casualties arising from the impact of hazards on the built environment. The essence of mitigation planning is to identify OSU facilities that are at high risk from one or more natural hazards and to evaluate ways to mitigate (reduce) the effects of future disasters on these high risk facilities.

The level of risk at a given location, building or facility depends on the combination of **hazard** frequency and severity plus the **exposure**, as shown in Figure 1 below.

**Figure 1.1**

Hazard and Exposure Combine to Produce Risk

<table>
<thead>
<tr>
<th>HAZARD</th>
<th>EXPOSURE</th>
<th>RISK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency and Severity of Hazard Events</td>
<td>Value and Vulnerability of Inventory</td>
<td>Threat to the Community: People, Buildings and Infrastructure</td>
</tr>
</tbody>
</table>

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 incidents that may cause damages, losses or casualties, such as earthquakes, tsunamis and floods. 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, earthquakes are characterized by the probable severity and duration of ground motions while tsunamis are characterized by the areas inundated and by the depth and velocity of the tsunami inundations.

A hazard incident, by itself, may not result in any negative effects 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 incident. 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 effects on the community. Indeed, in this case, the very frequent flooding (the high hazard) may be beneficial environmentally by providing wildlife habitat, recreational opportunities, and so on.
The important point is that hazards do not necessarily produce risk to people and property, unless there is vulnerable inventory exposed to the hazard. Risk to people, buildings or infrastructure occurs only when hazards are combined with an exposure to the hazard.

**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. For OSU, the built-environment inventory of concern is largely limited to the OSU's facilities and supporting infrastructure.

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 engineering measures of the vulnerability of buildings and infrastructure are used.
Risk is the threat to people and the built environment - the potential for damages, losses and casualties arising from hazards. Risk results from the combination of Hazard and Exposure as discussed previously and as illustrated in Figure 1.4.

Risk is the potential for future damages, losses or casualties. A disaster incident happens when a hazard incident is combined with vulnerable inventory (that is when a hazard incident strikes vulnerable inventory exposed to the hazard). The highest
risk in a community occurs in high hazard areas (frequent and/or severe hazard incidents) 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 (such as 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 incidents. Repair of buildings or infrastructure damaged in a disaster is not mitigation. Hazard mitigation projects may be initiated proactively - before a disaster, or after a disaster has already occurred. In either case, the objective of mitigation is always to reduce future damages, losses or casualties. A few common types of mitigation projects are shown in Table 1.1 below

### Table 1.1

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Common Mitigation Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earthquake</td>
<td>Structural retrofits for buildings</td>
</tr>
<tr>
<td></td>
<td>Nonstructural retrofits for building elements and contents</td>
</tr>
<tr>
<td></td>
<td>Replace existing building with new, current-code building</td>
</tr>
<tr>
<td>Tsunamis</td>
<td>Enhance evacuation planning, including practice drills</td>
</tr>
<tr>
<td></td>
<td>Build vertical evacuation shelters when the travel time to safe elevations is less than the anticipated warning time for tsunamis</td>
</tr>
<tr>
<td>Volcanic Hazards</td>
<td>Enhance evacuation planning, including practice drills</td>
</tr>
<tr>
<td>Floods</td>
<td>Flood barriers and other floodproofing measures</td>
</tr>
<tr>
<td></td>
<td>Elevate at risk buildings</td>
</tr>
<tr>
<td></td>
<td>Abandon campus at high risk (possible FEMA buyout) and build new campus outside of floodplain</td>
</tr>
<tr>
<td>Wildland/Urban Interface Fires</td>
<td>Enhance defensible space around buildings</td>
</tr>
<tr>
<td></td>
<td>Fuel reduction measures near campus</td>
</tr>
<tr>
<td></td>
<td>Improve fire resistance of existing buildings with non-flammable roofs and exterior finishes and other fire-safe measures</td>
</tr>
<tr>
<td>Landslides</td>
<td>Stabilize slopes with improved drainage and/or retaining walls.</td>
</tr>
<tr>
<td>Multi-Hazard</td>
<td>Replace vulnerable facility with new current-code facility, outside of high hazard zones when possible</td>
</tr>
<tr>
<td></td>
<td>Enhance emergency planning, including drills</td>
</tr>
<tr>
<td></td>
<td>Expand education/outreach to improve community understanding of natural hazards</td>
</tr>
</tbody>
</table>
The mitigation project examples above are not comprehensive; mitigation projects can encompass many 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 reductions in risk (i.e., the avoided damages, losses, and casualties attributable to the mitigation project). Benefits are the difference in expected damages, losses, and casualties before mitigation (as-is conditions) and after mitigation. These important concepts are illustrated on the following page.

Figure 1.5
Mitigation Projects Reduce Risk

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

Quantitative risk assessment is centrally important to hazard mitigation planning. When the level of risk is high, the expected levels of damages and losses are likely to be unacceptable to the community and mitigation actions have a high priority: 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. Therefore, when levels of risk are low and/or the cost of mitigation is high relative to the level of risk, the risk may be deemed acceptable (or at least tolerable). Therefore, proposed mitigation projects that
address low levels of risk or where the cost of the mitigation project is large relative to the level of risk are generally poor candidates for implementation.

The overall mitigation planning process is outlined in Figure 1.6 below, which shows the major steps in hazard mitigation planning and implementation for OSU.

Figure 1.6
The Mitigation Planning Process

The first steps are quantitative evaluation of the hazards (frequency and severity) affecting OSU and of the inventory (people and facilities) exposed to these hazards. Together these hazard and exposure data determine the level of risk for specific locations, buildings or facilities within OSU, within the limits of available data.
The next key step is to determine whether or not the level of risk posed by each of the hazards affecting OSU is acceptable or tolerable. 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. There is no absolute universal definition of the level of risk that is tolerable or not tolerable. Each entity has to make its own determination.

If the level of risk is deemed not acceptable or tolerable, then mitigation actions are desired. In this case, the mitigation planning process moves on to more detailed evaluation of specific mitigation alternatives, prioritization, funding and implementation of mitigation actions. 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 should be undertaken can only be made by OSU.

1.6 Incorporating Hazard Data, Risk Data and Mitigation Planning into Ongoing Programs, Policies and Activities

OSU’s addressing of hazards, risk and mitigation planning will be most effective if they are not viewed as stand-alone activities but, rather, robustly incorporated into ongoing programs, policies and activities, especially planning and capital improvement programs. For example:

- New facilities should be sited outside of high hazard areas whenever possible or designed to be resilient in natural hazard incidents if this is not possible.
- Design of new facilities should consider whether design to higher standards for earthquakes than the minimum required for life safety may be worthwhile, considering life-cycle costs.
- Decisions about renovations, modernization, repair or expansion of existing facilities should include assessment of seismic risk to determine whether replacement with a new current-code building may be preferable to improving an existing building.

1.7 The Role of Benefit-Cost Analysis in Mitigation Planning

Institutions, such as OSU, 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 incidents?
- Do we want to undertake mitigation actions?
- What mitigation actions are feasible, appropriate, and affordable?
- How do we prioritize between competing mitigation projects?
• Are our mitigation projects likely to be eligible for FEMA funding?

Benefit-cost analysis (BCA) is a powerful tool that can help provide solid, defensible answers to these difficult socio-political-economic-engineering questions. Benefit-cost analysis is required for nearly all FEMA-funded mitigation projects, under both pre-disaster and post-disaster mitigation programs. 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.

Further details about benefit-cost analysis are given in the Appendix 2: Principles of Benefit-Cost Analysis.

1.8 Hazard Synopsis

The OSU mitigation plan focuses on the five major hazards (earthquakes, tsunamis, floods, wildland/urban interface fires and landslides) that pose the overall greatest risks to OSU’s facilities. Other natural hazards that pose lesser risks to OSU’s facilities including (drought, severe weather, extreme temperatures, and volcanic) incidents are also addressed. Human-caused hazards are not addressed because they are better addressed via OSU’s ongoing emergency planning activities.

OSU’s facilities include:

• 3 campuses: Corvallis, Newport and Bend,
• 36 OSU Extension facilities, one in each county in Oregon, and
• 8 Branch Experiment Stations.

Overall, OSU’s facilities include approximately 622 buildings that range from major, high-occupancy academic teaching and research buildings to small buildings of lesser importance such as barns, greenhouses and storage buildings. The building inventory includes OSU owned facilities as well as leased buildings over which OSU has limited control. The mitigation plan includes information on all of these buildings. However, the emphasis is on the major, high-occupancy buildings owned by OSU, with lesser emphasis on the minor buildings and leased buildings.

Earthquake hazards exist for every location in Oregon and thus exist for all of OSU’s buildings. The level of earthquake hazard is highest near the Pacific coast, high in the Willamette Valley and gradually decreases further east. The Corvallis campus has numerous older buildings with significant seismic deficiencies including the unreinforced masonry buildings, lift-slab buildings and others.

Tsunami hazards are limited to OSU facilities very near the Pacific Coast with the Hatfield Marine Science Center having a very high tsunami hazard. The Extension Service Offices in Astoria and Gold Beach also have high tsunami risk.
Volcanic hazards for OSU facilities are almost entirely limited to possible ash falls from eruptions of volcanoes in the Cascades. However, there is a remote possibility with a very low probability of more severe volcanic incidents from the Three Sisters and Newberry Crater volcanos near the Cascade Campus.

Flood risks for OSU facilities are generally low. None of the major buildings are within the FEMA-mapped 100-year floodplain. Only three of the minor buildings (Oak Creek Building, Oak Creek Chemistry Lab and the OSU Crew Facility) are within the 100-year floodplain.

Wildland/urban interface fire risk is very low for the Corvallis Campus, the Cascade Campus and the Hatfield Marine Science Center. Some of the extension facilities and the experimental stations may have higher risk.

Other natural hazards including high winds, tornadoes, snow and ice storms, thunderstorms, hail storms, extreme temperatures, drought, and landslides generally pose lesser or very low probability risks to OSU facilities. Climate change may significantly increase risks from drought, wildland/urban interface fires, and severe weather. Sea level rise will increase the tsunami risk and coastal flood risks for OSU facilities near the coast at low elevations, including the Hatfield Marine Science Center.

Further details re: these hazards and the level of risk to OSU’s facilities and people are presented in the following chapters:

Chapter 6: Earthquakes
Chapter 7: Tsunamis
Chapter 8: Volcanoes
Chapter 9: Floods
Chapter 10: Wildland/Urban Interface Fires
Chapter 11: Other Natural Hazards
2.0 OREGON STATE UNIVERSITY PROFILE

2.1 Overview

Oregon State University was founded in 1868 and is now Oregon’s largest university. OSU is an international public research university located in Corvallis, one of safest, smartest, greenest small cities in the nation. With $336 million in external research funding in 2016, a second consecutive year of record-breaking growth, OSU accounts for more research funding than all of the state's comprehensive public universities combined. OSU’s has a statewide economic impact of $2.371 billion and an impact that reaches across the state and beyond.

OSU offers more than 200 undergraduate and 100 graduate degree programs through 11 colleges, the graduate school and the Honors College, one of only a handful of degree-granting honors programs in the United States.

Oregon State University Mission Statement

Preamble

Oregon State University is a comprehensive, research intensive public land-grant university. OSU is one of only two land-, sea-, space- and sun-grant universities with such designation in the country. Oregon State programs and faculty are located in every county of the state and investigate the state's greatest challenges. The state of Oregon is OSU's campus but our mission is to serve the state, the nation and the world. The university works in partnership with the K-12 school system, Oregon community colleges and other colleges and universities to provide access to high-quality educational programs. Strong collaborations with industry and state and federal agencies drive OSU's research enterprise.

Mission

As a land grant institution committed to teaching, research and outreach and engagement, Oregon State University promotes economic, social, cultural and environmental progress for the people of Oregon, the nation and the world.

This mission is achieved by producing graduates competitive in the global economy, supporting a continuous search for new knowledge and solutions and maintaining a rigorous focus on academic excellence, particularly in the three Signature Areas: Advancing the Science of Sustainable Earth Ecosystems, Improving Human Health and Wellness, and Promoting Economic Growth and Social Progress.

Vision

To best serve the people of Oregon, Oregon State University will be among the Top 10 land grant institutions in America.
Goals

1. Provide outstanding academic programs that further strengthen performance and pre-eminence in the three Signature Areas of Distinction: Advancing the Science of Sustainable Earth Ecosystems, Improving Human Health and Wellness, and Promoting Economic Growth and Social Progress;

2. Provide an excellent teaching and learning environment and achieve student access, persistence and success through graduation and beyond that matches the best land grant universities in the country; and

3. Substantially increase revenues from private fundraising, partnerships, research grants and technology transfers while strengthening our ability to more effectively invest and allocate resources to achieve success.

2.2 OSU Facilities

OSU has a statewide footprint, with facilities and programs in each of Oregon’s 36 counties, including:

- The main campus in Corvallis,
- The OSU-Cascades campus in Bend,
- The Hatfield Marine Science Center in Newport,
- 35 OSU Extension Offices, five of which are combined research and Extension Centers,
- 10 Agricultural Experiment Sites, and
- 10 Forest Research Sites.

OSU has over 600 buildings that range from large teaching, research and residential buildings to small agricultural buildings such as barns and greenhouses. The majority of OSU buildings are owned by OSU. However some buildings, including many of the Extension facilities, are leased.

The locations of OSU’s sites statewide are shown in Figure 2.1 on the following page.
2.3 Historic Preservation

Historic preservation is an important consideration for the Corvallis campus. The OSU National Historic District, is shown in Figure 2.2 on the following page.

The OSU Historic Preservation Plan (2010) documents OSU’s historic preservation policies and practices. The Historic Preservation Plan lists 47 historic buildings built between 1887 (Benton Hall) and 1957 (Cauthorn Hall and Poling Hall). In addition to Benton Hall, the oldest buildings on the OSU campus include: Benton Annex (1892), Fairbanks Hall (1892) Valley Gymnastics Center (1898), Apperson Hall (1899), Education Hall (1902), Waldo Hall (1907), Merryfield Hall (1909), Strand Agricultural Hall (1909), McAlexander Field House (1910) and the Shooting Range (1910).

The plan also lists other buildings that contribute to the historic significance of the Historic District. Additional buildings, structures, or places that are at least 50 years old may be eligible for future listing as historic.

Future remodeling, modernization, or seismic retrofit of buildings in the OSU National Historic District must comply with the City of Corvallis’ Land Development Code.
Figure 2.2
OSU National Historic Preservation District
2.4 OSU Demographic Information

OSU’s Enrollment Summary (Winter Term 2018) includes the following demographic data for students:

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>29,952</td>
</tr>
<tr>
<td>Women</td>
<td>46.3%</td>
</tr>
<tr>
<td>Men</td>
<td>53.7%</td>
</tr>
<tr>
<td>Undergraduate</td>
<td>83.5%</td>
</tr>
<tr>
<td>Graduate</td>
<td>14.6%</td>
</tr>
<tr>
<td>First Professional</td>
<td>1.9%</td>
</tr>
<tr>
<td>U.S. Minorities</td>
<td>23.9%</td>
</tr>
<tr>
<td>International</td>
<td>11.8%</td>
</tr>
</tbody>
</table>

OSU’s Employment Report (March 2018) shows a total of 13,340 employees, including faculty, classified, graduate assistant, students and temporary employees. Full time employees total 5,442; part-time employees total 7,898.
3.0 MITIGATION PLANNING PROCESS

3.1 Overview

The first step in the development of the OSU Natural Hazards Mitigation Plan was the submission of a FEMA mitigation planning grant application in 2014. The planning process began in earnest in the fall of 2015 when the FEMA grant was received.

The OSU Natural Hazards Mitigation plan draws on the 2015 Oregon Natural Hazards Mitigation Plan and the 2016 Benton County Multi-Jurisdictional Natural Hazards Mitigation Plan, including the Addendum for the City of Corvallis. However, the OSU Natural Hazards Mitigation Plan is specifically focused on OSU’s facilities and people.

3.2 Mitigation Planning Team

The mitigation planning team was led by Michael Bamberger, OSU’s Emergency Preparedness Manager. The mitigation planning team included the following members:

Kevin Blank, Intercollegiate Athletics
Bill Callender, Recreational Sports
Sid Cooper, Memorial Union Building Services
Marcia Dickson, Extension Service Administration
Jake Gibson, Intercollegiate Athletics
Jaimi Glass, Benton County Emergency Management
John Gremmels, Capital Planning and Development
Patrick Hughes, Enterprise Risk Services
Christina McKnight, Enterprise Risk Services
Joe McQuillin, University Housing and Dining

The mitigation planning team’s roles and responsibilities were defined as follows:

- Participate actively in planning team meetings,
- Provide local perspectives regarding: natural hazards and the threats that they pose to the University’s facilities and people.
- Help to identify existing plans, studies, reports and technical information for inclusion or reference in the mitigation plan.
- Forge consensus on mitigation action items and their priorities.
- Help to facilitate the public outreach actions during the mitigation planning process, and
Provide review comments on draft materials during development of the OSU Natural Hazards Mitigation Plan.

OSU’s mitigation planning effort also included a Work Team tasked with gathering data to support the hazard and risk assessments.

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Tom Miller</td>
<td>College of Civil Engineering</td>
</tr>
<tr>
<td>Masters Level Students</td>
<td>4 Civil Engineering classes, led by Dr. Miller</td>
</tr>
<tr>
<td>Jim Lewis</td>
<td>Hatfield Marine Science Center</td>
</tr>
<tr>
<td>John Condon</td>
<td>OSU-Cascades Bend Campus</td>
</tr>
<tr>
<td>Dan vanVliet</td>
<td>University Infrastructure and Operations - GIS</td>
</tr>
<tr>
<td>Lori Fulton</td>
<td>Capital Planning</td>
</tr>
</tbody>
</table>

The mitigation planning team also included a consulting team led by Kenneth Goettel (Goettel & Associates Inc.), structural engineers Kent Yu and James Newell (SEFT Consulting Group) and a Geographic Information Systems (GIS) expert, Eric Coughlin (Atkins North America, Inc.).

### 3.3 Mitigation Planning Meetings

Mitigation planning team meetings are documented below with dates and brief summaries. Agendas and additional information are provided in Appendix 3.

- **1st Meeting: December 1, 2015 - Mitigation Planning Meeting at Hatfield Marine Science Center (HMSC), Newport, Oregon**

  Present: Mike Bamberger, Jim Lewis, Consultant: Ken Goettel

  Summary: A site walk through of buildings with earthquake and tsunami risks was conducted by Ken Goettel, Mike Bamberger and Jim Lewis (HMSC Operations Manager). Building plans were discussed and reviewed. Discussion of the future Marine Science Initiative (MSI) Center identified the need for additional information from the OSU Capital Planning Department.

- **2nd Meeting: December 2, 2015 Mitigation Planning Meeting**

  Present: Mike Bamberger, Kevin Blank, Jaimi Glass, John Gremmels, Christina McKnight, Denise Hunt, Sid Cooper, Bill Callender, Patrick Hughes, Joe McQuilllin, Consultant: Ken Goettel

  Not Present: Marcia Dickson (sent Denise Hunt in lieu of)

  Ken Goettel presented an overview of the mitigation planning process, expectations of FEMA, and how the OSU Natural Hazards Mitigation Plan
would look when completed. The Steering Committee members were
identified and Working Committee member participation discussed, with
potential partners identified. Future communication would be conducted by
Mike Bamberger to potential members.

Attendees developed OSU priorities, discussed mitigation goals and identified
sources for data that would be needed to complete a hazard analysis. Future
site visits were also discussed. Finally, a discussion of what building(s) could
receive a detailed risk assessment was held.

• 3rd Meeting: May 17, 2016 Mitigation Planning Meeting

Present: Mike Bamberger, Kevin Blank, Christina McKnight, Marcia Dickson,
Theresa Hogue, Sid Cooper, Bill Callender, Patrick Hughes, Consultant: Ken
Goettel

Not Present: Jaimi Glass, John Gremmels, Joe McQuillin

Ken Goettel previewed draft Chapters 1 and 3 of the plan. Mike Bamberger
and Ken Goettel reviewed with the Planning Team the data collected/mapped
to date and where missing data points were. The group identified how to
collect additional information for processing. They also began considering
mitigation actions to include in the final plan.

The group reviewed the pre-meeting vote and determined that Weniger Hall
would be the building selected for advanced seismic analysis by an
engineering firm.

• 4th Meeting: September 7, 2017 Mitigation Planning and 1st Public Meeting

Present: (Planning Team) Mike Bamberger, John Gremmels, Patrick Hughes,
Marcia Dickson, Bill Callender, Christina McKnight (OSU Community) Anita
Azarenko, Rebecca Houghtaling, Jonathon Stoll (Public/Community
Agencies) Toby Lewis, Consultant: Ken Goettel

Present (Citizens) James Paul Rodell

Not Present: (Steering committee members) Keven Blank, Joe McQuillin, Sid
Cooper, Theresa Hogue (Partner community agencies): Shirley Keeton,
Jaimi Glass, Chris Bentley, Kevin Young, Bill Emminger, Josh Wheeler,
Douglas Baily, Adam Steele, Greg Gescher, Jim Patton, Bob Fenner, Jim
Minard, Nathan Garibay, Jenny Demaris, Joe Larsen, Robert Wheeldon,
Sarah Bates, Lori Fulton, Jim Bouziane, Tom Miller, Lowell Fausett, Joe
Majeski, Bill Coslow, Bob Mason, Jim Lewis, MaryAnn Bozza, Dan vanVliet,
John Condon
Local community and government stakeholders were invited, as well as the general public, to the meeting.

Ken Goettel presented the draft OSU Natural Hazards Mitigation Plan. Ken Goettel reviewed the hazard analysis conducted from the OSU data and described the impact to OSU property throughout the State of Oregon.

Participants reviewed the chapters, discussed questions, and developed or refined proposed mitigation actions to include in the final plan.

- **5th Meeting: April 23, 2018 Mitigation Planning Meeting**

  Present: (Planning Team) Mike Bamberger, John Gremmels, Patrick Hughes, Theresa Hogue, Bill Callender, Christina McKnight (OSU Community) Tom Miller, Erica Fischer (Public/Community Agencies) Cale Ash (Degenkolb Engineers), Consultant: Ken Goettel

  Not Present: *(Steering committee members)* Keven Blank, Joe McQuilllin, Sid Cooper, Marcia Dickson

  Ken Goettel presented a summary of the OSU Natural Hazards Mitigation Plan findings and an in-depth review the draft Chapter 6 Seismic of the. Ken Goettel reviewed the hazard analysis and its impact to the building inventory for OSU throughout the state. Additionally items of information were identified to complete the data tables. URM and Lift Slab construction design were discussed and the potential impact to OSU.

  Participants also reviewed Chapter 4 work action items.

- **April 23, 2018 2nd Public Planning Meeting**

  Present: (Planning Team) Mike Bamberger (OSU Community), Erica Fischer (Public/Community Agencies) Cale Ash (Degenkolb Engineers), Consultant: Ken Goettel

  A presentation of the of the hazard mitigation plan process, a summary of the OSU Natural Hazard Mitigation Plan chapters, findings, and action items, and the opportunity to provide discussion/feedback was offered. Participants discussed some of the retrofits that were conducted to existing buildings and provided comments.
3.4 Public Outreach Efforts During the Mitigation Planning Process

The University took robust efforts to try to engage the public and stakeholders throughout the mitigation planning process, including the following actions:

The University announced the initiation of the mitigation planning effort and invited the public and stakeholders to participate via:

- Posting a notice on the University’s Emergency Management website,
- Distributing the notice via the University daily electronic newspaper OSU Today to a wide audience of stakeholders,
- Publishing the notice in the Gazette Times local newspaper,
- E-mail notifications to cities and counties and agencies responsible for emergency response and mitigation planning activities

Copies of the above notices are included in Appendix 3.

Public meetings were announced via the modes listed above and held on the following dates:

- Public Meeting 1: September 7, 2017 (see 4th meeting on the previous page)
- Public Meeting 2: April 23, 2018 (see 5th meeting on the previous page)

Agendas and additional information are provided in Appendix 3.

Review and Comment on Mitigation Plan Drafts

Mitigation plan drafts were posted on the University’s website for review. Notices of the University’s requests for comments were solicited from all interested parties were made via direct email to identified community stakeholders as well as a general announcement published in the OSU Today electronic newsletter and the Gazette Times newspaper. Copies of the notices are included in Appendix 3.

Comments from the mitigation planning team and stakeholders were received during the meetings documented previously. No further comments were received the public or stakeholders from the draft versions of the OSU Natural Hazards Mitigation Plan that were posted on the website during the review and comments periods.

No comments were received via the website.

One citizen, an active member of the Community Emergency Response Team (CERT) actively participated in the September 7, 2017 public meetings. His inputs included the following:
• OSU should systematically plan for restoration of operational status of key facilities after major 100-year or 500-year natural hazard events, including identifying the highest priorities

• Discussion of liquefaction should be expanded.

3.5 Review and Incorporation of Existing Plans, Studies, Reports and Technical Information.

During the mitigation planning process, a detailed seismic vulnerability analysis of Weniger Hall was conducted by structural engineers (Kent Yu and James Newell, SEFT Consulting Group). This evaluation including development of conceptual seismic retrofit schemes to bring the building up to Life Safety or to Immediate Occupancy performance levels.

Existing Plans, Studies, Reports and Technical information reviewed and incorporated into the OSU Natural Hazards Mitigation Plan include the following:

1. OSU’s detailed inventory data for buildings, including location (latitude and longitude), building size, building use and occupancy, building importance, year built, structural building type, historical significance and other information bearing on vulnerability to natural hazard events and priorities for retrofit or replacement.

2. FEMA floodplain mapping to identify which OSU buildings are located with mapped 100-year or 500-year floodplains.

3. Tsunami inundation maps to determine which OSU buildings are located within or very near mapped inundation zones.

4. Existing seismic evaluations of OSU buildings, including detailed seismic evaluations by structural engineers and Rapid Visual Screening (RVS) of OSU buildings by Dr. Tom Miller’s Masters Level civil engineering classes using FEMA Publication 154 “Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook. Third Edition” as well as older studies using previous versions of RVS.

5. The Campus Master Plan that guides long range planning of the physical development of OSU’s Corvallis and Bend campuses over the next decade. The current plan is available at [http://fa.oregonstate.edu/university-land-use/osu-district-plan](http://fa.oregonstate.edu/university-land-use/osu-district-plan) and future revisions or updates are available by contacting the Capital Planning Department. An update of this plan is in process and will be posted on the website when it is finalized.

6. The Hatfield Marine Science Center (Newport, Oregon) provided detailed studies of existing building inventory plus future site expansion plans for building placement, with consideration of tsunami evacuations.
4.0 GOALS, OBJECTIVES, and ACTION ITEMS

4.1 Overview

The purpose of the OSU Natural Hazards Mitigation Plan is to reduce the impacts of future natural disasters on the university’s facilities, students, staff and volunteers. That is, the purpose is to make OSU more disaster resistant and disaster resilient, by reducing the vulnerability to disasters and enhancing the capability to respond effectively to and recover quickly from future disasters.

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

The OSU Natural Hazards Mitigation Plan is based upon 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 OSU Natural Hazards Mitigation Plan. The Mission Statement is an action-oriented summary that answers the question "Why develop a Natural Hazards Mitigation Plan?"

**Goals.** Goals identify priorities and specify how OSU intends to work toward reducing the risks from natural and human-caused hazards. The Goals represent the guiding principles toward which the OSU’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 OSU Natural Hazards Mitigation Plan’s Goals. Objectives lead directly to specific Action Items.

**Action Items.** Action Items are specific well-defined activities or projects that work to reduce risk. That is, the Action Items represent the specific, implementable steps necessary to achieve OSU’s Mission Statement, Goals and Objectives.
4.2 Mission Statement

The mission statement for the OSU Natural Hazards Mitigation Plan is to:

Proactively facilitate and support district-wide policies, practices, and programs that make OSU more disaster resistant and disaster resilient.

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

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

4.3 Mitigation Plan Goals and Objectives

The following Goals and Objectives serve as guideposts and checklists to begin the process of implementing mitigation Action Items to reduce identified risks to OSU’s facilities, students, staff and visitors from natural disasters.

The Goals and Objectives are generally consistent with those in the Oregon Natural Hazards Mitigation Plan and with those in the county and city natural hazard mitigation plans in locations where OSU has facilities. However, the specific priorities, emphasis and language in this mitigation plan are the OSU’s. These goals were developed with extensive input and priority setting by OSU’s Natural Hazards Mitigation Planning team, with inputs from the OSU community and other stakeholders in the communities served by OSU.

Goal 1: Reduce Threats to Life Safety

Reducing threats to life safety is the highest priority for OSU.

Objectives:

A. Enhance life safety by retrofitting existing buildings or replacing them with new current-code buildings and by locating and designing new buildings to minimize life safety risk from future disaster incidents, especially earthquakes.

B. Refine disaster evacuation plans and conduct practice drills for natural hazard incidents where evacuation of buildings or campuses may be necessary, including earthquakes, tsunamis, volcanic incidents and wildland/urban interface fires.

C. Enhance life safety by improving public awareness of earthquakes, tsunamis, volcanic incidents and other natural hazards that pose
substantial life safety risk to OSU’s facilities, students, staff, and volunteers.

**Goal 2: Reduce Damage to District Facilities, Economic Losses and Disruption of OSU’s Services**

**Objectives:**

A. Retrofit or replace existing buildings with a high vulnerability to one or more natural hazards to reduce damage, economic loss and disruption in future disaster incidents.

B. Ensure that new facilities are adequately designed for hazard incidents and located outside of mapped high hazard zones to minimize damage and loss of function in future disaster incidents, to the extent practicable.

**Goal 3: Enhance Emergency Planning, Disaster Response and Post-Disaster Recovery**

**Objectives:**

A. Enhance collaboration and coordination between OSU, local governments, utilities, businesses and citizens to prepare for and recover from future natural disaster incidents.

B. Enhance emergency planning to facilitate effective response and rapid recovery from future natural disaster incidents.

**Goal 4: Increase Awareness and Understanding of Natural Hazards and Mitigation**

**Objectives:**

A. Implement education and outreach efforts to increase awareness of natural hazards throughout OSU, including staff, students and the entire communities served by OSU.

B. Include links on OSU’s Emergency Preparedness website to FEMA and other publications dealing with natural hazards, especially focusing on life safety.

**4.4 OSU Natural Hazards Mitigation Plan Action Items**

Mitigation Action Items may include a wide range of measures such as: refinement of policies, studies and data collection to better characterize hazards or risk, education or outreach activities, enhanced emergency planning, partnership building activities as well as retrofits to existing facilities or replacement of vulnerable facilities with new current-code buildings.

The 2018 OSU Natural Hazards Mitigation Plan Action Items are summarized on the following pages.
This Page Left Blank
<table>
<thead>
<tr>
<th>Multi-Hazard Mitigation Action Items</th>
<th>Hazard</th>
<th>Action Item</th>
<th>Timeline</th>
<th>Source of Funds</th>
<th>Responsible Person or Department</th>
<th>Plan Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Long-Term #1</td>
<td>Integrate the findings and action items in the mitigation plan into ongoing programs and practices for the OSU.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>EP/UFIO</td>
<td>Life Safety: X, Protect Facilities: X, Enhance Emergency Planning: X, Enhance Awareness and Education: X</td>
</tr>
<tr>
<td></td>
<td>Long-Term #4</td>
<td>Ensure that new facilities are adequately designed to minimize risk from natural hazards.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>UFIO</td>
<td>Life Safety: X, Protect Facilities: X, Enhance Emergency Planning: X, Enhance Awareness and Education: X</td>
</tr>
<tr>
<td>Hazard</td>
<td>Action Item</td>
<td>Timeline</td>
<td>Source of Funds</td>
<td>Responsible Person or Department</td>
<td>Plan Goals Addressed</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>------------------------------------------------------------------------------</td>
<td>----------</td>
<td>-----------------</td>
<td>----------------------------------</td>
<td>----------------------</td>
<td></td>
</tr>
<tr>
<td>Long-Term #7</td>
<td>Add educational materials regarding natural hazards in libraries and include in curriculums.</td>
<td>Ongoing</td>
<td>OSU or Grants</td>
<td>EP</td>
<td>Life Safety</td>
<td>Protect Facilities</td>
</tr>
<tr>
<td>Long-Term #8</td>
<td>Keep the OSU's mitigation plan on the website and encourage comments from stakeholders for the periodic review and update of the mitigation plan.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>EP</td>
<td>Life Safety</td>
<td>Protect Facilities</td>
</tr>
</tbody>
</table>

Note: EP = Emergency Preparedness, UFIO = University Facilities, Infrastructure and Operations
<table>
<thead>
<tr>
<th>Hazard</th>
<th>Action Item</th>
<th>Timeline</th>
<th>Source of Funds</th>
<th>Responsible Person or Department</th>
<th>Plan Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Safety</td>
<td><strong>Enhance capital improvement planning to make seismic safety a very high priority.</strong></td>
<td>1-2 Years</td>
<td>OSU or Grants</td>
<td>UFIO</td>
<td>X</td>
</tr>
<tr>
<td><strong>Earthquake Mitigation Action Items</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-Term #1</td>
<td>Evaluate the feasibility of designing new buildings and seismic retrofits to higher performance levels than the minimum Life Safety criteria.</td>
<td>1-2 Years</td>
<td>OSU or Grants</td>
<td>UFIO</td>
<td>X</td>
</tr>
<tr>
<td>Short-Term #2</td>
<td>Establish an explicit priority list for retrofit or replacement of the highest risk buildings, including URM and lift-slab buildings.</td>
<td>1-2 Years</td>
<td>OSU or Grants</td>
<td>EP</td>
<td>X</td>
</tr>
<tr>
<td>Short-Term #3</td>
<td>Evaluate nonstructural seismic vulnerabilities in the OSU's buildings from building elements and contents that pose significant life safety risk (falling hazards) and mitigate by bracing, anchoring or replacing identified high risk items.</td>
<td>1-2 Years</td>
<td>OSU or Grants</td>
<td>Facilities/EP</td>
<td>X</td>
</tr>
<tr>
<td>Short-Term #4</td>
<td>Aggressively seek funding for the highest priority seismic retrofits or building replacements from federal sources, state sources, donors and existing OSU capital improvement funds.</td>
<td>Ongoing</td>
<td>OSU or Grants</td>
<td>UFIO</td>
<td>X</td>
</tr>
<tr>
<td>Hazard</td>
<td>Action Item</td>
<td>Timeline</td>
<td>Source of Funds</td>
<td>Responsible Person or Department</td>
<td>Plan Goals Addressed</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------------------------------------------------------------</td>
<td>------------</td>
<td>-----------------</td>
<td>----------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Long-Term #1</td>
<td>Prioritize and implement structural seismic retrofits or replacements based on the results of the seismic evaluations completed under the Short-Term Action Items #1 to #4 listed above, as funding becomes available.</td>
<td>Ongoing</td>
<td>OSU or Grants</td>
<td>UFIO</td>
<td>X  X</td>
</tr>
<tr>
<td>Long-Term #2</td>
<td>Maintain and update building data for seismic risk assessments in the GIS database.</td>
<td>Ongoing</td>
<td>OSU or Grants</td>
<td>UFIO</td>
<td>X  X</td>
</tr>
<tr>
<td>Long-Term #3</td>
<td>Enhance emergency planning for earthquakes including duck and cover and evacuation drills.</td>
<td>Ongoing</td>
<td>OSU or Grants</td>
<td>EP</td>
<td>X  X</td>
</tr>
<tr>
<td>Long-Term #4</td>
<td>Enhance education and outreach activities to increase knowledge of earthquake risks within OSU and within communities with OSU facilities.</td>
<td>Ongoing</td>
<td>OSU or Grants</td>
<td>EP</td>
<td>X  X</td>
</tr>
</tbody>
</table>

Note: EP = Emergency Preparedness, UFIO = University Facilities, Infrastructure and Operations
### Table 4-1 – Continued
**OSU Tsunami Mitigation Action Items**

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Action Item</th>
<th>Timeline</th>
<th>Source of Funds</th>
<th>Responsible Person or Department</th>
<th>Plan Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Life Safety</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-Term #1</td>
<td>Review and update evacuation plans for tsunami for facilities in or near mapped tsunami inundation areas, including identifying the shortest routes to safe havens that don't have major impediments to rapid travel on foot and conduct frequent practice drills.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>HMSC</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Long-Term #1</td>
<td>Construction of vertical evacuation structure(s) at the Hatfield Marine Science Center if feasible, as funding becomes available.</td>
<td>2-10 years</td>
<td>OSU or Grants</td>
<td>HMSC/UFIO</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

**Tsunami Mitigation Action Items**

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Action Item</th>
<th>Timeline</th>
<th>Source of Funds</th>
<th>Responsible Person or Department</th>
<th>Plan Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Protect Facilities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-Term #2</td>
<td>Continue and expand public education and outreach efforts to increase awareness of tsunamis and the urgency of immediate evacuation to safe areas.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>HMSC</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Long-Term #2</td>
<td>Locate new facilities outside of tsunami hazard areas whenever possible or in immediate proximity to natural high ground suitable for evacuation.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>UFIO</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

**Note:** HMSC = Hatfield Marine Science Center; UFIO = University Facilities, Infrastructure and Operations
## Table 4-1 – Continued
OSU Volcanic Hazards Mitigation Action Items

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Action Item</th>
<th>Timeline</th>
<th>Source of Funds</th>
<th>Responsible Person or Department</th>
<th>Plan Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-Term #1</td>
<td>Incorporate notification and response measures for volcanic ash events into OSU's emergency operations planning.</td>
<td>1-2 Years</td>
<td>OSU</td>
<td>EP</td>
<td>X</td>
</tr>
<tr>
<td>Short-Term #2</td>
<td>Monitor USGS volcanic alerts whenever such alerts are made in locations that might affect OSU facilities.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>EP</td>
<td>X</td>
</tr>
<tr>
<td>Long-Term #1</td>
<td>Locate new facilities outside of severe volcanic hazard locations, including areas subject to lahars, whenever possible.</td>
<td>1 Year</td>
<td>OSU</td>
<td>UFIO</td>
<td>X</td>
</tr>
</tbody>
</table>

Note: EP = Emergency Preparedness, UFIO = University Facilities, Infrastructure and Operations
## Table 4-1 – Continued
**OSU Flood Mitigation Action Items**

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Action Item</th>
<th>Timeline</th>
<th>Source of Funds</th>
<th>Responsible Person or Department</th>
<th>Plan Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Life Safety</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flood Mitigation Action Items</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Short-Term #1</strong></td>
<td>Assess all buildings within FEMA-mapped floodplains, including minor, ancillary and leased buildings, for attributes that pose 1) environmental or life safety risk (such as hazmat storage) or 2) disruptions of important functions or disruption of long-term research projects.</td>
<td>1-3 Years</td>
<td>OSU</td>
<td>Risk/Facilities</td>
<td>X</td>
</tr>
<tr>
<td><strong>Short-Term #2</strong></td>
<td>Enhance emergency planning, including flood response measures, for all buildings that have or may have significant flood risk.</td>
<td>1-3 Years</td>
<td>OSU</td>
<td>UFIO</td>
<td>X</td>
</tr>
<tr>
<td><strong>Short-Term #3</strong></td>
<td>Evaluate the vulnerability of utility system elements, including utility tunnels, which may have significant flood risk that could result in widespread loss of utility services.</td>
<td>1-10 Years</td>
<td>OSU</td>
<td>UFIO</td>
<td>X</td>
</tr>
<tr>
<td><strong>Long-Term #1</strong></td>
<td>Implement flood mitigation measures, if warranted by the assessments in the above action items, as funding becomes available.</td>
<td>Ongoing</td>
<td>OSU or Grants</td>
<td>UFIO</td>
<td>X</td>
</tr>
<tr>
<td><strong>Long-Term #2</strong></td>
<td>Locate new buildings outside of FEMA-mapped floodplains or other flood-prone areas whenever possible or construct new buildings in flood-prone areas at elevations as high as possible to minimize flood risk.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>UFIO</td>
<td>X</td>
</tr>
</tbody>
</table>
### Hazard Action Item

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Action Item</th>
<th>Timeline</th>
<th>Source of Funds</th>
<th>Responsible Person or Department</th>
<th>Plan Goals Addressed</th>
<th>Note: UFIO = University Facilities, Infrastructure and Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long-Term #3</td>
<td>Include consideration of future sea level rise from global climate change for new and existing facilities at low elevations near the coast.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>UFIO</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plan Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Safety</td>
</tr>
<tr>
<td>Protect Facilities</td>
</tr>
<tr>
<td>Enhance Emergency Planning</td>
</tr>
<tr>
<td>Enhance Awareness and Education</td>
</tr>
<tr>
<td>Hazard</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Wildland/Urban Interface Fire Mitigation Action Items</strong></td>
</tr>
<tr>
<td><strong>Short-Term #1</strong></td>
</tr>
<tr>
<td><strong>Short-Term #2</strong></td>
</tr>
<tr>
<td><strong>Long-Term #1</strong></td>
</tr>
</tbody>
</table>

**Note:** EP = Emergency Preparedness
### Table 4-1 – Continued
**OSU Other Natural Hazards Mitigation Action Items**

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Action Item</th>
<th>Timeline</th>
<th>Source of Funds</th>
<th>Responsible Person or Department</th>
<th>Plan Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Life Safety</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>OSU</td>
</tr>
<tr>
<td>Short-Term #1</td>
<td>Review and update, OSU's Emergency Operations Plan sections dealing with natural hazards identified in this chapter.</td>
<td>1-3 Years</td>
<td>OSU</td>
<td>EP</td>
<td>X</td>
</tr>
<tr>
<td>Long-Term #1</td>
<td>Evaluate landslide risk if future updated data suggest that landslide risk may be significant at any of the OSU sites.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>UFIO</td>
<td>X</td>
</tr>
<tr>
<td>Short-Term #3</td>
<td>Carefully evaluate sea level rise when siting new facilities or when considering remodeling or replacing existing facilities at low elevations near the coast.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>UFIO</td>
<td>X</td>
</tr>
</tbody>
</table>

*Note: EP = Emergency Preparedness, UFIO = University Facilities, Infrastructure and Operations*
5.0 MITIGATION PLAN ADOPTION, IMPLEMENTATION and MAINTENANCE

5.1 Overview

For the OSU Natural Hazards Mitigation Plan to be effective, it has to be implemented gradually over time, as resources become available. An effective plan must also be continually evaluated and periodically updated. The mitigation Action Items included in the OSU Natural Hazards Mitigation Plan will be accomplished effectively through a process which routinely incorporates logical thinking about hazards and cost-effective mitigation into ongoing decision making, capital improvement spending and emergency preparedness.

The following sections document OSU’s adoption of the plan and summarize/show OSU will implement and maintain the vitality of the OSU Natural Hazards Mitigation Plan.

5.2 Plan Adoption

The OSU Natural Hazards Mitigation Plan became effective on September 21, 2018, the date of adoption by the OSU Vice President of Finance and Administration, on behalf of the OSU Executive Leadership Team. The Team adopted the OSU Natural Hazards Mitigation Plan following FEMA issuing a letter indicating that the plan is “approvable pending adoption. ”The adoption resolution is shown on the following page.
Resolution Adopting the Oregon State University
Natural Hazards Mitigation Plan

The OSU Executive Leadership Team resolves as follows:

Whereas, Oregon State University has determined that it is in the best interest of the University to have an active natural hazard mitigation planning effort to reduce the long term risks from natural hazards to the university’s facilities, and

Whereas, Oregon State University recognizes that the Federal Emergency Management Agency (FEMA) requires the university to have an approved natural hazards mitigation plan as a condition of applying for and receiving FEMA mitigation project grant funding.

Now, therefore, be it resolved by Oregon State University as follows:

Oregon State University adopts the Oregon State University Natural Hazards Mitigation Plan.

Passed by the Oregon State University Executive Leadership Team on the 21st day of September, 2018.

Michael Green
Vice President of Finance and Administration
5.3 Implementation

OSU’s Emergency Preparedness Department will have the lead responsibility for implementing the OSU Natural Hazards Mitigation Plan, with ongoing support from the University Infrastructure and Operations Division.

5.3.1 Existing Authorities, Policies, Programs, Resources and Capabilities

Oregon State University has much narrower domains of authorities than do cities and counties. The university’s responsibilities are largely limited to constructing and maintaining its facilities and providing educational services for the university’s students and customers. Statutory and regulatory requirements that affect OSU’s policies and practices are promulgated by federal, state, county and city authorities, not by OSU.

OSU’s policies and programs related to hazard mitigation planning include capital planning, risk management, emergency preparedness and historic preservation, as well as the university’s criteria and practices for the siting and design of new buildings and the maintenance/modernization/renovation of existing buildings. OSU’s staff resources for these programs include not only OSU departments and staff involved in implementing the policies and programs listed above, but also OSU faculty, especially engineering faculty, with relevant technical expertise and experience. Furthermore, OSU employs contractors and consultants on an as-needed basis to supplement university staff.

The completion of the OSU’s Hazards Mitigation Plan has substantially raised OSU’s awareness and knowledge of natural hazards. Consideration of natural hazards will continue to be included in siting of new buildings and in the design of new buildings. Furthermore, mitigation measures to reduce risks from natural hazards will be incorporated into maintenance and modernization of buildings whenever possible.

OSU has the necessary human resources to ensure that the OSU Natural Hazards Mitigation Plan continues to be an actively used planning document. OSU staff have been active in the preparation of the Plan, and have gained an understanding of the process and the desire to integrate the Plan into ongoing capital budget planning. Through this linkage, the OSU’s Natural Hazards Mitigation Plan will be kept active and be a working document.

OSU staff has broad experience with planning and facilitation of community inputs. This broad experience is directly applicable to hazard mitigation planning and to implementation of mitigation projects.

Furthermore, recent earthquake, tsunami, flood and other natural hazards disasters in the United States and worldwide serve as a reminder of need to maintain a high level of interest in evaluating and mitigating risk from natural disasters of all types.
These events have kept the interest in hazard mitigation planning and implementation of mitigation measures very active in the OSU community.

To ensure efficient, effective and timely implementation of the identified mitigation action items, OSU will use the full range of its capabilities and resources and those of the community. OSU’s goal is to implement as many of the elements of its mitigation strategy (Action Items) over the next five years as possible, commensurate with the extent of funding that becomes available.

**Regulatory Tools (Ordinances and Codes)**
- OSU Construction Standards
- City of Corvallis Land Development Code
- Other

**Administrative Tools (Departments, Organizations, Programs)**

**OSU Resources**
- University Infrastructure and Operations
- Risk Management
- Emergency Preparedness
- Memorial Union Operations
- University Housing and Dining Operations

**Regional and State Resources**
- Oregon Higher Education Coordinating Commission
- County Emergency Management Agencies in all counties in Oregon, but especially Benton, Deschutes and Lincoln Counties.
- City Emergency Management Agencies in each city where OSU has a facility, but especially Corvallis, Bend and Newport.
- Benton, Lincoln, and Deschutes County, including Emergency Management, Public Works and GIS, Planning Department and Building Officials.
- City of Corvallis, City of Newport, and City of Bend Emergency Management, Public Works and GIS, Planning Department and Building Officials
- Fire Departments – Corvallis Fire Department, Newport Fire Department, Bend Fire Department
- Police Departments – City of Corvallis, City of Newport, City of Bend, Benton County Sheriff’s Office, Lincoln County Sheriff’s Office, Deschutes County Sheriff’s Office
Technical Tools (Plans and Others)

OSU Capabilities

- OSU Website
- OSU Emergency Operation Plan
- Fire/Evacuation Drills
- Earthquake and Tsunami Drills
- Bomb Threat Assessment Guide
- Campus Master Plan
- OSU Strategic Plan
- Policies, Standards, and Procedures
- Student Rights and Responsibilities

Regional Capabilities

- Benton, Lincoln, and Deschutes County Hazard Mitigation Plans and Emergency Response Plans
- Corvallis, Newport, and Bend City Hazard Mitigation Plans and Emergency Response Plans

Fiscal Tools (Taxes, Bonds, Funds and Fees)

OSU Capabilities

- Authority to Issue Bonds
- Funds
  - General Fund
  - Capital Project Funds
  - Debt Service Fund
  - Transportation Vehicle Fund
  - Trust Fund
  - Booster Funds
- External Funds
  - FEMA Grants
  - HUD “CDBG” Grants
  - Foundation Grants
  - Legislative Funding/Grants
  - Other Grants
5.3.2 Integration into Ongoing Programs

As noted previously, OSU’s ongoing programs are more narrowly defined than those for cities and counties.

An important aspect of the Plan’s integration into ongoing programs will be the inclusion of the mitigation plan’s hazard, vulnerability and risk evaluations and mitigation Action Items, into ongoing capital improvement planning and other OSU activities, such as building maintenance, periodic remodeling or modernization of facilities and future siting and construction of new facilities.

For example, in evaluating a possible remodeling or modernization of buildings, the OSU will consider including retrofits to reduce the vulnerability to natural hazards as well as considering other alternatives such as replacement with a new building, when the retrofit is very expensive or a site has substantial risks from natural hazards that cannot be mitigated at the existing site.

5.3.3 Prioritization of Mitigation Projects

Prioritization of future mitigation projects within OSU requires flexibility because of varying types of projects, OSU needs and availability of funding sources. Prioritized mitigation Action Items developed during the mitigation planning process are summarized in Chapter 4. Additional mitigation Action Items or revisions to the initial Action Items are likely in the future. The OSU Executive Leadership Team, through the VP of F&A, will make final decisions about implementation and priorities with inputs from OSU staff, the mitigation planning team, the public and other stakeholders.

OSU’s prioritization of mitigation projects will include the following factors:

1. The mission statement and goals in the OSU Natural Hazards Mitigation Plan including:
   
   Goal 1: Reduce Threats to Life Safety,
   
   Goal 2: Reduce Damage to OSU Facilities, Economic Losses and Disruption of the OSU’s Services,
   
   Goal 3: Enhance Emergency Planning, Disaster Response and Disaster Recovery, and
   
   Goal 4: Increase Awareness and Understanding of Natural Hazards and Mitigation

2. Benefit-cost analysis to ensure that mitigation projects are cost effective, with benefit exceeding the costs.
Cost Effectiveness of Mitigation Projects

As OSU considers whether or not to undertake specific mitigation projects or evaluate how to decide between competing mitigation projects, questions that don't always have obvious answers are likely to emerge, including:

- What is the nature of the hazard problem?
- How frequent and how severe are the hazard events of concern?
- 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?

OSU recognizes that benefit-cost analysis is a powerful tool that can help provide solid, defensible answers to these difficult socio-political-economic-engineering questions. Benefit-cost analysis is required for nearly all FEMA-funded mitigation projects, under both pre-disaster and post-disaster mitigation programs.

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 Hazards. Thus, OSU will use benefit-cost analysis and related economic tools, such as cost-effectiveness evaluation, to the extent practicable in prioritizing and implementing mitigation actions.

STAPLE Process

OSU will also use the STAPLE process to evaluate projects based on the Social, Technical, Administrative, Political, Legal, Economic, and Environmental (STAPLE) considerations and opportunities for implementing the specific mitigation action items in the OSU Natural Hazards Mitigation Plan. The STAPLE approach is helpful for doing a quick analysis of the feasibility of proposed mitigation projects.

The following paragraphs outline OSU's STAPLE Approach:

Social:
- Is the proposed action socially acceptable to the community?
- Are there equity issues involved that would mean that one segment of the community is treated unfairly?
- Will the action cause social disruption?
Technical:
- 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?
- Will OSU 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 OSU?
- What burden will this action place on the tax base or economy?
- What are the budget and revenue effects of this activity?

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 Plan Maintenance and Periodic Updating

5.4.1 Periodic Monitoring, Evaluating and Updating

Monitoring the OSU Natural Hazards Mitigation Plan is an ongoing, long-term effort. An important aspect of monitoring is having a continual process of ensuring that mitigation Action Items are compatible with the goals, objectives, and priorities established during the development of OSU’s Natural Hazards Mitigation Plan. OSU has developed a process for regularly reviewing and updating the Natural Hazards Mitigation Plan. As noted previously, OSU’s Emergency Preparedness Department will have the lead responsibility for implementing OSU’s Natural Hazards Mitigation Plan and for periodic monitoring, evaluating and updating of the Plan. There will be ample opportunities to incorporate mitigation planning into ongoing activities and to seek grant support for specific mitigation projects.

The OSU Natural Hazards Mitigation Plan will be reviewed annually as well as after any significant disaster event affecting OSU. These reviews will determine whether there have been any significant changes in the understanding of hazards, vulnerability and risk or any significant changes in Goals, Objectives and Action Items. These reviews will provide opportunities to incorporate new information into the Natural Hazards Mitigation Plan, remove outdated items and document completed Action Items. This will also be the time to recognize the success of OSU in implementing Action Items contained in the Plan. Annual reviews will also focus on identifying potential funding sources for the implementation of mitigation Action Items.

The periodic monitoring, evaluation and updating will assess whether or not, and to what extent, the following questions are applicable:

1. Do the plans Goals, Objectives and Action Items still address current and future expected conditions?
2. Do the mitigation Action Items accurately reflect OSU’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 OSU’s Natural Hazards 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 at OSU?
8. Have the FEMA requirements for the maintenance and updating of hazard mitigation plans changed?
9. What can OSU learn from declared federal and/or state hazard events in Oregon or elsewhere that share similar characteristics to OSU, such as vulnerabilities to earthquakes and tsunamis?

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 OSU’s Natural Hazards Mitigation Plan, but where hazard events occurred outside of OSU.

The Emergency Preparedness Department, with the support of University Infrastructure and Operations, will review the results of these mitigation plan assessments, identify corrective actions and make recommendations, if necessary, to the OSU Executive Leadership Team for actions that may be necessary to bring the OSU Natural Hazards Mitigation Plan back into conformance with the stated goals and objectives. Any major revisions of the OSU Natural Hazards Mitigation Plan will be taken to the Executive Leadership Team for formal approval as part of the OSU’s ongoing mitigation plan maintenance and implementation program.

The Emergency Preparedness Department will have lead responsibility for the formal updates of the OSU Natural Hazards Mitigation Plan every five years, as required by FEMA. The formal update process will be initiated at least one year before the five-year anniversary of FEMA approval of the OSU Natural Hazards Mitigation Plan, to allow ample time for robust participation by stakeholders and the public and for updating data, maps, goals, objectives and Action Items.

5.4.2 Continued Public Involvement and Participation

Implementation of the mitigation actions identified in the mitigation plan must continue to engage the entire community. Continued public involvement will be an integral part of the ongoing process of incorporating mitigation planning into land use planning, zoning, and capital improvement plans and related activities within the communities served by OSU. In addition, OSU will expand communications and joint efforts between the OSU and emergency management activities in the cities and counties, especially Benton, Linn and Deschutes Counties, and the cities of Corvallis, Bend and Newport.

The OSU Natural Hazards Mitigation Plan will be available on OSU’s website and hard copies will be placed in the OSU and public libraries and in the Office of Emergency Management. The existence and locations of these hard copies will be posted on OSU’s website along with contact information so that people can direct comments, suggestions and concerns to the appropriate staff.

OSU is committed to involving the public directly in the ongoing review and updating of the Natural Hazards Mitigation Plan. This public involvement process will include public participation in the monitoring, evaluation and updating processes outlined in the previous section. Public involvement will intensify as the next 5-year update process is begun and completed.
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 OSU's Natural Hazards Mitigation Plan. This process will provide the public with accessible and effective means to express their concerns, opinions, and ideas about any updates/changes that are proposed to the Mitigation Plan. OSU will ensure that the resources are available to publicize the press releases and maintain public participation through web pages, social media, newsletters and newspapers.
6.0 EARTHQUAKES

6.1 Introduction: Earthquakes in Oregon

Every location in Oregon has some level of earthquake hazard, but the level of earthquake hazard varies widely by location within the state. Historically, awareness of seismic hazards in Oregon was relatively low, among both the general public and among public officials.

However, awareness of seismic hazards in Oregon has markedly increased in recent years due in large part to the widespread publicity about the Cascadia Subduction Zone earthquake fault and its capability to generate M9.0 mega earthquakes. Earthquake awareness also increased after the devastating earthquakes and the resulting tsunamis in Indonesia in 2004 and in Japan in 2011. Both of these mega earthquakes occurred on subduction zone faults very similar to the Cascadia Subduction zone. Furthermore, the 2013 Oregon Resiliency Plan\(^1\) presented a detailed analysis of the consequences for Oregon of a M9.0 mega earthquake on the Cascadia Subduction Zone.

The technical information in the following sections is intended to provide a basic understanding of earthquake hazards, which is an essential foundation for making well-informed decisions about earthquake risks and the need for earthquake mitigation measures for OSU's facilities.

Earthquakes are described by their magnitude (M), which is a measure of the total energy released by an earthquake. The most common magnitude is called the “moment magnitude,” which is calculated by seismologists from two factors; 1) the amount of slip (movement) on the fault causing the earthquake and 2) the area of the fault surface that ruptures during the earthquake. Moment magnitudes are similar to the Richter magnitude, which was used for many decades but has now been replaced. The moment magnitudes for the largest earthquakes recorded worldwide are shown below.

<table>
<thead>
<tr>
<th>Earthquake</th>
<th>Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960 Chile</td>
<td>9.5</td>
</tr>
<tr>
<td>1964 Prince William Sound, Alaska</td>
<td>9.2</td>
</tr>
<tr>
<td>2004 Sumatra, Indonesia</td>
<td>9.1</td>
</tr>
<tr>
<td>2011 Japan</td>
<td>9.0</td>
</tr>
<tr>
<td>1952 Kamchatka, Russia</td>
<td>9.0</td>
</tr>
</tbody>
</table>
Table 6.1 and the narrative above do not include the January 26, 1700 earthquake on the Cascadia Subduction Zone which has been identified by tsunami records in Japan and paleoseismic investigations along the Pacific Coast. The estimated magnitude of the 1700 earthquake is approximately M9.0. This earthquake is not shown in Table 6.1 because it predates modern seismological records. However, this earthquake is among the largest known earthquakes worldwide and the largest earthquake affecting Oregon over the past several hundred years. The closest analogy to this earthquake and its effects is the 2011 Japan earthquake.

Earthquakes in 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 geological processes.

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

Figure 6.1
Cascadia Subduction Zone

![Cascadia Subduction Zone](image)
The Cascadia Subduction Zone is a geologically complex area off the Pacific Northwest coast that ranges from Northern California to British Columbia. In simple terms, several pieces of oceanic crust (the Juan de Fuca Plate and other smaller pieces) are being subducted (pushed under) the crust of the North American Plate. This subduction process is responsible for most of the earthquakes in the Pacific Northwest and for creating the chain of volcanoes in the Cascades.

There are three main types of earthquakes that affect Oregon:

1) “Interface” earthquakes on the boundary between the subducting Juan de Fuca Plate and the North American Plate,
2) “Intraplate” earthquakes within the subducting oceanic plates, and
3) “Crustal” earthquakes within the North American Plate.

“Interface” earthquakes are the M8+ and M9+ earthquakes shown in Figure 6.1 that occur in the Cascadia Subduction Zone off the Oregon Coast on the boundary between the subducting Juan de Fuca Plate and the North American Plate. The average return periods (the time period between earthquakes) for these M8+ and M9+ earthquakes is about 250 to 500 years. The last major interface earthquake on the Cascadia Subduction Zone occurred on January 26, 1700, more than 300 years ago. Ground shaking from such earthquakes would be the strongest near the coast. However, strong ground shaking would be felt throughout all of western Oregon, with the level of shaking decreasing further inland from the coast.

“Intraplate” earthquakes occur within the subducting Juan de Fuca Plate. These earthquakes may have magnitudes up to about 6.5 or 7.0, with probable return periods of about 500 to 1000 years at any given location. These earthquakes can occur anywhere along the Cascadia Subduction Zone. The 2001 Nisqually earthquake is the most recent example of an intraplate earthquake. These earthquakes occur deep in the earth’s crust, about 20 to 30 miles below the surface. They generate strong ground motions near the epicenter, but have damaging effects over significantly smaller areas than the larger magnitude interface earthquakes.

“Crustal” earthquakes occur within the North American Plate. Crustal earthquakes are shallow earthquakes, typically within the upper 5 or 10 miles of the earth’s surface, although some ruptures may reach the surface. Crustal earthquakes may occur not only on faults mapped as active or potentially active, but also on unknown faults. Many significant earthquakes in the United States have occurred on previously unknown faults.

Based on the historical seismicity in Oregon and on comparisons to other geologically similar areas, small to moderate crustal earthquakes up to about M5 or M5.5 are possible almost any place in Oregon. There is also a possibility of larger crustal earthquakes in the M6+ range on unknown faults, although the probability of such incidents is likely to be very low.
Paleoseismic investigations, which look at geologic sediments and rocks for signs of ancient earthquakes, have identified 41 Cascadia Subduction Zone interface earthquakes over the past 10,000 years, which corresponds to one earthquake about every 250 years. Of these 41 earthquakes, about half are M9.0 or greater earthquakes that represent a full rupture of the fault zone from Northern California to British Columbia. The other half of the interface earthquakes represents M8+ earthquakes that generally rupture only the southern portion of the subduction zone which includes the Oregon coast.

The 300+ years since the last major Cascadia Subduction Zone earthquake is longer than the average timeframe of about 250 years for M8 or greater and is shorter than some of the intervals between M9.0 earthquakes. The time history of these major interface earthquakes is shown in Figure 6.2 below.

```
Figure 6.2
Time History of Cascadia Subduction Zone Interface Earthquakes
```

The most recent significant earthquakes in Oregon are:
- September 20, 1993 M5.9 and M6.0 earthquakes in Klamath Falls that resulted in two deaths and about $10 million in damage, and
- March 25, 1993 M5.6 earthquake at Scott’s Mills that resulted in about $30 million in damage.

The above earthquakes are examples of crustal earthquakes than can occur anywhere in Oregon.
6.2 Earthquake Concepts for Risk Assessments

6.2.1 Earthquake Magnitudes

In evaluating earthquakes, it is important to recognize that the earthquake magnitude scale is not linear, but rather logarithmic (based on intervals corresponding to orders of magnitude). Each one step increase in magnitude, such as from M7 to M8, corresponds to an increase in the amount of energy released by the earthquake of a factor of about 32, based on 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 about 1,000 times more energy than a large earthquake of M7.

The public often assumes that the larger the magnitude of an earthquake, the “worse” it is. That is, the “big one” is a M9 earthquake and smaller earthquakes such as M6 or M7 are not the “big one”. However, this is true only in very general terms. Higher magnitude earthquakes do affect larger geographic areas, with much more widespread damage than smaller magnitude earthquakes. However, for a given site, the magnitude of an earthquake is not necessarily a good measure of the severity of the earthquake effects at that site.

For most locations, the best measure of the severity of an earthquake is the intensity of ground shaking. However, for some sites, ground failures and other possible consequences of earthquakes, which are discussed later in this chapter (Section 6.4), may substantially increase the severity.

For any earthquake, the severity and 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 de-amplify earthquake ground motions.

An earthquake will generally produce the strongest ground motions near the epicenter (the point on the ground above where the earthquake initiated) with the intensity of ground motions diminishing with increasing distance from the epicenter. The intensity of ground shaking at a given location depends on the four factors listed above. Thus, for any given earthquake there will be contours of varying intensity of ground shaking vs. distance from the epicenter. The intensity will generally decrease with distance from the epicenter, but often in an irregular pattern, not simply in perfectly shaped concentric circles. This irregularity is caused by soil conditions, the complexity of earthquake fault rupture patterns, and possible directionality in the dispersion of earthquake energy.
The amount of earthquake damage and the size of the geographic area affected generally increase with earthquake magnitude. In qualitative terms:

- Earthquakes below about M5 are not likely to cause substantial damage, even locally very near the epicenter.
- Earthquakes between about M5 and M6 are likely to cause mostly moderate damage near the epicenter, although a few very vulnerable buildings may have major damage.
- Earthquakes of about M6.5 or greater (e.g., the 2001 Nisqually earthquake) 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 very wide areas.
- A mega-quake 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, with the highest levels of damage generally near the coast.

**Figure 6.3**  
**Expected Severity of Damage in a Cascadia M9 Earthquake**¹

Figure 6.3 shows four impact zones for a Cascadia M9 earthquake.

- Red: Extreme damage in the tsunami zone, which is limited to locations on the coast at low elevations.
- Orange: Heavy damage in areas within about 25 to 30 miles of the coast.
- Yellow: Moderate damage in the Willamette Valley area.
- Green: Light damage in central and eastern Oregon.
6.2.2 Intensity of Ground Shaking

There are many measures of the severity or intensity of earthquake ground motions. The Modified Mercalli Intensity scale (MMI) was widely used beginning in the early 1900s. MMI is a descriptive, qualitative scale that relates severity of ground motions to the types of damage experienced. MMIs range from I to XII. More accurate, quantitative measures of the intensity of ground shaking have largely replaced the MMI. These modern intensity scales are used in the OSU Natural Hazards Mitigation Plan.

Modern intensity scales use terms that can be physically measured with seismometers (instruments that measure motions of the ground), such as acceleration, velocity, or displacement (movement). The intensity of earthquake ground motions may also be measured in spectral (frequency) terms, as a function of the frequency of earthquake waves propagating through the earth. In the same sense that sound waves contain a mix of low-, moderate- and high-frequencies, earthquake waves contain ground motions of various frequencies. The behavior of buildings and other structures depends substantially on the vibration frequencies of the building or structure vs. the spectral content of the earthquake waves. Earthquake ground motions also include both horizontal and vertical components.

A common physical measure of the intensity of earthquake ground shaking, and the one used in this mitigation plan, is Peak Ground Acceleration (PGA). PGA is a measure of the intensity of shaking, relative to the acceleration of gravity (g). For example, an acceleration of 1.0 g PGA is an extremely strong ground motion that may occur near the epicenter of large earthquakes. With a vertical acceleration of 1.0 g, objects are thrown into the air. With a horizontal acceleration of 1.0 g, 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 (strength) of the structures. The following generalized observations provide qualitative statements about the likely extent of damages from earthquakes with various levels of ground shaking (PGA) at a given site:

- Ground motions of only 1% g 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 light 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 more vulnerable buildings. At this level of ground shaking, some poorly designed buildings may be subject to 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 many buildings, including buildings designed to resist seismic forces.

### 6.3 Earthquake Hazard Maps

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 motion at a given location.

The current consensus estimates for earthquake hazards in the United States are incorporated into the 2014 US Geological Survey (USGS) National Seismic Hazard Maps. These maps are the basis of building code design requirements for new construction, per the International Building Code adopted in Oregon, as the Oregon Structural Building Code. The earthquake ground motions used for building design are set at 2/3rds of the 2% probability of exceedance in 50-year ground motion.

The ground shaking values on the USGS maps 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. This is related to the earthquake expected to occur, on average, roughly every 500 years.

In very qualitative terms, the 10% in 50-year ground motion represents a likely earthquake while the 2% in 50-year ground motion represents a level of ground shaking close to but not the absolute worst case scenario, and is expected to occur, on average, roughly every 2,500 years.

Figures 6.4 and 6.5 on the following pages show the 2014 USGS 10% in 50-year earthquake ground motions and the 2% in 50-year ground motions, respectively:

- The dark red, pink and orange areas have the highest levels of seismic hazard.
- The tan, yellow and blue areas have intermediate levels of seismic hazard.
- The bright green and pale green areas have the lowest levels of seismic hazard.

The detailed geographical patterns in the maps reflect the varying contributions to seismic hazard from earthquakes on the Cascadia Subduction Zone and crustal earthquakes within the North American Plate. The differences in geographic pattern between the 2% in 50-year maps and the 10% in 50-year maps reflect different contributions from Cascadia Subduction Zone earthquakes and crustal earthquakes.
These maps are generated by including earthquakes from all known faults, taking into account the expected magnitudes and frequencies of earthquakes for each fault. The maps also include contributions from unknown faults, which are statistically possible anywhere in Oregon. The contributions from unknown faults are included via “area” seismicity which is distributed throughout the state.

An important caveat for interpreting these maps is that the 2014 USGS seismic hazard maps show the level of ground motions for rock sites. Ground motions on soil sites, especially soft soil sites, may be significantly higher than for rock sites, although at high levels of shaking soft sites may deamplify ground motions. Thus, for earthquake hazard analysis at a given site it is essential to include consideration of the site’s soil conditions.

The ground motions shown in the following figures represent ground motions with the specified probabilities of occurrence. At any given site, earthquakes may be experienced with ground motions over the entire range of levels of ground shaking from just detectable with sensitive seismometers to higher than the 2% in 50-year ground motions.

**Figure 6.4**

2014 USGS Probabilistic Earthquake Ground Motions: 10% Chance of Exceedance in 50 Years

Peak acceleration, expressed as a fraction of standard gravity (g)
As shown above, the level of earthquake hazard is highest in Oregon along the Pacific Coast and generally decreases towards eastern Oregon, with exceptions.

6.4 Geologic Factors Affecting Earthquake Impacts

Much of the damage in earthquakes occurs from ground shaking that affects buildings and infrastructure. The level of ground shaking at a given location for a given earthquake depends not only on location but also on the soil or rock type.

There are also several geologic factors that may result in substantially increased levels of damage in some locations. These factors include: site class, liquefaction that may cause settlement and/or lateral spreading, surface ruptures, landslides; dam, reservoir or levee failures; and tsunamis or seiches.

The geologic factors are addressed in the following sections.

6.4.1 Site Class: Soil and Rock Types

As discussed previously, the soil or rock type at a given location substantially affects the level of earthquake hazard because the soil or rock type may amplify or de-amplify ground motions. In most cases, soil sites, especially soft soil sites amplify ground motions. That is, for a given earthquake, a soil site immediately adjacent to a...
rock site will generally experience higher levels of earthquake ground motions than the rock site.

In simple terms, there are six soil or rock site classes:

- A – Hard Rock
- B – Rock
- C – Very Dense Soil and Soft Rock
- D – Firm Soil
- E – Soft Soil
- F – Very Soft Soil

### 6.4.2 Liquefaction Potential – Settlement and Lateral Spreading

Liquefaction is a process where loose, wet sediments lose bearing strength during an earthquake and behave similar to a liquid. Once a soil liquefies, it may flow vertically and/or spread laterally. The extent of settlement or lateral spreading can be a few inches or several feet. Significant lateral spreading can occur even on sites with very slight slopes.

Settlement or lateral spreading can cause major damage to buildings and infrastructure. Buildings and infrastructure that are located on sites subject to liquefaction, settlement and lateral spreading are likely to have higher levels of damage than similar buildings and infrastructure on firm soil sites.

### 6.4.3 Surface Rupture

Surface rupture occurs when the fault plane from an earthquake reaches the surface. Surface rupture may be horizontal and/or vertical displacement between the sides of the rupture plane. For a building subject to surface rupture the level of damage is typically very high and often results in the destruction of the building.

Surface rupture does not occur with interface or intraplate earthquakes on the Cascadia Subduction Zone. However, surface rupture is possible on most of the crustal faults in Oregon.

### 6.4.4 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 and high water tables are most prone to earthquake-induced landslides.
6.4.5 Dam, Levee and Reservoir Failures

Earthquakes can also cause failure of dams, reservoirs and reservoirs. Sites located downslope from dams or water reservoirs or behind levees may be subject to flooding if the dams, reservoirs or levees fail as a result of an earthquake. Failures of potable water reservoirs or large water storage tanks may cause significant localized damage for buildings downslope of the reservoirs. Cascading failures of multiple dams on the Willamette River or its tributaries are highly unlikely but perhaps possible.

6.4.6 Tsunamis and Seiches

Tsunamis predominantly result from earthquakes that cause a sudden rise or fall of part of the ocean floor. Tsunamis may also be generated by undersea landslides or terrestrial landslides into bodies of water. A tsunami could also be generated by asteroid impact, albeit with an extremely low probability.

Seiches are sloshing of water in lakes, rivers or reservoirs that occurs during an earthquake. Seiches can cause damage to buildings and infrastructure near such bodies of water and can also cause damage or failure to reservoirs. Facilities very near bodies of water at elevations very near the elevation of the body of water may be damaged by seiches.

6.5 Seismic Risk Assessment for OSU Facilities

OSU’s seismic risk assessment focuses predominantly on buildings, although key infrastructure is also addressed. Overall, OSU has 622 buildings, including 453 OSU-owned buildings and 169 leased buildings. The leased buildings are mostly small buildings at OSU Extension offices, agricultural experiment sites and forest research sites of lesser significance than the large buildings on the Corvallis and Bend campuses and at the Hatfield Marine Science Center.

As a key part of OSU’s mitigation planning process, OSU’s buildings were characterized into five categories:

1. Major Importance and for which a detailed seismic evaluation is a high priority: Weniger Hall, Gilbert Hall and Kerr Administrative Services. The seismic evaluation of Weniger Hall was completed as part of the mitigation planning process.

2. Major Importance because of function, occupancy, historical significance and other factors. This category includes 77 buildings which are predominantly on the Corvallis campus, but also includes two buildings at the Cascades campus and three buildings at the Hatfield Marine Science Center.

3. Minor Importance because of function, size and other factors.

4. Ancillary Buildings which are predominantly small agricultural and storage buildings.
5. Leased Buildings.

The seismic risk assessment for buildings focuses on the 80 buildings of major importance in the first two categories above. The potential impacts of future earthquakes on OSU include damage to buildings and contents, disruption of educational services and research activities, displacement costs for temporary quarters if some buildings have enough damage to require moving out while repairs are made, and possible deaths and injuries for people in the buildings. The 80 buildings designated as being of major importance include 22 buildings that were built in 1999 or later or which have been seismically retrofitted, are scheduled for seismic retrofit or were replaced with a new building. Of the 22 buildings, 14 buildings were built in 1999 or later and were designed to the 1997 Uniform Building Code or to later International Building Code seismic design requirements, thus significantly improving their performance in an earthquake.

Of the 22 buildings, 7 older buildings have been retrofitted or are scheduled for retrofit in the near future:

- Burt Hall (2003)
- Cascade Hall (1997)
- Cordley Hall (2021)
- Fairbanks Hall (2020)
- Nash Hall (2008)
- Strand Agriculture (2015)
- Weatherford Hall (2003).

In very general terms only, the older a building is, the more likely it is to have significant seismic deficiencies. The level of seismic deficiencies of these buildings depends on the year of design vis-à-vis the time history of seismic design requirements in the building codes, the structural type of each building and the individual design and condition of each building.

The vast majority of the remaining 58 pre-1999 buildings designated by the mitigation planning team as of major importance almost certainly have significant or substantial levels of seismic deficiencies. These 58 buildings were built between 1889 (Benton Hall) to 1998 (Valley Football Center) and are listed in Table 6-2 on the following pages. Many of these buildings will be scheduled for renovation in the Capital Forecast and the need for seismic strengthening will be an important criterion for the selection and scope of future renovation. All three of the highest priority buildings in Table 6-2 are scheduled for demolition or retrofit. Kerr Administration Services is scheduled for seismic upgrade in 2024. Gilbert Hall is scheduled for renovation and seismic retrofit in 2026. Weniger Hall is scheduled for demolition in 2030-2032.

The following table includes the Hazus Building Types. Hazus is an acronym for “Hazards United States”, a widely-used FEMA methodology for evaluating the vulnerability of buildings to earthquakes and other natural hazards. The definitions for the Hazus Building Types for earthquakes are provided in Table 6-3.
<table>
<thead>
<tr>
<th>Building Importance</th>
<th>Building Name</th>
<th>City</th>
<th>Building Usage</th>
<th>Year Built</th>
<th>Primary Hazard Building Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Weniger Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1958</td>
<td>C2/Lift</td>
</tr>
<tr>
<td>1</td>
<td>Gilbert Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1939</td>
<td>C1 &amp; C2</td>
</tr>
<tr>
<td>1</td>
<td>Kerr Administrative Services</td>
<td>Corvallis</td>
<td>Office</td>
<td>1971</td>
<td>C2</td>
</tr>
<tr>
<td>2</td>
<td>AG &amp; Life Sciences</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1987</td>
<td>S4</td>
</tr>
<tr>
<td>2</td>
<td>Aquarium Visitor Center</td>
<td>Newport</td>
<td>OSU Marine Science Lab</td>
<td>1964</td>
<td>?</td>
</tr>
<tr>
<td>2</td>
<td>Arnold Cafeteria</td>
<td>Corvallis</td>
<td>Dining hall</td>
<td>1972</td>
<td>PC1</td>
</tr>
<tr>
<td>2</td>
<td>Ballard Extension Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1920</td>
<td>URM</td>
</tr>
<tr>
<td>2</td>
<td>Batcheller Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1913</td>
<td>URM</td>
</tr>
<tr>
<td>2</td>
<td>Bates Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1992</td>
<td>RM2</td>
</tr>
<tr>
<td>2</td>
<td>Benton Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1889</td>
<td>URM</td>
</tr>
<tr>
<td>2</td>
<td>Bexel Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1922</td>
<td>URM</td>
</tr>
<tr>
<td>2</td>
<td>Bloss Hall</td>
<td>Corvallis</td>
<td>Residence hall</td>
<td>1972</td>
<td>C2/Lift</td>
</tr>
<tr>
<td>2</td>
<td>Buxton Hall, Dorm 4</td>
<td>Corvallis</td>
<td>Residence hall</td>
<td>1961</td>
<td>RM2/Lift</td>
</tr>
<tr>
<td>2</td>
<td>Callahan Hall</td>
<td>Corvallis</td>
<td>Residence hall</td>
<td>1964</td>
<td>RM2/Lift</td>
</tr>
<tr>
<td>2</td>
<td>Cauthorn Hall</td>
<td>Corvallis</td>
<td>Residence hall</td>
<td>1957</td>
<td>RM2/Lift</td>
</tr>
<tr>
<td>Building Importance</td>
<td>Building Name</td>
<td>City</td>
<td>Building Usage</td>
<td>Year Built</td>
<td>Primary Hazus Building Type</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------------------</td>
<td>----------</td>
<td>--------------------------------</td>
<td>------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>2</td>
<td>College Inn (GEM)</td>
<td>Corvallis</td>
<td>Residence hall</td>
<td>1975</td>
<td>?</td>
</tr>
<tr>
<td>2</td>
<td>Covell Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1927</td>
<td>URM</td>
</tr>
<tr>
<td>2</td>
<td>Crop Sciences</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1981</td>
<td>C2</td>
</tr>
<tr>
<td>2</td>
<td>Dearborn Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1947</td>
<td>C2</td>
</tr>
<tr>
<td>2</td>
<td>Dixon Recreation Center</td>
<td>Corvallis</td>
<td>Student activities</td>
<td>1976</td>
<td>C2</td>
</tr>
<tr>
<td>2</td>
<td>Dryden Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1927</td>
<td>URM</td>
</tr>
<tr>
<td>2</td>
<td>Finley Hall</td>
<td>Corvallis</td>
<td>Residence hall</td>
<td>1968</td>
<td>C2/Lift</td>
</tr>
<tr>
<td>2</td>
<td>Gilbert Addition</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1980</td>
<td>C2</td>
</tr>
<tr>
<td>2</td>
<td>Gilkey Hall</td>
<td>Corvallis</td>
<td>Instruction &amp; administration</td>
<td>1913</td>
<td>URM</td>
</tr>
<tr>
<td>2</td>
<td>Gill Coliseum</td>
<td>Corvallis</td>
<td>Student activities</td>
<td>1947</td>
<td>C2</td>
</tr>
<tr>
<td>2</td>
<td>Gleeson Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1955</td>
<td>C1/C2</td>
</tr>
<tr>
<td>2</td>
<td>Graf Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1920</td>
<td>URM</td>
</tr>
<tr>
<td>2</td>
<td>Hawley Hall, Dorm 3</td>
<td>Corvallis</td>
<td>Residence hall</td>
<td>1959</td>
<td>RM2/Lift</td>
</tr>
<tr>
<td>2</td>
<td>Kidder Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1917</td>
<td>URM</td>
</tr>
<tr>
<td>2</td>
<td>Langton Hall</td>
<td>Corvallis</td>
<td>Physical education</td>
<td>1915</td>
<td>URM</td>
</tr>
<tr>
<td>Building Importance</td>
<td>Building Name</td>
<td>City</td>
<td>Building Usage</td>
<td>Year Built</td>
<td>Primary Hazus Building Type</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------------------</td>
<td>--------------</td>
<td>---------------------------------</td>
<td>------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>2</td>
<td>Lasells Stewart Center</td>
<td>Corvallis</td>
<td>Other</td>
<td>1981</td>
<td>RM2 &amp; C2</td>
</tr>
<tr>
<td>2</td>
<td>Magruder Hall - Animal Hospital</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1979</td>
<td>S1 &amp; S2</td>
</tr>
<tr>
<td>2</td>
<td>McNary Dining</td>
<td>Corvallis</td>
<td>Dining hall</td>
<td>1964</td>
<td>C2/Lift</td>
</tr>
<tr>
<td>2</td>
<td>McNary Hall</td>
<td>Corvallis</td>
<td>Residence hall</td>
<td>1964</td>
<td>C2</td>
</tr>
<tr>
<td>2</td>
<td>Memorial Union</td>
<td>Corvallis</td>
<td>Student activities</td>
<td>1928</td>
<td>C2</td>
</tr>
<tr>
<td>2</td>
<td>Merryfield Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1909</td>
<td>URM</td>
</tr>
<tr>
<td>2</td>
<td>Milam Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1914</td>
<td>URM</td>
</tr>
<tr>
<td>2</td>
<td>Milne Computer Center</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1969</td>
<td>C2</td>
</tr>
<tr>
<td>2</td>
<td>Moreland Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1917</td>
<td>URM</td>
</tr>
<tr>
<td>2</td>
<td>MSC Education</td>
<td>Newport</td>
<td>Library</td>
<td>1977</td>
<td>PC1</td>
</tr>
<tr>
<td>2</td>
<td>MSC Ship Operations</td>
<td>Newport</td>
<td>Instruction and research</td>
<td>1996</td>
<td>PC1</td>
</tr>
<tr>
<td>2</td>
<td>Orchard Court Apartments</td>
<td>Corvallis</td>
<td>Residence hall</td>
<td>1961</td>
<td>?</td>
</tr>
<tr>
<td>2</td>
<td>OSU Cascades Grad &amp; Research Ctr</td>
<td>Bend</td>
<td>Classrooms</td>
<td>1997</td>
<td>?</td>
</tr>
<tr>
<td>2</td>
<td>Oswald West, Dorm 5</td>
<td>Corvallis</td>
<td>Residence hall</td>
<td>1960</td>
<td>C2/Lift/Retro</td>
</tr>
<tr>
<td>2</td>
<td>Owen Hall</td>
<td>Corvallis</td>
<td>Instruction &amp; administration</td>
<td>1988</td>
<td>S1/C2</td>
</tr>
</tbody>
</table>
Table 6.2 – Continued
58 Buildings – Possible Priority for Seismic Evaluations

<table>
<thead>
<tr>
<th>Building Importance</th>
<th>Building Name</th>
<th>City</th>
<th>Building Usage</th>
<th>Year Built</th>
<th>Primary Hazus Building Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Pharmacy</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1924</td>
<td>C2</td>
</tr>
<tr>
<td>2</td>
<td>Plageman Student Health Ctr</td>
<td>Corvallis</td>
<td>Health Services Building</td>
<td>1936</td>
<td>C2</td>
</tr>
<tr>
<td>2</td>
<td>Poling Hall, Dorm 1</td>
<td>Corvallis</td>
<td>Residence hall</td>
<td>1957</td>
<td>RM2/Lift</td>
</tr>
<tr>
<td>2</td>
<td>Radiation Center</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1983</td>
<td>RM2/RM1</td>
</tr>
<tr>
<td>2</td>
<td>Reser Stadium</td>
<td>Corvallis</td>
<td>Student activities</td>
<td>1929</td>
<td>S2/C2</td>
</tr>
<tr>
<td>2</td>
<td>Rogers Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1967</td>
<td>C2</td>
</tr>
<tr>
<td>2</td>
<td>Sackett Hall</td>
<td>Corvallis</td>
<td>Residence hall</td>
<td>1947</td>
<td>C2</td>
</tr>
<tr>
<td>2</td>
<td>Snell Hall</td>
<td>Corvallis</td>
<td>Student activities</td>
<td>1958</td>
<td>C2/Lift</td>
</tr>
<tr>
<td>2</td>
<td>Waldo Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1903</td>
<td>URM</td>
</tr>
<tr>
<td>2</td>
<td>Wiegand Hall</td>
<td>Corvallis</td>
<td></td>
<td>1949</td>
<td>C2</td>
</tr>
<tr>
<td>2</td>
<td>Wilkinson Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1973</td>
<td>C2/Lift</td>
</tr>
<tr>
<td>2</td>
<td>Wilson Hall</td>
<td>Corvallis</td>
<td>Residence hall</td>
<td>1964</td>
<td>S4/Lift</td>
</tr>
<tr>
<td>2</td>
<td>Withycombe Hall</td>
<td>Corvallis</td>
<td>Instruction and administration</td>
<td>1949</td>
<td>S4</td>
</tr>
<tr>
<td>2</td>
<td>Womens Bldg</td>
<td>Corvallis</td>
<td>Physical Education</td>
<td>1927</td>
<td>URM</td>
</tr>
</tbody>
</table>

72% of the buildings above were built before 1970, when seismic design provisions in Oregon were generally non-existent. Even many of the post-1970 buildings were
built when the seismic design provisions were significantly less than those in more recent building codes.

The Hazus Building Types are defined in Table 6-3.

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>Light Wood Frame &lt; 5 000 SF</td>
</tr>
<tr>
<td>W1A</td>
<td>Light Wood Frame, Multi-unit, Multi-Story Residential, &gt;3 000 SF per floor</td>
</tr>
<tr>
<td>W2</td>
<td>Wood Commercial and Industrial &gt;5 000 SF</td>
</tr>
<tr>
<td>S1</td>
<td>Steel Moment Frame</td>
</tr>
<tr>
<td>S2</td>
<td>Steel Braced Frame</td>
</tr>
<tr>
<td>S3</td>
<td>Steel Light Frame</td>
</tr>
<tr>
<td>S4</td>
<td>Steel Frame with Cast-in-Place Concrete Shear Walls</td>
</tr>
<tr>
<td>S5</td>
<td>Steel Frame with Unreinforced Masonry Infill Walls</td>
</tr>
<tr>
<td>C1</td>
<td>Reinforced Concrete Moment Resistant Frames</td>
</tr>
<tr>
<td>C2</td>
<td>Concrete Shear Walls</td>
</tr>
<tr>
<td>C3</td>
<td>Concrete Frame with Unreinforced Masonry Infill Walls</td>
</tr>
<tr>
<td>PC1</td>
<td>Precast Concrete Tilt-up Walls</td>
</tr>
<tr>
<td>PC2</td>
<td>Precast Concrete Frames with Concrete Shear Walls</td>
</tr>
<tr>
<td>RM1</td>
<td>Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms</td>
</tr>
<tr>
<td>RM2</td>
<td>Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms</td>
</tr>
<tr>
<td>URM</td>
<td>Unreinforced Masonry Bearing Walls</td>
</tr>
<tr>
<td>RH</td>
<td>Mobile Homes</td>
</tr>
</tbody>
</table>

As mentioned previously, the level of seismic deficiencies of buildings depends on the year of design vis-à-vis the time history of seismic design requirements in the building codes, the structural type of each building and the individual design and condition of each building.

One type of building that is widely recognized as especially vulnerable in earthquakes is unreinforced masonry buildings (URMs) where the brick walls are held together only with mortar without reinforcing steel bars and are not well
connected to the floors and roof. The OSU Corvallis campus has 21 URM buildings with a total of nearly 1,000,000 square feet, built between 1889 and 1928. Only three of these URM buildings have had seismic retrofits.

OSU also has “lift-slab” buildings. Floor slabs for these buildings are cast at the foundation level and the steel columns are erected to the roof level. Then, a slab is lifted to the roof level and connected to the columns with shear collars. Next, a slab is lifted to the second floor from the top and the slab placement proceeds sequentially downwards. Walls may be reinforced concrete and/or reinforced masonry. It is thought that “lift slab” buildings may be subject to progressive failure resulting in complete collapse if the connections between the columns and the slabs fail. OSU has 16 “lift slab” buildings with a total of over 1,500,000 square feet, built between 1956 and 1973.

The actual performance of “lift slab” buildings in earthquakes has not been well documented. However, for reference, there were two 1970’s-era “lift slab” buildings affected by an earthquake in Leninakan, Armenia. In the 1988 earthquake, the 10-story building collapsed completely and the 16-story building was severely damaged and demolished afterwards. These “lift slab” buildings had precast concrete columns, rather than the steel columns used in the OSU “lift slab” buildings.

OSU’s inventory of URM and “lift slab” buildings is listed in Tables 6.4 and 6.5 on the following pages.

The RVS columns in Tables 6.4 and 6.5 refer to FEMA’s Rapid Visual Screening methodology. RVS is a well-established way to identify, inventory and screen buildings that are potentially seismically hazardous. RVS yields preliminary determinations of the seismic vulnerability of buildings, based on the year built, the structural system (HAZUS building type), vertical and plan irregularities and other factors. RVS Level 2 requires more data and is deemed more accurate than RVS Level 1. Buildings with RVS scores of 2.0 are interpreted as being potentially seismically hazardous. Lower scores indicate a greater likelihood of a building collapse in the maximum considered earthquake.

Once identified as potentially hazardous, such buildings should be further evaluated by a design professional experienced in seismic design to determine if, in fact, they are seismically hazardous. Further evaluations are often done using the American Society of Civil Engineers Seismic Evaluation and Retrofit of Existing Buildings (ASCE 41) methodology.
Table 6.4
Unreinforced Masonry Buildings (URM)

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Owner</th>
<th>Date Built</th>
<th>Building Type</th>
<th>RVS Level 1 Score</th>
<th>RVS Level 2 Score</th>
<th>Square Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>BALLARD EXTENSION HALL</td>
<td>E&amp;G</td>
<td>1921</td>
<td>URM</td>
<td>0.6</td>
<td>1.0</td>
<td>45,250</td>
</tr>
<tr>
<td>BATCHELLER HALL</td>
<td>E&amp;G</td>
<td>1913</td>
<td>URM</td>
<td>1.0</td>
<td></td>
<td>19,953</td>
</tr>
<tr>
<td>BENTON HALL</td>
<td>E&amp;G</td>
<td>1889</td>
<td>URM</td>
<td>1.0</td>
<td></td>
<td>25,806</td>
</tr>
<tr>
<td>BEXELL HALL</td>
<td>E&amp;G</td>
<td>1922</td>
<td>URM</td>
<td>0.6</td>
<td>0.6</td>
<td>58,621</td>
</tr>
<tr>
<td>COVELL HALL</td>
<td>E&amp;G</td>
<td>1928</td>
<td>URM</td>
<td>0.2</td>
<td></td>
<td>35,760</td>
</tr>
<tr>
<td>DRYDEN HALL</td>
<td>E&amp;G</td>
<td>1927</td>
<td>URM</td>
<td>1.0</td>
<td>1.0</td>
<td>22,515</td>
</tr>
<tr>
<td>GILKEY HALL</td>
<td>E&amp;G</td>
<td>1912</td>
<td>URM</td>
<td>1.0</td>
<td>1.0</td>
<td>22,263</td>
</tr>
<tr>
<td>GILMORE HALL</td>
<td>E&amp;G</td>
<td>1912</td>
<td>URM</td>
<td>0.6</td>
<td>0.6</td>
<td>16,683</td>
</tr>
<tr>
<td>GLADYS VALLEY GYMNASTICS</td>
<td>E&amp;G</td>
<td>1898</td>
<td>W2A/RM/C2</td>
<td>0.2</td>
<td>0.2</td>
<td>18,702</td>
</tr>
<tr>
<td>GRAF HALL</td>
<td>E&amp;G</td>
<td>1920</td>
<td>URM</td>
<td>1.0</td>
<td>1.0</td>
<td>38,221</td>
</tr>
<tr>
<td>HOVLAND HALL</td>
<td>E&amp;G</td>
<td>1919</td>
<td>URM</td>
<td>0.3</td>
<td></td>
<td>15,471</td>
</tr>
<tr>
<td>KIDDER HALL</td>
<td>E&amp;G</td>
<td>1918</td>
<td>URM</td>
<td>0.2</td>
<td></td>
<td>81,329</td>
</tr>
<tr>
<td>LANGTON HALL</td>
<td>E&amp;G</td>
<td>1915</td>
<td>URM</td>
<td>0.2</td>
<td></td>
<td>95,037</td>
</tr>
<tr>
<td>MERRYFIELD HALL</td>
<td>E&amp;G</td>
<td>1908</td>
<td>URM</td>
<td>0.6</td>
<td></td>
<td>26,919</td>
</tr>
<tr>
<td>MILAM HALL</td>
<td>E&amp;G</td>
<td>1914</td>
<td>URM</td>
<td>0.2</td>
<td></td>
<td>110,283</td>
</tr>
<tr>
<td>MORELAND HALL</td>
<td>E&amp;G</td>
<td>1917</td>
<td>URM</td>
<td>1.0</td>
<td>1.0</td>
<td>28,943</td>
</tr>
<tr>
<td>SHEPARD HALL</td>
<td>E&amp;G</td>
<td>1908</td>
<td>URM/W1</td>
<td>0.3</td>
<td></td>
<td>11,512</td>
</tr>
<tr>
<td>STRAND AGRICULTURAL HALL</td>
<td>E&amp;G</td>
<td>1909</td>
<td>URM</td>
<td>0.6</td>
<td>0.6</td>
<td>114,932</td>
</tr>
<tr>
<td>WALDO HALL</td>
<td>E&amp;G</td>
<td>1907</td>
<td>URM</td>
<td>0.2</td>
<td>0.2</td>
<td>75,362</td>
</tr>
<tr>
<td>WEATHERFORD HALL</td>
<td>E&amp;G</td>
<td>1928</td>
<td>C2/URM</td>
<td>2.3</td>
<td>1.7</td>
<td>105,362</td>
</tr>
<tr>
<td>WOMENS BUILDING</td>
<td>E&amp;G</td>
<td>1926</td>
<td>URM</td>
<td>0.6</td>
<td>0.5</td>
<td>87,441</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>1,056,363</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 These two buildings have had seismic retrofits: Strand to Life Safety (ASCE 41-06), Weatherford to Life Safety (1998 Oregon Structural Specialty Code).
2 Building types per Hazus: URM (Unreinforced Masonry), W2 (Wood Frame), W1 (Light Wood Frame), C2 (Concrete Shear Wall).
3 FEMA Rapid Visual Screening (Third Edition) by OSU engineering students with review by Prof. Thomas Miller. Lower Scores indicate higher seismic vulnerability. Level 2 Scores are more accurate and should be used, when available.
4 These seven buildings were not included in the initial list of 58 buildings with potential priority for further evaluation. The five buildings in this category that have had no seismic strengthening warrant seismic evaluations.
5 E&G = Education and General Funds.
**Table 6.5**

**Lift Slab Buildings**

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Owner²</th>
<th>Date Built</th>
<th>Building Type²</th>
<th>RVS Level 1 Score</th>
<th>RVS Level 2 Score³</th>
<th>Square Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLOSS HALL Aux</td>
<td>Aux</td>
<td>1972</td>
<td>C2</td>
<td>1.2</td>
<td></td>
<td>84,031</td>
</tr>
<tr>
<td>BUXTON HALL¹</td>
<td>Aux</td>
<td>1961</td>
<td>RM2</td>
<td>1.0</td>
<td></td>
<td>63,355</td>
</tr>
<tr>
<td>CALLAHAN HALL</td>
<td>Aux</td>
<td>1964</td>
<td>RM2</td>
<td>1.0</td>
<td></td>
<td>71,389</td>
</tr>
<tr>
<td>CAUTHORN HALL</td>
<td>Aux</td>
<td>1956</td>
<td>RM2</td>
<td>1.0</td>
<td></td>
<td>60,971</td>
</tr>
<tr>
<td>FINLEY HALL</td>
<td>Aux</td>
<td>1967</td>
<td>C2</td>
<td>1.2</td>
<td></td>
<td>84,282</td>
</tr>
<tr>
<td>HAWLEY HALL¹</td>
<td>Aux</td>
<td>1959</td>
<td>RM2</td>
<td>1.0</td>
<td></td>
<td>60,514</td>
</tr>
<tr>
<td>KERR ADMINISTRATION</td>
<td>E&amp;G</td>
<td>1971</td>
<td>C2</td>
<td>0.3</td>
<td></td>
<td>141,231</td>
</tr>
<tr>
<td>MCNARY HALL</td>
<td>Aux</td>
<td>1963</td>
<td>C2</td>
<td>1.2</td>
<td>1.9</td>
<td>71,334</td>
</tr>
<tr>
<td>NASH HALL¹,⁴</td>
<td>E&amp;G</td>
<td>1970</td>
<td>C2</td>
<td>2.0</td>
<td></td>
<td>107,306</td>
</tr>
<tr>
<td>POLING HALL</td>
<td>Aux</td>
<td>1957</td>
<td>RM2</td>
<td>1.0</td>
<td></td>
<td>60,007</td>
</tr>
<tr>
<td>SNELL HALL/MU EAST</td>
<td>E&amp;G</td>
<td>1959</td>
<td>C2</td>
<td>0.6</td>
<td></td>
<td>114,534</td>
</tr>
<tr>
<td>THE VALLEY LIBRARY⁵</td>
<td>E&amp;G</td>
<td>1963/1997</td>
<td>C2</td>
<td>2.7</td>
<td>3.4</td>
<td>333,920</td>
</tr>
<tr>
<td>WENIGER HALL</td>
<td>E&amp;G</td>
<td>1959</td>
<td>C2</td>
<td>2.0</td>
<td>2.3</td>
<td>213,206</td>
</tr>
<tr>
<td>WEST HALL¹,⁴</td>
<td>Aux</td>
<td>1960</td>
<td>C2</td>
<td>3.3</td>
<td></td>
<td>28,583</td>
</tr>
<tr>
<td>WILKINSON HALL</td>
<td>E&amp;G</td>
<td>1973</td>
<td>C2</td>
<td>1.2</td>
<td>1.9</td>
<td>56,478</td>
</tr>
<tr>
<td>WILSON HALL</td>
<td>E&amp;G</td>
<td>1964</td>
<td>C2</td>
<td>1.2</td>
<td>1.9</td>
<td>71,353</td>
</tr>
</tbody>
</table>

Total 1,622,494

¹ These buildings have had renovation and seismic strengthening.

² Building types per Hazus: C2 (Concrete Shear Wall), RM2 (Reinforced Masonry with Concrete Diaphragms).

³ FEMA Rapid Visual Screening (Third Edition) by OSU engineering students with review by Prof. Thomas Miller. Lower Scores indicate higher seismic vulnerability. Level 2 Scores are more accurate and should be used, when available. The higher vulnerability of lift slab buildings is not included in FEMA's RVS methodology. The stated RVS scores may significantly underestimate the seismic vulnerability of these buildings.

⁴ These two buildings were not included in the list of 58 buildings with potential priority for further evaluation. Further evaluation may be warranted.

⁵ The 1997 addition was designed to a recent building code, albeit with somewhat lower seismic design levels than the current code.

⁶ Ownership: E&G = Education and General Fund; Aux = Auxiliary
The 21 URMs and 16 lift-slab buildings in Tables 6.4 and 6.5, with the possible exception of the buildings that have had some level or seismic strengthening, are almost certain to have very substantial seismic deficiencies and to pose substantial risk of heavy damage, including possible collapse and casualties in future earthquakes.

Together, the URM and lift-slab buildings constitute 2,678,857 square feet, which is nearly 25% of the total square footage of OSU buildings. Most of these buildings are very important for the operability of OSU. The estimated replacement value of these buildings is nearly $1.75 billion, at an average of $650 per square foot.

6.5. Earthquake Damage Estimates

Historical Earthquake Damage
OSU has not incurred noticeable earthquake damage in the recent past – there have been no significant earthquakes with epicenters close enough to Corvallis or other locations of OSU facilities to cause damage.

The 1993 M5.9 and M6.0 earthquakes in Klamath Falls and the 1993 M5.6 Scott’s Mills earthquake were relatively small earthquakes that caused substantial localized damage near the epicenters but no damage to OSU facilities. The intensity of ground shaking experienced in Corvallis in these earthquakes was very low.

Nevertheless, the risk of future damage to OSU’s facilities is very high, especially from M8.3+ or M9.0+ partial rupture or full rupture earthquakes on the Cascadia Subduction Zone. There is additional significant earthquake hazard from smaller crustal earthquakes nearer to the Corvallis campus, or other OSU locations.

Earthquake Damage Estimates: Methodology and Results
Fully-quantitative earthquake damage estimates for scenario earthquakes or statistical average annual damage estimates considering the full range of probabilistic earthquake ground motions necessarily require at least a data set that includes the following parameters:

- HAZUS structural building type for each OSU building,
- Number of stories,
- Year built (vs. the time history of seismic provisions in building codes),
- Information about each building’s current condition, including any previous seismic strengthening or other structural renovations,
- Information about design details such as diaphragm to wall connections and other structural details that profoundly affect the level of seismic vulnerability.
- Information about other factors such as whether a building has significant vertical or plan irregularities, pounding issues from adjacent buildings, and
Site information such as site class, the liquefaction potential and the risk of earthquake-induced landslides or lateral spreading.

Furthermore, some OSU buildings have parts with different structural building types, either from the original construction or from later additions. These require careful review to characterize their expected seismic performance.

**Damage Estimates for Probabilistic Earthquake Ground Motions**

As discussed above, fully quantitative evaluations of existing buildings, or robust estimates of potential damages for specific buildings or building parts cannot be completed without additional building-specific data. Absent all of the necessary data, the damage estimates provided below are based on limited information and should be interpreted as preliminary and approximate.

Given the limited data, the damage estimates focus on the two most vulnerable building types at OSU: URMs and lift-slab buildings. Four levels of earthquake ground motions are considered: 20%, 10%, 5% and 2% probability of exceedance in 50 years, using the 2014 USGS National Seismic Hazard Dataset, adjusted for Site Class D (firm soil). The estimated return periods, the average time periods between various intensities of earthquake ground motions at the Corvallis Campus, are shown below in Table 6.6.

<table>
<thead>
<tr>
<th>Exceedance Probability in 50 Years</th>
<th>PGA (g)</th>
<th>Average Return Period (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>0.117</td>
<td>250</td>
</tr>
<tr>
<td>10%</td>
<td>0.230</td>
<td>475</td>
</tr>
<tr>
<td>5%</td>
<td>0.327</td>
<td>975</td>
</tr>
<tr>
<td>2%</td>
<td>0.457</td>
<td>2,475</td>
</tr>
</tbody>
</table>

For example, the average return period for earthquake ground motions with a 10% probability of being exceeded in 50 years is 475 years. This does not mean, however, that this level of ground shaking won’t happen for 475 years. Rather, an earthquake with this level of ground shaking could happen next month or next year or several decades from now or not for several hundred years or even much longer. Its ground motions will be exceeded, though, on average every 475 years.

The probabilistic earthquake ground motions shown in Table 6.6 include earthquakes on the Cascadia Subduction Zone as well as earthquakes on crustal earthquakes nearer to Corvallis. Given the 300+ years since the last Cascadia Subduction Zone earthquake, the current and future probability of earthquakes is significantly higher.
than the time-independent (long term average) USGS national seismic hazard estimates shown in Table 6.6 data indicate. After a major earthquake, such as the approximately M9.0 mega-earthquake on the Cascadia Subduction Zone in 1700, the stress on the fault gradually builds up. The longer the time interval has been since a major earthquake, the greater the stress level on the fault and the higher the probability of a major earthquake. Chris Goldfinger, an OSU professor and nationally-recognized expert on Cascadia Subduction Zone earthquakes, estimates that the probability of M8+ (partial fault rupture) or M9+ (full fault rupture) earthquakes over the next 50 years is 16% to 22%. Over time, the earthquake probability will gradually increase.

The 21 URMs at the Corvallis campus were built between 1889 and 1928. For the URMs, the damage estimates are based on the Hazus fragility data for pre-code URMs, using Peak Ground Acceleration (PGA) as the ground motion parameter. The Hazus term “pre-code” means that a building was designed and built with very minimal or no consideration of earthquakes.

Hazus does not have fragility data for lift-slab buildings, so the RVS scores in Table 6.5 do not reflect the additional concerns for lift-slab construction. However, for the preliminary analysis discussed below, we assume that lift-slab buildings have the same vulnerability as URMs. This assumption is predicated not only on the problematic connections between the lift-slab floors and the columns, but also on the multiple other seismic vulnerabilities that may be present in this type of construction. For example, the seismic evaluation of Weniger Hall, a lift-slab building, by Kent Yu, PE, SE, identified the following major deficiencies:

- Insufficient shear walls to resist lateral forces,
- Insufficient capacity of the connections between the slab reinforcing and the shear walls to transfer seismic forces from the diaphragms to the shear walls,
- The foundation system has insufficient capacity to resist seismic overturning loads delivered by the shear walls, and
- The welded wedge system may not have adequate capacity to accommodate the deformation expected to occur at the slab-to-column connections during a major earthquake. Failure of this system would result in loss of gravity support for the slab and a partial or complete pancaking-type collapse of the structure.

In combination, these deficiencies suggest that the seismic vulnerability of the lift-slab buildings is probably comparable to URMs or perhaps even worse due to the size and mass of the lift slab buildings.

FEMA’s Hazus earthquake loss estimation methodology has consensus seismic fragility parameters that are used to estimate the expected damage levels for buildings subjected to earthquakes at any specified intensity of earthquake ground shaking. In simple terms, these fragility parameters provide estimates of the seismic vulnerability of buildings and thus identify the buildings likely to pose the greatest risk in future major earthquakes.
The fragility parameters used in the calculations below are based on the Hazus building type for typical buildings designed to the life-safety performance level for four levels of seismic design: pre-code, low code, moderate code and high code. Hazus also has fragility parameters for "special" buildings designed to higher than the minimum code requirements for ordinary buildings.

The Hazus code levels are related to the Seismic Zones used in the Uniform Building Code, which preceded the current International Building Code. A pre-code building means that seismic considerations for the design of a building were nil or very minimal. The low-, moderate and high-codes represent increasingly robust seismic design levels. In Oregon, the seismic design provisions have varied significantly with location within the state and with the date of design. Progressively older buildings were designed to lower performance levels than newer buildings.

The Hazus methodology facilitates calculation of the probabilities that typical buildings of a given structural system, such as URM, are in each of four defined damage states: Slight, Moderate, Extensive and Complete at specified levels of earthquake ground motions. The Hazus fragility parameters for URMs of 3 or more stories were used for several levels of earthquake ground motions applicable to the Corvallis campus (using the latitude and longitude of Weniger Hall).

The damage percentages are expressed as percentages of the replacement value of buildings. Typical damage percentages for the Slight, Moderate, Extensive, and Complete damages states are 5%, 15%, 50%, and 100%, respectively. However, buildings that are nominally in the "extensive" damage states are very likely to be demolished and rebuilt because it is not practical from an engineering perspective or economically feasible to repair them. The results shown below assume that 90% of buildings in the "extensive" damage state will not be repairable and thus will be a complete loss.
Table 6-7
Earthquake Damage Estimates for OSU URM and Lift-Slab Buildings in Corvallis

| Exceedance Probability In 50 Years | PGA (g) | None  | Slight | Moderate | Extensive | Complete | Extensive or Complete | Statistical Damage Estimates
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>0.117</td>
<td>34.09%</td>
<td>22.45%</td>
<td>25.42%</td>
<td>14.75%</td>
<td>3.28%</td>
<td>18.04%</td>
<td>22.24%</td>
</tr>
<tr>
<td>10%</td>
<td>0.230</td>
<td>7.13%</td>
<td>11.50%</td>
<td>25.71%</td>
<td>34.01%</td>
<td>21.64%</td>
<td>55.65%</td>
<td>58.38%</td>
</tr>
<tr>
<td>5%</td>
<td>0.327</td>
<td>2.19%</td>
<td>5.28%</td>
<td>16.97%</td>
<td>34.83%</td>
<td>40.72%</td>
<td>75.55%</td>
<td>76.62%</td>
</tr>
<tr>
<td>2%</td>
<td>0.457</td>
<td>0.56%</td>
<td>1.92%</td>
<td>8.74%</td>
<td>27.44%</td>
<td>61.34%</td>
<td>88.78%</td>
<td>88.82%</td>
</tr>
</tbody>
</table>

1 Seismic fragility parameters for these calculations are HAZUS values for Pre-Code Mid-Rise URM buildings. Hazus does not have seismic fragility parameters for lift-slab buildings. However, the seismic vulnerability of lift-slab buildings is estimated to be comparable to that for URM buildings.

2 Percent of building replacement value.

The statistical damage estimates shown in Table 6-7 are expressed as a percentage of the replacement value of the buildings. The results are probabilistic because in a given earthquake a population of buildings of the same structural type – such as URMs - will have widely variable levels of damage. For example, as shown in Table for an earthquake with a PGA of 0.117 g, given a population of URM buildings some will have no damage, some will have slight or moderate damage and others will have extensive or complete damage. In this example, 3.28% of the buildings are estimated to have complete damage. These results should not be interpreted verbatim, but rather as estimates of the approximate distribution of damage states. As discussed previously, the seismic vulnerability of the lift-slab buildings is likely to be comparable to that of the URM buildings. The total replacement value of the URM and lift-slab buildings is approximately $1.75 billion based on an average replacement value of $650 per square foot. The economic impact of earthquake damage ranges from severe to catastrophic for the four levels of earthquake ground motions shown above.

To some extent, the damage estimates shown above may underestimate the damage levels for Cascadia Subduction Zone earthquakes because the estimates were not adjusted for the very long duration of ground shaking from these earthquakes. The longer duration of Cascadia earthquakes is expected to exacerbate building damage levels.
The damage estimates in Table 6-8 were calculated from the total building replacement value of the URM and lift-slab buildings multiplied by statistical damage percentages.

The earthquake damage estimates above include only building damages. The total damages including contents damages and loss of function economic impacts will be substantially higher. In any of the above earthquake levels of ground shaking, there will be injuries and a high likelihood of deaths, especially for the three highest levels of ground shaking shown. The best indicator of the relative number of casualties is the probability of buildings being in the complete damage state. Buildings in this damage state are close to collapse, or have suffered partial collapse, or full collapse. Especially for the three highest levels of earthquake ground shaking, there is a substantial risk of mass casualties.

Earthquake risk for OSU is not limited only to URM and lift-slab buildings. Of the 130 major buildings (Categories 1, 2, and 3 as defined previously), 70% were built before 1975, a time period when seismic design was minimal or non-existent. The total campus-wide building damage will be significantly higher than shown in Tables 6-8, perhaps by roughly 30% to 40%. This is a rough order-of-magnitude estimate based on the totals square footage for all campus buildings, recognizing that non-URM and non-lift-slab buildings will have substantially lower damage percentages than URM and lift-slab buildings because of their structural systems and also because many of the other buildings were built to more recent building codes than the URM and lift-slab buildings.

These results indicate that OSU has profound seismic vulnerabilities. The very high level of risk can be reduced only by retrofitting or replacing the most vulnerable buildings. Doing so is a high priority for OSU.

To compare the seismic vulnerabilities of the URM and life-slab buildings at OSU with other buildings, the tables on the following pages include a summary of the expected
damages and the life safety risk for the URM and Lift-Slab buildings and for Concrete Shear Wall Buildings. Concrete Shear Wall buildings were a common OSU building type for many years, up to and including recent or current buildings.

The seismic vulnerabilities of older OSU buildings vary between the various Hazus Building Types. Reinforced Masonry Buildings with Concrete Diaphragms (RM2) have similar to but slightly lower than the seismic performance of C2 buildings. Wood Frame buildings (W2) have better seismic performance than C2 buildings. The seismic vulnerabilities of other building types vary.

### Table 6-9

**Expected Building Damage and Life Safety Risk for URM and Lift-Slab Buildings and Concrete Shear Wall Buildings**

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Seismic Code Level</th>
<th>Statistical Damage Estimate&lt;sup&gt;2&lt;/sup&gt; Percent of Building Replacement Value</th>
<th>Life Safety Risk&lt;sup&gt;1&lt;/sup&gt; Probability of Being in the Complete Damage State</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PGA 0.117</td>
<td>PGA 0.230</td>
<td>PGA 0.327</td>
</tr>
<tr>
<td>URM and Lift Slab</td>
<td>Pre-Code</td>
<td>22.24%</td>
<td>58.38%</td>
</tr>
<tr>
<td>C2&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Special High Code</td>
<td>0.94%</td>
<td>4.16%</td>
</tr>
<tr>
<td>C2&lt;sup&gt;1&lt;/sup&gt;</td>
<td>High Code</td>
<td>1.86%</td>
<td>7.24%</td>
</tr>
<tr>
<td>C2&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Moderate Code</td>
<td>3.43%</td>
<td>14.95%</td>
</tr>
<tr>
<td>C2&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Low Code</td>
<td>7.31%</td>
<td>28.00%</td>
</tr>
<tr>
<td>C2&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Pre-Code</td>
<td>12.18%</td>
<td>39.68%</td>
</tr>
</tbody>
</table>

<sup>1</sup> Hazus Building Type C2 is Concrete Shear Walls

<sup>2</sup> Statistical damage estimates are calculated from the probability and damage percentage for each of the four Hazus damage states: Slight, Moderate, extensive and Complete

<sup>3</sup> Life safety risk is governed primarily by the probability that building is in the Hazus Complete Damage State, which means threat the building is on the verge of collapse or has collapsed partially or completely.

The PGA values shown in Table 6-9 are Peak Ground Acceleration, relative to “g,” the acceleration of gravity – a measure of the intensity of earthquake ground shaking. In qualitative terms, PGA values of 0.117 g, 0.230 g, 0.327 g and PGA 0.457 g, represent low, moderate, high and very high levels of ground shaking, respectively. The damage levels increase with increasing levels of earthquake ground shaking.
The High, Moderate, Low Codes are as defined by Hazus, as discussed previously. These Hazus code levels reflect the seismic forces to which buildings of a given structural system were designed at the time a given building was built. In Oregon the seismic zones per the Uniform Building Code varied over the decades and the seismic design requirements for each seismic zone also evolved or time. Thus, the Hazus code levels are related to the Uniform Building Code zones, but don’t map one-to-one.

The results in Table 6-9 are intended to show that URM and Lift-Slab buildings have substantially greater seismic vulnerability than other building types. The five different code levels for C2 buildings illustrate that buildings of the same building type but built at very different times have very different seismic vulnerabilities because building codes have evolved markedly over the decades. A further complexity is that a given building may best be characterized as between the Hazus code levels. For example, a given building may characterized as mid-way between a Low Code and a Moderate Code building.

Pre-Code means a building built with no consideration of earthquake performance. The “Special” High Code typically refers to an important building, such as a hospital or other Risk Category IV in the International Building Code that was designed to a higher performance level than an ordinary High Code building.

The results shown in Table 6-9 are interpreted as follows:

- URM and lift-slab buildings have by far the highest levels of damage and life safety risk, with significant damage and life-safety risk even at the lowest level of ground shaking shown. With increasing levels of ground shaking, the level of damage and life safety risk increase dramatically. These buildings have extremely high levels of earthquake risk.

- Special High Code C2 buildings have minimal damage and minimal life safety risk, even at the highest level of earthquake ground shaking. No current OSU buildings have been designed to this performance level.

- High Code buildings have minimal life safety risk for all levels of ground shaking and generally low levels of damage, except for the highest level of earthquake ground shaking (0.457 g).

- Moderate Code buildings have generally low life safety risk, except for the highest level of earthquake ground shaking (0.457 g). However, damage levels are moderate to high, with increasing levels of earthquake ground shaking.

- Low Code buildings have moderate to high or very high levels of damage and life safety risk. New buildings could not be designed to this code level. However, many OSU buildings were built in past years to this code level.
• Pre-Code buildings have significant damage levels and life safety risk at all levels of ground shaking, with the damage levels and life safety risk increasing markedly at higher levels of ground shaking.

More detailed tables of the expected seismic performance of C2 buildings designed to various code levels are shown in the Appendix at the end of this chapter.

6.6 OSU Earthquake Mitigation

6.6.1 Seismic Retrofitting Progress and Future Plans

The seismicity of Oregon was not fully understood until the 1990s when consensus understanding of the Cascadia Subduction Zone drastically changed the understanding of the level of seismic hazard near the Pacific Coast as far inland as the Willamette Valley. Previously, large parts of Oregon were deemed to be nearly aseismic.

Beginning in the late 1990s, OSU has included seismic strengthening when older buildings have been renovated, including Cascade Hall, Burt Hall, Nash Hall, Weatherford Hall, Buxton Hall, Hawley Hall, West Hall and Strand Agricultural. Retrofit planning is also underway for Fairbanks Hall and Cordley Hall, with construction scheduled for 2020 and 2021, respectively.

Seismic safety improvements and building replacements are at the core of OSU’s prioritization of capital improvement projects. The in-progress draft 2019-2027 OSU Capital Forecast Plan includes renovations with seismic strengthening, or demolition and replacement, for 22 buildings with total estimated costs (2018 dollars) of approximately $800 million.

All three of the Building Importance “1” buildings tabulated previously in Table 6-2 are included, as are many of the Importance “2” buildings. The Capital Forecast Plan includes seismic strengthening for six major URM buildings. Retrofits for URMs are complex because most are legacy buildings in the Historic District. The Capital Forecast Plan also includes retrofit or replacement with new current-code buildings for six of the lift-slab buildings.

6.6.2 OSU Earthquake Mitigation Action Items

The mitigation action items in Table 6.8 include the following types of measures:

• Evaluation and refinement of existing policies, practices and priorities for seismic evaluations and seismic strengthening or replacement of high risk buildings,

• Develop an explicit list of the OSU buildings at highest priority for seismic retrofit or replacement with new buildings and incorporate this list into capital planning,
• Aggressively seek funding for the highest priority seismic retrofits or building replacements from federal sources, state sources, donors and existing OSU capital improvement funds,
• Structural seismic strengthening measures,
• Nonstructural bracing and anchoring of building elements or contents that pose life safety threats such as falling hazards or spills of hazardous materials or may affect valuable research or other mission critical functions; seismic retrofits are not complete unless these nonstructural measures are completed,
• Enhanced emergency planning for earthquakes, and
• Enhanced education and outreach activities.

Given the high seismic vulnerability of many older OSU buildings, it is very important to:
• Evaluate and determine appropriate levels of seismic design for retrofits of existing buildings, including consideration of designing retrofits to higher than the minimum life safety standard to enhance OSU’s resilience in future earthquakes,, and
• Review and refine decision making protocols for deciding between retrofit or replacement for buildings with significant seismic deficiencies.

There is also an important policy issue to consider for future new buildings:
• Evaluate and determine appropriate levels of seismic design for new buildings, including the possibility of designing some buildings to higher than the minimum code requirements such as high occupancy buildings and buildings that have critical functions. The incremental cost is typical minor – only about 1% or 2% – and designing to a higher performance standard would substantially enhance OSU’s resiliency in future earthquakes. Designing to an Immediate Occupancy performance level would greatly reduce damage levels and eliminate or greatly reduce loss of function time in future earthquakes.
This Page Left Blank
**Table 6.8**
Earthquake Mitigation Action Items

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Action Item</th>
<th>Timeline</th>
<th>Source of Funds</th>
<th>Responsible Person or Department</th>
<th>Plan Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Life Safety</td>
</tr>
<tr>
<td>Short-Term #1</td>
<td>Enhance capital improvement planning to make seismic safety a very high priority.</td>
<td>1-2 Years</td>
<td>OSU or Grants</td>
<td>UFIO</td>
<td>X</td>
</tr>
<tr>
<td>Short-Term #2</td>
<td>Evaluate the feasibility of designing new buildings and seismic retrofits to higher performance levels than the minimum Life Safety criteria.</td>
<td>1-2 Years</td>
<td>OSU or Grants</td>
<td>UFIO</td>
<td>X</td>
</tr>
<tr>
<td>Short-Term #3</td>
<td>Establish an explicit priority list for retrofit or replacement of the highest risk buildings, including URM and lift-slab buildings.</td>
<td>1-2 Years</td>
<td>OSU or Grants</td>
<td>EP</td>
<td>X</td>
</tr>
<tr>
<td>Short-Term #4</td>
<td>Evaluate nonstructural seismic vulnerabilities in the OSU's buildings from building elements and contents that pose significant life safety risk (falling hazards) and mitigate by bracing, anchoring or replacing identified high risk items.</td>
<td>1-2 Years</td>
<td>OSU or Grants</td>
<td>Facilities/ EP</td>
<td>X</td>
</tr>
<tr>
<td>Short-Term #5</td>
<td>Aggressively seek funding for the highest priority seismic retrofits or building replacements from federal sources, state sources, donors and existing OSU capital improvement funds.</td>
<td>Ongoing</td>
<td>OSU or Grants</td>
<td>UFIO</td>
<td>X</td>
</tr>
<tr>
<td>Hazard</td>
<td>Action Item</td>
<td>Timeline</td>
<td>Source of Funds</td>
<td>Responsible Person or Department</td>
<td>Plan Goals Addressed</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------------------------------------------------</td>
<td>----------</td>
<td>-----------------</td>
<td>----------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Long-Term #1</td>
<td>Prioritize and implement structural seismic retrofits or replacements based on the results of the seismic evaluations completed under the Short-Term Action Items #1 to #4 listed above, as funding becomes available.</td>
<td>Ongoing</td>
<td>OSU or Grants</td>
<td>UFIO</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Long-Term #2</td>
<td>Maintain and update building data for seismic risk assessments in the GIS database.</td>
<td>Ongoing</td>
<td>OSU or Grants</td>
<td>UFIO</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Long-Term #3</td>
<td>Enhance emergency planning for earthquakes including duck and cover and evacuation drills.</td>
<td>Ongoing</td>
<td>OSU or Grants</td>
<td>EP</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Long-Term #4</td>
<td>Enhance education and outreach activities to increase knowledge of earthquake risks within OSU and within communities with OSU facilities.</td>
<td>Ongoing</td>
<td>OSU or Grants</td>
<td>EP</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

**Note:** EP = Emergency Preparedness, UFIO = University Facilities, Infrastructure and Operations
6.10 References


4. Oregon Department of Geology and Mineral Industries.
   http://www.oregongeology.org/sub/earthquakes/HistoricEqs.htm

   https://earthquake.usgs.gov/hazards

   https://www.fema.gov/hazus-mh-user-technical-manual

   http://db.concretecoalition.org/building/104


10. Chris Goldfinger, Oregon State University, e-mail communication, October 25, 2016.

# APPENDIX

Seismic Performance of C2 (Concrete Shear Wall Buildings) Designed to Various Code Levels

### Concrete Shear Wall (C2): Special High-Code Typical Building

<table>
<thead>
<tr>
<th>Exceedance Probability In 50 Years</th>
<th>PGA (g)</th>
<th>None</th>
<th>Slight</th>
<th>Moderate</th>
<th>Extensive</th>
<th>Complete</th>
<th>Extensive or Complete</th>
<th>Statistical Damage Estimates¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>0.117</td>
<td>83.81%</td>
<td>14.93%</td>
<td>1.25%</td>
<td>0.011%</td>
<td>0.000%</td>
<td>0.01%</td>
<td>0.94%</td>
</tr>
<tr>
<td>10%</td>
<td>0.230</td>
<td>47.23%</td>
<td>40.90%</td>
<td>11.44%</td>
<td>0.42%</td>
<td>0.0032%</td>
<td>0.42%</td>
<td>4.16%</td>
</tr>
<tr>
<td>5%</td>
<td>0.327</td>
<td>26.79%</td>
<td>46.84%</td>
<td>24.51%</td>
<td>1.84%</td>
<td>0.028%</td>
<td>1.86%</td>
<td>7.79%</td>
</tr>
<tr>
<td>2%</td>
<td>0.457</td>
<td>12.67%</td>
<td>41.67%</td>
<td>39.72%</td>
<td>5.77%</td>
<td>0.17%</td>
<td>5.94%</td>
<td>13.70%</td>
</tr>
</tbody>
</table>

¹ Percent of building replacement value.

2 Seismic fragility parameters for these calculations are HAZUS values for Special High-Code Mid-Rise C2 buildings.

### Concrete Shear Wall (C2): High-Code Typical Building

<table>
<thead>
<tr>
<th>Exceedance Probability In 50 Years</th>
<th>PGA (g)</th>
<th>None</th>
<th>Slight</th>
<th>Moderate</th>
<th>Extensive</th>
<th>Complete</th>
<th>Extensive or Complete</th>
<th>Statistical Damage Estimates¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>0.117</td>
<td>72.03%</td>
<td>24.01%</td>
<td>3.87%</td>
<td>0.09%</td>
<td>0.001%</td>
<td>0.09%</td>
<td>1.86%</td>
</tr>
<tr>
<td>10%</td>
<td>0.230</td>
<td>31.84%</td>
<td>43.97%</td>
<td>22.31%</td>
<td>1.84%</td>
<td>0.042%</td>
<td>1.88%</td>
<td>7.34%</td>
</tr>
<tr>
<td>5%</td>
<td>0.327</td>
<td>15.34%</td>
<td>40.63%</td>
<td>37.72%</td>
<td>6.05%</td>
<td>0.26%</td>
<td>6.31%</td>
<td>13.70%</td>
</tr>
<tr>
<td>2%</td>
<td>0.457</td>
<td>6.12%</td>
<td>29.35%</td>
<td>48.81%</td>
<td>14.55%</td>
<td>1.17%</td>
<td>15.72%</td>
<td>23.78%</td>
</tr>
</tbody>
</table>

¹ Percent of building replacement value.

2 Seismic fragility parameters for these calculations are HAZUS values for High-Code Mid-Rise C2 buildings.

### Concrete Shear Wall (C2): Moderate-Code Typical Building

<table>
<thead>
<tr>
<th>Exceedance Probability In 50 Years</th>
<th>PGA (g)</th>
<th>None</th>
<th>Slight</th>
<th>Moderate</th>
<th>Extensive</th>
<th>Complete</th>
<th>Extensive or Complete</th>
<th>Statistical Damage Estimates¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>0.117</td>
<td>65.11%</td>
<td>24.29%</td>
<td>9.83%</td>
<td>0.74%</td>
<td>0.036%</td>
<td>0.78%</td>
<td>3.43%</td>
</tr>
<tr>
<td>10%</td>
<td>0.230</td>
<td>25.21%</td>
<td>32.39%</td>
<td>33.75%</td>
<td>7.66%</td>
<td>1.00%</td>
<td>8.66%</td>
<td>14.95%</td>
</tr>
<tr>
<td>5%</td>
<td>0.327</td>
<td>11.17%</td>
<td>24.84%</td>
<td>43.16%</td>
<td>17.05%</td>
<td>3.77%</td>
<td>20.83%</td>
<td>27.69%</td>
</tr>
<tr>
<td>2%</td>
<td>0.457</td>
<td>4.09%</td>
<td>14.82%</td>
<td>42.48%</td>
<td>28.13%</td>
<td>10.48%</td>
<td>38.61%</td>
<td>44.32%</td>
</tr>
</tbody>
</table>

¹ Percent of building replacement value.

2 Seismic fragility parameters for these calculations are HAZUS values for Moderate-Code Mid-Rise C2 buildings.
## Concrete Shear Wall (C2): Low-Code Typical Building

<table>
<thead>
<tr>
<th>Exceedance Probability In 50 Years</th>
<th>PGA (g)</th>
<th>None</th>
<th>Slight</th>
<th>Moderate</th>
<th>Extensive</th>
<th>Complete</th>
<th>Extensive or Complete</th>
<th>Statistical Damage Estimates¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>0.117</td>
<td>51.58%</td>
<td>25.99%</td>
<td>19.15%</td>
<td>2.86%</td>
<td>0.43%</td>
<td>3.28%</td>
<td>7.31%</td>
</tr>
<tr>
<td>10%</td>
<td>0.230</td>
<td>15.47%</td>
<td>22.80%</td>
<td>40.10%</td>
<td>15.87%</td>
<td>5.77%</td>
<td>21.64%</td>
<td>28.00%</td>
</tr>
<tr>
<td>5%</td>
<td>0.327</td>
<td>5.86%</td>
<td>13.95%</td>
<td>39.47%</td>
<td>25.44%</td>
<td>15.28%</td>
<td>40.72%</td>
<td>46.07%</td>
</tr>
<tr>
<td>2%</td>
<td>0.457</td>
<td>1.83%</td>
<td>6.68%</td>
<td>30.14%</td>
<td>30.55%</td>
<td>30.80%</td>
<td>61.34%</td>
<td>64.67%</td>
</tr>
</tbody>
</table>

¹ Percent of building replacement value.

² Seismic fragility parameters for these calculations are HAZUS values for Low-Code Mid-Rise C2 buildings.

## Concrete Shear Wall (C2): Pre-Code Typical Building

<table>
<thead>
<tr>
<th>Exceedance Probability In 50 Years</th>
<th>PGA (g)</th>
<th>None</th>
<th>Slight</th>
<th>Moderate</th>
<th>Extensive</th>
<th>Complete</th>
<th>Extensive or Complete</th>
<th>Statistical Damage Estimates¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>0.117</td>
<td>40.31%</td>
<td>24.80%</td>
<td>27.83%</td>
<td>5.90%</td>
<td>1.16%</td>
<td>7.06%</td>
<td>12.18%</td>
</tr>
<tr>
<td>10%</td>
<td>0.230</td>
<td>9.66%</td>
<td>15.55%</td>
<td>40.89%</td>
<td>22.65%</td>
<td>11.25%</td>
<td>33.90%</td>
<td>39.68%</td>
</tr>
<tr>
<td>5%</td>
<td>0.327</td>
<td>3.21%</td>
<td>7.96%</td>
<td>33.48%</td>
<td>30.01%</td>
<td>25.35%</td>
<td>55.36%</td>
<td>59.28%</td>
</tr>
<tr>
<td>2%</td>
<td>0.457</td>
<td>0.88%</td>
<td>3.21%</td>
<td>21.45%</td>
<td>30.05%</td>
<td>44.41%</td>
<td>74.46%</td>
<td>76.34%</td>
</tr>
</tbody>
</table>

¹ Percent of building replacement value.

² Seismic fragility parameters for these calculations are HAZUS values for Pre-Code Mid-Rise C2 buildings.
7.0 TSUNAMIS

7.1 Tsunami Overview

Tsunamis are ocean waves that are most commonly initiated by earthquakes with vertical deformation of the seafloor. Tsunami waves propagate outwards from the location of origin for very large distances. For example, a tsunami-triggering incident anywhere in the Pacific Ocean will result in measurable tsunamis for the entire Pacific Ocean coastline.

The mechanism by which undersea earthquakes trigger tsunamis is illustrated by the following figure.

Figure 7.1
Earthquake-Generated Tsunamis¹
In deep open ocean waters, tsunami waves have very long wavelengths, up to about 150 miles, and small amplitudes, ranging from a few inches to a couple of feet. In the open ocean, tsunami waves may be barely perceptible to a ship.

However, as tsunami waves reach shallow water near coastlines, the wavelengths shorten and their amplitudes increase markedly and may reach to 10 feet or 20 feet or more. Once tsunami waves reach shore, the maximum run-up elevation above sea-level and the inundation distance inland vary markedly from incident to incident and location to location. Run-up elevations and inundation distances from the coast depend strongly not only on the offshore wave height but also on the near shore bathymetry of the ocean floor and the detailed local topography at any given location.

Tsunami inundations are flood incidents, but the level of damage may be much more severe than typical riverine or coastal flooding incidents for several reasons:

- Tsunami inundation depths may be much higher than flood incidents,
- Tsunami current velocities may be much higher than for flood incidents, especially on outgoing surges as tsunami waters return to the ocean,
- Tsunami inundations typically involve multiple surges of flooding, with both incoming and outgoing surges, and
- The depth, velocity and multiple surges in tsunami incidents typically result in widespread damage to buildings, infrastructure and vegetation, which generates heavy debris loads that further exacerbate tsunami damage.

The multiple-surges experienced during tsunamis are illustrated in Figure 7.2.

**Figure 7.2**

*Tsunami Surges in Hilo, Hawaii from M9.5 1960 Chile Earthquake²*
The power of tsunamis to result in nearly total destruction of buildings is illustrated by the photograph below from the March 2011 Tohoku tsunami in Japan where hundreds of buildings were left with little but the foundations after the tsunami incident. Only a very small number of very robust buildings survived.

**Figure 7.3**
**Complete Destruction: March 2011 Tohoku Tsunami, Japan**

The March 2011 Tohoku tsunami in Japan was generated by a M9.0 earthquake on a subduction zone that is nearly identical to the Cascadia Subduction Zone along the coast of the Pacific Northwest. See: Chapter 6 Earthquakes for further information about earthquakes on the Cascadia Subduction Zone.

### 7.2 Tsunami Sources

The most common source mechanism for tsunami generation is earthquakes within the oceanic floor. Earthquake sources for Oregon tsunamis are commonly divided into:

- **Distant or far-field earthquake incidents** within the Pacific Ocean that occur thousands of miles from Oregon. For far-field incidents, the warning time between an earthquake incident that generates a tsunami and the arrival of tsunami waves is several hours or more.

- **Indigenous or near-field earthquake incidents** that occur very close to the Oregon coast. For near-field incidents, the warning time is generally an hour or less and may be as short as a few minutes. For Oregon, the predominant near-field earthquake source is the Cascadia Subduction Zone.
The following figure shows tsunami travel times for the 1964 Prince William Sound M9.2 earthquake, which generated tsunamis throughout the Pacific Ocean. For Oregon, the travel times for this tsunami were between 4 and 5 hours.

**Figure 7.4**


(Travel Time Contours are Hours)

For the Oregon coast both distant and local earthquake sources contribute significantly to the total tsunami hazard. However, distant earthquakes generate much smaller tsunamis in Oregon, with long warning times while local earthquakes may generate larger tsunamis with very short warning times.

**Local earthquake-generated tsunamis from earthquakes on the Cascadia Subduction Zone are the greatest tsunami hazard for coastal areas of Oregon.**

The estimated return periods for tsunamis generated by major earthquakes on the Cascadia Subduction Zone are about 250 to 500 years. The last major earthquake occurred in 1700, more than 300 years ago.

Tsunamis can also be generated by other sources including: submarine landslides, landslides from land into bodies of water and asteroid impacts. These non-earthquake sources can generate large tsunamis, but are much less likely to occur. These tsunami sources typically have very long return periods, from thousands of years to hundreds of thousands of years to millions of years.
7.3 Tsunami Hazards and Risk for OSU Facilities

For OSU, there are only three facilities located within mapped tsunami inundation areas:

- The Hatfield Marine Science Center in Newport,
- The Clatsop County Extension Service Office in Astoria, and
- The Curry County Extension Service Office in Gold Beach.

In addition, there are two facilities in Tillamook that are located very near, but just outside the mapped tsunami inundation areas: the Tillamook County Extension Service Office and the Tillamook Bay Community College Office.

The tsunami modeling by the Oregon Department of Geology and Mineral Industry (DOGAMI) considers two tsunami sources with a total of seven tsunami incidents:

- Distance source tsunamis – two earthquake sources in Alaska, and
- Local source tsunamis – five earthquakes on the Cascadia Subduction Zone.

For each location in Oregon, the distance source inundation areas are smaller than the local source inundation areas. The Cascadia Subduction Zone tsunamis are modeled in five degrees of severity: Small, Medium, Large, Extra Large, and Extra Extra Large, based on the magnitude of the earthquake, the location of the fault slip and the extent of the slip on the fault.

The state-of-the-art of tsunami modeling has improved markedly in recent years. Nevertheless, there are substantial uncertainties in estimating the tsunami run-up elevation and inundation depth at specific locations for a given tsunami-generating incident, such as a M9.0 earthquake on the Cascadia Subduction Zone.

Given the uncertainties in tsunami modeling, campuses near the coast with elevations less than 100 feet may have enough life safety risk to warrant development of an evacuation plan and for immediate evacuation to be implemented for earthquakes which generate strong ground shaking at the campus. Evacuation should occur as soon as the ground shaking stops.

In the March 2011 Tohoku tsunami in Japan many people died who were outside the mapped tsunami inundation zones or who went to designated evacuation points. The tsunami was much larger than anticipated, with much higher inundation depths and inundation over much wider areas than anticipated.

The Hatfield Marine Science Center has by far the highest level of tsunami risk of the OSU facilities with tsunami risk: the entire facility is likely to be inundated and the nearest save havens are at a significant distance. Immediate evacuation is essential. The DOGAMI tsunami evacuation map for the South Newport Area is shown on the following page.
The level of tsunami risk at the Clatsop County Extension Service Office in Astoria and at the Curry County Extension Service Office in Gold Beach is lower because both facilities are located close to save havens. The color coding in the DOGAMI evacuation maps for these two locations are the same as that shown on the previous page for the Hatfield Marine Science Center. Orange areas are subject to inundation in distant source or local source tsunamis. Yellow areas are subject to inundation in local source tsunamis. Green areas are designated by DOGAMI as out of the tsunami hazard area. The red stars indicate the approximate location of the OSU facilities at risk.

**Figure 7.6**
Tsunami Evacuation Map: Astoria
Figure 7.7
Tsunami Evacuation Map: Gold Beach
As noted previously, OSU’s facilities in Tillamook are located outside of the mapped tsunami hazard area, but are very close to the mapped tsunami inundation area. Given the significant uncertainties in tsunami modeling, pro-active evacuation is recommended. Evacuation should be immediate after an earthquake with strong ground motion.

**Tsunami Loss Estimates**

OSU’s potential losses from distant tsunamis are low. None of the OSU facilities are within mapped inundation areas for distant tsunamis, although minor damages are possible.

However, OSU’s potential losses from local tsunamis generated by earthquake on the Cascadia Subduction Zone are extremely high. OSU’s facilities in Newport total
more than 150,000 square feet of buildings with a replacement value of approximately $60,000,000, assuming an average replacement value of about $400 per square foot. Including building contents, the total value at risk is probably about $80 million. These buildings are at risk from both earthquakes and tsunamis.

In a major Cascadia Subduction Zone earthquake and the resulting tsunami, the complete or nearly complete destruction of these facilities appears virtually certain.

The life safety risk is also extremely high. Absent immediate and complete escape from the inundation areas to safe havens, widespread deaths and injuries would be inevitable.

7.4 Tsunami Mitigation Measures

For tsunamis affecting OSU facilities and the nearby community, the overwhelming priority is life safety: to eliminate or minimize casualties. There are four main tsunami mitigation measures:

- Enhanced evacuation planning, including conducting practice drills.
- Enhanced outreach and education efforts to increase awareness of tsunamis and the urgency of immediate evacuation to safe areas.
- Vertical evacuation to structures where natural high ground is not reachable in the anticipated time between the end of earthquake ground shaking and the first arrival of tsunami waves.
- Replacement of a campus at high risk with a new campus well outside the tsunami hazard zones.

Evacuation to natural high ground is the preferred evacuation choice if and only if natural high ground is high enough to be above the worst-case tsunami and it is reachable within the estimated arrival times for local tsunami incidents. Designated safe areas for tsunami evacuation should be as close as possible to the campus and community at risk at an elevation of at least 50 feet above sea level. Whenever possible, designated safe areas should be at an elevation of 100 feet or higher.

A critically important factor in designating locations for tsunami evacuation is travel time – the best location is the location meeting the above elevation criteria that is reachable in the shortest time. Ideal evacuation routes should not have impediments to rapid evacuation such as bridges that may fail in the earthquake or routes that may be blocked by earthquake-induced landslides or debris from collapsed buildings.

Vertical evacuation to structures may be the only viable life safety measure when natural high ground is not reachable. Vertical evacuation structures may be single-purpose (evacuation only) structures such as concrete platforms or earthen berms or buildings, including existing buildings or new buildings. In all cases, a vertical evacuation structure must be robust with the capacity to withstand both earthquake
forces and tsunami forces with a high degree of confidence. FEMA publications\textsuperscript{5,6} provide details regarding vertical evacuation structures.

Replacement of a campus at high risk from tsunamis with a new campus well outside tsunami hazard zones is the best mitigation measure for life safety because the risk is completely eliminated. Replacement may be viable when the tsunami life safety risk is very high, especially if the existing campus facilities are in poor condition or otherwise inadequate.

OSU’s mitigation measures for tsunamis are summarized in Table 7.1.
Table 7.1
OSU Tsunami Mitigation Action Items

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Action Item</th>
<th>Timeline</th>
<th>Source of Funds</th>
<th>Responsible Person or Department</th>
<th>Plan Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Life Safety</td>
</tr>
<tr>
<td><strong>Tsunami Mitigation Action Items</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-Term #1</td>
<td>Review and update evacuation plans for tsunami for facilities in or near mapped tsunami inundation areas, including identifying the shortest routes to safe havens that don't have major impediments to rapid travel on foot and conduct frequent practice drills.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>HMSC</td>
<td>X</td>
</tr>
<tr>
<td>Short-Term #2</td>
<td>Continue and expand public education and outreach efforts to increase awareness of tsunamis and the urgency of immediate evacuation to safe areas.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>HMSC</td>
<td>X</td>
</tr>
<tr>
<td>Long-Term #1</td>
<td>Construction of vertical evacuation structure(s) at the Hatfield Marine Science Center if feasible, as funding becomes available.</td>
<td>2-10 years</td>
<td>OSU or Grants</td>
<td>HMSC/UFIO</td>
<td>X</td>
</tr>
<tr>
<td>Long-Term #2</td>
<td>Locate new facilities outside of tsunami hazard areas whenever possible or in immediate proximity to natural high ground suitable for evacuation.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>UFIO</td>
<td>X</td>
</tr>
</tbody>
</table>

Note: HMSC = Hatfield Marine Science Center; UFIO = University Facilities, Infrastructure and Operations
7.5 References


3. Tsunami photo, Tohoku, Japan, 2011. Source unknown


8.0 VOLCANIC HAZARDS

8.1 Overview

The Cascade Mountain Range, which runs from British Columbia into northern California, contains more than a dozen major volcanoes and hundreds of smaller volcanic features. Figure 8.1 shows the volcanoes that have been active in the past several thousand years.

Figure 8.1
Cascade Volcanoes Activity

![Volcanic Activity Diagram]

The Oregon volcanoes shown above include Mount Hood, Three Sisters, Newberry Volcano and Crater Lake. These four Oregon volcanoes are also included in the United States Geological Survey’s very high threat potential volcanoes. Very high threat potential means that these volcanoes are capable of very large eruptions affecting wide areas.

Several smaller volcanoes, including Diamond Craters and Jordan Craters in the High Lava Plains of southeast Oregon have erupted in the last 6,000 years. These eruptions have built complexes of lava flow fields and cinder cones. Unlike the far-reaching effects that may be generated by large, potentially explosive stratovolcanoes – including the four in Oregon listed above – the hazards associated with future eruptions in sparsely populated southeast Oregon are most likely limited to localized lava flows.
8.2 Volcanic Hazard Types

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, landslides or debris flows, ash falls, and lahars.

Proximal Volcanic Hazards
(Effects Near a Volcano)

Lava flows are eruptions of molten rock. Lava flows for the major Cascades volcanoes tend to be thick and viscous, forming large steep cones and typically affecting only those areas near the eruption vent. However, lava flows from the smaller volcanoes in volcanic fields tend to 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 up to 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 °F and move downslope at 100 to 150 miles per hour. Pyroclastic flows are extremely deadly for anyone caught in their path.

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

Distal Volcanic Hazards
(Effects at Considerable Distances from a Volcano)

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. Large lahars may be hundreds of yards wide, tens of yards deep and capable of carrying large boulders more than 30 feet in diameter. In most cases, inundation by a lahar will result in complete destruction of buildings.
**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.

For the vast majority of OSU facilities the only volcanic hazard is ash falls. Figure 8.2 on the following page shows the probabilities of one centimeter (0.4 inch) of ash in a 30 year time period. These probabilities are governed in large part by Mount St. Helens, which is by far the most active volcano in the Cascades. However, all of the other volcanoes shown are deemed active by the USGS and capable of eruptions. The probabilistic ash fall contours are higher eastwards from Mount St. Helens and the other volcanoes because the prevailing winds are from the west.

Most ash fall incidents impacting OSU facilities are likely to be relatively minor with an inch or less of ash likely. However, even minor amounts of ash fall can result in significant impacts. The impacts of ash falls include health effects and several other disruptive effects such as:

a) The possible inability of some locations to evacuate due to a combination of the disruption of vehicular traffic and health concerns that may preclude people being outside during heavy ash falls. In this case, shelter in place may be necessary, possibly for up to several days,

b) Respiratory problems for at-risk populations such as young children, people with respiratory problems and the elderly,

c) 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,

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

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

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

g) Disruptions of vehicular and air traffic.
The term “tephra” used on the above USGS maps includes volcanic ash, dust, cinders and other ejecta from an erupting volcano. Mount Jefferson is shown on the above maps. However, the USGS threat potential for Mount Jefferson is low to very low.\textsuperscript{2}
8.3 Volcanic Hazard and Risk Assessment

As noted previously, the only significant volcanic hazard for the vast majority of OSU facilities is the possibility of ash falls.

However, for the Cascades Campus there is a remote possibility with an extremely low probability of more severe volcanic hazard incidents from the Three Sisters and Newberry Crater volcanoes. Eruptions of lava and/or cinder cones are possible on the flanks of either volcano at considerable distances from the main peaks in the area shown in light peach shading in the figures below. The many buttes in the greater Bend area, including Pilot Butte, were formed by such volcanic activity.

Figure 8.3
Three Sisters: USGS Volcanic Hazard Zones

Figure 8.4
Newberry: USGS Volcanic Hazard Zones
Caveat:

The USGS volcanic hazard mapping for the Three Sisters and Newberry volcanoes does not mean that the Bend area is at high risk from volcanic activity. As stated previously, the risk is not zero, but it is extremely low. It has been over a thousand years since either volcano had even minor activity. The return periods for major volcanic activity may be in the tens of thousands of years or longer. The return period for volcanic activity in the immediate vicinity of Bend would be substantially longer. The risk assessment on the previous pages is included for completeness.

8.4 Volcano Monitoring and Volcano Activity Alerts

The USGS monitors volcanic activity in the Cascade Range 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 and notification system with several levels of alert as a potential eruption becomes more likely and more imminent.

**Figure 8.5**
Volcanic Alert Levels for People on the Ground\(^4\)

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

There is an important caveat on volcanic alerts: in most cases, volcanic eruptive incidents have precursor activity for days, weeks or months before an eruption. However, the exact time of an eruption cannot be predicted.
It is also possible that some eruptions may have no precursor activity and thus no warning. For example, a major collapse of a volcanic peak could trigger a volcanic eruption without any warning.

8.5 Volcanic Hazard Mitigation Measures

There are no physical measures that are practical from either an engineering perspective or an economic perspective to protect an OSU facility from volcanic ash falls or other types of volcanic activity.

The most effective mitigation measures to reduce life safety risks from volcanic incidents for OSU facilities located within or near mapped volcanic hazard zones include the following:

1. Awareness. Ensure that staff and students are aware of volcanic hazards.
2. Emergency Planning. Incorporate notification and response measures for volcanic ash incidents into OSU's emergency response plans, including possible shelter in place.
3. Whenever possible, avoid building new facilities in or near mapped lahar zones or other volcanic hazard zones.

The OSU mitigation Action Items for volcanic hazards are shown in Table 8.
# Volcanic Hazard Mitigation Action Items

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Action Item</th>
<th>Timeline</th>
<th>Source of Funds</th>
<th>Responsible Person or Department</th>
<th>Plan Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Life Safety</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Short-Term #1**
Incorporate notification and response measures for volcanic ash events into OSU's emergency operations planning.

1-2 Years
OSU
EP
X
X
X
X

**Short-Term #2**
Monitor USGS volcanic alerts whenever such alerts are made in locations that might affect OSU facilities.

Ongoing
OSU
EP
X
X
X

**Long-Term #1**
Locate new facilities outside of severe volcanic hazard locations, including areas subject to lahars, whenever possible.

1 Year
OSU
UFIO
X
X
X

*Note: EP = Emergency Preparedness; UFIO = University Facilities, Infrastructure and Operations*
8.6 References

1. Meyers and Driedger, Eruptions in the Cascade Range during the past 4,000 Years, General Information Product 63, U.S. Geological Survey.

2. Cascades Volcanic Observatory: https://volcanoes.usgs.gov/observatories/cvo/


9.0 FLOOD

9.1 Introduction

Floods have occurred in Oregon throughout recorded history. There are several different types of flood sources, including:

- Overbank flooding from rivers and streams,
- Coastal storm surge flooding,
- Local stormwater drainage flooding,
- Channel migration,
- Sheet flow (alluvial fan) flooding,
- Flooding from failures of dams, reservoirs or levees, and
- Flooding from other sources, including subsidence, tsunamis, and seiches.

**Overbank flooding** from rivers and stream occurs throughout Oregon, most commonly from winter storms with heavy rainfall from November to February. Flood incidents with significant contributions from snowmelt may also occur during the spring snowmelt season for watersheds with high enough elevations to have significant snowfalls. Although it is less common, overbank flooding can also occur at any time of the year. The severity of overbank flooding depends primarily on flood depth. However, other factors such as flood duration, flow velocity, debris loads, and contamination with hazardous materials also significantly impact the severity of any given flood incident. Overbank flooding from major rivers can be very severe and affect broad geographic areas.

**Coastal storm surge flooding** affects low elevation areas along the Pacific Coast and is most common from winter storm incidents, generally from November through February. Coastal flooding results from the combination of storm-driven surges and daily tides. Maximum flooding occurs when the peaks of storm-driven surges coincide with high tides. The severity of coastal flooding depends not only on flood depths but also on wave effects and debris impacts. Wave pounding exerts substantial forces on structures and extended pounding by frequent waves may destroy structures not designed to withstand wave forces. Wave action may also destroy structures by erosion scour that undermine foundations. Debris impacts may greatly increase damages for a given flood depth.

Coastal flood incidents are expected to become more frequent and more severe in the future because of global warming and sea level rise. Current consensus estimates by climate scientists are that sea level on the Oregon Coast at Newport may gradually rise by about 12 to 47 inches by 2100. Sea level rise is also expected to exacerbate beach erosion which may further increase flooding potential in coastal areas.
Storm water drainage flooding, which is sometimes referred to as urban flooding, occurs when inflows of storm water exceed the conveyance capacity of a local storm water drainage system. With this type of flooding, the drainage system overflows, resulting in water ponding in low lying areas. Storm water drainage flooding is generally localized, with flood depths that may range from a few inches to several feet or more.

Channel migration flooding occurs when ongoing erosion/deposition on the banks of a river result in the channel of the river or stream migrating (moving) to an extent that structures are affected by floods. Rivers or streams with low gradients (flat topography) and meandering patterns are prone to channel migration.

Sheet flow flooding occurs when stream flows are not confined to a channel but occur over a broad area. Sheet flows are common in areas within alluvial fans, which are sloping accumulations of sediments eroded from adjacent mountains or hills.

Failure of dams, reservoirs for potable water systems or levees results in flooding areas downstream of dams and reservoirs or behind levees. Failures of major dams operated and regulated by state or federal agencies are possible, but unlikely because these dams are generally well-designed, well-monitored and well-maintained. However, failures of smaller dams maintained by local governments, special districts or private owners are more common.

Failures of reservoirs for potable water systems occur, especially from earthquakes. These reservoirs typically have much smaller storage volumes than dams, so flooding from these types of failures is generally localized, but may be severe where flows are confined in narrow channels which contain structures or infrastructure. Similar flooding may occur from failures of large diameter water pipes.

Levee failures before overtopping may occur at any time, not only during high water incidents, but also under normal non-flood conditions. There are numerous causes for such failures, including scour, foundation failures, under-seepage, through-seepage, animal burrows, and others.

Flooding from other sources may also occur, including subsidence, tsunamis and seiches. Major earthquakes on the Cascadia Subduction Zone are expected to result in coastal subsidence of several feet along the Pacific Coast. This subsidence will result in permanent flooding of some low elevation areas. Further details about earthquakes on the Cascadia Subduction Zone are provided in Chapter 6 Earthquakes and in the Oregon State K-12 Facilities Hazard Mitigation Plan. OSU facilities in Newport, Astoria and Gold Beach have major flood risk from tsunamis.

Every county in Oregon is subject to flood risk and has experienced major flood incidents. However, Western Oregon has higher annual precipitation and has experienced more major flood incidents than Eastern Oregon.
9.2 Flood Hazard Assessments: Within FEMA-Mapped Floodplains

FEMA Flood Insurance Rate Maps (FIRMs) delineate the regulatory (100-year) flood hazard areas in Oregon. Per FEMA regulations, there are limitations on new development within the 100-year floodplain.

The 100-year flood is defined probabilistically. A 100-year flood does not occur exactly every 100 years. Rather, 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. A given location may have two or more 100-year (or greater) flood incidents within a few years or have none in several decades or longer.

FEMA’s floodplain mapping provides a good starting point for flood hazard risk assessments. Facilities within FEMA mapped floodplains have at least some level of flood risk. However, determining the level of risk quantitatively requires additional flood hazard data, including the elevation of facilities relative to the elevation of a range of flood incidents. It is also important to recognize that some facilities not within FEMA-mapped floodplains also have high levels of flood risk.

FEMA floodplain maps represent the best available data at the time the maps were prepared. FEMA has an ongoing map modernization/update process, but many existing FIRM maps are old – some more than 30 years old. In many cases, flood risk in a given location increases with time because increasing development within the watershed increases runoff, and because development and fill within floodplains or sedimentation in a river channel may increase flood elevations. In some cases, flood elevations for a 100-year flood using current data may be up to several feet higher than outdated floodplain maps indicate.

Flood risk at a given location may also decrease over time if flood control structures such as levees or upstream dams for flood control are constructed or improved. Old floodplain maps are not necessarily incorrect. However, older maps should be interpreted carefully because the older a map is, the more likely it is to be significantly incorrect.

Recent and future FEMA floodplain maps are available in digital GIS-format and are known as DFIRMs. Older maps, which were originally prepared in paper format only, have been digitized, but contain less detailed information than DFIRMs. These maps are known as Q3 maps. For any given location, the most recent FEMA maps should be used for flood risk assessments.

FEMA floodplain maps identify several types of flood zones, with varying levels of flood hazard. The FEMA flood zone designations have evolved over time, with older maps using different nomenclature than recent maps. FEMA’s current and historical flood zone designations are summarized on the following pages.
Table 9.1
FEMA Flood Zones

HIGH RISK AREAS

<table>
<thead>
<tr>
<th>ZONE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Areas with a 1% annual chance of flooding and a 26% chance of flooding over 30 years. Because detailed analyses are not performed for such areas; no depths or base flood elevations are shown within these zones.</td>
</tr>
<tr>
<td>AE, A1 – A30</td>
<td>The base floodplain where base flood elevations are provided. AE Zones are now used on new format FIRMs instead of A1-A30 Zones.</td>
</tr>
<tr>
<td>AH</td>
<td>Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over 30 years. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.</td>
</tr>
<tr>
<td>AO</td>
<td>River or stream flood hazard areas and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over 30 years. Average flood depths derived from detailed analyses are shown within these zones.</td>
</tr>
<tr>
<td>AR</td>
<td>Areas with a temporarily increased flood risk due to the building or restoration of a flood control system (such as a levee or a dam).</td>
</tr>
<tr>
<td>A99</td>
<td>Areas with a 1% annual chance of flooding that will be protected by a federal flood control system where construction has reached specified legal requirements. No depths or base flood elevations are shown within these zones.</td>
</tr>
</tbody>
</table>
### HIGH RISK COASTAL AREAS

<table>
<thead>
<tr>
<th>ZONE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>Coastal areas with a 1% of greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over 30 years. No base flood elevations are shown with these zones.</td>
</tr>
<tr>
<td>VE, V1 – V30</td>
<td>Coastal areas with a 1% of greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over 30 years. Base flood elevations derived from detailed analysis are shown at selected intervals within these zones.</td>
</tr>
</tbody>
</table>

### MODERATE TO LOW RISK AREAS

<table>
<thead>
<tr>
<th>ZONE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>B and X (shaded)</td>
<td>Area of moderate flood hazard, usually the area between the limits of the 100-year and 500-year floods. B Zones are also used to designate base floodplains of lesser hazards, such as areas protected by levees from 100-year flood, or shallow flooding areas with average depths of less than one foot or drainage areas less than 1 square mile.</td>
</tr>
<tr>
<td>C and X (unshaded)</td>
<td>Area of minimal flood hazard, usually depicted on FIRMs as above the 500-year flood level. Zone C may have ponding and local drainage problems that don't warrant a detailed study or designation as base floodplain. Zone X is the area determined to be outside the 500-year flood and protected by levee from 100-year flood.</td>
</tr>
</tbody>
</table>

### UNDETERMINED RISK AREAS

<table>
<thead>
<tr>
<th>ZONE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Areas with possible but undetermined flood hazards. No flood hazard analysis has been conducted. Flood insurance rates are commensurate with the uncertainty of the flood risk.</td>
</tr>
</tbody>
</table>

FEMA Flood Insurance Rate Maps are always accompanied by Flood Insurance Studies. Flood Insurance Studies contain summaries of historical floods, details of the flood mapping, and quantitative flood hazard data which is essential for quantitative flood risk assessments.
FEMA Flood Insurance Studies and Flood Insurance Rate Maps include a large number of FEMA-specific terms and acronyms. A good summary of the terms used in flood hazard mapping is available from FEMA.²

For buildings within most FEMA mapped flood zones, quantitative flood data in the Flood Insurance Study allow calculation of the probability of flooding for any building, if the building’s first floor elevation is known. The flood data used to make this calculation include stream discharges (volume of water flowing in a river) and flood elevations for floods of several different return periods (typically, the 10-, 50-, 100- and 500-year floods).

The level of flood hazard (frequency and severity of flooding) for a given campus or building is not determined simply by whether the campus or building is or is not within the mapped 100-year floodplain. Rather, the level of flood hazard depends to a great extent on the elevation of buildings relative to the elevation of various flood incidents, such as the 10-year, 50-year or 100-year flood incident.

For example, consider two buildings both within the 100-year floodplain of a given river. The first school has a first floor elevation three feet above the 100-year flood elevation and the level of flood hazard is low (but not zero). The second school has a first floor elevation three feet below the 100-year flood elevation and the level of flood hazard is very high. In this example, the six foot difference in elevations of the two schools makes an enormous difference in the level of flood hazard.

An important caveat is that buildings, especially those without basements, within mapped 100-year floodplains may have low or very low flood risk if the elevation of the first floor is well above the 100-year flood elevation.

On the other hand, the flood hazard level may be overestimated for:

- Buildings that have been elevated or protected by flood barriers, or
- Buildings in areas where flood mitigation measures such as raising levees, increasing water storage upstream or constructing diversion channels have been implemented but not yet been incorporated into FEMA’s floodplain mapping.

Conversely, the level of flood hazard may be higher than indicated by FEMA’s floodplain mapping if the Flood Insurance Study on which the flood maps are based have not been updated in many years. Many of the FEMA Flood Insurance Studies that document flood prone areas are outdated. In some locations, the FEMA studies have not been updated for 20 or more years and may not accurately reflect the current level of flood hazard for several reasons including:

- Increased development upstream of a given locations typically results in more impervious areas (buildings and streets) that reduce infiltration and thus increase runoff, and
Channelization of waterways or sediment accumulation may raise water levels in rivers and streams.

The likelihood that a FEMA Flood Insurance Study and FEMA floodplain maps may not accurately reflect current flood hazard levels increases with the length of time period since the FEMA study has been updated. In some cases, updated FEMA studies have raised the elevation of the 100-year flood by up to 3 feet or more in some locations and thus greatly increased the areal extent of the 100 year floodplain.

9.3 Flood Hazard Assessments: Outside FEMA-Mapped Floodplains

A building located outside of FEMA-mapped floodplains does not necessarily have nil or very low flood risk for two main reasons:

- FEMA’s floodplain mapping focuses mainly on flood sources in areas with substantial numbers of buildings and does not typically include areas with limited numbers of buildings or very small streams, or
- The FEMA flood study may be outdated and may underestimate the current level of flood hazard.

Nationwide, more than 25% of flood damage occurs outside of FEMA-mapped floodplains. Buildings located outside of FEMA-mapped floodplains may have significant flood risk if any of the following conditions apply:

- There is a history of floods from any source affecting or near a building.
- Local storm water drainage flooding is common near a building.
- A building is near a river, stream or drainage channel not mapped by FEMA, and the building is at an elevation close to that of the water source.
- A building is on an alluvial fan subject to sheet flows.
- A building is near a migrating river or stream.
- A building is protected by a levee that is not FEMA-certified.

For buildings that appear to have significant flood risk, especially buildings with high value or high functional importance, further investigation of the flood hazard may be warranted. It may be worthwhile to have a local hydrologic and hydraulic study completed to obtain the types of quantitative flood hazard data contained in a FEMA Flood Insurance Study. Such local studies may also be worthwhile when the FEMA Flood Insurance Study is old and there are reasons, such as increased development in a watershed, to suspect that flood hazards may have significantly increased.

For locations subject to stormwater drainage flooding, engineers knowledgeable about the stormwater system may be able to provide quantitative data on the conveyance capacity of the system to supplement historical flood data. Stormwater systems are often designed to handle only 2-year or 5-year flood incidents, and are
infrequently designed to handle rainfall incidents greater than 10-year or 15-year incidents.

Evaluation of flood hazards and flood risk outside of mapped-floodplains necessarily requires more engineering experience and judgment than that required to interpret the flood data in mapped floodplains. Consultation with flood engineers is recommended.

9.4 National Flood Insurance Program Insured Structures

OSU currently does not have any structures insured under the National Flood Insurance Program (NFIP), but will be applying for coverage in the near future.

None of OSU’s structures are on FEMA’s repetitive loss or severe repetitive loss lists.

OSU does not have regulatory authority regarding adoption and enforcement of floodplain management requirements, floodplain identification, or community assistance and monitoring activities. That is, OSU is not a community in the NFIP, as defined for NFIP purposes.

9.5 OSU Flood Risk Assessment

9.5.1 Overview

OSU’s statewide building inventory itemizes 622 buildings of which 453 are OSU-owned and 169 are leased. For risk management, OSU considered five categories of buildings:

1. Major Buildings (3 buildings) for which seismic evaluations are a high priority. The seismic evaluation of Weniger Hall was completed as part of OSU’s Natural Hazards Mitigation Plan. None of these buildings are in FEMA-mapped floodplains.

2. Major Buildings (77 buildings), excluding buildings in Category 1. None of these buildings are within the 100-year floodplain. There are 4 buildings identified as being in Zone X (shaded or unshaded) with low flood risk: Cascades Campus Building 1 and three buildings at the Marine Science Center (Aquarium Visitor Center, Education and Ship Operations).

3. Minor Buildings (77 buildings). Only three buildings in this category are within the 100-year floodplain: The Oak Creek Building and Oak Creek Chemistry Lab near Oak Creek and the OSU Crew (Boat) Facility on the Willamette River. There are also 44 buildings in this category identified as being in Zone X (shaded or unshaded) with low flood risk.

4. Ancillary Buildings (318 buildings), including agricultural barns, storage buildings and other buildings of generally very minor importance. 82 of these buildings are within the 100-year floodplain. However, nearly all of these are very minor agricultural buildings. There are a few buildings in this category.
that warrant further evaluation, including the Oak Creek Hazmat Storage building and several small oceanography program support buildings. There are also 161 buildings in this category mapped as being in Zone X (shaded or unshaded) or Zone D, with low levels of flood risk. The vast majority of these are very minor agricultural buildings.

5. Leased Buildings (147 buildings). OSU has limited control over these leased buildings, other than to vacate the buildings if the flood risk were to be deemed unacceptably high. Only two of these buildings are within the 100-year floodplain: the Morrow County and Wheeler County Extension Buildings. There are 88 buildings in this category that are predominantly agricultural buildings or Extension buildings that are mapped as being in Zone Z (shaded or unshaded) with low levels of flood risk.

9.5.2 Flood Loss Estimates

Historically, flood losses at OSU facilities have been very low. From 2001 to mid-2017, total flood insurance claims totaled only about $127,000. Most of the damage was from flooding of OSU utility tunnels.

An important caveat is that the absence of a history of past flood incidents for a given campus or building may indicate that flood risk is low, but this is not necessarily the case. Flood risk is inherently probabilistic. A campus that hasn’t had a flood in 10, or 20 or 50 years may have just been “lucky” and significant flood damage might occur with floods of such return periods. Or, the flood risk might have increased over time because of increasing development upstream in the watershed (which increases runoff) or because of channel changes. Or, a campus might not have frequent minor flooding, but the level of damages for a 50-year or 100-year incident might be severe.

In larger flood incidents than those that have affected OSU in recent decades, flood damages could be substantially higher. As noted previously, there are no major buildings in the mapped 100-year flood incident and only three minor buildings and two leased Extension buildings. However, there are large numbers of ancillary buildings (82) and leased buildings (88) within the 100-year floodplain. The vast majority of these buildings are small predominantly agricultural buildings.

Nevertheless, a widespread 100-year flood incident with damage to the majority of these buildings within the mapped 100-year floodplain could result in one million or perhaps several million dollars in flood damage.

In widespread flooding more severe than the 100-year flood incidents, total damages could be significantly higher, perhaps up to $10 million or more.
9.6 Flood Mitigation Action Items

For OSU facilities with significant levels of flood risk there are several types of potential flood mitigation measures available:

- Replacement of a facility at high risk from floods with a new facility located outside of flood hazard zones.
- Elevation of an existing building.
- Relocation of important records, equipment or functions from basements to above grade locations.
- Construction of levees, berms or flood walls to protect a facility.
- Installation of flood gates along with building water proofing measures.
- Minor floodproofing actions that address the most vulnerable elements in a facility; such projects include elevating at-grade utility infrastructure or relocating critical equipment or contents from basement levels of a building to higher levels.
- Local drainage improvements where stormwater drainage is a problem.

On a community or regional level, larger-scale flood control measures such as construction of upstream dams or detention basins and channel improvements may be effective in reducing flood risks. However, such larger-scale projects are largely outside OSU’s domain of responsibility or authority.

OSU’s flood mitigation Action Items are shown in Table 9.5.
<table>
<thead>
<tr>
<th>Hazard</th>
<th>Action Item</th>
<th>Timeline</th>
<th>Source of Funds</th>
<th>Responsible Person or Department</th>
<th>Plan Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Flood Mitigation Action Items</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-Term #1</td>
<td>Assess all buildings within FEMA-mapped floodplains, including minor, ancillary and leased buildings, for attributes that pose 1) environmental or life safety risk (such as hazmat storage) or 2) disruptions of important functions or disruption of long-term research projects.</td>
<td>1-3 Years</td>
<td>OSU Risk/Facilities</td>
<td>x x x x</td>
<td></td>
</tr>
<tr>
<td>Short-Term #2</td>
<td>Enhance emergency planning, including flood response measures, for all buildings that have or may have significant flood risk.</td>
<td>1-3 Years</td>
<td>OSU UFIO</td>
<td>x x x x</td>
<td></td>
</tr>
<tr>
<td>Short-Term #3</td>
<td>Evaluate the vulnerability of utility system elements, including utility tunnels, which may have significant flood risk that could result in widespread loss of utility services.</td>
<td>1-10 Years</td>
<td>OSU UFIO</td>
<td>x x x x</td>
<td></td>
</tr>
<tr>
<td>Long-Term #1</td>
<td>Implement flood mitigation measures, if warranted by the assessments in the above action items, as funding becomes available.</td>
<td>Ongoing</td>
<td>OSU or Grants UFIO</td>
<td>x x x x</td>
<td></td>
</tr>
<tr>
<td>Long-Term #2</td>
<td>Locate new buildings outside of FEMA-mapped floodplains or other flood-prone areas whenever possible or construct new buildings in flood-prone areas.</td>
<td>Ongoing</td>
<td>OSU UFIO</td>
<td>x x x x</td>
<td></td>
</tr>
<tr>
<td>Hazard</td>
<td>Action Item</td>
<td>Timeline</td>
<td>Source of Funds</td>
<td>Responsible Person or Department</td>
<td>Plan Goals Addressed</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------</td>
<td>-----------------</td>
<td>----------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td></td>
<td>areas at elevations as high as possible to minimize flood risk.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-Term #3</td>
<td>Include consideration of future sea level rise from global climate change for new and existing facilities at low elevations near the coast.</td>
<td>Ongoing</td>
<td>OSU</td>
<td>UFIO</td>
<td>X</td>
</tr>
</tbody>
</table>

Note: UFIO = University Facilities, Infrastructure, and Operations
9.5 References


This Page Left Blank
10.0 Wildland/Urban Interface Fires

10.1 Overview

Fires often cause substantial damage to property and may 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 fuel. In dealing with structure fires, fire departments typically have three primary objectives: 1) minimize casualties, 2) prevent a structure fire from spreading to other structures, and 3) minimize damage to the structure and contents. Structure fires and the other common types of fires, such as vehicle or trash fires are most often limited 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 with few or no structures involved. For wildland fires, the most common suppression strategy is to contain the fire at its boundaries 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 generally with state and federal fire agencies, although local agencies may also participate.

**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, simply become additional fuel sources. Fire suppression efforts for wildland/urban interface fires focus first on saving lives and then on protecting structures to the extent possible. Local fire agencies have primary fire suppression responsibility for most wildland/urban interface fires, although state and federal agencies may also contribute.

This chapter focuses on wildland/urban interface fires that pose a significant threat to OSU facilities in locations subject to wildland/urban interface fires.
10.2 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 likelihood 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 more similar to those for wildland fires. The level of fire hazard for wildland/urban interface fires depends on:

- Vegetative fuel load,
- Topography,
- Climate and weather conditions,
- Ignition sources and frequency of fire ignitions, and
- Fire suppression resources (fire agency response time and resources of crews and apparatus, access and water supplies).

High vegetative fuel loads, especially brush and trees, increase the level of wildland/urban interface fire hazard. Steep topography increases the level of fire risk by exacerbating fire spread and impeding fire suppression efforts by making access more difficult.

The level of fire hazard in areas prone to wildland/urban interface fires is also substantially increased when weather conditions including high temperatures, low humidity, and high winds greatly accelerate the spread of wildland fires and make containment difficult or impossible.

Fire suppression resources are typically much lower in wildland/urban interface fire areas than in more highly developed areas. Fire stations are more widely spaced, with fewer resources of crews and apparatus and longer response times because of distance and/or limited access routes. Water resources for fire suppression are typically lower in these areas, which are often predominantly residential and may be served by pumped pressure zones with limited water storage or by individual wells which provide no significant water supply for fire suppression.
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.

The level of risk from wildland/urban interface fires for OSU facilities depends on:

- Level of fire hazard as outlined above,
- Value and importance of buildings and infrastructure,
- Vulnerability of inventory at risk, including whether fire-safe construction practices and defensible space measures have been implemented, and
- Population at risk and the efficacy of evacuations.

Life safety risk in wildland/urban interface fires arises in large part from delays in evacuations, once a fire has started. For OSU facilities with significant risk from wildland/urban interface fires, a well-defined, practical and practiced evacuation plan is essential to minimize potential life safety risk.

10.3 Wildland and Wildland/Urban Fire Hazard Mapping and Hazard Assessment

The map on the following page shows the United States Geological Survey Landfire Mean Fire Return Interval (MFRI) map for Oregon. The numerical values are in years. Shorter return periods mean higher fire risk, while longer fire return periods mean lower fire risk. The USGS Landfire Mean Fire Return Intervals are based on statistical analysis of fire regime characteristics – such as vegetative fuel loads, topography, climate and fire suppression resources.

Historically, the vast majority of acreage burned in wildland/urban interface fires has been in wildland areas with very few, if any, structures. The probability of wildland/urban interface fires in more developed areas is lower than the overall risk because of the proximity of fire suppression assets, including fire crews, apparatus, and water supply in developed areas. Furthermore, fire suppression efforts are focused on protecting developed areas.

The USGS Landfire Return Period values are best interpreted as semi-quantitative indicators of the relative level of risk. The numerical estimates of the burn return period and the corresponding probabilities over various time periods should not be interpreted literally for developed areas. Rather, the numerical estimates may be indicative of the burn return period for fires near a developed area, but not necessarily reaching into the developed area.
State of Oregon - Wildland Fire Frequency

Legend:
- State Boundary
- County Boundary
- Mean Fire Return Interval
- MFRI Range (years)
  - <=50
  - 51-100
  - 101-200
  - 201-500
  - 501-1,000
  - >1,000
  - Other

Data Source: LANDFIRE 2014, Wildland Fire Science, Earth Resources Observation and Science Center, U.S. Geological Survey
10.4 Wildland/Urban Interface Fire Hazard and Risk Assessments

The potential impacts of future wildland/urban interface fires on OSU are primarily damage to buildings, contents and infrastructure (include possible complete destruction), disruption of educational services, and displacement costs for temporary quarters if some buildings have enough damage to require moving out while repairs are made. The likelihood of deaths or injuries is generally low, because buildings will presumably be evacuated whenever fire warnings are issued. However, in incidents where evacuation is not timely, there may a substantial risk of deaths and injuries.

The risk to OSU’s facilities to wildland/urban interface fires varies from campus to campus and from building to building. The Landfire Mean Fire Return Intervals were extracted from the GIS files for each location of an OSU facility, with the expectation that these data would provide meaningful ranking of the relative level of wildland/urban interface fires from location to location. However, the data at this level of spatial resolution appear to be erratic and not credible. For example, for the Newport facilities, the burn return periods varied from <50 years to 500-1,000 years for buildings in very close proximity.

More meaningful evaluation of the relative risk of wildland/urban interface fire risk requires additional data collection that is not available in GIS databases. The necessary data includes:

- Documentation of historical wildland/urban interface fires that affected a given facility and/or burned near a given facility.
- Assessment of the vegetative fuel types, fuel density and proximity to each campus or building.
- Assessment of the extent to which buildings have or do not have fire-safe construction details and defensible space.
- Assessment of the fire response capabilities and capacities for fire suppression, including fire crews, apparatus, equipment and water supply.
- The number of available evacuation routes and the effectiveness of evacuation plans.

Qualitatively, based on the general patterns in the Landfire map shown previously and in climates in Oregon, the trends in wildland/urban interface fire risk are:

- Locations in Eastern Oregon generally have higher risk than locations in Western Oregon because of the hotter drier climate in Easter Oregon.
- In Central and Western Washington, locations on the eastern (drier) slopes of the Coast Range and Cascades have higher risk than locations on the western slopes.
The wildland/urban interface fire risk for the Corvallis Campus, the Cascades Campus and the Hatfield Marine Science Center appears to be very low or minimal. The vegetative fuel loads near buildings for these three sites are low and all three locations are in urban communities with good water supply and robust fire response capabilities from local fire departments. For these sites, possible damage from wildland/urban interface fires is likely limited to minor damage from small localized grass or brush fires affecting only one building or two buildings. Total damage in such incidents is likely to be well below $1 million.

The wildland/urban interface fire risk for the small extension facilities and the experimental stations varies with location. The level of risk for these facilities is not well known. The mitigation action items include further evaluation of the fire risk levels for these facilities. For some of these facilities, wildland/urban interface fires could result in complete destruction of a building or a group of buildings. Given the generally small size and replacement value of most of these facilities, the total damage in such incidents is also likely to be less than $1 million, although very severe events could result in somewhat higher damages.

Historically, OSU property and buildings have not been encroached upon by wildfire. Some County Extension Offices and the OSU-Cascades campus in Bend have been impacted by smoke from nearby fires, but have not been damaged or impacted by wildland fire directly.

10.5 Mitigation for Wildland/Urban Interface Fires

Common goals for reducing wildland/urban interface fire risk include:

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

OSU is not responsible for fire suppression or community-wide mitigation measures for wildland/urban interface fires, which are the responsibility of cities, counties and fire agencies.

For locations determined to be at significant risk from wildland/urban interface fires, there are three types of practical mitigation measures:

- For life safety, develop and practice effective evacuation plans for wildland/urban interface fires,
- For existing facilities with significant risk:
  - Maintain the maximum possible defensible space around buildings and reduce vegetative fuel loads adjacent to a campus,
  - Implement fire-safe improvements such as non-flammable roofs,
covering vent openings and overhangs with wire mesh to prevent entry and trapping of embers and others, and

- Whenever possible, site new facilities outside of areas with high risk of wildland/urban interface fires, include fire-safe features in the design and ensure the maximum possible defensible space around new buildings.

Some types of mitigation projects for wildland/urban interface fire may be eligible for FEMA and other grant funding, including:

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

For existing buildings, implementing many ignition resistant building upgrades may be most cost-effective when done incrementally. For example, replacing an old roof covering with a non-flammable roof covering may be done at the time the existing roof has reached the end of its useful life and is scheduled for replacement.

OSU’s mitigation Action Items for wildland/urban interface fires are shown Table 10.1.
This Page Left Blank
<table>
<thead>
<tr>
<th>Hazard</th>
<th>Action Item</th>
<th>Timeline</th>
<th>Source of Funds</th>
<th>Responsible Person or Department</th>
<th>Plan Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Life Safety</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Life Safety</td>
</tr>
<tr>
<td>Wildland/Urban Interface Fire Mitigation Action Items</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-Term #1</td>
<td>Consult with local fire agencies regarding the level of fire risk for facilities located near areas with high vegetative fuel loads and/or a history of nearby wildland/urban interface fires.</td>
<td>1-2 Years</td>
<td>OSU</td>
<td>EP</td>
<td>X</td>
</tr>
<tr>
<td>Short-Term #2</td>
<td>Enhance emergency evacuation planning for all facilities for which wildland/urban interface fires are possible.</td>
<td>1 year</td>
<td>OSU</td>
<td>EP</td>
<td>X</td>
</tr>
<tr>
<td>Long-Term #1</td>
<td>For locations with significant risks from wildland/urban interface fires, evaluate and implement mitigation measures to reduce fire risk, including enhancing defensible space around buildings, fuel reduction measures adjacent or near a facility and upgrading building elements with materials designed to be fire-resistant.</td>
<td>Ongoing</td>
<td>OSU or Grants</td>
<td>Facilities</td>
<td>X</td>
</tr>
</tbody>
</table>

11.0 OTHER NATURAL HAZARDS

Previous chapters have addressed the natural hazards which pose the most severe threats to OSU’s facilities and people: earthquakes, tsunamis, volcanic hazards, floods, and wildland/urban interface fires.

In addition to these hazards there are other natural hazards which pose lesser, but perhaps significant risks to OSU. This chapter addresses these other natural hazards.

11.1 High Winds

High wind incidents in Oregon typically occur during severe winter storms, although locally high winds an also occur from severe thunderstorms. High wind incidents can occur anywhere in Oregon, but the most severe incidents have occurred on the Pacific Coast and in the Cascades. The most common impacts from high wind incidents are loss of electric power from downed overhead power lines due to tree falls or from direct wind forces on power lines. Damage to buildings can range from limited roof damage to major structural damage from wind or from tree falls onto buildings. More severe incidents such as the 1962 Columbus Day windstorm may result in more widespread damage to vulnerable buildings.

Most of OSU’s facilities will suffer little or no damage in minor to moderate windstorms, with higher levels of damage mostly limited to very severe wind incidents, especially for the most vulnerable buildings such as small modular buildings such as portable classrooms.

For OSU, the major concern about high wind incidents is loss of grid power to facilities for which electric power is critical. This risk is largely mitigated by the availability of back-up generators for most such critical facilities.

11.2 Tornadoes

Tornadoes 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 incidents are characterized on the Enhanced Fujita Scale which ranges from EF0 to EF5, with EF5 being the most severe. Of these, nearly all are small EF0 or EF1 tornadoes, with only three EF2 tornadoes and one EF3 tornado. Cumulatively, over a period of record of nearly 70 years, these records document only 5 injuries and about $31 million in damage in Oregon. 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).

For OSU, tornado hazards are addressed via emergency planning, with notifications to take shelter when high wind or tornado warnings are issued.
11.3 Snow and Ice Storms

Numerous snow storms every year in Oregon. The principal impacts from severe snow storms are disruption of transportation and outages of electric power from downed overhead lines. Severe snow storms may result in campus closures but very rarely result in significant damage to OSU facilities.

In severe storms, with unusually heavy loading of snow and/or ice, a few very vulnerable buildings may suffer damage. The vast majority of OSU buildings were designed for snow loads or have sufficient capacity to handle snow loads without damage and thus are unlikely to suffer significant damage except for very extreme incidents with snow and/or ice loads well above the design loads. However, some minor buildings such as greenhouse may be vulnerable to damage in severe incidents.

Parts of Oregon have a high hazard level for ice storms. As illustrated by the ice thickness contour map below, the risk of ice storms in western Oregon is highest along the Columbia Gorge. This area has the highest level of ice storm hazard in the entire United States.

**Figure 11.1**
50-Year Ice Thickness from Freezing Rain¹

Notes:
1. Ice thicknesses on structures in exposed locations at elevations higher than the surrounding terrain and in valleys and gorges may exceed the mapped values.
2. In the mountain west, indicated by the shading, ice thicknesses may exceed the mapped values in the foothills and passes. However, at elevations above 5,000 ft, freezing rain is unlikely.
Locations further south than shown in Figure 11.1 have minimal risk of ice storms severe enough to have significant impacts.

The impacts of ice storms on OSU are very similar to those for snow storms: outages of electric power and campus closures, with possible damage to buildings in more severe incidents.

Severe ice storms along the Columbia Gorge may affect wider areas than the directly affected areas because much of Oregon’s power is transmitted from Bonneville Power Authority sites along the Columbia River.

For OSU, snow storms and ice storms are addressed predominantly via emergency planning, with notifications of facility closures.

11.4 Thunderstorms and Hail Storms

Thunderstorms and hail storms occur fairly frequently in Oregon, although the frequency and severity of such incidents is much lower than in many parts of the United States. Severe thunderstorms may have high enough winds to result in downed overhead electric lines and tree falls with disruptions to utilities and transportation and possible damage to buildings. Thunderstorms are typically accompanied by lightning strikes which may result in minor building damage as well as injuries or deaths to people struck by lightning.

However, the likelihood of thunderstorms, hail storms or lightning strikes severe enough to result in significant damage to OSU’s facilities appears low.

11.5 Extreme Temperatures

Extreme cold or extreme heat may pose some risks to OSU’s people and facilities, especially when they occur concurrently with power outages. Proactive decisions to close facilities are sometimes made for either extreme cold or extreme heat periods. Closures during extreme heat are more likely for facilities without air conditioning.

Extreme temperatures also pose some risk to OSU’s facilities in several ways:

- Heating and air conditioning systems in buildings are more prone to equipment failures at times of extreme demand, such as during periods of extreme temperatures.
- Water pipes in poorly insulated buildings may freeze during periods of extreme cold, resulting in burst pipes and water damage.
- Utility systems providing electric power and water to facilities are more prone to failures during periods of extreme temperatures.

Protocols for dealing with extreme temperatures are included in OSU’s emergency planning.
11.6 Drought

Drought is defined as a prolonged period of lower than normal precipitation severe enough to reduce soil moisture, water and snow levels below the minimums necessary for sustaining plant, animal and economic systems. Drought is a significant concern in many communities in Oregon, especially east of the Cascades.

For OSU, the impacts of possible future droughts are likely to be relatively minor. In most cases, water restrictions during droughts affect irrigation and industrial water uses, but not water use for drinking and sanitation. OSU will continue and enhance existing water conservation measures.

A secondary impact of droughts is an increase in the wildfire risk. Under severe drought conditions, OSU will issue notifications about increased fire risk.

11.7 Climate Change

Global climate change has several major impacts: rising temperatures, rising sea levels and widespread changes in climate and weather.

Gradual sea level rise is a very significant issue along the Pacific Coast and will increase the frequency and severity of future flood incidents as well expanding areas affected by future tsunamis. See information in Chapter 7 Tsunamis and Chapter 9 Floods. Carefully evaluate sea level rise when siting new facilities or when considering remodeling or replacing existing facilities at low elevations near the coast.

Other significant impacts of global climate change may be changes in climate and weather, including possible increases in the frequency and severity of droughts, increased risk of wildland/urban interface fires, and possible increases in severe weather incidents.

11.8 Landslides

The landslide risk for OSU's main locations (Corvallis, Newport, and Bend) appears to be very low, with no landslide hazard areas identified in the Benton, Lincoln and Deschutes County Natural Hazards Mitigation Plans, based on DOGAMI’s Statewide Landslide Information Layer for Oregon (SLIDO). Similarly, the landslide risk appears very low for the other OSU sites in Oregon.

OSU’s mitigation Action Items for the Other Natural Hazards considered in this chapter are shown in Table 11.1.
### Table 11.1: Mitigation Action Items for Other Natural Hazards

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Action Item</th>
<th>Timeline</th>
<th>Source of Funds</th>
<th>Responsible Person or Department</th>
<th>Plan Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Plan Goals Addressed</strong> referenced in Table 11.1: Life Safety, Protect Facilities, Enhance Emergency Planning, Enhance Awareness and Education.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Natural Hazards Mitigation Action Items</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short-Term #1</strong></td>
</tr>
<tr>
<td>Review and update, OSU's Emergency Operations Plan sections dealing with natural hazards identified in this chapter.</td>
</tr>
<tr>
<td><strong>Long-Term #1</strong></td>
</tr>
<tr>
<td>Evaluate landslide risk if future updated data suggest that landslide risk may be significant at any of the OSU sites.</td>
</tr>
<tr>
<td><strong>Short-Term #3</strong></td>
</tr>
<tr>
<td>Carefully evaluate sea level rise when siting new facilities or when considering remodeling or replacing existing facilities at low elevations near the coast.</td>
</tr>
</tbody>
</table>

**Note:** EP = Emergency Preparedness; UFIO = University Facilities, Infrastructure and Operations.
11.9 References:

APPENDIX 1

FEMA MITIGATION GRANT PROGRAMS
Overview

For public entities in Oregon, including OSU, FEMA mitigation funding possibilities fall into three main categories:

- The post-disaster Public Assistance Program which typically covers eligible emergency response and restoration (repair) costs for public entities whose facilities suffer damages in a presidentially-declared disaster. The Public Assistance Program also may fund mitigation projects for facilities damaged in the declared event.

- The post-disaster Hazard Mitigation Grant Program which includes both mitigation and planning projects.

- Two annual mitigation grant programs: Pre-Disaster Mitigation (PDM) and Flood Mitigation Assistance which include both mitigation and planning projects.

FEMA grants typically cover 75% of costs; however, in some specifically defined cases the grants may cover 90% or 100% of costs. For OSU, the sources of possible FEMA grant funds include all of the post-disaster and pre-disaster grant programs: Public Assistance Program, Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program and Flood Mitigation Assistance.

For all of these FEMA grant programs, applications to FEMA are submitted through Oregon Military Department, Office of Emergency Management.

Each of these grant programs are summarized below. For FEMA grants, the term “facilities” includes both buildings and infrastructure. For more detailed information, see the references to FEMA publications in the narratives below.

FEMA Public Assistance Programs

The objective of the FEMA’s Public Assistance (PA) Grant Program is to provide funding so that communities can quickly respond to and recover from major disasters or emergencies declared by the President. The PA program is often referred to as the 406 program because it is authorized under Section 406 of the Stafford Act which established FEMA’s disaster programs.

Through the PA Program, FEMA provides supplemental federal disaster grant assistance for debris removal, emergency protective measures, and the repair, replacement, or restoration of disaster-damaged, publicly-owned facilities and the facilities of certain private non-profit (PNP) organizations.
PA funding for OSU facilities becomes available only when all three of FEMA’s eligibility criteria are met:

- There is a presidentially-declared disaster in Oregon,
- An OSU facility is located in a county included in the disaster declaration, and
- An OSU facility has incurred emergency response costs or damage in the declared disaster event.

The PA Program also encourages protection of these damaged facilities from future events by providing assistance for hazard mitigation measures during the recovery process. The PA Program’s distinction between repairs and mitigation is important:

- Repairs restore a damaged facility to its pre-disaster condition, with the possible addition of code-mandated upgrades.
- Mitigation measures go beyond repairs to make the facility more resistant to damage in future disaster events. However, PA mitigation grants are limited to the same type of hazard event that resulted in the disaster declaration, such as floods or earthquakes.

Under the PA Program, FEMA funding for emergency response costs and repairs of damaged facilities are largely automatic, subject only to FEMA’s eligibility criteria. That is, such grants are not competitive between applicants. However, to garner PA grants, OSU needs to be proactive, document disaster costs (including staff time) and apply for PA grants within FEMA-specified time limits.

Post-disaster mitigation measures under the PA Program are at the discretion of FEMA and are not automatically funded. Mitigation measures under PA generally have to meet eligibility criteria very similar to those for the other FEMA mitigation grant programs, including having a benefit-cost ratio greater than 1.0.

However, Public Assistance mitigation projects are automatically determined to be cost effective and a project-specific benefit-cost analysis is not required if the cost of mitigation is no more than the following percentages of the repair costs:

- 15% of the repair costs for any PA-eligible mitigation project, or
- 100% of the repair costs for categories of mitigation projects defined in the March 30, 2010 version of FEMA Recovery Policy RP9526.1 Hazard Mitigation Funding Under Section 406 (Stafford Act).

Further details of FEMA’s PA programs are available on FEMA’s website at:

https://www.fema.gov/site-page/public-assistance-grant-program
FEMA Mitigation Grant Programs

The Federal Emergency Management Agency (FEMA) has three mitigation grant programs which provide federal funds to supplement local funds for specified types of mitigation activities.

There are two distinct types of FEMA mitigation grant programs:

1. The post-disaster Hazard Mitigation Grant Program (HMGP) for which funds are available in Oregon after each presidentially-declared disaster in Oregon. The HMGP program is often referred to as the 404 program because it is authorized under Section 404 of the Stafford Act which established FEMA’s disaster programs.

2. Annual pre-disaster programs, contingent upon Congressional appropriations, for which funds are available nationwide, including:
   - The Pre-Disaster Mitigation (PDM) program which includes mitigation for all natural hazards, and
   - The Flood Mitigation Assistance (FMA) program which includes mitigation for flood only, with a focus predominantly on facilities with flood insurance.

For applicants, an important eligibility criterion for all FEMA mitigation grants is that an applicant must have a FEMA-approved hazard mitigation plan or be covered by a city or county FEMA-approved hazard plan for which the applicant participated in the planning process. OSU’s Natural Hazards Mitigation Plan is a stand-alone plan that covers the entire OSU system statewide. This means that OSU can apply for FEMA mitigation grants independently of applications from cities or counties in which OSU has facilities.

Further details of these mitigation grant programs are provided in the following two FEMA publications:

   Hazard Mitigation Assistance Guidance (February 27, 2015), and
   Hazard Mitigation Assistance Guidance Addendum (February 27, 2015).

Additional information is available on the FEMA website:

   https://www.fema.gov/media-library/assets/documents/103279

Each of the FEMA mitigation grant programs has specific eligibility requirements, applications and application deadlines, which may vary from year to year. These grant programs are not entitlement programs, but rather are very competitive grant programs which require strict adherence to the eligibility and application requirements and robust documentation.
All physical mitigation projects must be cost-effective, which for FEMA means a benefit-cost ratio >1.0. Therefore, most FEMA mitigation projects require completing a benefit-cost analysis using FEMA software and following FEMA’s detailed benefit-cost analysis guidance.

However, there are some categories of mitigation projects which are automatically determined to be cost-effective per FEMA policies:

- Acquisition of properties within a Special Flood Hazard Area – the 100-year, FEMA-mapped floodplain – when the structure is substantially damaged. Substantial damage is defined as: “damage of any origin sustained by a structure whereby the cost of restoring the structure to its before damaged condition would equal or exceed 50% of the market value of the structure before the damage occurred.”

- Acquisition or elevation projects with a Special Flood Hazard Area that meet the cost limits established in the FEMA Memorandum “Cost Effectiveness Determinations for Acquisitions and Elevations in Special Flood Hazard Areas,” August 15, 2013.

- Mitigation planning grants do not require a benefit-cost analysis.

**Hazard Mitigation Grant Program (HMGP)**

The Hazard Mitigation Grant Program (HMGP) is a post-disaster grant program. HMGP funds are generated only following a Presidential Disaster Declaration for a Oregon. Declared disasters for Oregon are relatively common, often with one or more declarations in a given year for winter storms, floods, or other disasters.

The amount of HMGP grant funding available after a given declared disaster is a percentage of total FEMA spending for various other FEMA programs such as the Individual and Family Assistance and Public Assistance programs. Thus, the total amount of HMGP mitigation funds available within Oregon will vary from year to year and disaster event to disaster event. In some years, there may be no HMGP funding available.

For most disaster declarations in Oregon, the amount of HMGP grant funds available is few million dollars. However, larger disasters may result in tens of millions of dollars of HMGP grant funds. In an extreme event, such as a Cascadia Subduction Zone M9 earthquake, the HMGP funding may be hundreds of millions of dollars.

The Oregon Military Department, Office of Emergency Management (OEM) administers the HMGP in Oregon and sets the priorities and guidelines after each disaster. HMGP is the most flexible grant program: grants may be possible for any natural hazard and may include hazard mitigation planning and risk assessments as well as physical mitigation projects.
For HMGP applications, OEM’s application process has included the following steps after a declared disaster in Oregon:

- Public announcement of HMGP funds availability, perhaps with guidance regarding priorities and grant award limits,
- Review of submitted applications and possible requests for additional documentation.
- Selection of applications to be submitted to FEMA.
- FEMA approval of grants, for applications submitted by OEM that meet FEMA’s minimum criteria for eligibility.

In most cases, for the HMGP program, OEM has accepted applications statewide for all hazards. That is, applications have not been limited to the counties included in the Presidential Disaster Declaration or to mitigation projects that address the hazard(s) that resulted in the declaration.

For HMGP mitigation grants, OEM selects the mitigation projects for funding, with FEMA’s only role being to verify that a submitted project meets FEMA’s minimum eligibility criteria. That is, HMGP grant applications are competitive only with other Oregon applications submitted for each disaster declaration. Because of this, HMGP grant applications often have a higher success rate that the pre-disaster grant programs discussed below, which are competitive nationwide.

**Annual Pre-Disaster Grant Programs**

FEMA’s annual pre-disaster grant programs – Pre-Disaster Mitigation (PDM) and Flood Mitigation Assistance (FMA) are contingent each fiscal year upon future Congressional approval and appropriation of funding.

OEM processes grant applications for these programs in a step-wise manner generally similar to that described above for HMGP grant applications. However, there is an important difference. For these programs OEM forwards ranked applications to FEMA, but FEMA makes the grant determinations, which may or may not match OEM’s rankings. Thus, applications for these programs are competitive nationally, not just within Oregon, although there may be partial set-asides guaranteeing Oregon some level of funding, if submitted applications meet FEMA’s eligibility criteria.

**Pre-Disaster Mitigation Grant Program (PDM)**

The PDM grant program is a broad program which includes mitigation projects for any natural hazard as well as mitigation planning grants which must result in the development of a Local Hazard Mitigation Plan.
PDM grants typically cover 75% of the costs of mitigation projects up to a maximum federal share of $3,000,000 per project. However, for eligible local government applicants in communities that meet FEMA’s definition of small, impoverished community, the federal share may be 90%.

**Flood Mitigation Assistance Grant Program (FMA)**

The FMA grant program funds only flood projects, with its predominant focus being on flood mitigation projects for properties with flood insurance. FMA special emphasis and priorities on properties which are on FEMA’s national listing of Repetitive Flood Loss (RFL) and Severe Repetitive Loss (SRL) properties.

FMA grants generally cover 75% of total eligible project costs, with 25% local match required. However, grants for Repetitive Loss properties provide 90% FEMA funding and grants for Severe Repetitive Loss properties provide 100% FEMA funding.

**General Guidance for FEMA Grant Applications**

All of FEMA’s mitigation grant programs are competitive, either within a given state or nationally. Thus, successful grant applications must be complete, robust and very well documented. The key elements for successful mitigation project grant applications include:

- Project locations within high hazard areas.
- Project buildings or infrastructure that have major vulnerabilities which pose substantial risk of damages, economic impacts, and (especially for seismic projects) deaths or injuries.
- Mitigation project scope is well defined with at least a conceptual design with enough detail to support a realistic engineering cost estimate for the project.
- The benefits of the project are carefully documented using the current FEMA benefit-cost software, with all inputs meticulously meeting FEMA’s guidance and expectations. A benefit-cost analysis meeting FEMA’s requirements is very often the most critical step in determining a mitigation project’s eligibility and competitiveness for FEMA grants.
- Making sure that the proposed project is eligible for the specific FEMA grant program to which it is being submitted.
- Making sure that the application is 100% complete with credible information and easy for FEMA to understand.

The effort required for developing a good mitigation project and completing a successful grant application varies with the size and complexity of the mitigation project. In some cases, a successful FEMA grant application requires technical
expertise, which may be available on-staff within a given local government entity, or which may require outside consulting support. For example, technical expertise may be desired for:

- Understanding the level of hazard (flood, earthquake, tsunami, etc.) at a given location.
- Quantifying the vulnerability of the building(s) exposed to the hazard at the project site(s).
- Developing a preliminary or conceptual engineering design for the mitigation project.
- Developing a realistic engineering cost estimate for the mitigation project.
- Completing the benefit-cost analysis in full conformance with FEMA’s guidance and expectations, along with robust documentation of the credibility of the inputs into the benefit-cost analysis.

Good mitigation projects which address high-risk situations are effective in reducing future damages and losses, with robust, well-documented applications have a reasonable chance of FEMA funding. Conversely, weakly conceived or poorly documented projects have little or no chance of FEMA funding.

Guidance for FEMA grant applications is available on the FEMA website (www.fema.gov) and in the FEMA guidance documented referenced previously. Thorough review of this guidance is strongly encouraged before undertaking a FEMA grant application.

Additional guidance is also available on Oregon Military Department, Office of Emergency Management’s website:

http://www.oregon.gov/OEM/Pages/default.aspx

See the Grants category on the OEM website. Further assistance is available from OEM’s mitigation staff.
APPENDIX 2

PRINCIPLES

OF

BENEFIT-COST ANALYSIS
Introduction

Benefit-cost analysis is required for nearly all FEMA mitigation project grant applications for all FEMA grant programs with only four exceptions:

- Acquisition of facilities located within FEMA-mapped 100-year floodplains that have been determined to be substantially damaged,
- Acquisition or elevation projects within FEMA-mapped 100 -year floodplains that meet the cost limits established in the FEMA memorandum “Cost Effectiveness Determinations for Acquisitions and Elevations in Special Flood Hazard Areas,” August 15, 2013.
- Public Assistance mitigation projects with costs less than 15% of repair costs, and
- Specified types of Public Assistance mitigation projects that have costs less than 100% of repair costs. In addition, benefit-cost analysis is not required for mitigation planning projects.

FEMA’s definition of substantial damage is “damage of any origin sustained by a structure whereby the cost of restoring the structure to its before damaged condition would equal or exceed 50% of the market value of the structure before the damage occurred.” The categories of Public Assistance mitigation projects which do not require benefit-cost analysis are listed in FEMA Disaster Assistance Policy 9526.1 (March 30, 2010).

In addition, benefit-cost analysis is not required for mitigation planning projects.

For all FEMA-funded mitigation projects, other than the exceptions noted above, the benefit-cost ratio must be greater than 1.0 for a project to be eligible for FEMA funding. The benefit-cost ratio must be calculated using FEMA’s benefit-cost analysis software, with all data inputs consistent with FEMA’s guidance and expectations.

The primary references for FEMA benefit-cost analysis are:

BCA Reference Guide (June, 2009), and

There are also numerous other FEMA publications related to benefit-cost analysis which are available on the FEMA website:

www.fema.gov/benefit-cost-analysis

Help with project-specific benefit-cost analysis is available at 1-855-540-6744 or bchelpline@fema.dhs.gov

The best approach is to e-mail questions to the helpline because this provides written answers than can be attached to grant applications as documentation.
What are Benefits?

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

The categories of benefits included in FEMA benefit-cost analysis varies with the type of facility being mitigated, the hazard being addressed and the type of mitigation project. Common categories of benefits include the reductions in: building damages, contents damages, displacement costs for temporary quarters if a building is damaged, the economic impacts of loss of service from a damaged facility and casualties. The economic value of avoided deaths and injuries are calculated using FEMA’s standard statistical values for deaths and injuries.

Some mitigation projects, such as most flood mitigation projects, focus predominantly on reducing future damages and losses. Other mitigation projects, such as most earthquake mitigation projects, focus on reducing casualties as well as reducing damages and losses; in this case, life safety is often the primary motivation for the mitigation project. In some cases, such as tsunami vertical evacuation mitigation projects, life safety is the sole purpose of a mitigation project.

More precisely, a benefit-cost ratio is calculated as the net present value of benefits divided by the mitigation project cost. Net present value means that the time value of money must be considered - benefits that accrue in the future are worth less than those that accrue immediately. The FEMA benefit-cost software discussed in the next section automatically calculates the net present value of benefits from data inputs, including the mitigation project useful lifetime, which varies depending on the type of facility and type of project, and the FEMA-mandated discount rate of 7%.

Because the benefits of a hazard mitigation project accrue in the future, it is impossible to know exactly what they will be. For example, it cannot be known in advance when a future earthquake or other natural hazard event will occur in a given location or how severe the event will be. However, in most cases, it is possible to estimate the probability of future hazard events. Therefore, the benefits of mitigation projects must be evaluated statistically or probabilistically.

Hazard events don’t come in only one size. Rather, the severity of every type of natural hazard event can range from minimal to severe. A benefit-cost analysis always considers a range of severity for hazard events, such as the 10-, 50-, 100- and 500-year floods, and the analysis includes estimates of the expected damages and losses for each level of event.
The FEMA benefit-cost software integrates such data to determine the average annual damages and losses considering the full range of hazard events. The term “average annual” damages and losses doesn’t mean that such damage and losses occur every year, but rather represents the long term average from hazard events of many different severities and probabilities occurring.

**FEMA Benefit-Cost Analysis Software**

The current version of FEMA’s benefit-cost analysis software (Version 5.3.0 may be downloaded and installed from the FEMA website noted previously. There are seven benefit-cost modules applicable to different types of hazards and different types of mitigation projects:

- Floods,
- Hurricane Winds,
- Earthquake Structural Projects,
- Earthquake Nonstructural Projects,
- Tornado Safe Rooms,
- Wildfire, and
- Damage Frequency Assessment.

The applicability of most of the above BCA modules is self-evident, with a couple of exceptions:

- The flood BCA module can be used only when a full set of quantitative flood hazard data is available, including first floor elevations of buildings, stream discharge and flood elevation data for four flood return periods (typically, the 10-, 50-, 100- and 500-year events) and stream bottom elevations. For coastal storm surge flooding, the above data are necessary, less the stream discharge and stream bottom elevation data.
- The Damage Frequency Assessment module is applicable for any natural hazard for which a damage-frequency relationship can be defined from historical data and/or engineering analysis/judgment.

All of the BCA modules, except for the Damage Frequency Assessment module, have some built-in data which significantly simplifies the BCA process. However, all of the modules also require a considerable number of user-defined data inputs to complete a benefit-cost analysis.

The Damage Frequency Assessment (DFA) module has no built-in data: all of the data inputs are user-defined. The DFA module is the most flexible module, but also the most difficult to use because it requires the most technical expertise to input FEMA-credible data.
The Damage Frequency Assessment BCA module is used for the following types of hazards and facilities:

- Tsunamis,
- Landslides,
- Flood projects where the quantitative flood hazard data necessary to use the flood BCA module are unavailable,
- Seismic projects for utility or transportation infrastructure,
- All other natural hazards for which a damage-frequency relationship can be defined, including snow storms, ice storms, erosion, avalanches and others.

Benefit-cost analysis of most hazard mitigation projects is unavoidably somewhat complex and requires at least a basic technical understanding of facilities, hazards, vulnerability, risk and the economic parameters of benefit-cost analysis. For many types of mitigation projects, especially seismic projects, technical support from an engineer is almost always necessary. For some mitigation projects, technical support from subject matter experts with experience in making estimates of damages, casualties, and economic losses for benefit-cost analysis may also be helpful.

**Benefit-Cost Analysis: Use and Interpretation**

For FEMA mitigation grants, the immediate use of benefit-cost analysis is to determine whether a project has a benefit-cost ratio above 1.0 and thus meets FEMA’s eligibility criterion. However, benefit-cost analysis can also play a larger role in the evaluation and prioritization of mitigation projects.

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

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

Benefit-cost analysis is a powerful tool that can help OSU provide solid, defensible answers to these often difficult socio-political-economic-engineering questions. As noted previously, benefit-cost analysis is required for all FEMA-funded mitigation
projects, under both pre-disaster and post-disaster mitigation programs. 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.

Overall, benefit-cost analysis provides answers to a central question for hazard mitigation projects: “Is it worth it?” That is, are the benefits large enough to justify the costs necessary to implement a mitigation project?

Whether or not a mitigation project is “worth it” depends on many factors, including:

- The level of hazard at a given location,
- The value and importance of the facility being mitigated,
- The vulnerability of the facility to the hazard,
- The cost of the mitigation project,
- The effectiveness of the mitigation project in reducing future damages, economic losses and casualties.

The best mitigation projects address high risk situations: a high level of hazard for an important facility which has substantial vulnerability to the hazard.

All well-designed mitigation projects reduce risk. However, just because a mitigation project reduces risk does not make it a good project. A $1,000,000 project that avoids an average of $100 per year in flood damages is not worth doing, while the same project that avoids an average of $200,000 per year in flood damages is worth doing.

**Benefit-Cost Analysis Example**

The principles of benefit-cost analysis are illustrated by the following simplified conceptual example. Consider a small building in the town of Acorn, located on the banks of Squirrel Creek. The building is a one story building; about 1,500 square feet on a post foundation, with a replacement value of $60/square foot (total building value of $90,000). We have flood hazard data for Squirrel Creek (stream discharge and flood elevation data) and elevation data for the first floor of the house.

For this BCA, the FEMA flood BCA module is used, because the necessary quantitative flood hazard data are available. The data built into the BCA module, along with user data inputs, allow the module to calculate the annual probability of flooding in one-foot increments, along with the resulting damages and losses shown in Table A2.1.
Table A2.1
Damages Before Mitigation

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

Flood depths shown above in Table A2.1 are in one foot increments of water depth above the lowest floor elevation. Thus, a “3” foot flood means all floods between 2.5 feet and 3.5 feet of water depth above the floor. We note that a “0” foot flood has, on average, damages because this flood depth means water plus or minus 6” of the floor; even if the flood level is a few inches below the first floor, there may be damage to flooring and other building elements because of wicking of water.

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

The Annualized (expected annual) damages and losses are calculated as the product of the flood probability times the scenario damages. For example, a 4 foot flood has slightly less than a 1% chance per year of occurring. If it does occur, we expect about $32,100 in damages and losses. Averaged over a long time, 4 foot floods are thus expected to cause an average of about $315 per year in flood damages.

Note that the smaller floods, which cause less damage per flood event, actually cause higher average annual damages because the probability of smaller floods is so much higher than that for larger floods. With these data, the building is expected to average $6,312 per year in flood damages. This expected annual or “annualized” damage estimate does not mean that the building has this much damage every year. Rather, in most years there will be no floods, but over time the cumulative damages and losses from a mix of relatively frequent smaller floods and less frequent larger floods is calculated to average $6,312 per year.

The calculated results in Table A2.1 are the flood risk assessment for this building for the as-is, before mitigation situation. The table shows the expected levels of
damages and losses for scenario floods of various depths and also the annualized damages and losses.

The risk assessment shown in Table A2.2 shows a high flood risk, with frequent severe flooding which the owner deems unacceptable. The owner explores mitigation alternatives to reduce the risk: the example below is to elevate the house 4 feet. These results are shown in Table A2.2.

<table>
<thead>
<tr>
<th>Flood Depth (feet)</th>
<th>Annual Probability of Flooding</th>
<th>Scenario Damages and Losses Per Flood Event</th>
<th>Annualized Flood Damages and Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.2050</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>1</td>
<td>0.1234</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>2</td>
<td>0.0867</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>3</td>
<td>0.0223</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>4</td>
<td>0.0098</td>
<td>$6,400</td>
<td>$63</td>
</tr>
<tr>
<td>5</td>
<td>0.0036</td>
<td>$14,300</td>
<td>$49</td>
</tr>
<tr>
<td><strong>Total Expected Annual (Annualized) Damages and Losses</strong></td>
<td></td>
<td></td>
<td><strong>$112</strong></td>
</tr>
</tbody>
</table>

By elevating the building 4 feet, the owner has reduced the expected annual (annualized) damages from $6,312 to $112 (a 98% reduction) and greatly reduced the probability or frequency of flooding affecting the building. The annualized benefits are the difference in the annualized damages and losses before and after mitigation or $6,312 - $112 = $6,200.

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

The benefits, however, accrue statistically over the lifetime of the mitigation project. Following FEMA guidance for this type of project, we assume that this mitigation project has a useful lifetime of 30 years. Money (benefits) received in the future has less value than money received today because of the time value of money. The time value of money is taken into account with present value calculation. We compare the present value of the anticipated stream of benefits
over 30 years in the future to the up-front out-of-pocket cost of the mitigation project.

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

Table A2.3
Benefit-Cost Results

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Annualized Benefits</td>
<td>$6,200</td>
</tr>
<tr>
<td>Present Value Coefficient</td>
<td>12.41</td>
</tr>
<tr>
<td>Net Present Value of Future Benefits</td>
<td>$76,942</td>
</tr>
<tr>
<td>Mitigation Project Cost</td>
<td>$20,000</td>
</tr>
<tr>
<td>Benefit-Cost Ratio</td>
<td>3.85</td>
</tr>
</tbody>
</table>

These results indicate a benefit-cost ratio of 3.85. Thus, in FEMA’s terms the mitigation project is cost-effective and eligible for FEMA funding.

Taking into account the time value of money (essential for a correct economic calculation), results in lower benefits than if we simply multiplied the annual benefits times the project’s 30-year useful lifetime. Economically, simply multiplying the annual benefits times the project lifetime would ignore the time value of money and thus would yield an incorrect result.

The above discussion of benefit-cost analysis of a flood hazard mitigation project illustrates the basic concepts.

The actual FEMA BCA modules calculate each category of damage or loss separately and the specific built-in data and the specific user-input data vary from module to module, depending on the hazard, type of facility and type of mitigation project.
This Page Left Blank
APPENDIX 3

MITIGATION PLANNING

PUBLIC PROCESS

DOCUMENTATION
Good Morning,

I would like to invite you, or a representative of your agency, to participate on the OSU Natural Hazards Mitigation planning committee. This group, working through a Contractor, will provide input and knowledge to develop a plan for OSU that will identify efforts to reduce the impact facing OSU from natural hazards. Completion of this plan will allow OSU to apply for FEMA grant monies for pre-disaster mitigation efforts and to be eligible for post-disaster FEMA money.

The Committee will be co-chaired by Emergency Preparedness and Capital Planning and will meet periodically to provide guidance and resources to the Contractor performing the analysis and developing the plan. At the first meeting, an overview of the process will be given to introduce everyone to Mitigation Planning and to establish a common knowledge. As your agency's representative, you will be asked to participate and also reach into your agency to obtain information that others may have (e.g. building plans, floor plans, knowledge of building infrastructure, etc…)

I am asking for a representative from the following areas due to your knowledge and responsibility for buildings, system infrastructure, and developing a safe environment for students and staff.

- Memorial Union (MU)
- University Housing and Dining Services (UHDS)
- Recreational Sports
- OSU Facilities
- OSU Athletics
- Information Services
- Capital Planning
- HMSC
- Cascades Campus
- Others (as identified during the planning process)
Please let me know who will be involved so I can begin to schedule our first meeting. The contractor has been selected and we are almost finished with the FEMA/OSU contract to begin the planning process. I anticipate mid-November to early December as our first meeting.

If you have any questions about the scope or think someone else should have been asked, please call or email me so I can re-send the invitation.

Thank you,

Mike

Mike Bamberger
Emergency Preparedness Manager
Oregon State University
3015 SW Western Blvd
Oak Creek Building, RM 226
Corvallis, Oregon 97333
Phone: 541-737-4713 | Fax: 541-737-4810 | Cell: 541-758-9126
Michael.Bamberger@oregonstate.edu | http://emergency.oregonstate.edu
December 2015: Mitigation Planning Kick-Off Meetings

- **December 1, 2015** - Mitigation Planning Kick-Off Meeting at Hatfield Marine Science Center (HMSC), Newport, Oregon

  Present: Mike Bamberger, Jim Lewis, Consultant: Ken Goettel

  Summary: A site walk through was conducted between the Consultant and HMSC Operations Manager. Building plans were discussed and reviewed. Discussion of the future Marine Science Initiative (MSI) Center identified the need for additional information from the OSU Capital Planning Department.

- **December 2, 2015** - Steering Committee Planning Kick-Off Meeting at OSU, Corvallis, Oregon

  Present: Mike Bamberger, Kevin Blank, Jaimi Glass, John Gremmels, Christina McKnight, Denise Hunt, Sid Cooper, Bill Callender, Patrick Hughes, Joe McQuilllin, Consultant: Ken Goettel

  Not Present: Marcia Dickson (sent Denise Hunt in lieu of)

  Summary: Ken Goettel presented an overview of the mitigation planning process, expectations of FEMA, and how the OSU Natural Hazard Mitigation plan would look when completed. The Steering Committee members were identified and Working Committee member participation discussed, with potential partners identified. Future communication would be conducted by Mike Bamberger to potential members.

  Attendees developed OSU priorities, discussed mitigation goals and identified sources for data that would be needed to complete a hazard analysis. Future site visits were also discussed. Finally, a discussion of what building(s) would receive a detailed risk assessment was discussed.
<table>
<thead>
<tr>
<th>Welcome</th>
<th>Mike Bamberger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductions</td>
<td></td>
</tr>
<tr>
<td>Agenda Review</td>
<td></td>
</tr>
<tr>
<td>Mitigation Planning</td>
<td>Ken Goettel</td>
</tr>
<tr>
<td>Process Overview</td>
<td></td>
</tr>
<tr>
<td>Discussion</td>
<td></td>
</tr>
<tr>
<td>Expectations of FEMA</td>
<td></td>
</tr>
<tr>
<td>Planning Process</td>
<td>Mike and Ken</td>
</tr>
<tr>
<td>Steering Committee</td>
<td></td>
</tr>
<tr>
<td>Work Committee</td>
<td></td>
</tr>
<tr>
<td>Member selection</td>
<td></td>
</tr>
<tr>
<td>Create e-mail notification list of OSU, community and neighboring jurisdictions and send notice that the planning process is starting -</td>
<td></td>
</tr>
<tr>
<td>Scope of project</td>
<td>Mike and Ken</td>
</tr>
<tr>
<td>OSU Priorities</td>
<td></td>
</tr>
<tr>
<td>Mitigation Goals</td>
<td></td>
</tr>
<tr>
<td>Data Sources</td>
<td></td>
</tr>
<tr>
<td>Site Visits</td>
<td></td>
</tr>
<tr>
<td>Detailed risk assessment of select buildings</td>
<td></td>
</tr>
<tr>
<td>Timeline</td>
<td>Mike and Ken</td>
</tr>
<tr>
<td>Oct – Dec 2015</td>
<td>Develop strategies, make committees, gather info</td>
</tr>
<tr>
<td>Dec – Mar 2016</td>
<td>compile hazard data</td>
</tr>
<tr>
<td>Dec – Jun 2016</td>
<td>assess risk of each campus, site visits</td>
</tr>
<tr>
<td>Apr – Jun 2016</td>
<td>Develop risk reduction actions</td>
</tr>
<tr>
<td><strong>Apr – Jun 2016</strong> community sessions (better to have at least one near the start of the planning process)</td>
<td></td>
</tr>
<tr>
<td>Apr – Jun 2016</td>
<td>plan drafting</td>
</tr>
<tr>
<td>July 2016</td>
<td>draft submission to FEMA</td>
</tr>
<tr>
<td>Sep 2016</td>
<td>Grant ends</td>
</tr>
<tr>
<td>Information Sources</td>
<td>Mike and Ken</td>
</tr>
<tr>
<td>Existing plans?</td>
<td></td>
</tr>
<tr>
<td>GIS information?</td>
<td></td>
</tr>
<tr>
<td>Inventory and seismic data for existing buildings and infrastructure</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Mike and Ken</td>
</tr>
</tbody>
</table>
# OSU Natural Hazard Mitigation Planning Session

**Date/Time:** 12/2 1300 - 1630

**Location:** OEB 201

<table>
<thead>
<tr>
<th></th>
<th>Name (print)</th>
<th>Organization/Agency</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Kevin Blank</td>
<td>OSU Athletics</td>
<td>Event Manager</td>
</tr>
<tr>
<td>2.</td>
<td>Shanae Glass</td>
<td>BASP EHL</td>
<td>Emergency Services Planner</td>
</tr>
<tr>
<td>3.</td>
<td>John Grommers</td>
<td>OSU Capital Planning</td>
<td>Capital Planner</td>
</tr>
<tr>
<td>4.</td>
<td>Christina McKnight</td>
<td>OSU Risk Management</td>
<td>Assistant Risk Officer</td>
</tr>
<tr>
<td>5.</td>
<td>Denise Hund (for Paul Aiken)</td>
<td>Extension Admin</td>
<td>Admin Program Specialist</td>
</tr>
<tr>
<td>6.</td>
<td>Sid Cooper</td>
<td>Memorial Union</td>
<td>Assoc. Director - Bldg 505</td>
</tr>
<tr>
<td>7.</td>
<td>Mike Buckingham</td>
<td>OSU EM Mgmt</td>
<td>Emergency Manager</td>
</tr>
<tr>
<td>8.</td>
<td>Bill Callender</td>
<td>OSU ResPublic</td>
<td>Assoc. Director</td>
</tr>
<tr>
<td>9.</td>
<td>Patrick Hogan</td>
<td>OSU Risk</td>
<td>CRO</td>
</tr>
<tr>
<td>10.</td>
<td>Joe McDoulin</td>
<td>OSU VANDS</td>
<td>Asst. Director</td>
</tr>
</tbody>
</table>

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
May 17, 2016 - Steering Committee Mitigation Planning Meeting

Present: Mike Bamberger, Kevin Blank, Christina McKnight, Marcia Dickson, Theresa Hogue, Sid Cooper, Bill Callender, Patrick Hughes, Consultant: Ken Goettel

Not Present: Jaimi Glass, John Gremmels, Joe McQuillin

Ken Goettel previewed draft Chapters 1 and 3 of the plan. Mike Bamberger and Ken Goettel reviewed with the Planning Team the data collected/mapped to date and where missing data points were. The group identified how to collect additional information for processing. They also began considering mitigation actions to include in the final plan.

The group reviewed the pre-meeting vote and determined that Weniger Hall would be the building selected for advanced seismic analysis by an engineering firm.
## Welcome
- Introductions
- Agenda Review

### Mitigation Planning Process
- Overview
- Chapter 1 draft

### Planning Process
- Steering Committee
- Work Committee
- Member selection

### Review of project to date
- Data collected – list, maps
- Data missing
- Chapter 3
- Weniger Hall

### Action Table Development
- Chapter 4

### Questions
- Insurance – Earthquake, Flood
- Missing information to be filled
- Ag Sci Expt station and Extension Lat/Long of buildings
- Which buildings do we want in report analysis

### Timeline
- Oct – Dec 2015: Develop strategies, make committees, gather info
- Dec – Mar 2016: compile hazard data
- Dec – Jun 2016: assess risk of each campus, site visits
- Apr – Jun 2016: Develop risk reduction actions
- **Apr – Jun 2016:** community sessions (better to have at least one near the start of the planning process)
- Apr – Jun 2016: plan drafting
- July 2016: draft submission to FEMA
- Sep 2016: Grant ends

### Other

**Mike Bamberger**

**Ken Goettel**

**Mike and Ken**
### Pending Data Tasks

<table>
<thead>
<tr>
<th>Pending Data Tasks</th>
<th>Database Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seismic retrofits yes/no</td>
<td></td>
</tr>
<tr>
<td>Retrofit performance level</td>
<td></td>
</tr>
<tr>
<td>Lat-longs</td>
<td></td>
</tr>
<tr>
<td>Check minor buildings to see if any more should be added (e.g. chemical storage, just to increase visibility and awareness as we look at stuff)</td>
<td></td>
</tr>
<tr>
<td>Hazus building types</td>
<td>P</td>
</tr>
<tr>
<td>Retrofit yes/no</td>
<td>W</td>
</tr>
<tr>
<td>Retrofit year</td>
<td>X</td>
</tr>
<tr>
<td>Retrofit performance level</td>
<td>Y</td>
</tr>
<tr>
<td>Retrofit planned in Cap. Plan</td>
<td>Z</td>
</tr>
<tr>
<td>RVS data</td>
<td>AF-AH</td>
</tr>
<tr>
<td>Important for risk evaluation, Goettel will due from existing reports</td>
<td></td>
</tr>
<tr>
<td>New data added by OSU GIS</td>
<td>AJ-AL</td>
</tr>
<tr>
<td>Need codes for numerical rankings</td>
<td></td>
</tr>
<tr>
<td>Liquefaction potential</td>
<td>AM</td>
</tr>
<tr>
<td>Add from GIS (Check column AK red titles and move to AM)</td>
<td></td>
</tr>
<tr>
<td>EQ Data PGAs etc.</td>
<td>AO-AQ</td>
</tr>
<tr>
<td>Goettel will add</td>
<td></td>
</tr>
<tr>
<td>Earthquake insurance</td>
<td>AR</td>
</tr>
<tr>
<td>None?</td>
<td></td>
</tr>
<tr>
<td>Flood Insurance</td>
<td>AS</td>
</tr>
<tr>
<td>For whole campus? Why?</td>
<td></td>
</tr>
<tr>
<td>Flood Data</td>
<td>AT-AV</td>
</tr>
<tr>
<td>Add 1,00 ft from GIS</td>
<td></td>
</tr>
<tr>
<td>First floor elevation</td>
<td>AW</td>
</tr>
<tr>
<td>Only for buildings at flood risk, need reference datum also</td>
<td></td>
</tr>
<tr>
<td>Reference datum</td>
<td>AX</td>
</tr>
<tr>
<td>Ditto. Essential to compare to FEMA Flood Data</td>
<td></td>
</tr>
<tr>
<td>Flood return periods (years)</td>
<td>AY</td>
</tr>
<tr>
<td>Goettel will add</td>
<td></td>
</tr>
<tr>
<td>History of flooding</td>
<td>AZ</td>
</tr>
<tr>
<td>Add OSU information</td>
<td></td>
</tr>
<tr>
<td>Severity of Flooding</td>
<td>BA</td>
</tr>
<tr>
<td>Add OSU information</td>
<td></td>
</tr>
<tr>
<td>Other Hazards</td>
<td></td>
</tr>
<tr>
<td>Tsunami, volcanic, landslide, WUI - OSU GIS? wildfire return period</td>
<td></td>
</tr>
</tbody>
</table>
2nd Session Attendance

Attend:

Mike    Bamberger    Emer Prep
Kevin   Blank        Athletics
Bill    Callender    Rec Sports
Sid     Cooper       Memorial Union
Marcia  Dickson     Extension
Ken     Goettel      Consultant
Teresa  Hogue       URM
Patrick Hughes      Risk
Christina McKnight  Risk

Not Attend:

Jaimi   Glass       BC EM
John    Gremmels    CPD
Joe     McQuillin   UHDS
September 7, 2017 Steering Committee, Work Group Planning Team and Public Meeting

- September 7, 2017 – Public, Steering Committee, and Work Group Mitigation Planning and Public Meeting

Present: Anita Azarenko, John Gremmels, Mike Bamberger, Mark Becker, Marcia Dickson, Bill Callender, Patrick Hughes, Christina McKnight, Toby Lewis, James Paul Rodell, Jonathon Stoll, Rebecca Houghtaling, Consultant: Ken Goettel

Not Present: (Steering committee members) Keven Blank, Joe McQuillin, Sid Cooper, Theresa Hogue (Partner community agencies): Shirley Keeton, Jami Glass, Chris Bentley, Kevin Young, Bill Emminger, Josh Wheeler, Douglas Baily, Adam Steele, Greg Gescher, Jim Patton, Bob Fenner, Jim Minard, Nathan Garibay, Jenny Demaris, Joe Larsen, Robert Wheeldon, Sarah Bates, Lori Fulton, Jim Bouziane, Tom Miller, Lowell Fausett, Joe Majeski, Bill Coslow, Bob Mason, Jim Lewis, MaryAnn Bozza, Dan vanVliet, John Condon

Local community and government stakeholders were invited, as well as the general public, to the meeting.

Ken Goettel presented the draft OSU Natural Hazard Mitigation Plan. Ken Goettel reviewed the hazard analysis conducted from the OSU data and described the impact to OSU property throughout the State of Oregon.

Participants reviewed the chapters, discussed questions, and developed/refined proposed mitigation actions to include in the final plan.
AGENDA

<table>
<thead>
<tr>
<th>Welcome</th>
<th>Mike Bamberger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductions</td>
<td></td>
</tr>
</tbody>
</table>

| Summary of Natural Hazard Mitigation Plan grant and work efforts to date | Mike Bamberger |

<table>
<thead>
<tr>
<th>Overview of Natural Hazard Mitigation Planning process PowerPoint</th>
<th>Ken Goettel</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What is mitigation</td>
<td></td>
</tr>
<tr>
<td>• How does it apply to OSU?</td>
<td></td>
</tr>
<tr>
<td>• Review risk</td>
<td></td>
</tr>
<tr>
<td>• Describe screening criteria for natural hazards</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Review of draft plan chapters and discussion/input</th>
<th>Ken Goettel</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Introduce chapter</td>
<td></td>
</tr>
<tr>
<td>• Review scientific content/background of chapter</td>
<td></td>
</tr>
<tr>
<td>• Develop mitigation action items</td>
<td></td>
</tr>
</tbody>
</table>

| Conclusion | Mike Bamberger |

Minutes

General discussion
- When looking at the cost of a building, 20% of the cost is structural, 80% is interior/contents
- ASCE 41-13 _Seismic Evaluation and Retrofit of Existing Buildings_ is the standard used to evaluate buildings OSU.

Possible Mitigation action items discussed:
- Earthquake – Develop a policy/plan/philosophy on how to respond when rebuilding after an incident – priorities/time frame/what buildings are needed. _The intent is to give planners and builders a focus on what to start with first. Need input from the Executive Leadership Team._
- Earthquake – Utility infrastructure bracing/reinforcement for on-site utilities (e.g. steam pipes)
- Earthquake – What is OSU’s plan after 100 or 500 year events with getting back to operational status – Priorities/time frame to be operational, what buildings would be priorities for what reason.
Send to Ken a copy of the Campus Master Plan

- Earthquake – mention liquefaction more and its consequences since OSU is built on liquefactionable soils
- Tsunami - #3 – we are committed to building the new center.
  - Get with Lori Fulton to get a schematic sketch for Ken
- Flood – Develop a policy for construction in or near a flood plain on OSU property

<table>
<thead>
<tr>
<th>Invited</th>
<th></th>
<th>Attend</th>
</tr>
</thead>
<tbody>
<tr>
<td>*OSU – Capital Planning and Development</td>
<td>Anita Azarenko</td>
<td>x</td>
</tr>
<tr>
<td>*OSU – Capital Planning and Development</td>
<td>John Gremmels</td>
<td>x</td>
</tr>
<tr>
<td>*OSU – Emergency Management</td>
<td>Mike Bamberger</td>
<td>x</td>
</tr>
<tr>
<td>*OSU – Emergency Management</td>
<td>Mark Becker</td>
<td>x</td>
</tr>
<tr>
<td>*OSU – Extension Services</td>
<td>Marcia Dickson</td>
<td>x</td>
</tr>
<tr>
<td>*OSU – Rec Sports</td>
<td>Bill Callender</td>
<td>x</td>
</tr>
<tr>
<td>*OSU – Risk</td>
<td>Patrick Hughes</td>
<td>x</td>
</tr>
<tr>
<td>*OSU – Risk</td>
<td>Christina McKnight</td>
<td>x</td>
</tr>
<tr>
<td>Benton County Planning Department</td>
<td>Toby Lewis</td>
<td>x</td>
</tr>
<tr>
<td>Citizen</td>
<td>James Paul Rodell</td>
<td>x</td>
</tr>
<tr>
<td>OSU – Corvallis Community Relations</td>
<td>Jonathon Stoll</td>
<td>x</td>
</tr>
<tr>
<td>OSU – Historic Preservation</td>
<td>Rebecca Houghtaling</td>
<td>x</td>
</tr>
<tr>
<td>*OSU – Athletics</td>
<td>Keven Blank</td>
<td></td>
</tr>
<tr>
<td>*OSU – Housing and Dining Services</td>
<td>Joe McQuillen</td>
<td></td>
</tr>
<tr>
<td>*OSU – Memorial Union</td>
<td>Sid Cooper</td>
<td></td>
</tr>
<tr>
<td>*OSU – University Relations and Marketing</td>
<td>Theresa Hogue</td>
<td></td>
</tr>
<tr>
<td>American Red Cross</td>
<td>Shirley Keeton</td>
<td></td>
</tr>
<tr>
<td>Benton County Emergency Management</td>
<td>Jaimi Glass</td>
<td></td>
</tr>
<tr>
<td>Benton County Planning Department</td>
<td>Chris Bentley</td>
<td></td>
</tr>
<tr>
<td>Benton County Planning Department</td>
<td>Kevin Young</td>
<td></td>
</tr>
<tr>
<td>Benton County Public Health</td>
<td>Bill Emminger</td>
<td></td>
</tr>
<tr>
<td>Benton County Public Works</td>
<td>Josh Wheeler</td>
<td></td>
</tr>
<tr>
<td>City Corvallis Fire Department</td>
<td>Douglas Baily</td>
<td></td>
</tr>
<tr>
<td>City Corvallis Planning Department</td>
<td></td>
<td></td>
</tr>
<tr>
<td>City of Corvallis COC PWC</td>
<td>Adam Steele</td>
<td></td>
</tr>
<tr>
<td>City of Corvallis Engineer</td>
<td>Greg Gescher</td>
<td></td>
</tr>
<tr>
<td>City of Corvallis FD</td>
<td>Jim Patton</td>
<td></td>
</tr>
<tr>
<td>City of Corvallis Public Works</td>
<td>Bob Fenner</td>
<td></td>
</tr>
<tr>
<td>Invited</td>
<td>Attend</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-----------------</td>
<td></td>
</tr>
<tr>
<td>City of Philomath</td>
<td>Jim Minard</td>
<td></td>
</tr>
<tr>
<td>Deschutes County Emergency Mgmt</td>
<td>Nathan Garibay</td>
<td></td>
</tr>
<tr>
<td>Lincoln County Emergency Mgmt</td>
<td>Jenny Demaris</td>
<td></td>
</tr>
<tr>
<td>Linn County Emergency Management</td>
<td>Joe Larsen</td>
<td></td>
</tr>
<tr>
<td>Linn County Planning Department</td>
<td>Robert Wheeldon</td>
<td></td>
</tr>
<tr>
<td>Linn County Public Health</td>
<td>Sarah Bates</td>
<td></td>
</tr>
<tr>
<td>OSU - Capital Planning</td>
<td>Lori Fulton</td>
<td></td>
</tr>
<tr>
<td>OSU - Cascades Public Safety</td>
<td>Jim Bouziane</td>
<td></td>
</tr>
<tr>
<td>OSU - Civil Engineering College</td>
<td>Tom Miller</td>
<td></td>
</tr>
<tr>
<td>OSU – College of Agricultural Sciences</td>
<td>Lowell Fausett</td>
<td></td>
</tr>
<tr>
<td>OSU – Facilities</td>
<td>Joe Majeski</td>
<td></td>
</tr>
<tr>
<td>OSU – Facilties - Landscaping</td>
<td>Bill Coslow</td>
<td></td>
</tr>
<tr>
<td>OSU – Faculty Senate</td>
<td>Bob Mason</td>
<td></td>
</tr>
<tr>
<td>OSU - Hatfield Marine Science Center</td>
<td>Jim Lewis</td>
<td></td>
</tr>
<tr>
<td>OSU - HMSC Education</td>
<td>MaryAnn Bozza</td>
<td></td>
</tr>
<tr>
<td>OSU - University Infrastructure and Operations - GIS</td>
<td>Dan vanVliet</td>
<td></td>
</tr>
<tr>
<td>OSU-Cascades Bend Campus</td>
<td>John Condon</td>
<td></td>
</tr>
<tr>
<td>Topic/Content of Meeting:</td>
<td>Participants</td>
<td>Organization</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>9/7/2017</td>
<td>Marcia Dickson</td>
<td>Extension Service</td>
</tr>
<tr>
<td></td>
<td>Rebecca Houghtaling</td>
<td>OSU Yuan Long R своболь</td>
</tr>
<tr>
<td></td>
<td>Mark Becker</td>
<td>Emergency Management</td>
</tr>
<tr>
<td></td>
<td>Druick Higman</td>
<td>Risk Management</td>
</tr>
<tr>
<td></td>
<td>James Postell</td>
<td>Resident of</td>
</tr>
<tr>
<td></td>
<td>Ken Goedl</td>
<td>OSU RecSports</td>
</tr>
<tr>
<td></td>
<td>Bill Calender</td>
<td>OSU RecSports</td>
</tr>
</tbody>
</table>

Date of Meeting: 9/7/2017
Location of Meeting: Ag Science Room, LaSells Conference Center, Corvallis

Time of Meeting: 8:30 a.m. - 10:30 a.m.
Date of Meeting: 9/7/2017  Time of Meeting: 0830-1030

Location of Meeting: Ag Science Room, LaSells Conference Center, Corvallis

Topic/Content of Meeting: Public Comment/Working Group Meeting for OSU NHMP

<table>
<thead>
<tr>
<th></th>
<th>Printed Name</th>
<th>Organization</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jonathan Stoll</td>
<td>Office of Student Life</td>
<td><a href="mailto:jonathan.stoll@oregonstate.edu">jonathan.stoll@oregonstate.edu</a></td>
</tr>
<tr>
<td>2</td>
<td>Anita Azarenko</td>
<td>UO</td>
<td><a href="mailto:amita.azarenko@oregonstate.edu">amita.azarenko@oregonstate.edu</a></td>
</tr>
<tr>
<td>3</td>
<td>John Giemelser</td>
<td>UO</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
From: Office of Emergency Management
To: "Robyn.bassett@corvallisoregon.gov"; douglas.baily@corvallisoregon.gov;
"Bob.fenner@corvallisoregon.gov";
"jim.minard@philomathoregon.gov"; Bates, Sarah; "rwheeldon@co.linn.or.us";
"jlarsen@linnsheriff.org";
"Bill.emminger@co.benton.or.us"; "Toby.a.lewis@co.benton.or.us";
"Chris.bentley@co.benton.or.us";
"Jaimi.glass@co.benton.or.us"; "Joshua.wheeler@co.benton.or.us";
"patwray@comcast.net"; Bamberger, Michael; Becker, Mark; Gremmels, John Henry; Azarenko, Anita Nina; Majeski, Joseph; Stoll, Jonathan;
Blank, Kevin; Callender, William; Cooper Jr, Sidney Edward; McQuillin, Joseph E; Fausett, Lowell Albert;
"mason@science.oregonstate.edu"; Hogue, Theresa;
"Rebecca.houghtaling@oregonsttae.edu"; Dickson, Marcia Lynn; McKnight, Christina;
Hughes, Patrick
Cc: Ken Goettel
Subject: Invitation to participate with OSU"s Natural Hazard Mitigation Plan development
Date: Monday, June 5, 2017 9:39:10 AM

Dear Community Partner,

As an agency involved with development at OSU, we invite you to help us with our Natural Hazard Mitigation Plan development process. We are reaching out to you to involve you in periodic plan review and input meetings to help us develop a comprehensive plan that will ultimately help OSU reduce the vulnerability from natural hazards.

OSU began working on the project in 2015, using a fact-based methodology to identify the scope of hazards and risks facing the building infrastructure at Oregon State University. Over the past 18 months, a collection of building inventory and natural hazard data were created or collected to facilitate an accurate and realistic analysis of the effect of hazards to OSU. The results are nearing completion and will be used in the next phase of plan development – identifying potential mitigation tasks to reduce the impact of the hazards.

As we complete portions of the Mitigation Plan, we will be posting them on our website for interested parties and partners to review and provide feedback. When completed, the entire plan will be posted and stakeholder and public meetings will be held to summarize the report information and solicit comments for further refinement for final review and comment before we consider the planning process complete. Additional information and updates are available at:
http://emergency.oregonstate.edu/nhmp.
If you know of someone else that should be involved, please let me know and we will extend the invitation to them also.

Thank you,

Mike Bamberger
Co-Chair NHMP Steering Committee/ OSU Emergency Preparedness Manager
emergency@oregonstate.edu

Invited partners:

| City Corvallis Planning Department | Robyn Bassett |
| City Corvallis Fire Department     | Douglas Baily |
| City of Corvallis Public Works    | Bob Fenner   |
| City of Philomath                | Jim Minard   |
| Linn County Public Health        | Sarah Bates  |
| Linn County Planning Department  | Robert Wheeldon |
| Linn County Emergency Management | Joe Larsen   |
| Benton County Public Health      | Bill Emminger |
| Benton County Planning Department| Toby Lewis, Chris Bentley |
| Benton County Emergency Management | Jaimi Glass |
| Benton County Public Works       | Josh Wheeler |
| American Red Cross               | Pat Wray     |
| *OSU – Emergency Management      | Mike Bamberger |
| Mark Becker                      |              |
| *OSU – Capital Planning and Development | John Gremmels, Anita Azarenko |
| OSU – Facilities                 | Joe Majeski |
| OSU – Corvallis Community Relations | Jonathon Stoll |
| *OSU – Athletics                 | Keven Blank |
| *OSU – Rec Sports                | Bill Callender |
| *OSU – Memorial Union            | Sid Cooper |
| *OSU – Housing and Dining Services | Joe McQuillin |
| OSU – College of Agricultural Sciences | Lowell Fausett |
| OSU – Faculty Senate             | Bob Mason |
| *OSU – University Relations and Marketing | Theresa Hogue |
| OSU – Historic Preservation      | Rebecca Houghtaling |
| *OSU – Extension Services        | Marcia Dickson |
| *OSU – Risk                      | Christina McKnight, Patrick Hughes |
OSU Natural Hazards Mitigation Plan

Oregon State University is seeking input from community members as we develop our Natural Hazards Mitigation Plan.

As draft chapters are developed, they will be posted to this web page for review and comments. Please provide comments to: emergency@oregonstate.edu

As you invest your time and expertise with the review, please record the amount of time you contributed. It will help OSU identify your partnership and allow us to keep you informed.

› Time Tracking Sheet - to record time spent assisting with plan review

Once the majority of the plan is developed, a public meeting will be announced to discuss the plan and identify possible mitigation activities to reduce the effect of natural hazards to OSU.

Thank you,
Mike Bamberg
OSU Emergency Manager

› Open Letter Invitation to Participate

Plan Public Comment Meeting

A Public Comment meeting will be held September 7, 2017 at LaSells Stewart Center (875 SW 26th Street, Corvallis) from 8:30 – 10:30 a.m. to review and solicit input for the plan.

DRAFT OSU Natural Hazard Mitigation Plan

Chapter 0 - Exec Summary Posted: 8-12-2017

Chapter 1 - Introduction Posted: 8-13-2017
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Date Posted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 2 - OSU Profile</td>
<td>8-12-2017</td>
</tr>
<tr>
<td>Chapter 3 - Planning Process</td>
<td>8-24-2017</td>
</tr>
<tr>
<td>Chapter 4 - Goals</td>
<td>8-13-2017</td>
</tr>
<tr>
<td>Chapter 5 - Adoption</td>
<td>8-24-2017</td>
</tr>
<tr>
<td>Chapter 6 - Earthquake</td>
<td></td>
</tr>
<tr>
<td>Chapter 7 - Tsunami</td>
<td>8-21-2017</td>
</tr>
<tr>
<td>Chapter 8 - Volcano</td>
<td>8-22-2017</td>
</tr>
<tr>
<td>Chapter 9 - Flood</td>
<td>8-21-2017</td>
</tr>
<tr>
<td>Chapter 10 - Wildfire</td>
<td>8-21-2017</td>
</tr>
</tbody>
</table>
Thursday

- The Finance and Administration Committee of the Oregon State University Board of Trustees will meet by telephone from 2:30 to 4 p.m. The public can listen to the meeting in the Allworth Conference Room of OSU’s Memorial Union, 2501 SW Jefferson Way, or by calling 877-474-7020 and entering conference number 22516#.

- The Corvallis City Council meets in a 4 p.m. work session at the Madison room and will hold a second discussion on priorities. City Manager Mark Shepard distilled the lengthy list of goals and initiatives councilors discussed at an Aug. 10 session to five main priorities: land use, charter review, continuing council initiatives in progress, public safety and a sustainable budget.

- A public comment session for Oregon State University’s new natural hazard mitigation plan is scheduled for 8:30 a.m. at the LaSells Stewart Center, 875 SW 26th St. A draft of the plan is available online at http://emergency.oregonstate.edu/nhmp.

Contact reporter James Day at jim.day@gazettetimes.com or 541-758-9542. Follow at Twitter.com/JamesDay or gazettetimes.com/blogs/jim-day.
NEW! OSU Natural Hazard Mitigation Plan process. OSU Emergency Management and OSU Capital Planning are developing a natural hazards mitigation plan for OSU. The plan will summarize the vulnerability of OSU to natural hazards and identify risk reduction activities to decrease the vulnerability. As plan chapters are developed, comments and input are welcome via the plan’s website. Once the data analysis and the draft plan is fully developed, public meetings will be held to summarize the plan and seek additional comments. Follow our progress and review draft chapters at http://emergency.oregonstate.edu/nhmp or email comments to emergency@oregonstate.edu.

For comments or feedback about this email contact osutoday@oregonstate.edu.

Find the OSU Today Web site and archive online.

Submission guidelines

Copyright © 2017 Oregon State University. Disclaimer.

OSU Today is a daily e-mail news briefing provided by OSU News and Communication Services. Contact us to unsubscribe or subscribe, or visit lists.oregonstate.edu to manage your subscriptions.
April 23, 2018 – Steering Committee Planning Meeting

Present: (Planning Team) Mike Bamberger, John Gremmels, Patrick Hughes, Theresa Hogue, Bill Callender, Christina McKnight (OSU Community) Tom Miller, Erica Fischer (Public/Community Agencies) Cale Ash (Degenkolb Engineers), Consultant: Ken Goettel

Not Present: (Steering committee members) Keven Blank, Joe McQuillin, Sid Cooper, Marcia Dickson

Ken Goettel presented a summary of the OSU Natural Hazards Mitigation Plan findings and an in-depth review the draft Chapter 6 Seismic of the. Ken Goettel reviewed the hazard analysis and its impact to the building inventory for OSU throughout the state. Additionally items of information were identified to complete the data tables. URM and Lift Slab construction design were discussed and the potential impact to OSU.

Participants also reviewed Chapter 4 work action items
# AGENDA

<table>
<thead>
<tr>
<th>Welcome</th>
<th>Introductions</th>
<th>Agenda Review</th>
<th>Mike Bamberger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitigation Planning Process</td>
<td>Ken Goettel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chapter 6 Review</td>
<td>Ken</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Action Table Development</td>
<td>Chapter 4</td>
<td>Mike and Ken</td>
<td></td>
</tr>
<tr>
<td>Questions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timeline</td>
<td>Mike and Ken</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr 23 2nd Public Input Session</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 2018 draft submission to State of Oregon State University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 2018 Revisions and submission to FEMA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2018 Signature by OSU Leadership</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Date of Meeting: 4/23/2018  
Time of Meeting: 1 – 2 pm  

Location of Meeting: Oak Creek Building  

Topic/Content of Meeting: Steering Committee – Review of chapters  

<table>
<thead>
<tr>
<th></th>
<th>Printed Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>JOHN GROTHMANS</td>
<td>OSU URSO</td>
</tr>
<tr>
<td>2</td>
<td>Bill Callender</td>
<td>OSU Rezorts</td>
</tr>
<tr>
<td>3</td>
<td>Patrick Hughes</td>
<td>OSU Risk Management</td>
</tr>
<tr>
<td>4</td>
<td>CHRISTINE MCKNIGHT</td>
<td>OSU Risk Management</td>
</tr>
<tr>
<td>5</td>
<td>Ken Goettel</td>
<td>Consultant</td>
</tr>
<tr>
<td>6</td>
<td>Theresa Hughes</td>
<td>OSU News Office</td>
</tr>
<tr>
<td>7</td>
<td>Tom Miller</td>
<td>OSU CCE School</td>
</tr>
<tr>
<td>8</td>
<td>CATE ASH</td>
<td>DEKONASCH ENGINEERING</td>
</tr>
<tr>
<td>9</td>
<td>ERICA FISCHER</td>
<td>OSU CCE SCHOOL</td>
</tr>
<tr>
<td>10</td>
<td>MIKE HAMBERGER</td>
<td>OSU EM MGT</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
April 23, 2018  2nd Public Planning Meeting

Present: (Planning Team) Mike Bamberger (OSU Community), Erica Fischer (Public/Community Agencies) Cale Ash (Degenkolb Engineers), Consultant: Ken Goettel

A presentation of the hazard mitigation plan process, a summary of the OSU Natural Hazard Mitigation Plan chapters, findings, and action items, and the opportunity to provide discussion/feedback was offered. Participants discussed some of the retrofits that were conducted to existing buildings and provided comments.

AGENDA

<table>
<thead>
<tr>
<th>Welcome</th>
<th>Mike Bamberger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductions</td>
<td>Mike Bamberger</td>
</tr>
<tr>
<td></td>
<td>Mike Bamberger</td>
</tr>
<tr>
<td>Summary of Natural Hazard Mitigation Plan grant and work efforts to date</td>
<td>Ken Goettel</td>
</tr>
<tr>
<td>Summary of plan findings and review of Chapter 6 - Seismic</td>
<td>Mike Bamberger</td>
</tr>
<tr>
<td>Conclusion</td>
<td>Mike Bamberger</td>
</tr>
</tbody>
</table>

Minutes

- Discussion of missing data on tables
- Review of structural plans to fill in data
- No further comments regarding action items
Natural Hazard Mitigation Plan Public Meeting #2
04/23/2018
1500-1600
La Sells Stuart Conference Center, Wells Fargo/Ag Science Room

Date of Meeting: 4/23/2018 Time of Meeting: 3 - 4 pm

Location of Meeting: LaSells Center

Topic/Content of Meeting: Public Form – OSU NHMP Review and Input

<table>
<thead>
<tr>
<th>Participants</th>
<th>Printed Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mike Hamburger</td>
<td>OSU EM</td>
</tr>
<tr>
<td>2</td>
<td>Erica Fischer</td>
<td>OSU CCE SCHOOL</td>
</tr>
<tr>
<td>3</td>
<td>Cave Ash</td>
<td>Degenkolb Engineers</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Today in the News Media is a synopsis of some of the most prominent coverage of OSU people and programs. Inclusion of any item constitutes neither an endorsement nor a critique, but rather is intended only to make the OSU community aware of significant items in the media.

NEW! OSU Natural Hazards Mitigation Plan. Public comment meeting for the final draft OSU Natural Hazards Mitigation Plan. The plan will help OSU identify ways to reduce the potential loss of life and property by studying the impact of natural hazards and identifying ways to lessen the impact of disasters caused by earthquakes, floods and other hazards. Draft chapters of the plan can be reviewed at http://emergency.oregonstate.edu/nhmp or email comments to emergency@oregonstate.edu. Join us on Monday April 23 from 2 to 4 p.m. in the LaSells Stewart Center, Wells Fargo Room.

For comments or feedback about this email contact osutoday@oregonstate.edu.

Find the OSU Today Web site and archive online.

Submission guidelines

Copyright © 2018 Oregon State University. Disclaimer.

OSU Today is a daily e-mail news briefing provided by OSU News and Communication Services. Contact us to unsubscribe or subscribe, or visit lists.oregonstate.edu to manage your subscriptions.
OSU Natural Hazards Mitigation Plan

Oregon State University is seeking input from community members as we develop our Natural Hazards Mitigation Plan. As draft chapters are developed, they will be posted to this web page for review and comments. Please provide comments to: emergency@OregonState.edu

As you invest your time and expertise with the review, please record the amount of time you contributed. It will help OSU identify your partnership and allow us to keep you informed.

- Time Tracking Sheet - to record time spent assisting with plan review

Once the majority of the plan is developed, a public meeting will be announced to discuss the plan and identify possible mitigation activities to reduce the effect of natural hazards to OSU.

Thank you,
Mike Bamberger
OSU Emergency Manager

- Open Letter Invitation to Participate

Plan Public Comment Meeting

A Public Comment meeting was held September 7, 2017 at LaSells Stewart Center (875 SW 26th Street, Corvallis) from 8:30 – 10:30 a.m. to review and solicit input for the plan.

A second Public Comment meeting will be held on April 23, 2018, from 3-4 p.m. on the OSU Campus, in the La Sells Conference Center - Wells Fargo room.

DRAFT OSU Natural Hazard Mitigation Plan

Chapter 0 - Exec Summary Posted: 6-12-2017
Chapter 1 - Introduction Posted: 8-31-2017
Chapter 2 - OSU Profile Posted: 11-29-2017
Chapter 3 - Planning Process Posted: 12-1-2017
Chapter 4 - Goals Posted: 8-13-2017
Chapter 5 - Adaption Posted: 11-29-2017
Chapter 6 - Earthquake Posted: 2-25-2018
Chapter 7 - Tsunami Posted: 12-6-2017
Chapter 8 - Volcano Posted 12-6-2017
Chapter 9 - Flood Posted: 12-7-2017
Chapter 10 - Wildfire Posted: 12-7-2017
Chapter 11 - Other Posted: 12-7-2017
This Page Left Blank