OSPI Mitigation Planning Toolkit
April 28th – 30th 2014

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Toolkit Components

- Washington State K-12 Facilities Hazard Mitigation Plan
- ICOS PDM Database
- Reference Documents
- Public Process Guidance
- Chapter Templates for District Plans
- Hazard and Risk Assessment Guidance and Materials
Washington State K-12 Facilities Hazard Mitigation Plan

- Overview of mitigation planning for K-12 facilities
- Lots of useful reference information
- Detailed Hazard Chapters
  - Earthquakes, Tsunamis, Volcanic Hazards, Floods, Wildland/Urban Interface Fires, Landslides
  - Essential background information to help understand each hazard
ICOS PDM Database

- Provides automated hazard data for each campus from statewide GIS data layers
- District data inputs complement the GIS data
- Automated campus-level hazard and risk assessment reports for the 6 major hazards
- Automated building-level hazard and risk assessment reports: earthquakes & floods
Toolkit: Reference Guidance

- Mitigation Planning Checklist and Suggested Timeline
- FEMA Local Mitigation Plan Review Tool
- Catalog of Federal Grant Programs related to natural hazards
Toolkit: Public Process Guidance

- Communicating with stakeholders
- Conducting Public Meetings
- Stakeholder Surveys
- Mitigation Plan Review and Adoption
Templates: District Mitigation Plan Chapters

- Word files for each chapter in district hazard mitigation plans including:
  - Introductory and background information
  - Highlighting where district-specific information needs to be added
  - All content can be edited to reflect each district’s specific perspectives

- Chapter templates designed to minimize level of effort necessary for districts to complete robust hazard mitigation plans
District Mitigation Plan Chapters

- 1 Introduction
- 2 District Profile
- 3 Planning Process
- 4 Goals, Objectives and Action Items
- 5 Plan Adoption, Implementation and Maintenance
District Mitigation Plan Chapters

- 6 Earthquakes
- 7 Tsunamis
- 8 Volcanic Hazards
- 9 Floods
- 10 Wildland/Urban Interface Fires
- 11 Landslides
- 12. Other Hazards
District Mitigation Plan Chapters

- Appendix 1: FEMA Mitigation Grants
- Appendix 2: Benefit-Cost Analysis
- Excel template for Mitigation Action Items

Note: most districts don’t have significant risk from all 6 of the major hazards. District mitigation plans can exclude the chapters for hazards posing little or no risk to a district’s facilities and people.
Show Example Chapter

Tsunami Chapter
Toolkit: Hazard and Risk Assessments

- Mitigation Measures for Natural Hazards
- Hazard Maps
- FEMA Flood Maps and Flood Insurance Studies
- How to Make a Firmette
- ICOS PDM Database Reports
## Example ICOS Campus-Level Report

### Tsunamis

<table>
<thead>
<tr>
<th>Campus</th>
<th>In Mapped Tsunami Zone</th>
<th>Campus Elevation (Feet, NAVD 1988)</th>
<th>Distance to Coast (Miles)</th>
<th>Tsunami Hazard Level</th>
<th>Travel Distance to Safe Area (Miles)</th>
<th>Travel Time (Minutes)¹</th>
<th>Life Safety Risk Level</th>
<th>Significant Impediments on Evacuation Route²</th>
<th>Recommendations</th>
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<tbody>
<tr>
<td>Columbia Middle School</td>
<td>Yes</td>
<td>12.34</td>
<td>0.53</td>
<td>High or Very High</td>
<td>1.75</td>
<td>45</td>
<td>Extremely High</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Lincoln Elementary School</td>
<td>No</td>
<td>211.13</td>
<td>4.04</td>
<td>Extremely Low</td>
<td>N/A</td>
<td>N/A</td>
<td>Extremely Low</td>
<td>N/A</td>
<td>N/A</td>
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<td>Kennedy High School</td>
<td>No</td>
<td>33.33</td>
<td>3.33</td>
<td>Low</td>
<td>0.75</td>
<td>28</td>
<td>Low to Moderate</td>
<td>No</td>
<td>Yes</td>
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</table>

¹ Travel time is based on distance to safe area and on typical walking speeds (which vary for elementary, middle and high schools), plus 10 minutes for mobilization after the end of earthquake ground shaking.

² If the shortest route to a designated evacuation location has significant impediments to evacuation, the recommendation is to consider other evacuation routes, other evacuation locations, or a vertical evacuation structure.
Hazard and Risk Assessments


- The type of data necessary to make hazard and risk assessments varies markedly from hazard to hazard

- Hazard: the frequency and severity of natural hazard events

- Risk: the frequency and severity of consequences from natural hazard events
Hazard + Exposure = Risk

HAZARD
- Frequency and Severity of Hazard Events

EXPOSURE
- Value and Vulnerability of Inventory

RISK
- Threat to the Community: People, Buildings and Infrastructure
Hazard and Risk Assessments

- OSPI’s Stepwise Assessment Approach
  - Preliminary screening using GIS data
  - Refinements using district data
  - Campus-level assessments
  - Building-level assessments
  - Detailed engineering evaluations, only for the highest risk facilities with high priority for mitigation
Earthquakes

- **Concerns: Damage and Life Safety**
- **Hazard Data**
  - USGS probabilistic earthquake data
  - DNR site class (soil/rock types)
  - DNR liquefaction Potential
- **Earthquake risk evaluated at building level**
  - Year built and structural system
  - Building vulnerability to earthquake damage
  - Building size, value, importance, occupancy
Predominant concern is life safety

Life safety risk depends on:
- Within mapped tsunami zone?
- Elevation and distance from coast
- Distance to nearest safe haven
- Travel time to nearest safe haven
- Impediments to rapid evacuation?
Volcanic Hazards

- Predominant concern is life safety
- Life safety risk depends on:
  - Within mapped volcanic hazard zone?
  - Distance to nearest safe haven
  - Travel time to nearest safe haven
  - Impediments to rapid evacuation?
- Key question: When to evacuate?
  - Proactively?
  - After event starts?
Flooding

- Primary concern is damage

- Hazard Assessment
  - Quantitative data if in mapped floodplain
    - Stream discharge data
    - Flood Elevation data
  - History of flooding if not in mapped floodplain

- Risk depends strongly on building elevations relative to flood elevations
FEMA Flood Insurance Rate Map or Firmette

ABC School
**FLOOD INSURANCE STUDY**

**KING COUNTY, WASHINGTON AND INCORPORATED AREAS VOLUME 1 OF 3**

<table>
<thead>
<tr>
<th>Community Name</th>
<th>Community Number</th>
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<td>*ALGONA, CITY OF</td>
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<td>AUBURN, CITY OF</td>
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<td>*BEAUX ARTS VILLAGE, TOWN OF</td>
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<td>TUKWILA, CITY OF</td>
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<td>WOODINville, CITY OF</td>
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<td>KING COUNTY, UNINCORPORATED AREAS</td>
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*NON-FLOODPRONE COMMUNITIES*

REVISED: APRIL 19, 2005

Federal Emergency Management Agency
FLOOD INSURANCE STUDY NUMBER 5303SCV001A
<table>
<thead>
<tr>
<th>Flooding Source and Location</th>
<th>Drainage Area (sq. miles)</th>
<th>Peak Discharges (cfs)</th>
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<tr>
<td></td>
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<td>10-Year</td>
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<td>Big Soos Creek</td>
<td></td>
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<tr>
<td>At USGS gage 12-112600</td>
<td>66.7</td>
<td>1,130</td>
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<td>Below Covington Creek confluence</td>
<td>49.4</td>
<td>870</td>
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<td>Above Covington Creek confluence</td>
<td>31.2</td>
<td>580</td>
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<td>Above Jenkins Creek confluence</td>
<td>13.5</td>
<td>270</td>
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<td>Above Little Soos Creek confluence</td>
<td>9.3</td>
<td>200</td>
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<td>At S.E. 244th Street</td>
<td>7.1</td>
<td>150</td>
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<td>At S.E. 208th Street</td>
<td>4.5</td>
<td>100</td>
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<td>White River</td>
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<td>At Pacific and Auburn</td>
<td>440.0</td>
<td>15,870</td>
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<td>Sammamish River</td>
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<td>At mouth</td>
<td>240.0</td>
<td>2,300</td>
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<td>At Redmond (downstream of Bear Creek)</td>
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<td>Swamp Creek</td>
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<td>600</td>
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<td>21.9</td>
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<td>At N.E. 205th Street</td>
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<td>North Creek</td>
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<tr>
<td>Near Bothell (USGS gage No. 12-1260)</td>
<td>24.6</td>
<td>454</td>
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<td>Little Bear Creek</td>
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<td>Above Sammamish River confluence</td>
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<td>320</td>
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<td>Above SR-202</td>
<td>15.5</td>
<td>340</td>
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<td>At Highway 522</td>
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<td>330</td>
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<tr>
<td>At N.E. 205th Street</td>
<td>13.6</td>
<td>310</td>
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</tbody>
</table>
Wildland/Urban Interface Fires

- Concerns are damage and casualties
- Hazard level varies with location – climate, topography, fuel load, and daily weather conditions (wind, temperature, humidity)
- Hazard mapping:
  - Landfire burn return period estimates
  - DNR classes of wildland/urban communities
Wildland/Urban Interface Fires

- Campus- and building-level risk depends on many factors:
  - Proximity to high fuel wildland area
  - Extent of defensible space
  - Building characteristics: fire safe construction details (or not)
  - Fire suppression resources

- Life safety depends on rapid evacuation
Landslides

- Landslides are the most difficult major hazard to evaluate
- Hazard assessments based on:
  - DNR mapping of historical landslides
  - DNR maps of landslide potential
  - Slope data near campuses
  - Site-specific geotechnical studies of slope stability
Natural Hazards

Overview
Natural Hazards - 1

- Natural hazards are natural phenomena that may pose threats to buildings, infrastructure and people - floods, earthquakes and so on.

- Natural hazards are characterized by:
  - Geographic areas affected
  - Probability of events
  - Severity of hazard events
Natural Hazards - 2

- Natural hazard events are inherently probabilistic.
- It is impossible to predict exactly where or when a hazard event will occur or how severe it will be.
- But, for a given location it is generally possible to estimate the annual probabilities of hazard events of various sizes or severities.
Probabilistic Hazard Assessment: Example 1

- A 100-year flood doesn't happen exactly every 100 years. A 100-year flood simply means a flood that has a 1% chance of happening every year.

- A given location may have a 100-year flood in 2012 and another in 2013 or may not have another for much more than 100 years.
Probabilistic Hazard Assessment: Example 2

- Geologists know that great earthquakes have happened on the Cascadia Subduction Zone about 40 times in the past 10,000 years, most recently in 1700.

- We can estimate the annual probability of a great earthquake, but cannot predict whether it will happen at 2:00 this afternoon, 10 years from now or 200 years from now.
Hazard: Frequency and Severity
Exposure: Value and Vulnerability of Assets Exposed to a Hazard
Risk: Hazard and Exposure
Disaster: Hazard Event Impacts
Inventory of Assets
Mitigation Reduces Risk
Hazard Events: Return Periods

- Consider a school which is subject to:
  - Flooding every 10 or 20 years and
  - Major earthquakes and/or tsunamis every 250 to 500 years

- Which hazard event is of most concern?

- Why?

- How do we make this decision?
How Do We Evaluate Risk?

- Risk means the level of threat to buildings, infrastructure and people.
- Risk depends on the combination of probability and consequences.
- Decision making about level of concern – that is, whether or not mitigation is desired and if so, at what priority is really about risk.
The Essence of Mitigation Planning for Schools

- Evaluate hazards posing threats to schools
- Evaluate the level of risk these hazards pose to each facility: damage, economic losses, deaths and injuries
- Determine the most cost-effective way to eliminate or reduce risk for the highest risk situations
Mitigation Planning

Risk Assessment
Quantify the Threat
to the Built Environment

Is Level of Risk Acceptable?

Risk Acceptable?
Mitigation Not Necessary

Risk Not Acceptable?
Mitigation Desired
Mitigation Planning

Risk Not Acceptable?  
Mitigation Desired

Identify Mitigation Alternatives  
Find Solutions to Risk

Prioritize Mitigation Alternatives  
Benefit-Cost Analysis and related tools

Obtain Funding  
Implement Mitigation Measures  
Reduce Risk
Relative Risk to K-12 Facilities in Washington Posed By Hazards

- **High Life Safety Risk**
  - Earthquakes
  - Tsunamis
  - Volcanic Lahars

- **High Damage Risk**
  - Earthquakes
  - Floods
  - Tsunamis
  - Volcanic Lahars

- **Lower Risk Statewide – but may be locally high**
  - Wildland/Urban Interface Fires
  - Landslides and Other Hazards
Earthquakes
Earthquakes in Washington

- **Every** location in Washington State has some level of seismic hazard
- However, the level of seismic hazard varies dramatically with location
  - Highest earthquake hazard level near the Pacific Coast and in parts of Puget Sound area
  - Hazard level generally decreases west to east
What Causes Earthquakes?

- Most earthquakes are caused by plate tectonics – the movement of plates of rock near the surface of the earth.
- Earthquakes also caused by:
  - Volcanic activity
  - Other geologic processes
    - Glacial rebound
    - Reservoir filling
    - Deep water wells or deep fluid injection
Cascadia Subduction Zone

- Three types of earthquakes:
  - Interplate earthquakes on the boundary between the Juan de Fuca Plate and the North American Plate
  - Intraplate earthquakes within the Juan de Fuca Plate subducting under the North American Plate
  - Crustal earthquakes within the North American Plate
Earthquake Magnitude

- Earthquake “magnitude” is a measure of the amount of energy released by the earthquake.
- The magnitude scale is NOT linear:
  - A M9 earthquake releases about 30 times the energy of a M8 and about 900 times that for a M7.
  - A M7 earthquake releases about 30 times that for a M6 and so on.
Quiz #1

- For a given school, which earthquake is likely to cause more damage?
  - M9
  - M8
  - M7
Quiz #1

- For a given school, which earthquake is likely to cause more damage?
  - M9
  - M8
  - M7

- ANSWER: Magnitude is NOT a measure of how severe the damage is at any given location
The level of earthquake ground motion is the best measure of earthquake severity at any given location.

Several measures of ground motion:
- Peak ground acceleration (PGA)
- Peak ground velocity (PGV)
- Peak ground displacement (PGD)
Earthquake Ground Motions - 2

- Modified Mercalli Intensity Scale - MMI
  - An archaic, qualitative scale based on descriptions of expected damage
  - Although still used fairly commonly, the MMI scale is **not** very useful because the level of damage depends very strongly on the vulnerability of buildings and infrastructure – not just on ground motion
  - MMI is NOT used in the K-12 Mitigation plan
Level of Ground Shaking at a Given Location

- Depends on 4 Factors:
  - Magnitude of the earthquake
  - Depth of the earthquake
  - Distance to the earthquake
  - Soil/Rock Type at the site which may significantly amplify or deamplify earthquake ground motions
Liquefaction and Lateral Spreading

- Liquefaction: loose, saturated soils may liquefy under ground shaking – buildings may settle or tilt
- Lateral Spreading: soils may move downslope under ground shaking
- Both factors may substantially increase damage
USGS National Seismic Hazard Maps (2008)

- Probabilistic hazard maps considering all known earthquake faults
- Includes “area seismicity” to account for earthquakes on unknown faults
- Several types of maps showing different measures of ground motion for various return periods
- Maps do not consider soil/rock conditions.
Floods
FEMA-Mapped Floodplains

- FEMA maps developed areas with significant flood risk:
  - Overbank flooding from rivers and streams
  - Coastal storm-surge flooding

- FEMA does not map:
  - Areas with limited development
  - Some very small streams
  - Areas subject to local stormwater drainage flooding
School Campuses in FEMA-Mapped Floodplains

- Campuses in 100-year floodplain: 85
- Campuses in 500-year floodplain: 170***

*** Including those in 100-year floodplain
Quiz #2

- Is a school being in a FEMA-mapped 100-year floodplain a good measure of flood risk?
Quiz #2

- Is a school being in a FEMA-mapped 100-year floodplain a good measure of flood risk?

- NO – this information provides an indication that a school does have some level of flood risk – but the level of risk is NOT determined.

- Why?
Flood Risk for a Given Building

- Flood risk depends on:
  - Annual probability of floods of various elevations
  - First floor elevation of building vis-à-vis the flood elevations
  - The value, importance and vulnerability of the building to flood damage
Determining Flood Risk - 1

- Identify the flood source – find the FIRM
- Gather data from FEMA Flood Insurance Study:
  - Stream Discharge Data for 10-, 50-, 100-, 500-year floods
  - Flood Elevation Data for 10-, 50-, 100-, 500-year floods
  - Determine first floor elevation of school
Determining Flood Risk -

- The above data allows calculation of the annual probability of flooding for any flood depth relative to the first floor: 1 foot, 2 feet, 3 feet etc.

- Flood vulnerability – percentage of damage as function of flood depth – from FEMA depth-damage functions

- Value and importance from District data
Evacuation Impediments

- Seismically vulnerable buildings may suffer major damage, with casualties, and impediments on egress for survivors
- Co-seismic subsidence of up to several feet may block evacuation routes – flooding
- Bridge failures may block evacuation routes
Tsunami Mitigation Measures: Focus is Predominately Life Safety

- **Robust** evacuation planning – when high ground is nearby within arrival time
- Vertical evacuation structure – when no high ground is nearby within arrival time
- Relocate at-risk schools at high elevations – well outside the tsunami inundation area
- Build future new schools at high elevations well outside the inundation area
Wildland/Urban Interface Fires
Wildland/Urban Fire Risk Factors

- All of the wildland fire factors
- Proximity of development to high fuel load areas
- Extent of fire breaks
- Extent to which building stock has fire-safe construction
- Fire suppression resources in developed area, including capacity of water system
Volcanic Events
Active Volcanoes in Washington

- Mount St. Helens
- Mount Rainier
- Mount Baker
- Mount Adams
- Glacier Peak
- Mount Hood (Oregon) - eruptions may affect parts of Washington State
Volcanic Hazards:
Proximal Hazards (Near Volcano)

- Lava flows
- Blast effects
- Landslides or massive collapses
- Pyroclastic flows
  - Avalanches of hot ash, rock fragments and gases – with temperatures up to 1500 °F and moving downslope at 100 to 150 mph

- **NO** schools located in proximal hazard areas
Volcanic Hazards: Distal (Far From Volcano)

- **Lahars – Volcanic Mudflows**
  - Occur when volcanoes with high amounts of snow/ice erupt
  - May travel 50 miles or more at 20 to 40 mph

- **Volcanic Ash**
  - Ash falls may extend for hundreds of miles downwind
  - Highest accumulations near volcano
Landslides
Landslide Types

- Rockfalls
- Translational landslides
- Rotational landslides
- Debris flows (mudslides)
Rockfalls

FIRM BEDDED ROCK

SOFTWARE ROCK
Translational Landslides
Rotational Landslides
Debris Flows

- Scar (area of initial failure)
- Track (may or may not be eroded)
- Zone of deposition (fan)

Soil or Colluvium

Bedrock