



OREGONPREPARED

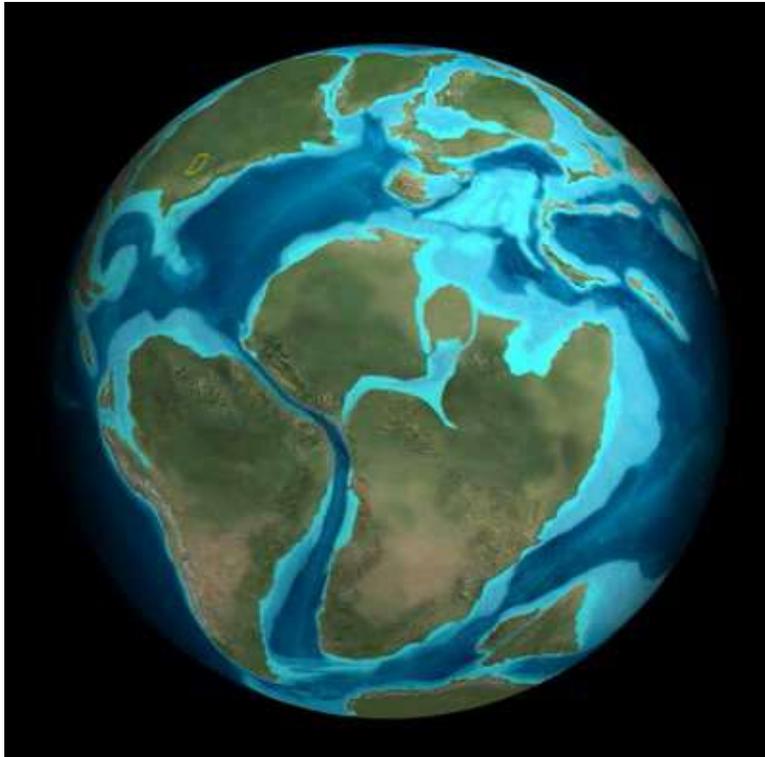
**The Impacts of the
Cascadia Subduction
Zone Earthquake on
Oregon**

**Oregon Military Department
Office Of Emergency Management**



OREGON PREPARED

Everything you wanted to know about plate tectonics...



... in 30 seconds or less

- Tectonic Plates move around
- Tectonic Plates spread apart and create new land
- Tectonic Plates dive under each other
- Tectonic Plates roll over each other



OREGON PREPARED

What are the geologic hazards in Oregon?

- **Earthquakes**
- **Volcanoes**
- **Tsunami**
- **Landslides**





OREGON PREPARED

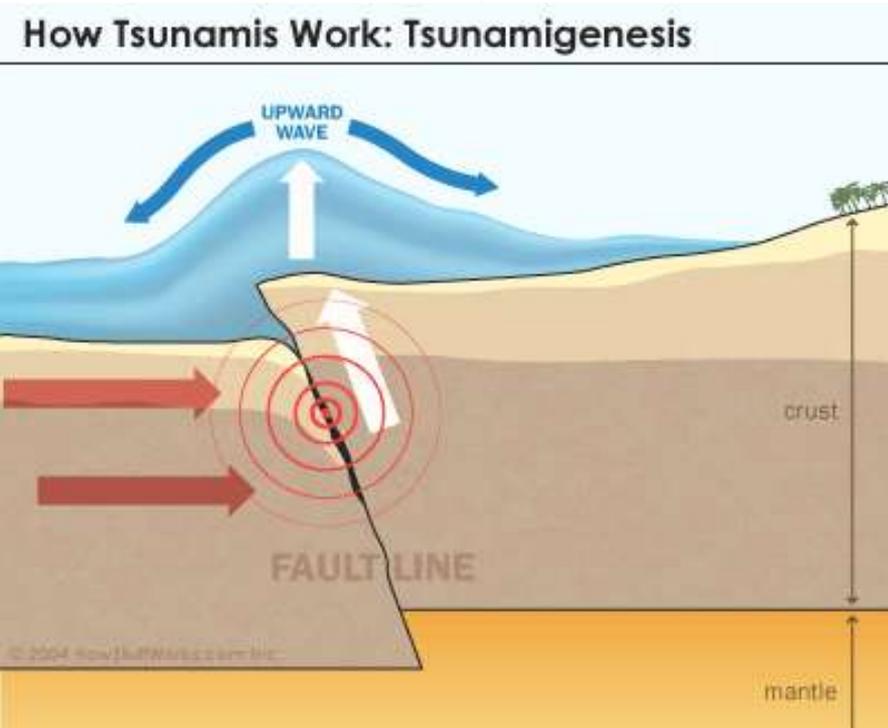
Earthquakes

- **Earthquakes occur when rock underground suddenly breaks along a fault. This sudden release of energy causes the seismic waves that make the ground shake.**



OREGON PREPARED

Tsunamis



- **Tsunamis are generated when geologic events cause large, rapid movements in the sea floor that displace the water column above.**
- **The Pacific Coast is at risk both from locally and distantly generated tsunamis.**



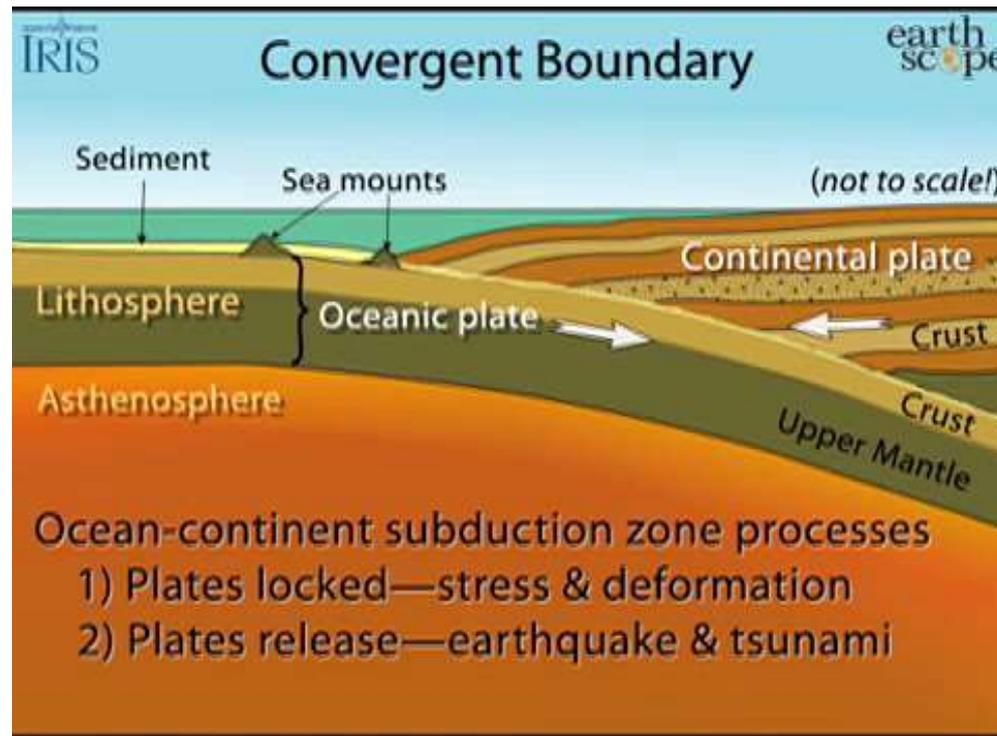
OREGON PREPARED

- **Earthquakes**
 - **Cascadia Subduction Zone**
 - **Crustal**
 - **Deep Intraplate**
 - **Volcanic**
- **Tsunami**
 - **Local (from subduction zone off our coast)**
 - **Distant (from subduction zone elsewhere)**



OREGON PREPARED

What is the Cascadia Subduction Zone?

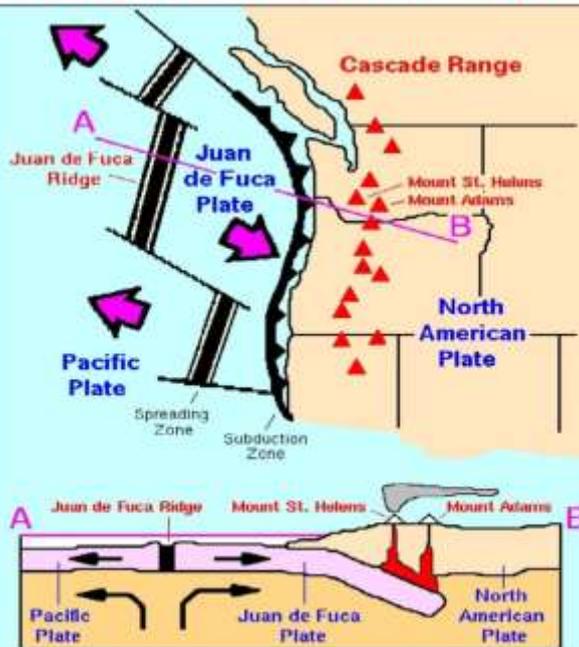




OREGON PREPARED

Know your Cascadia Subduction Zone

Plate Tectonics – Cascade Range



- 600 miles long, from northern California to British Columbia
- Capable of producing very large earthquakes (M9+) that impact a wide area
- Similar in size and impact to the 2004 Sumatra earthquake
- Can produce devastating tsunamis
- 37% chance of a mega-thrust earthquake in the next 50 years *

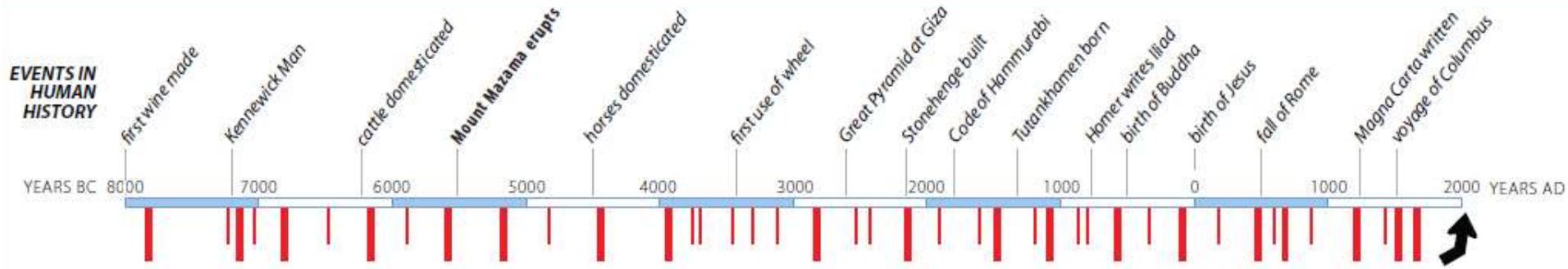


OREGON PREPARED

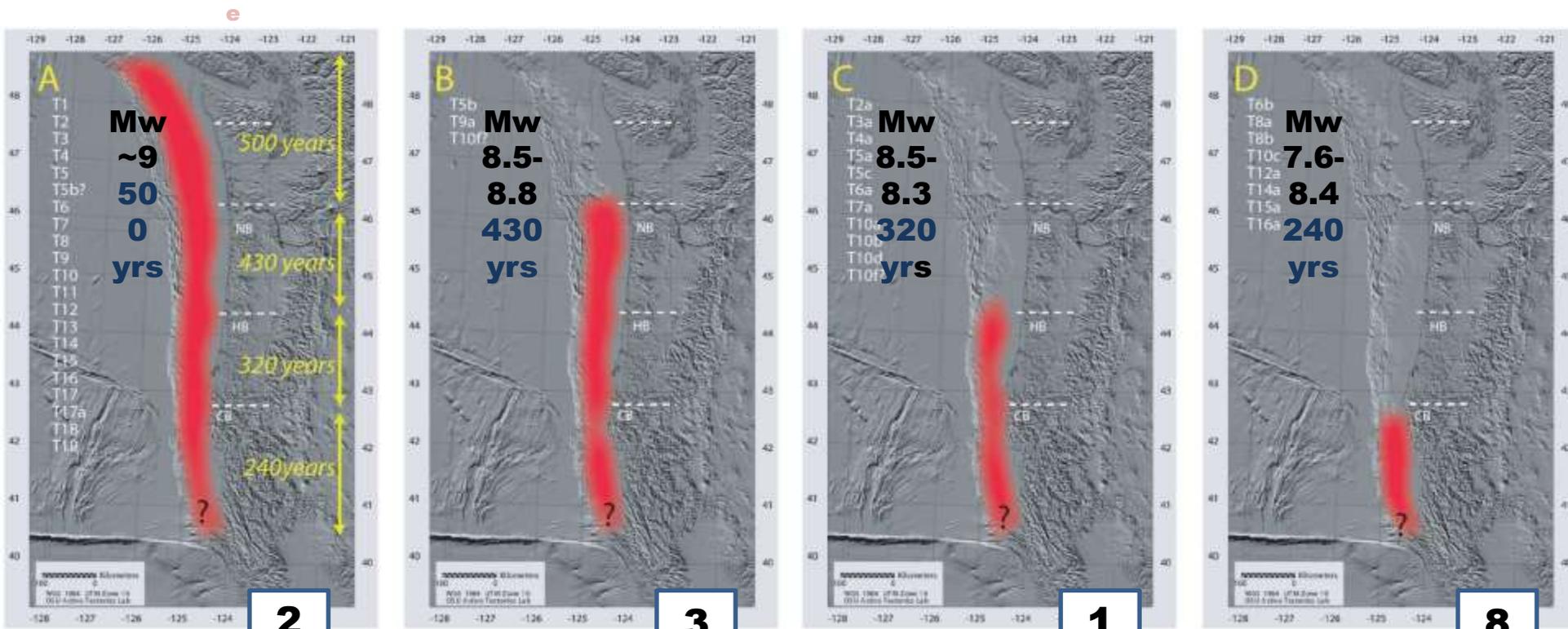


Ghost forest at Copalis River, WA

- **Last Cascadia Subduction Zone earthquake occurred in 1700**
- **When will the next one occur?**
 - **We just don't know**
- **Average recurrence:**
 - **240 years (south of Cape Blanco)**
 - **5-600 years (entire length)**
 - **190-1,200 years between EQ**



- Earthquake of Magnitude 9+ (fault breaks along entire subduction zone)
- Earthquake of Magnitude 8+ (fault breaks along southern half of subduction zone)



(Modified from [Langer et al. \(in press\)](#) by adding magnitude estimates and some labels)



OREGON PREPARED



- **Past 10,000 years**
 - **19 earthquakes that extended along most of the margin, stretching from southern Vancouver Island to the Oregon-California border**
 - **8.7 to 9.2 – really huge earthquakes.**
- **22 additional earthquakes that involved just the southern end of the fault**
 - **slightly smaller – more like 8.0 – 8.2**

We're in the Zone
And it WILL happen again



OREGON PREPARED

Cascadia

=

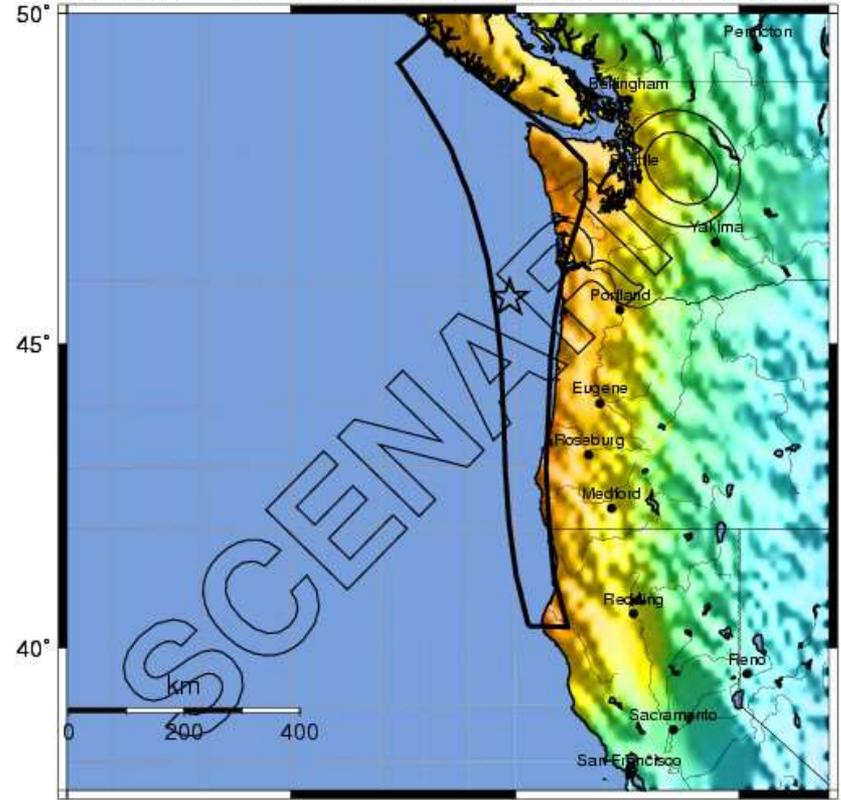
Strong Shaking and Tsunami

- **Strong Ground Shaking**
 - M9 w/ 2 - 4 min shaking
- **Tsunami**
 - within 15 to 25 minutes

-- Earthquake Planning Scenario --

ShakeMap for Casc9.0_expanded Scenario

Scenario Date: Tue Sep 20, 2011 12:00:00 GMT M 9.0 N45.73 W125.12 Depth: 0.0km



PLANNING SCENARIO ONLY -- Map Version 2 Processed Thu Sep 22, 2011 06:44:54 PM MDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC (%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL (cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+



OREGON PREPARED

Strong ground shaking



2010 Haiti earthquake



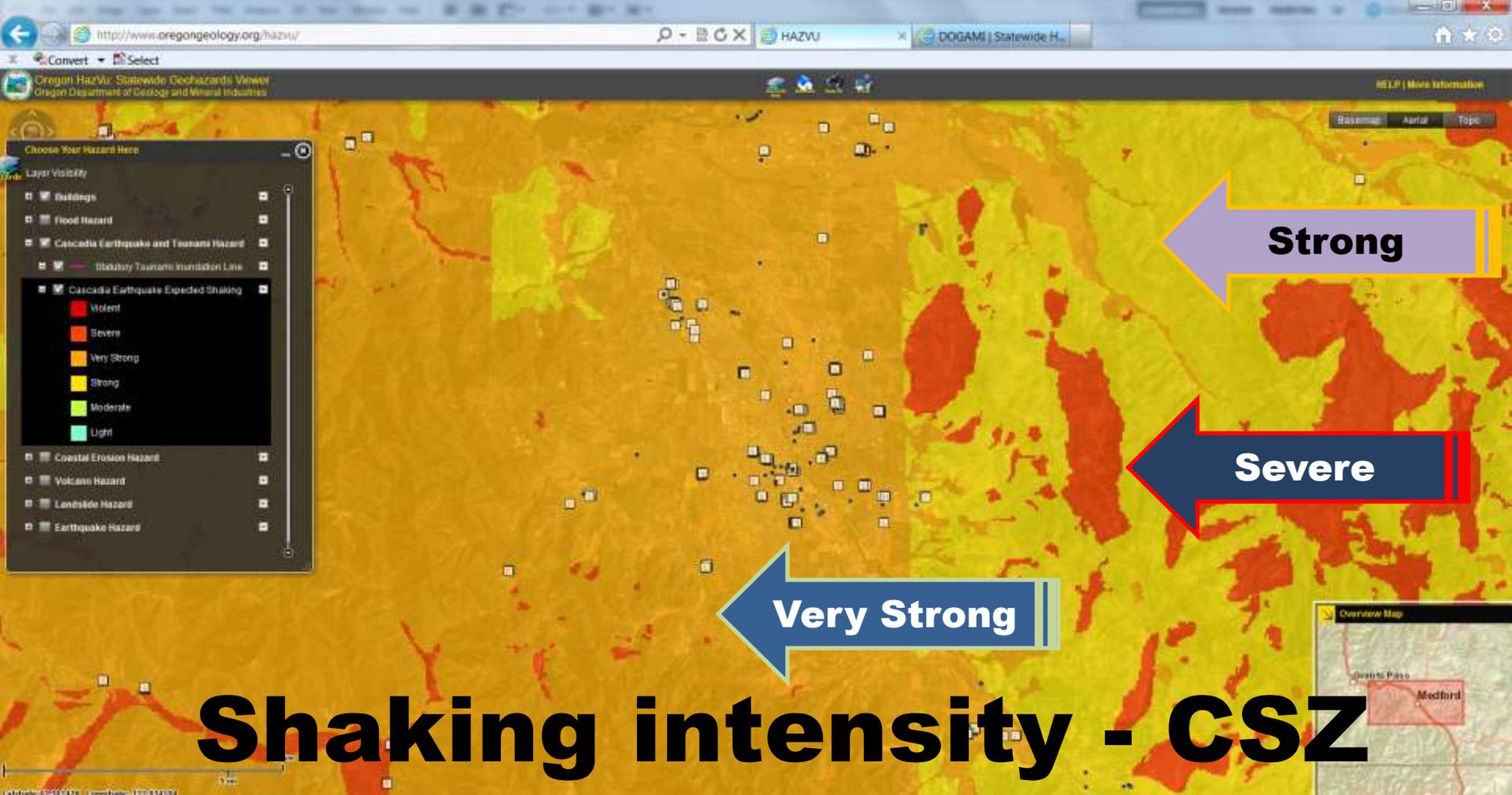
2011 Tohoku earthquake



1993 Molalla High School



OREGON PREPARED



Source: <http://www.oregongeology.org/hazvu>



OREGON PREPARED

Coastal subsidence



Mainichi Shimbun, Reuters

2004 Sumatra



OREGON PREPARED

Landslides



Landslides in Ferndale, WA

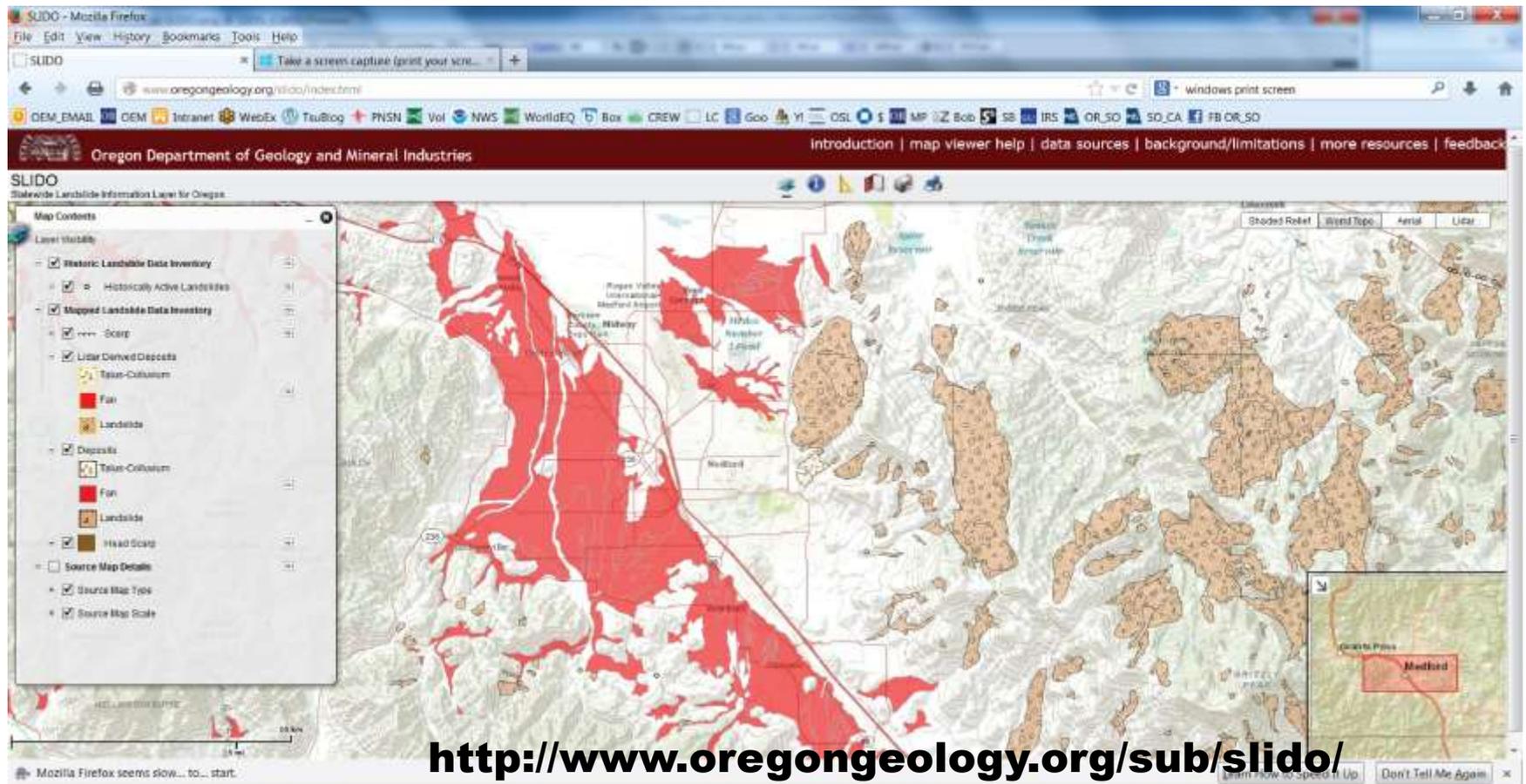


2010 Taiwan



OREGON PREPARED

Landslides in Jackson County



<http://www.oregongeology.org/sub/slido/>



OREGON PREPARED

Liquefaction



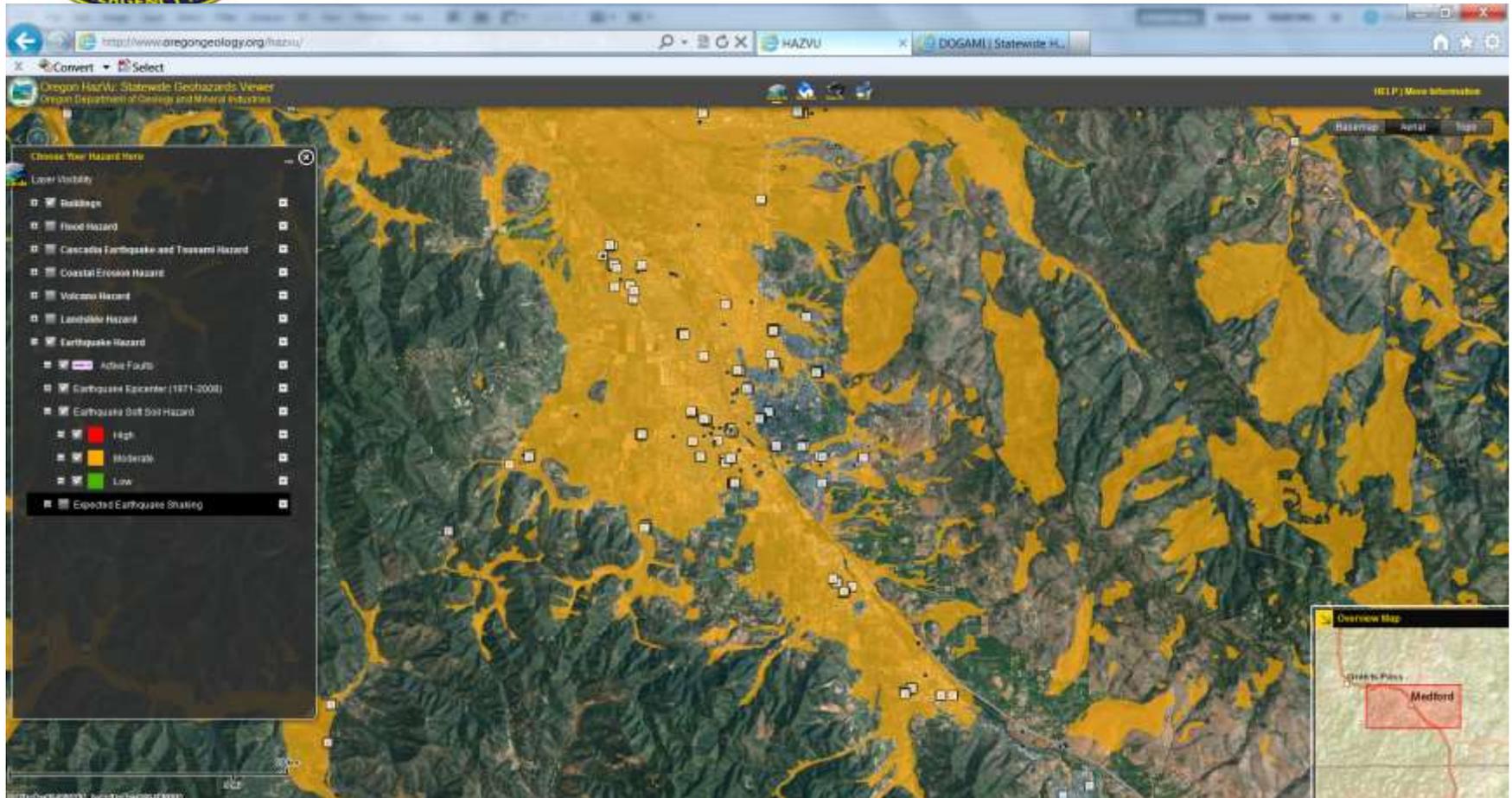
1964 Alaska



2011 Christchurch, New Zealand



OREGON PREPARED



Source: <http://www.oregongeology.org/hazvu>



OREGON PREPARED

Tsunami



2004 Indonesian tsunami

2011 Tohoku tsunami



OREGON PREPARED

Tsunami

- **Local** – Caused by a subduction zone earthquake near the Oregon shore
- **Distant** – Caused by a subduction zone earthquake far away from the Oregon shore



OREGON PREPARED

Distant Tsunami

- **Arrives 4 + hours after the earthquake**
- **Lower damage and flooding than local tsunamis**
- **National Tsunami Warning System can warn you**
 - **Warning and Advisory require protective action**
- **National Tsunami Warning Center**
 - **<http://wcatwc.arh.noaa.gov/>**



OREGONPREPARED

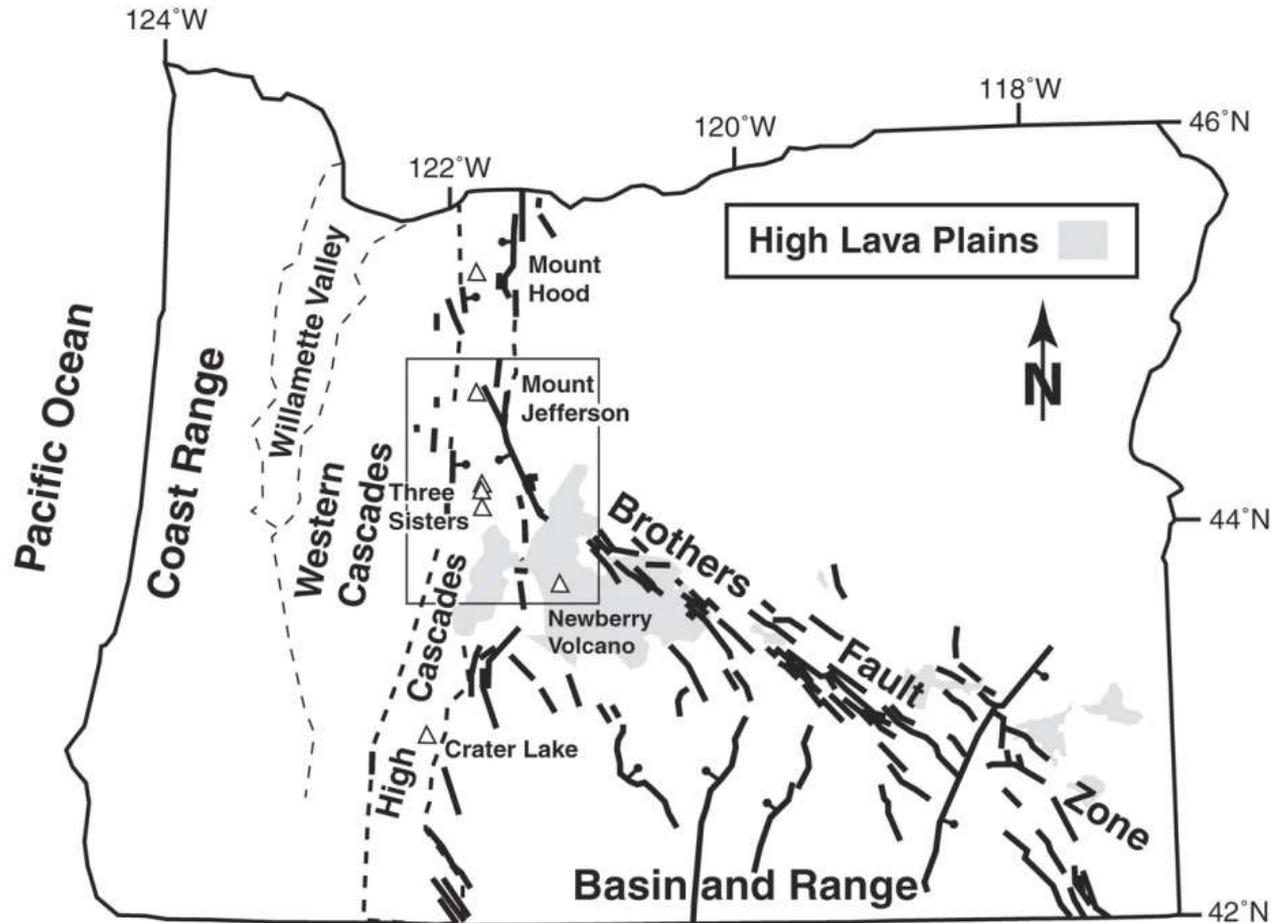
Local Tsunami

- **Arrives minutes after the earthquake**
- **Much higher waves**
- **Much further inland penetration**
- **NOAA Tsunami Warning System ineffective**
- **Earthquake = Only Warning**
 - **NO OFFICIAL WARNING!**
 - **Self Evacuation required**



OREGON PREPARED

Crustal faults

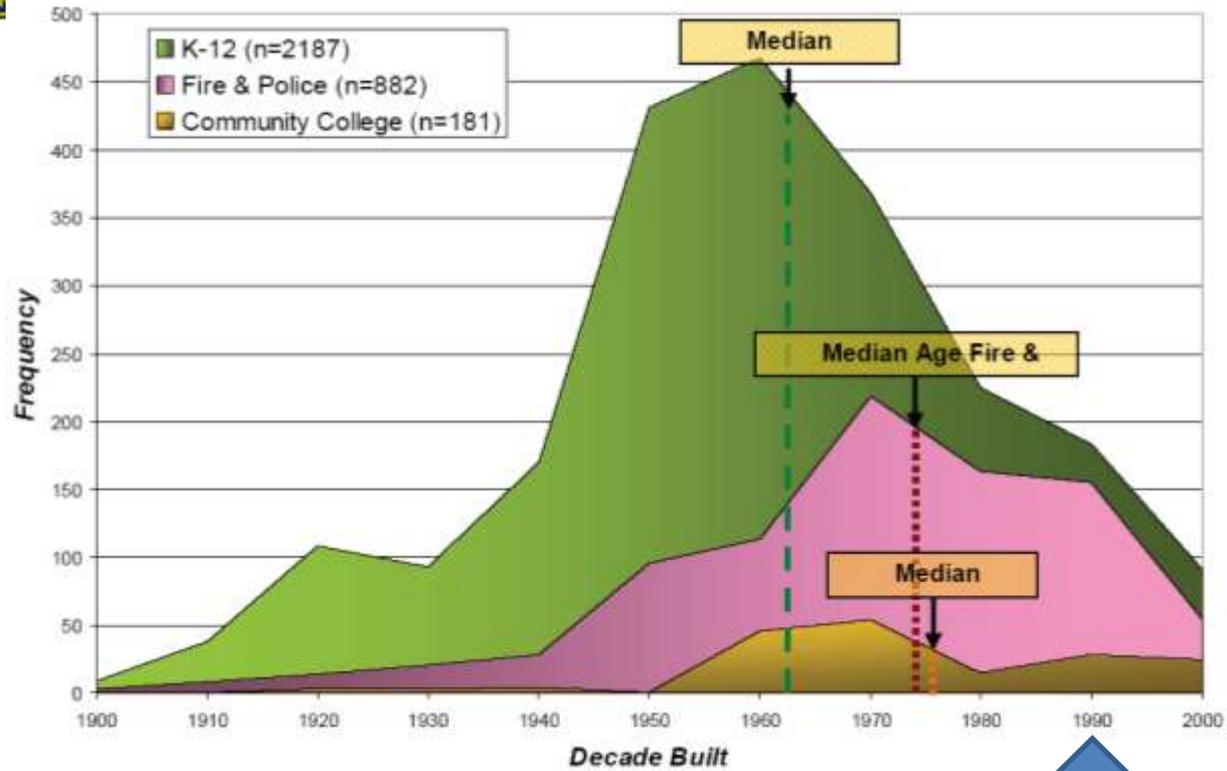


An aerial photograph of a complex multi-level highway interchange. The image shows several levels of concrete overpasses and ramps. A large white semi-truck is visible on one of the upper levels, and a smaller dark car is on a lower level. The surrounding landscape is dry and hilly. In the top left corner, there is a small circular logo with the word 'STARYO' partially visible. Overlaid in the center of the image is the text 'What are the Implications?' in a large, bold, white font.

What are the Implications?



OREGON PREPARED



First seismic building codes in Oregon



OREGON PREPARED

Damage to Homes



- **Displaced households**
 - 17,300*
- **Short-term shelter needs**
 - 12,400 People*

(Taken from a DOGAMI study (1999) of an 8.5M CSZ quake)
- *this study does not include tsunami damage



OREGON PREPARED

Damage to Schools



- **300,000 students in buildings subject to collapse during a Cascadia event**
- **Non-structural damage**
- **Needed for cultural continuity**



OREGON PREPARED

Damage to Businesses

- **\$12-\$50 Billion in Economic damages***
- **30,000-80,000 buildings destroyed***

(Taken from a DOGAMI study (1999) of an 8.5M CSZ quake) - *this study does not include tsunami damage





OREGON PREPARED

Roads Damaged





OREGON PREPARED

State of Oregon's bridges

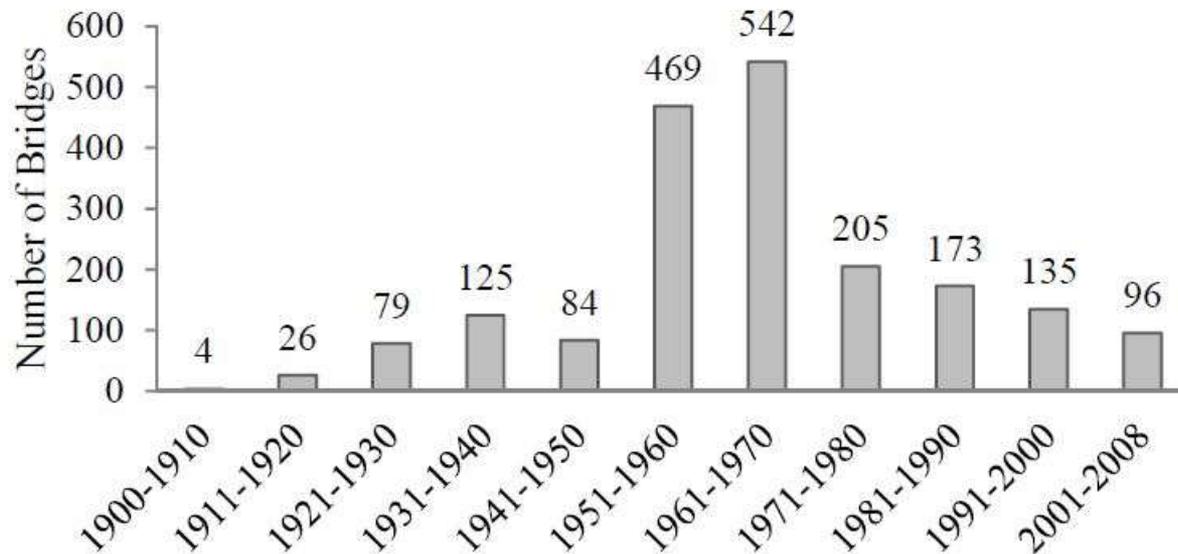


Figure 3: Distribution of year of construction completion



OREGON PREPARED

State of Oregon's bridges

A quake's toll on Oregon bridges

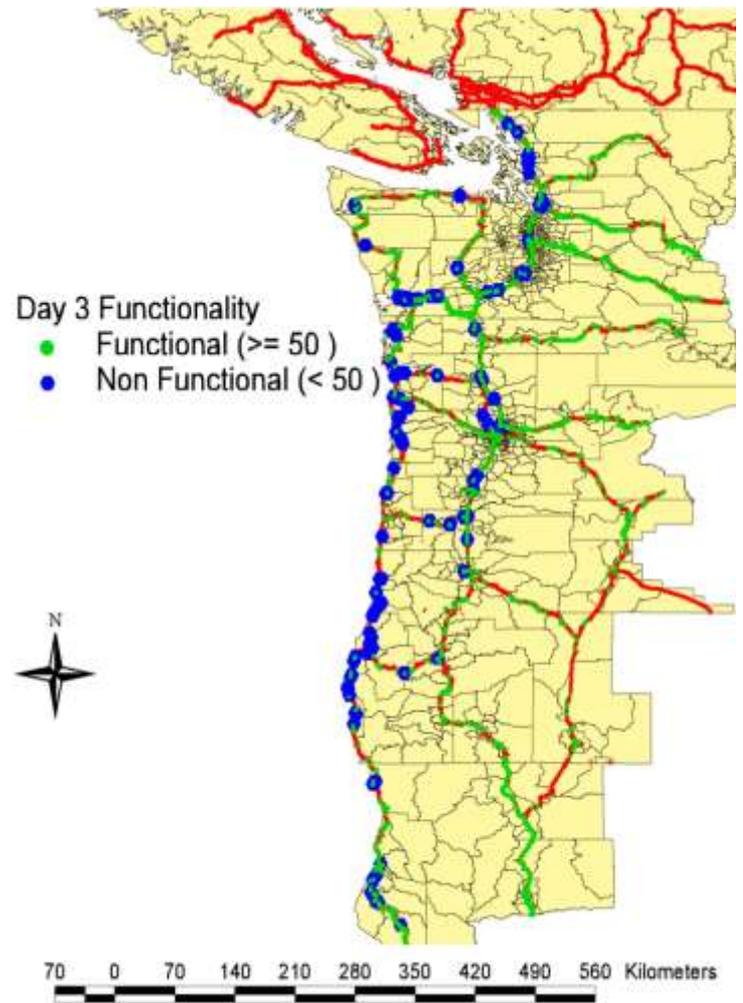
Computer modeling shows a 9.0 earthquake off the Oregon coast – similar to what happened in January 1700 – would collapse six major highway bridges, extensively damage others and cost \$1 billion for bridge repair and replacement.

- Slight
- Moderate
- Extensive
- Collapse



Source: Oregon Department of Transportation/Portland State University

STEVE COWDEN/THE OR

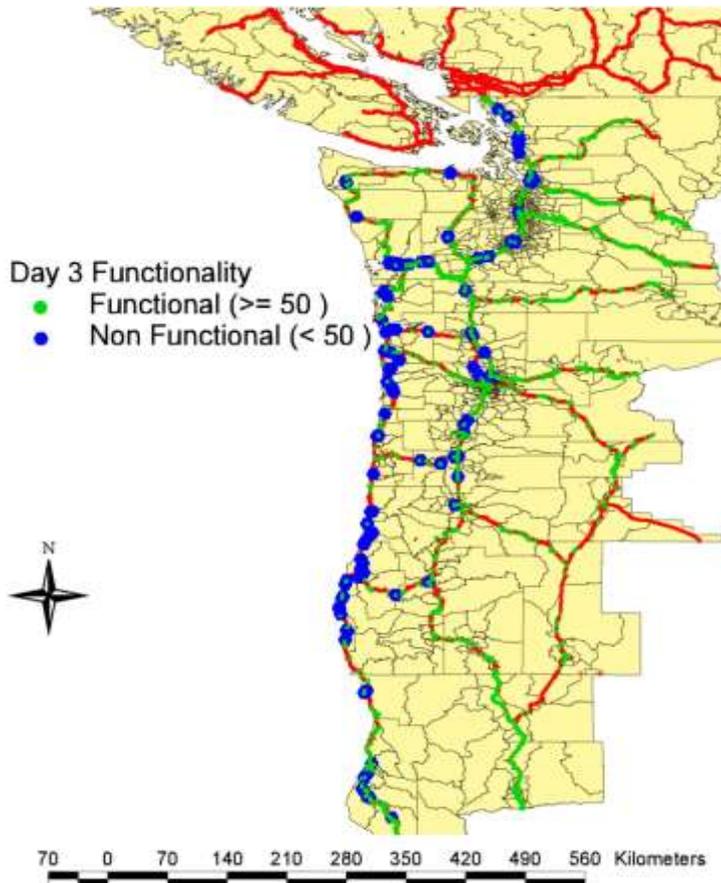


Cascadia Scenario Bridge Functionality



OREGON PREPARED

What are the risks & impacts based on our assumptions?



- **Infrastructure and lifelines will be seriously damaged**
 - **In Oregon, 399 bridges would have totally or partially collapsed under an M 9.0 Cascadia Subduction Zone earthquake, and 621 bridges would have been heavily damaged.**
 - **Most state routes connecting Interstate I-5 with the Oregon Coast Highway would be closed. The estimated time of closure could be 3 to 12 months.**
 - **The restoration of the entire transportation network could take 3 to 5 years, and would require a nationwide effort.**



OREGONPREPARED

**Oregon is at risk
from an earthquake and
tsunami that can
significantly impact our
people and economy
for decades.**



OREGON PREPARED

Cascadia Planning Assumption

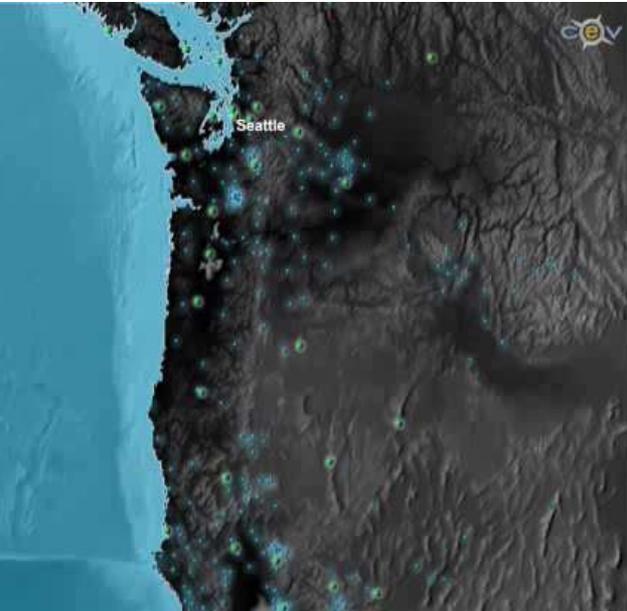
- **Widely accepted that a very large, 9+ subduction zone earthquake is not just possible, but probable**
- **Strong to Very Strong shaking inland to Cascade mountains**
- **Three metropolitan cities in impact zone**
 - **Portland**
 - **Seattle**
 - **Vancouver, B.C.**
- **Heavy urbanization along the I-5 corridor**
- **Approximately 15 million people live in the hazard zone**



OREGON PREPARED

What will Oregon look like if Cascadia happened today?

- **15 million people live in the impact zone**
 - **No power for weeks/months/years**
 - **No fuel for weeks/months/years**
 - **No deliveries of food/water for weeks/months**
 - **No running water for weeks/months/years**
 - **No sewer system for weeks/months/years**





OREGON PREPARED

Critical Service	Zone	Estimated Time to Restore
Electricity	Valley	1 to 3 months
Electricity	Coast	3 to 6 months
Police and fire stations	Valley	2 to 4 months
Drinking water and sewer	Valley	1 month to 1 year
Drinking water and sewer	Coast	1 to 3 years
Top-priority highways (partial restoration)	Valley	6 to 12 months
Healthcare facilities	Valley	18 months
Healthcare facilities	Coast	3 years



OREGONPREPARED

Earthquake mitigation in Oregon

- **Oregon Resiliency Plan (OSSPAC)**
 - <http://www.oregon.gov/OMD/OEM/Pages/osspace/osspace.aspx>
- **Cascadia Catastrophic Plan (OEM)**
 - http://www.oregon.gov/OMD/OEM/Pages/plans_train/CSZ.aspx
- **Land-use planning guidance (DLCD)**
- **Natural Hazards Mitigation Plan (DLCD)**
- **Tsunami inundation mapping (DOGAMI)**
 - <http://oregontsunami.org>



OREGON PREPARED

**House Resolution 3, adopted in April 2011,
directed the Oregon Seismic Safety Policy
Advisory Commission (OSSPAC)**

**“to lead and coordinate preparation of an
Oregon Resilience Plan that reviews policy
options, summarizes relevant reports and
studies by state agencies, and makes
recommendations on policy direction to protect
lives and keep commerce flowing during and
after a Cascadia earthquake and tsunami.”**



OREGON PREPARED

The Oregon Resilience Plan: Reducing Risk and Improving Recovery

for the Next Cascadia Earthquake and Tsunami

- **Report to the 77th Legislative Assembly
from Oregon Seismic Safety Policy
Advisory Commission (OSSPAC)**
- **February 2013**
- **http://www.oregon.gov/OMD/OEM/osspace/docs/Oregon_Resilience_Plan_Final.pdf**



OREGON PREPARED

Key Findings

- **Casualties (1,250 to more than 10,000)**
- **Economic Loss (close to 20% state GDP)**
- **More than one million truck loads of debris**

Liquid fuel vulnerability

How much liquid fuel do you use in one month?



OREGONPREPARED

Key recommendations

- **Complete an inventory**
 - **critical buildings**
 - **local agency, transit, port, and rail assets**
 - **energy and information and communications sectors**
 - **water and wastewater**



OREGON PREPARED

- **Launch a sustained program of capital investment in Oregon's public structures, including**
 - **Fully funding Oregon's Seismic Rehabilitation Grants Program for K-12 schools, community colleges, and emergency response facilities**
 - **Seismically upgrading lifeline transportation routes into and out of major business centers statewide by 2030**



OREGON PREPARED

- **Craft a package of incentives to engage Oregon's private sector**
 - **Developing a seismic rating system for new buildings to incentivize construction of buildings more resilient than building code compliance requires and to communicate seismic risk to the public**
 - **Tasking the Oregon Public Utilities Commission to provide oversight for seismic preparedness of the energy providers currently under its jurisdiction**
 - **Working with the hospitality industry to develop plans to assist visitors following a major earthquake and tsunami and to plan strategies to rebuild the tourism industry**



OREGON PREPARED

- **Update Oregon's public policies**
 - **Revising individual preparedness communications to specify preparation from the old standard of 72 hours to a minimum of two weeks, and possibly more**
 - **Developing a policy and standards for installation of temporary bridges following earthquake disruption**



OREGONPREPARED

- **Tasks the Resilience plan workgroup to develop an implementation plan**
- **Report due to Oregon State Legislature**
 - **October 1, 2014**



OREGON PREPARED

ORP Key Findings

- **Oregon is far from resilient to the impact of a great Cascadia earthquake today**
 - **Casualties (1,250 to more than 10,000)**
 - **Economic Loss (close to 20% state GDP)**
 - **More than one million truck loads of debris**
- **Liquid Fuel vulnerability**





**It doesn't take collapse to make
a building unusable**



OREGONPREPARED

Resiliency CAN be achieved

- **After the February 27, 2010 M8.8 Maule Earthquake, Chile**
 - **90% communication services and 95% power supply within two weeks, and re-start commercial flights after ten days.**
- **After the March 11, 2011 M9.0 Tohoku Earthquake,**
 - **90% power supply in ten days, 90% telephone lines in two weeks, and 90% cellular base stations in 19 days.**



OREGONPREPARED

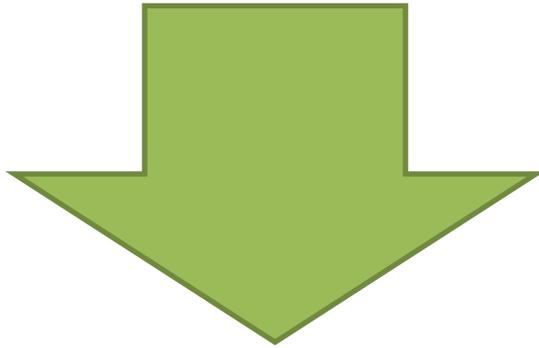
What your community can do

- **Assess your risk**
 - **Inventory public buildings**
 - **FEMA 154 - Rapid Visual Screening of Buildings for Potential Seismic Hazards**
 - **Assess lifelines and infrastructure**



OREGON PREPARED

Survive the Earthquake



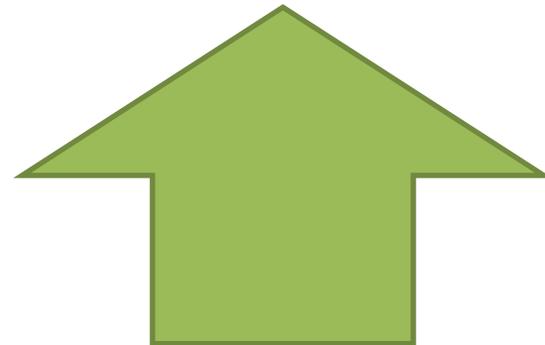
Prevention

- **Modify Your Environment**



Protection

- **Modify Your Behavior**





OREGON PREPARED

Community actions

- **Educate**
 - Public
 - Public officials
 - Continuity of operations
- **Mitigate**
 - What does your community value?

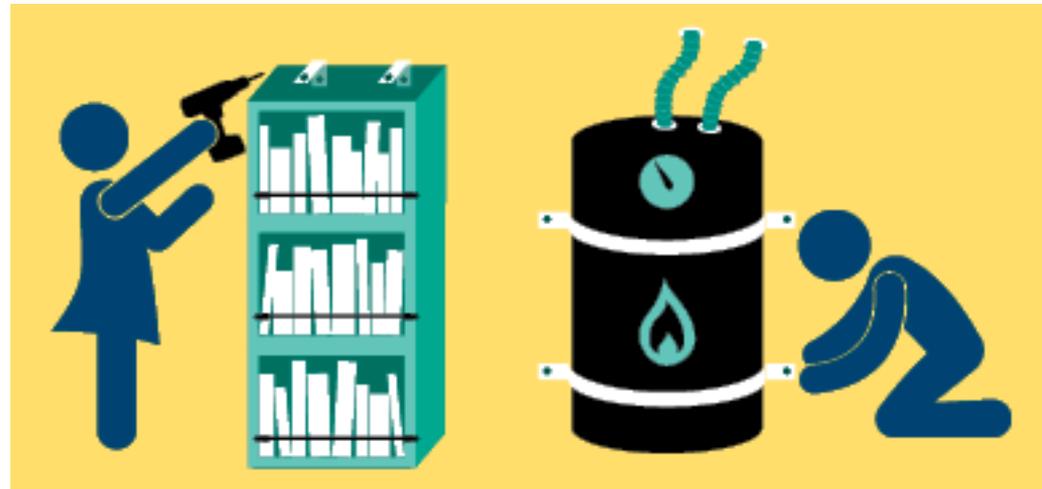




OREGON PREPARED

Key Preparedness Messages

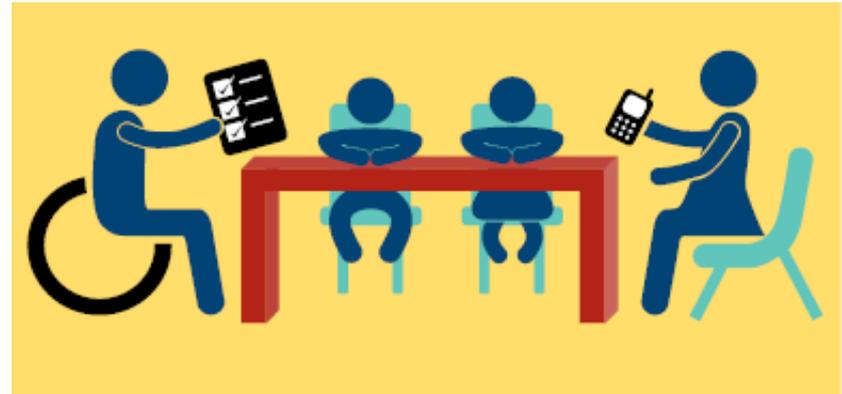
- ❖ **Secure your space by identifying hazards and securing moveable items.**





OREGON PREPARED

- * **Plan on how to respond after an earthquake or tsunami**





OREGON PREPARED

- **Go-Kit – minimum of 72 hours**
- **Car – 7 to 10 days**
- **Home – 3+ weeks**

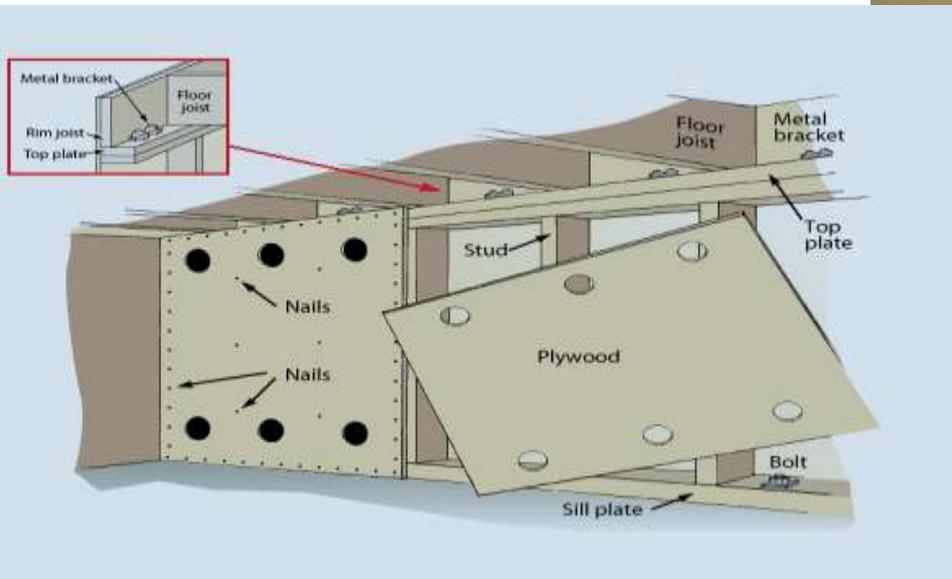


<http://www.ready.gov/america/getakit/>



OREGON PREPARED

- **Inadequate foundations**
- **Un-braced cripple walls**



Earthquake Safety Guide for Homeowners

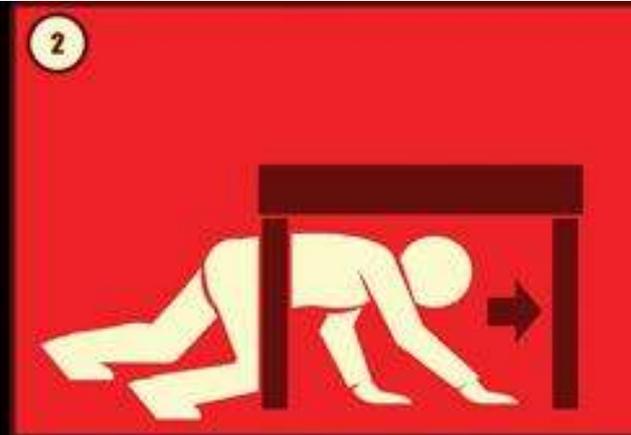
<http://www.fema.gov/media-library/assets/documents/1017?id=1449>



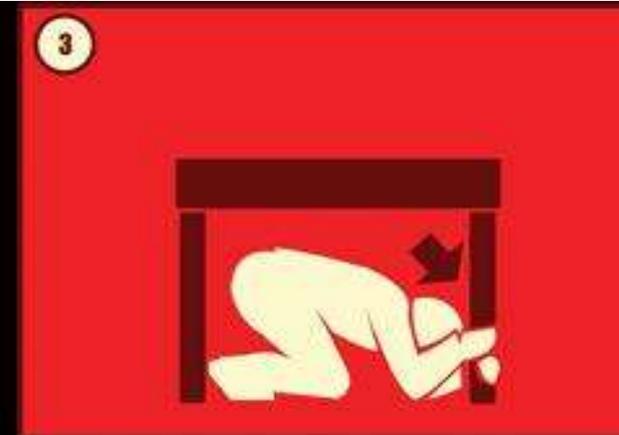
OREGON PREPARED



DROP!



COVER!



HOLD ON!

Protect Yourself. Spread The Word.



OREGON PREPARED

- **DO NOT**
run out of
the building!

Run



- **DO NOT**
get in a
doorway!

Doorway



- **DO NOT**
believe the
triangle of life!

**Triangle
of Life**



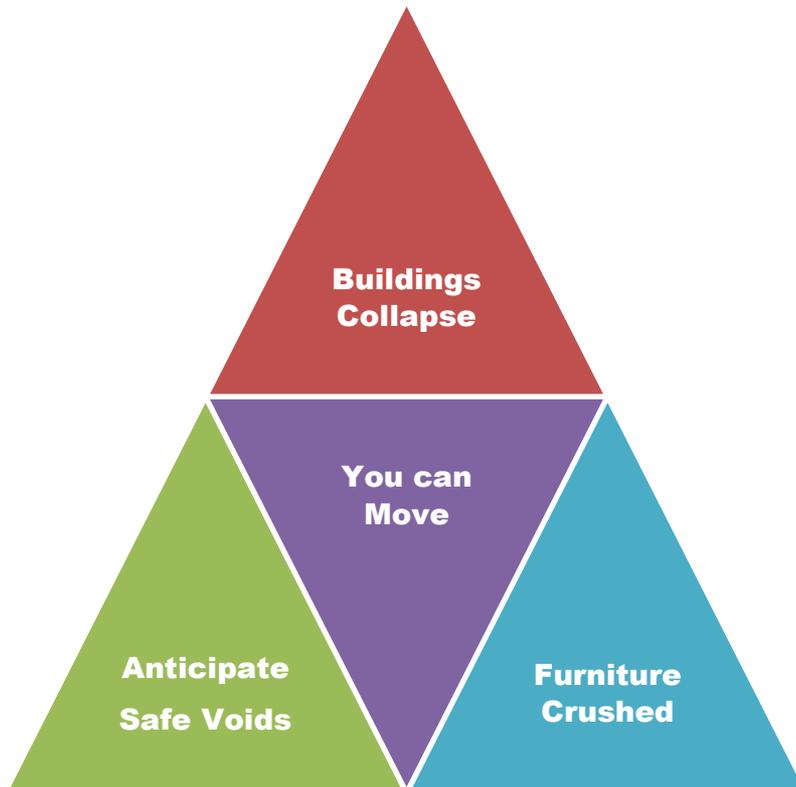


OREGON PREPARED

The Triangle of Life MYTHS

MYTHS

TRUTH



- 1. Collapse: Most buildings do not collapse**
- 2. Moving: Strong shaking makes moving very difficult and dangerous**
- 3. Voids: The direction of shaking and unique structural aspects of the building make this impossible.**
- 4. Furniture: People DO survive under furniture or other shelters.**



OREGON PREPARED

Improve safety immediately after an earthquake by evacuating if necessary, helping the injured and preventing further injuries or damage.





OREGON PREPARED

After the Earthquake

Assess

- Glass
- Dust
- Fire
- Darkness

Protect

- Gloves
- Mask
- Flashlight

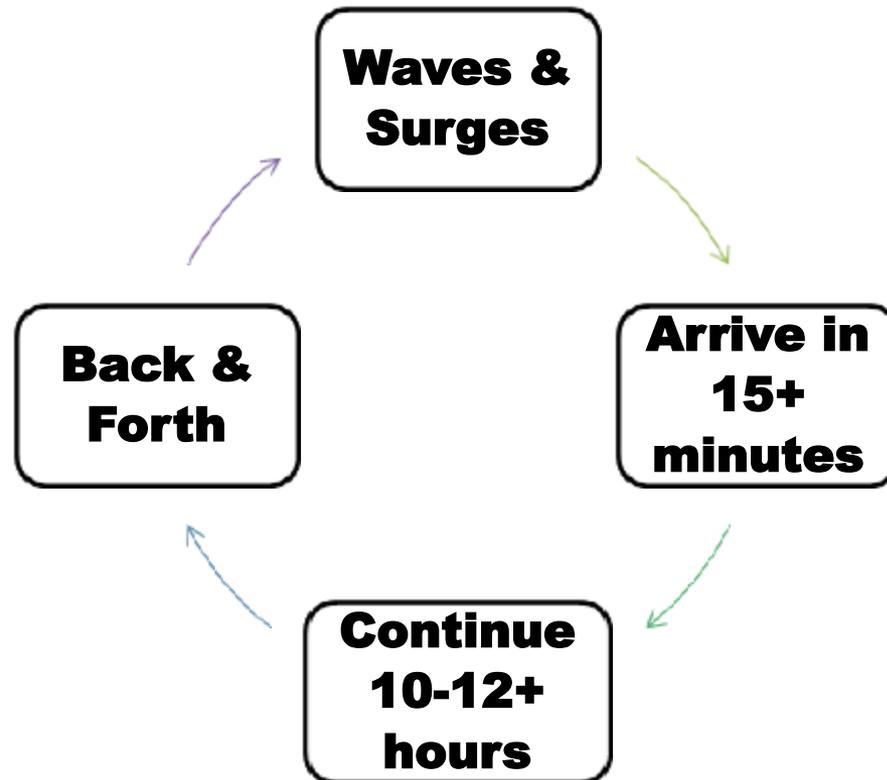
Evacuate

- Obstacles
- Routes
- Assistance



OREGON PREPARED

Local (Cascadia) Tsunami

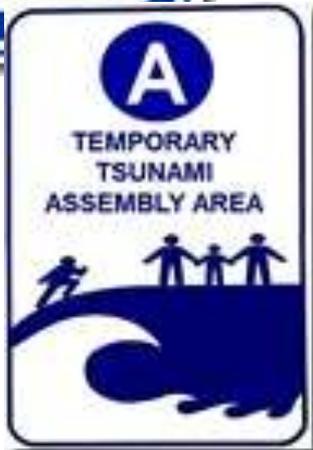




OREGON PREPARED

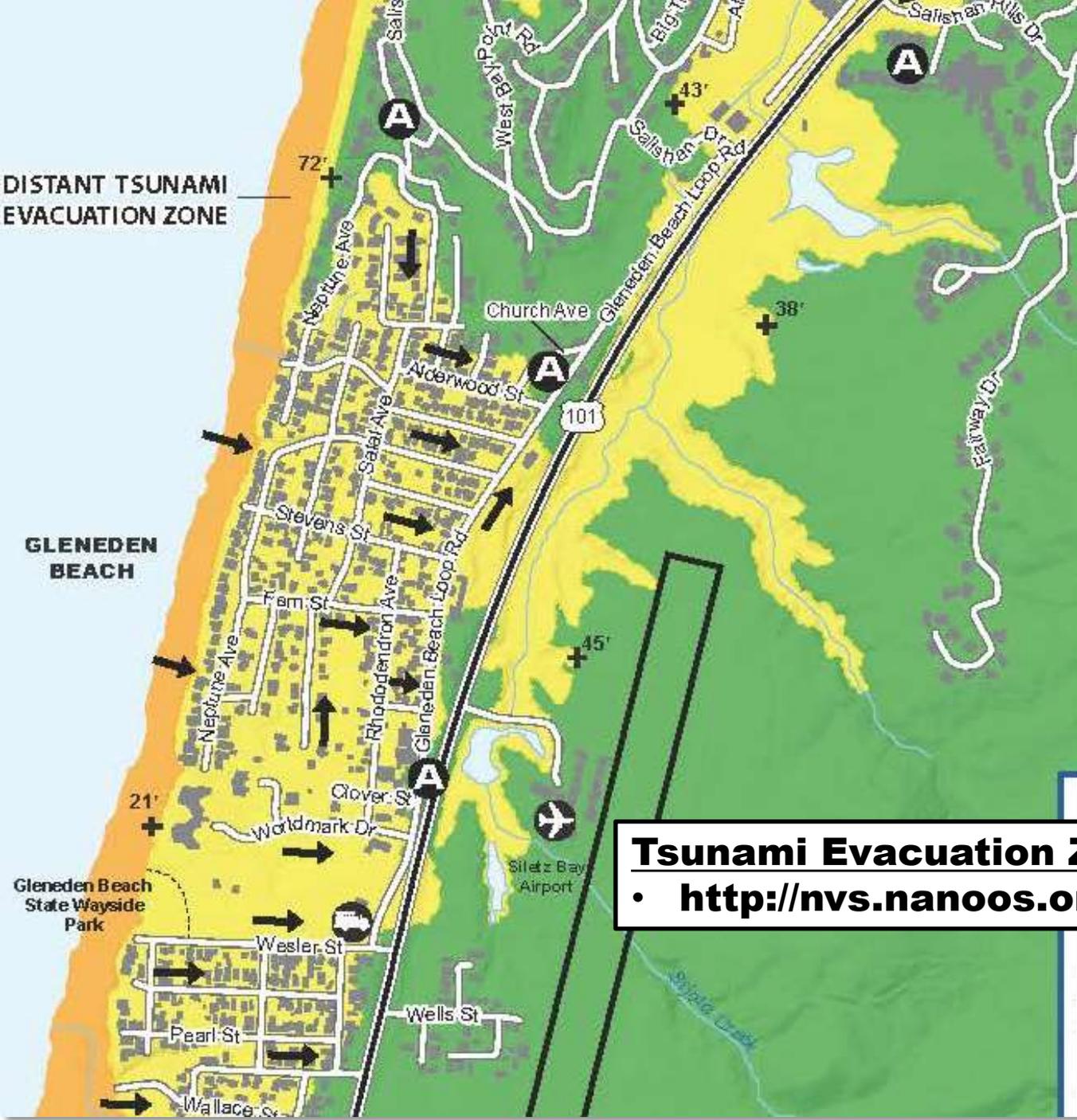
Identify High Ground

- **Signs**
- **Evacuation Routes**
- **Safe Areas**
 - **Temporary Assembly Areas**
 - **Vertical Evacuation Options**



PARED

DISTANT TSUNAMI EVACUATION ZONE



GLENEDEN BEACH

Gleneden Beach State Wayside Park

Tsunami Evacuation Zone Map Viewer
• <http://nvs.nanoos.org/TsunamiEvac>



Tsunami Inundation Maps

- <http://www.oregongeology.org/tsuclearinghouse/pubs-inumaps.htm>

A



OREGON PREPARED

Distant Tsunami

Earthquake Far Away

You won't feel the ground shake

4+ hours before waves arrive

Limited Inundation

Local Planning Guidance on Distant Tsunami Response

http://www.oregon.gov/OMD/OEM/plans_train/Tsunami/Guidance_for_Distant_Tsunami_Response.pdf



OREGON PREPARED

- **Beaches**
- **Harbors**
- **Rivers, Inlets**
- **Other low-lying areas**





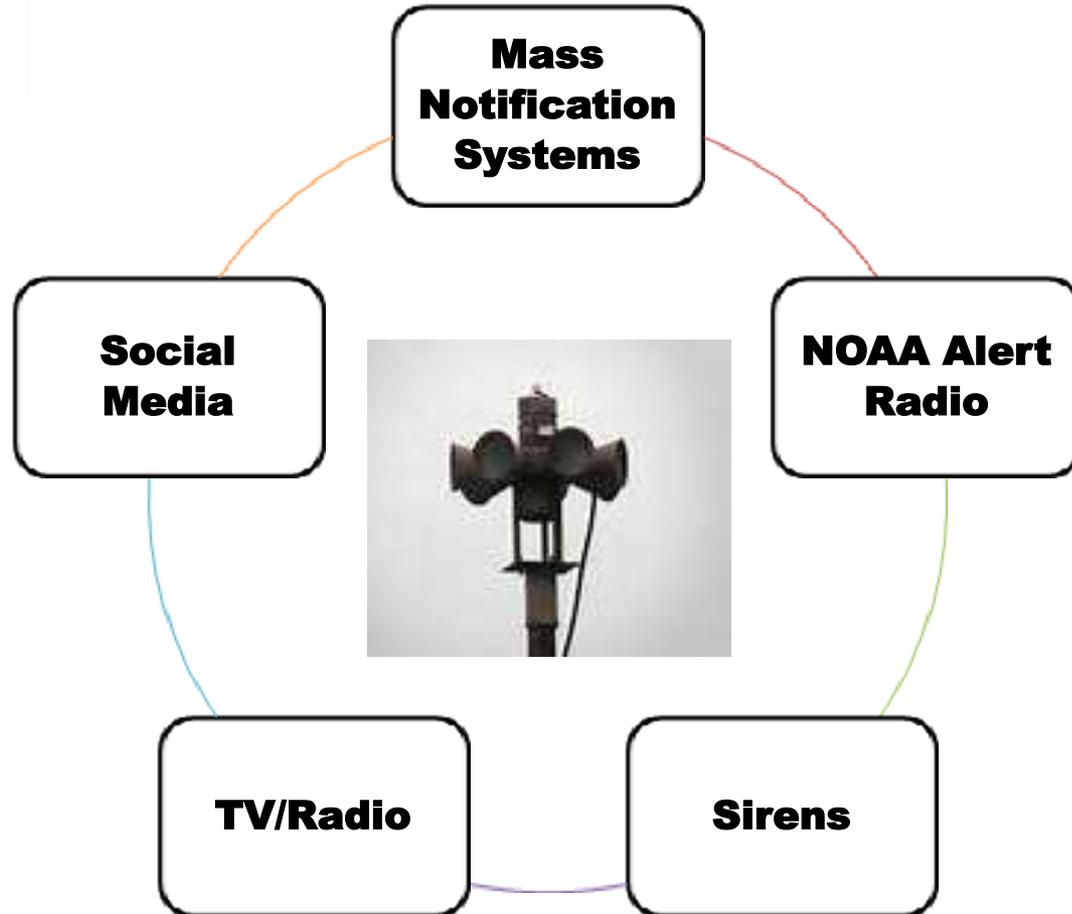
OREGONPREPARED

Tsunami Alert Messages

Alert Level	Threat	Action
Information Statement	Minor waves at most	No action suggested
Watch	Danger level not yet known	Stay alert for more info
Advisory	Strong currents likely	Stay away from the shore
Warning	Inundating waves possible	Full evacuation suggested



OREGON PREPARED



Distant Tsunami Notification



OREGON PREPARED

Distant Tsunami Evacuation



- **WHO:** Only those in the distant tsunami zone
- **HOW:** Probably by car
- **WHERE:** ???



OREGONPREPARED

- **Cancellation Message**
- **Re-enter with Caution**
- **Damage**
 - **Harbors**
 - **Beaches**
 - **Low-lying areas**
 - **Roads, Bridges**
- **Clean up**



OREGONPREPARED

**SHOULD ANYONE DIE
FROM A DISTANT TSUNAMI?**

NO



OREGONPREPARED

**Great Oregon ShakeOut
October 16, 2014**

**A state-wide
Drop, Cover and Hold On
Earthquake drill.
Shakeout.org/Oregon**



OREGONPREPARED

Contact Information

**Geological Hazard
Program Coordinator
Althea Rizzo
(503) 378-2911 ext.
22237**

Althea.rizzo@state.or.us

