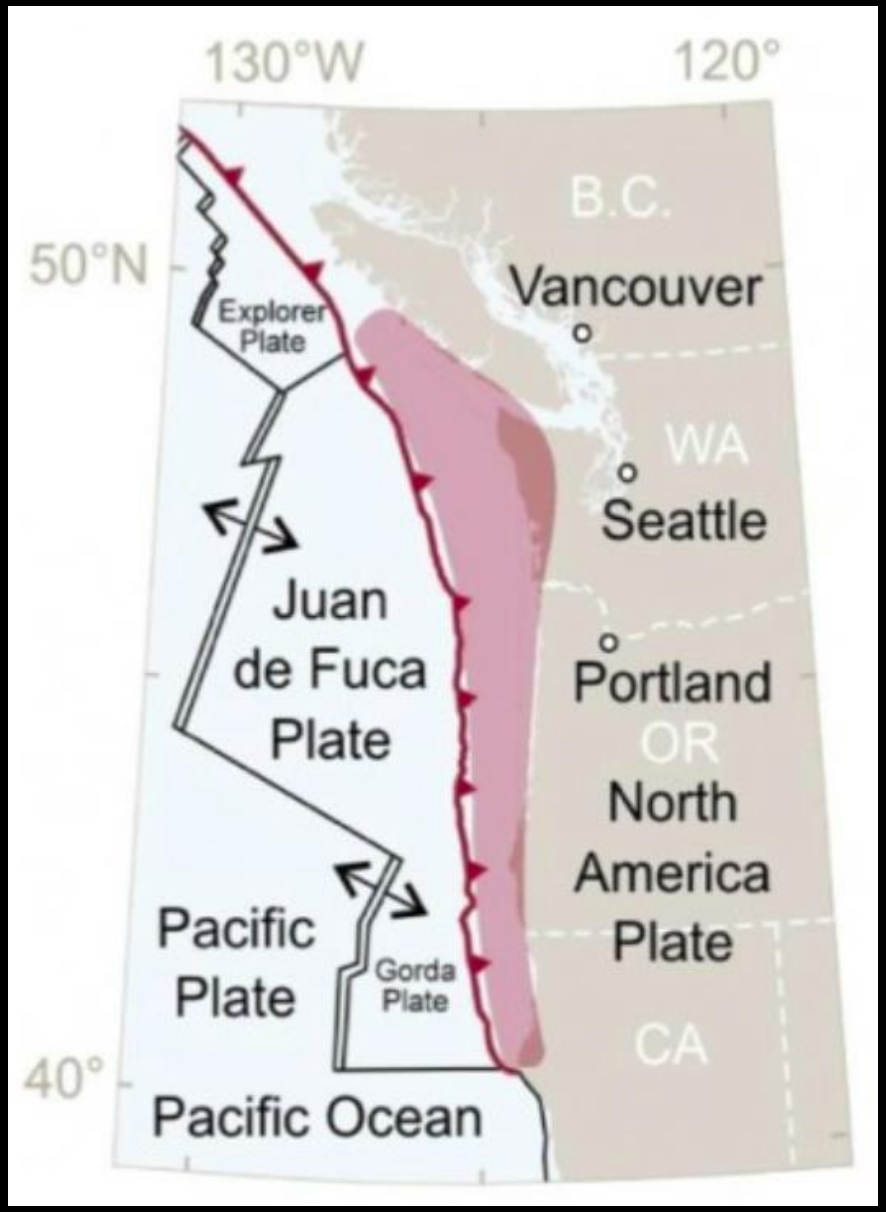
How to communicate Cascadia Subduction Zone earthquake hazards

Tom Brocher
Research Geophysicist
Earthquake Science Center
U.S. Geological Survey
Menlo Park, California

USGS
science for a changing world



Seattle Post-Intelligencer

Lessons from other earthquakes

- ✓ Provide context – discuss the hazard in relation to what people have experienced in the past
- ✓ Be realistic about hazards – don't conflate them
- ✓ Be clear about what is known and what is not known – make sure everyone appreciates that our knowledge will evolve over time
- ✓ Coordinate our communications with emergency managers, engineers, and public health officials
- ✓ Use simple language and a range of formats

USGS
science for a changing world

To encourage preparedness

- ✓ Provide examples of how preparedness has made a difference in previous earthquakes and tsunamis
- ✓ Talk about what is already been done to prepare
- ✓ Tell people what they can do to prepare
- ✓ Showing images of others preparing will more likely lead the audience to take action

Retrofit House

USGS
science for a changing world

Learning Lessons for Resiliency from Similar Earthquakes

The 1960, 2010, and 2015 Chile, 1964 Alaska, 2004 Sumatra, and the 2011 Japan M9+ subduction earthquakes all taught valuable lessons on survival strategies, hazard mitigation, and building practices. The US sent teams of geoscientists and engineers to learn these lessons.

There is good news: Modern building codes in Japan (2011) and in Chile (2010, 2015) resulted in relatively little building damage to newer buildings

Biggest lesson: Almost all of the property damage and fatalities resulted from the tsunamis produced by the earthquakes and submarine landslides

USGS
science for a changing world

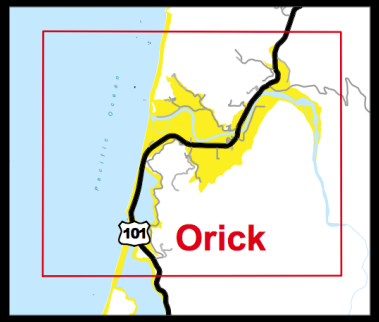
Tsunami Hazard Mitigation

Tsunami inundation maps, signed evacuation routes, tsunami sirens

Training in coastal communities that when one feels the earthquake to evacuate when the shaking stops*

Vertical evacuation structures: one is under construction in Westport, Washington

Hazard avoidance: Land use planning and zoning



USGS
science for a changing world

Tools are in place to hasten recovery

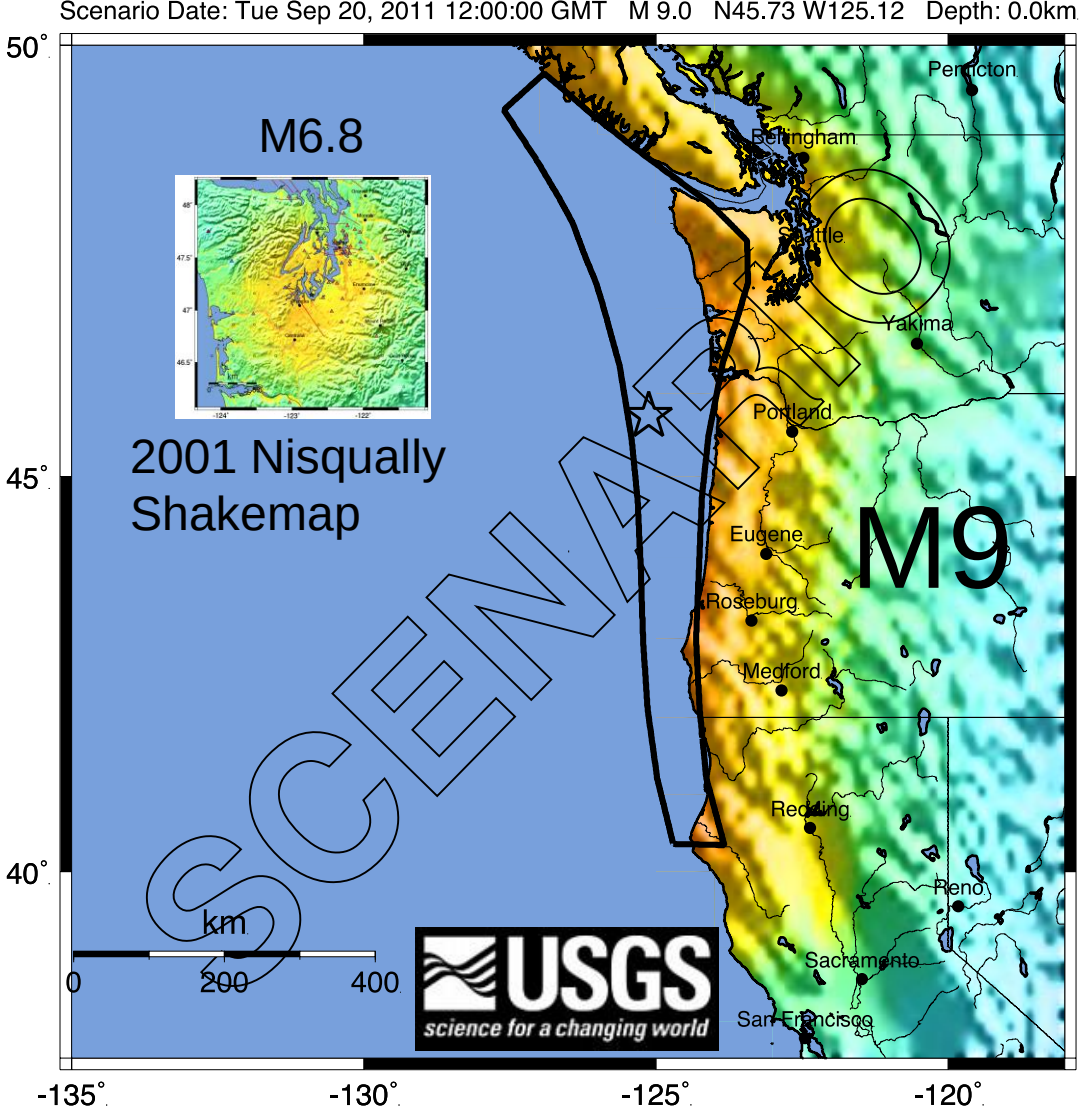
Cascadia subduction zone earthquakes have been included in the USGS National Seismic Hazard Map since 1996 and in the building codes since International Building Code 2000. The USGS National Seismic Hazard Maps and building codes are updated about every 6 years to incorporate the latest science into local resilience.

In the 2011 Japan and the 2010 and 2015 Chilean subduction earthquakes, similar building codes prevented significant building damage to modern buildings

USGS earthquake scenario maps

USGS is performing supercomputer simulations of strong ground motions: these show that ground motions in the I-5 corridor will be lower than those on the coast

USGS
science for a changing world

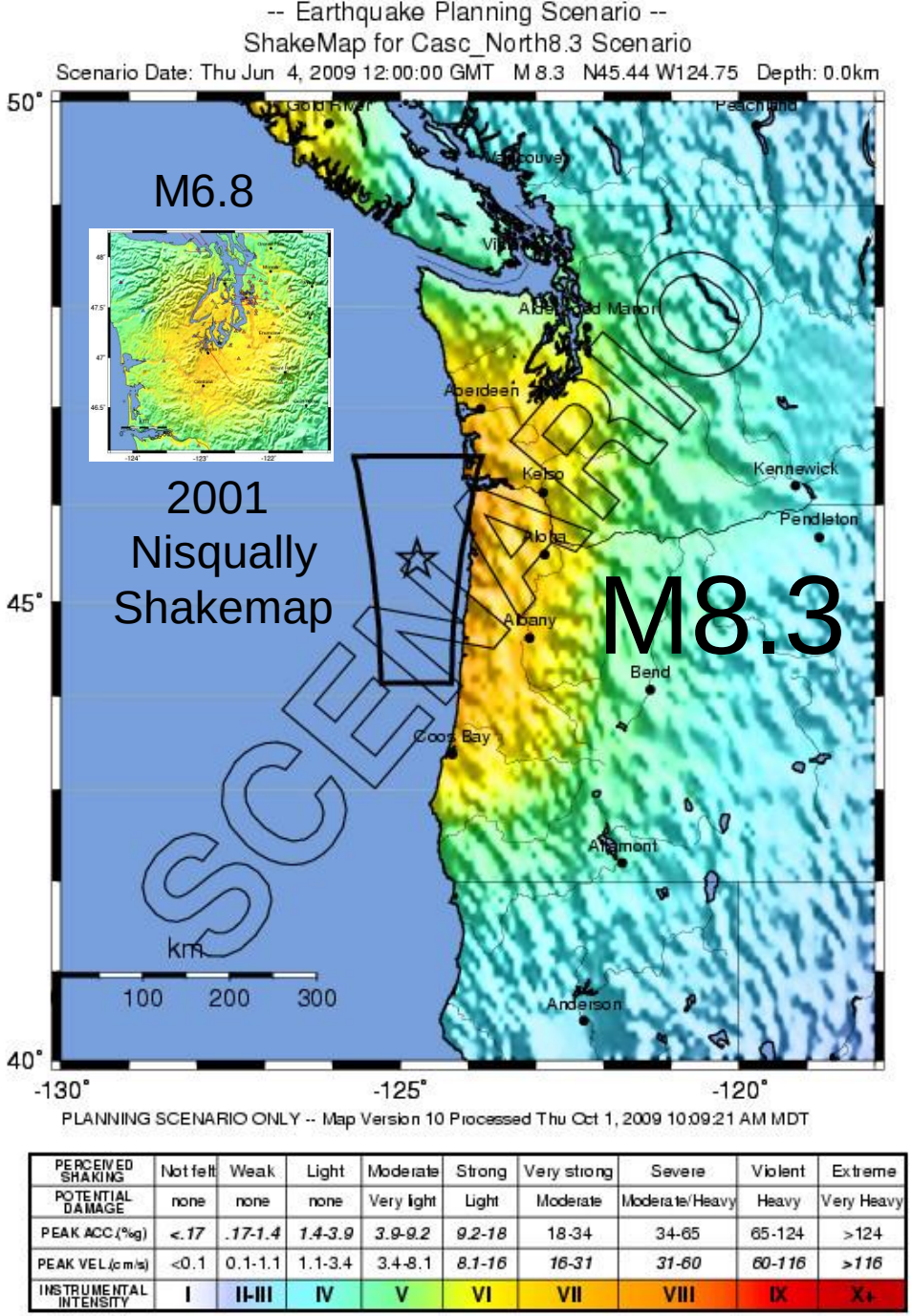


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1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

We've experienced similar shaking levels before (albeit not the duration of the shaking)

The expected shaking levels along the I-5 urban corridor are comparable to the shaking levels experienced in the M6.8 2001 Nisqually earthquake

Shaking levels are reduced by fact that the earthquake is primarily offshore and deep



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+

USGS National Seismic Hazard Maps include many possibilities to cover all unknowns and uncertainties, including the possibility of M8 earthquakes anywhere on the Cascadia subduction zone

Once again, shaking levels along the I-5 urban corridor are comparable to those of the Nisqually earthquake

USGS
science for a changing world

Tools to mitigate aftershocks

Large (magnitude 6 to 7) aftershocks will begin immediately after the earthquake

Aftershocks will be widespread: along the megathrust, in the downgoing oceanic crust, and in the crust of the Coast Ranges

Aftershocks can cause additional damage, hamper rescue operations, and take a psychological toll on people

USGS issues aftershock forecasts

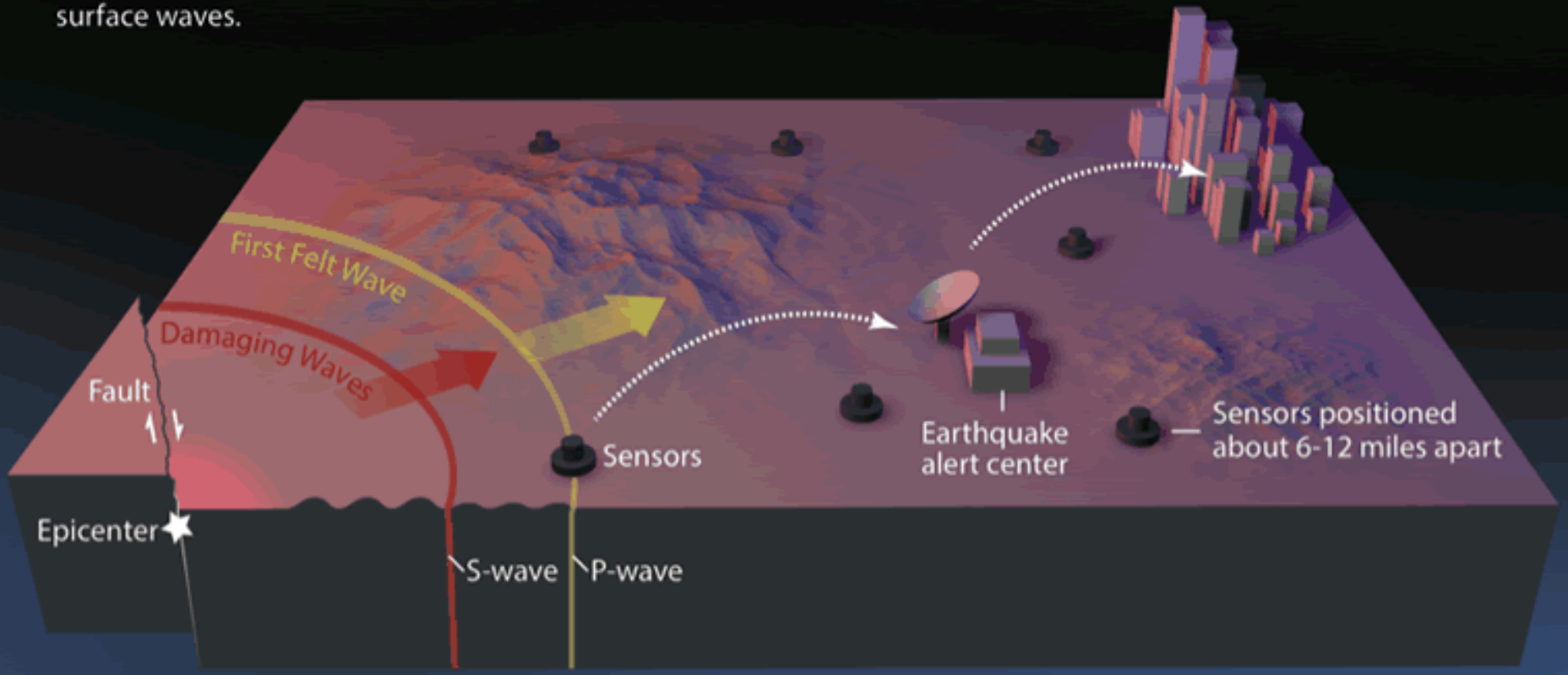
After the 1989 Loma Prieta earthquake the USGS issued realtime aftershock alerts to rescuers working in a collapsed freeway

Earthquake Early Warning Basics

1 In an earthquake, a rupturing fault sends out different types of waves. The fast-moving P-wave is first to arrive, but damage is caused by the slower S-waves and later-arriving surface waves.

2 Sensors detect the P-wave and immediately transmit data to an earthquake alert center where the location and size of the quake are determined and updated as more data become available.

3 A message from the alert center is immediately transmitted to your computer or mobile phone, which calculates the expected intensity and arrival time of shaking at your location.



USGS science for a changing world

Shaking Warning

The USGS, University of Washington, UC Berkeley, and Caltech are partnered on a prototype earthquake early warning system called ShakeAlert

A similar system in Japan worked during the M9 2011 Tohoku, Japan earthquake

ShakeAlert will provide up to a few minutes of warning for a Cascadia subduction zone earthquake

Among many other uses, aftershock alerts can reduce anxiety and inform rescue operations

USGS
science for a changing world

There will be a new coastline along the Pacific Ocean

There will be an instant and permanent lowering of the Pacific coast of 3 to 6 feet and daily tides will reach further inland in many low-lying areas.

Plan for immediate flooding hazard resulting from this “instant” sea level rise

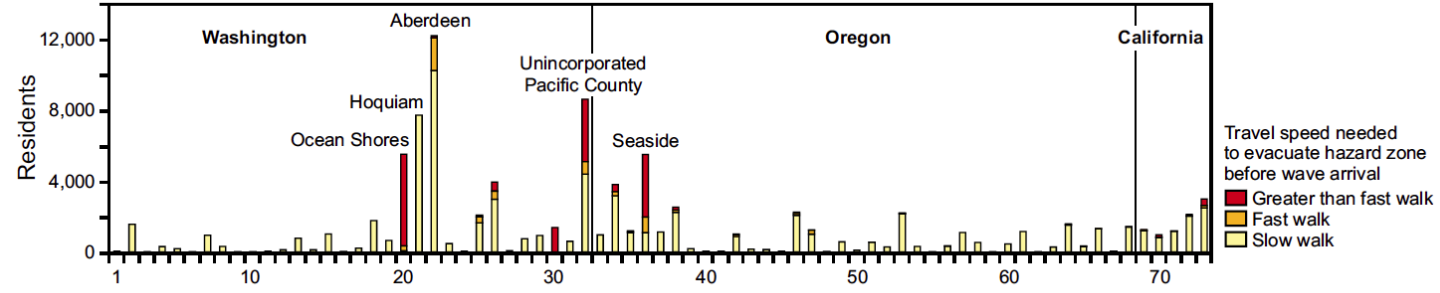
Plan for longer term coastal erosion

Mitigate known vulnerabilities

Older pre-code & other vulnerable buildings

- unreinforced masonry buildings
- buildings with structurally weak first stories
- pre-code buildings in soft soils
- tall buildings in sedimentary basins

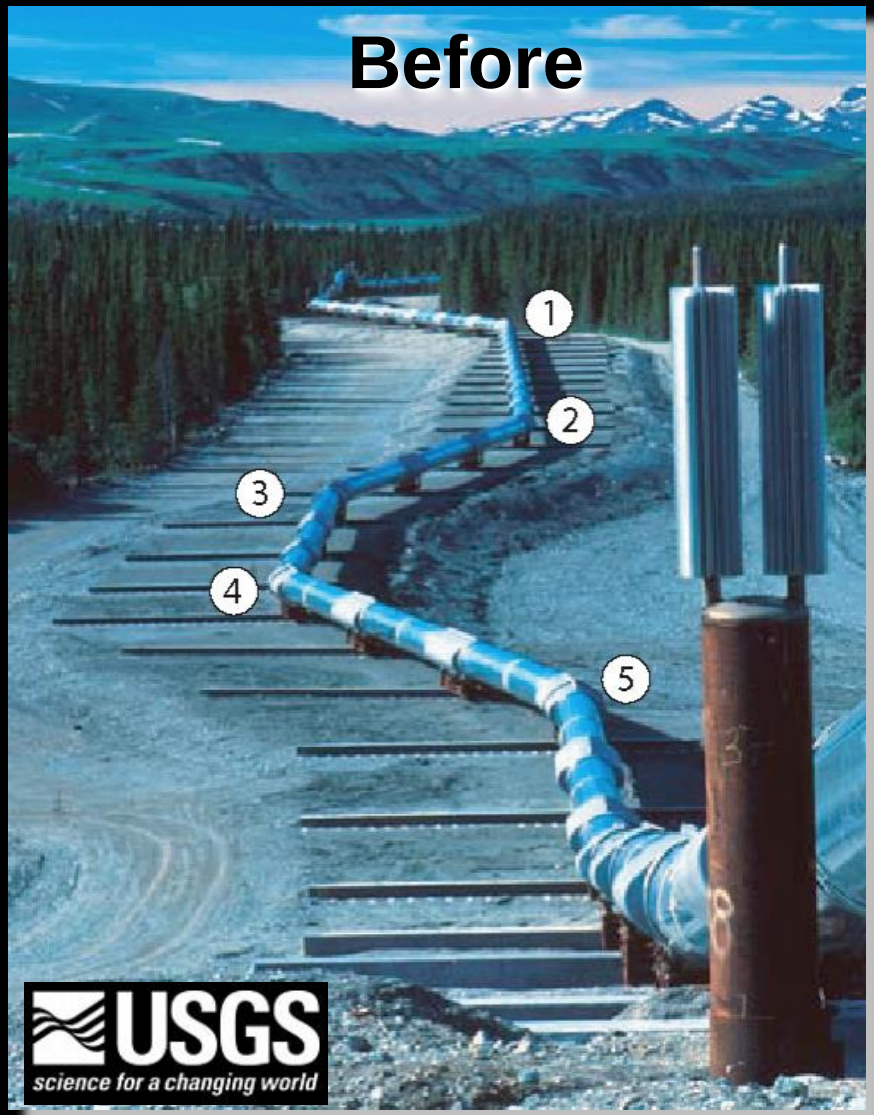
Tsunami evacuation challenges



USGS authored report, 2015

USGS
science for a changing world

Hazard Assessment led to a successful mitigation: Alaska Oil Pipeline in 2002 M7.9 Denali earthquake



We have recognized the hazards before the event, now they can be mitigated

Geological histories going back thousands of years converge on 500 years as an approximate average amount of time between back-to-back earthquakes along most of the Cascadia subduction zone. This average interval implies a one-in-ten chance of a Cascadia earthquake as large as magnitude 9 within 50 years.

For context, the odds of a repeat of a M6.8 Nisqually type earthquake in the Puget Lowland within 50 years are about 8 to 9 times higher.

USGS
science for a changing world

Contact me:

Tom Brocher
Earthquake Science Center
U.S. Geological Survey
Menlo Park, California
brocher@usgs.gov