



Seismic Vulnerabilities of Multnomah County's Willamette River Bridges

November 6, 2014

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Response to the Budget Note

- 1) Are there really earthquakes in Oregon?
- 2) Are the Willamette River bridges vulnerable?
- 3) What are examples of similar vulnerabilities?
- 4) What can be done to prepare for “The Big One”?
- 5) What have other Agencies done in response to their seismic vulnerabilities?

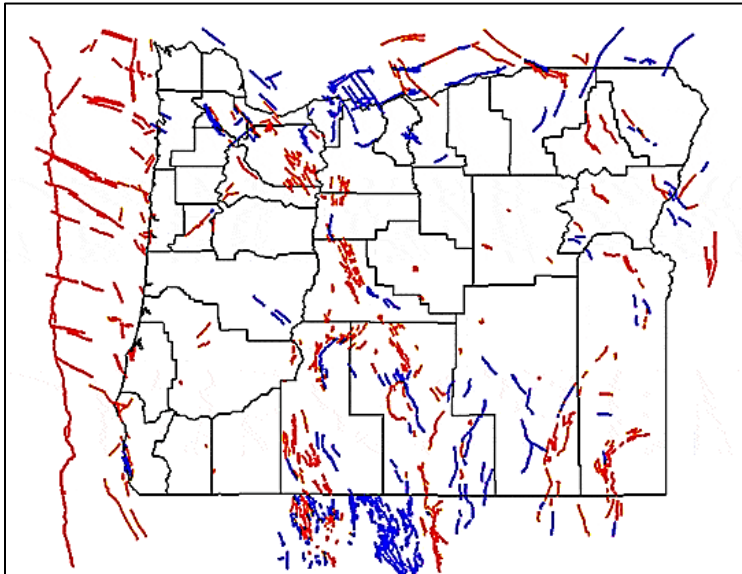


Are there really
earthquakes in
Oregon?

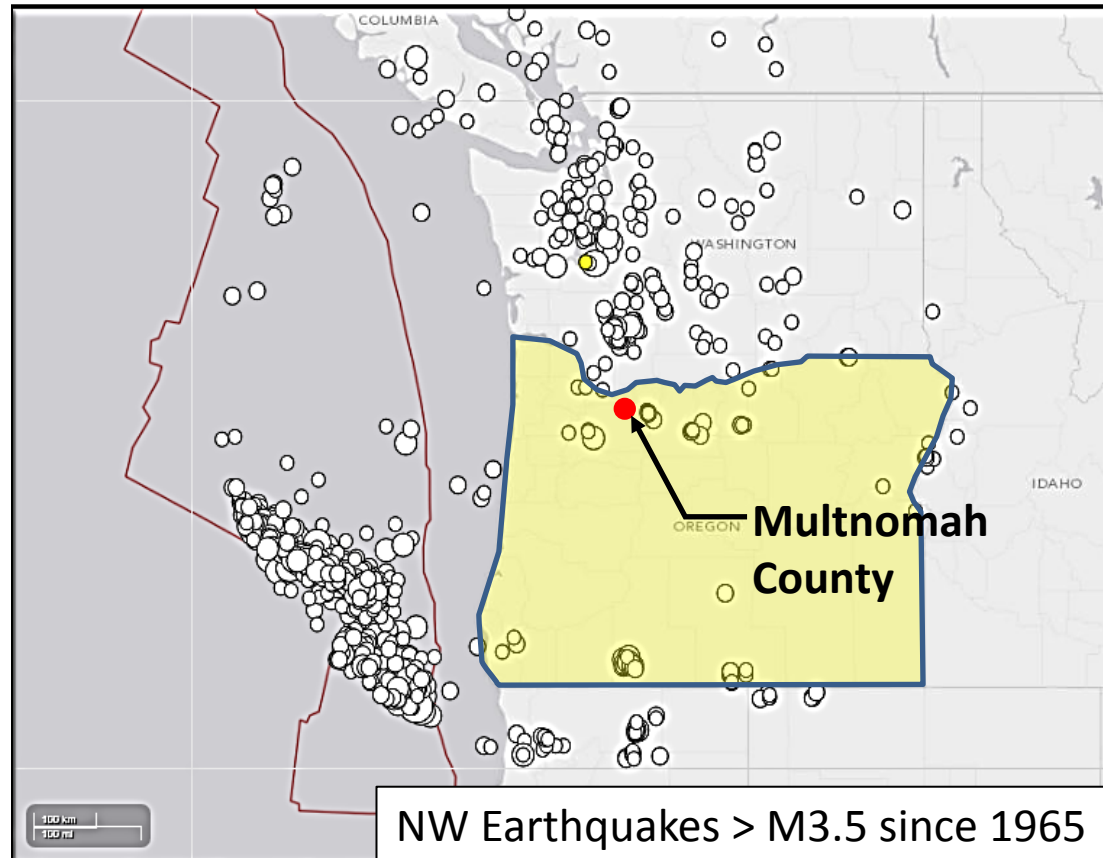
NW Earthquake Activity

Source	Magnitude	Frequency	Latest Occurrence
Crustal	$M < 5.5$	Every 15–20 years	Annually
	$M \geq 5.5$???	1993: Scotts Mills & Klamath-Falls
CSZ*	$M \geq 8.0$	Every 350–500 years	January, 1700
Intraplate	$M = 4-7$	Every 30–50 years	Feb., 2009 M4.1, Grants Pass, OR

Note: $M9.0 = 1000 \times$ 2014 Napa EQ

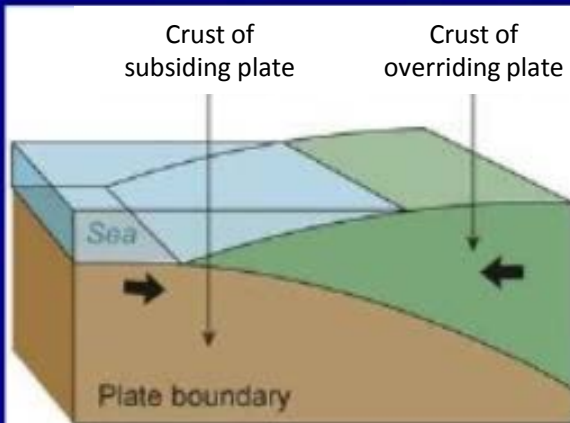
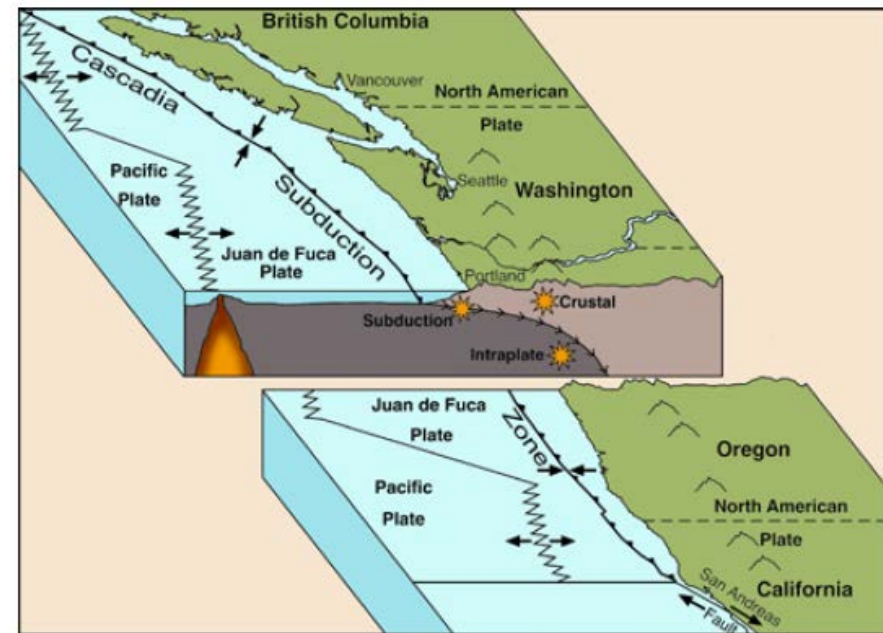


Known Oregon EQ Faults

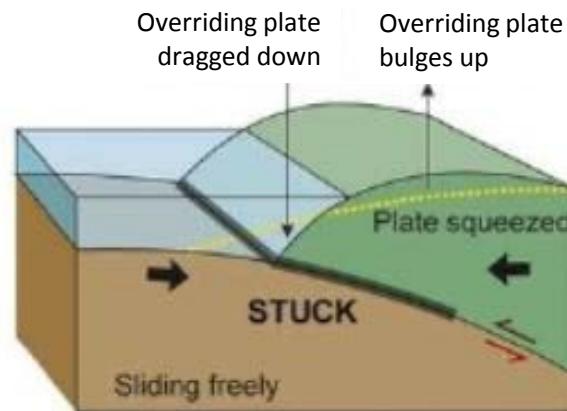


NW Earthquakes $> M3.5$ since 1965

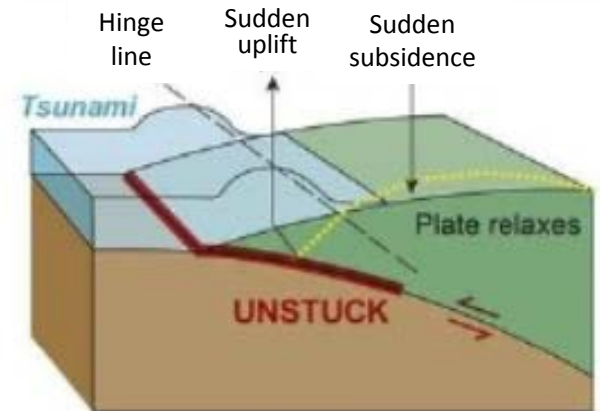
Oregon's Cascadia Subduction Zone (CSZ) EQ: AKA, "The Big One"



1 OVERALL: A tectonic plate descends, or "subducts" beneath an adjoining plate. But it does so in a stick-slip fashion.



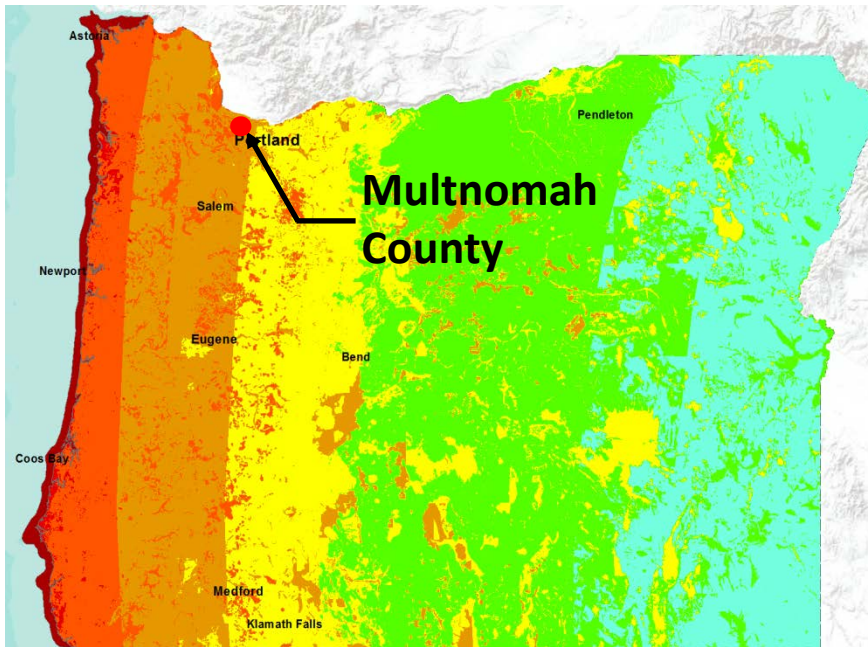
2 TIME BETWEEN EARTHQUAKES: The plates slide freely at great depths, where hot and ductile. But at shallow depths, where cool and brittle, they stick together. Slowly squeezed, the top plate thickens.



3 DURING AN EARTHQUAKE: The leading edge of the top plate breaks free, springing seaward and upward. Behind, the plate stretches; its surface falls. The vertical displacements set off a tsunami.

M8+ Cascadia Subduction Zone EQ Predictions

- **37% Chance in next 50 Years**
- **2 to 4 minutes of *intensive* shaking**
- **1,250 to 10,000 immediate fatalities**
 - **Up to 5,000 more fatalities** due to lack of emergency response
- **\$350 Billion** in economic loss over 8-10 years
- **10s of thousands** of displaced households and destroyed buildings
- **Hundreds** of bridge failures

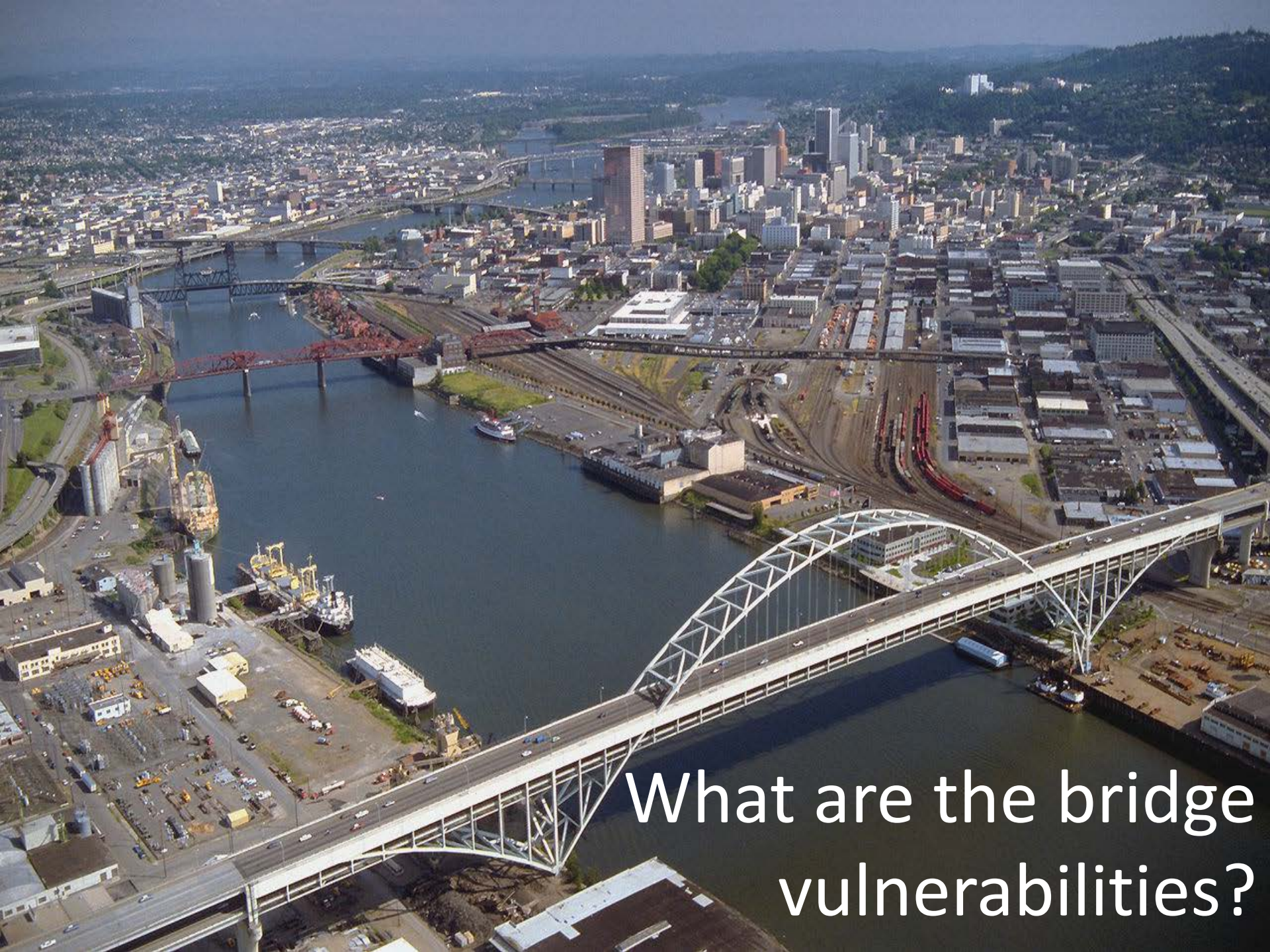


“ODOT has expended minimal resources on seismic retrofitting. As a result, much of Oregon’s highway system will not be usable immediately after a major seismic event.” – *ORP*

Sources:

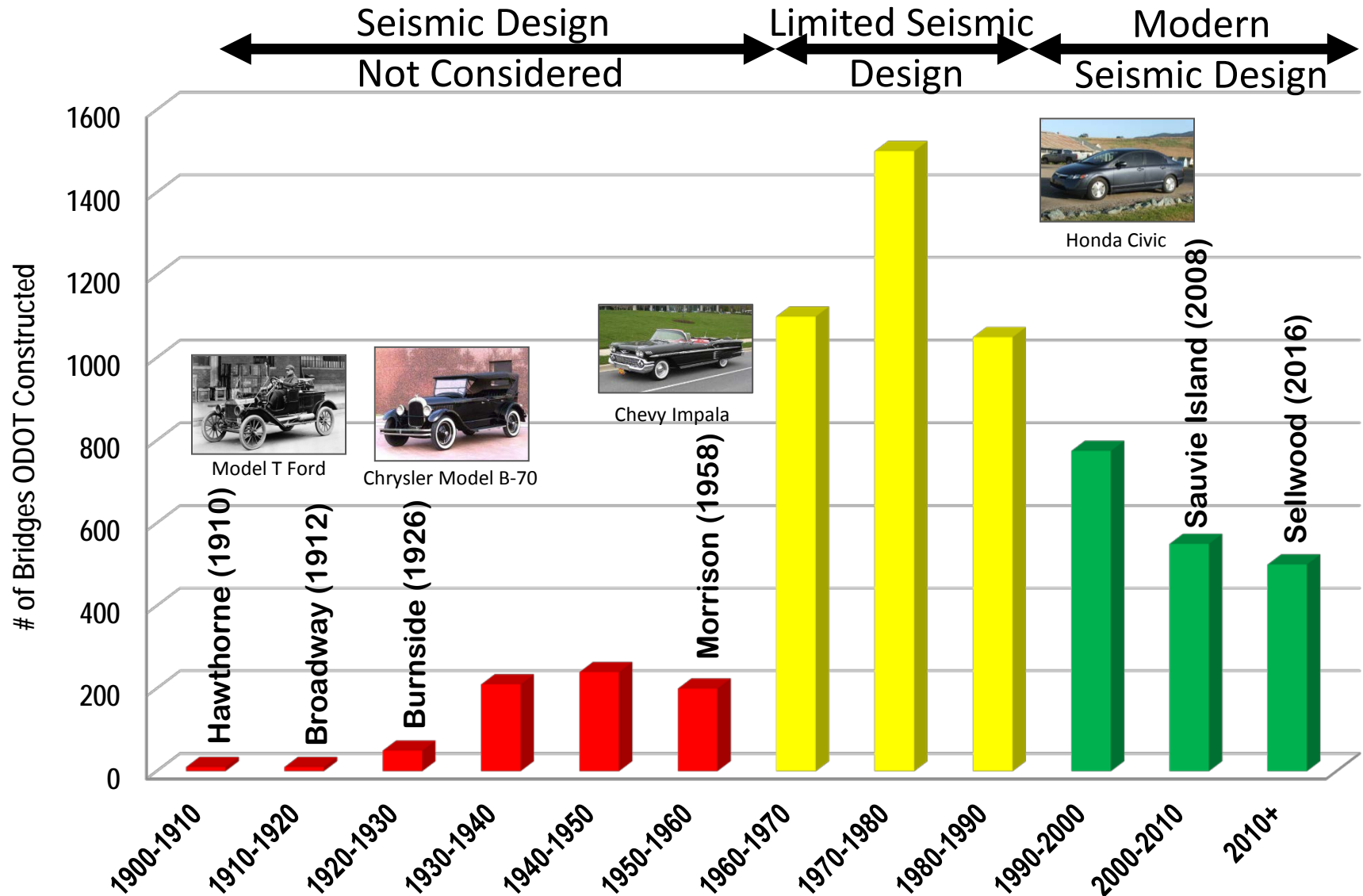
“Oregon Highway Seismic Options Report” (Mar, 2013)
Oregon Department of Transportation

“Oregon Resiliency Plan” (Feb, 2013)
Report to the 77th Legislative Assembly from Oregon
Seismic Safety Policy Advisory Commission (OSSPAC)



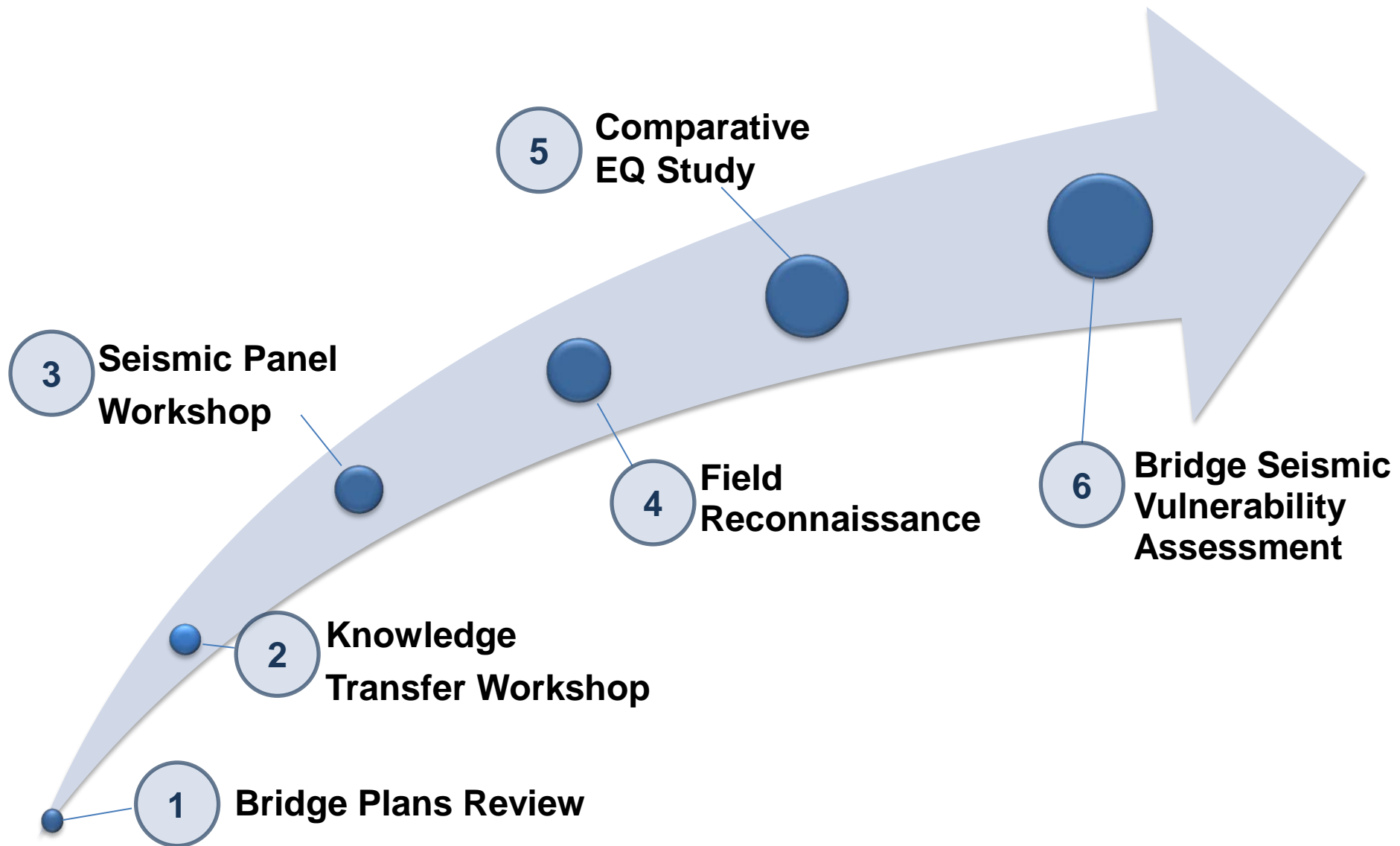
What are the bridge
vulnerabilities?

Oregon Seismic Design History





2014 Seismic Assessment Process



Multnomah County's Willamette River Bridges

✓ Sauvie Island Bridge (Seismically OK)

x Broadway Bridge

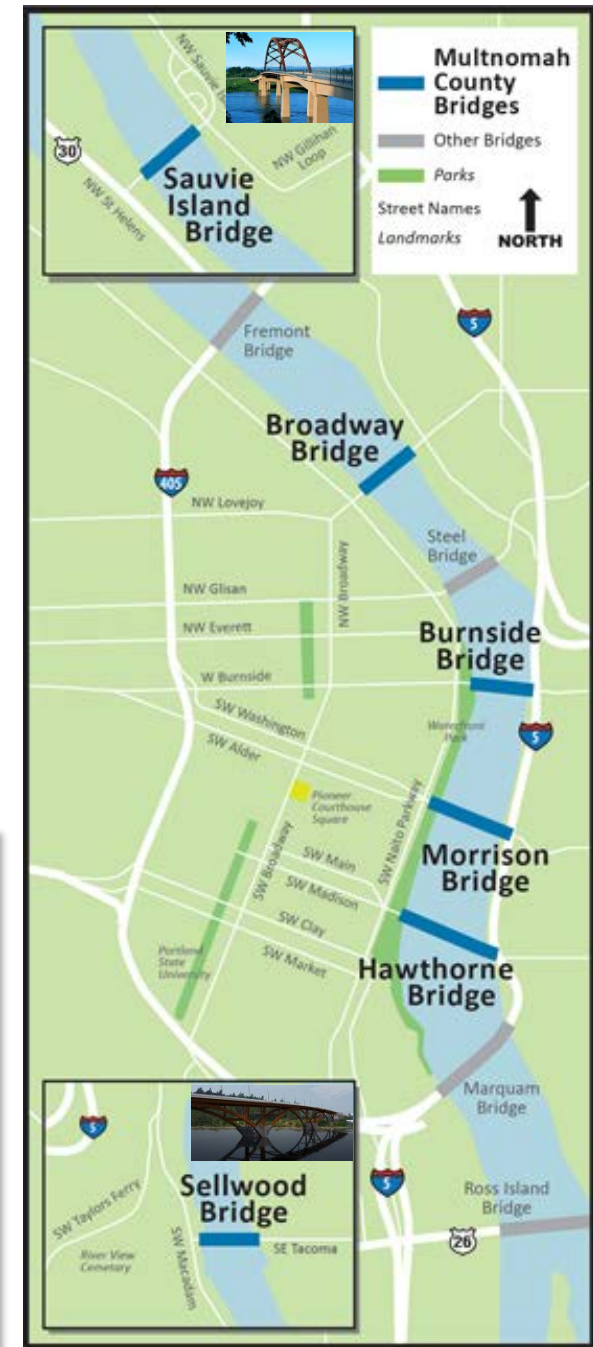
x Burnside Bridge

x Morrison Bridge

x Hawthorne Bridge

✓ Sellwood Bridge (Seismically OK)

Note: Multnomah County is also responsible for 20 other smaller bridges.



Broadway Bridge Extents & Unique Details



Broadway Bridge – Double-Leaf Rail-type Bascule Bridge



Primary Seismic Vulnerabilities:

- Bridge falling from its supports
- Piers and columns
- Below-water foundations
- Rail wheel and track
- Mechanical and electrical systems
- Liquefaction settlement
- Bearing connections
- Truss members

Broadway Bridge – Double-Leaf Rail-type Bascule Bridge



Primary Seismic Vulnerabilities:

- Bridge falling from its supports
- Piers and columns
- Below-water foundations
- Rail wheel and track
- Mechanical and electrical components
- Soil liquefaction settlement
- Truss members
- Bearing elements

Burnside Bridge Extents & Unique Details



Burnside Bridge – Double-Leaf Strauss-type Bascule Bridge



Primary Seismic Vulnerabilities:

- Bridge falling from its supports
- Piers and columns
- Below-water and on-land foundations
- Counterweight connections and trunnion supports
- Mechanical and electrical components
- Soil liquefaction settlement
- Truss members
- Bearing elements

Morrison Bridge Extents & Unique Details



Morrison Bridge – Double-Leaf Chicago-type Bascule Bridge

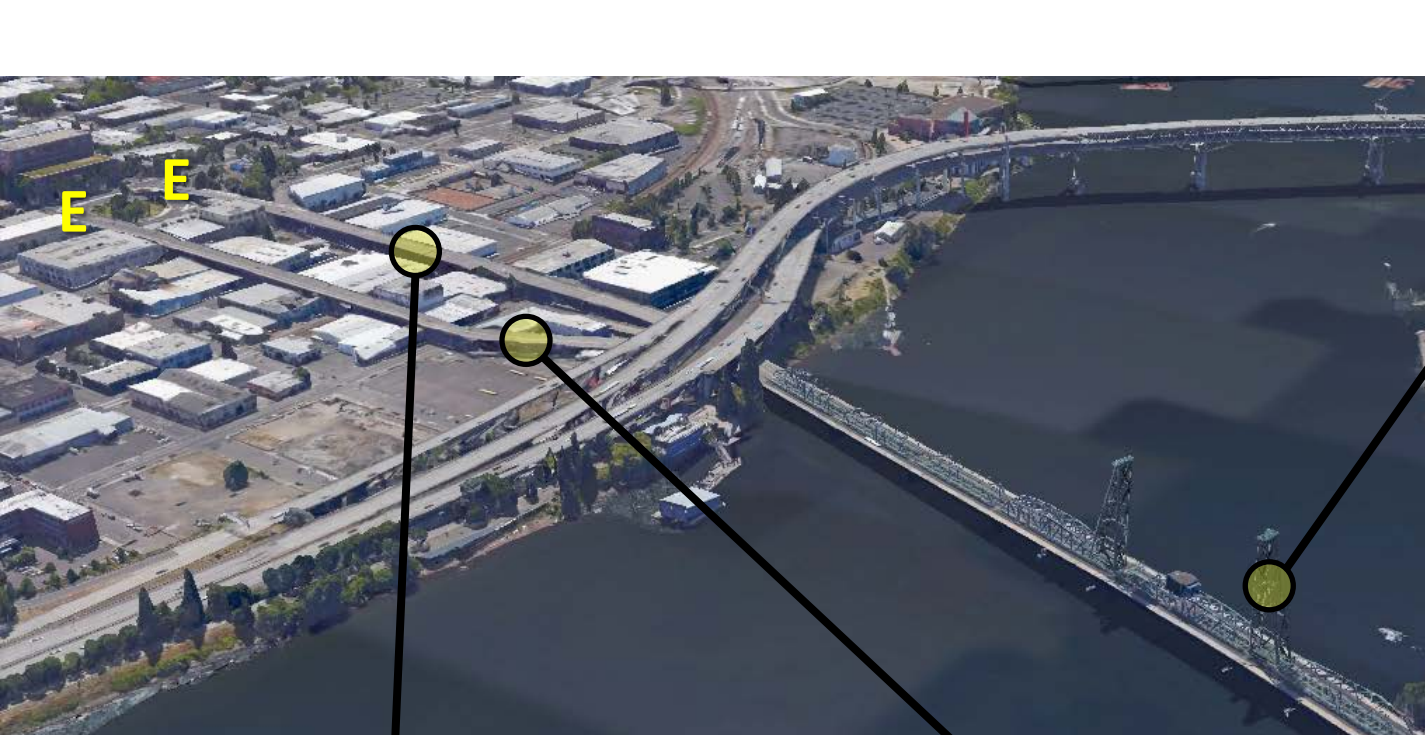


Primary Seismic Vulnerabilities:

- Bridge falling from its supports
- Piers and columns
- Below-water and on-land foundations
- Counterweight connections and trunnion supports
- Mechanical and electrical components
- Truss members
- Bearings elements



Hawthorne Br. Extents & Unique Details



Hawthorne Bridge – Vertical Lift Bridge



Primary Seismic Vulnerabilities:

- Bridge falling from its supports
- Piers and columns
- Below-water and on-land foundations
- Mechanical and electrical components
- Lift tower steel members
- Supporting cap beams
- Soil liquefaction settlement
- Truss members
- Bearing elements



Where were similar
vulnerabilities?

Major Comparable Earthquakes

Subduction Zone Earthquakes

- 2011 Tohoku (Japan) EQ – M9.0; \$235B in economic loss
 - 15,889 deaths
 - Massive Force generation (2.99g)
- **2010 Chile EQ – M8.8; \$15-30B in economic loss**
 - **525 deaths**
 - **Thirteen aftershocks > M6.0 (131 total)**
- 2004 Indian Ocean EQ – M9.0; \$Unknown
 - 280,000 deaths
 - 100' high tsunami
- 2001 Nisqually CSZ EQ (WA) – M6.8; \$1B Damage
 - 1 death
- 1964 Alaska EQ - M9.2; \$0.5B damage
 - 138 deaths (15 from EQ; Tsunami: 5 in OR, 13 in CA, & 105 elsewhere)
 - Large tsunamis and up to 38' vertical shifts
- **1700 Oregon CSZ EQ – M9; \$Unknown**



The NW's CSZ Event is expected to be similar to the 2010 Chile EQ.



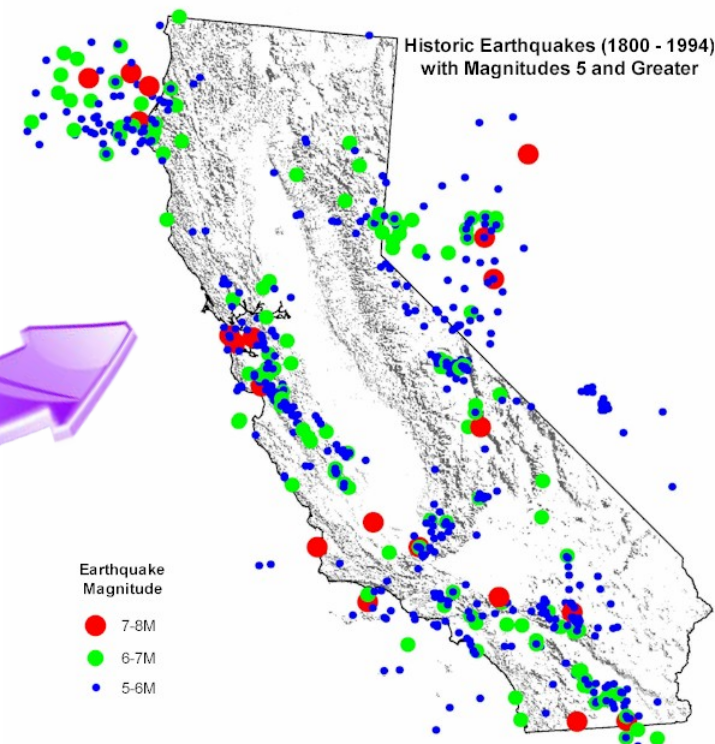
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Other West Coast Earthquakes

- 2014 Napa EQ (CA) – M6.0; \$0.7B
 - 200 injuries
- 1994 Northridge EQ (CA) – M6.7; \$20B
 - 57 deaths
 - Many bridge collapses (even post-1970 designs)
 - Very large force generation (1.8g horiz and 1.2g vertical)
- 1989 Loma Prieta EQ (CA) – M6.9; \$5.8B damage
 - Many bridge collapses (even post-1970 designs)
 - 63 deaths



2011 Tohoku (Japan) EQ and Tsunami

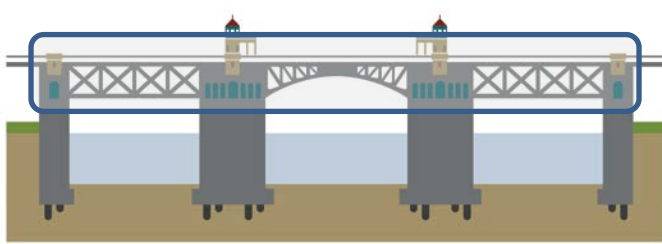


Before



After

2011 Tohoku Earthquake Bridge Sliding off its Supports



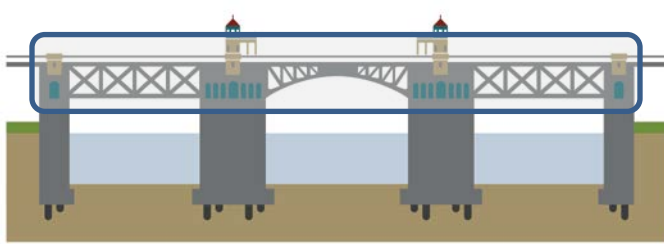
Bridge Applicability

Broadway	Burnside	Morrison	Hawthorne
●	●	●	●



2010 Chili Earthquake

Bridge Sliding off its Supports

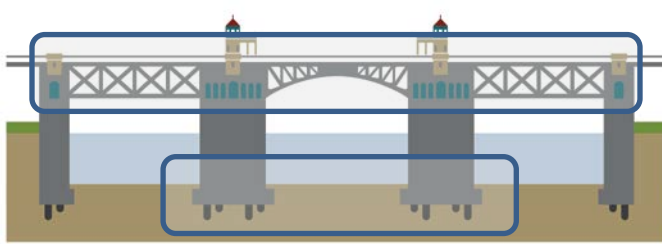


Bridge Applicability

Broadway	Burnside	Morrison	Hawthorne
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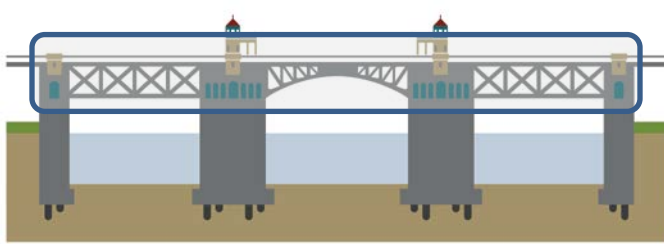
2010 Chili Earthquake Bridge Sliding off its Supports / Soil Liquefaction Settlement



Bridge Applicability

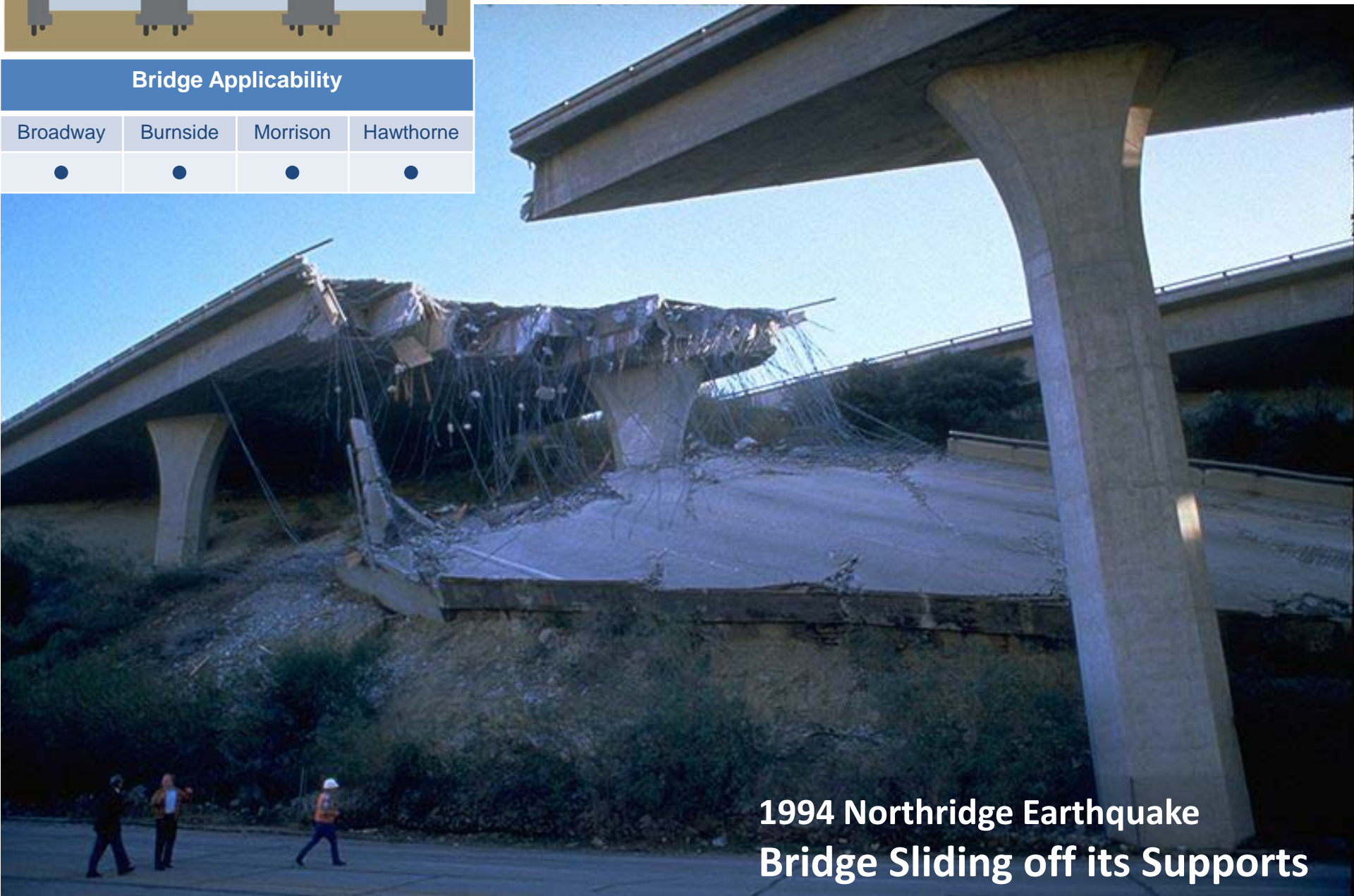
Broadway	Burnside	Morrison	Hawthorne
●	●	●	●



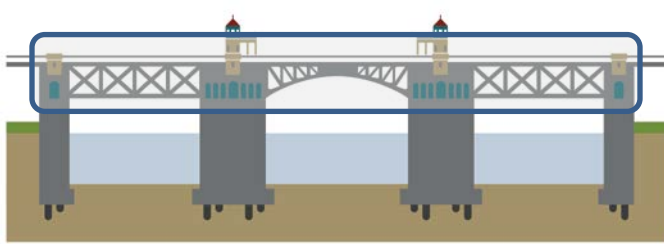


Bridge Applicability

Broadway	Burnside	Morrison	Hawthorne
●	●	●	●



**1994 Northridge Earthquake
Bridge Sliding off its Supports**

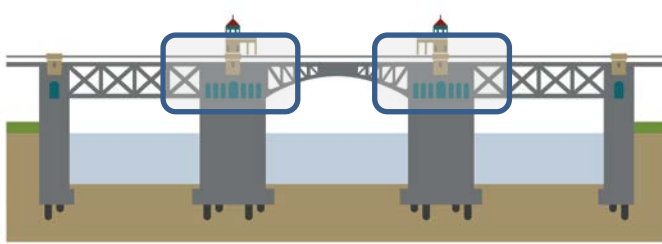


Bridge Applicability

Broadway	Burnside	Morrison	Hawthorne
●	●	●	●



**1989 Loma Prieta Earthquake
Bridge Sliding off its Supports**



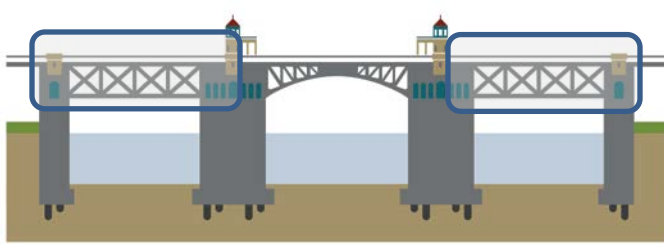
Bridge Applicability

Broadway	Burnside	Morrison	Hawthorne
●	●	●	●



**1964 Alaska Earthquake
Bridge Sliding off its Supports**

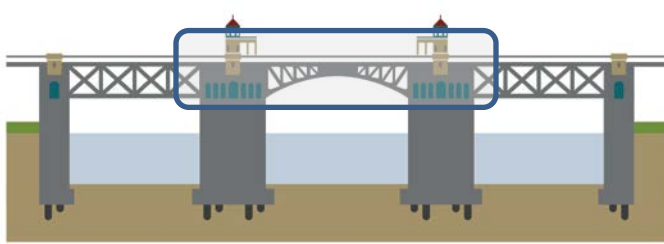
2010 Chili Earthquake Bridge Girder Damage



Bridge Applicability

Broadway	Burnside	Morrison	Hawthorne
●	●	●	●

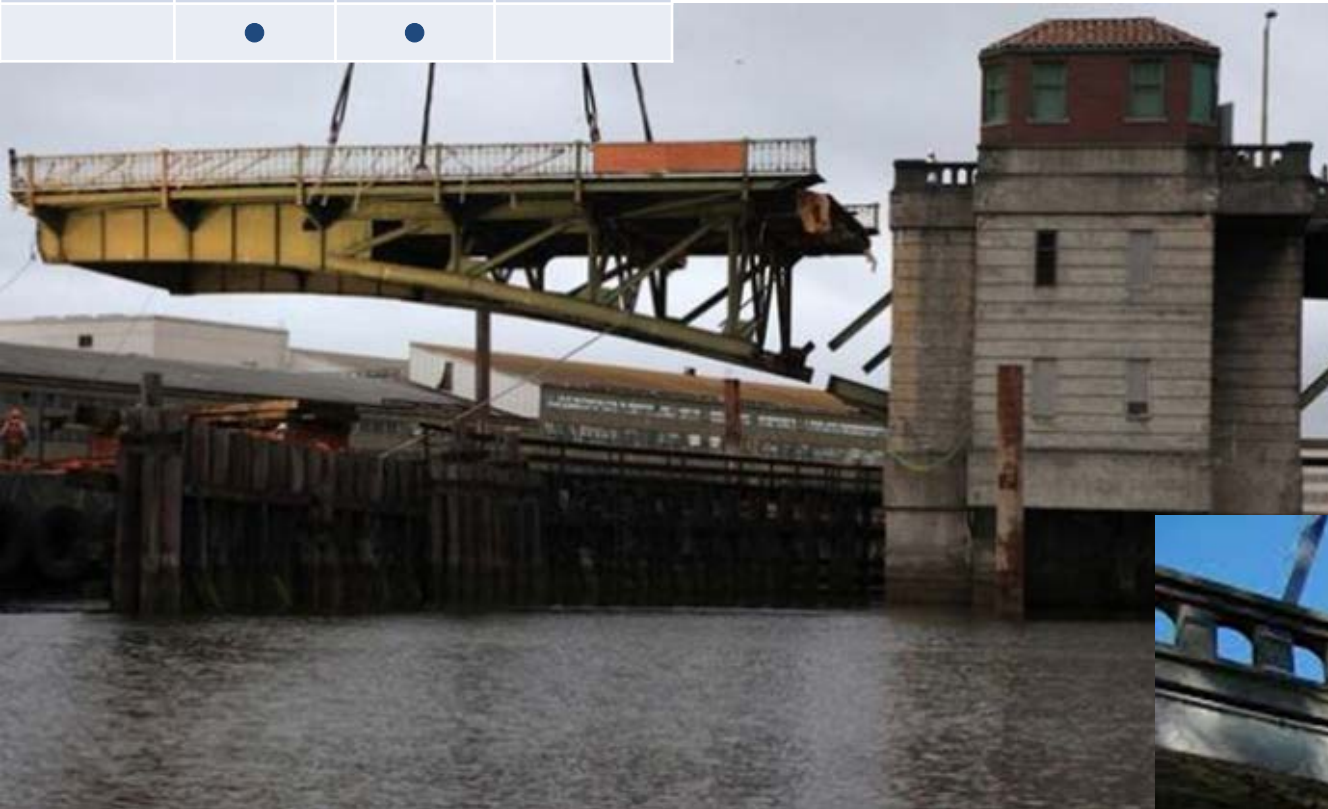




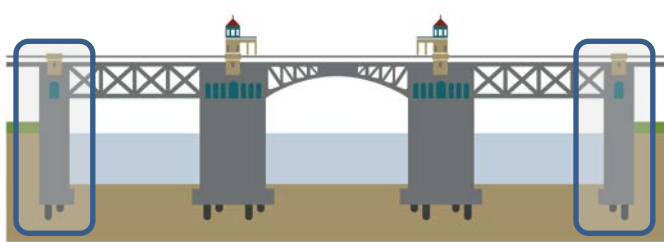
Bridge Applicability

Broadway	Burnside	Morrison	Hawthorne
	●	●	

2001 Nisqually (WA) Earthquake Retrofit costs drove the replacement of Seattle's South Park Bascule Bridge

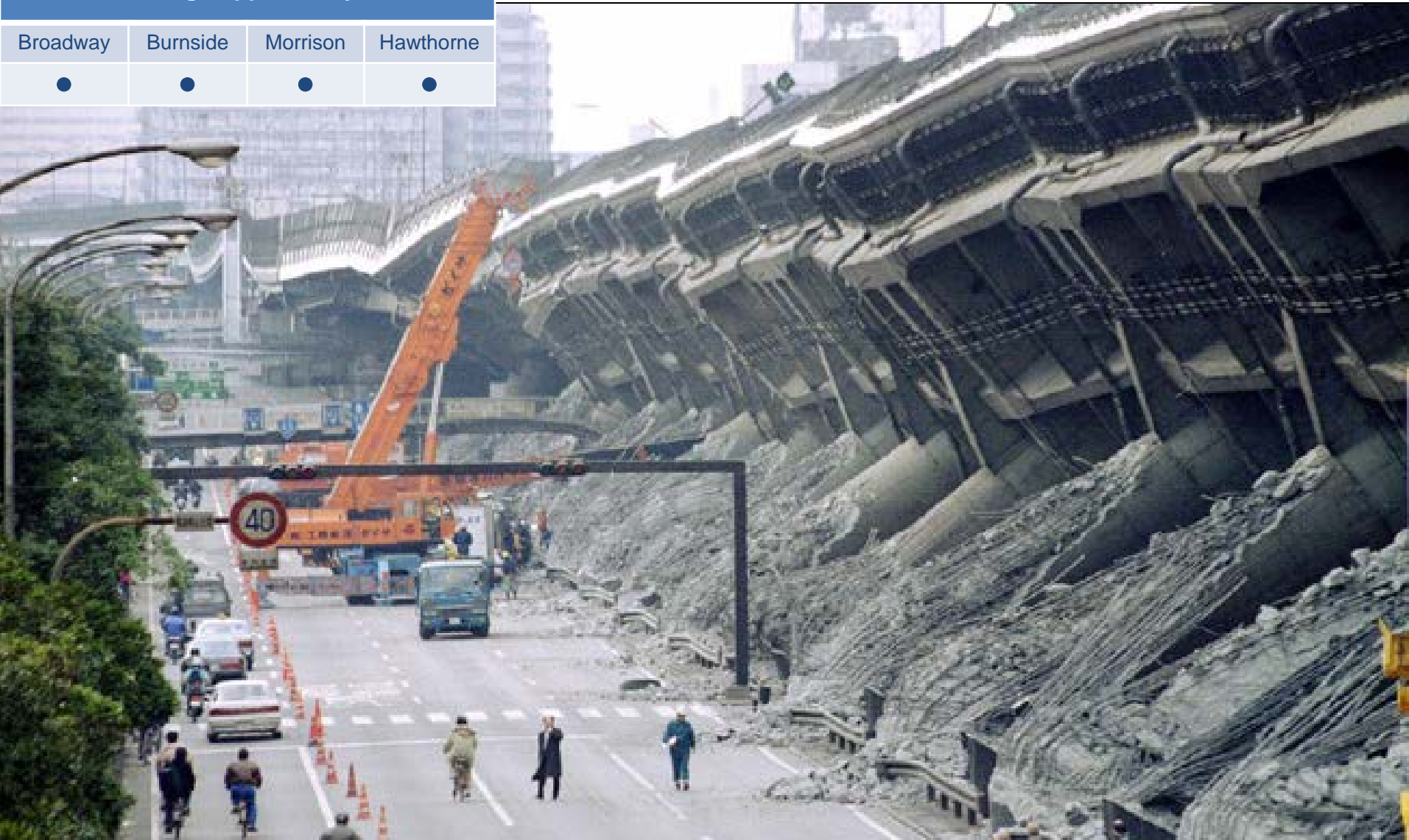


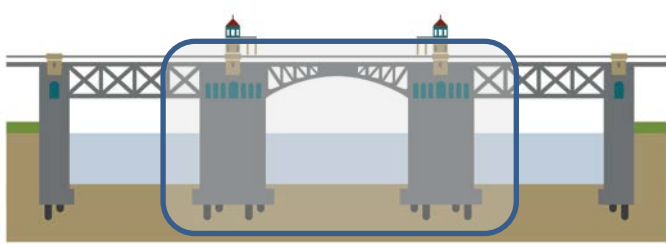
1995 Kobe Japan Earthquake Column Failure



Bridge Applicability

Broadway	Burnside	Morrison	Hawthorne
●	●	●	●





Bridge Applicability

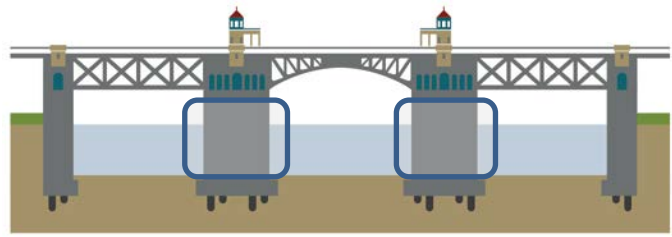
Broadway	Burnside	Morrison	Hawthorne
●	●		●



2010 Chili Earthquake
Under-Reinforced Pier Failure



**2011 Tohoku Earthquake
Soil Liquefaction Settlement / Column Damage**

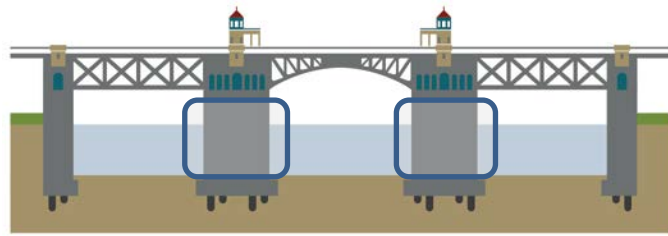


Bridge Applicability

Broadway	Burnside	Morrison	Hawthorne
●	●	●	●

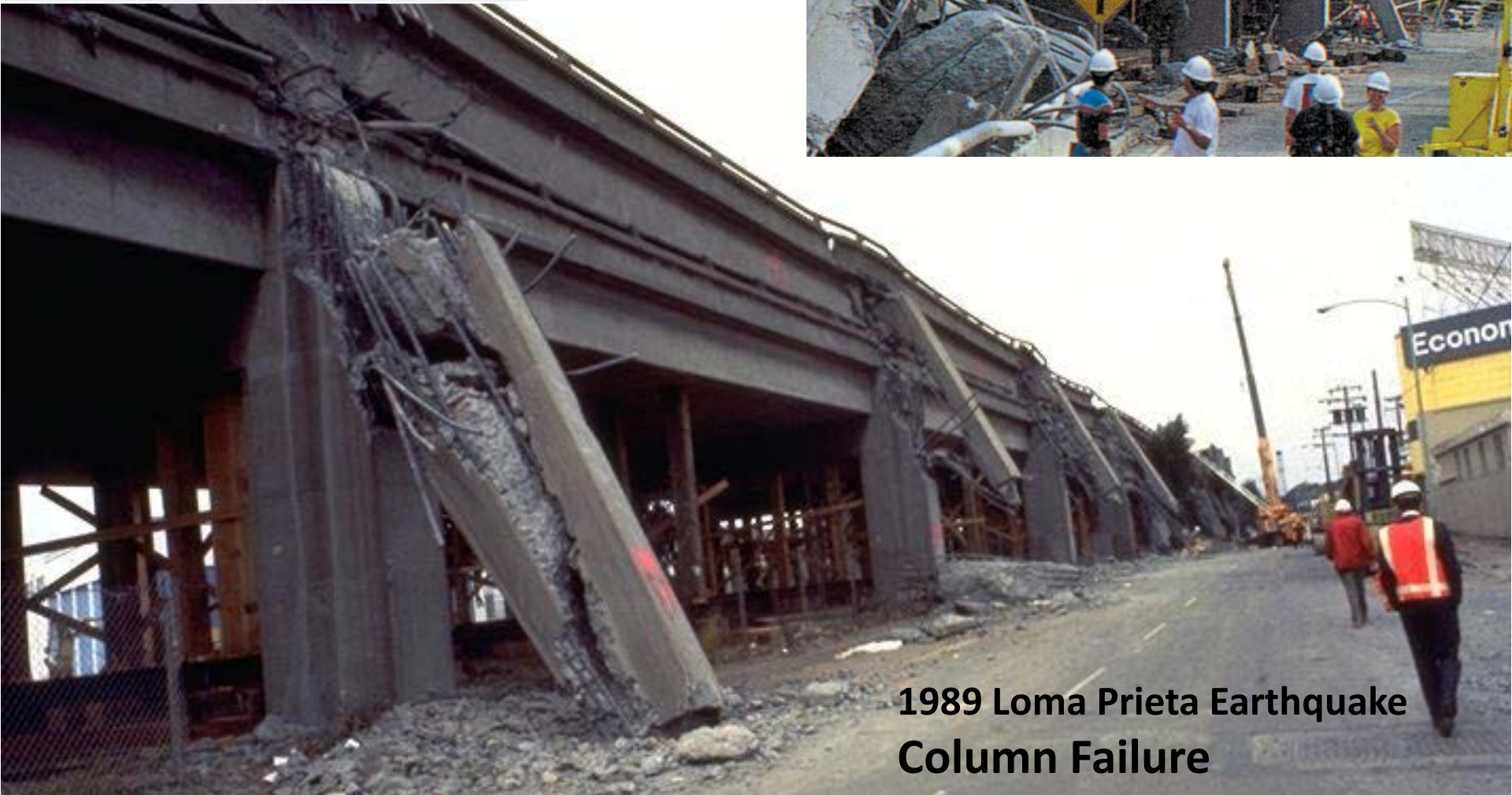


**1994 Northridge Earthquake
Column Failure**

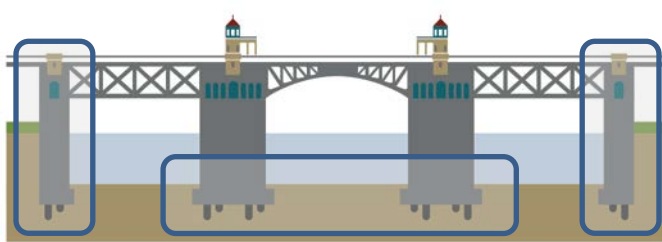


Bridge Applicability

Broadway	Burnside	Morrison	Hawthorne
●	●	●	●



**1989 Loma Prieta Earthquake
Column Failure**

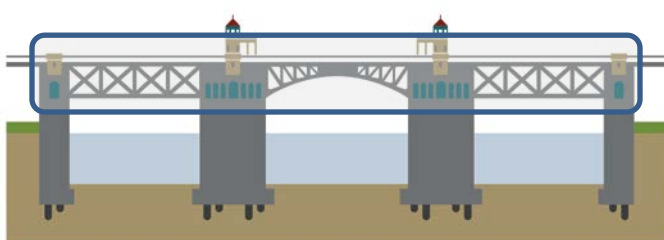


Bridge Applicability

Broadway	Burnside	Morrison	Hawthorne
●	●	●	●



2010 & 2011 New Zealand Earthquakes
Canterbury / Christchurch
Soil Liquefaction Settlement



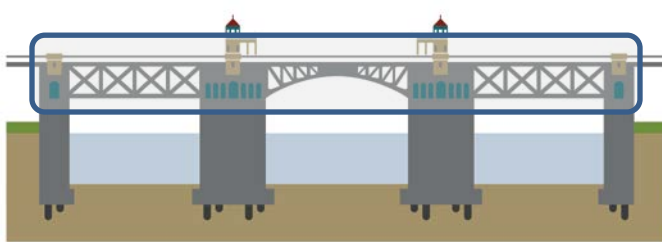
Bridge Applicability

Broadway	Burnside	Morrison	Hawthorne
●	●	●	●



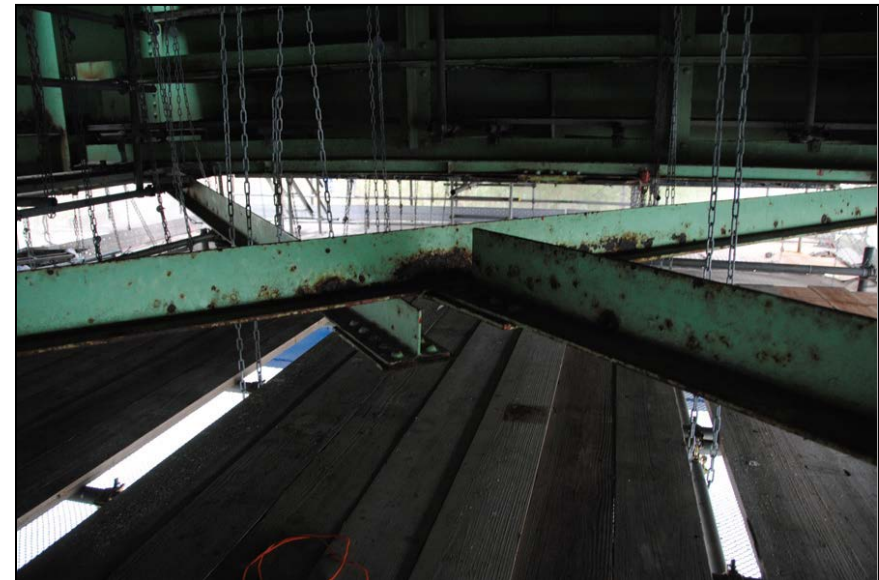
**2010 New Zealand Earthquakes
Pedestrian Bridge Damage**

2011 Tohoku Earthquake Truss Member and Connection Failures

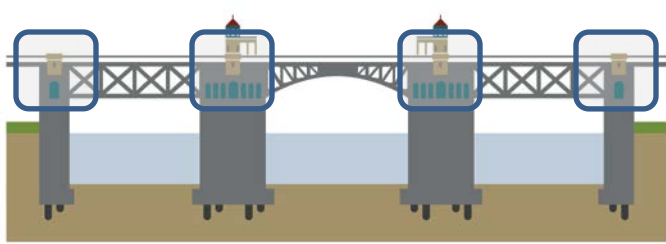


Bridge Applicability

Broadway	Burnside	Morrison	Hawthorne
●	●	●	●



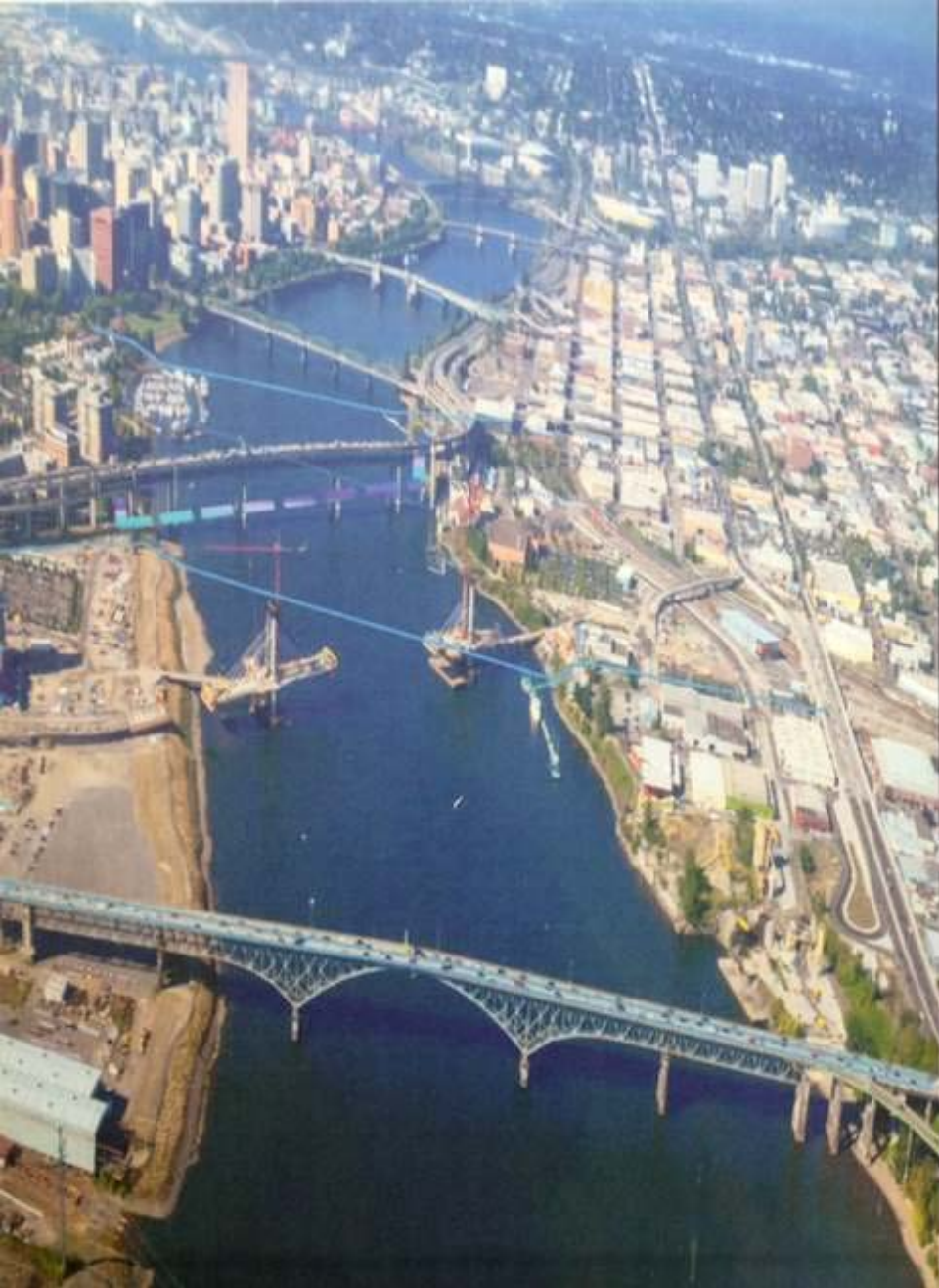
1993 Scotts Mills, OR Earthquake: Yamhill River - Rocker Bearing Failure



Bridge Applicability

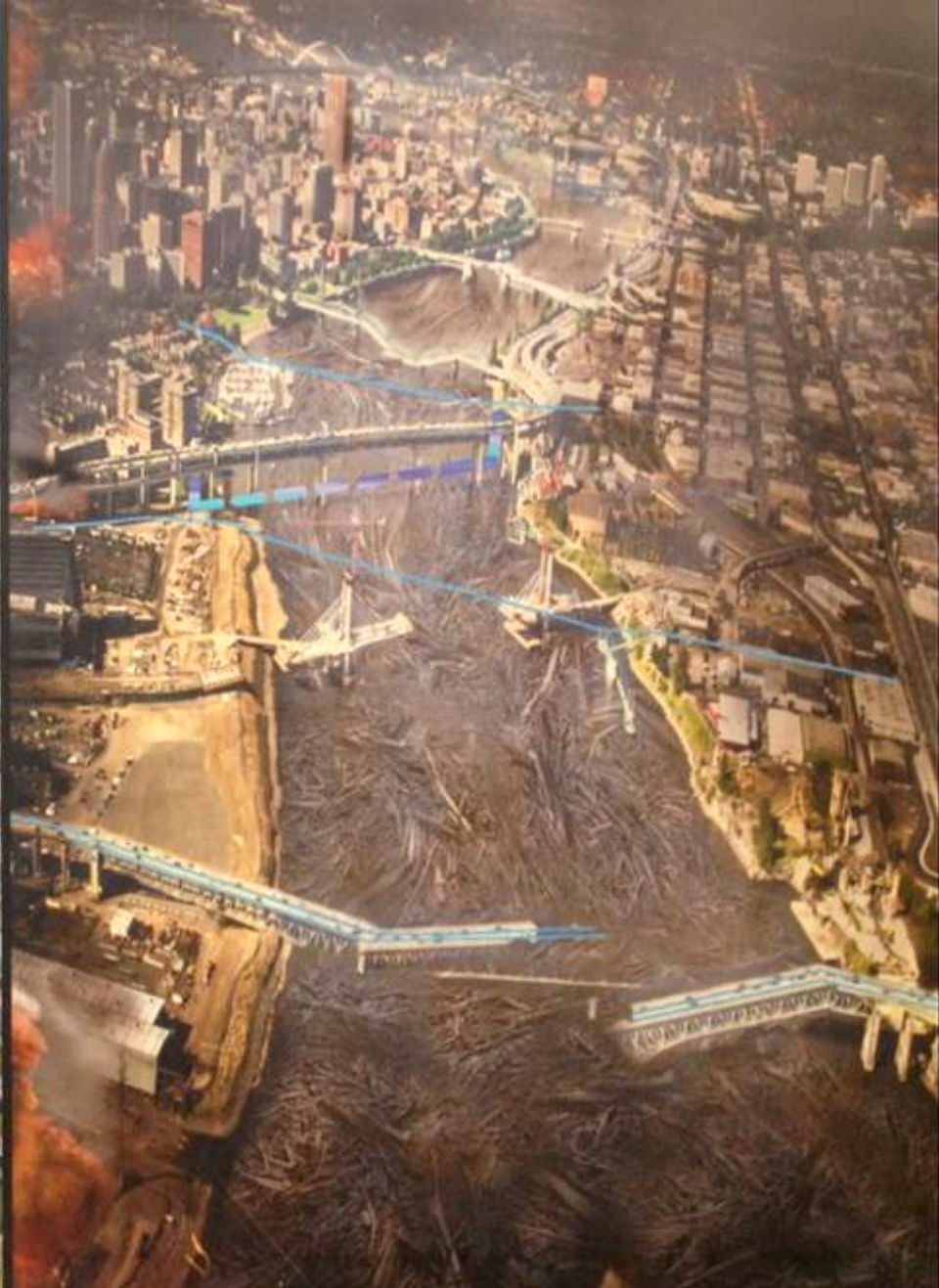
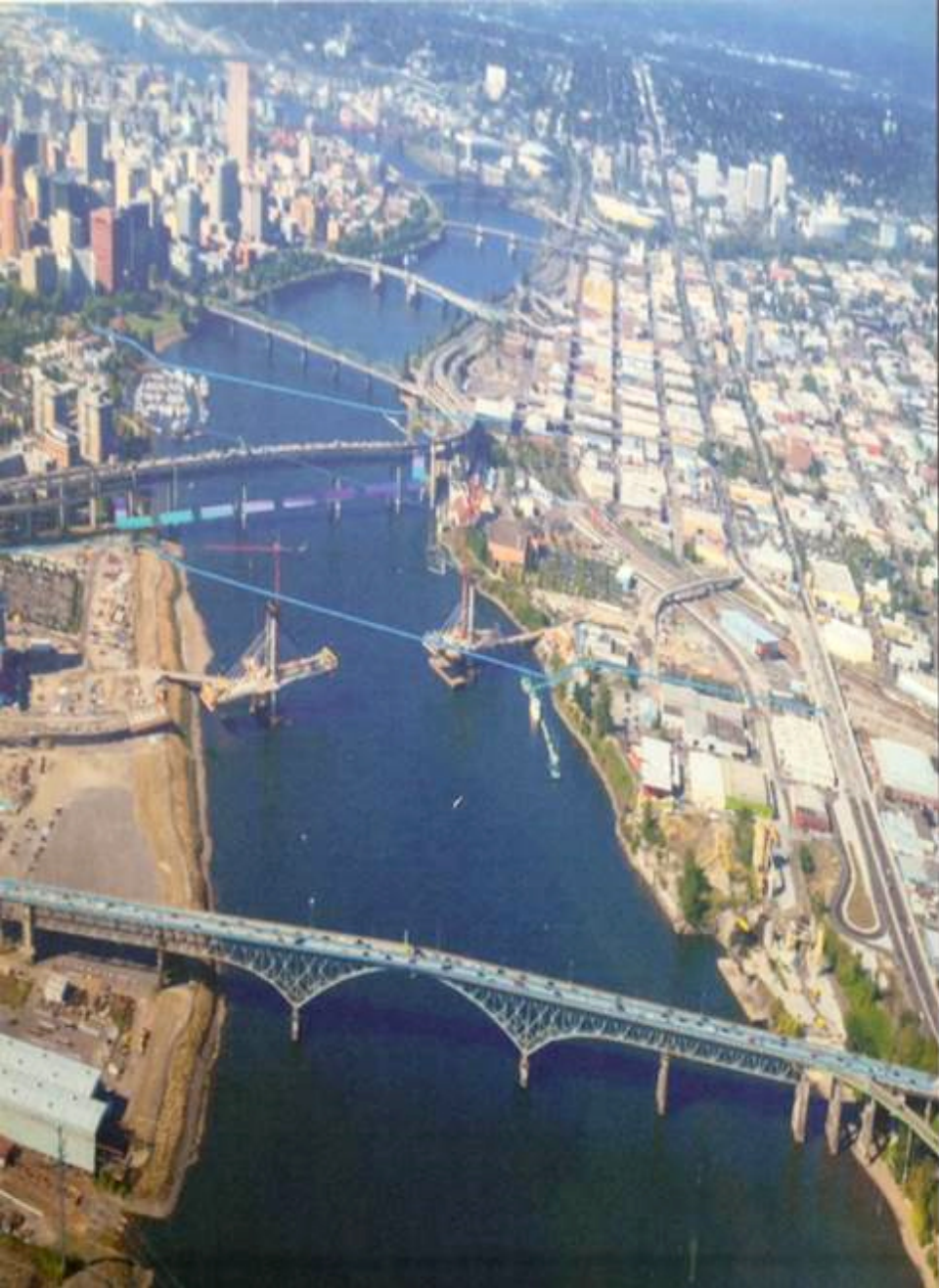
Broadway	Burnside	Morrison	Hawthorne
●	●	●	●





Artist Rendering of Portland in 2013 (Pre-CSZ Event)

Courtesy of City of PDX Water Bureau



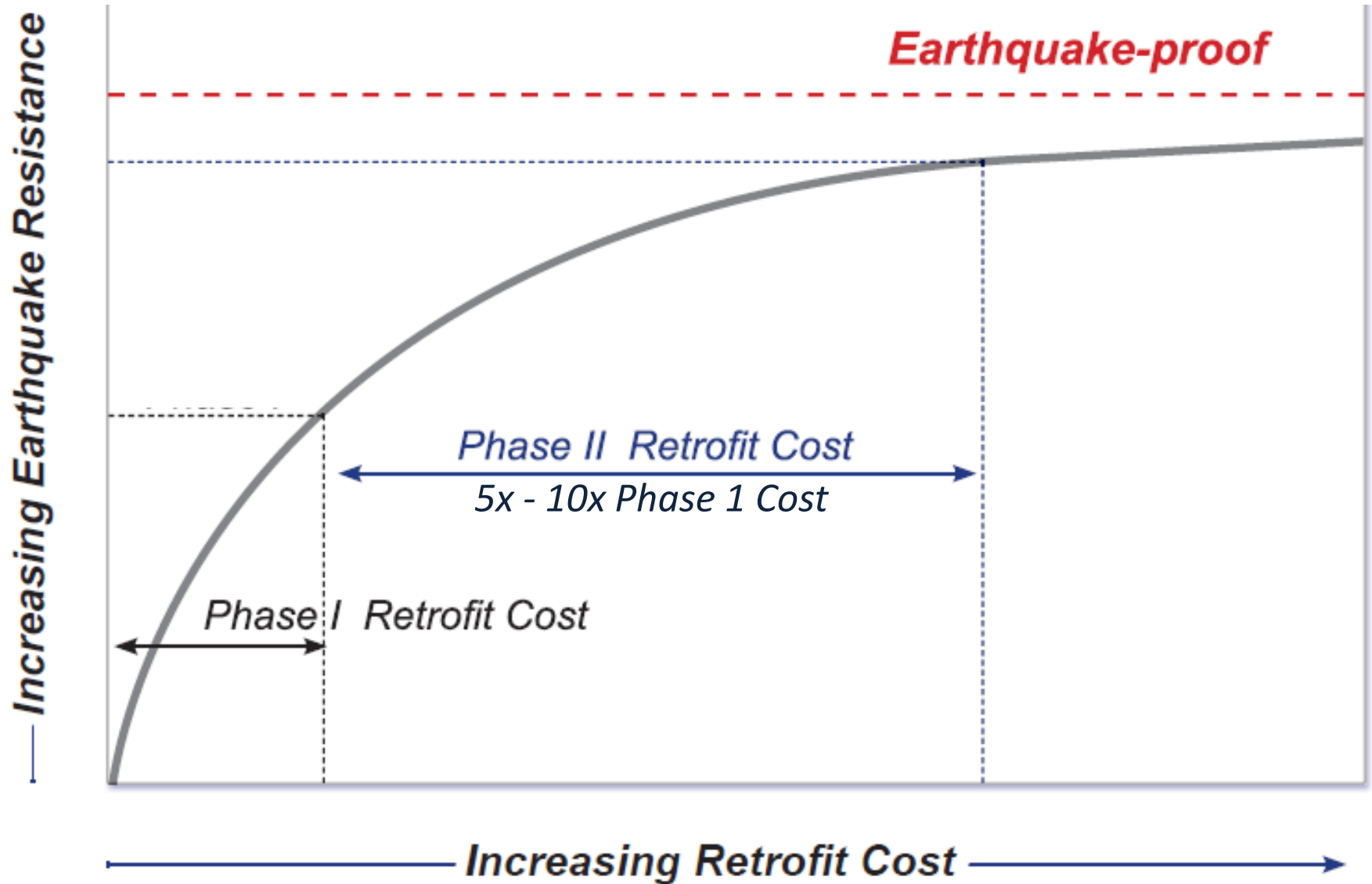
Artist Rendering of Portland in 2013 (Pre- & Post-CSZ Event)

Courtesy of City of PDX Water Bureau



Can anything
be done?

YES, with the proper investment.



Low Seismic Resiliency Investment



Phase 1 Seismic Retrofit Elements

High Seismic Resiliency Investment



Phase 1 and 2 Seismic Retrofit Elements



How have
other Agencies
responded?

Oregon's Bridge Seismic Reports



http://www.oregon.gov/ODOT/HWY/BRIDGE/docs/2009_Seismic_Vulnerability_final.pdf

http://www.oregon.gov/ODOT/HWY/BRIDGE/docs/Oregon_Highways_Seismic_Options_Report_3_2013.pdf

http://www.oregon.gov/OMD/OEM/Pages/osspace/osspace.aspx#Oregon_Resilience_Plan

Other Agency Seismic Programs



In 2006, City of Seattle voters passed a 9-year, \$365 million levy for transportation maintenance and improvements. The levy is complemented by a commercial parking tax.



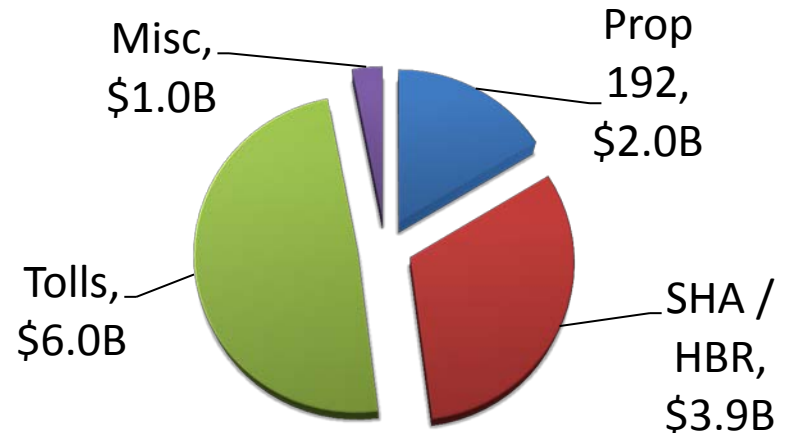
Clark County relies on HBR funds distributed through the WSDOT-led BRAC (Bridge Replacement Advisory Committee) selection process. Clark County received \$4M in HBR funds for seismic retrofits in 2012-13.



\$177M Bridge Seismic Retrofit Program started in 1977.

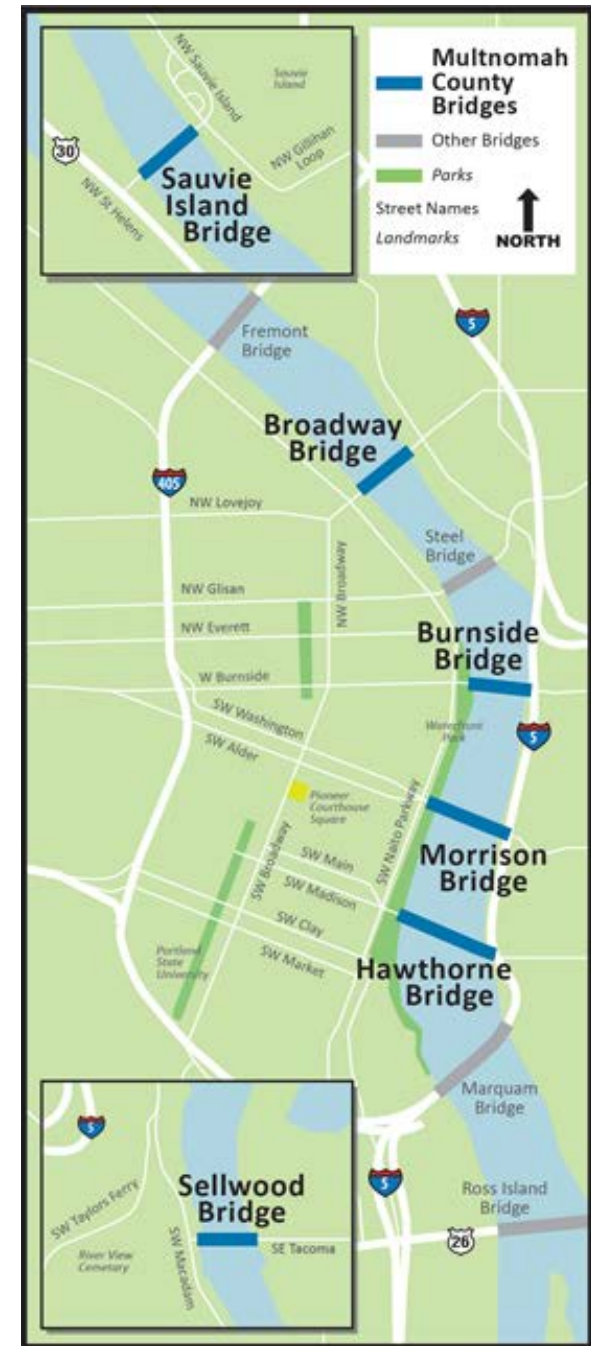


\$13B Bridge Seismic Retrofit Program since 1989.



Next Steps:

- Recommend bridge seismic resiliency projects within the Mult Co. Bridge CIP for the:
 - Broadway Bridge
 - Burnside Bridge
 - Morrison Bridge
 - Hawthorne Bridge
- Distribute Draft Bridge CIP for BCC and Public comment
- Publish Final Bridge CIP





Questions?

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