Oregon Department of Transportation

Seismic Retrofit Program Priorities & Options for Seismic Resilience

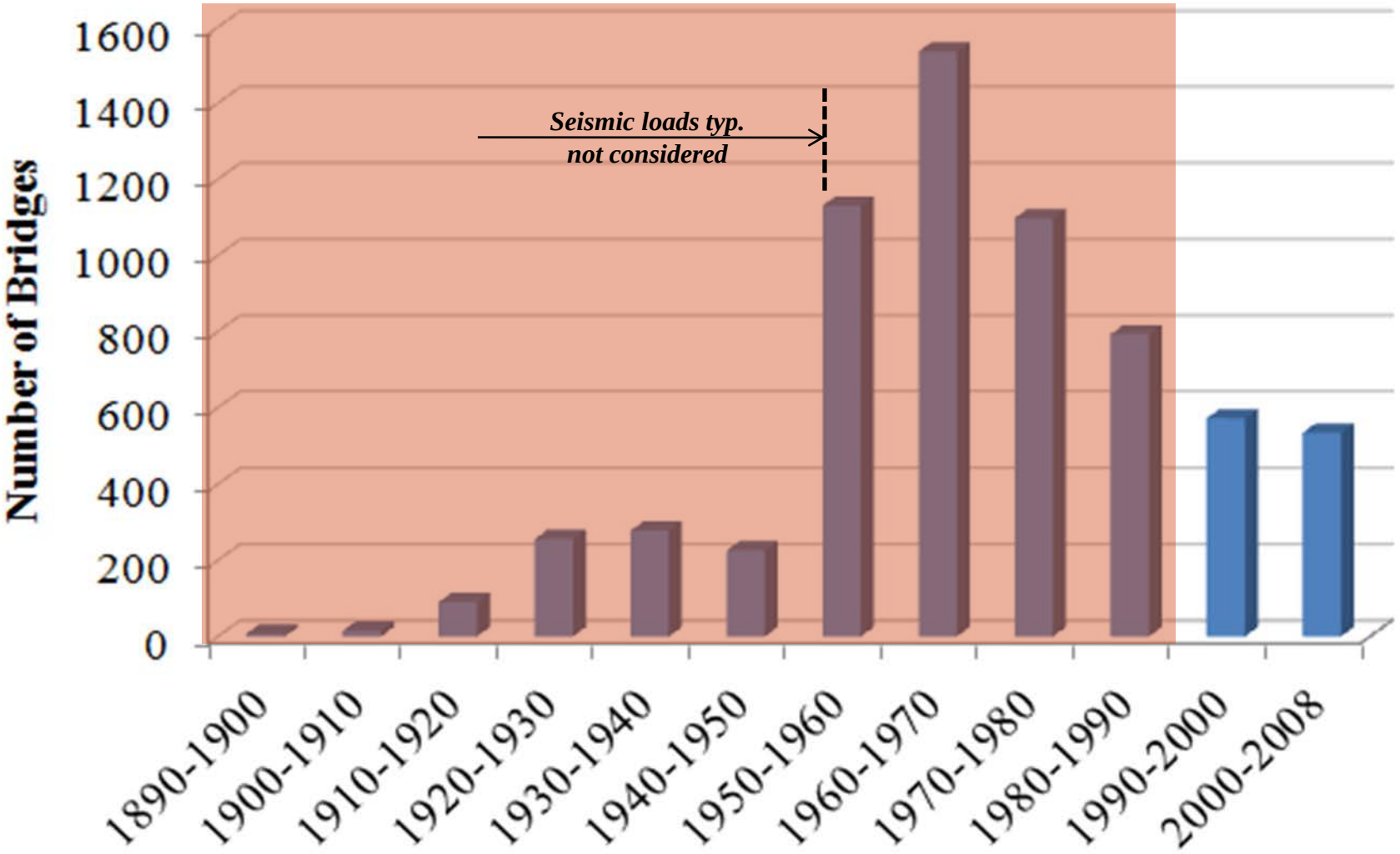
WESTERN BRIDGE ENGINEER'S SEMINAR - September 4, 2013

Bruce Johnson, Oregon DOT

Outline

- *Vulnerability Assessment*
  - *Bridge Hazard*
  - *Seismic Hazard*
  - *Geotechnical Hazard*
- *Economic Loss Model*

Seismic Bridge Design in Oregon



Seismic Hazard Assessment

March 25,1993 Scotts Mills Spring Break Earthquake

The Seattle Times
Winner of Nine Pulitzer Prizes

Search

Thursday, March 25, 1993 - Page updated at 12:00 AM

Quake Cracks Oregon Capitol -- Temblor Registers 5.4, Causes Minor Injuries

AP: Times Staff

PORTLAND - An earthquake centered in the Cascade foothills east of Silverton rattled northwest Oregon and parts of Western Washington early today, cracking the rotunda of the Oregon Capitol in Salem and causing minor injuries.

The quake, focused about 12 miles deep and about 30 miles southeast of Portland, registered 5.4 on the Richter scale of ground motion at 5:34 a.m. and lasted about 45 seconds.

"It felt like I was on a boat going down rapids. It woke me right up," said Bill Holder, a cook at Rod's Lafayette Restaurant in Lafayette, near the epicenter.

The original wing of the state Capitol in Salem was closed after serious cracks were found in the rotunda, House Speaker Larry Campbell said. A newer wing remained open. Engineers were considering removing the gold-plated pioneer statue on top of the Capitol.

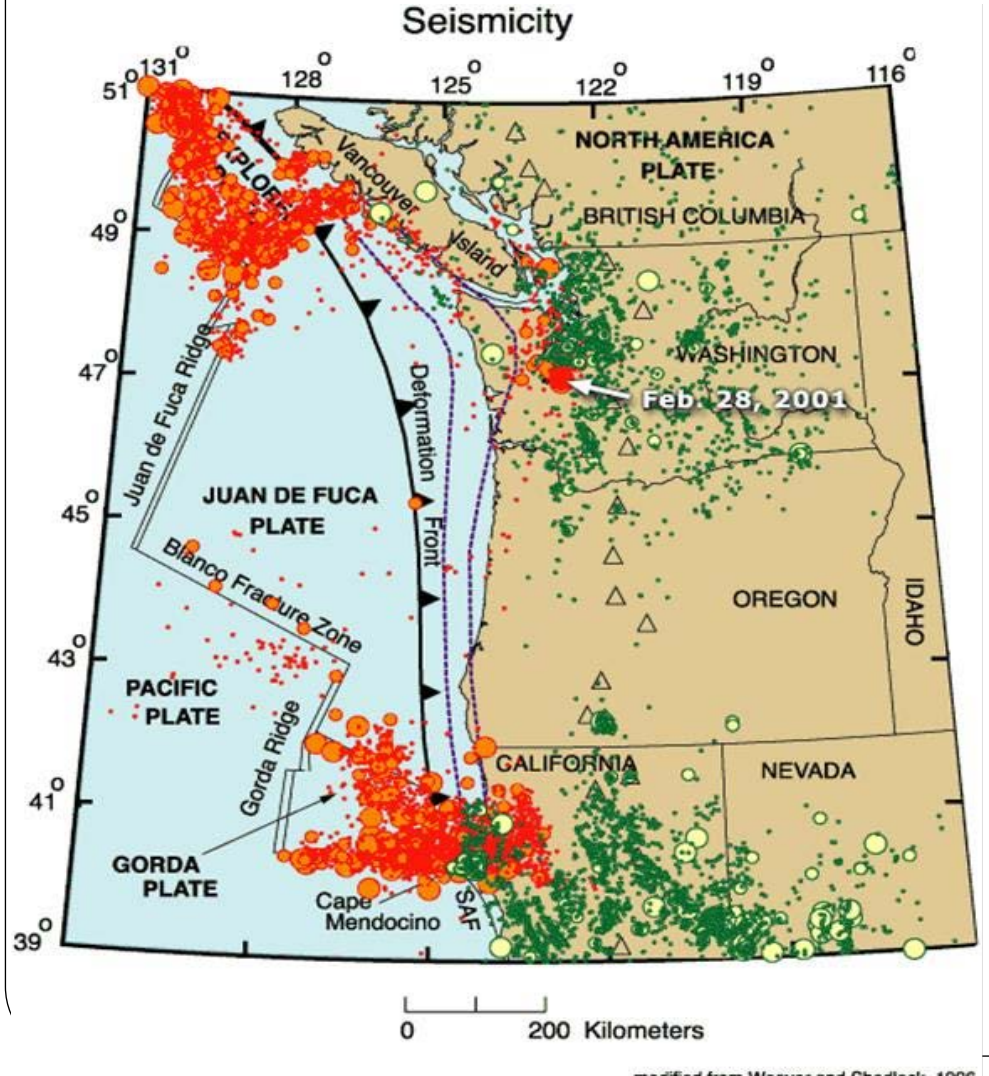
Two people came to the emergency room at Salem Hospital with minor cuts from falling glass.

In Molalla, 27 miles southeast of Portland, two walls at the high school partially collapsed. Bricks and a chimney fell from the school, which was built in 1925.

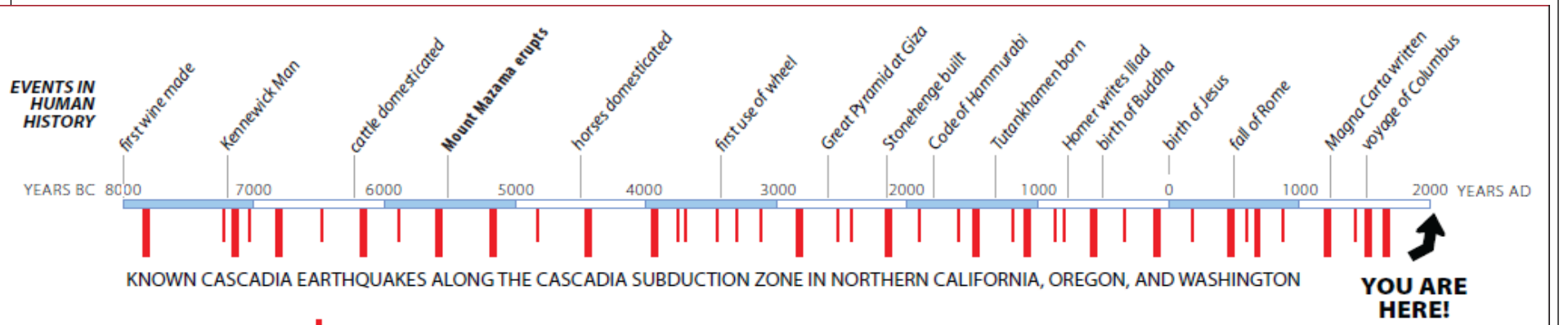
Brick planters and windows also were broken at some homes and businesses in the town of 3,800, and goods were knocked off grocery store shelves.

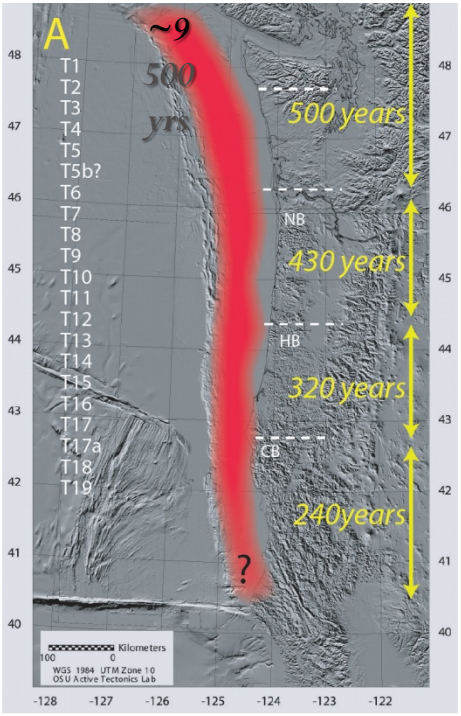
Strong Shaking and Tsunami

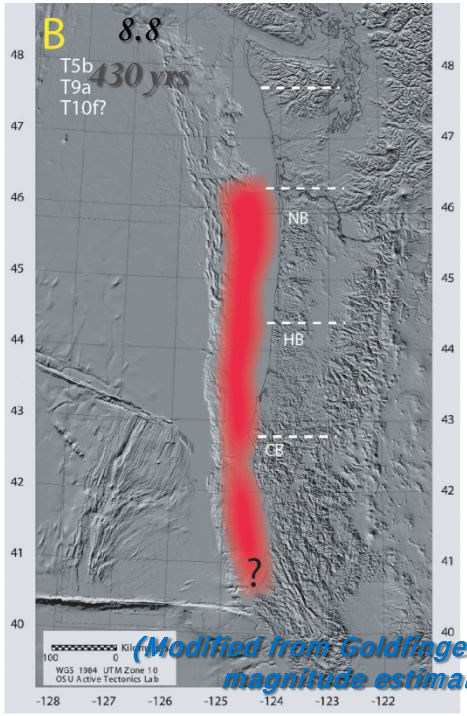
- Strong Ground Shaking (M9 w/ 2 - 4 min shaking)
- Tsunami within 15 to 25 minutes

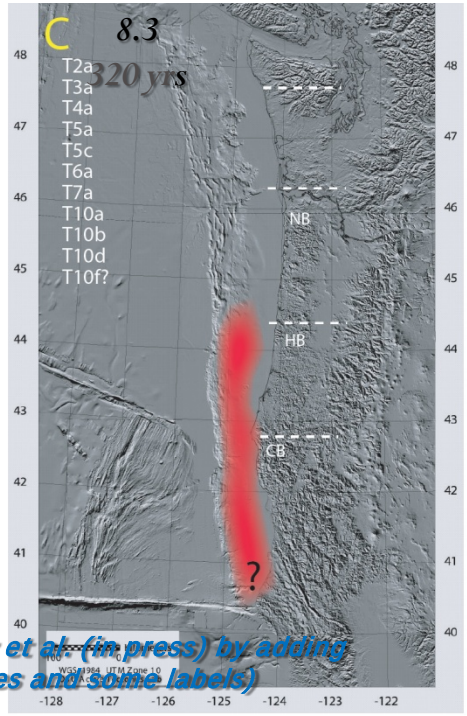


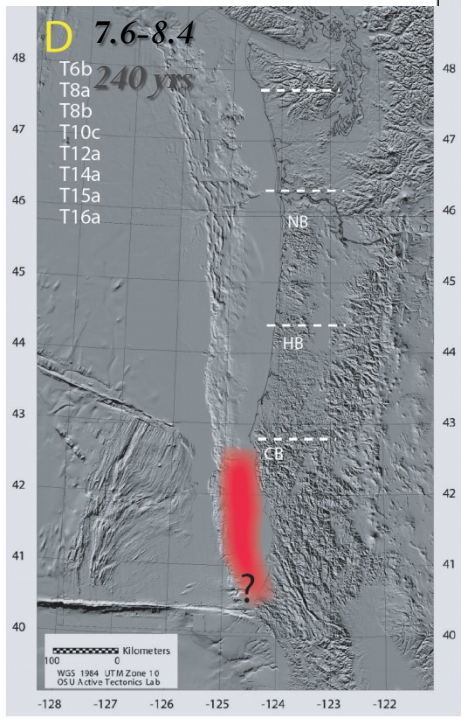
Cascadia Subduction Zone Earthquakes





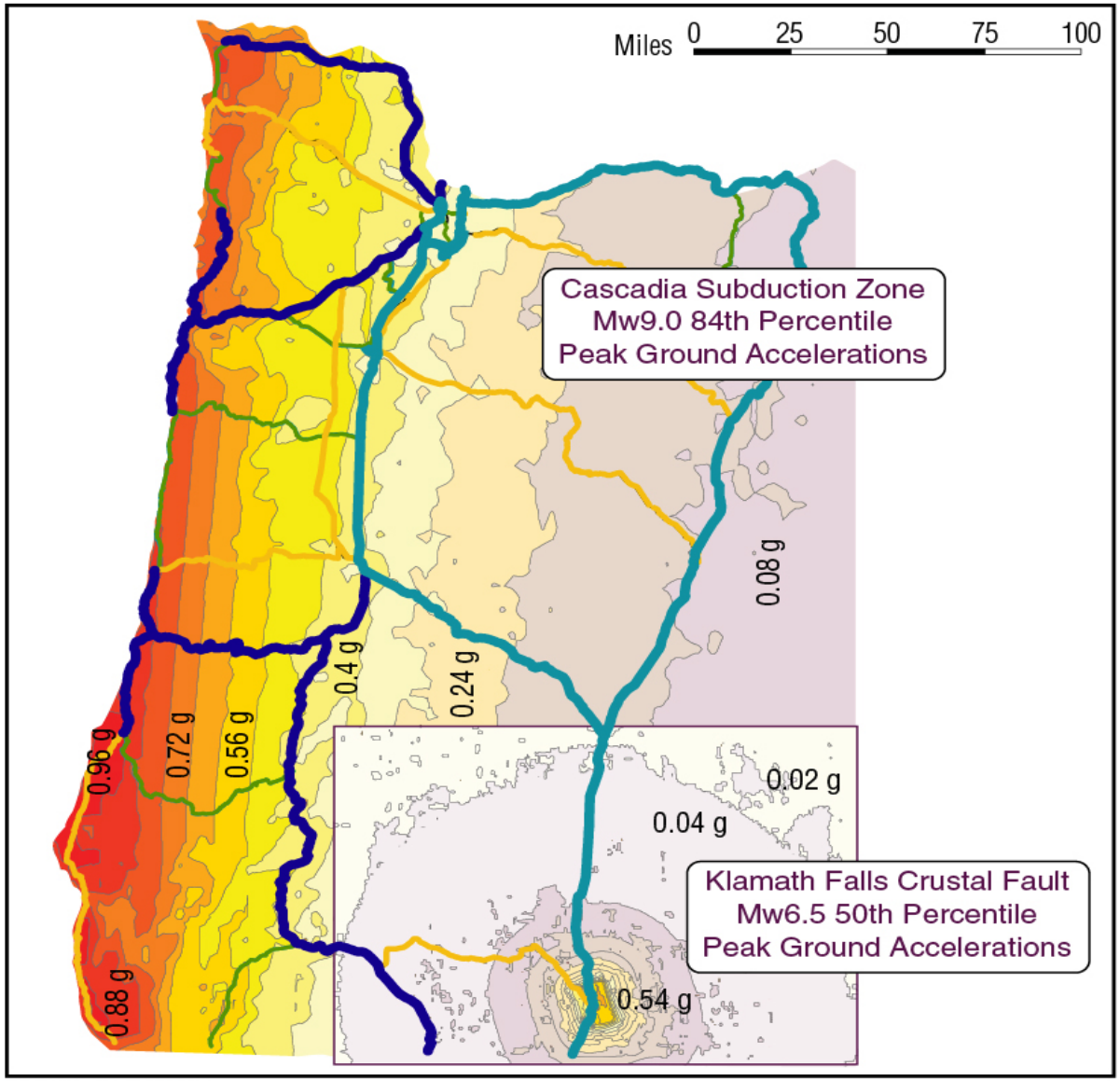






(Modified from Goldfinger et al. (in press) by adding magnitude estimates and some labels)

PGA for CSZ and Crustal Event in Klamath Falls



Oregon Seismic Lifeline Routes and Seismic Hazards

- LifelineTier 1, Phase 1
- LifelineTier 1, Phase 2
- LifelineTier 2
- LifelineTier 3

Peak Ground Acceleration

- 0.96
- 0.88
- 0.8
- 0.72
- 0.64
- 0.56
- 0.48
- 0.4
- 0.32
- 0.24
- 0.16
- 0.08
- 0.04

Source: 2013 Oregon Highways Seismic Options Report

TBG021213133632CVO

Data Sources for Geotechnical Hazard Assessment

Data Source	Title and Year	Landslide Data	Liquefaction Data
DOGAMI	DRAFT Statewide Liquefaction Mapping 2011		X
SLIDO-2	Statewide Landslide Information Database for Oregon - Release 2, 2011	X	
IMS-24	Geologic Hazards, Earthquake and Landslide Hazards Maps, and Future Earthquake Damage Estimates for Six Counties in the Mid/Southern Willamette Valley, Including Yamhill, Marion, Polk, Benton, Linn, and Lane Counties, and the City of Albany, Oregon, 2008	X	X
IMS-22	Hazard Map of Potential Rapidly Moving Landslides in Western Oregon, 2002	X	
USGS	Digital Elevation Model		
ODOT	Water body data for the Oregon Hydrography Framework, 2011		

Liquefaction Evaluation Criteria

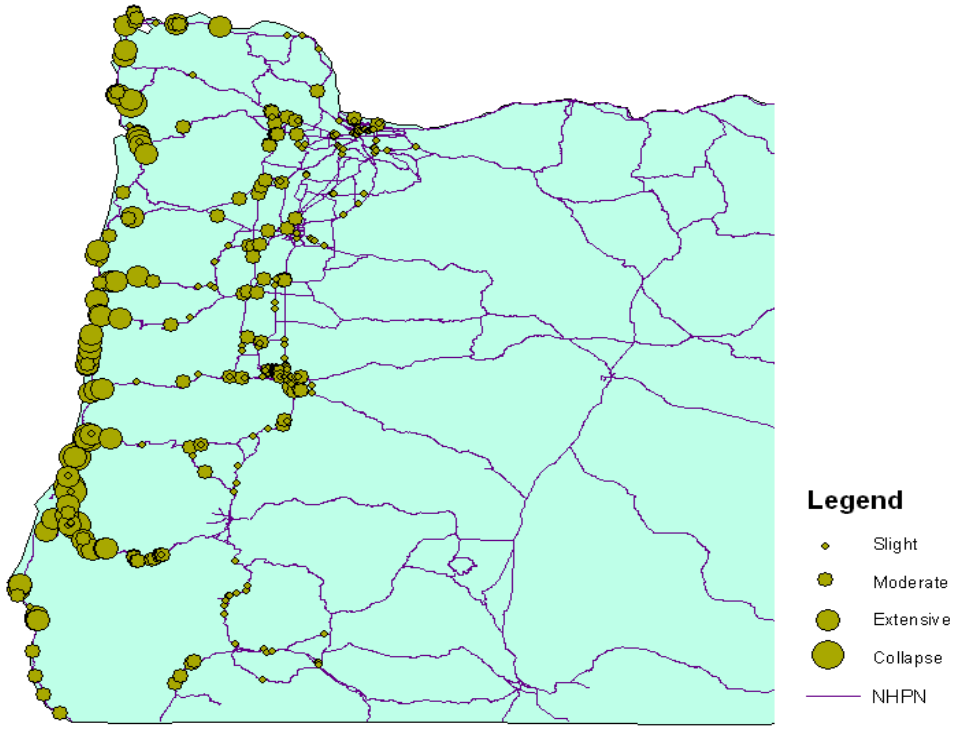
Within Water Boundary?	Liquefaction Potential Zones		
	Low	Medium	High
No	Low	Moderate	High
Yes	Moderate	High	High

Cascadia Subduction Zone Earthquake (Magnitude 9.0)

6 complete collapses
64 extensive
106 major
164 slight

Estimates Loss:

- **$1,080** million for bridge repair and replacement
- **Significant Economic losses** (travel time related losses)



Route	Damage States			
	Slight	Moderate	Extensive	Complete
I-5 (MWC)	4	1	0	0
I-5 (MLL)	16	3	1	0
I-5 (DJJ)	27	0	0	0
I-84	13	1	0	0
US-101	7	14	36	5
US-26	7	5	0	0
I-205	8	2	0	0
I-405	7	0	0	0
US-30	4	2	2	0
US-20	5	3	5	0
OR-38	3	2	1	0
OR-42	4	13	13	1
Others	59	60	6	0
Total	164	106	64	6

LIFELINE PRIORITIZATION CRITERIA

- Support survivability immediately following the event
- Provide transportation facilities critical to life support for an interim period following the event
- Support statewide economic recovery

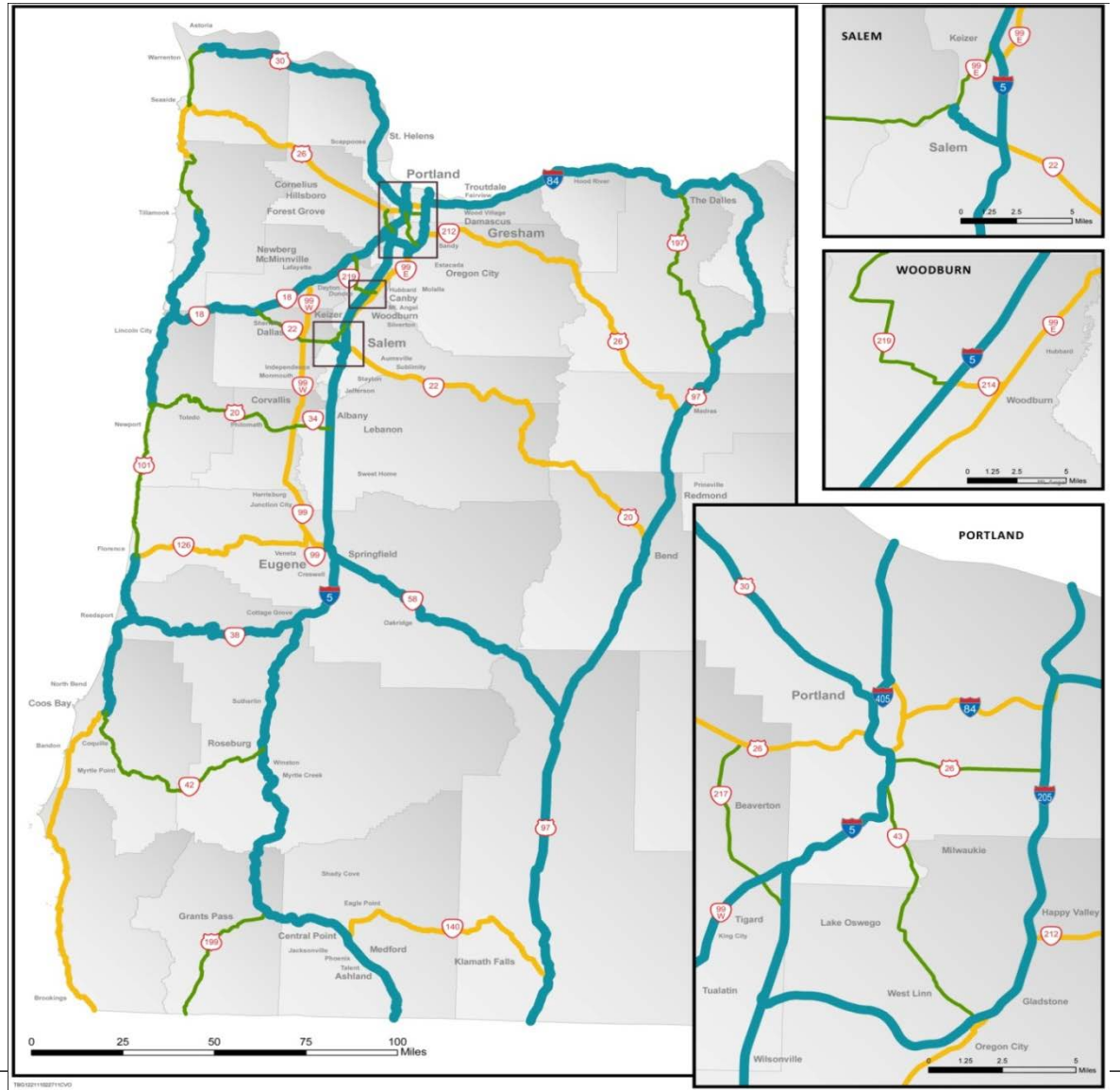
Route Evaluation Criteria

Connections	Capacity	Resilience
• Access to fire stations • Access to hospitals • Access to ports and airports • Access to railroads • Access to ODOT maintenance facilities • Access to population centers • Access to emergency response staging areas • Access to critical utilities • Access to central Oregon	• Width of roadway • Ability to control use of the highway • Freight access	• Bridge seismic resilience • Roadway seismic resilience • Bridge seismic resilience after short-term repair • Roadway seismic resilience after short-term repair • Dam Safety

Evaluation Framework: Goals & Objectives for Route Selection

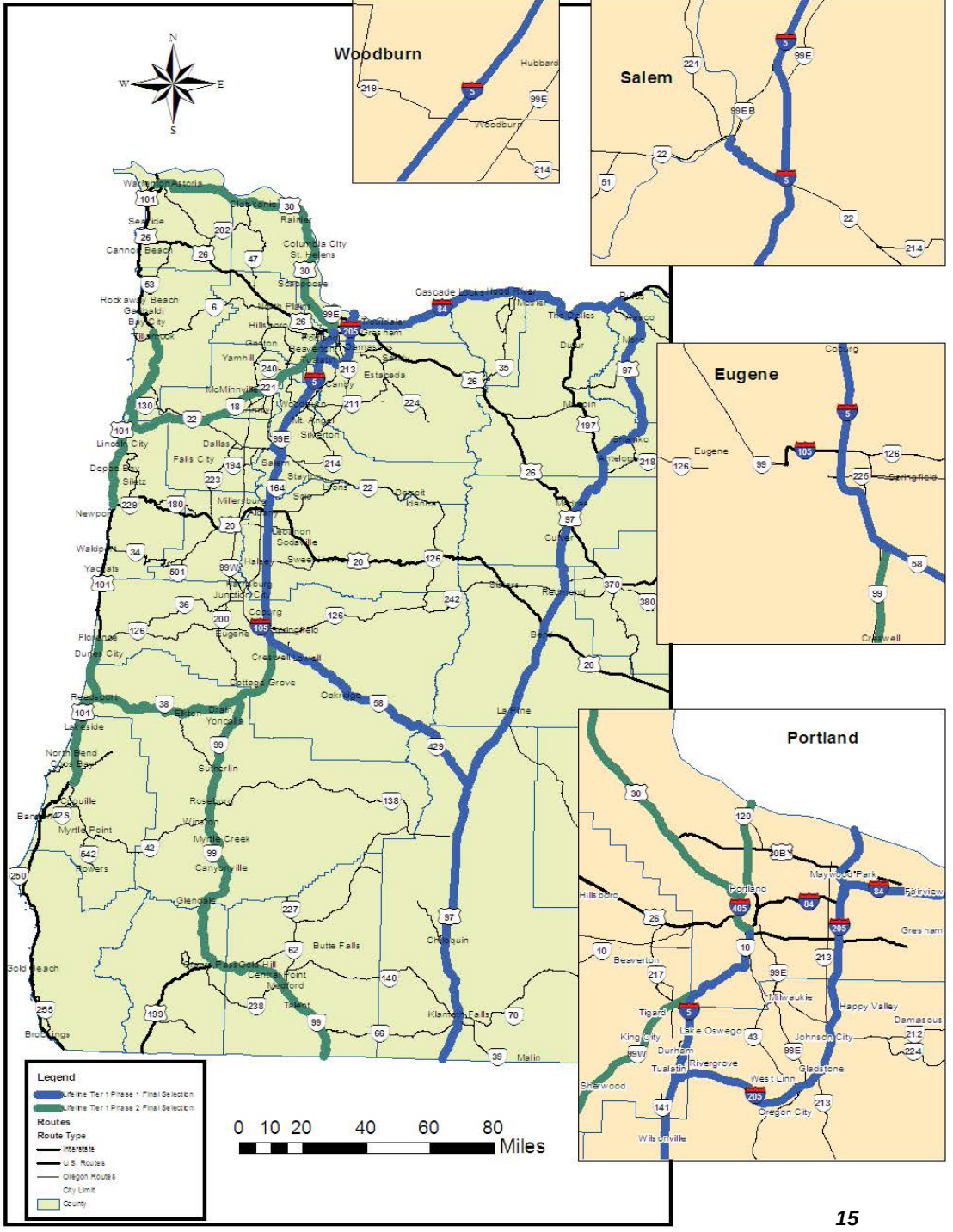
Goal	Objective
1. Short Term Survivability	1A: Routes from emergency responders 1B: Routes to critical care facilities (hospitals, etc.)
2. Interim Life Support	2A: Routes for life support resources (food, water, repair crews, etc.) 2B: Routes to critical care facilities (hospitals, etc.) 2C: Evacuation routes
3. Economic Recovery	3A: Retain designated critical freight corridors 3B: Facilitate mobility out of affected region 3C: Provide routes between large metro areas

Recommended Lifeline Routes



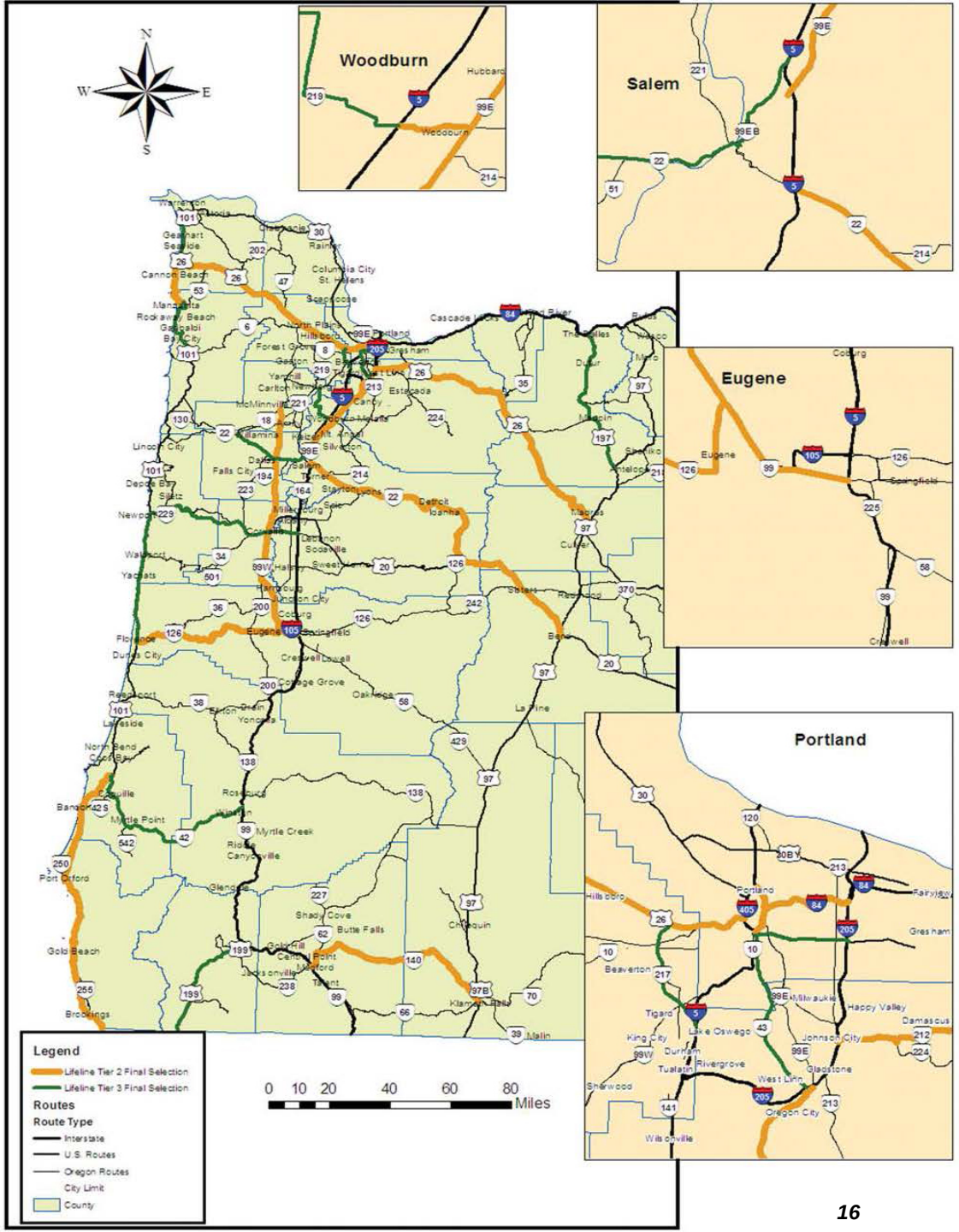
Tier 1 Route Map

- **Phase 1 – $400 M**
- **Phase 2 – $500 M**
- **Total $900 M**



Tier 2 & 3 Route Map

- ***Tier 2 – $600 M***
- ***Tier 3 – $300 M***



Solution: Retrofit

Phase 1 for “life safety” connects superstructure to the substructure.

Phase 2 for “serviceability” strengthens the substructure. Design for 500-year recurrence interval.

Recurrence Interval

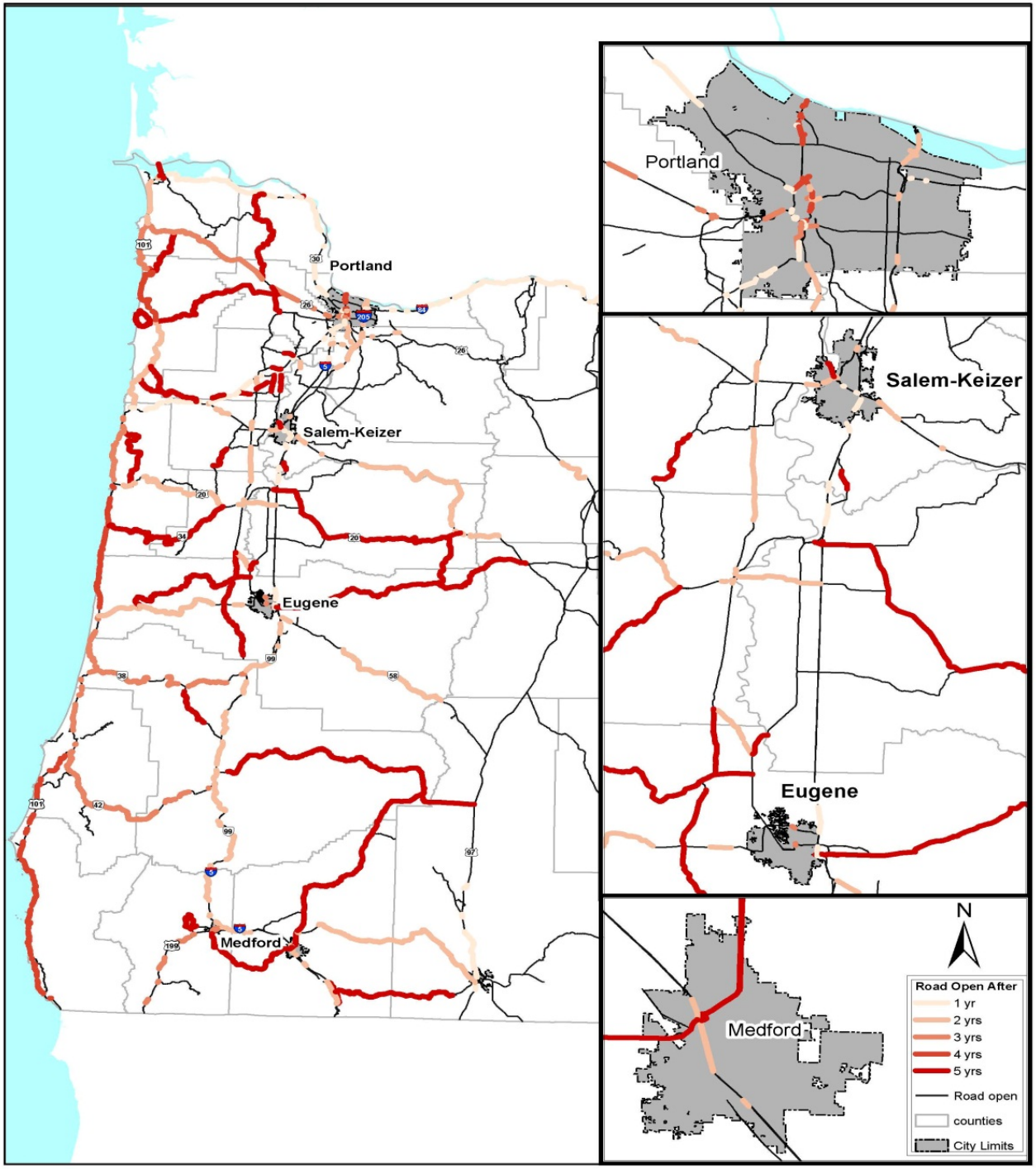
National Code (AASHTO) - Design for no collapse at a 1000-year recurrence interval.

Oregon Code - Design for no collapse at a 1000-year recurrence interval and design for usability within 72 hours at a 500-year recurrence interval.

Economic Impact of a Large CSZ Event Study Approach: Guidelines

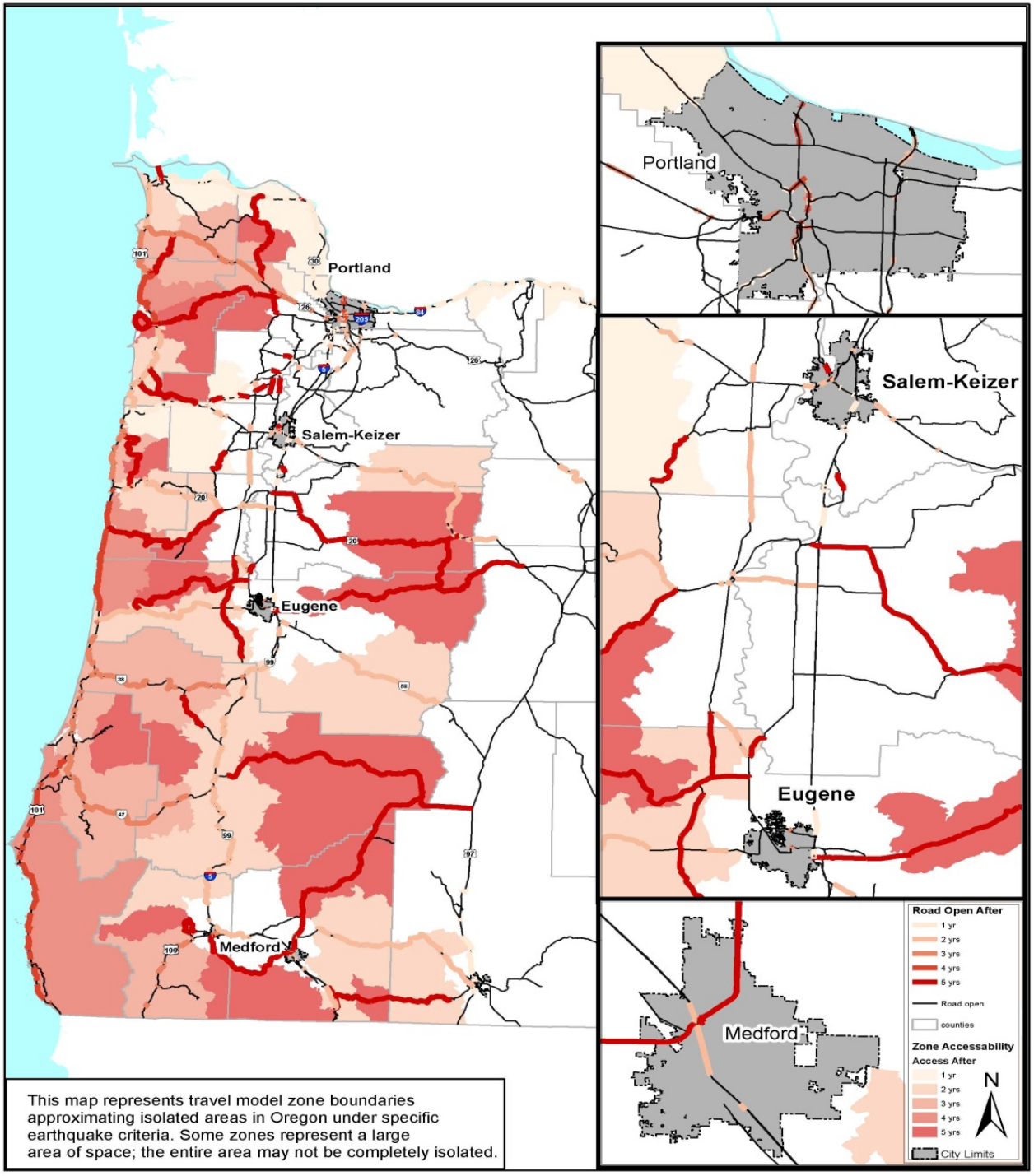
- Emphasis on regional mobility, not local access
- Enable emergency response and economic recovery
- Only study state highways

Oregon State Highway Economic Impact Model - Major CSZ Seismic Event



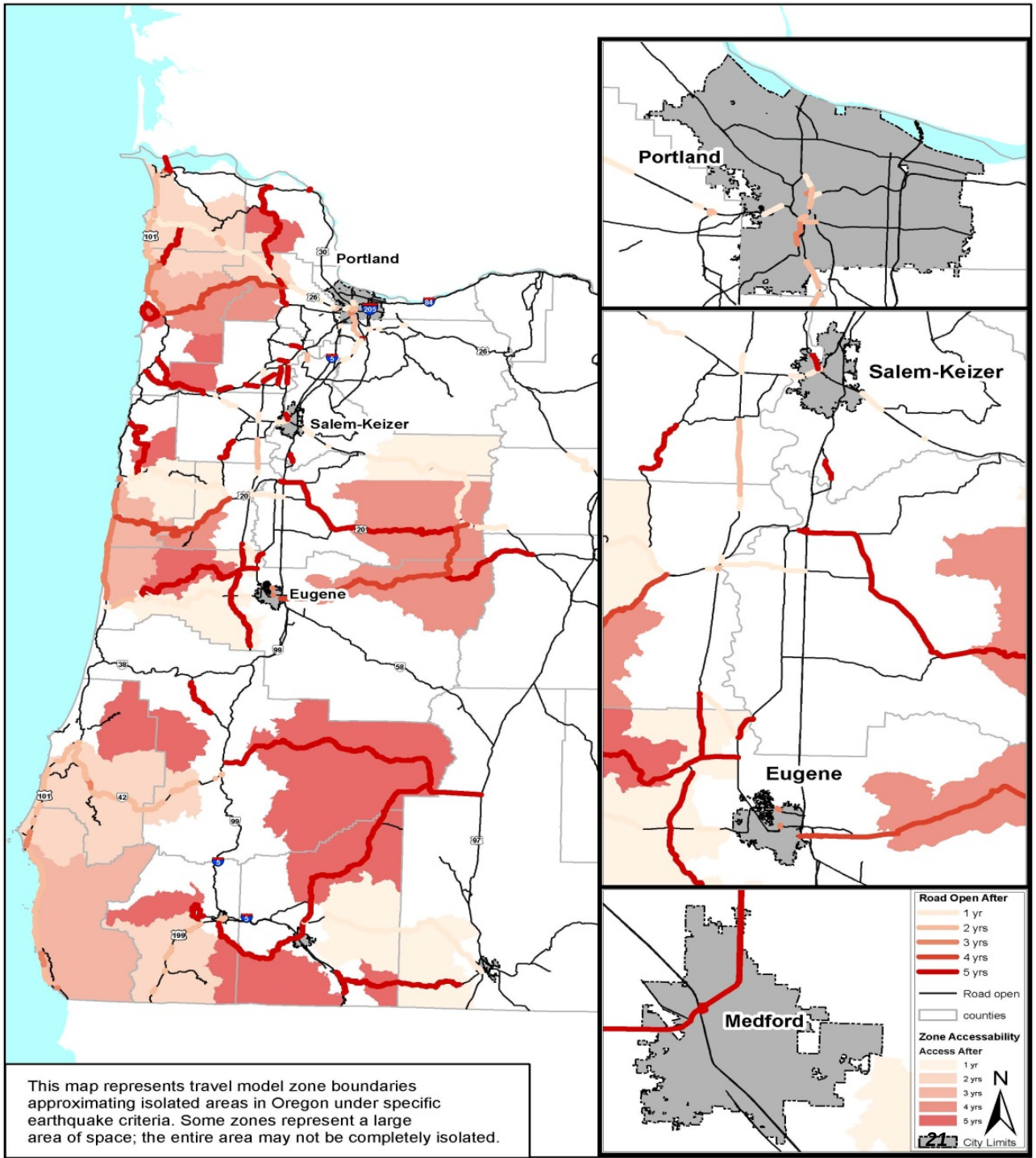
Major Seismic Event: Isolated Areas

- Total Economic loss: $350B



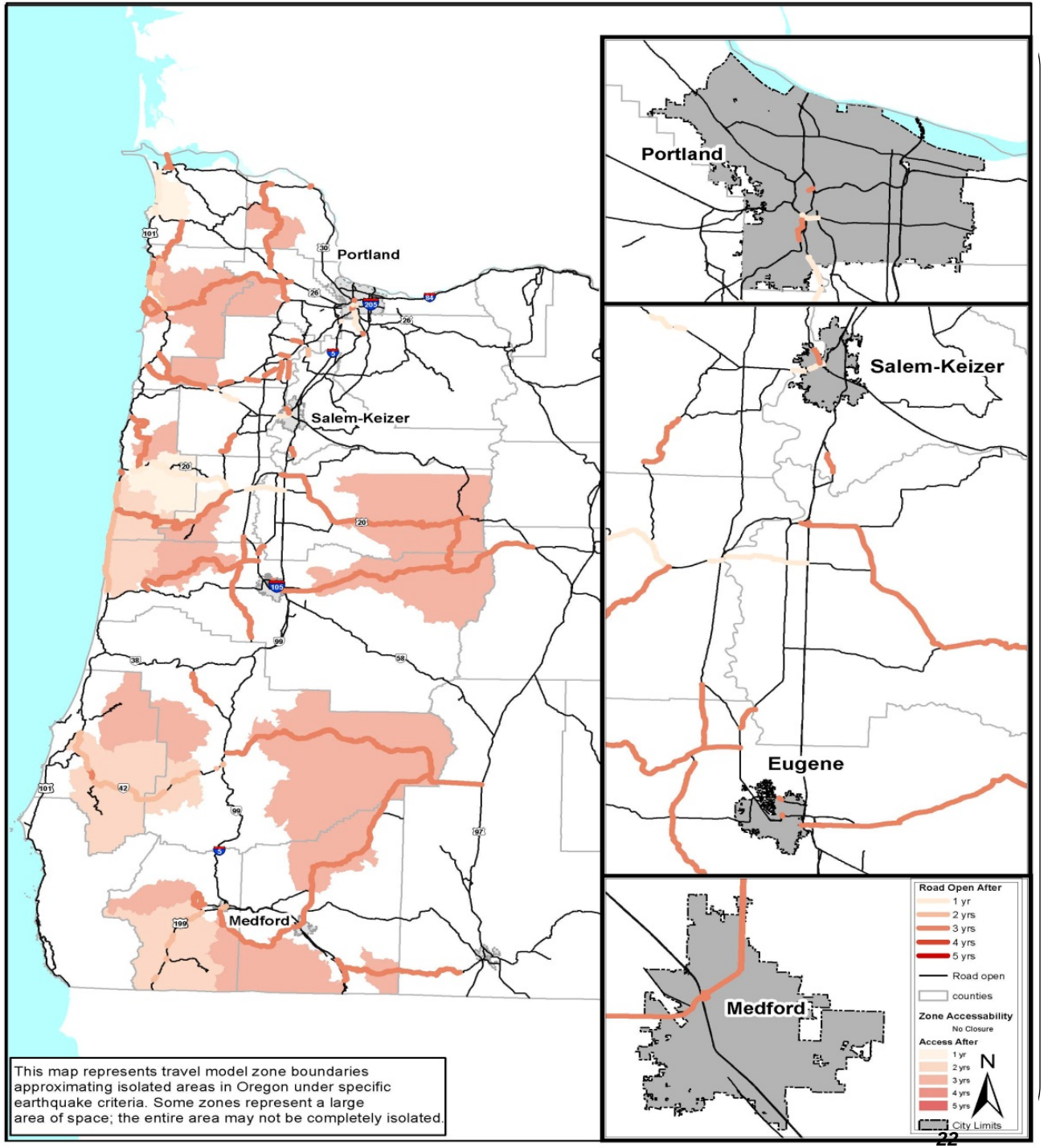
Isolated Zones: Stage 1 Scenario

Reduce Economic Loss by: $35B



Isolated Zones: Stage 1 & 2 Scenario

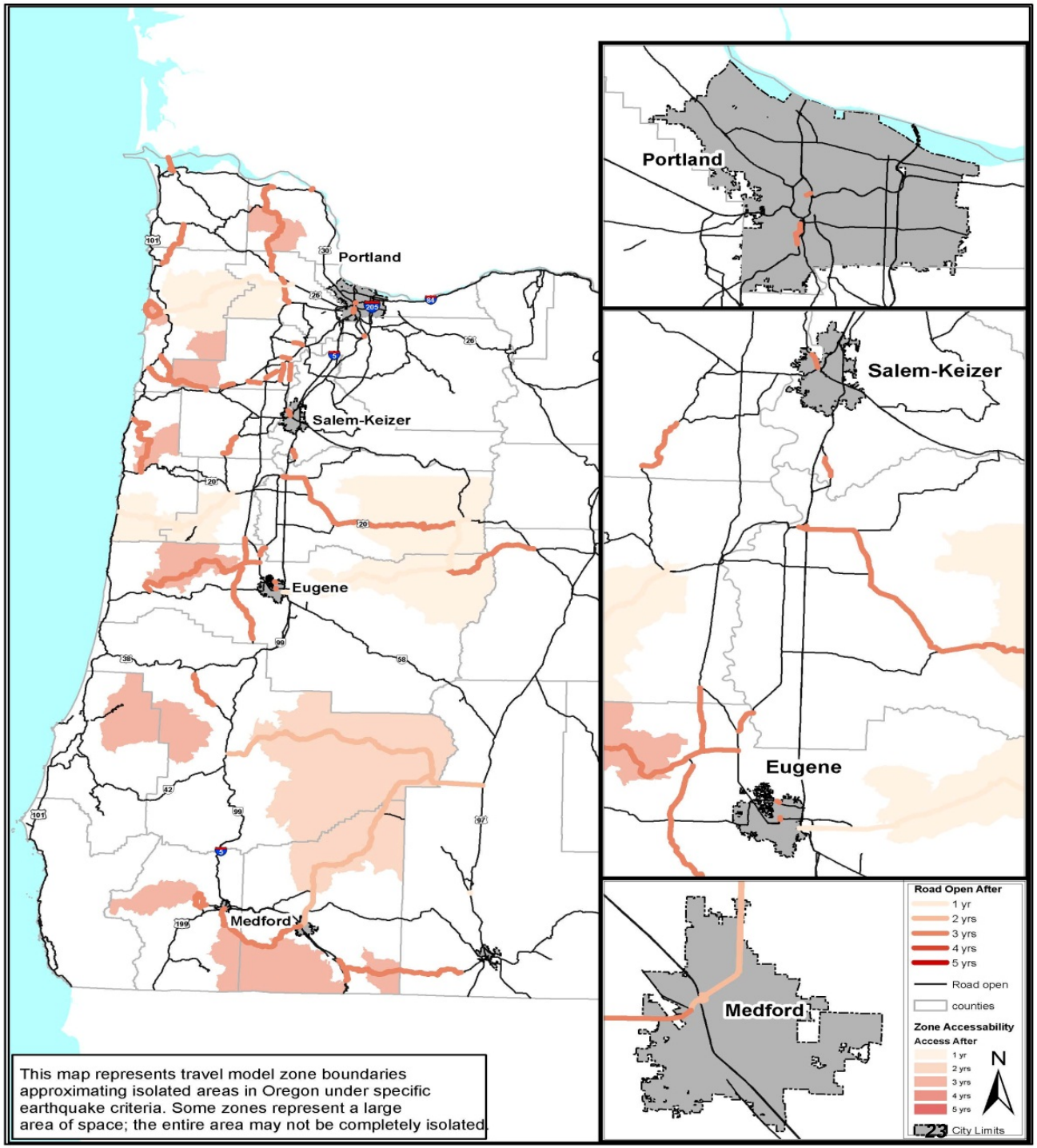
Reduce Economic Loss by: $55B



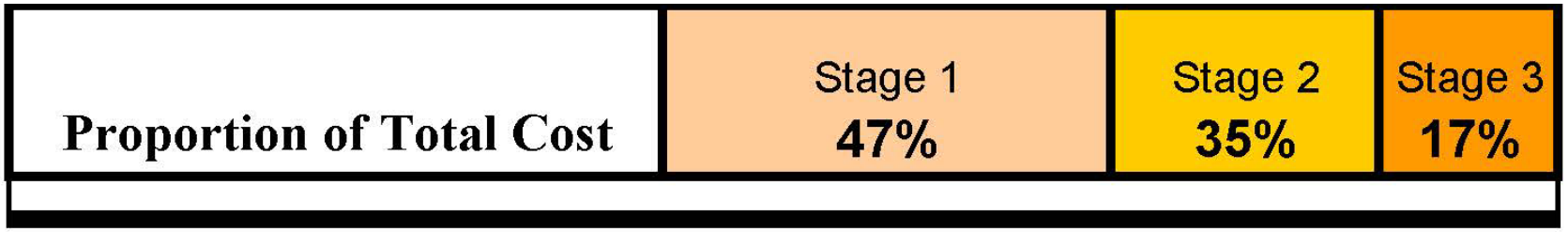
Isolated Zones: Full Seismic Program

(Stage 1, 2, 3)

Reduce Economic Loss by: $84B

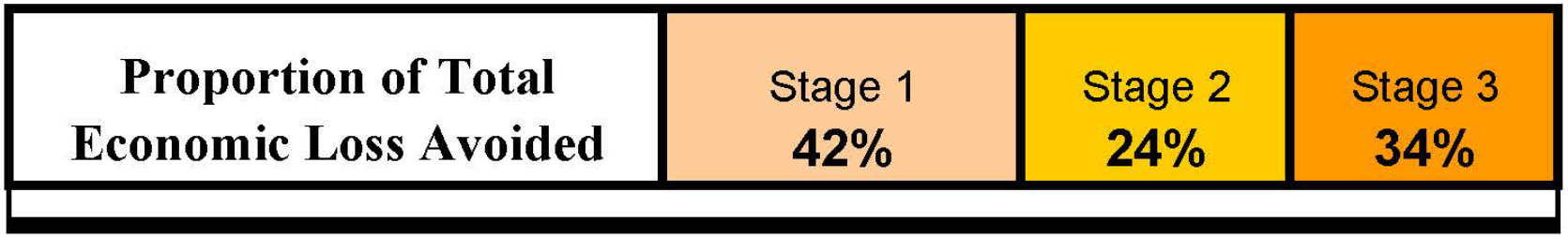


Rate of Return is 46:1



Total Program Budget = $1.8 Billion

Benefit/Cost
46



Total Economic Losses Avoided = $84 Billion

Oregon Needs to Increase Retrofit Investment and Increase Resiliency Now

- Transportation is key to the overall response
- California and Washington are ahead
  - California: **5147 Bridges - $13.1 billion**
  - Washington: **416 Bridges - $177 million**
  - Oregon: **143 Bridges - $44 million**

Thank you!

ACKNOWLEDGEMENTS:

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