Steve's proposed title: Why Ducks are more advanced than Beavers on the Evolutionary Scale?

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Considered alternative title: Why Cats are more advanced than Dogs on the Evolutionary Scale?

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Recent Earthquakes: Renewed Interest in Oregon's Lifeline Infrastructure

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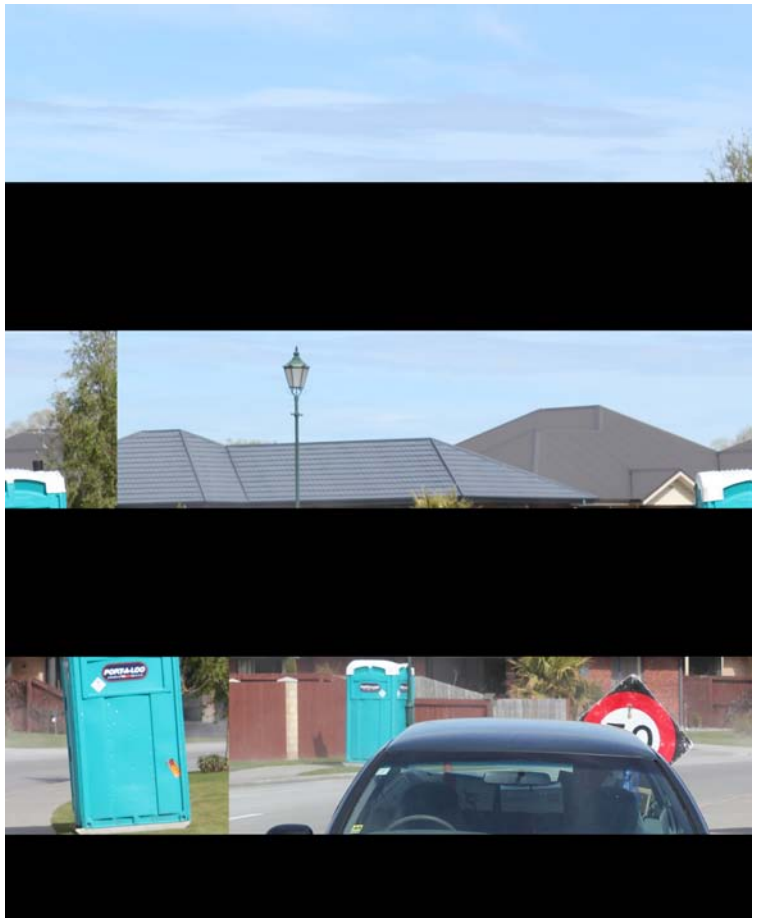
2010 Chile Earthquake

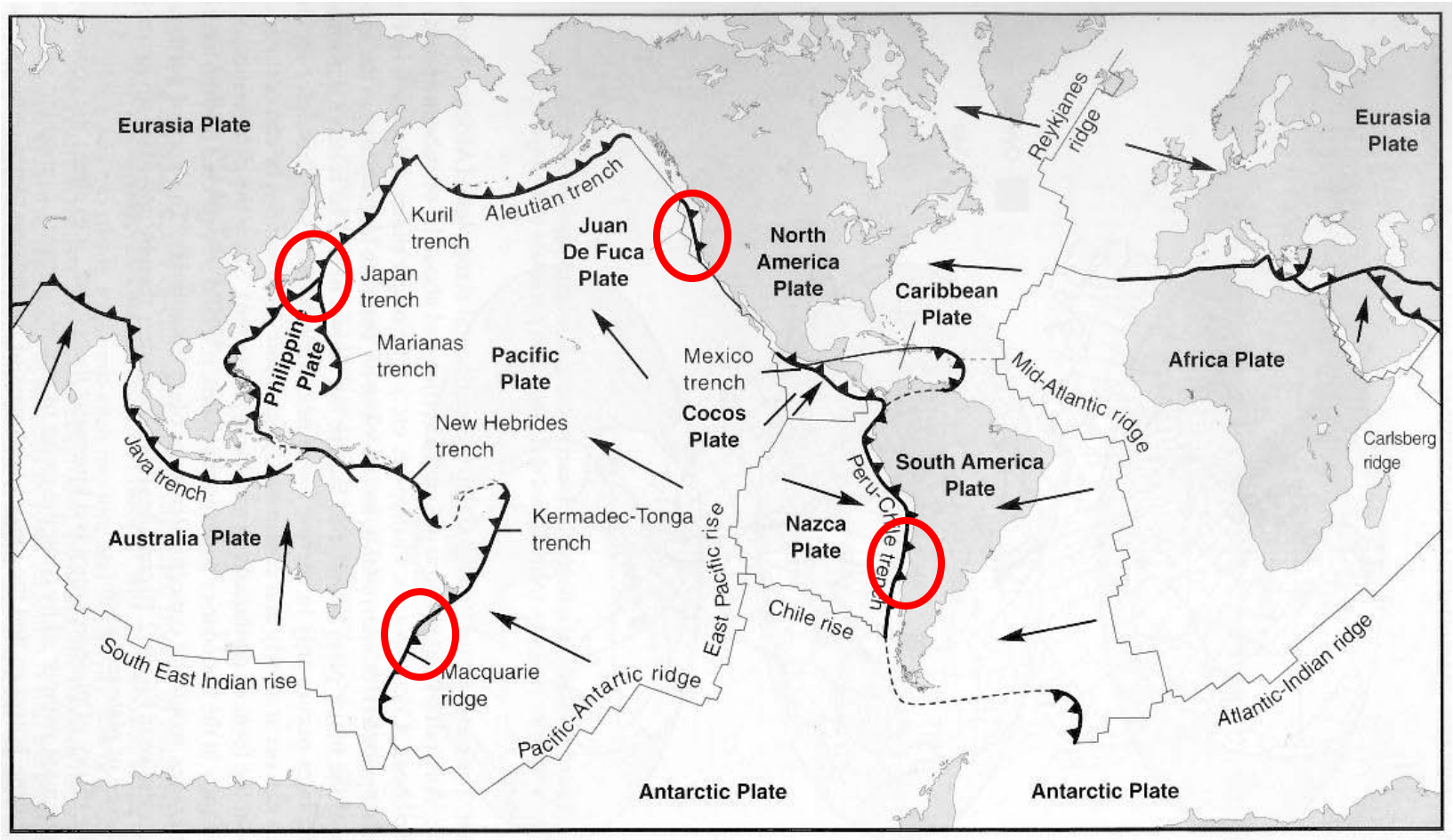
2010 Darfield Earthquake



2011 Japan Earthquake

LA Times Photo

Pacific “Ring of Fire”



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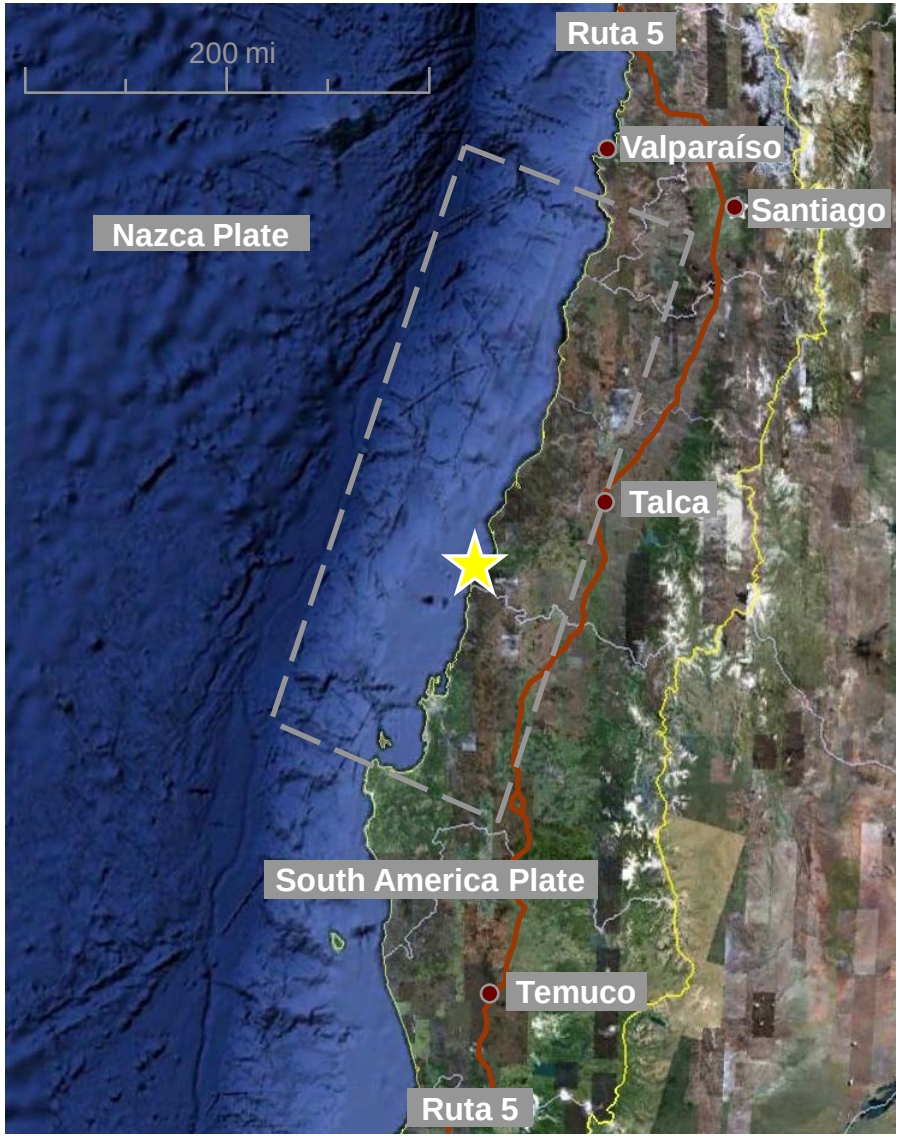

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What are the implications for Oregon?

- 2010 Chile Earthquake
  - Peru-Chile Subduction Zone
  - Magnitude 8.8
  - Shaking and Tsunami
  - Modern Building Codes
  - $30B damages
  - About 500 dead
  - 7 EQ M=8.0+ in past 100 yrs
  - Last M=8.0 in 1995
  - Occur about every 15 yrs

- Future CSZ Earthquake
  - Cascadia Subduction Zone
  - Magnitude 9.0
  - Shaking and Tsunami
  - Modern Building Codes
  - Damages estimated at $30B*
  - Estimated up to 5000 dead*
  - No M=7.0 is past 100 years
  - Last M=9.0 in 1700
  - Occur about every 300 yrs

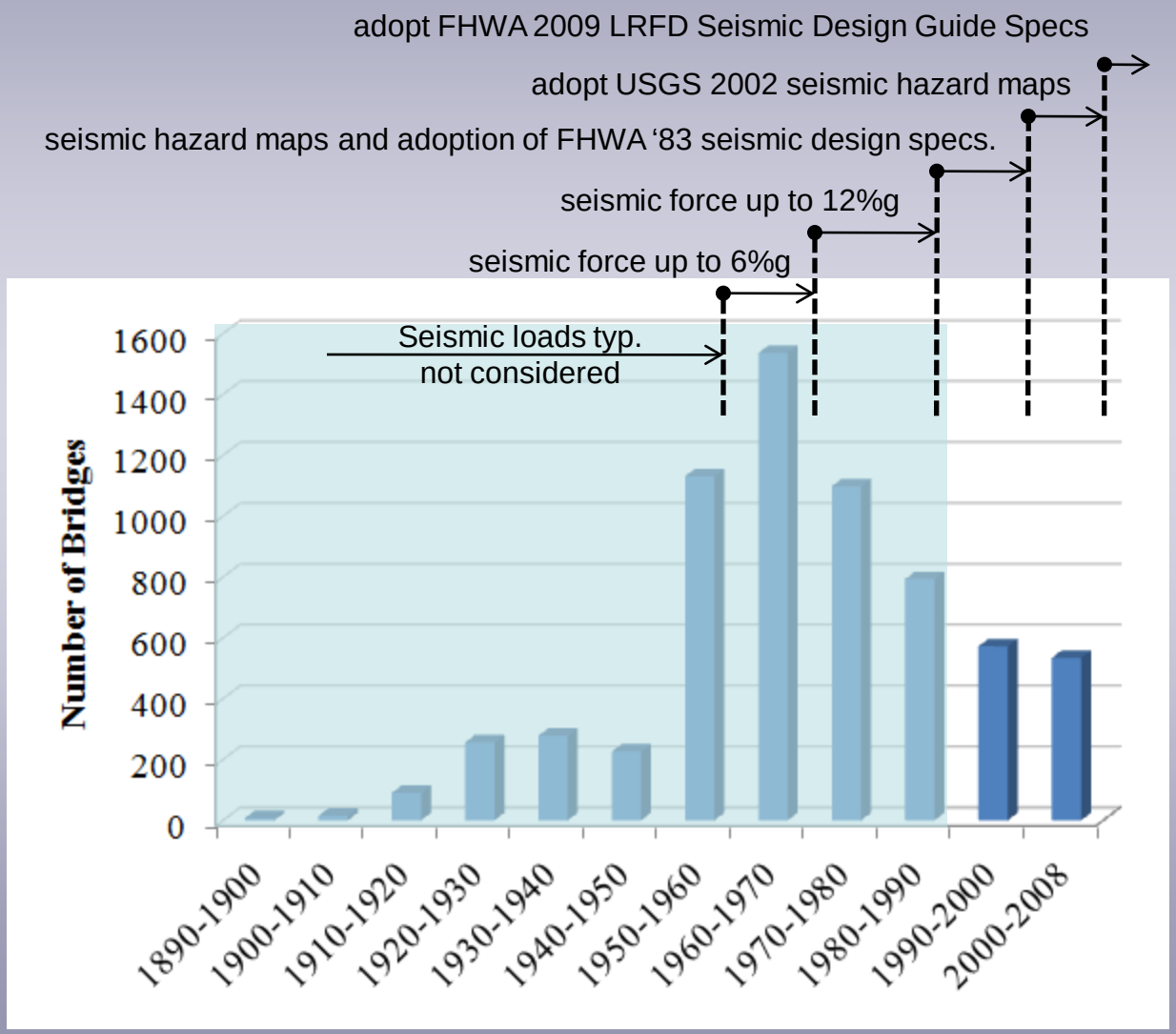
*Source: DOGAMI 2010

Oregon Department of Transportation

Seismic Risks to Oregon Highways and ODOT Mitigation Actions

State Interagency Hazard Mitigation Team - July 21, 2011

Seismic Bridge Design in Oregon

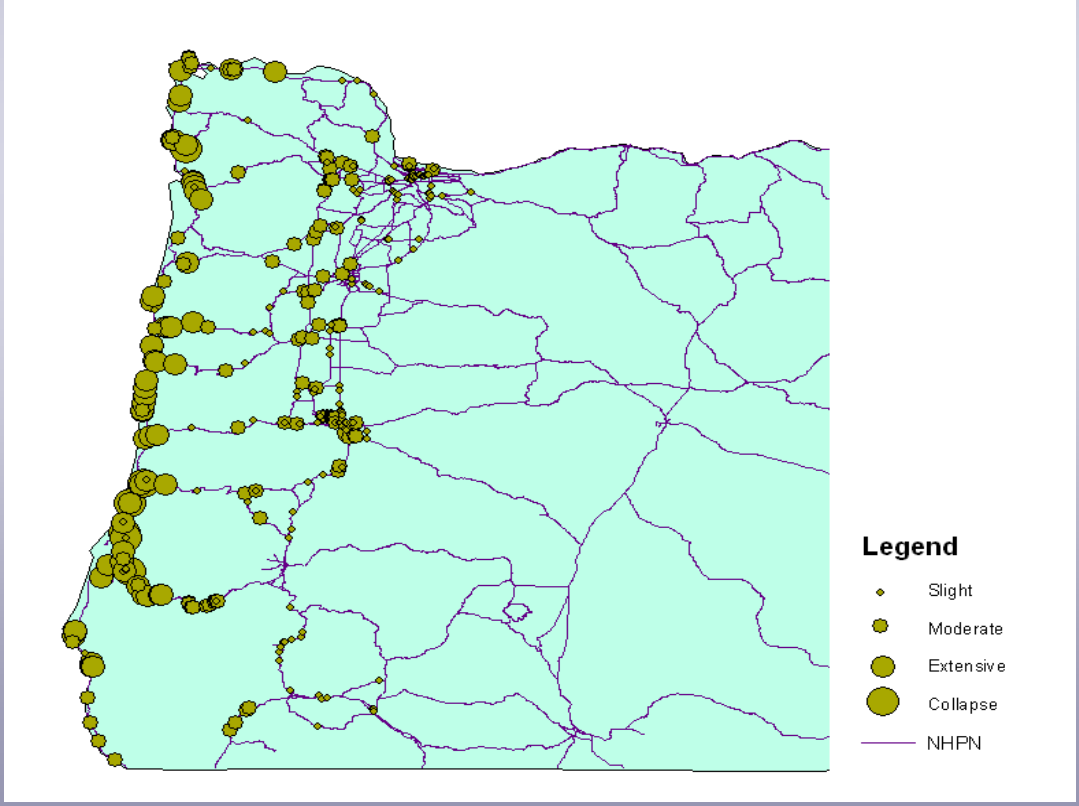


Cascadia Subduction Zone Earthquake (Magnitude 9.0)

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

Retrofitting Progress

First 16 Years Since Vulnerability was Identified

Years	Actions
1994/1997	CH2M Hill prioritization includes all state and local bridges. Priority state bridges 1155
1994-2010	• Phase 1 retrofit added to repair projects 72 In the OTIA III program 6 • Replacements with seismic design 40 In the OTIA III program 150 Total number of bridges addressed 268
Future	Bridges still need retrofitting (219 years) 887 Impact of OTIA III payback for 20 years.

Seismic Vulnerability of Oregon State Bridges – Recommendations

Action that needs broad support and additional funding to accomplish:

Develop a long-term strategy for mitigation of seismic vulnerability and risk for entire highway system including bridges, landslides, local roads, and critical facility access to support a dedicated seismic retrofitting program for critical transportation features.

Seismic-induced landslides damaging lifeline corridors

- Few lifeline routes connect Oregon's coastal communities to valley

- Highway 101 presents significant maintenance issues for ODOT

- These highways are prone to landslides
  - (unstable slopes and saturated, weak soils)

- Closure = significant safety and economic impacts

Photo by: Michael Lloyd, The Oregonian

ODOT Project on Lifeline Corridors (Olsen & Ashford)

- Integrate USGS ground motions, aerial LiDAR, geologic mapping, rainfall, and existing landslide mapping into a GIS regional slope stability analysis

3D laser scan of slope failure – Highway 20 Re-alignment

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Seismic Behavior of Willamette Silts (Mason)

- Pervasive in the Willamette Valley or Oregon (Portland to Eugene)
- Very soft to very loose alluvial silt
  - $(N_1)_{60}$ ~ 2 to 15
  - ML/MH
  - PI =10++
- Much of Oregon's infrastructure rests on this silt, and we need a better of its seismic behavior

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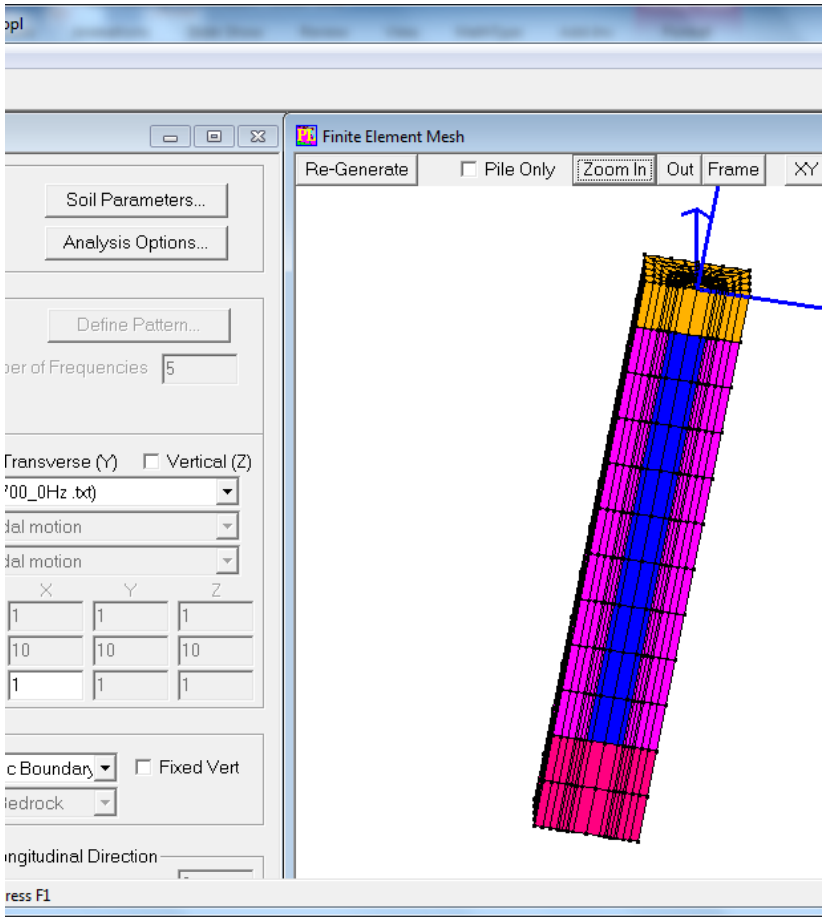
Ground Improvement Research with PEER

- Joint project funded by ODOT, PEER, and Hayward Baker
- Boulanger/UCD, Shao/HB, Elgamal/UCSD, Ashford/OSU
- First effort to bring ODOT into PEER



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We have a lot of work to do

- Improving pre- and post-earthquake mobility
  - Cost effectively
  - Impact of tsunami
- Seismic behavior of silts
- Impact of long duration motions on liquefaction damage
- Assessment and retrofit of “legacy” lifeline infrastructure
- Understanding system behavior to improve resilience

As PEER, we are in a unique position to help