Tualatin Valley Water District

Seismic Resiliency Planning for a Large Water Distribution System: Tualatin Valley Water District

May 4th, 2016

AWWA-PNWS 2015 Annual Conference

Boise, ID

carollo
Engineers...Working Wonders With Water®

Learning Objectives

1. Raise awareness of the “Big One”
2. Raise awareness of the Oregon Resilience Plan
3. Encourage utilities to take the first steps in planning

Session Outline

INTRODUCTION

Let’s Start with Some Context about Water

Water is a gift

Water is precious

Water is essential

Resiliency Recently in the Media

What is Resiliency?

re·sil·ience \ri-ˈzil-yən(t)s\

: the ability to become strong, healthy, or successful again after something bad happens

: the ability of something to return to its original shape after it has been pulled, stretched, pressed, bent, etc.

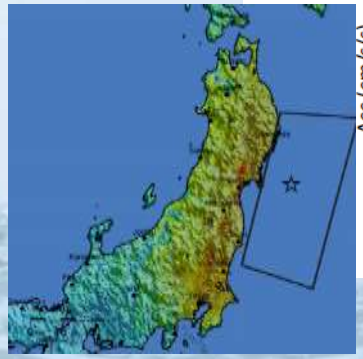
http://www.merriam-webster.com/dictionary/resilience

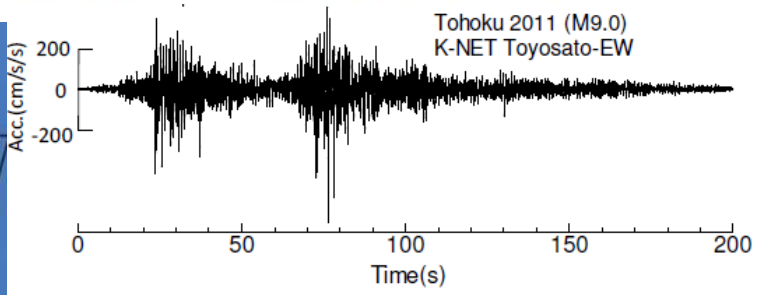
Cascadia Subduction Zone Earthquake Expected to be Similar to Tohoku Japan

M9.0 Earthquake (March 11, 2011)

FEMA

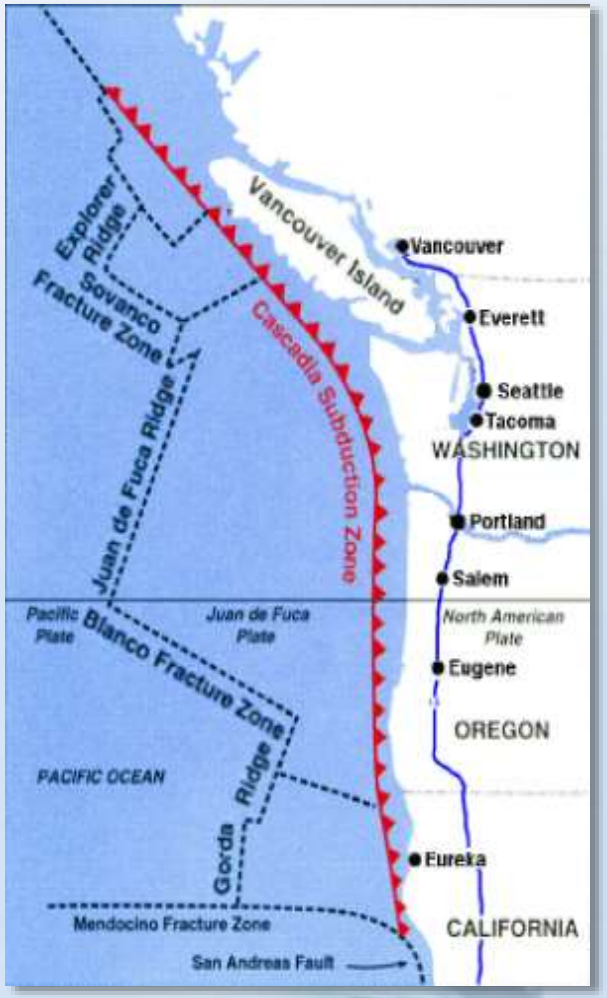
- 16,447 Deaths
- 4,787 Missing
- 5,888 Injured
- 430,000 Homeless
- 111,944 Buildings destroyed
- 637,277 Buildings damaged
- Honshu Island moved 7.8 feet West
- Nuclear power meltdown
- Cost could exceed $300 billion

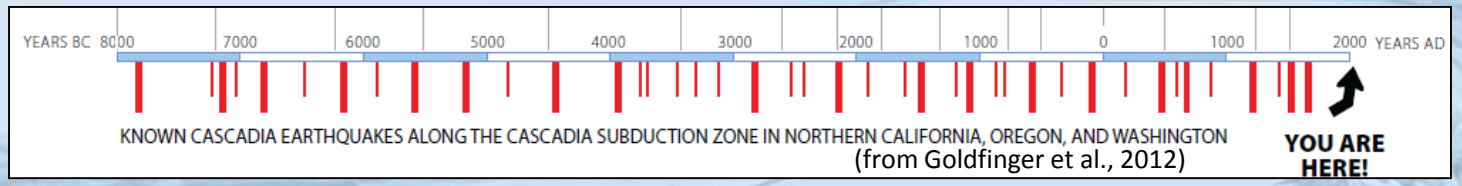




FEMA's Planning Scenario

- M9.0 Earthquake
- February 6, 2012 at 9:41 AM PST
- Direct impact to 3 states, 2 FEMA Regions
- Complete rupture of the 800 mile fault line
- Impacts affecting over 140,000 sq. mi.
- Ground shaking lasts up to 5 minutes
- Numerous aftershocks, several M7.0+
- 1,000+ deaths from earthquake, 24,000+ injuries
- 10,600+ deaths from tsunami, 2,600+ injuries





NIST Approach to Community Resilience

Six Step Process:

1. Form a collaborative planning team
2. Understand the situation
3. Determine goals & objectives
4. Plan development
5. Plan preparation, review and approval
6. Plan implementation and maintenance

Figure ES-3: Six-step planning process for community resilience

ave.pptx

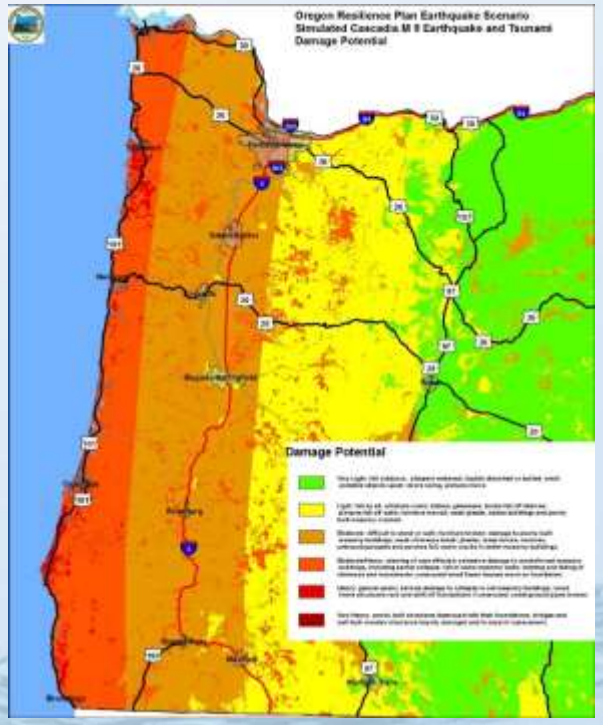
Community Resilience

NIST National Institute of Standards and Technology U.S. Department of Commerce

Level of Service Goals Provide the Targets for Infrastructure Performance

Oregon Resilience Plan major finding:

- Very large earthquakes will occur in Oregon's future, and our state's infrastructure will perform poorly unless action is taken now

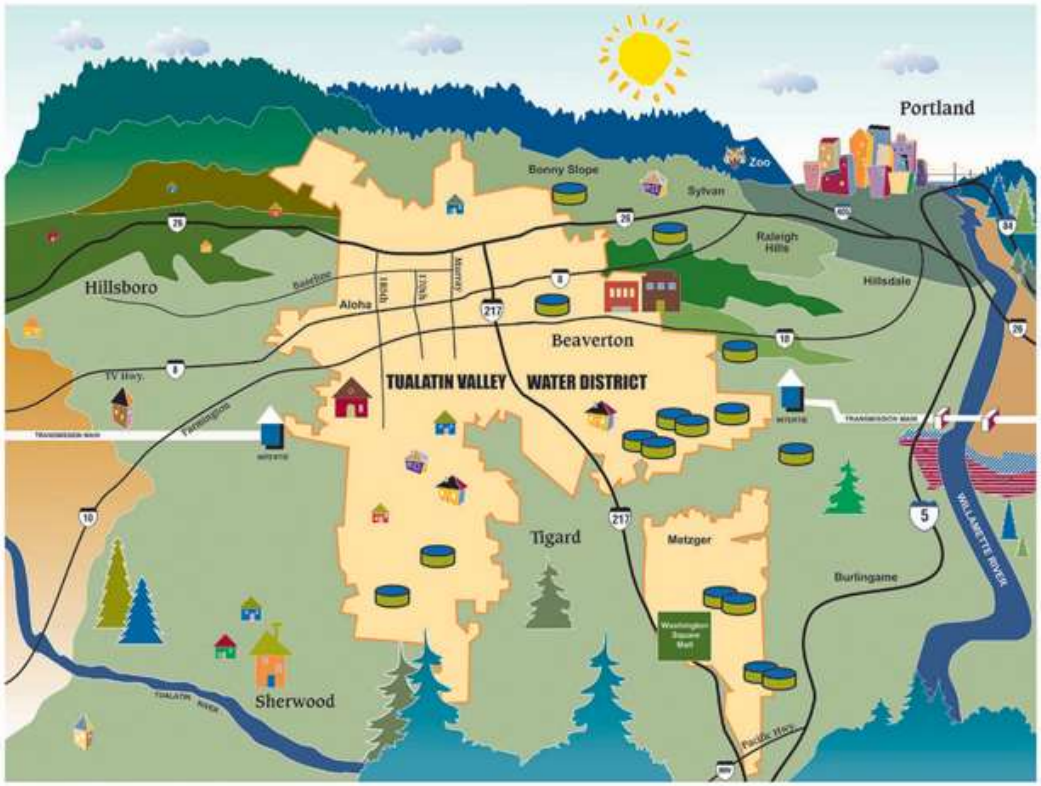


"The backbone water system would be capable of supplying key community needs, including fire suppression, health and emergency response, and community drinking water distribution points, while damage to the larger (non-backbone) system is being addressed."
(Oregon Resilience Plan)

About the Tualatin Valley Water District

- Population of 211,360
- Covers 23,000 acres
- 25 Major Pressure Zones
- 762 Miles of pipe
- 25 Storage Reservoirs
- 13 Pump Stations

Joint Water Commission

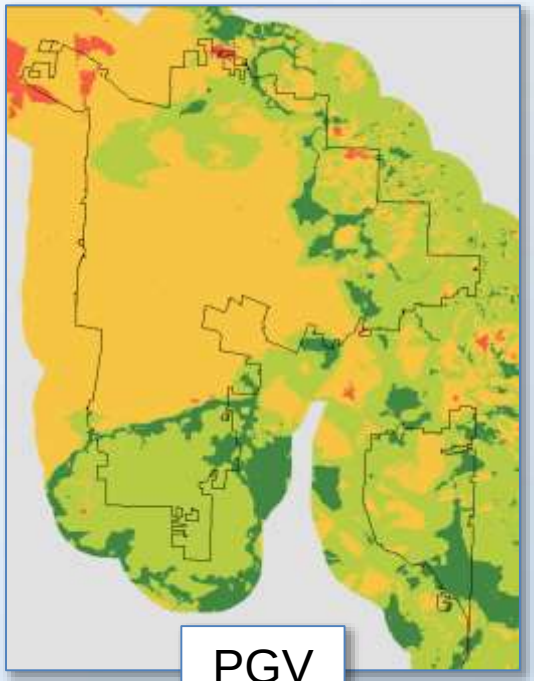


Bull Run Water Supply

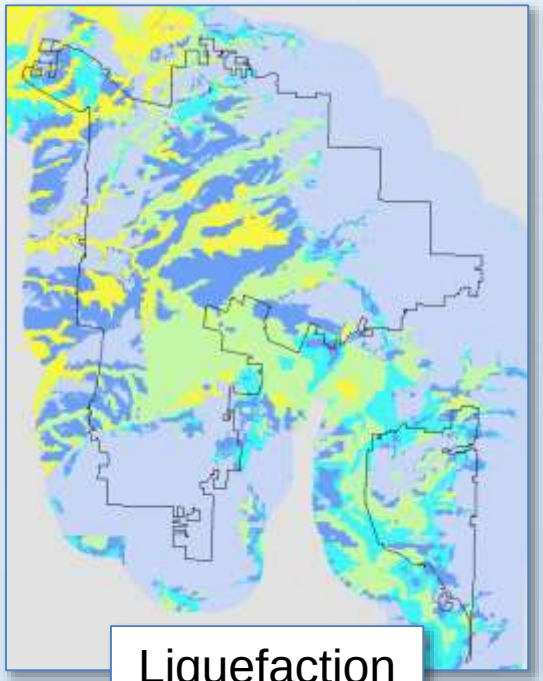
TVWD CURRENT STATE: IF THE EARTHQUAKE HAPPENED TOMORROW…

Seismic Hazard Identification

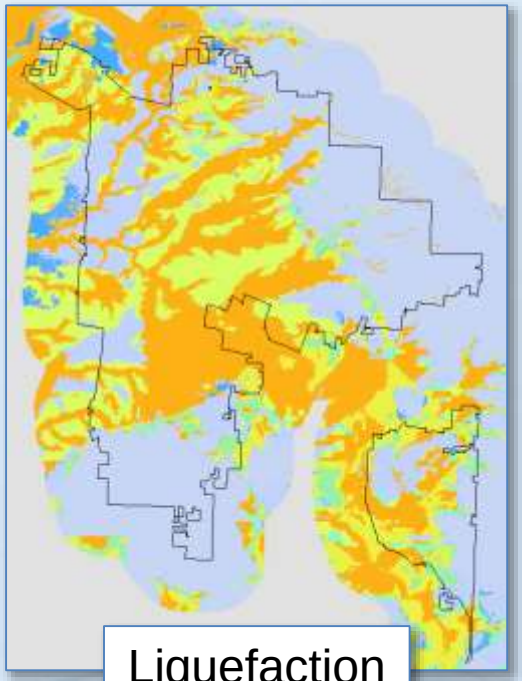
- Oregon Department of Geology and Mineral Industries (DOGAMI) publishes seismic hazard data in GIS format.
  - Data is on *regional* scale, best used for high level evaluations



PGV



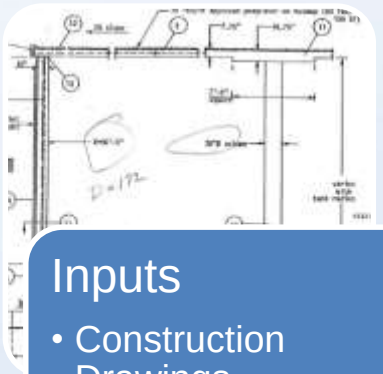
Liquefaction Probability



Liquefaction PGD

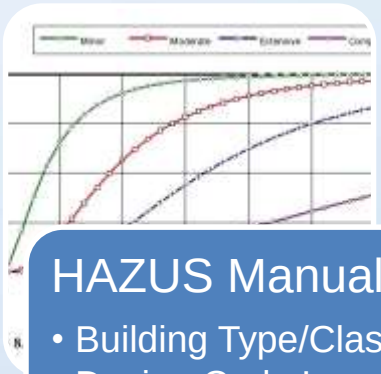
Anticipated Damage to Storage and Pumping Facilities

- HAZUS: Multi-Hazard Loss Estimation model developed by FEMA
- Specific section for water/wastewater infrastructure (Ch 08)



Inputs

- Construction Drawings
- Geotech Reports
- Seismic Reports
- Hazard Data



HAZUS Manual

- Building Type/Class
- Design Code Level
- Appropriate Fragility Curve

Anticipated Damage

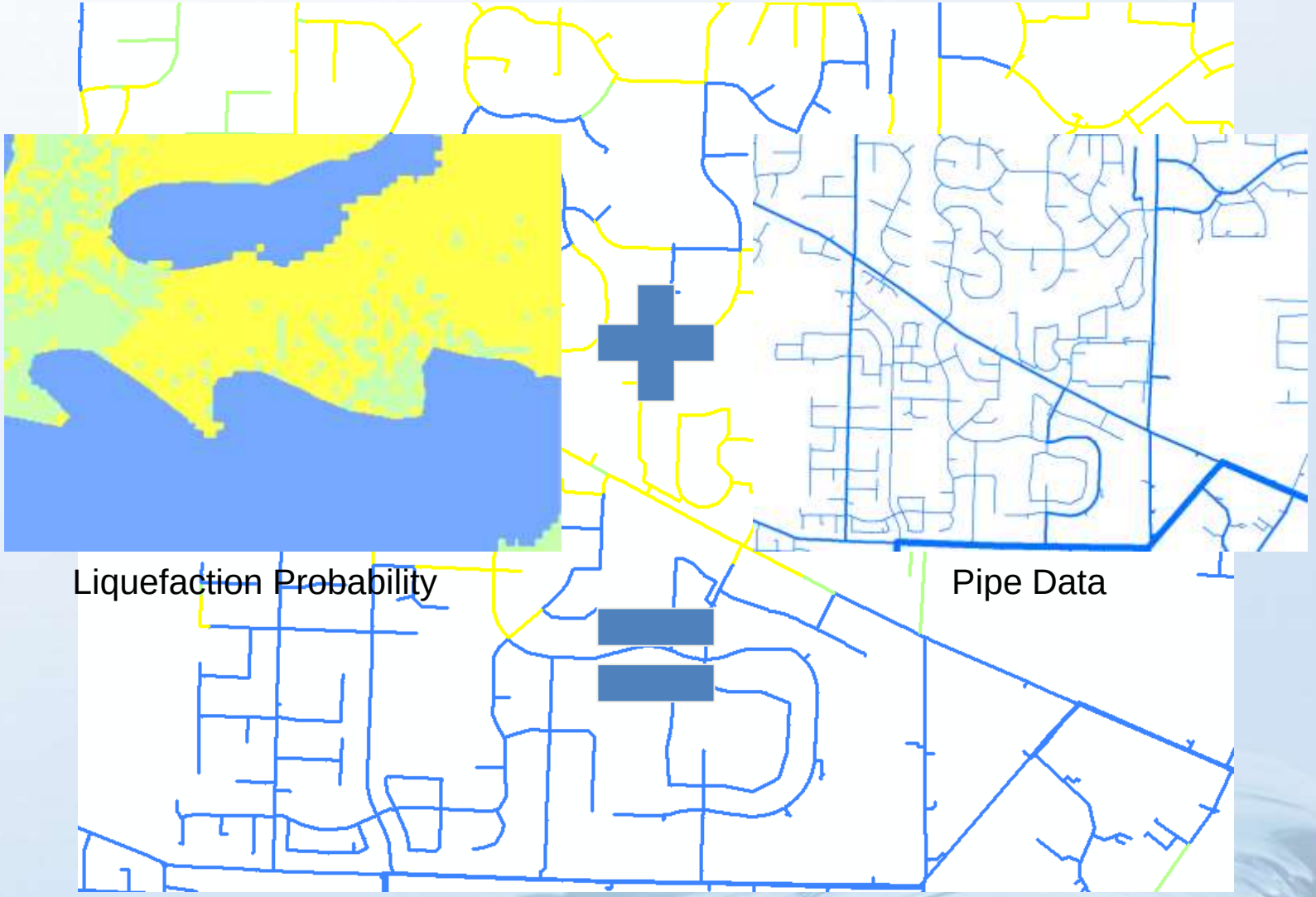
- Slight to Complete

Anticipated Damage to Pipelines

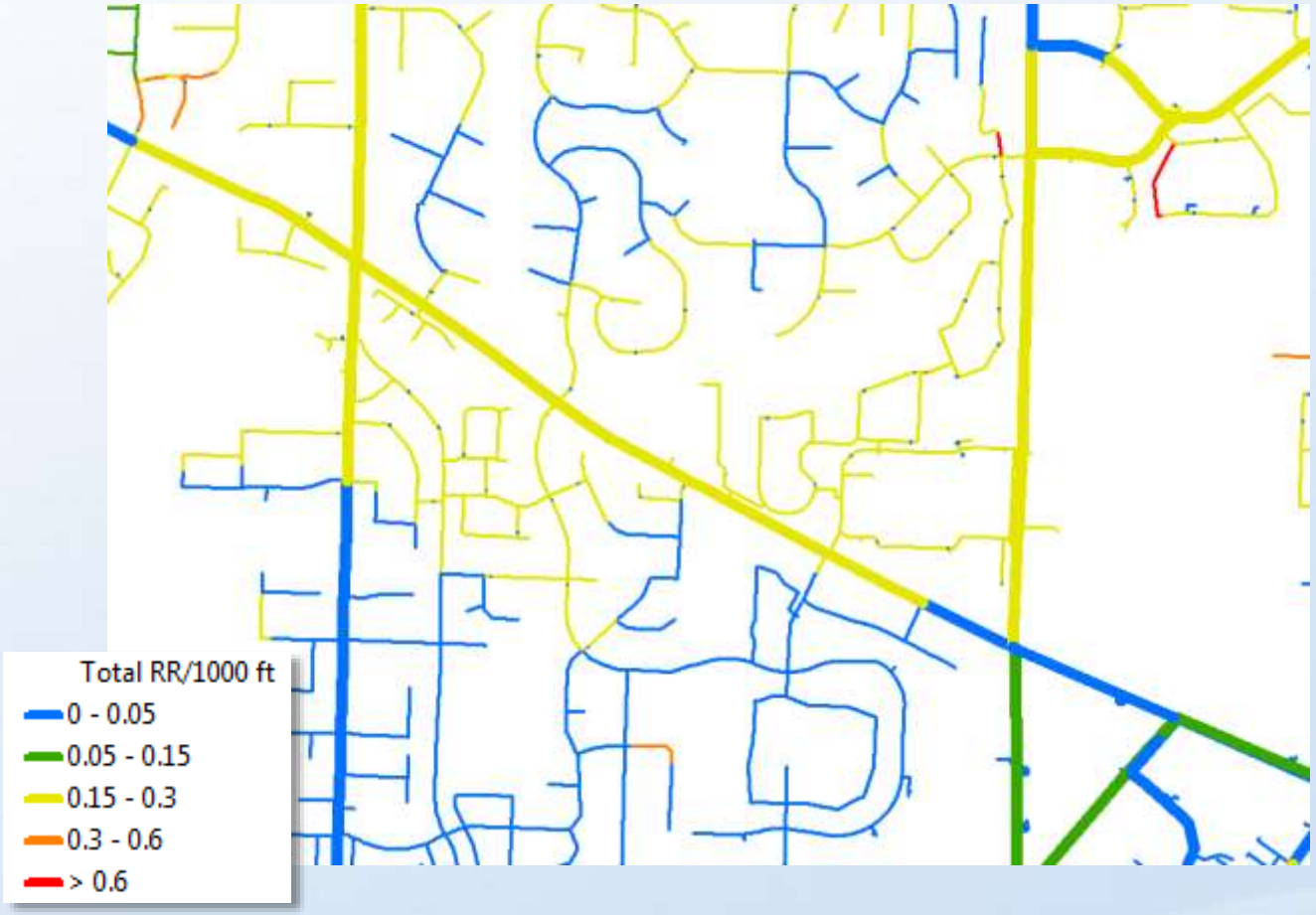
- Assign pipe fragility values based on pipe material in GIS
- Required Data
  - Pipe Material
  - Diameter
  - Joint Type
  - Soil Type

Pipe Material	K_1, PGV	K_2, PGD
Ductile Iron	0.15 - 0.5	0.5
Cast Iron	0.7 – 1.4	0.7 – 1.0
Concrete	0.15 – 1.3	0.15 – 0.7
Welded Steel	0.15 – 1.3	0.6 – 1.0
PVC	0.15 – 0.5	0.8
HDPE	0.15	-

Anticipated Damage to Pipelines

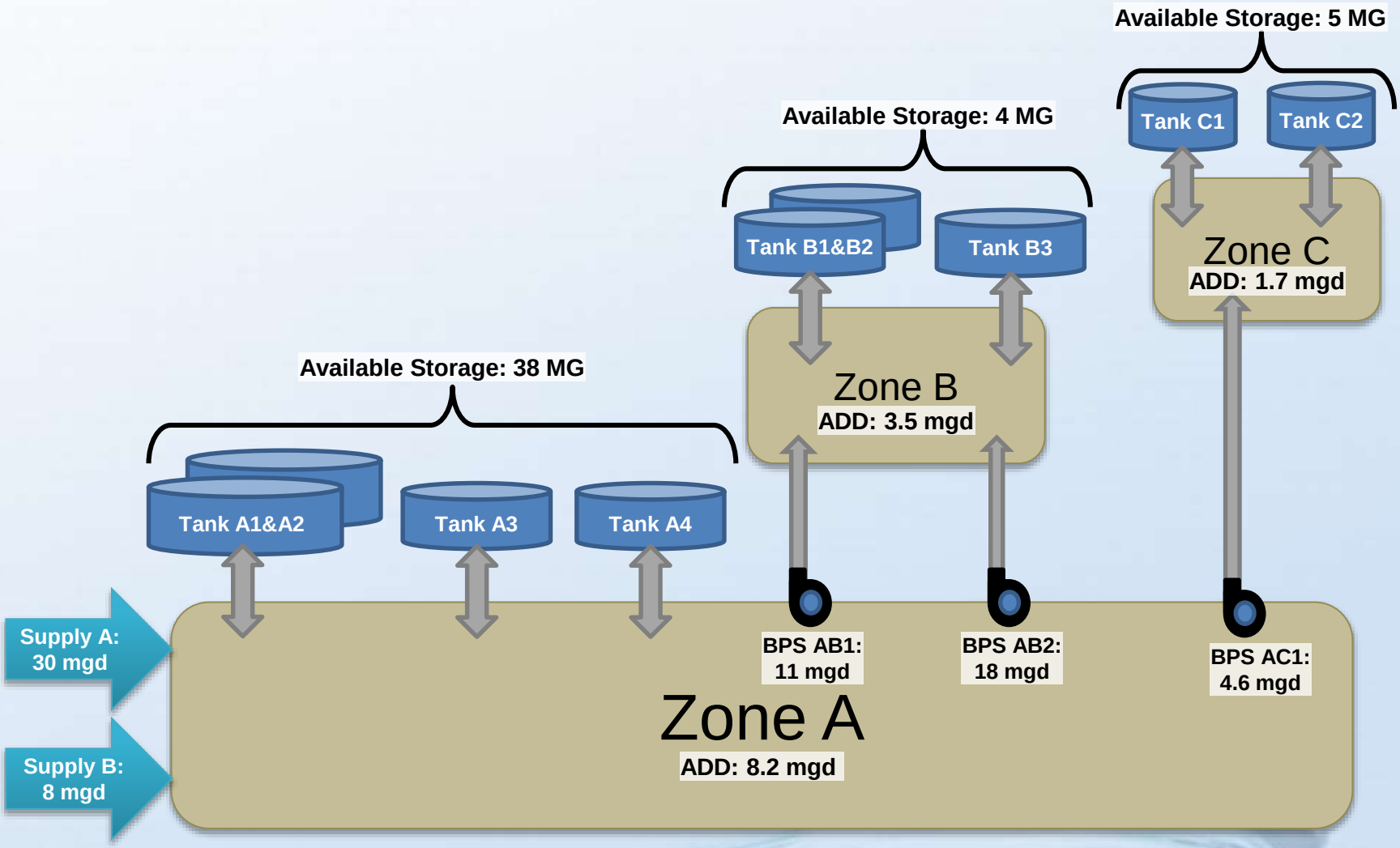


Anticipated Damage to Pipelines



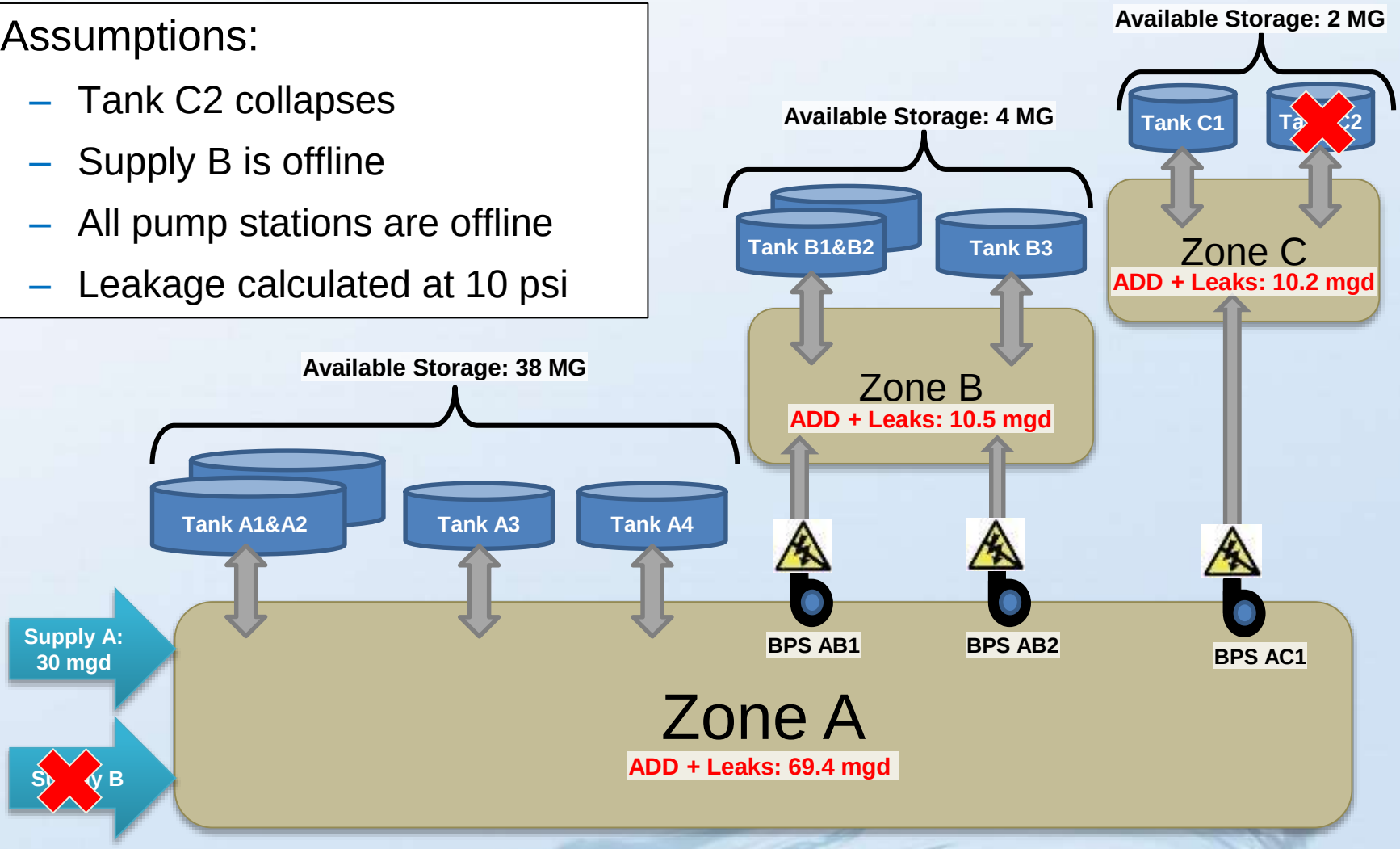
Pipe fragilities and seismic hazard data are combined in GIS to calculate a “repair rate” per 1,000 LF

System Operability Example

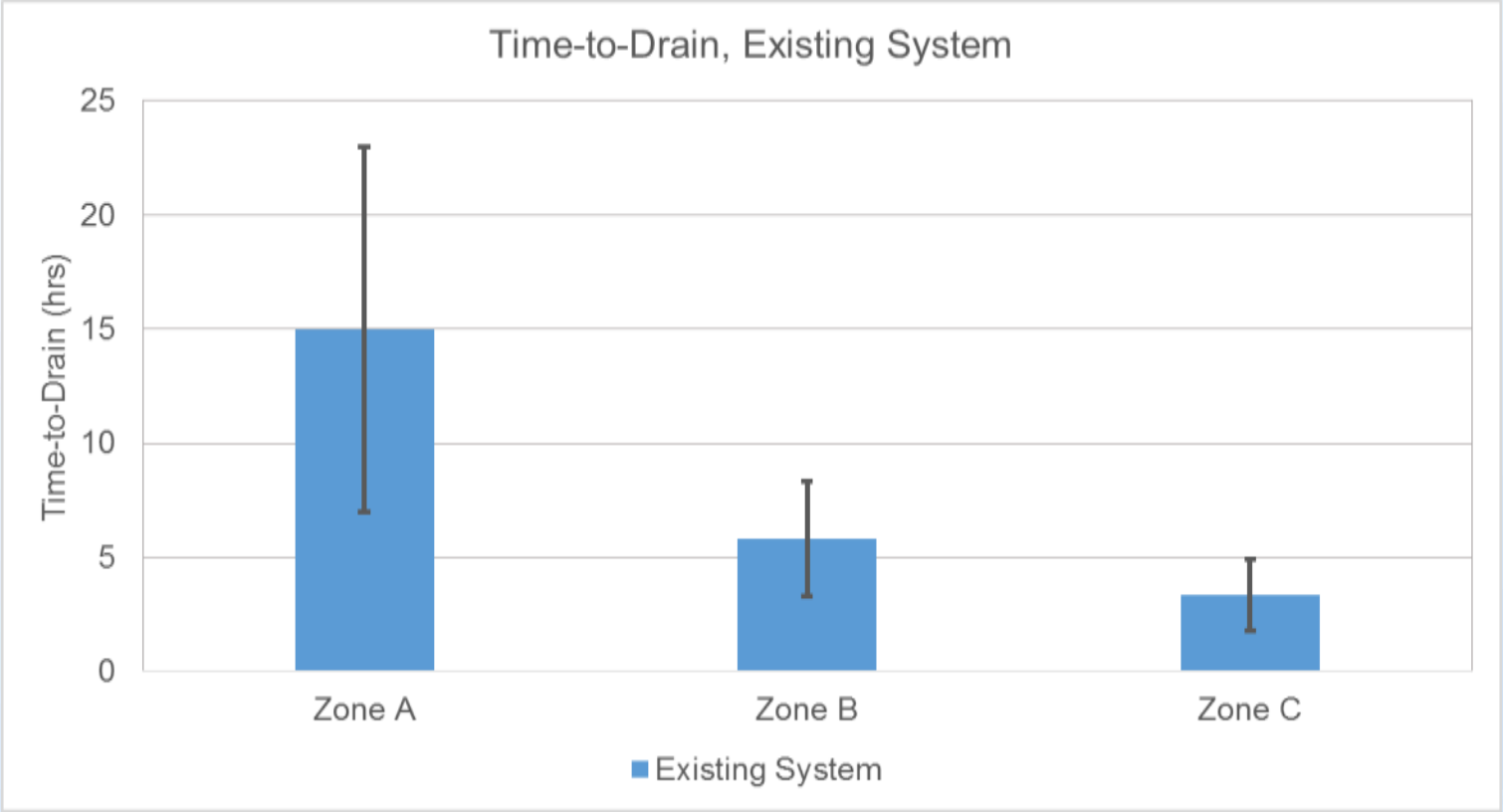


System Operability Example – Post Event

- Assumptions:
  - Tank C2 collapses
  - Supply B is offline
  - All pump stations are offline
  - Leakage calculated at 10 psi



Range of Time to Drain

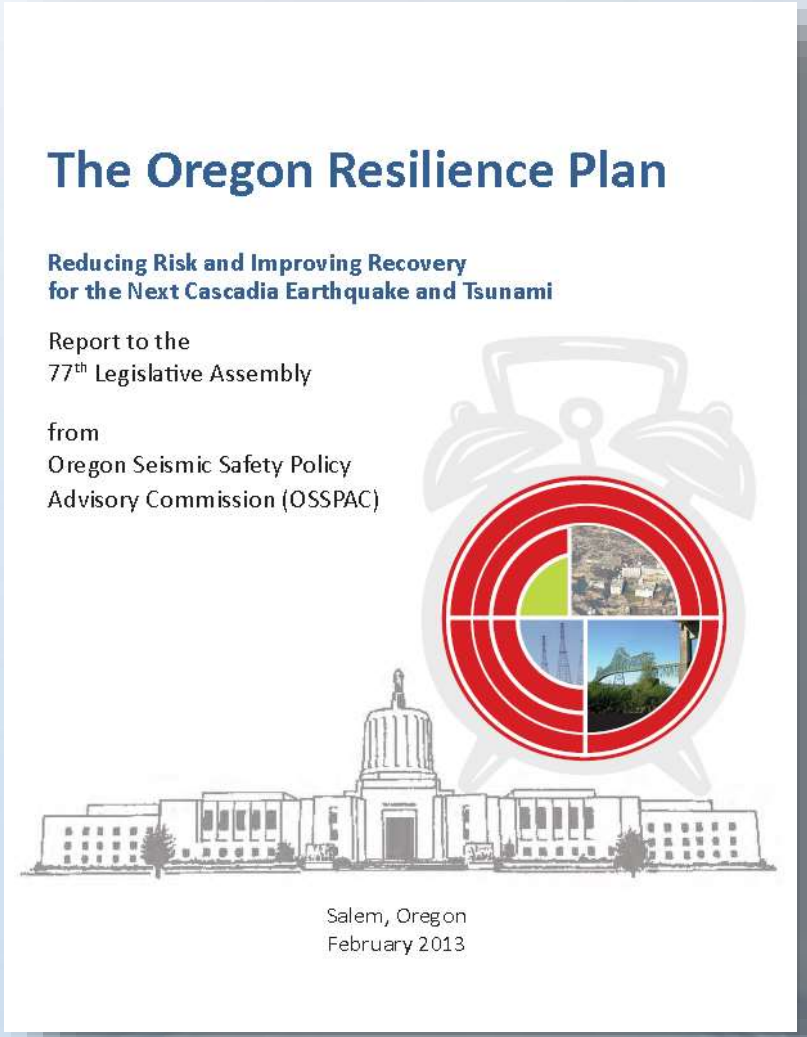


BUILDING A RESILIENT SYSTEM

Level of Service Goals

1. Normal Conditions
2. Emergency
3. **Catastrophic Event**

TVWD opted to meet the ORP goals for the catastrophic event



Oregon Resilience Plan provides clear goals for operation following a major event

TARGET STATES OF RECOVERY: WATER & WASTEWATER SECTOR (VALLEY)

	Event occurs	0–24 hours	1–3 days	3–7 days	1–2 weeks	2 weeks–1 month	1–3 months	3–6 months	6 months –1 year	1–3 years	3 + years
Domestic Water Supply											
Potable water available at supply source (WTP, wells, impoundment)		R	Y		G			X			
Main transmission facilities, pipes, pump stations, and reservoirs (backbone) operational		G					X				
Water supply to critical facilities available		Y	G				X				
Water for fire suppression—at key supply points		G		X							
Water for fire suppression—at fire hydrants				R	Y	G			X		
Water available at community distribution centers/points			Y	G	X						
Distribution system operational			R	Y	G				X		

80 – 90% Operational

50 – 60% Operational

20 – 30% Operational

Current State/90% Operational

G

Y

R

X

Selecting and "hardening" the right system backbone meets 4 out of 7 goals

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Potable water available at supply source (WTP, wells, impoundment)		R	Y		G			X			
Main transmission facilities, pipes, pump stations, and reservoirs (backbone) operational	✓	G					X				
Water supply to critical facilities available	✓	Y	G				X				
Water for fire suppression—at key supply points	✓	G		X							
Water for fire suppression—at fire hydrants				R	Y	G			X		
Water available at community distribution centers/points	✓		Y	G	X						
Distribution system operational			R	Y	G				X		

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Y

R

X

A backbone system should connect supplies to critical customers

A resilient backbone “survives” the earthquake

- Facilities
  - Hardening structures
  - Flexible connections
  - Bracing equipment
  - Backup power
  - Tanks: seismic-actuated isolation valves
- Pipes
  - Restrained Joints
  - Earthquake Resistant Pipe
  - Flexible connections

What about the rest of the system?

TARGET STATES OF RECOVERY: WATER & WASTEWATER SECTOR (VALLEY)

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Potable water available at supply source (WTP, wells, impoundment)		R	Y		G			X			
Main transmission facilities, pipes, pump stations, and reservoirs (backbone) operational	✓	G									
Water supply to critical facilities available	✓	Y	G								
Water for fire suppression—at key supply points	✓	G		X							
Water for fire suppression—at fire hydrants				R	Y	G			X		
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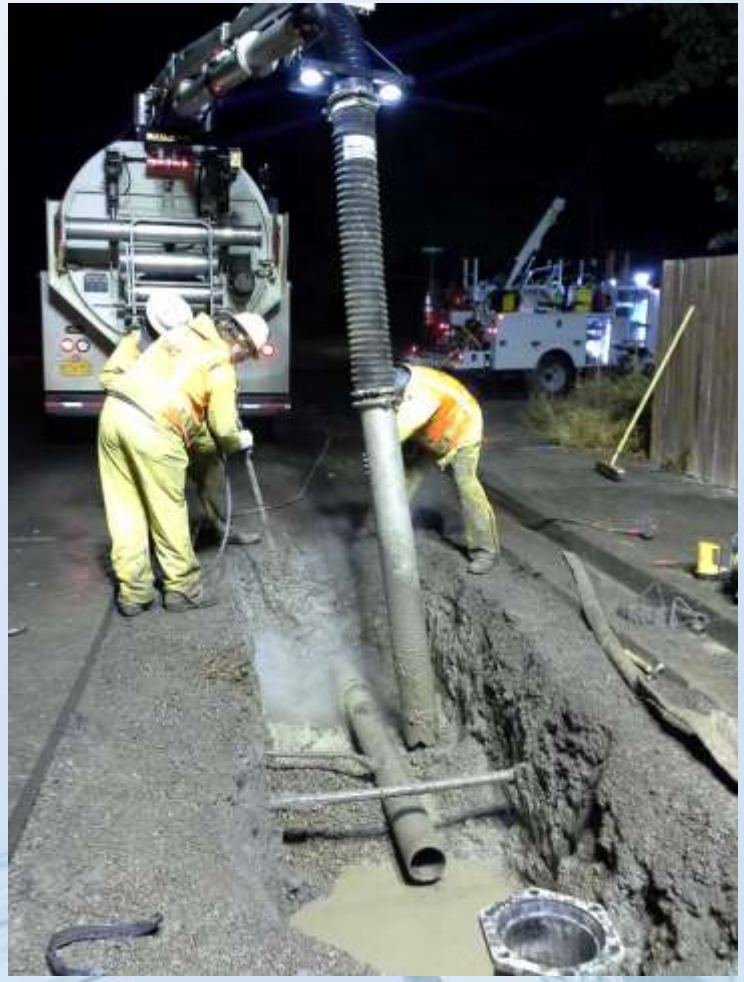
Y

R

X

Number of crews needed to reach 90% operational with no improvements

Transmission	
Repairs	80
Labor Hours	18,135
Distribution	
Repairs	208
Labor Hours	7,410
Repair Crews	
Crew Size (# workers)	4
Shift Length (hrs)	12
4-Person Crews Needed	**39**



Start building in resilience over time with updated design standards

Design standards should consider:

Diameter: small vs. large

Risk: low vs. high (confirm soils, pipe material, joint type, etc. in the field)

Criticality: backbone vs. non-backbone

Assumptions for Cost Estimating:

Pipe Size	Low Risk	High Risk
Small	Standard DIP	ERDIP
Large	Standard steel w/ some flex couplings	Double-welded steel pipe with flex couplings

ERDIP = Earthquake Resistant Ductile Iron Pipe

Through backbone selection and design standards, the District is well on its way to resilience

TARGET STATES OF RECOVERY: WATER & WASTEWATER SECTOR (VALLEY)

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G

Y

R

X

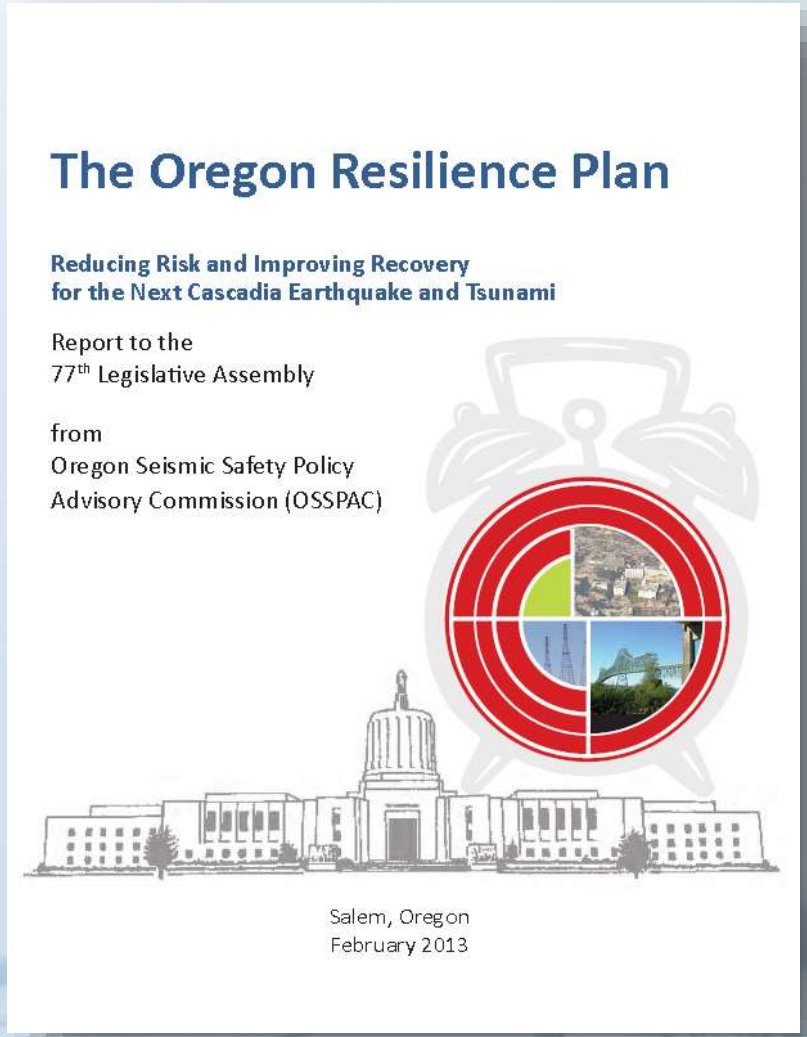
How can you reduce the cost of resilience planning?

1. Select backbone facilities/pipes from already planned CIP projects;
2. Identify “do-nothing” pipes using GIS hazard mapping;
3. Develop higher design standards for high-hazard areas.

Summary – Learning Objectives

1. Raise awareness of the “Big One”
2. Raise awareness of the Oregon Resilience Plan
3. Encourage utilities to take the first steps in planning

Questions?


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)
Salem, Oregon
February 2013

System Leakage and Demands