Tualatin Valley Water District's Approach to Seismic Resiliency

April 29, 2015

Tualatin Valley Water District

American Water Works Association
Pacific Northwest Section

Outline

TVWD Background

Why is Seismic Resiliency Important

Different Models for Seismic Resiliency

TVWD's Approach to Seismic Resiliency

Water Infrastructure Resiliency

"AlaskaQuake-FourthAve" by U.S. Army - http://libraryphoto.cr.usgs.gov/

Alaska 9.2 M Earthquake
March 27, 1964, at 5:36 p.m.

TVWD Background

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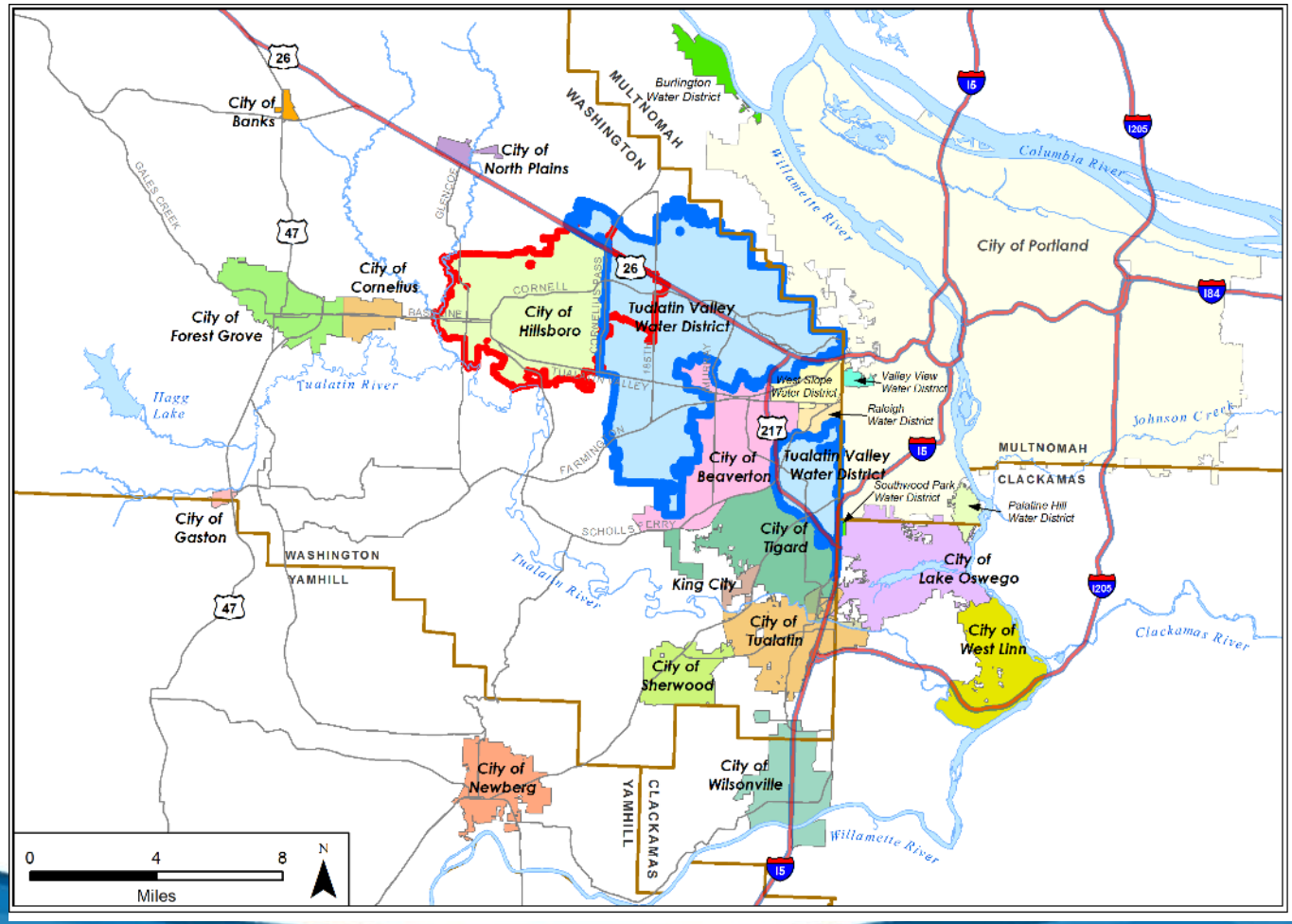
Water Infrastructure Resiliency

Tualatin Valley Water District

- Statistics:
  - 2nd largest water provider in the state
  - 200,000 people served
  - 800 miles of pipelines
  - 60 MG storage (8MG additional next year
  - 12 pump stations
  - 28 pressure zones



TVWD Background

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Water Infrastructure Resiliency

Let’s start with some context about water

Water is a Gift

Water is Precious

Water is Essential

Resiliency

re·sil·ience **\ri-'zil-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.

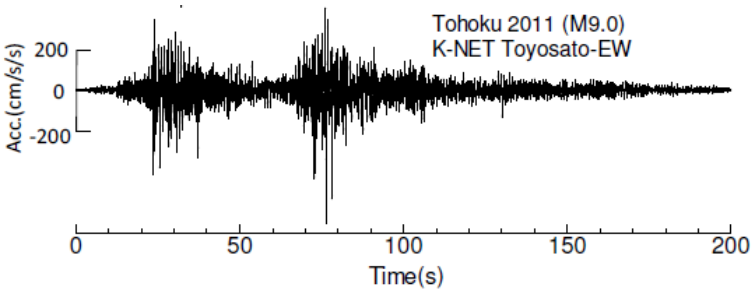
http://www.merriam-webster.com/dictionary/resilience

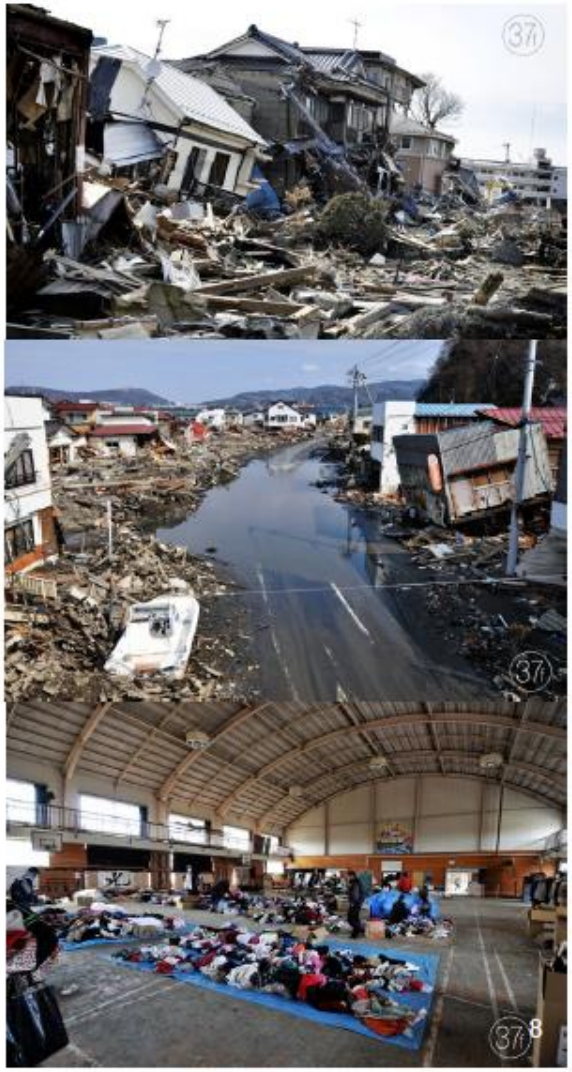
Tohoku Japan

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

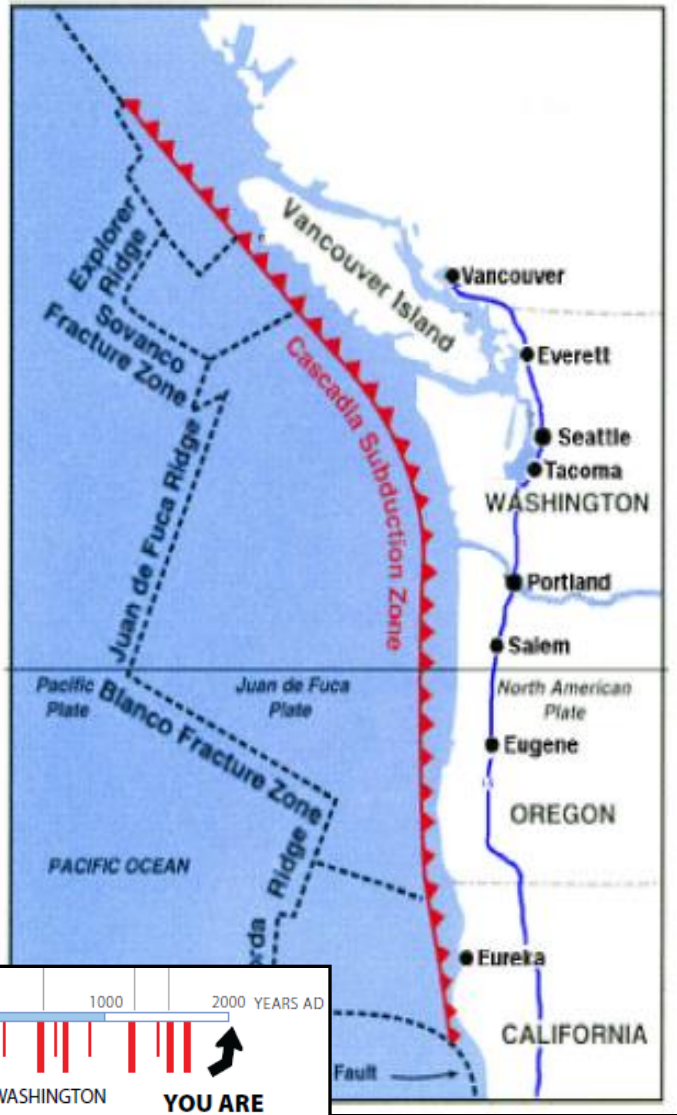


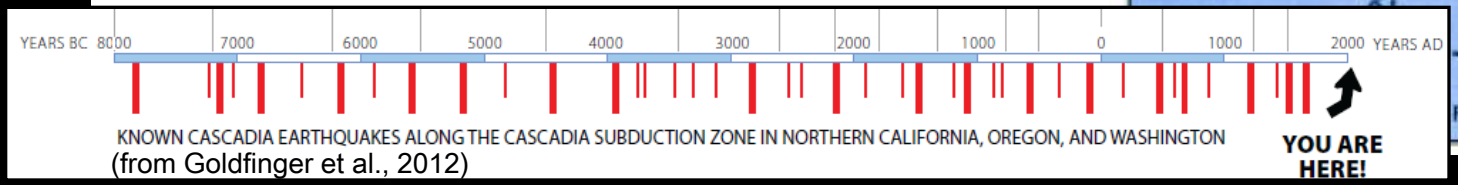


FEMA Planning Scenario

FEMA

- 9.0 m. 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 with several of M7.0+
- 1,100+ Deaths From Earthquake 24,000+ injuries
- 10,600+ Deaths from tsunami & 2,600 injuries





KNOWN CASCADIA EARTHQUAKES ALONG THE CASCADIA SUBDUCTION ZONE IN NORTHERN CALIFORNIA, OREGON, AND WASHINGTON
(from Goldfinger et al., 2012)

Definition of Resiliency

Presidential Policy Directive (PPD) 21 - Critical Infrastructure Security and Resilience (February 12, 2013)

- The term **"resilience"** means the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents.

TVWD Background

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Water Infrastructure Resiliency

Flames billow from a ruptured gas main beyond a crater in the 11600 block of Balboa Boulevard in Granada Hills. (Los Angeles Times)

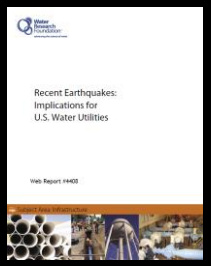
Northridge 6.7 M Earthquake
January 17, 1994, at 4:31 a.m.

Different Models for Seismic Resiliency

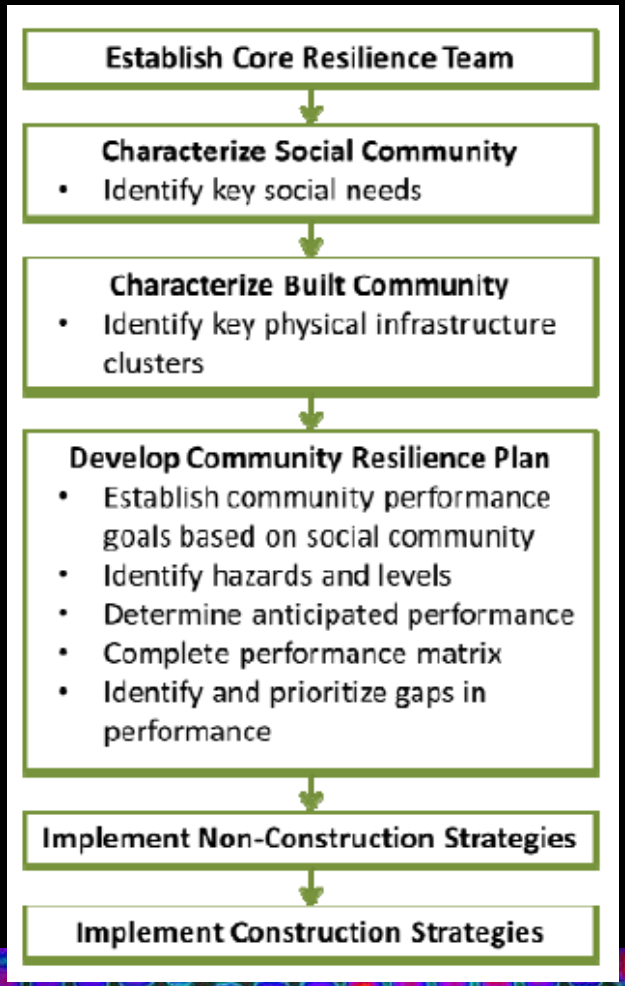
Recommendation	Charleston Water System[1]	Water Res. Fndn. Web Report #4408[2]
Soils/geohazards	X	
Design stds/resil. pipe	X	X
Redundancy crit. cust.	X	
Iso. valves vuln. areas	X	
Response planning	X	
Vuln. analysis		X
Performance goals		X
CIP exist. & new	X	X

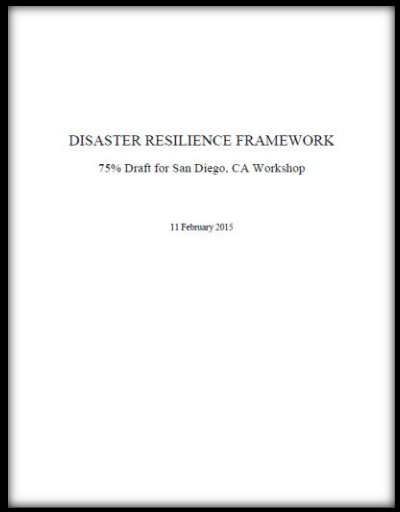
[1]Priatla, K., Fisher, K., Andrus, R., Simonson, L., & Farahmandfar, Z. (2014). Evaluating the Resiliency of the Water System in Charlston, South Carolina against Liquefaction Hazard Through the Use of Seismic Hazard Maps. *ASCE Pipelines 2014*, 1217-1228.

[2] Eidinger, J and Davis, C. (2012). Recent Earthquakes: Implications for U.S. Water Utiliites, Web Report #4408, Water Research Foundation, Denver, CO.



NIST Flow Chart for Developing Resilience Plan




DISASTER RESILIENCE FRAMEWORK

75% Draft for San Diego, CA Workshop

11 February 2015

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Water Infrastructure Resiliency

http://www.portstrategy.com/news101/world/australasia/christchurch-port-rebounds-from-quake

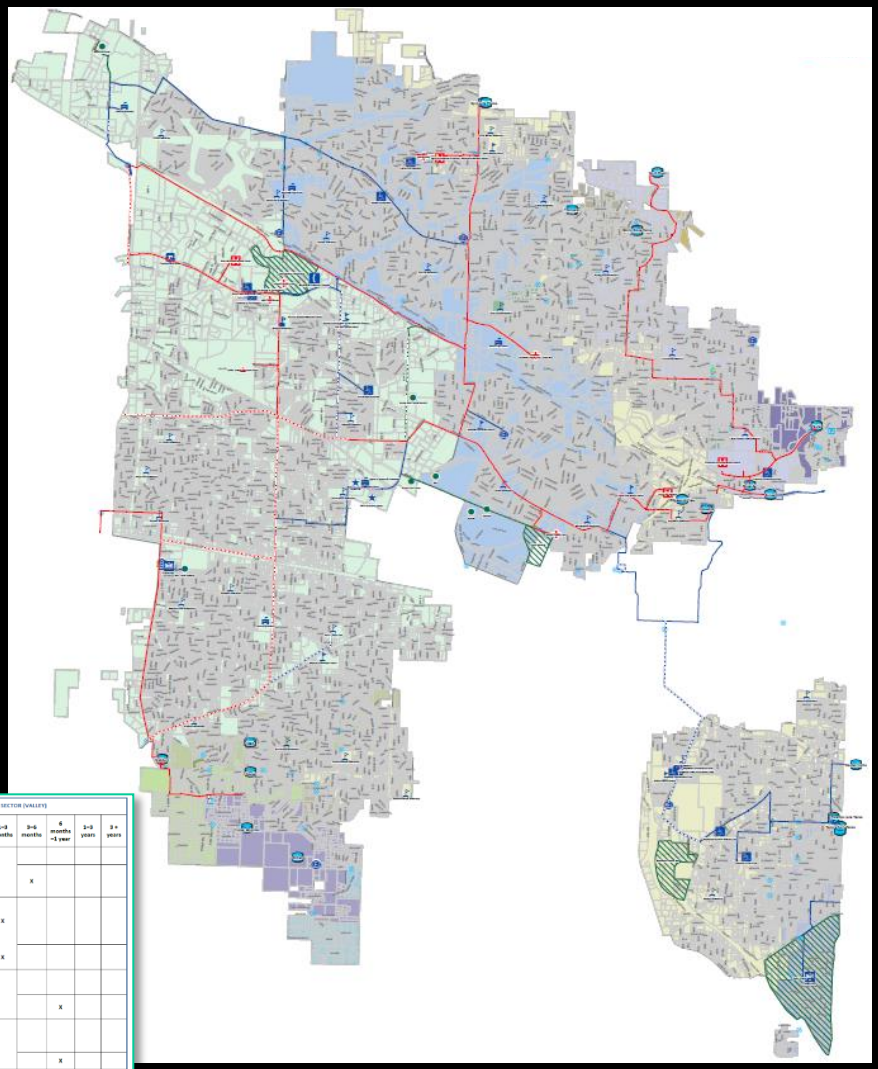
Christchurch 7.1 M Earthquake
September 4, 2010

TVWD's Approach to Seismic Resiliency

- Figure out where are the critical places you need water.
- Discussions with:
  - Internal staff
  - Hospitals
  - TVFR
  - Washington County

TVWD's Approach to Seismic Resiliency

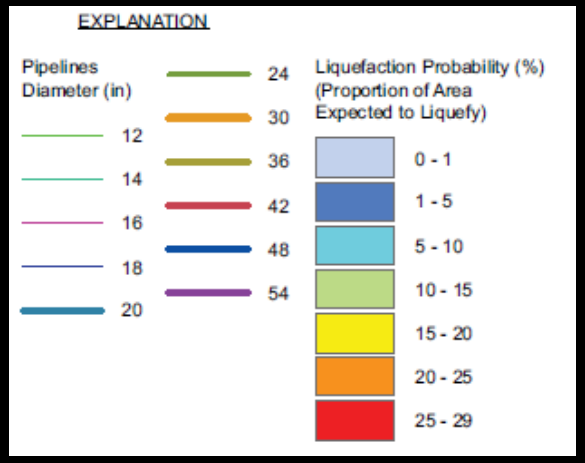
- Established 3 tiers of critical customers & critical infrastructure to serve them:
  - Life Safety
  - Emergency Services
  - Economic Recovery
- Developed Preliminary Level of Service (LOS) Goals (3 event scenarios):
  - Normal operations
  - Significant event
  - Catastrophic event

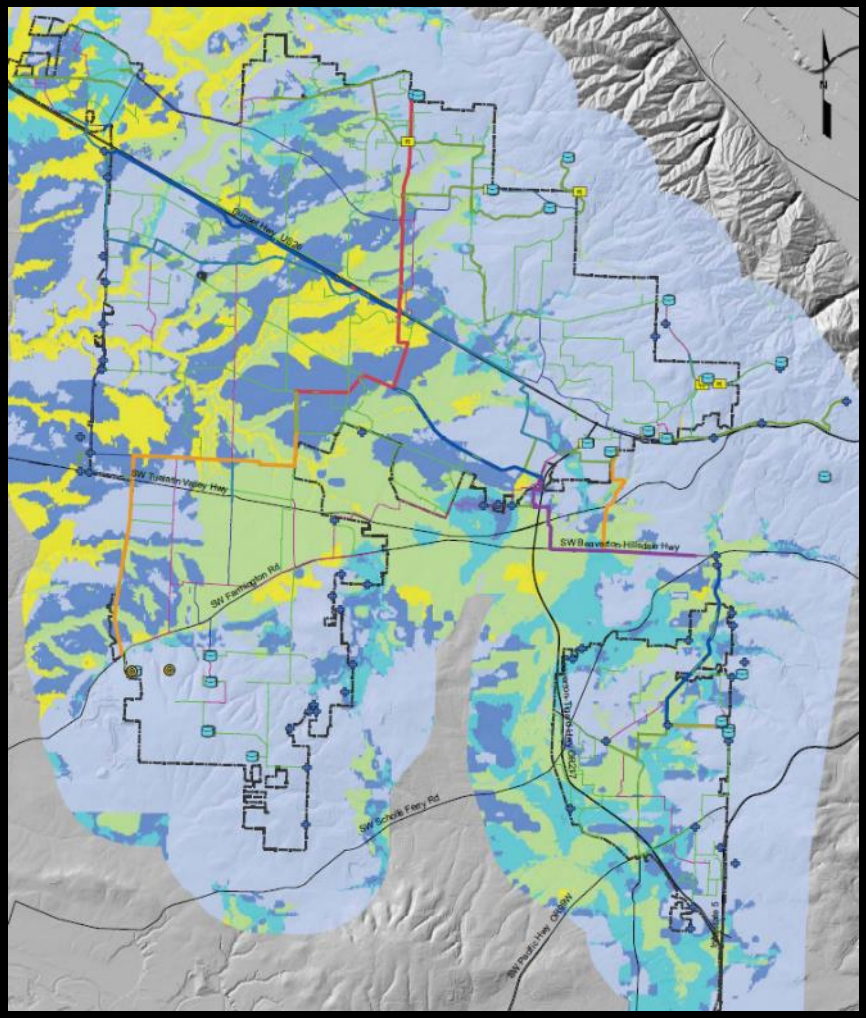


TVWD's Approach to Seismic Resiliency

Identified Earthquake Geohazards

- Peak ground velocity
- Liquefaction probability
- Landslide probability

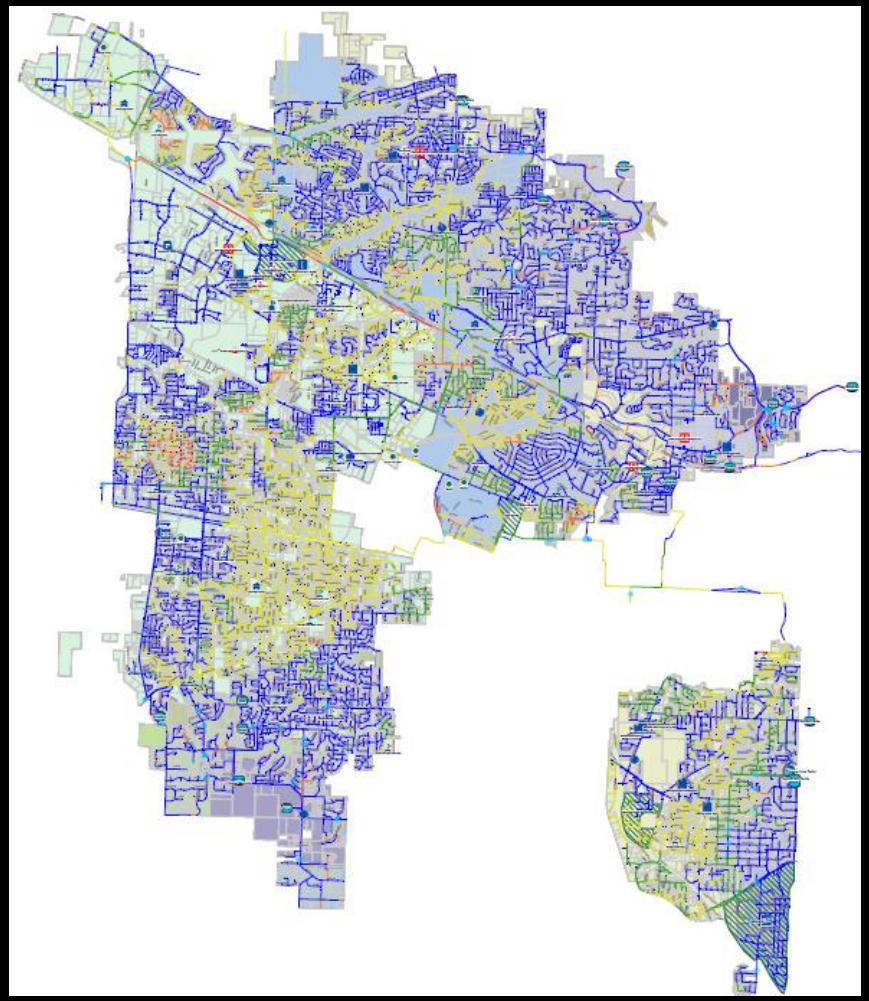




TVWD's Approach to Seismic Resiliency

Evaluated Pipeline Fragility & Capital Improvement Plan

- Estimated system breakage
- Developed multi-year (50 yr) CIP
- Confirmed LOS goals & reviewed proposed CIP with Board



TVWD Background

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Water Infrastructure Resiliency

https://oades24.files.wordpress.com/2010/05/2010-chile-earthquake-81.jpg

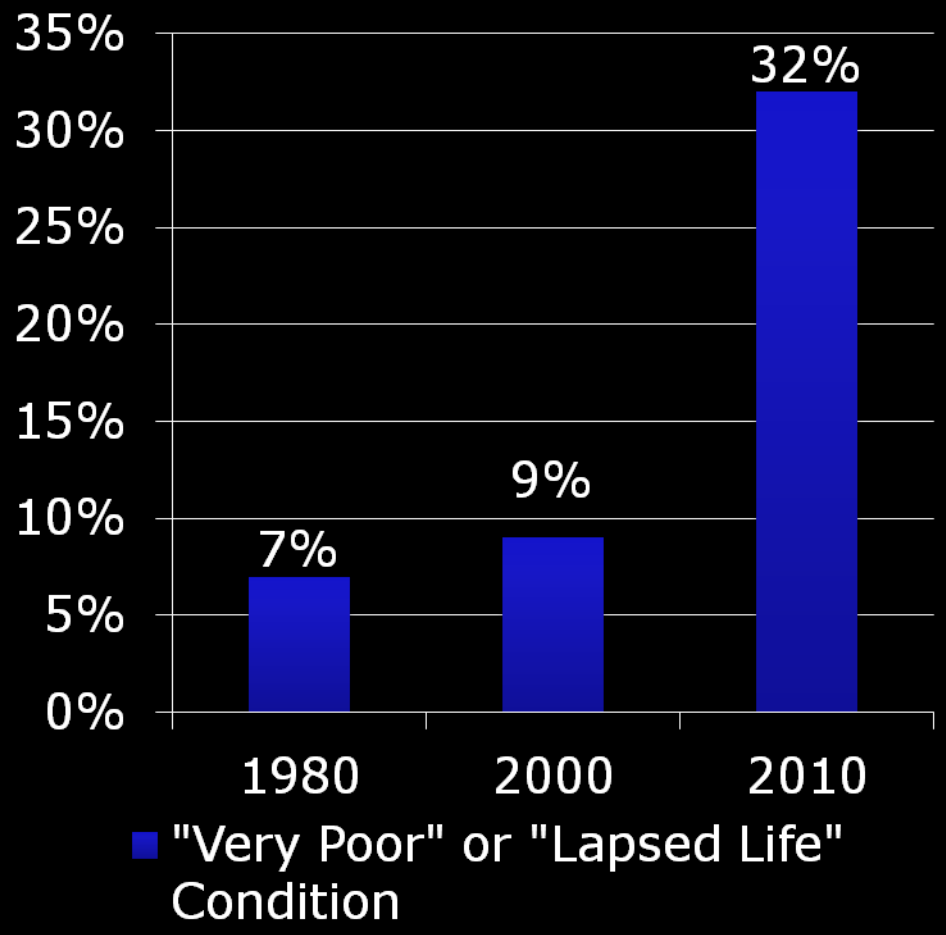
Chile 8.8 M Earthquake
February 27, 2010, at 3:34 a.m.

Existing Infrastructure

The term "**resilience**" means the ability to prepare for and ***adapt to changing conditions*** and withstand and recover rapidly from disruptions.

Utah State University 2012 Report

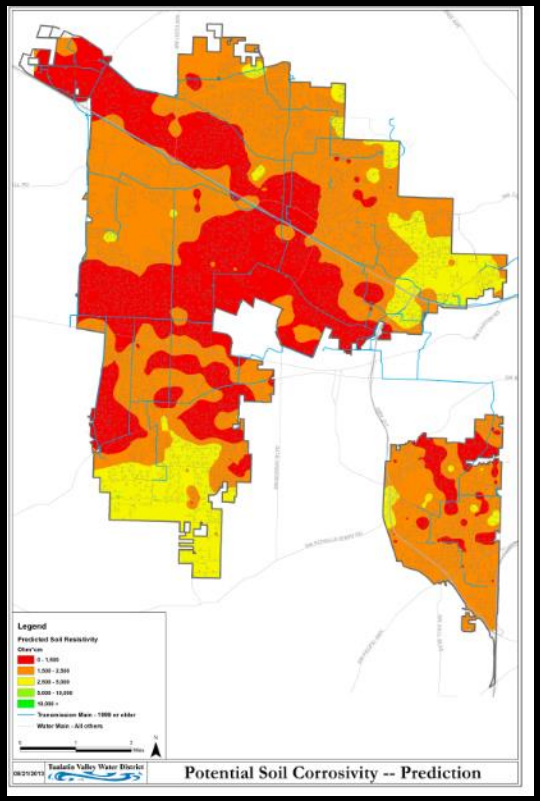
- **188 utilities**
- **10% of the nation's waterlines**



Existing Infrastructure

Need to Adopt Strategies to Address Aging Infrastructure

- Effective replacement strategies to address corrosion

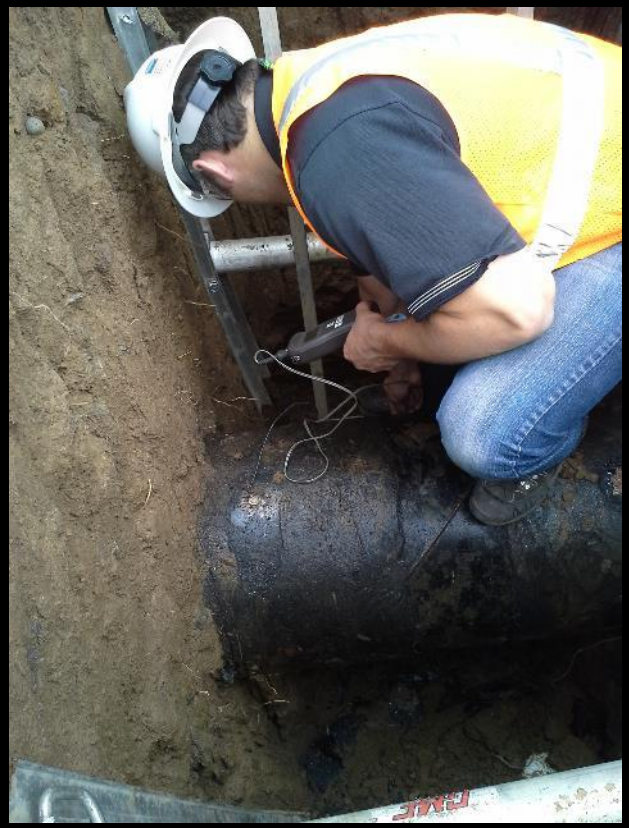


Level of Soil Corrosivity	Non-Critical Pipe and Pipe 8 in (200 mm) and Smaller	Critical and High Consequence of Failure Pipe and Pipe 12 in (300 mm) and Larger
Non-corrosive	Normal Ductile Iron Pipe installation or PVC Pipe (>5,000 ohm-cm)	Normal Ductile Iron Pipe installation (>10,000 ohm-cm) Ductile Iron Pipe w/ polyethylene bags (>5,000 – 10,000 ohm-cm)
Slightly corrosive (>2,500 – 5,000 ohm-cm)	Ductile Iron Pipe with w/ polyethylene bags or PVC pipe (protect fittings same as ductile pipe)	Ductile Iron Pipe w/ bonded joints, anodes, & PE bags ***or possibly*** no anodes and no bonded joints with good PE bag installation, no groundwater issues, sand bedding and more inspection
Moderately corrosive (>1,500 – 2,500 ohm-cm)	Ductile Iron Pipe w/ bonded joints, anodes, & polyethylene bags or PVC pipe (protect fittings same as ductile pipe)	Ductile Pipe w/ tightly bonded coating, bonded joints, & anodes
Highly corrosive (≤1,500 ohm-cm)	Ductile Iron Pipe w/ tightly bonded coating, bonded joints, & anodes or PVC pipe (protect fittings same as ductile pipe)	Ductile Iron Pipe w/ tightly bonded coating, steel or CCP, w/ bonded joints & anodes or impressed current

Existing Infrastructure

Need to Adopt Strategies to Address Aging Infrastructure

- Extend the life (anode retrofit)
- Condition assessment



New Infrastructure

Seismic Design Standards/ Considerations

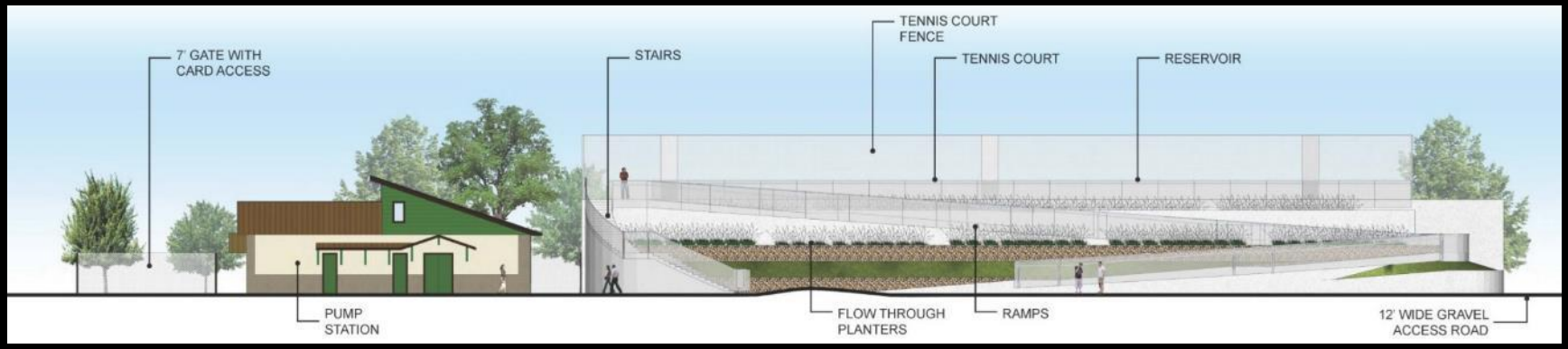
- Design facilities as essential structures (importance factor 1.5)
- Consider pipe connections to structures
- Consider other kinds of transitions

U.S. Geological Survey Fact Sheet 068-03

New Infrastructure

Seismic Design Standards/ Considerations

- Larger generator fuel tanks for extended run times



New Infrastructure

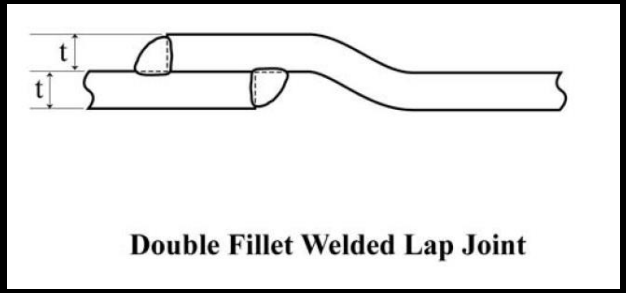
Seismic Design Standards, Considerations

- Electrical equipment tested for seismic conditions

New Infrastructure

Steel Pipe Joints Are the Weak Link

- Lap welded joints have strength limitations
  - According to ASME lap joints are not as strong as the pipe
    - Single Lap Welded joints are 45% as strong
    - Double Lap Welded Joints are 55% as strong
    - Butt welds can be as strong as the pipe
- Butt welded joints are costly
  - Reduce production 60 to 70 percent
  - Installation crew cost is approximately $25,000/day
  - Investigate research on the subject to identify possible solution that balances cost and resiliency



Double Fillet Welded Lap Joint


Single Welded, Complete Joint Penetration (CJP) Butt Joint with Backing

Call, J., & Sundberg, C. (2007). A Basis for Using Single-Welded or Double Welded Lap-Joints for Steel Water Pipe. *ASCE Pipelines 2007*.

New Infrastructure

DRAFT Methodology on Resilient Pipe Selection

Pipe Category	Minor Hazard	Moderate Hazard	Severe Hazard[1]
Distribution (< 12”)	Ductile Iron w/ RJ1, HDPE, PVC w/ RJ	Ductile Iron w/ RJ2, HDPE, PVC w/ RJ	Ductile Iron w/ RJ3, HDPE
Transmission (≥12” & < 30”)	Ductile Iron w/ RJ1, HDPE, Steel w/ single lap weld (≥ 24”)	Ductile Iron w/ RJ2, HDPE, Steel w/ single lap weld (≥ 24”)	Ductile Iron w/ RJ3, HDPE
Transmission (≥ 30”)	Steel (single lap weld joint)	Steel (double lap weld or equivalent)	Steel (butt welded or equivalent)

RJ1 – Field Lok or equiv., RJ2 – TR Flex or equiv., RJ3 – Kobota or equiv.

[1]Critical customers use “Severe” category.

Questions

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