



Condition Assessment of High Consequence Pipes

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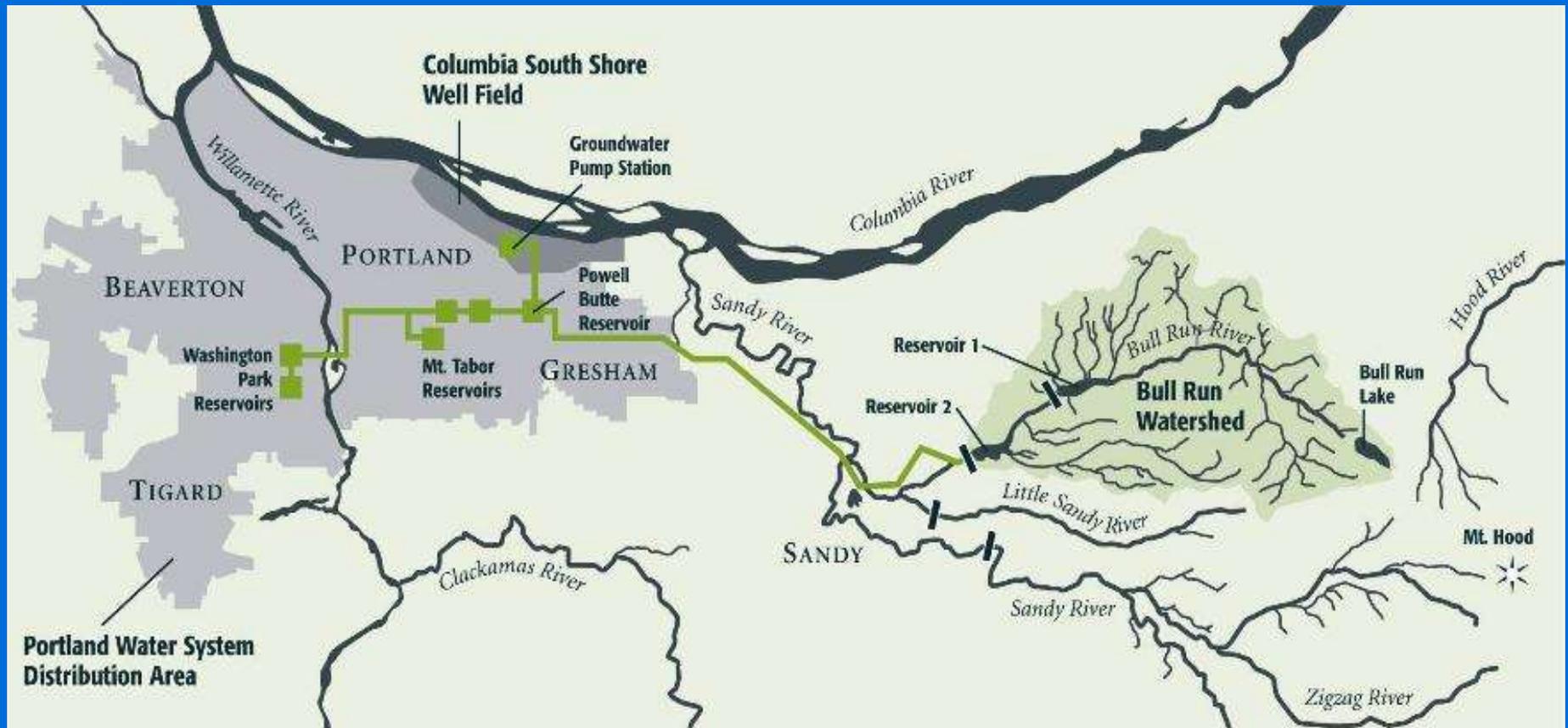




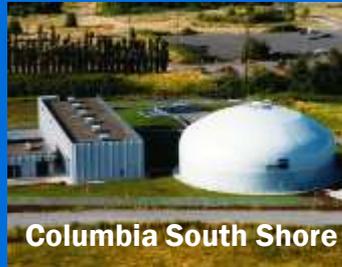
This presentation will describe what we have learned about pipe failure and how we've used that knowledge to apply the appropriate condition assessment technique and to mitigate the risk of high consequence pipe failures.



Portland Water System



Water System Assets



Two Water Sources

39 Pump Stations

**63 Tanks and Covered
Reservoirs**



2,300 Miles of Pipe

**130 Drinking
Fountains**



177,770 Meters

14,400 Hydrants

**Estimated replacement value:
\$8 billion.**

High Consequence Pipe Categories

- Transportation system crossings
 - Freeway/Highway
 - Railroad
- Environmental crossings
- High landslide potential
- Primary supply lines
- Critical customers
- Very large diameter



Service Level Goals

- Limit outages
- Maintain pressure
- Manage risks of asset failure



Major topics

- High consequence pipe failure examples
 - Pipe failure modes & root causes of failure
 - Quantifiable data for business cases
- Condition assessment methodologies
 - Improve likelihood of failure estimates
- Risk mitigation



High Consequence Pipe Failure – Horizontal break of uncased under-crossing (Highway 99E)

Utility cost, repair \$50,000

Utility cost, pavement \$450,000

Social cost, traffic disruption = \$1,000,000



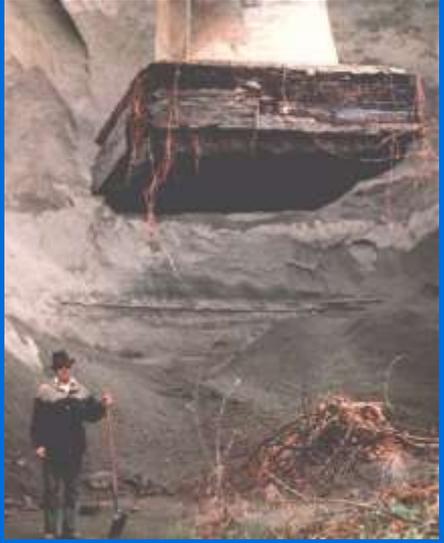
High Consequence Pipe Failure – Blow out of uncased under-crossing (arterial)



Utility cost, \$135,000

Social cost, traffic disruption and economic loss \$550,000

High Consequence Pipe Failure – Blow out on bridge (local road, 6 months out of service)



Utility cost, pipe and bridge repair, legal costs \$700,000
Social cost, traffic disruption = \$4,500,000

Pipe Failure Modes by Cohort, 2010 - 2015

Pipe Material & Size Grouping	Seal failure	Vertical break	Horizontal break	Pinhole leaks	Other	Total
Cast Iron 8-inch or less	2%	74%	6%	5%	13%	491
Cast Iron 10- to 12-inch	21%	24%	17%	7%	31%	29
Cast Iron 14-inch or greater	33%	7%	13%	0%	47%	15
Ductile Iron 8-inch or less	7%	72%	0%	3%	17%	29
Ductile Iron 10- to 12-inch	50%	0%	0%	0%	50%	2
Ductile Iron 14-inch or greater	0%	0%	0%	0%	100%	1
Steel 8-inch or less	0%	29%	6%	56%	9%	133
Steel 10- to 12-inch	0%	100%	0%	0%	0%	1
Steel 14-inch or greater	0%	0%	0%	100%	0%	3

Failure Modes – Consequence of Failure Costs

8-inch Steel Pump Main Crossing under I-5 Consequence of Failure Example

Type of failure	Traffic Delay Costs	Pavement Repair Costs	Micro-Tunnel New Main Under 1-5	Total TBLCcosts	CMMS Failure Mode % Probability	Weighted Consequence Costs
Horizontal Break	\$14,447,000	\$1,500,000	\$1,200,000	\$17,147,000	6%	\$1,028,820
Vertical Break	\$11,674,000	\$1,000,000	\$1,200,000	\$13,874,000	29%	\$4,023,460
Leak	\$8,901,000	\$500,000	\$1,200,000	\$10,601,000	65%	\$6,890,650
					Total	\$11,900,000

Pipe 1 fails. Impacts 1000 service connections. One day supply outage.

$$1000 \times \$116/\text{service}/\text{day} = \$116,000 \text{ consequence}$$

Condition Assessment – Acoustic leak detection & broadband electromagnetic (BEM) wall thickness measurements



- Extrapolate remaining service life (BEM)

**Condition Assessment –
Pipes on bridges
(failure avoided)**



Condition Assessment – Internal inspections

- Identify defects/deficiencies
- Ultrasonic metal thickness measurements
- Non destructive; no excavation



Uncased Under-Crossings – Risk Mitigation

- Condition assessment
 - Refines likelihood of failure estimate
- Add cathodic protection
 - Potentially extend life
 - Refines likelihood of failure estimate

Test or inspect assets rated as “extreme risk” immediately. Repair immediately if needed; otherwise renew or replace within 12 months;

Test or inspect assets rated as “high risk” annually, or repair within 12 months. Renew or replace within 5 years;



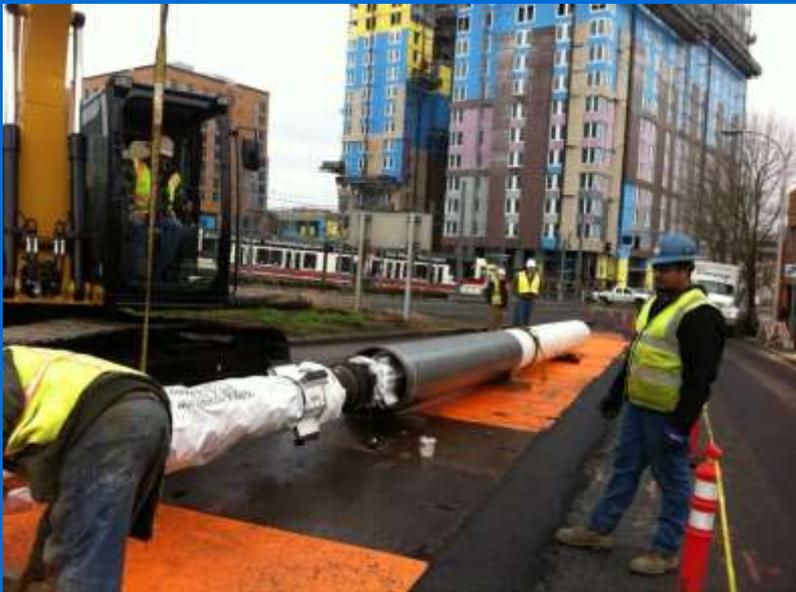
Uncased Under-Crossings – Risk Mitigation

- Valve testing (test shutdown)
 - Helps limit damage (consequence)
- Add valves



Uncased Under-Crossings – Risk Mitigation

- Cased pipe replacement



Questions?

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