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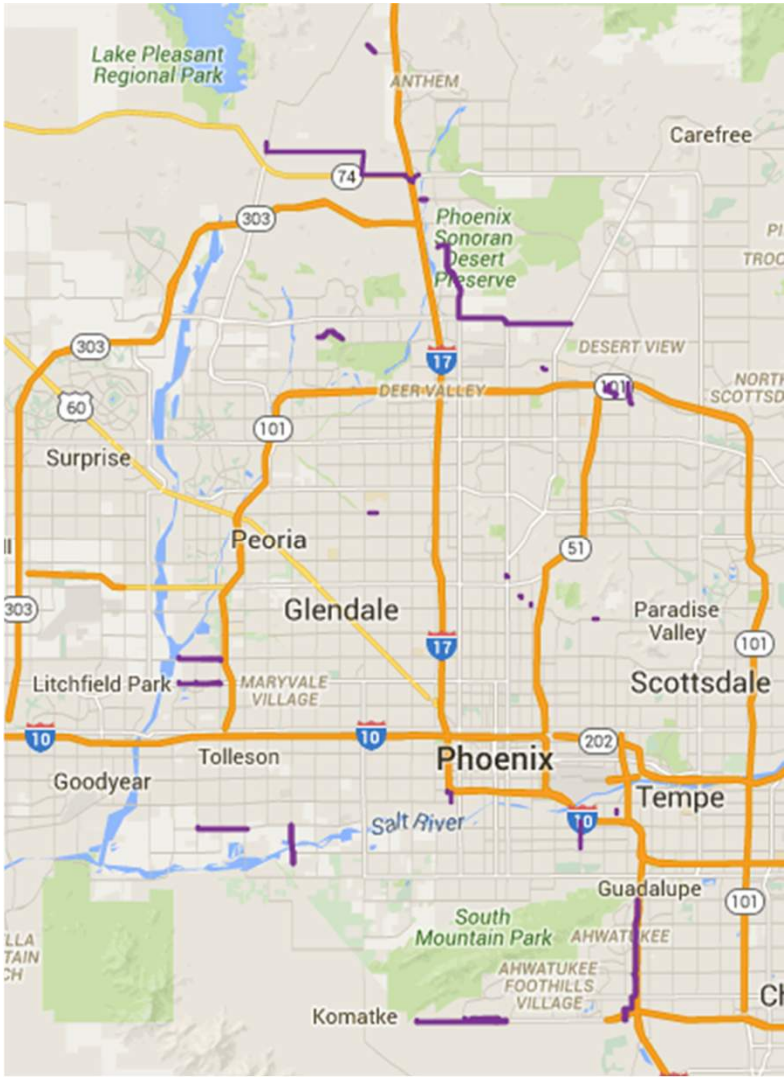
Lessons Learned From a 24-inch FM Inspection

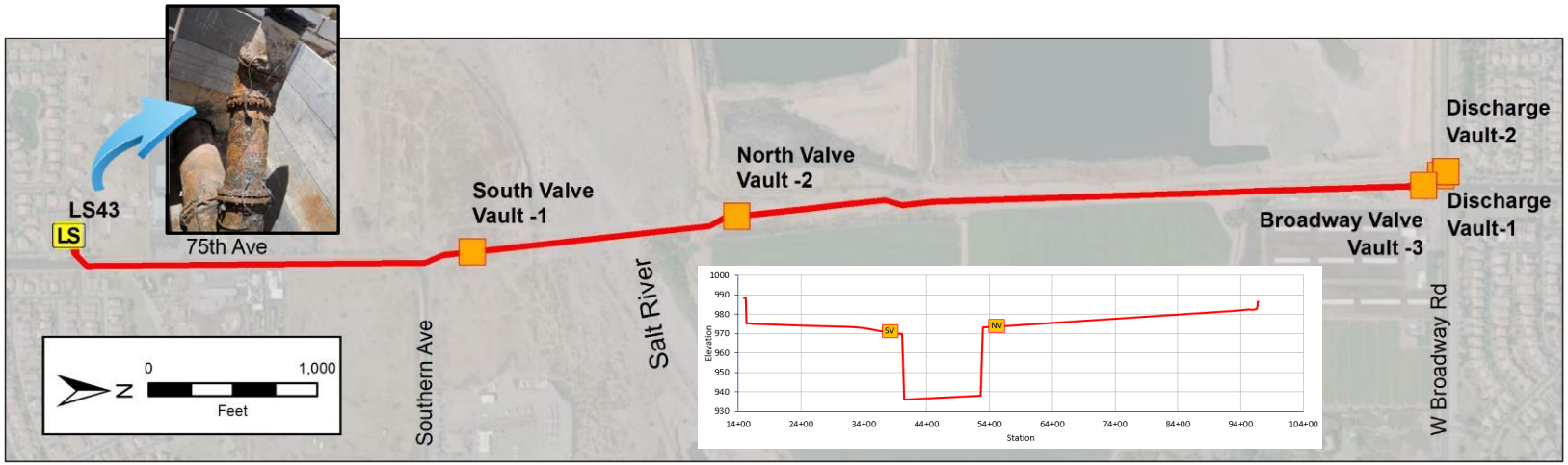
Chandler Carpenter

Phoenix’s Force Mains

- 70 miles of 4-inch to 48-inch
- 28 lift stations
- Earliest construction: 1972



Lift Station 43 Force Main Overview



Project Background

- Three parallel 24-inch DIP barrels
- 1.5 miles from LS 43 to DV-1&2
- 2001 – Original FM Construction
- Prior failures

Project Goals

- Perform condition assessment
- Repair recommendations
- Remaining useful life extension

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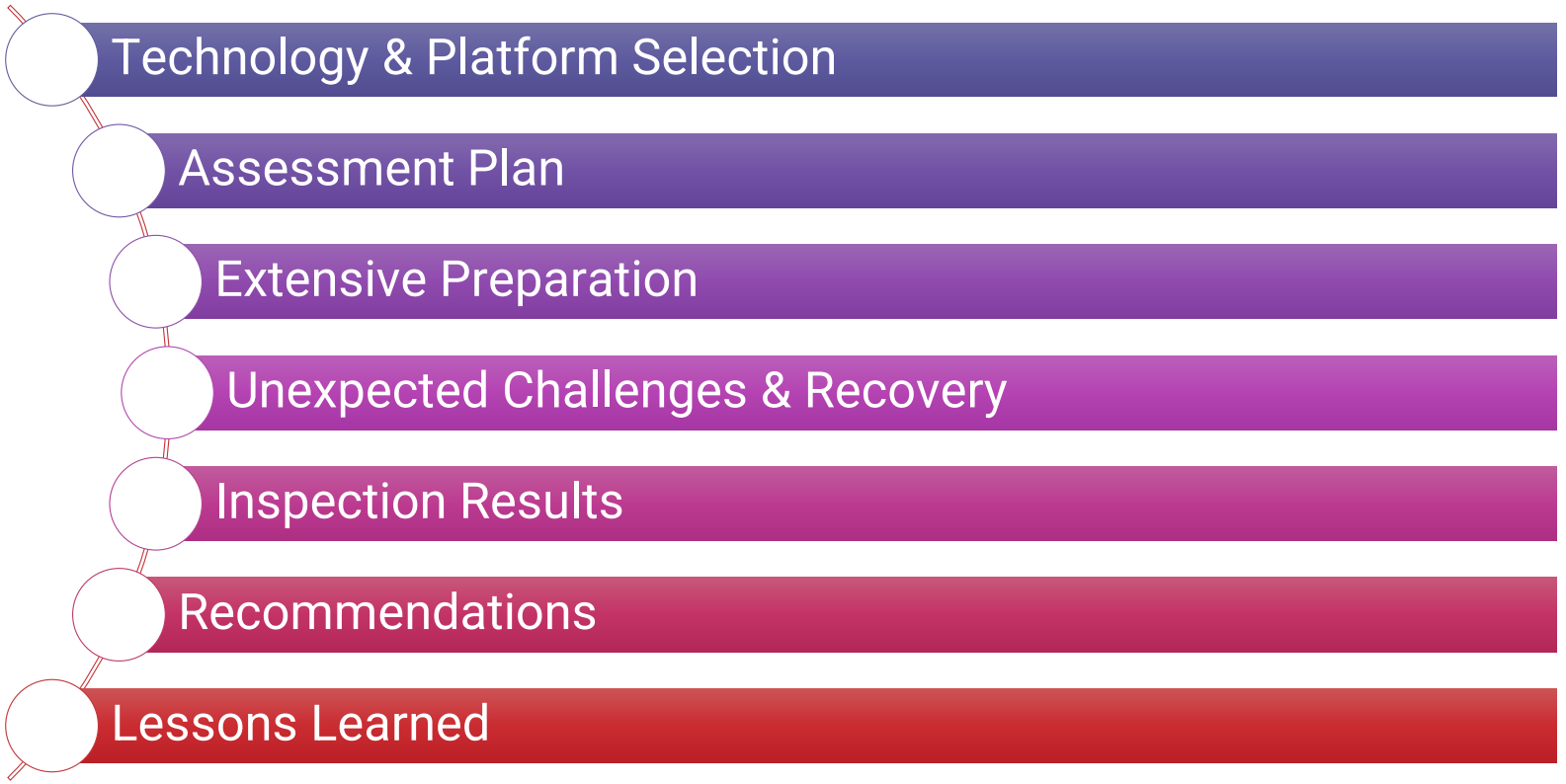
LS43 FM Assessment Overview



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Inspection Technology & Platform Selection

Technology

- Remote field electromagnetics

Platform

- PICA See Snake Tool

Information obtained

- Locations of pipe wall thinning
- Resolution - 10% wall loss / 1-sq.in

Inspection requirements

- Full diameter pipe access
- Debris removed from pipe
- Constant flowrate

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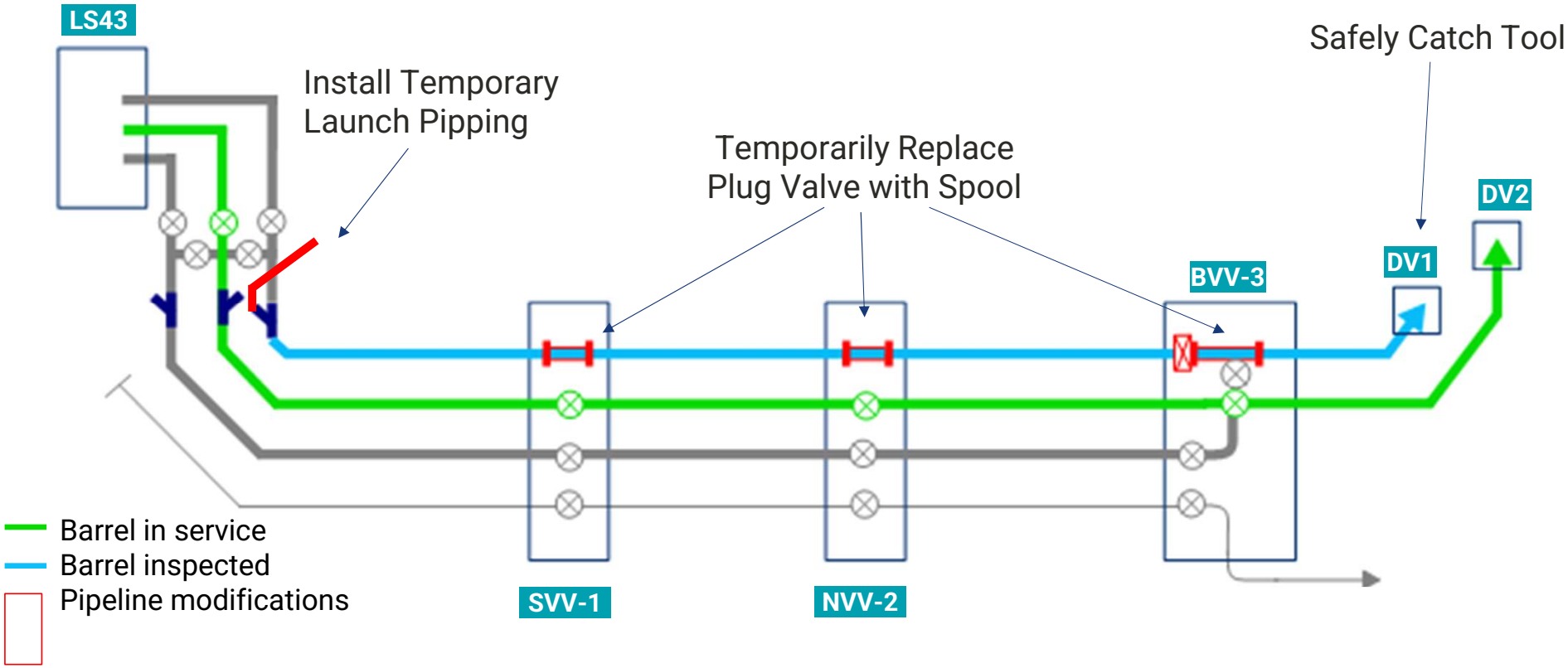
Assessment Plan: Barrel 1 Example



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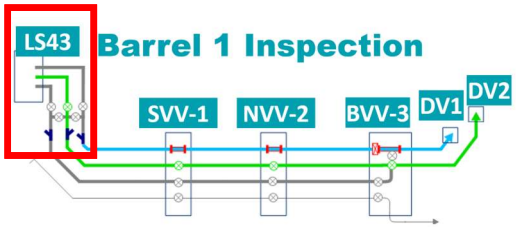
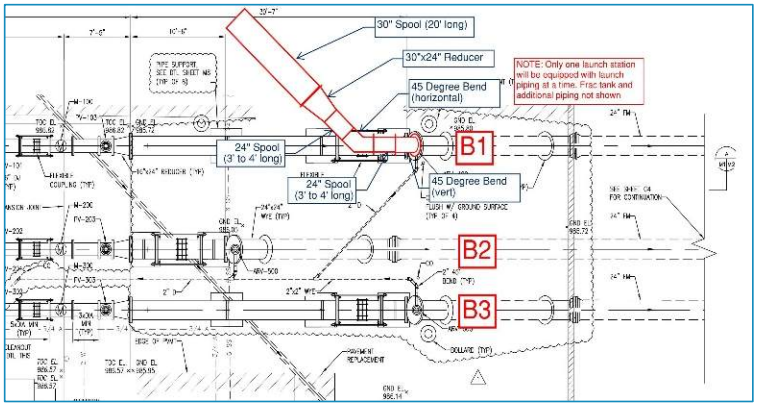
Extensive Preparation:
Tool Launching Set-up





Tool Requirement: Full diameter access to pipe

Inspection Prep: Install temporary launch piping

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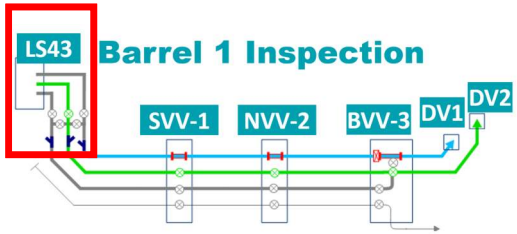
Extensive Preparation:
Tool Conveyance Set-up



Risk: Tool stopping

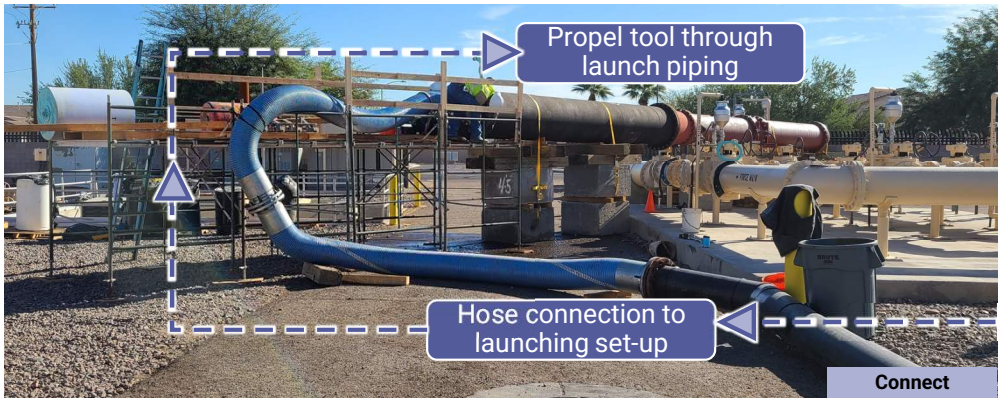
Mitigation: Provide constant flow rate.

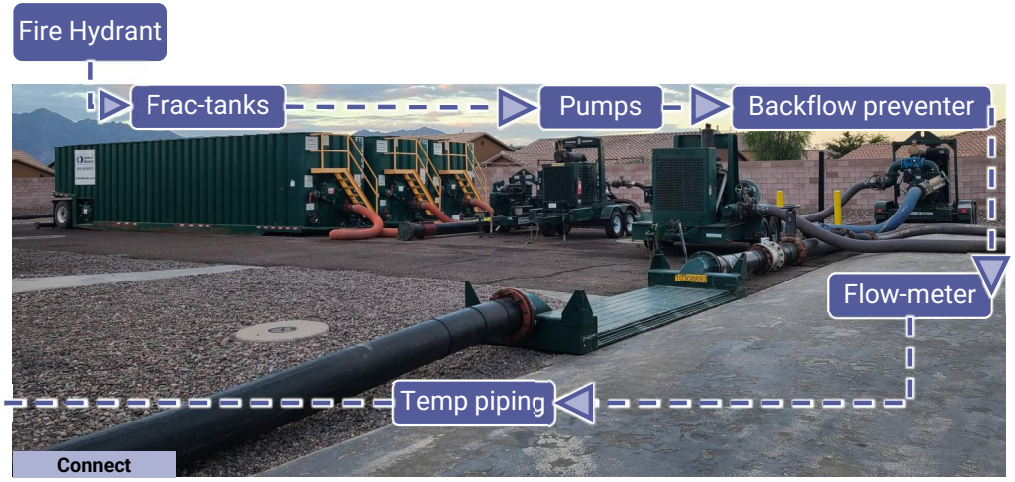
Risk: Spills

Mitigation: Vac-truck on site, containment, post-inspection clean-up.

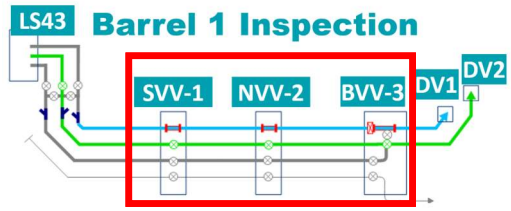
Risk: Cross-contamination

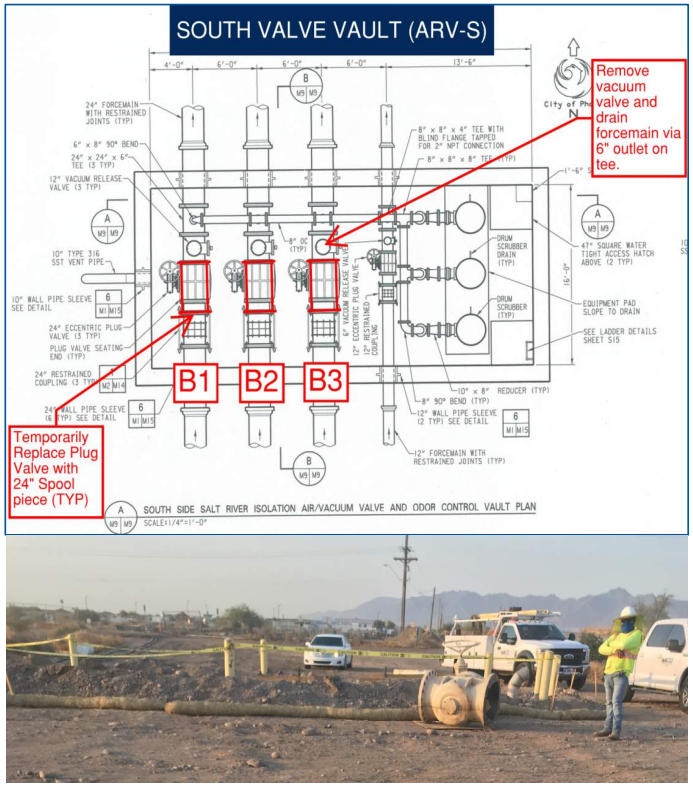
Mitigation: Using backflow preventor, air gap, and frac-tank

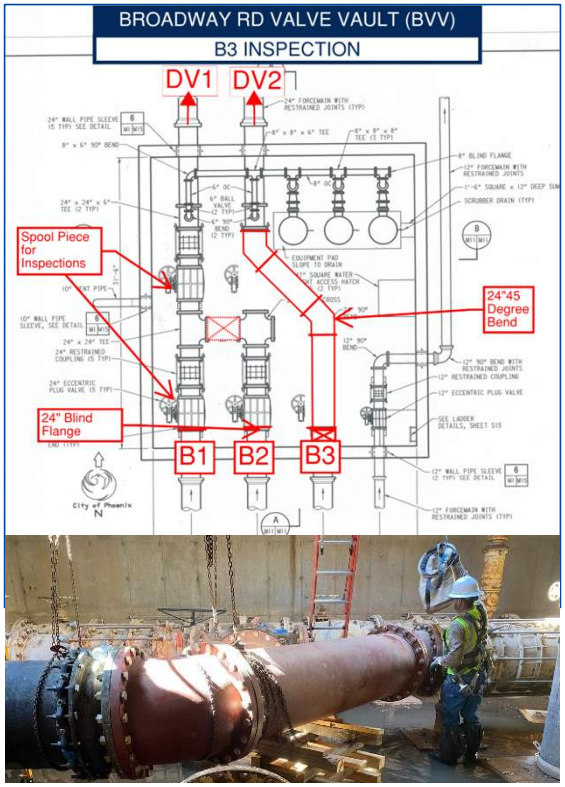




Extensive Preparation:
Temporary Valve Replacement







Tool Requirement: Full diameter access to pipe

Inspection Prep: Replace reduced port plug valves with spool pieces

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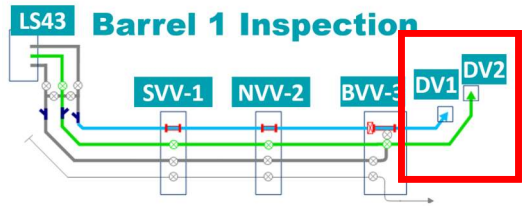
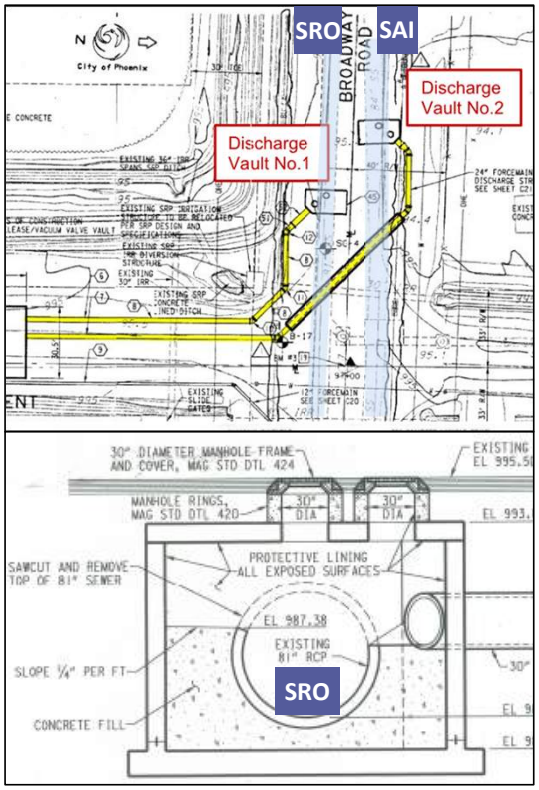
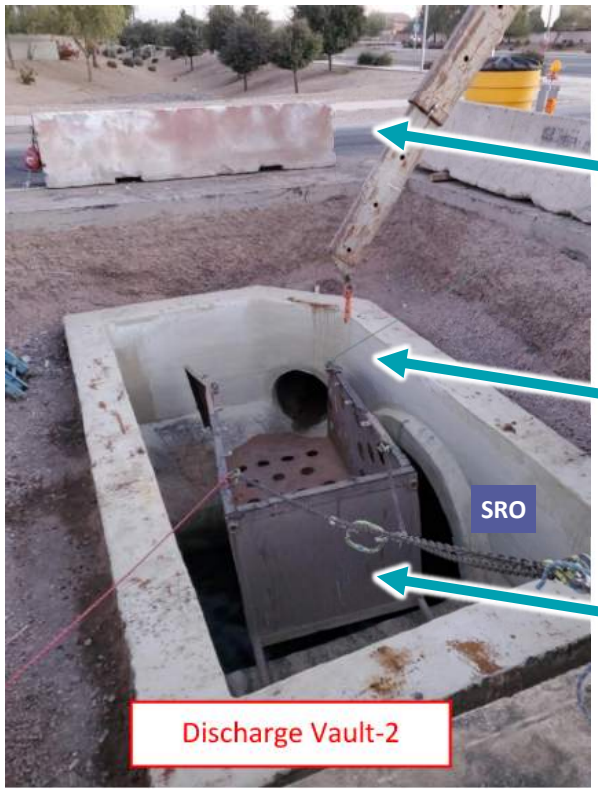
Extensive Preparation:
Tool Retrieval







Risk: Working in/near traffic

Mitigation: Traffic control plan

Risk: Confined space in vaults

Mitigation: Remove vault lid

Risk: Equipment entering SRO/SAI

Mitigation: Tool-catching basket

Extensive Preparation: *Progressive Pigging*

Risk: Tool stopping

Mitigation: Clear the line of grit, grease, and other debris by pigging.

24” Bare foam pig (BFP) → 26” BFP → 26” BFP+ 18” Poly pig → 26” BFP + 20” Poly pig → 26” BFP + 22” Poly pig → 26” BFP + 24” Poly pig → 26” BFP → Disk Pig → Gauge Pig





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Extensive Preparation Summary

TYPE	RISK	MITIGATION
Safety	Confined space in vaults	Remove vault lid
	Working in/near traffic	Traffic control plan
	Hazardous H2S exposure	Hazmat suit near discharge vault
Operations	Service disruption	One barrel always in service
	Tool stopping	Modifications, pigging, constant flow rate, and tool tracking
	Equipment entering SRO/SRI	Tool-catching basket
	Over pressurizing main	Pressure test prior to project begins
Public	Spills	Vac-truck on site, containment, post inspection clean-up
	Cross contamination	Using backflow preventor and frac-tank
	Traffic disruption	Higher traffic control during tool retrieval only

Ready for Barrel 1 Inspection

- ✓ Safety mitigation complete
- ✓ Operational mitigation complete
- ✓ Public impacts mitigation complete
- ✓ Pipeline prepared
- ✓ Tool tracking prepared

August 28, 2020

4:00 AM Tool is launched

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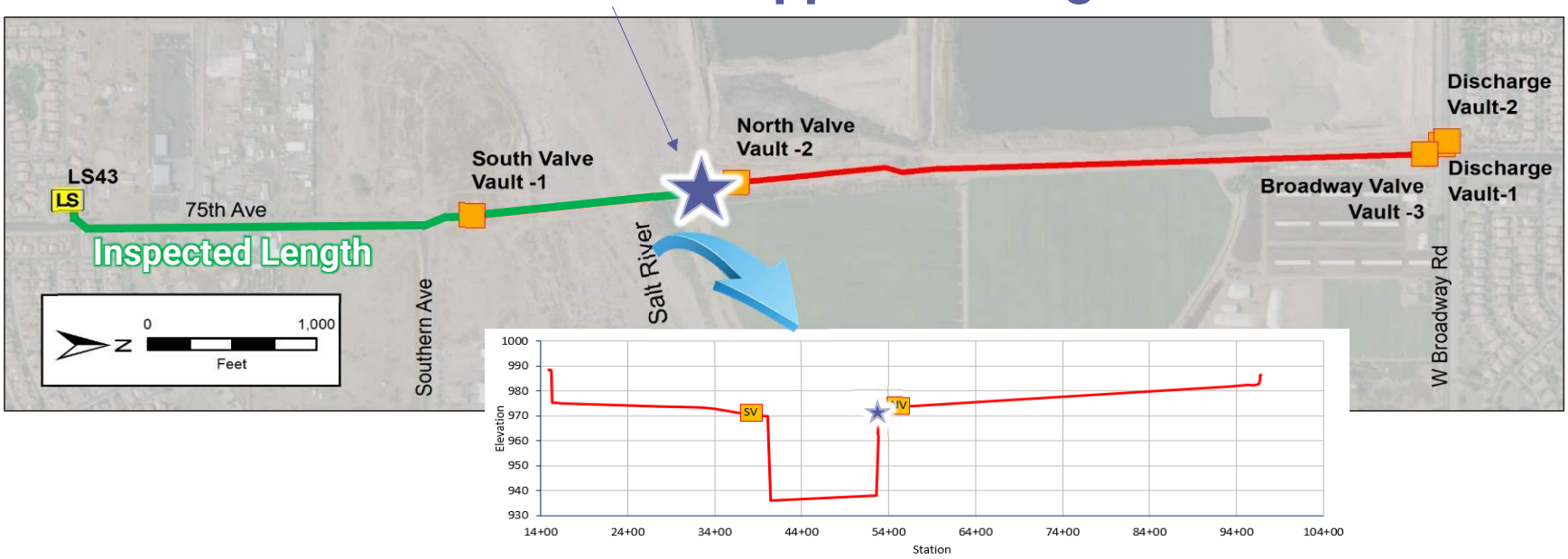
Barrel 1 Unexpected Challenge

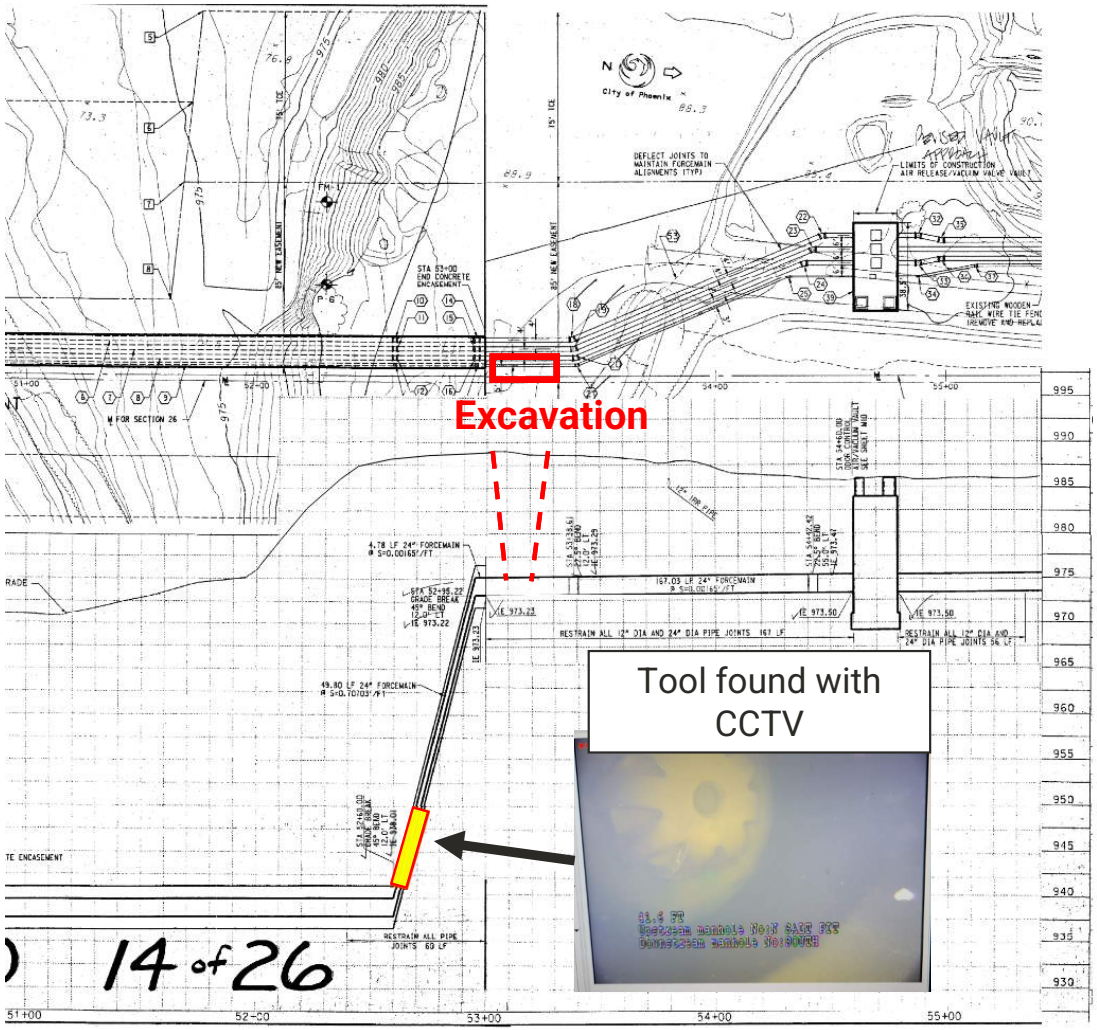
12:30 PM Tool stopped moving here



Barrel 1 Inspection Recovery

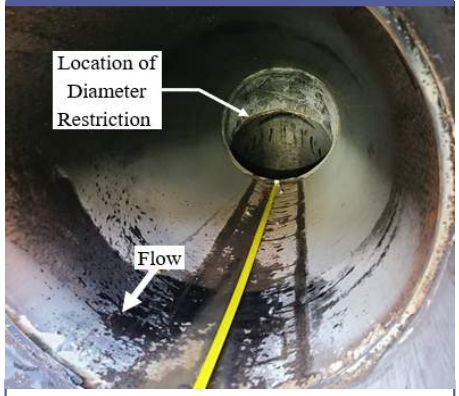
Step 1: Team meeting

Step 2: Excavate & locate tool



Barrel 1 Inspection Recovery

Step 3: Investigate Root-cause

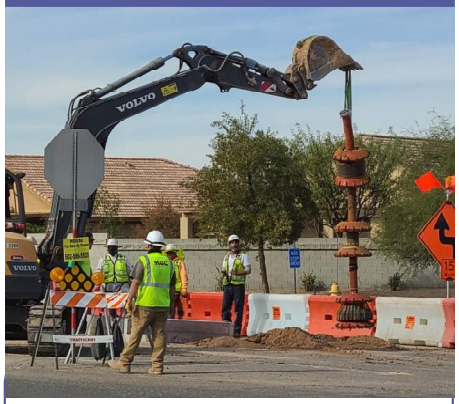


- 1.2” ID reduction at 45-deg bend
- Abrupt transition

Step 4: Implement Mitigation

- Grout applied at lip
- Gradual and smooth ID transition

Step 5: Tool Retrieval



- Increased flow and flushed tool out

Calm collaboration and experience lead to recovery

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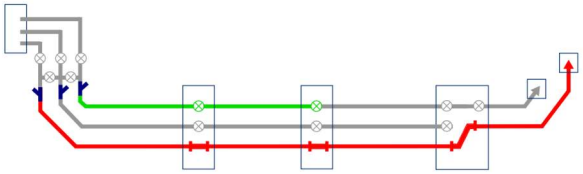
Next Steps

Assumed diameter reduction present in Barrels 2 and 3

Tool modifications completed to mitigate diameter reduction

Continued with Barrel 3 inspection only (Barrel in service 20+ years)



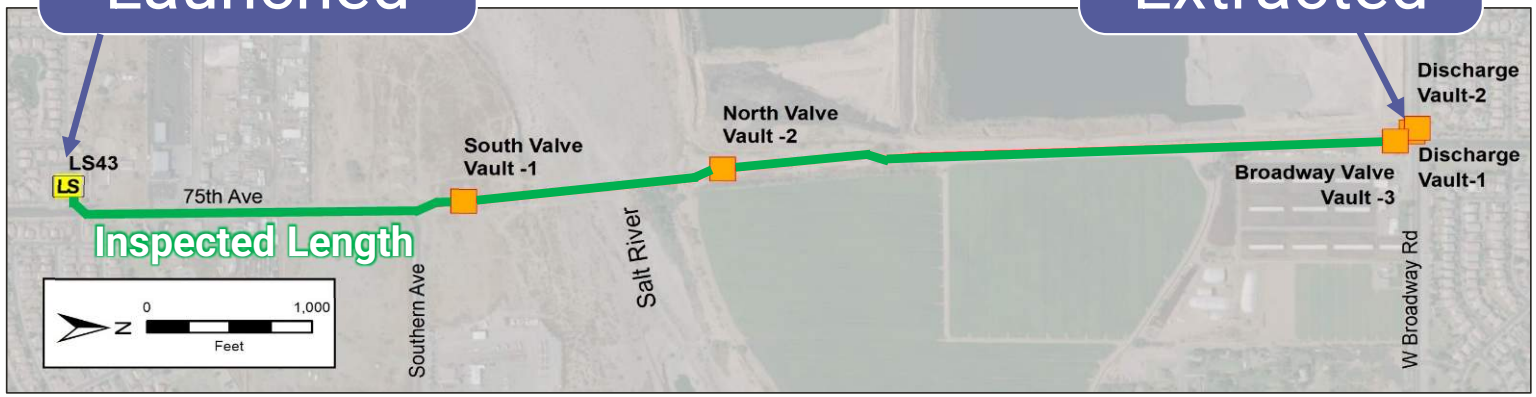
Barrel 3 Inspection Completed

Inspection Prep Completed

- ✓ Safety mitigation complete
- ✓ Operational mitigation complete
- ✓ Public impacts mitigation complete
- ✓ Pipeline prepared
- ✓ Tool tracking prepared

Tool Launched

Tool Extracted



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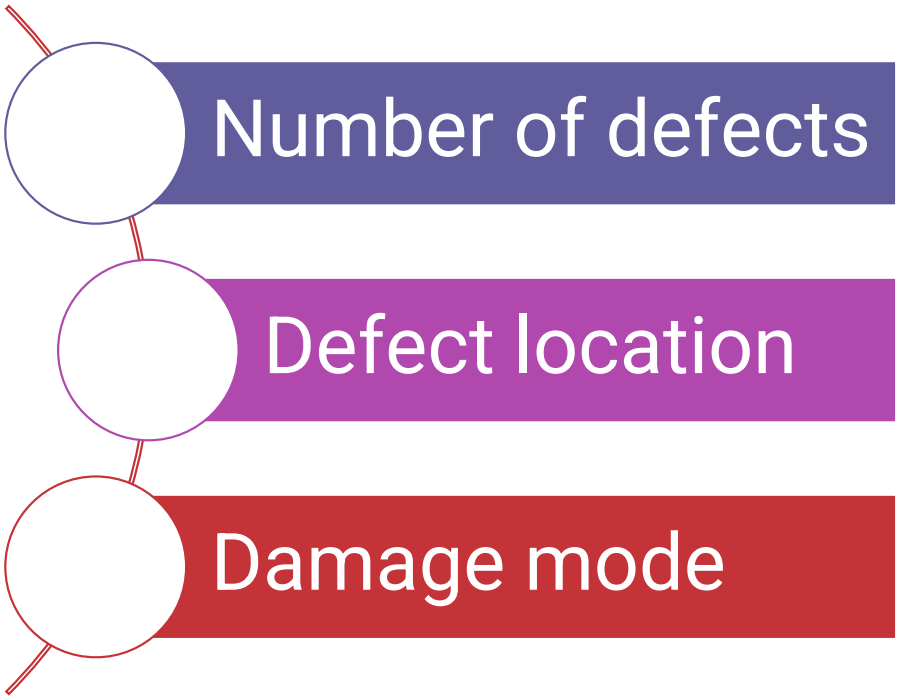
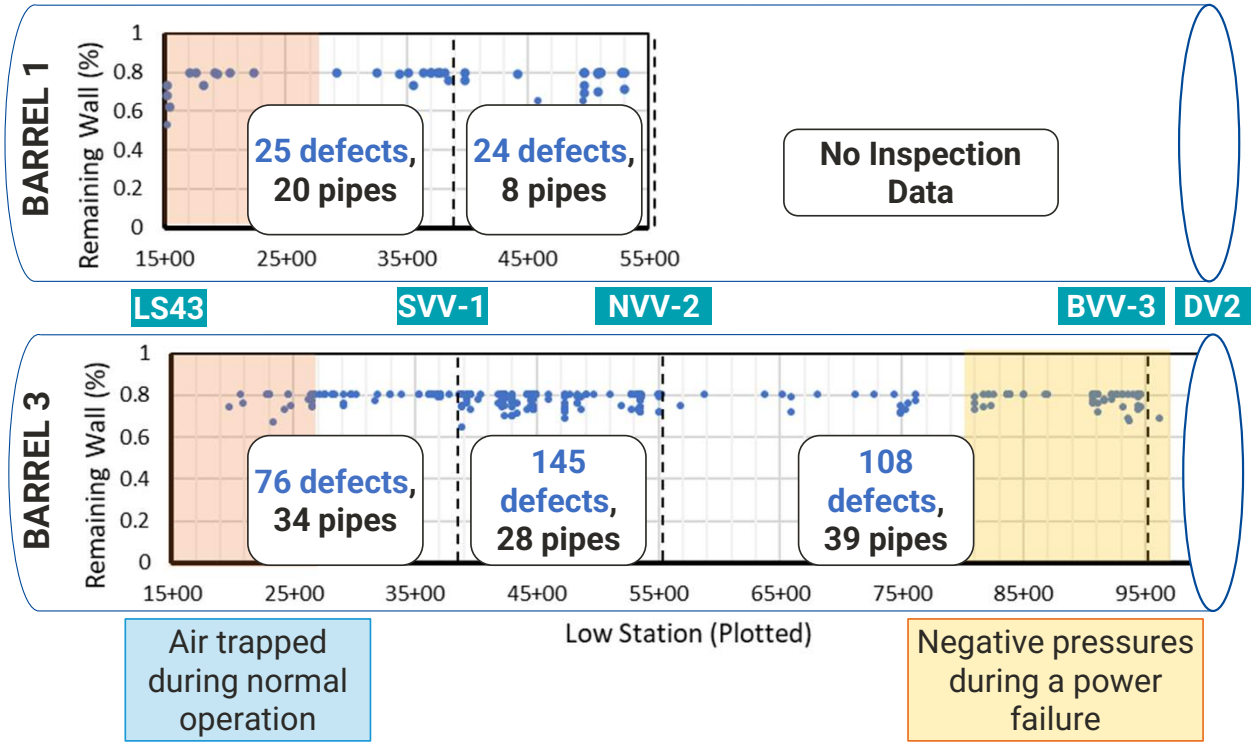
Barrels 1 & 3 Inspection Results



Inspection Results: Number of Defects

< 1 year in-service

20 years in-service

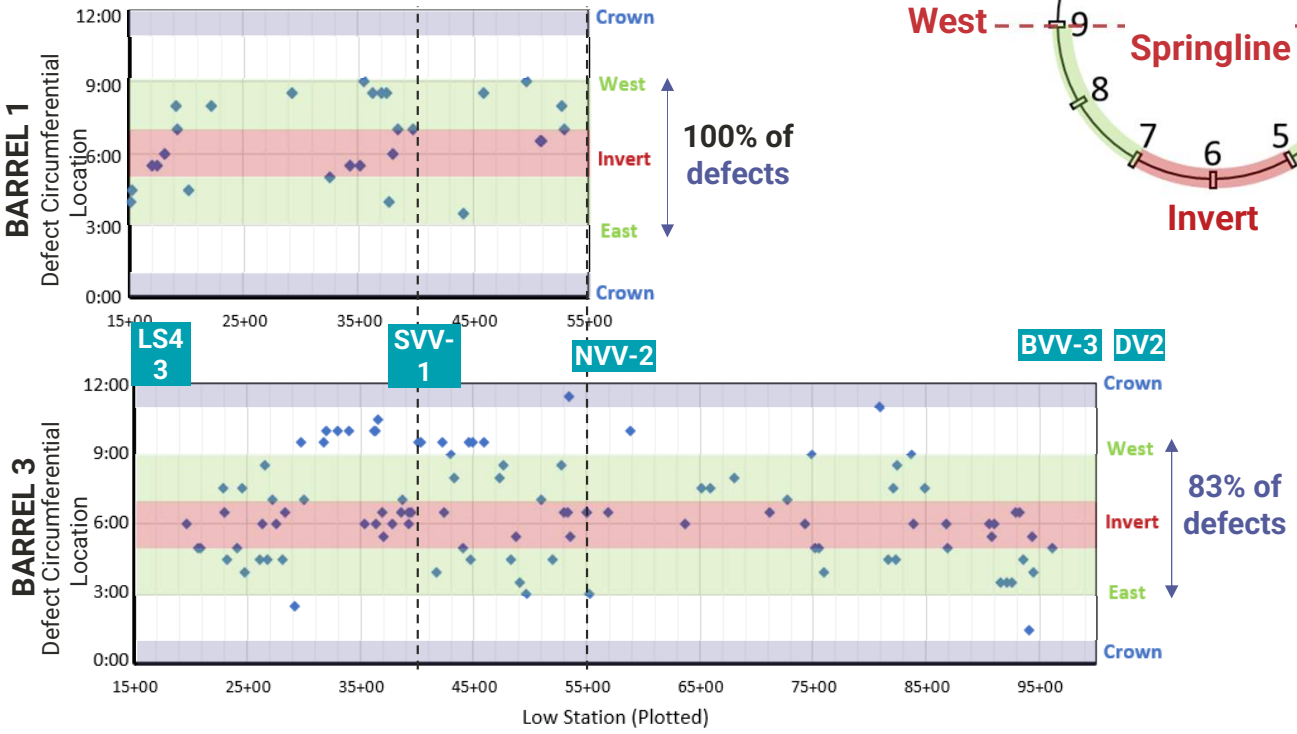


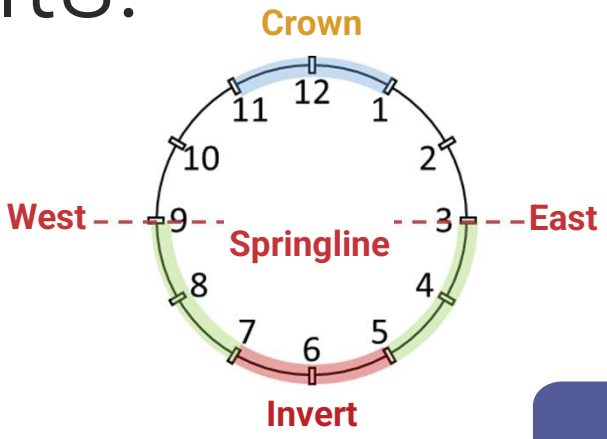
Findings

Correlation between pipe in service & # of defects

No correlation between negative pressures and air pockets & # of defects

Inspection Results: Defect Location





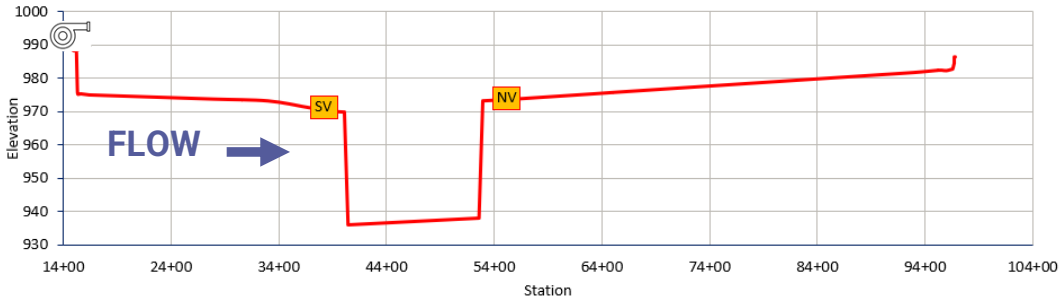
Findings

Damage concentrated below springline

No correlation between negative pressures and air pockets & defect location

Damage Mode: Low Velocities

# of Pumps in Operation	One Barrel, fps	Two Barrels, fps	Three Barrels, fps
1	3	1.8	1.3
2	4	3.0	2.2
3	4.4	3.6	2.9



Findings

Low Velocities

Results in solids accumulation and internal corrosion

Recommendations

Required Velocities to Prevent Accumulation:

- Normally operate at 4-5 fps
- Increase to ≥6 fps once per day

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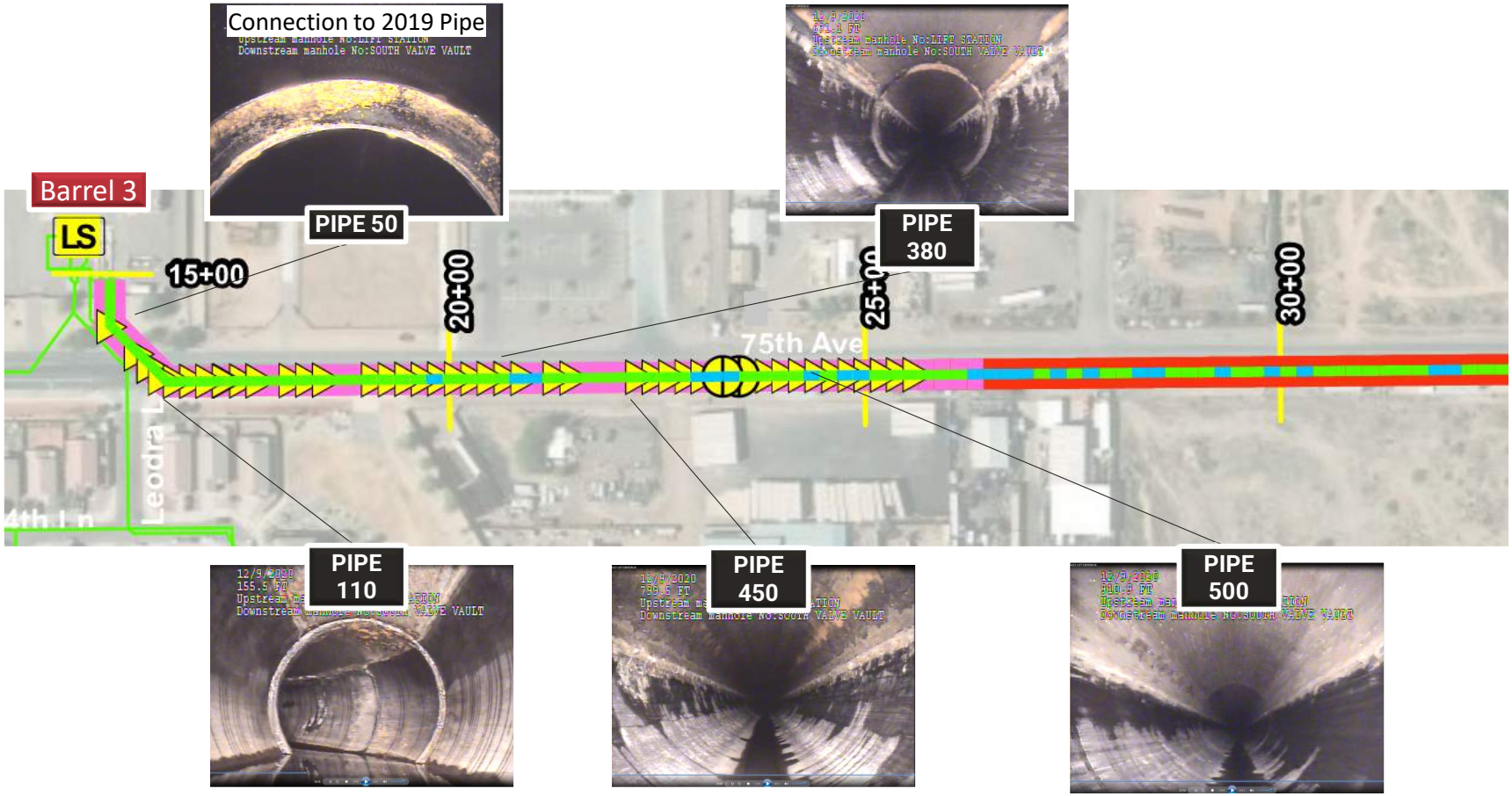
CCTV Inspection Observations

Scenario 1 | Scenario 2 | Scenario 3



Inspection Type

- RFEM Inspection Only
- CCTV Inspection Only
- RFEM and CCTV Inspection
- No Internal Inspection

EM Inspection Results

% Remaining Wall

- 80%+
- 60% to 80%
- 40% to 60%
- 20% to 40%
- 0% to 20%
- No RFEM Inspection

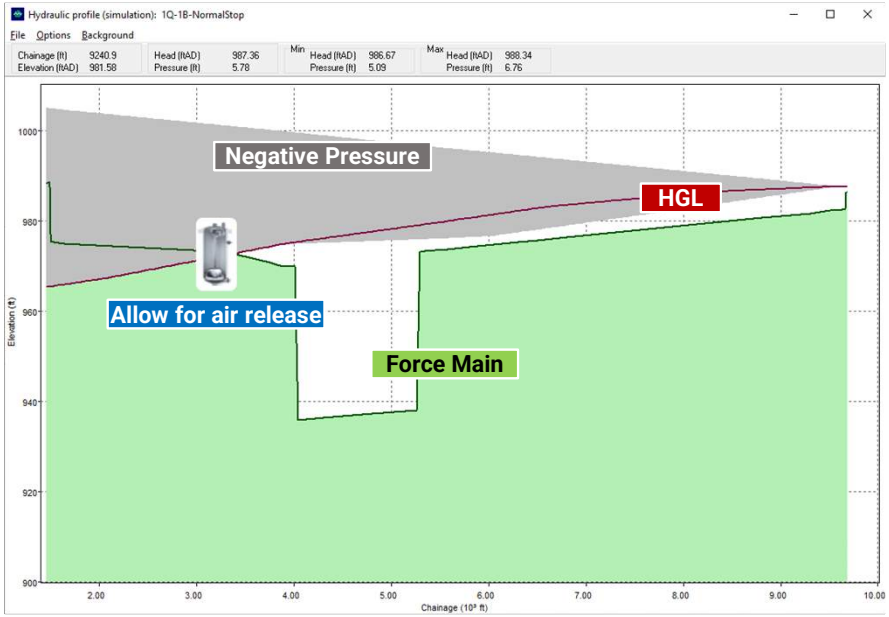
Internal Visual Observations (CCTV)

- Corrosion Staining
- Lining Defect

Scenario 1 | Scenario 2 | Scenario 3

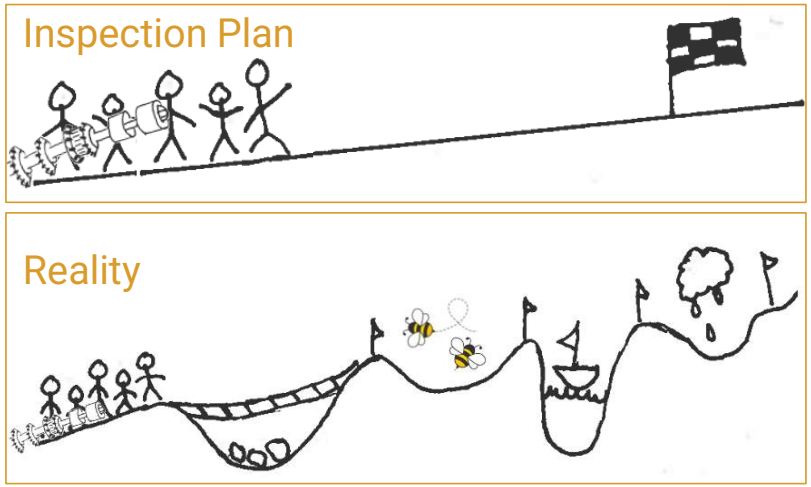
LS 43 and South Valve Vault-1

Install new 2-inch ARV at STA 27+00 on each Barrel



Lessons Learned

Inspections don’t always go as planned.



Experience & calm collaboration increases the likelihood of a successful recovery.

THANK YOU

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Discussion