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Wisconsin Wastewater Operators' Association – SE Regional Meeting

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No Longer "Out of Sight, Out of Mind": Force Main Condition Assessment

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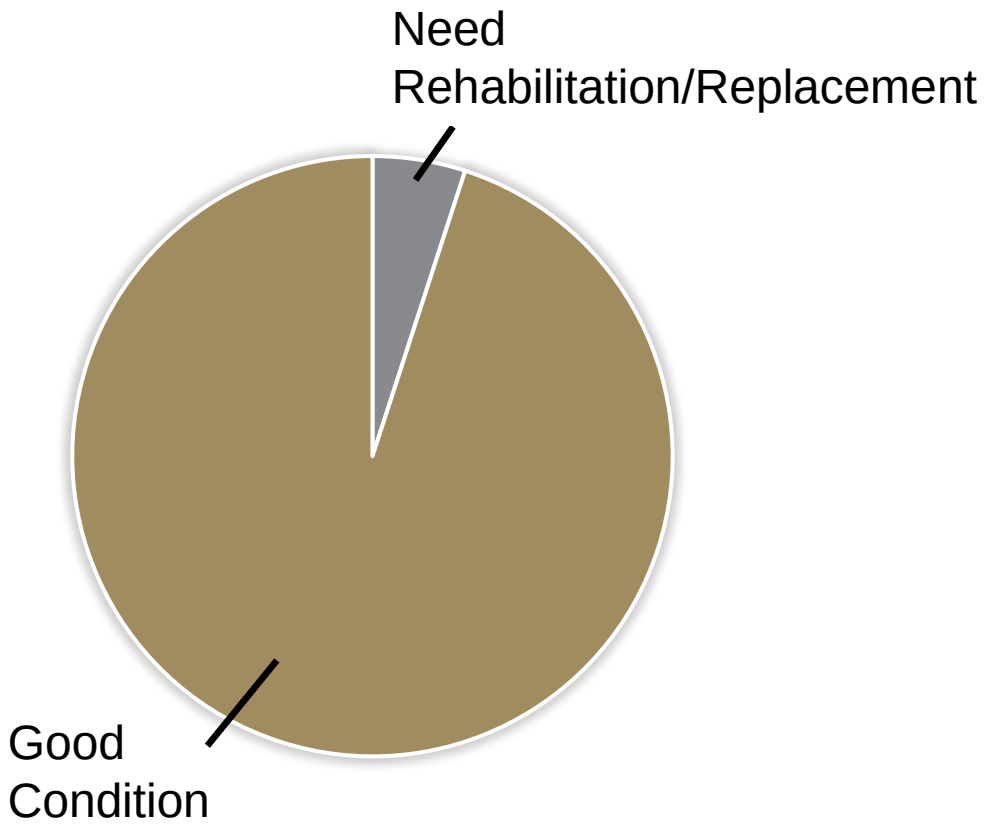
Key Topics of Today's Presentation Illustrates Process of Evaluating Force Mains

- Introduction
- Inventory and Data Gap Analysis
- Desktop Level Risk-Based Evaluation and Prioritization
- Condition Assessment Methods and Technologies
- Additional Condition Assessment Considerations
- Case Studies
- Summary

Introduction – Why Consider Evaluation and Condition Assessment of Force Mains?

- Continuous operation
- Lack redundancy
- Inaccessibility
- Failures are typically emergency situations
- Proactive approach
- Confident decision making
- More cost-effective



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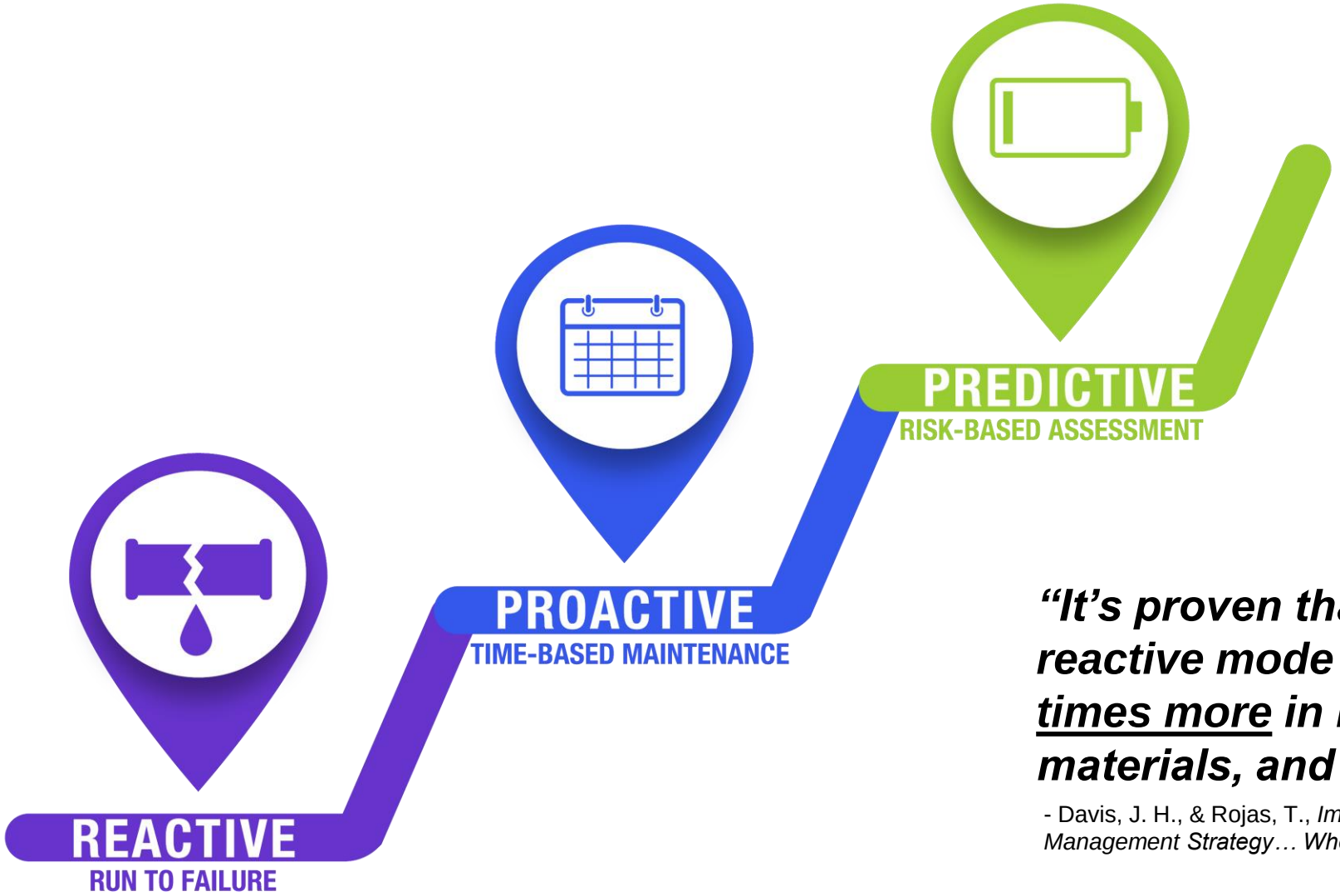
Why Consider Asset Management Planning?



"It's proven that operating in a reactive mode <u>costs two to three times more</u> in labor, parts, materials, and loss of service."

- Davis, J. H., & Rojas, T., *Implementing an Asset Maintenance Management Strategy… Where do you Start?* Waterworld Magazine

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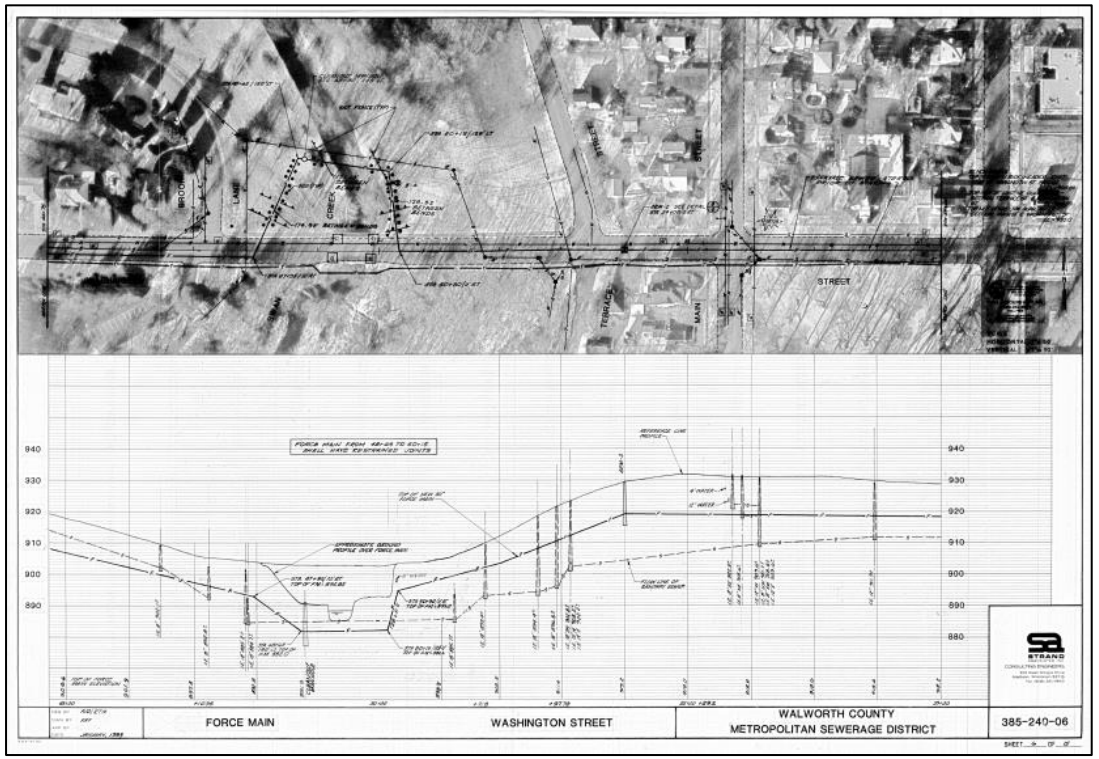
Inventorying Force Mains and Understanding Data Gaps is Critical First Step

- Gather available existing data to identify:
  - Location
  - Size
  - Age
  - Length
  - Material
  - Past failures
  - Existing condition data
  - Operating conditions (flows, pressures)
- Record drawings
- Modeling hydraulic conditions
- Pipe specifications and laying schedules
- Photos



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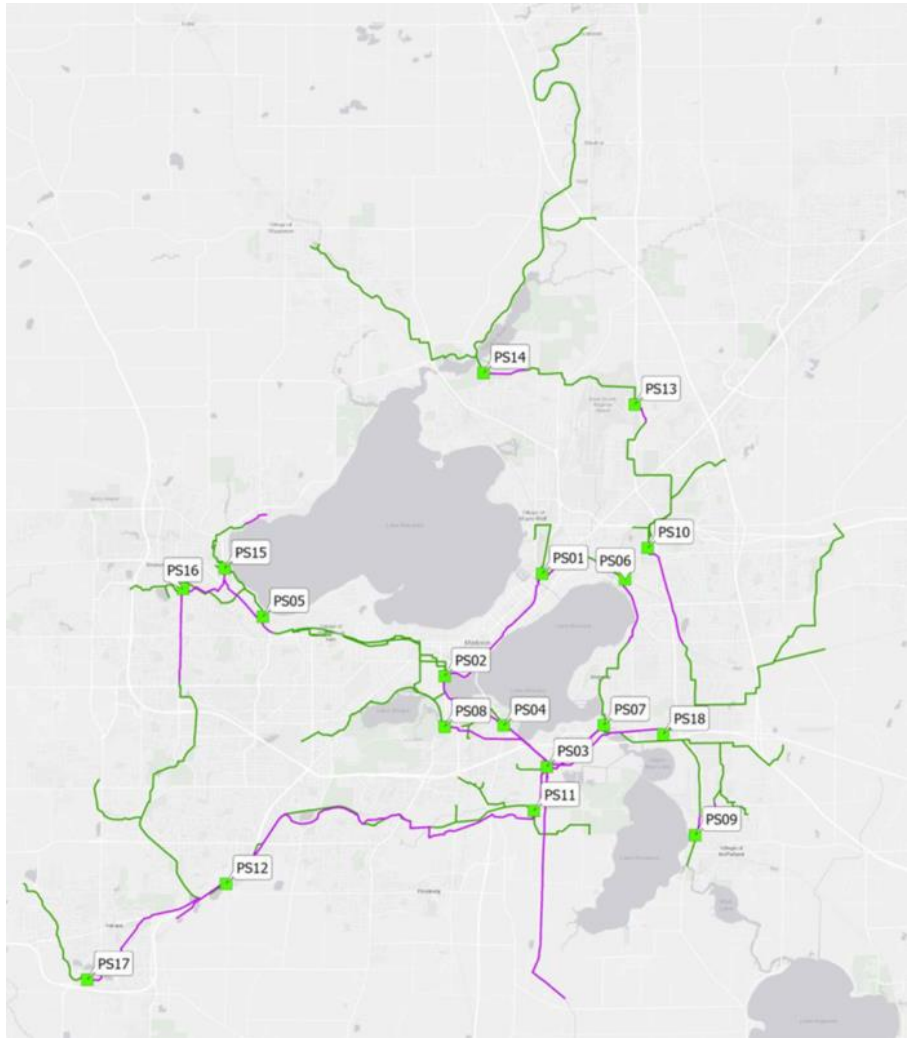
Madison MSD: Force Main Condition Assessment Plan Update



- 18 pumping stations
- 50 total miles of force main
- 8-inch to 54-inch
- 3 to 76 years old

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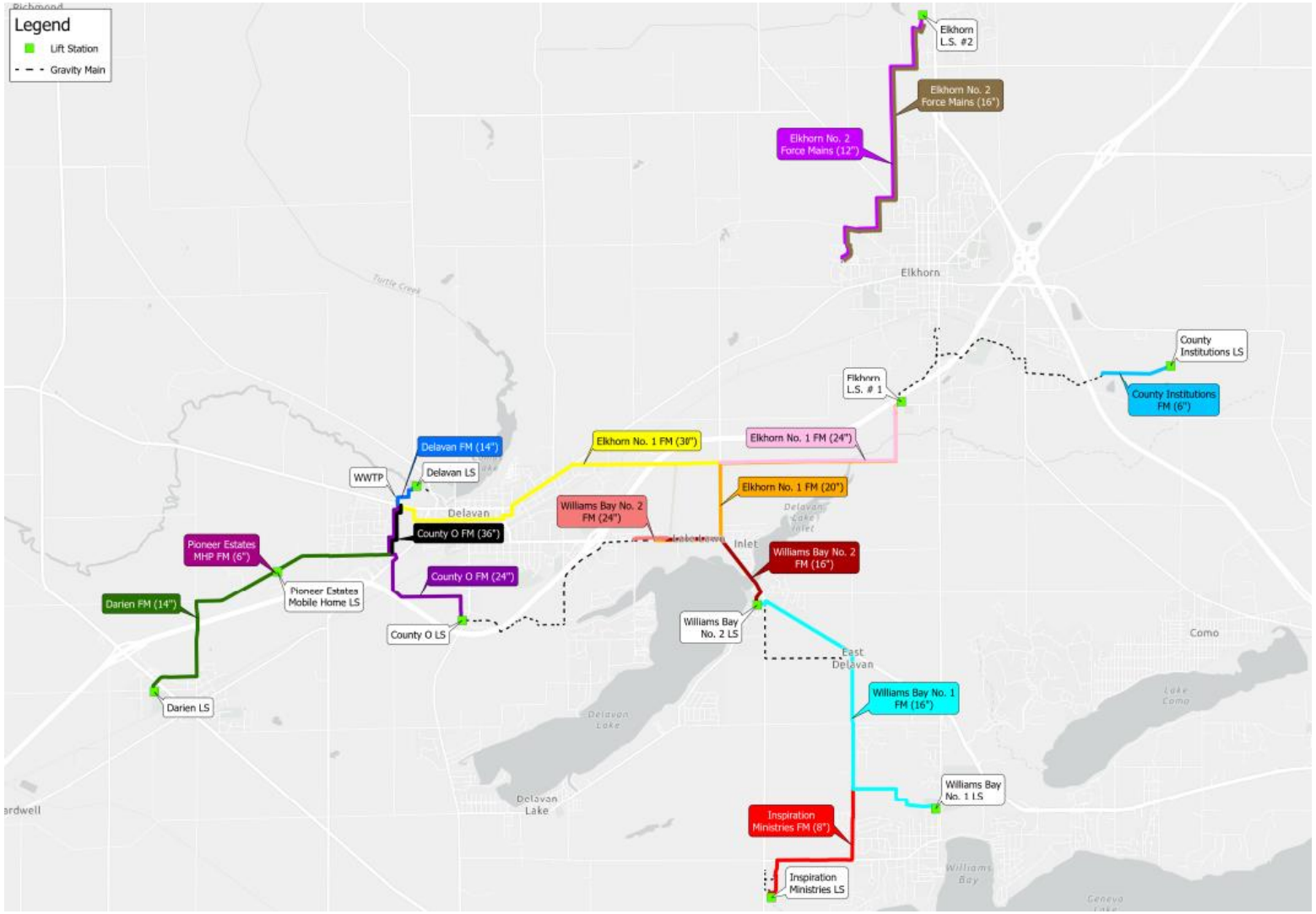
Desktop Level Evaluation Provides Cost-Effective Prioritization

- Organize available data (GIS, spreadsheets, asset management software)
- Fill data gaps
- Logically delineate force main segments
- Risk-based assessment methodology

WalCoMet: Delineation of Force Main Segments



- 10 pumping stations
- 31 total miles of force main
- 6-inch to 36-inch
- Delineated into 14 logical segments

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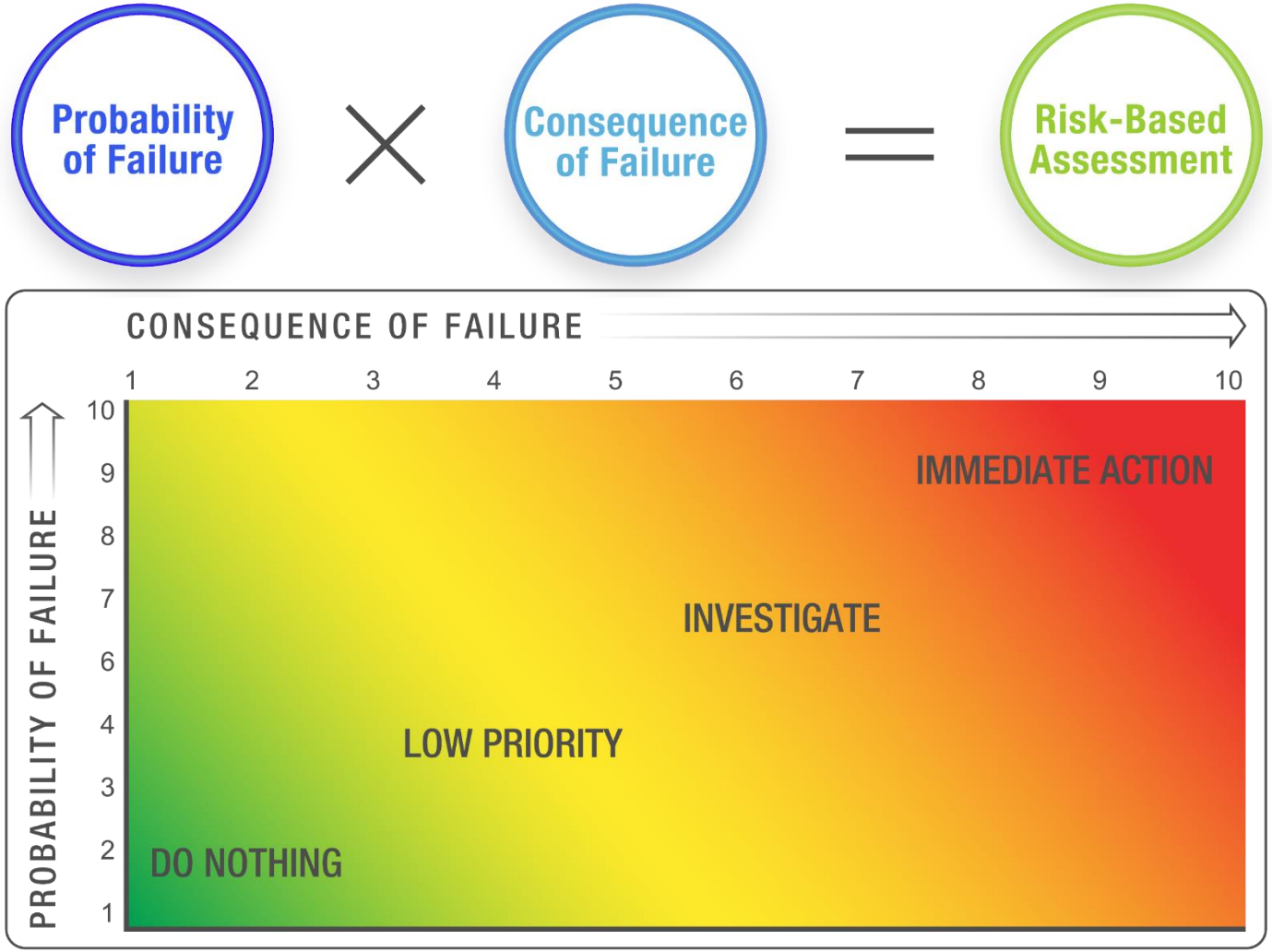
Risk Based Assessment Highlights Most Significant Risks Based on Available Data



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Many Criteria Can Be Incorporated Into a Risk-Based Evaluation

Probability of Failure	Consequences of Failure
• Installation date • Material • Operating and surge pressures • Soil corrosivity • Condition data • Past failures and issues • Remaining useful life • Other	• Critical customers • Proximity to streams/wetlands • Economic impacts – i.E. Business district • Public health • Proximity to buried utilities • Proximity to railroad • Diameter • Proximity to buildings • Depth of bury • Proximity to pavement • Pressure • Redundancy • Other

Weighting Factors Assign Higher Influence to the Most Important Criteria

- Higher a rating criteria is weighted, the more it influences the ultimate risk score
- Every community is different, and the risk evaluation should reflect this
- Collaboration is critical in the selection of ranking factors and weights

Likelihood of Failure
Criteria
Previous Failures
Useful Life Remaining
Soil Corrosivity
Operating Pressures

Consequence of Failure
Criteria
Pipe Depth
Pipe Diameter
Proximity to Railroad
Street Classification

WalCoMet: Force Main Desktop Level Risk Ranking and Prioritization

Delineated Force Main Segment	Diameter (in)	Length (LF)	Material	Year Installed/ Replaced	Assessed Condition	Notes for Assessed Condition	Consequence of Failure	Notes for Consequence of Failure	Asset Approx. Useful Life	Asset Age	Asset Approx. Useful Life Remaining	% Useful Life Remaining	POF Score	COF Score	NORMALIZED Asset Risk = POF x COF
1 - County HWY O (24-inch)	24	12,800	PCCP	1981	2 - Unlikely Chance of Failure	Located in private properties with easements.	3 - Moderate Disruption	No redundancy and high flows.	60	43	17	28%	2.20	3.47	31
2 - County HWY O (36-inch)	36	3,800	PVC	2021	2 - Unlikely Chance of Failure	Lowest risk ranking of all assessed force main segments.	2 - Minor Disruption	Large diameter and high flows.	50	3	47	94%	1.50	2.32	14
3 - Delavan	14	1,700	PCCP	1981	2 - Unlikely Chance of Failure	Approximately 50% useful life remaining.	3 - Moderate Disruption	No redundancy.	60	43	17	28%	1.68	2.65	18
4 - Darien (PVC)	14	5,900	PVC	1994	2 - Unlikely Chance of Failure	Deep force main.	3 - Moderate Disruption	Deep force main. No redundancy.	50	30	20	40%	2.13	3.12	27
5 - Darien (PCCP)	14	17,000	PCCP	1994	3 - Moderate Chance of Failure	1 previous failure (natural causes)	4 - Major Disruption	Force main is under an interstate and has no redundancy.	60	30	30	50%	2.58	3.78	39
6 - Pioneer Estates MHP	6	100	PVC	1996	2 - Unlikely Chance of Failure	Approximately 50% useful life remaining.	2 - Minor Disruption	No redundancy.	50	28	22	44%	1.90	2.26	17
7 - Williams Bay No. 1	16	21,200	RCP	1985	3 - Moderate Chance of Failure	2 previous failures (both caused by a third-party contractor)	3 - Moderate Disruption	Long force main with no redundancy.	70	39	31	44%	3.13	3.39	42
8 - Williams Bay No. 2 (DI)	16	5,200	DI	1985	2 - Unlikely Chance of Failure	Deep force main.	4 - Major Disruption	No redundancy. Close proximity to surface water.	80	39	41	51%	2.13	3.56	30
9 - Williams Bay No. 2 (RCP)	16	3,500	RCP	1985	2 - Unlikely Chance of Failure	Deep force main.	4 - Major Disruption	No redundancy. Close proximity to surface water.	70	39	31	44%	1.98	3.62	29
10 - Williams Bay No. 2 (PCCP)	27	1,900	PCCP	2005	2 - Unlikely Chance of Failure	Approximately 50% useful life remaining.	4 - Major Disruption	No redundancy. Close proximity to surface water.	60	19	41	68%	1.90	3.70	28
11 - Inspiration Ministries	8	11,000	PCCP	1987	2 - Unlikely Chance of Failure	Approximately 50% useful life remaining.	3 - Moderate Disruption	No redundancy.	60	37	23	38%	1.93	2.70	21
12 - Elhorn No. 1 (20-inch)	20	22,500	PCCP	1979	3 - Moderate Chance of Failure	2 previous failures (both caused by a third-party contractor)	3 - Moderate Disruption	Long force main with high flows. Close proximity to surface water.	60	45	15	25%	3.05	2.80	34
13 - Elhorn No. 1 (24-inch)	24	14,100	PVC	2006	2 - Unlikely Chance of Failure	Approximately 50% useful life remaining.	3 - Moderate Disruption	High flows and close proximity to surface water.	50	18	32	64%	2.15	2.56	22
14 - Elhorn No. 1 (30-inch)	30	22,100	PCCP	1993	4 - Likely Chance of Failure	2 previous failures (both natural causes)	4 - Major Disruption	Deep force main that is under an interstate. Large diameter and close proximity to surface water.	60	31	29	48%	3.55	3.74	53

Some Force Mains May Warrant Additional Condition Assessment

- Wide range of methods, tools, technologies
- Rapidly advancing technologies
- Several service providers

INSIGHT WATER TECHNOLOGIES

PICA Pipeline Inspection and Condition Analysis Corporation

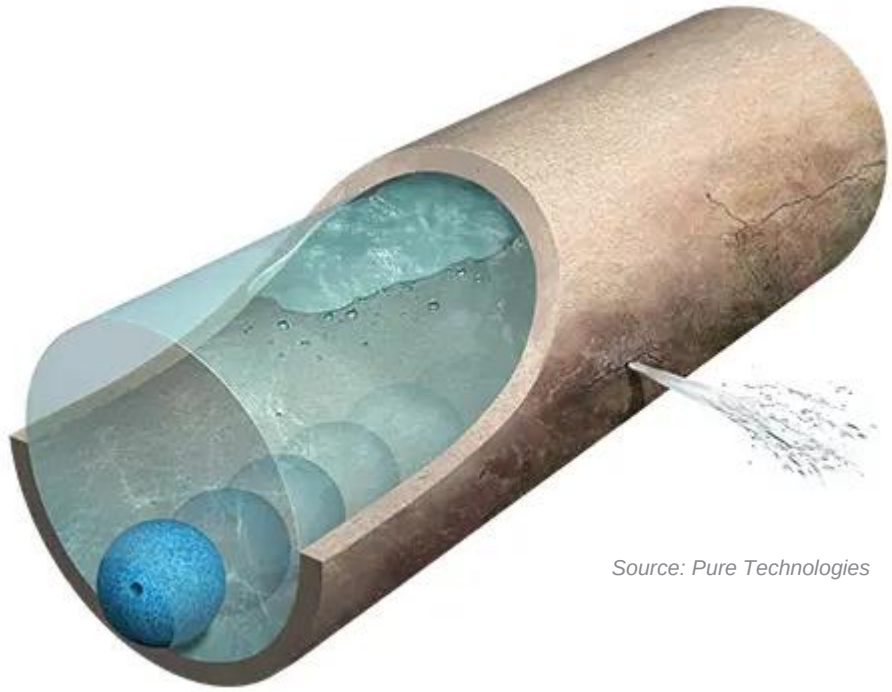
CPM PIPELINES

acquaint

pure TECHNOLOGIES a xylem brand

Acoustic Technology Identifies Leaks, Gas Pockets, Entrained Air

- Offered by several service providers
- Many are multi-sensor
  - XYZ location
  - Pressure
- Baseball sized – easier access



Source: Pure Technologies

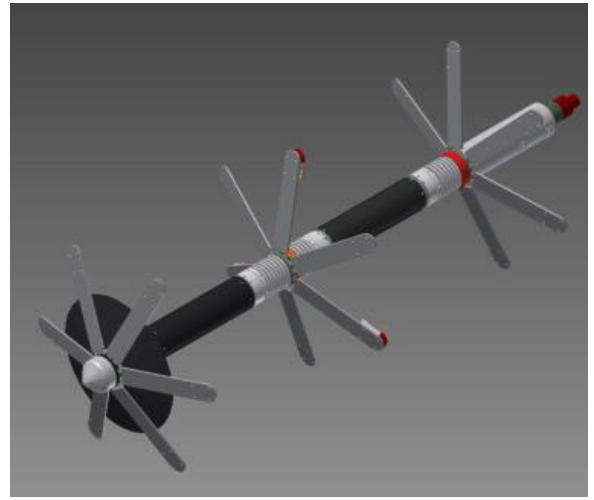
Electromagnetic Assessments Can Identify Wire Breaks and Deterioration of Cylinder in Prestressed Concrete Cylinder Pipe

- More significant access requirements
- Manual (out of service) or pumped through


Source: Pure Technologies

Source: Pure Technologies


Courtesy of Insight Water Technologies


Courtesy of Insight Water Technologies

Dubuque 42-inch force main assessment

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Electromagnetic Assessments Can Also be Used to Identify Wall Loss in Metallic Pipes

Courtesy of Strand Associates, Inc.

Source: CPM Pipelines

Source: Pipeline Inspection and Condition Analysis Corporation

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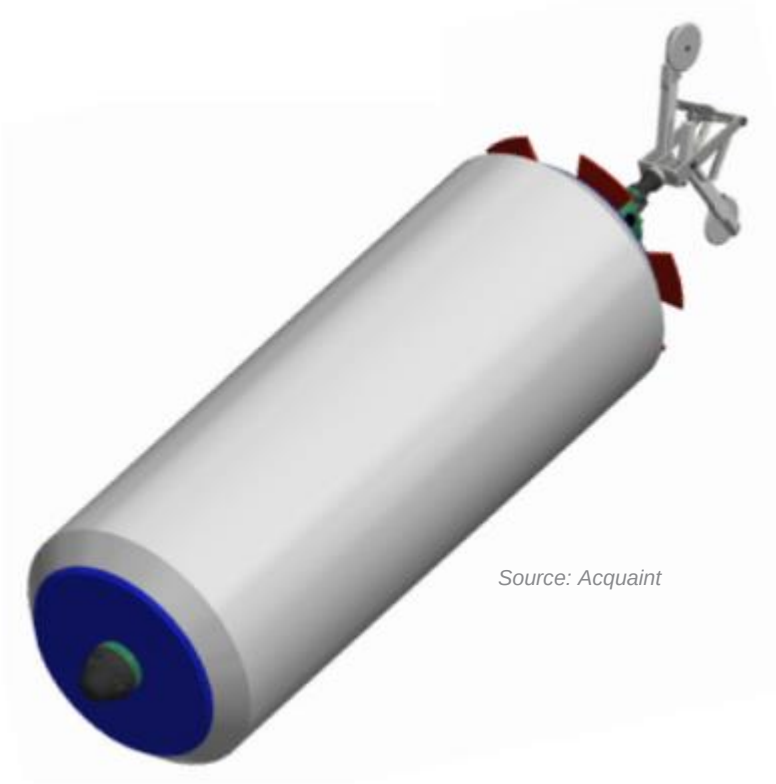
Ultrasonic Inspection Can Provide Additional Data

- Sends and collects sound waves
- Measures:
  - Geometry of pipe
  - Joint deflection
  - Anomalies in wall of pipe



Source: Acquaint

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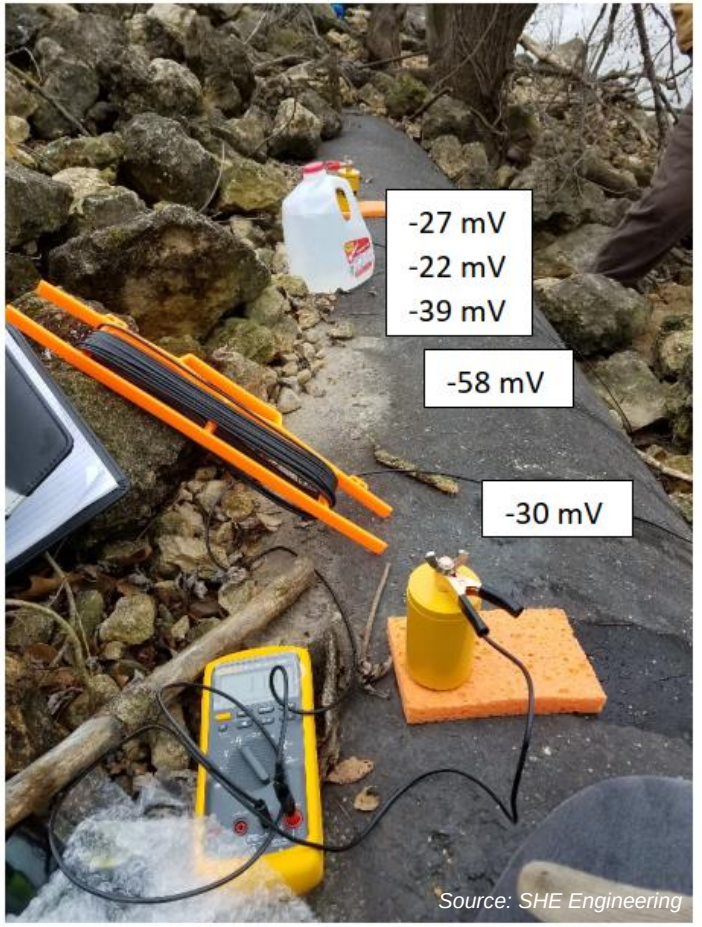
Pipe to Soil Potential Testing Provides Information Regarding Likelihood of Active Corrosion

- Measures electrical potential between reference electrode and pipe
- Can provide indication of active corrosion (or lack of)



Dubuque 42-inch force main assessment

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Visual Assessment Provide Significant Information

- Potholing
- Sounding
- CCTV

Courtesy of Strand Associates, Inc.

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Transient Pressure Monitoring

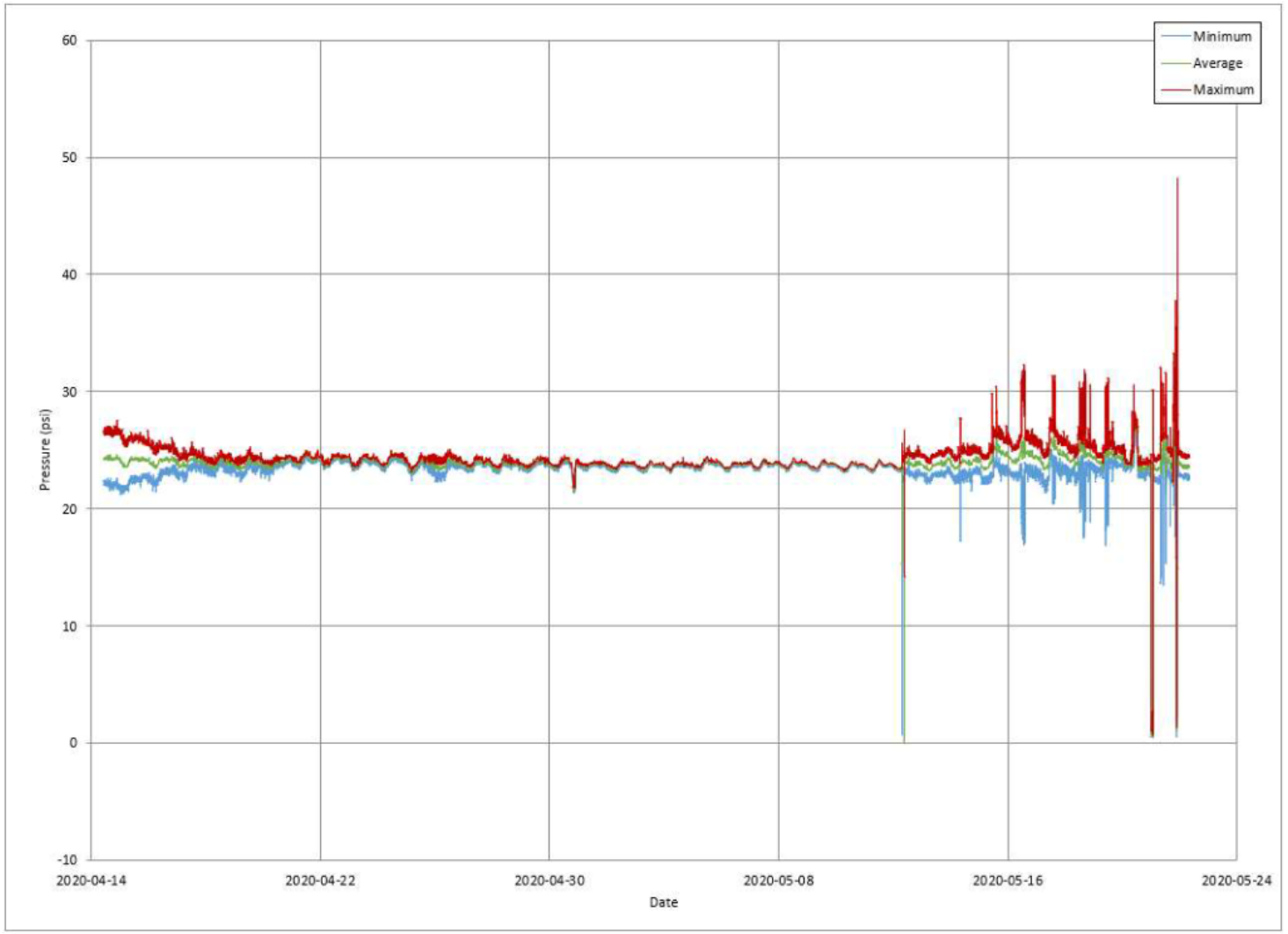

Figure 3.3: Terminal Street Force Main (downstream of pump) TPM Data - Full Monitoring Period

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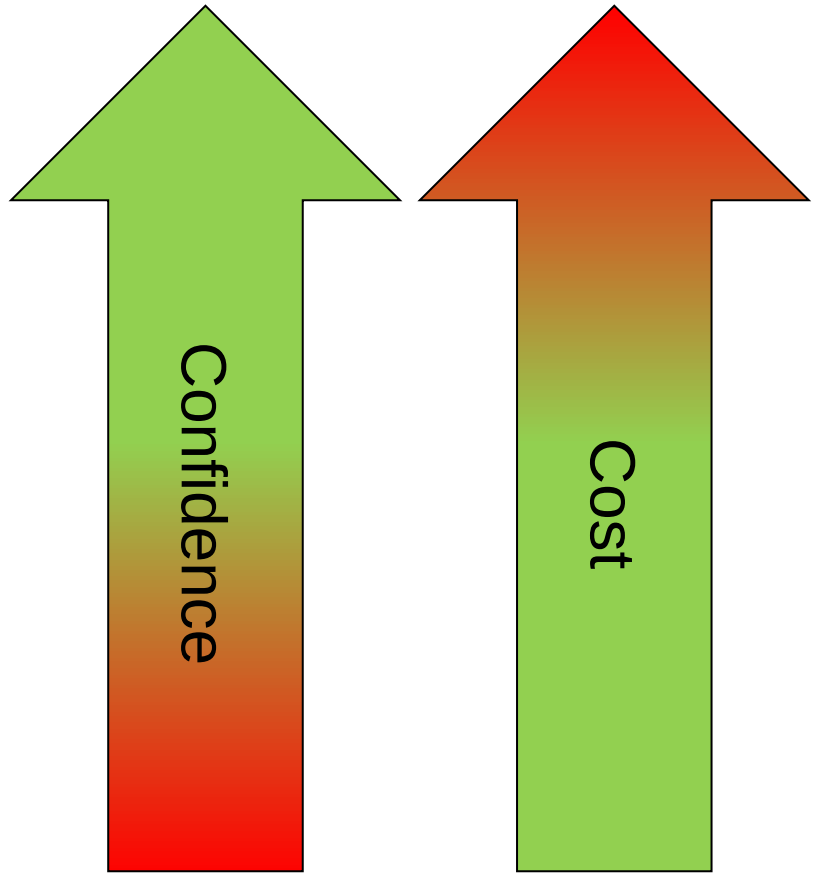
Consider Ancillary Items and Costs When Planning Condition Assessment Approach

- Access for in-line tools
- Risk of assessment
- Ability to take line out of service
- Confidence in data
- Data coverage
- Cost



Additional Resources Prove Helpful

ACPA
American Concrete Pipe Association

PVCPIPE association

THOMPSON PIPE GROUP

AMERICAN Concrete Pressure Pipe ASSOCIATION

dipra
Ductile Iron Pipe Research Association

NASSCO

What if Detailed Condition Assessment is More Than We Need?

- Be as proactive as possible
  - At a minimum, inventory and understand existing conditions. Understand risks with your force mains
  - Utilize cost-effective means to gain information on condition
- Do you have a plan in place for responding to issues?
  - Repair sleeves, fittings, pipe, etc. available?
  - On-call emergency contractor?
- When constructing new force mains, be sure they are properly designed and constructed!
  - Material selection
  - Coatings and other corrosion protection methods
  - Sizing
  - Air/Vacuum relief
  - Surge protection
  - Bedding/cover/backfill material

Case Studies Identify Unique Circumstances and Challenges

- Ashland, WI: 24-Inch Ductile Iron
- Dubuque, IA: 30-Inch Duction Iron and 42-Inch PCCP

Ashland, WI: Main Lift Station Force Main Failure History

Courtesy of Strand Associates, Inc.

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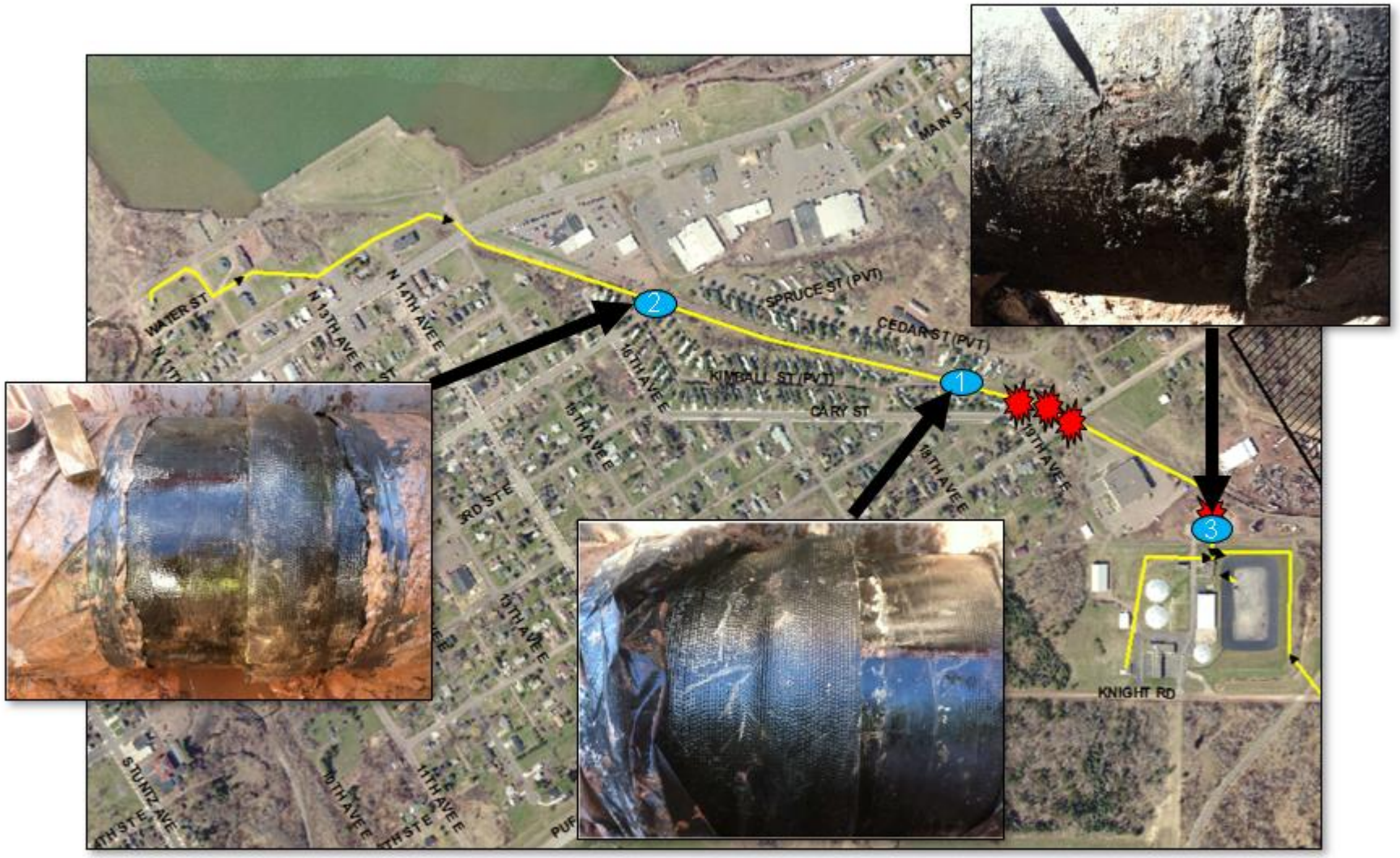
Ashland, WI: Condition Assessment Findings



Courtesy of Strand Associates, Inc.

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Ashland, WI: Condition Assessment Findings – Location 3

dipra
Ductile Iron Pipe Research Association

Courtesy of Strand Associates, Inc.

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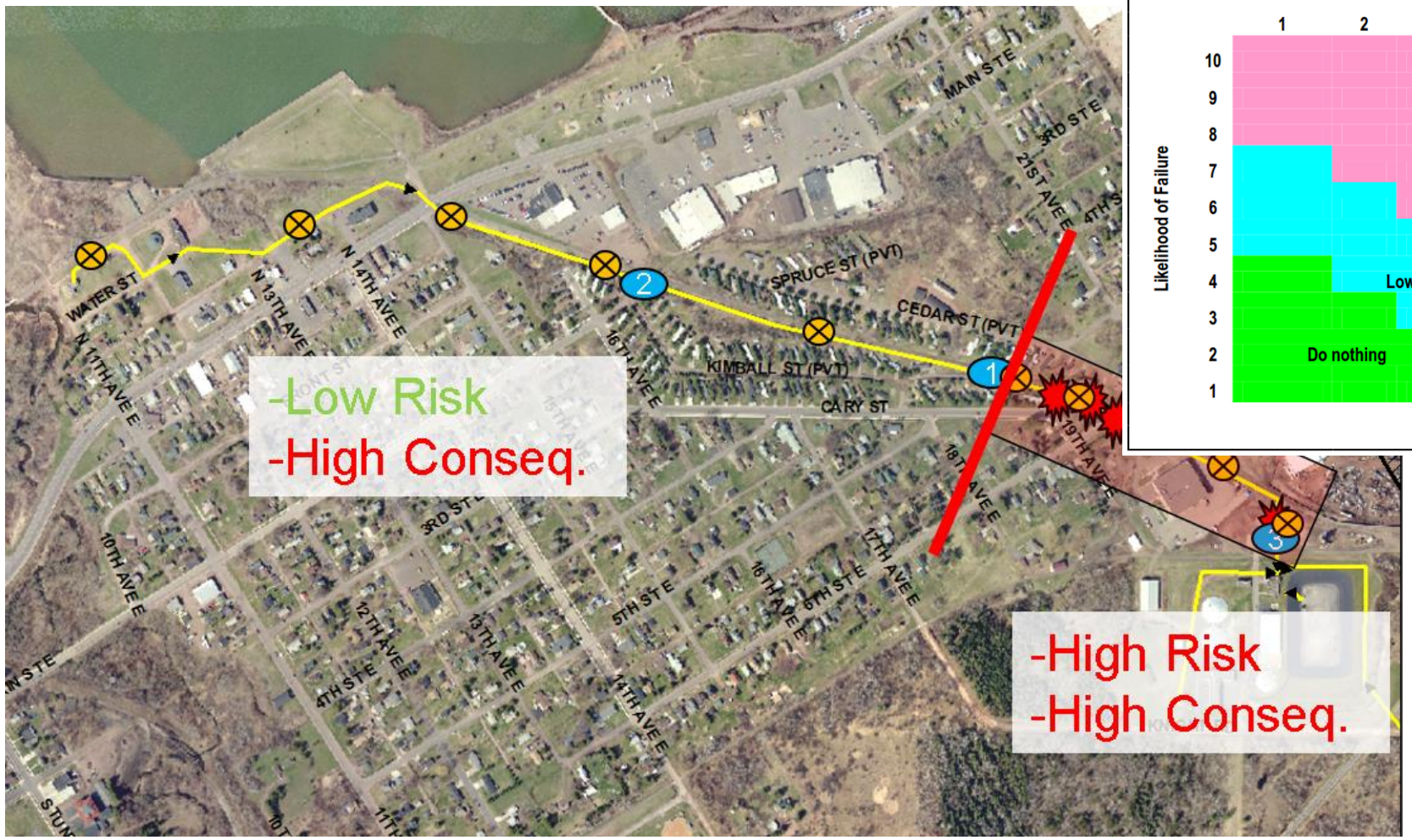
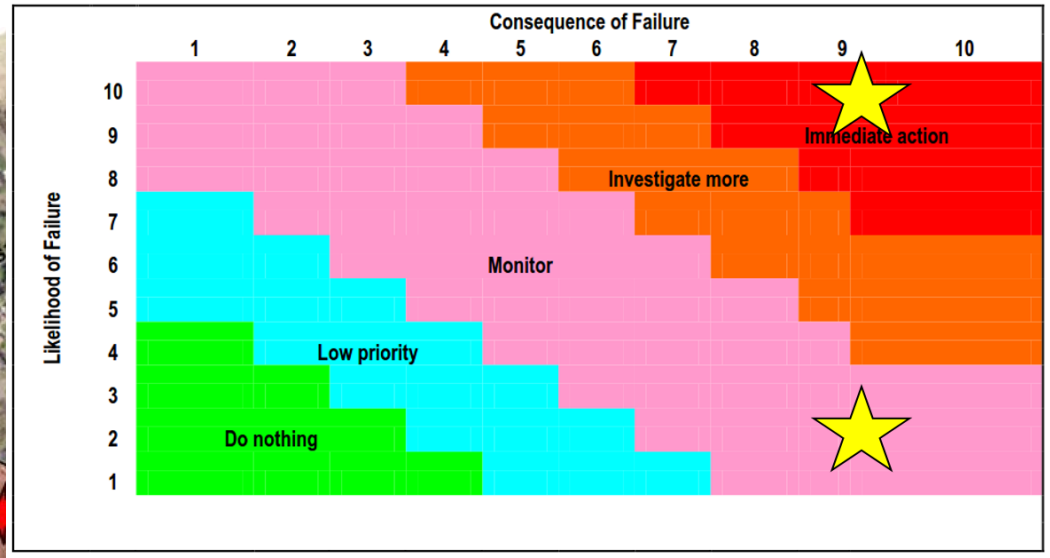
Ashland, WI: Condition Assessment Findings





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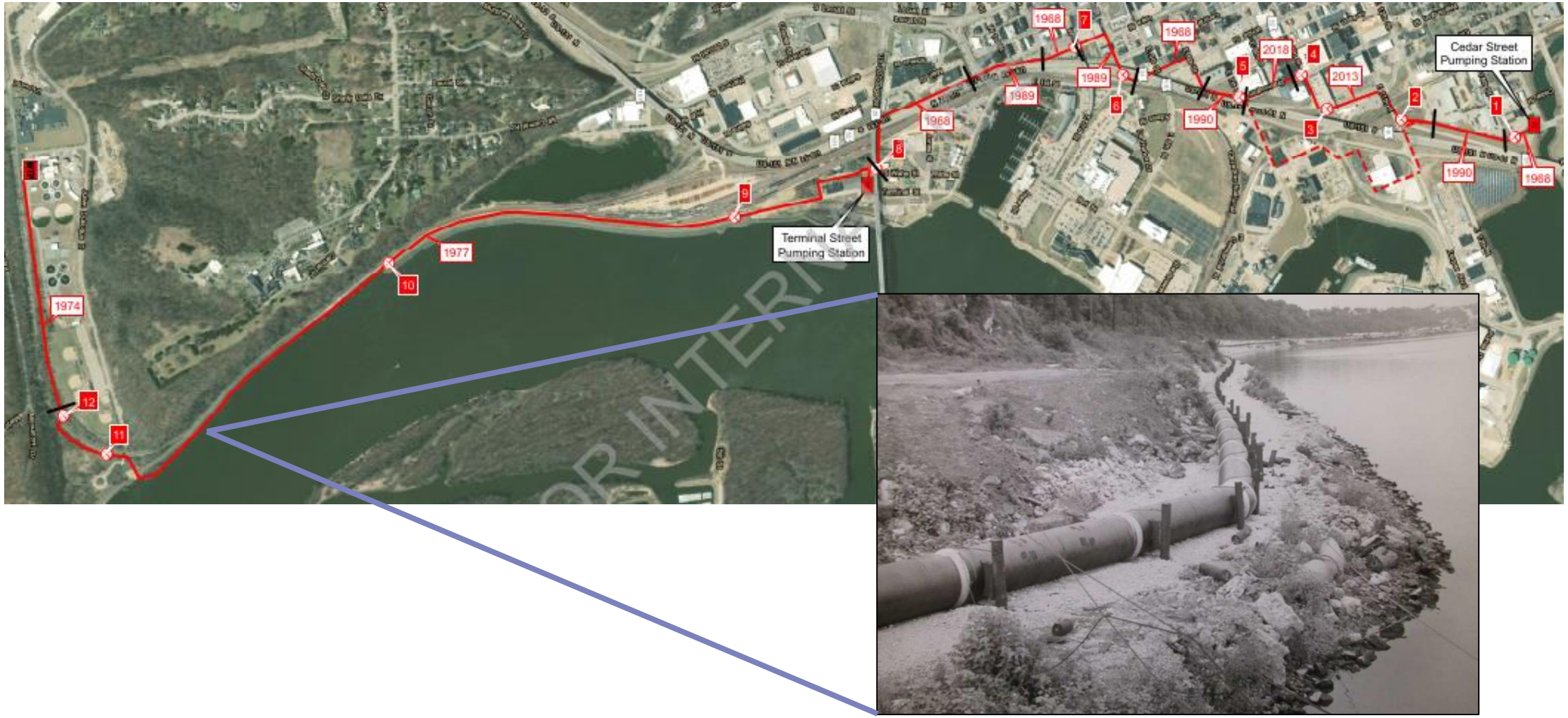
Dubuque, IA: 30-Inch Ductile Iron, 42-Inch PCCP Condition Assessment



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Dubuque, IA: Walk Through Identified Issues

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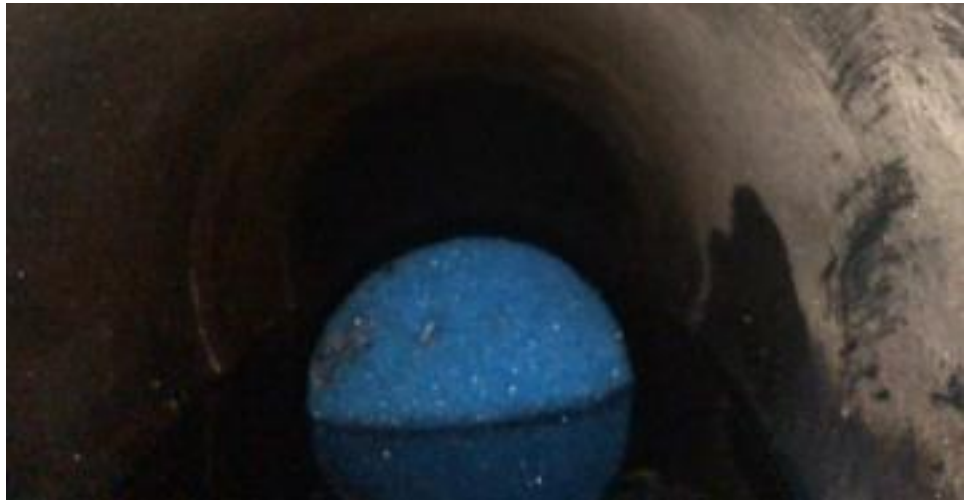
Dubuque, IA: High Consequences of Failure Warranted Additional Condition Assessment



Source: Pure Technologies

Source: Pure Technologies

Source: Pure Technologies

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Dubuque, IA: Transient Pressure Monitoring

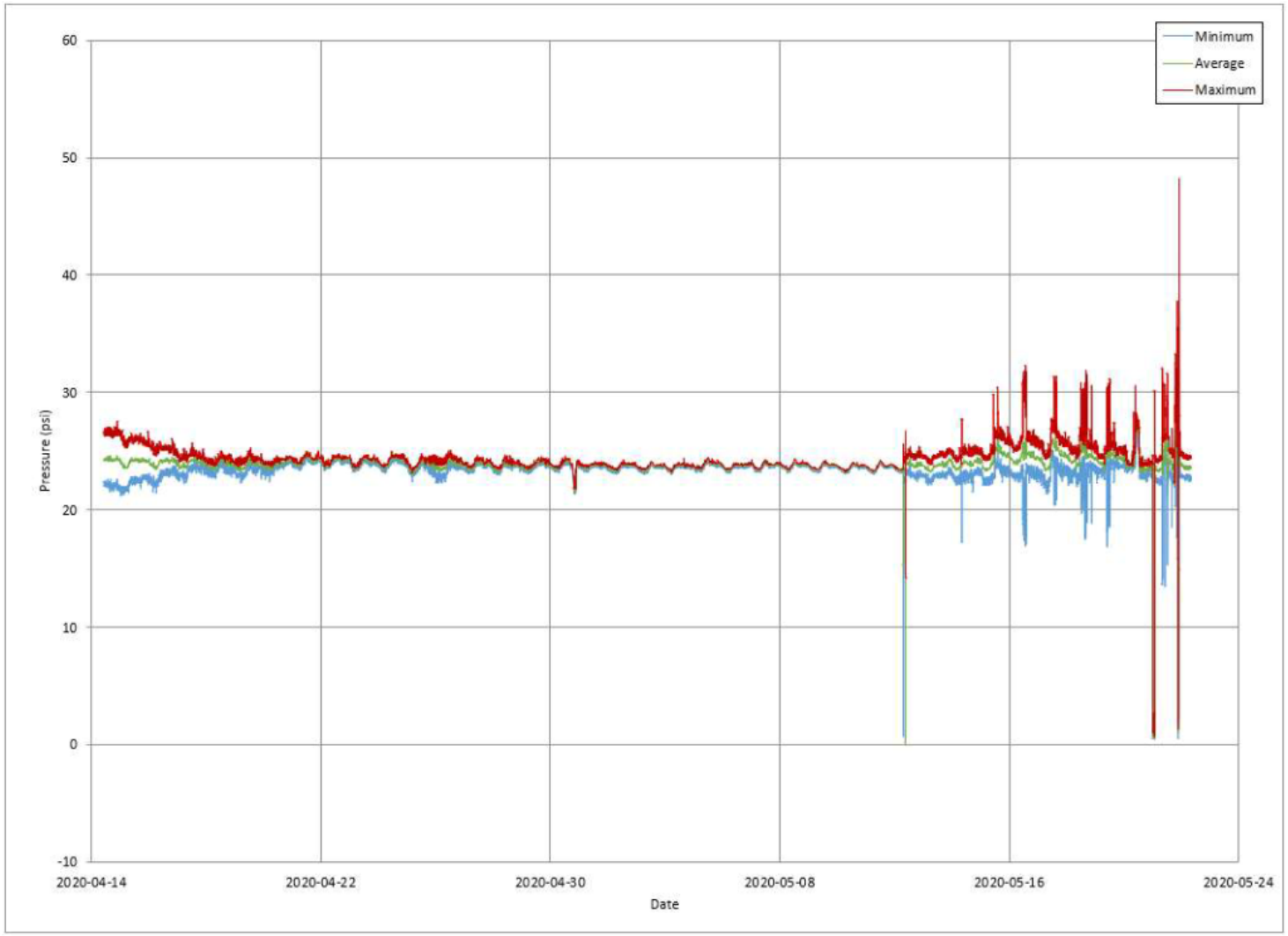

Figure 3.3: Terminal Street Force Main (downstream of pump) TPM Data - Full Monitoring Period

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Dubuque, IA: Surge Analysis Identified Risks

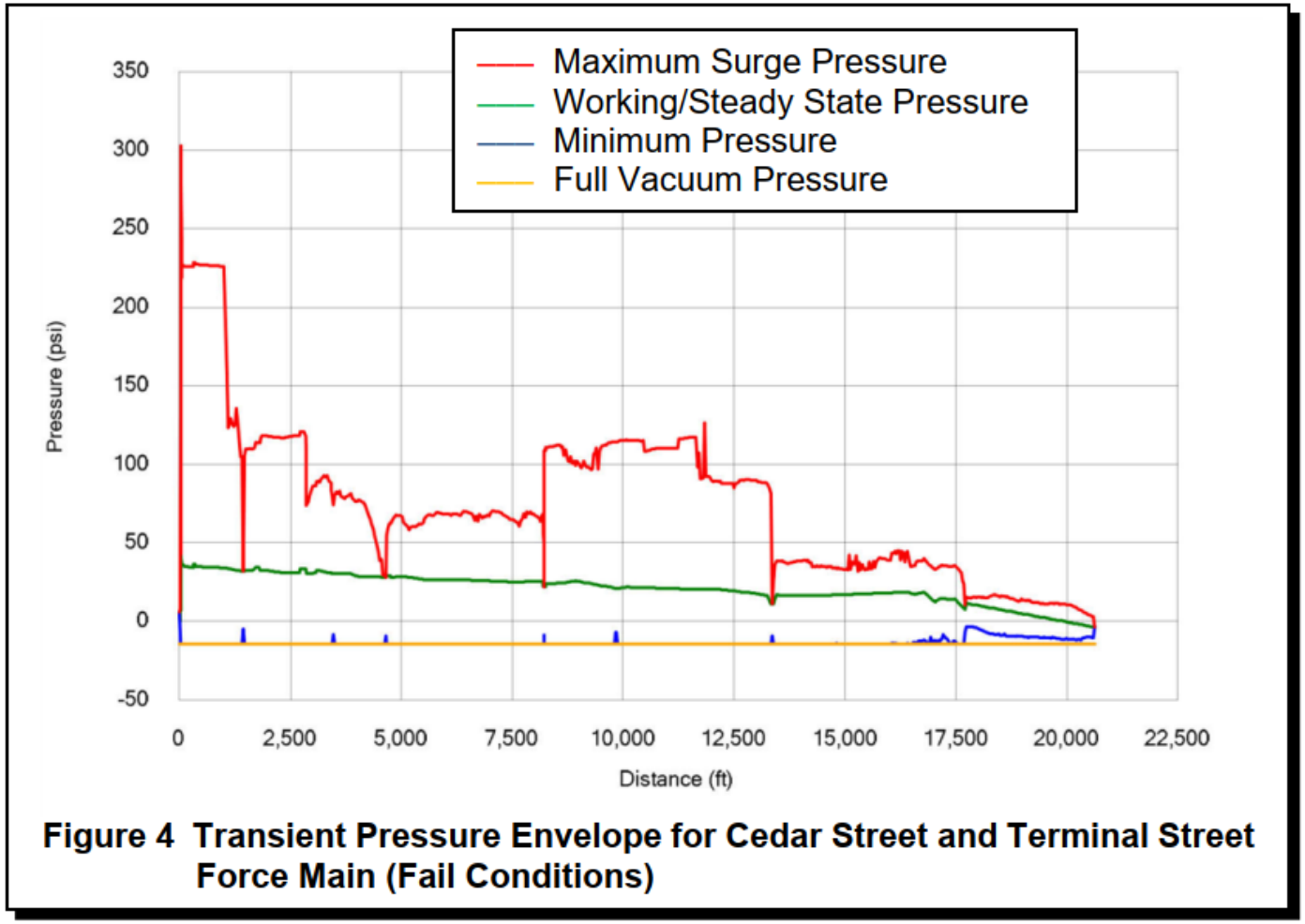

Figure 4 Transient Pressure Envelope for Cedar Street and Terminal Street Force Main (Fail Conditions)

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Dubuque, IA: Assessment Results Indicated Vast Majority of Pipe Was in Good Condition

Table 3.6: Pipe with Broken Wire Wraps in the 42-inch Terminal Street Force Main						
Pure Reference Number	**Piece Number**	**Low Station**	**Pipe Length (feet)**	**Break Position (feet)**	**Number of Broken Wire Wraps by Region**	**Total Number of Broken Wire Wraps**
10163	S-1	31+21	20	4.0	5	5

Table 3.2: Summary of Migratory Acoustic Events				
Acoustic Event	**Event Type**	**Event Length**	**Start of Event from Nearest Upstream Feature**	**End of Event from Nearest Downstream Feature**
1	Entrained Air	32 feet	72 feet from TEE, tracking location 8 (Station 0+33.25)	1,555 feet before ARV, tracking location 9 (Station 17+00)
2	Entrained Air	22 feet	369 feet from ARV, tracking location 11 (Station 88+50)	266 feet before ARV, tracking location 12 (Station 95+30)
3	Entrained Air	52 feet	15 feet from ARV, tracking location 12 (Station 95+30)	2,337 feet before Extraction, tracking location 13 (Station 0+00)[1]
4	Entrained Air	4 feet	2,262 feet from ARV, tracking location 12 (Station 95+30)	138 feet before Extraction, tracking location 13 (Station 0+00)[1]

Dubuque, IA: Recommendations

- Repair areas of exposed prestressing wire
- Remove trees growing around pipe
- Restore proper cover material and rip rap above pipe (Army Corps of Engineers Project)
- Replace combination air/vacuum valves and surge relief valves

Consider Force Main Condition Assessment for The Following Reasons

- Emergencies are expensive!
- Proactive approach
- Confident decision making
- More cost-effective
- Overall better for utility and customers

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