Assessment Methods For Large Diameter Water & Sewer Pressure Pipelines

Procrastinator's Workshop

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Midwest Regional Manager

Pure Technologies

- An Engineering and Inspection firm focused on providing non-destructive means to assess/monitor the condition of pipelines
- Experience in the Condition Assessment/Monitoring of over 5000 miles of pipe
- Specialize in the evaluation of large diameter water and sewer pressure pipes
- Provide specialized engineering support in new assessment technologies

Three Approaches to Pipeline Management

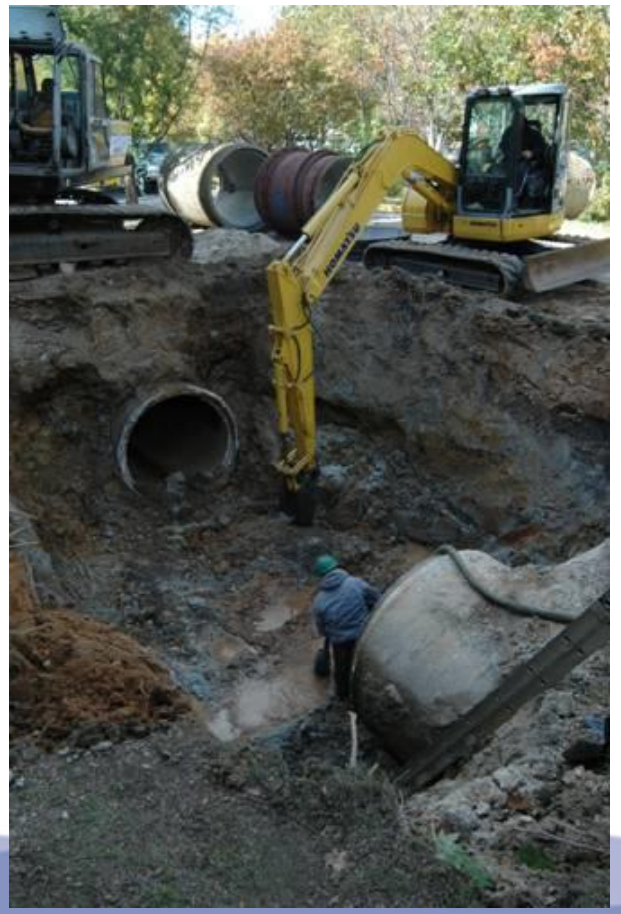
1. Capital program

   (Dig & Replace)

2. Run to Failure
   - $500,000 to $1,700,000 per failure
   - Safety concerns
   - Public relations

3. Proactive Condition Assessment

   (2%-4% of Replacement Costs)



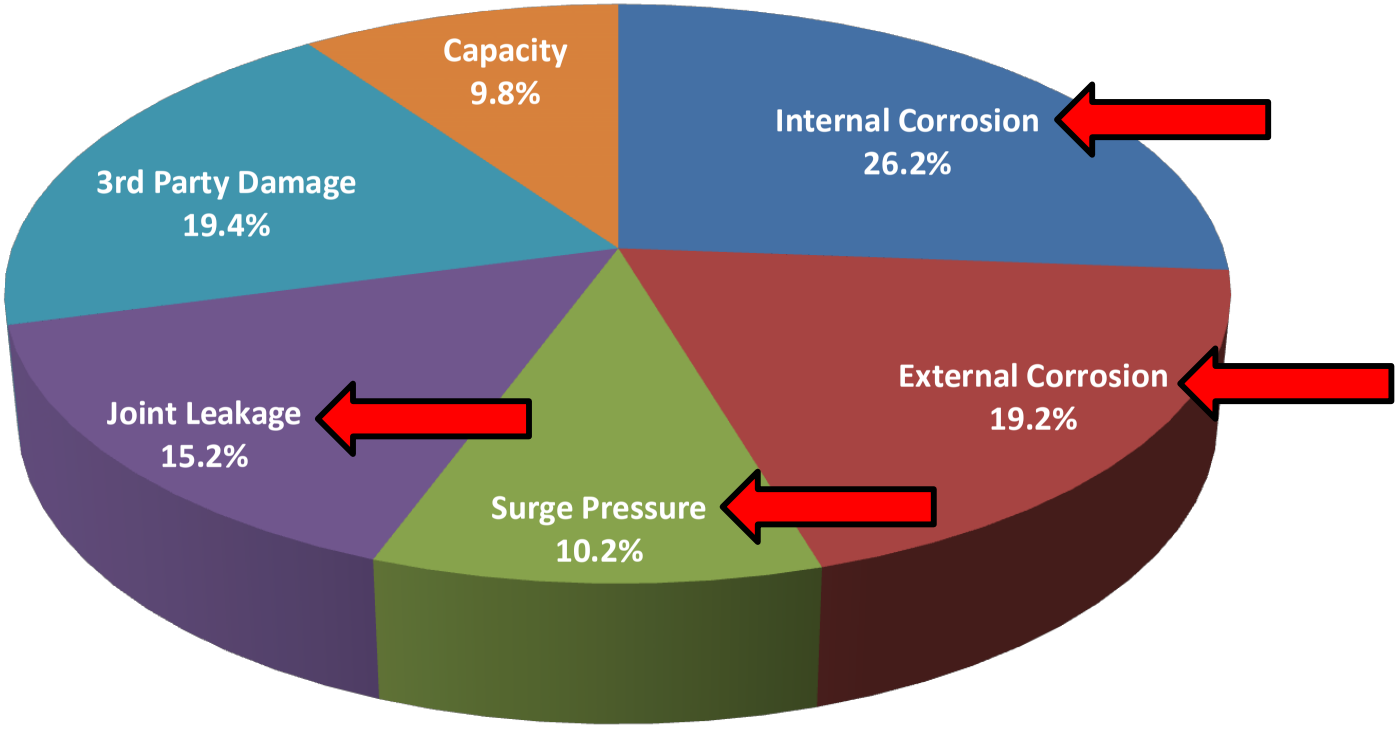
Transmission Main Assessment

Transmission Line Systems Typically >24" Dia.

- Pipes usually have limited redundancy
- The Impact of Large Diameter Transmission lines Breaks are significant
- Condition Assessment and Leak detection in large diameter pipe has been challenging for conventional technologies
- Replacement typically cost prohibitive

Comprehensive Condition Assessments – Large Diameter Pressure Mains

Failure modes for large diameter pressure mains



What methodologies can we use to prevent failure?

Condition Assessment Objectives

- Identify Areas of Corrosion
- Find and Repair Leaks
- Avoid Pipeline Failures
- Reduce Risk
- Extend Life of Pipeline

Deterioration of Metallic Pipe

Comes in many different forms:

- Damage to outer coating
- External corrosion pitting
- Pinhole **leaks** form in barrel

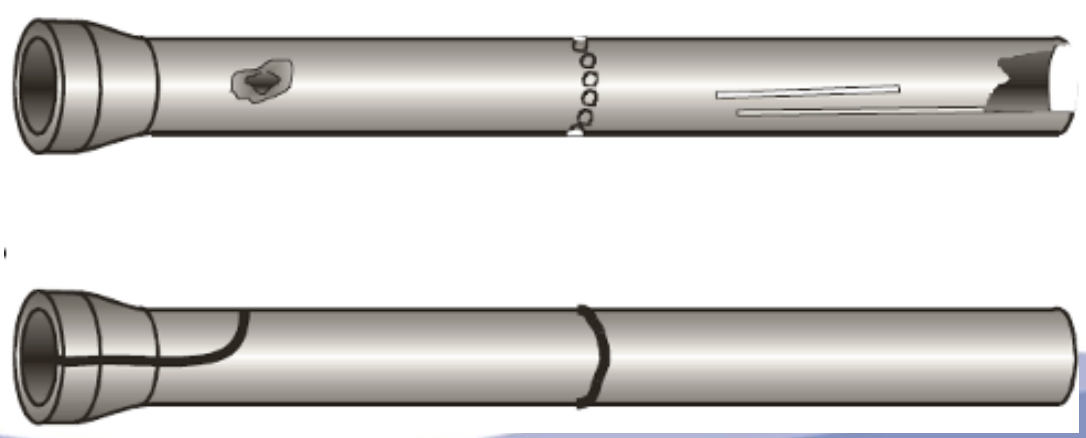
- Lead joint sealer strains joints
- Cracks form at bell end
- Joint begins to **leak**

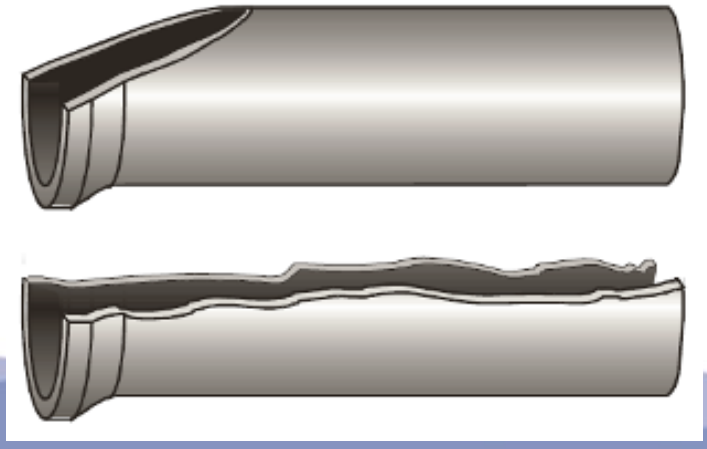
Cracks, corrosion pits, and pinholes weaken pipe wall

Bedding loss removes external support

Pressure transient or extreme temperature adds extra strain

Failure





General (Uniform) Corrosion

- Applicable to all metallic pipe
- Generally slower rate of deterioration than pit corrosion

Pit Corrosion

- Applicable to all metallic pipe
- Particularly a problem when pits line up
- Can be a rapid deterioration process

Pit Corrosion

Cracking

- Cast Iron Pipe & AC Pipe
- Typically starts at the bell end
- Grows with time, eventually leads to rapid crack propagation
- Leaks prior to failure

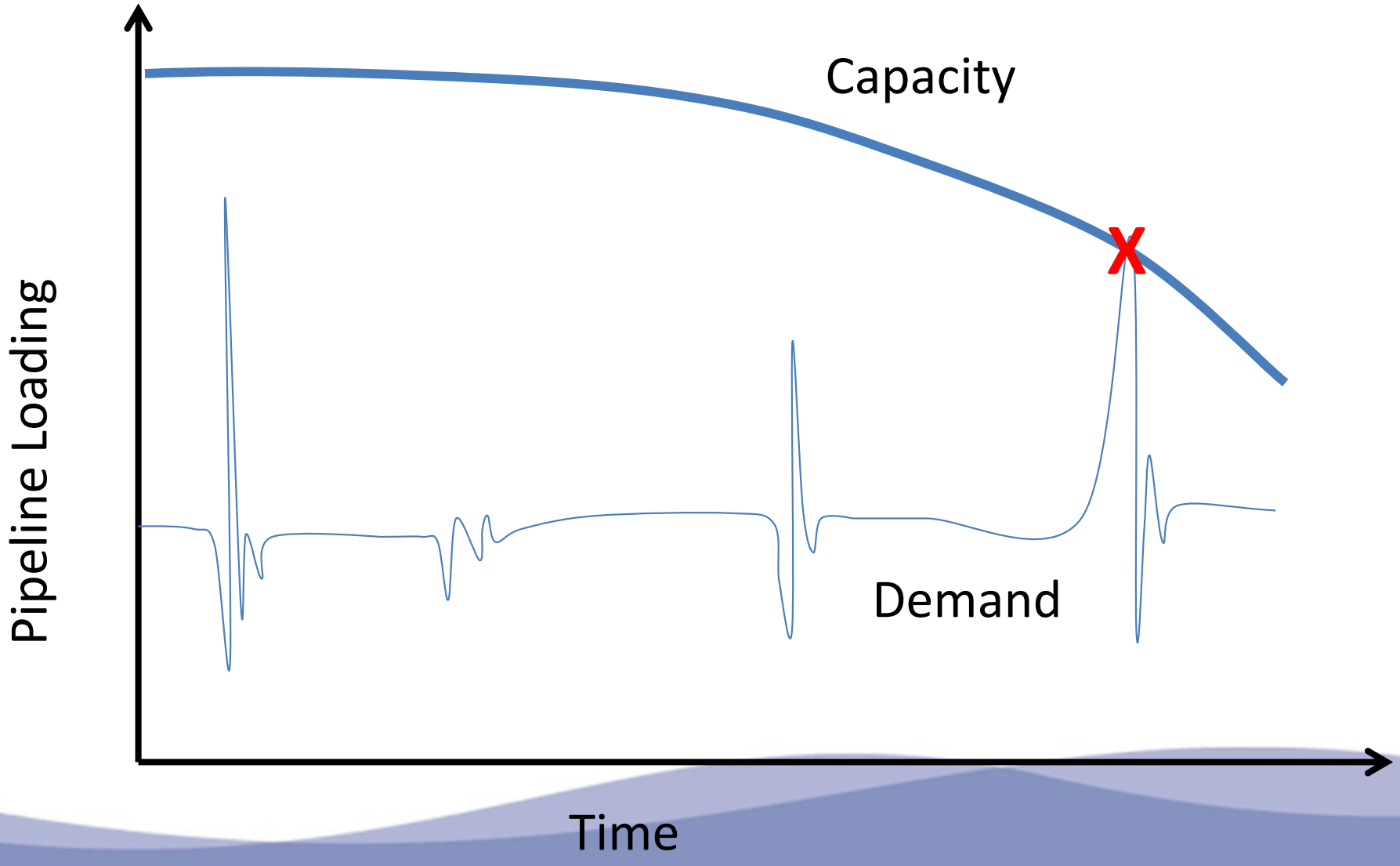
Cracking: Large Diameter CIP

- Longitudinal Cracking
  - Internal pressure/surges
  - Crushing effects
  - Compressive forces

- Bell Shearing
  - Compressive forces pushing spigot into bell
  - Bending forces

Tuberculation

Pipeline Capacity/Demands



Joint Failures

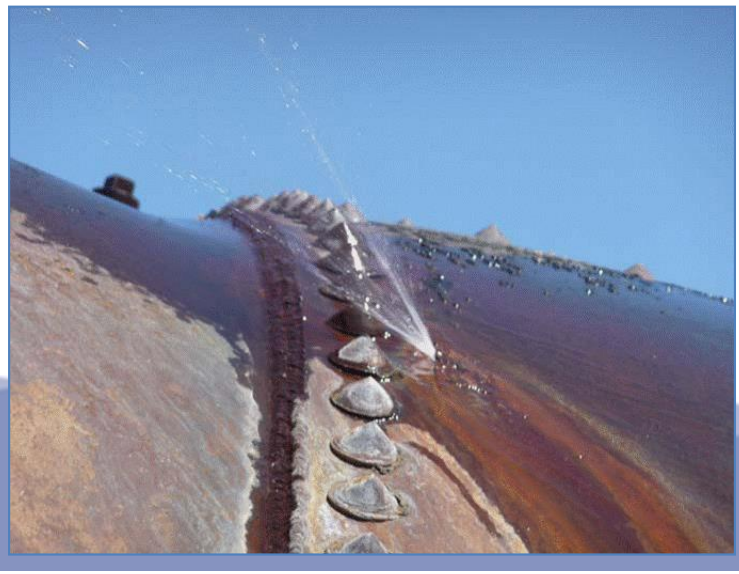
- Problematic joints lead to leaks
- Leaks accelerate degradation (corrosion, lack of pipe support)
- Leaks get larger with time
- Water loss

Current State of Technologies

- Current practice for large diameter pipeline assessment:
  - Desktop studies
  - Acoustic leak/gas pocket detection
  - Electromagnetic Pipe Inspection for PCCP
  - External corrosivity survey
  - Pressure monitoring
  - Test pits and pipe wall assessment
  - Engineering and Statistical analyses

Acoustic Leak & Gas Pocket Detection

- Leaks are often precursors to failures
- Transmission main leaks may contribute a significant amount to system leakage
- Gas pockets may promote corrosion (force mains), compound the effects of hydraulic transients, and reduce capacity



Acoustic Leak & Gas Pocket Detection

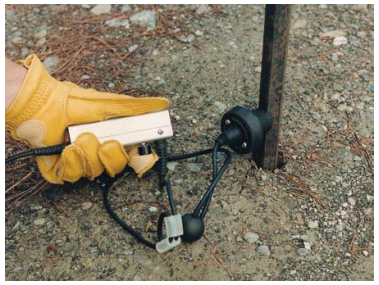
	Utility No. 1		Utility No. 2		Utility No. 3	
	Dist. Mains	Trans. Mains	Dist. Mains	Trans. Mains	Dist. Mains	Trans. Mains
Distance (miles)	2,400		2,900		4,400	
No. of Leaks	92%	8%	91%	9%	93%	7%
Avg. leak size (GPM)	2.3	14	1.9	18	4.5	36
Total leakage (GPM)	51%	49%	13%	87%	63%	37%

Current State of Technologies

Acoustic leak/gas pocket detection

External

- Listening microphones
- Noise Loggers/Correlators



Internal

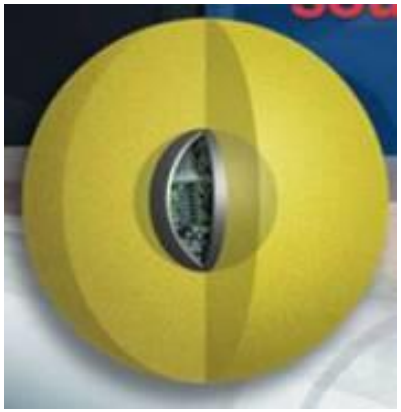
- Free-swimming system
- Tethered system

Current State of Technologies

Internal Leak Detection Options

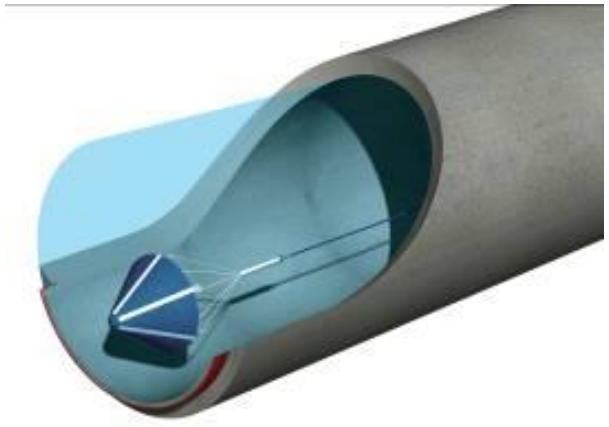
Free Swimming Systems

- Long point-to-point transmission pipelines
- Minimal laterals



Tethered Systems

- Complex interconnecting networks
- Urban centers



The noise of flowing water in a large diameter pipe masks the sound of small/medium sized leaks making them harder to find with external tools.

Internal tools pass right over the leak.

Deterioration of PCCP Mains

- Wire breakage due to corrosion
- Wire breakage due to hydrogen embrittlement
- Leakage
- Manufacturing deficiencies
- Other (transients, overloading, third party damage)

PCCP Condition Assessment Methods

PIPES THAT CAN BE ACCESSED (TAKEN OUT OF SERVICE)

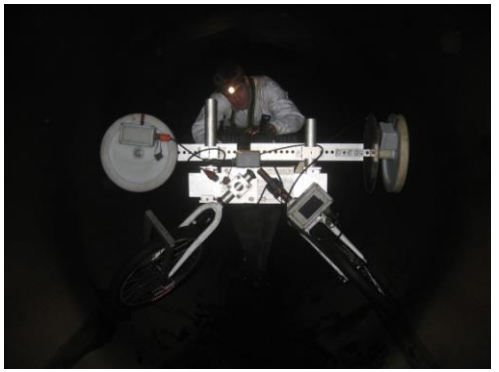
- Electromagnetic Inspection – Structural Analysis
- Internal Pipe Inspection – Visual and Sounding
- External Pipe Inspection – Site Corrosion Study and Pipe Wall Inspection
- Pipe Screening – Design Review, Finite Element Analysis

PIPES THAT MUST REMAIN IN SERVICE

- PipeDiver Electromagnetic Inspection
- Acoustic Monitoring / Pressure Transient Monitoring
- Leak Detection
- External Pipe Inspection – Site Corrosion Study and Pipe Wall Inspection
- Pipe Screening – Design Review, Finite Element Analysis

LONG TERM MANAGEMENT

- Acoustic Monitoring
- Transient Pressure Monitoring



Electromagnetic Inspection Methods for PCCP

Internal Manned

Diameter: 36”+

Line Preparation: Dewatered or Depressurized

Manned and track systems available

Robotic

Diameter: 18”+

Line Preparation: Depressurized

Multi-sensor inspection vehicle with EM, CCTV, Sonar, GIS mapping

PipeDiver

Diameter16”+

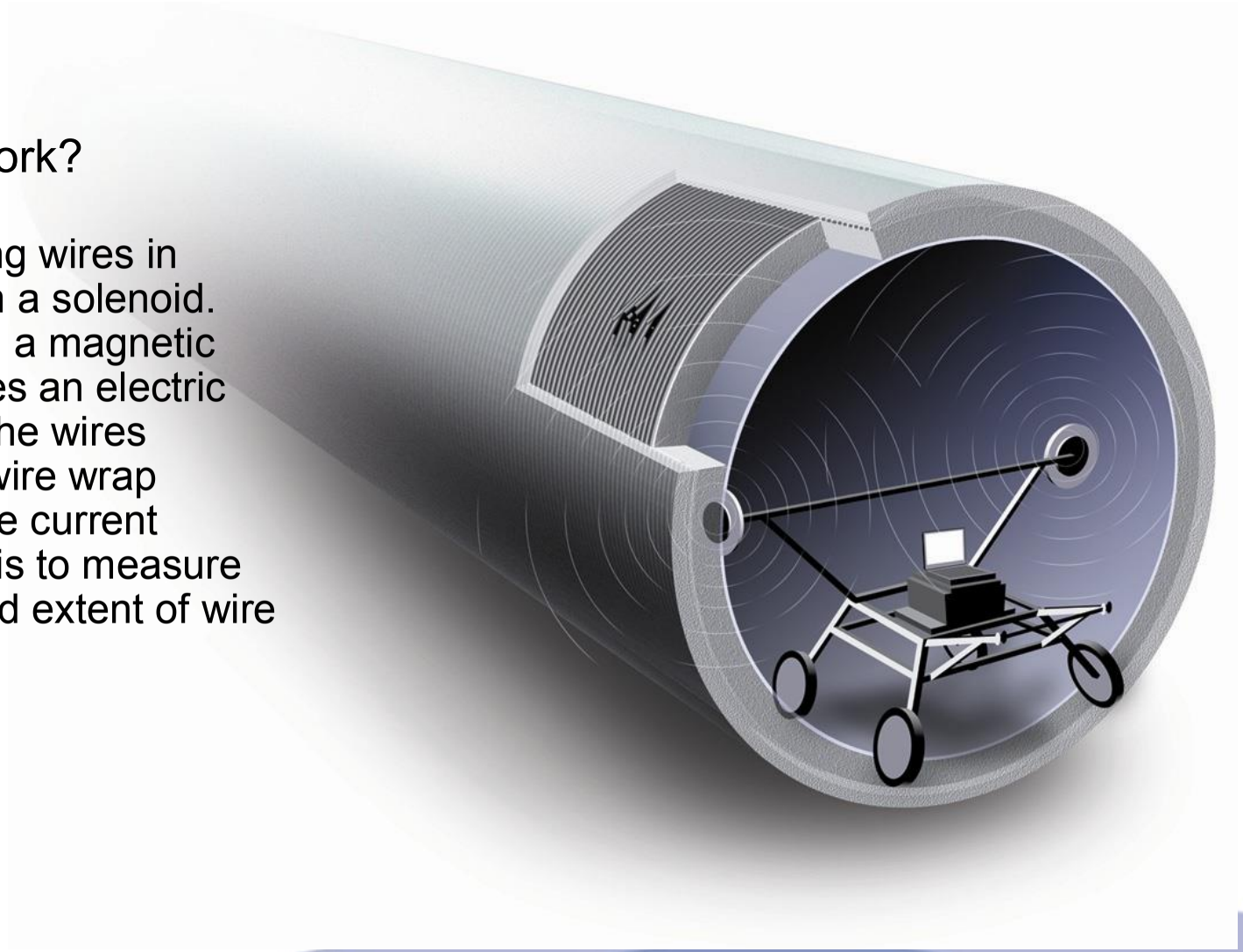
Line Preparation: In Service

Free swimming tool ideal for long distance inspections

Electromagnetic Inspection

How does it work?

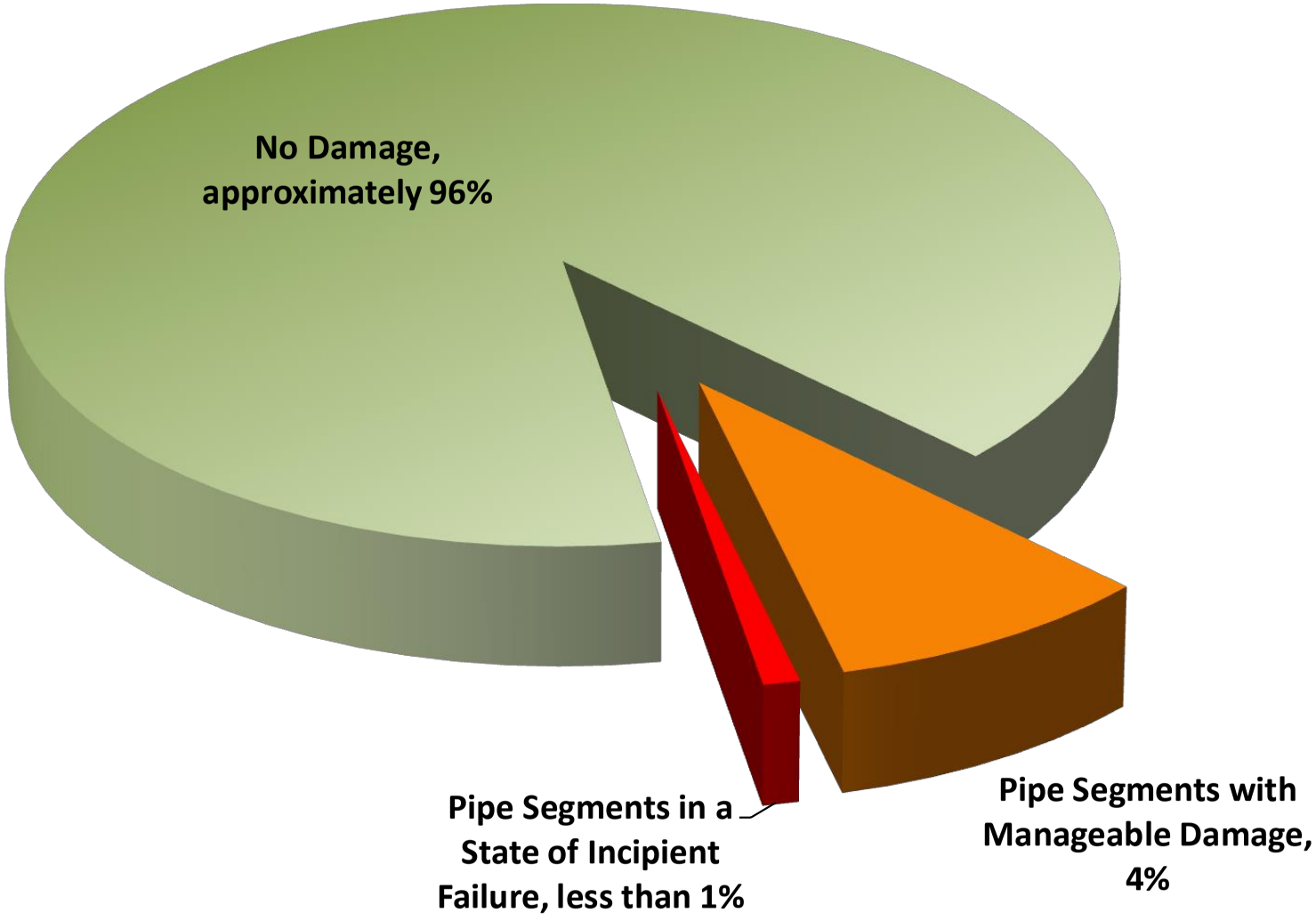
- Prestressing wires in PCCP form a solenoid.
- Generating a magnetic field induces an electric current in the wires
- Breaks in wire wrap interrupt the current
- Challenge is to measure location and extent of wire damage



Electromagnetic Inspection

- Detects and quantifies wire break damage
- Provides estimate of wire breaks in each pipe section
- Provides location of wire breaks

PCCP Inspection History



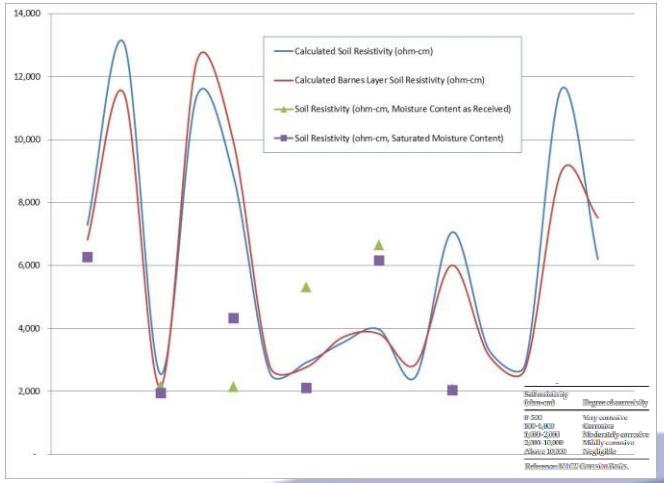
Current State of Technologies

External Corrosivity Survey

- Electromagnetic conductivity survey, soil resistivity tests, pipe/cell to cell survey at hot spot areas, inspect for rectifiers or other sources of stray current
- Soil sampling at potentially corrosive areas identified during corrosion investigation

Soil resistivity (ohm-cm)	Degree of corrosivity
0–500	Very corrosive
500–1,000	Corrosive
1,000–2,000	Moderately corrosive
2,000–10,000	Mildly corrosive
Above 10,000	Negligible

Reference: *NACE Corrosion Basics.*

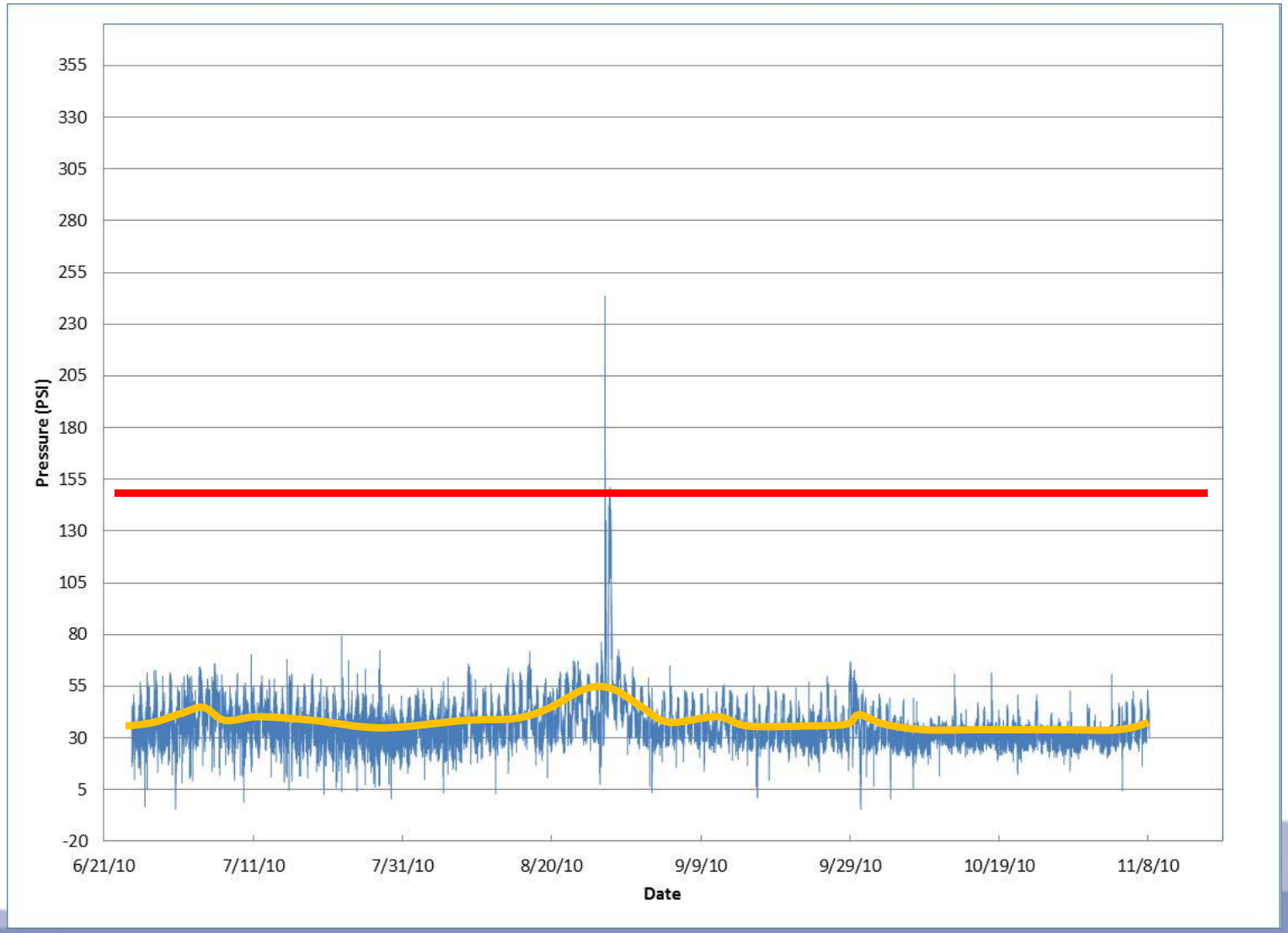


Current State of Technologies

Pressure Monitoring

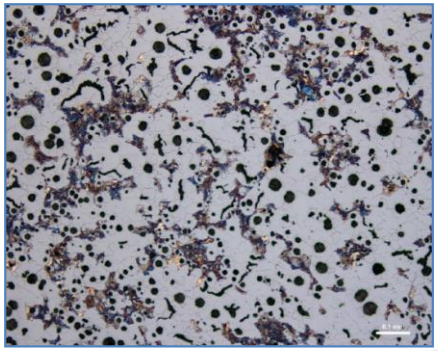
- Pressure transients above the design pressure of the pipe can cause the main to fail (especially in corroded areas or joints)
- Accumulated pressure transients can eventually decrease the structural integrity of the pipe
- Standard pressure monitors sample in intervals of seconds
- A pressure transient monitor samples at a rate of up to 100 samples per second

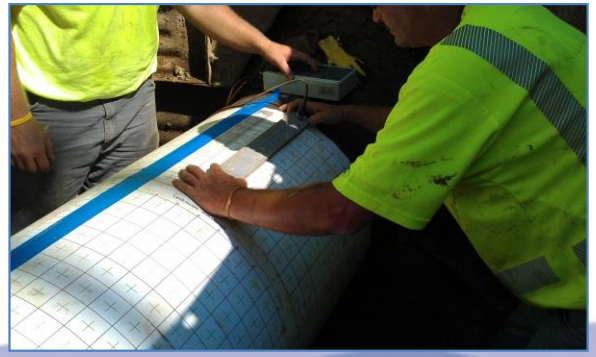
Current State of Technologies

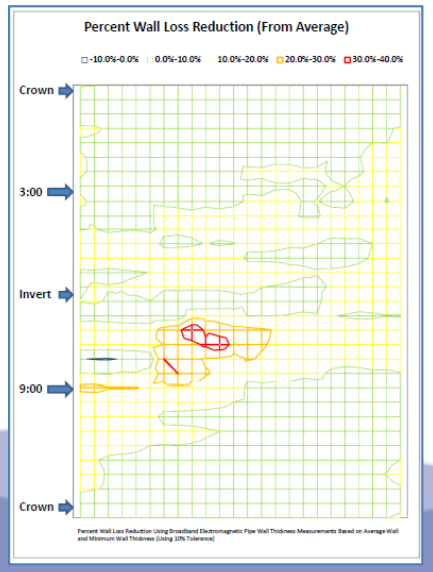


Metallic Pipe Assessment

- Excavation and external assessment techniques
  - Visual
  - Coupon sampling
  - Metallurgical testing
  - Ultrasonic testing
  - Pulsed or near field eddy current testing

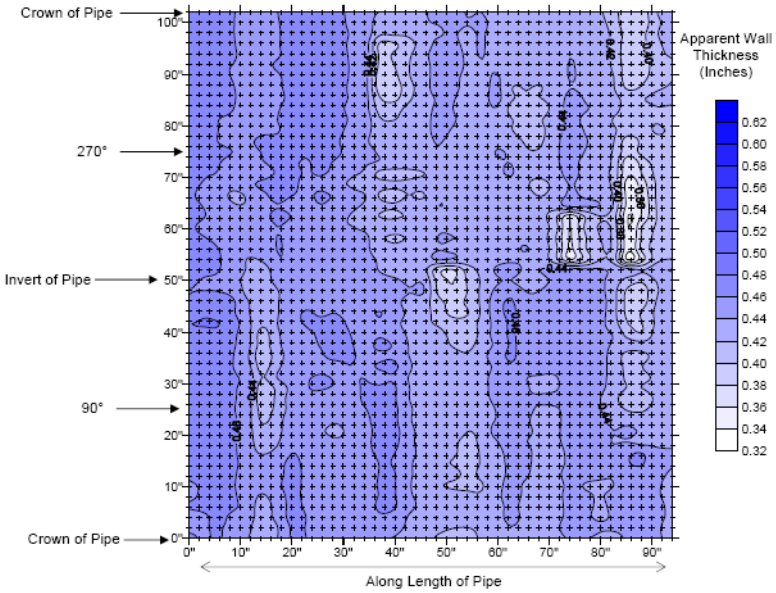


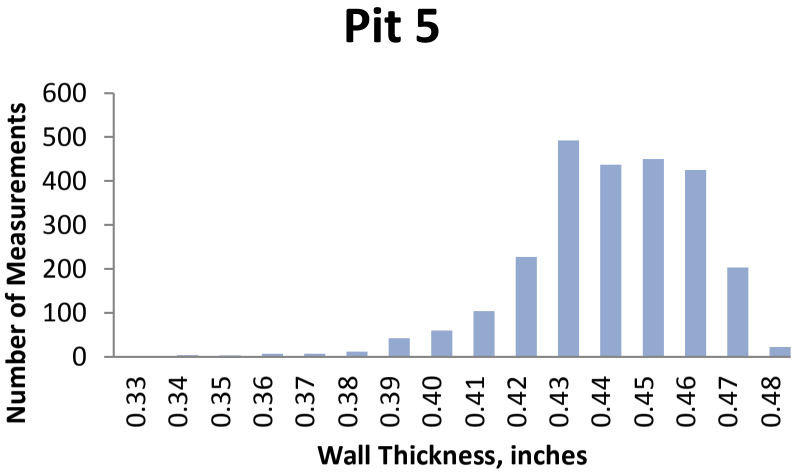




WALL THICKNESS TESTING

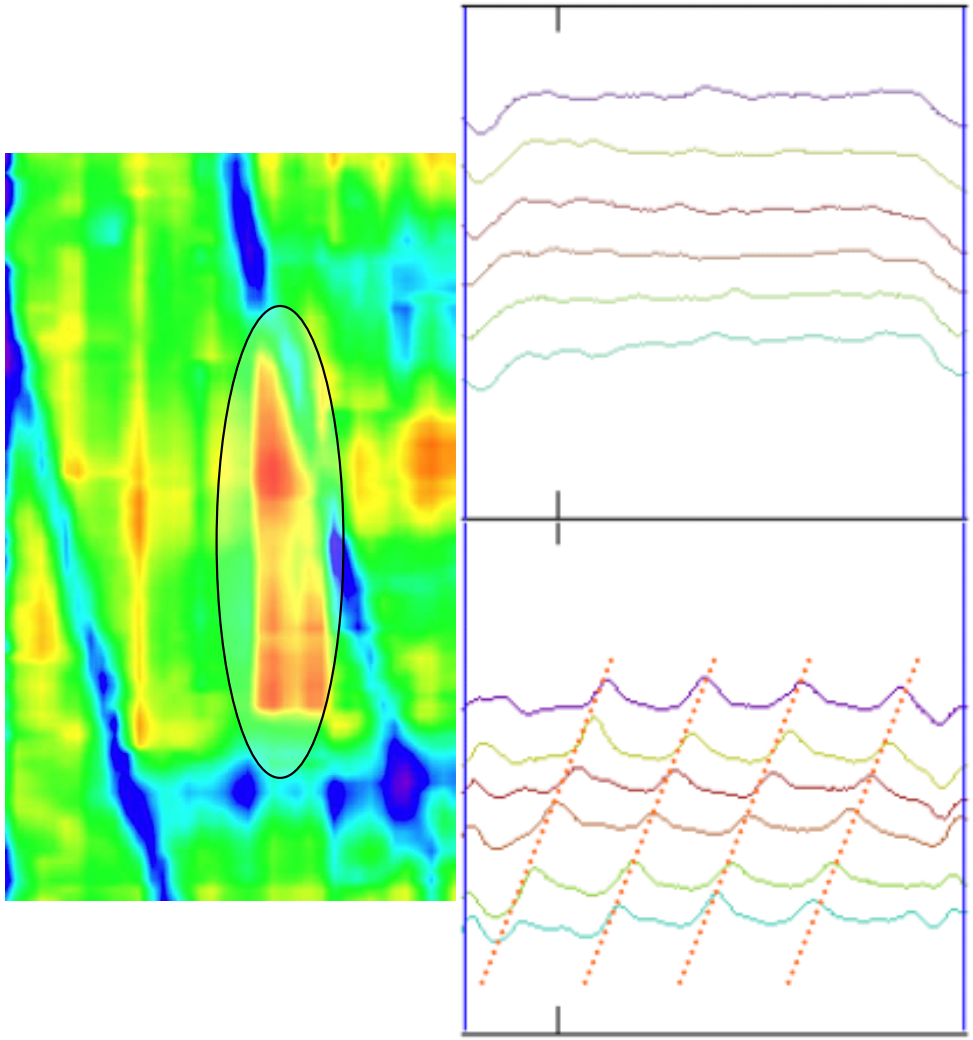
- Broadband electromagnetic
- Ultrasound
- Impact echo
- Magnetic flux leakage





Inline Enhanced EM Pipe Assessment

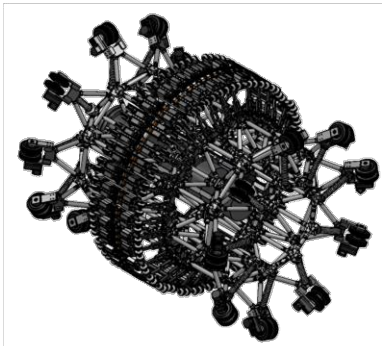
- Enhanced Electromagnetics
  - Similar to PCCP assessment technology
  - Provides data on wall loss for metallic pipe

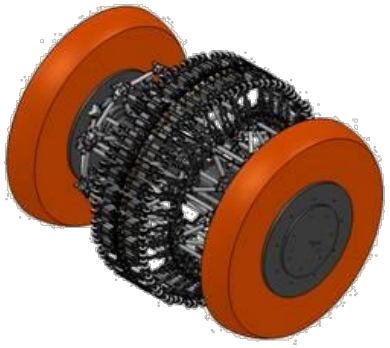


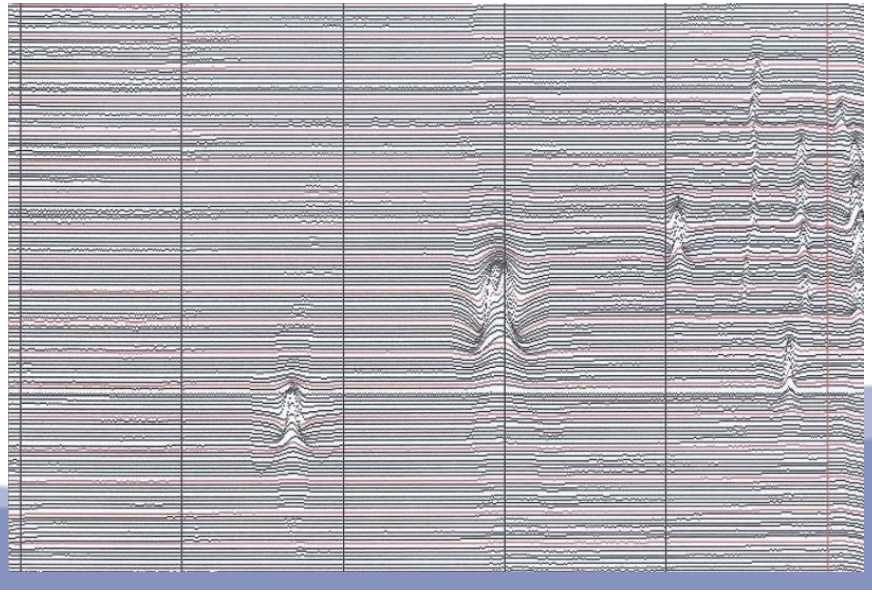
Current State of Technologies

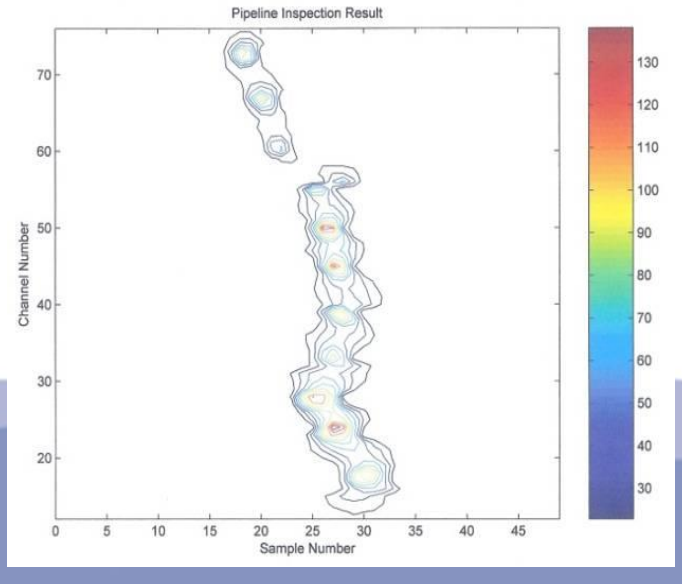
Extra High Resolution Magnetic Flux Leakage

- Capable of collecting wall deterioration through mortar coating





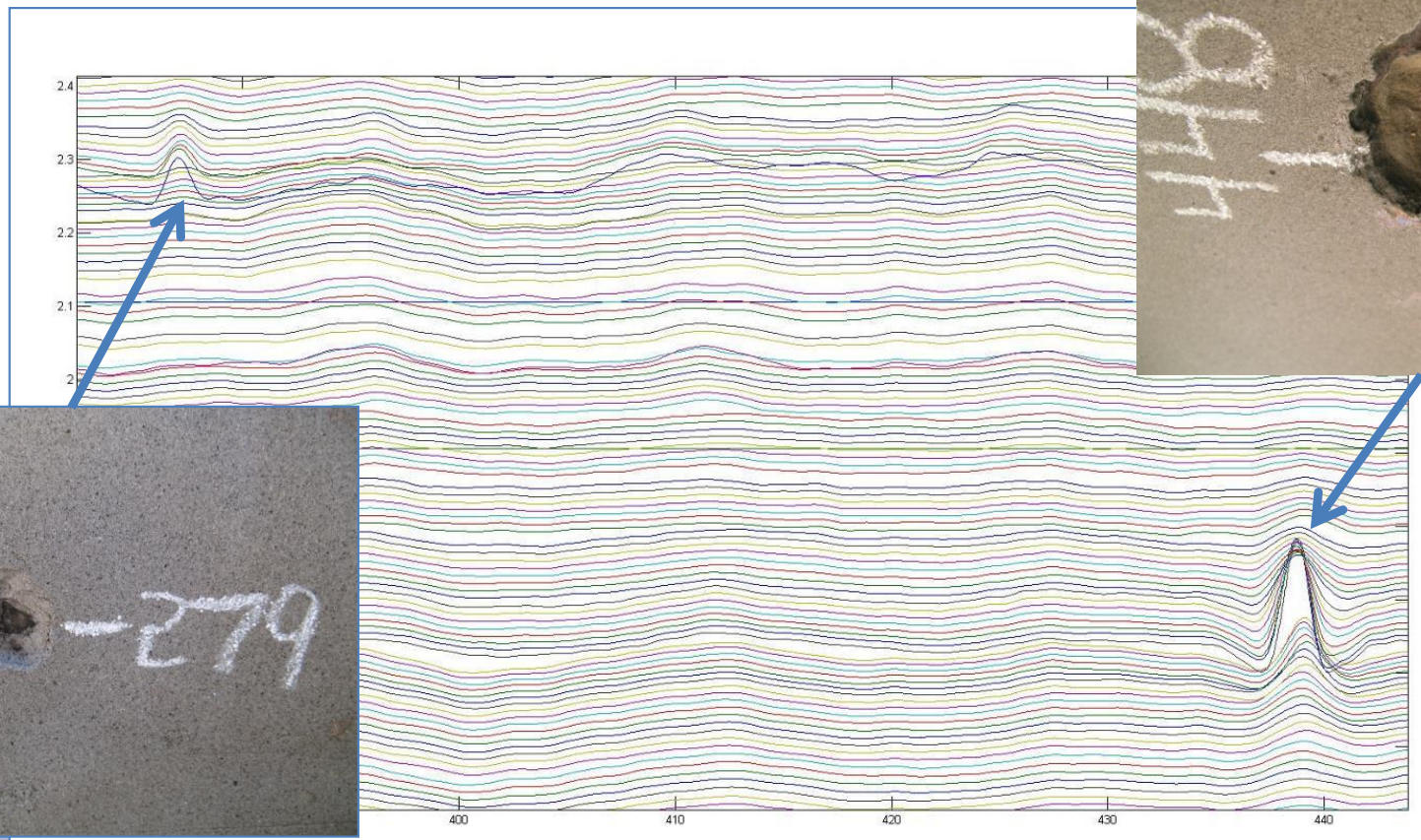




Current State of Technologies

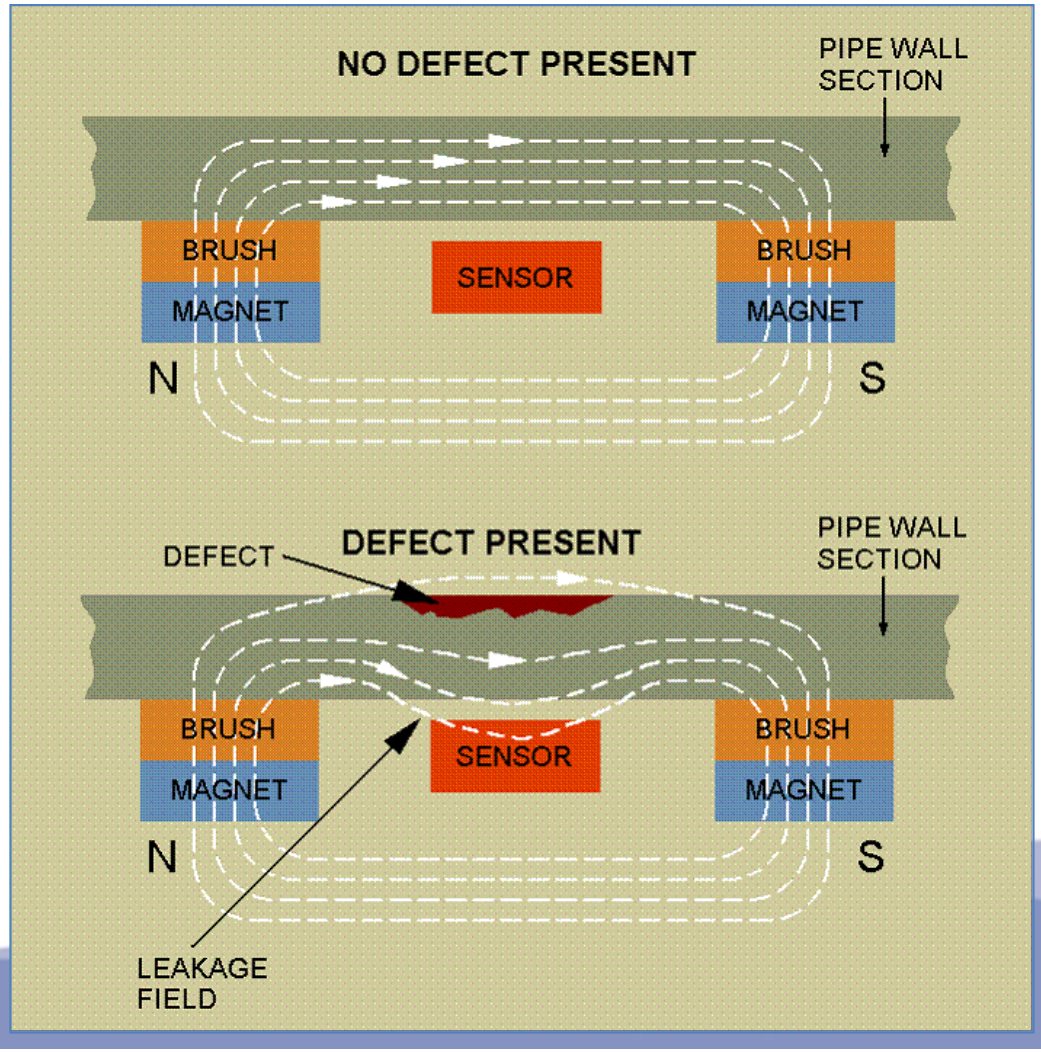
Extra High Resolution Magnetic Flux Leakage

- Hetch Hetchy case study

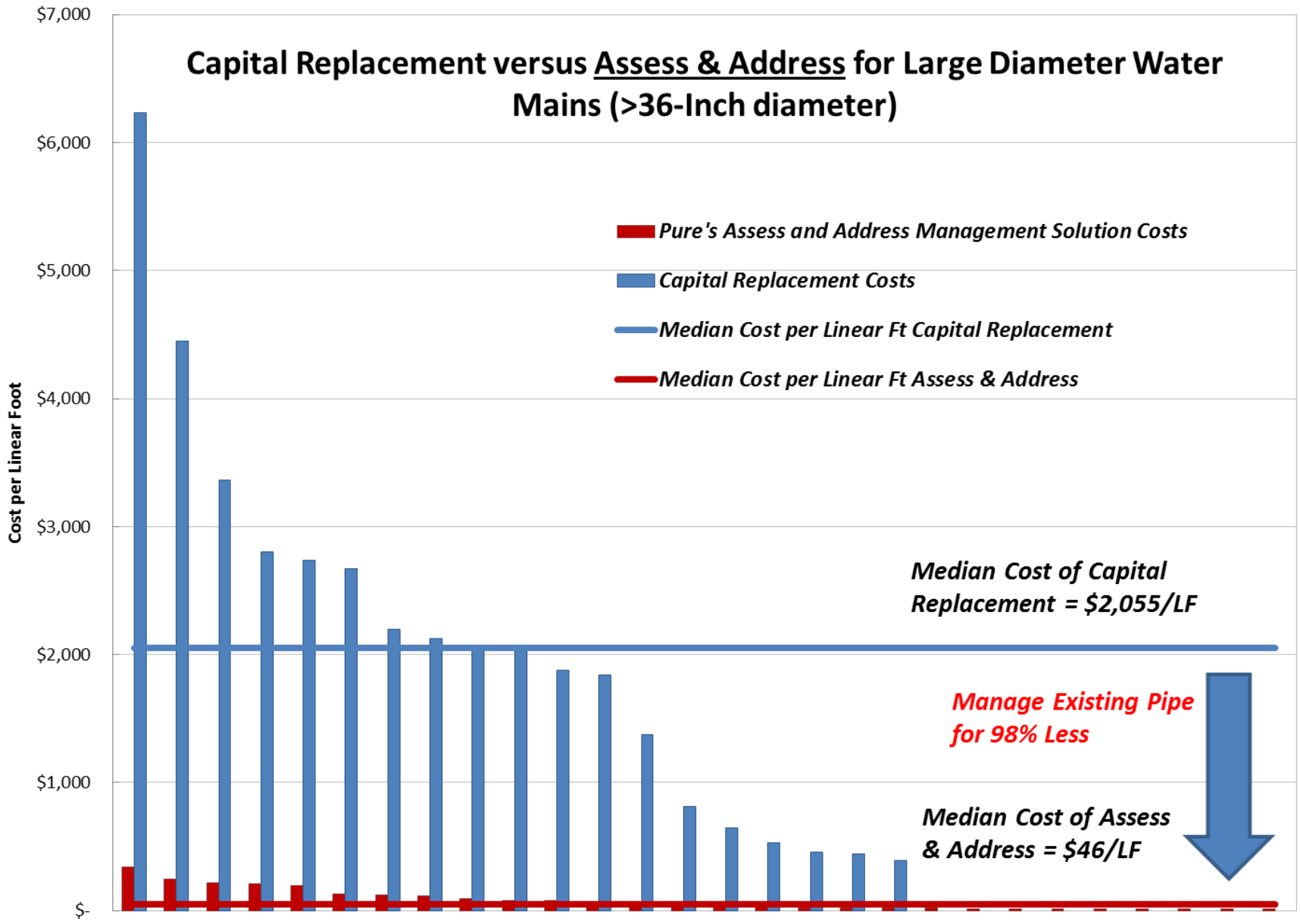


Current State of Technologies

Extra High Resolution Magnetic Flux Leakage

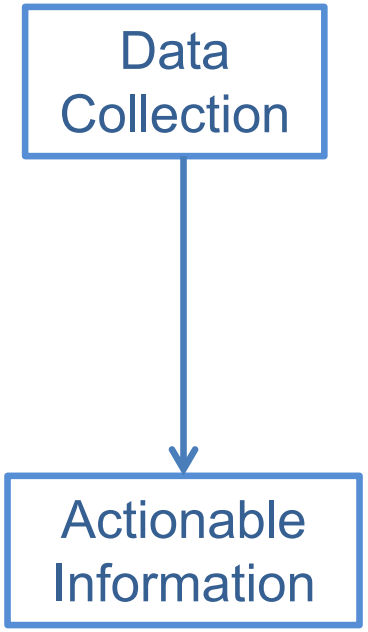


Value of Pipeline Management

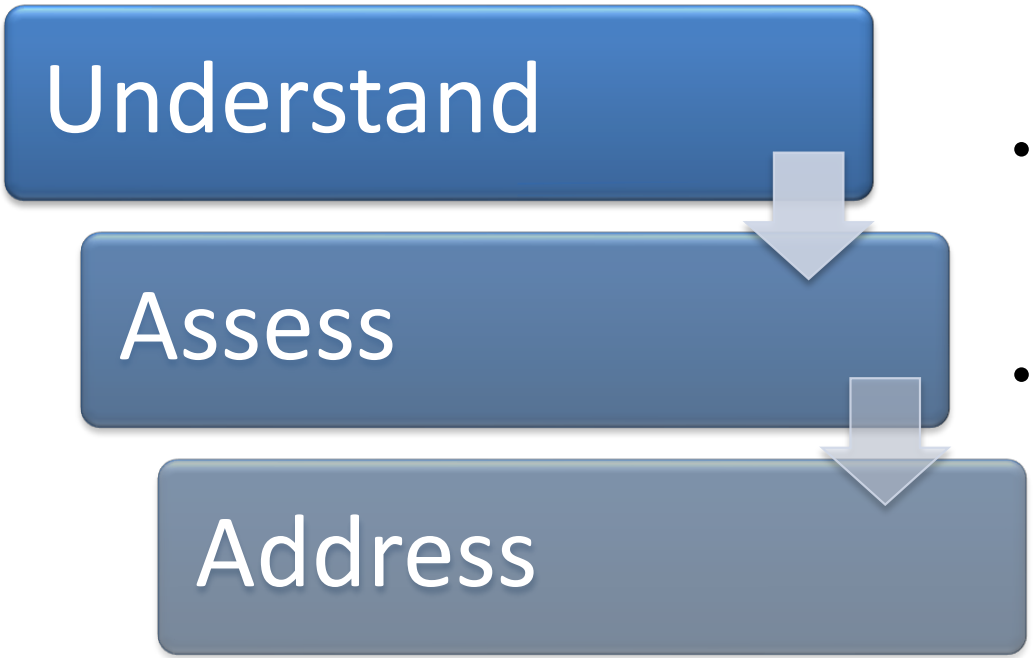


Getting to Actionable Information

- Interpreting condition assessment data
- Forensic evaluations
- Visual and sounding inspections
- Structural analysis
- Soil sampling
- Groundwater sampling
- Pipe sampling
- Test pitting and inspection
- Pipe locating
- Hydraulic analysis
- Surge detection/analysis
- Estimate remaining useful life
- Root cause analysis
- Wall thickness measurements
- Pipe repair design
- Pipe repair construction inspection
- Program management
- Pipe inventory prioritization



Conclusions



- Pressure pipes have historically been one of the most difficult buried pipeline assets to inspect and assess
- Technology, assessment, and rehabilitation techniques now exist to safely manage these assets
- In order to adequately manage force or transmission mains, a comprehensive strategy must be developed for each pipeline

There is no "one size fits all" approach to comprehensive pressure pipe management!