Condition Assessment of Pressure Pipes

Pressure Pipe Technical Track

Session 1

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Senior Professional Associate

HDR

Program Development

Mission: "Assemble and disseminate reliable information related to condition assessment …"

- Building Support
- Planning

Assessment Challenges

- No Manholes
- Disruption of Service
- Inspection Risks
  - Might trigger a pipe break
  - Tool could get stuck or lost
  - Water pipe contamination or other water quality concerns
- Results *Can* be Hard to Interpret
- No Perfect Method
- Cost

Factors to Consider

- Type of Pipe
- Types of Defects
- Pipe Access
- Size of Pipe
- System Operations
- Value of Pipe
- Consequences of Failure
- Cost of Assessment
- Protection of Health
- [Water] Potential Water Discoloration
- Risk Tolerance
- Available Data
- Available Technologies
- Permits / Traffic

Degree of Inspection		Conditions Inferred from Samples	Conditions Directly Measured
	Specific Defects	**External Direct Assessment**, using: ☐ Magnetic flux ☐ Ultrasonic ☐ Electromagnetic ☐ Visual exams ☐ Coupon sampling ☐ Electrical potential measurements	**In-pipe condition assessment**: ☐ Remote-field electromagnetic scan ☐ Remote-field transformer-coupled scan ☐ Magnetic flux leakage scan ☐ In-pipe leak detection ☐ In-pipe acoustic velocity wall thickness ☐ Other methods, where applicable
	General Conditions	**Statistical Studies**, using: ☐ Leak/break history ☐ Age ☐ Diameter ☐ Corrosivity and other soil properties ☐ Material class ☐ Pressure and other data	**Non-invasive methods**: ☐ External acoustic velocity wall thickness measurements ☐ Leak-noise correlation ☐ Other active leak detection ☐ Pipe-to-soil potential measurements ☐ Pressure testing

Inspection Coverage

Method	Soil Corrosivity Surveys	Acoustic	Remote Field Electromagnetic	Ultrasonic	Magnetic Flux Leakage	Broadband Electromagnetic	Other	Typical Recommended Approach
Description	Various electro-magnetic, electrical, and laboratory methods characterize the corrosivity of soils, detect/measure corrosion activity, and assess effectiveness of corrosion protection / cathodic protection.	Acoustic velocity: pipe wall stiffness is calculated from the speed of sound transmission Acoustic monitoring: alerts and pinpoints the location of wire breaks	Changes in electromagnetic signals indicate broken wires, corrosion pits, and changes in wall thickness and stress anomalies.	Reflection of sound waves is used to measure the thickness of various types of materials. Tool must have direct contact or liquid coupling with material being measured.	Changes in magnetic fields are used to detect corrosion pits and other defects. Tool must be at constant, close distance from pipe wall.	Changes in electromagnetic signals indicate corrosion pits and changes in thickness. Scanner held near pipe, but works through coatings, linings, and scale.	Sampling of pipes for various physical tests Manned entry for visual and sounding (delamination testing) Petrographic (micro-scopic) examinations of concretes and mortars	GENERAL APPOACH (all pipe types): 1. Statistical analysis of available data 2. Risk prioritization (likelihood and consequence of failure) 3. Records review (leak/break repairs, drawings, specs, reports, soil info) 4. Site reconnaissance (accessibility, traffic conditions, other utilities) 5. Inspection planning (shut downs, bypass, permits, alternatives) 6. Leak detection and/or field condition assessment inspection
Asbestos Cement (AWWA C402)	Assess potential for AC (concrete) deterioration (pH and sulfates)	Acoustic velocity can detect gross deterioration	Not applicable (n/a)	n/a	n/a	n/a	Testing of samples: • Phenolphthalein stain • SEM/EDS • petrography	1. Tests of opportunity samples from repairs and service taps 2. GIS mapping of soil data, breaks, and condition assessment data 3. Targeted condition assessment of high-consequence pipes
Prestressed Concrete Cylinder Pressure Pipe (AWWA C301 and C304)	Assess potential for metal and concrete deterioration. Detect active corrosion.	Acoustic monitoring for detection of wire breaks. Acoustic velocity can be used for prioritization of other assessments.	Used to detect broken wires	n/a	n/a	External and internal spot assessments. .	Internal sounding to detect delamination Internal visual (manned entry or CCTV)	1. Risk analysis based on pipe type, manufacturer, wire type, year of manufacturer, corrosivity 2. Manned entry/sounding (if feasible) 3. Electromagnetic scanning 4. Acoustic monitoring
Non-Prestressed Concrete Pressure Pipe (AWWA C300, C302, and C303)	Assess potential for metal and concrete deterioration. Detect active corrosion.	n/a	Emerging method to detect broken bars and cylinder corrosion	n/a	n/a	External spot assessments. Emerging method for internal scanning.	External direct assessment Petrographic analysis of mortar / concrete	1. Corrosivity survey 2. External direct assessment where corrosion risk is highest 3. Manned entry examination 4. Electromagnetic scanning
Ductile Iron Cast Iron (AWWA C150 & C153)	Assess corrosivity to iron. Monitor corrosion activity.	Acoustic velocity can detect gross deterioration	Detailed internal scan of pipes and external spot assessment. Works with cement mortar and tuberculation	Used for external spot assessments	Internal scanning of non-CML lined pipes. External spot assessments	External spot assessments. Emerging method for internal scanning.	Petrographic analysis of mortar	1. Corrosivity survey 2. Remote field electromagnetic
Steel (AWWA C200)	Assess potential for metal and concrete deterioration. Monitor corrosion activity	Acoustic velocity can detect gross deterioration	Used for detailed internal scan of pipes. Works with cement mortar and tuberculation	Used for external spot assessments	Internal and external scanning of both CML and non-CML pipes	External spot assessments. Emerging for internal scanning.	Petrographic analysis of mortar	1. Corrosivity survey 2. Pipe-to-soil potential; cathodic protection assessment 3. Remote field electromagnetic or magnetic flux leakage
Copper	Assess potential for metal deterioration	n/a	Used for detailed internal scan of pipes	n/a	n/a	Potential for detailed scan of pipes	Forensic examinations of failed pipes Electrochemical noise monitoring	1. Evaluate construction methods and standards 2. Evaluate soil corrosivity 3. Forensic exams of failures
Plastic Pipes (HDPE – AWWA C906) (PVC – AWWA C900)	n/a	n/a	n/a	n/a	n/a	n/a	Forensic examinations of failed pipes, using laboratory and mechanical tests.	1. Review of drawings, specs, and inspection records 2. Forensic examination, if early or frequent failures have occurred

Desktop Assessment

- Calculate and forecast system performance
- Estimate the remaining useful lives of assets and determine appropriate renewal rates
- Determine which mains represent the highest risks to the utility, based on likelihood and consequence of failure
- Determine which of the high-risk mains are candidates for physical condition assessment

Life Expectancy of Pipe?

- Unlike a person, the death of a pipe is not a definitive event
- Unlike a person, a pipe is not a definitive thing

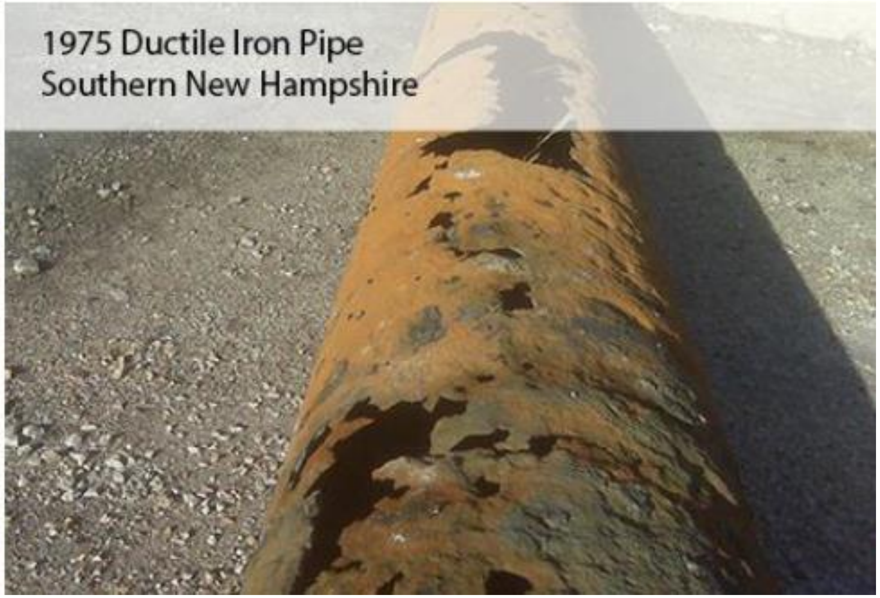
- A pipe lasts until someone decides to replace it
- Decisions may be rational, objective, based on data … or not

<u>Good Reasons to Replace a Pipe</u>

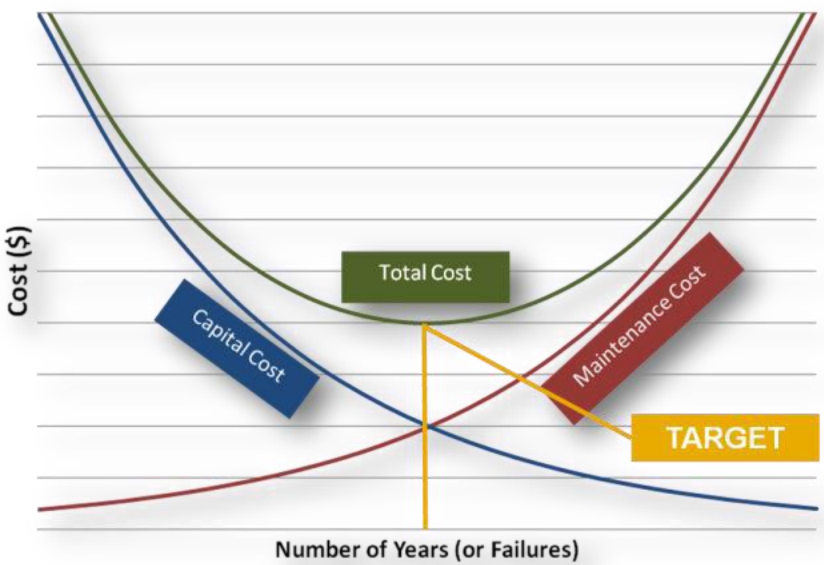
1. Repairs get too costly
2. Service is substandard
3. Infrastructure stewardship

Age: Poor Predictor of Condition

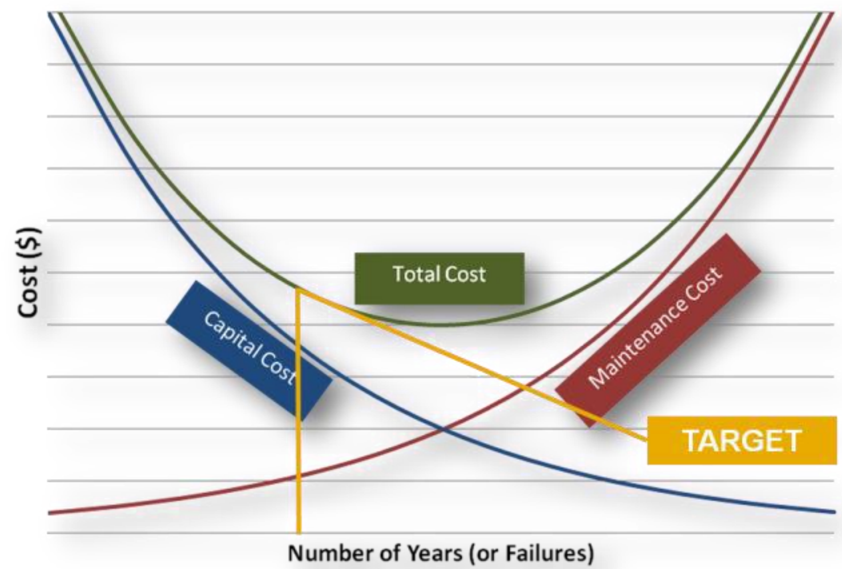
- **Yes**, pipe failures increase with age
- **No**, pipe lives are not found in a book



Economics and Levels of Service



theory



practice

Michelle Antilla, PE

Project Delivery Manager

Pure Technologies

Surveys and Testing

- Soil Corrosivity Surveys
- Spot Assessments
- Leak Detection
- Internal Robotic Visual Inspection
- Physical Entry Inspections
- Acoustic Velocity Testing
- Electromagnetic Testing
- Magnetic Flux Leakage Testing

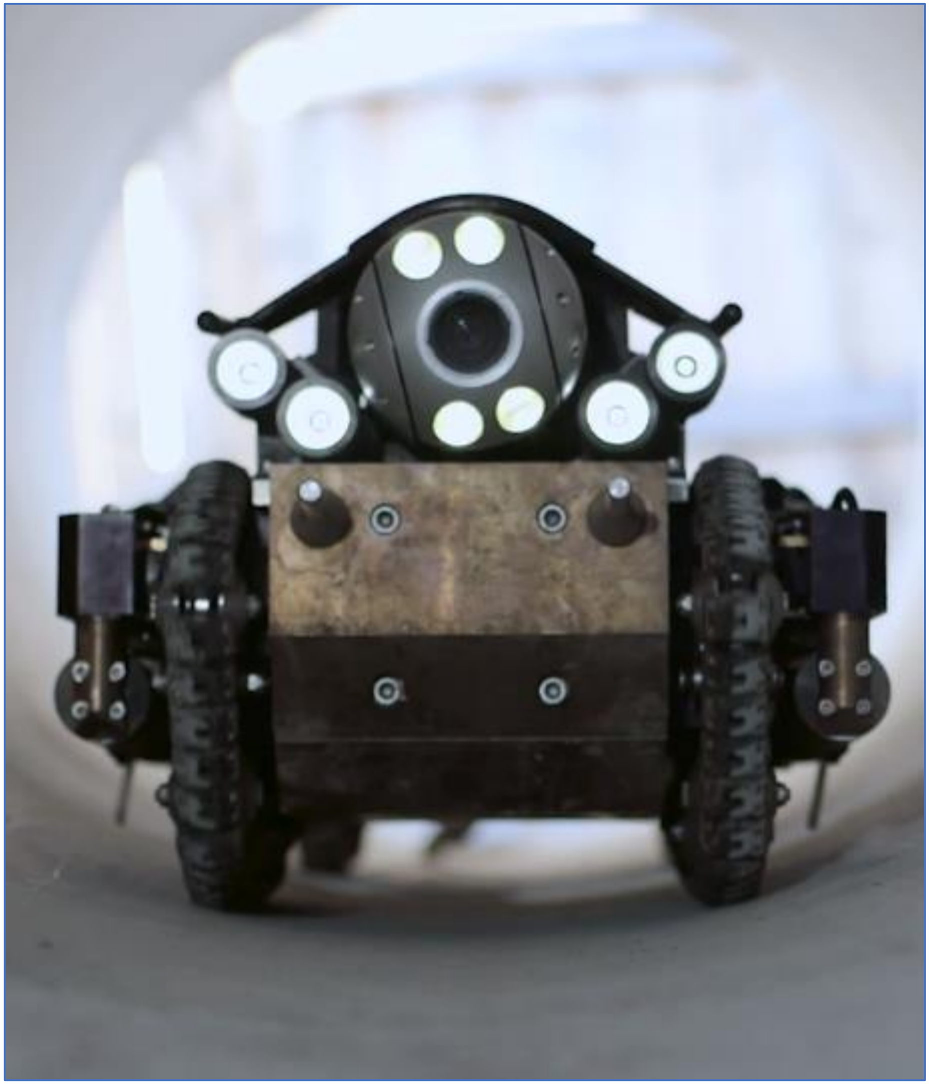
Soil Corrosivity Surveys

- Screening Technique
- Lower Cost
- Identifies Possible Locations of Corrosion
- Does Not Detect:
  - Leaks
  - Internal Corrosion
  - Third Party Damage
  - Settlement Issues
  - Thrust Issues

Ultrasonic

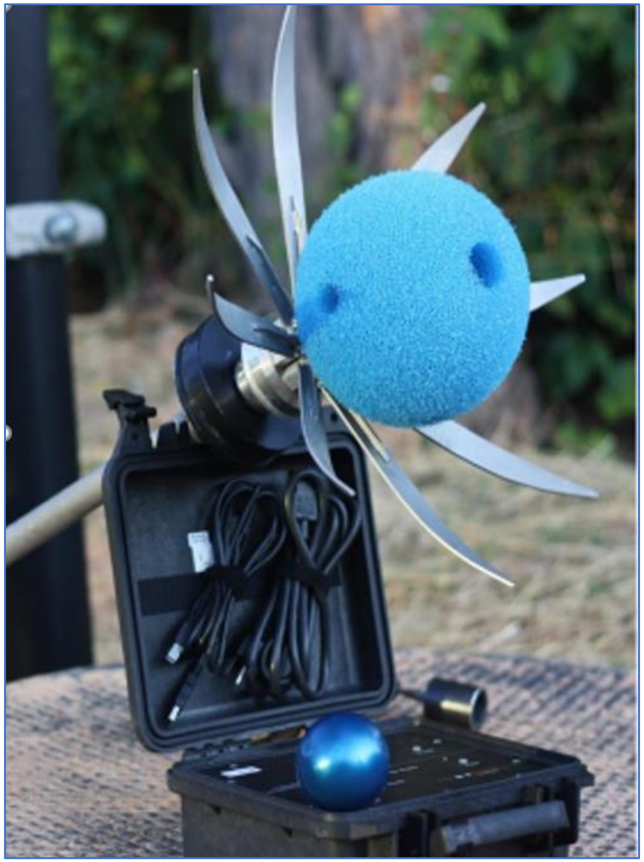
- Applicable to Metallic Pipes
- Provides Wall Thickness
- Exterior or Interior of Pipe Wall
- Requires Excavation or Manned Entry
- Economical

Internal Robotic Visual Inspection

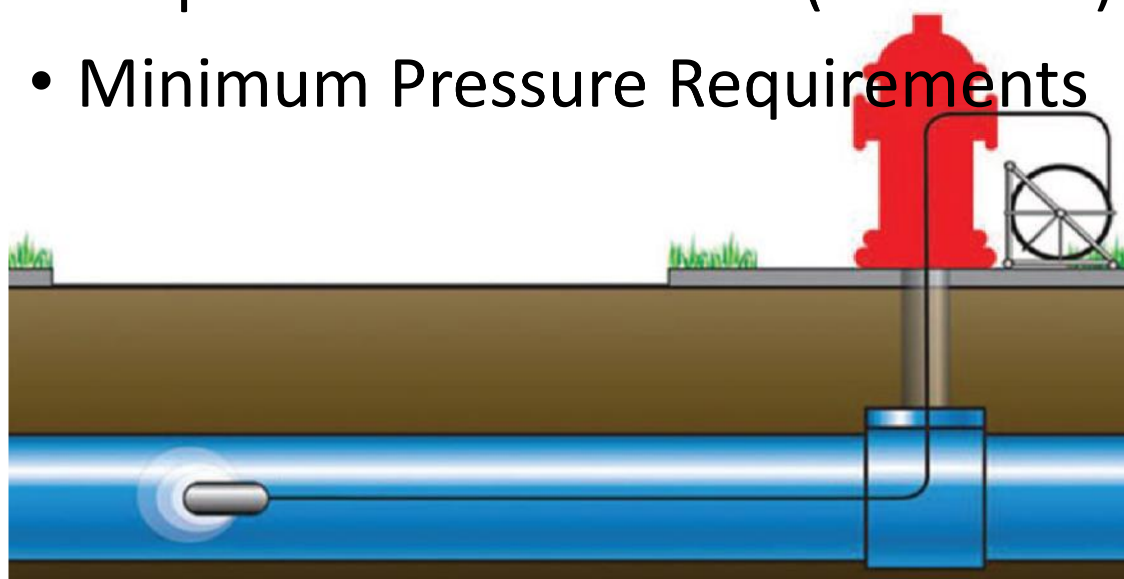


- Identifies Visual Defects:
  - Failed Linings,
  - Internal Corrosion
  - Deformation
  - Joint Separation
- Multiple Entry Points
- Video Quality Varies
- Limited Assessment of Pipe Wall

In-Line Leak Detection



- Free Swimming or Tethered
- Pipeline Remains In Service
- Survey Long Distances (Free Swimming)
- Map Leaks in Real Time (Tethered)
- Minimum Pressure Requirements



Acoustic Correlators

- Little to No Disruption to Flow
- Requires Access to Pipeline or Appurtenances
- Cannot Detect Gas Pockets

Electromagnetic Testing

- Manned, Robotic, Free Swimming
- Pipe Diameter Limited to Tool
- Access requirements – Vary with Tool

Lars Stenstedt

Chief Innovation Officer

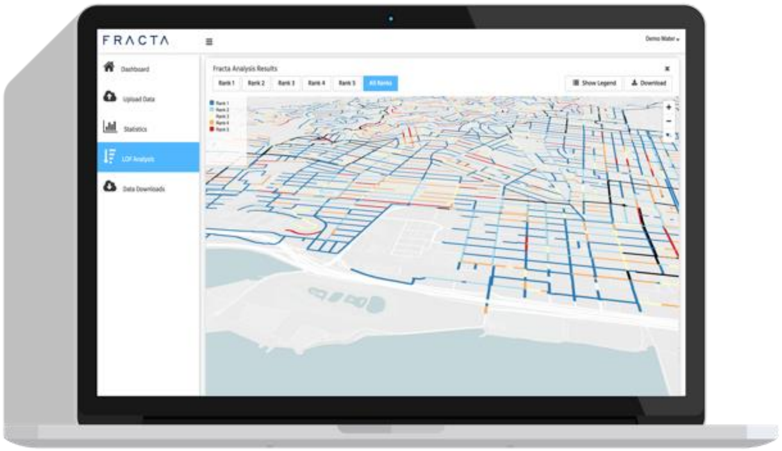
Fracta

Artificial Intelligence

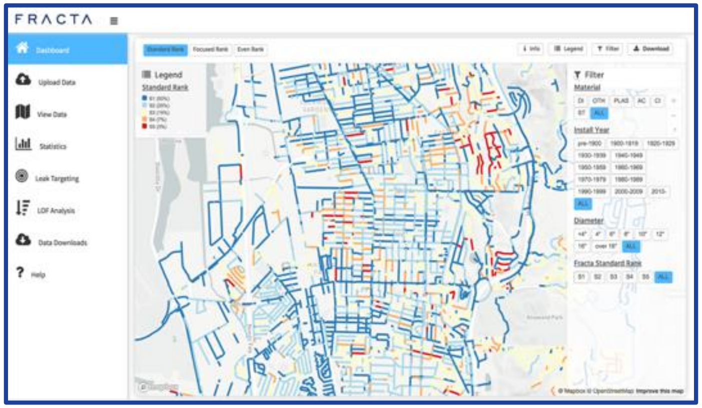
Data-driven method being used to assess the condition of water main pipes. Software calculates and visualizes the Likelihood of Failure (LOF) for every water main pipe segment. The LOF score represents the mathematical probability of pipe failure, enabling utilities to make better pipe replacement decisions.

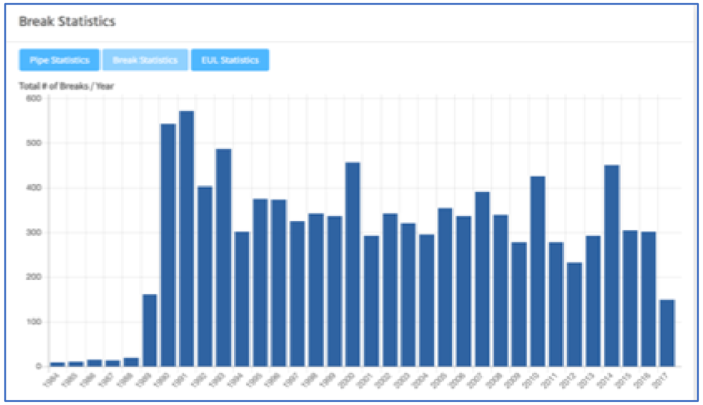
How is Artificial Intelligence being Applied by Water Utilities?

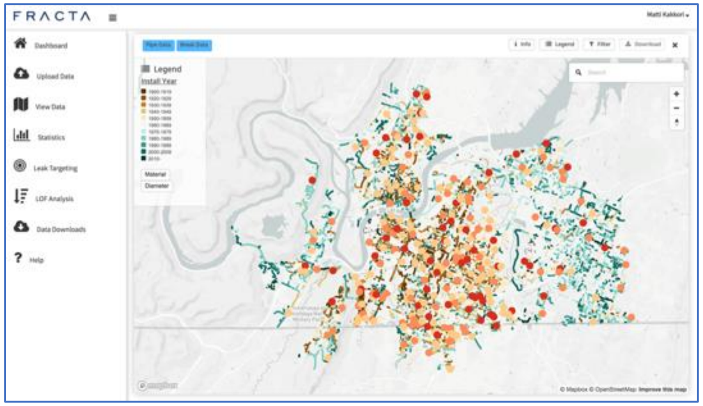
- Prioritize mains for replacement
- Prioritize mains for further analysis
- Target valve maintenance
- Target leak detection

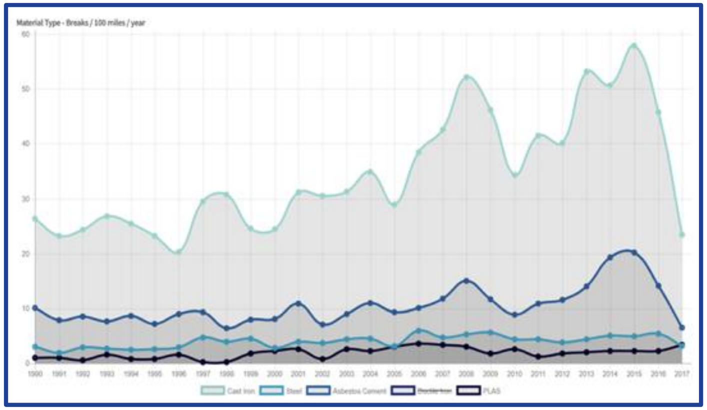


Example: Fracta

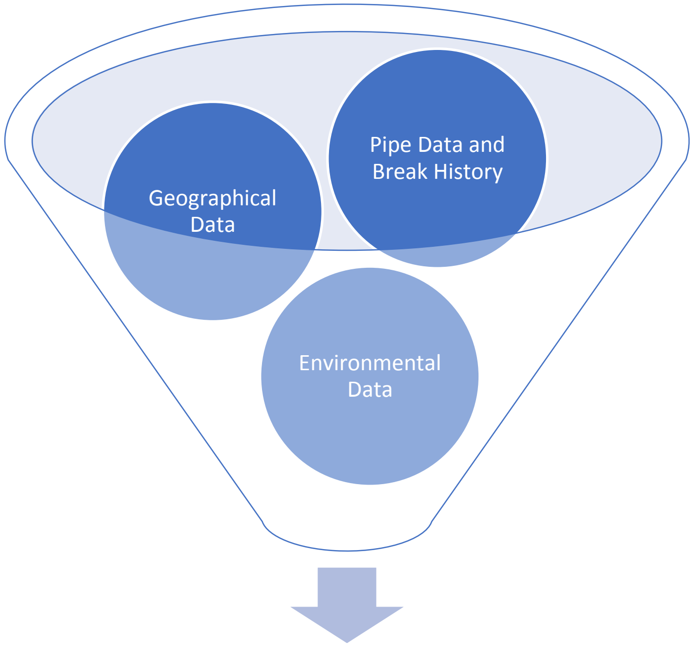








Data Inputs and Outputs



Likelihood of Failure (LOF)

Required Water Main Pipe Data from Utility

<u>Asset data from GIS or AutoCAD</u>

- Pipe ID
- Pipe location
- Pipe diameter
- Pipe length
- Material of construction
- Install date

<u>Operations Data</u>

- Hydraulic pressure

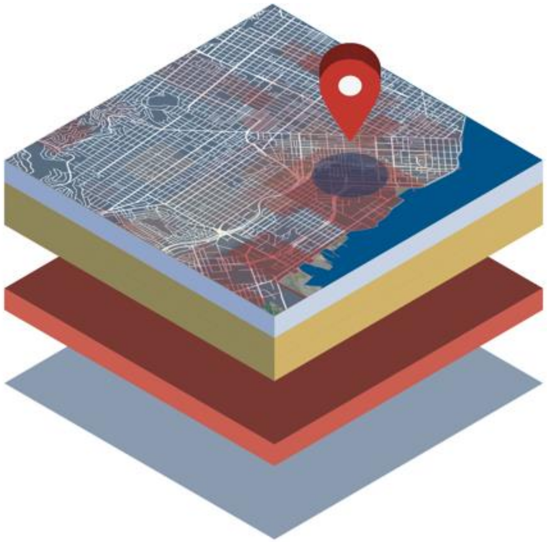
<u>Failure Data</u>

- Break history as .csv or .shp file
- 5 years or more preferred

Data Aggregated

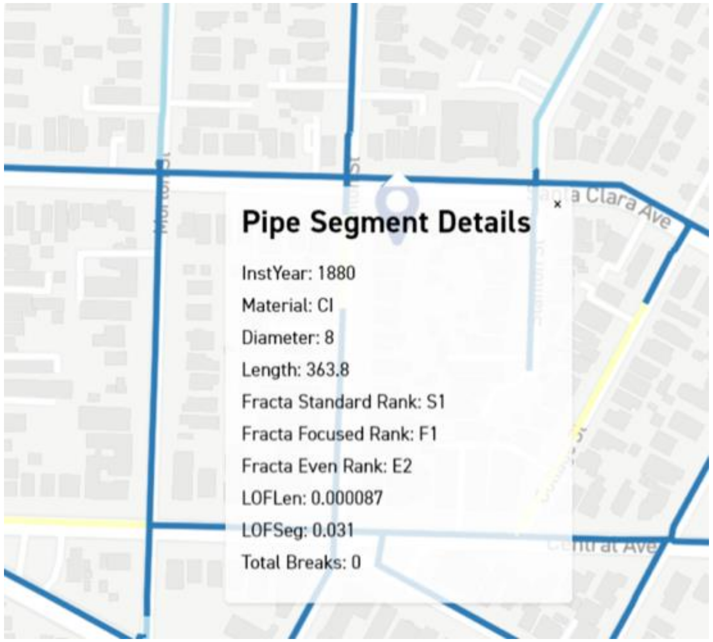
Hundreds of environmental and geographic data points

- Pipe slope and elevation
- Soil properties
- Proximity to structures, water bodies, roads, rail, etc.
- Climate and weather
- Break density
- Urban density

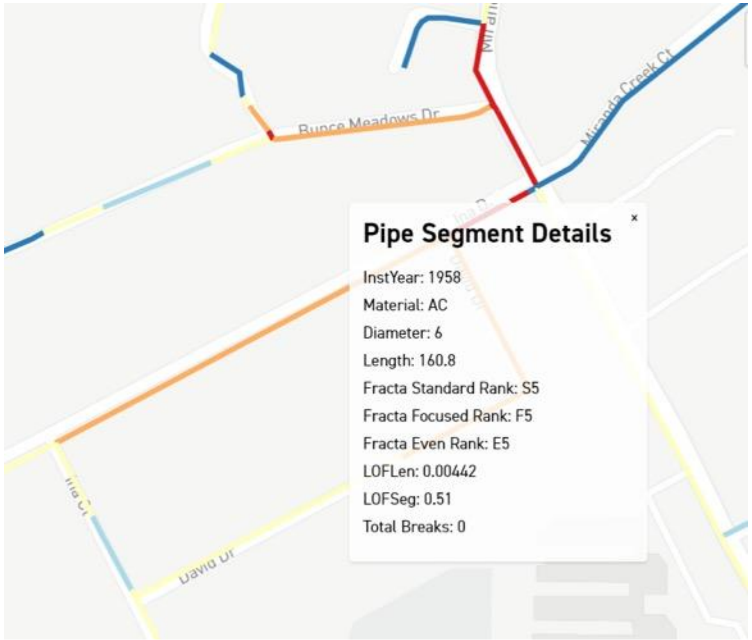


Application of Results

Which old pipes could stay in service even if the city is paving the street?

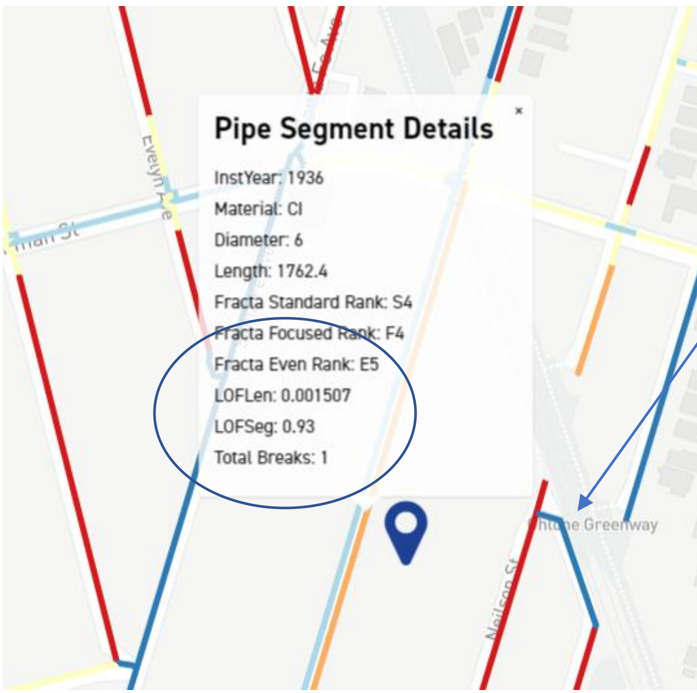


Which newer pipe, with no break history, should we watch closely or do further analysis on?



Application of Results

Which pipes are high risk – but won't be identified by desktop assessment?

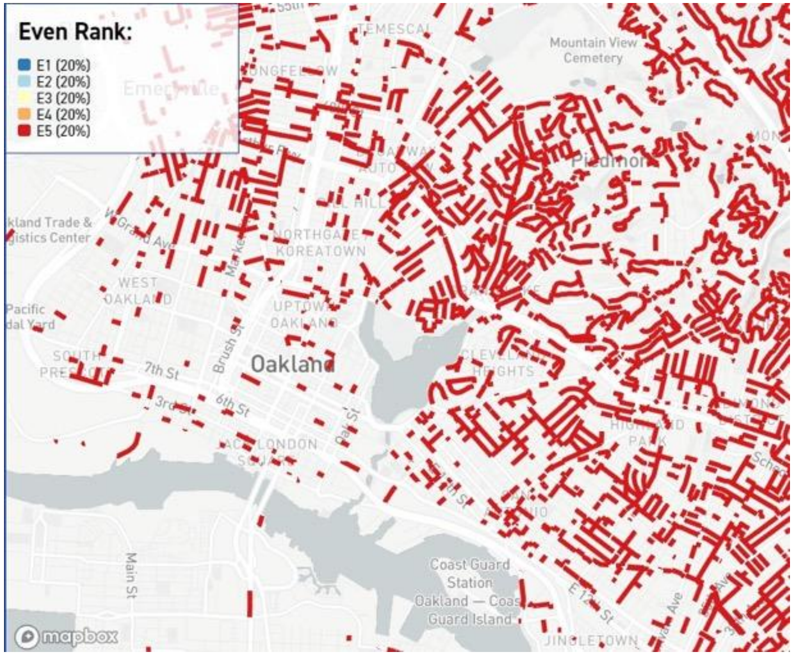


BART tracks

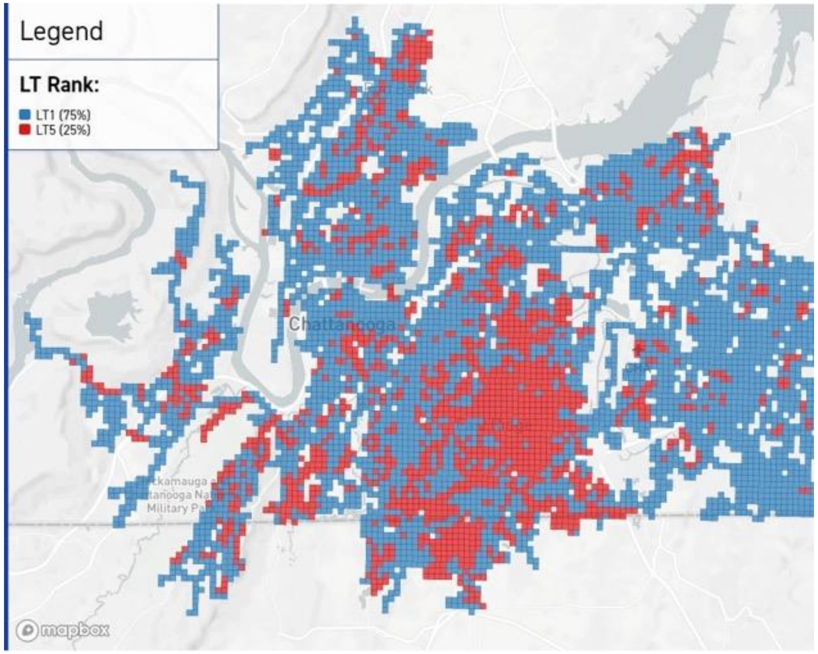
Pipe from 1341 Curtis

Application of Results

We only have budget to exercise 20% of our valves each year, which ones?

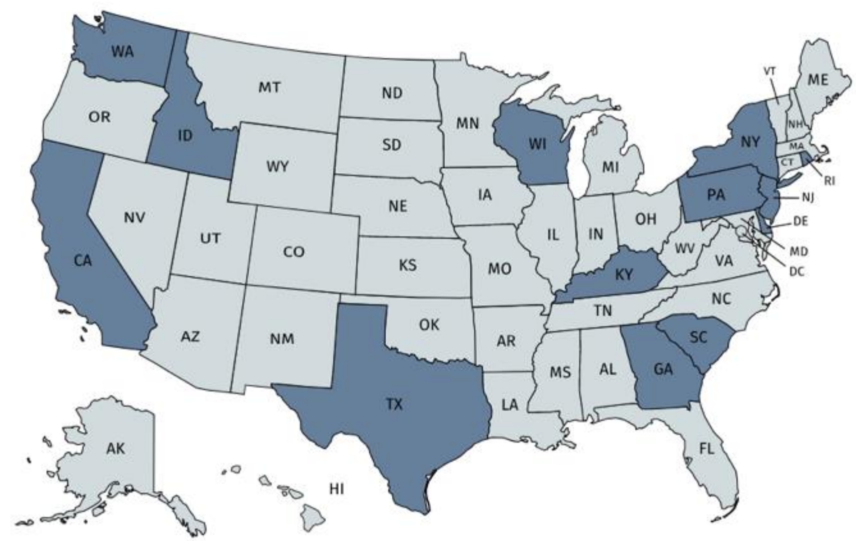


We only have budget for annual leak detection on 25% of our system

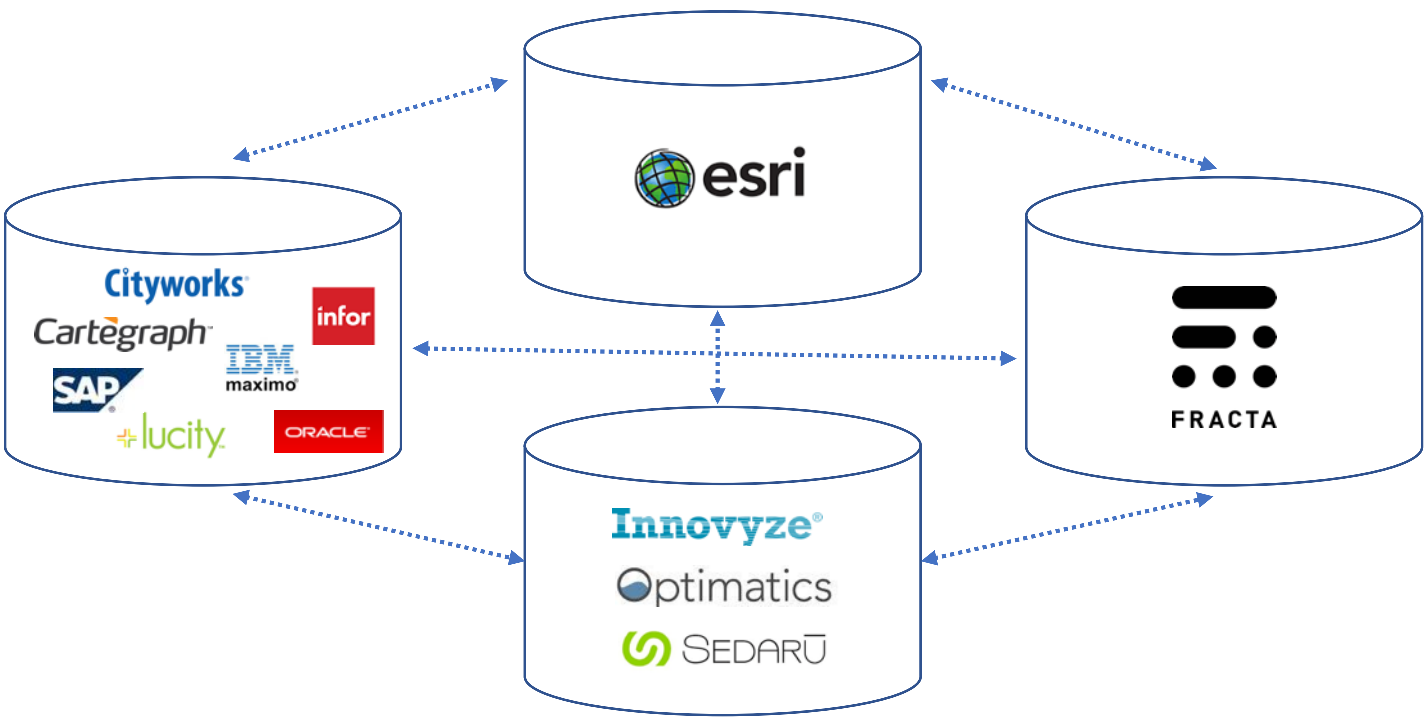


Key Metrics – US Potable Water

Utilities Engaged	• 31
Total Population Served	• ~12,000,000
Customer Locations	• 14 US States
Miles of Water Main	• 50,470
Pipe Segments	• ~1,400,000
Breaks Captured	• ~107,000
Data Points Processed (GB)	• ~1,140,0000,000



Existing Tools and Systems



Artificial Intelligence [Fracta] Summary

Fast

Accurate

Affordable

Using the Information

Next Steps