

# Pairing The Right Technology With The Level Of Risk:

## A Defensible Way To Approach Condition Assessment

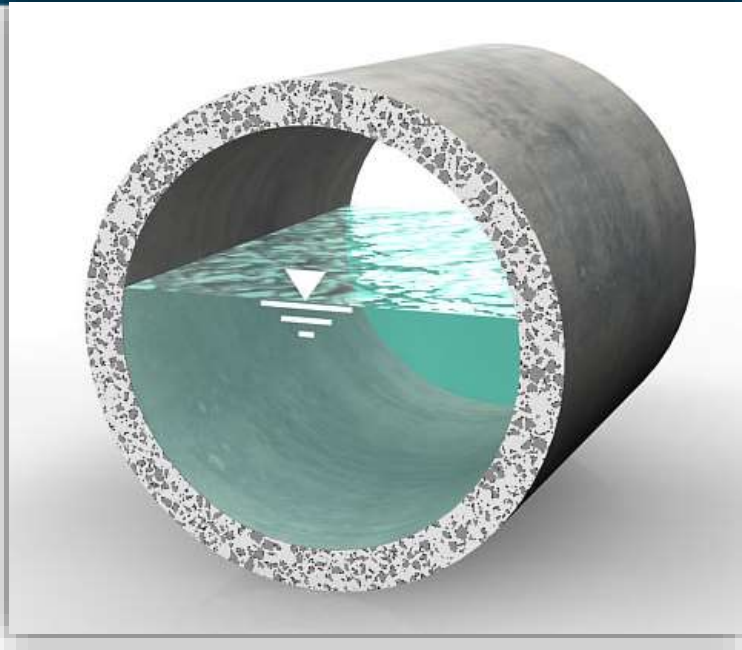
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# Who is Pure Technologies?

- *Over 30 years experience in pipeline asset management*
- *Buried infrastructure experience*
  - *14,000+ miles of pipe*
  - *3,000+ miles of PCCP*
  - *500+ miles of force mains*
  - *900,000+ valves assessed*
- *Expertise includes*
  - *Leak detection*
  - *Control programs*
  - *Non-destructive technologies*
  - *Hydraulic transient monitoring & analysis*
  - *Forensic evaluations*
  - *Structural modeling*
  - *Life-cycle & financial assessment*
- *Over 400 employees across North American (>500 worldwide)*



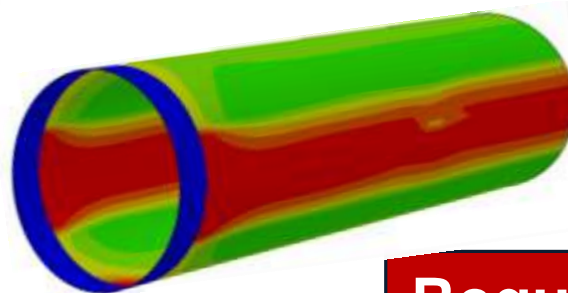
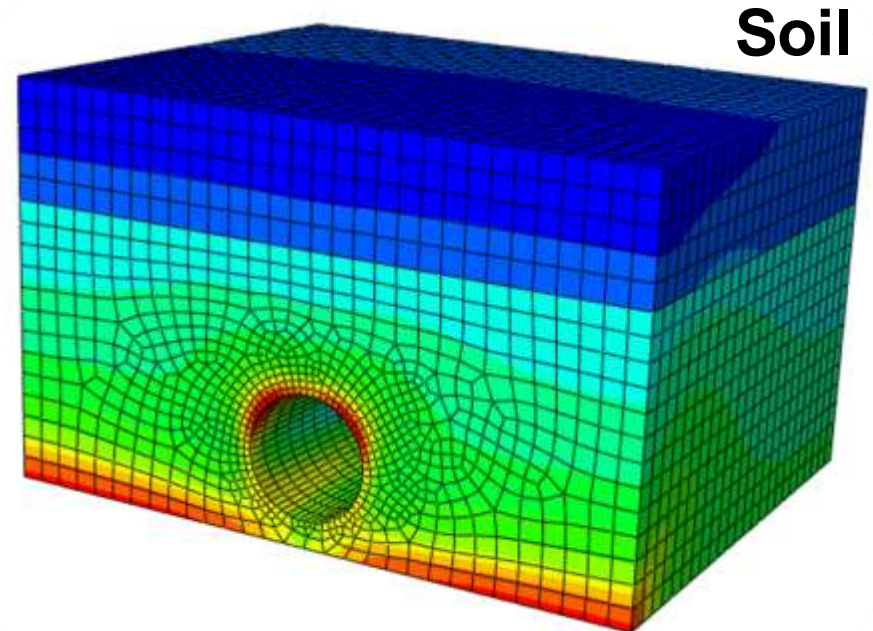
# Not all pipe is created equal



**Gravity Pipe**



**CCTV is usually enough**



**Pressure Pipe**

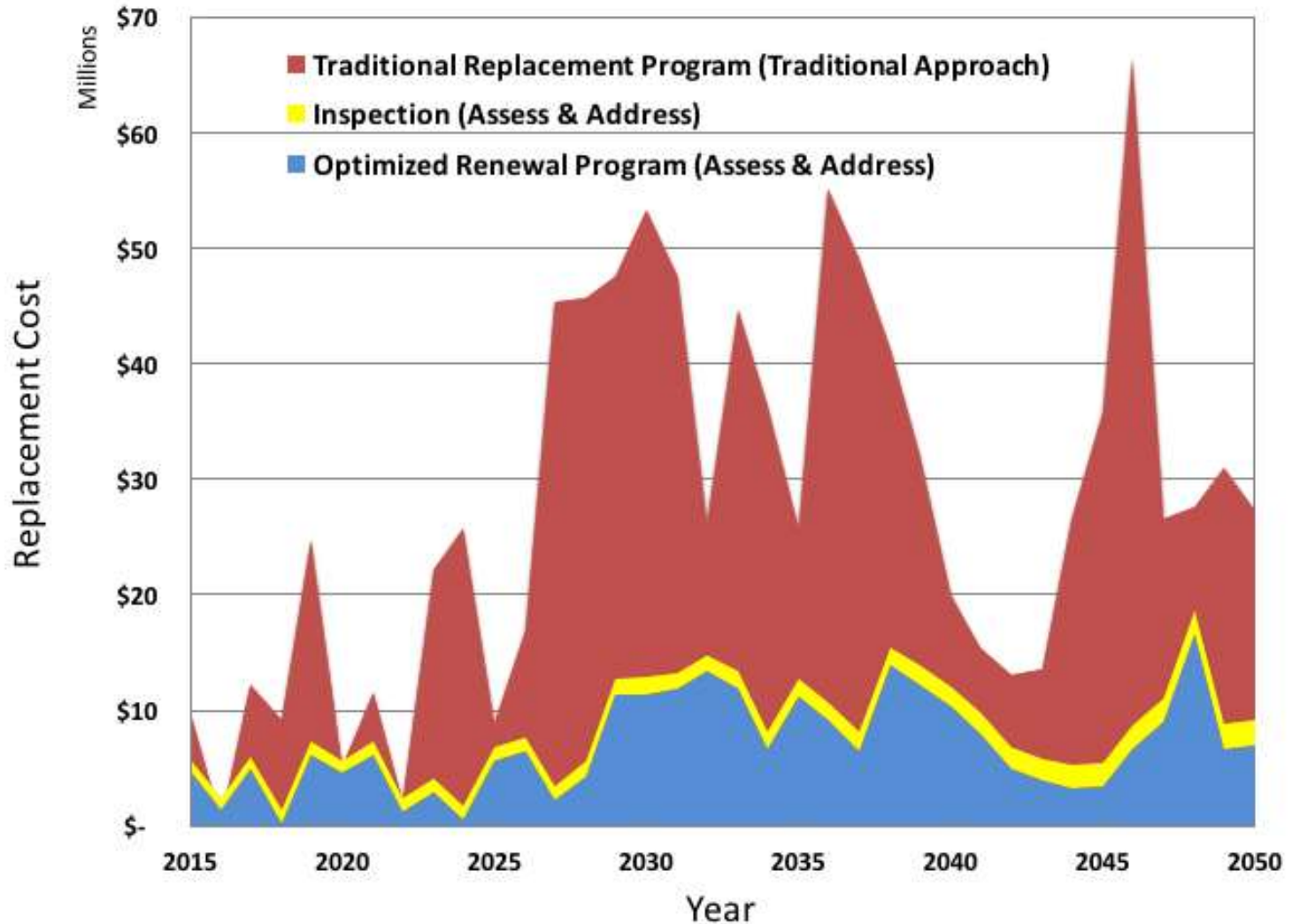
**Requires Advanced Tools & Analysis**



# What's the Goal?-Prevent Pipeline Failures...



# And Optimize Budgets...



# Asset Management & Pipeline Risk



Focused capital and operational budgets

- Often based on basic prioritization

Pressurized pipe management decisions

- Age, breaks, and material

Age is not primary factor for failure (WRF, 2013)

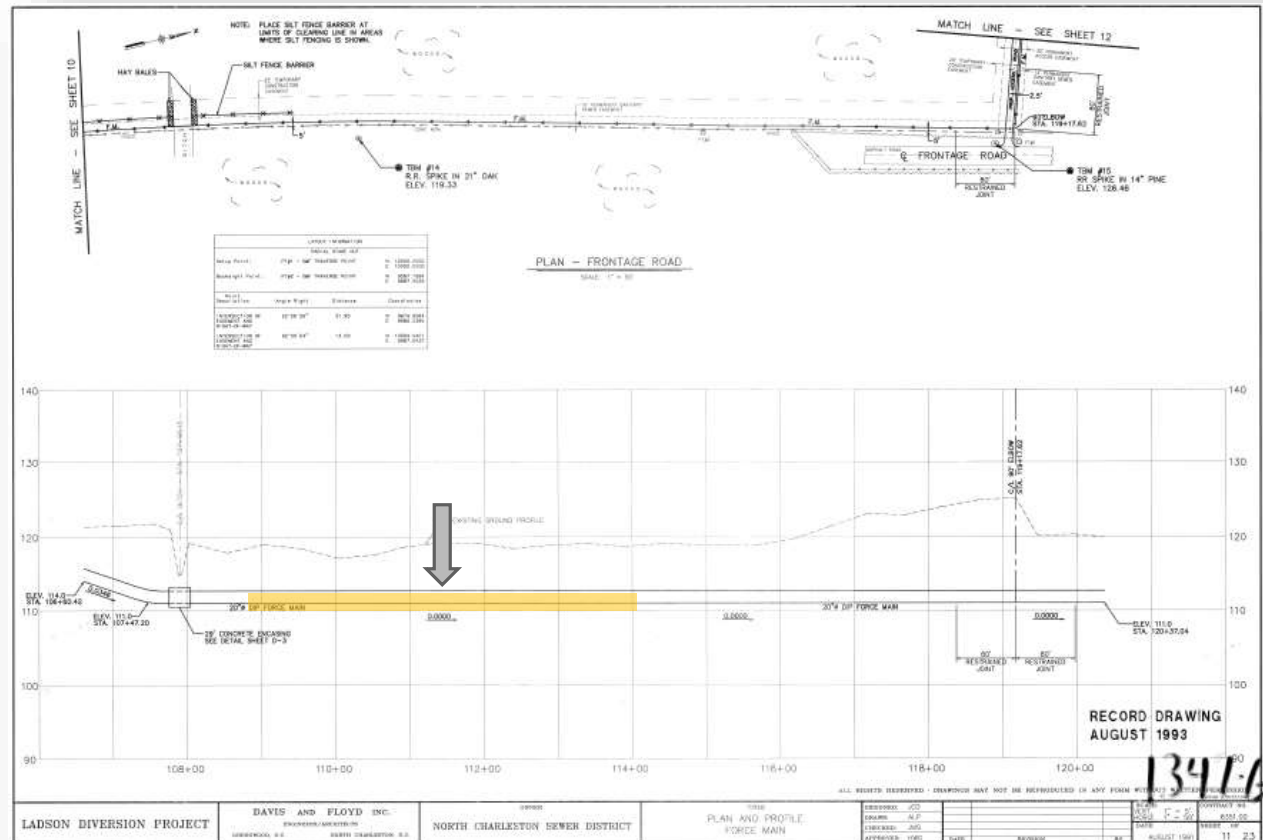
Risk models typically overly conservative

- Majority of pipes being replaced before necessary (US EPA, 2009)

# Data to Make Good Decisions

*Desktop studies do not always reflect actual field conditions.*

*Over 70% of gas pockets located in the field are NOT at known high point.*





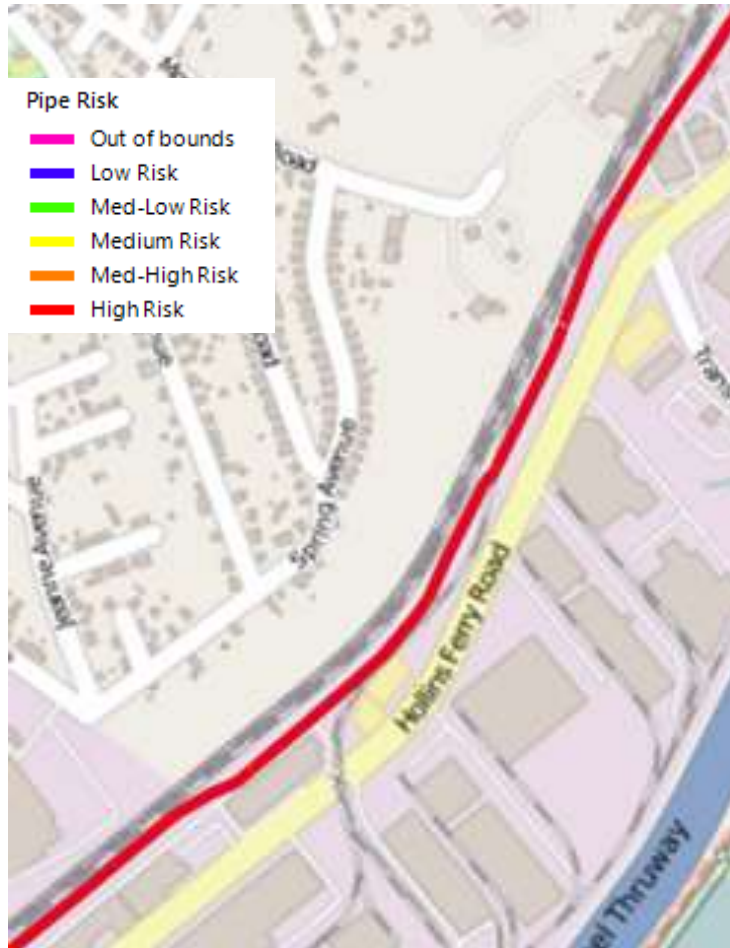
# Why Not Just Replace?

- Desktop Risk Evaluations Conservative
- High Risk Often Driven Lack Of Or Poor Data Quality
- Use Risk Analysis To Drive Data Collection, Not Renewal
- Approach Can Be Executed For A Fraction Of The Cost Of Full-Scale Replacement

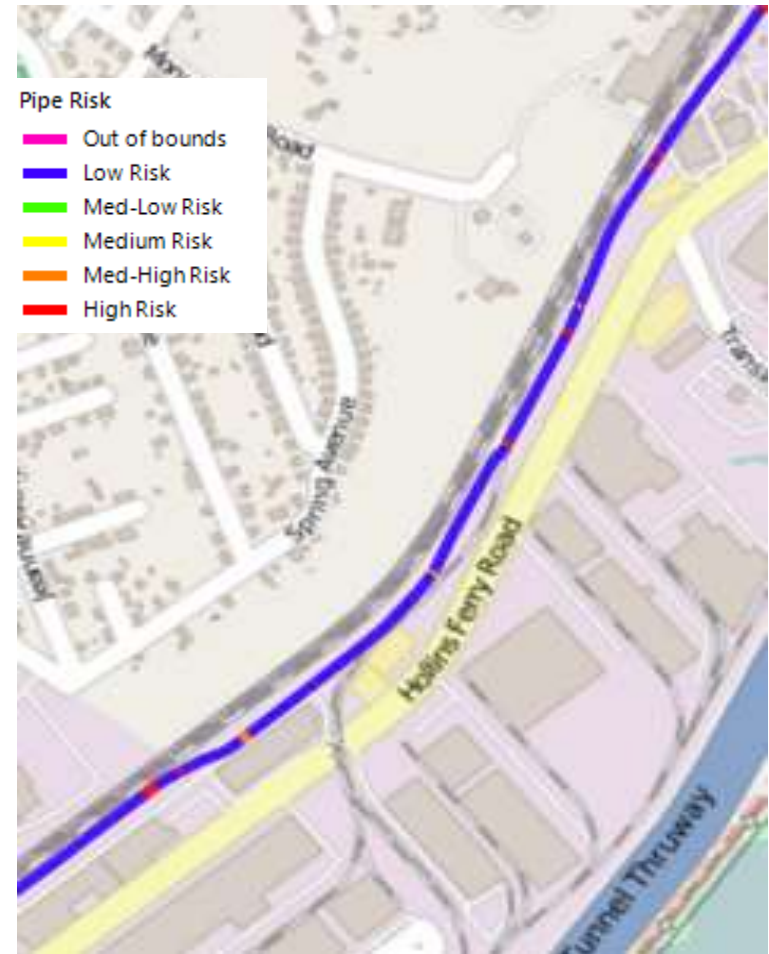




# Good News: Most Pipes Are in Good Condition



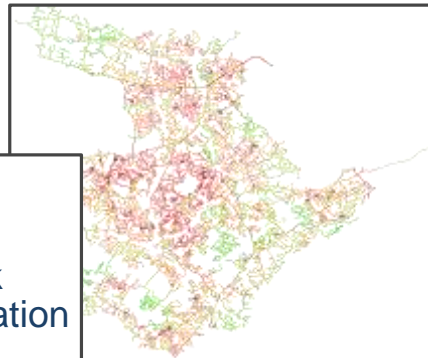
**Before Condition Assessment**



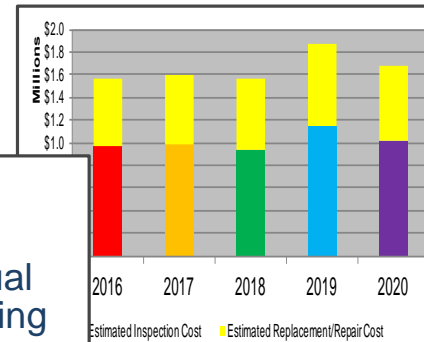
**After Condition Assessment**

# Asset Management – A Learning Process

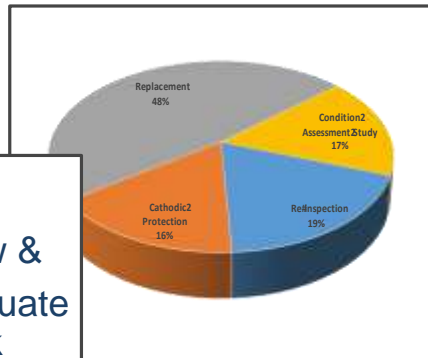
1.  
Risk  
Prioritization



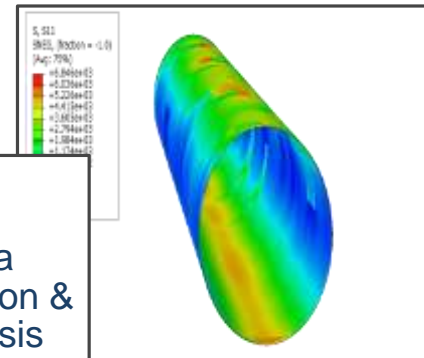
2.  
Annual  
Planning



4.  
Renew &  
Re-Evaluate  
Risk



3.  
Data  
Collection &  
Analysis



# Traditional Approach to Assessment



- Traditionally, prioritizations were based on age, material and break history
- Node to Node Approach
- EPA reports that **70-90%** of pipe being replaced with 'Remaining Service Life'

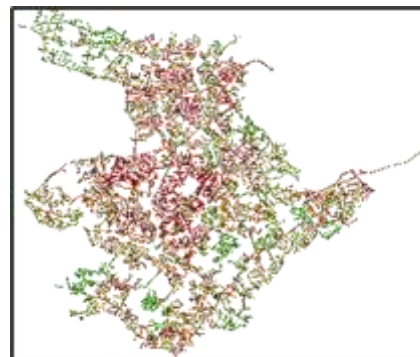
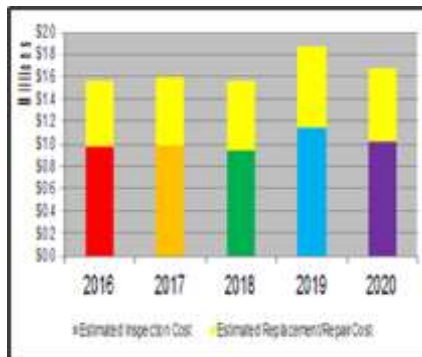
# A Brief History

## Historical Approach to Managing Metallic Pipelines

**THEN**



**NOW**





# Technology Selection



# Pipe Assessment Options

## Lower

- Resolution
- Reliability
- Cost

Desktop Study

Walk the Alignment

Soil Survey

Test Pits

External Leak Detection

External Acoustic Pipe Wall Assessment

Inline Leak Detection and CCTV

Transient Pressure Monitoring

Inline Stress Pipe Wall Assessment

Near Field Electromagnetic

Broadband Electromagnetic

Remote Field Electromagnetic

Magnetic Flux Leakage

## Higher

- Resolution
- Reliability
- Cost

# So...Why do Pressure Mains Fail?

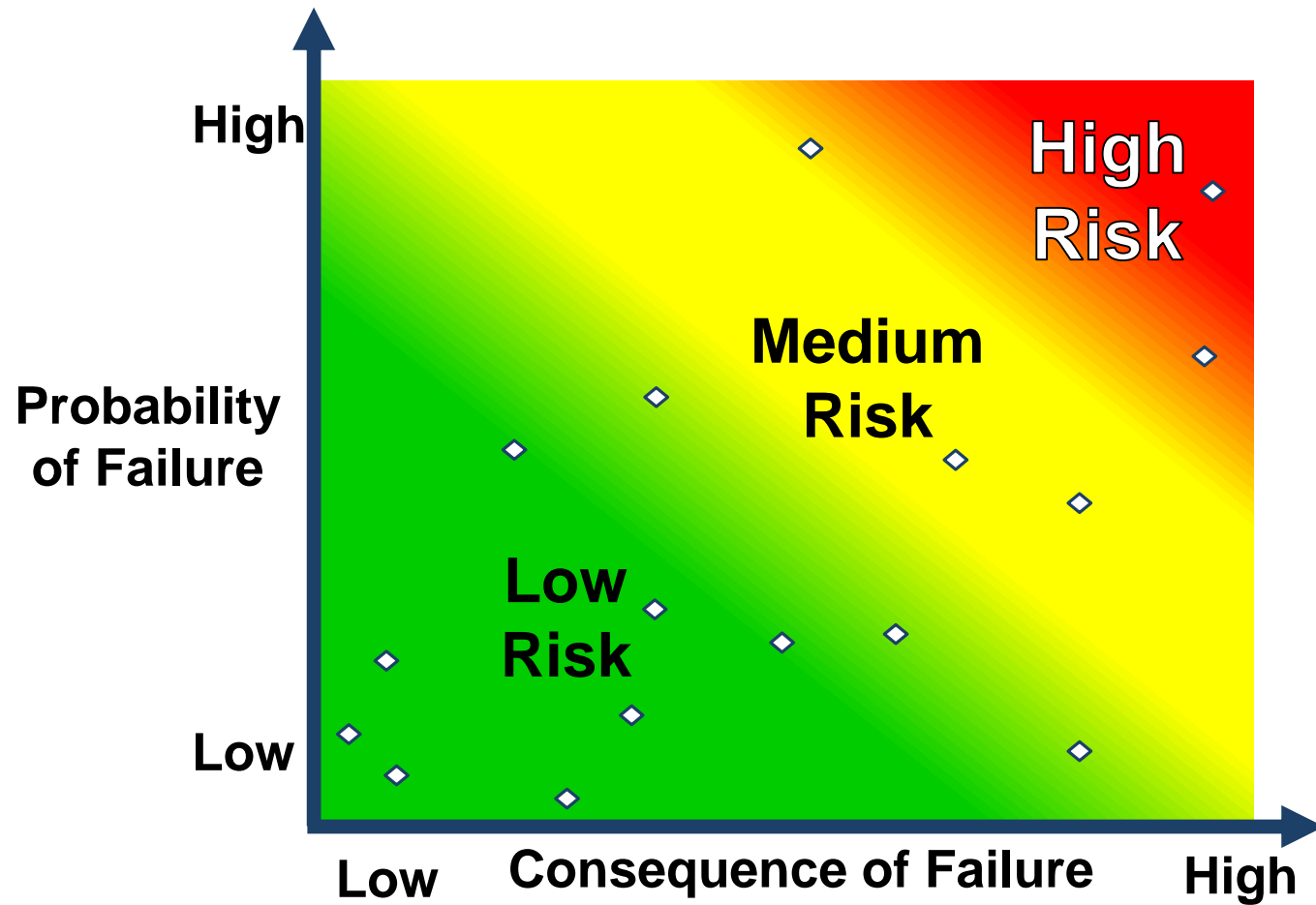
*If age is not the primary factor...what is?*

- *Material quality and manufacturing*
- *Design*
- *Environmental*
- *Operational*
- *3<sup>rd</sup> party damage*
- *Installation*



***Failures are often a combination of several factors***

# Risk-based asset management is cost effective & defensible





# Data Collection Resolution



## Multi-Pipe Level

- Corrosion Surveys
- Correlator Leak Detection
- Pressure Monitoring
- Wall Thickness Averaging



## Pipe Level

- Inline Leak and Gas Pocket Survey
- PWA
- Pulsed Eddy Current



## Pit Level

- RFEC/EEM
- MFL
- Physical Test Pit Measurements

# Location & Corrosivity Surveys

***GPS – Pipe Centerline***

***GIS Data Collection***

***Depth of Cover***

***AC Current Attenuation***

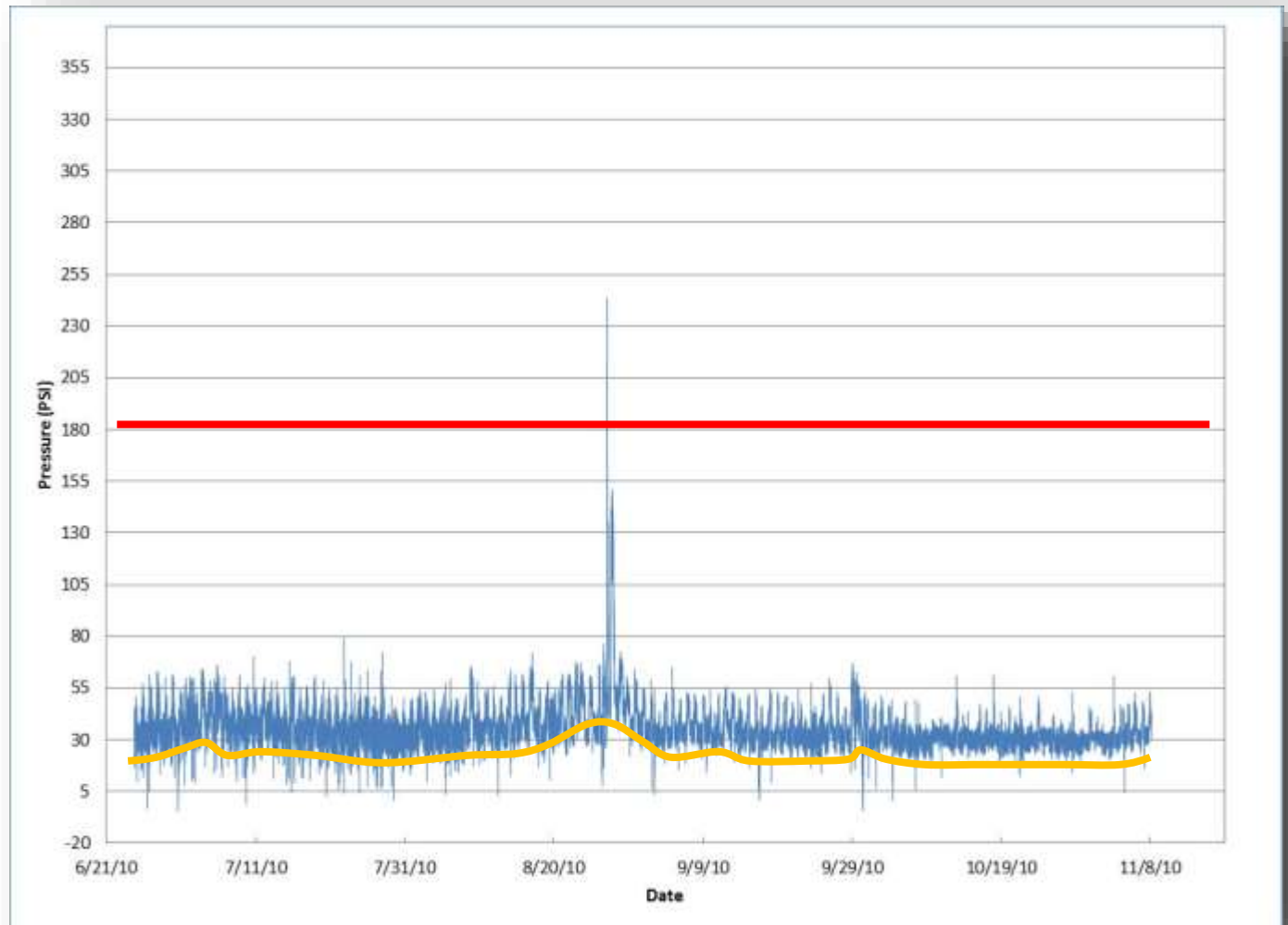
***AC Voltage Gradient***

***DC Voltage Gradient***

***Cathodic Protection Close  
Interval***



# Pressure Monitoring



# External Screening

- **Screening**

- ✓ **Leak Survey**

- **Listening Mics**
- **Noise Loggers**
- **Correlators**
- **Flow Measurement**

- ✓ **Relative Hoop Stiffness**

- **Using surface mounted correlators**





# Data Collection Resolution



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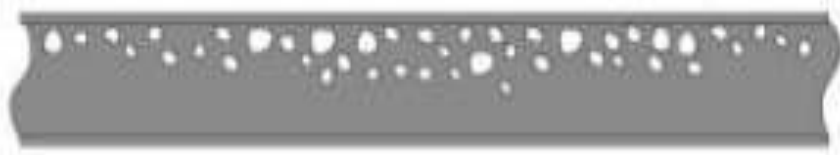
# Leak and Gas Pocket Detection

Leaks are often precursors to failures

Gas pockets may compound the effects of hydraulic transients, reduce capacity, and are the primary locations for failure in wastewater force mains



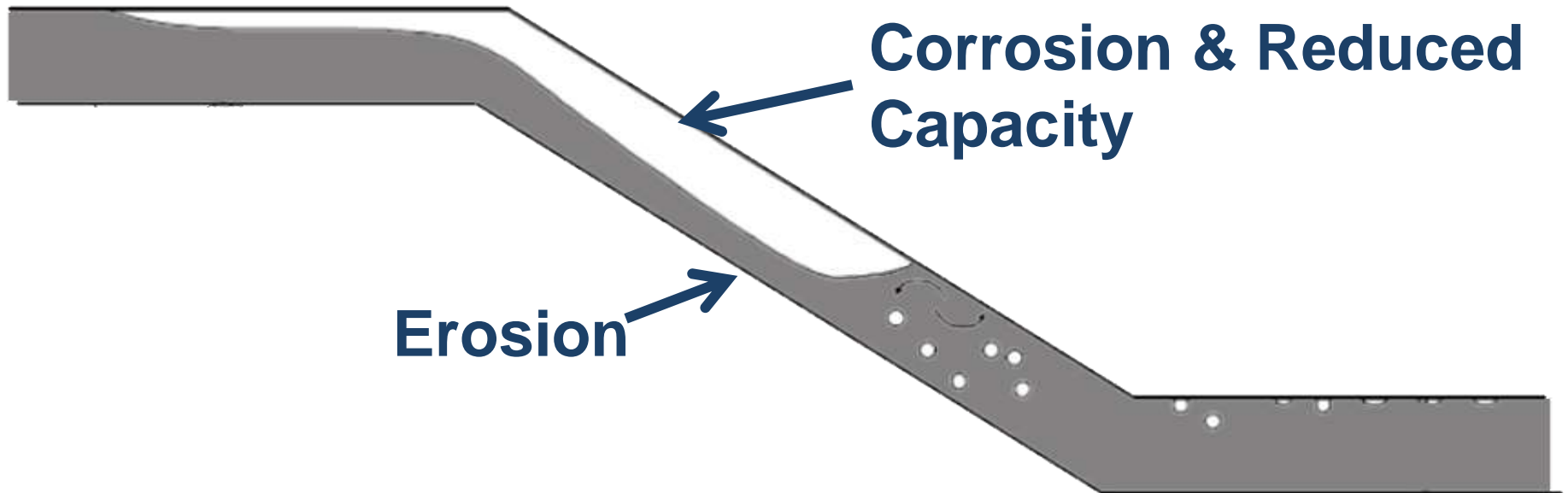
# Anatomy of a Gas Pocket



**Entrained Air Bubbles**



**Entrained Air Slugs**



# Inline Leak & Gas Pocket Technologies

# Pipe Wall Assessment- PWA



Identify areas of **stress** on metallic pipes

Screening tool

- use to focus test pitting
- identify areas of higher concern

Stress is caused by:

- Significant defects;  
corrosion, pits, cracks
- Overloading or point-loading
- Joints and appurtenances
- Material changes

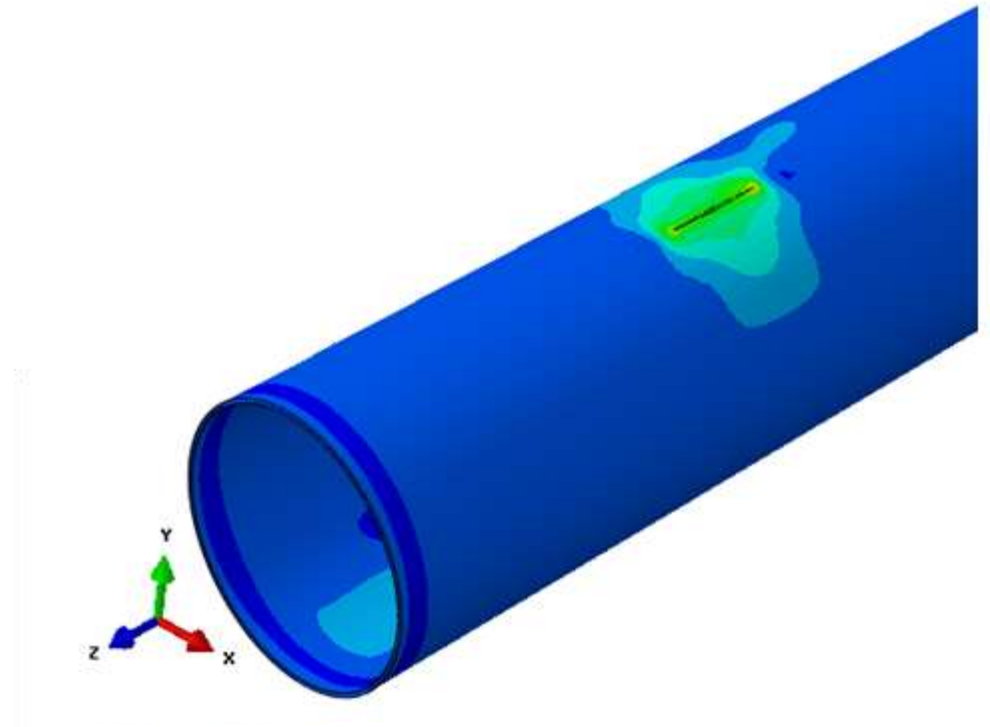
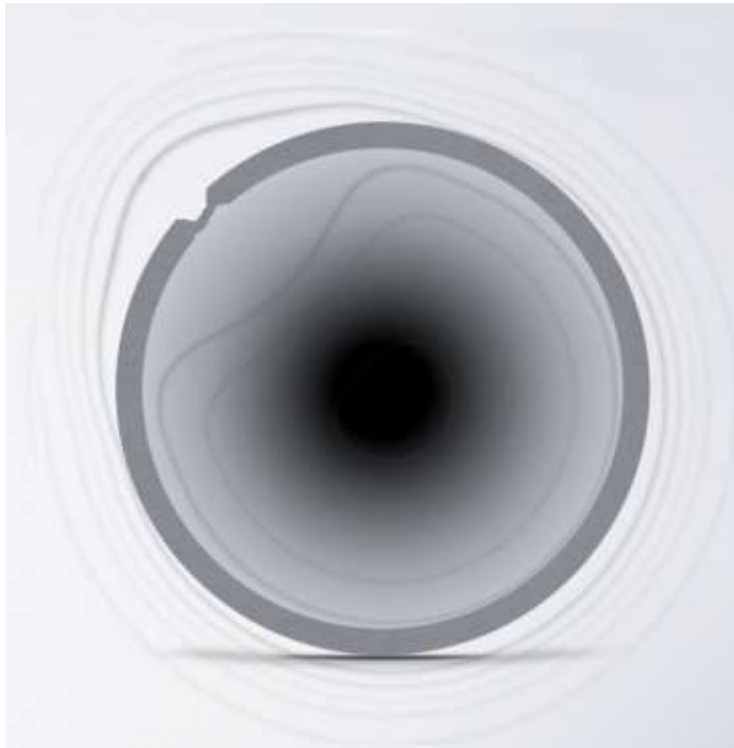




# How PWA Works

PWA measures the change in the magnetic field.

**Villari Effect:** Metallic materials in stress change the magnetic field.



# Using PWA Technology

- Pipeline condition assessment with test pits



- Screen and prioritize pipes in a network



# Data Collection Resolution



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## Pit Level

- RFEC/EEM
- MFL
- Physical Test Pit Measurements

# Test Pits and Validations

- Ultrasonic (UT)
- Pulsed Eddy Current
- External MFL
- Visual Inspection
- Soil Testing
- Material testing





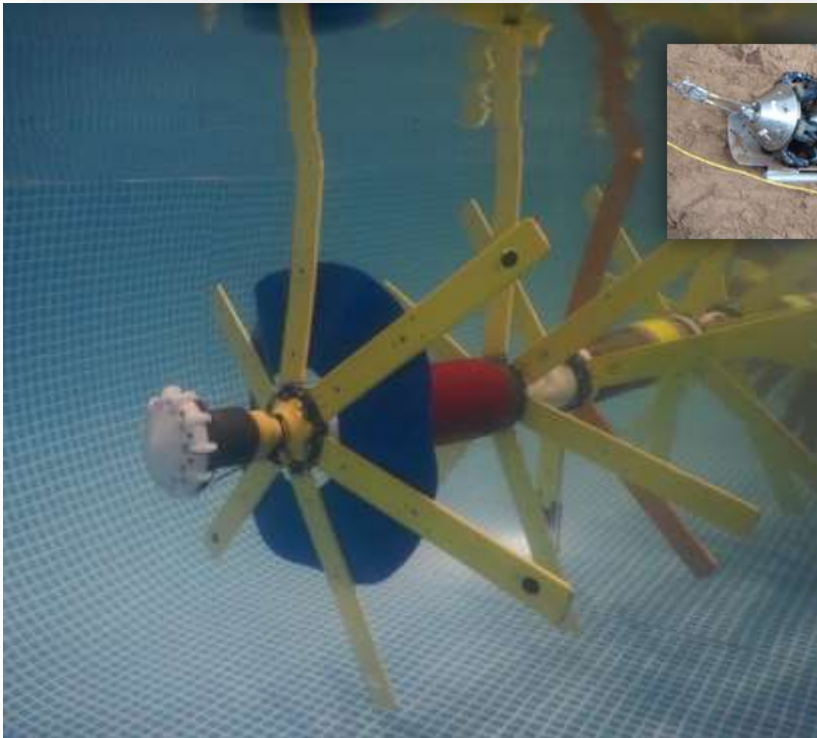
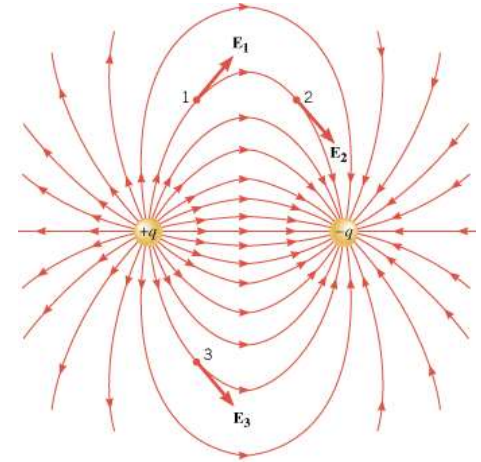
# Electromagnetics



Electromagnetics identify **defects** in metallic pipe wall.

Measures relative wall thickness

Understand the general condition of the pipe.





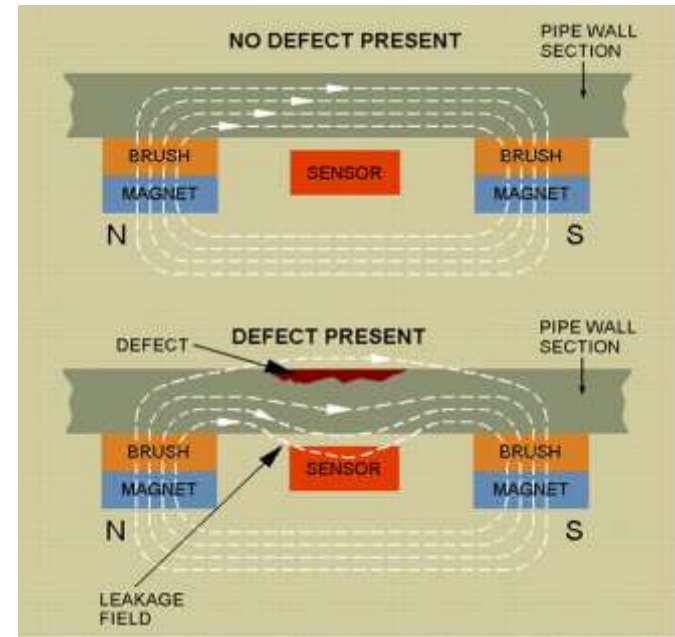
# EM Inspection and Results

# Magnetic Flux Leakage

Magnetic Flux Leakage

Detailed and accurate *condition* of the pipe.

Detects *pitting and wall loss* on steel and ductile iron pipes.





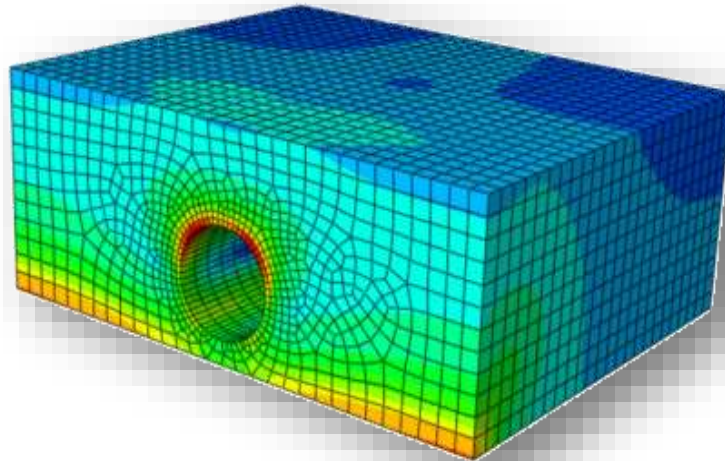
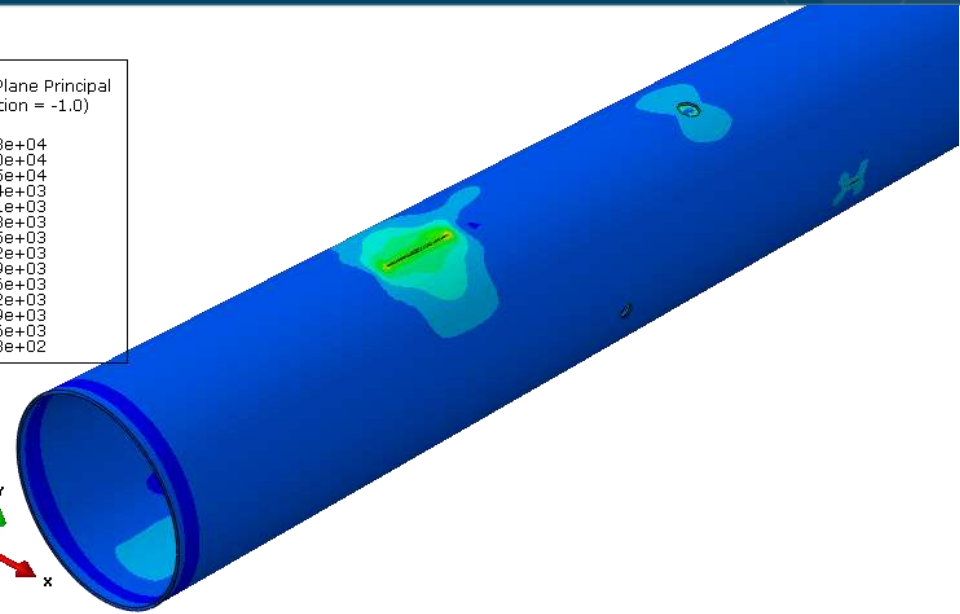
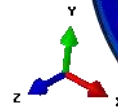
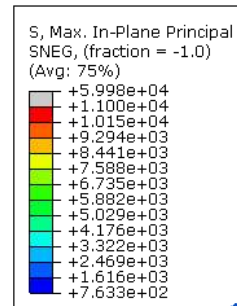
# MFL Inspection and Results



# Condition Assessment Engineering

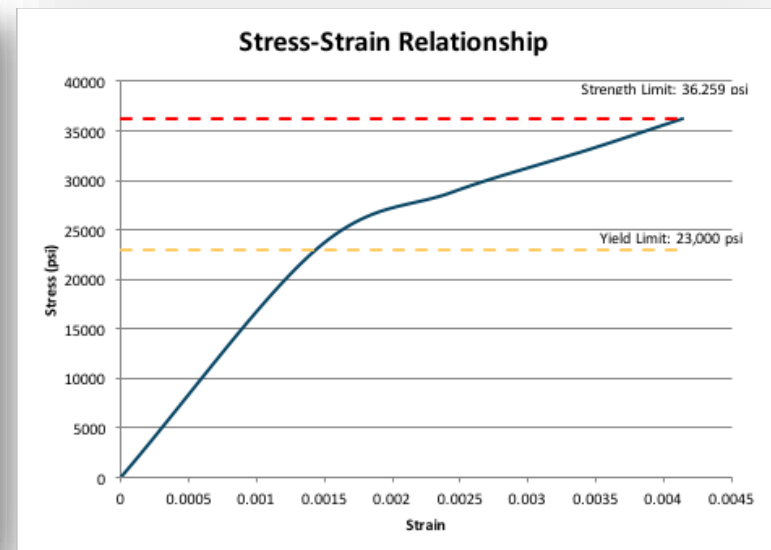
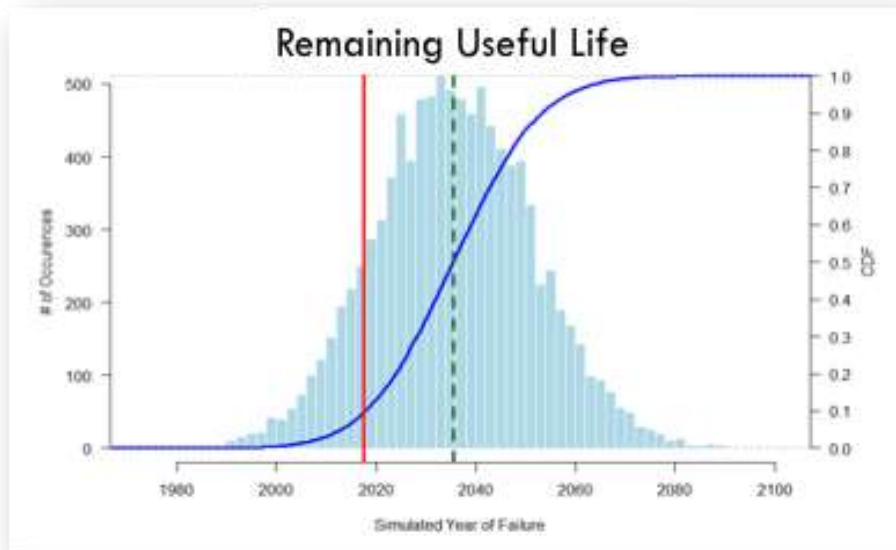
- Structural models created to assess the actual risk of failure

- Design check using AWWA standard
- Finite element analysis of actual pipe wall deterioration



# Condition Assessment Engineering

- Remaining useful life analysis performed using Monte Carlo simulation
  - RUL on AWWA design standards is overly conservative
  - Re-evaluating RUL based on maximum stress measurement and FEA



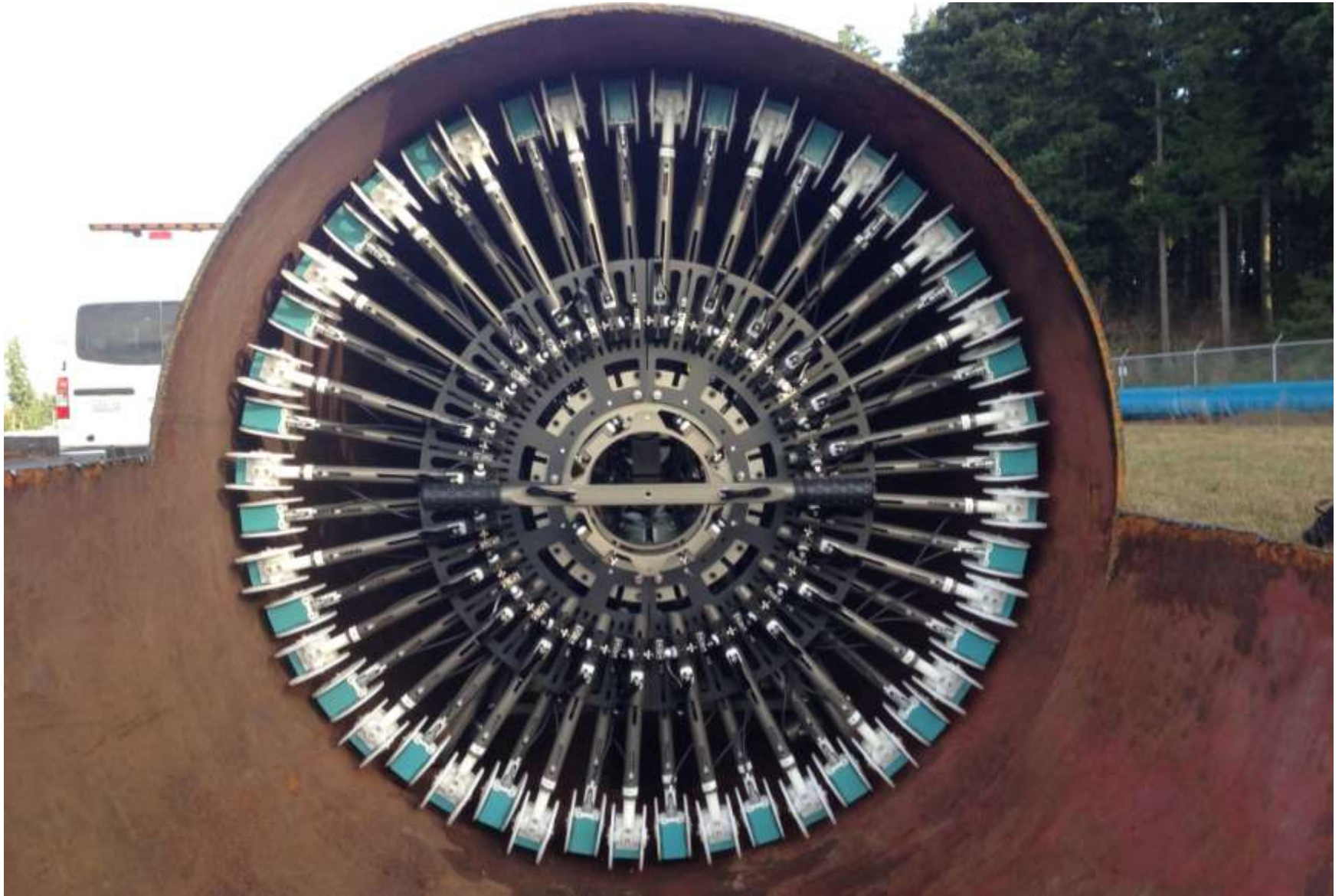


# Tacoma Water- Case Study





# Enhanced Electromagnetics (EEM)



# Tool Setup and Calibration



**Building 48D Tool**





**Creating various defects in the calibration pipe**





# Assembled 48D Tool







**Multiple Passes**





# 48D Tool Assembly in Pipeline



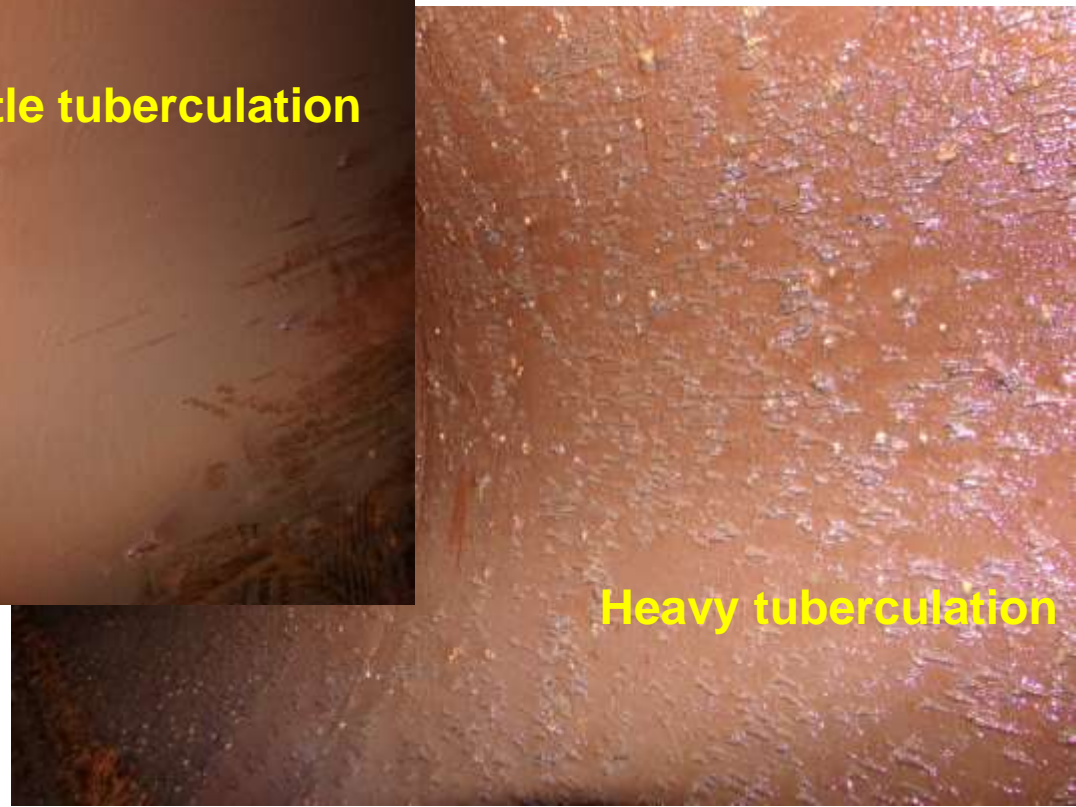


# Evaluation of Interior Coating

Limited tuberculation

Very little tuberculation

Heavy tuberculation





# Pits behind tubercles

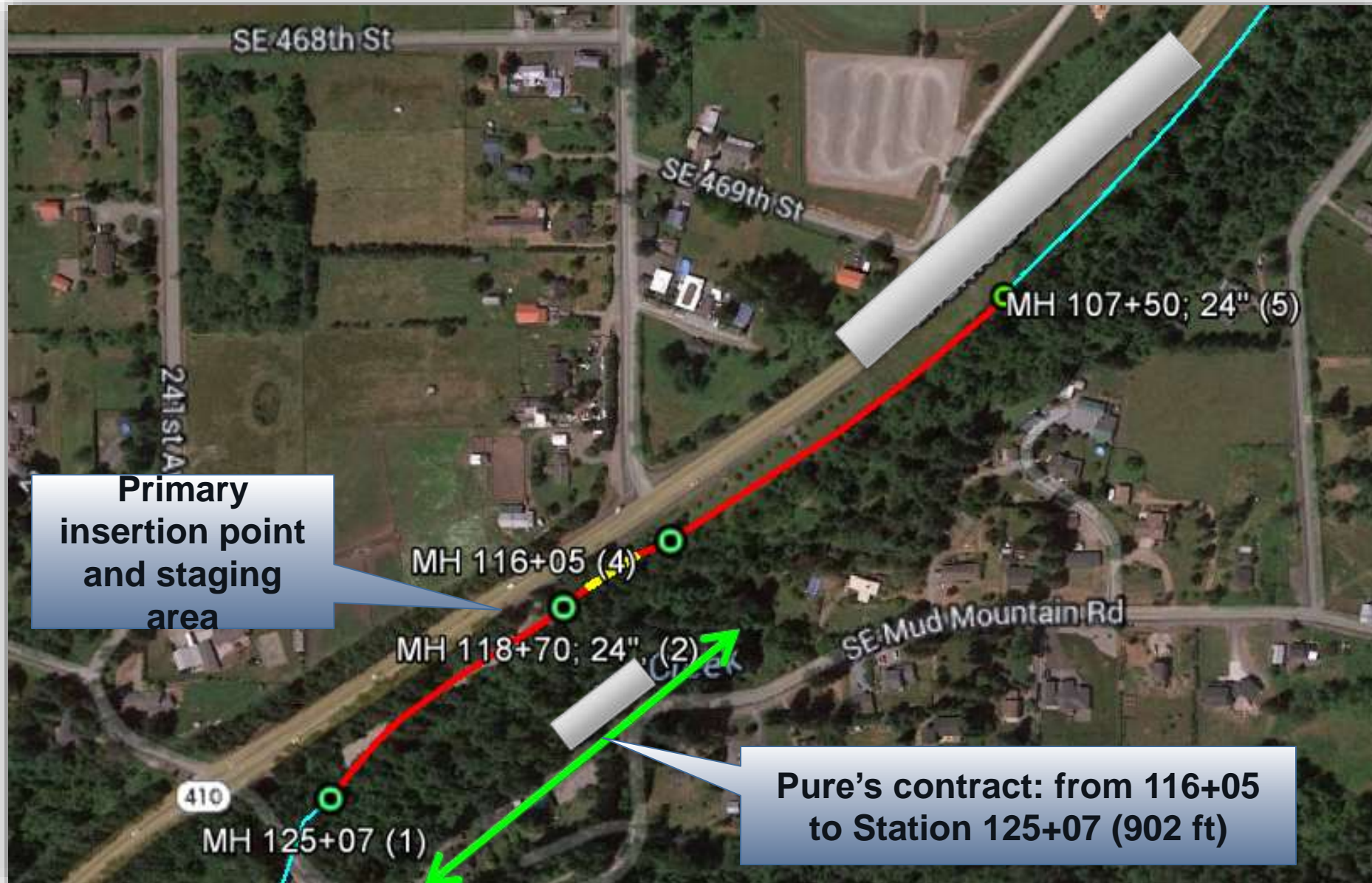


# 784 Wall Thickness measurements with UT gauge





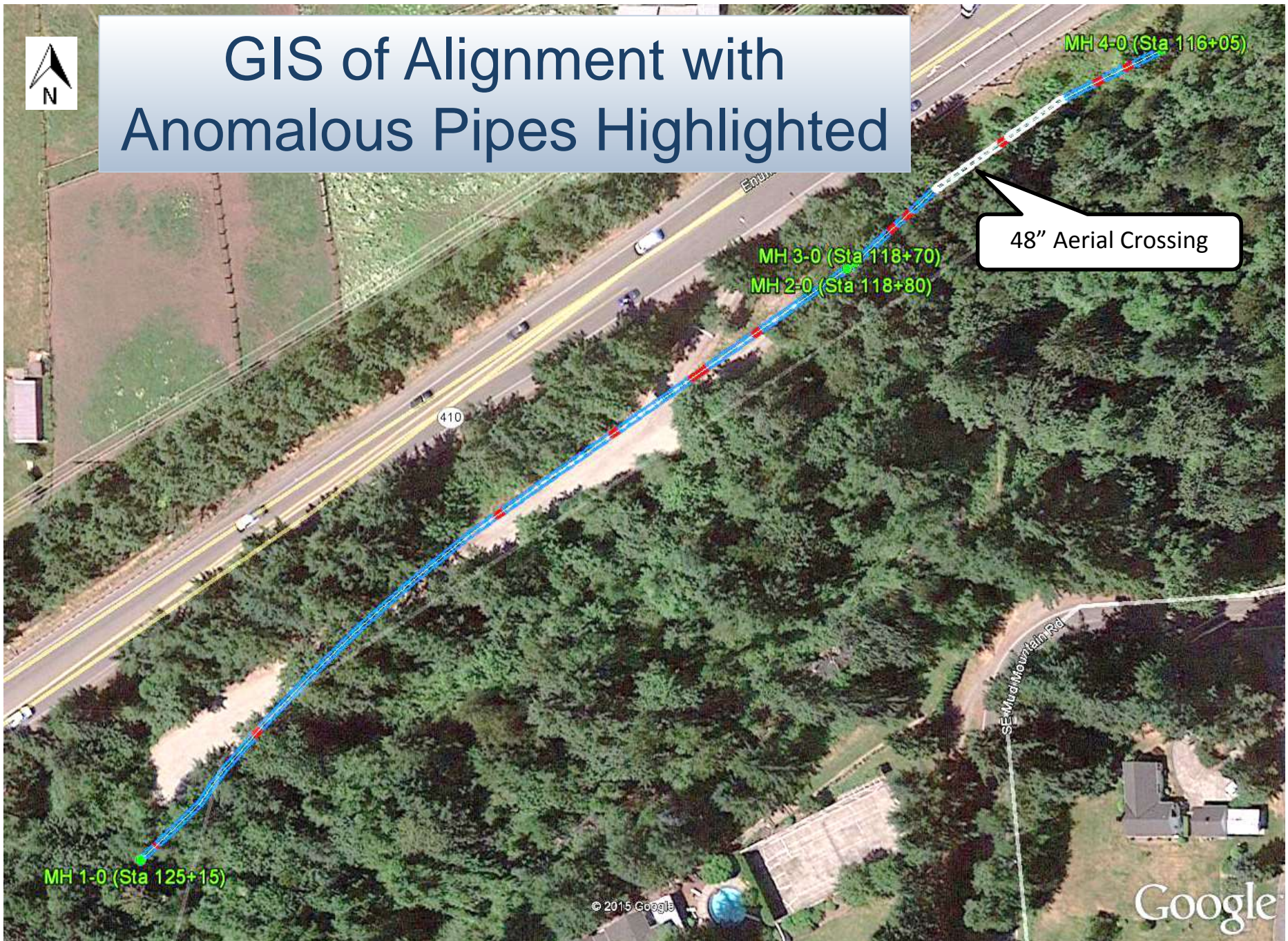
~1,757 feet scanned with 48D EM





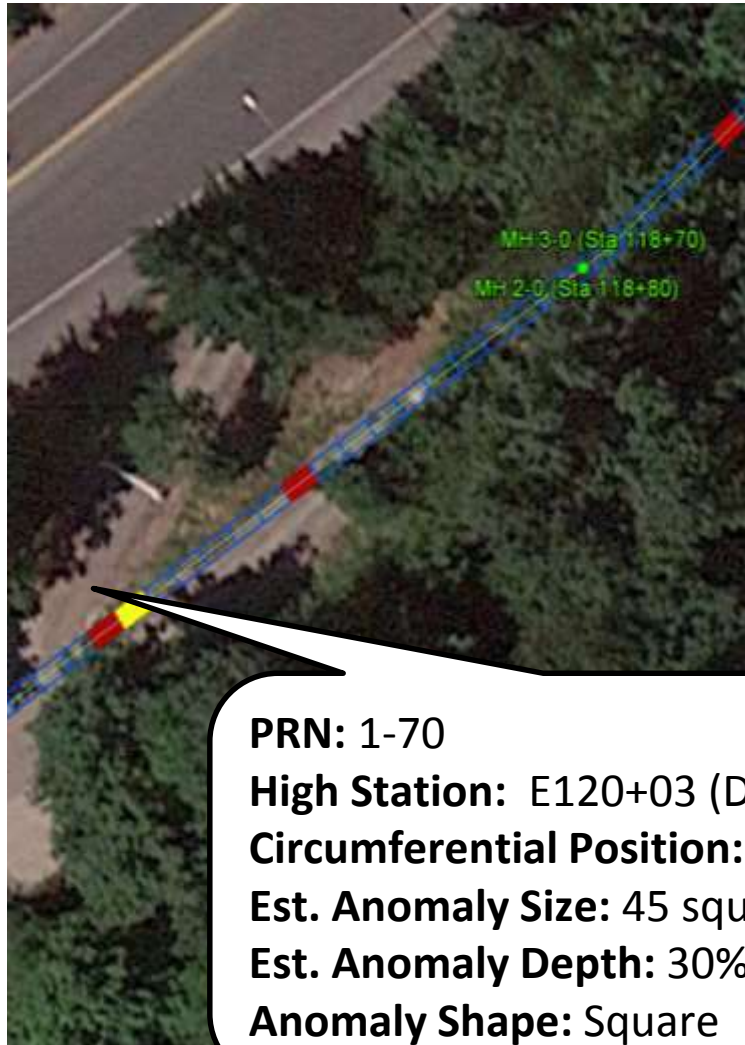


# GIS of Alignment with Anomalous Pipes Highlighted





# EM Anomaly Example



**PRN: 1-70**

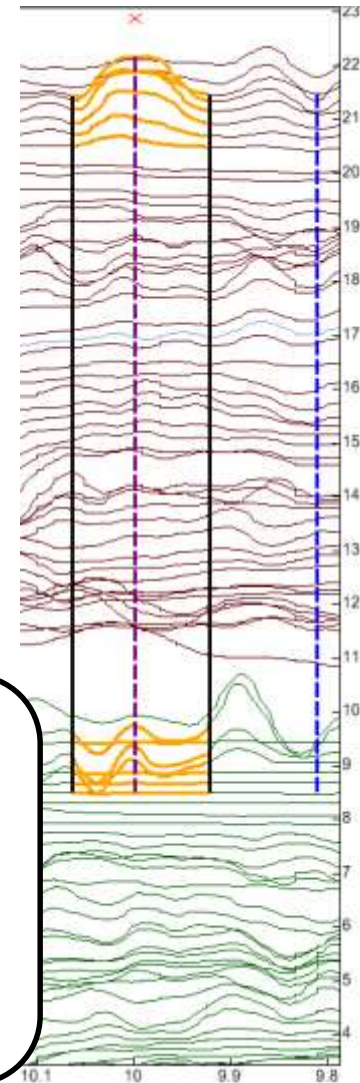
**High Station: E120+03 (DS joint)**

**Circumferential Position: 1 o'clock**

**Est. Anomaly Size: 45 square inches**

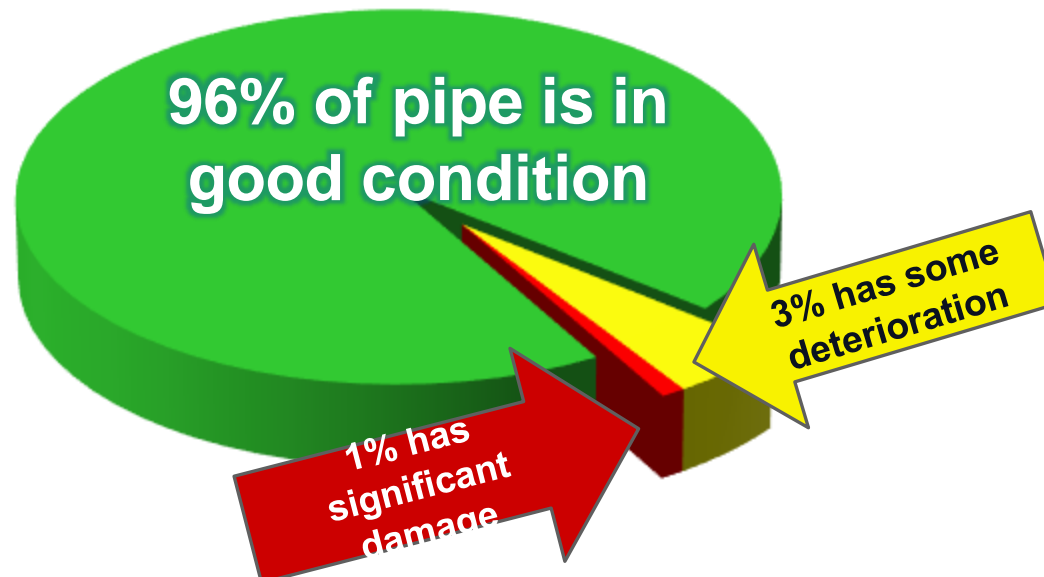
**Est. Anomaly Depth: 30%**

**Anomaly Shape: Square**

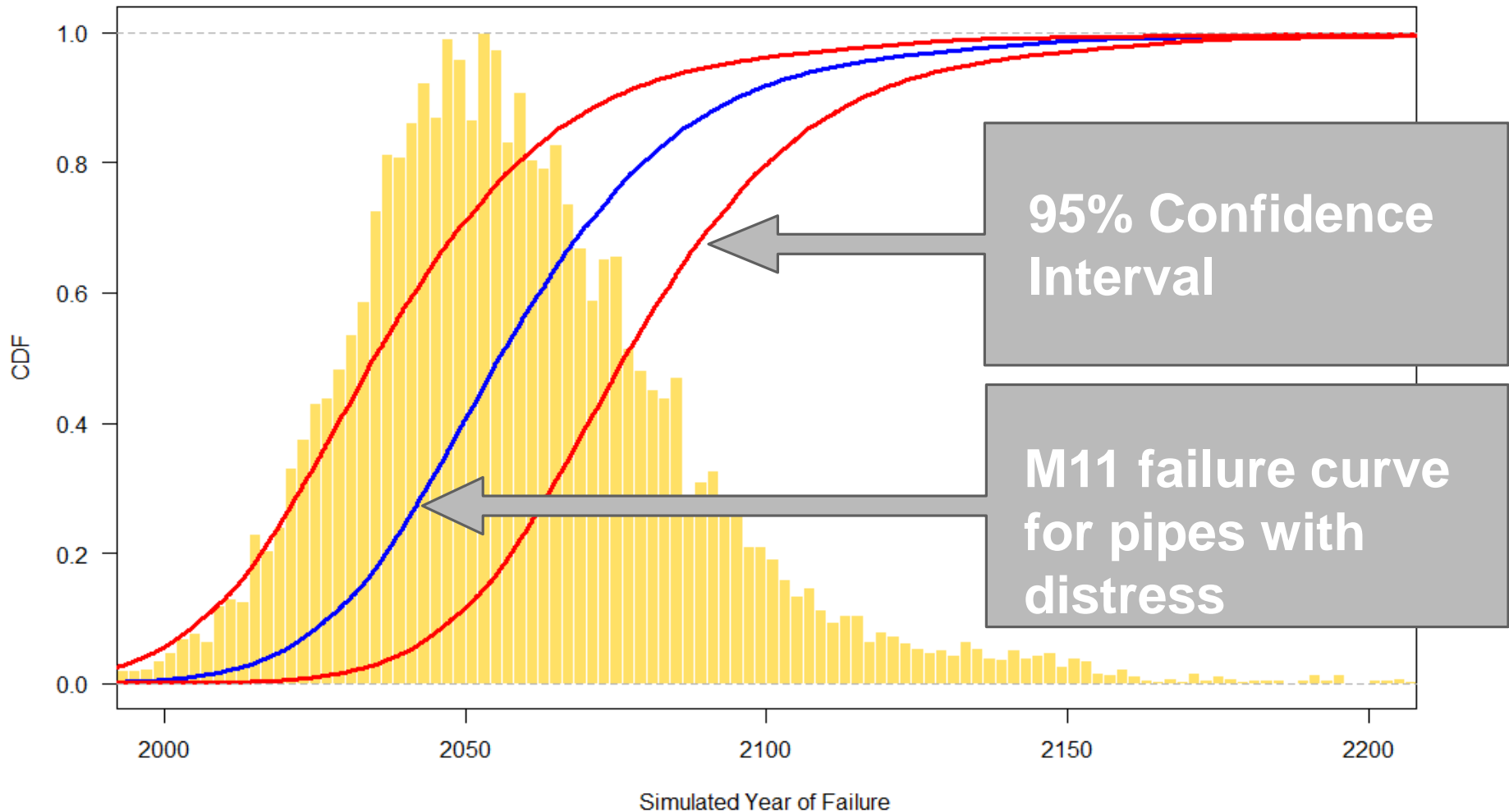


# EM Inspection Results

1. Calibration allowed reporting less than 50% wall loss (down to 15% in some pipes)
2. Only 12 of 125 pipes had detectable EM anomalies (9.6%)
3. Maximum wall loss detected with EM was 35%



# Remaining Useful Life Forecast for Anomalous Pipes



# Engineering Evaluation Conclusions

1. Structural Analysis: Pipeline is currently not at risk of structural failure
  - The largest corrosion cells still have a significant built in factor of safety.
  - At 10ft of cover, all corrosion cells can withstand 80% wall loss at their current dimensions.
2. Remaining useful life: anomalous pipes will last 46 years while the rest of the pipeline will last until the year 2705, on average, before failing.



# Summary

**10,000 miles** of pressure main condition assessment data has told us a few things...

- *Manage pressure mains by **understanding** the failure modes*
- *Use **risk** based assessment techniques*
- *Decision making should be driven by the **right** data*
- *Understand **operations***
- *Proper data analysis is **critical***
- *Allow condition, risk, and cost to drive **long-term decisions***
- *Strategies should **reduce risk of failure***

**10,000 miles** of pipeline condition assessment data indicates that **selective rehabilitation** is a **cost effective** way to **extend the useful life** while also **reducing the likelihood of failure** for pressure mains



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# Questions?

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