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Efficient Asset Management with Acoustics

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Agenda

- Background
- Innovative Solutions for Buried Pipeline Asset Management
  - Acoustic Leak Detection
  - Acoustic Pipe Wall Integrity Testing
- Case Studies
  - Newark, NJ
  - Las Vegas
- Q&A

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Optimizing Pipeline Asset Management:

How to Prioritize Based on Condition?

Pipeline 1	Pipeline 2
Installed 1860	Installed 1860
Brown clay soil	Brown clay soil
Corrosive soil	Moderately corrosive soil
6” Cast Iron Pipe	18” Cast Iron Pipe

47.3% Measured Loss

18.5% Measured Loss

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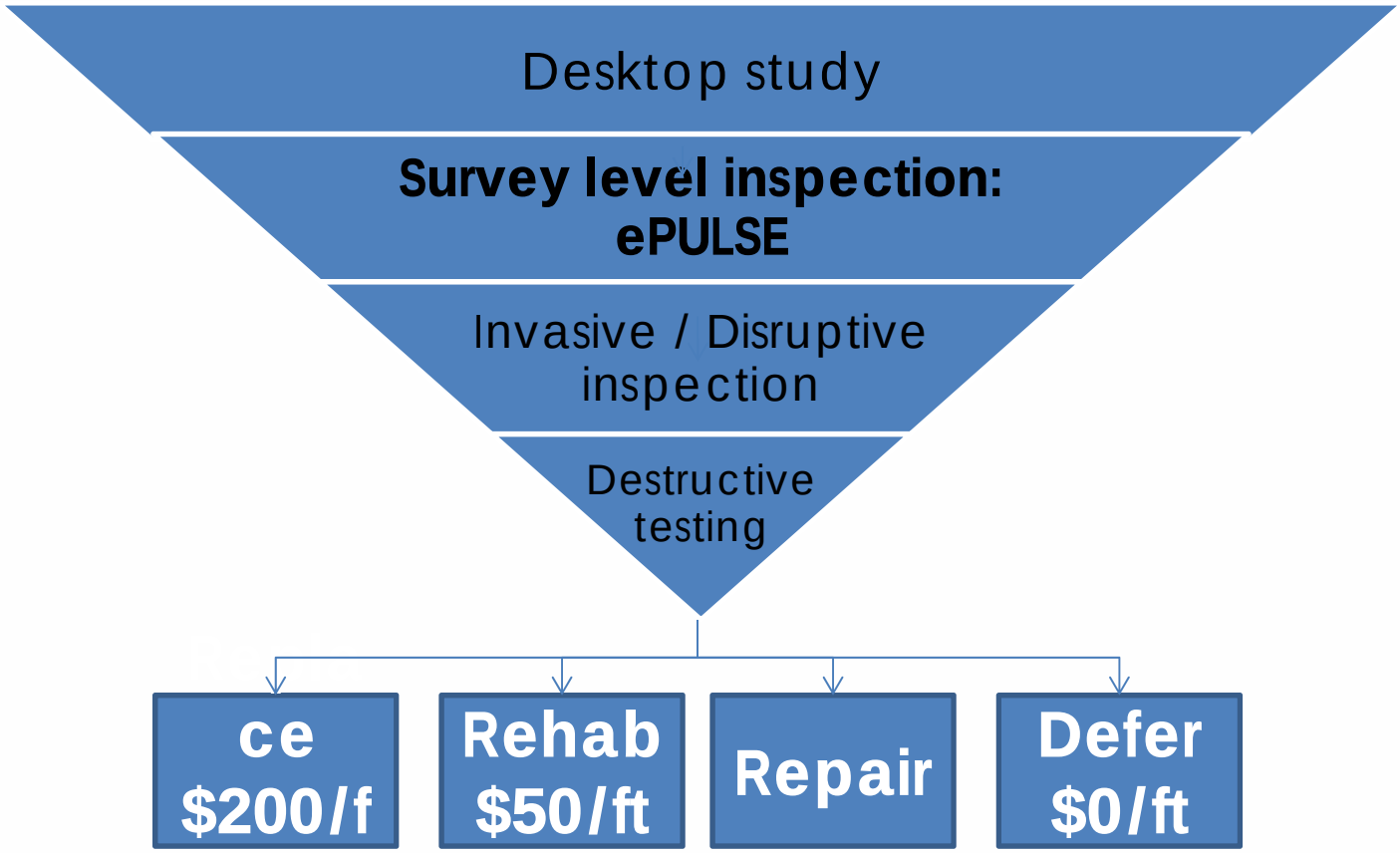
Condition Assessment: Pyramid Model



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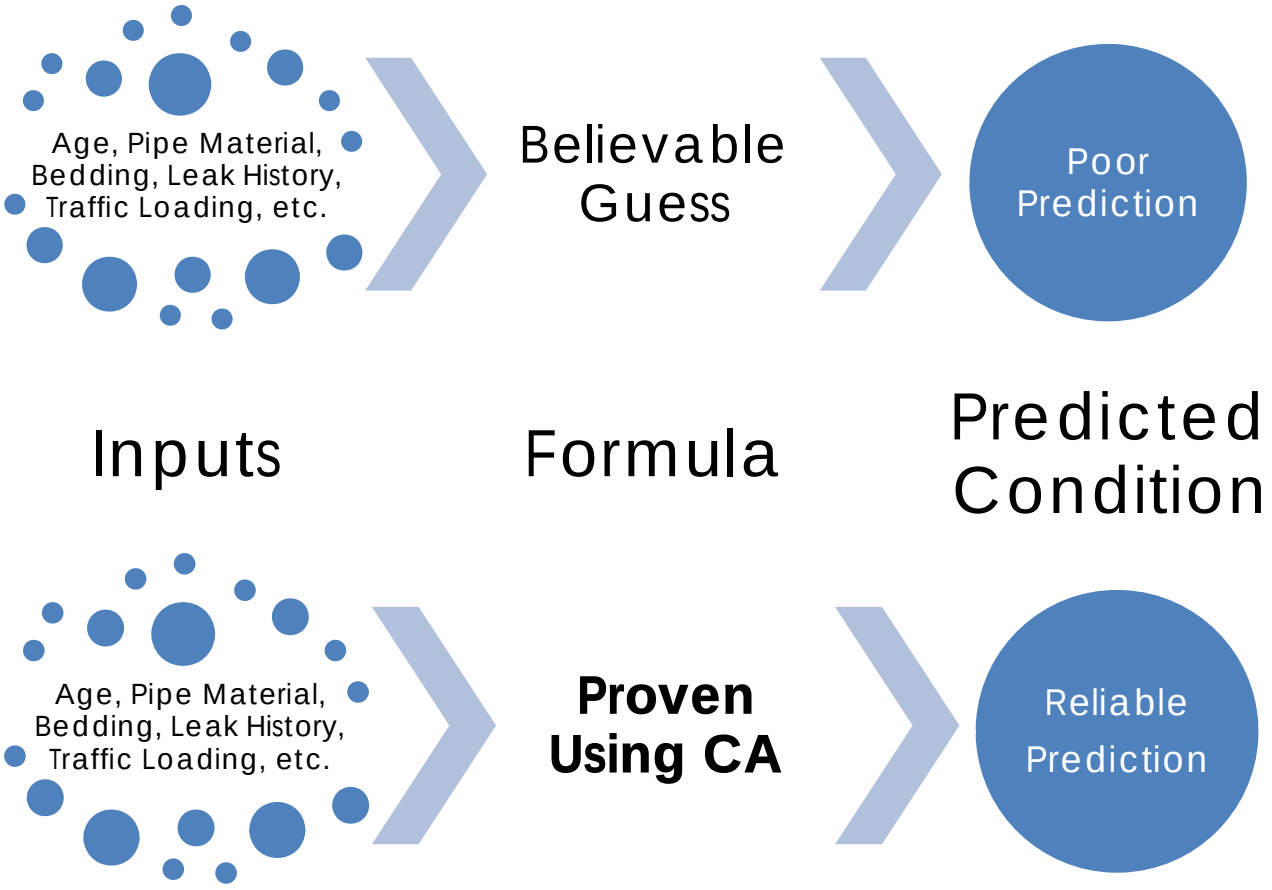
Condition Assessment: Prioritization Model



Optimizing Pipeline Asset Management:
Economic Value of Non-Invasive Assessment

- Prioritize utility investments based on actual pipe condition
  - Enables a Master Planning approach to pipeline Asset management
    - Condition-driven schedule for pipe replacement and rehabilitation
  - Offers objective data for "proof of need" in rate cases
- Offers an immediate Return on Investment
  - Interest on deferred capital: Finding good pipe
  - Reduced water loss: Isolating leaks years in advance

QuickTime™ and a decompressor are needed to see this picture.

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Innovative Solutions for Buried Pipeline Asset Management

The Myth of Aging Pipes

- Contrary facts about aging water mains
  - *Rate of rise* (water loss) accelerates as water distribution systems age
  - **However**, 70%$^{+}$ of pipes being replaced have remaining life
- Asset Management critical to pipe life cycle management
  - Active leakage control to minimize water loss
  - Direct Inspection used to prioritize rehabilitation / replacement
- Innovative, non-invasive solutions are available to:
  - Prevent catastrophic failures
  - Significantly reduce Non-Revenue Water (NRW)
  - Prioritize capital spending for pipe infrastructure

Economics of Water Main Leaks

- **Main Break Repair:** $5,000 - $20,000 per incident
- **Typical 5-10 GPM Leak**
  - *ENERGY:* 8,800 kWh annual energy loss for pumps and systems
    - $1,057 annually at $.12/kWh
  - *CARBON*:* Lost energy creates 5,300 lbs of CO_2, work of ~ 100 trees
- **Catastrophic Failures:** $50K to $ Millions per break
  - Collateral damage, contamination, EPA/state penalties
- **Cost of Water**

** 1 kWh saves 1.3 lbs of CO_2*

At 70 PSI					
Classification	**Hole Size (inch)**	**Leakage (g/min)**	**Leakage (g/day)**	**Marg Cost/Yr @ $600 / MG**	**Value/Yr @ $2,000 / MG**
Small	0.125	2	2,880	$631	$2,102
	0.250	7	10,080	$2,208	$7,358
	0.375	15	21,600	$4,730	$15,768
Medium	0.500	25	36,000	$7,884	$26,280
	0.625	39	56,160	$12,299	$40,997
	0.750	55	79,200	$17,345	$57,816
Large	0.875	74	106,560	$23,337	$77,789
	1.000	95	136,800	$29,959	$99,864
	4.000	1436	2,067,840	$452,857	$1,509,523

Leakage Control

Leak Detection Technologies

- Acoustic
- Acoustic with Correlation

} Most Popular, Invented 1970s

- Infrared Thermography
- Chemical
- Mechanical
- Ground Penetrating Radar
- RFEC - Intrusive technologies for transmission mains
  - Sahara and Smartball

Leak Locations

- Water and force mains
- Fire hydrants
- Valves
- Blow-offs
- Meters
- Service connections

Sources of Leaks

- **Environmental factors:**
  - Ground heave and slip
  - Earth and Traffic loading
  - Ground support: pipe spans
  - Thermal changes
- **Corrosion**
- **Public works:**
  - Road salts
  - 3rd party digging
- **Age and neglect**

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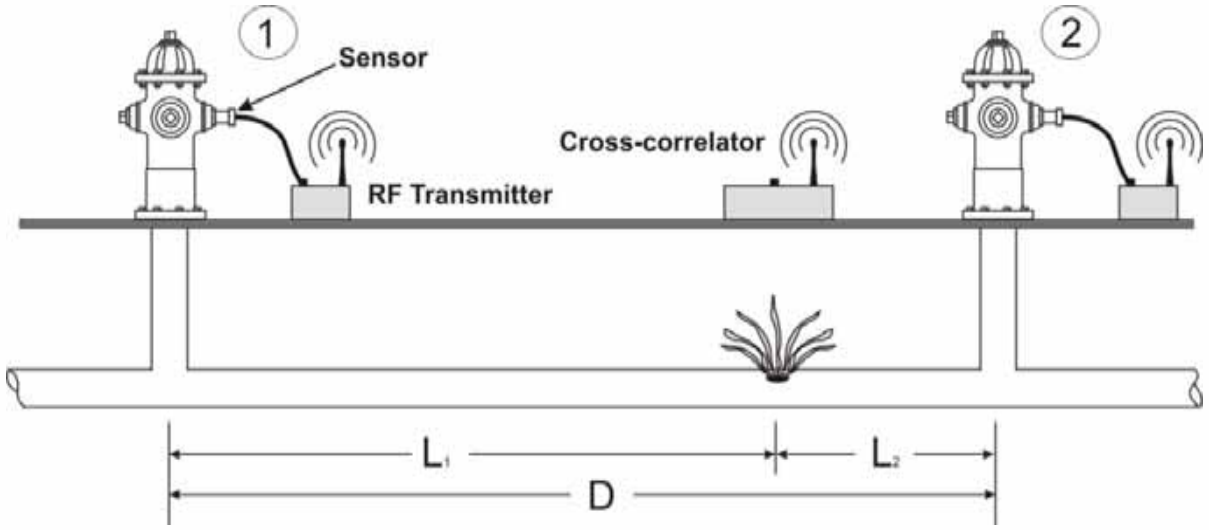
Acoustic Leak Detection Technology
Limited Technology Advancement

- Interference from surroundings and ambient noise
- Unable to detect low frequency noise
  - **Plastic and AC pipe**
  - **Larger diameter mains**
  - **Muffled leaks, e.g., underwater**
- Questionable accuracy

Solving the Problem

- Human Voice: 125 – 5000 Hz
- Music - Middle C Note: 256 Hz
- Music - A440: 440 Hz
- Typical 6” Cast Iron Pipe: 200 – 800 Hz
- Typical ¾” copper pipe: 400 – 2000Hz
- **Typical 6” PVC Pipe: 5 – 30 Hz**



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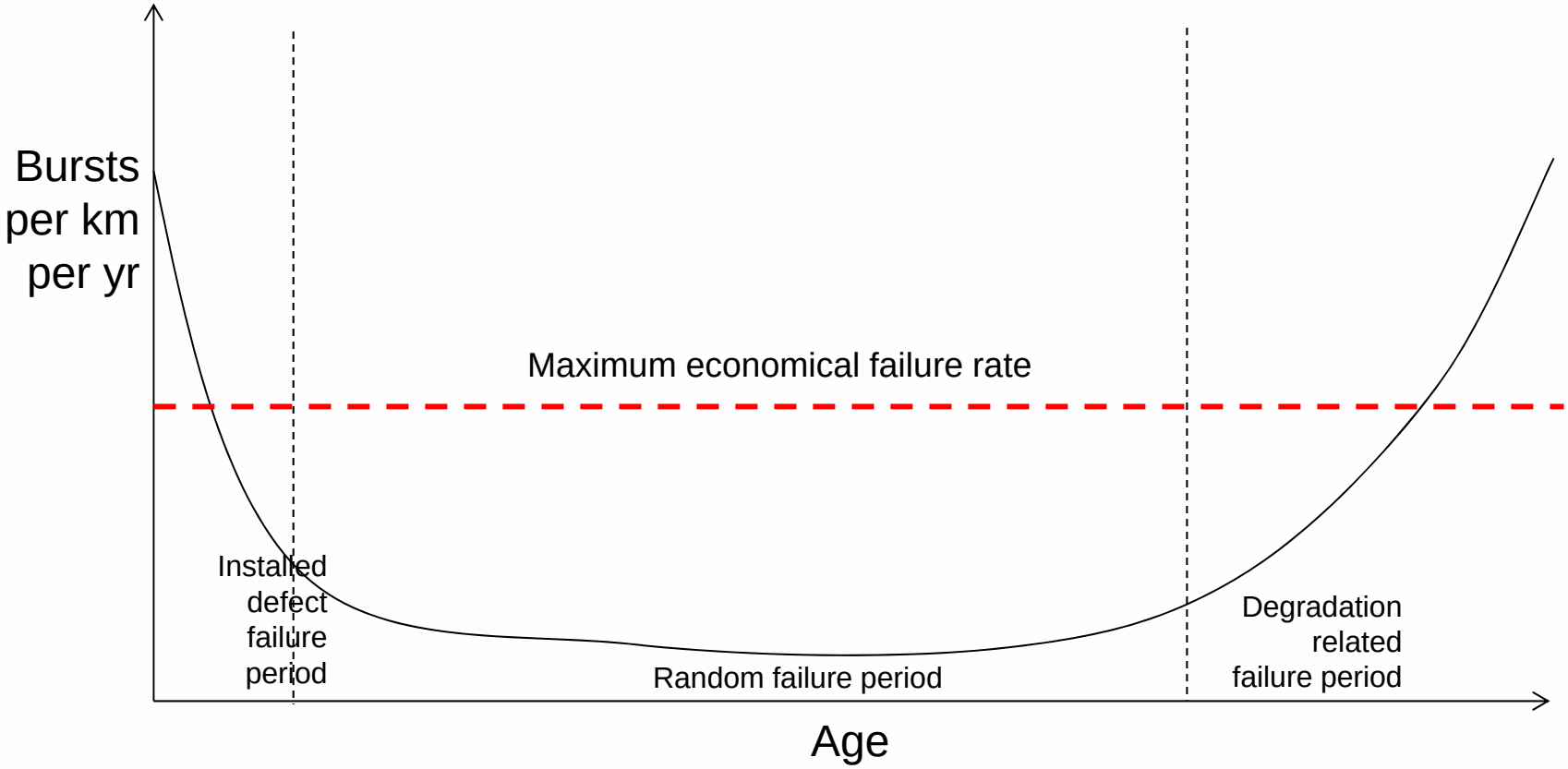
Assessing Pipe Condition



Indirect Condition Assessment:
Current Methods

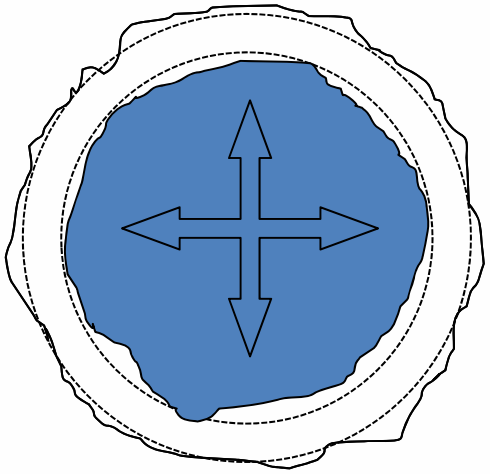
- Internal Environment
  - Water Quality Testing, including Corrosivity
  - Flow rate, temperature, pressure, etc.
- Soil Environment
  - Soil / Geological mapping
  - Soil corrosivity (pH, sulphate content)
  - Soil testing
- Desktop - Statistical/Criticality Models
  - Review break rate, soil type
  - Includes consequence of failure

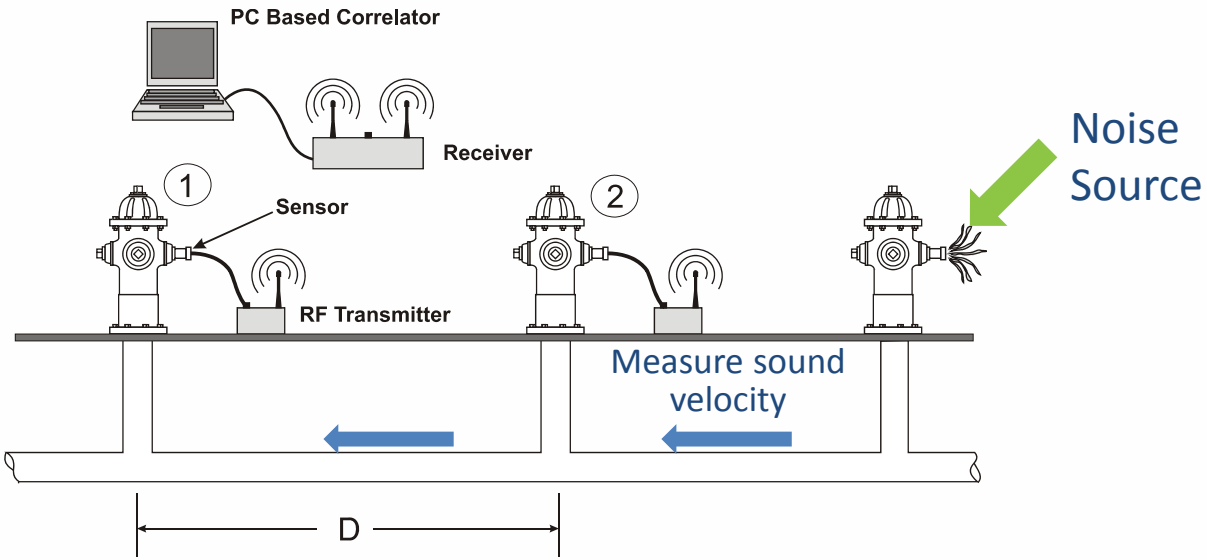
Direct Condition Assessment:
Ferrous Pipe

- Historical Methods
  - Electromagnetic
    - Broadband (BEM), Magnetic flux leakage (MFL), RFEC
    - Requires direct access to the pipe through a pit, and 360 degree access to the pipe, or a pig inserted into the pipe
  - Pipe Sampling (coupons)
    - Tuberculation level
    - Graphitic Corrosion
    - Metallurgical, e.g. Young's modulus, metal loss, thickness
- Acoustic Assessment Methodology - *Pipe Integrity Testing*
  - Provides an *Minimum Average Structural Thickness* measurement
  - Leak detection is performed at the same time
  - Cost: **1.0 - 1.5%** of the cost of pipe replacement

Pipe Condition Assessment: How it Works

- Acoustic signals induced in pipe by flowing water from hydrants or using acoustic exciters
  - Causes pipe to "breath"
- Velocity of acoustic wave is measured, wall thickness is calculated from propagation delay
- Derive ***Minimum Average Wall Thickness*** for typically 300 – 400 feet sections





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Case Study: City of Newark

- Condition assessment performed on section of 1890s era 6" cast iron pipe
- Service leak discovered
- 3 coupon samples extracted along street to confirm
- Pipes in area were part of Concrete Mortar relining program

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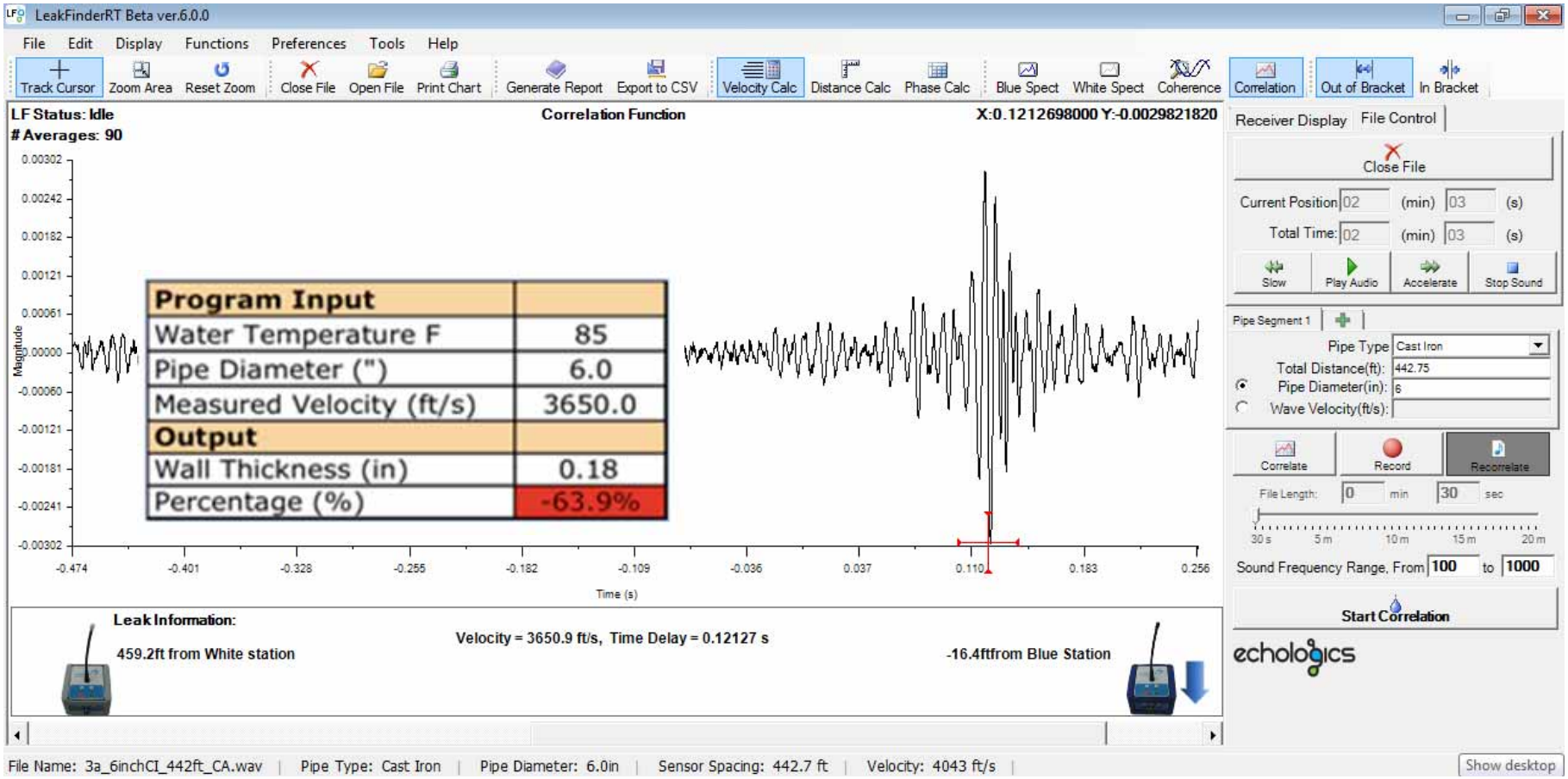
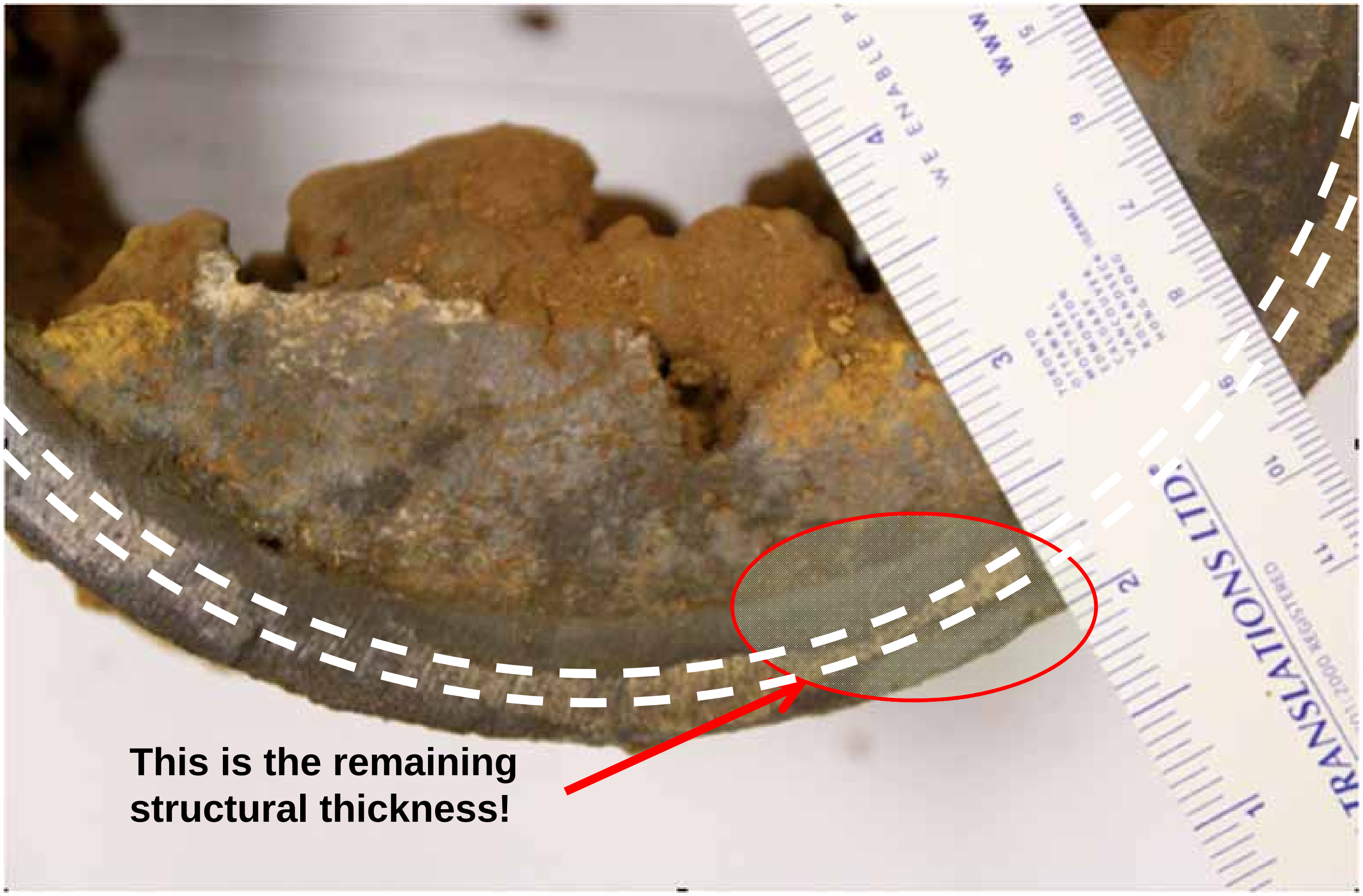
Pilot Study in Newark



Pilot Study in Newark



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Case Study:
Las Vegas Valley Water District

- LVVWD planned to replace 6.5 miles of 16” to 36” bar-wrapped steel cylinder transmission main on Las Vegas Blvd
  - Expected to spend $10,300,000
- Identified mains that did NOT need rehab or replacement
  - Only 15-20% of pipe sections had lost >15% of pipe wall thickness
  - Degraded mains were prioritized for renewal
- **LVVWD reallocated over $2M budget to other projects**

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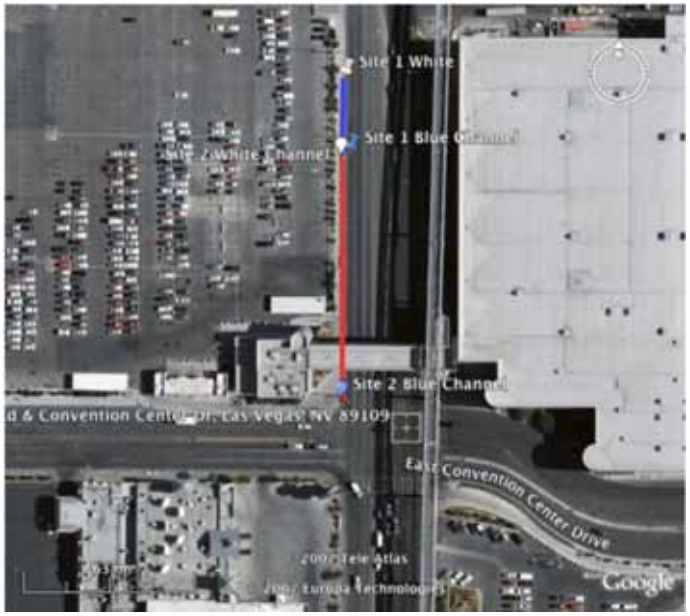
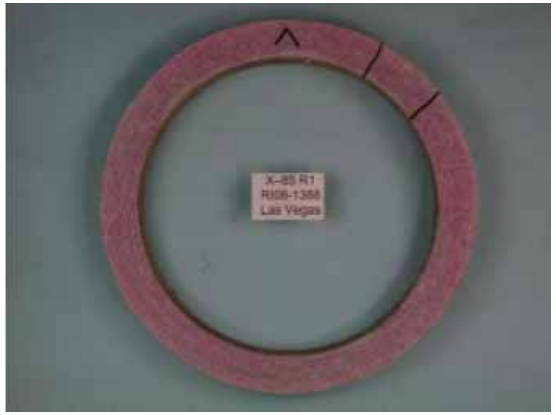
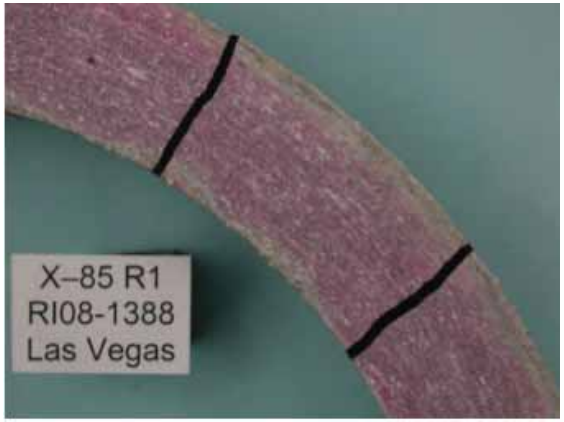
Pilot Study - LVVWD

- Two Sections of 6” AC pipe tested
- Excavated 6” Pipe to confirm our results
- Also tested a 24” AC pipe
  - Showed it was in good condition







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LVVWD Contract

- LVVWD standardized on acoustics testing for AC Pipe based on confidence and repeatability
- To date have assessed approximately 30 miles of AC in Las Vegas, NV
- Most AC in excellent condition
- Several areas of degraded AC pipe found
- Case Study: 14” pipe assessed to be approximately 30% degraded

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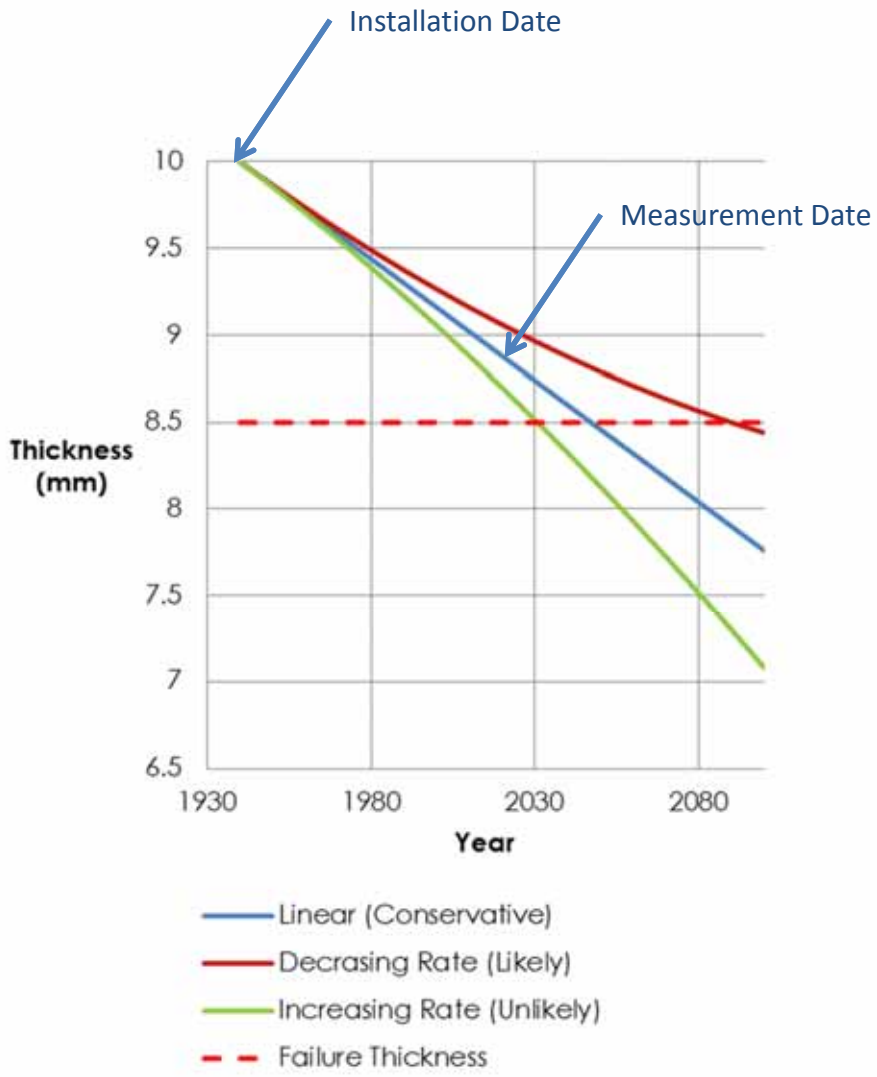
Serviceable Lifetime Prediction: What is it?

- Models developed to predict remaining serviceable life based on condition assessment measurements
- Based on the measurement results and current loading conditions of the pipe (pressure and depth), an estimate will be provided on how many more years the pipe can be used
- Provides an accurate idea of when in the future the pipe will need to be rehabilitated or replaced

Translation: **When to spend capital on this pipe section?**

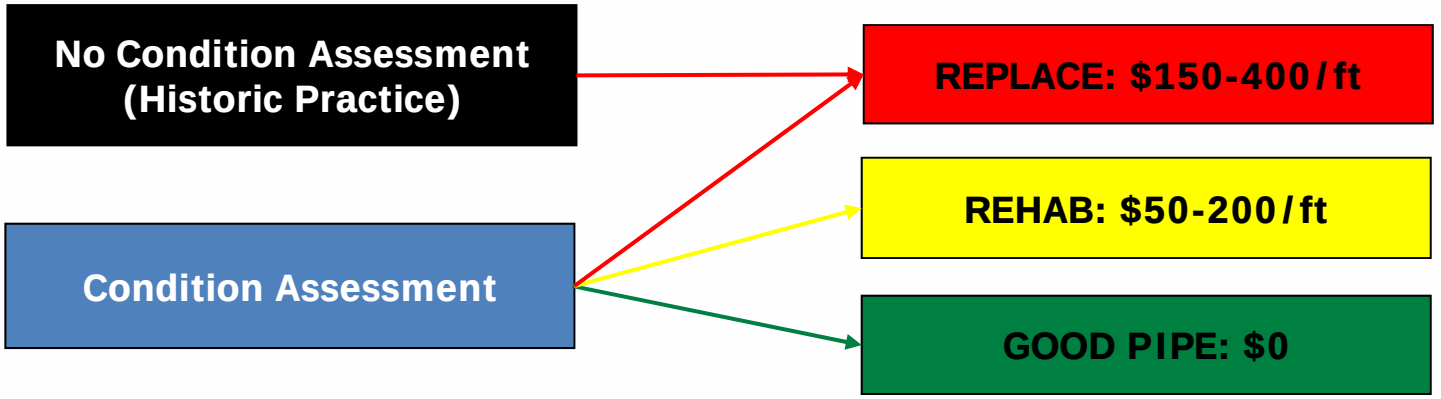
Serviceable Lifetime Prediction: How does it work?

- The Failure thickness is predicted by calculating the minimum required thickness to carry the given loads
- The loads include: internal pressure from the water column and external pressure from the soil and traffic loads



Summary - Creating New Options
Master Planning Pipe Improvements

- Capital Improvement Programs lack Direct condition data
  - Joint leaks often false indicator of pipe condition
  - Relining programs ineffective on pipes lacking structural integrity
  - Estimate 70% of replaced pipes have remaining life
- Leakage
  - Pipe Replacement Programs do not typically address service leaks, estimated to be 2/3 of the leaks in distribution networks
  - Conventional leak detection fails on Plastic / Asbestos Cement



Summary

- Utilities need to understand the condition of their assets
- Much of the pipe is in excellent condition and has significant remaining life
- There are several assessment options available to utilities, both indirect and direct assessment options have a place in the assessment process
- Acoustic assessment has distinct advantages over other methods of direct assessment, but is complementary with other techniques
- Utilities should undertake some kind of assessment for their pipe assets

Questions?

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