IDEA Campus Energy 2015

Acoustic Pipe Wall Thickness Testing and Leak Detection in Aging Water Mains

Water Efficiency, Capital Efficiency, and System Resiliency

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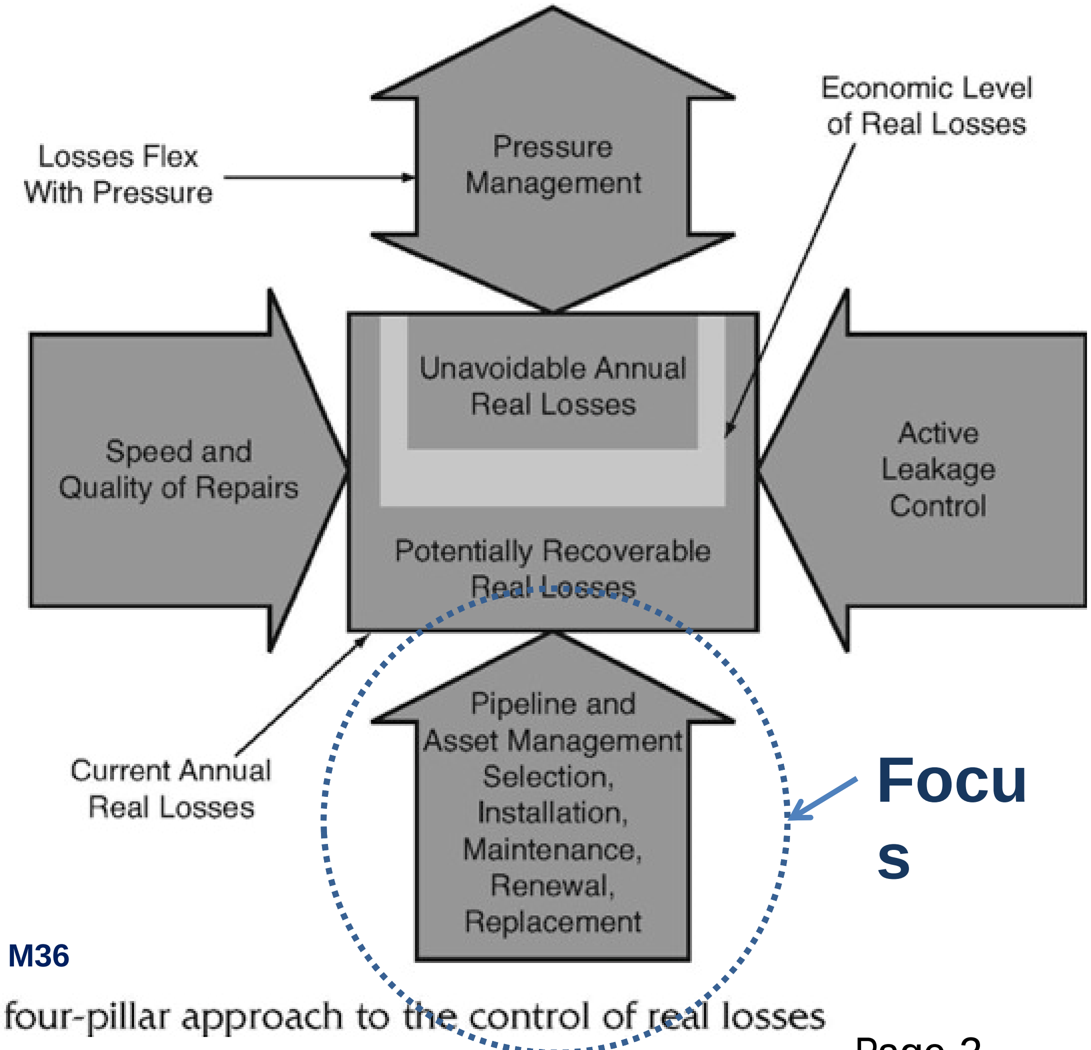
Campus Facility Manager View

NRW, Energy, Pressure, and Pipe

Older pipe networks:

- Leak more (background leakage)
- Leak quieter (more difficult to find)
- Have higher risk of catastrophic failure

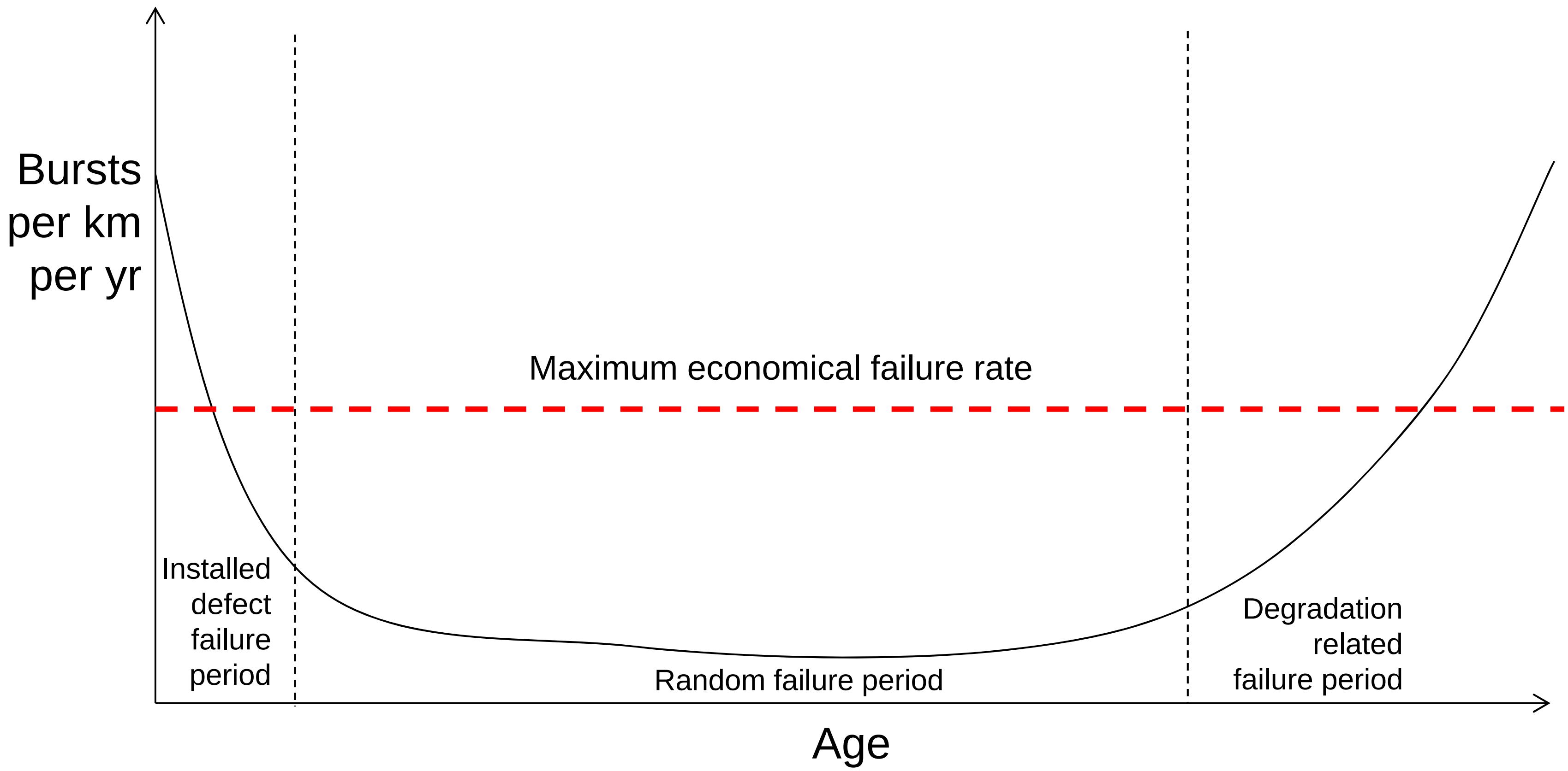


Reference: AWWA M36

Figure 5-1 The four-pillar approach to the control of real losses

Assessing Pipe Condition

Service Life ≠ Design Life



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	6” Cast Iron Pipe

47.3% Measured Loss

0.5% Measured Loss

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The Problem of Pipe Failure
Why Condition Assessment Matters

- All pipe will degrade and fail over time but at varying rates
  - Consequences = water loss and catastrophic breaks
- Pipe is hidden underground
  - No visual way to determine good versus bad pipe
- Reliance on pipe failure history and age is ineffective
  - Up to 70% of mains being replaced are still in good condition
- Replacing and rehabilitating pipe is expensive
  - Pipe replacement costs of $1,000,000 ore more per mile
- Because of price and selection error, wrong pipes are targeted
  - Increasing water loss and likelihood of catastrophic breaks

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Focus: Capital Efficiency

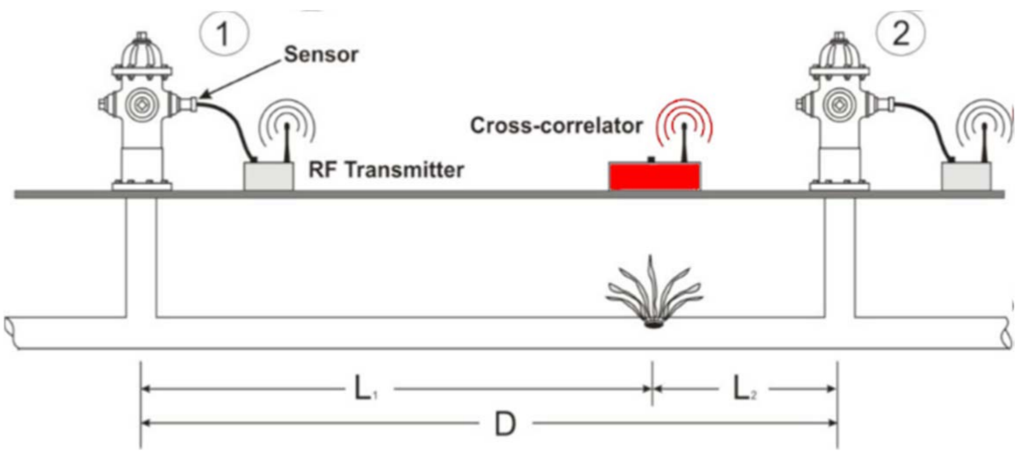
Acoustic Pipe Wall Thickness Testing

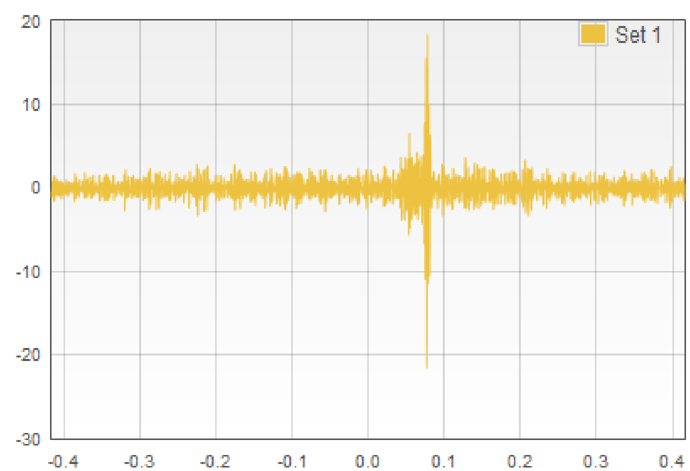
ePULSE

Mueller Co.

Acoustic Leak Correlation Analysis
Principle of Operation

1. Bracket the leak with two sensors
2. The leak sound propagates in both directions
3. Correlator measures the time difference to reach each of the sensors to determine the exact leak location





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Correlation - Connections

Hydrophone - Connection to Fire Hydrant

White Station Radio Transmitter

Surface Mounted Sensor - Connection to Piping in Manhole

Acoustic Pipe Wall Thickness Testing
Survey-Level Condition Assessment

- Overview of the APWTT Approach
  - Targets survey zones within a transmission or distribution main network
  - Completely non-destructive, non-invasive technique
  - Works on any diameter, most materials
- What APWTT results are used for:
  - Direct indicator of the pipeline structural integrity
  - The fitness of the pipeline for service
  - The pipeline remaining useful life

APWTT Benefits - $$$

- ✓ **Identifies the 'good pipe'**
  - **Only 'bad pipe' are replaced/rehabilitated**
- ✓ **Leaks are identified in the process**
  - **Leaks are independent of condition**

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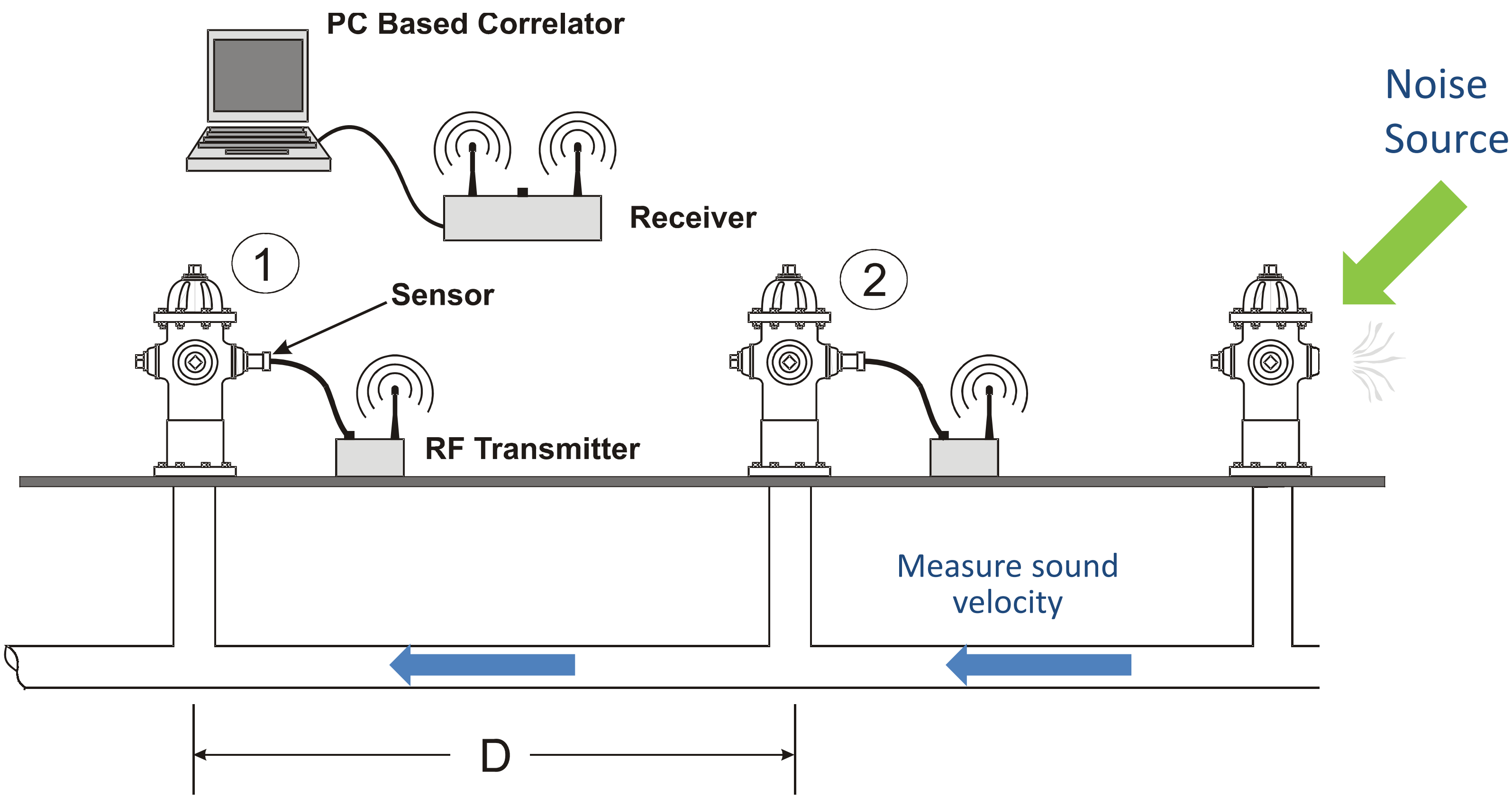
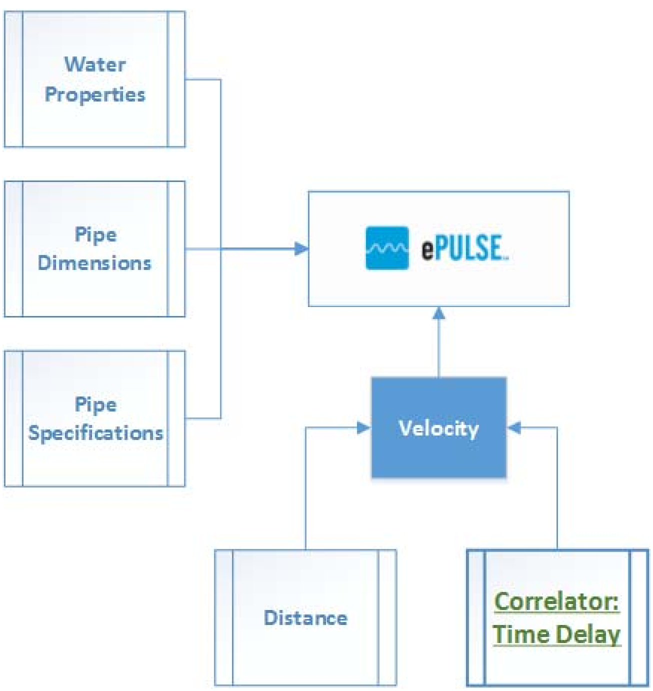
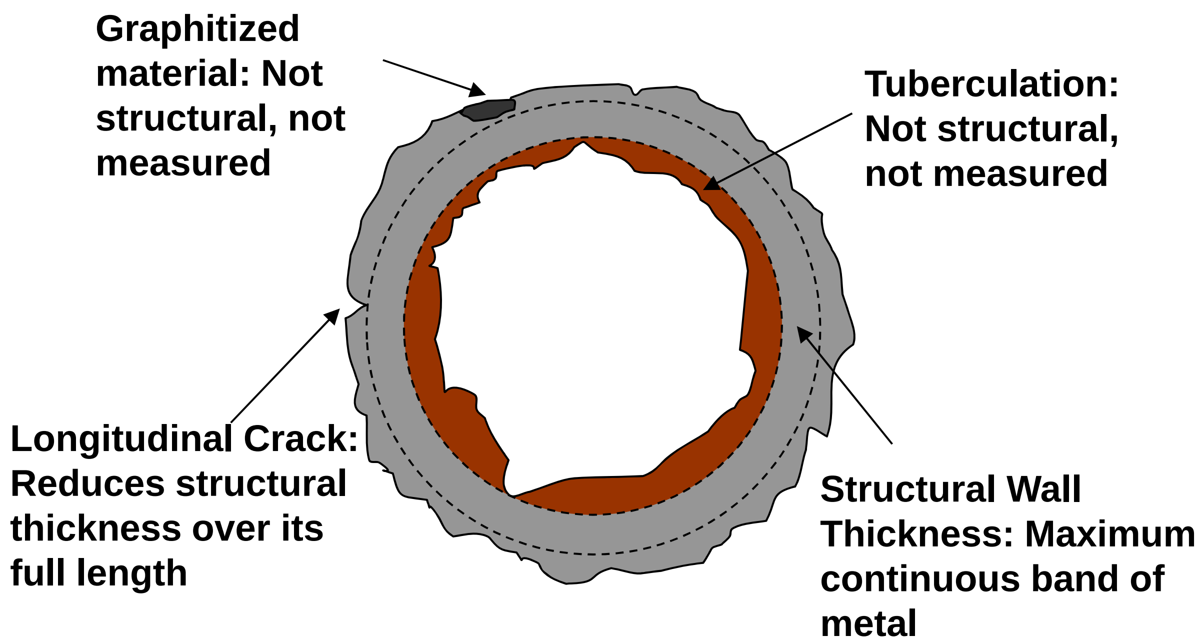
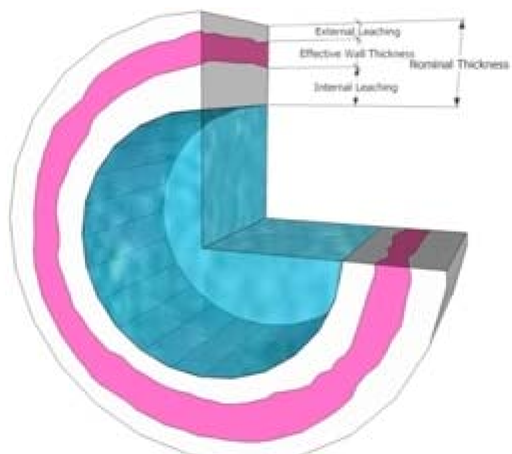
APWTT Survey-Level Testing



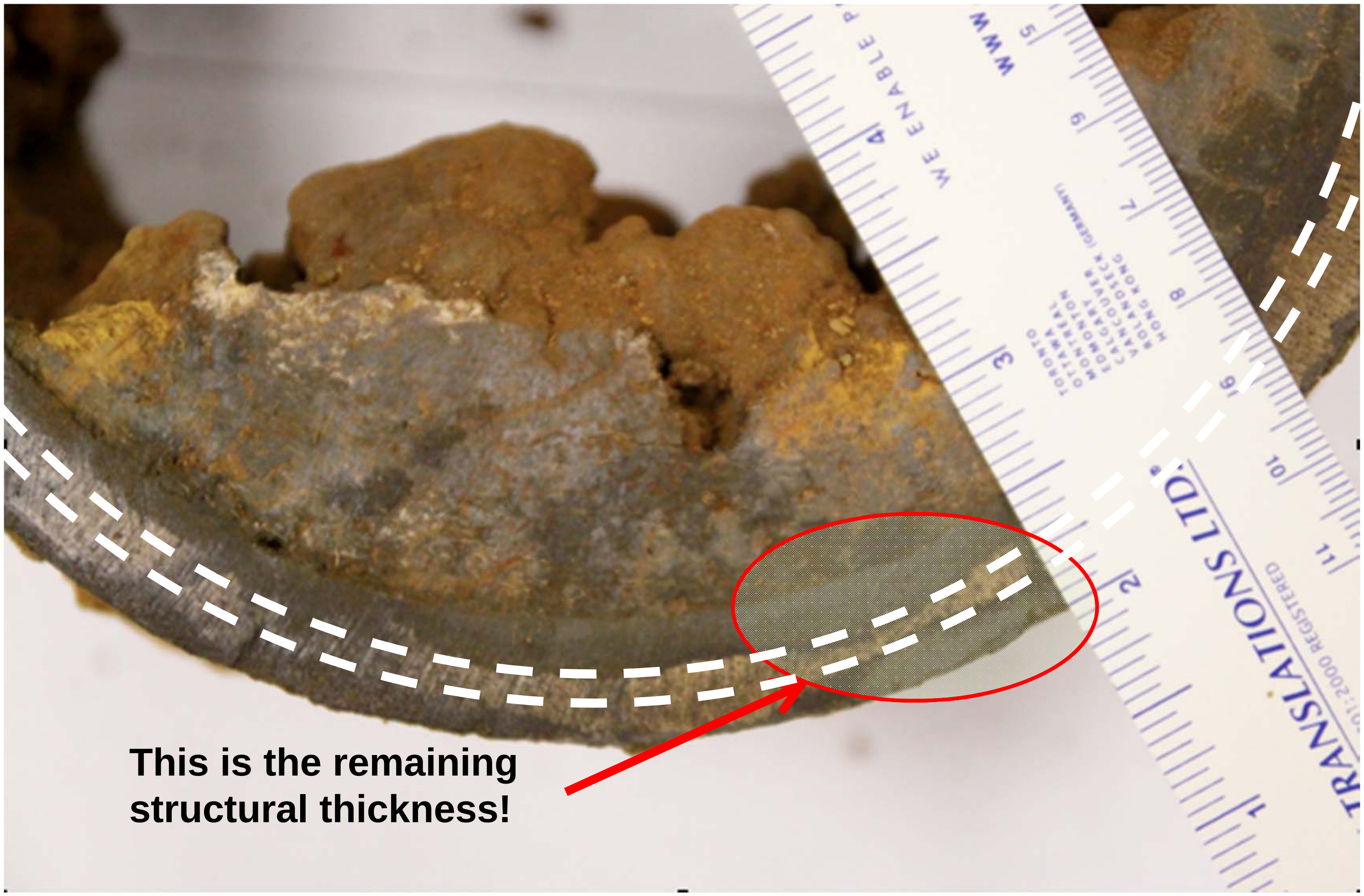
APWTT Survey-Level Testing:
Structural Wall Thickness Only





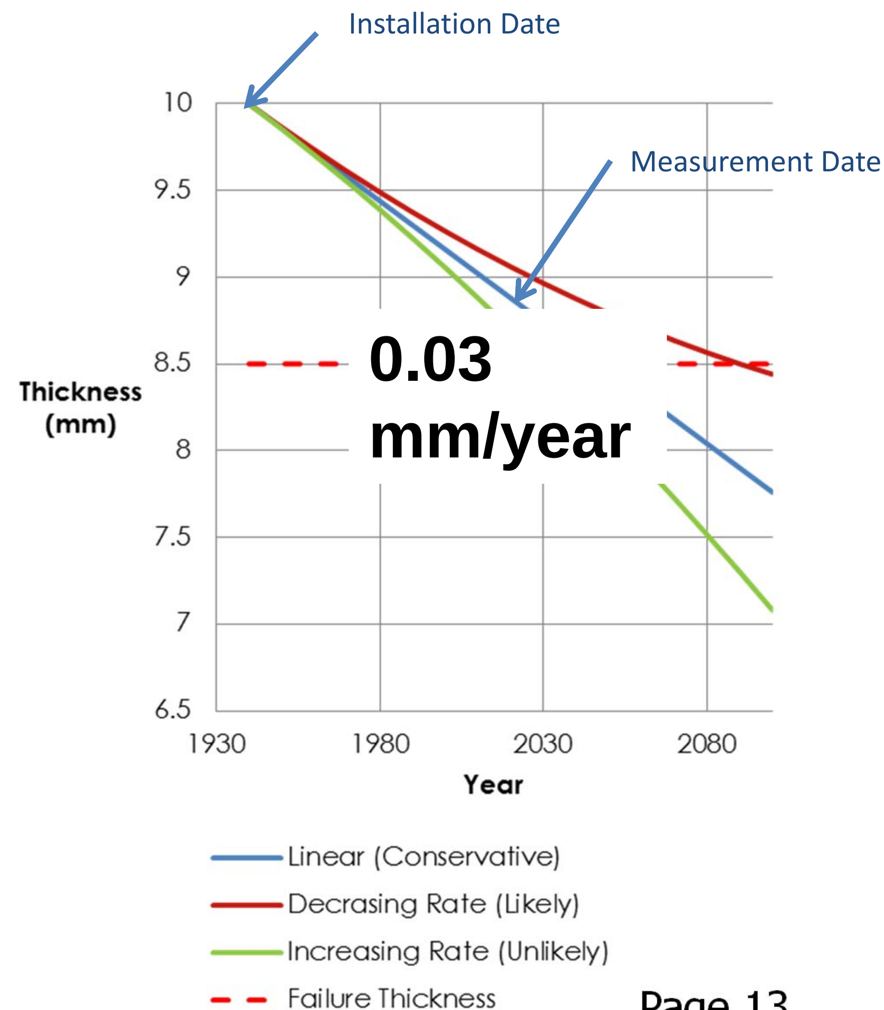


Case Study: City of Newark



Remaining Service Life Analysis
Cast Iron, Asbestos Cement

- The current thickness of the pipe is measured using APWTT
- A linear extrapolation is performed by using the measured thickness, the nominal thickness and the installation date
- 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



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Case Study: Cleaning & Lining

New Jersey American Water

- Used APWTT with Remaining Service Life to pre-assess township area targeted for *Cleaning & Lining*
- Minimal history of breaks
  - Expected pipelines to be in good to moderate condition
  - Expected entire area would be Cement Mortar Lined
- Unlined pit cast, pressure Class C: 4” to 12”
- **Results**
  - **8% of segments in Good Condition** **≤ 10% degraded**
  - **26% of segments in Moderate Condition** **10 – 30% degraded**
  - **66% if segments in Poor Condition** **≥ 30% degraded**
- Verified results via coupon samples
- Used Echologics results to determine level of rehabilitation required, i.e., 3M liner or CML

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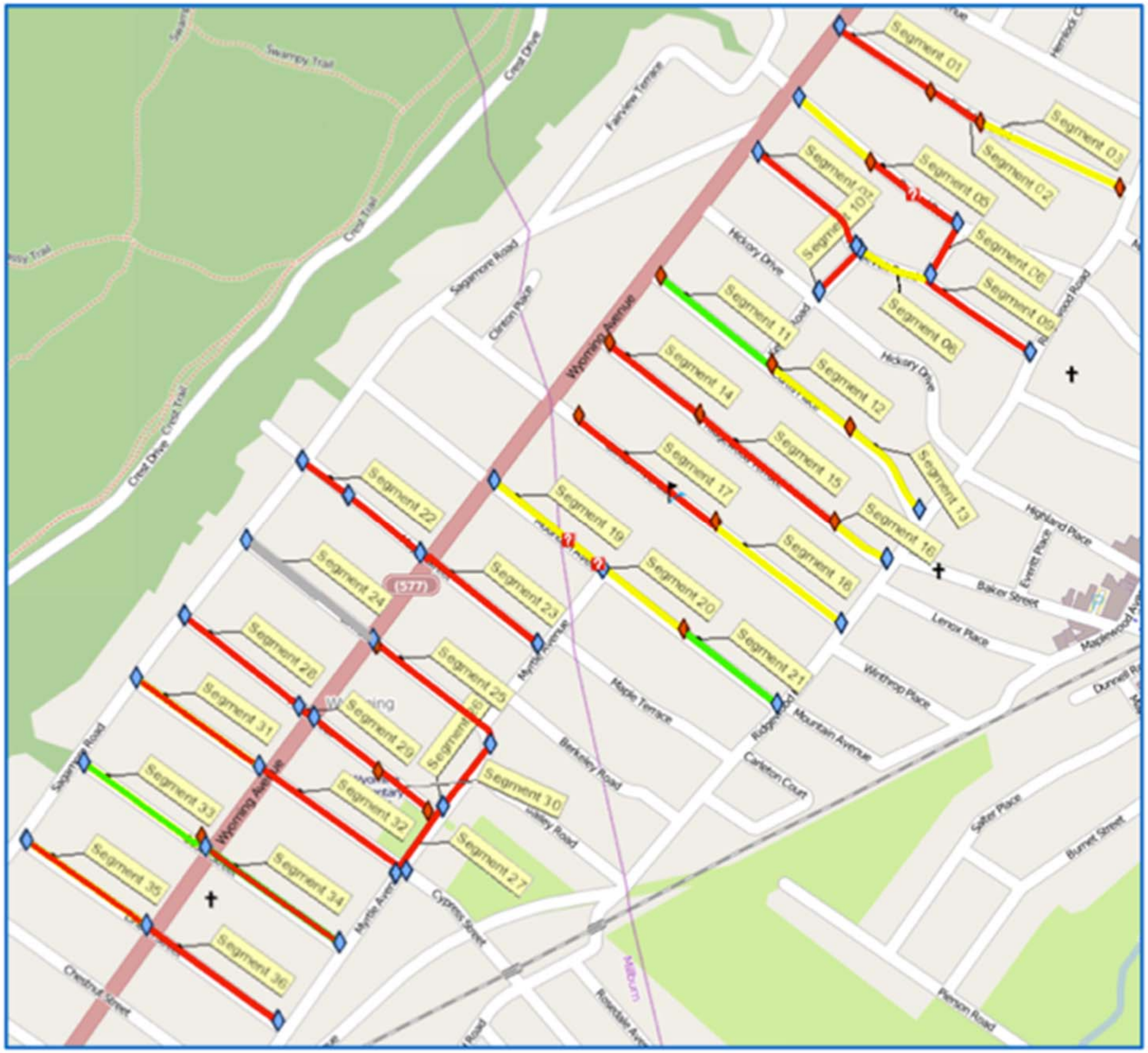
Condition Map: NJAW C&L Project

Good Pipe, Rehabilitate, or Replace?



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Case Study: NJAW C&L Program

Mapping Service Life to Level of Rehabilitation

Cement Total	4839 / 19263	3365 / 19263

Segment Number	Street	Segment Length	Diameter	Nominal Structural Thickness	Measured Structural Thickness	Degradation %	Remaining Safe Service Life	Lining Type
		FT	IN	IN	IN	%	YR	
1	Euclid	452	6	0.49	0.14	71	1	Semi-Structural
2	Euclid	415	6	0.49	0.16	67	7	Semi-Structural
3	Euclid	660	6	0.49	0.21	57	19	Water Quality
4	Durand	501	6	0.49	0.22	55	32	Cement
5	Durand	460	6	0.49	0.17	65	11	Semi-Structural
6	Quentin	259	6	0.49	0.17	65	11	Semi-Structural
7	Roosevelt	684	6	0.49	0.18	62	8	Semi-Structural
8	Roosevelt	370	6	0.49	0.23	53	37	Cement
9	Roosevelt	660	6	0.49	0.13	73	Exceeded	Semi-Structural
10	Kermit	294	6	0.49	0.13	73	Exceeded	Semi-Structural
11	Curtis	759	6	0.49	0.28	43	50	Cement
12	Curtis	396	6	0.49	0.23	53	36	Cement
13	Curtis	536	6	0.49	0.24	51	36	Cement
14	Ridgewood	357	6	0.49	0.16	67	5	Semi-Structural
15	Ridgewood	799	6	0.49	0.17	66	6	Semi-Structural
16	Ridgewood	520	6	0.49	0.24	51	35	Cement
17	Clinton	828	6	0.49	0.17	65	6	Semi-Structural
18	Clinton	764	6	0.49	0.20	59	21	Water Quality
19	Mountain	653	10	0.63	0.34	46	23	Water Quality
20	Mountain	320	10	0.63	0.27	57	37	Cement
21	Mountain	701	10	0.63	0.4	36	50	Cement
22	Maple	440	6	0.49	0.13	73	Exceeded	Semi-Structural
23	Maple	694	6	0.49	0.16	67	5	Semi-Structural
24	Elm	740	4	0.48	N/A	N/A	N/A	REPLACED
25	Elm	706	6	0.49	0.13	73	Exceeded	Semi-Structural
26	Myrtle	407	6	0.49	0.14	71	Exceeded	Semi-Structural
27	Myrtle	367	12	0.68	0.28	59	Exceeded	Semi-Structural
28	Pine	738	6	0.49	0.13	74	Exceeded	Semi-Structural
29	Pine	372	12	0.68	0.25	63	Exceeded	Semi-Structural
30	Pine	379	12	0.68	0.23	66	Exceeded	Semi-Structural
31	Cypress	737	6	0.49	0.1	79	Exceeded	Semi-Structural
32	Cypress	755	6	0.49	0.12	76	Exceeded	Semi-Structural
33	Cedar	736	6	0.49	0.33	33	50	Cement
34	Cedar	786	6	0.49	0.13	74	[illegible]	[illegible]

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Case Study: WSSC

- Over $1.0B is projected over the next decade to address water pipe infrastructure needs
- Increased condition assessment accuracy will result in better use of infrastructure renewal funds
- A pilot project was initiated in 2012 to inspect the pipes already scheduled for replacement to calibrate and verify the desktop model
  - Ultrasonic sensor remaining wall thickness measurements
  - Destructive testing and micrometer measurements for corrosion, graphitization, tuberculation, cracks, and degradation of internal lining

Example Measurement Comparisons

Cooper 1-3:

	Echologics	Correng	Dacco
% loss	8.1		11
Average wall thickness (inch)	0.35	0.34	0.35

Ladd 2-13

	Echologics	Correng	Dacco
% loss	53.6		
Average wall thickness (inch)	0.23	0.27	0.37

Sheridan 1-3

	Echologics	Correng	Dacco
% loss			
Average wall thickness (inch)	0.32	0.31	0.36

WSSC Results: Cast Iron Pipe
From Oct-2013 EAM Conference

		CA Score FY2014 PIT Result				
	35.30 mi	1	2	3	4	5
CA Score FY2013 AMP Result	5	4.00	1.63	0.46	0.79	0.86
	4	5.42	1.24	1.75	0.38	0.54
	3	9.60	2.88	3.28	1.22	1.01
	2	0.08	0.01	-	-	-
	1	0.06	0.11	-	-	-

	LF	miles	% of Total
No change in CA Score:	24,212	4.59	13%
Better* CA Score:	146,978	27.84	79%
Worse CA Score (probable accelerated aging):	15,210	2.88	8%
Potentially deferrable replacements:	76,539	14.50	41%
PIT-assessed critical replacements:	12,718	2.41	7%

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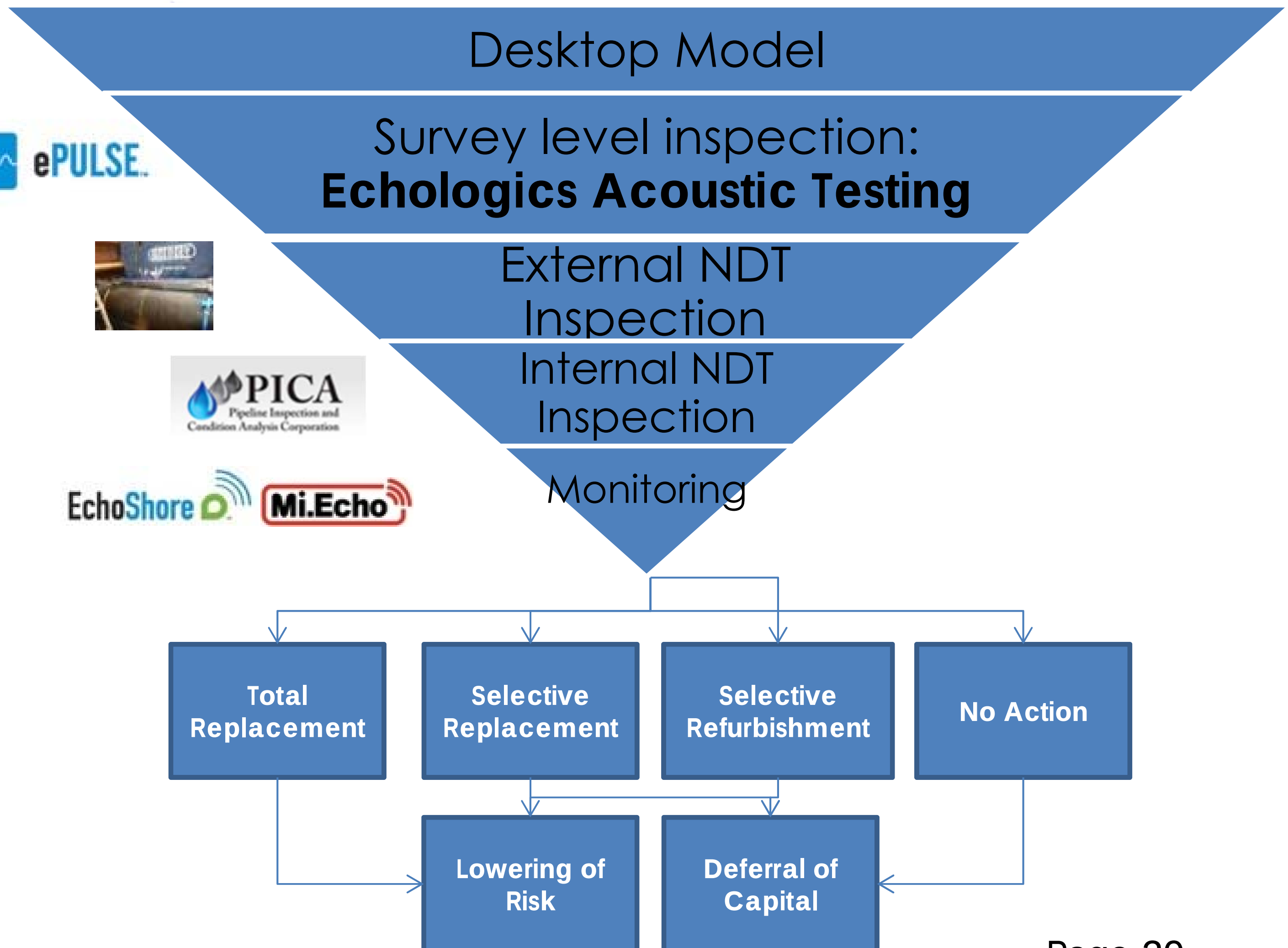
WSSC Program: Ferrous Water Mains

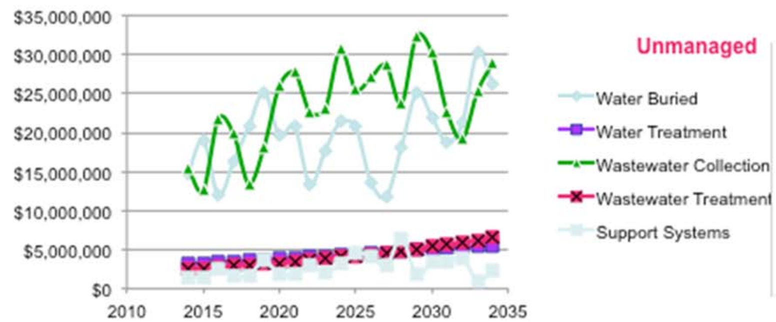
75 Miles/Yr: 65 Distribution and 10 Transmission

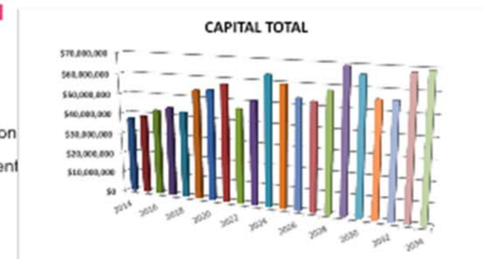
- GIS Map / Data
- Leak Detection
- Wall Thickness
- Electromagnetic External
- Electromagnetic In-Pipe
- Monitoring
  - Distribution
  - Transmission

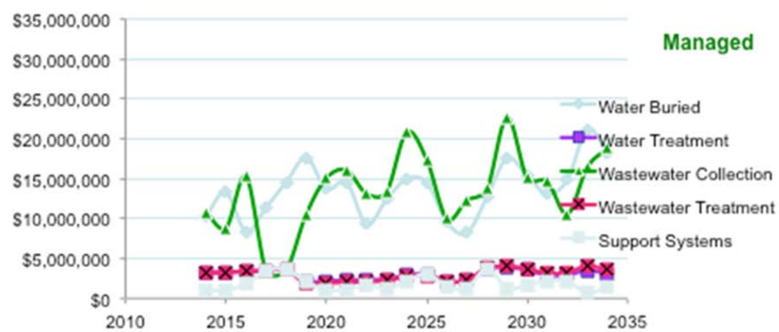


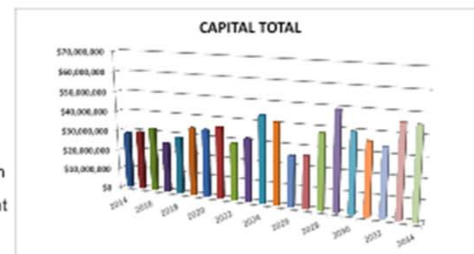
WSSC Monetization of Results

Managed versus Unmanaged Consumption









No Condition Assessment (Historic Practice) → **REPLACE: $150-400/ft**

Condition Assessment → **REPLACE: $150-400/ft** / **REHAB: $50-200/ft** / **GOOD PIPE: $0**

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WSSC Pipeline Inspection Programs

Three Levels of Inspection

- **Level 1: Desktop Modeling**
  - Develop condition scores based on decay curves by asset type and maintenance history.

- **Level 2: Inspection**
  - Assess the condition of pipes targeted for rehabilitation to make rehab/replacement decisions and update Level 1 condition scores. Examples: acoustic-based testing, electromagnetic assessment, visual inspection, etc.

- **Level 3: Monitoring**
  - Do selective monitoring of critical (high risk) pipelines.

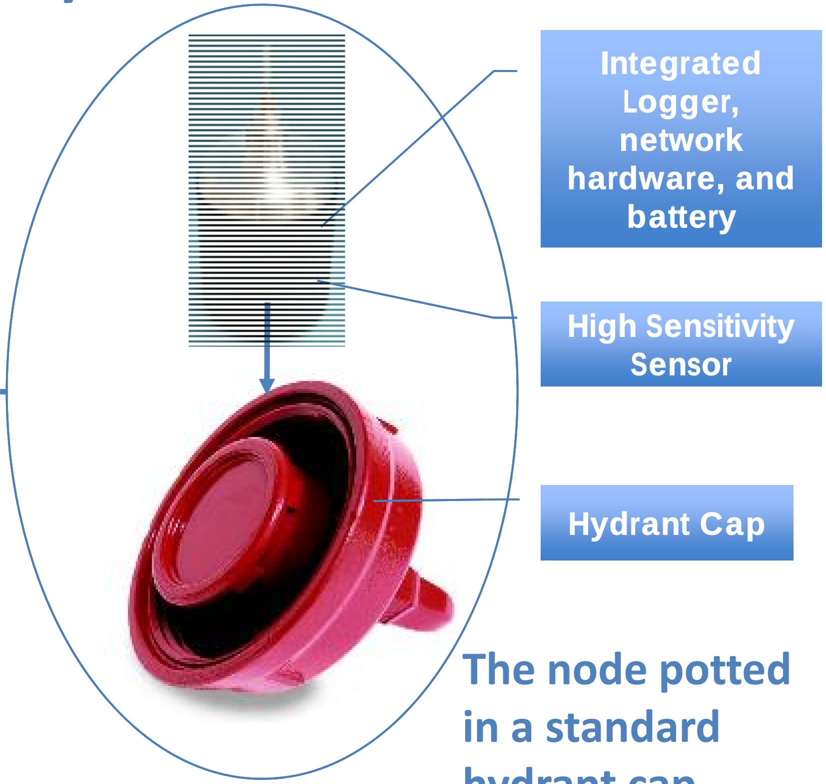
Water Efficiency and System Resiliency

Benefits of Fixed Leak Monitoring

- **Reduces *Non-Revenue Water*** with early leak detection
  - Average leak goes undetected for up to 9 months
  - Decreases background/quiet leaks which may account for up to 3% of water loss
- **Avoids catastrophic bursts** by fixing leaks early
  - Liabilities $1M+ including collateral damage for transmission mains
  - Avoid bad publicity and customer dissatisfaction
- **Saves repair costs** by planning out repairs instead of emergency repairs
  - Prioritizes limited capital and maintenance spending
  - Significantly reduces *false positives*
- **Extends Asset service life**

Distribution Fixed Leak Monitoring

RF transceiver featuring high sensitivity sensor*



The node potted in a standard hydrant cap

** Based on the next-generation proven LeakFinder™ technology*

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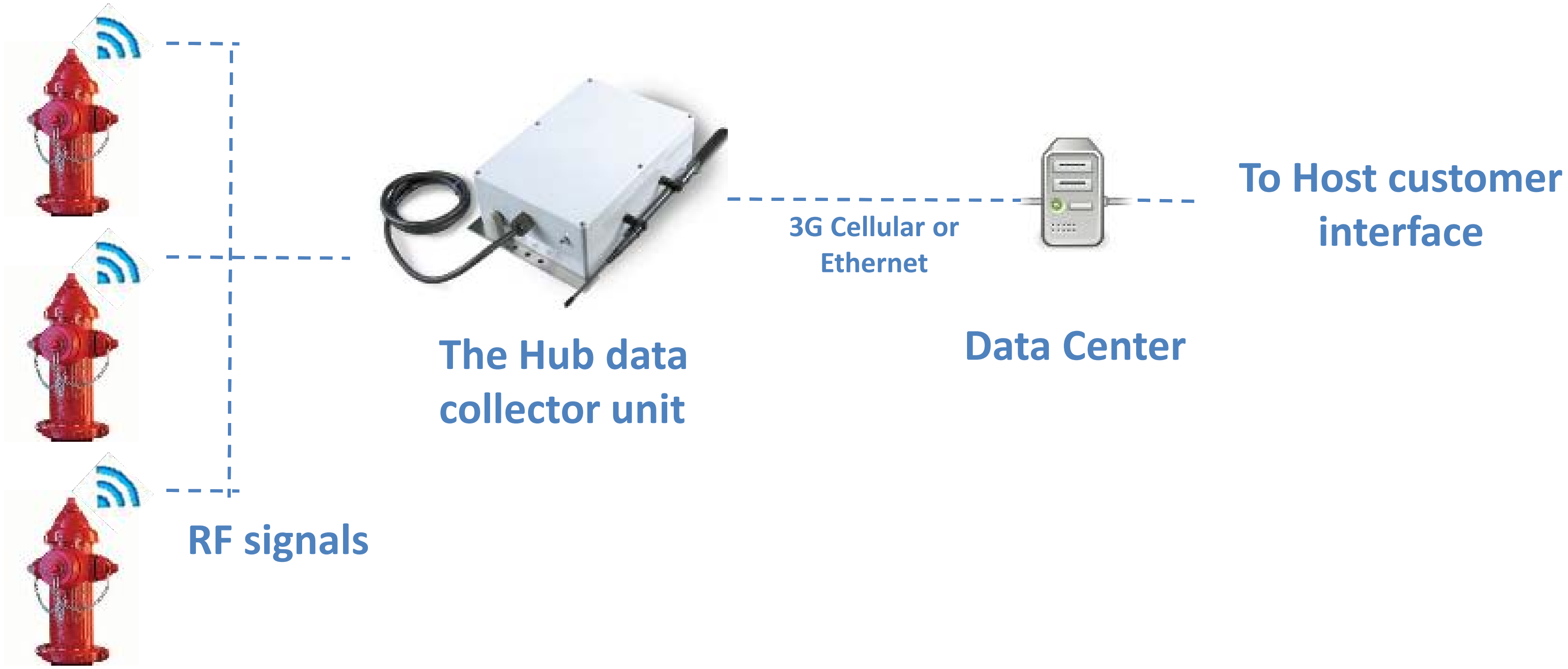
Distribution Fixed Leak Monitoring

System comprised of a series of leak loggers and collectors:



Network of interconnected logger nodes monitors a service area

Distribution Fixed Leak Monitoring

Specifications

→ **GIS Data for the geographic area to be monitored**

→ **Pipe material, pipe diameter, hydrant locations**

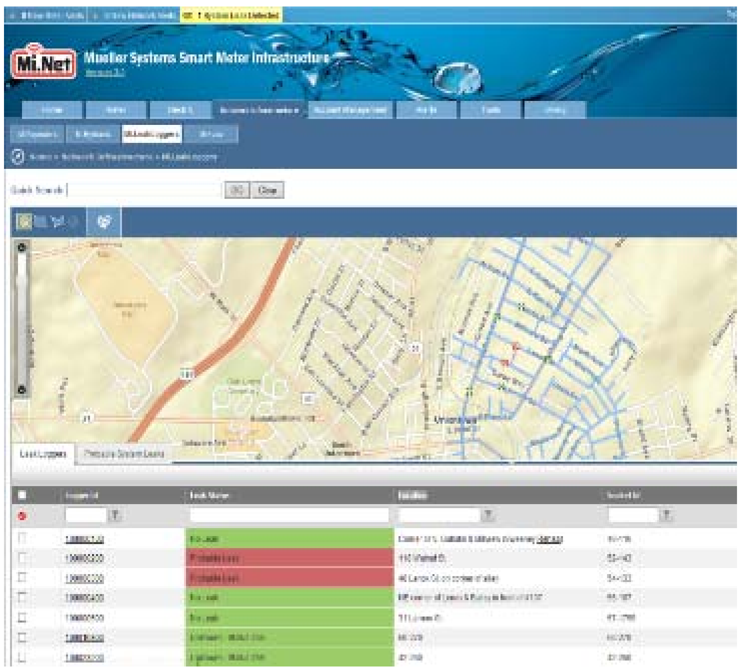
→ **Network propagation study to determine network infrastructure reqs**

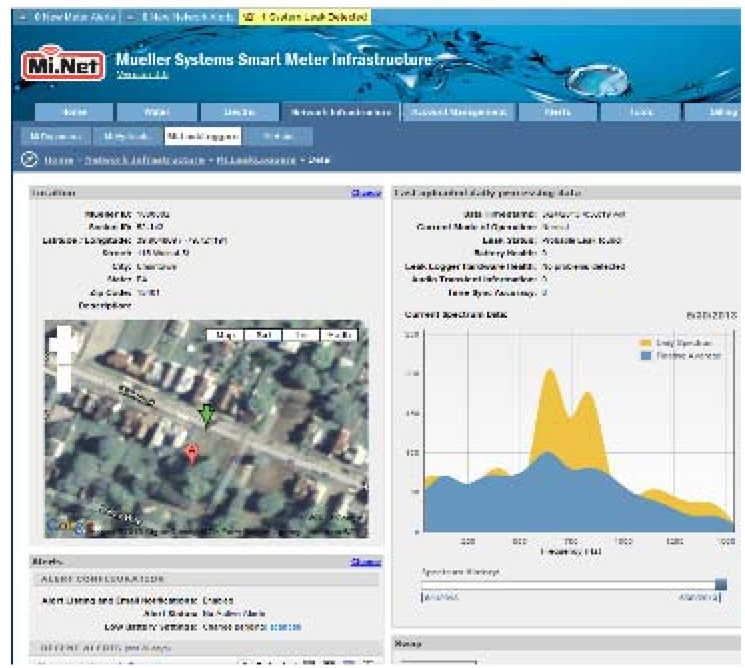
Operating Parameters	
Maximum Mi.Echo Node Spacing	1,500 ft. for non-plastic pipe materials A site specific survey is required for plastic pipe materials
Pipe Diameter	Up to 12" diameter (300 mm)
Pipe Material	Cast Iron, Steel, Ductile Iron, Asbestos Cement, PCCP, PVC, PE, and other plastics
Battery life	5 years
Liquid Temp	33°F to 100°F (0.5°C to 38°C)
Ambient Temp	-27°F to 130°F (-33°C to +55°C)

Distribution Fixed Leak Monitoring

User Interface

- **Leverages existing functionality of AMI host system**
- **Graphical and visual display of system status**
- **Leak events geospatially positioned within water infrastructure**





Advanced leak detection integrated with AMI host interface

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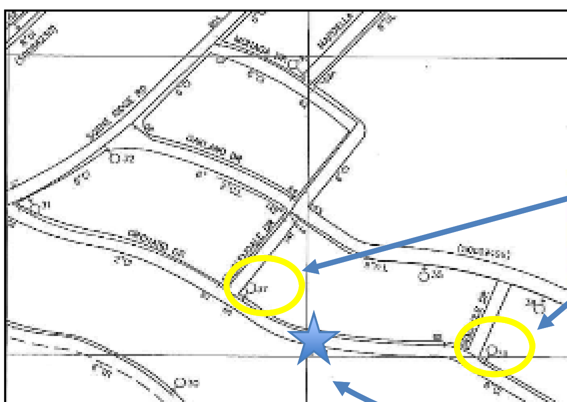
Fixed Leak Monitoring
Case Study: Liberty, Pennsylvania

Confirmed leak occurrence on May 1, 2014

- PA American Water first informed of the possible leak on April 4
- PA American leak detection crew investigated the area using other leak detection products – could not confirm the leak.
- Based on proprietary indicators, the fixed monitoring system registered the progressive severity of the leak over 4 weeks.



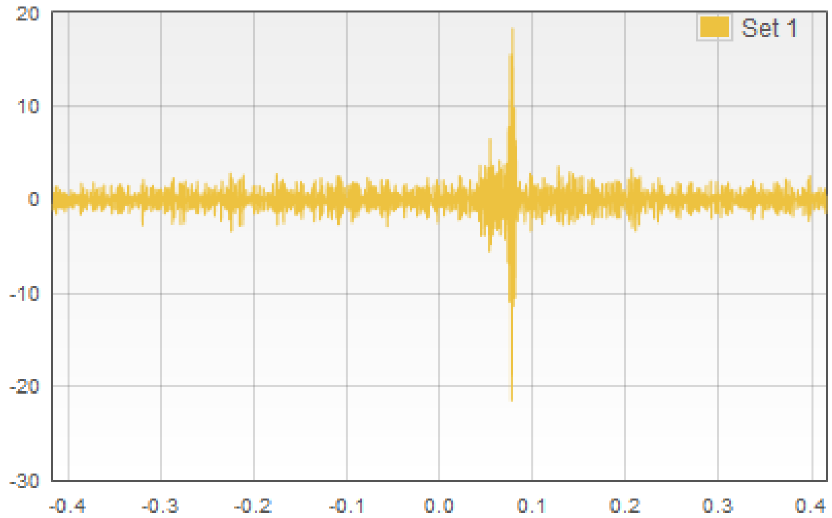
Correlating hydrant nodes 961 ft. apart

Leak location at 337 ft.

Continuous Monitoring
What is the potential?

Ability to track the progression of a leak from…

$95,000 system price



+4 weeks

(prior to excavation)

"It was a time bomb diffused" – Dave Hughes, American Water

~$100,000 repair cost from a 5 gpm leak mitigated

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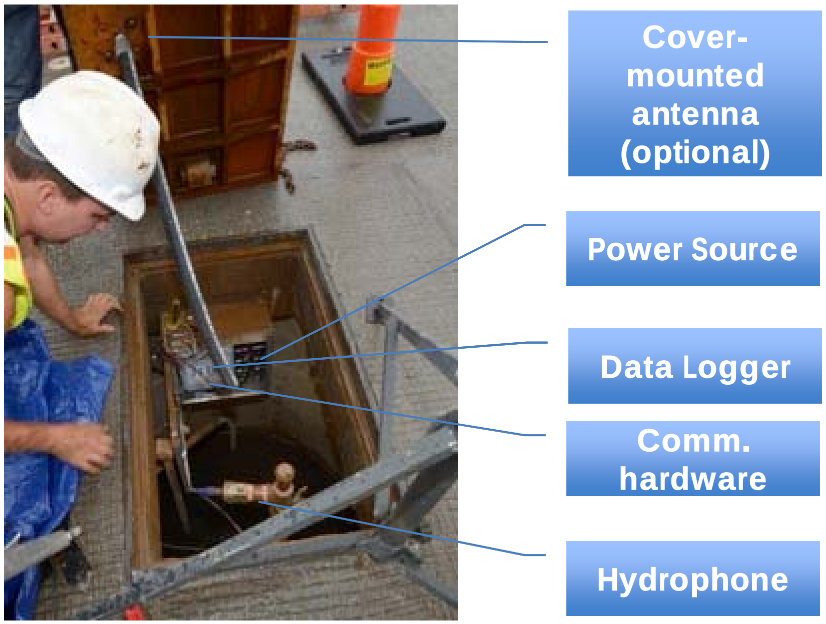
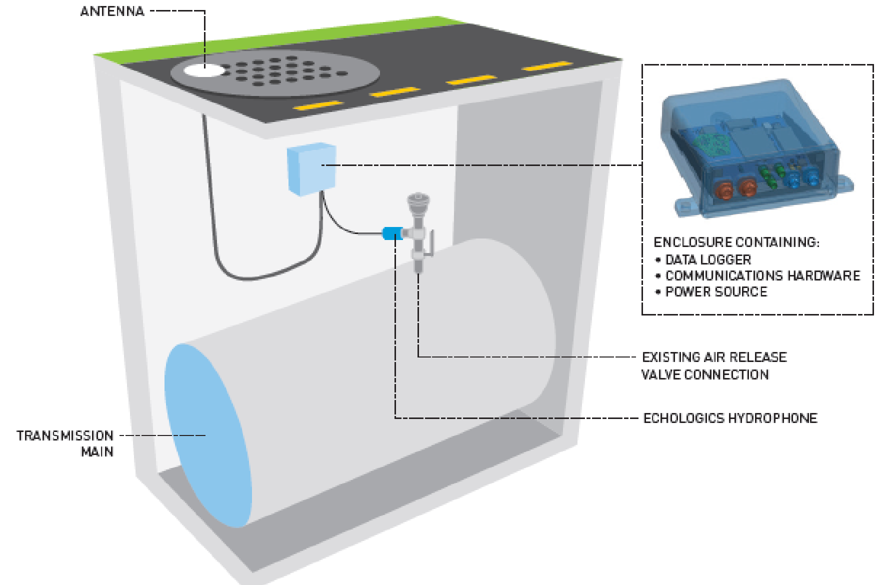
Transmission System Monitoring

*Sampling Node**



EchoShore node installed in an access chamber



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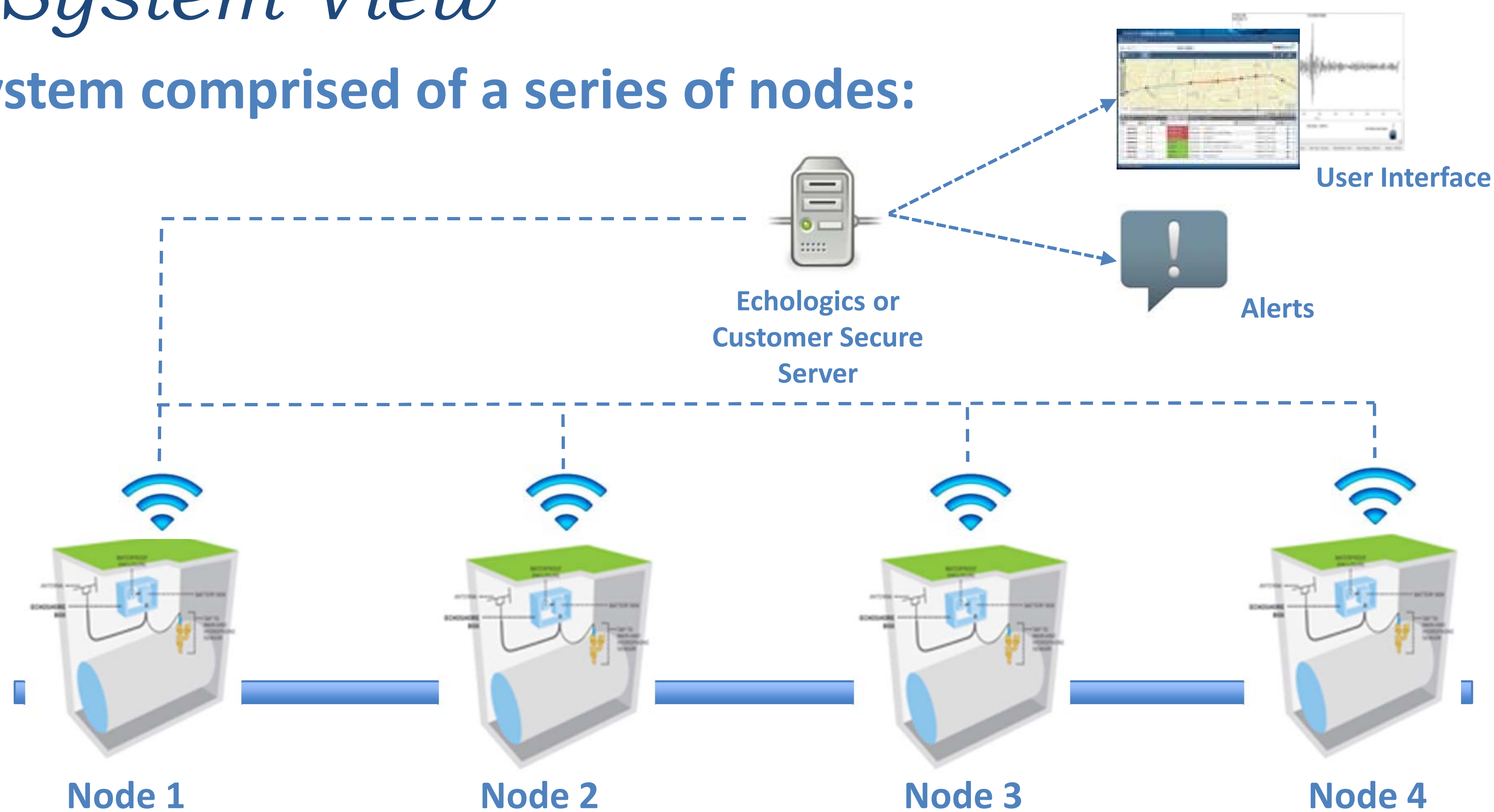
Transmission System Monitoring

System View

System comprised of a series of nodes:



Network of interconnected nodes monitors a service area

Continuous Monitoring

Platform for Other Critical Parameters

Turbidity

Pressure/Flow

Temperature

Chlorine

Additional input ports reserved for sensor signals

Opportunity to expand from advanced leak detection to customized pipeline monitoring

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Back-up Slides

Severn Trent: Challenges of Plastic Pipe

The ineffectiveness & impracticality of standard correlators to locate and pinpoint leaks on plastic pipe:

- Poor propagation and rapid attenuation of leak signals
- Low frequency leak signals at distance
- Existing accelerometers not sensitive enough to low frequencies
- Insufficient processing power and speed
- Minimal frequency analysis and filtering
- Inaccuracies due to incorrect default velocity data
- Alternative in-pipe technology risky and costly
- Water companies still using standard correlators and resorting to manually sounding on plastic pipes despite these issues!

"Secret Sauce"

- 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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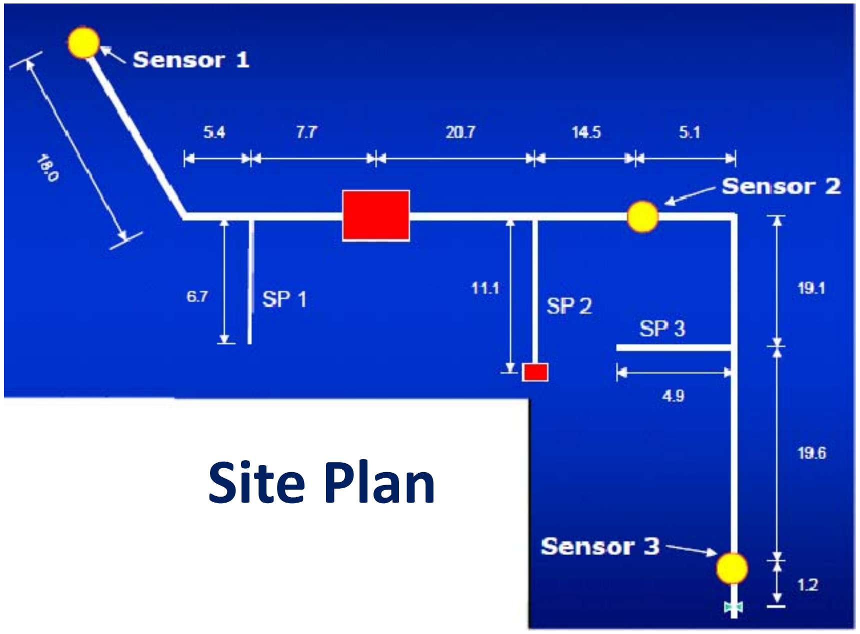
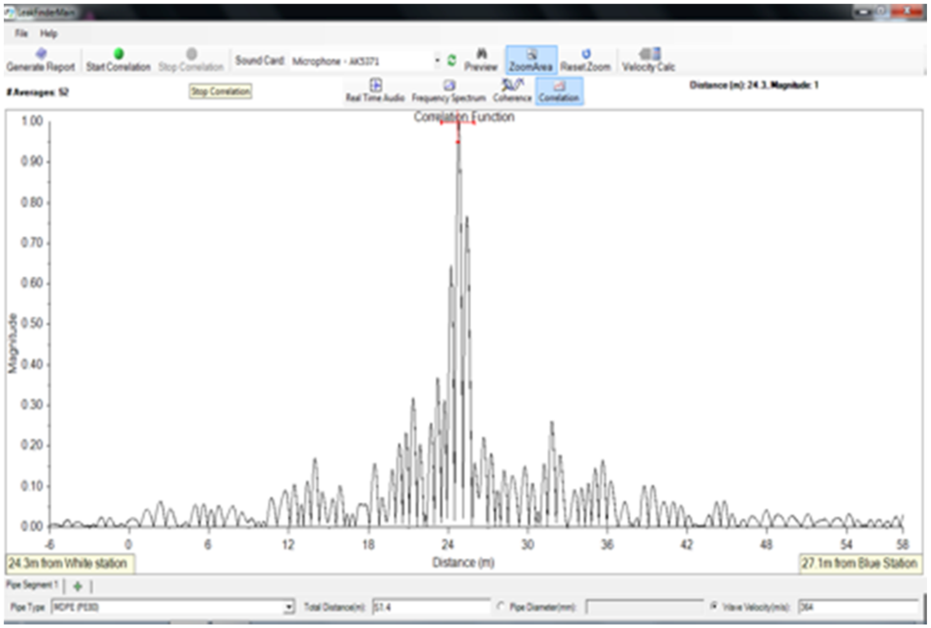
Severn Trent Water (STW)

Test Center – Lake House

- STW Lake House – 6” MDPE
- Induced leaks at variable flow
- **NO correlator had ever succeeded on this test leak**

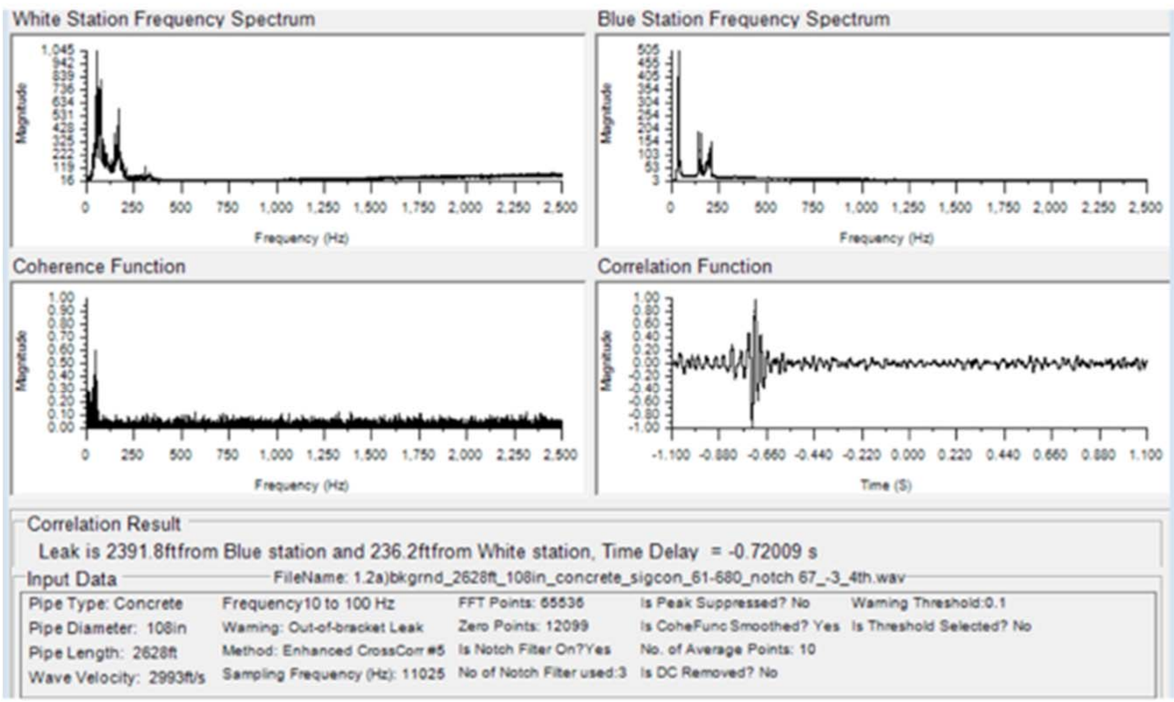




Transmission Main Leak – Confirmed:
108” Concrete 2,627’ Between Sensors

Utility: East Bay Municipal Utilities District
Project Location: California, USA
Project Timeframe: September 2010

Pipeline Diameter: 108”
Correlation Plot Number: 3
Material: Concrete



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