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Improved Management of Water Infrastructure Assets Using Non-Invasive Acoustics to Help Determine Rehabilitation Strategy

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Presentation Outline

NEW JERSEY AMERICAN WATER

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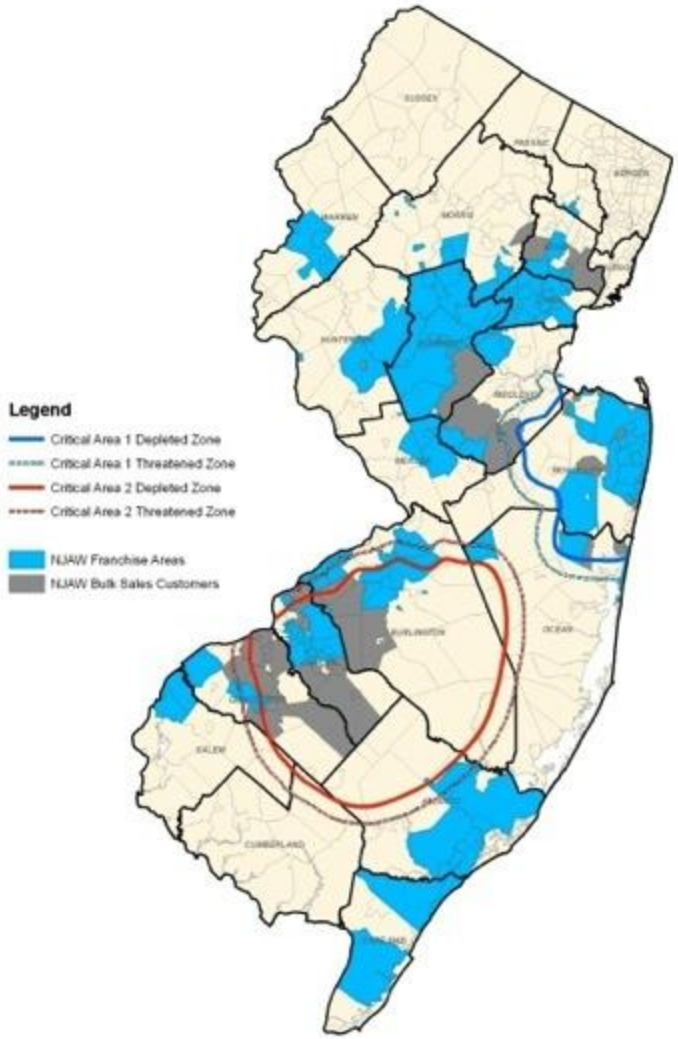
- Introduction
- Replacement vs Rehabilitation
- Acoustic Condition Assessment
- Piloting
- Results and Validation

New Jersey American Water at a Glance



Population Served	**2.5 million**
Counties Served	**18**
Municipalities Served	**188**
Total Employees	**800**
Water Systems	**32**
WW & Sewer Collection Systems	**21**
Average System Delivery	**330 MGD**
Average Non Revenue Water	**15%**
Annual Electric Energy	**196million kWh**
Annual Greenhouse Gas Emissions	**129,000 metric tons CO2e**

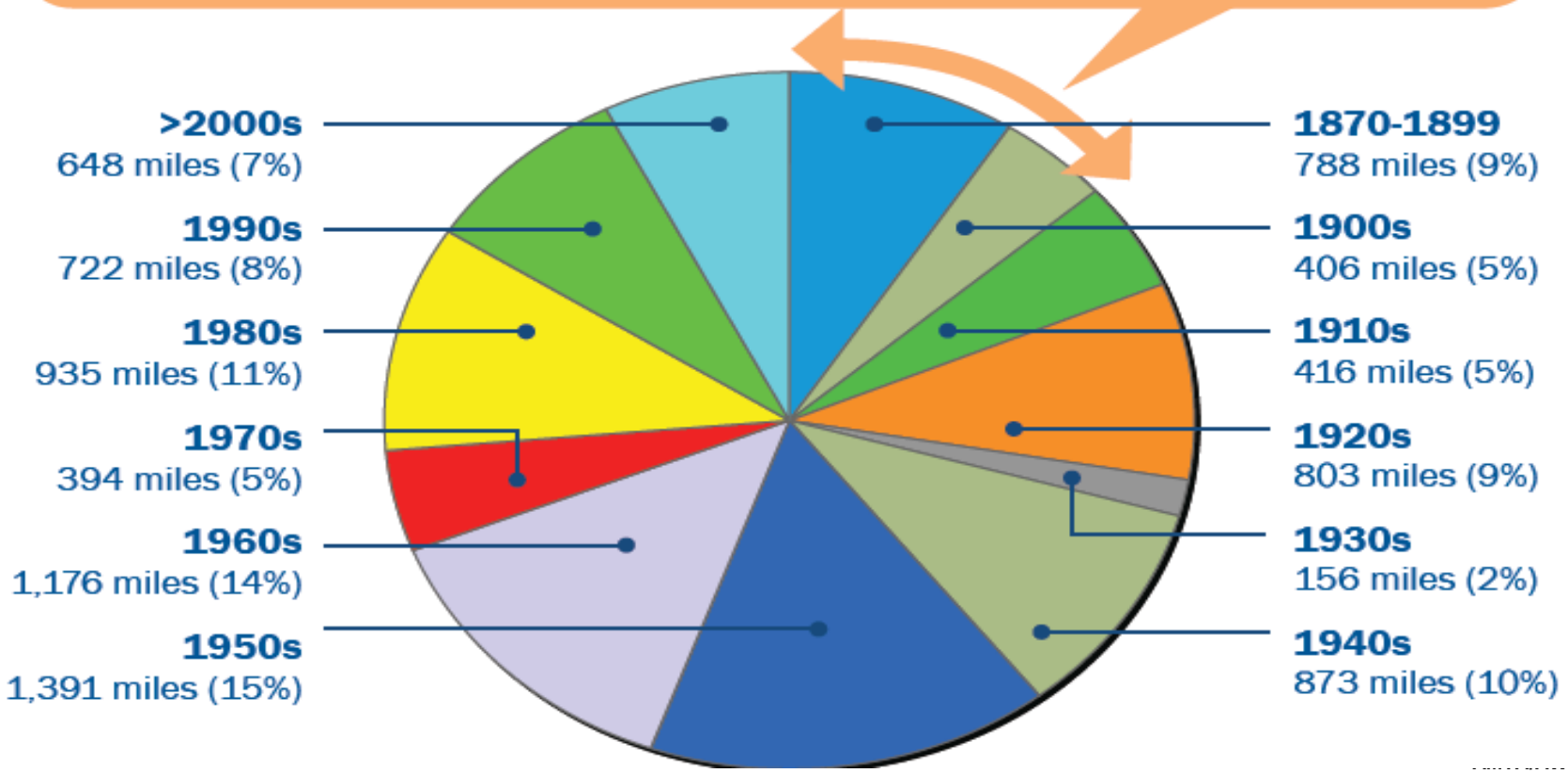
New Jersey American Water Infrastructure

Surface Water Treatment Plants	**7** (combined capacity of 350 MGD)
Reservoirs	**5** (combined capacity of 6 billion gallons)
Wells	**170** (combined capacity of 110 MGD)
Tanks	**241**
Operating Centers	**11**
Water & Sewer Mains	**8,600 miles** (2" to 72" diameter)
Aging Pipes	**15% of pipes over 100 years by 2020**
Valves	**170,000**
Hydrants	**45,000**

New Jersey American Water's Distribution System

Age of New Jersey American Water's Pipes by Decade

As it stands today, over 15 percent - or 1,300 miles -- of New Jersey American Water's 8,700 miles of pipe are between 100 and 140 years old and nearing the end of their useful lives.



Rehabilitation Methodology Decision Driver

Figure 6 – 2012 Main Breaks

Main Breaks

The two municipalities have had a total of 106 main breaks over the last four years, see Table 1. This study is not inclusive of either municipality in its entirety. Figure 6 below identifies main breaks reported in Mapcall for the year 2012. There does not appear to be any major structural issues with the water mains but a condition assessment to measure remaining wall thickness is recommended prior to implementing the project(s) and selection of rehabilitation methods.

Table 1 – Water Main Breaks

Main Breaks	Year				
Town	2010	2011	2012	2013	Grand Total
MILLBURN	20	16	16	31	83
MAPLEWOOD	5	4	2	12	23
Grand Total	25	20	18	43	106

Replacement vs Rehabilitation?

- **Water distribution pipe problems can be addressed through either rehabilitation, trenchless or open-cut replacement.**

  - **Main Rehabilitation: Improvements of the functional service of an existing pipeline system by lining the interior, involves placing a water tight surface inside of an existing pipeline system without requiring extensive excavation of the soil.**

  - **Replacement: Installing a new pipeline without retaining the existing pipeline by either open cut or trenchless replacement.**

Drivers For Rehabilitation?

- Deliver best value to our customer and stakeholders
- Improve water quality and fire flows
- Labor, material and restoration cost increases
- Minimize neighborhood disruption
- Emerging technologies and applications
- Extending the life of existing assets
- Structural and semi-structural rehabilitation opportunities
- Utilize green alternatives
- Larger target area potential

New Jersey American Water's Rehabilitation Strategy Pre-2013

- **Traditional Main Replacement**: Leak history was assessed and mains that had multiple leaks in the past 5 years were retired and replaced with ductile pipe via open cut.
- **Cement Mortar Cleaning and Lining**: Leak history was assessed and mains that did not have multiple leaks in the past 5 years were rehabilitated.

BEFORE

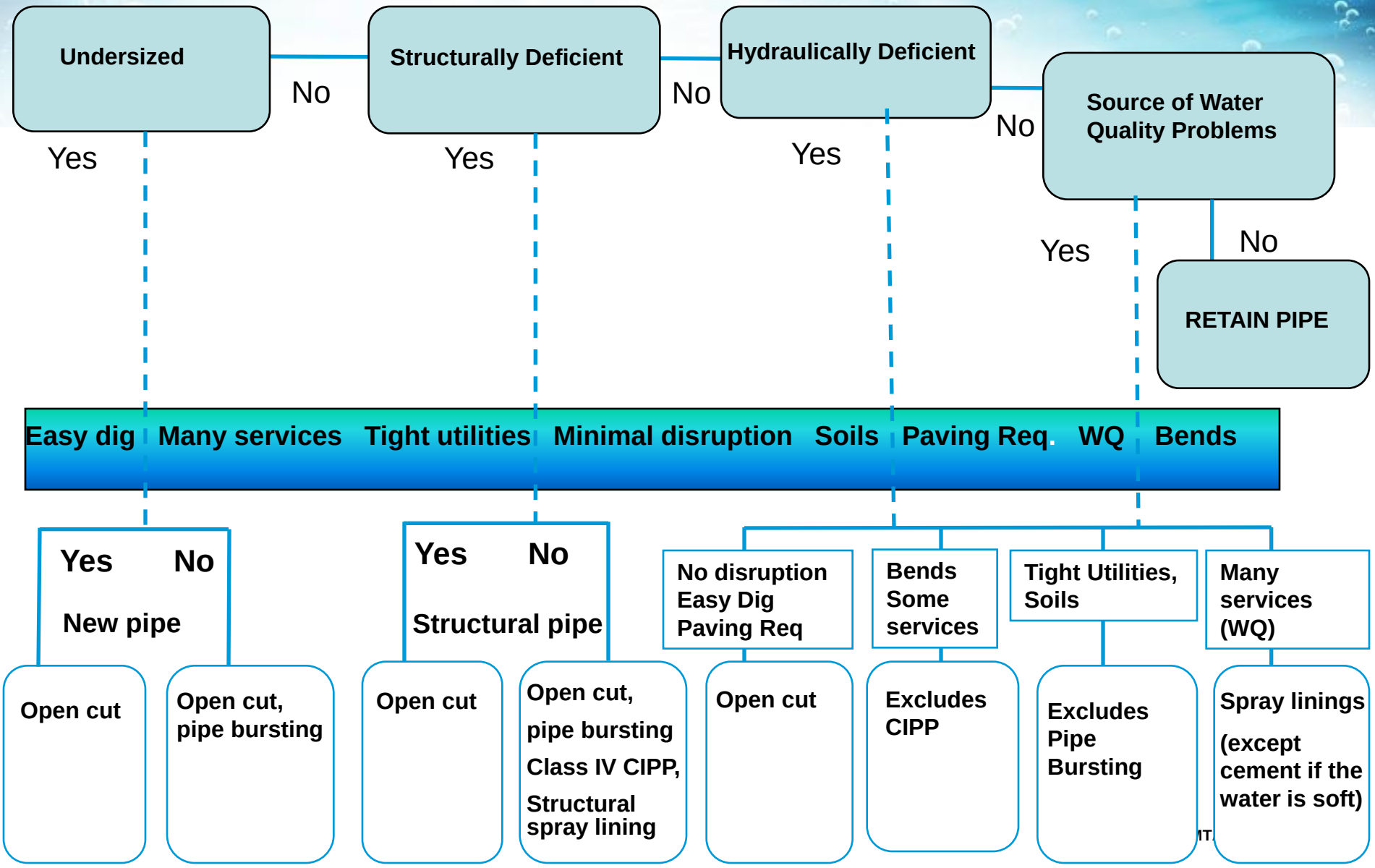
AFTER

Primary Target for Main Rehabilitation

Pre-1960 Cast Iron Main

- Mineral deposits decrease water volume and cause discoloration especially during higher flow conditions
- Graphitization in cast iron causes main breaks

New Jersey American Water's Decision Matrix



What Methodology Is Best?

Cement Mortar Lining

Open Cut

Slip Line

Cured in Placed

Two Stage Poly Urea

Acoustic Condition Assessment

What is it?

- A method to non-intrusively measure the condition of water mains
- There is no disruption to service while mains are being tested
- Existing valves and fire hydrants can be used as test points

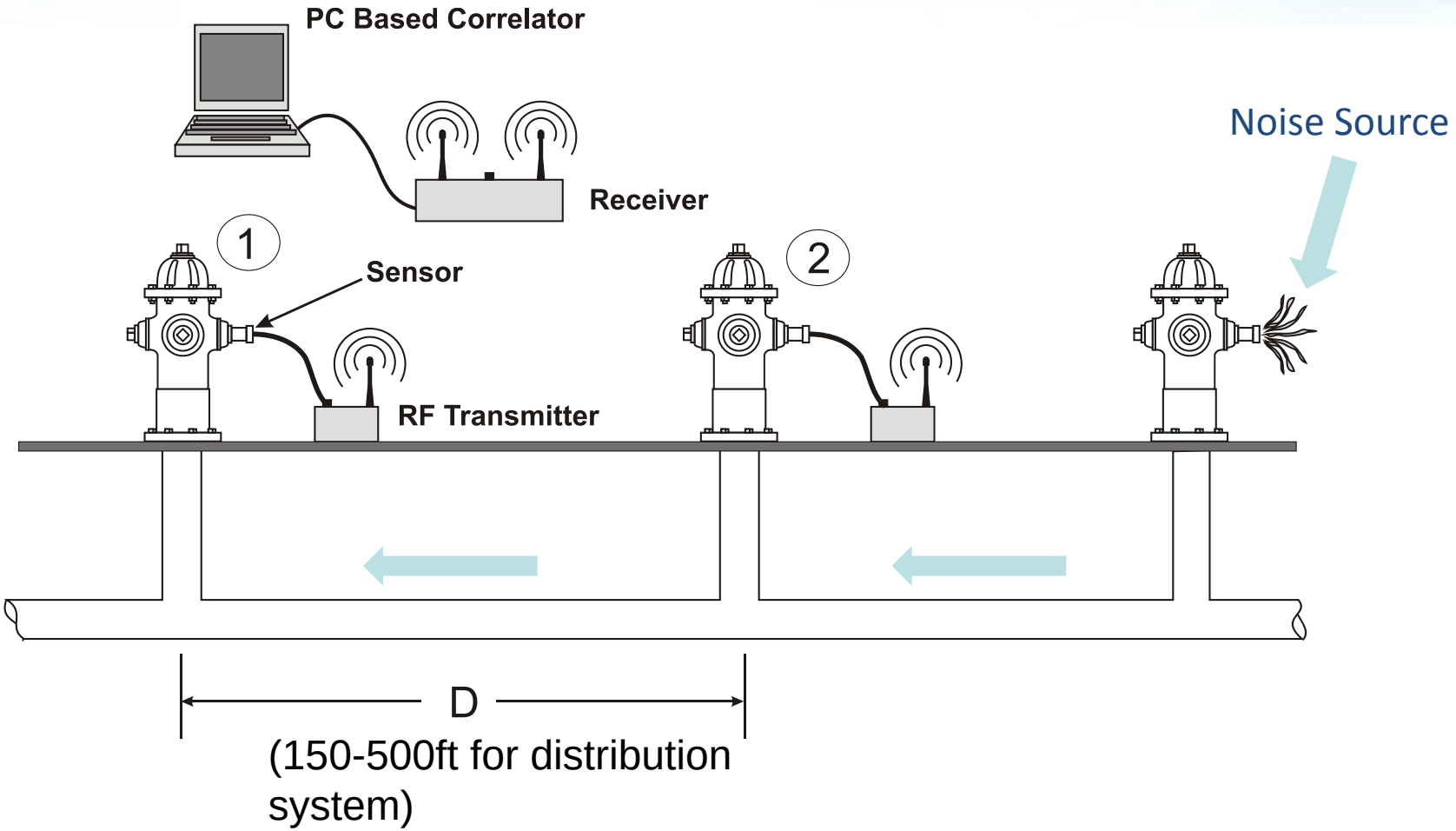
Requirements?

- Pressure >= 15 PSI
- No air in pipe
- Accurate pipe information (maps, as-built, specs)
- Access points, ideally every 300’ to 500’
- Cast Iron, Ductile Iron, Steel, Asbestos Cement

Where is it applied?

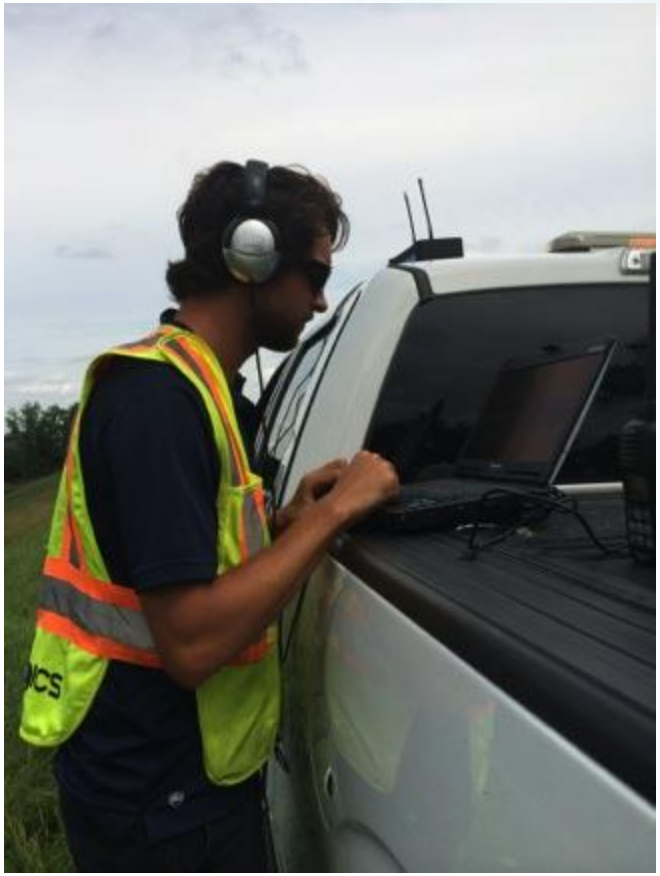
- Survey level condition assessment of large networks
- One-off measurements on critical pipelines
- When leak detection alone is not enough

Acoustic Condition Assessment



Acoustic Condition Assessment

- A low frequency acoustic pressure wave is induced in the pipe
- This pressure wave causes pipe wall to “flex” on a microscopic level
- Thicker pipe walls are more resistant to this “breathing,” causing the wave to travel faster
- Measuring this phenomenon allows calculation of remaining wall thickness



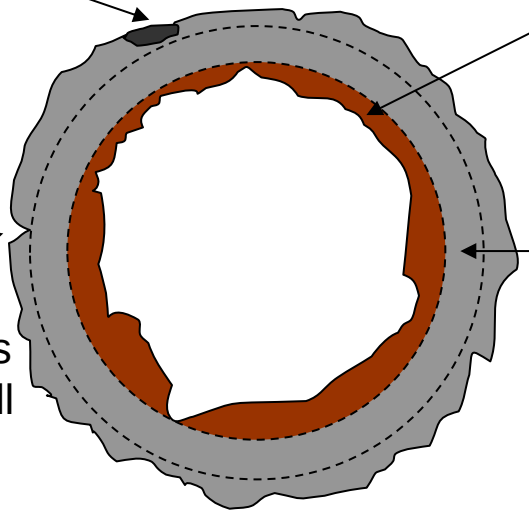
Structural Wall Thickness: A Direct Measurement of Structural Strength

Average structural wall thickness

- Band of continuous material

Graphitized material: Not structural, not measured

Tuberculation: Not structural, not measured



Structural Wall Thickness: Maximum continuous band of metal

Longitudinal Crack: Reduces structural thickness over its full length

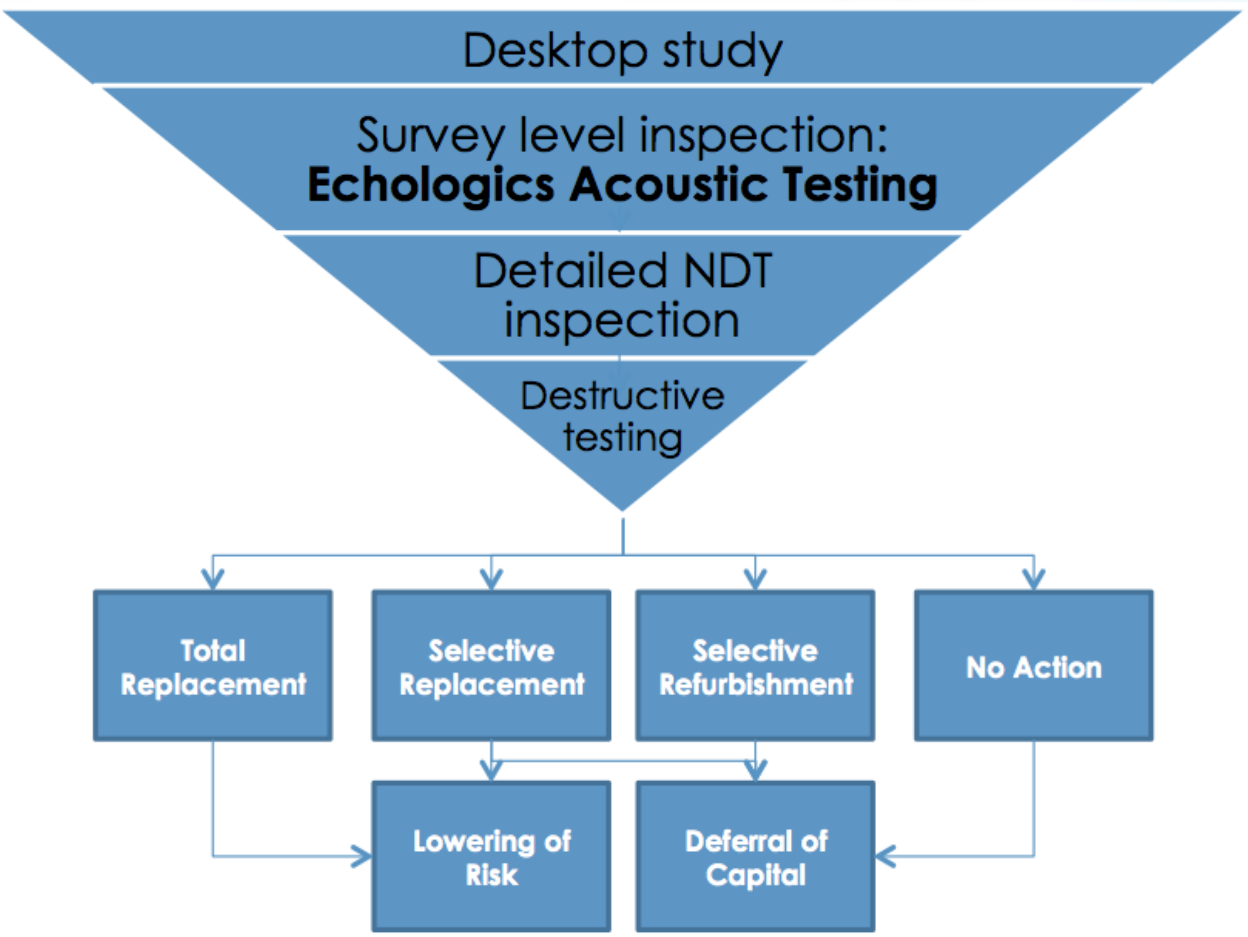
Sensor Attachment

- Existing Valves
- Chambers
- Pot holes

Sensor Attachment

Vacuum Excavation

The Approach



The Approach

Wall Thickness Measurement

- ePulse or other similar method to measure wall thickness

Failure Criterion

- pipe material
- internal load
- external load
- safety factors

Statistics

- distribution of pitting
- probability of pit being deep enough for failure

Time

- installation date and corrosion rate
- tolerance to failure
- consequence of failure

Asset Management System

- probability of failure or
- condition score or
- remaining service life

Integration with Asset Management

- Schlick Failure Criterion:

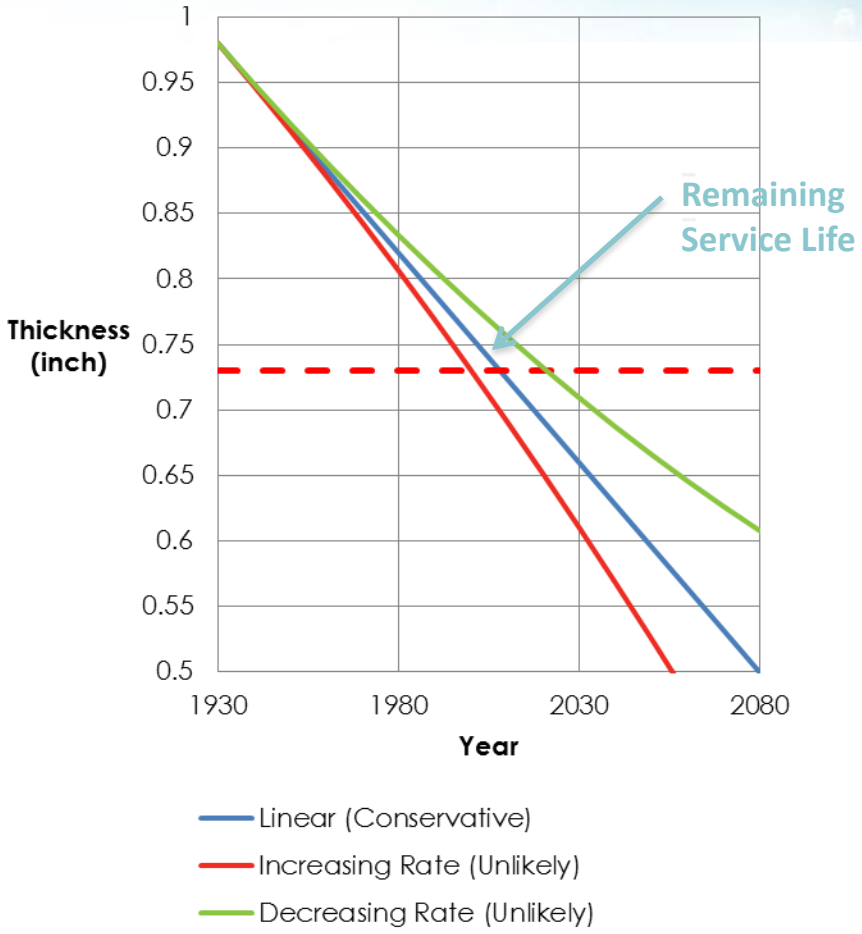
$$\left(\frac{P}{P_c}\right)+\left(\frac{W}{W_c}\right)^2 > 1$$

- Internal Pressure:

$$Pc = \frac{2t_c s}{D}$$

- External Load:

$$Wc = \frac{s\,t_c^2}{0.0795F_m(D+t_c)}$$



Project Summary

4-24 inch Diameter Cast Iron Mains

20 Miles of Pipe in Five Different Areas

Project Completed in Less than 2 Years

Leaks

- 2 main breaks
- 1 hydrant leak
- 3 POIs

Validations on 4 Sections

199 Unique Pipe Condition Measurements

2014 Testing

Cleaning and Lining Project

- Thirty-six (36) segments tested in Millburn/Maplewood
- 20,904 feet of main tested
- Pipe Type: pit cast iron
- Pipe Diameter: 4 to 12 inches

Results

- Most pipes experienced greater than 30% pipe wall loss
- 1 pipe segment has 50 years or more of service life remaining
- 9 segments have between 15 to 50 years of service life remaining
- 23 segments have less than 15 years of service life remaining or have exceeded their estimated service life

Millburn-Maplewood Condition Map

2015 Testing

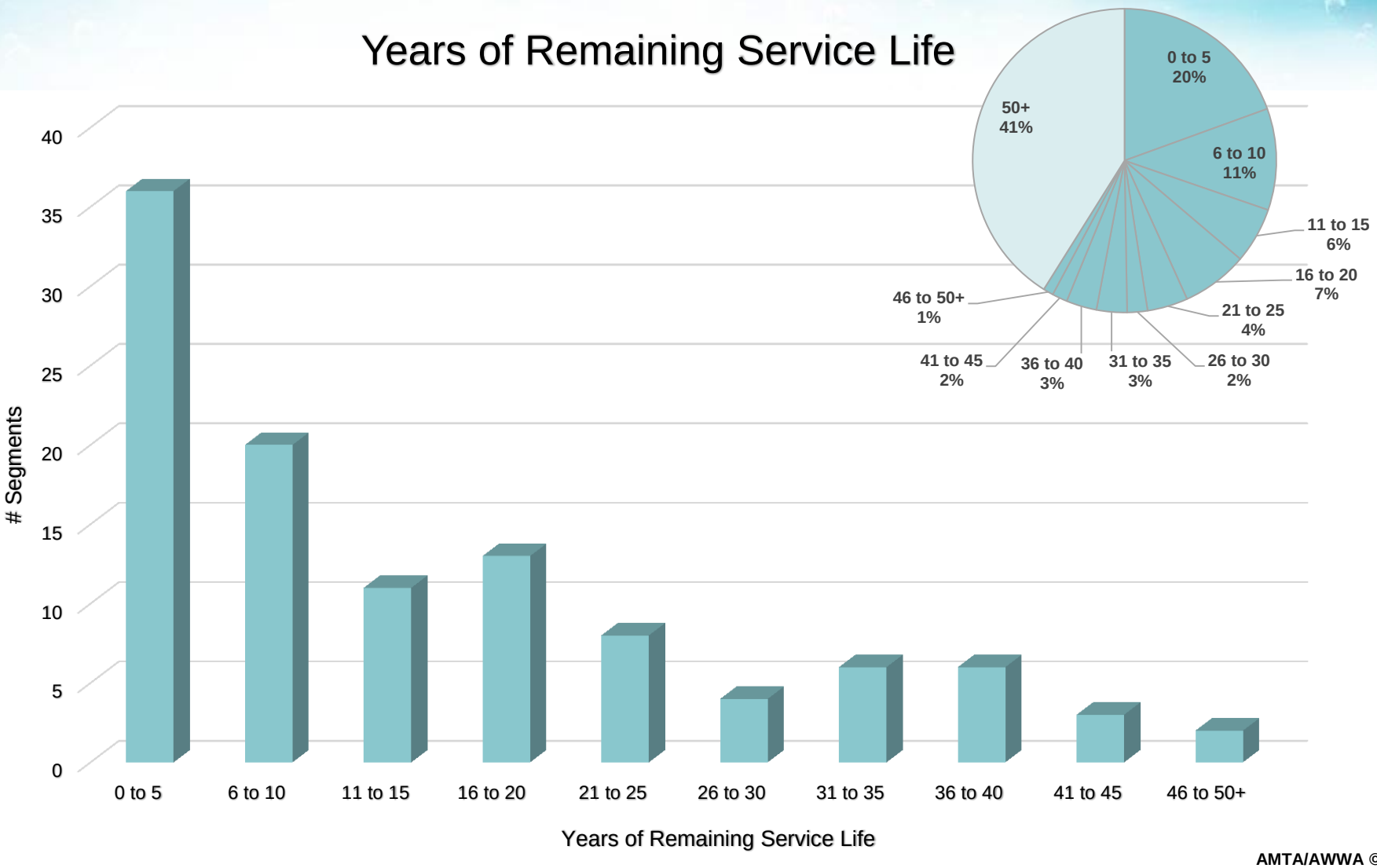
Cleaning and Lining Project (Millburn Only)

- Thirteen (13) segments tested along Glen Ave
- 6,465 feet of main tested
- Pipe type: pit cast iron
- Pipe Type: 18 to 24 inches

Results

- Most pipes experienced greater than 10% wall loss
- 11 segments have 50 years or more of service life remaining
- 2 segments have less than 20 years of service life remaining

Results


Years of Remaining Service Life
Segments
40
35
30
25
20
15
10
5
0
0 to 5
6 to 10
11 to 15
16 to 20
21 to 25
26 to 30
31 to 35
36 to 40
41 to 45
46 to 50+
Years of Remaining Service Life
0 to 5 20%
6 to 10 11%
11 to 15 6%
16 to 20 7%
21 to 25 4%
26 to 30 2%
31 to 35 3%
36 to 40 3%
41 to 45 2%
46 to 50+ 1%
50+ 41%

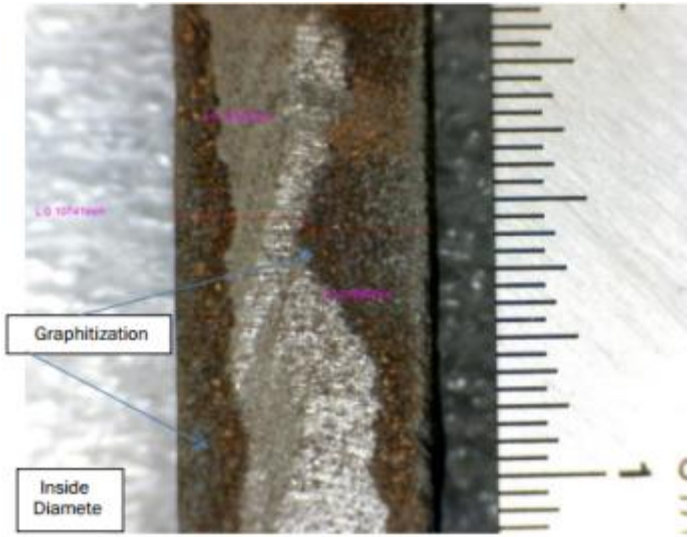
External Physical Testing Locations

TABLE 3: PIPE WALL CONDITION ASSESSMENT AND REMAINING SERVICE LIFE RESULTS

Segment Number	Street	Segment Length	Diameter	Nominal Structural Thickness	Measured Structural Thickness	Degradation Percent	Remaining Safe Service Life
		(ft)	(in)	(in)	(in)	(%)	(yr)
1	Euclid	452	6	0.49	0.14	71%	1
2	Euclid	415	6	0.49	0.16	67%	7
3	Euclid	660	6	0.49	0.21	57%	19
4	Durand	501	6	0.49	0.22	55%	32
5	Durand	460	6	0.49	0.17	65%	11
6	Quentin	259	6	0.49	0.17	65%	11
7	Roosevelt	684	6	0.49	0.18	62%	8
8	Roosevelt	370	6	0.49	0.23	53%	37
9	Roosevelt	660	6	0.49	0.13	73%	Exceeded
10	Kermit	294	6	0.49	0.13	73%	Exceeded
11	Curtis	759	6	0.49	0.28	43%	50
12	Curtis	396	6	0.49	0.23	53%	36
13	Curtiss	536	6	0.49	0.24	51%	36
14	Ridgewood	357	6	0.49	0.16	67%	5
15	Ridgewood	799	6	0.49	0.17	66%	6
16	Ridgewood	520	6	0.49	0.24	51%	35
17	Clinton	828	6	0.49	0.17	65%	6
18	Clinton	764	6	0.49	0.2	59%	21

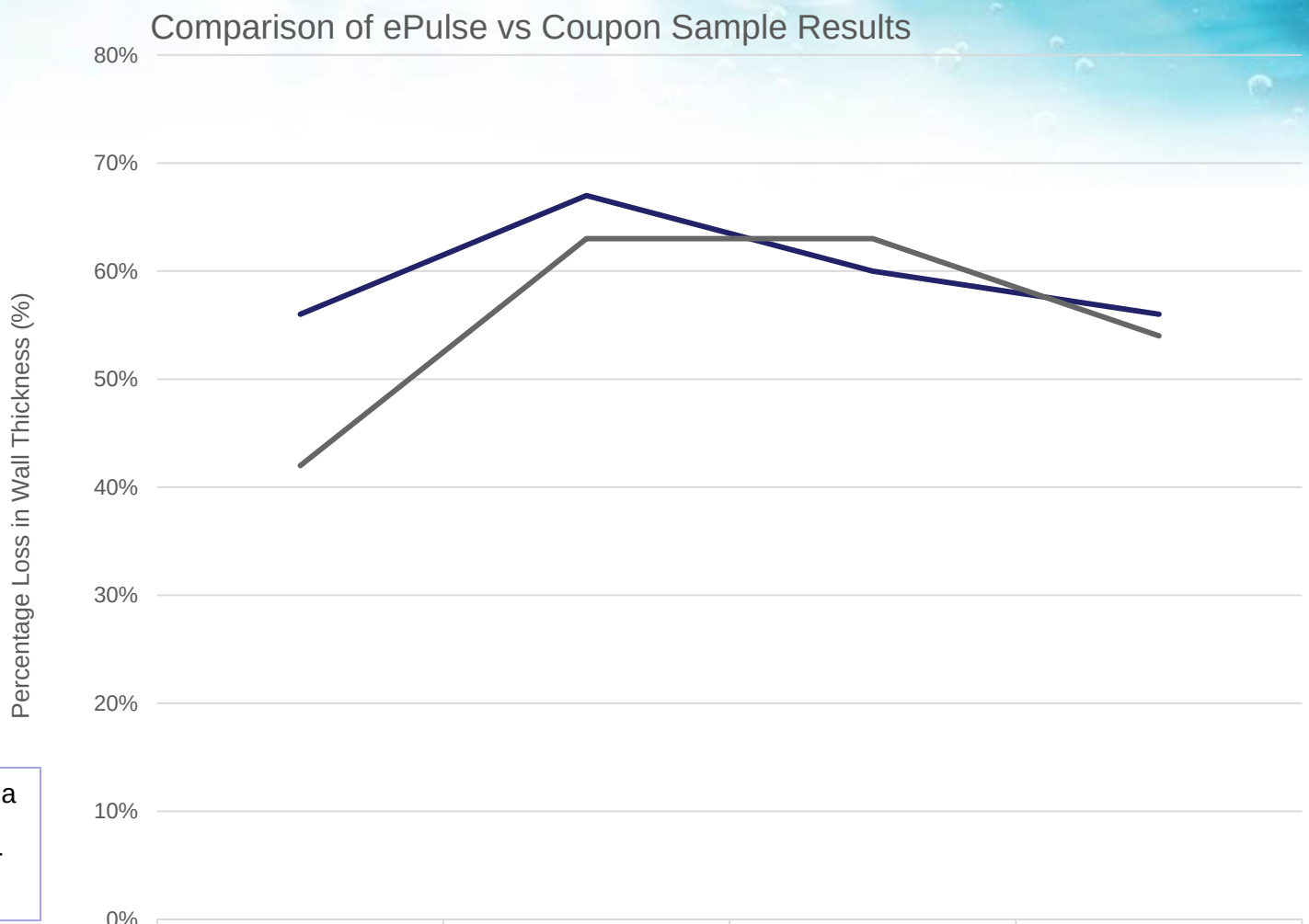
Validation

- Coupon validations for four (4) sites that were tested
- Matched up well with acoustic results



Samples from Kermit St.

Validation

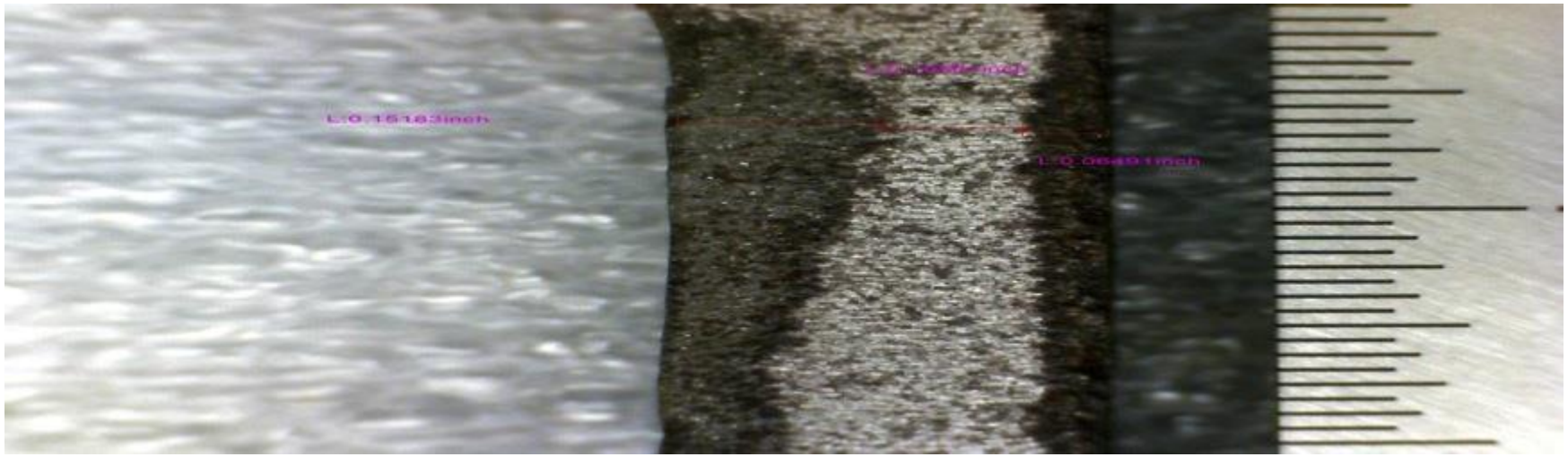


	Durand	Kermit	Ridgewood	Clinton
Revised Degradation Percentage	56%	67%	60%	56%
Forensic Degradation Percentage	42%	63%	63%	54%

* Note: There was a discrepancy in the forensics report for Durand.

Validation:
Physical Testing Results

Street	Acoustic Testing Measured Structural Thickness	Nominal Structural Thickness (AWWA C106)	Physical Testing Measured Minimum Thickness	Minimum Modulus of Rupture	Tested Modulus of Rupture	Maximum Phosphorus Level (AWWA C106)	Measured Phosphorus Level
	in	in	in	psi	psi	%	%
Durand	0.17	0.49	0.329	40,000	36,300	0.9	2.88
Kermit	0.13	0.49	0.419	40,000	32,300	0.9	1.75
Ridgewood	0.16	0.49	0.389	40,000	36,300	0.9	2.88
Clinton	0.17	0.49	0. 430	40,000	35,000	0.9	2.64



Questions