Pipeline Condition Assessment and Rehabilitation

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Water System Consultant
Advanced Solutions

Overview

- **Introduction**
- **Pipe Condition Assessment**
  - The Problem
  - Condition Assessment Alternatives
  - Acoustic Condition Assessment
  - Case Study
  - Summary
  - Questions
- **Pipe Rehabilitation**
  - Current Problems
  - Pipe Rehabilitation
  - 100% Solid Epoxy SIPP
  - Epoxy SIPP In Practice
  - Questions

Who is SUEZ?

Our History: The SUEZ Canal Company

- **SUEZ Canal Company** formed in 1858
- Used **innovative coal and steam-powered technology to** build canal
- **SUEZ Canal** opened in 1869

Today:

- Present in 70 countries
- 80,990 employees
- 323,000 Municipal and Industrial customers
- $ 18+ billion revenue annually

SUEZ’ HISTORY IN NORTH AMERICA

Founded as Hackensack Water Company	Integration of Infilco by Degremont	Integration of United Water	Integration of Utility Service Group	Integration of SENA Waste Services	Acquisition of GE Water & Process Technologies
1869	**1974**	**2000**	**2008**	**2011**	**2017**

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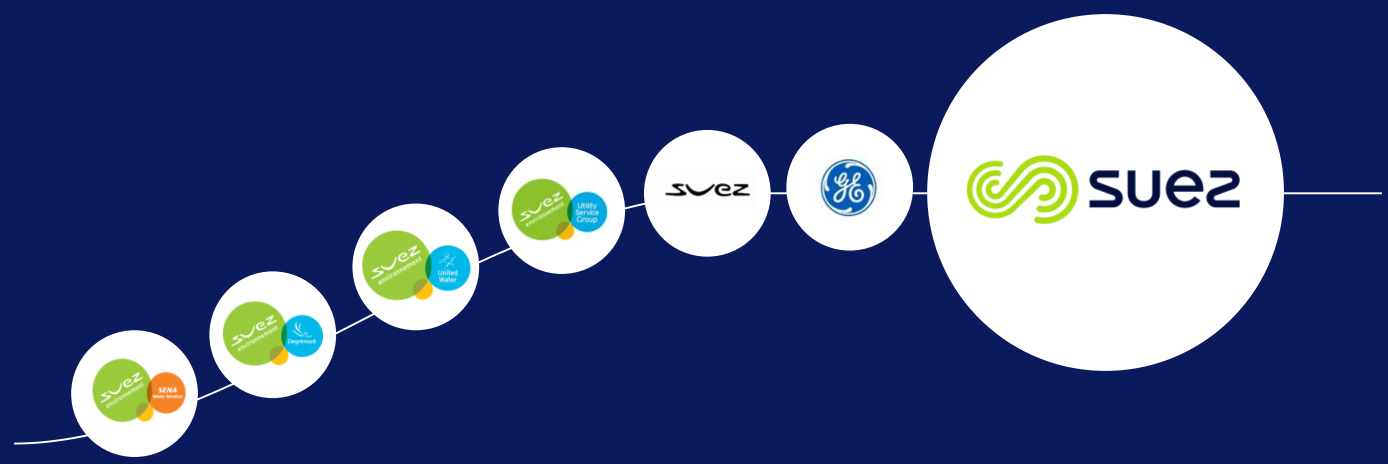
SUEZ’ HISTORY IN NORTH AMERICA

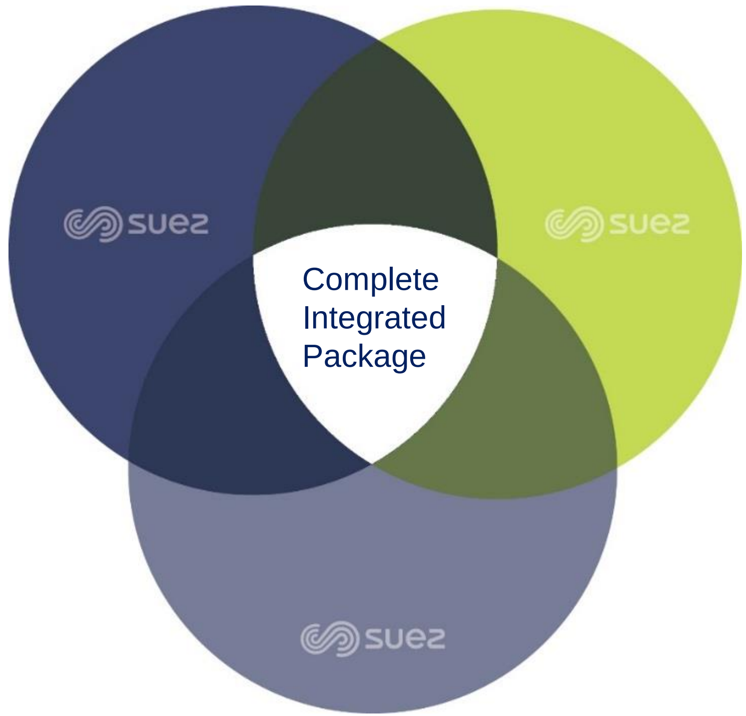


SUEZ Advanced Solutions:

Infrastructure Rehabilitation & Maintenance

- Rehabilitate
- Maintain
- Back-up short-staffed internal teams

Extend
life of asset



New Technologies

- Do more with existing assets to meet new regulations

Lower capital costs

SUEZ can provide water utilities with an integrated solution.

Smart Asset Management

- Increased efficiency
- Optimized operations

Lower operating expenses

Suez Advanced Solutions

Water Wells

- Condition assessment
- Maintenance program
- Pumps services
- Rehabilitation
- Drilling

Water Quality

- Asset chemical cleaning
- Mixers
- THM removal
- Ice Pigging
- Filter media replacement

Steel Water Tanks

- Condition assessment
- Maintenance program
- Rehabilitation
- Drone inspections

Concrete Structures

- Condition assessment
- Maintenance program
- Rehabilitation
- Water, wastewater and storm water assets

Network assets & Meters

- Maintenance program with AMI
- Advanced Network management (Aquadvanced)
- Network condition assessment and rehabilitation

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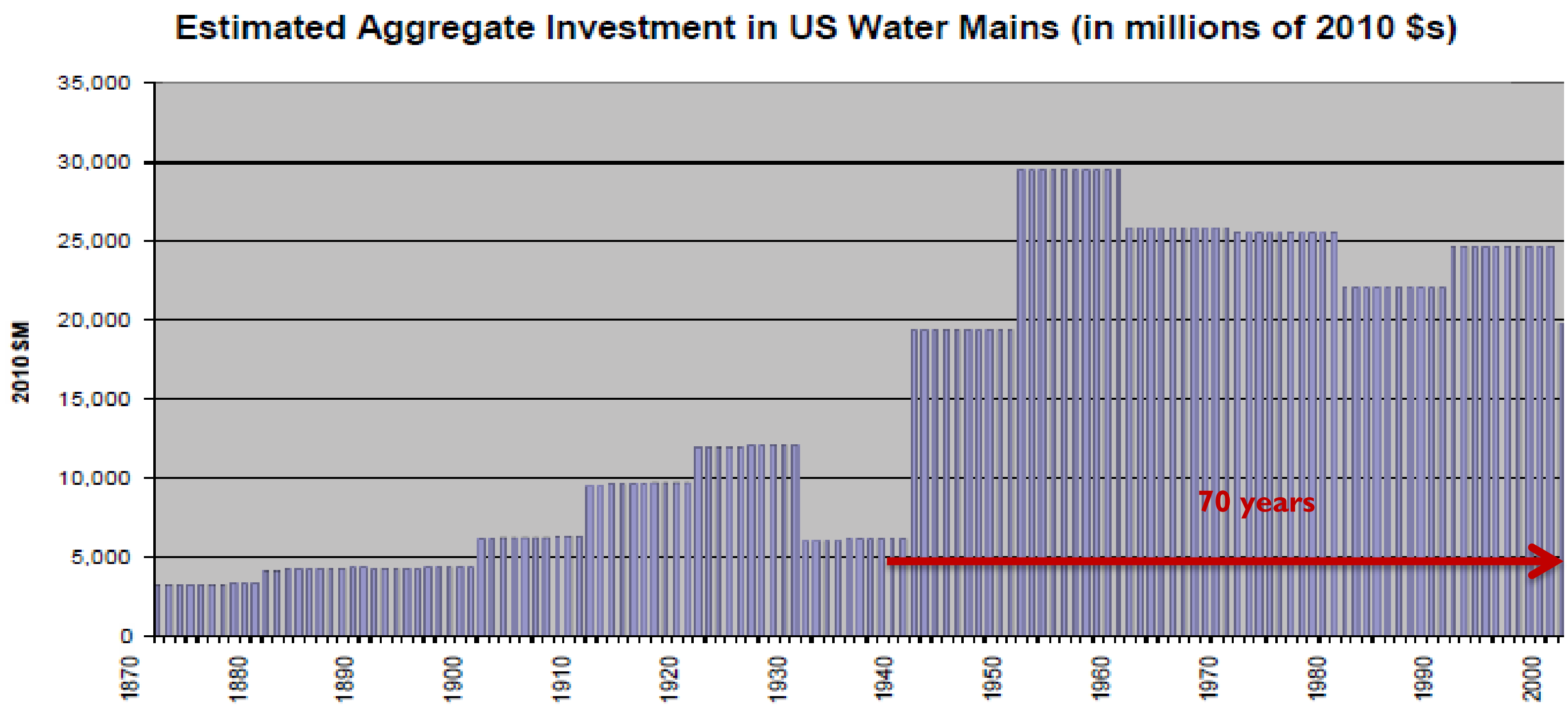
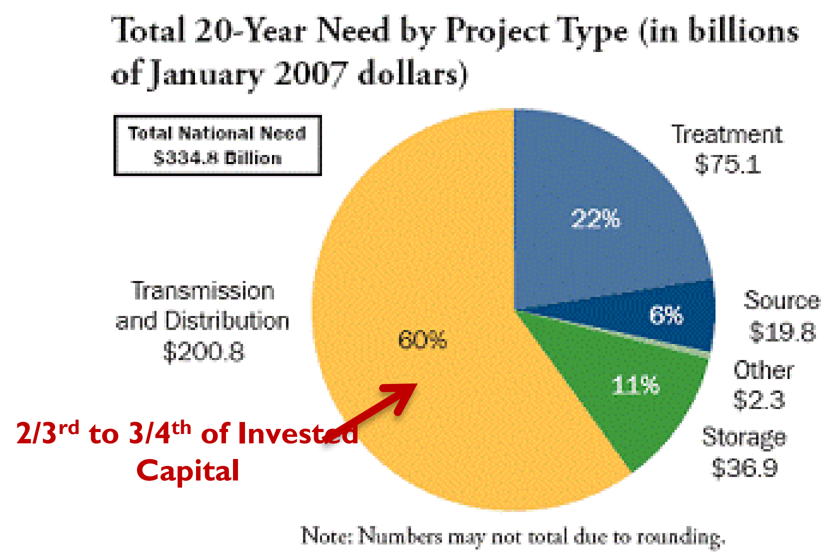
The Problem

Pipe Age:



The Investment Bubble

- AWWA Buried, No Longer Confronting Americas Infrastructure Challenge - $1Trillion Need
- American Society of Civil Engineers gives drinking water systems a D- Grade
- America's drinking water systems face an annual shortfall of at least $11 billion to replace aging facilities

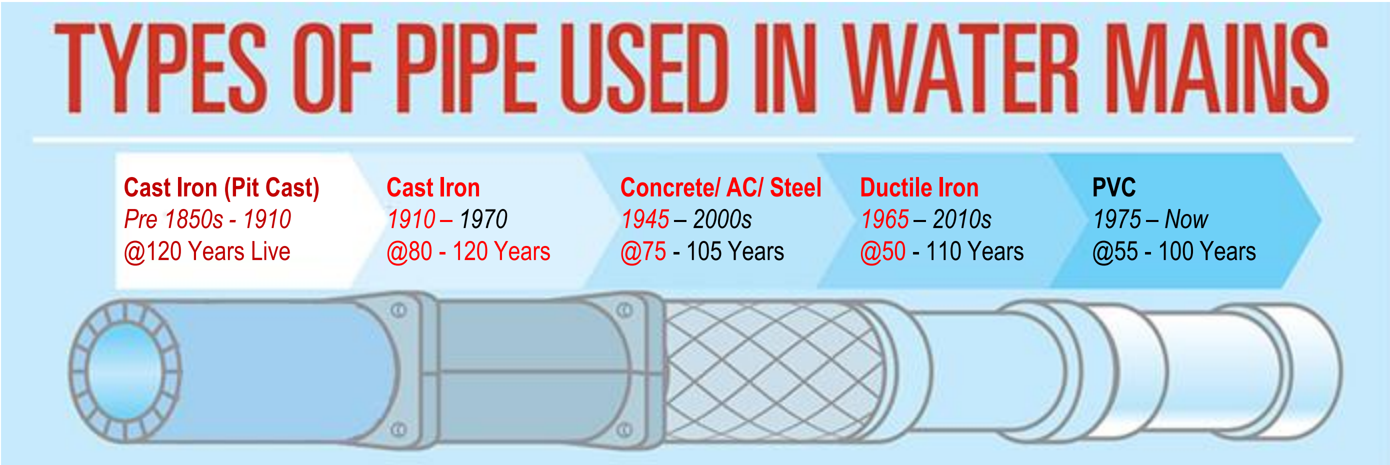


USEPA Drinking Water Needs Survey

The Problem

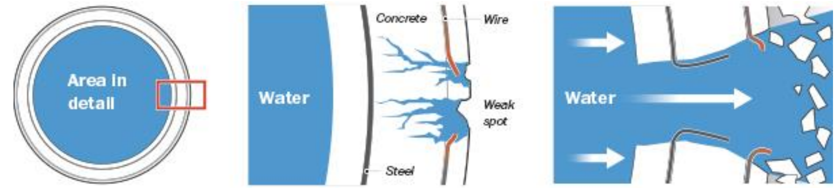
Municipal infrastructure is decaying faster than it is being renewed:

- **Pipes are surpassing useful life**

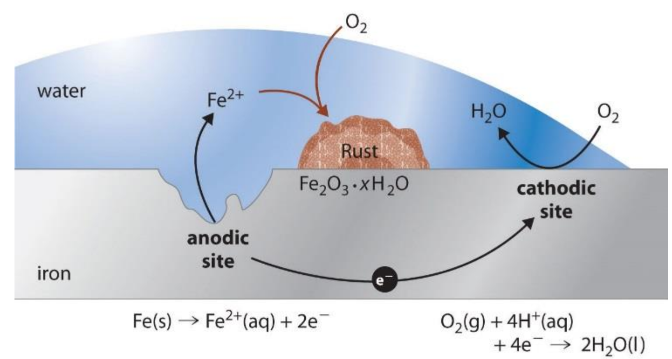


Pipes are surpassing useful life due to:

- **Internal Corrosion**
- **Tuberculation build up**
- **Loosing wall thickness**
- **Main breaks**



Example of concrete water pipe failure



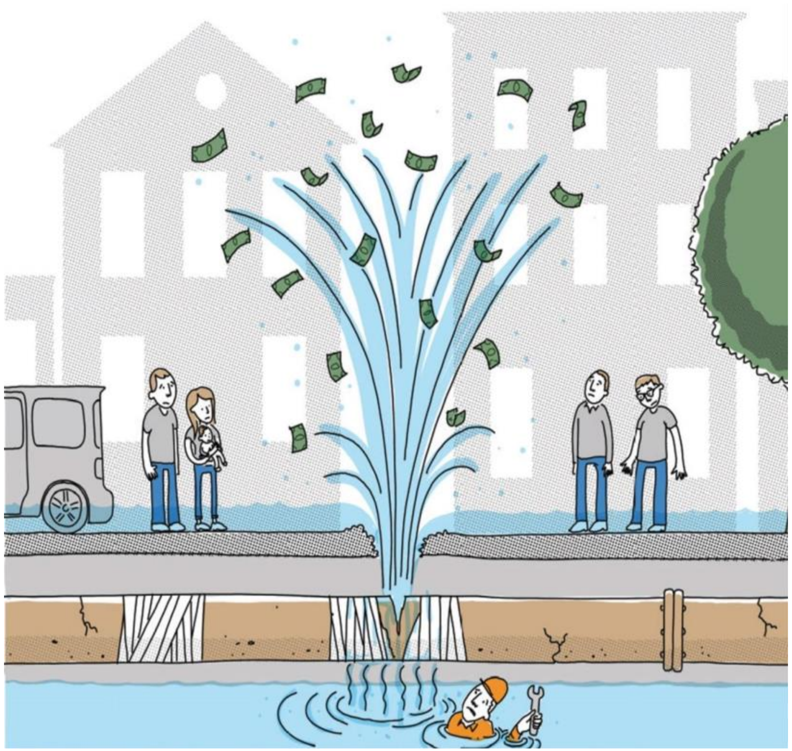
Example of Cast Iron Pipe Corrosion

The Problem

Underground environment
creates a situation
for stress cracking and seal
leaks.

By design, these systems
are subject to initial
and subsequent differential
settlement

Out of sight, out of mind…
until it leaks!



Run To Failure Approach

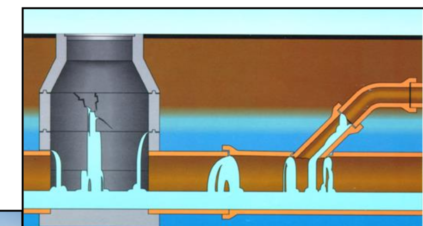
Consequences on water distribution:

- Loss of hydraulic capacity
- Water loss
- Degradation of water quality / Poisoning
- Collapses

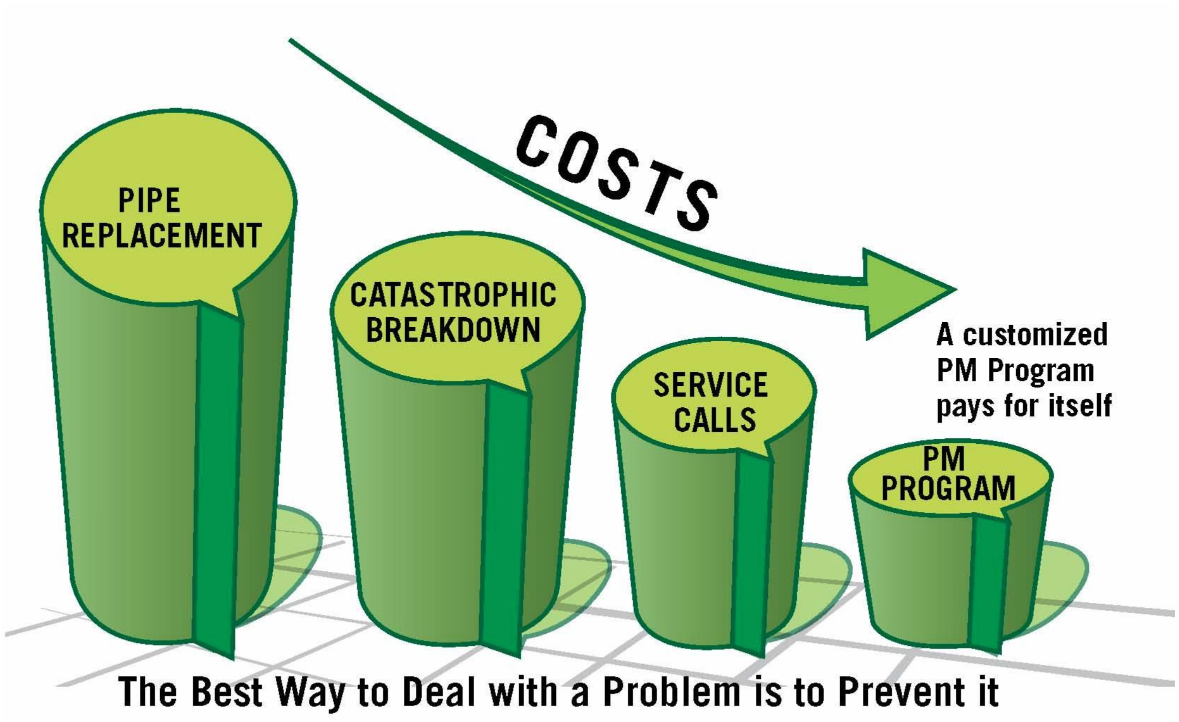
14th Street, Atlanta

Consequences on collection systems:

- Contamination due to Overflows, Violations
- Inflow & Infiltration / Pumping & treatment cost
- Collapses



The Solution



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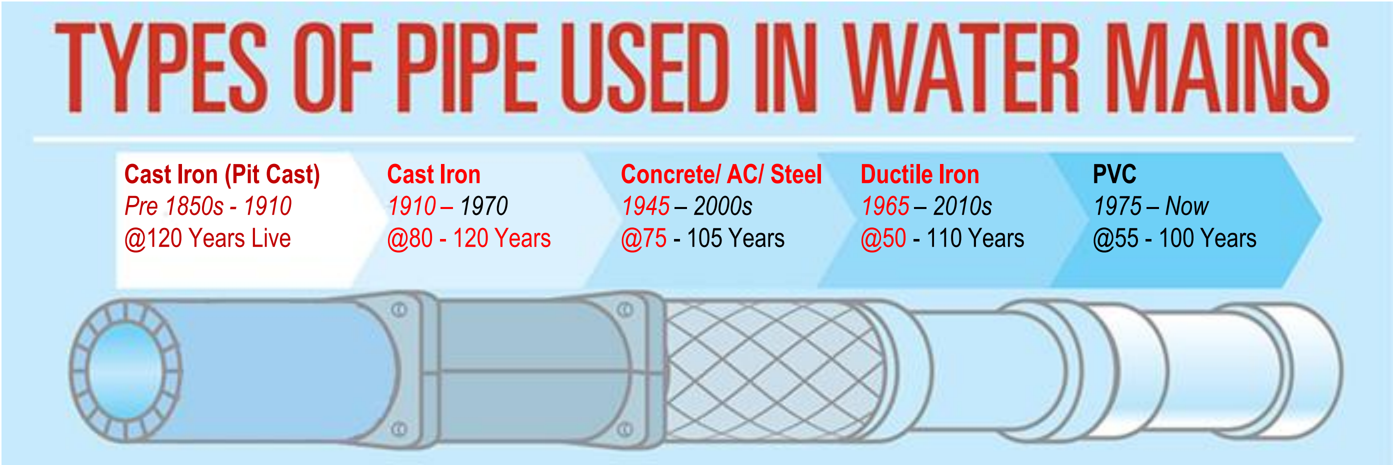
Traditional Approach

Due to the difficulties to inspect pressurized pipes, pipe rehabilitation in distribution systems is prioritize based on pipe age and material:



Traditional Approach: The Problem

Two Pipelines Sound The Same

Pipeline 1	Pipeline 2
Installed 1860	Installed 1860
Brown sandy soil	Brown clay soil
Moderate soil corrosivity	Moderate soil corrosivity

The Problem

But Look Very Different

Pipeline 1	Pipeline 2
Installed 1860	Installed 1860
Brown sandy soil	Brown clay soil
Moderate soil corrosivity	Moderate soil corrosivity
Results: **31% degraded**	Results: **1% degraded**
Condition: **Poor**	Condition: **Good**

Condition Assessment Alternatives

What is Available?

- Non Pressurized (Sewers)
  - Pole Cameras
  - CCTV inspection
  - Advanced Pipe Condition Assessment Systems (Redzone, Cleanflow, PPR, etc.)
  - Manual and Entry Inspection Methods

These methods require to take pipes out of service in potable water

- Pressurized system (Drinking Water)
  - Desktop Studies
  - Sahara (Online / Intrusive)
  - Smart Ball (Online / Intrusive)
  - Hydrant Camera / JD7 (Online / Intrusive)
  - Acoustic (Online / Non intrusive)

Require insertion of devices in the potable water (Intrusive)

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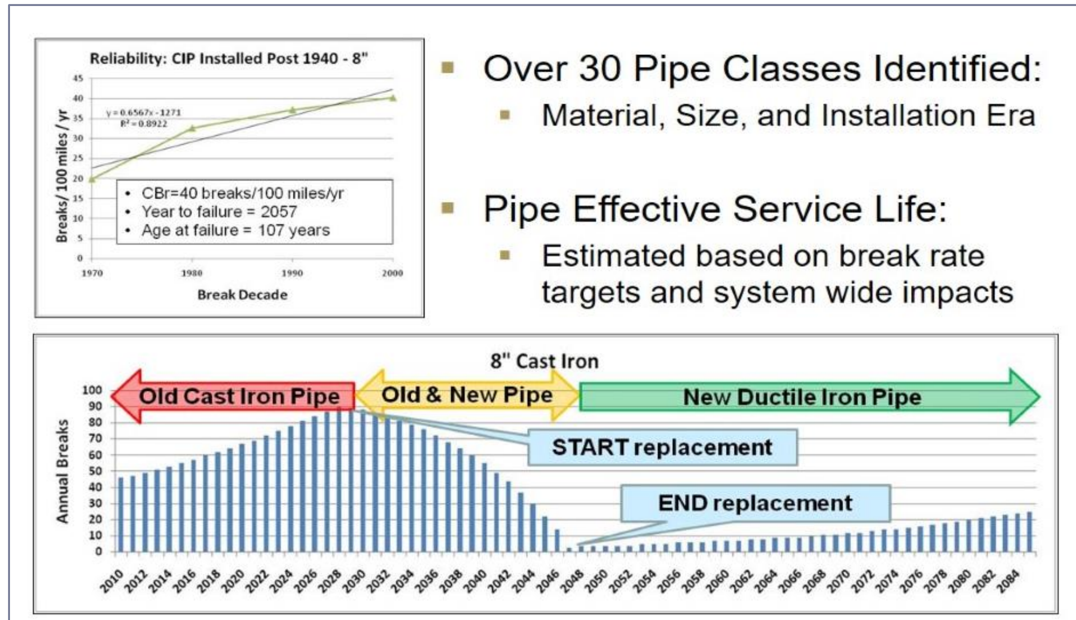
Alternatives: Traditional Approach

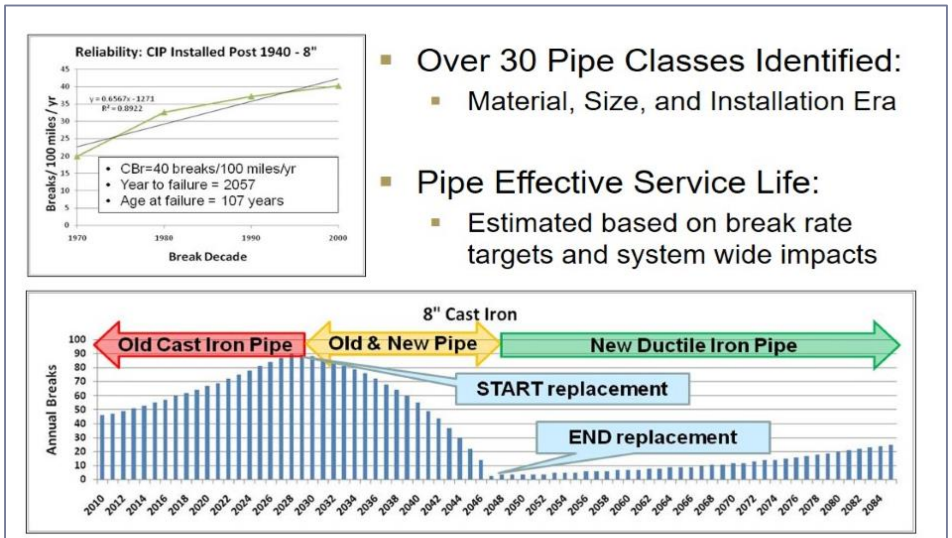
More sophisticated engineering studies include additional data to estimate the pipe condition:

- Pipe Material
- Size
- Age
- Soil Type
- History of leaks / main breaks
- Other indirect data



Alternatives: Traditional Approach

Desktop Study Alone:



Scenario:	Desktop
Desktop Study	$0.05 / ft
Error Rate	50%
Replacement Cost	$200 / ft
Error Risk	$100 / ft
Total Cost	**$100.05 / ft**

The actual cost of a desktop Study can be high when considering the cost to rehabilitate the wrong pipes

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Alternatives: Invasive Condition Assessment

Disruptive Condition Assessment: Smart pigs

Benefits:

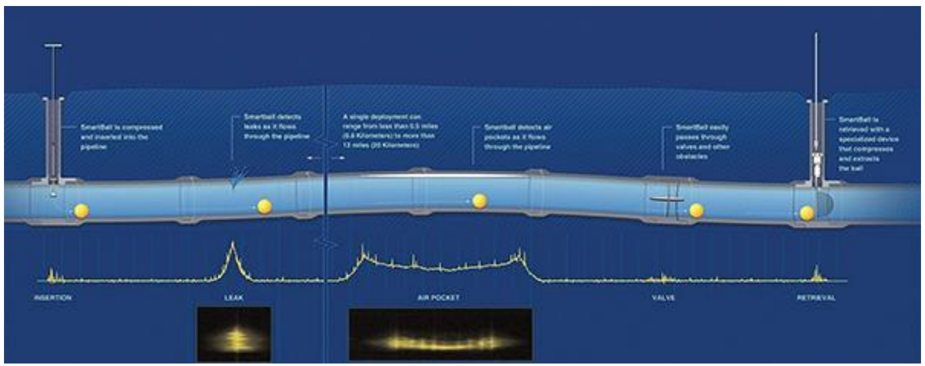
- **Very accurate**

Main Drawbacks:

- **Cost / Availability**
- **Application constraints**
  - Pipe diameter
  - Velocity
  - Pressure
  - Geometry
  - Deployment

Alternatives: Invasive Condition Assessment

Disruptive Condition Assessment:



(Example)

Scenario:	Disruptive
Preparation Cost	$40 / ft
Inspection Cost	$10 / ft
Error Rate	5%
Replacement Cost	$200 / ft
Error Risk	$10 / ft
Total Cost	**$60 / ft**

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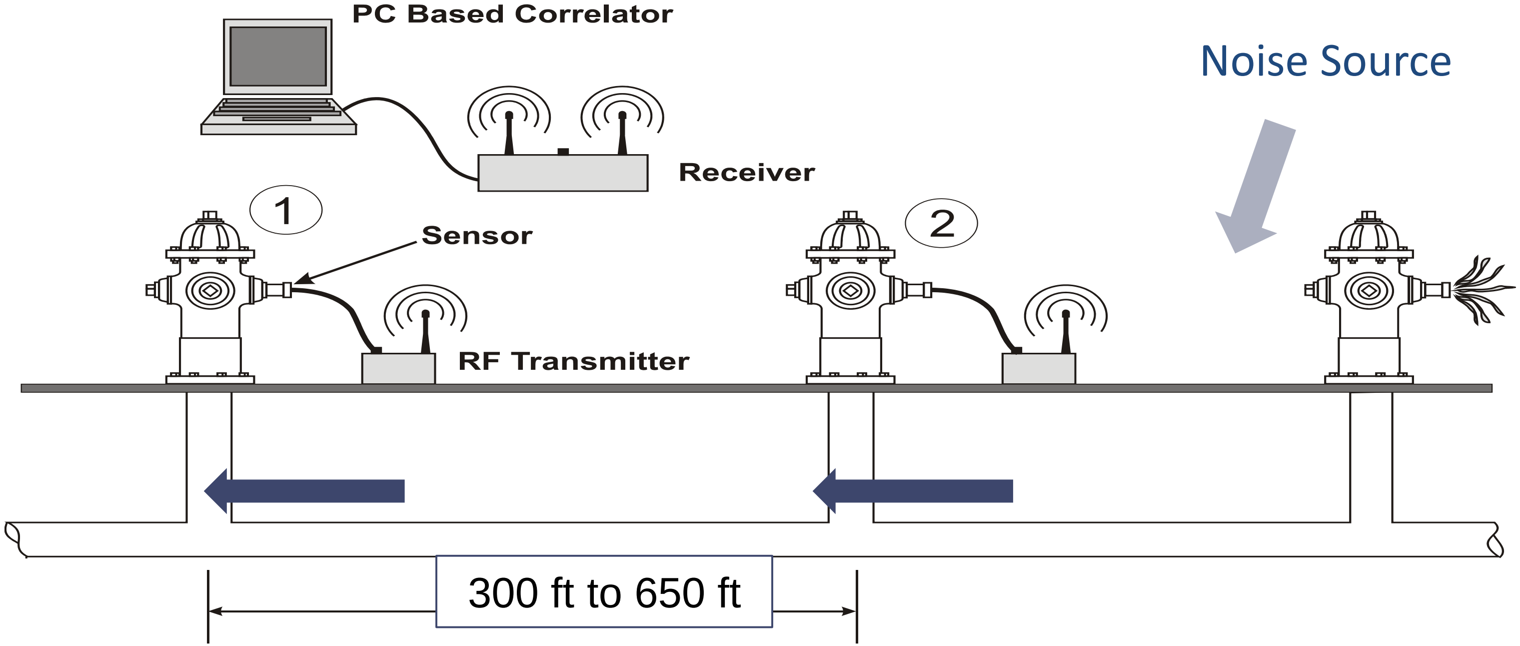
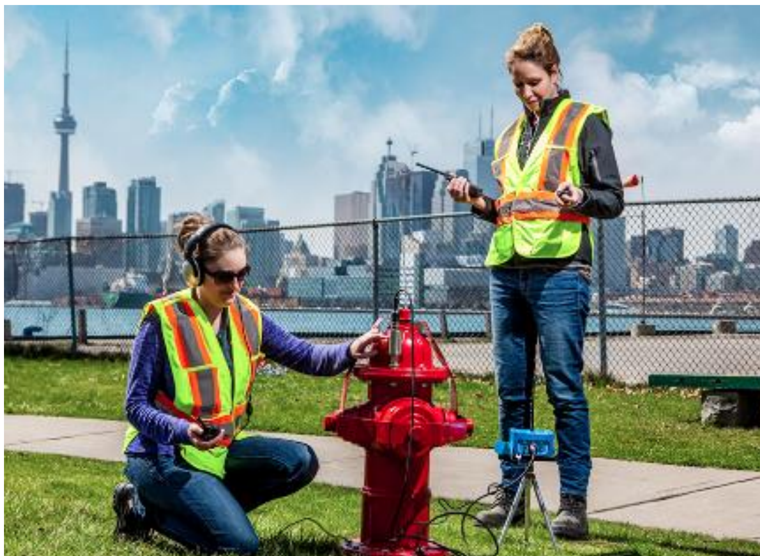
Acoustic Condition Assessment: How Does it work?

Equipment Measures Average Wall Thickness Over Intervals



Acoustic Condition Assessment:
How Does it work?

Sensors to be placed on Hydrants, valves or directly on top of the main



echologics A Mueller Co. COMPANY suez

Acoustic Condition Assessment: How Does it work?

Testing results match best with the thinnest point around the circumference, averaged over test interval

Tuberculation and graphitized material do not contribute to structural thickness

This is the remaining structural thickness!

Acoustic Condition Assessment: Method Summary

Method Requirements

- Pressure >15 psi
- No air in pipe
- Contact points every 100m to 200m
- Diameter : Thickness ratio of 30:1 or less
- Pipe information (maps, as-builts, repair sections, etc.)

Deliverables For Each Test Segment

- Average structural wall thickness
- Percentage loss
- Qualitative condition
- Leak locations and estimated sizes
- Remaining service live also available for AC and iron mains

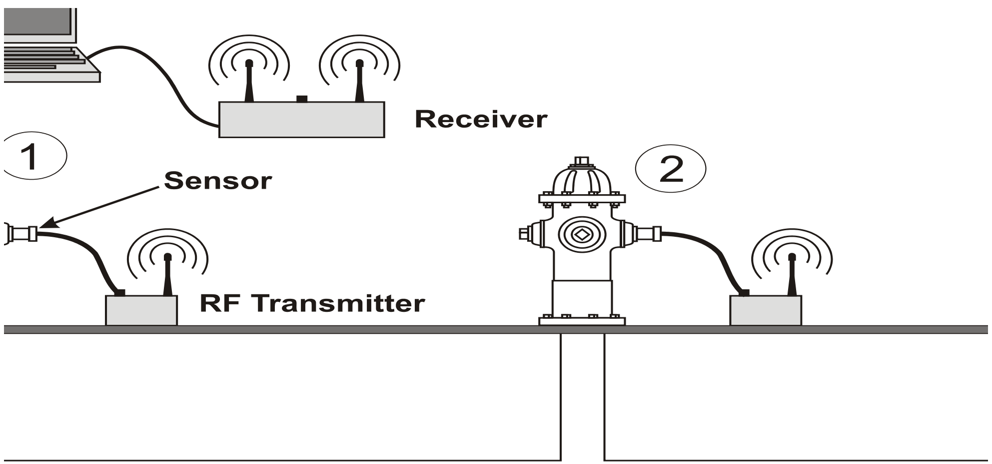
Acoustic Condition Assessment: Features and Benefits

Feature	Advantage	Benefit
Test from outside the main	No operational disruptions	Lower preparation costs. Water never contaminated. Sediment undisturbed.
Works with all appurtenances	No need to dig up the main or install new ports	Lower total project costs. Minimal traffic disruptions.
Field tests fast, non-disruptive	Test 1 km / team / day with minimal support	Scalable to large portions of a network
Report current wall thickness	Easily predict remaining useful life	Allows clear decisions about replacement or rehabilitation.
Verified and proven	Dozens of utilities have verified our results	Utilities can act with confidence in the information provided

The low cost and minimal support required for Acoustic Condition Assesment make it easy to scale to large portions of a network.

Alternatives: Acoustic

Non-Disruptive Condition Assessment:



Measures Average Wall Thickness Over Intervals

Scenario:	Non-Disruptive
Preparation Cost	$3.50 / ft
Inspection Cost	$1.50 / ft
Error Rate	10%
Replacement Cost	$200 / ft
Error Risk	$20 / ft
Total Cost	**$25 / ft**

Acoustic Condition Assessment provides savings by making sure the pipes in worst conditions are selected:

Field Verification / Condition Assessment

Acoustic Condition Assessment provides savings in a rehabilitation program, making sure the pipes in worst conditions are selected:

Scenario:	Desktop	Invasive	Acoustic
Preparation Cost	$0 / ft	$40 / ft	$3.50 / ft
Inspection Cost	$0.05 / ft	$10 / ft	$1.50 / ft
Error Rate	50%	5%	10%
Replacement Cost	$200 / ft	$200 / ft	$200 / ft
Error Risk	$100 / ft	$10 / ft	$20 / ft
Total Cost	**$100.05 / ft**	**$60 / ft**	**$25 / ft**

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Value Proposition

Provides Up to 50% savings by implementing a systematic Asset Management approach including verification (condition assessment) after a traditional engineering study:

- Acoustic Condition Assessment (Distribution water pipes) is the most efficient solution
  - Non-Invasive
    - No service interruption
    - No Risk
  - Most Cost Efficient
  - Quick
    - Minimum preparation required
    - Usually no site preparation / construction needed

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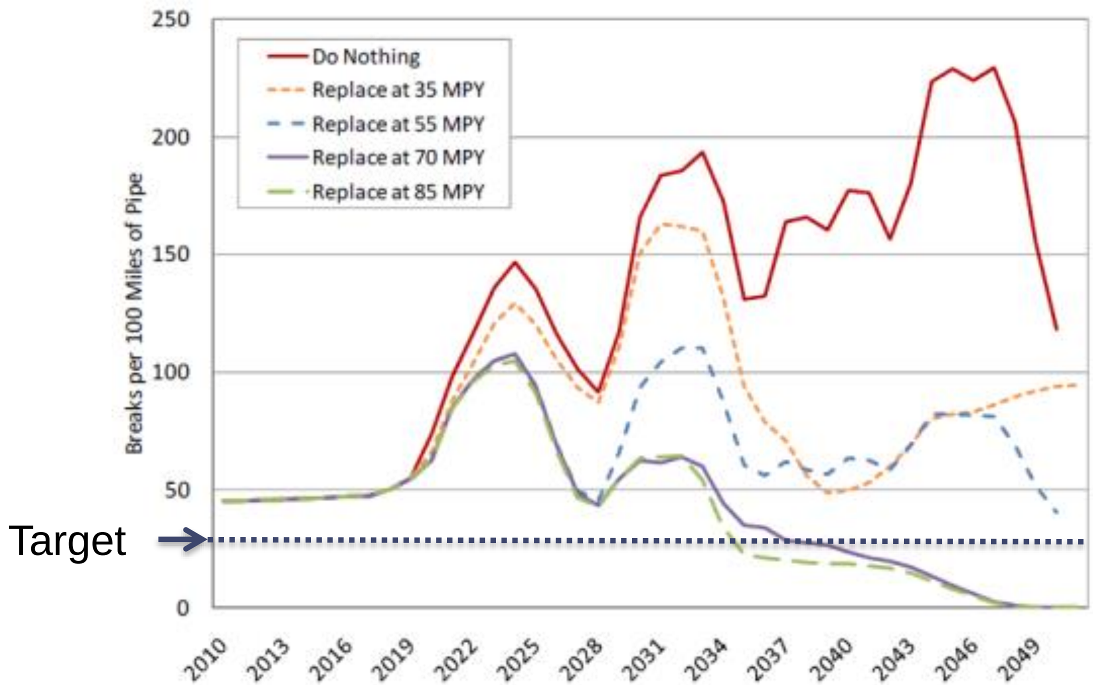
Case Study: Washington DC

Traditional Desktop Study:

- Pipes selected by a computer model considering age, material, soil, break history, and other factors
- Replacing 55 miles of pipe per year to reduce burst rate



Case Study: Washington DC

Traditional Desktop Study:

- After digging up pipes selected for replacement, found that more than 50% were still in good condition.

- Decided to run a pilot program using Acoustic to check the condition of the selected pipes before replacing them.

Project Details

- 43 miles of Acoustic testing
- < $1M invested in Condition Assessment
- 10 weeks of testing
- 0 excavations / 0 disruptions

Case Study: Washington DC

Condition Assessment results:

Project Details

- 43 miles of Acoustic testing
- < $1M invested in Condition Assessment
- 10 weeks of testing
- 0 excavations / 0 disruptions

Results

- **20 miles of good pipe found**
- **$14M saved (46%)**
- $117k worth of leaks found
- Budget redirected from pipes actually in good shape

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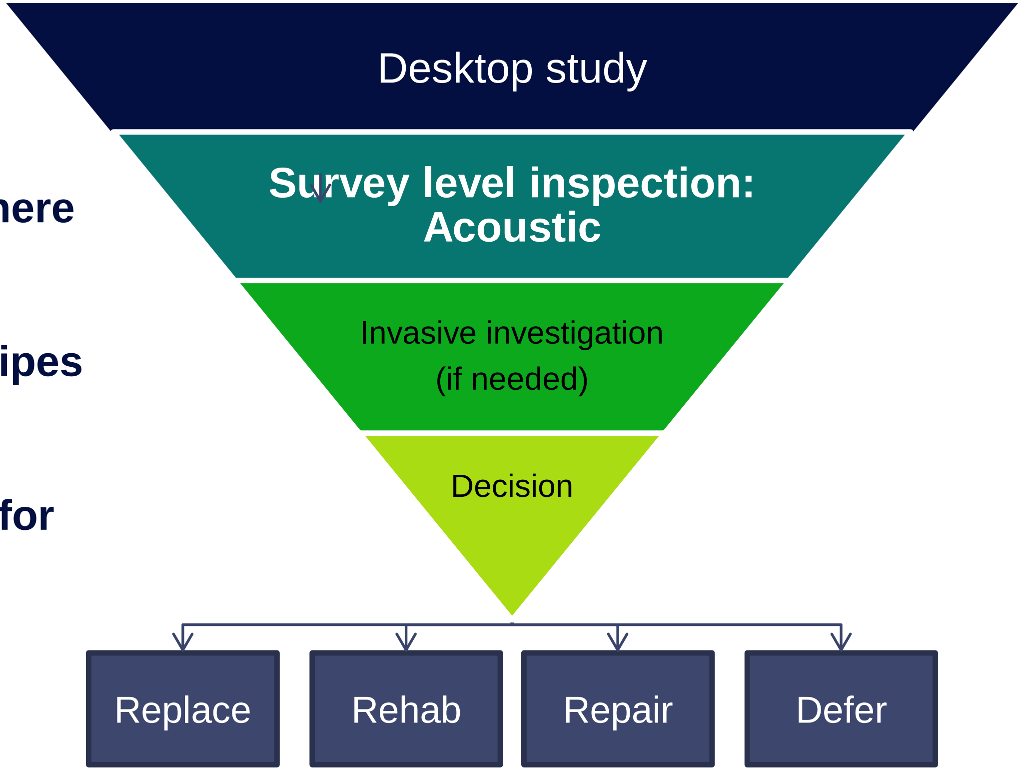
The solution: Pyramid Model

The best approach is:

1- Use a desktop study to prioritize where to perform annual acoustic surveys

2- Use acoustic surveys to prioritize pipes for rehabilitation

3- Use invasive inspections if needed for spot investigations



Condition Assessment: Benefits

Key Questions:

- **Do any of your pipes keep you up at night?**
    - Condition Assessments can help you understand that pipe’s condition
- **Do you have an annual budget for replacing mains?**
    - Condition Assessments can let you be sure you are replacing the right ones
- **Are you happy with how your pipe replacement choices are being made?**
    - Condition Assessments lets you make decisions based on actual condition
- **Have you ever replaced pipes and then discovered they were still in good shape?**
    - Condition Assessments can help you avoid wasting this money
- **Is your existing condition assessment program too costly?**
    - Condition Assessments offers the lowest total project cost on the market

Questions?

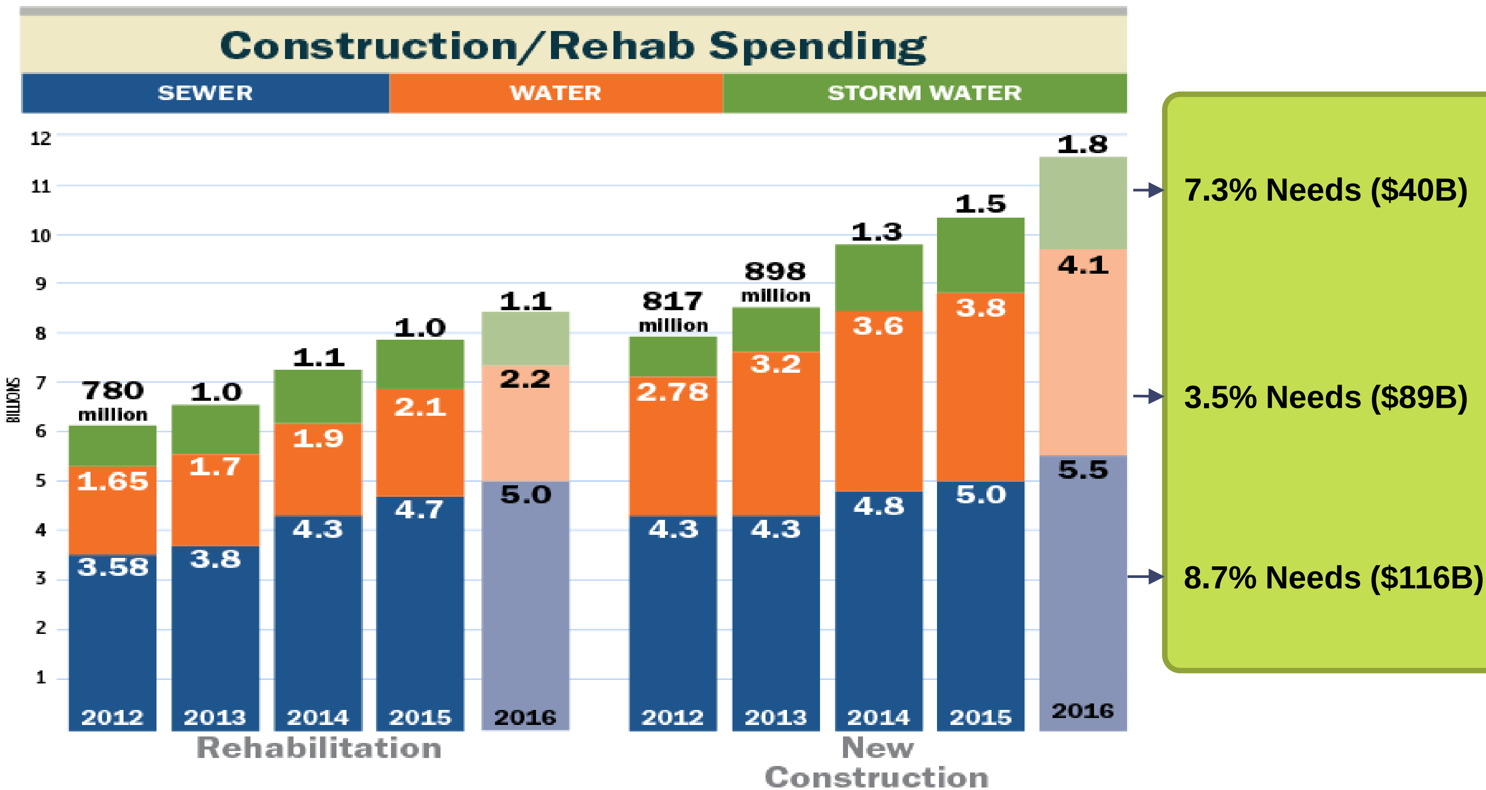
Pipe Rehabilitation

Overview

Market Overview

Actual annual expense

19th Annual Municipal Infrastructure Survey conducted by *Underground Construction* (Oildom Publishing Co., Houston, Texas).



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Cured in Place Pipe

- **Fabric tube impregnated with thermosetting resin**
- **Inserted in host pipe and heat cured – 2 Methods**
  - Pulled into host pipe and expanded by water pressure
  - Liner turned inside out (Inversion)

Advantages:

- Service connections can be reinstated by robotic cutters

Disadvantage:

- Requires extensive pre-investigation

Spray in Place Pipe

- **Thorough cleaning of host pipe**
- **Spray host pipe with a thin lining of resin (typically 1mm thick)**

Advantages:

- Minimal excavation

Disadvantage:

- Requires a completely clean and dry host pipe
- Traditionally not providing structural rehabilitation (WQ)

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Sliplining

- **HPPE pipe is pulled into host pipe**

Advantages:

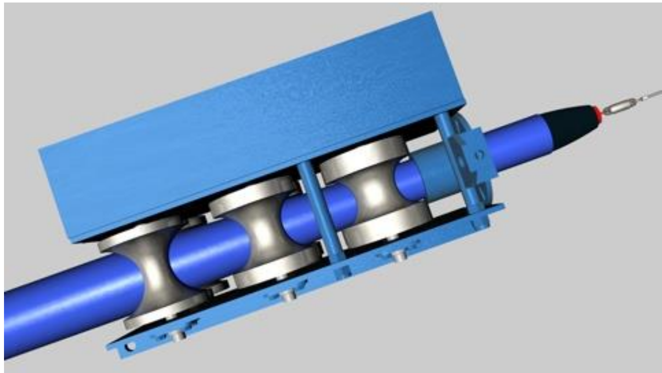
- Not reliant on integrity of host pipe

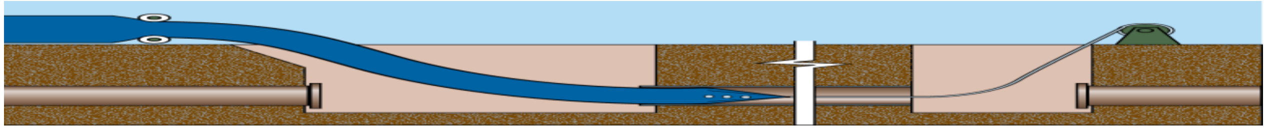
Disadvantages:

- Reduction in pipe diameter (but maybe not in capacity)

Close Fit Sliplining – Diameter Reduction

- **New pipe temporarily deformed**
- **Two methods**
  - Swaging
  - Compression Rollers





Advantages:

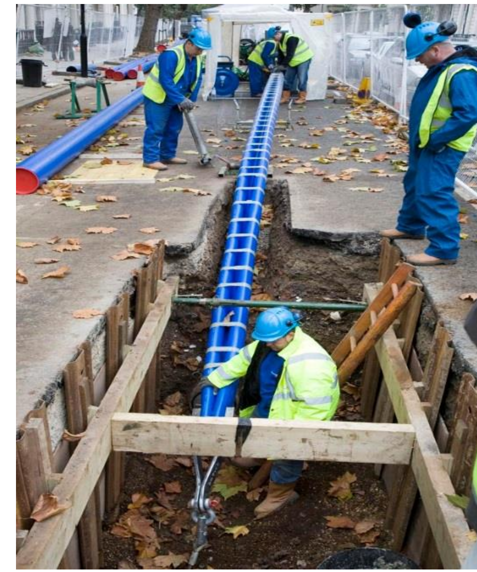
- Limited loss of pipe diameter

Disadvantage:

- Difficult to install if irregularities in host pipe

Close Fit Sliplining – Rolldown

- **Liner is heated and folded**
- **Liner is winched into host pipe and reshaped by heat and pressure**



Advantages:

- Limited loss of pipe diameter and accommodates bends

Disadvantage:

- Reversion process may be difficult

Pipe Bursting/Pipe Splitting

- **HPPE pipe is attached to bursting head**
- **Break and displace host pipe**
- **Pull replacement pipe into the void**

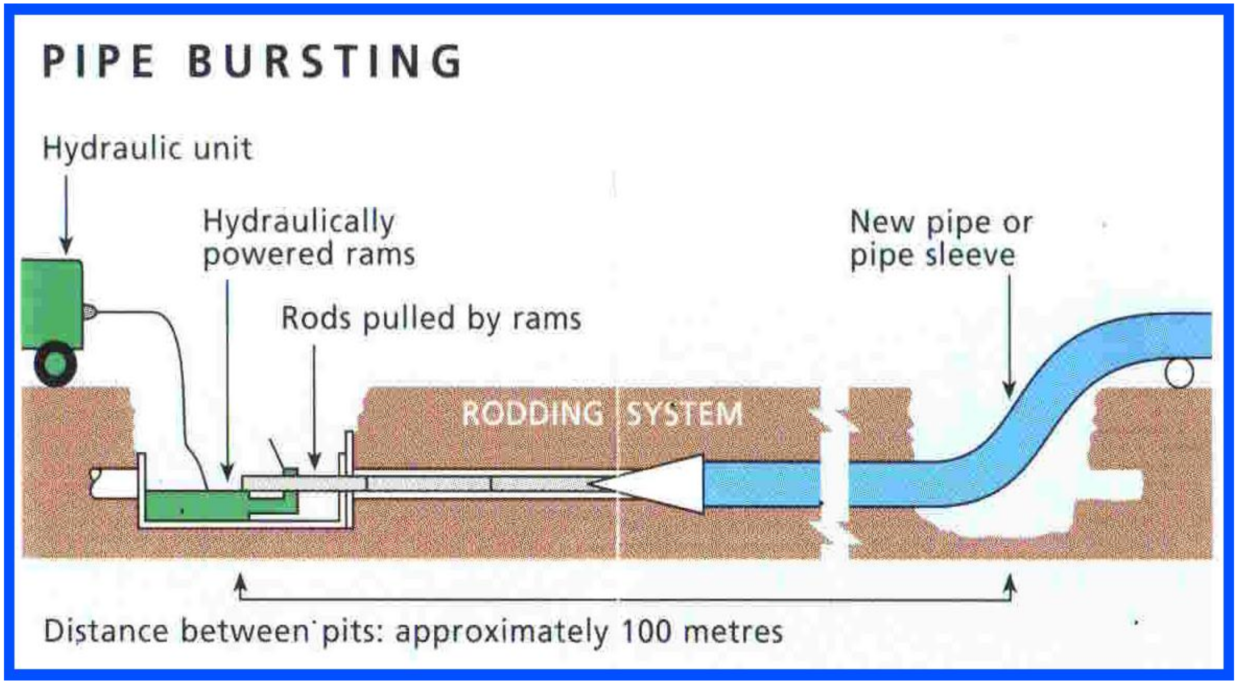
Advantages:

- No cleaning required; facilitates upsizing

Disadvantage:

- Difficult in some situations; not suitable for Asbestos Cement mains

Pipe Bursting - Execution



Horizontal Directional Drilling

- **Pilot bore to line and grade**
- **Reamer and new HPPE pipe pulled through in reverse direction**

Advantages:

- Less disruption compared to open cut; existing supplies not cut-off

Disadvantage:

- Depends on suitable soil conditions and corridor free from existing services

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100% Solids Epoxy

- Structural Epoxy Spray Lining
- Rapid cure (< 2 hr)
- Moisture tolerant (i.e. surfaces don't have to be 100% dry)
- Single coat monolithic coating (i.e. no multiple coats)
- NSF approved and Bisphenol free
- Less downtime and significant savings

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Coating Specification Details

Coatings Specification Details

	ASTM F-1743	100% Solid Epoxy	%
Tensile Strength	3,000	7,000	233%
Flexural Strength	4,500	11,000	244%
Compressive Strength	Not Listed	12,000	--
Flexural Modulus	250,000	500,000	200%

AWWA M-28 Standards for rehabilitation of water mains. This specifies ASTM F-1743 as the class 4 Structural lining standard.

- **AWWA M-28 Standards for rehabilitation of water mains. This specifies ASTM F-1743 as the class 4 Structural lining standard.**
- **ASME PCC-2 Design considerations for buried pipe test standards were utilized and documented by Madero Engineering, Houston, TX. Certified wall thickness for our lining material for partially deteriorated pipe to resist both internal and external loads.**
- **ASTM F1216 Standard practice for rehabilitation of existing pipeline standards were utilized and documented by Madero Engineering, Houston, TX. Certified wall thickness of our material comply with this standard.**

"the ultimate capacity of all specimens exceeds 400 psi hydrostatic pressure"

– Kent Harries, Ph.D., FACI, P.Eng.

Associate Professor of Structural Engineering and Mechanics University of Pittsburgh.

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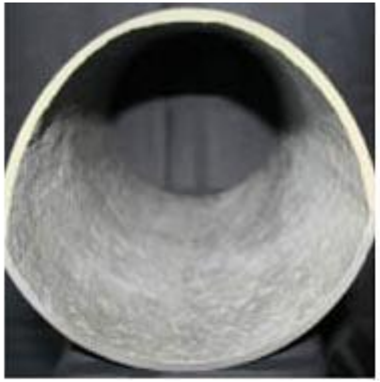
Coating Specification Details

- **Coatings are able to withstand prolonged exposure to heat, chemical and aggregate**
- **Other situational applicable coatings include:**
  - HVAC
  - Sewer
  - High Temperatures
  - Cooling Tower
  - Fire hydrant lines / stand pipe
  - Steam vaults
  - Steam condensate lines
  - Cogeneration
  - Domestic Water

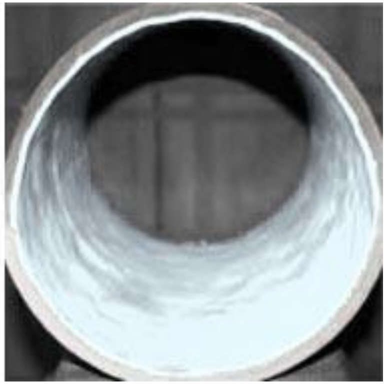
Structurally Enhance & Reinforce

Before | **During** | **After**

Severely corroded



Completely cleaned



Epoxy lined

State of the art robotic spray application

- Computer-controlled for more refined application and curing.

Material bonds to your piping system–

- Preventing and sealing cracks
- moves with the structure, abating leaks caused by settlement.

Spray-In-Place Pipelining Process

1. System Diagnosis

- Map system
- Utilize computerized pipe video surveillance to inspect and digitally record findings
- Review findings with property management
- Diagnose and identify restoration plan

2. Repair/Replacement

- Repair or replace damaged pipe sections
- Flushing & drying
- Tuberculation removal
- Grit blasting

3. Abrasive Cleaning

- Abrasive cleaning with conical spray head to near-white metal finish *(as specified by manufacturer)*
- Pipe is now in a good state of repair

4. Epoxy Lining and Reassembly

- Pipe's state of good repair enhanced with epoxy lining
- Extends life of repaired or replaced pipe
- Prevents corrosion and biological buildup
- Enhances flow capacity
- Dampens vibration

5. Final Inspection & System Testing

- TV inspection
- Epoxy inspection of pipe lining for thickness
- and need for coating repair
- Hydrostatic pressure testing
- Leakage pressure testing
- Bacteriological disinfection
- Leaching test
- Restoration of system

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The Process

SIPP Demo

Benefits
Technology Benchmarking

No Excavation in sewer	✓
Minimal Excavation in water	✓
Structural Rehabilitation	✓
Stronger than the host pipe	✓
Not exhaust cleaning	✓
Moisture tolerant	✓
Keeps Connections	✓
Suitable for angles, turns, elbows	✓
Less downtime and significant savings	✓
No significant pipe diameter loss	✓
No depends on soil conditions	✓
NSF approved Rapid cure coating	✓
Suitable for all materials	✓
No limitations in small diameter pipes	✓

Epoxy vs Polyurea

	Epoxy	Polyurea
Tensile Strength	48 MPa	26 MPa
Flexural Strength	75 MPa	45 MPa
Flexural Modulus	3.4 GPa	2.8 GPa
Size Of Pipe	1¼ - 72 inches	4 - 24 inches
Coating Thickness	Up to 6mm in one run	Requires 3+ runs
Product Lifetime	Indefinite	Degrades in a few years
Cure Time	Allows for margin of error	No margin of error

Epoxy vs Polyurea

	Epoxy	Polyurea
Cures At Low Temperature	✓	✗
Cures At High Humidity	✓	✗
Withstand Frost	✓	✗
Withstand Heat	✓	✗
Withstand Chemicals	✓	✗
Withstand Aggregate	✓	✗

Technology Summary

	Spray Lining (New)	Spray Lining (Old)	Cement Mortar Lining	Sliplining	CIPP	Pipe Bursting	HDD
No Excavation in sewer	✓	✓	✓	✓	✓	✗	✗
Minimal Excavation in water	✓	✓	✓	✓	✓	✓	✓
Structural Rehabilitation	✓	✗	✗	✓	✓	✓	✓
Stronger than the host pipe	✓	✗	✗	✗	✗	✓	✓
Not exhaust cleaning	✓	✗	✓	✗	✗	✓	✓
Moisture tolerant	✓	✗	✓	✗	✗	✓	✓
Keeps Connections	✓	✓	✓	✗	✗	✗	✗
Suitable for angles, turns, elbows	✓	✓	✓	✗	✗	✗	✗
Requires extensive pre-investigation	✓	✗	✓	✗	✗	✓	✓
No significant pipe diameter loss	✓	✓	✓	✗	✓	✓	✓
No depends on soli conditions	✓	✓	✓	✓	✓	✗	✗
Rapid Cure	✓	✓	✗	✗	✗	✓	✓
Suitable for all materials	✓	✓	✗	✓	✓	✗	✓
No limitations in small diameter pipes	✓	✓	✗	✗	✗	✓	✓

Benefits of
Protective Coatings to Consumer

- Protects against future corrosion & degradation
- Extends service life of system piping & components
- Significantly enhances water and air quality
- Reduces frequency of maintenance and decreases costs and system down-time
- Eliminates the leaching of lead from the soldered joints, and the corrosion of copper and steel pipe
- Enhances flow capacity and system efficiency

Overview

- **Introduction**
- **Pipe Condition Assessment**
  - The Problem
  - Condition Assessment Alternatives
  - Acoustic Condition Assessment
  - Case Study
  - Summary
  - Questions
- **Pipe Rehabilitation**
  - Current Problems
  - Pipe Rehabilitation
  - 100% Solid Epoxy SIPP
  - Epoxy SIPP In Practice
  - Questions

100% Solid Epoxy In Practice

Feature Project

Merrick Road – New York American Water Works

- Restored a 100-year-old water main with a history of leaks, severe corrosion and poor water quality in Massapequa, NY
- Successfully lined over a 2 month period in Spring 2016
- Using our proprietary SIPP process, a structural 3 mil (1/8th") epoxy coating was evenly applied through the entire length of 2 miles of 12" cast iron domestic water pipe under strict zero-VOC policy
- Developed logistics to minimize disruption to 4-lane highway, despite multiple adverse conditions, such as multiple trapezoid sweeps, including underneath small rivers and other utility services

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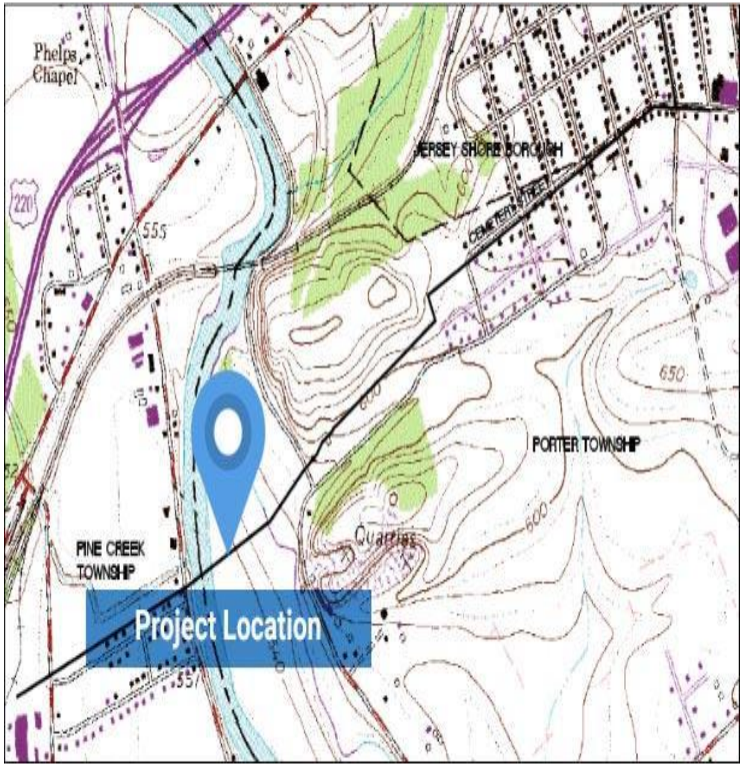
Feature Project

Jersey Shore Pennsylvania Domestic Water Lining Project



- Rural town of Jersey Shore, Pennsylvania, has a gravity fed domestic water distribution system.
- Successfully lined two miles of pipe on time and on budget.
- Base infrastructure 16” and 12” cast iron mains originally installed in the 1890s, to supply steam locomotive station
- System’s lead sealed joints had tuberculation levels as high as 50%
- Bypass system for approximately 150 residences installed and successfully maintained Several trapezoidal pipe layouts under streams and rivers were successfully lined in place.
- This was a turn key project: attended to all site safety, excavation, mechanical and road restoration.

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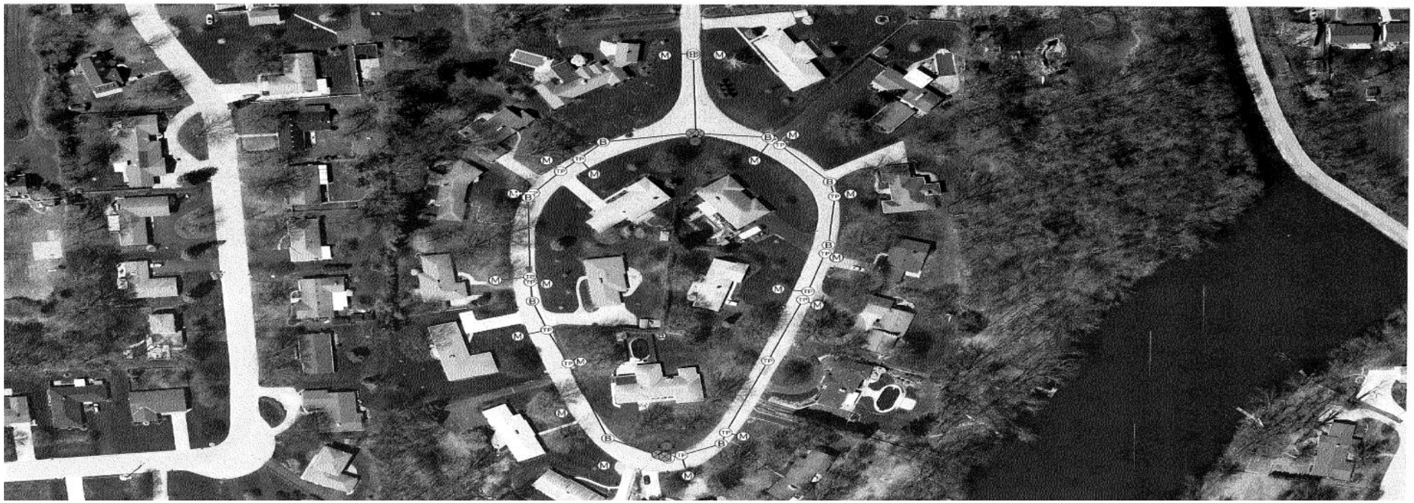
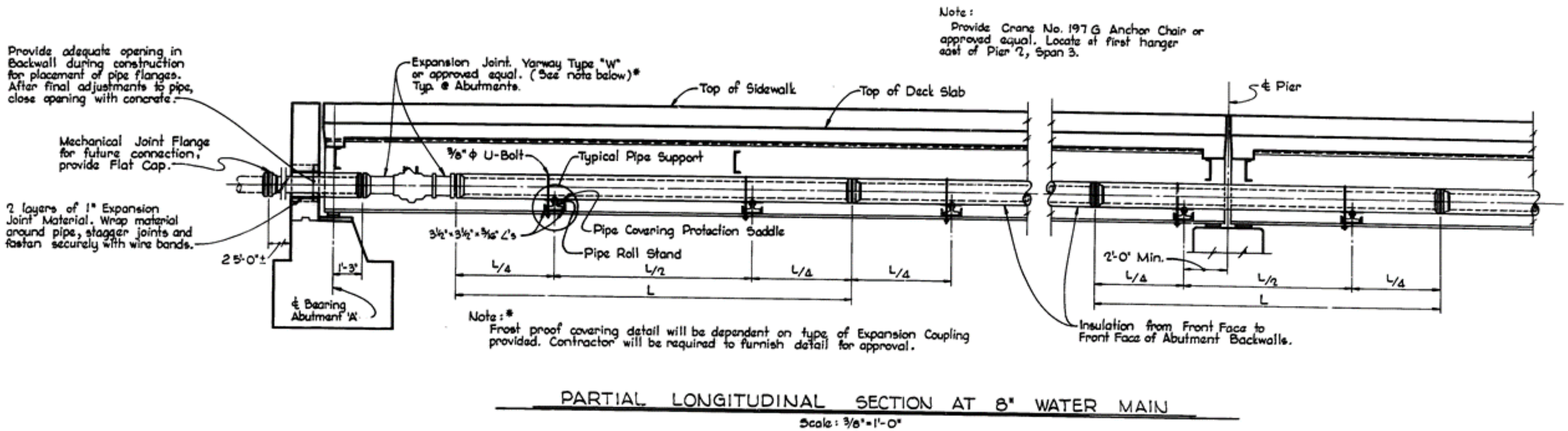
Marymont Drive – Piqua, Ohio



	Epoxy Cleaning and Lining	Traditional Pipe Replacement
Time Required	**3-5 days**	4-6 weeks
Access Requirements	**4 access points needing just 3 feet of pipe access**	Trench the entire street causing severe and long traffic disruptions

Rte. 42 bridge – Woodstock, Virgina



	Epoxy Cleaning and Lining	Traditional Pipe Replacement
Time Required	**2-3 days**	2-4 weeks
Access Requirements	**2 access points needing just 3 feet of pipe access**	Close half of the bridge down causing severe and long traffic disruptions

Franklin Avenue - Salem, Ohio

Time Required	**SUEZ Epoxy Cleaning and Lining**	**Traditional Pipe Replacement**
	3-5 days	4-6 weeks
Access Requirements	**4 access points needing just 3 feet of pipe access**	Trench the entire street causing severe and long traffic disruptions

Past Performance Examples

Kent County Courthouse
Dover, DE

U.S. Government GSA
Washington, D.C.

Indian Head Naval Base
Indian Head, MD

Bechtel
San Francisco, CA

DuPont Facility
Wilmington, DE

Horizon House
Naples, FL

JFK Airport
New York, NY

Saks 5th Ave
New York, NY

WTC Tower 4
New York, NY

299 Park Ave
New York, NY

Christie Street
New York, NY

The Prince
Marco Island, FL

NEW YORK AMERICAN WATER

Lehigh County Authority

GSA

PennState

pepco

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Spray-In-Place Pipelining Process – Summary

- **Extends asset life**
- **Eliminate corrosion and WQ issues**
- **Recover capacity**
- **Provides thermal isolation**
- **Rapid cure and Minimal disruption**
- **Withstanding prolonged exposure to heat, chemical and aggregate**
- **Suiteable for small diameters, turns and bends (1 ¼ to 72 inches)**

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Questions?

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