Acoustic Monitoring of Large Diameter Water Transmission Mains - City of Ottawa Case Study

CERIU - INFRA - 2011

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"Solutions for Sustainable Infrastructure"

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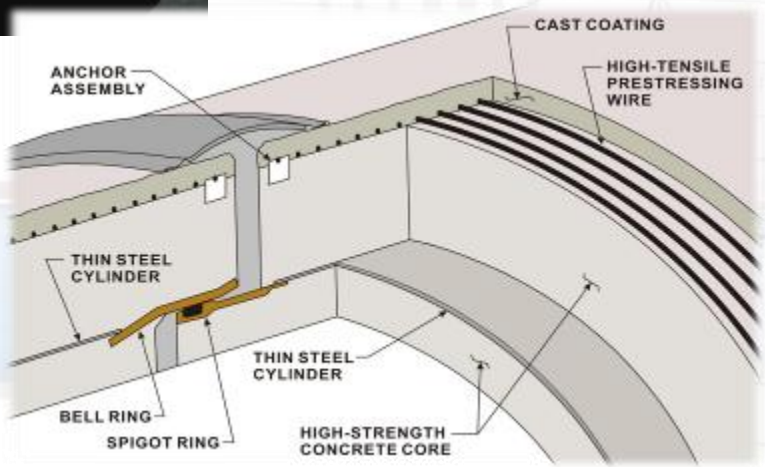
Reasons for doing condition assessment.

- Avoid replacing pipes that are still in good condition
- Rehabilitate individual pipes for a fraction of the full line replacement cost
- Optimize utility budgets
- Minimize the risk of significant pipeline failures
- Understand the true valuation of your underground infrastructure

PCCP Cross Section

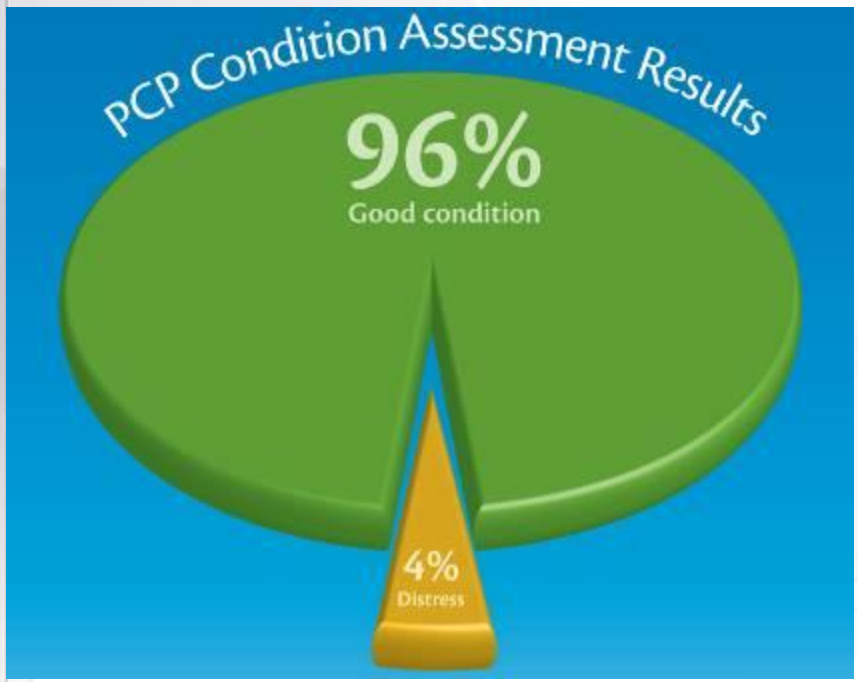
- Proven for a wide variety of pipe classes:
  - PCCP
    - *Embedded cylinder pipe*
    - *Lined cylinder pipe*
  - Non-cylinder pipe
  - Bar wrapped pipe



PCCP Deterioration

- Cracking of Outer Mortar
- Corrosion or Embrittlement of Wires
- Wires Break
- Bell and spigot corrodes and fails
- Cylinder corrodes and fails
- Mortar Coating Delaminates
- Concrete Core Delaminates
- Core Cracks
- Failure

Summary of Inspections

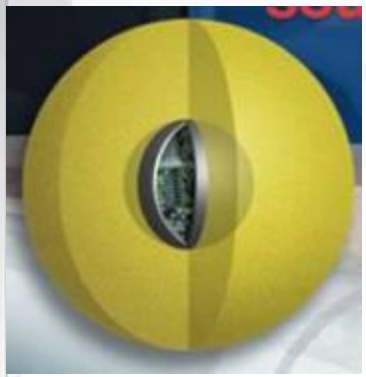


- Vast majority of PCCP which has been inspected is in good condition
- Trick is to find the “bad pipe” prior to failure and not waste money replacing pipes that are in good condition

Inspect for Leaks Prior to Dewatering

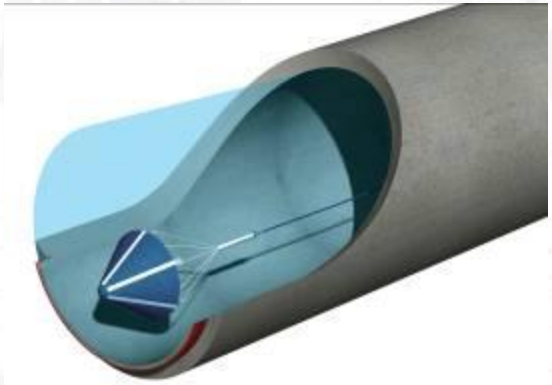
SmartBall® (free swimming)

- Long point-to-point transmission pipelines
- Minimal laterals



Sahara® (tethered)

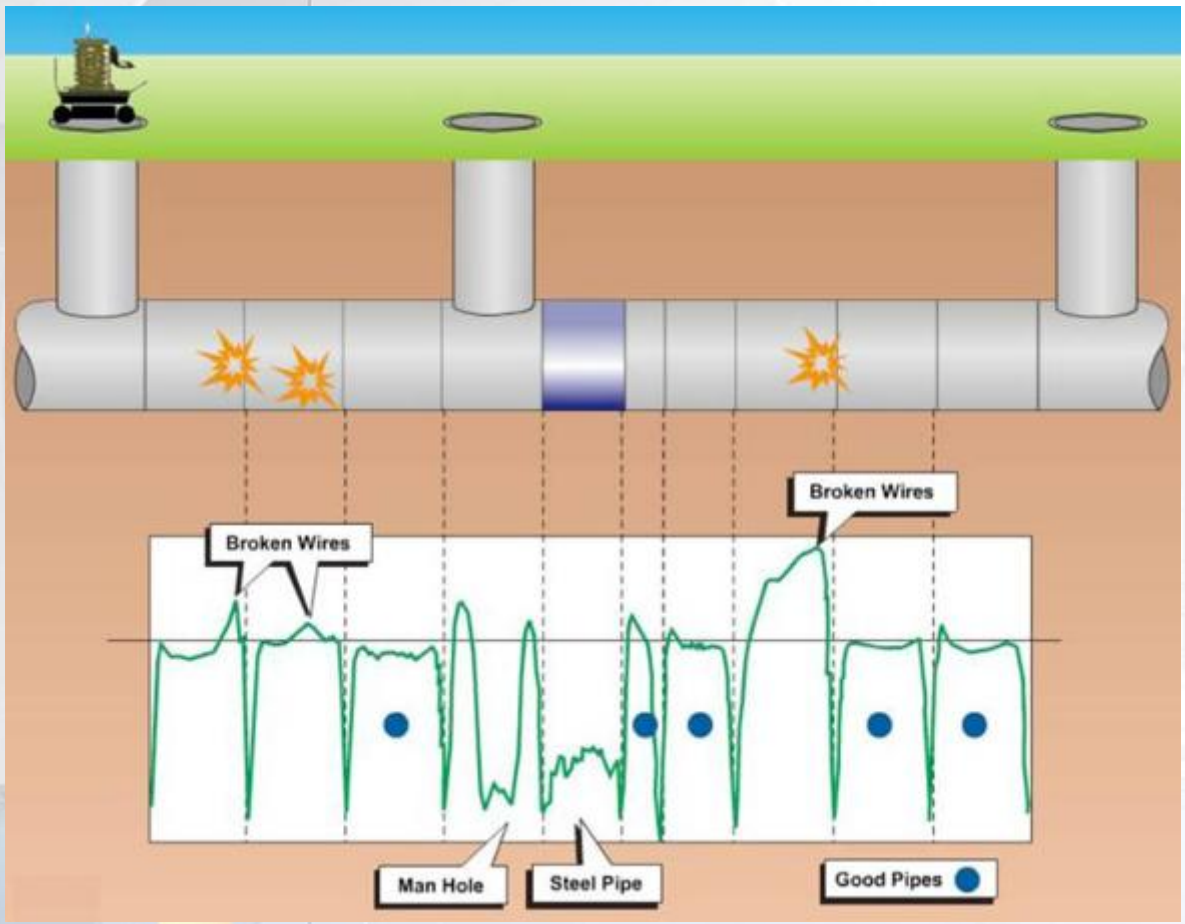
- Complex interconnecting networks
- Urban centers



Gives you the ability to inspect and fix leaks during shut down

Leak inspection prior to line shut-down as part of maintenance routine

Electromagnetic Basics



Functions like a radio transmitter and receiver

Transmitter produces an electromagnetic field which is amplified by prestressing wires

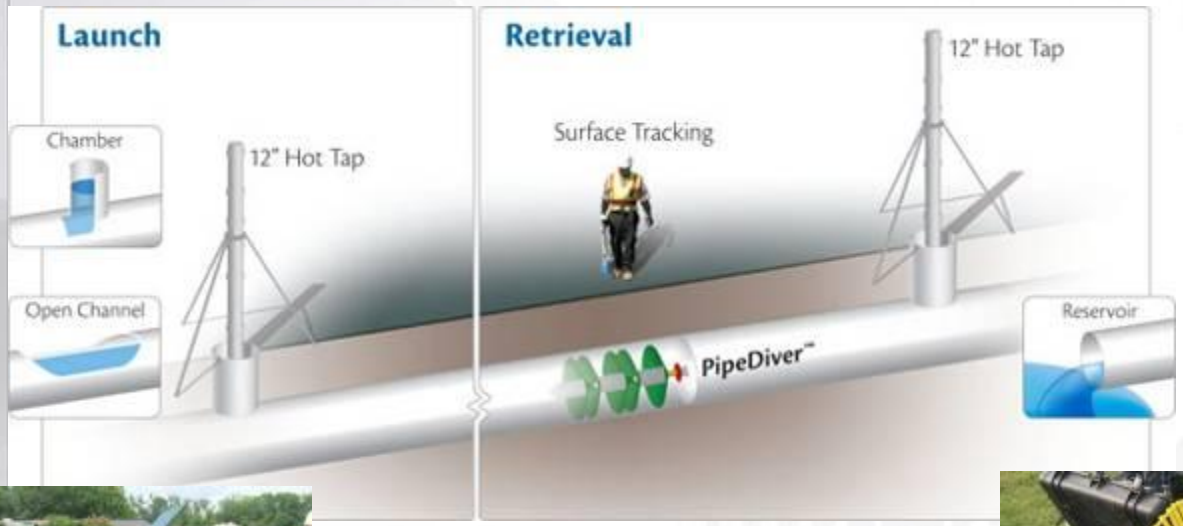
Receiver captures the signal and:

- Detects and quantifies wire break damage

- Provides estimate of wire breaks in each pipe section

- Provides location of wire breaks

PipeDiver™ Process



Insertion sleeve with guide

Extraction sleeve with net

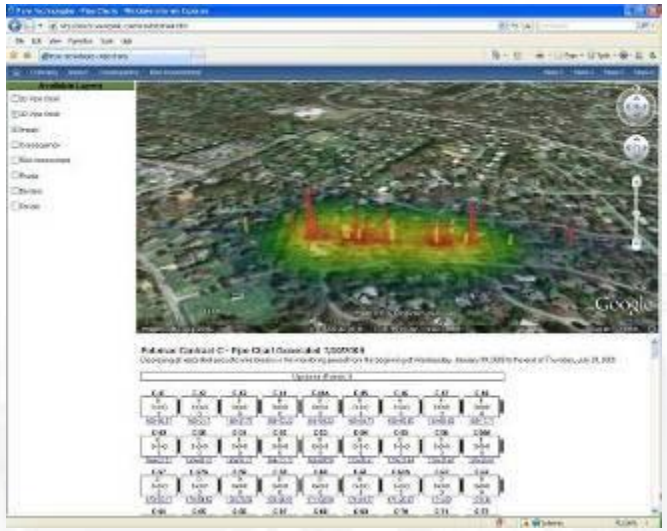
Visual & Sounding

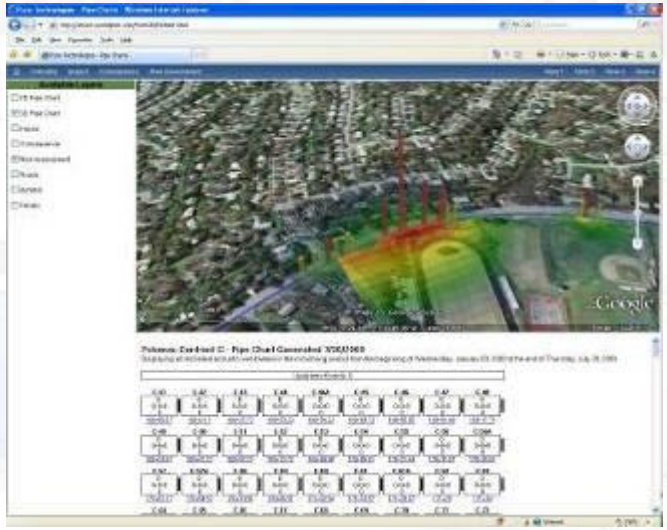
- Visual and sounding inspection complements other inspection methods
- Identify problems with joints that are not addressed by EM methods
- Find problems that are not related to wire breaks (i.e., over loading, cracking, etc.)

GIS Mapping

Web based data management

- Visual consequence of failure and risk management
- Accurate asset monitoring for repair and replace programs
- Data inputs: manual inspections, electromagnetic inspections, leak identification, fiber optic monitoring





Understanding the Inspection Results

Extending the life of critical assets

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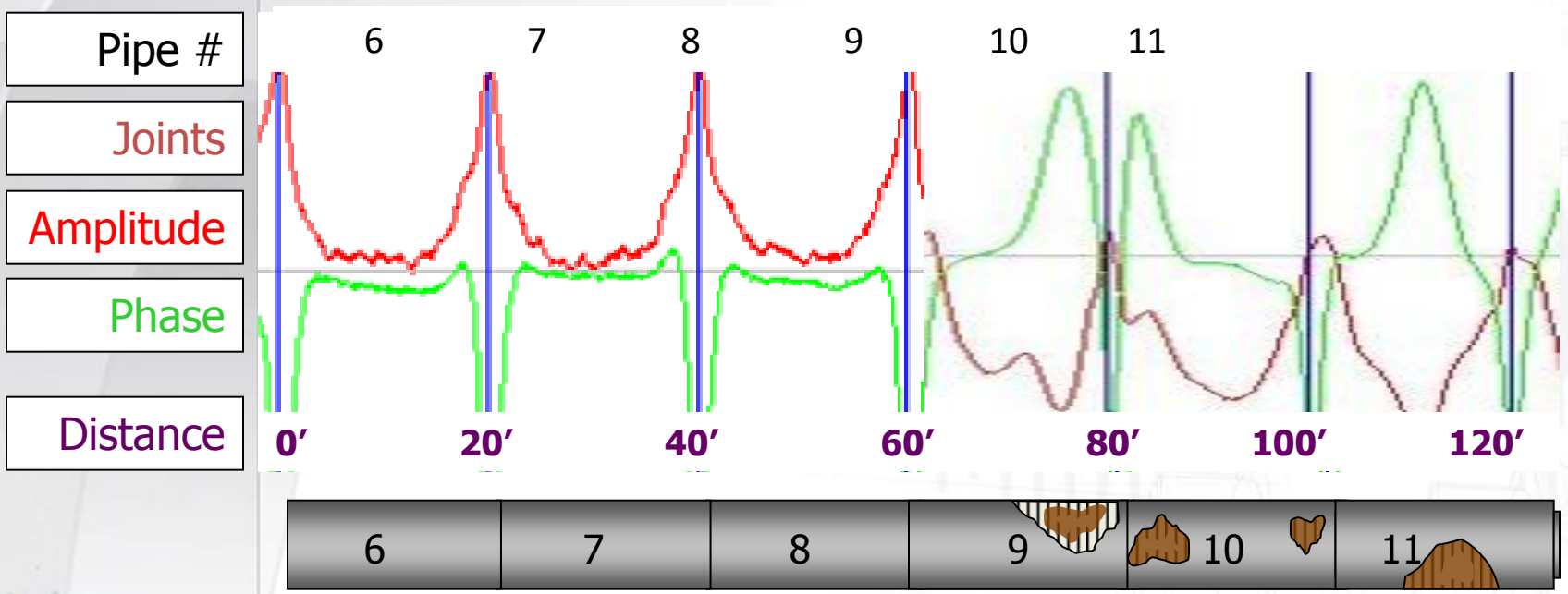
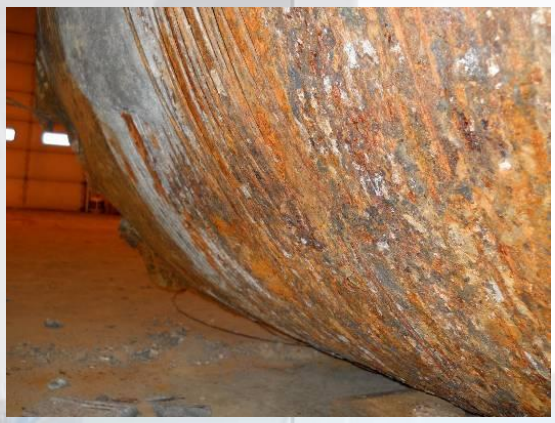
EM Data Analysis

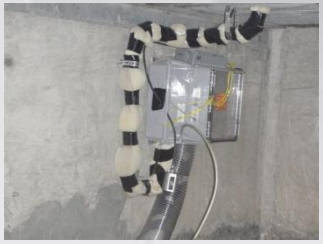


Forensic Study and Internal Inspection



What is AFO?



- AFO stands for:
  - *Acoustic Fiber Optics*

- We use fiber optics to monitor the breaking of pre-stressed wires in Pre-stressed Concrete Cylinder Pipe (PCCP). Also, currently in service as a continuous leak detection system.

- The fiber optic cable is able to *LISTEN*, *IDENTIFY*, and *LOCATE* breaks of the pre-stressed wires in the PCCP.

How does AFO work?

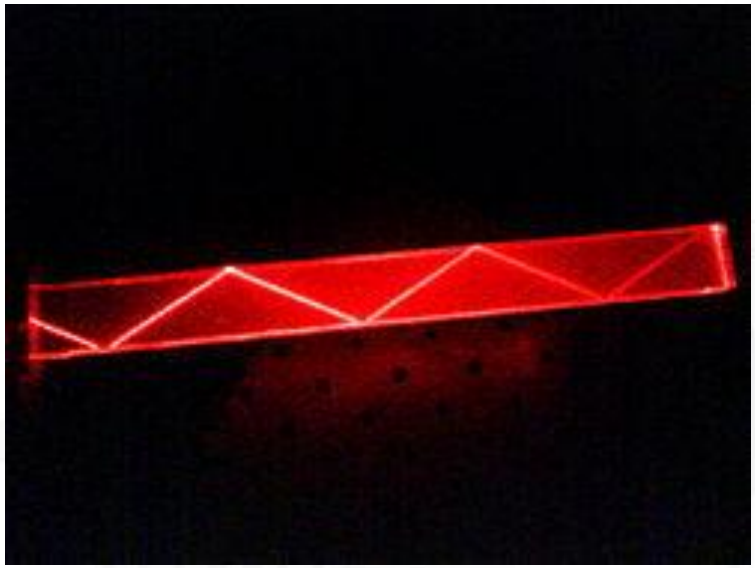
- Fiber optic cable is laid on the inside surface of PCCP and acts as one long underwater microphone
- Data Acquisition Unit interprets and saves the Data
- AFO works as a two part system using two different fibers:
  - The first fiber LISTENS to the pipeline (acoustic fiber)
  - The Data Acquisition Unit IDENTIFIES events, and saves the information
  - The second fiber LOCATES the wire break along the length of the pipeline (locating/OTDR fiber)

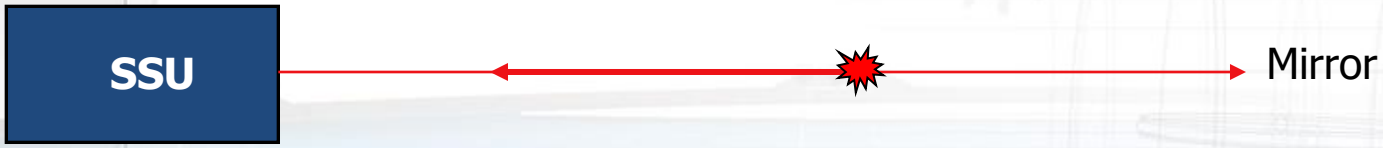
Both fibers operate differently, but with the same principle that pressure waves from wire breaks will create light reflections in the fiber bundles which are then measured and interpreted.

How Does AFO Listen?

Acoustic

- Sound is a pressure wave
- Constant light beam
- Changes the shape of the fiber
- Causes change in the wavelength
- Translated into sound





DAQ Cabinet

- The cabinet contains all electronic components which monitor the fiber optic line
- All the information acquired by the DAQ system is sent to Calgary via the internet for analysis
- Extra fiber bundles can be used for IT and SCADA applications

The Data Acquisition Unit is able to *LISTEN*, *IDENTIFY*, and *LOCATE* breaks of the pre-stressed wires in the PCCP, leaks in both PCCP and metallic pipes

AFO Long-term Monitoring

AFO installation

Data acquisition

AFO Wet installation – permanent or multiple site

Using AFO to take Action

Primary Objective -> Prioritize Rehabilitation Schedule

- Identify pipes as they pass the yield/damage limit state
- Plan repair/replacement in a timely manner

Secondary Objective-> Warning for Immanent Failure

- Identify pipes that are rapidly deteriorating
- Repair/replacement ASAP

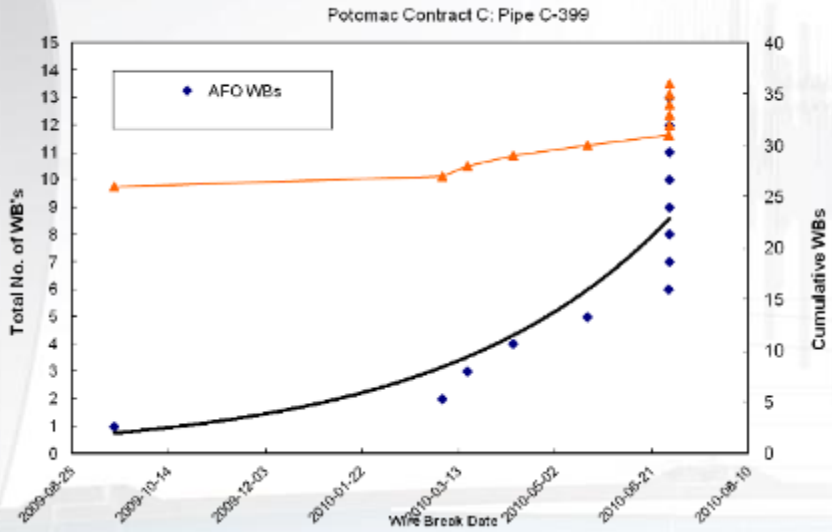
pure™ TECHNOLOGIES & PPIC the Pressure Pipe Inspection Company

better, together

Long-term Monitoring Success

Potomac 96-inch Transmission Main – Emergency Repairs

- 8 wire breaks detected in less than 10 hours (6 in ½ hour)
  - WSSC immediately mobilized for repairs
  - Mandatory water restrictions issued for 1.8 million customers



Warning for Immanent Failure

Potomac 96” ECP Transmission Main

10:30 Pure alerts WSSC of rapid deterioration

12:00 Pure and WSSC perform impacts to double check location

24:00 Client decides to issue water restrictions and take line out of service

+1 Day Pipe is excavated and wire breaks are confirmed

+4 Days Pipe is replaced

+5 Days Pipe is

The Washington Post

Housing market's recovery stalls

1.8 million face limits on water over the holiday

Case Study

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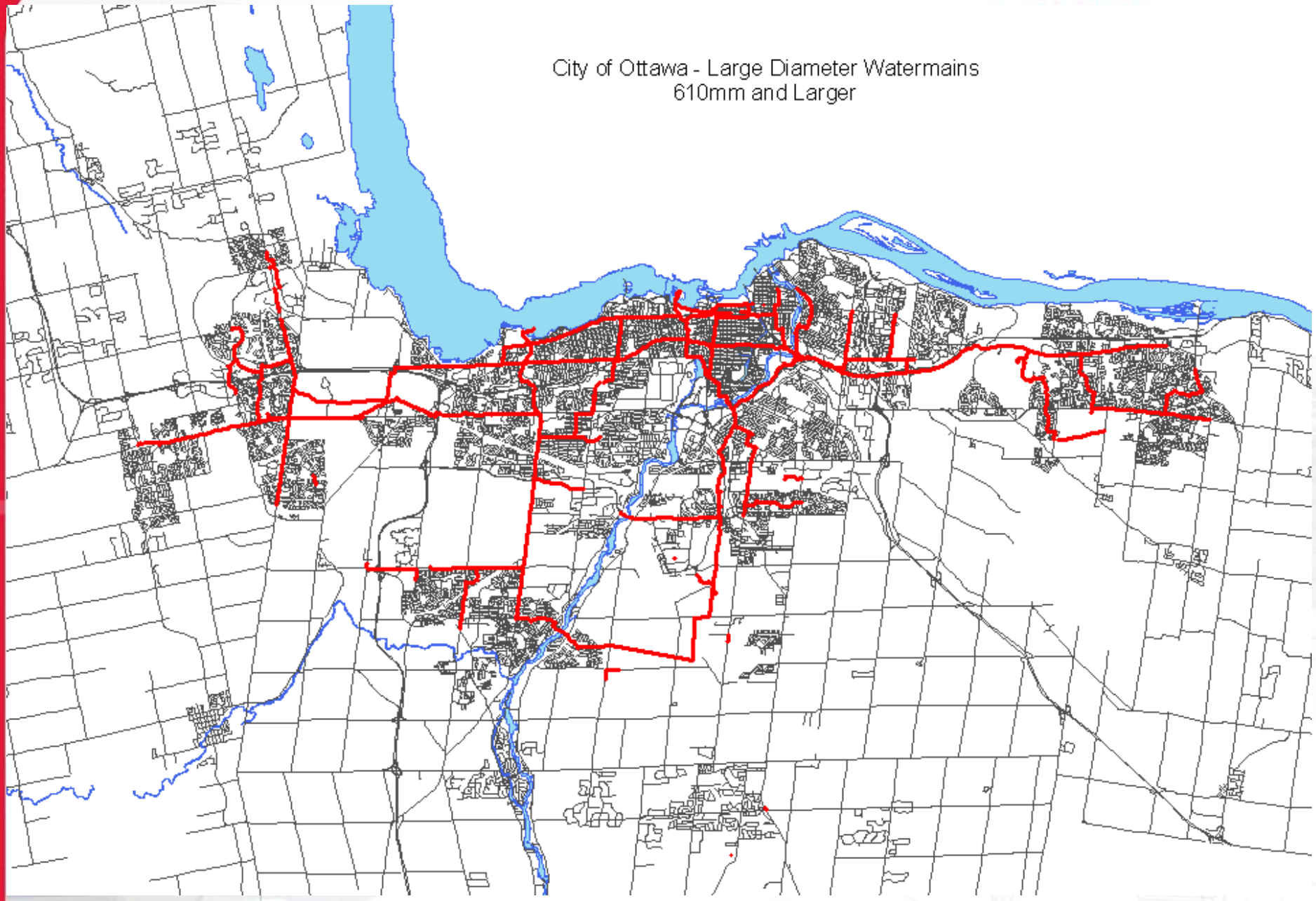
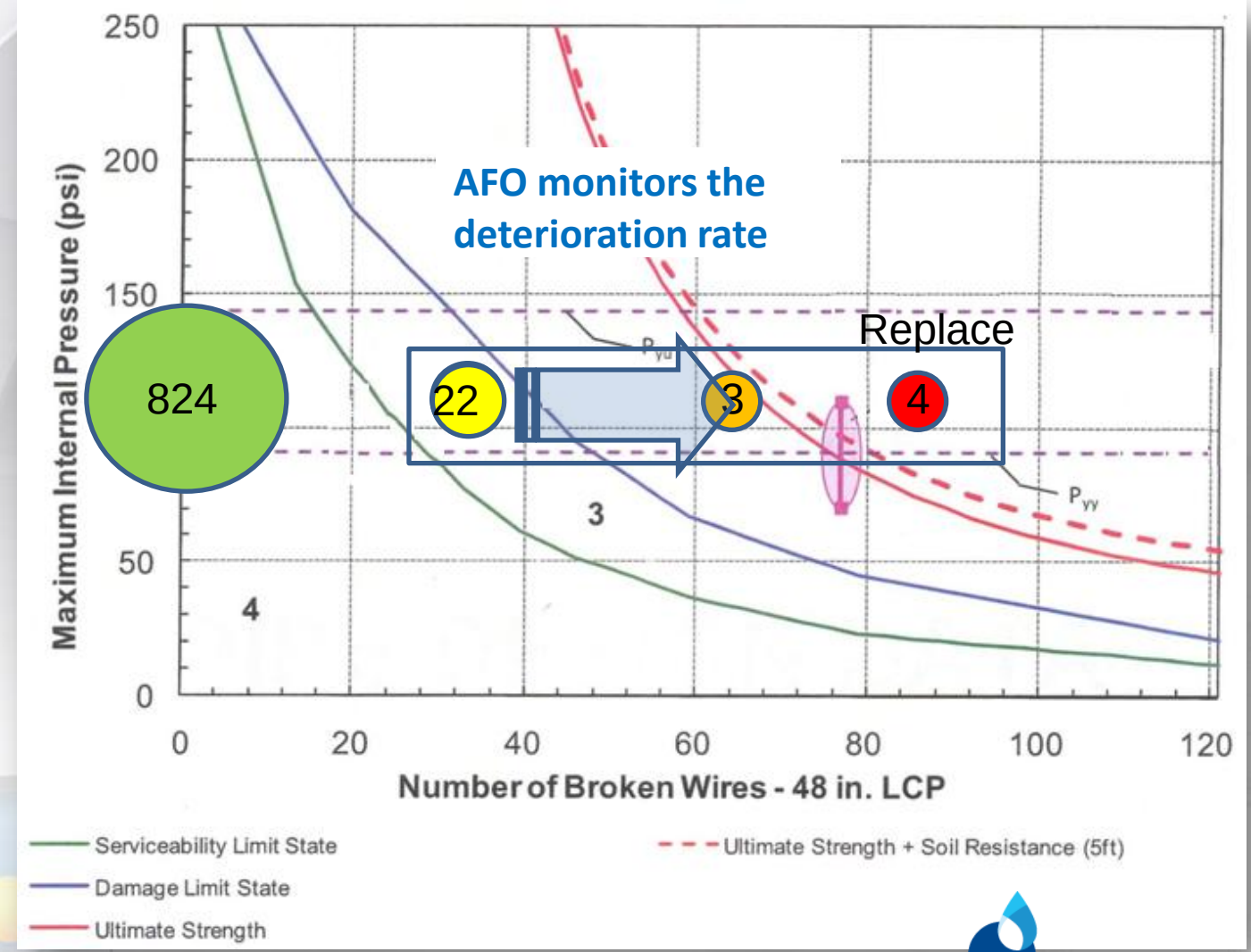
City of Ottawa Statistics

- Serviced population – 824,656
- Length of public main – 2,838 km
- Length of main > 600 mm – 236 km
- Service area – 2770 km^2
- Number of hydrants – 18,293
- Number of valves - 40,553
- Number of services – 204,277
- Average system pressure – 45 m (64 psi)


City of Ottawa - Large Diameter Watermains
610mm and Larger

Performance Curves



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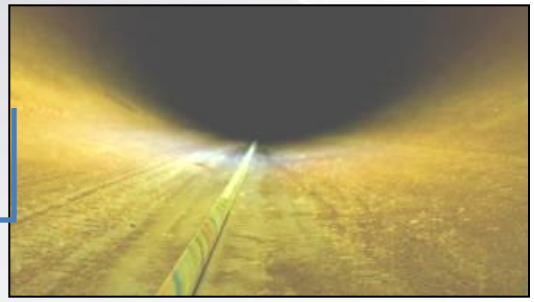
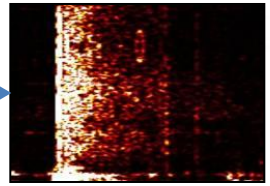
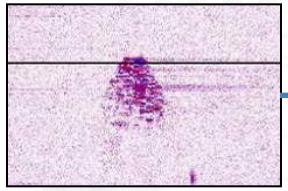
AFO – Continuous Monitoring



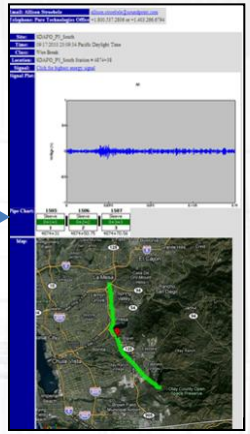
- ✓ Listen
- ✓ Locates
- ✓ Identifies Wire Breaks

Data Acquisition System





Data Analysis



E-mail Notification

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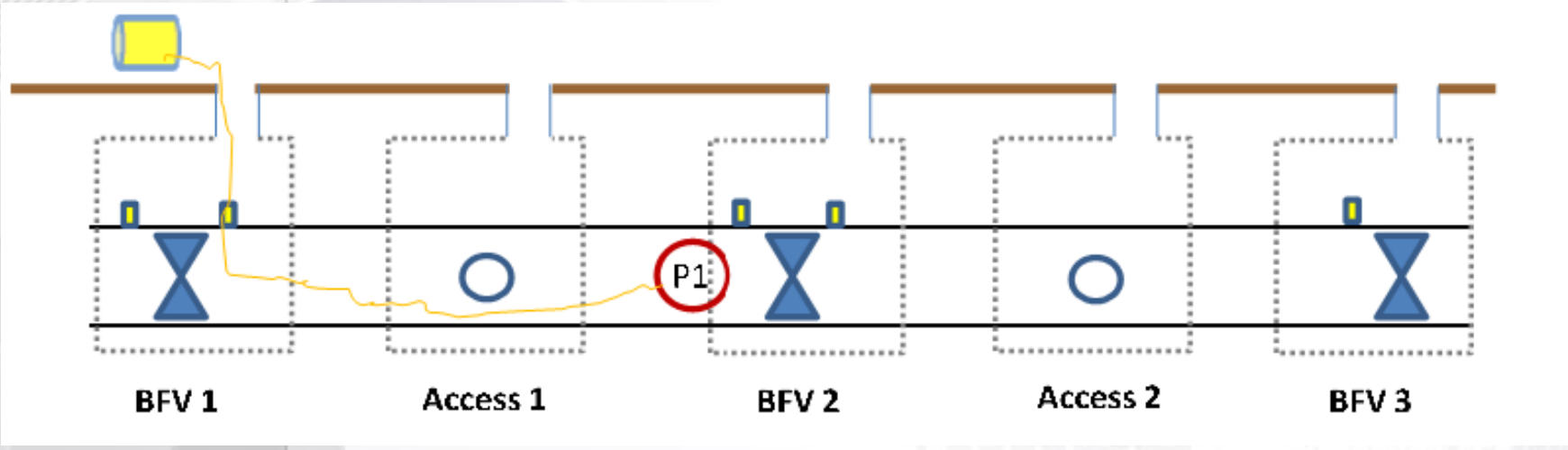
Dry Install



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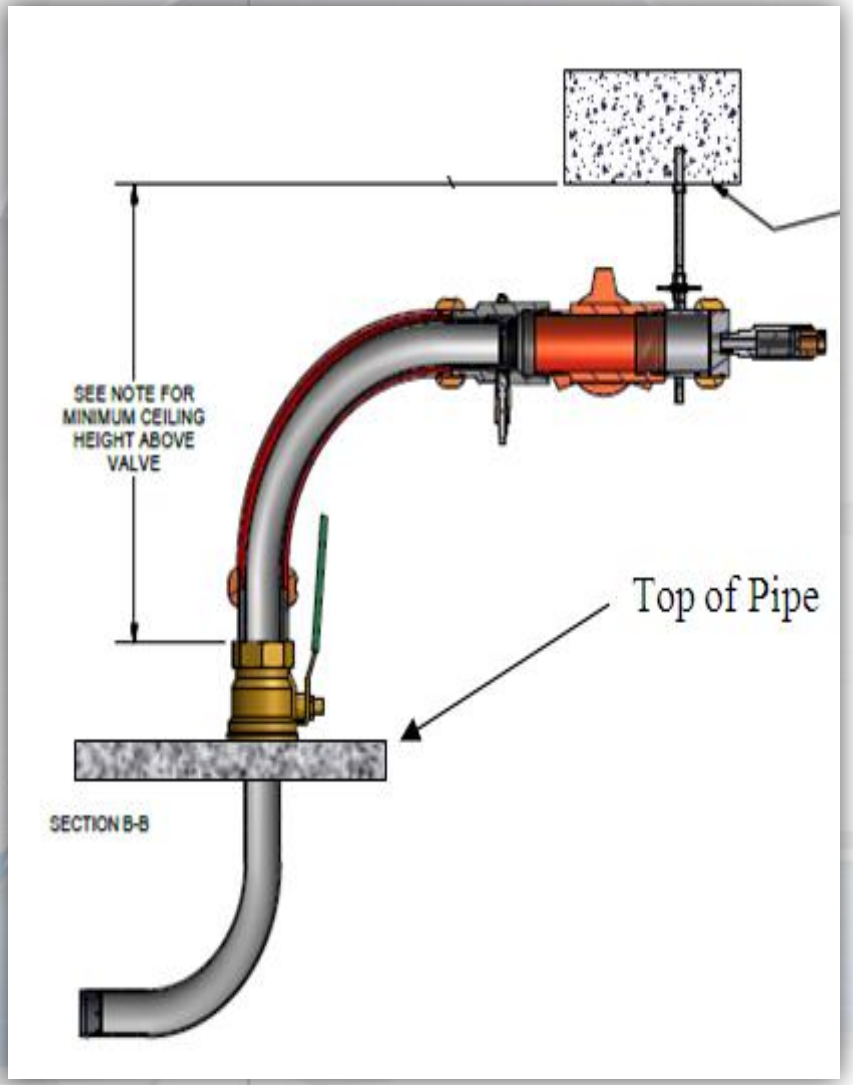
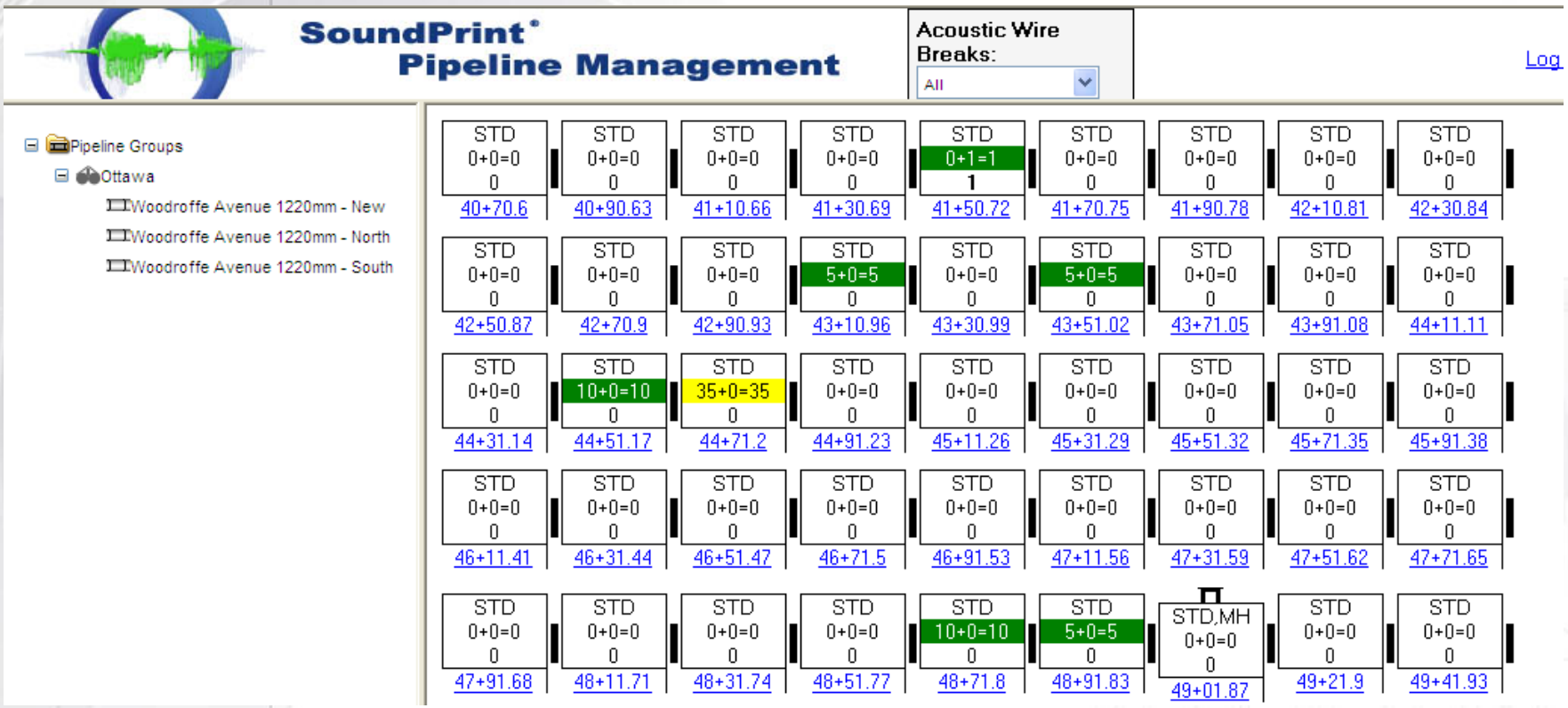
FO Cable Entry/Exit Details

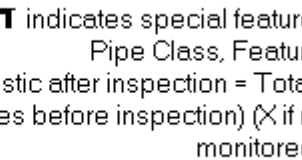


Pipeline Management System



Legend

Pipe # (⊓ indicates special feature):
Pipe Class, Feature:
Total Wire Breaks(P-Wave + Acoustic after inspection = Total):
Acoustic Wire Breaks (Includes before inspection) (X if not monitored):
Beginning Chainage (click for pipe details):



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Transient Pressure Monitoring

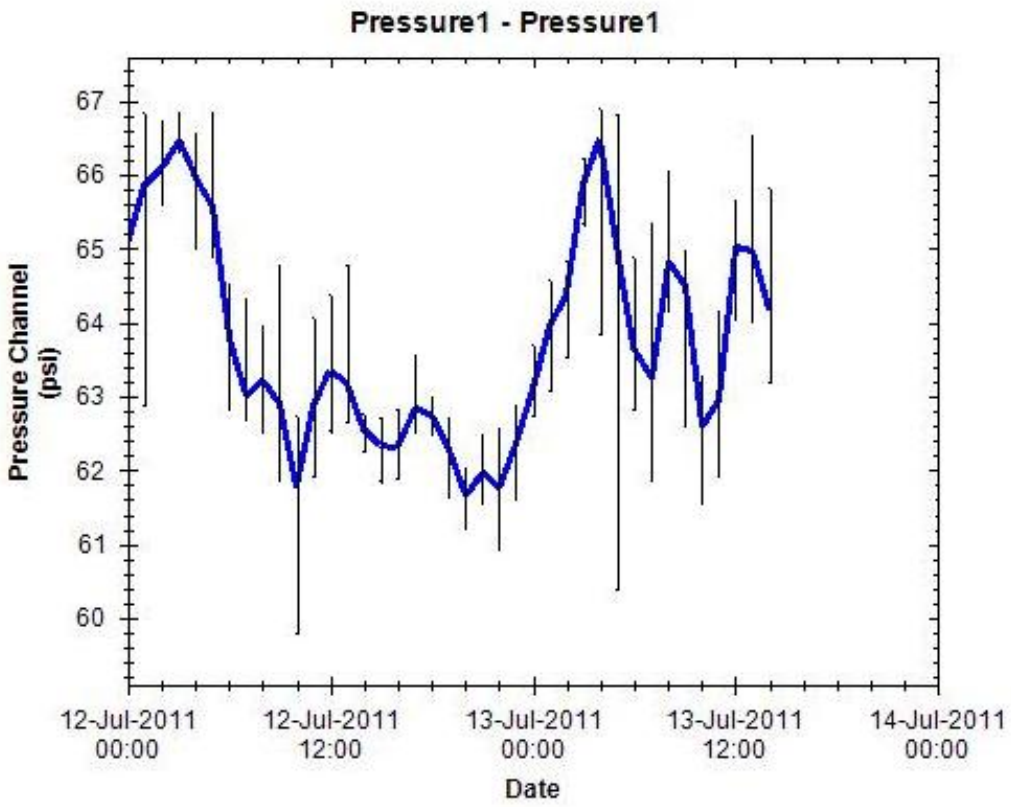
SoundPrint® Pipeline Management

Acoustic Wire Breaks: All

- Pipeline Groups
  - Ottawa
    - Woodroffe Avenue 1220mm - New
    - Woodroffe Avenue 1220mm - North
    - Woodroffe Avenue 1220mm - South

Record Rate
Normal: 5 min
Transient: 1 ms

Threshold
psi change over 1 s (exp 10 psi)
or
Standard deviation



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Email Notification

From: Pure Technologies Lt
To: Cameron White
Cc:
Subject: Wire Break Alert Otta

The SoundPrint® event for the moni

Site:
Date / Time:
Event Classification:
Location:
Pipe Diameter:
Pipe Class:
Repaired / Replaced:
Pipe Chart:

Zoomed Map:

STD	STD	STD
0+0=0	0+1=1	0+0=0
0	1	0
122+20.16	122+40.19	122+60.22

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AFO Projects in Canada

<u>To date, there are two projects in Ontario:</u>

- The first is in London Ontario – 20km system, phase one installed in 2010, second phase scheduled for fall of 2011.
- In April/May of 2011 a 6km system was installed for the City of Ottawa.

Thank you! Merci!

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