AMERICAN WATER

Pressure Management:
Baseline to Optimized Utility Case Studies

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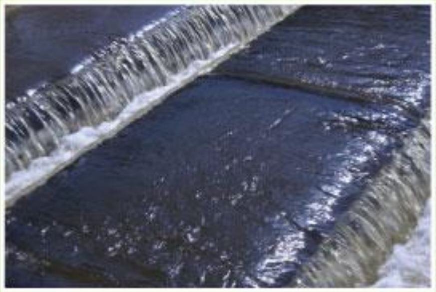


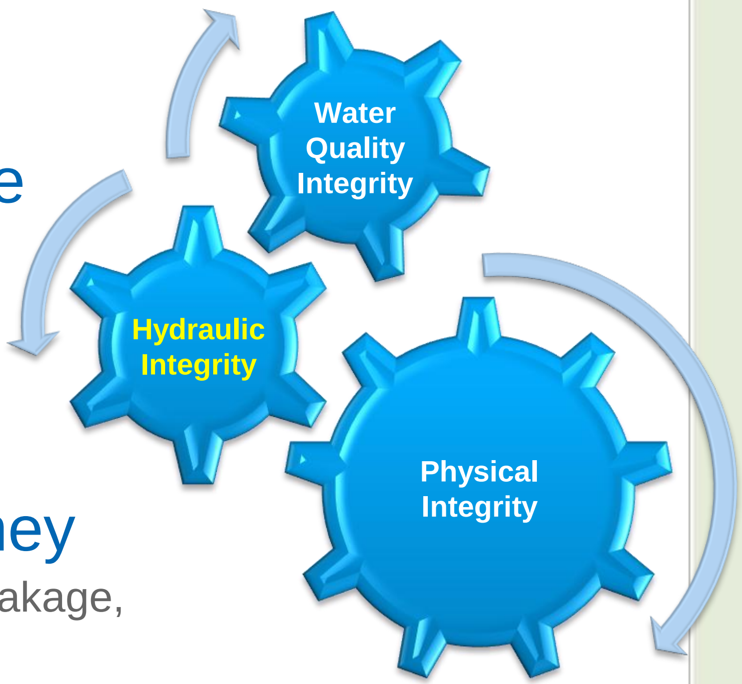
Importance of Maintaining Adequate Pressure

Fundamental to providing safe drinking water

- Loss of pressure can allow intrusion of contaminants in to the distribution system

Fluctuations in pressure can affect the physical integrity of pipes

- Pressure spikes can result in leaks, main breaks, and premature failure



Pressure management can save money

- Reduced energy costs, system maintenance, leakage, customer complaints, water quality problems

National Research Council. 2006. *Drinking Water Distribution Systems Assessing and Reducing Risks.* National Academy of Science.

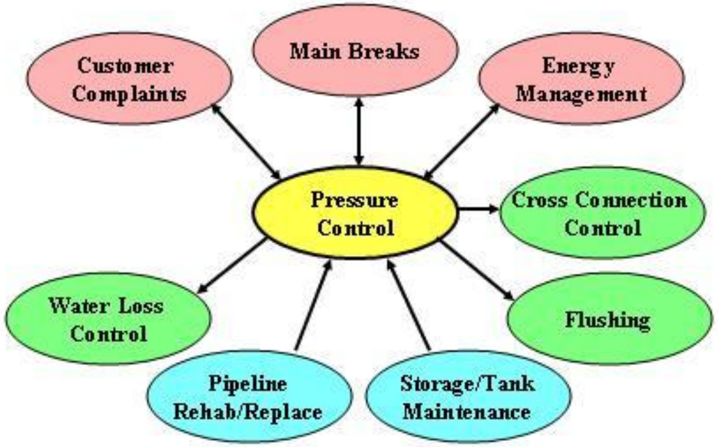
Pressure Management – Optimized Distribution Systems

Distribution System Optimization consists of thee focus areas:

- Disinfectant residual, Pressure management, Main breaks
- Impact most of the 19 categories examined

Optimized Pressure Management Goals

- >0 psi during emergencies
- >20 psi under max day and fire flow conditions
- >35 psi under normal conditions
- <100 psi under normal conditions
- Within +/- 10 psi of average, >95% of the time



Optimized Pressure Monitoring

- A minimum of two pressure recorders in each pressure zone placed at the minimum and maximum pressure locations

Friedman et al., 2010. *Criteria for Optimized Distribution Systems.* Water Research Foundation, Denver CO.

#4321 Pressure Management: Baseline to Optimized

Task 1: Conduct a utility survey

- Determine prevalence of distribution system attributes leading to undesirable pressure variations

Task 2: Conduct baseline and optimized pressure monitoring

- Conduct 12 month baseline (existing) and optimized pressure monitoring at 24 participating systems

Task 3: Integrate pressure management with other distribution system activities

- Demonstrate how the cost of an optimized pressure management program can be offset by cost reductions in other system operations (backflow sensing metering, water quality, model optimization, main break/repair activities, customer complaints, etc)

Task 4: Develop best practice guidance

- Strong utility focus on best practices and strategies for pressure management.

Task 1: Utility Survey

- Zoomerang online survey
- Distributed to ~330 water utilities (36 responded)
- One third each: small, medium, and large systems
- Surface/Groundwater/Both: 47%, 19%, and 33%

	Minimum	Median	Maximum
# of service connections	414	20,000	475,371
Total population	1,040	77,600	2,500,000
Retail service area ($miles^2$)	<1	28	1,300
Total lengths of water mains	16	300	5,500
Average daily delivery (MGD)	0.2	11	245

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Survey – Low Pressure Criteria/Goal

- Most States have some requirement for maintenance of pressure

During Fire Flow

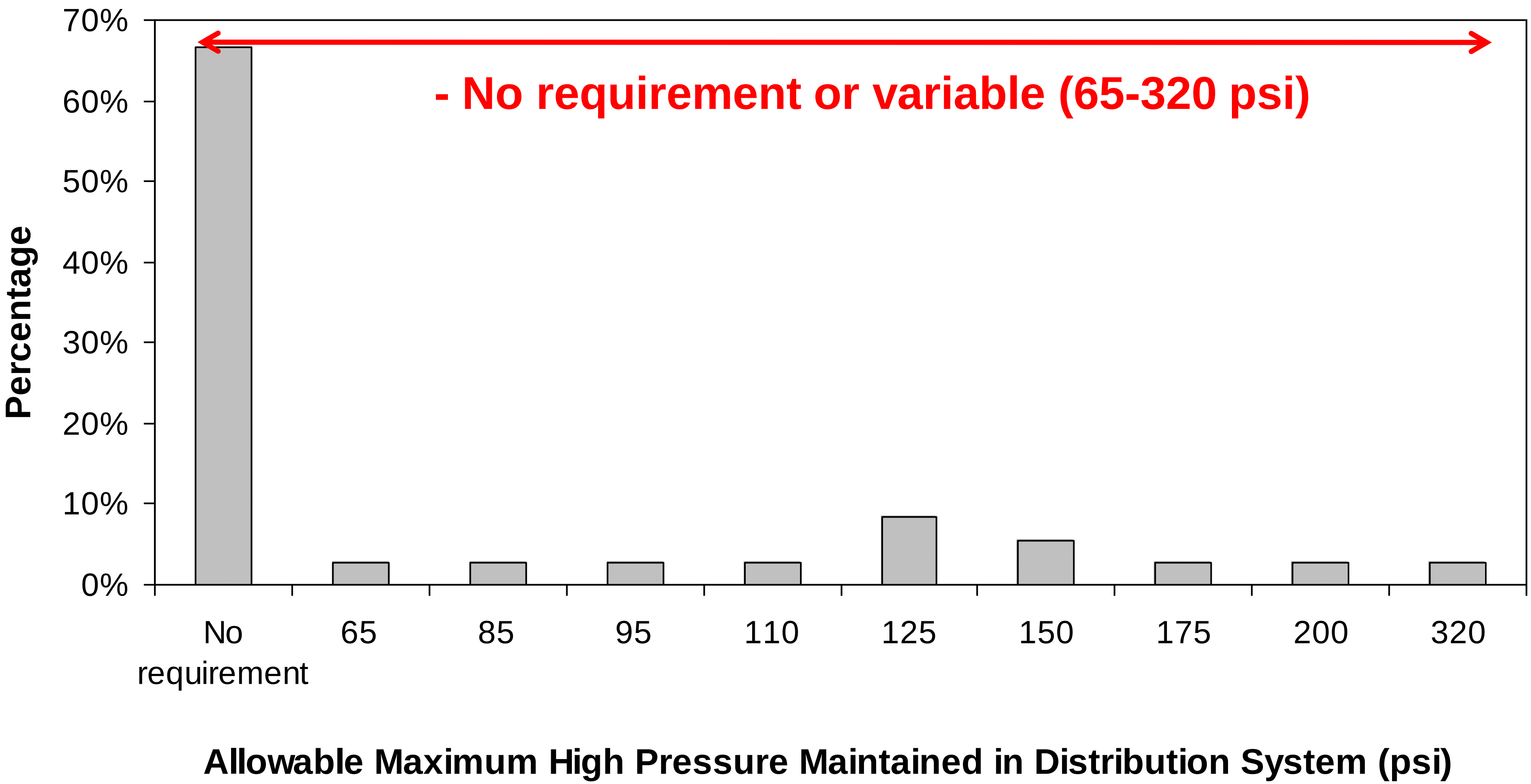
Pressure (psi)	Percentage (%)
0	2.7
20	95.0
30	2.7

During Emergency Conditions

Pressure (psi)	Percentage (%)
0	21.0
0 to 20	2.6
20	68.0
30	2.6
No requirement	5.3

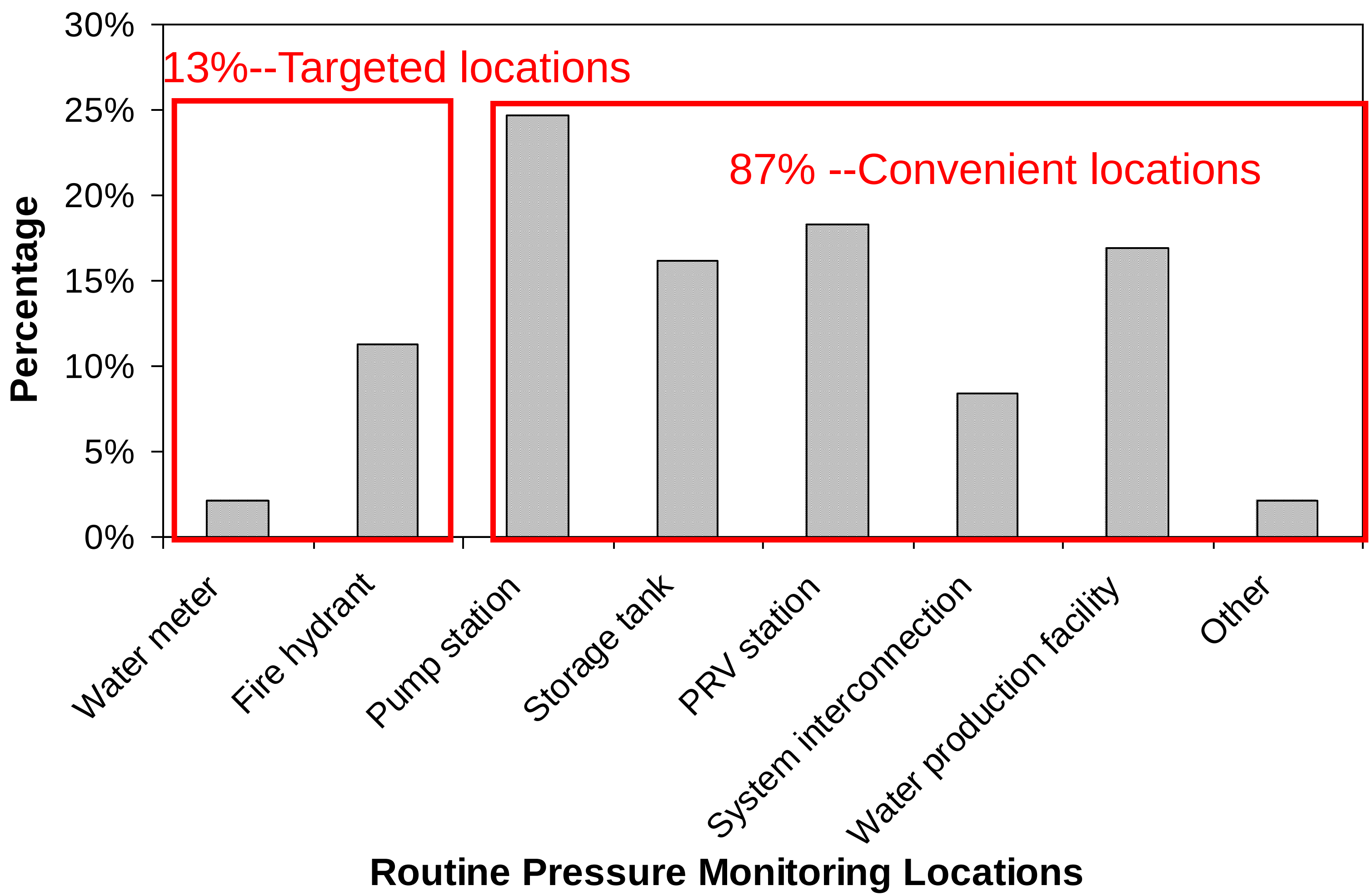
Most have a minimum requirement of at least 20 psi
Highly variable after this point

Survey – High Pressure Criteria/Goal



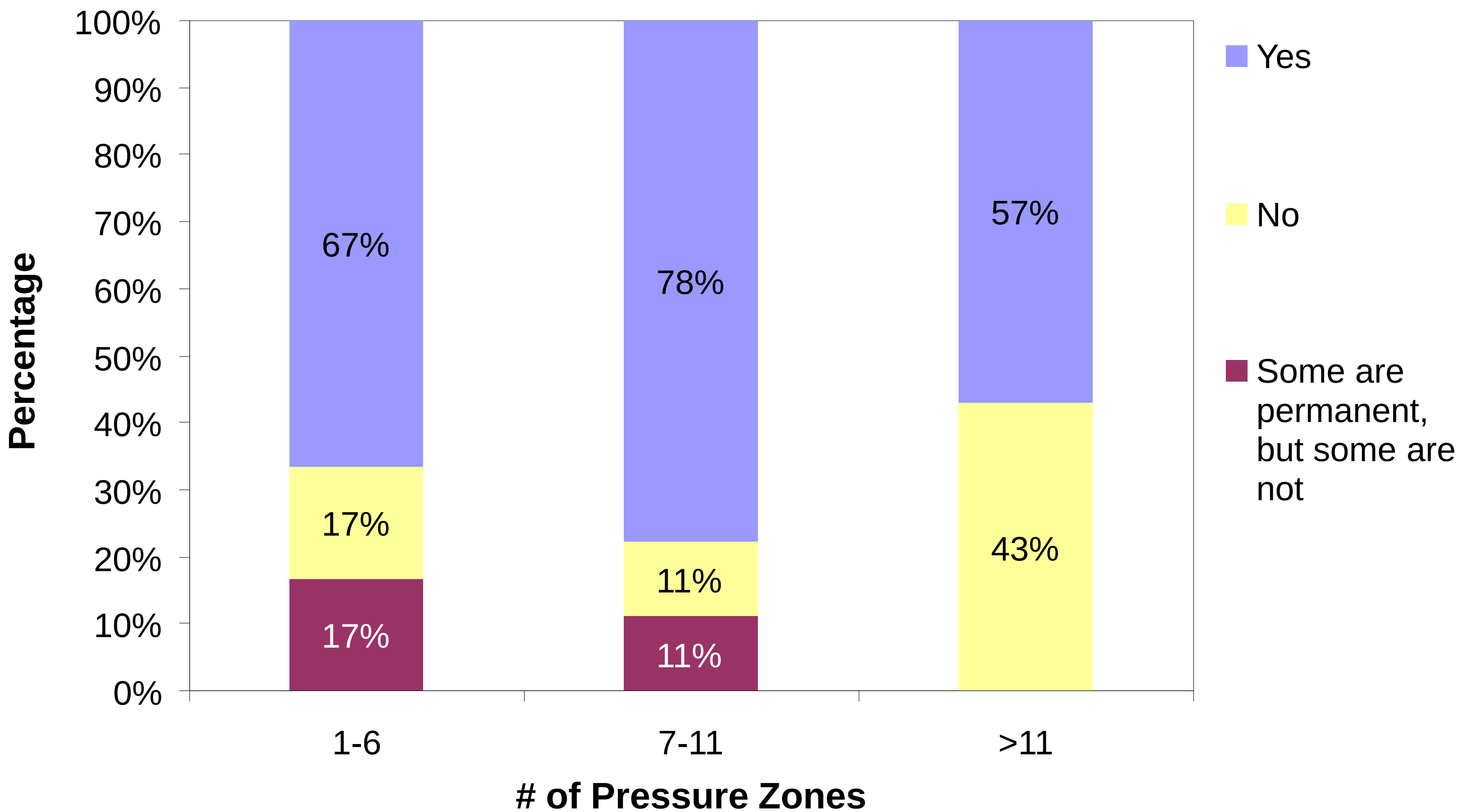
Survey – Pressure Monitoring

- **Pressure monitoring locations**



Survey – Pressure Monitoring

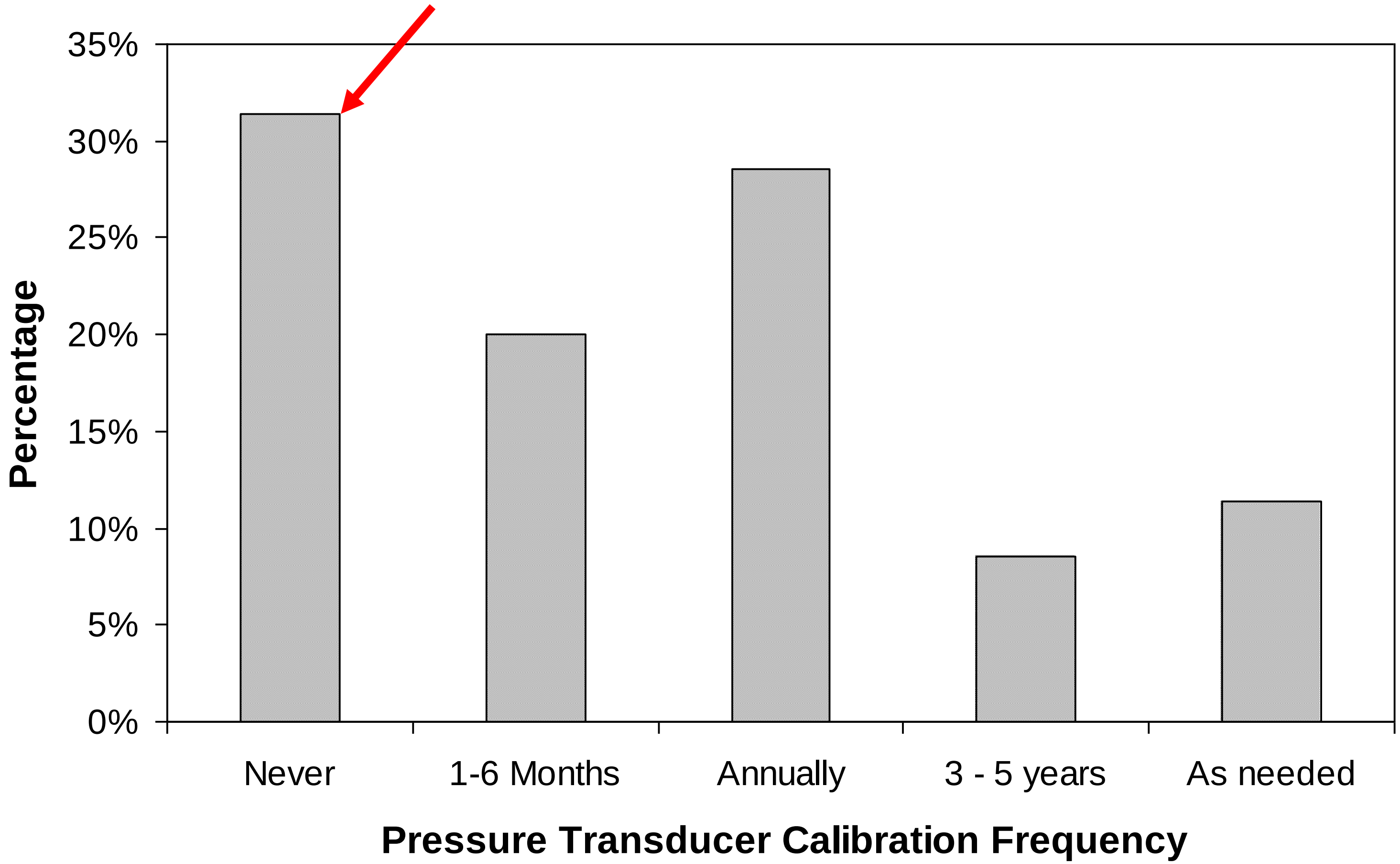
- **Smallest pressure zone – Are the routine monitors permanently installed ?**



Survey – Pressure Monitoring

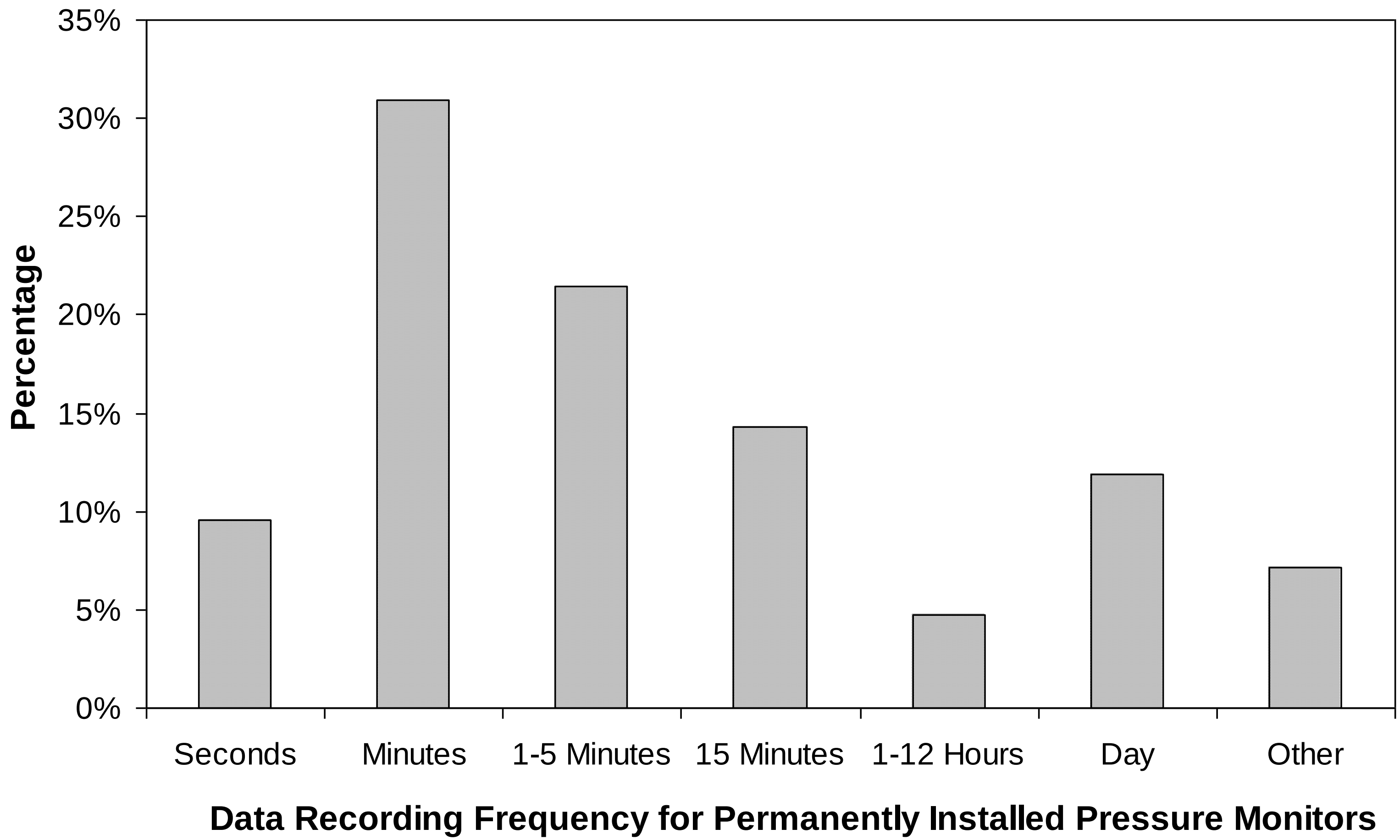
- Monitor calibration

What? You're supposed to calibrate these things?

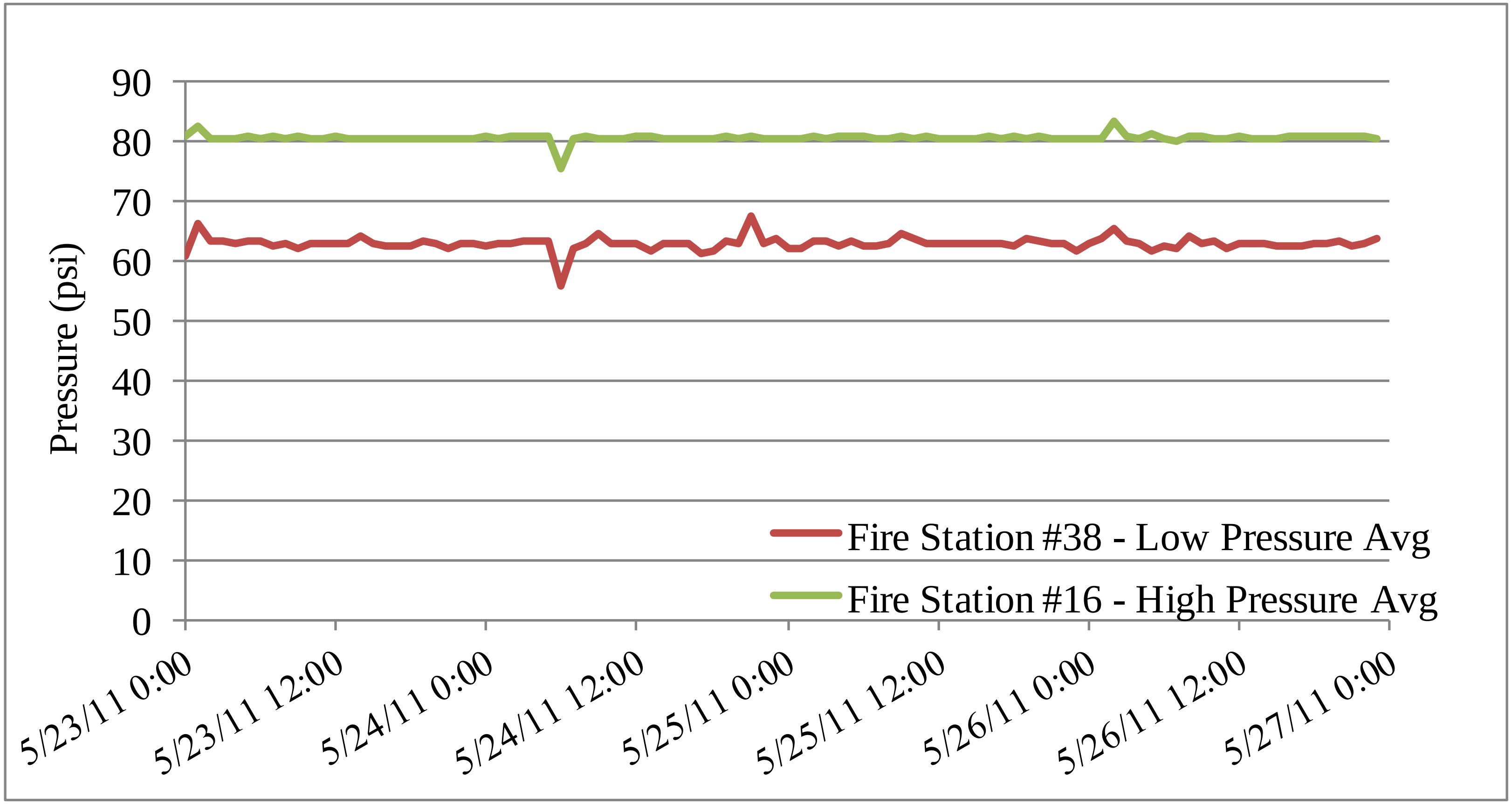


Survey – Pressure Monitoring

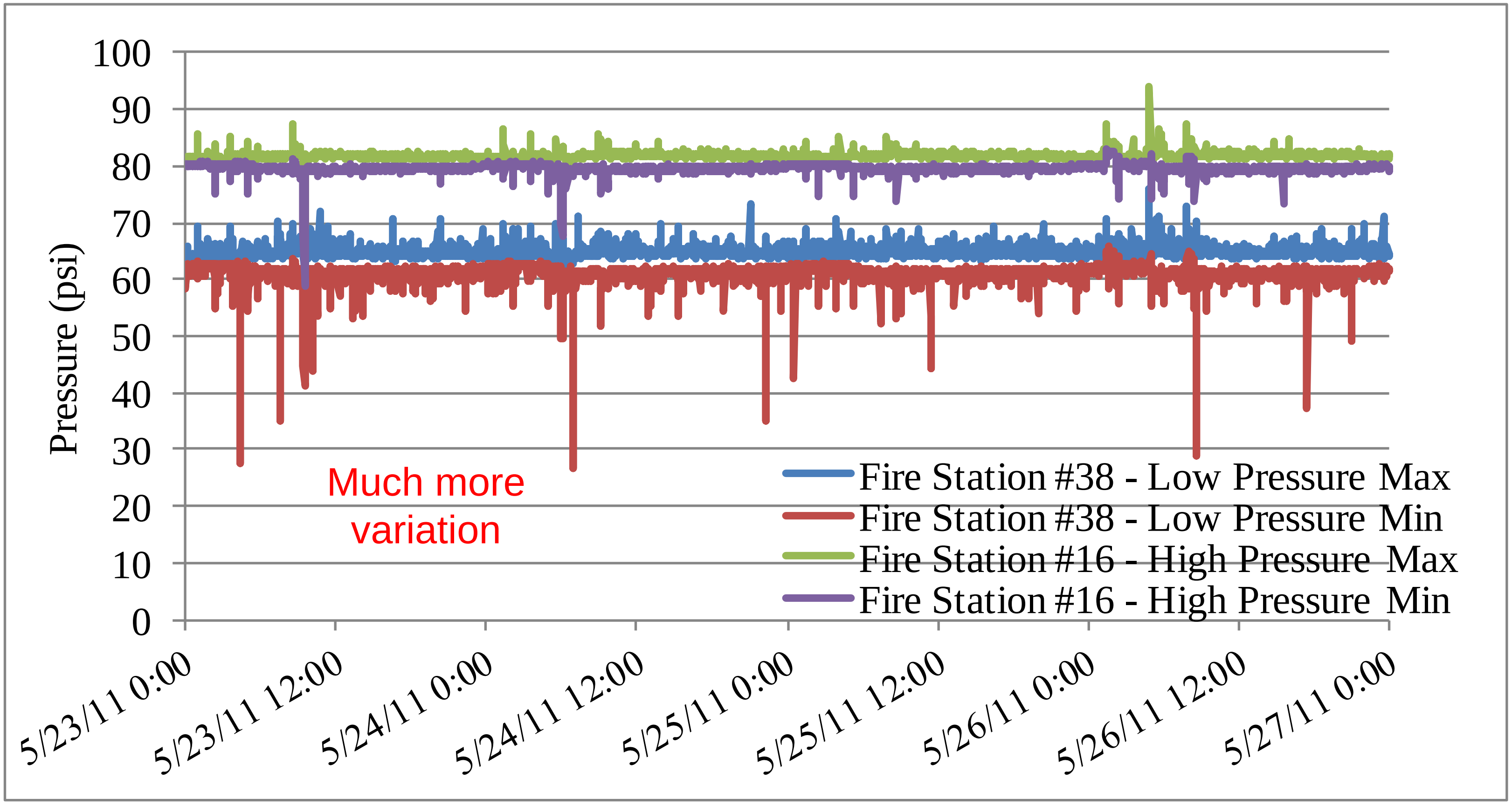
- Monitor recording



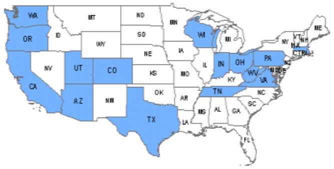
Pressure monitoring data in 1-hour interval



Pressure monitoring data in 2-minute intervals



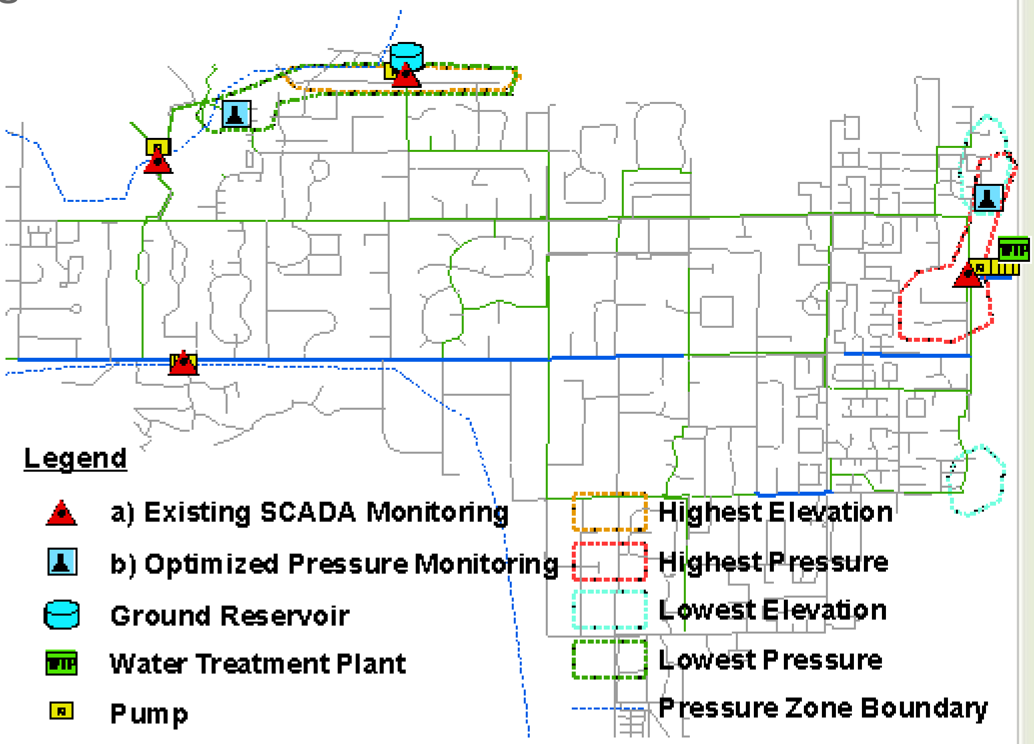
Task 2: Optimized and baseline monitoring



- **Approach**
  - Select a study pressure zone
  - Choose two optimized monitoring locations
  - Conduct baseline and optimized pressure monitoring over 12 months
- **Optimized pressure monitoring**
  - A minimum of two pressure loggers at the min/max pressure locations (WaterRF #4109)
- **Baseline pressure monitoring**
  - Existing pressure monitoring (e.g. SCADA pressure monitoring at pump stations or PRV stations)
  - A “baseline” monitoring may be already “optimized” (e.g., lowest pressure at monitored tank, highest pressure at monitored pump or PRV station)

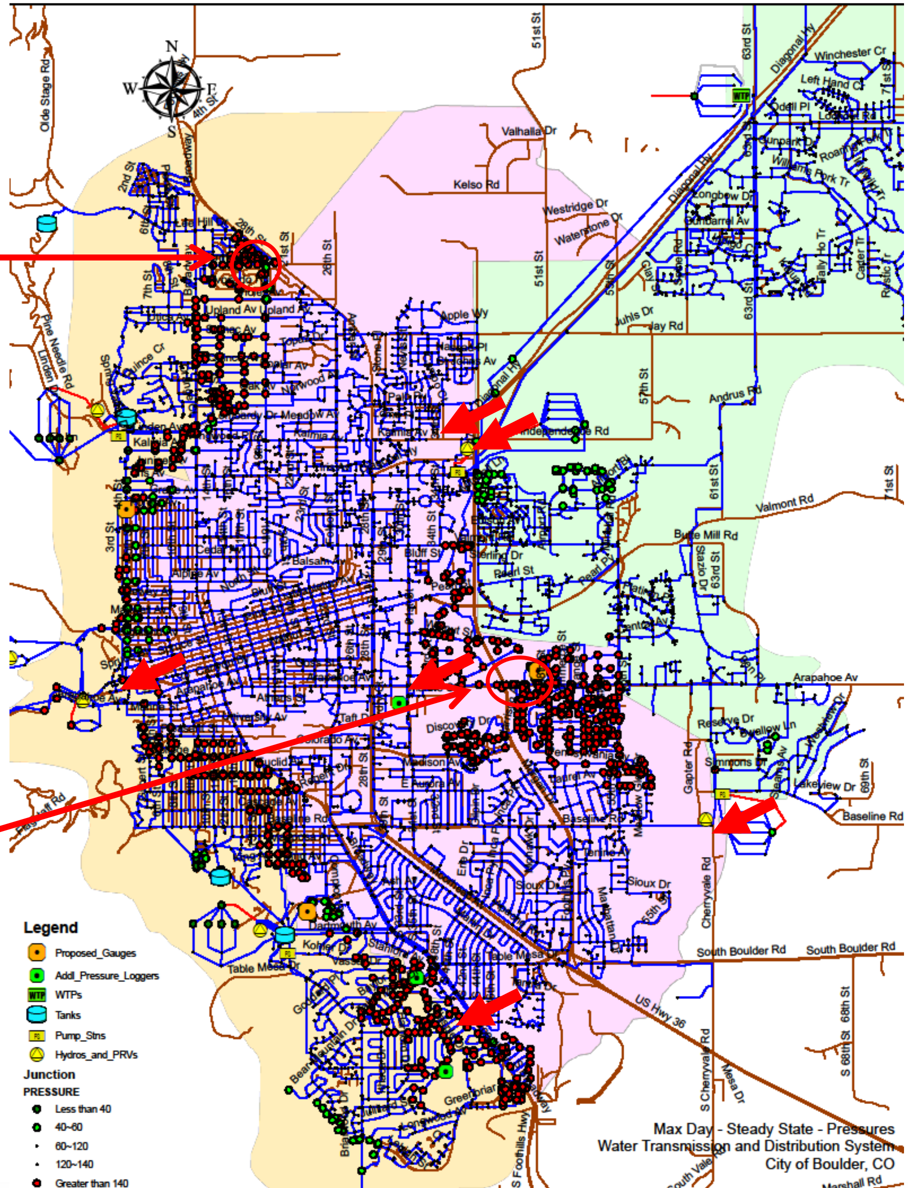
Optimized monitoring location selection

- **Use hydraulic model, historical pressure data, operational experience, and/or customer complaints**
  - Area with min/max pressures or min/max elevations
  - Far away from tanks/pumps
  - Hydrants
  - Alternative locations not subject to freezing
- **Pressure recording rate**
  - No less than hourly data
  - Most in minutes interval
  - Impulse reading



CO-1

Optimized Low Monitoring Location

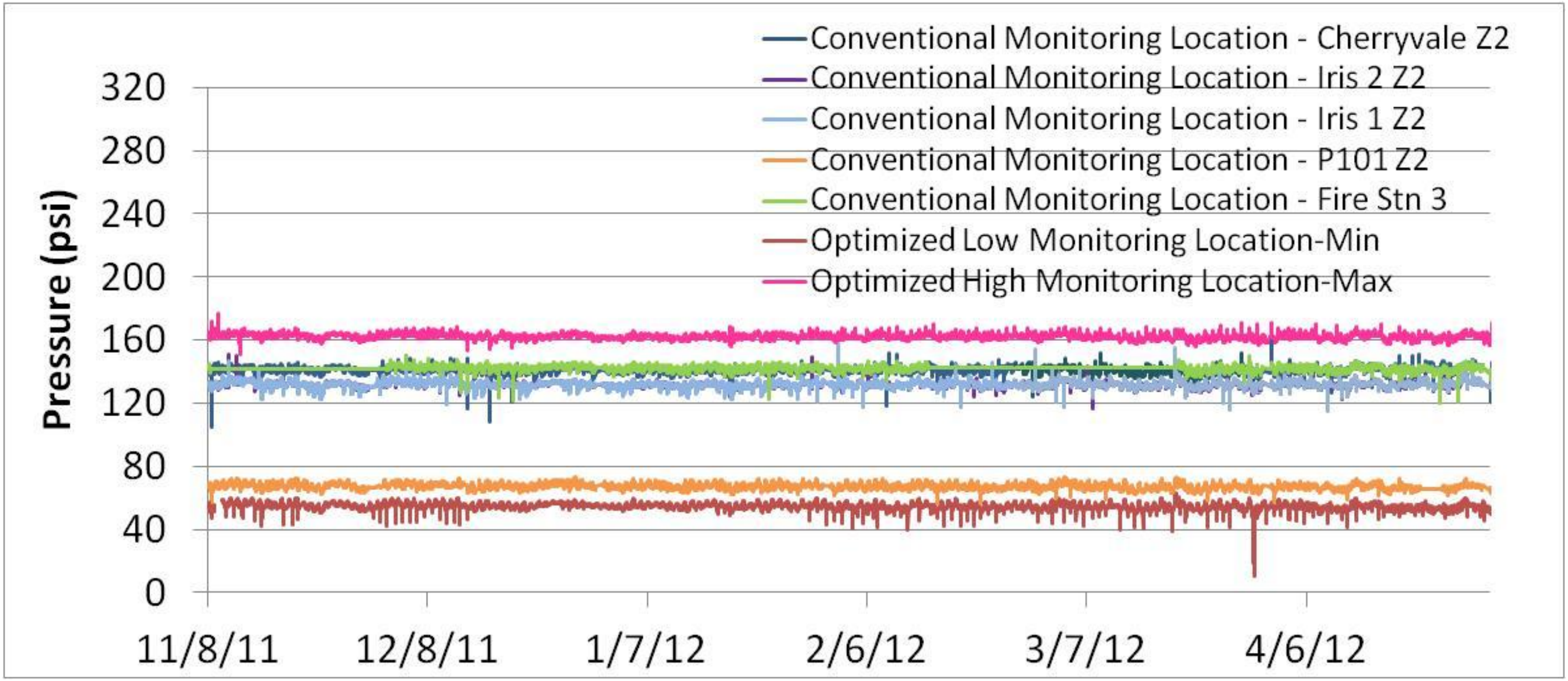


Optimized High Monitoring Location

System has 6 pressure monitors in test zone

CO-1 – Importance of monitor placement

Conventional monitors still do not capture the full range of pressures within the system.

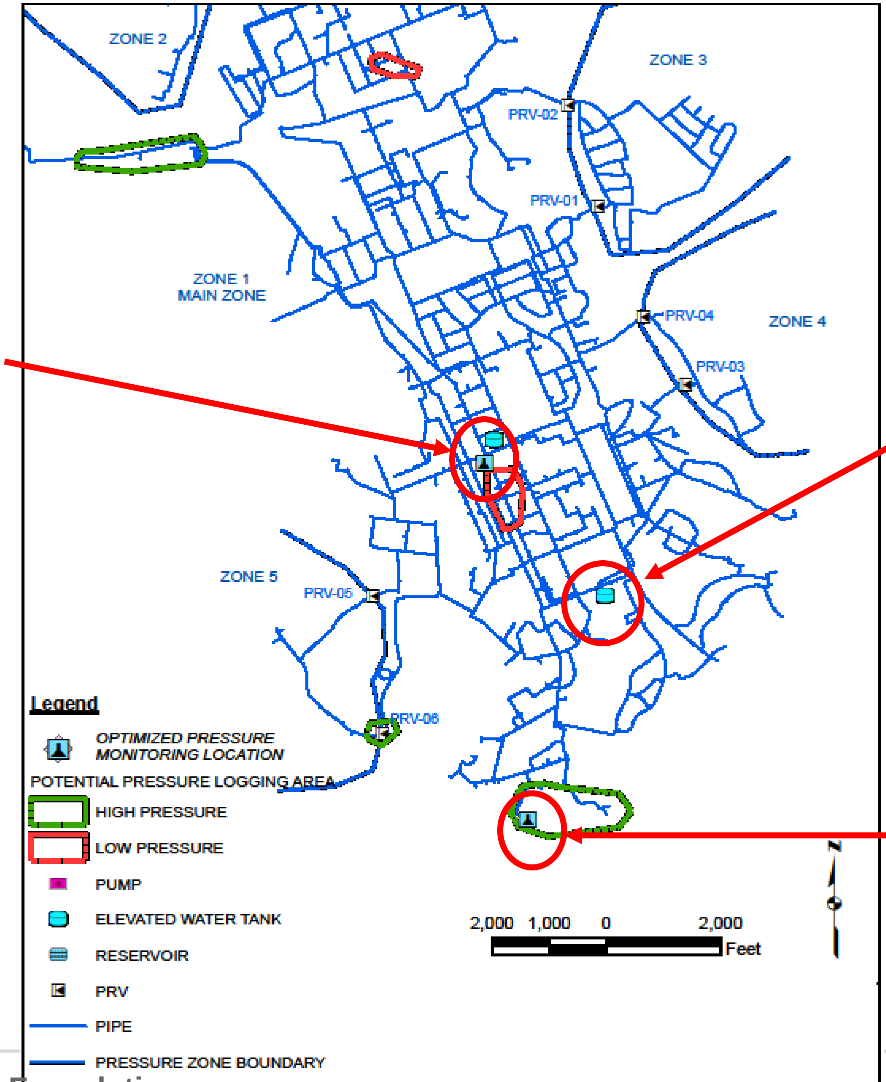


Impact of Monitoring Location: VA-1

Optimized low pressure location

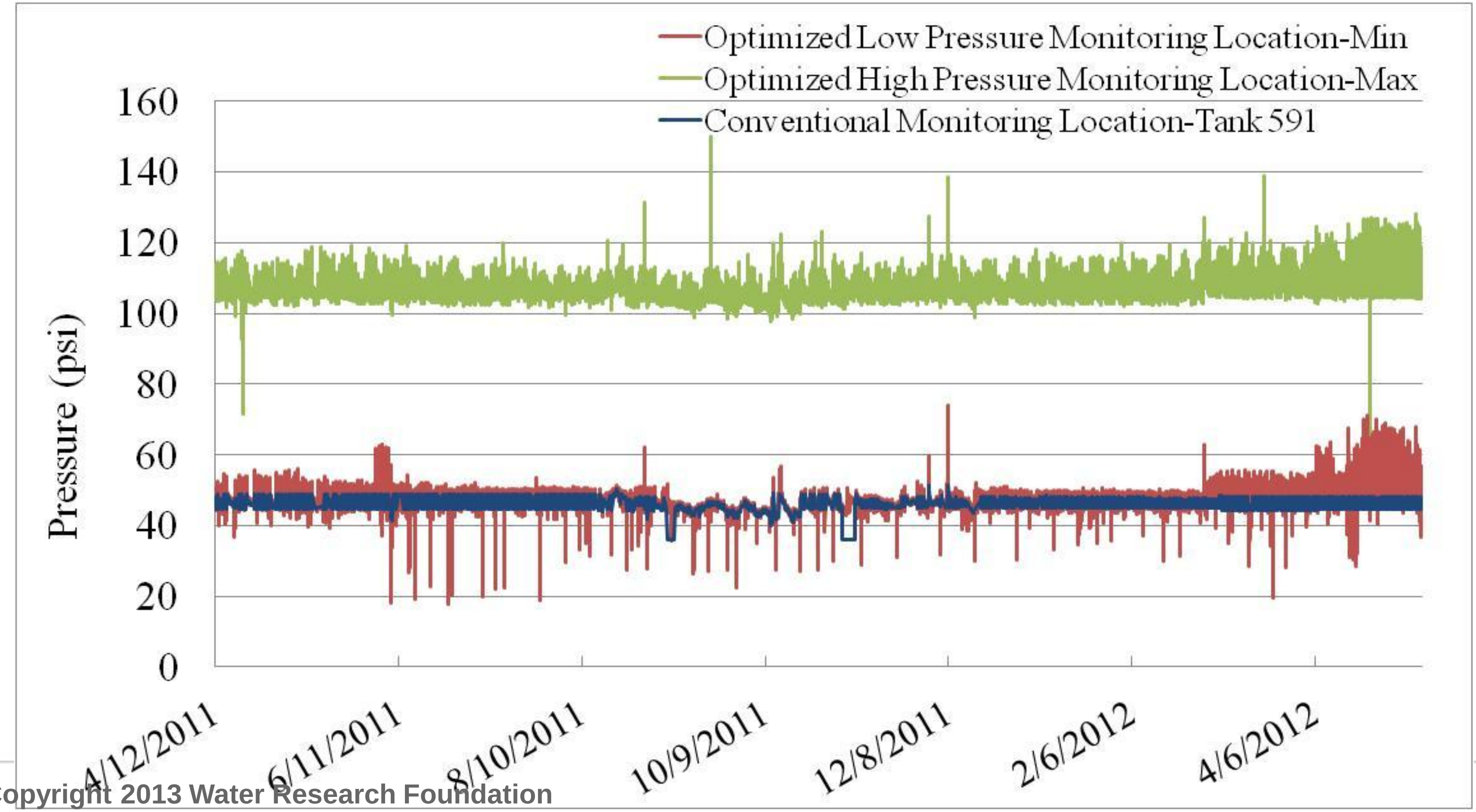
Conventional Monitoring (SCADA) at Tank 591

Optimized high pressure location

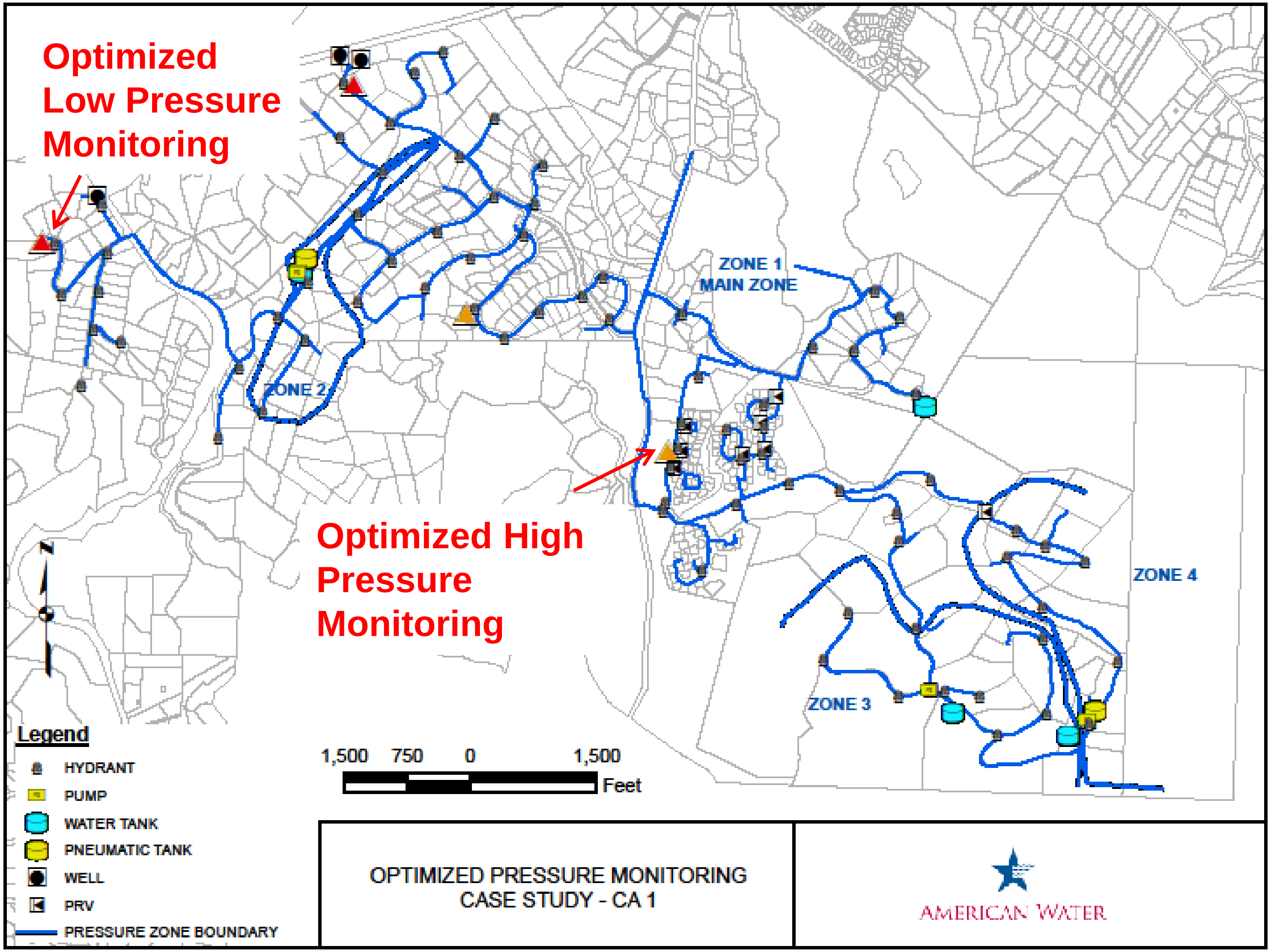


Impact of Monitoring Location: VA-1

Low pressure events captured at optimized low pressure monitoring location but missed by conventional monitor. Pressure in system is much higher than anticipated

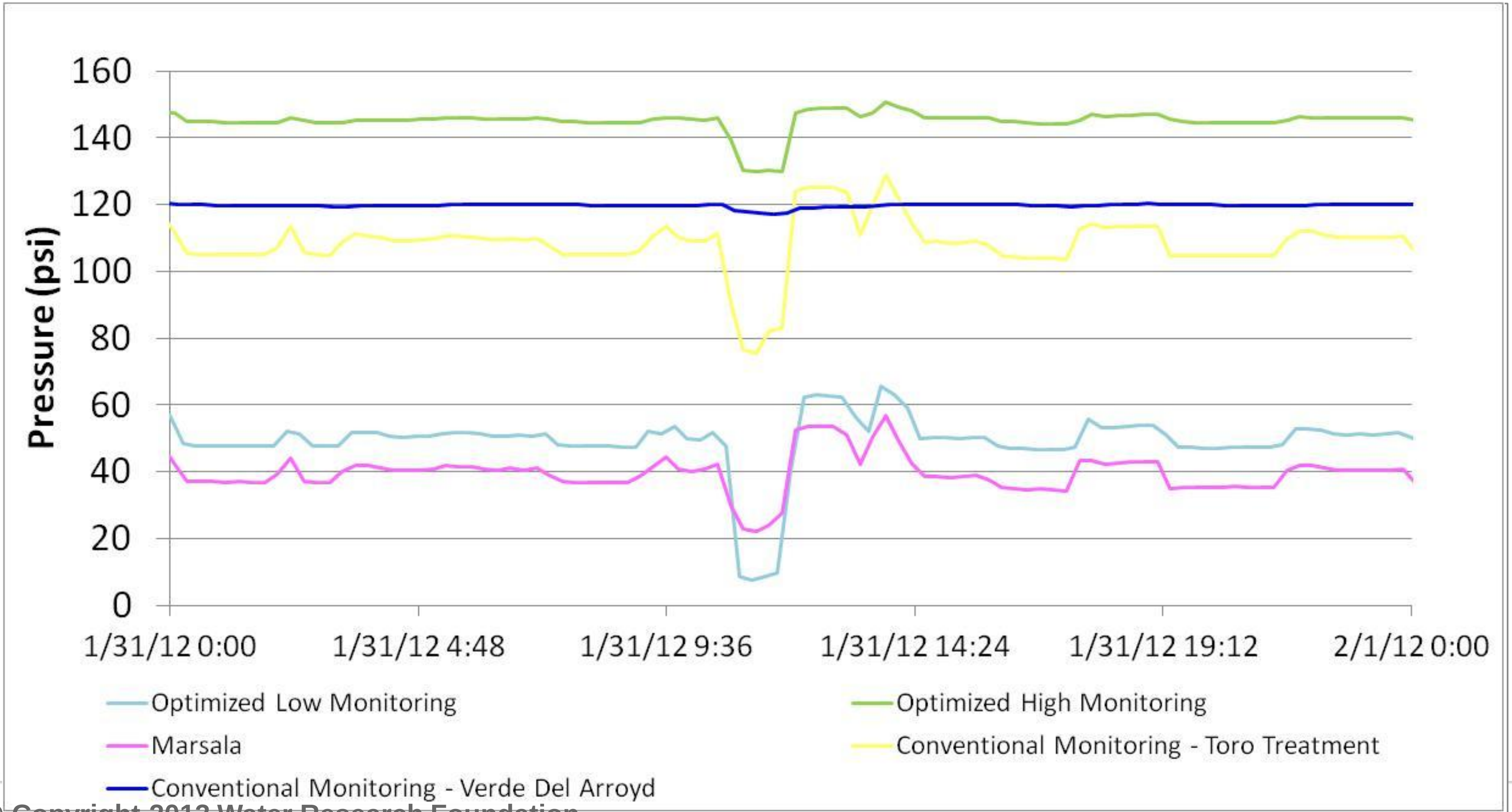


CA-1

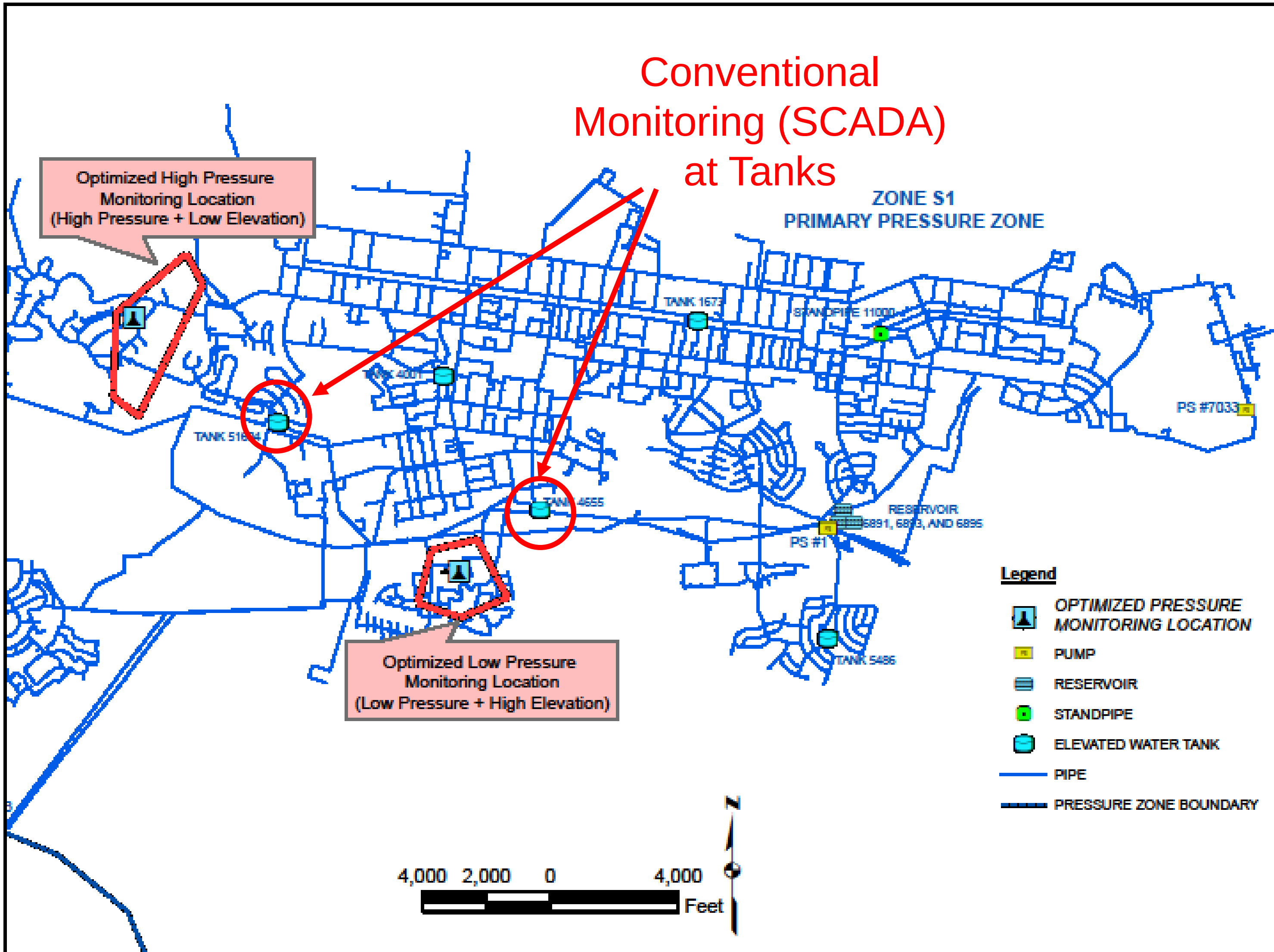

Optimized
Low Pressure
Monitoring
Optimized High
Pressure
Monitoring
ZONE 1
MAIN ZONE
ZONE 2
ZONE 3
ZONE 4
N
Legend
HYDRANT
PUMP
WATER TANK
PNEUMATIC TANK
WELL
PRV
PRESSURE ZONE BOUNDARY
1,500 750 0 1,500
Feet
OPTIMIZED PRESSURE MONITORING
CASE STUDY - CA 1
AMERICAN WATER

CA-1 – Detection of a Low Pressure Event

Jan. 31, 2012: Pressures dropped due to a **break** on a 4" main**;**
Monitoring of tank levels not as sensitive as pressure monitoring



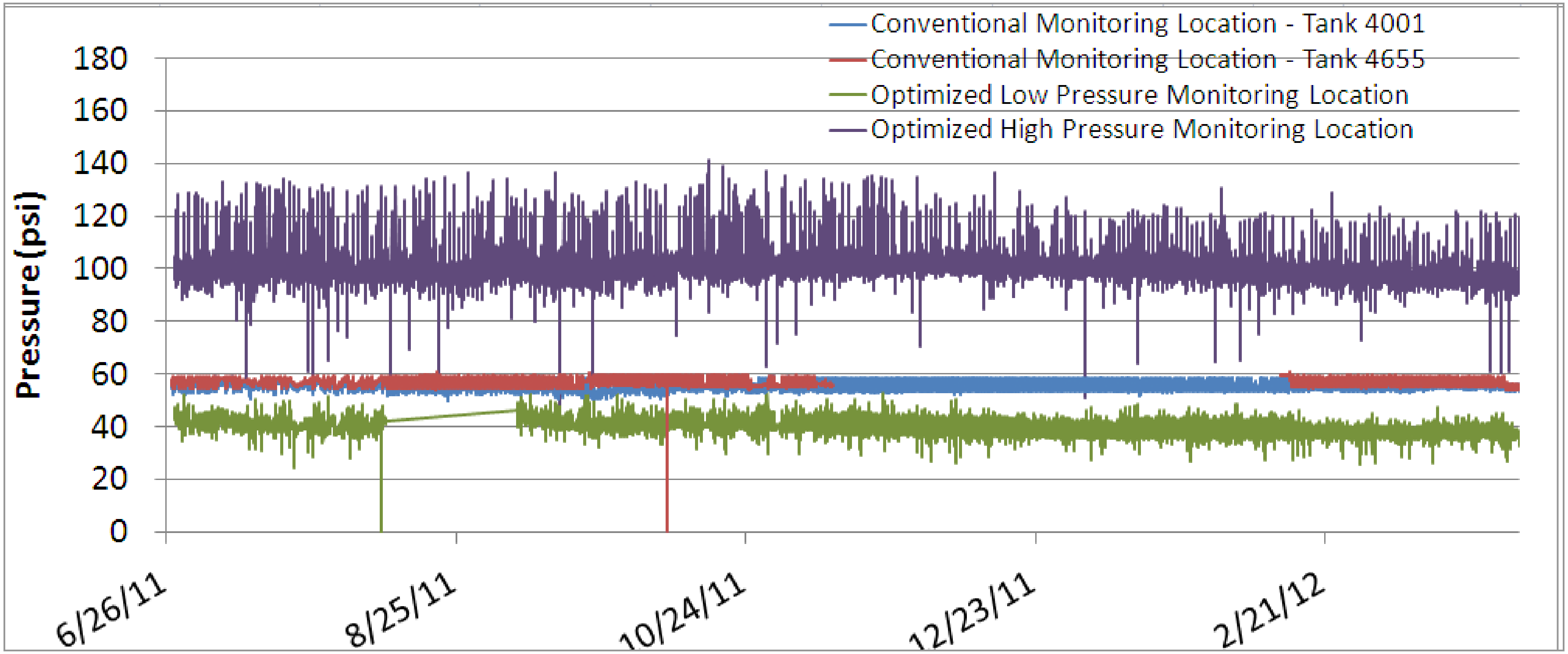
TX-1



Conventional Monitoring (SCADA) at Tanks
Optimized High Pressure Monitoring Location (High Pressure + Low Elevation)
Optimized Low Pressure Monitoring Location (Low Pressure + High Elevation)
ZONE S1
PRIMARY PRESSURE ZONE
TANK 1673
STANDPIPE 11000
TANK 4001
TANK 5486
PS #7033
PS #1
Legend
OPTIMIZED PRESSURE MONITORING LOCATION
PUMP
RESERVOIR
STANDPIPE
ELEVATED WATER TANK
PIPE
PRESSURE ZONE BOUNDARY
4,000 2,000 0 4,000
Feet
N

Impact of Monitoring Location: TX-1

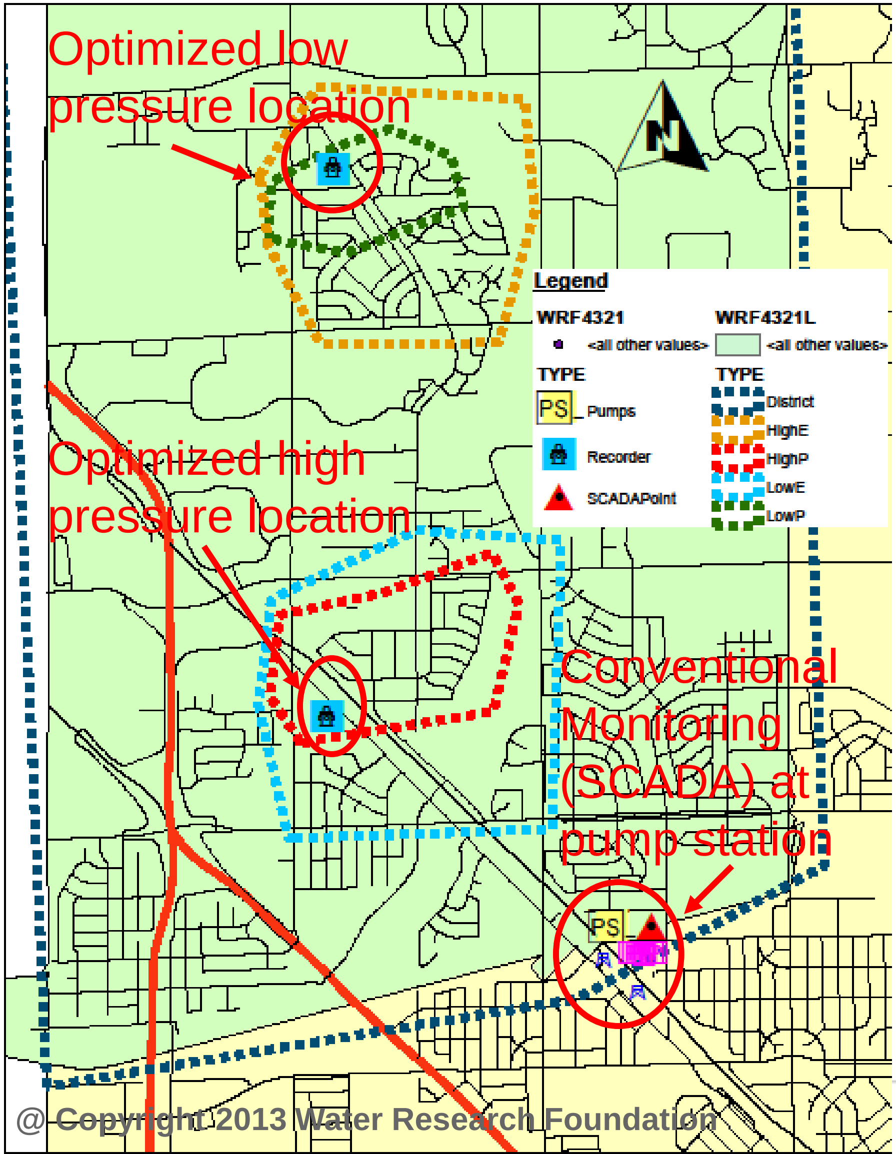
Conventional monitor shows average 55 psi, while optimized monitoring ranges from 40 to 120 psi



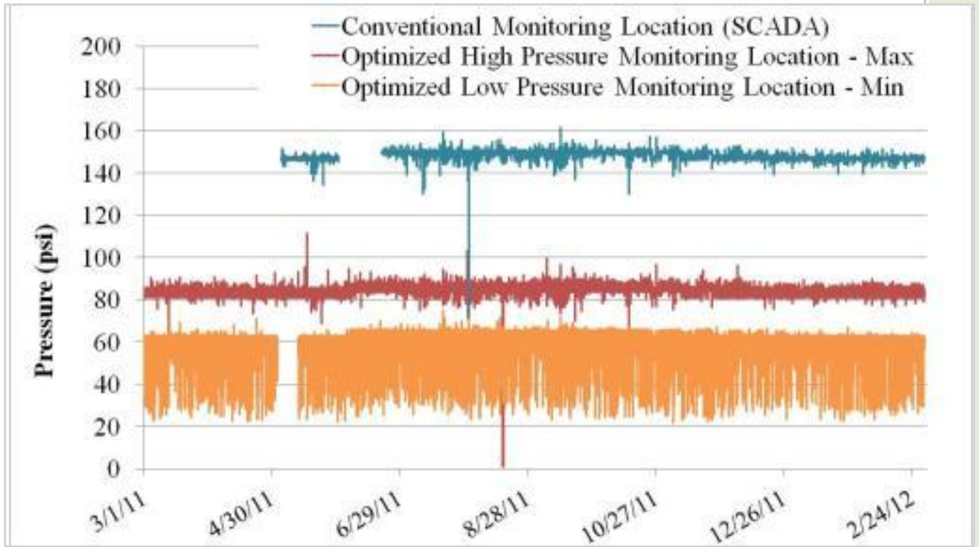
Task 3: Integrate pressure management with other distribution system activities

- **System specific**
- **Purpose**
  - Estimate benefits of optimized pressure management
- **Examples**
  - Link optimized pressure monitors to SCADA for real-time monitoring
  - Collect case study and operational experiences
  - Assist hydraulic model calibration
  - Conduct spatial analysis of pressure, main breaks, backflow events, etc.
  - Correlate low pressures and water quality
  - Evaluate water distribution energy efficiency

Change pump settings: WI-1

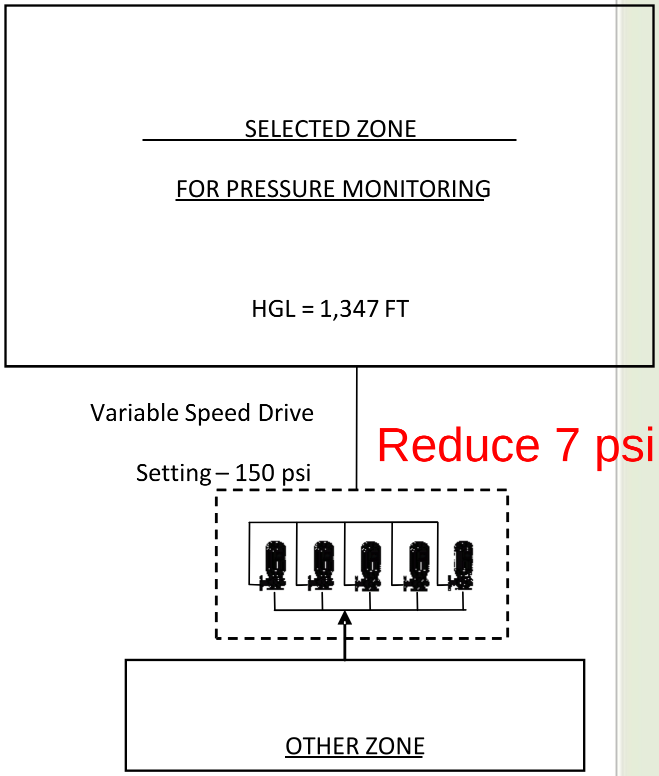


Conventional monitor at pump discharge point shows >145 psi, while optimized monitoring locations are 60-80 psi.



Change pump settings: WI-1

- **Existing pressure met all pressure criteria**
- **Propose to reduce** the VFD pump setting by 7 psi (~10% pressure reduction)



Expected benefits:

1. Cost minimal to implement the pressure reduction;
2. Reduce water loss by ~10-15%;
3. Reduce main break frequency;
4. Reduce some pumping energy usage.

Potential concerns:

1. Customers sensitive to pressure;
2. Water usage and revenue might go down;
3. This district had minimum water loss and pipe break frequencies, i.e. no need for pressure reduction.

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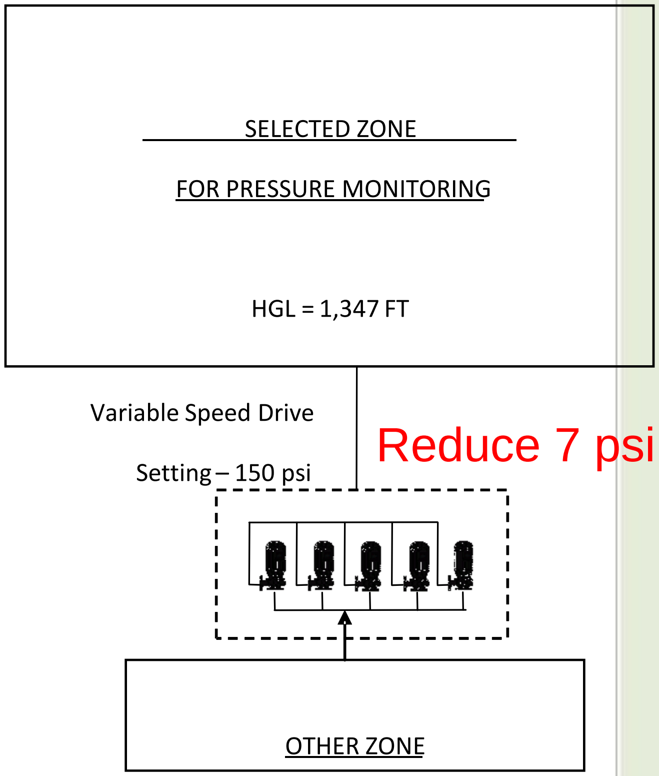
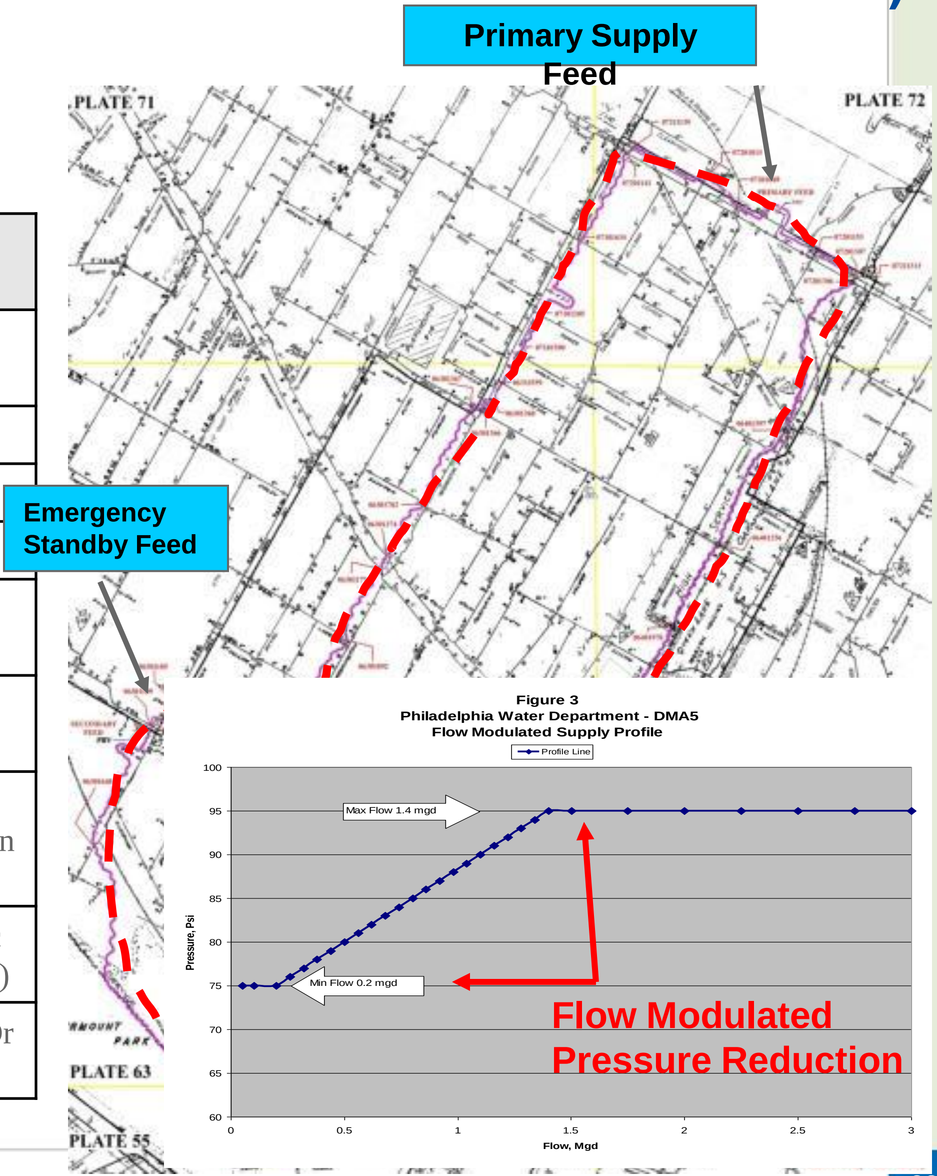


Pressure and Water Loss (Findings from Philadelphia's First Permanent District Metered Area)

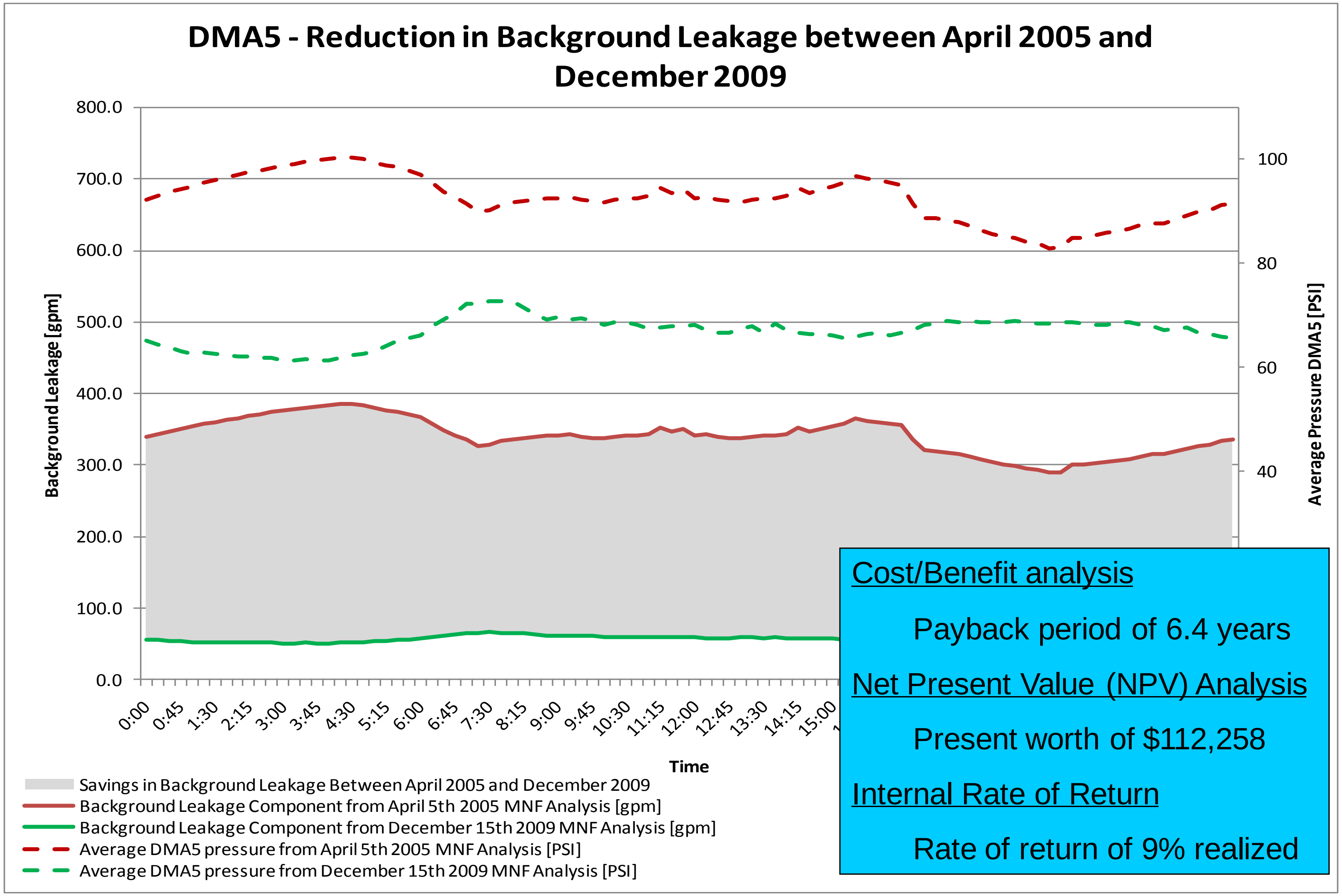
Provided by George Kunkel, P.E.
Philadelphia Water Department

Philadelphia Water Department – DMA5 Attributes	
Length of Pipeline (all metallic), miles	12.6
Average age of Pipelines, years	52.6
Number of Fire Hydrants	117
Number of Valves	382
Number of Customer Service Connections	2,261
Number of separate Fire Connections to buildings	17
Highest Elevation, ft (Critical Point)	310 (Magnolia St & Washington La)
Average Zone Pressure site elevation, ft (AZP)	254 (Mechanic St & Morton St)
Lowest Elevation, ft	180 (Lincoln Dr & Morris St)



Provided by George Kunkel, P.E. (Philadelphia Water Department)

DMA5: advanced pressure management turned the water pressure profile "upside down"



<u>Cost/Benefit analysis</u>

Payback period of 6.4 years

<u>Net Present Value (NPV) Analysis</u>

Present worth of $112,258

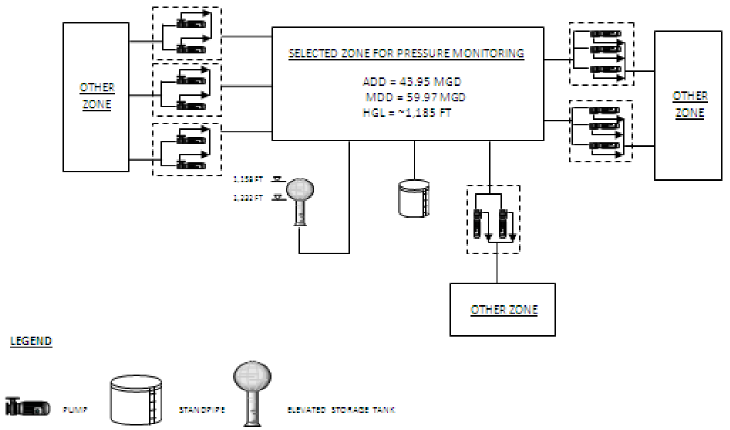
<u>Internal Rate of Return</u>

Rate of return of 9% realized

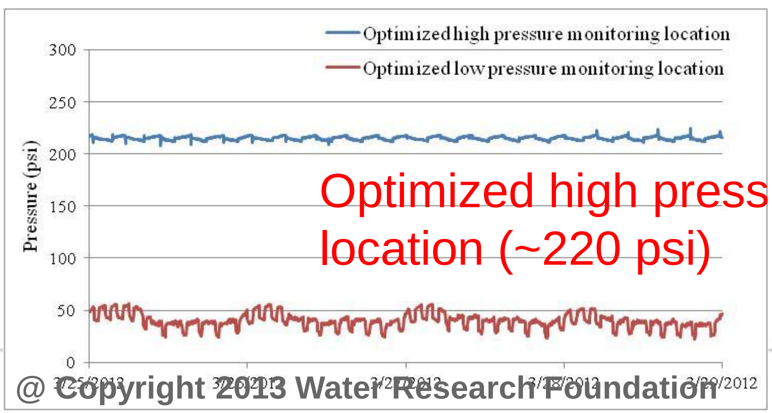
Pressure and Main Breaks

Case Study TN 1 – High Pressure Locations

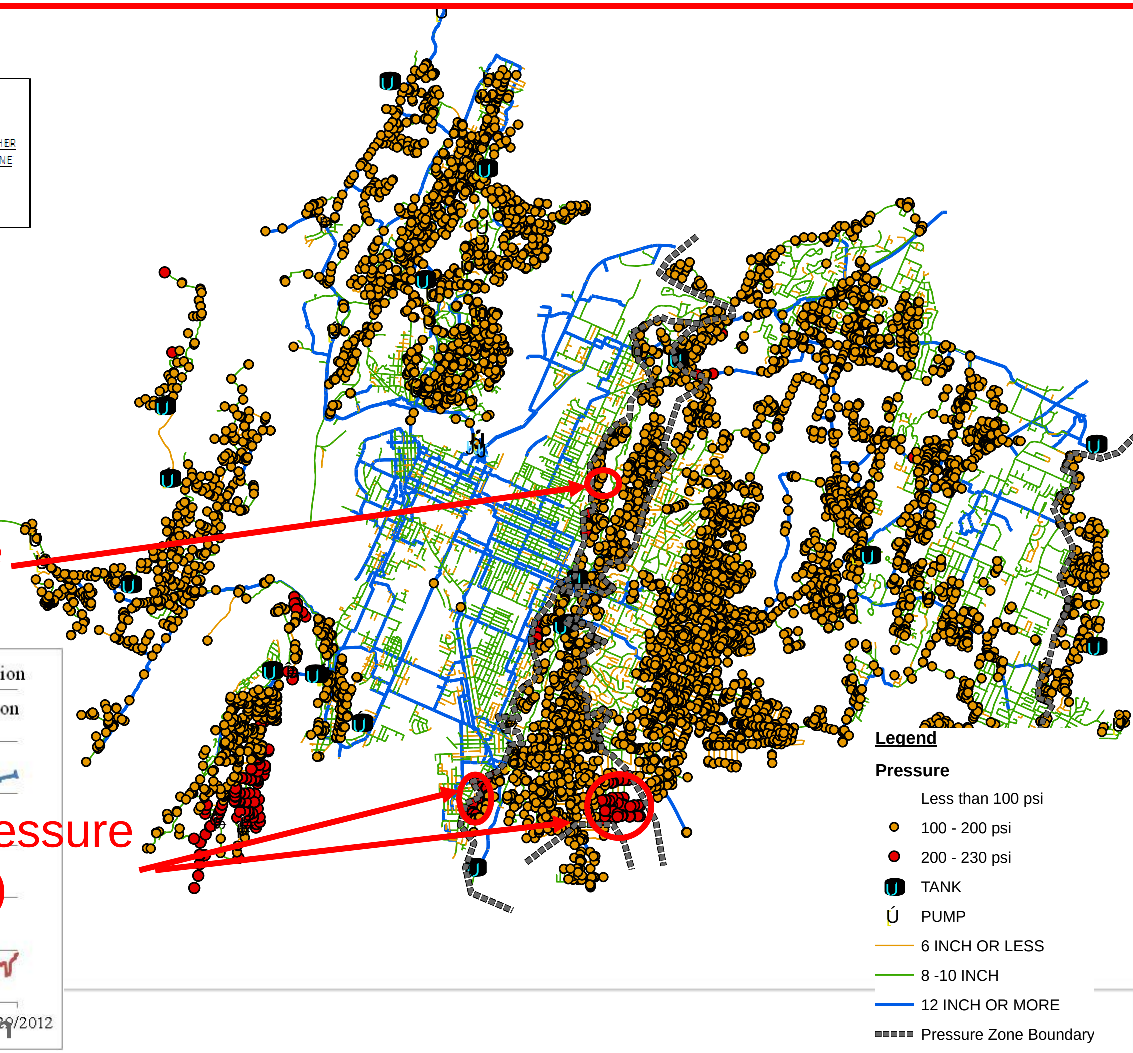
What case studies show?



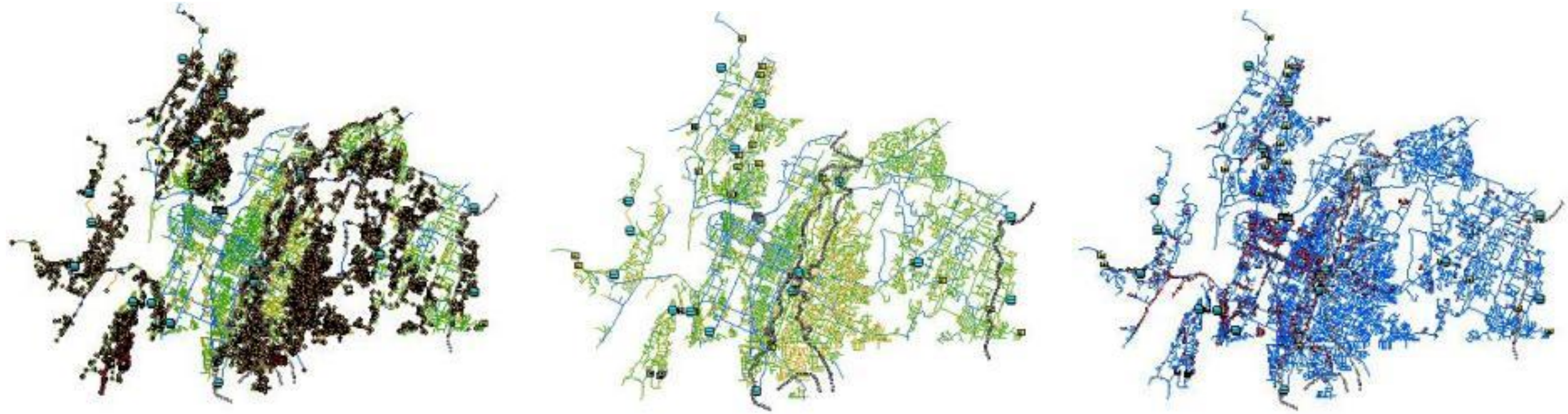
Optimized low pressure location (~40 psi)



Optimized high pressure location (~220 psi)

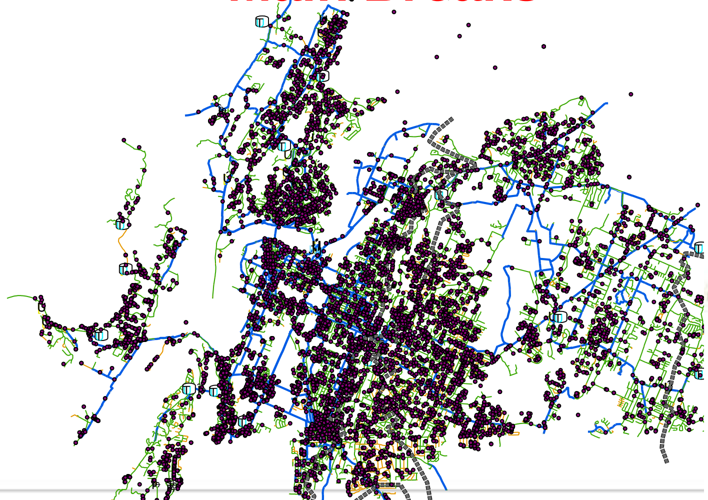


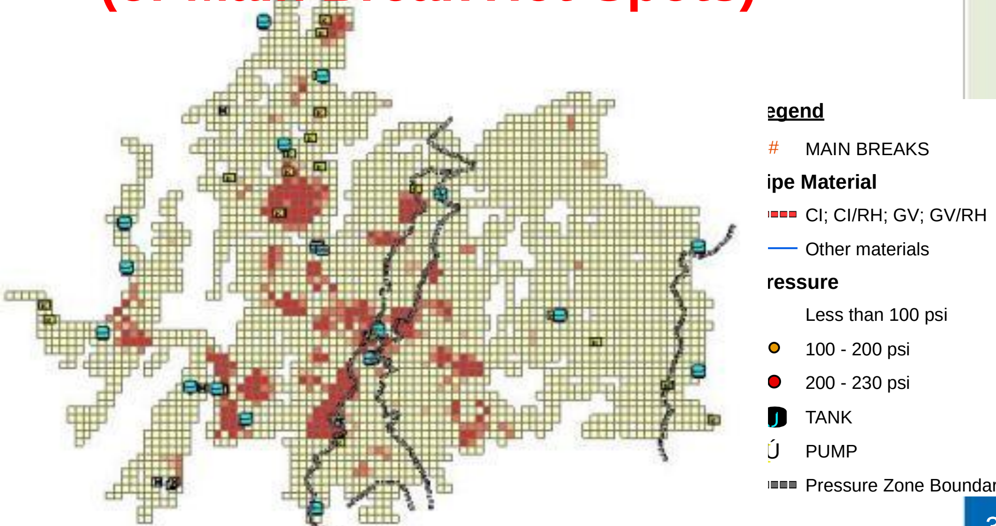
Spatial Analysis of Pressure and Main Breaks



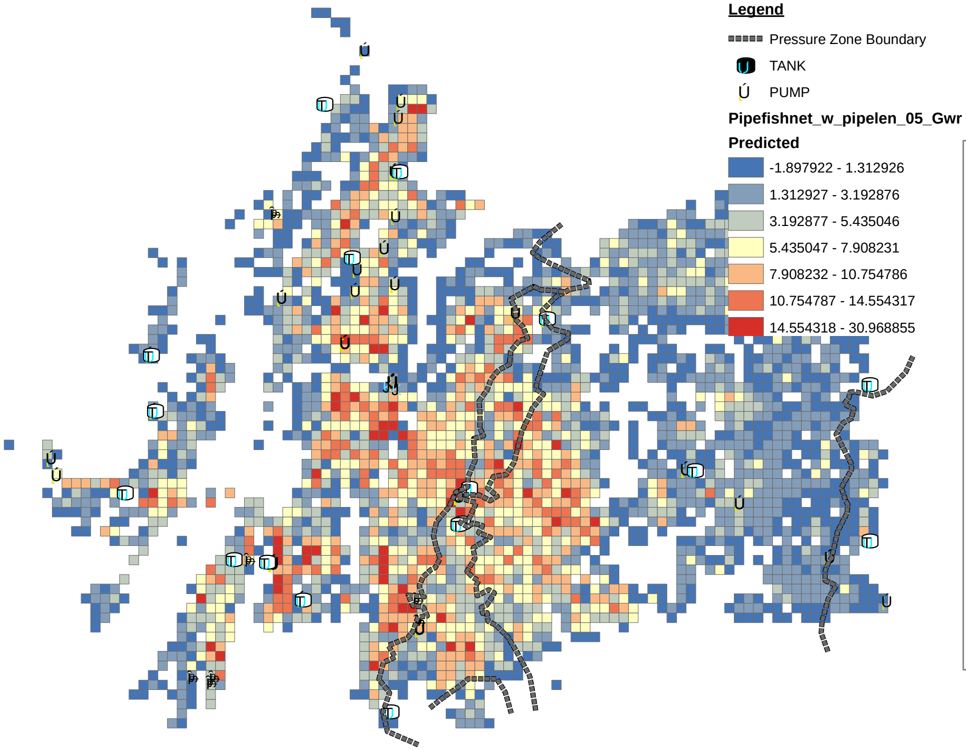
High Pressure + Pipe Diameter + Pipe Material

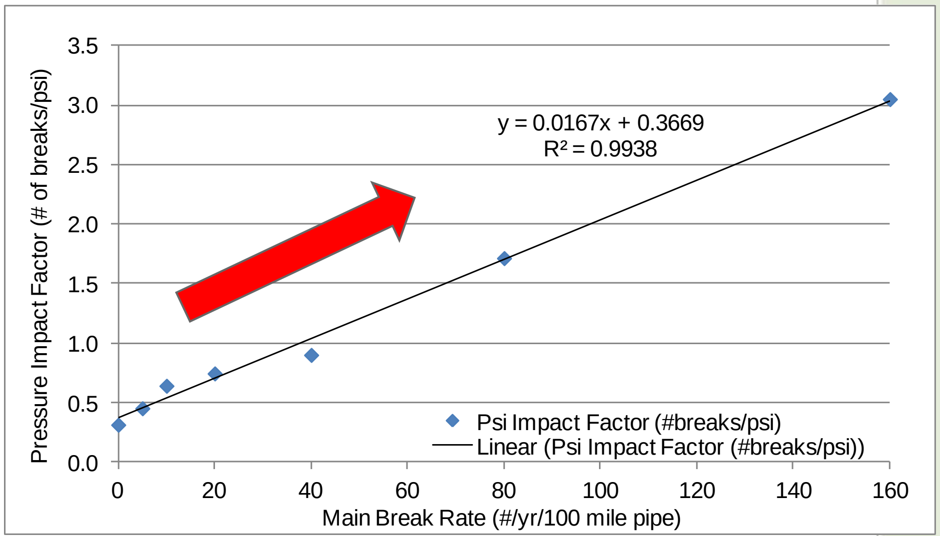
==> Main Breaks (or Main Break Hot-Spots)





How Much High Pressure Contributes to Main Breaks?





Predicted Main Break Rate (R^2=41%)

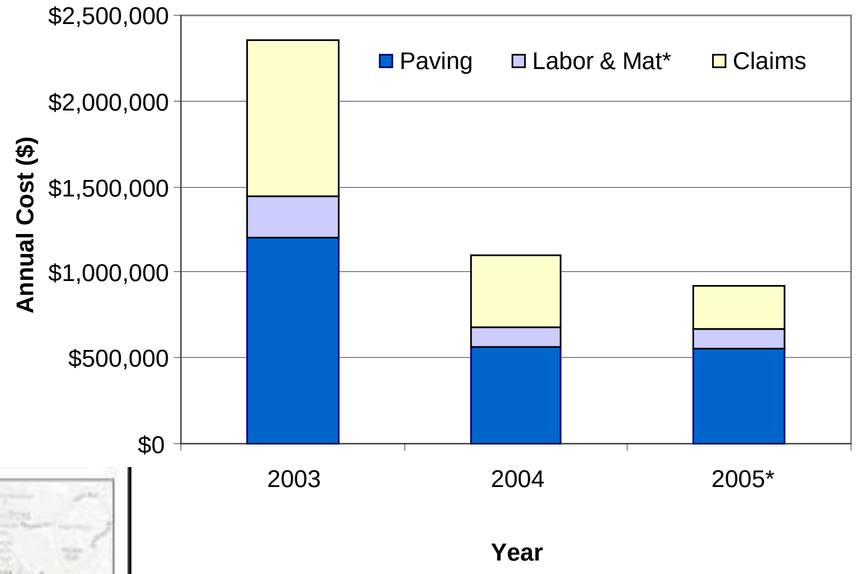
System average of 39 breaks/year/100 miles

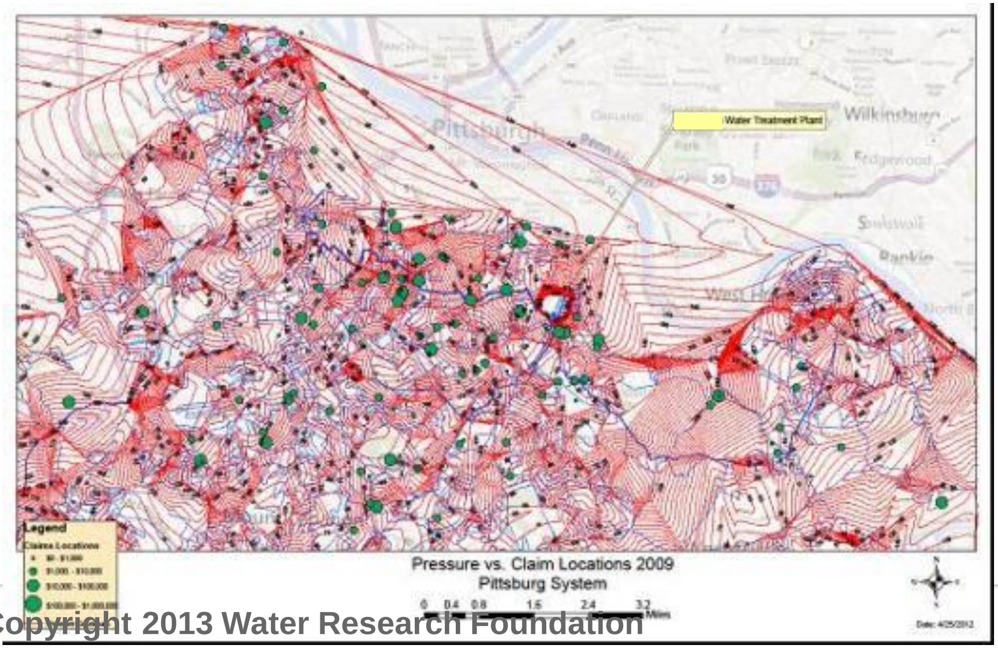
- Minor contribution from high pressures (mainly small diameter & cast iron pipes)
- However, higher impact at higher main break rate (+3 breaks/10 psi @ zero breaks/yr/100 mi; +10 breaks/10 psi @ 40 breaks/yr/100 mi)
- Weather, soil conditions, etc. not modeled

Pressure and Insurance Claim Cost

Case Study – PA 1

- Reduced peak pressures from 179 psi to 145 psi
- 60% reduction in main breaks
- 30% reduction in non revenue water loss
- $1.4 million per year cost savings



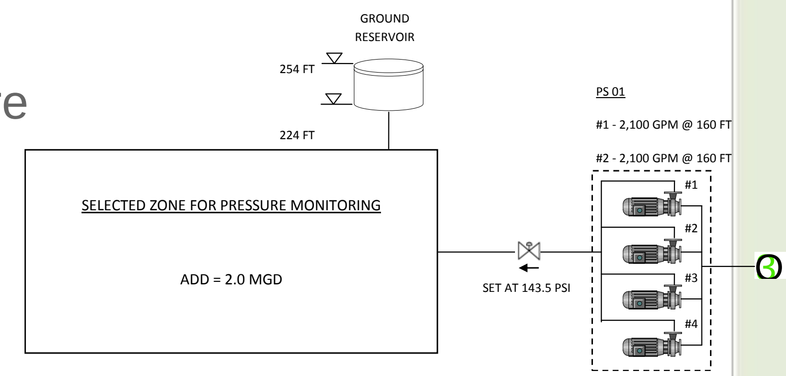


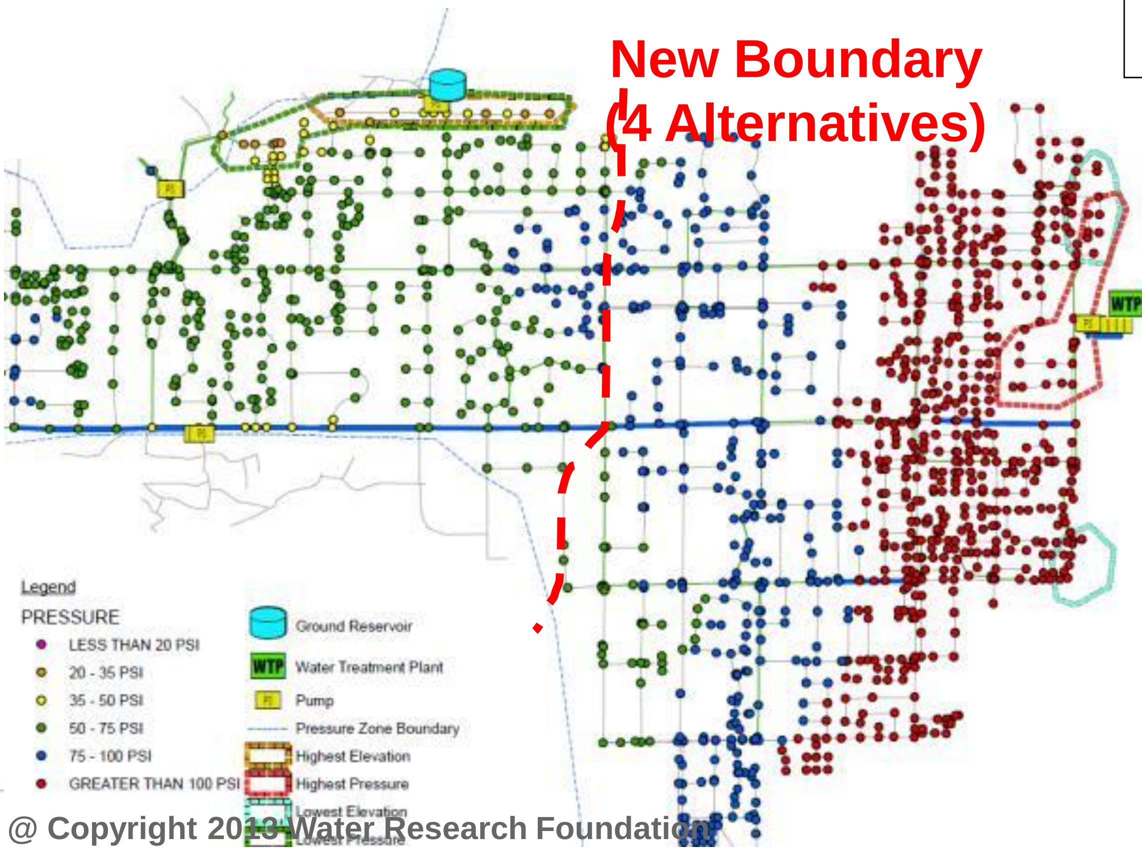
- Overlay system pressure contours
- Insurance claims due to main breaks
- Size of the circle related to cost of the claim

Pressure and Energy Analysis (Case Study – AZ 1)

Pressure = Energy

- Large area of water supplied at high pressure
- System topography allowed
- To create a new pressure gradient/zone



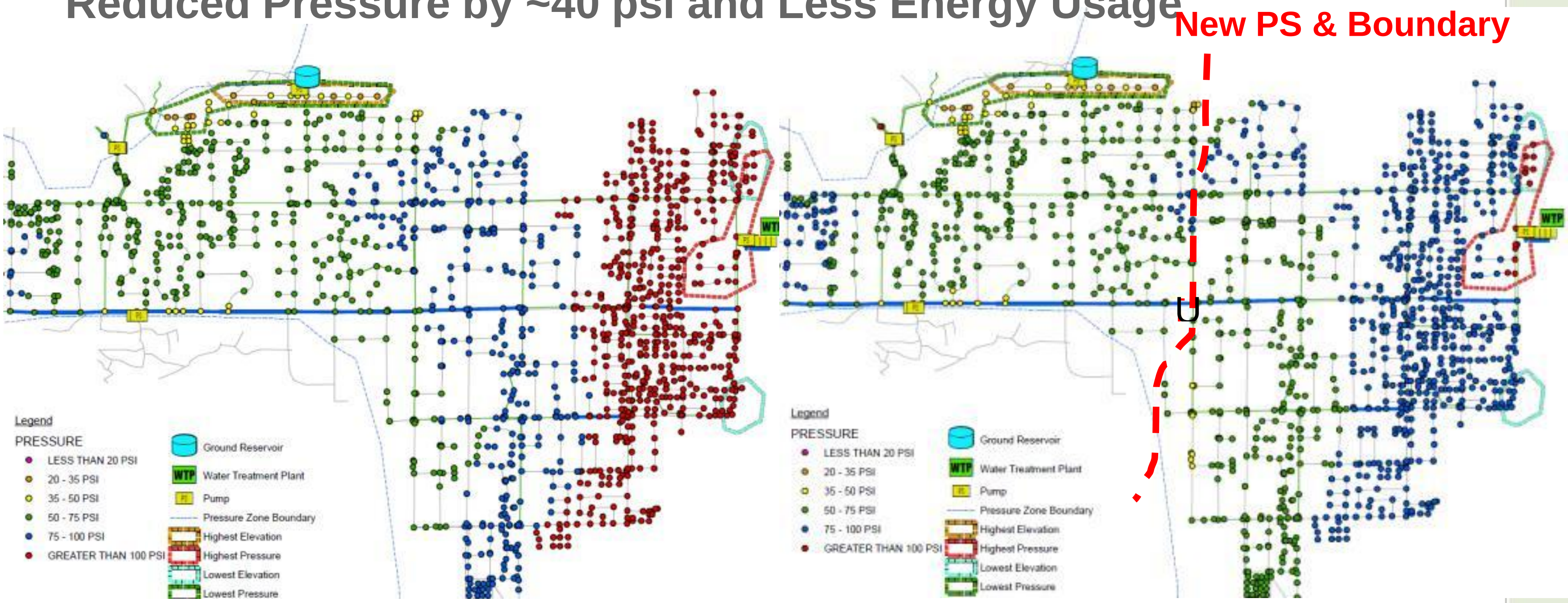


Cost & Benefit

- Capital, O&M costs, etc.
- Reduce main breaks and NRW
- Reduce energy consumption

Pressure and Energy (Case Study – AZ 1)

Reduced Pressure by ~40 psi and Less Energy Usage



	Description	Energy usage (kWh/MG)	Energy cost ($/YR)
Baseline	Average day demand (ADD)	3,344	$1.2 M
Alt01	ADD with a VFD at the treatment plant	2,000	$0.69 M
Alt02	ADD after pressure zone realign with no new pump station added	3,344	$1.2 M
Alt03	ADD after pressure zone realign	3,523	$1.2 M
Alt04	ADD after pressure zone realign and a VFD at the treatment plant	1,404	$0.49 M

The Future of Pressure Management

- **Some states are placing greater emphasis on requirements for pressure management**
- **The USEPA Research & Information Collection Partnership includes emphasis on pressure management:**
  - Survey of Distribution System Pressure Management Practices
  - Characterize Propagation of Pressure Events through Water Distribution Systems to Improve Pressure Management Approaches
  - Develop Strategies to Diagnose and Monitor Pressure Fluctuations in Water Distribution Systems
  - Toolkit for Pressure Management
- **Partnership for Safe Water**
  - Distribution System Optimization
  - www.awwa.org/Resources/PartnershipDistribution

Summary

- **Pressure management is fundamental to protecting public health, maintaining infrastructure and effective utility management**
- **Although pressure monitoring is required by regulations, implementation varies across the inductry**
  - Permanently installed monitors do not exist in all pressure zones
  - Routine pressure monitoring is mostly at convenient locations
  - Most pressure monitors either never calibrated or calibrated annually
  - Monitoring frequency will not capture short-term events

- **Negative pressure events may occur**
  - Main breaks, power outages may occur routinely
  - Power outages may cause regional depressurization events
- **Pressure management has been identified by USEPA as an important topic for distribution system research**
- **A program for optimized distribution systems, including pressure management has been formulated by the Partnership Program**

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- **Funding provided by Water Research Foundation and in-kind contributions from 30 water utilities; American Water**

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  Bill Soucie

  Graham MacDonald

  Steve Rupar

- **Technical Advisors:**

  Dave Hughes and Norm Ansell (AW)

  George Kunkel (PWD)

  Mike Hotaling (NNW)

- **Water utility participants (36) of this survey**

Questions??

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