

# **City of Mercer Island *E. coli* Event After Action**

**Pacific Northwest Section - AWWA  
Boise, ID  
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**Brian McDaniel**  
Utilities Operations Manager  
City of Mercer Island

**Melinda Friedman, P.E.**  
Confluence Engineering Group, LLC  
[www.confluence-engineering.com](http://www.confluence-engineering.com)

# Presentation Overview

- **Summary of Events**
- **Assessment Objectives and Approach**
- **Coliform Occurrences Pathways**
- **Key Findings**

# Community

## Mercer Island Facts

- Population 22,270
- 120 miles water main
- 83 Pressure reducing stations
- 8 million gallons reservoir storage
- Water supplied by Seattle Public Utilities (SPU)





# Mercer Island *E. coli* Event



Figure 1-3: Mercer Island Supply Line

Date: 1/16/2014



# Mercer Island *E. coli* Event

## Incident Timeline

### Phase 1

- Sept. 24 SPU conducts routine coliform testing system-wide (61 samples)
- Sept. 26 3 utilities, (5 Samples) show positive coliform (TC+)
- Sept. 26 Repeat samples & add'l investigative samples collected in MI system
- Sept. 27 4 MI investigative sites positive for *E.coli* and TC (with Cl<sub>2</sub> present) but repeat sites showed no coliform
- Sept. 27 With strong guidance from DOH, City issues Boil-Water advisory
- Sept. 27 Applies to all residents; Public Health Seattle & King County closes food service venues (62)
- Sept. 28 Of 8 samples collected: all *E.coli* negative; one sample TC+
- Sept. 29 Of 11 samples collected: all *E.coli* negative; one sample TC+

**Boil Water Advisory lifted**



# Mercer Island *E. coli* Event

## Incident Timeline

### Phase 2

***Despite initial corrective measures, contamination was detected again two days later...***

- Sept 30      Sample results all clear
- Oct. 1      Sample results all clear
- Oct. 2      One sample *E.coli* +, another sample TC+; Boil Water Advisory reinstated
- Oct. 3      Fifteen samples all clear; some foodservice venues reopen w/limited menus
- Oct. 4      Reservoir inspection



# Mercer Island *E. coli* Event

## Incident Timeline Phase 2 (continued)

- Oct. 5 Additional chlorine injected; flushing continues; *E.coli* case confirmed in child
- Oct. 6 Samples increased to 18/day; flushing continues; inspect pipe vaults; explore backflow prevention
- Oct. 7 50% of restaurants back open; checklist of actions near-complete
- Oct. 8 Boil Water Advisory lifted at noon

*No cause of the transient contamination was ever found.*

*One known case of confirmed *E. coli* illness (not hospitalized); testing showed *E. coli* species had no relation to those in MI water system.*

# Objectives and Approach

- 1. Review MI's routine O&M and water quality maintenance practices**
- 2. Where possible, identify potential causes and risk factors for *E. coli* event**
- 3. Develop recommendations to fill data gaps and minimize risk of future events**

**Independent Desk-Top  
Review of Available  
Information**

# Coliform Occurrence Pathways

## ■ Source Pathways

- Source water contamination event
- Inadequate treatment
- Problem with treatment

## ■ Distribution System Pathways

- Direct contamination of the distribution system
- Regrowth in pipe biofilms, scales, and sediments

## ■ Sampling/Analytical Pathways

- Poor sample collection techniques
- Laboratory errors

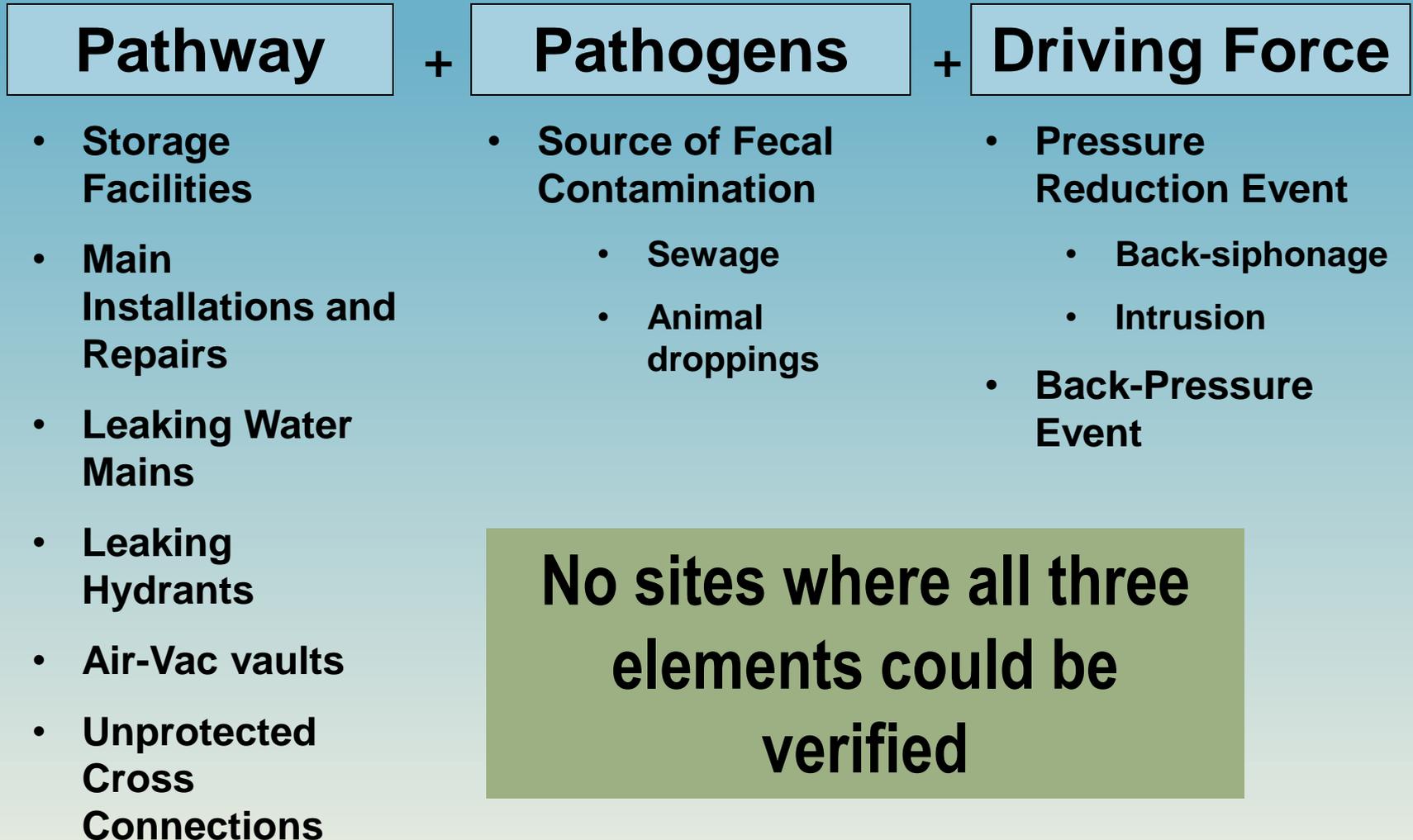
## ■ Purposeful Contamination Pathway

# Source Water/Treatment Breakthrough

- **DOH found no issues with SPU treatment process**
- **Unusual distribution system bacteriological results from 9/24 – 9/25**
  - 7 total coliform positives in 3 separate systems
  - Of 10,000 samples collected by SPU per year, typically  $\leq 4$  positives per year since 2011
- **No other systems had positive follow-ups**
- **Only Mercer Island had on-going positives with *E. coli***

**Source water/POE contribution unlikely  
but can't be completely ruled out...**

# Direct Microbial Contamination - Three Critical Elements



# But Specific Risks Were Identified...

## ■ Contamination Pathway Risks

- ❑ Cross connection hazards
- ❑ Air-vac vaults with out proper venting

## ■ Contamination Source Risk

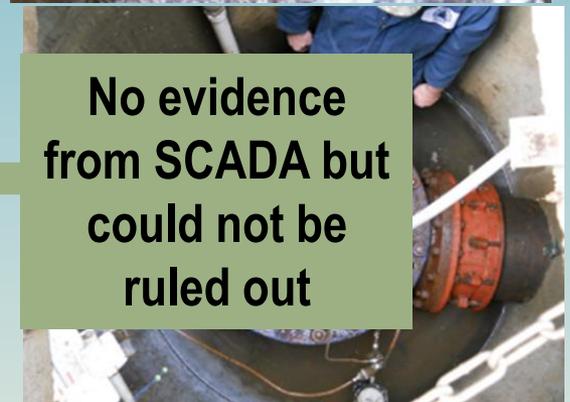
- ❑ Unprotected cross connections
- ❑ Standing water in some vaults

## ■ Contamination Driving Force Risks

- ❑ Potential for pressure transients around bypass valve operation?
- ❑ Potential for pressure transients associated with pump stations?

## ■ Additional Considerations

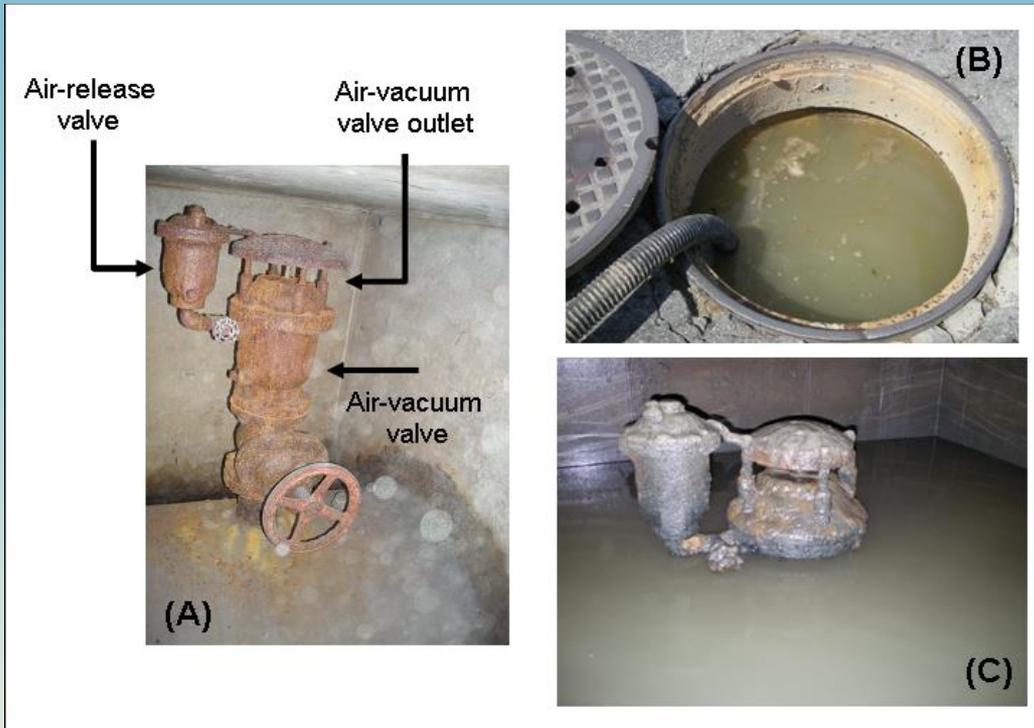
- ❑ Need for water quality surveillance monitoring
- ❑ Inadequate resources
- ❑ Need for enhanced documentation and data management



No evidence from SCADA but could not be ruled out

# Examples of Below Grade/Submerged Air-Vac Valve – **NOT FROM MERCER ISLAND**

Must be designed so that they are vented and screened above grade!



Besner R&IC Needs Analysis for Intrusion

# Key Findings – Cross Connection Control

- **City Ordinance has not been updated since 1980's**
- **Due to staffing levels, program not as robust as should be**
  - Hazard surveys
  - Obtaining test results
- **Clearer authority to implement and enforce the CCCP is needed**
- **More attention needed for irrigation systems using lake water**
  - Interconnected unapproved auxiliary supplies are considered “high health risk hazard”

**Unprotected cross connections present on-going risks to the DS**

# Biofilm and Regrowth Pathway

## ■ Pipe Conditions

- ❑ Internal conditions indicative of deferred maintenance
  - Replacement rate of 0.4% per year significantly lower than industry recommendation of >1% per year
- ❑ WQ is not included CIP decisions
- ❑ High proportion of unlined cast iron

## ■ Lack of Main Cleaning Program

- ❑ Flushing program is organized and dedicated
- ❑ Focus is on bulk water turnover to maintain disinfectant residuals
- ❑ Unable to achieve scouring velocities due to discharge limitations
- ❑ Does not serve as main cleaning program

## ■ Disinfectant Residual Maintenance

- ❑ Focus of flushing program
  - Limited monitoring and data trending
  - Available data suggest it is helping
  - Need for auto-flushers?



**Biofilm and pipe scale impacting water quality, but not likely cause of coliform event**

# Sample Collection/Site Issues

- Positive results occurred with different samplers
- Positive results occurred at different locations
- City's sampling techniques reviewed and approved by SPU and DOH
- Laboratory verification of *E. coli* – not laboratory errors
- Sample stands are protected and well-maintained by MI

**Seems Unlikely...**

# Purposeful Contamination

- **City conducted assessment of potential for purposeful contamination**
  - No evidence found (trespassing, vandalism, alarms, credible threat)
- **Reservoir ladders and access hatches are alarmed**
- **Key facilities are visited on a daily basis**
- **City always looking for ways to increase security**

**Seems Unlikely...**

# City Strengths Were Identified Too!

- **Staff very knowledgeable and dedicated to protecting public health**
- **Staff work hard to do the best they can given resources and authority allocated to them**
- **Main break rate about half of industry optimization goal**
  - Suggests good pressure management
  - Aggressive leak detection
  - Lots of strong cast iron pipe!
- **Aggressive reservoir inspection and maintenance program**
- **Set chlorine residual goal and conduct flushing to maintain it**
- **Main installation practices place emphasis on water quality protection**
- **Good PRV and coliform sample stand maintenance programs**

# Summary of Key Findings

- **Appears to be transitory event**
  - Nearly 500 samples collected from 15 locations since the event have been clear for total coliform and *E. coli*.
- **No “smoking gun”, but some risks and vulnerabilities identified – more information needed**
- **City staff knowledgeable, forthright, and eager to do their best to protect public health**
- **No evidence of short-cuts**
- **Where they exist, short-comings are due to lack of resources and funding relative to demands of managing an aging distribution system**
- **Event presents opportunities for City, SPU, DOH, and other wholesalers to assess and modify practices where appropriate**

# Presentation Overview

- Evaluation Objectives and Approach
- Coliform Occurrences Pathways
- Key Findings
- **Preliminary Recommendations**

# Recommendations in Three Key Areas

- **Reduce Contamination Risks**
- **Enhance Water Quality Management**
- **Additional Improvements**
  - Resource Availability
  - Written Documentation
  - Data Management

# Reduce Contamination Risks

## ■ Inactivate and Purge System of Initial Contamination Slug

- ❑ Increased chlorine residual
- ❑ Conducted flushing to replace water in system

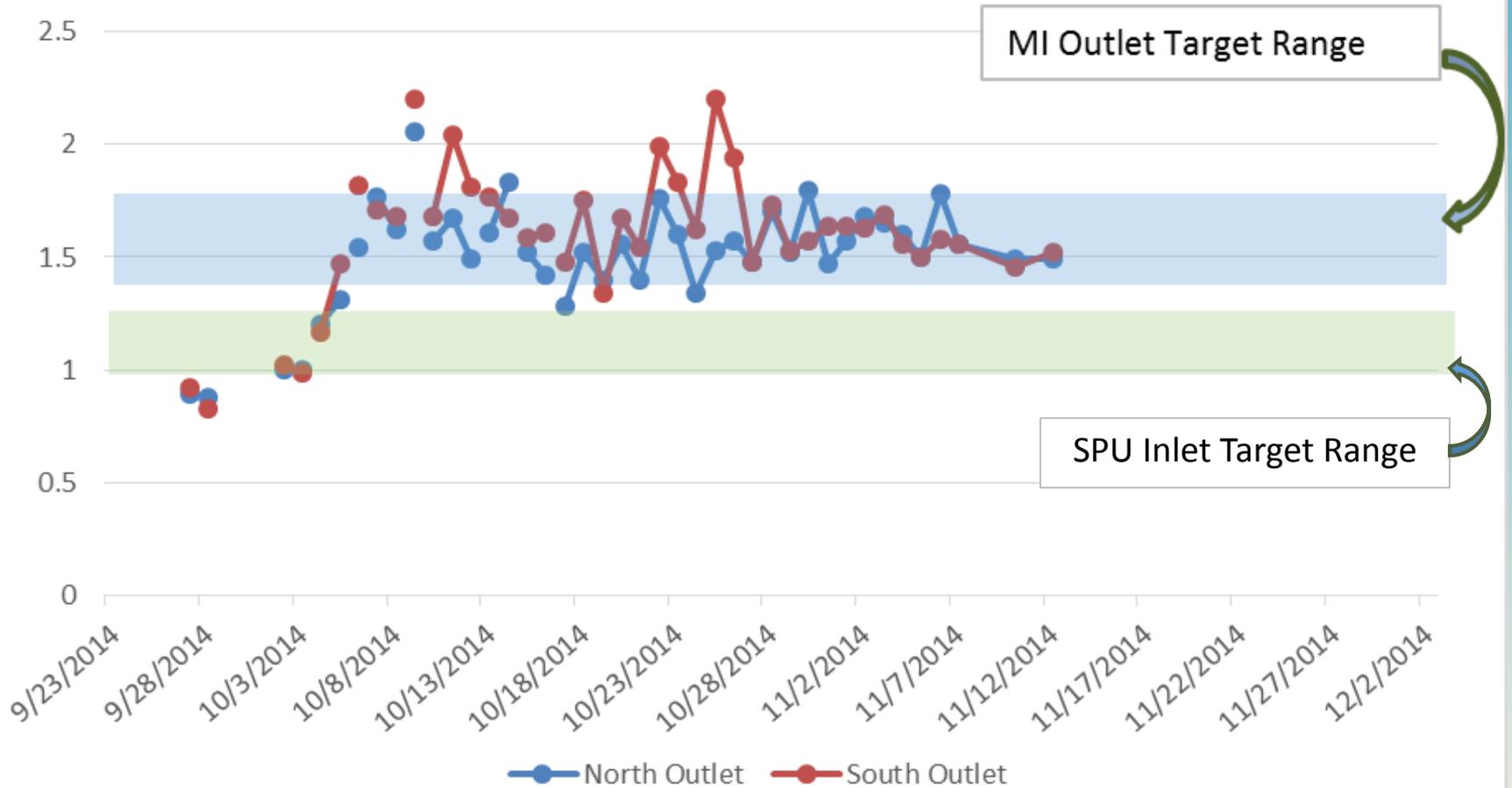


## ■ Minimize Risk of Future Contamination

- ❑ Eliminate pathways
  - Retrofit air-vac vaults
  - Update and enhance cross connection control ordinance, surveys, and enforcement
- ❑ Demonstrate pressure maintenance
  - Install high-speed portable pressure data loggers
- ❑ Maintain elevated chlorine residuals
  - On-going chlorine boosting and mixing
  - Reducing water age
  - Reducing pipe wall demands

# Boosted chlorine residual results

Chlorine Residual - Reservoir Outlets



# Booster Disinfection

- **On-going operation until contamination risks reduced**
- **Current practice has been effective for meeting water quality goals**
  - However, little dose and mixing control
  - Requires significant staff time to maintain operation and respond in DS
  - Consider auto-flushers in strategic locations
- **Conduct evaluation of need for permanent flow controlled system and mechanical mixers**

# Need for Enhanced Main Cleaning

- **Reduce disinfectant demand**
- **Reduce shielding of microorganisms**
- **Improve flow, pressure, water quality**
- **Flushing program constrained by discharge limitations**
- **Additional study needed:**
  - Demonstrate effectiveness (or lack of) current flushing program for main cleaning
  - Desk top and field evaluations alternative main cleaning strategies
    - Ice pigging
    - NO-DES (no discharge flushing system)
    - Swabbing of cement lined and AC pipes
    - Pigging and relining
  - Develop metrics and use data collected to help prioritize main replacements
- **Optimize use of staff and water resources while improving water quality delivered to customers**

# Enhancing Water Quality Management

- **Develop and implement a water quality surveillance monitoring program**
  - Understand water quality conditions
    - From POE to meter
    - Spatially and seasonally
  - Identify potential upsets
  - Timely data for quick decision making

# Conclusions

- **City is fortunate to have knowledgeable, diligent, capable staff**
- **Scrutiny of practices and system conditions uncovered opportunities for improvement, as would be the case for most water systems regionally and nationally**
- **The City has meaningful opportunities to:**
  - Reduce contamination risk,
  - Enhance water quality and asset management, and
  - Optimize practices and resource use
- **Additional resources will be needed to implement recommendations**

# Next Steps

- **Develop implementation plan and timeline for operating and capital improvements**
- **Assess costs and potential staffing needs**
- **Continue to consult with DOH, SPU**
- **Will continue working with Confluence where technical expertise is needed**

# One Year Later....Update November 2015

# Action Plan

## Disinfectant Residual Increase and Maintenance

- Booster Disinfection
  - Meeting inactivation goals
  - Mixers not needed at reservoirs
  - Design for permanent system on the shelf
- Flushing to Reduce Water Age
  - Adequate residual maintained Island-wide
- Evaluate Chlorine Demand
  - Bench-scale CDD Evaluation
  - Bulk water v. pipe wall CDD
- Main Cleaning Evaluation
  - Desk-top comparison of technologies
  - High-velocity UDF pilot
  - Verified feasibility and effectiveness of UDF

Phase 2 activity  
Phase 1 or City activity

## Reduce Contamination Risks

- Retrofit Vaults
  - 100% of Combined PRV Vaults
    - Work completed Q2 2015
  - Stand Alone Vaults
    - Inspections
    - Retrofits on-going
- Cross Connection Control Program
  - Ordinance adopted 6/15/15
  - Contract underway to develop policies and procedures
  - Developing educational materials
  - Certification letters/surveys sent to homeowners

## Operating Procedures and Documentation

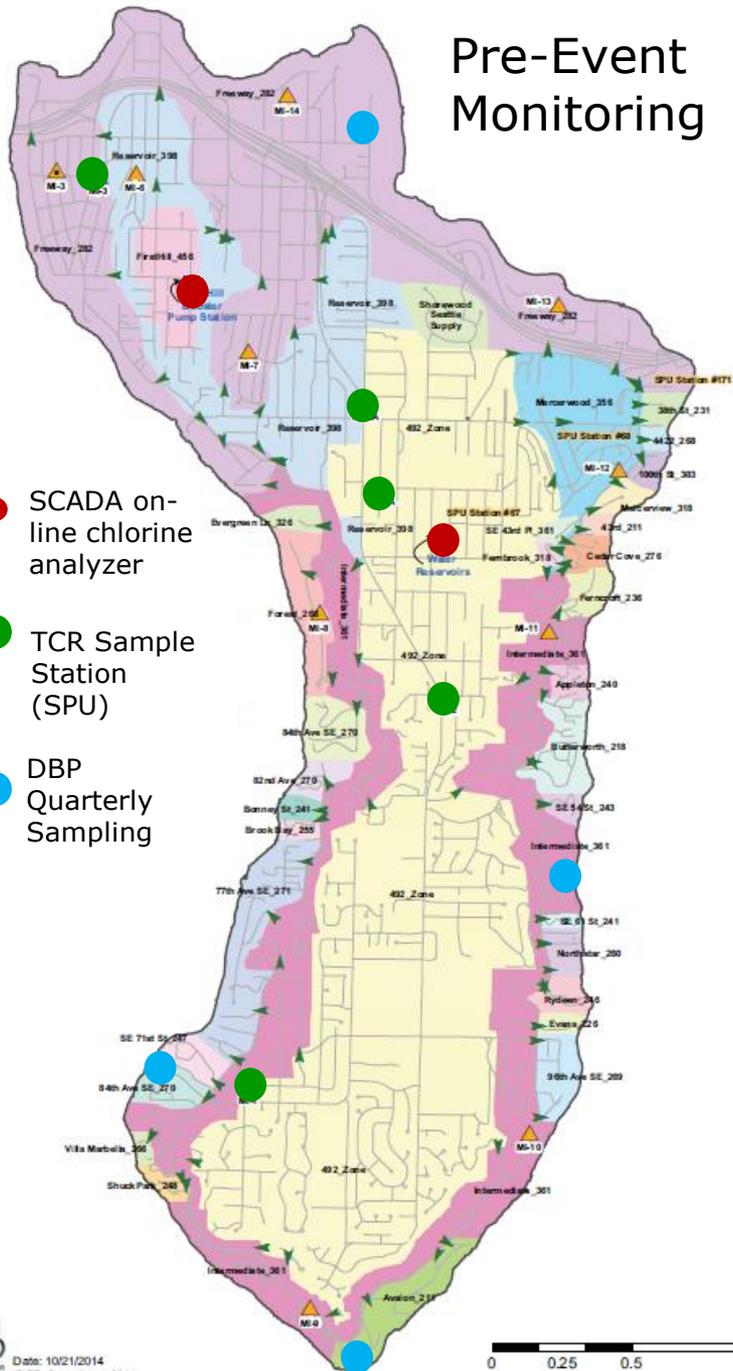
- Pressure Control
  - Purchased and tested 2 high-speed pressure data loggers
    - Tested bypass valve and other locations
    - Good pressure control verified
  - Verified SCADA capabilities
- Development of written SOPs
  - Flushing
  - Surveillance monitoring and analytical equipment upkeep

## Water Quality Monitoring

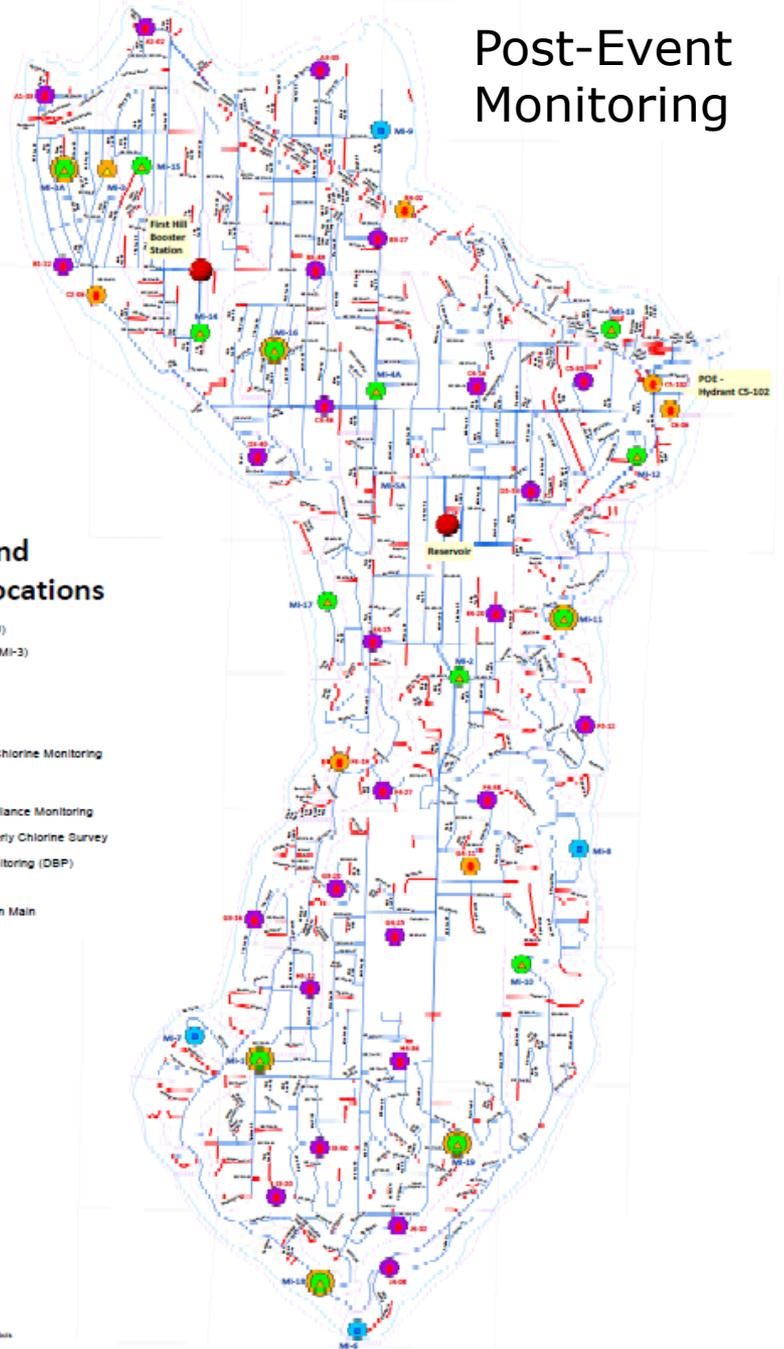
- Event Response and Transition Monitoring
  - > 1300 samples met goal
  - > 350 negative coliform samples
- Permanent TCR Monitoring
  - Plan approved by DOH
  - Sample stands installed
  - Began Q3 2015
- Surveillance Monitoring
  - Plan development
  - Equipment purchase, training, & implementation
- Island-Wide Chlorine Surveys
  - Adequate residual at hydrants and dead-ends
- Hourly/Continuous Monitoring
- On-line analyzer upgrades

# Water Quality Monitoring Activities

# Pre-Event Monitoring



# Post-Event Monitoring

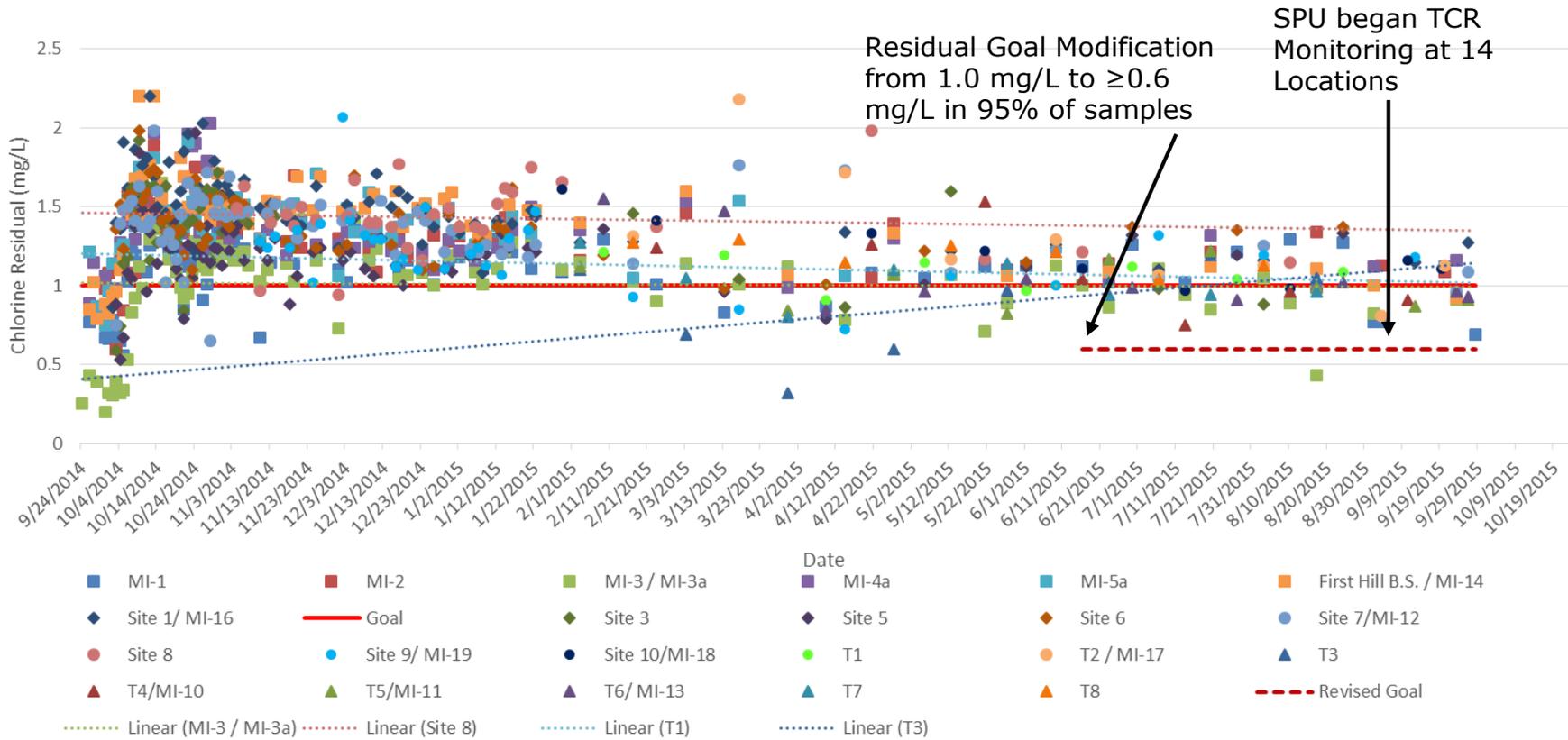


## Mercer Island Sampling Locations

- ▲ Sample Station (SPU)
- ▲ Old Sample Station (MI-3)
- Meter
- Hydrant
- Scada- Continuous Chlorine Monitoring
- TCR Sample Site
- Mercer Island Surveillance Monitoring
- Mercer Island Quarterly Chlorine Survey
- TTMH Quarterly Monitoring (DBP)
- Dead End Distribution Main
- Other Water Main
- Pressure Zone
- Map Grid



# Transitional and TCR Monitoring 14 Permanent TCR Sites



# Surveillance Monitoring

- **Monthly snap shot of conditions**
- **More parameters to provide increased understanding of conditions**
  - Chlorine
  - Iron
  - pH
  - Turbidity
  - Heterotrophic bacteria
- **Still in process of building baseline to understand trends and relationships specific to MI's system**



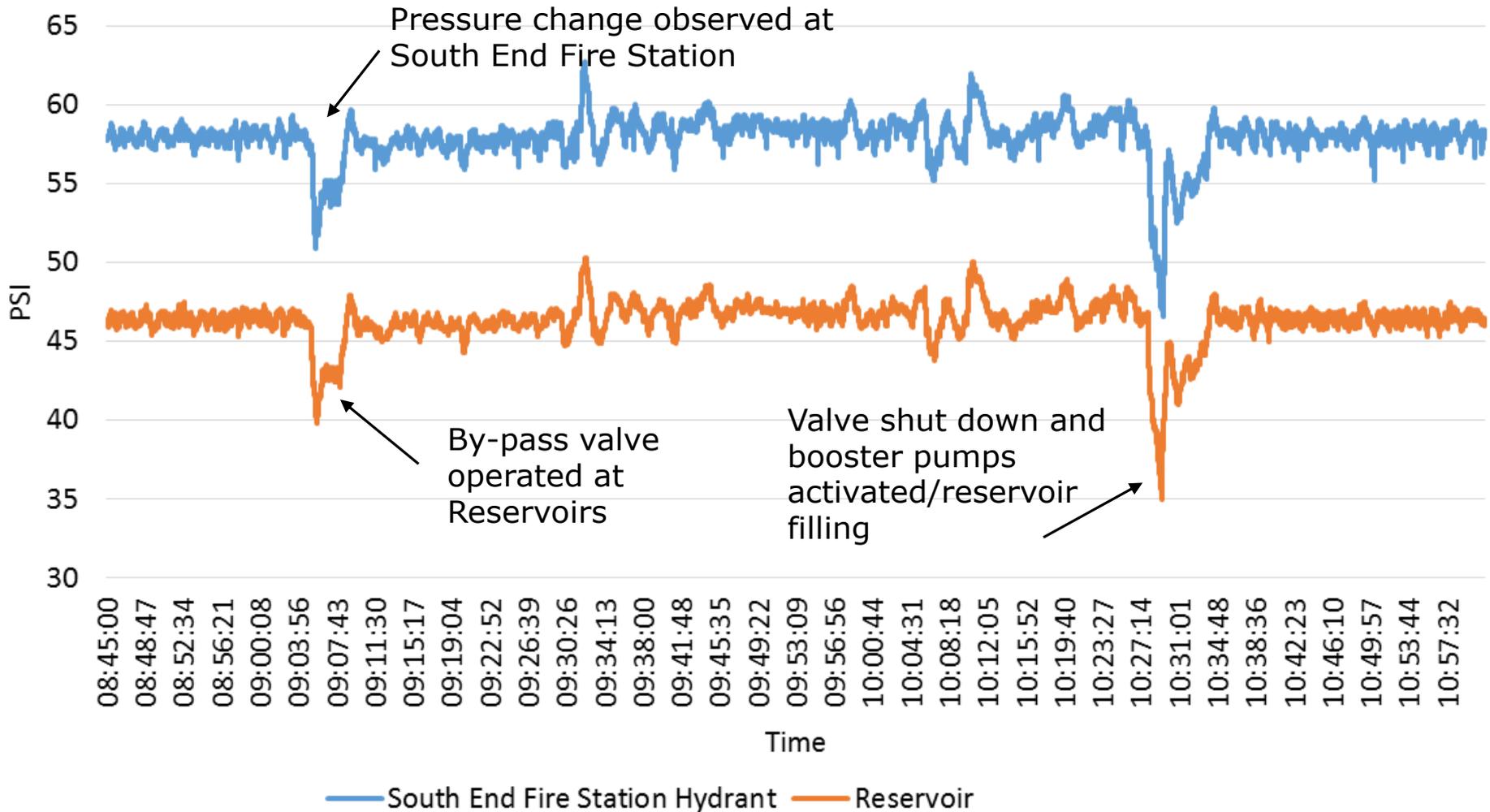
# Pressure Management

## High-Speed Pressure Data Loggers

- Needed to verify absence of pressure transients during routine operations
- City purchased two high-speed pressure data loggers
  - Takes readings up to 10x per second
  - Can study specific O&M practices
- City assessed:
  - First Hill Booster Station
  - Downtown Area
  - Intermediate Pressure Zone
  - By-pass Valve Operation



# High Zone By-Pass Valve Operation 10/28/15



# Air-Vac Vault Inspections and Retrofits

Example –  
Properly Vented  
No Retrofit



Example -  
Improperly Vented  
Before Retrofit



Example –  
Properly Vented  
After Retrofit



# High Velocity Unidirectional Flushing (UDF) Trials

- **Current flushing program focuses on water turnover, not “main cleaning” due to discharge limitations**
- **A field trial comparing UDF vs. water turnover is underway**
  - Procedures, field cards, equipment lists developed
  - Equipment procured
  - Training underway
  - Field inspections complete
  - Trials completed January 2016
- **Final SOP with recommended approach will be prepared**

# Summary of Risk Reductions to Date

- **Verified excellent pressure control**
  - No risk of backsiphonage observed based on data collected
  - If original event was caused by a cross connection, it was unlikely due to poor pressure management by the City
- **Vault retrofits have eliminated numerous potential contamination pathways**
- **Increased protection through enhanced disinfectant residual maintenance and water quality tracking**
- **Crews have come a long way**
  - Learning to collect and interpret a wider range of water quality and operational data
  - Recognize potential upsets and appropriate responses
- **Cross-Connection Control Program will be significantly more protective**
- **Enhanced communications between City, SPU, DOH**

# To Do List – as of March 2016

- **Develop Island-wide UDF program if determined both feasible and beneficial (2016 onward)**
- **Finalize additional O&M SOPS (Q2 2016)**
- **Complete phase 3 air-vac valve retrofits (Q3 2016)**
- **On-going monitoring**
  - On-line analyzer upgrades
  - Daily (per DOH)
  - TCR (Weekly)
  - Surveillance (Monthly)
  - Island-Wide Surveys (Quarterly)
- **Permanent booster disinfection design available if needed**
  - Design on the shelf by Q2 2016
- **Cross-Connection Control Program**

# No Smoking Gun Evident

**More than likely source of contamination will never be positively identified**

**Goal still remains:**

**Committed to ensuring safe drinking water  
to the community in which we serve.**

**Discussion / Questions?**

**THANK YOU**