SPU Water Quality Security

Presented by
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Agenda

- □ Purpose
- □ Rationale
- □ History
  - □ EPA Guidance
  - □ SPU Initiatives
- □ SPU Online Monitoring
- □ Conclusions & Recommendations

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Purpose

- Purpose:

  To provide an overview of Water Quality Security at SPU

- Problem:

  How should SPU increase and maintain water quality security appropriately based on risk of accidental or intentional contamination to Seattle drinking water

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Rationale

- EPA has established the expectation of due diligence through extensive guidance, but has not set prescriptive requirements or regulations
- The Water Sentinel Program is providing lessons learned at U.S. pilot cities
- The EPA Monitoring and Surveillance model provides a robust framework
- SPU has implemented multiple initiatives based on EPA guidance

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SPU Initiatives

- Emergency Response Protocol (SPU Internal Document)
- Threat Ensemble Vulnerability Assessment (TEVA)
- Tri-agency Agreement
- Extensive Physical Security Upgrades
- Expanded Laboratory Capabilities
- Access to Information Sources
- EPA Region 10 Response Plan and Practical Exercise
- EPA Regional Contamination Exercise
- ICS Training & Emergency Response Preparedness
- Equipment Analysis and Pilot Testing

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EPA Emergency Response - Prepare

- Internal guidelines/checklists
- ICS
- Maintain plans & system records
- Relationships/roles with local responders
- Communication plan & notification system
- Contingency for alternate water supply
- Accurate records of any incident
- Baseline water quality monitoring
- Staff training
- Maintain access to additional information resources

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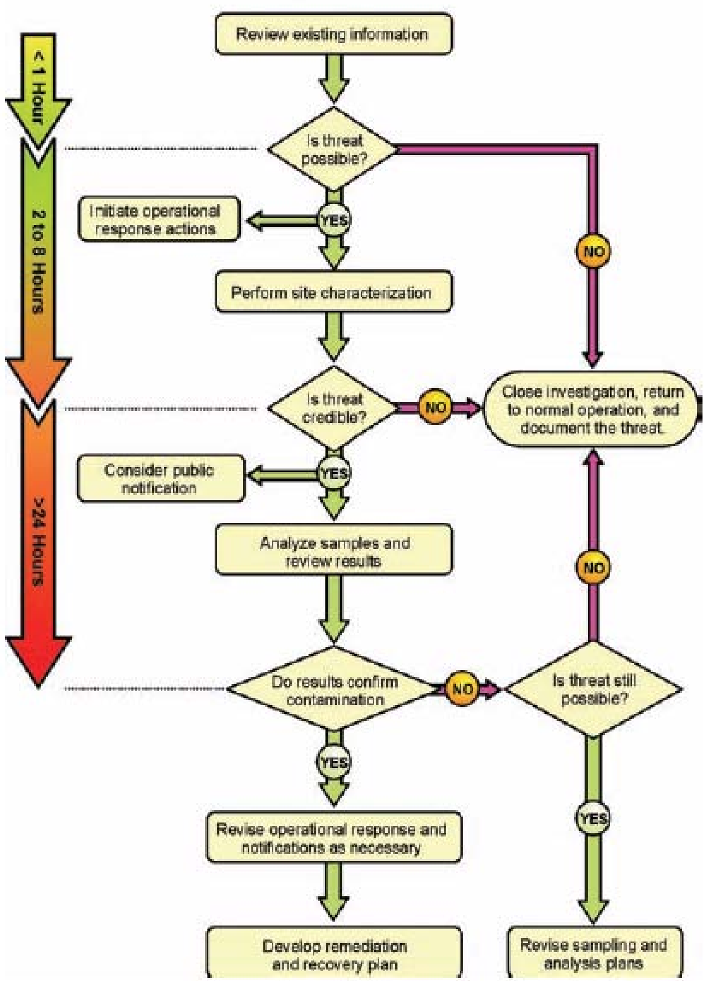
EPA Emergency Response - Respond

- Determine threat possibility
- Determine if threat is credible
- Confirm threat
- Remediate water system
- Return to normal service



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EPA Guidance: Water Security Initiative

- EPA established this initiative in response to Homeland Security Presidential Directive 9, under which the Agency must:

"develop robust, comprehensive, and fully coordinated surveillance and monitoring systems, including international information, for…water quality that provides early detection and awareness of disease, pest, or poisonous agents."

- Three Phases

Phase 1 (completed), develop the conceptual design

Phase 2 (ongoing), pilot testing and refinement

Phase 3 (ongoing), develop practical guidance and outreach

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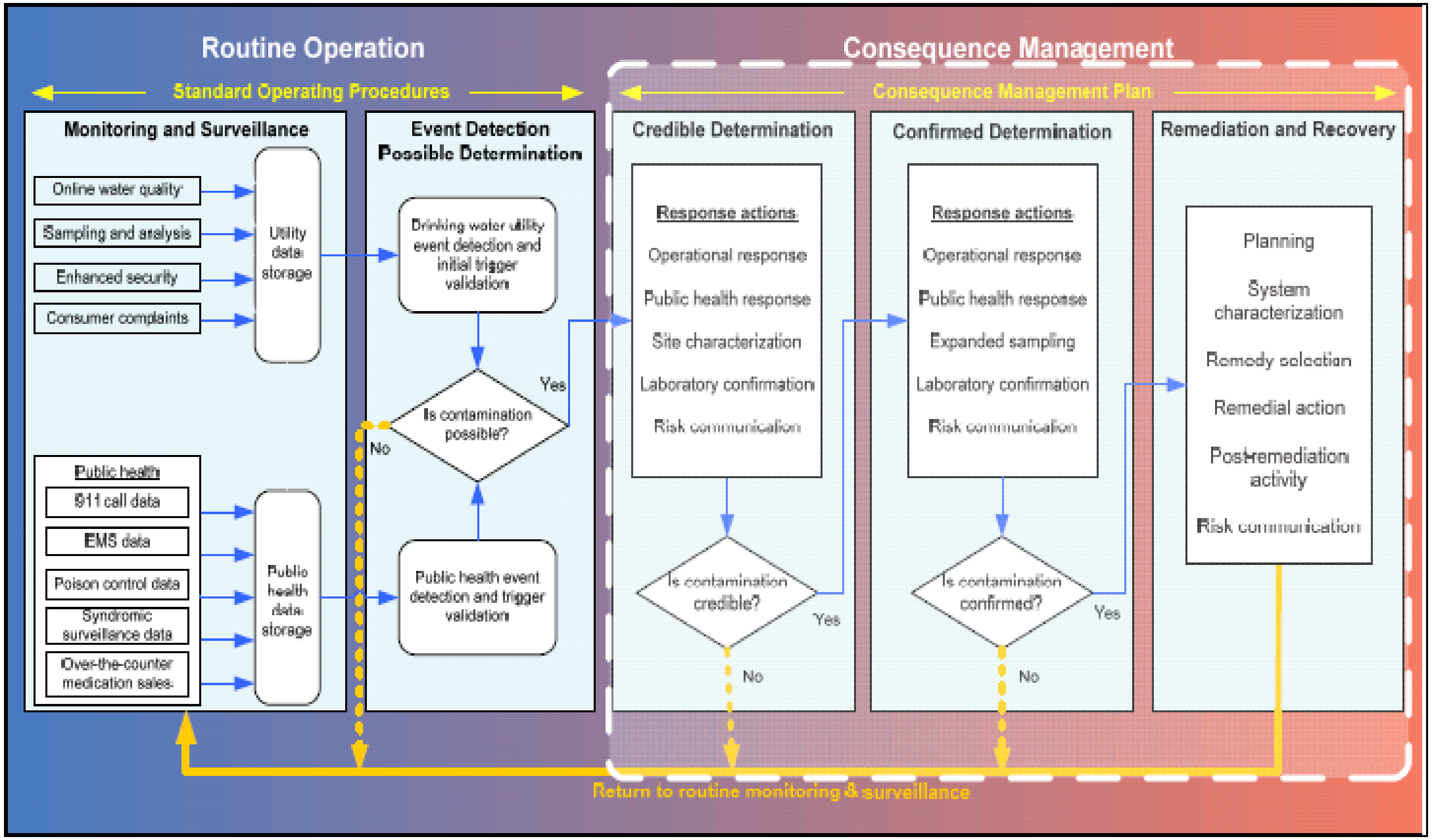
EPA Guidance: Water Security Initiative



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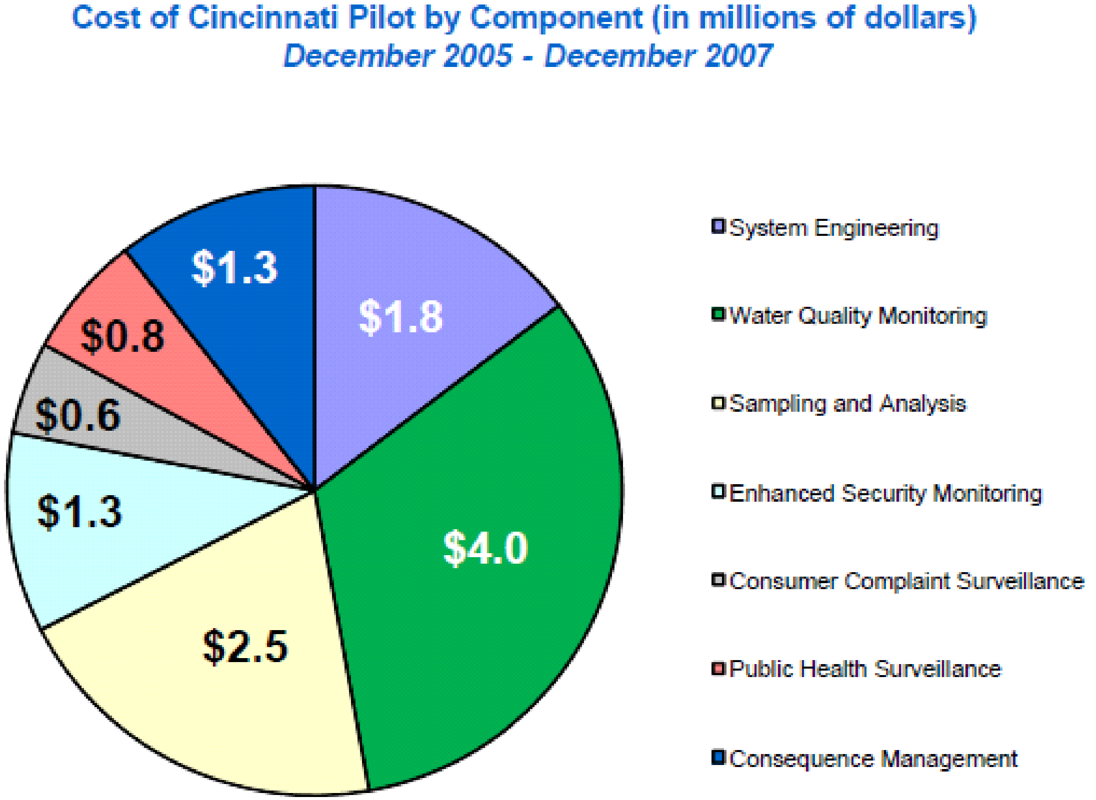
EPA Guidance: Water Security Initiative

- Cincinnati Highlights



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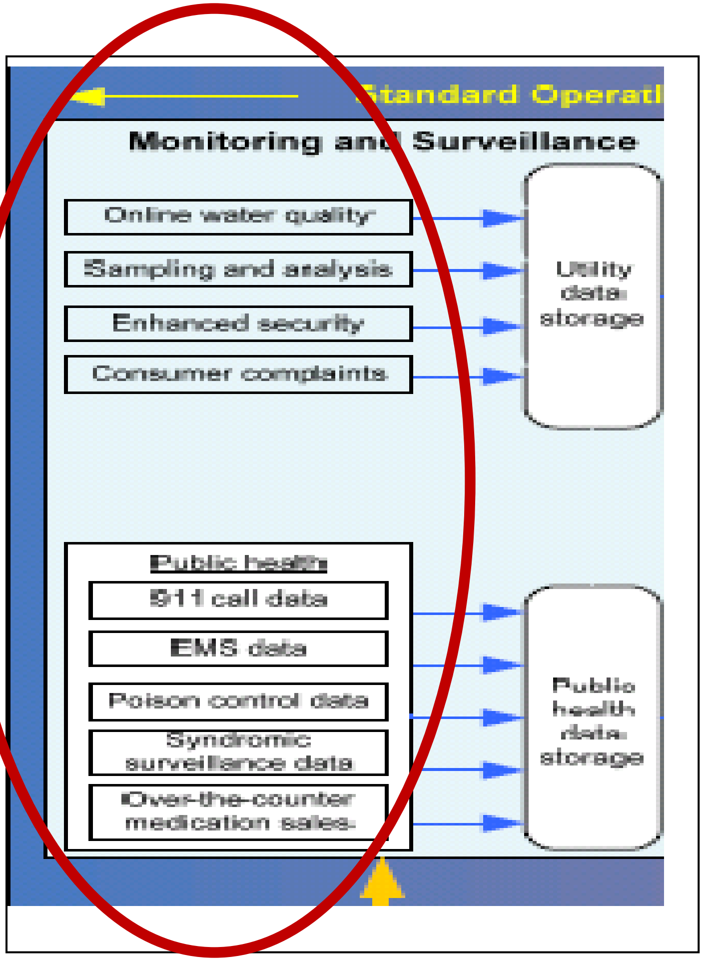
EPA Guidance: Contamination Warning System



- ☐ Online water quality monitoring
- ☐ Sampling and analysis
- ☐ Enhanced security
- ☐ Consumer complaints
- ☐ Public Health

EPA Guidance: Monitoring and Surveillance

- **Online water quality monitoring**
  - throughout distribution system
  - chlorine, total organic carbon, conductivity, and other parameters
  - software required to analyzes the monitoring data (e.g. Canary)
- **Sampling and analysis**
  - collection of distribution samples
  - routine and incident response
  - analyzed for classes of contaminants and specific contaminants
- **Enhanced security monitoring**
  - detect and respond to security breaches
  - equipment/procedures at distribution system facilities
  - may be: cameras, motion sensing lights, door contacts, ladder and window motion detectors, and access hatch detectors
- **Consumer complaint surveillance**
  - collect and analyze customer calls
  - may detect contaminants that impart an odor, taste, or visual change to the drinking water
- **Public health surveillance**
  - analysis of health-related data
  - identify disease events that may stem from drinking water contamination
  - may include over the counter drug sales, hospital admission reports, infectious disease surveillance, 911 calls, and poison control center calls

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EPA Guidance: Monitoring and Surveillance

- Contaminant Classes and Means of Detection

Class	Description	Water Quality	Consumer Complaints	911 calls / EMS	Syndromic Surveillance
1	Petroleum products	X	X		
2	Pesticides (with odor or taste)	X	X	X	
3	Inorganic compounds	X	X	X	
4	Metals	X	X	X	
5	Pesticides (odorless)	X	X	X	
6	Chemical warfare agents	X		X	
7	Radionuclides	X		X	
8	Bacterial toxins	X			X
9	Plant toxins	X			X
10	Pathogens causing diseases with unique symptoms	X			X
11	Pathogens causing diseases with common symptoms	X			X
12	Persistent chlorinated organic compounds	X			

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SPU Monitoring and Surveillance

- ***Online water quality monitoring***
  - Modeled contaminant scenarios with TEVA
  - Installed 4 online analyzers in the distribution system
  - Improvement needed:
    - Increase number of analyzers
    - Add data monitoring software (e.g. Canary)
- ***Sampling and analysis***
  - Extensive routine sample collection
  - In-house screening capabilities
  - Emergency sample collection kits
  - Improvement needed:
    - Refine/practice site characterization
    - Update sample collection kits
- ***Enhanced security monitoring***
  - Extensive physical security improvements through CIP (locks, gates, cameras, fences)
  - Protocols developed for specific incidents (IAP)
  - Improvement needed:
    - Link facility surveillance to other monitoring elements
- ***Consumer complaint surveillance***
  - Greatly improved call center tracking and categorization
  - WQ Inspectors monitor and respond
  - Improvement needed:
    - Trending call data in relation to other monitoring data
- ***Public health surveillance***
  - Good working relationship with Public Health
  - Syndromic surveillance data collected currently, but not readily accessible by SPU
  - Improvement needed:
    - Track Public Health data in parallel with WQ data

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SPU Online Water Quality Monitoring

- TEVA model developed for Seattle system
  - Hydraulic characteristics and system demand
  - Theoretical contamination scenarios run on model
  - 8 to 10 locations identified based on:
    - Optimized response time for detection
    - Minimized impact to greatest population
- Several instruments currently deployed
  - Pipe sonde
  - Guardian Blue
  - Multi-parameter panels

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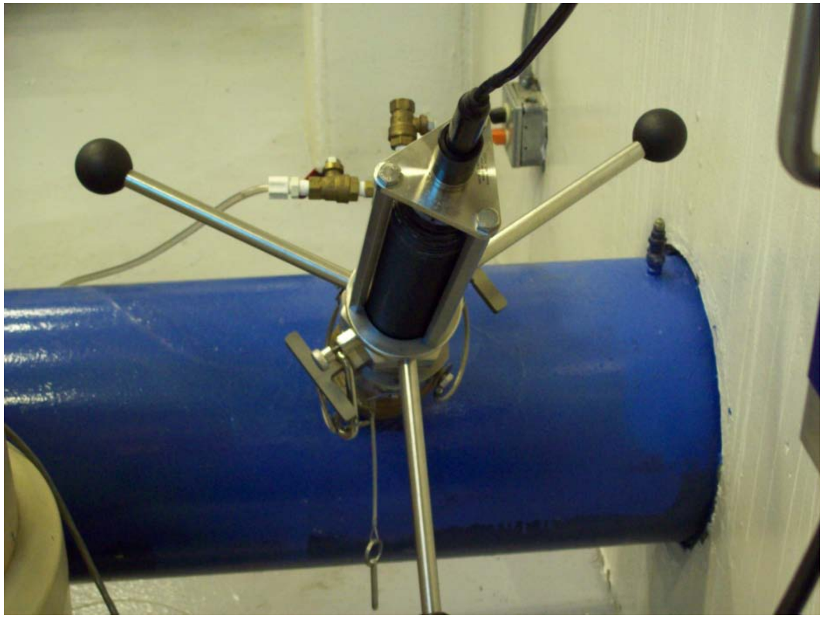
Pipe Sonde

- pH
- ORP
- Conductivity
- DO or chlorine



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Guardian Blue

- □ pH or ORP
- □ Conductivity
- □ Pressure
- □ Temperature
- □ Chlorine
- □ TOC

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Multi-Parameter Panel

- pH
- ORP
- Conductivity
- Turbidity
- Chlorine

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Event Monitor

- □ Receives up to 6 separate signals
- □ Calculates 1 combined signal
- □ Can be used with contaminant library
- □ May be used with additional monitors and auto-samplers

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S::CAN

- □ pH
- □ Conductivity
- □ Turbidity
- □ Chlorine
- □ TOC surrogate

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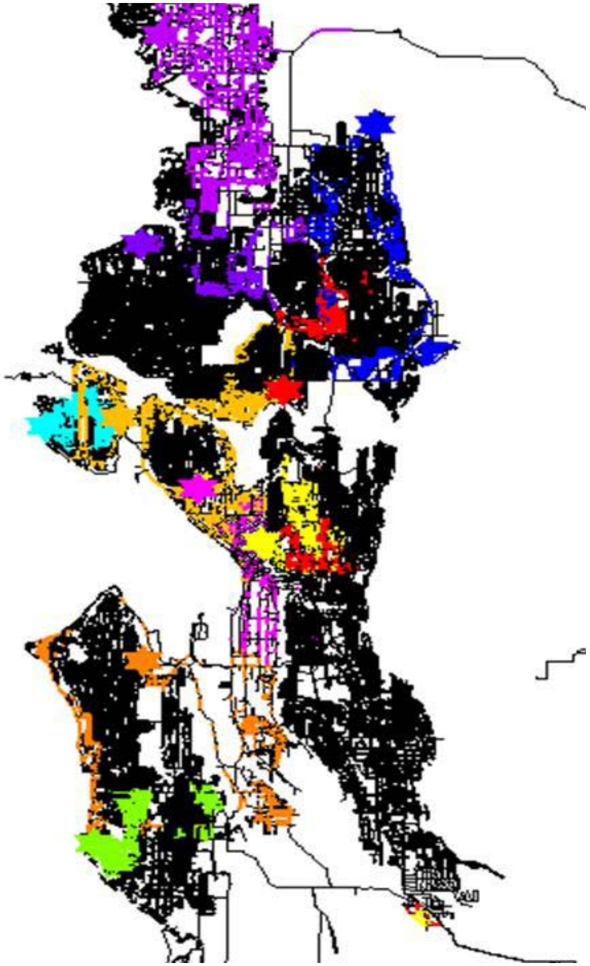
Site Location

- TEVA Sensor Protection Plot
  - Optimal 10 Sensor Network Design
  - Color coding highlights pipes of network protected by each sensor of the same color
  - Black indicates events not detected or unknown



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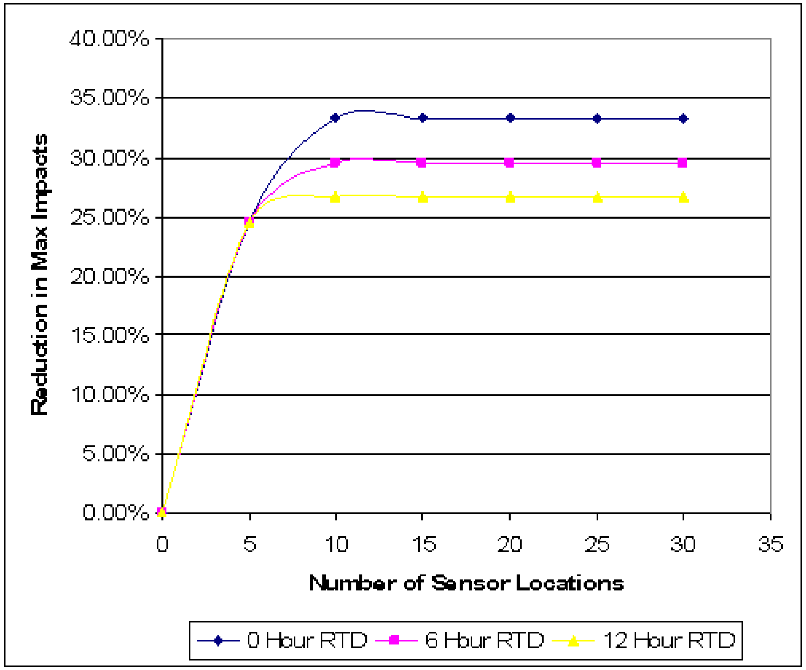
Number of Analyzers

- TEVA performance based on number of sensors
  - Reduction in maximum health impacts vs. number of sensor locations
  - Theoretical biological contaminant



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Other Considerations…

- Threshold levels/alarm sensitivity

- Operation and maintenance staffing

- Response actions

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Conclusions

- Intentional or accidental contamination possible
- SPU has made significant efforts and improvements to water quality security, for example:
  - Extensive physical security improvements
  - Established Emergency Response Plan and IAP
  - Trained staff on NIMS/ICS
  - Partnered with WDOH and Public Health (Tri-agency agreement)
  - Partnered with EPA Region 10 Laboratory Response Plan
  - Expanded testing and monitoring capabilities
- Areas of improvement still exist
- Greatest challenge is balancing investment of effort and expense appropriately with hard-to-quantify risk

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Recommendations

- Communicate with stake holders/elected officials regarding potential risks and mitigation options
- Build on past and current SPU actions
- Revise/update SPUs existing Emergency Response Plan with respect to drinking water quality security
- Practice and train
- Utilize existing EPA guidance and pilot city lessons learned

Questions ?

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Continuous Water Quality Monitoring for the Distribution System Comes of Age

PNWS AWWA

May 2012

Paul Berg, CH2M HILL

Is it realistic to monitor water quality in the distribution system?

Is it realistic to monitor water quality in the distribution system?

Do we have the tools to detect intentional contamination?

Outline

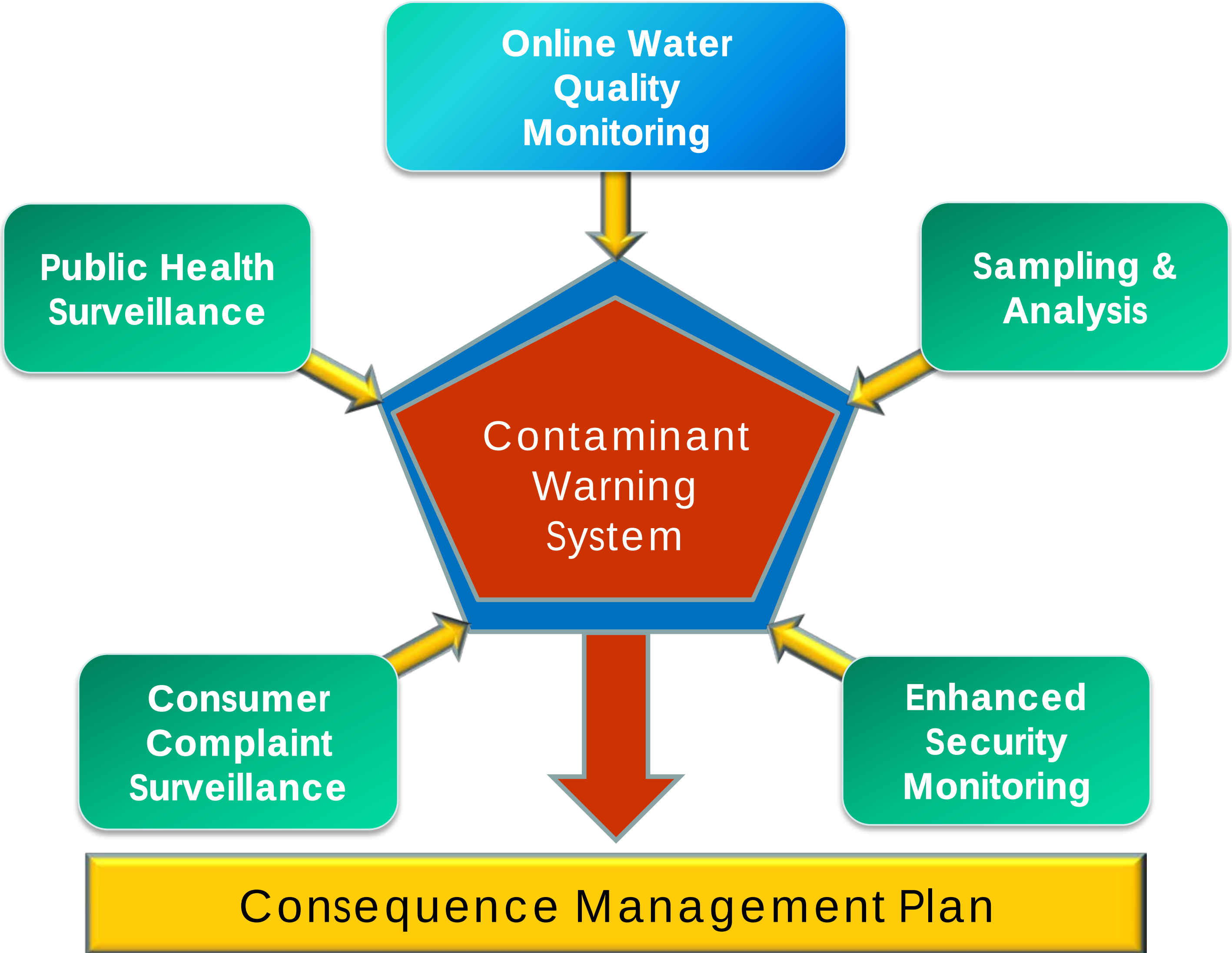
- Need and challenge
- Instruments
  - Hach GuardianBlue
  - s::can
  - ZAPS
- Costs and summary

NW Buchanan Ave
NW 16th St
Corvallis High School Track
NW Pierce Way
NW 10th St
NW 9th St
NW Fillmore Ave
NW Reiman Ave
NW 15th St
NW 14th St
NW 13th St
NW 12th St
NW 11th St
NW 8th St
NW Fremont Ave
NW Polk Ave
© 2012 Google
Google earth
Imagery Date: 7/8/2010
44°34'25.27" N 123°15'57.01" W elev 231 ft
Eye alt 2847 ft

Potential contaminants

- Petroleum products
- Pesticides
- Organics compounds
- Metals
- Pesticides
- Chemical warfare agents
- Radionuclides
- Plant toxins
- Pathogens

Contamination Warning System



INSTRUMENTS

Ideal characteristics

- Rapid detection
- Alarms
- Detect wide range of contaminants
- Identify contaminant source
- Affordable
- Robust/reliable
- Minimal number of false positives
- Remote operation

Adapted from T. Brosnan, 1999. “Early Warning Monitoring to Detect Hazardous Events in Water Supplies,” International Life Sciences Institute Workshop Report.

HACH GUARDIANBLUE

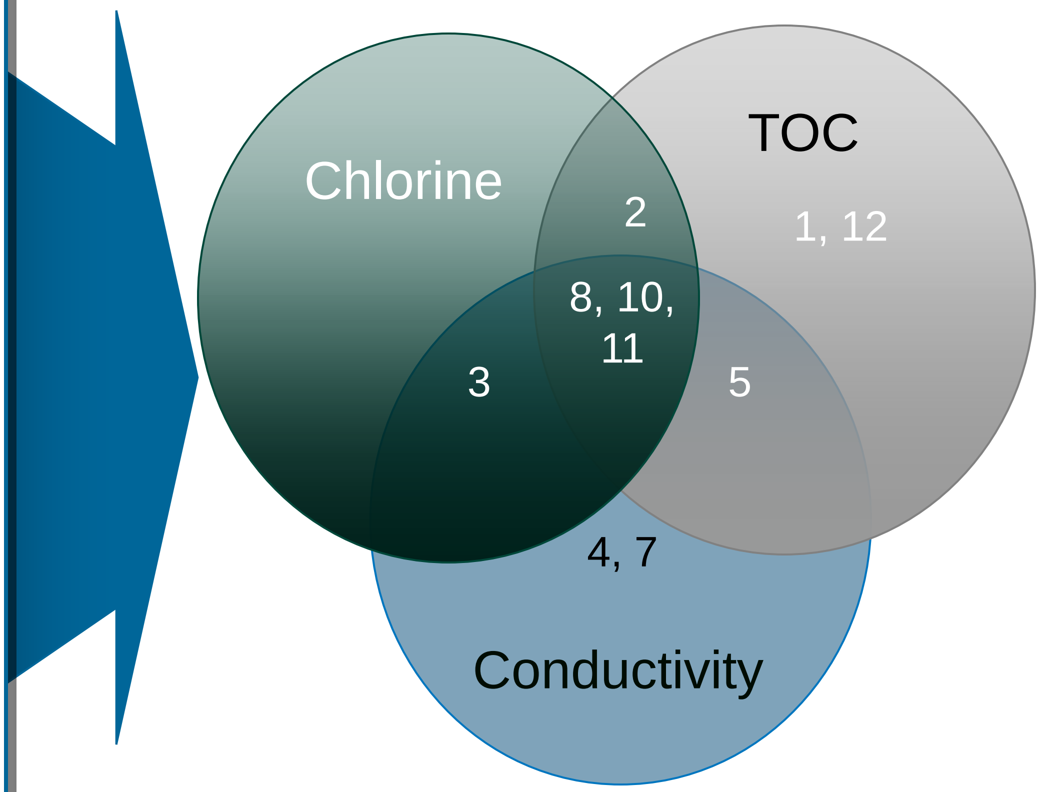

GUARDIANBLUE™ Event Monitor
HACH
Homeland Security Technologies

Capability of Hach GuardianBlue

- Free chlorine
- Conductivity
- pH
- Turbidity
- Temperature
- Pressure
- Total organic carbon
- (Auto-sampler)

→ Proprietary list of 90 contaminants

1. Petroleum products
2. Pesticides (with odor or taste)
3. Inorganic compounds
4. Metals
5. Pesticides (odorless)
6. Chemical warfare agents
7. Radionuclides
8. Bacterial toxins
9. Plant toxins
10. Pathogens (unique symptoms)
11. Pathogens (common symptoms)
12. Persistent chlorinated organic compounds



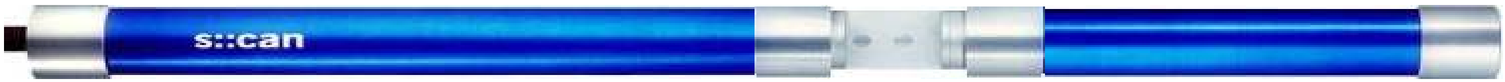
Source: U.S. EPA Water Sentinel System Architecture, Draft. Version 1.0

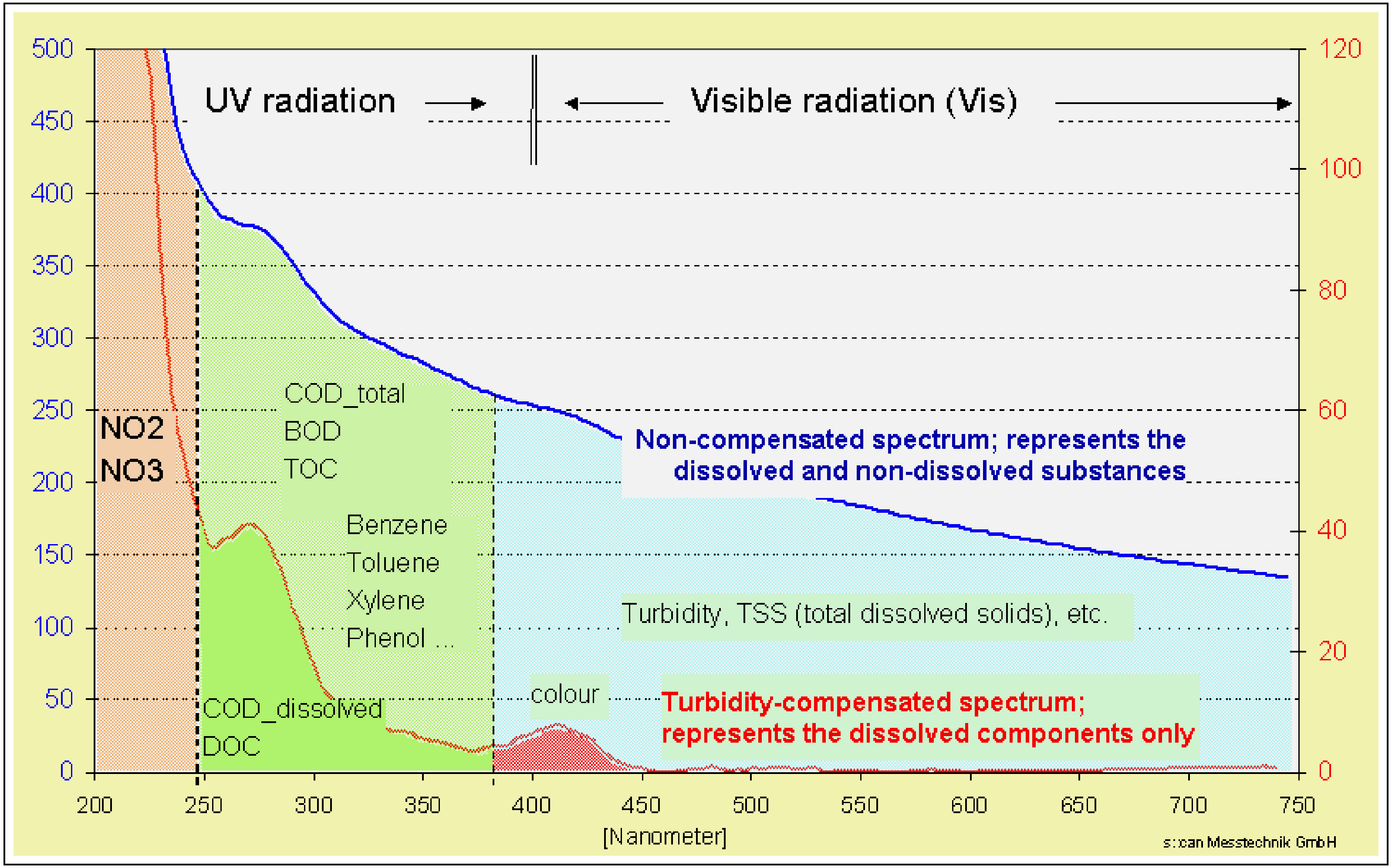
Published list for GuardianBlue

- Roundup
- Methyl ethyl ketone
- Cyanide
- Sodium fluoride
- Enterobacter

S::CAN

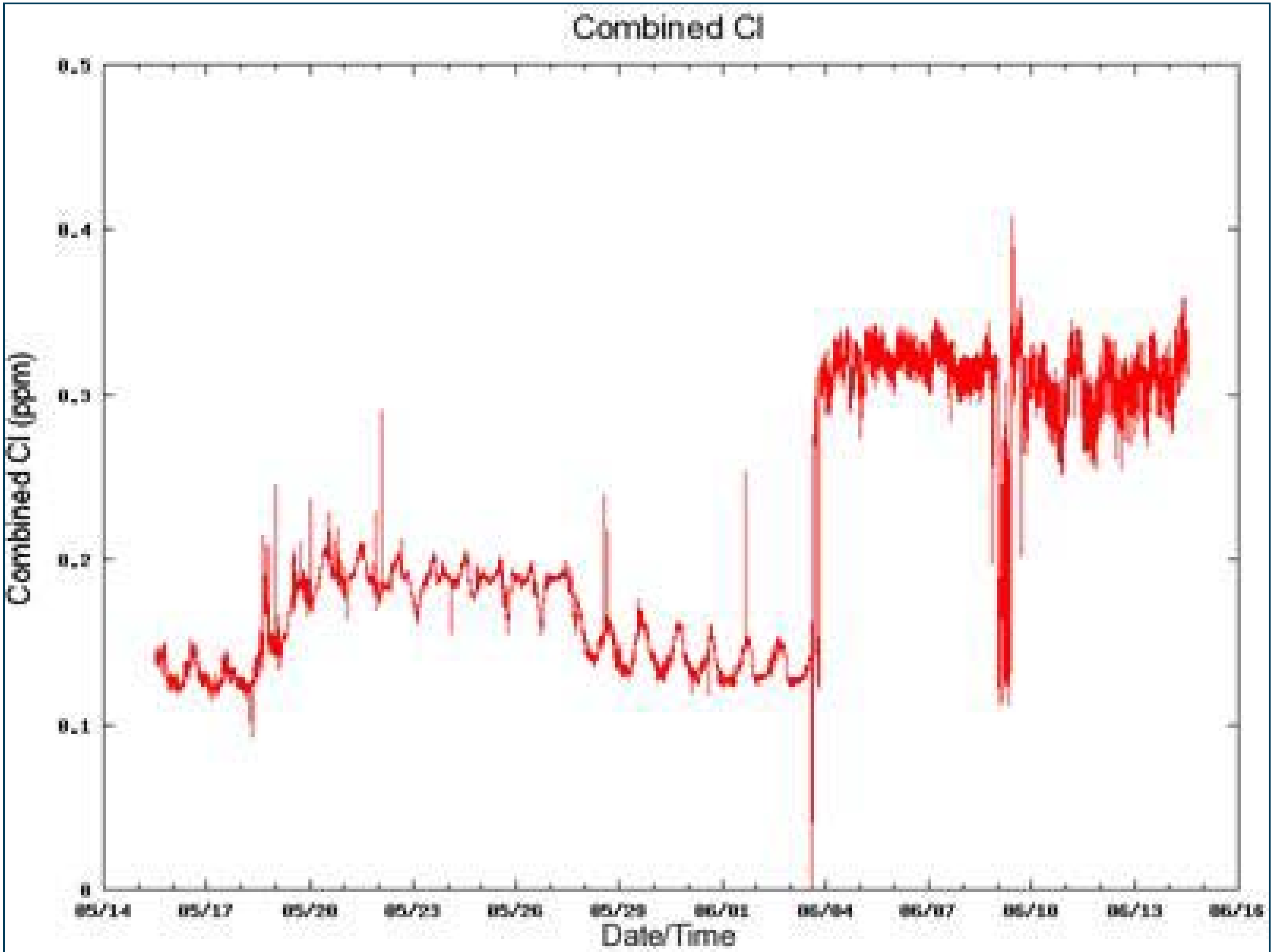
s::can Spectrolyzer

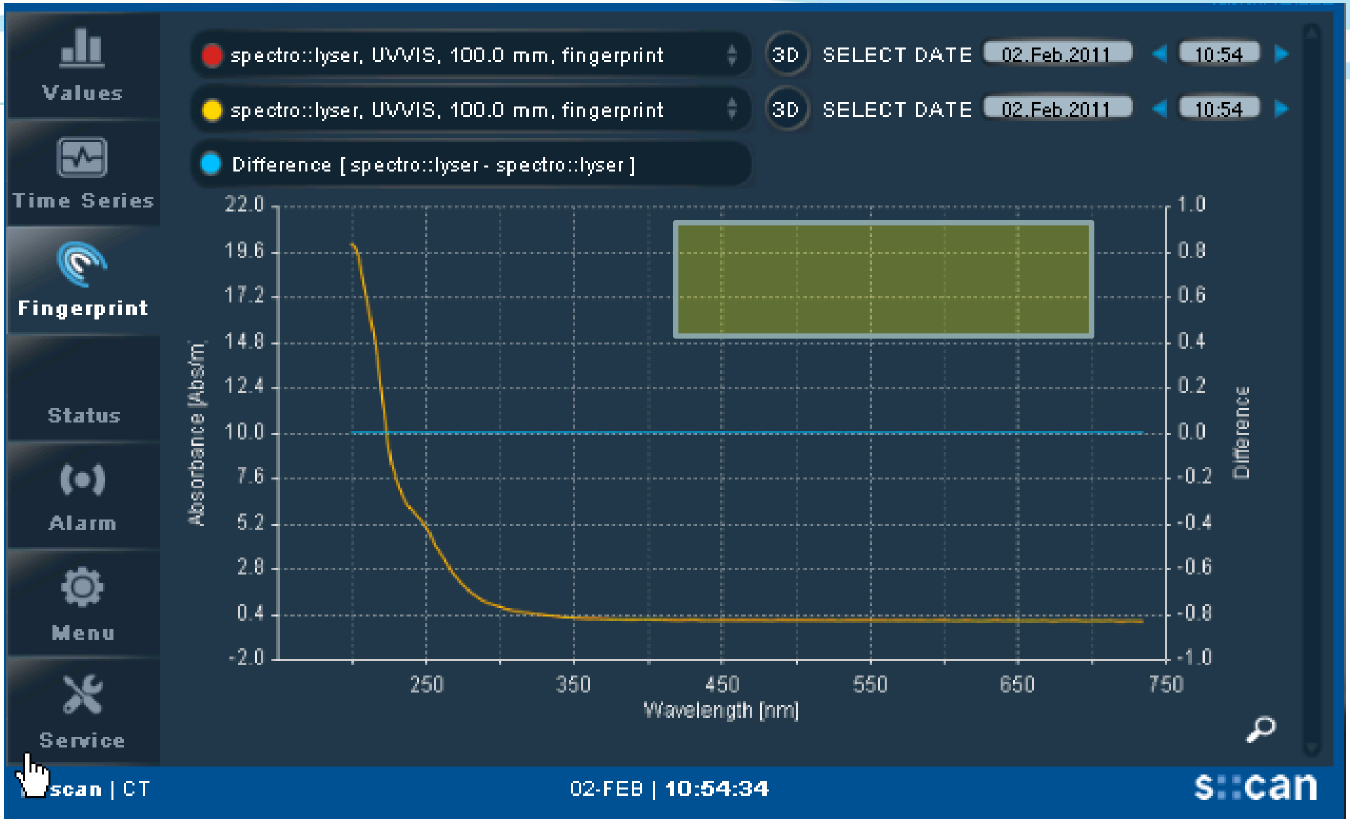




s::can sample screen

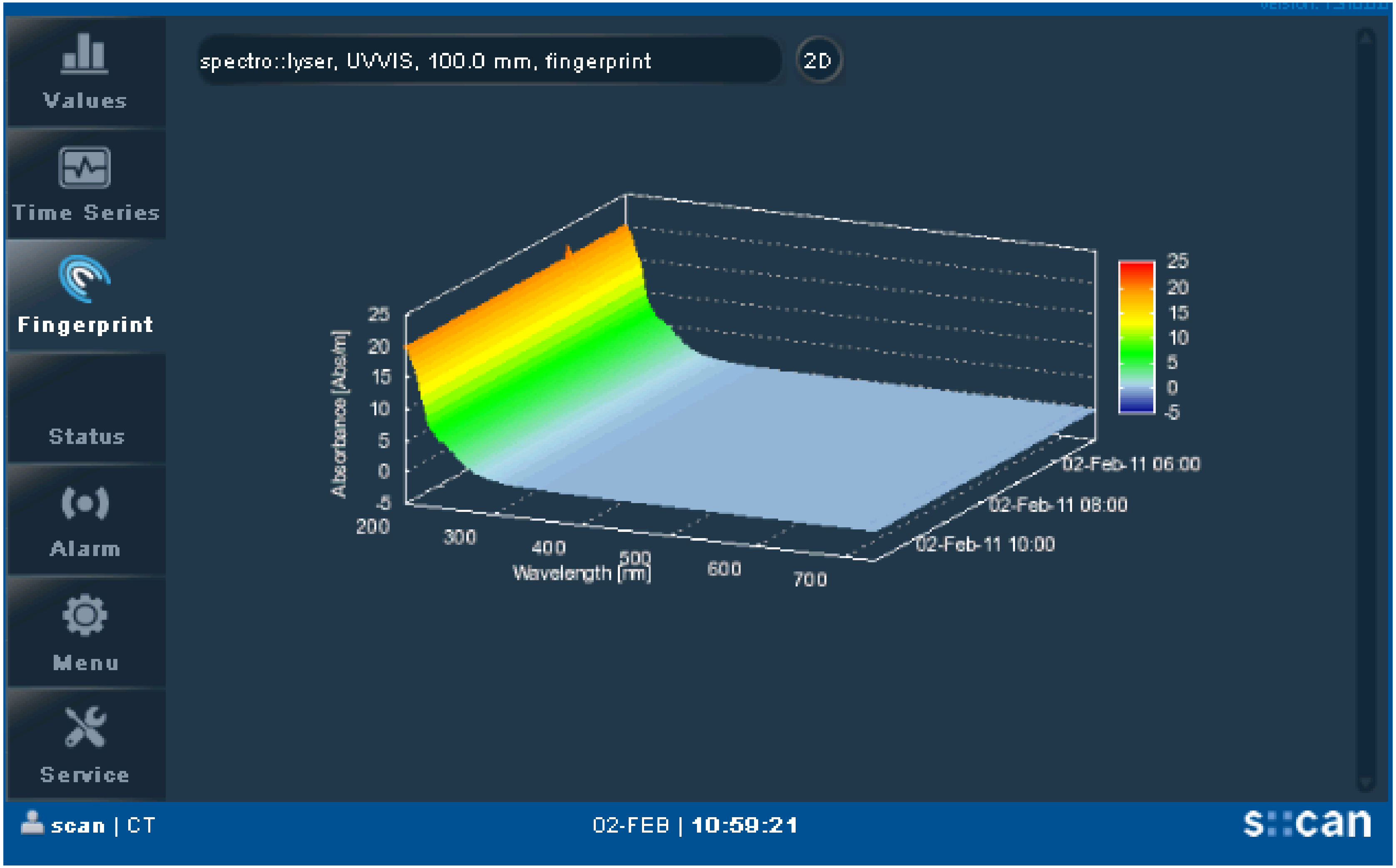
s::can provides time-value charts





- The Fingerprint tab displays the raw spectral absorbance curve
- By changing the dates at the top of the screen, different spectra can be displayed simultaneously, and the difference between the two spectra will be graphed (blue line)

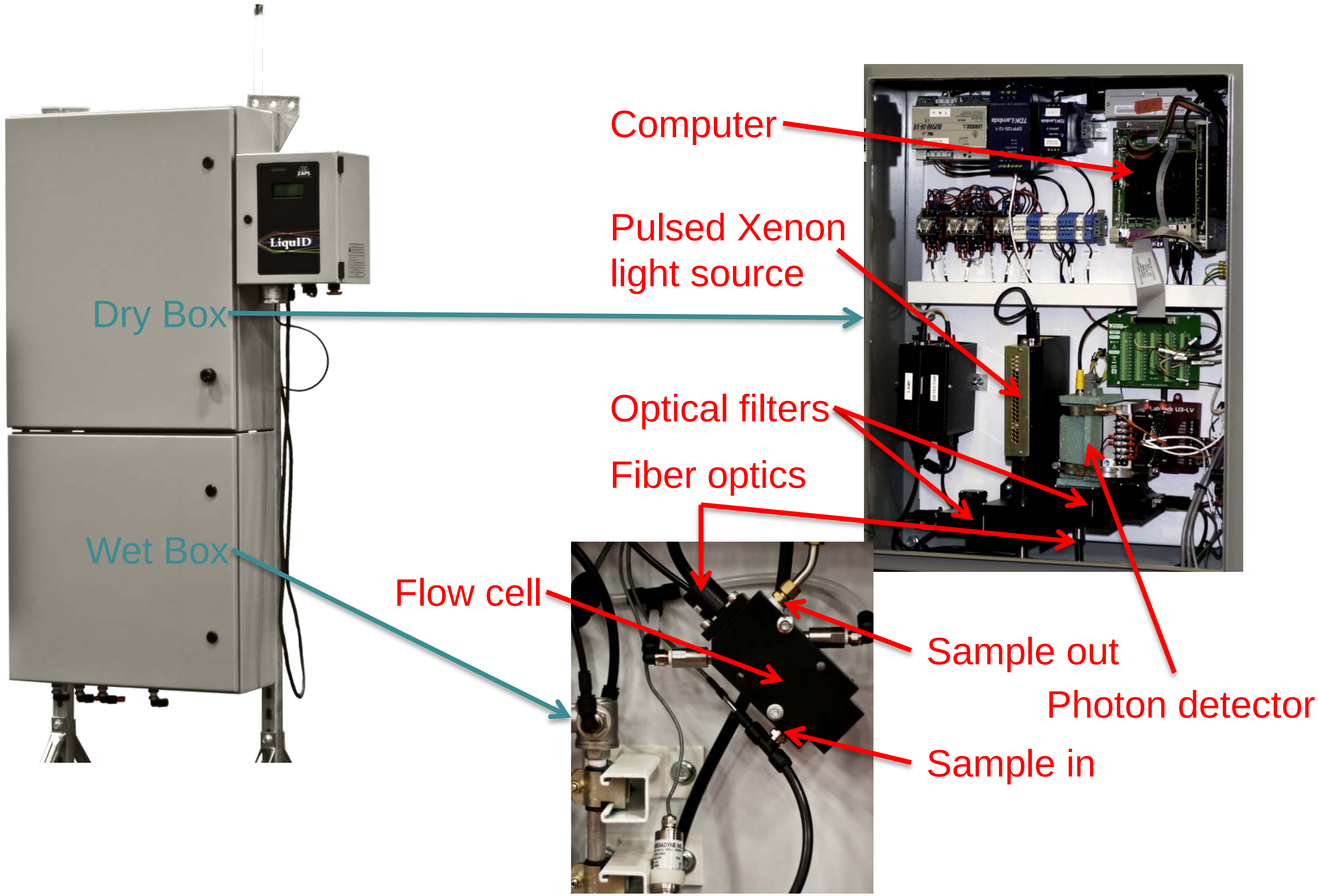
Fingerprint capability of s::can



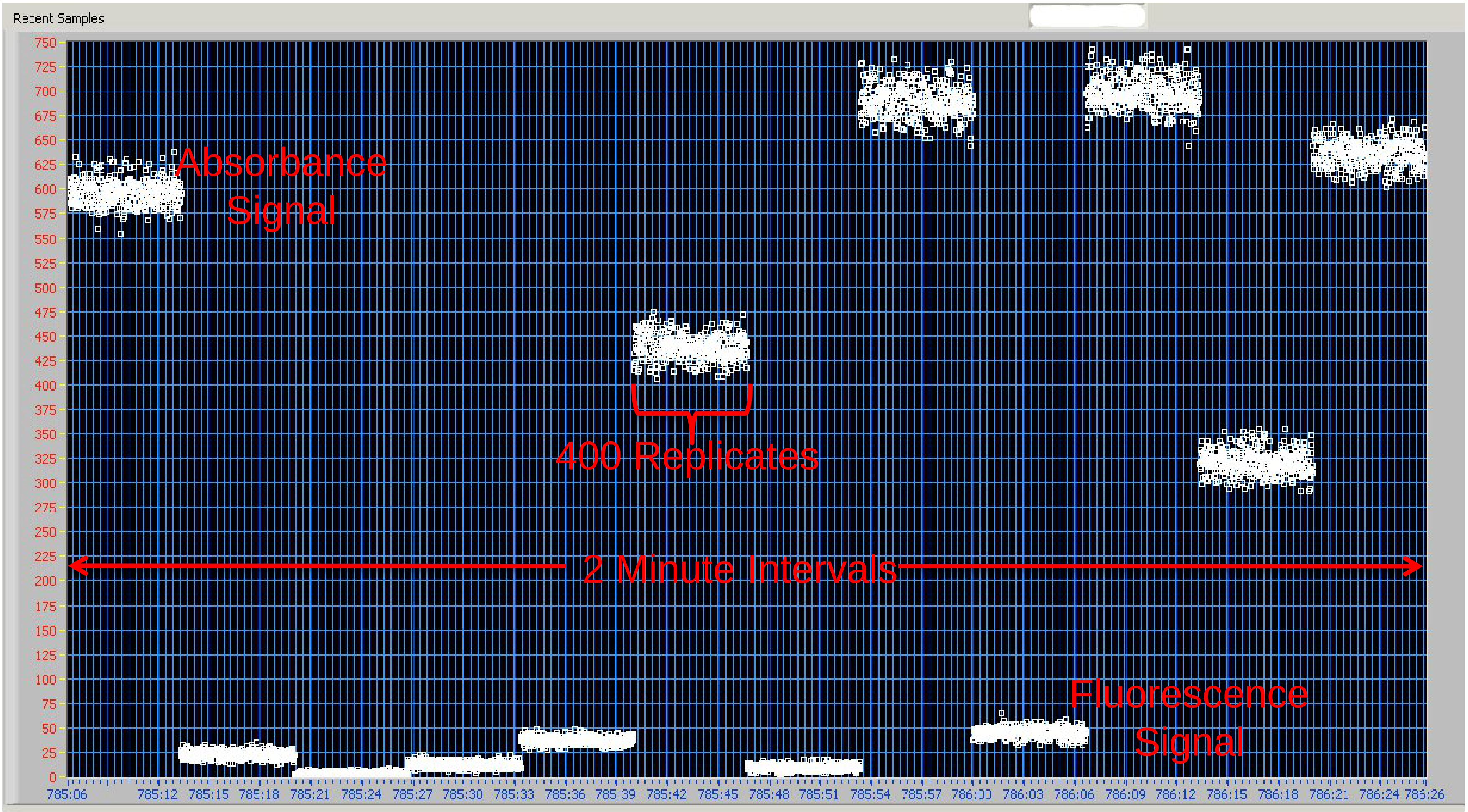
ZAPS

ZAPS LiquID Station

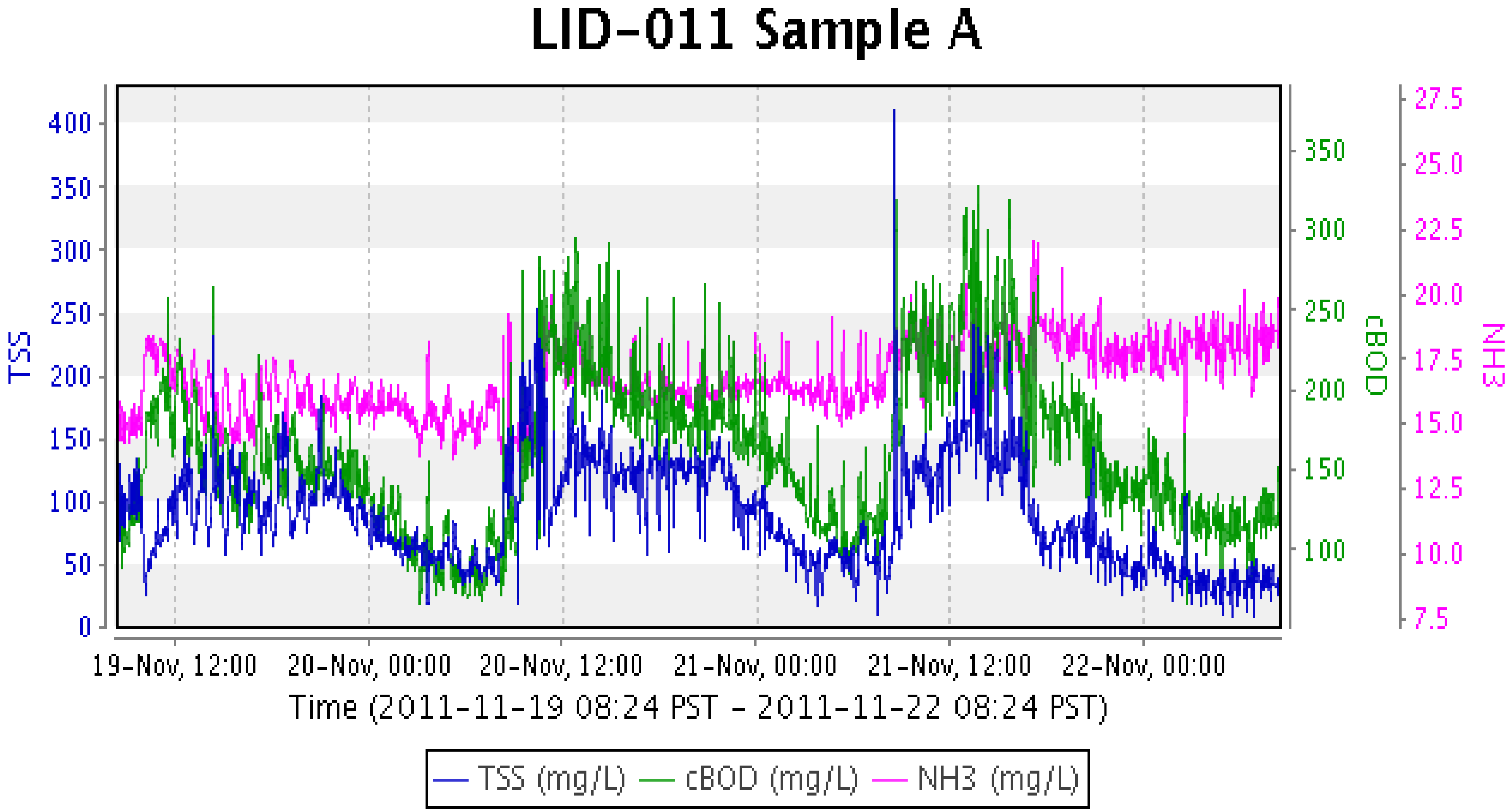

SODIUM BISULFITE


LiquID
Dry Box
Wet Box
Computer
Pulsed Xenon
light source
Optical filters
Fiber optics
Flow cell
Sample out
Photon detector
Sample in

ZAPS real-time monitoring



Detects using absorbance, fluorescence, and reflectance

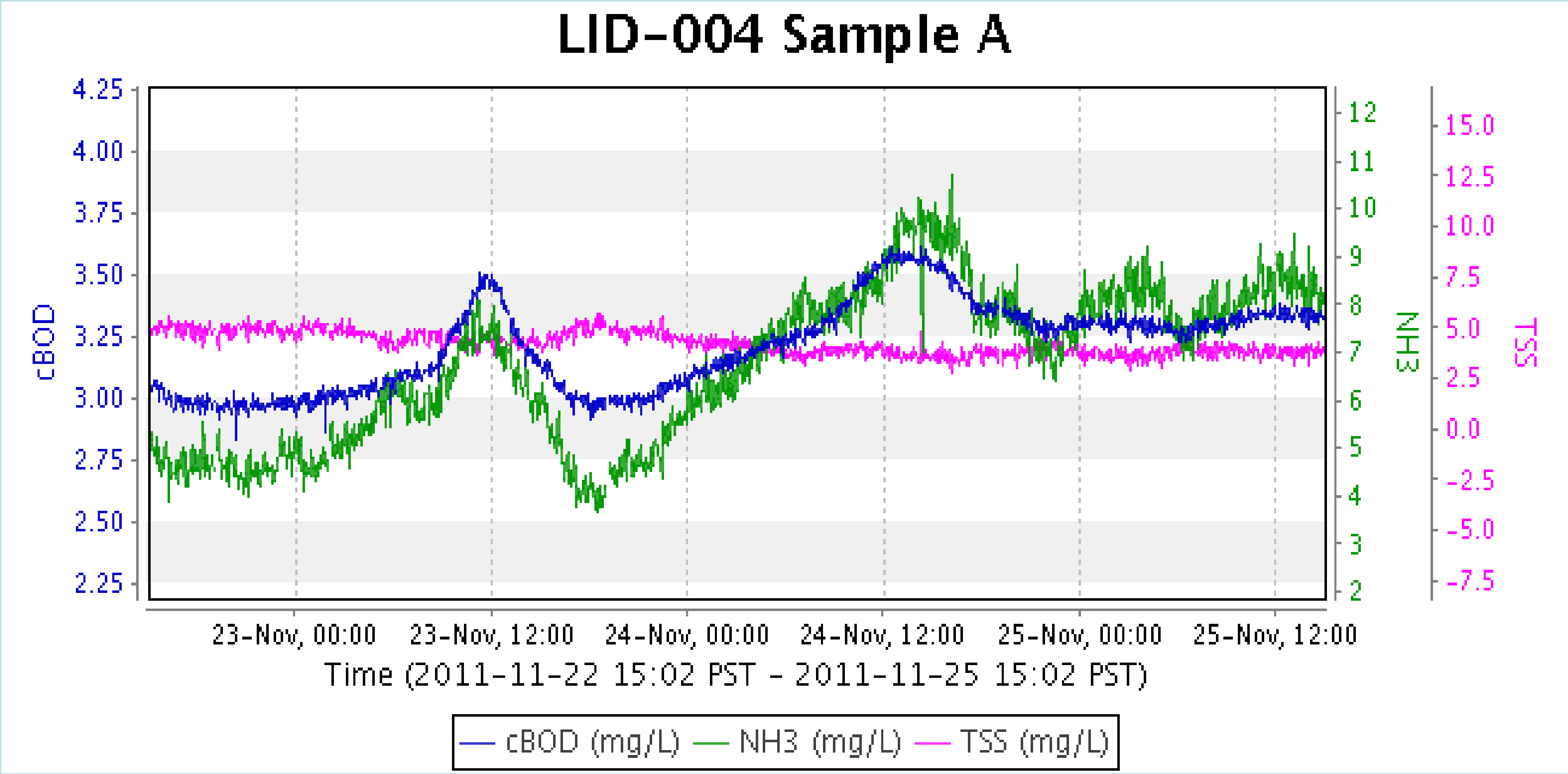


Detection values for ZAPS

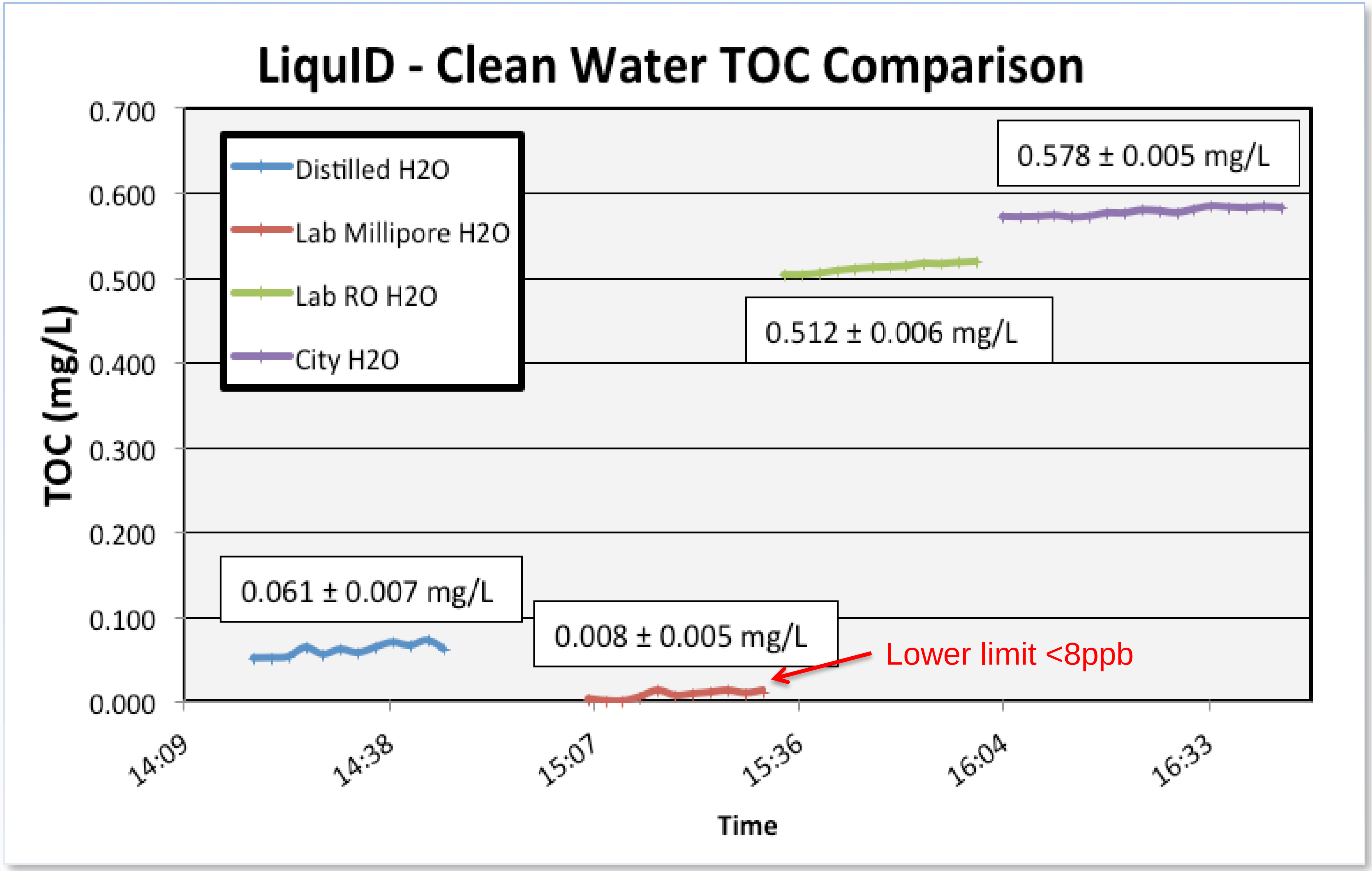
Parameter	Detection Range		
Total organic carbon	0.01	5000	mg/L
UV254 Transmission	1	100	%
Specific UV Absorbance	0.1	5.0	L/mg-C-m
Nitrite and Nitrate	0.01	8.0	mg/L
Turbidity	0.1	100	NTU
Chlorine	0.2	500	mg/L
Biochemical oxygen demand	0.01	32,000	mg/L
Carbonaceous BOD	0.01	32,000	mg/L
Chemical oxygen demand	1	32,000	mg/L
Total suspended solids	1	400	mg/L

ZAPS interface

Historical data view



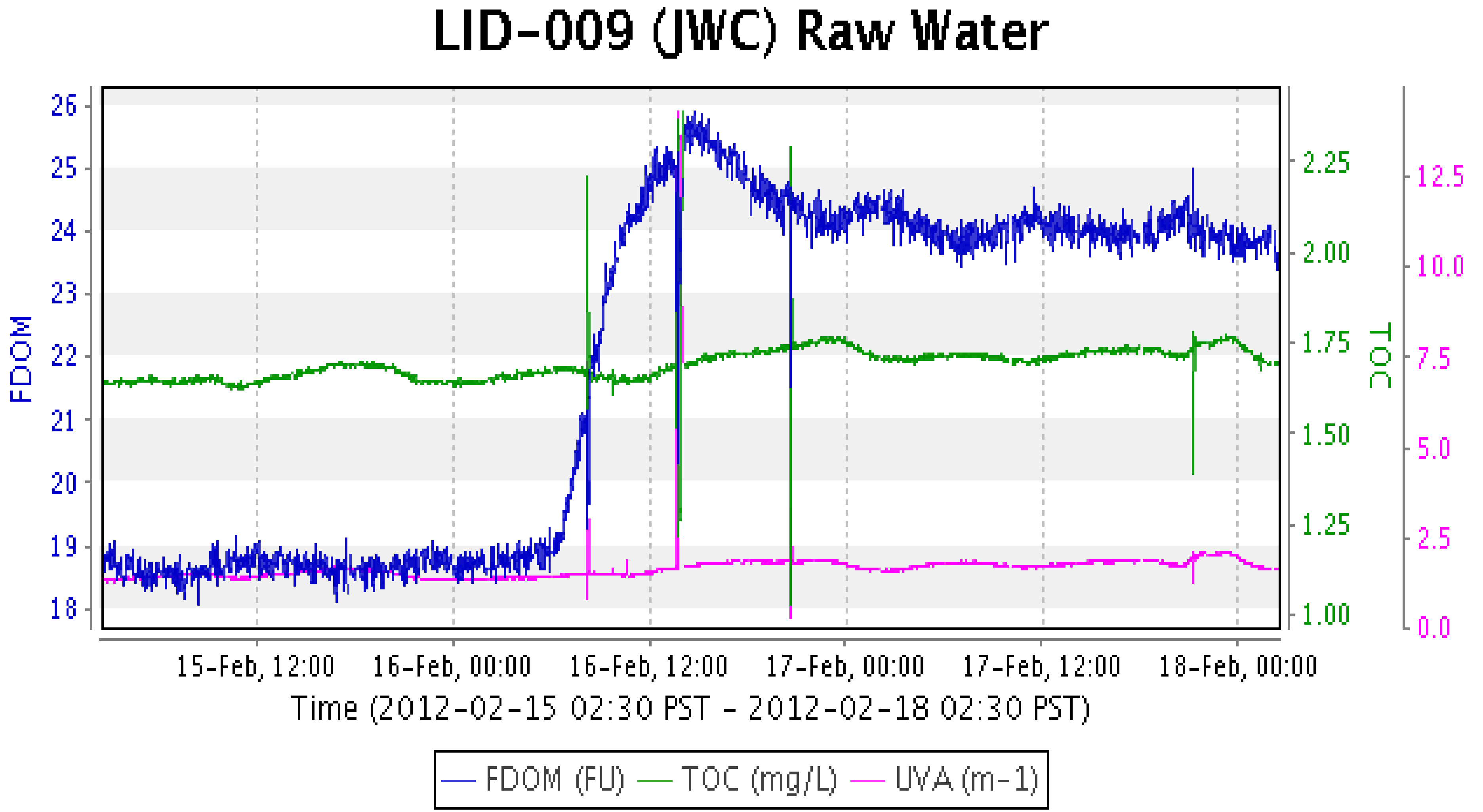
Excellent TOC resolution



ZAPS for source water monitoring

Parameter		Indicative of
Trypt	Tryptophan fluorescence	*E. coli*
FDOM	Fluorescent dissolved organic matter	Organic composition and quantity
CHLa	Chlorophyll a fluorescence	Algae
CHLb	Chlorophyll b fluorescence	Algae type
Oil	Refined hydrocarbons	Urban runoff
Size	Relative particle size	Particle characterization
TOX	Total organic halide absorption	DBP formation potential & other contaminants

Source water quality monitoring



COST & SUMMARY

Cost

- Hach GuardianBlue, s::can, and ZAPS—each $60,000
- Additional capital costs for installation
- Annual maintenance costs—each about $2,000-$3,000

Distribution system benefits

- Contaminant warning
- Identify unintentional contamination
- Manage chlorine levels
- Monitor for corrosion control parameters
- Manage TOC and DBPs

Other applications for on-line monitoring

- Source water quality monitoring
  - Algae
  - Dissolved organics
  - Contaminants
- Process control within water treatment plants
- Monitor re-use water quality
- Wastewater treatment: in-plant control, discharge quality

Questions?

Jason M Canady
Water Treatment Plant superintendent
City of Grants Pass

Part 1!

Stage II DBP Rule Overview and City of Grants Pass TTHM Formation Study

Reservoir mixing for the purpose of THM reduction

City of Grants Pass Oregon
Where the Rogue River Runs

SOUTHERN OREGON SUBSECTION

GO WITH THE FLOW
2012 PNWS • YAKIMA, WA

About Me…

- Water Treatment Plant Superintendent for the City of Grants Pass
  - 15 plus years of water treatment experience.
    - DHS-DWP Grade IV with Filtration Endorsement
  - Experience in all aspects of conventional treatment.
    - Included programming filter and backwash controls
  - Numerous projects to diagnose, troubleshoot and improve treatment plant water quality issues.

What we are going to cover…

- Cursory discussion of what causes DBP's
  - Tri-HaloMethanes (THM's)
- Overview of Stage II DBP rule
- Grants Pass Case Study
  - Historical results
  - Project design and goals
  - Initial data
    - Pre and post mixing
  - Next steps

What are DBP's…

- Disinfection and Disinfectant By-Products
  - 4 Total Trihalomethanes
    - Formed when chlorine or other disinfectant reacts with naturally occurring organic and inorganic compounds found in water.
    - MCL = 80 ppb
  - 5 Haloacetic Acids
    - MCL = 60 ppb

DDBP's (cont'd)

  - People who drink water with DBP's in excess of the MCL for extended periods of time potentially have an increased risk of contracting certain types of cancer.
- DBP's can continue to form in the distribution system
  - Exacerbated by the addition of chlorine for the purpose of residual maintenance – a practice common in large distribution systems.
  - As water age increases, so too can THM's – HHA5's may start to decrease.

SOUTHERN OREGON SUBSECTION

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Stage II DBPR Rule Overview

- The goal remains the same:
  - Improve public health by reducing the exposure to DDBP's.
- Rule is similar, but with several key changes that operators need to be aware of
  - LRAA as opposed to RAA compliance calculations
  - OEL – Operational Evaluation Level. Planning processes for exceedances before they occur.

Overview of Requirements

This table shows how the requirements for the Stage 2 DBPR build on the existing requirements established in the Stage 1 DBPR. For more information on changes in monitoring requirements, see Table 1.

		Stage 1 DBPR	Stage 2 DBPR	For More Info:
Coverage	All CWSs and NTNCWSs that add disinfectant other than UV light and TNCWSs that treat with chlorine dioxide.	✓	✓	
	Consecutive systems that deliver water treated with a disinfectant other than UV light.		✓	
TTHM & HAA5 MCL Compliance	MCL compliance is calculated using the running annual average (RAA) of all samples from all monitoring locations across the system.	✓		See Table 3 and Table 4.
	MCL compliance is calculated using the locational RAA (LRAA) for each monitoring location in the distribution system.		✓	
Regulated Contaminants & Disinfectants	*Contaminants*			See Table 2.
	Total Trihalomethanes (TTHM)	✓	✓	
	5 Haloacetic Acids (HAA5)	✓	✓	
	Bromate	✓	Regulated under Stage 1 DBPR[1]	
	Chlorite	✓	Regulated under Stage 1 DBPR	
	Disinfectants			
	Chlorine/chloramines	✓	Regulated under Stage 1 DBPR	
	Chlorine dioxide	✓	Regulated under Stage 1 DBPR	
Operational Evaluation	If an operational evaluation level (OEL) is exceeded, systems must evaluate practices and identify DBP mitigation actions.		✓	See Table 5.

1. A new analytical method for bromate was approved with the Stage 2 DBPR.

SOUTHERN OREGON SUBSECTION

Table 1. Changes in Monitoring Requirements

			Stage 1 DBPR	Stage 2 DBPR
TTHM/ HAA5 Routine Monitoring	Number of Samples		Based on source water type, population, and number of treatment plants or wells.	Based on source water type and population.
	Sample Locations		At location of maximum residence time.[1]	Based on Initial Distribution System Evaluation (IDSE) requirements.[2]
	Compliance Calculation		RAA must not exceed the MCL for TTHM or HAA5.	LRAA must not exceed the MCL for TTHM or HAA5.
Reduced Monitoring	Eligibility	TTHM/HAA5	All systems need TTHM RAA ≤ 0.040 mg/L and HAA5 ≤ 0.030 mg/L. Subpart H systems also need source water TOC RAA at location prior to treatment ≤ 4.0 mg/L .[3, 4] The Stage 2 DBPR left eligibility unchanged but specifies that Subpart H systems must take source water TOC samples every 30 days. Subpart H systems on reduced monitoring must take source water TOC samples every 90 days to qualify for reduced monitoring.	
		Bromate[5]	Source water bromide RAA < 0.05 mg/L. With the Stage 2 DBPR specified entry point to distribution system bromate RAA ≤ 0.0025 mg/L.	

[1]Subpart H systems serving ≥ 10,000 must have at least 25 percent of samples at the location of maximum residence time; the remaining samples must be representative of average residence time.

[2]All systems are required to satisfy their IDSE requirement by July 10, 2010.

[3]Subpart H systems are water systems that use surface water or ground water under the direct influence of surface water (GWUDI).

[4]Ground water systems serving < 10,000 must meet these RAA for 2 years; can also qualify for reduced monitoring if the TTHM RAA is ≤ 0.020 mg/L and a HAA5 RAA ≤ 0.015 mg/L for 1 year.

[5]A new analytical method for bromate was established with the Stage 2 DBPR.

Table 2. Regulated Contaminants and Disinfectants

	Stage 1 DBPR		Stage 2 DBPR	
Regulated Contaminants	MCL (mg/L)	MCLG (mg/L)	MCL (mg/L)	MCLG (mg/L)
TTHM	0.080		Unchanged[2]	
Chloroform		-		0.07
Bromodichloromethane		Zero		Unchanged[2]
Dibromochloromethane		0.06		Unchanged[2]
Bromoform		Zero		Unchanged[2]
HAA5	0.060		Unchanged[2]	
Monochloroacetic acid		-		0.07
Dichloroacetic acid		Zero		Unchanged[2]
Trichloroacetic acid		0.3		0.2
Bromoacetic acid		-		-
Dibromoacetic acid		-		-
Bromate (plants that use ozone)[1]	0.010	Zero	Unchanged[2]	Unchanged[2]
Chlorite (plants that use chlorine dioxide)	1.0	0.8	Unchanged[2]	Unchanged[2]
Regulated Disinfectants	MRDL[3] (mg/L)	MRDLG[3] (mg/L)	MRDL (mg/L)	MRDLG (mg/L)
Chlorine	4.0 as Cl_2	4	Unchanged[2]	Unchanged[2]
Chloramines	4.0 as Cl_2	4	Unchanged[2]	Unchanged[2]
Chlorine dioxide	0.8	0.8	Unchanged[2]	Unchanged[2]

[1]A new analytical method for bromate was established with the Stage 2 DBPR.

[2]Stage 2 DBPR did not revise the MCL or MRDL for this contaminant/disinfectant.

[3]Stage 1 DBPR included MRDLs and MRDLGs for disinfectants, which are similar to MCLs and MCLGs.

Table 3. Compliance Determination

	Stage 1 DBPR	Stage 2 DBPR
TTHM/HAA5	RAA	LRAA
Bromate[1]	RAA	Unchanged[2]
Chlorite	Daily/follow-up monitoring	Unchanged[2]
Chorine dioxide	Daily/follow-up monitoring	Unchanged[2]
Chlorine/chloramines	RAA	Unchanged[2]
DBP precursors (TOC sample set)*	Monthly for TOC and alkalinity	Every 30 days for TOC and alkalinity

[1]A new analytical method for bromate was established with the Stage 2 DBPR.

[2]Stage 2 DBPR did not change the compliance requirements for this contaminant/disinfectant.

*TOC sample set is comprised of source water alkalinity, source water TOC, and treated TOC.

Table 4. Compliance with MCLs and MRDLs (Routine Monitoring)

Contaminant/ Disinfectant	Coverage		Stage 1 DBPR		Stage 2 DBPR	
	Source Water	Population	Monitoring Frequency	Total Distribution System Monitoring Locations	Monitoring Frequency[1]	Total Distribution System Monitoring Locations
TTHM/HAA5	Subpart H	< 500	Per year[2]	1 per treatment plant	Per year[2]	2
		500 - 3,300	Per quarter	1 per treatment plant	Per quarter	2
		3,301 - 9,999				
		10,000 - 49,000		4 per treatment plant		4
		50,000 - 249,999				8
		250,000 - 999,999				12
		1,000,000 - 4,999,999				16
		≥ 5,000,000				20
	Ground water	< 500	Per year[2]	1 per treatment plant	Per year[2]	2
		500 - 9,999				
		10,000 - 99,999	Per quarter		Per quarter	4
		100,000 - 499,999				6
		≥ 500,000				8
Bromate[3]	Systems that use ozone as a disinfectant		Monthly	1 at entry point to distribution system	Unchanged[4]	
Chlorite	Systems that use chlorine dioxide as a disinfectant		**Daily** (at entrance to distribution system); **monthly** (in distribution system)	1 at entry point to distribution system; 3 in distribution system	Unchanged[4]	
Chlorine dixoide	Systems that use chlorine dioxide as a disinfectant		Daily	1 at entry point to distribution system	Unchanged[4]	
Chorine/ Chloramines	All systems		Same location and frequency as Total Coliform Rule (TCR) sampling		Unchanged[4]	
DBP precursors (TOC sample set)*	Systems that use conventional filtration		Monthly	1 per source water source	Unchanged[4]	

[1]All systems must monitor during the month of highest DBP concentrations. Systems on quarterly monitoring, except Subpart H systems serving 500 - 3,300, must take dual sample sets every 90 days at each monitoring location. Systems on annual monitoring and Subpart H systems serving 500 - 3,300 are required to take individual TTHM and HAA5 samples (instead of a dual sample set) at the locations with the highest TTHM and HAA5 concentrations, respectively. If monitoring annually, only one location with a dual sample set per monitoring period is needed if the highest TTHM and HAA5 concentrations occur at the same location and in the same month.

[2]Ground water systems serving < 10,000 and Subpart H systems serving < 500 must increase monitoring to quarterly if an MCL is exceeded.

[3]A new analytical method for bromate was established with the Stage 2 DBPR.

[4]Stage 2 DBPR did not revise the monitoring frequency or location requirements for this contaminant/disinfectant.

*TOC sample set is comprised of source water alkalinity, source water TOC, and treated TOC.

Table 5. Operational Evaluation Levels (OELs)

Applies to:	All systems subject to Stage 2 DBPR monitoring requirements that conduct compliance monitoring and collect samples quarterly.
Purpose of establishing OELs:	To reduce peaks in DBP levels and exposure to high DBP levels.
OEL calculations:	▶ Calculated for both TTHMs and HAA5s at each monitoring location using Stage 2 DBPR compliance monitoring results. ▶ OEL is determined by the sum of the two previous quarter's TTHM or HAA5 result plus twice the current quarter's TTHM or HAA5 result at that location, divided by four. ▶ OEL = (Q1 + Q2 + 2Q3) / 4
OELs are exceeded:	During any quarter in which the OEL is greater than the TTHM or HAA5 MCL.
If an OEL is exceeded, a system must:	▶ Conduct an operational evaluation. ▶ Submit a written report of the evaluation to the state no later than 90 days after being notified of the analytical results that caused the exceedance(s). ▶ Keep a copy of the operational evaluation report and make it publically available upon request.
The operational evaluation must include:	▶ An examination of the treatment and distribution systems' operational practices that may contribute to TTHM and HAA5 formation. ▶ Steps to minimize future exceedances.
OEL requirements take effect:	When the system begins compliance monitoring for the Stage 2 DBPR.

Table 6. Standard Monitoring Compliance Dates

If You are a System Serving:	Schedule[1]	Begin LRAA TTHM & HAA5 Monitoring By:
At least 100,000 people or part of a combined distribution system (CDS) serving at least 100,000 people.	1	April 1, 2012
50,000 to 99,999 people or part of a CDS serving 50,000 to 99,999 people.	2	October 1, 2012
10,000 to 49,999 people or part of a CDS serving 10,000 to 49,999 people.	3	October 1, 2013
Less than 10,000 people or part of a CDS serving less than 10,000 people.	4	October 1, 2013[2]

[1]Your schedule is determined by the largest system in your CDS.

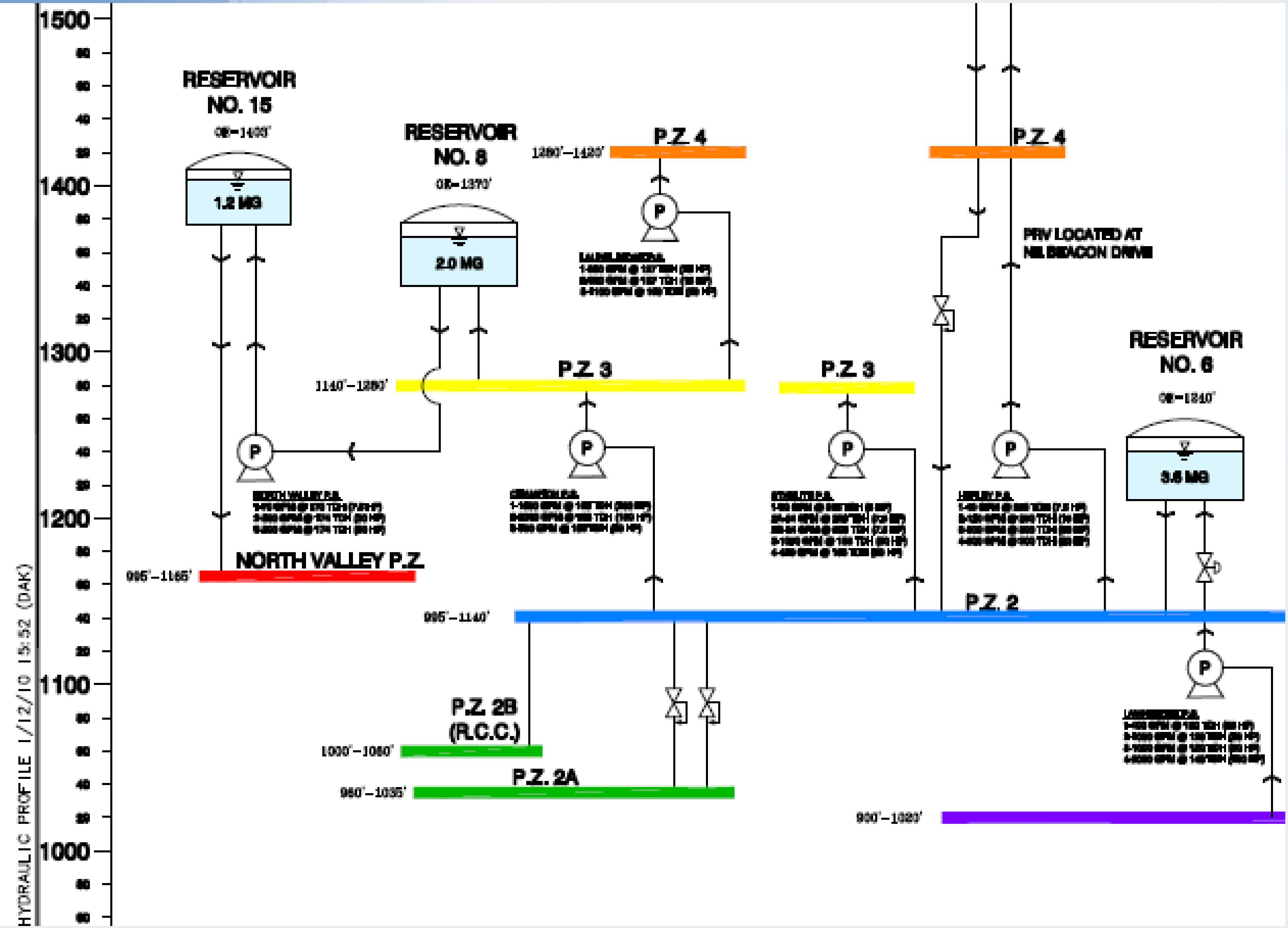
[2]Systems not conducting *Cryptosporidium* monitoring under Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) must begin LRAA TTHM/HAA5 monitoring by this date. Systems conducting *Cryptosporidium* monitoring under LT2ESWTR must begin LRAA TTHM/HAA5 monitoring by October 1, 2014.

Technologies available for Removing THM's

- Don't form them!
  - Silly, but the easiest way to eliminate THM's is to not form them in the treatment process.
    - Eliminate or reduce pre-chlorination
    - Alternative coagulants – cloramines, chlorine dioxide, ozone
- Distribution system management
  - Keep water age low
  - Reduce or eliminate re-chlorination
- Air Stripping
  - Volatize THM compounds

Technologies available for Removing THM's (cont'd)

- Micro, Ultra or Nanofiltration
  - Physically remove TOC/DOC prior to addition of disinfection
- GAC 10
  - Adsorptive media to remove TOC
- Enhanced coagulation


HYDRAULIC PROFILE 1/12/10 15:52 (OAK)
1500
1400
1300
1200
1100
1000
RESERVOIR NO. 15
1.2 MG
RESERVOIR NO. 8
2.0 MG
P.Z. 4
1280'–1420'
P.Z. 4
PRV LOCATED AT NE BEACON DRIVE
P.Z. 3
1140'–1280'
P.Z. 3
RESERVOIR NO. 6
3.6 MG
P
NORTH VALLEY P.Z.
995'–1165'
P.Z. 2
995'–1140'
P.Z. 2B (R.C.C.)
1000'–1060'
P.Z. 2A
980'–1035'
900'–1020'

City of Grants Pass' Strategy

- Implement distribution system BMP's
  - Pumping coordination
  - Flushing
  - Bleeder Stations
- Moving or eliminating the point of pre-chlorination
- Investigate the use of enhanced coagulation to remove TOC/DOC prior to the addition of Cl_2
- Investigate the conversion to chloramines
  - Not likely to occur.

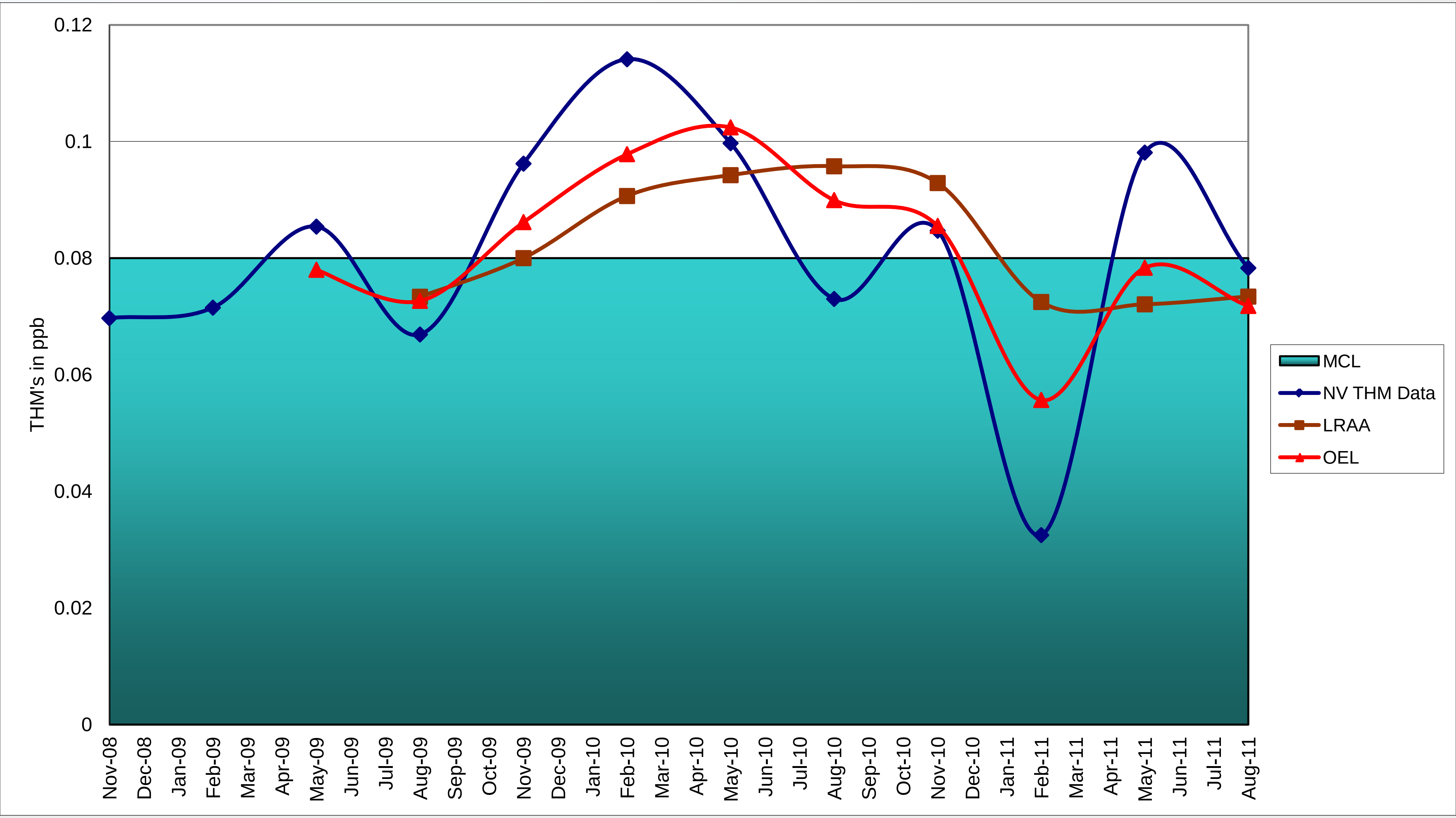
City of Grants Pass' Strategy (cont'd)

- Many of the strategies have been implemented, some have not…
- Grants Pass still struggles with THM's at far end of the distribution system

Review of Grants Pass THM Data

Sample ID	Result in ppb	Sample Date	LRAA	OEL
8112107-03	0.0697	11/20/2008		
9022519-04	0.0715	2/24/2009		
9051412-06	*0.0854*	5/13/2009		0.0780
9081215-05	0.0669	8/11/2009	0.0734	0.0727
9111016-06	*0.0962*	11/9/2009	0.0800	*0.0862*
0021712-06	*0.1141*	2/26/2010	*0.0906*	*0.0978*
0051917-05	*0.0997*	5/18/2010	*0.0942*	*0.1024*
0081221-05	0.0730	8/11/2010	*0.0957*	*0.0900*
0111022-04	*0.0847*	11/9/2010	*0.0929*	*0.0855*
1020917-05	0.0325	2/8/2011	0.0725	0.0557
1051112-03	*0.0981*	5/10/2011	0.0721	0.0783
1081102-05	0.0783	8/10/2011	0.0734	0.0718

Merlin North Valley THM's



Study Goals

- Where are DBP's being formed in the City's distribution system (particularly THM's)?
- Are reservoirs stratified? Allowing water age to increase at some levels with-in the tank.
  - Temperature
  - Chlorine residual
- Will low cost reservoir mixing reduce THM's to a level that will ensure compliance with Stage II DBPR?

Study Design

- Data Collection Needs
  - Reservoir temperature data from various levels within the tank
  - Chlorine residual data from various levels within the tank
  - THM levels entering and leaving the tank (combined with temperatures and chlorine residuals)

Study Design (cont'd)

- Data Collection Challenges
  - How to monitor temperatures and chlorine residuals with risking contamination of the tank
  - THM testing is $$$
- Data Collection Solutions
  - OneSet TidBit Data loggers
    - Submersible, can collect data for months.
  - THM-Plus from Hach.
    - Reduces test cost to roughly $?
  - Chlorine Residual
    - Did not adequately resolve…

UTBI-001

Temperature (1,000 ft.) TidBit v2

Temperature Sensor
Operation range:*
-20° to 70°C (-4° to 158°F) in air;
maximum sustained temperature of 30°C (86°F) in water*

Accuracy: 0.2°C over 0° to 50°C (0.36°F over 32° to 122°F)

Resolution: 0.02°C at 25°C (0.04°F at 77°F)

Response time: 5 minutes in water; 12 minutes in air moving 2 m/sec; 20 minutes in air moving 1 m/sec (typical to 90%)

Stability (drift): 0.1°C (0.18°F) per year

Logger
Real-time clock: ± 1 minute per month 0° to 50°C (32° to 122°F)

Battery: 3 Volt lithium, non-replaceable

Battery life (typical use): 5 years with 1 minute or greater logging interval

Memory (non-volatile): 64K bytes memory (approx. 42,000 12-bit temperature measurements)

Trihalomethanes

DOC316.53.01143

THM Plus™ Method | **Method 10132**

(10 to 600 ppb as Chloroform) | **Water Bath Method**

Scope and Application: For screening THMs in drinking water samples and Formation Potential tests.

Test preparation

Table 3 Additional disinfection by-products (DBPs) that are included in results

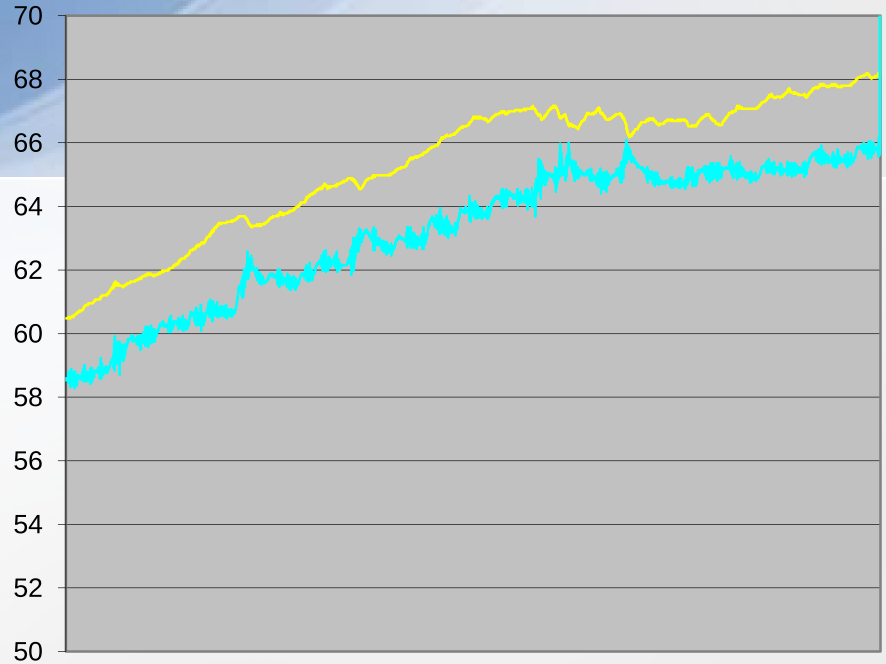
Compound	Effect
1,1,1-trichloro-2-propanone	Interferes positively
1,1,1-tricholoacetonitrile	Interferes positively
Chloral hydrate	Interferes positively
Dibromochloroacetic acid	Interferes positively
Dichlorobromoacetic acid	Interferes positively
Tribromoacetic acid	Interferes positively
Trichloroacetic acid	Interferes positively

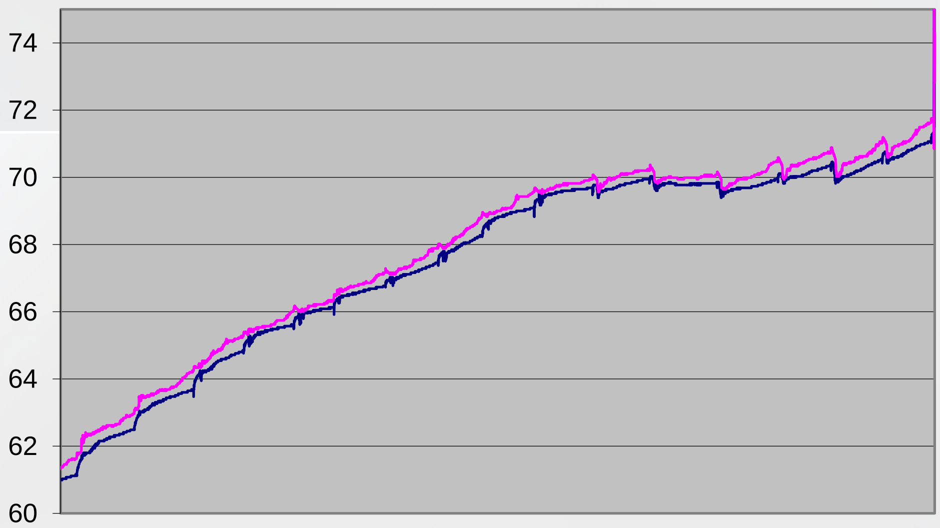
- All other DDBP's interfere positively on the test!

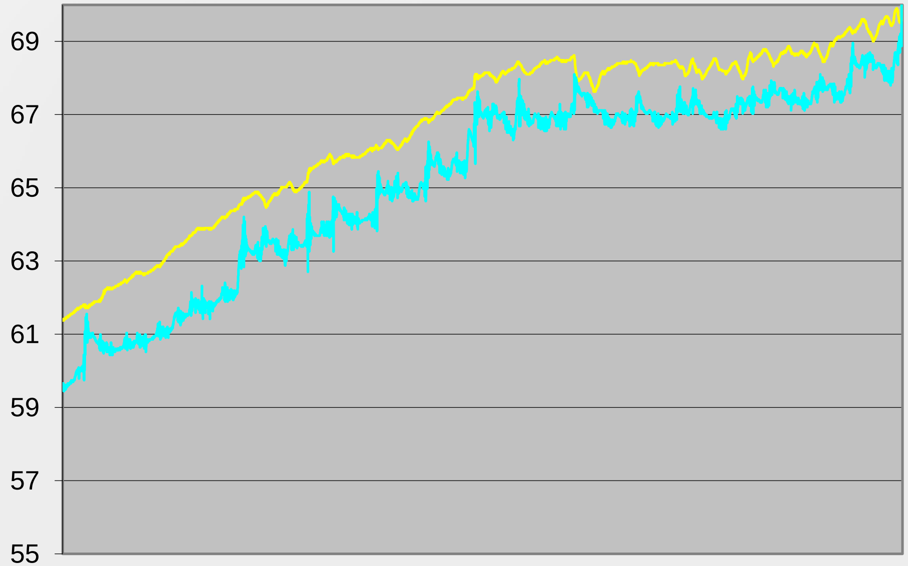
- Had issues getting reliable chlorine residual data with the peristaltic pump…
  - Suction tubing too small?
  - Air injection at some point in sample line?
  - Volatizing the cl2 because of friction?

Collecting the data

- Proved to be more difficult that first anticipated…
  - Very limited staffing spread across three shifts
- Important factors in THM-Plus Sample Collection
  - Sample must be from the very end of the fill cycle to get accurate picture of the THM's entering the tank
  - Sample must be collected from the very end of the drain cycle to accurately measure the amount of THM increase while the water was sitting in the tank
  - Getting there on time was tough!

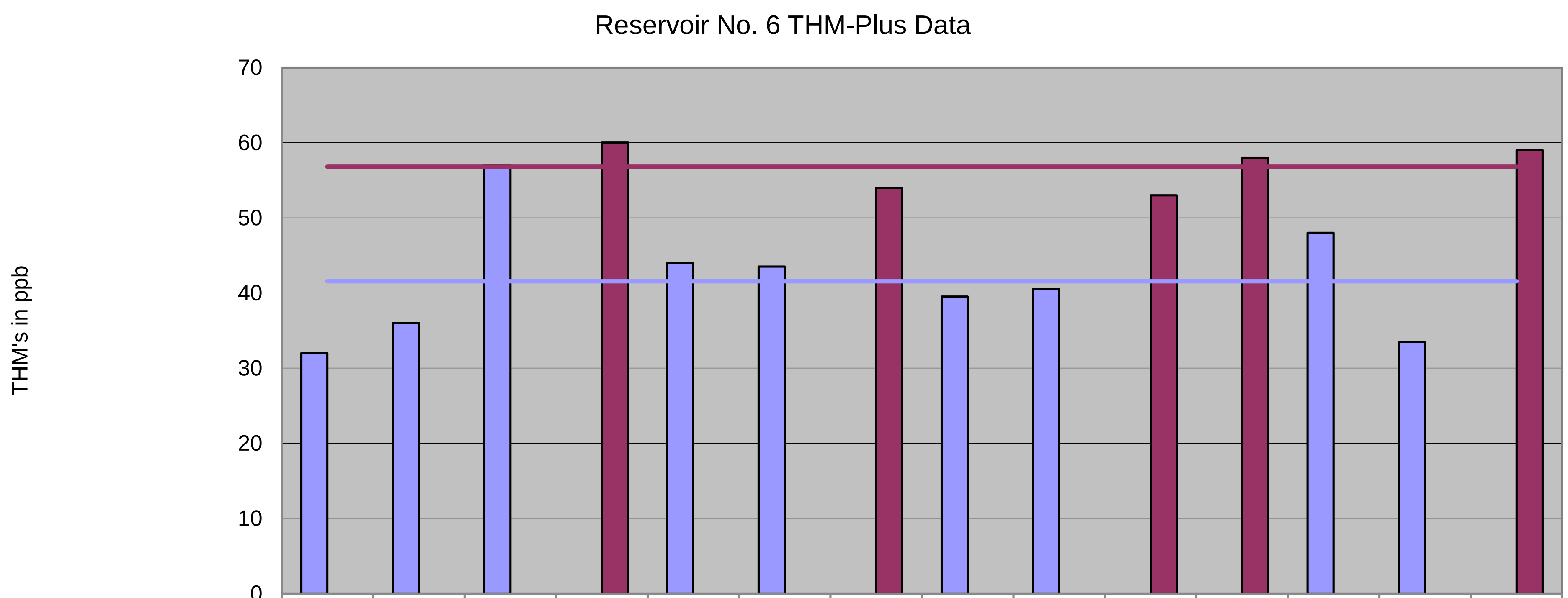






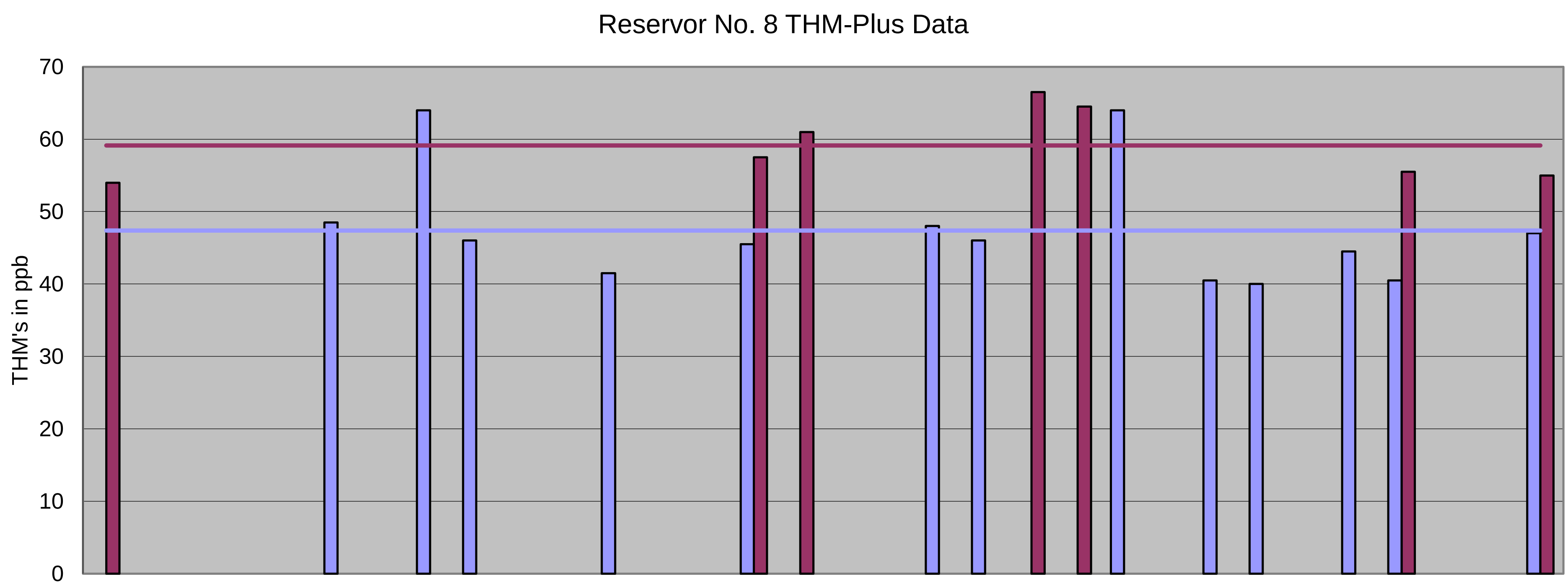
- Temperature data showed only limited stratification except in the upper 1 – 2 feet where temperatures were close to air temps.

So What Did The Data Show? (cont'd)



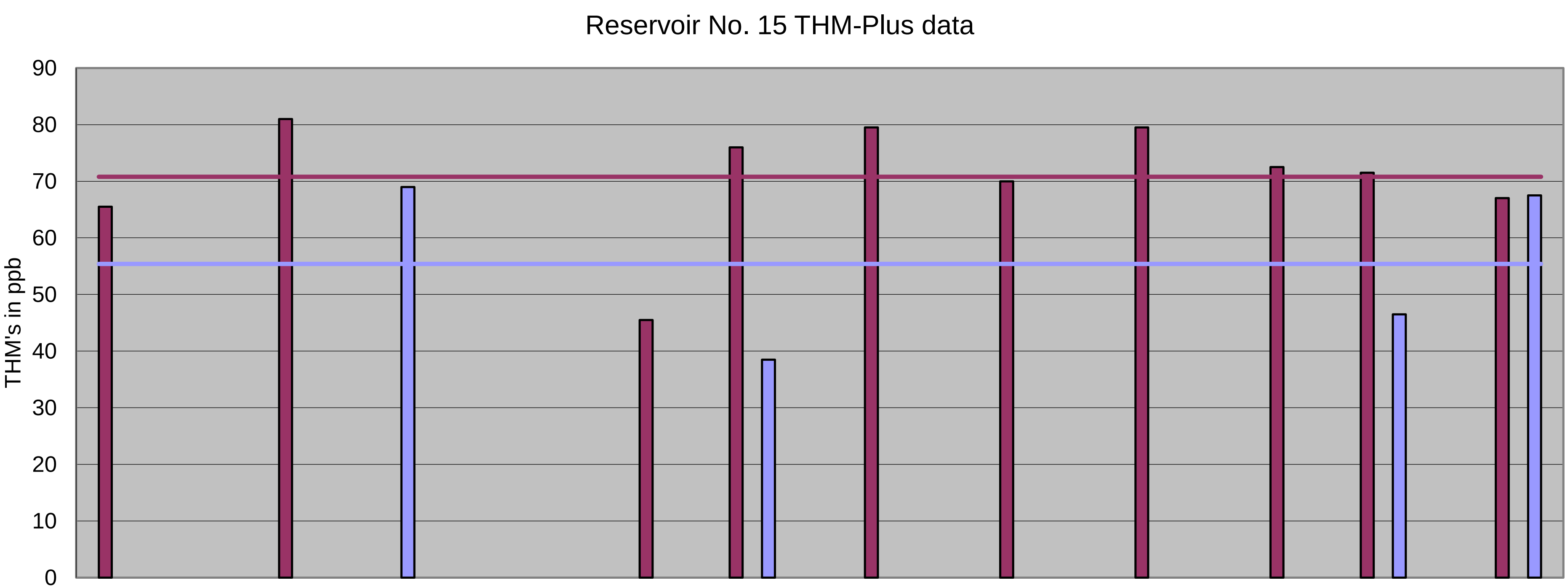
	8/10/2011	8/20/2011	8/23/2011	8/24/2011	8/27/2011	8/29/2011	9/1/2011	9/1/2011	9/6/2011	9/7/2011	9/9/2011	9/101/11	9/10/2011	9/11/2011
Fill Cycle THM's	32	36	57	0	44	43.5	0	39.5	40.5	0	0	48	33.5	0
Drain Cycle THM's	0	0	0	60	0	0	54	0	0	53	58	0	0	59
Drain Cycle Average	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8	56.8
Fill Cycle Average	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6

So What Did The Data Show? (cont'd)



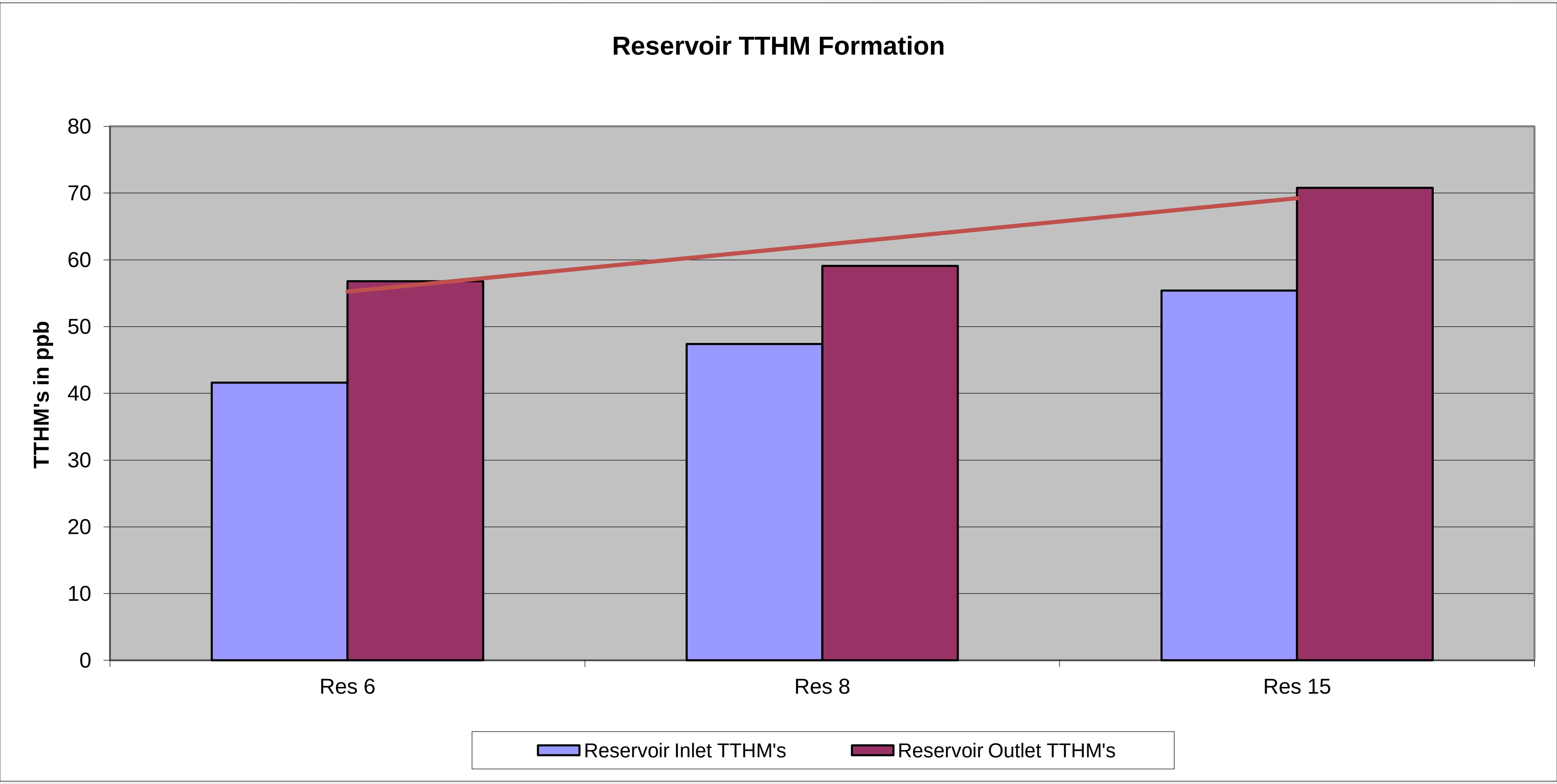
	8/10/2011	8/15/2011	8/17/2011	8/18/2011	8/21/2011	8/24/2011	8/24/2011	8/25/2011	8/28/2011	8/29/2011	8/30/2011	8/31/2011	9/1/2011	9/3/2011	9/4/2011	9/6/2011	9/7/2011	9/7/2011	9/10/2011	9/10/2011
Fill Cycle THM's	0	48.5	64	46	41.5	0	45.5	0	48	46	0	0	64	40.5	40	44.5	0	40.5	0	47
Drain Cycle THM's	54	0	0	0	0	57.5	0	61	0	0	66.5	64.5	0	0	0	0	55.5	0	55	0
Drain Cycle Average	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1	59.1
Fill Cycle Average	47.4	47.4	47.4	47.4	47.4	47.4	47.4	47.4	47.4	47.4	47.4	47.4	47.4	47.4	47.4	47.4	47.4	47.4	47.4	47.4

So What Did The Data Show? (cont'd)



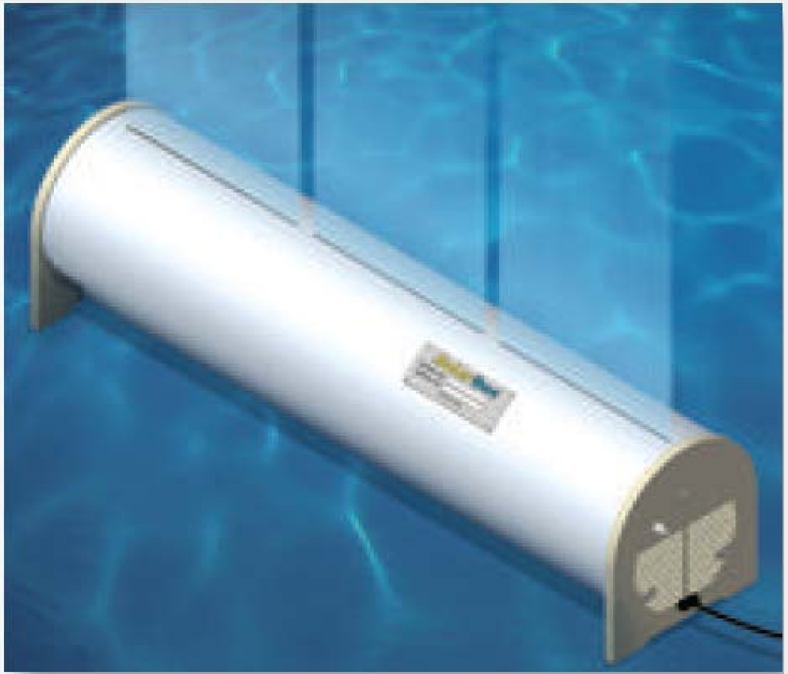
	8/10/2011	8/14/2011	8/17/2011	8/22/2011	8/24/2011	8/25/2011	8/27/2011	8/30/2011	9/2/2011	9/5/2011	9/7/2011	9/8/2011	9/10/2011	9/11/2011
Fill Cycle THM's	0	0	69	0	0	38.5	0	0	0	0	0	46.5	0	67.5
Drain Cycle THM's	65.5	81	0	45.5	76	0	79.5	70	79.5	72.5	71.5	0	67	0
Fill Cycle Average	55.4	55.4	55.4	55.4	55.4	55.4	55.4	55.4	55.4	55.4	55.4	55.4	55.4	55.4
Drain Cycle Average	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8

So… What does that mean?

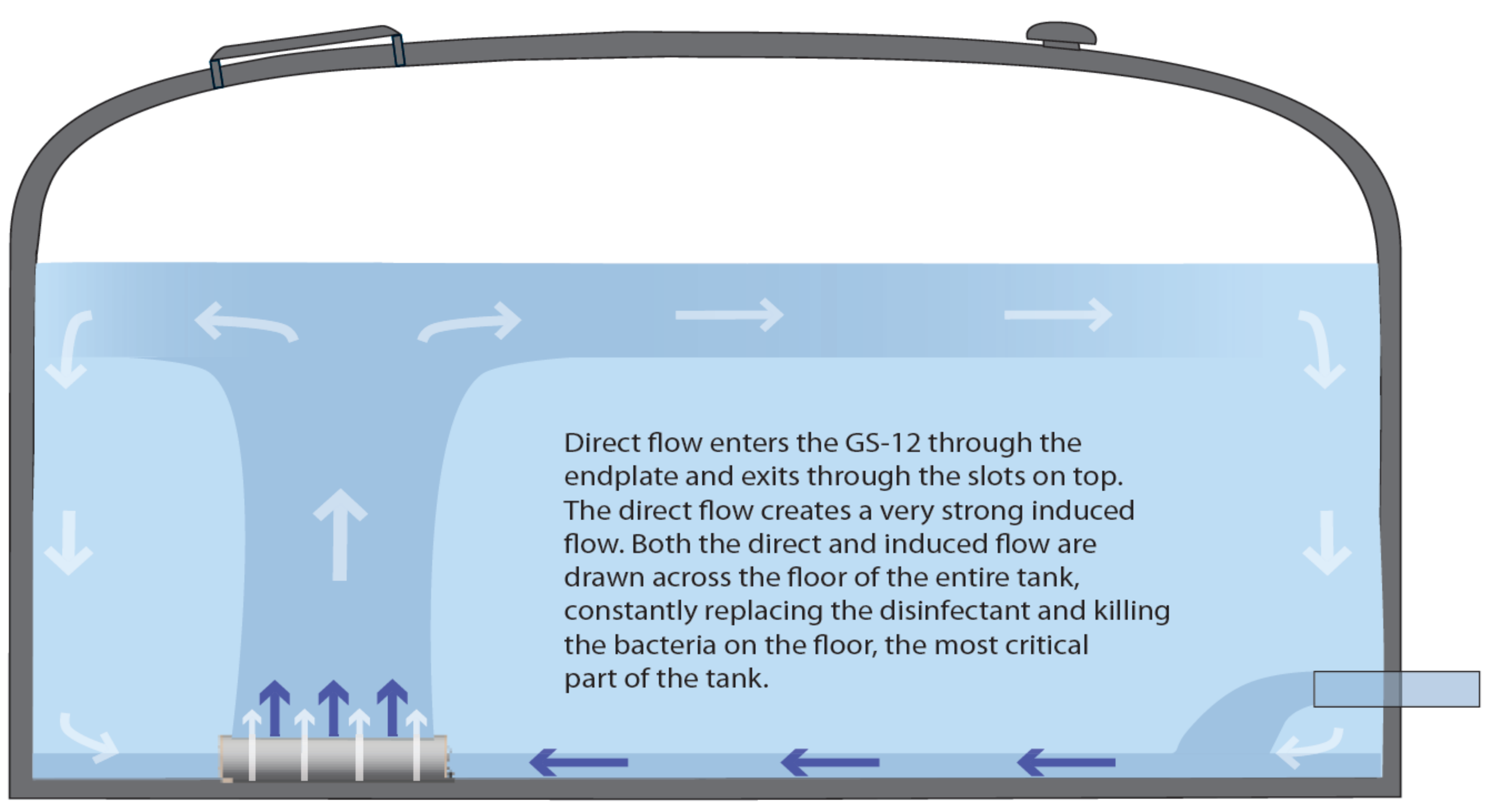


Next Steps

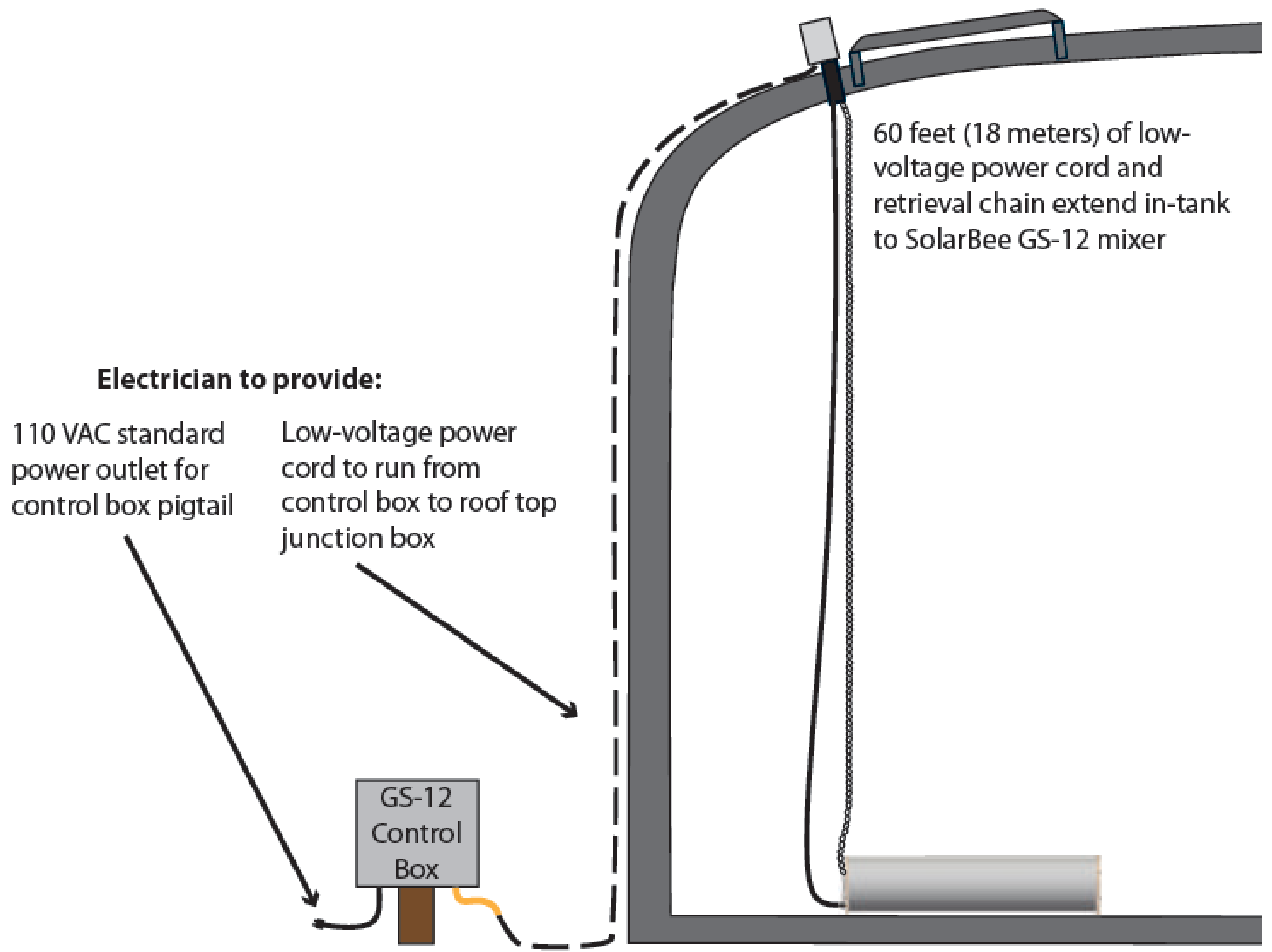
- Install Reservoir Mixers
  - SolarBee GS-12 submersible mixers
    - Low cost
    - Newer technology – unproven track record
    - Owner installation without the use of divers.



GS-12 Flow Overview



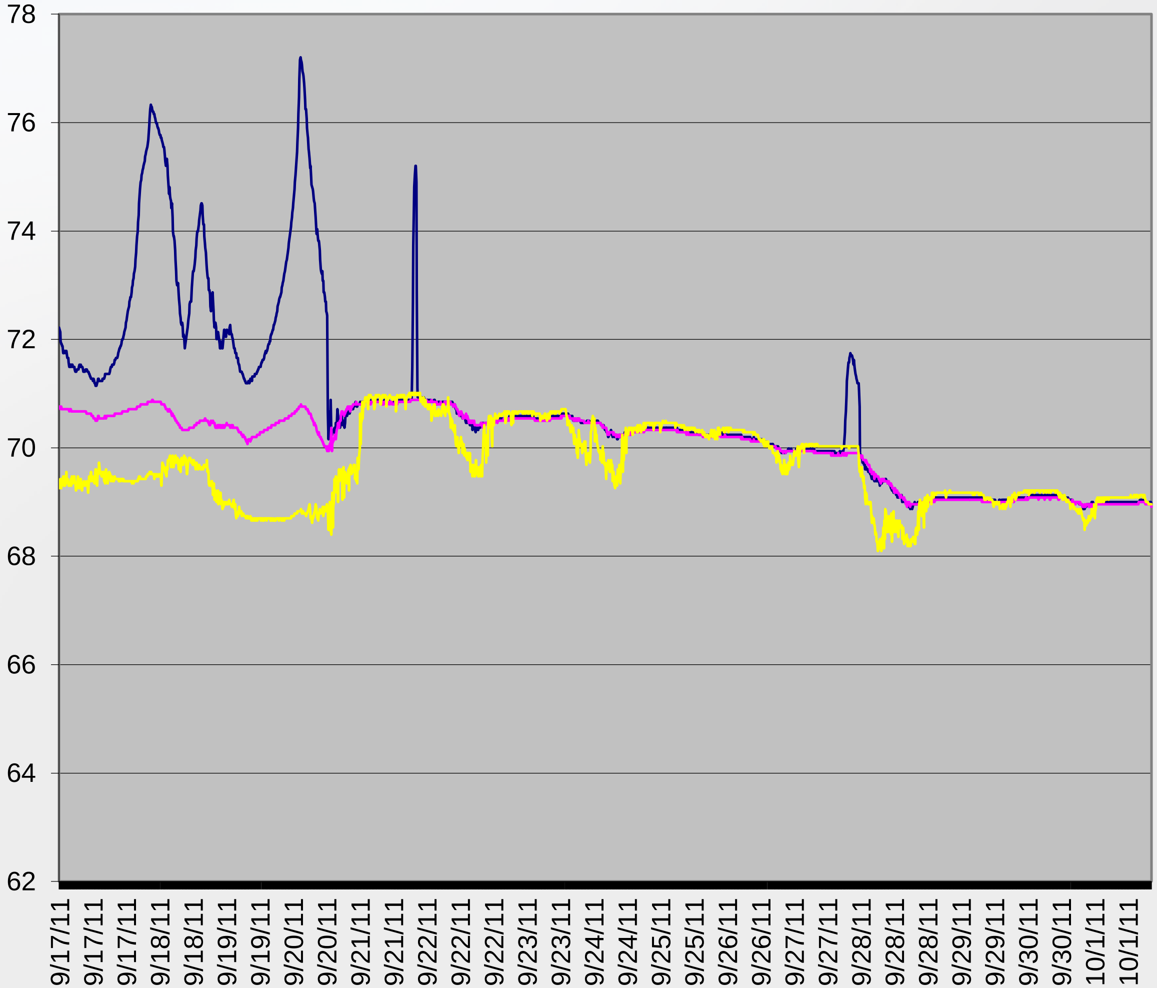
Installation Overview



Next Steps Cont'd

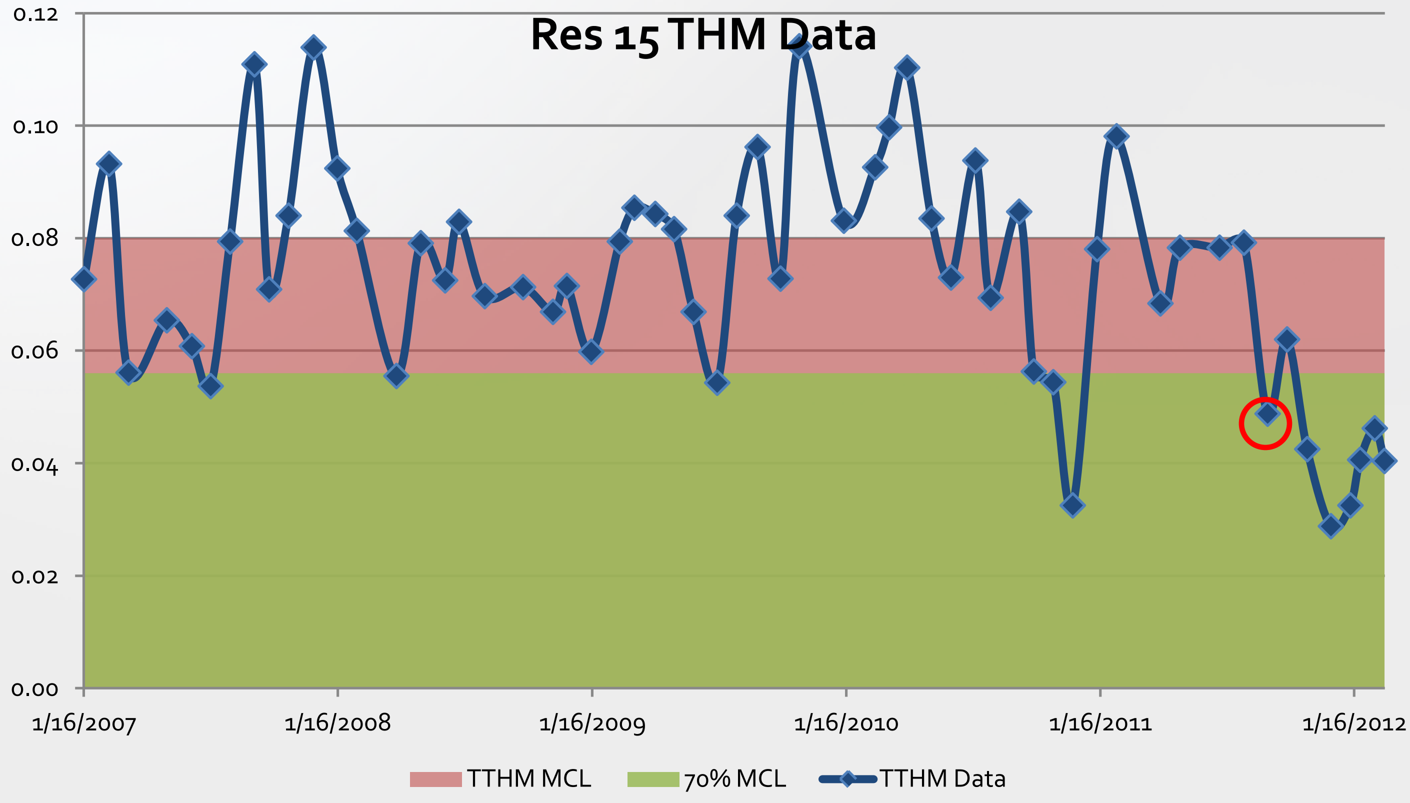
- Mixers started on 9/20/11
- Begin data collection post mixing
  - Similar data collections needs to pre-mixing
- See if post mixing data shows reductions in THM's, re-chlorination needs, temperature stratification.
- If reductions are realized – purchase mixers for permanent installation.

So What did the Data Show?



- After mixing temperatures showed even distribution of temps.
- Fill cycles chilled the bottom – but quickly equalized

Next Steps (cont'd)



Next Steps (cont'd)

- If study goals are not realized:
  - Look at adding aeration in addition to mixing
  - Look at eliminating pre-chlorination
  - More coordination of pumping when filling reservoirs
  - Reducing reservoir levels
    - Risk!

Questions?

Dead End Nitrification Mystery

Eloise Eccles/Water Quality Engineer
Portland Water Bureau
April 2012

PORTLAND WATER BUREAU
FROM FOREST TO FAUCET

Portland Water Source

- Bull Run management area provides an unfiltered surface water source
- Groundwater is used infrequently as supplemental supply (3-4% of total water provided)

Portland's Water Treatment

- Free chlorine is added at headworks to meet SWTR disinfection requirements for giardia and viruses.
- At entry point to distribution
  - NH_3 is added to form chloramine
  - NaOH is added to raise pH for LCR corrosion control requirements

Portland's Water Quality

at entry Point to Distribution System

pH	*7.8 – 8.2*
Chloramine residual	*1.8 - 1.9 mg/L*
Temperature	*4 - 16° C*

Nitrification Issues in Portland's Distribution System

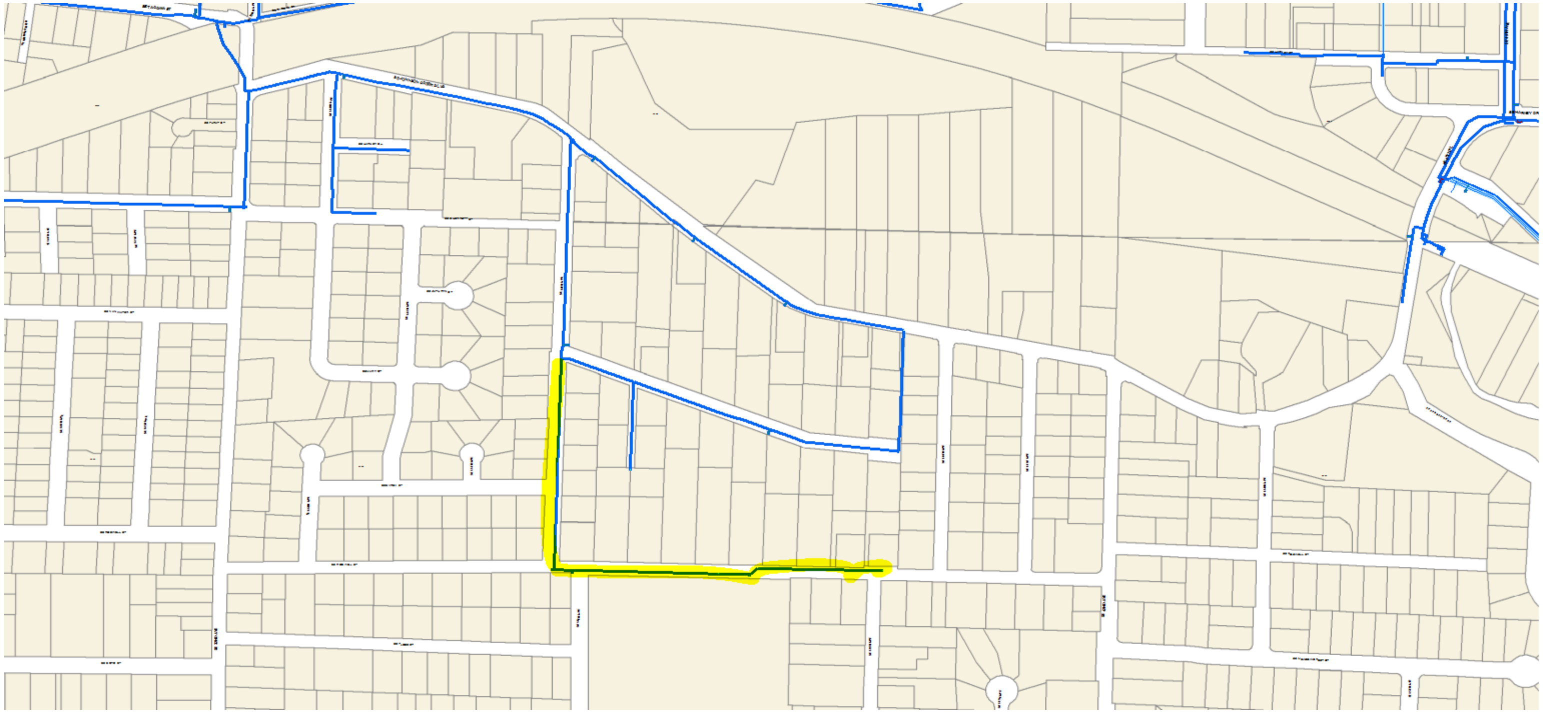
- Some nitrification activity occurs in late summer; the cool season is generally not a problem.
- The nitrification activity is relatively mild in that there is a depressed chlorine residual but not a total loss of chlorine residual.
- The problem areas <u>that we know of</u> are typically associated with tanks in areas of high water age.

Except…..in the Roswell Area

While conducting the DBP Rule Initial Distribution System Evaluation, an area of very active nitrification was uncovered.

- **The water route does not include any enclosed tanks.**
- **Nitrification activity is problematic year round.**
- **Nitrification is severe with chlorine residuals undetectable or at best, very low.**

Roswell is a Dead End



…at the Periphery of the Distribution System

There.

Roswell customer feedback has not been negative.

The Roswell dead end serves 17 homes.

The area is not a historic or current source of customer complaints.

Roswell is added to the TCR Route as a non-regulatory sample

Routine monitoring begins at Roswell in June 2010.

- Total chlorine residual
- Temperature
- Presence of total coliform/E.coli
- *pH added in December 2011*

Water Quality is Poor

- Chlorine residuals are at or below the detection limit.
- Water temperature is higher than that measured at other TCR sites.
- pH is depressed → ~ 7.5 (average of ~ 7.7 system wide)

This is consistent with nitrification

(Bacteriological monitoring over the past 2 years has yielded one total coliform detection from 39 samples. It was not confirmed in a repeat sample).

Quick Nitrification Lesson

- Predisposing Conditions
  - High water age
  - High water temperature

Chloramine decay → free ammonia

Result is depressed chloramine residual and elevated free ammonia concentration.

Quick Nitrification Lesson cont'd

Early stage Nitrification –

Ammonia oxidizing Bacteria become established

$$AOB + NH_3 \rightarrow NO_2$$

- Depressed chlorine residual
- Decreased free ammonia levels
- Increased nitrite concentration

Quick Nitrification Lesson cont'd

Full Nitrification -

Nitrite oxidizing bacteria become established

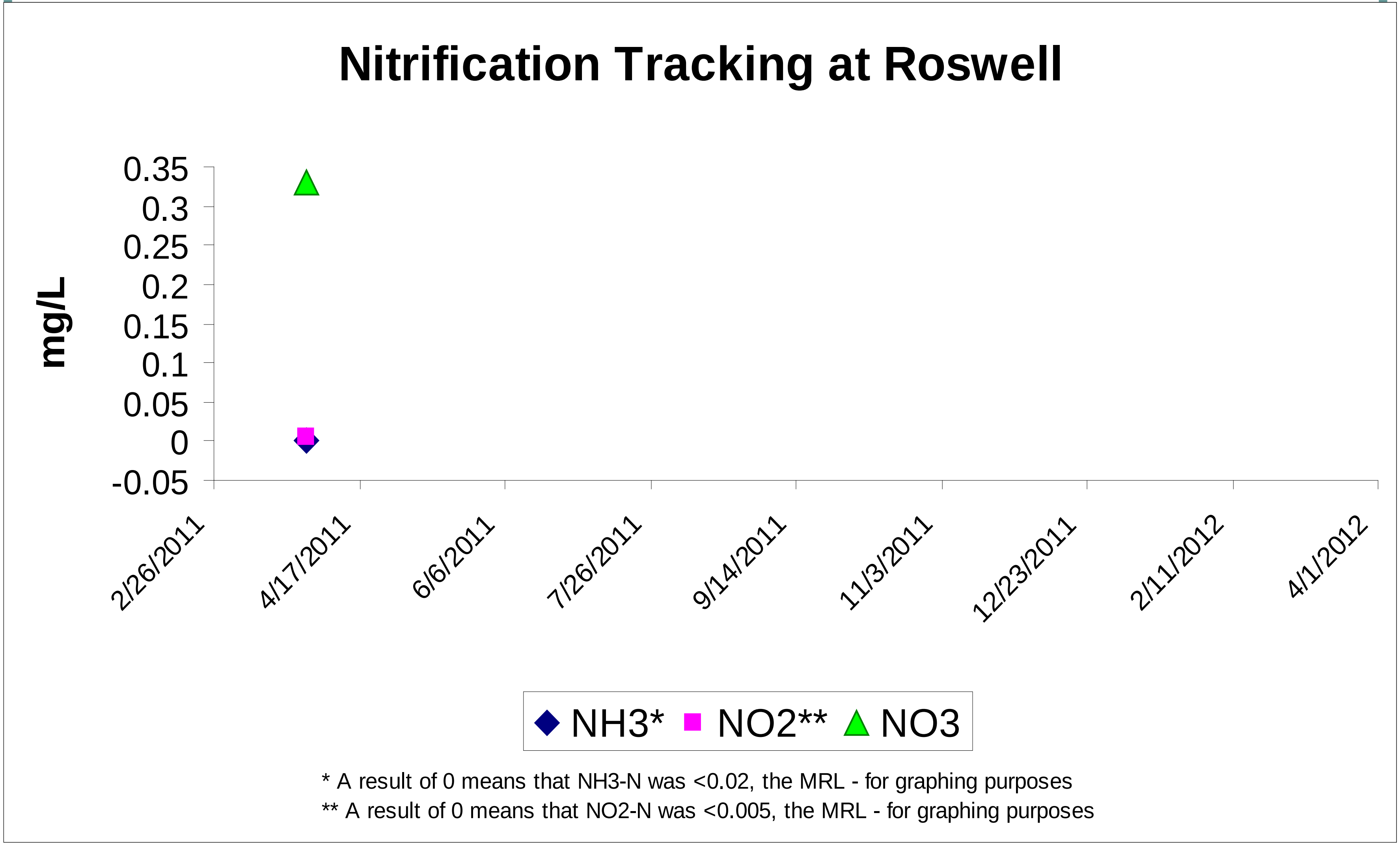
$$NOB + NO_2 \rightarrow NO_3$$

- Low chlorine residual
- Low free ammonia concentration
- Low nitrite concentration
- Elevated nitrate concentration

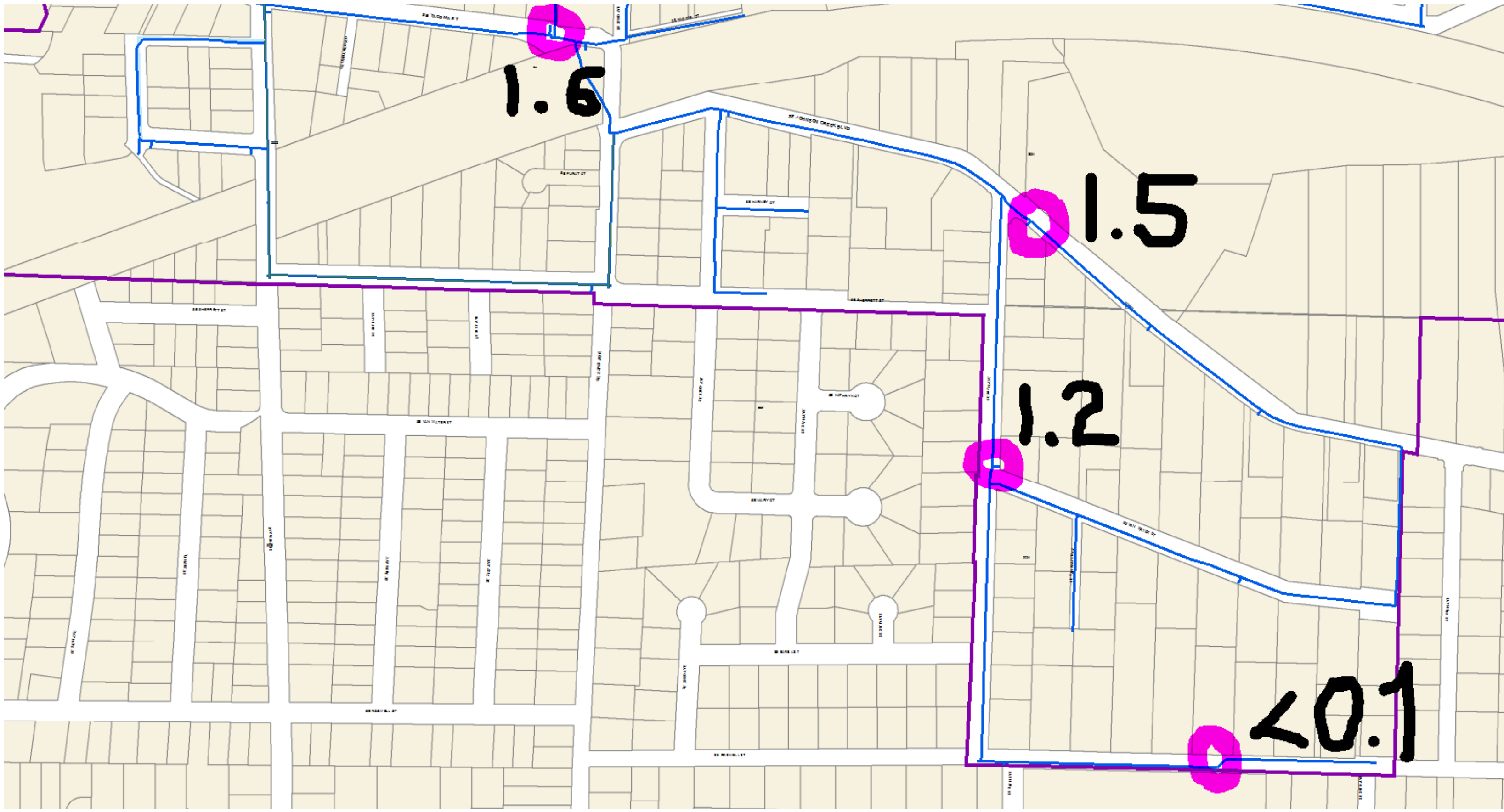
Water Quality Test Results Indicate Fully Nitrified Conditions at Roswell

- Chlorine residuals are at or near detection limit.
- Free ammonia-nitrogen is not detectable
- Nitrite-nitrogen is not detectable
- Nitrate-nitrogen concentration is very high.

Full Nitrification Looks like this.



A Look at Chlorine Residuals in the Area Feeding Roswell



We make plans to improve water quality at Roswell.

- Asked engineering to loop the system.
- Investigated an automatic flushing device.
- Purchased a Hach Nitrification Control Test Kit (DR 890) with reagents to measure -
  - Free ammonia
  - Nitrite-nitrogen
  - Nitrate-nitrogen

Some Discouraging Barriers

- Engineering would not consider looping the system.
- Flushing device would discharge to storm sewers that empty into a nearby creek. The storm sewers are owned by the adjacent municipality, the City of Milwaukie, which did not approve our request to locate an automatic flushing device in the area.

Problems with Hach Nitrification Control Test Kit

- **Field testing for 2 nitrification parameters was not successful**.
  - Free ammonia-nitrogen results were not reliable in side by side tests versus a laboratory specific ion probe test method.
  - Nitrate-nitrogen tests were also not reliable in side-by-side tests with lab techniques. Also the method was time consuming and cumbersome.

The next step:
Slug treatment with free chlorine

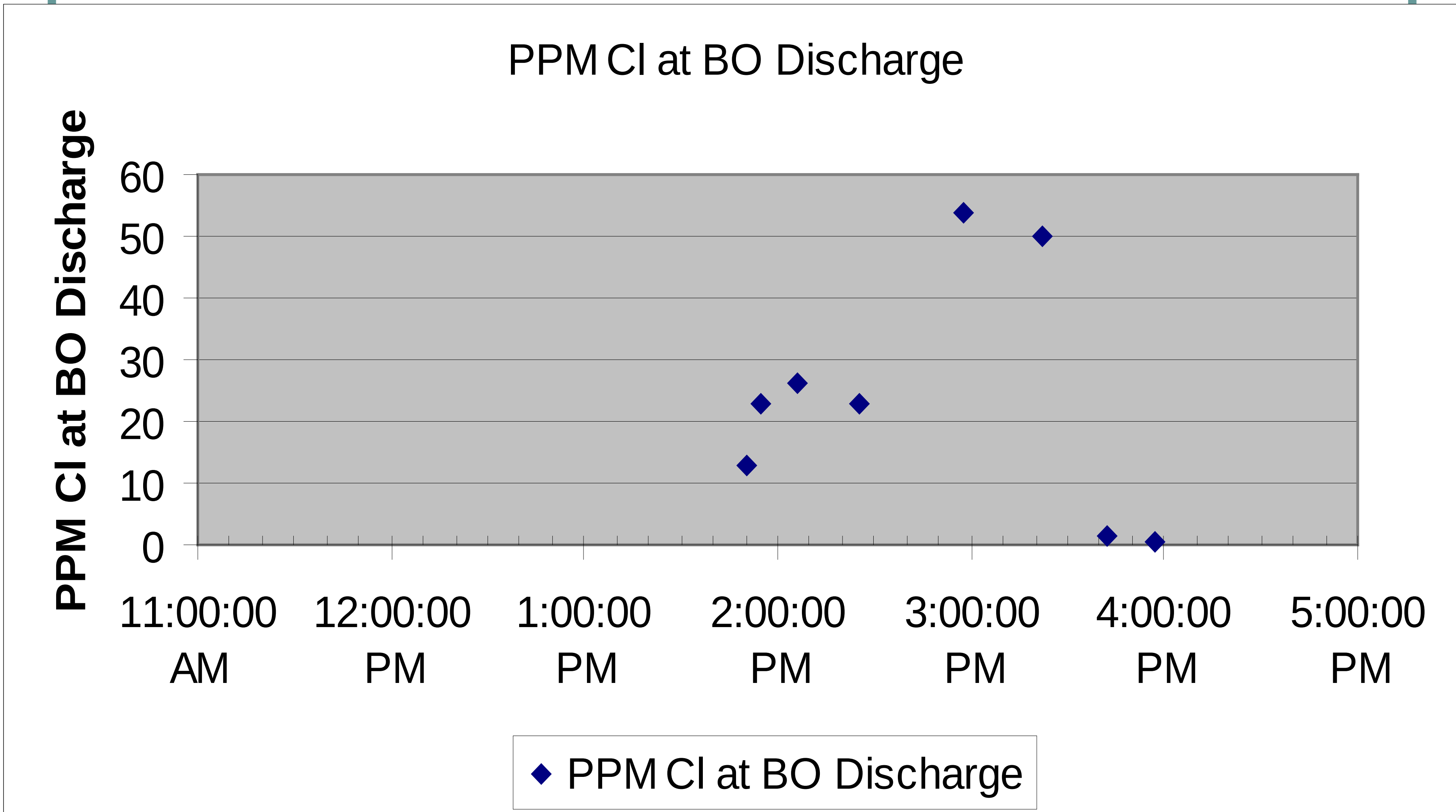
- Target CT of 20,000 mg-min/L
- Added 1+ gallons of 12% NaOCl into the main in 10 minutes, pinched back the flow in the main to ~7 gpm.
- Approximately 25 customers were out of service for 6 hours.

Slug Chlorination at Roswell

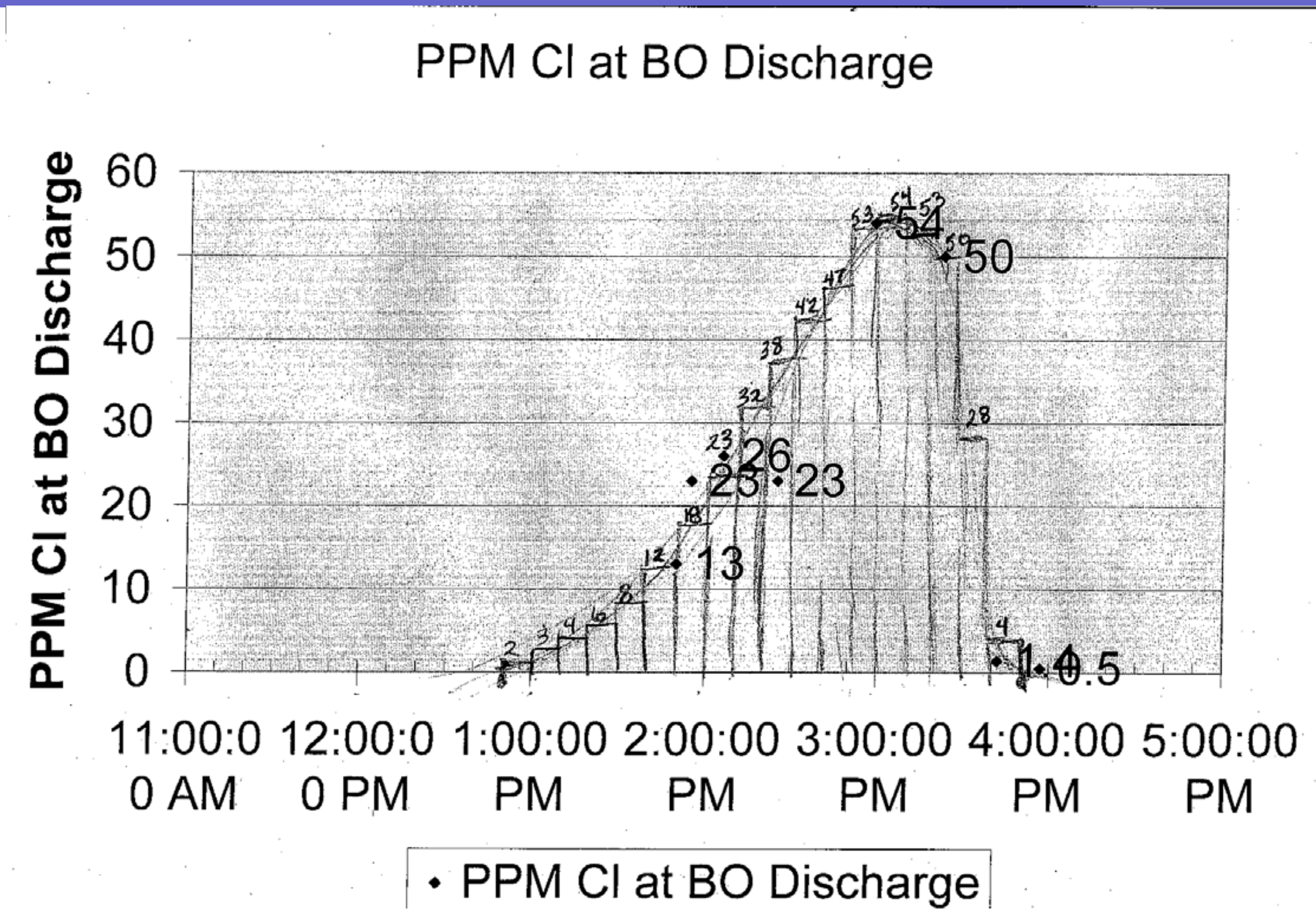
Charging the chlorine

Controlling Slug Flow Rate

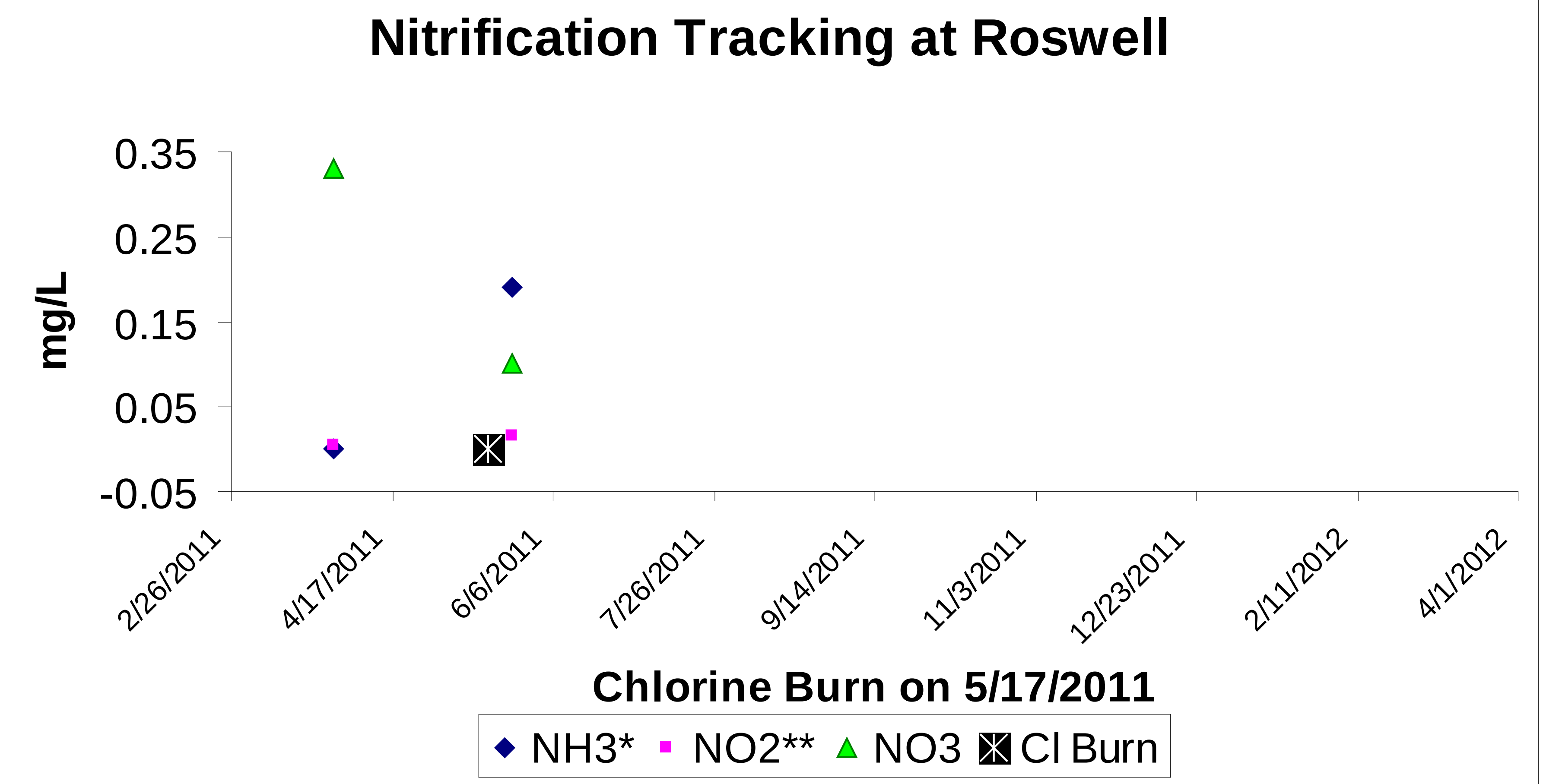
Chlorine Slug at Blow-off



An estimated 75% of the chlorine was consumed during the slug treatment.



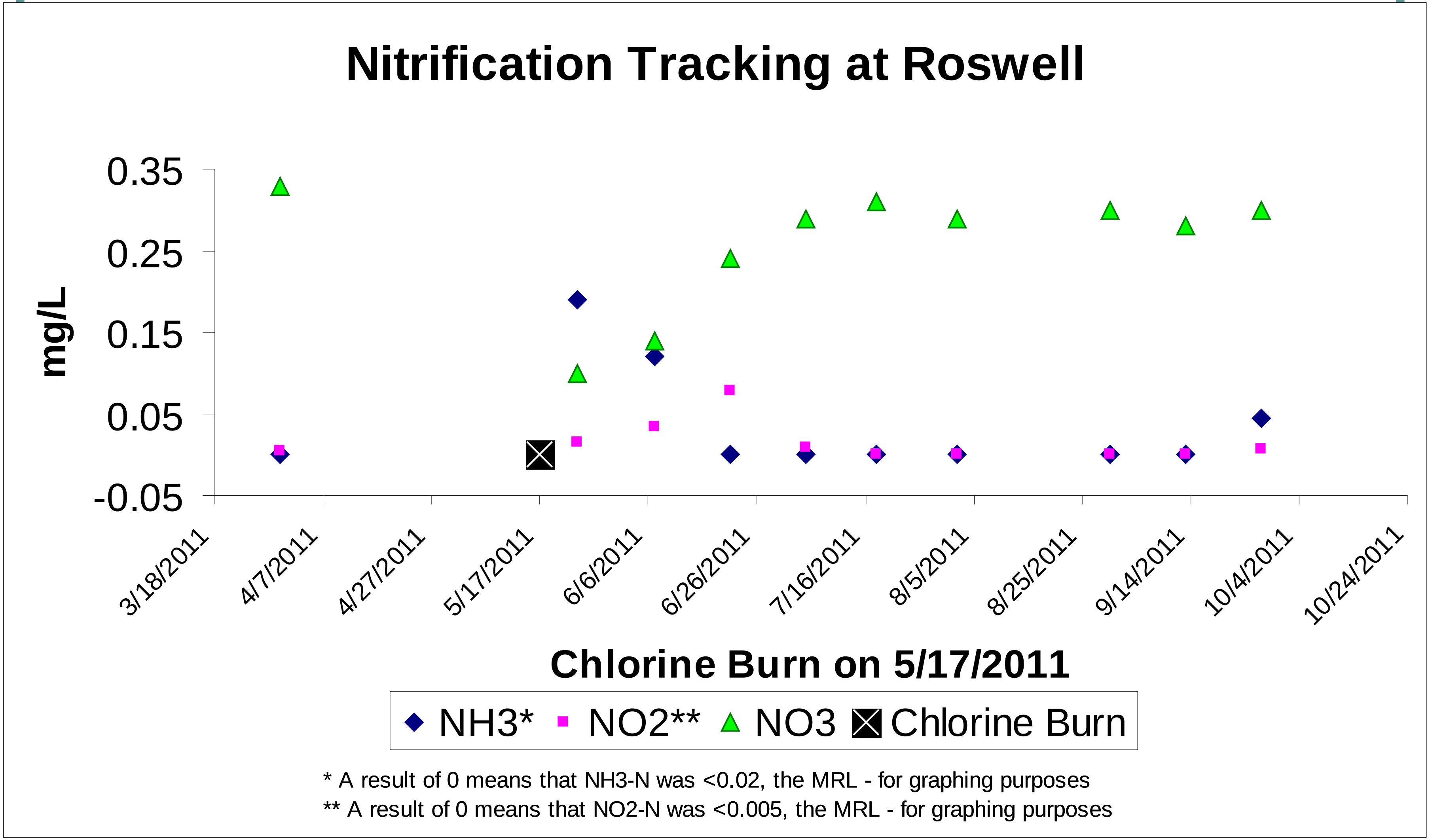
The Result of the Slug Chlorination at Roswell:



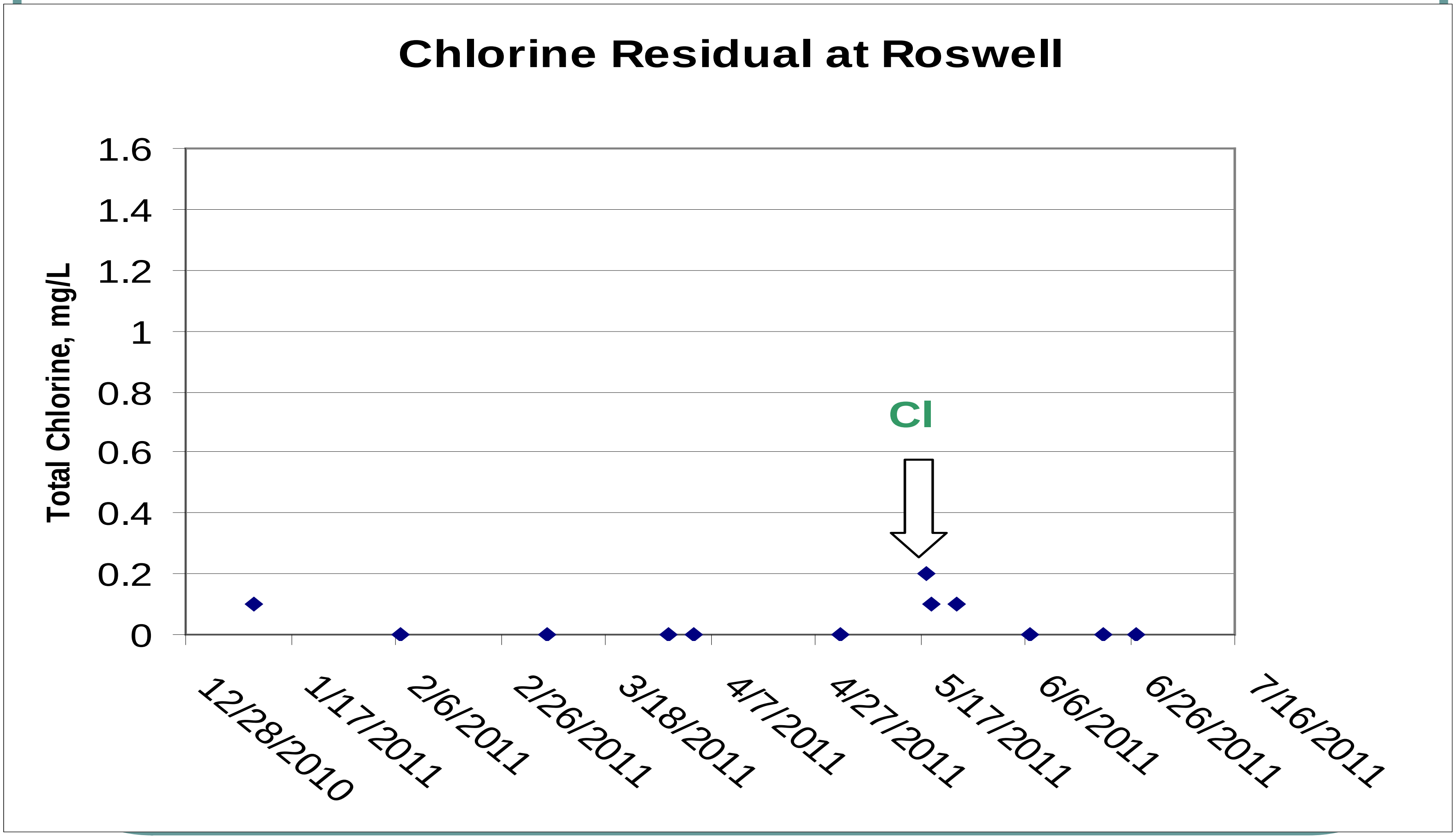
* A result of 0 means that NH3-N was <0.02, the MRL - for graphing purposes

** A result of 0 means that NO2-N was <0.005, the MRL - for graphing purposes

But the AOB & NOB quickly re-established.



The effect of the chlorine burn on total chlorine residual was minimal and short lived.



Chlorine dioxide is effective for control of biofilm…..

…..so maybe it could be used to spot treat the Roswell area.

- DuPont is marketing ClO_2 for controlling nitrification in drinking water distribution systems.
- Small scale ClO_2 generators are now available.

Chlorine Dioxide Drawbacks

It must be used immediately after generation because

- ClO_2 decays rapidly
- ClO_2 is explosive and cannot be transported

  Therefore it would have to be generated on site for immediate application.

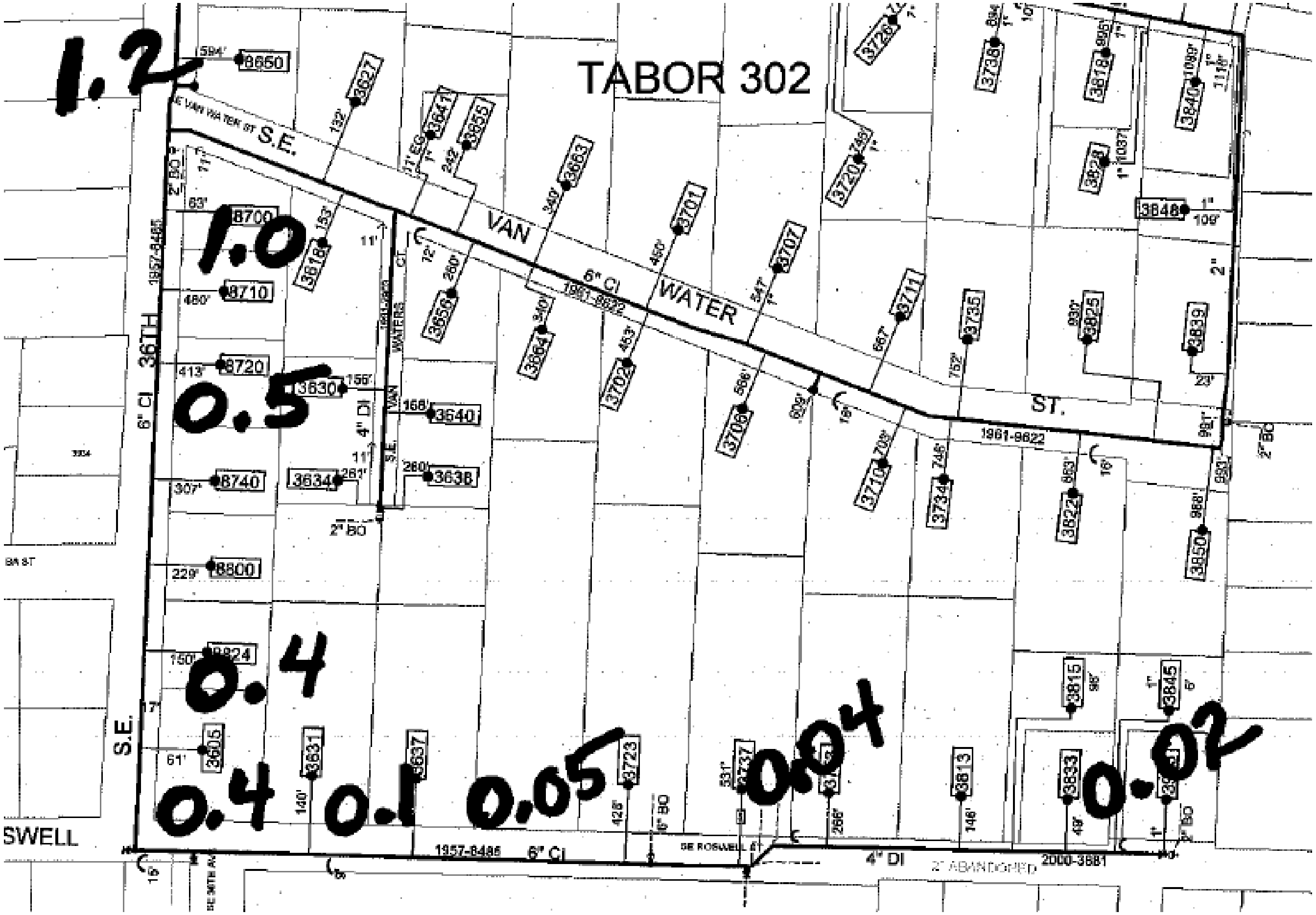
- More research is needed to determine how well it would work for spot treatment and how this could be done safely.

Another approach: Look for the root cause and correct that.

- Investigate the delivery system in the area for flow restriction:
  - Water main locates showed that the mains were positioned as recorded on PWB maps.
  - Gate valve positions were checked to rule out the possibility of errantly closed valves. All were correctly set open. One buried valve was uncovered and confirmed to be properly open.

A buried valve is rescued.

Chlorine residuals were measured at customer taps.



Customer consumption data was reviewed….

….and used to calculate a turnover time for the dead end.

Turnover time =

Internal pipe volume ÷ consumption rate

The DC WASA system observed that turnover times exceeding ***12 hours*** on dead ends were associated with nitrification problems.

Roswell turnover times were very high.

- ***20 hours*** *during summer quarter*
- ***30 – 33*** *hours during the other 3 quarters*

A cause of high turnover time

The PWB main serves only one side of the street along the dead end. Homes on the other side are served from a City of Milwaukie water main in the same street.

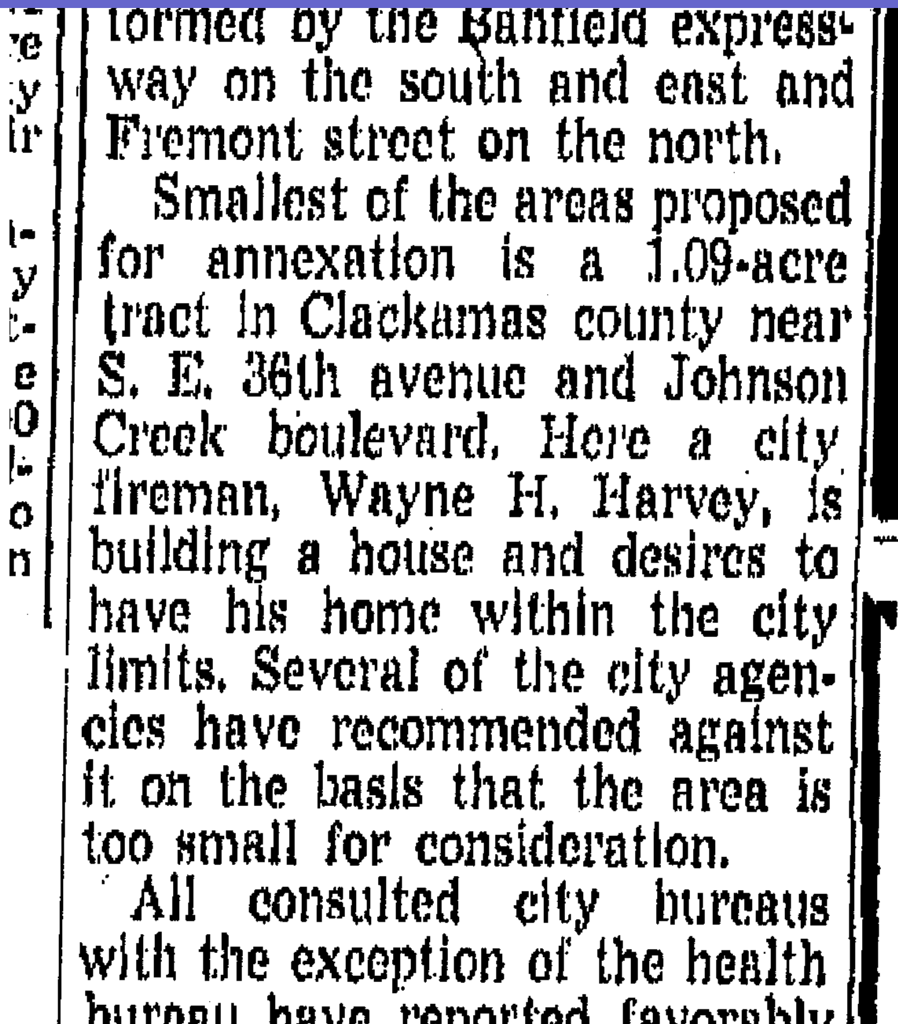
This is a configuration that distribution system design engineers try to avoid.

The main serves only one side of the street.

Fun with History!

The Roswell area was annexed into the City of Portland under unusual circumstances in 1953.

Annexation of Roswell Area in 1953



formed by the Banfield express-way on the south and east and Fremont street on the north.

Smallest of the areas proposed for annexation is a 1.09-acre tract in Clackamas county near S. E. 36th avenue and Johnson Creek boulevard. Here a city fireman, Wayne H. Harvey, is building a house and desires to have his home within the city limits. Several of the city agencies have recommended against it on the basis that the area is too small for consideration.

All consulted city bureaus with the exception of the health bureau have reported favorably

A Project was planned to improve flushing capability

To achieve higher flushing velocity along the dead end a 6” blow off was installed at the junction where the main reduces from 6” to 4”

Bonus activities for 6” BO project

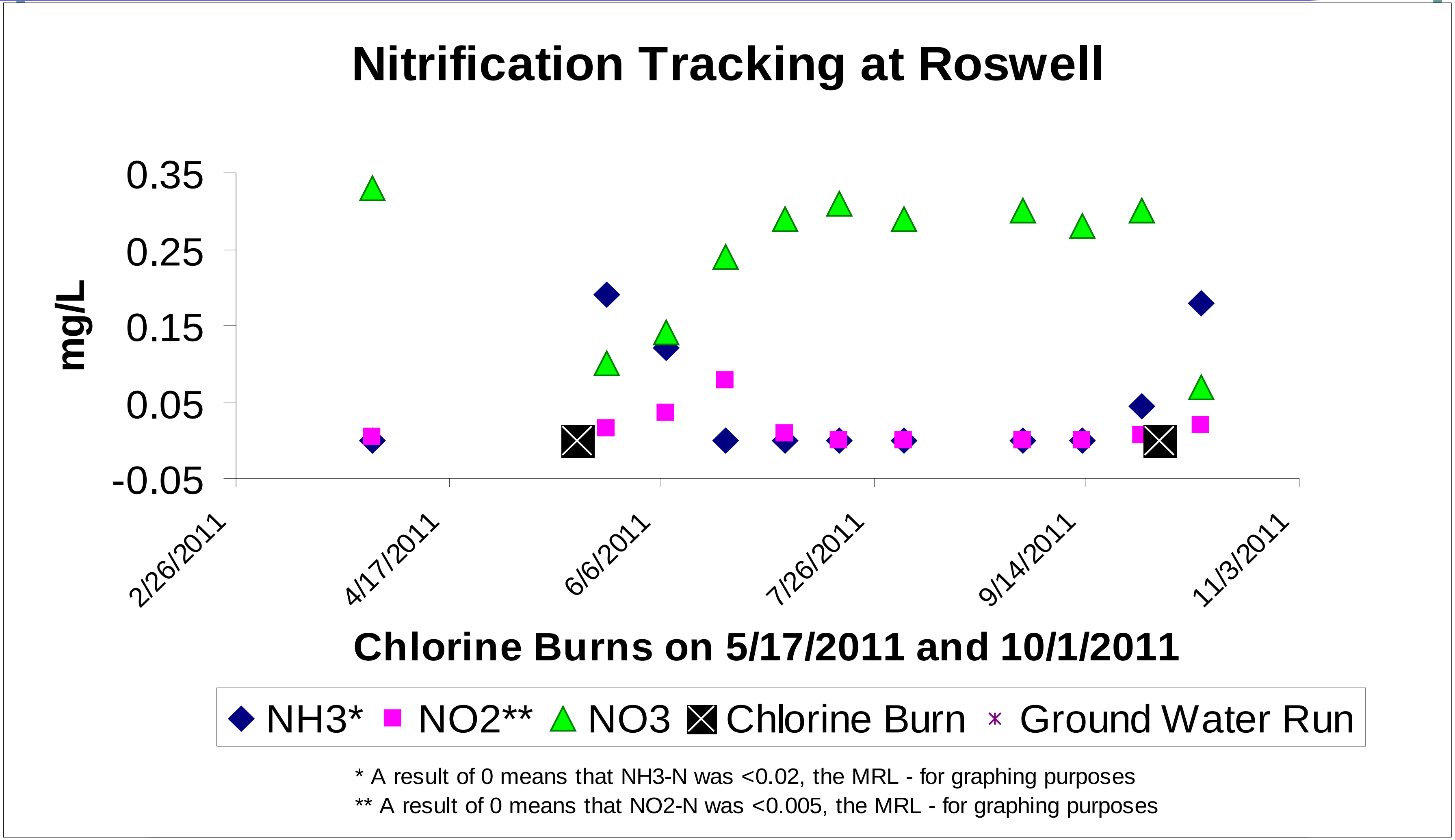
- Video the main to find out if there is a restriction.
- Scour the main to remove sediment and tubercles
- Do a second chlorine burn.

The video results:

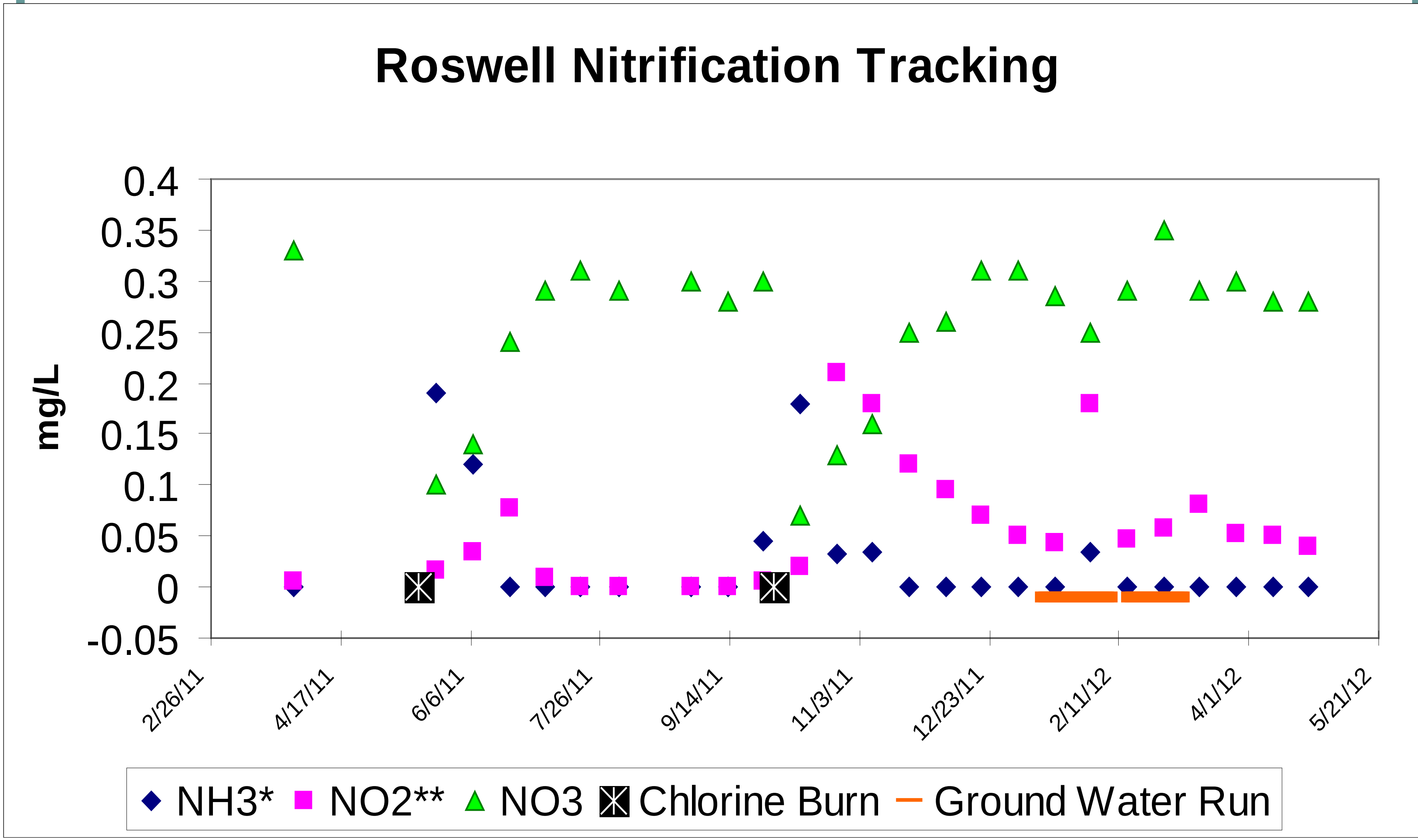
Sanitary Procedure for Using Video in Water Main

The new 6” blow-off in action

Second Chlorine Burn



Again, the AOB & NOB quickly re-established.



After the second chlorine burn,

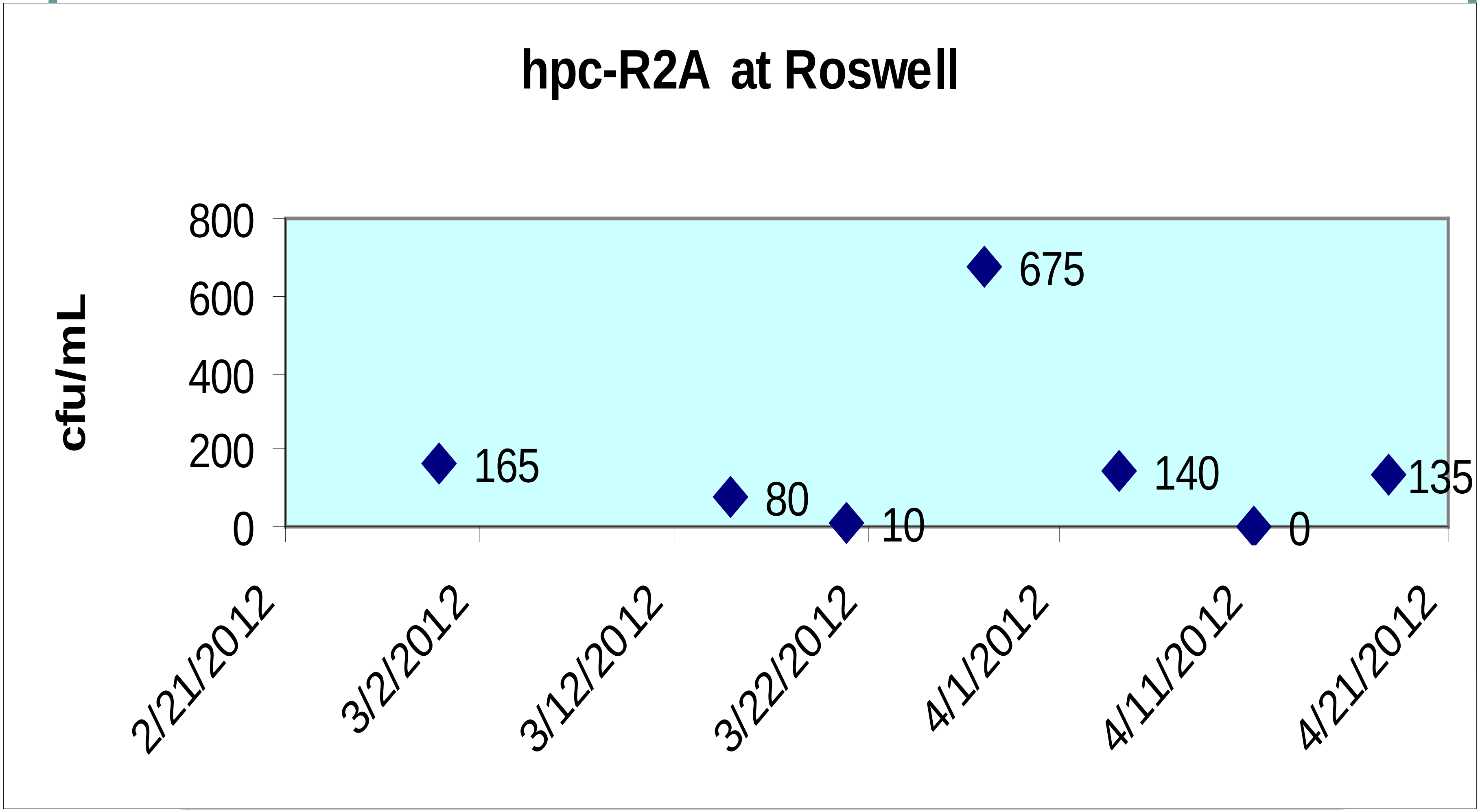
Continued routine flushing did not improve water quality.

And customers in homes connected below the 6” BO complained of low pressure when the blow-off was flushed.

Ongoing Monitoring

- Nitrification parameters of NH_3, NO_2-N, & NO_3-N
- Total chlorine
- pH (depressed)
- hpc-R2A method

Results of hpc-R2A tests



What next?

- Routine flushing was discontinued on the theory that it served mainly to bring in fresh “food” for the AOB and NOB.
- We have proposed to the City of Milwaukie that PWB provide and maintain a continuous flow drinking fountain in the park or school that border the dead end.

Full Circle

- We are essentially back to the original plan to install an auto flushing device, though the one we envision would be multipurpose:
  - Improve water quality
  - Provide drinking water in a park on Roswell Street.
  - Look good

Acknowledgements

- Matthew Wyllie – photos and charts

  Senior in PSU Environmental Engineering Program

- Gordon Penner – Roswell history

  PWB Water Quality Inspector

- Rich Giani – a fresh approach

  PWB Water Quality Manager

Contact Information

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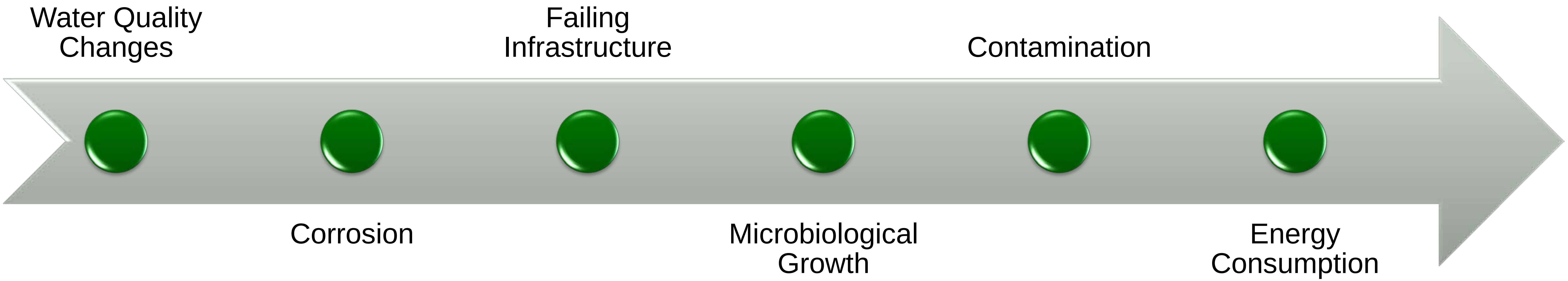
Distribution System Best Management Practices

Meeting regulatory, customer, and supply challenges

Distribution System Challenges



Treatment Technology is Evolving to Make Treatment for Cost Effective

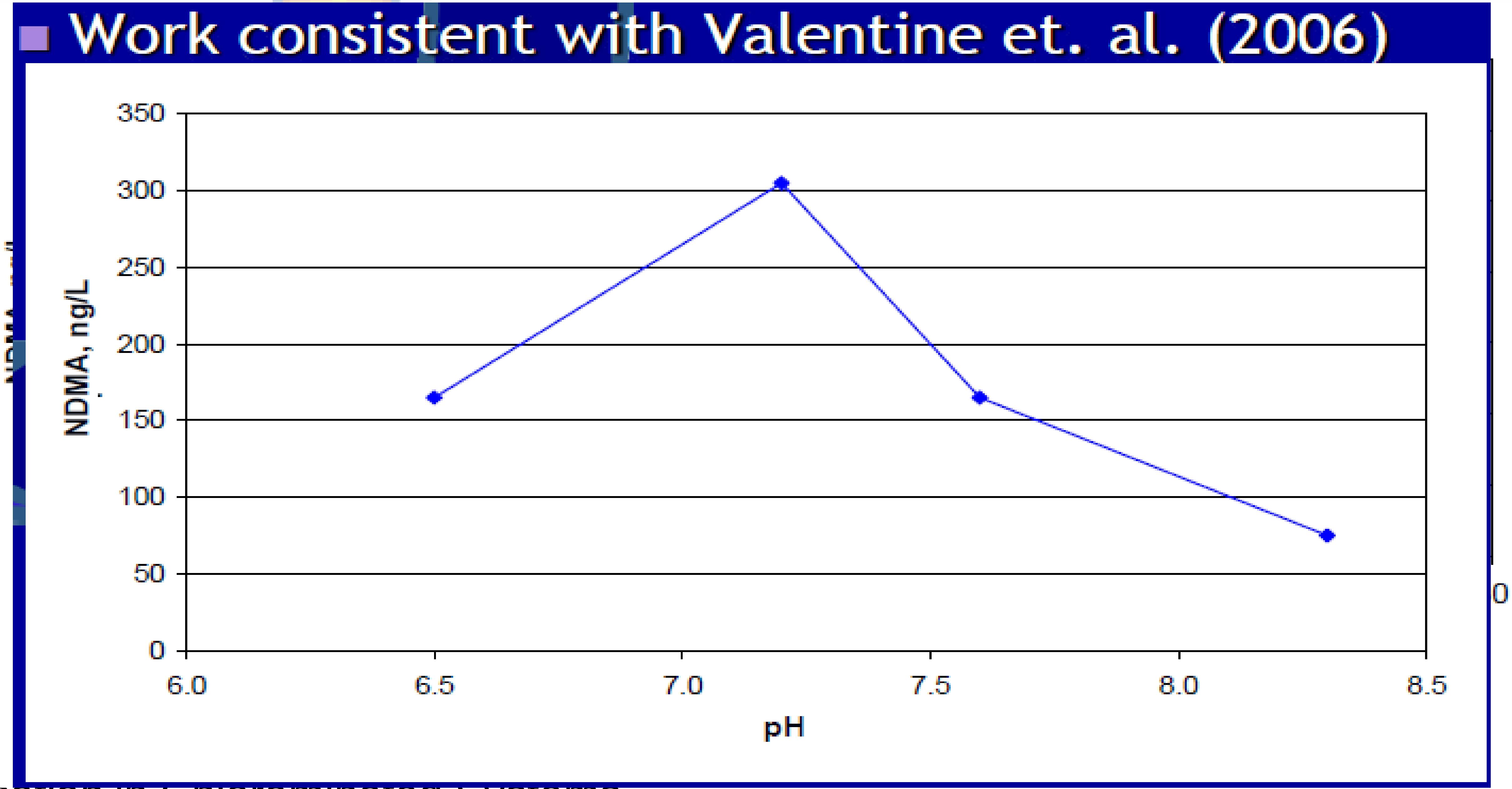
Potential Negative Water Quality Changes

- **Disinfection residual loss**
- **Disinfection by-products increase**
- **Formation of nitrite in chloraminated water system**
- **Formation of nitrosamines in chloraminated water systems**
- **ORP changes leading to increase in lead levels**
- **Biological growth**
- **Accumulation of inorganic material**
- **Accumulation of radionuclides**
- **Reduction of sulfide/sulfate compounds to hydrogen sulfide**
- **Temperature changes/changes in dissolved oxygen**

Chloramination

Nitrit

- Oc   from
- An   RF
  in s
  sys
- Ev   use
- Nit   free
  be
  for



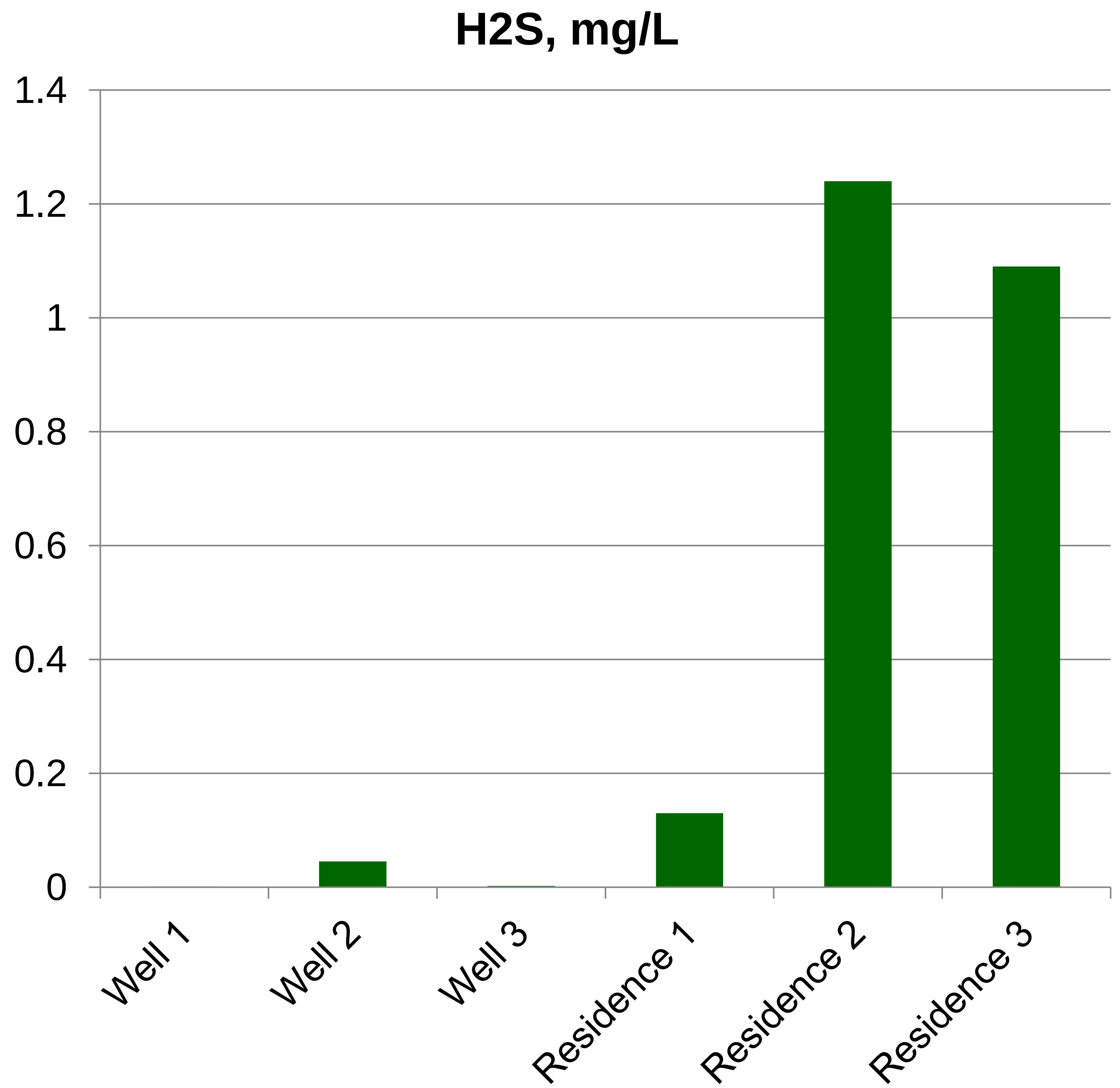
Source
Nitrification in Chloraminated Systems,
Journal AWWA, vol. 88:7:86-98

Accumulation of Inorganics and Radionuclides
(USEPA 4601M)

Contaminant	Sample Source [A]	Contaminant Concentration [B]	Potential for MCL Exceedance [C,D]	Reference [E]
Antimony (Sb)	Scale from lead service line	100 mg/kg	60 mg of scale per liter	Schock, 2004, City "A1"
	Flush water	0.027 mg/L	n/a	Clement and Carlson, 2004
	Reservoir Sediment	48 mg/kg	125 mg sediment per liter	Scanlan, 2003
Arsenic (As)	MnO_2 solution	1 mg/kg	10 g MnO_2 per liter	Reiber et al., 1997a
	$Fe(OH)_3$ solution	80,000 mg/kg	0.13 mg $Fe(OH)_3$ per liter	Reiber et al., 1997a
	$Cu(OH)_2$ solution	180,000 mg/kg	0.0556 mg $Cu(OH)_2$ per liter	Reiber et al., 1997a
	Scale in cast iron and galvanized pipes	1,300 mg/kg	7.7 mg of scale per liter	Reiber et al., 1997a
	Scale in copper service line	2,100 mg/kg	4.8 mg of scale per liter	Reiber et al., 1997a
	MnO_2 scale	20 mg/kg	500 mg of scale per liter	Schock, 2004
	Sediment in water main	1,400 mg/kg	7.1 mg of scale per liter	Reiber et al., 1997a
	Scale from lead service line	229 mg/kg	44 mg of scale per liter	Schock, 2004, City "D"
	Flush water	0.151 mg/L	n/a	Clement and Carlson, 2004
	Reservoir Sediment	300 mg/kg	33 mg sediment per liter	Scanlan, 2003
Barium (Ba)	Scale from lead service line	88 mg/kg	22,700 mg of scale per liter	Schock, 2004, City "A1"
Beryllium (Be)	Scale from lead service line	460 mg/kg	8.7 mg of scale per liter	Schock, 2004, City "A2"
	Scale from lead service line	290 mg/kg	13.8 mg of scale per liter	Schock, 2004, City "D"
Cadmium (Cd)	Scale from lead service line	76.8 mg/kg	65.1 mg of scale per liter	Schock, 2004, City "D"
Chromium (Cr)	Scale from lead service line	65.4 mg/kg	1,529 mg of scale per liter	Schock, 2004, City "A2"
Copper (Cu)	Scale from lead service line	350 mg/kg	3,714 mg of scale per liter	Schock, 2004, City "A"
	Scale from lead service line	1,100 mg/kg	1,182 mg of scale per liter	Schock, 2004, City "B"
	Scale in cast iron and galvanized pipes	7,600 mg/kg	171 mg of scale per liter	Reiber et al., 1997a
Lead (Pb)	Scale in cast iron and galvanized pipes	6,000 mg/kg	2.5 mg of scale per liter	Reiber et al., 1997a
	Scale in copper pipes	79 mg/kg	190 mg of scale per liter	Reiber et al., 1997a
	Flush water	1.37 mg/L	n/a	Clement and Carlson, 2004
	Reservoir Sediment	830 mg/kg	18.1 mg sediment per liter	Scanlan, 2003
	Scale in copper service lines	574 – 2940 mg/kg		Fuge et al., 1992, Aberystwyth
Mercury (Hg), inorganic	Scale from lead service line	1.24 mg/kg	1,613 mg of scale per liter	Schock, 2004, City "C"
Selenium (Se)	Scale from lead service line	7.8 mg/kg	6,410 mg of scale per liter	Schock, 2004, City "D"
Thallium (Tl)	Scale from lead service line	12.7 mg/kg	157 mg of scale per liter	Schock, 2004, City "C"

Formation of Hydrogen Sulfide in the Distribution System/Premise Plumbing

Small Community Water System
Montana



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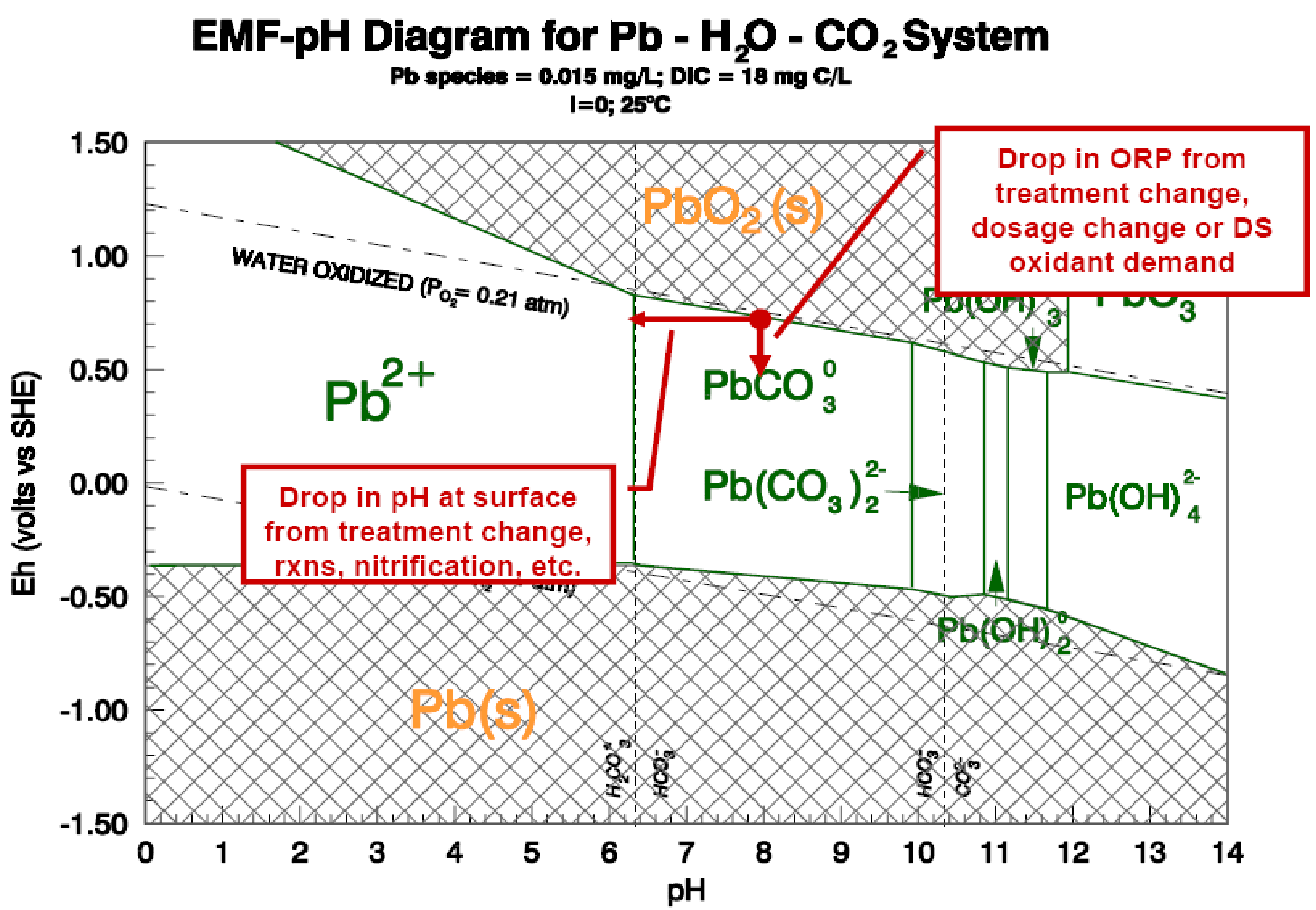
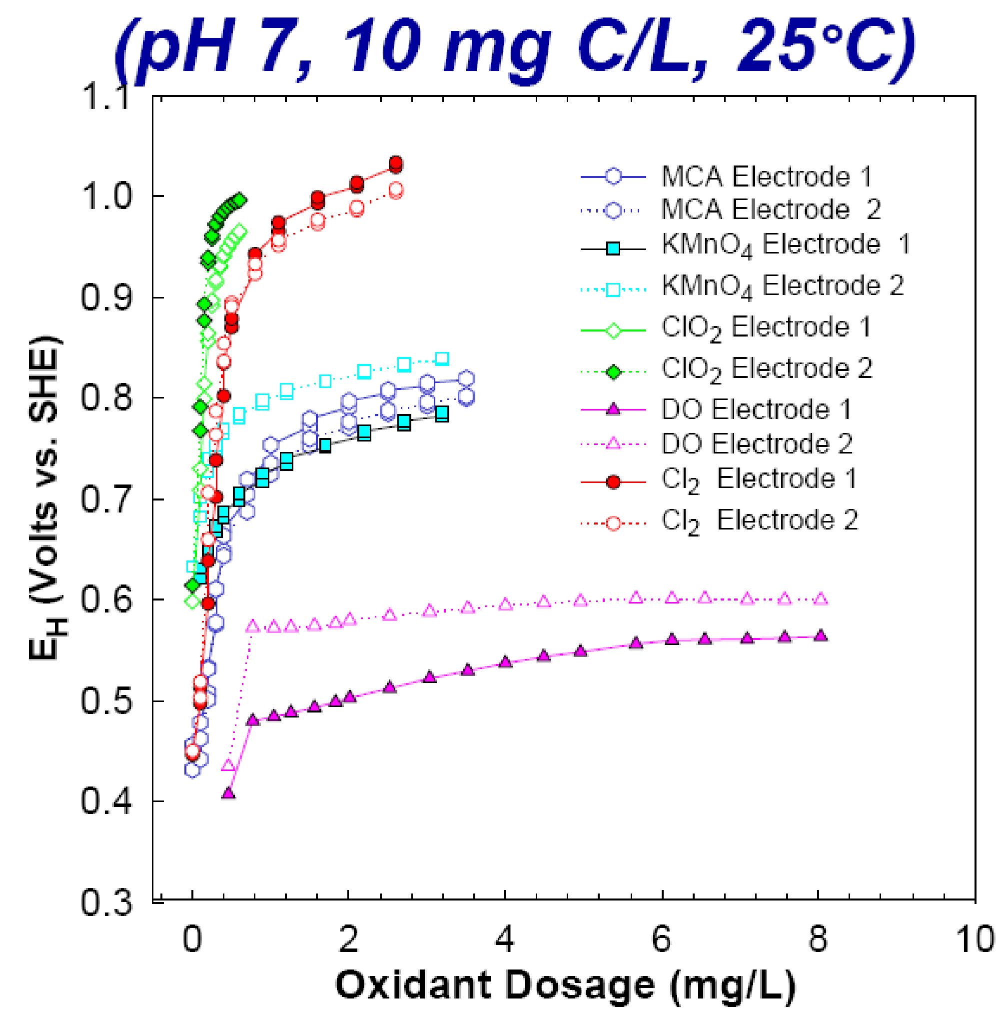
Corrosion

ORP – Important Factor In Lead Releases

Corrosion Control





Lead Solubility Contour Diagram, pH vs DIC, I=0.01,
Source, Lead Control Strategies, AWWARF

Source: New Insights into Lead and Copper Corrosion Control and Treatment Change Impacts, Michael Schock, USEPA, ORD, NRMRL, WSWRD

Oxidation Reduction Potential has a Significant Impact on Lead

Failing Infrastructure

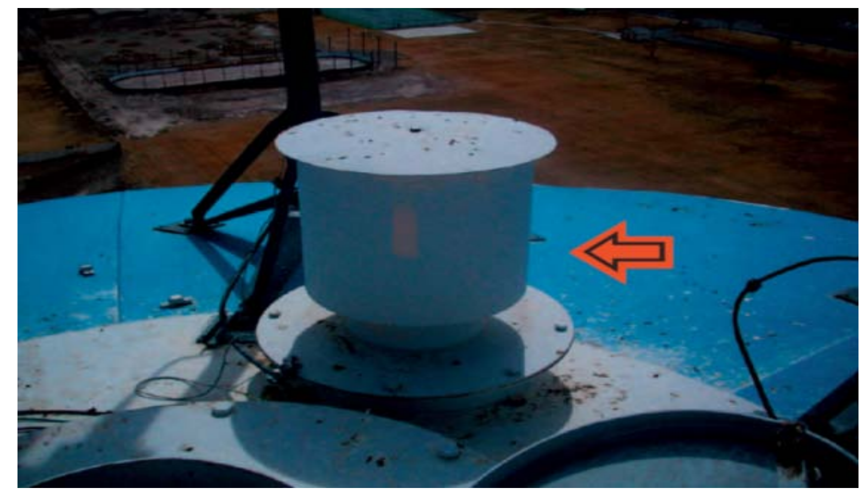
Main Breaks	**-**	**Disrupting Cities**
Reservoirs	**-**	**Deadly Leaks?**

Failing Infrastructure

Reservoirs

Alamosa, CO

- Town of 8,900 people
- 7 wells in confined aquifers, unchlorinated
- Also high arsenic > MCL – treatment in design phase
- March, April 2008:
  - 442 people reported being ill (estimates way higher)
  - 122 lab-confirmed cases (salmonella)
  - 1 death attributed to salmonella



Microbial Growth

Biofilm	**-**	**Total Coliform & HPC**
Nitrification	**-**	**Chloraminated Water Systems**
Iron Bacteria	**-**	**Slime forming, Clogging Bacteria**
Other Microbes	**-**	**Midge Fly Larvae, Others**

Midge Fly Larvae

Woodburn Independent | Local News | Midge fly resurfaces in

650 N. First Street

News Education Sports Hometown Opinion Free Access
Young Writers

Local News Features News Briefs Obituaries Regional News
Archives Photos/Videos

Saturday, April 28, 2012 Cloudy, 61° F

Midge fly resurfaces in Woodburn water

City officials say Woodburn's water is still safe to drink

Contamination

Backflow/Cross Connections	**-**	**More events**
Deliberate Acts	**-**	
Main Breaks/Pressure Loss	**-**	**Backflow Conditions**
Other	**-**	**Chemical Feed**

Contamination


Breaking news and must-read stories

Home Archives Forum About

« Yearbook recalled over alleged 'child porn' photo of students at dance

Saudi women start their engines in defiance of ban on female drivers »

Jun 16, 2011

Portland, Ore., drains reservoir after man pees in it

Comment 83 Tweet 33 +1 0

By Michael Winter, USA TODAY

Updated 2011-06-17 3:25 PM

Water officials in Portland, Ore., decided to drain a reservoir

	Tel Aviv	Camelford
Event	Unintentional	Unintentional
Source	Initially unknown	Initially unknown
Physical cause	Malfunction of ammonia measuring buoy results in 5 tons of ammonia dumped into drinking-water reservoir	Relief driver dumps 20 tons of $Al_2(SO_4)_3$ into wrong hopper that directly enters the drinking-water supply
Initial observation	Turbidity spike at monitoring station	Acidic taste, slippery or slimy to the touch
Chemical cause	Ammonia	Aluminum sulfate
Public disclosure	Immediate, full transparency	2 – 3 d delay
Advice to public	Don't drink even if boiled	Water is safe to drink
Health effects documented	None	Acute and chronic – burning sensation, irritation
Action taken	System flushed	System flushed
Initial toxicological assessment	Precautionary principle invoked, possible tracer of chemical or bacteriological contamination	Precautionary principle not invoked, public assured water was safe
Aftermath of event	Public poll indicated that communication was adequate and situation handled satisfactorily	Event continues to have health, political and legal ramifications today
Lessons learned	Provided opportunity to re-evaluate public health agency's role in drinking-water contamination events	Provided opportunity to re-evaluate public health agency's role in drinking water contamination events

Energy Consumption

Pumping	**-**	**1/3 of utility costs**
Pressure Reducing Valves	**-**	**lost energy**
Water Losses	**-**	**lost energy**
Treatment Processes	**-**	**chemical use and treatment**

Energy also requires lots of Water

- 1.9 billion gallons per day
- 393,000 mwh by 2020
- 25 gallons per kwh

Best Management Practices for Drinking Water Systems

A look at sustainable practices

BMPs

Table 1: Best Management Practices for Water Quality in the Distribution System

i. Element	Best Management Practice (WRF, 2010)
Biofilm Management and Control	• Investigate and remediate all coliform/*E. coli* occurrences • Meet regulations for bacteriological quality
Microbiological Monitoring and Response	• Response protocols for compliance and surveillance • Meet regulations for bacteriological quality
Post Precipitation Control	• Measurement goals for aluminum, iron and manganese
Disinfection Residual	• Goals and monitoring for disinfectant residuals throughout the system. • Meet disinfectant residual regulatory limits
Disinfection By-Product Monitoring and Control	• Control of water age and disinfectant demand • Meet regulations for disinfection by-products
Corrosion Control and Monitoring	• Meet regulations for lead and copper rule • Monitor corrosion related parameters • Control pH stability and scale formation
Nitrification Control	• Monitoring of free ammonia, pH, nitrite and other key parameters
Customer Complaint Monitoring and Tracking	• Follow up to customer complaints/inquiries • Trend customer complaints/inquiries
Emergency Preparedness and Response	• Updated plan exists • Plan has been implemented/exercised • Reverse 911 capability to reach customers
Security	• Real-time monitoring to detect purposeful contamination (e.g. automated remote monitoring and response) • Elimination of submerged air valves and other susceptible appurtenances.

BMPs

Table 2: Best Management Practices for the Physical Integrity of the Distribution System

Element	Best Management Practice (WRF, 2010)
Cross Connection Control	• Develop and implement a cross connection control program
Maintenance of Hydrants, Valves and Blow-offs	• Develop and implement a valve and hydrant maintenance program • Conduct hydrant flow testing
External Corrosion Control	• Implement procedures to minimize external corrosion
Storage Facility Maintenance	• Routine inspection, repair and cleaning of tanks • Implement a program for security/inspection of water storage facilities
Main Breaks	• Track number and type of main break by material • Response time
Disinfection of New Mains or Repairs	• Implementation of disinfection and flushing procedures • Bacteriological testing of new mains
Pipeline Installation Rehabilitation and Repair	• Pipe inventory by material and size • Buried asset database and condition assessment • Asset management and replacement plan • Conditioning and maintenance of coatings and linings

BMPs

Table 3: Best Management Practices for Hydraulic Integrity of the Distribution System

Element	Best Management Practice (WRF, 2010)
Distribution System Flushing	• Plan for systematic (unidirectional) and spot flushing
Energy Management	• Pump and energy audits • Management systems/plans for tracking and controlling energy use
Hydraulic Modeling and Planning	• Level of service criteria established • Validation of model using operational data • Ability to meet fire flows • Ability to track water age, blending etc
Pressure Management	• Maintain positive pressure under all conditions • Pump maintenance and repair • Use hydraulic models to detect areas of low pressure
Water Age Management	• Procedures for minimizing water age in storage vessels • Procedures for managing water age at pressure zone boundaries • Procedures for managing water age in pipelines • Procedures for assessing impacts of water age on water quality
Sample Collection Plans	• Sample plant representative of populations/areas of the system • Sample sites are properly designed and maintained • Regulatory compliance achieved • Monitoring conducted beyond regulatory requirements • Water quality goals established for key parameters/locations within the system

Why Implement BMPs?

Table 4: Example Business Drivers for Distribution System BMPs

Business Drivers	Potential effect of BMPs
Meeting growth in demand	Reduce distribution system leakage, preserve water resources
Maintaining the existing level of service in an existing asset	Maintain needed pressure for Supply and fire fighting, protect assets from corrosion
Complying with existing regulations	Meet corrosion control, disinfection by-product and coliform rule requirements
Complying with new regulatory requirements	Achieve compliance with Revised Total Coliform Rule
Improving environmental standards	Reduce main breaks, optimize use of chemicals, minimize replacement of materials
Improving strategic position & reputation	Improved water quality aesthetics, reduced risk of backflow events
Managing risks	Reduced formation of disinfection by-products, corrosion by products, nitrite formation, and microbial contaminants in the distribution system
Improving efficiency	Improved C Factor through scale and biofilm control, reduced system leakage, reduced pumping

BMP Category	Do Nothing	Adjust secondary disinfectant residual	Change secondary disinfectant	Adjust pH and other WQ parametes	Reduction of TOC, DOC, and/or BDOC	Increased Flushing	Increase reservoir turnover	Improved cross connections and backflow program	Clean/Pig mains	Purchase/lease leak detection equipment	Installation of dedicated monitoring stations	Installation of real time monitoring	Additional utility staff	Improved laboratory capacity	Additional contracting	Additional training	Change construction standards	Construct additional storage	Change pump operation	Change asset replacement policy	Maintain larger replacement inventory	Construct new water treatment facilities	Modify storage facilities	Construct additional mains	Technology Investment	Improved business process	Improved facility reliability
Biofilm Management and Control	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑			☑		☑										☑		
Microbiological Monitoring and Response	☑										☑	☑	☑	☑	☑	☑									☑		
Post Precipitation Control	☑			☑					☑		☑	☑	☑		☑	☑						☑			☑		
Disinfection Residual	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑		☑	☑		☑				☑		☑		
Disinfection By-Product Monitoring and Control	☑	☑	☑	☑	☑	☑	☑		☑		☑	☑						☑	☑			☑	☑		☑		
Corrosion Control and Monitoring	☑	☑	☑	☑	☑	☑					☑	☑	☑		☑	☑	☑								☑		
Nitrification Control	☑	☑	☑	☑	☑	☑	☑		☑		☑	☑	☑	☑	☑	☑			☑					☑	☑		
Customer Complaint Monitoring and Tracking	☑												☑			☑									☑	☑	
Emergency Preparedness and Response	☑							☑		☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑		☑
Security	☑							☑		☑	☑	☑	☑	☑	☑	☑	☑						☑		☑	☑	☑
Cross Connection Control	☑							☑					☑		☑	☑	☑								☑	☑	
Maintenance of Hydrants, Valves and Blow-offs	☑												☑		☑	☑				☑	☑				☑	☑	
External Corrosion Control	☑									☑			☑		☑	☑	☑			☑			☑	☑	☑		☑
Storage Facility Maintenance	☑									☑			☑		☑	☑	☑			☑			☑		☑		
Main Breaks	☑			☑						☑		☑	☑		☑	☑	☑		☑	☑	☑			☑	☑	☑	☑
Disinfection of New Mains or Repairs	☑												☑	☑	☑	☑	☑	☑							☑	☑	
Pipeline Installation Rehabilitation and Repair	☑															☑	☑	☑		☑	☑				☑	☑	☑
Distribution System Flushing	☑					☑			☑				☑		☑	☑							☑	☑	☑		
Energy Management	☑															☑	☑	☑	☑	☑					☑	☑	
Hydraulic Modeling and Planning	☑												☑		☑	☑									☑	☑	☑
Pressure Management	☑					☑			☑	☑	☑	☑	☑		☑	☑		☑	☑				☑	☑	☑	☑	☑
Water Age Management	☑					☑					☑	☑	☑		☑	☑			☑	☑			☑	☑	☑	☑	
Sample Collection Plans	☑										☑	☑	☑	☑	☑	☑									☑	☑	

Table 6: Potential Triple Bottom Line Effects for Options

Category of Effect	Description of effects
Financial	
Financial Impact on Utility	Capital and operating expenditures, including residuals values and decommissioning costs. Revenue generated and expenditures avoided
Financial Impact on Others	Costs or savings imposed on opthers (example - home filter units)
Local/Regional Economy	Effect on prices, jobs or business opportunities
Environmental	
Air - Local	Change in air pollutants except greenhouse gases
Air - Global	Greenhouse gas emmissions
Water - Fresh	Changes in water quality for fresh water systems and habitat
Water - Ground	Changes in flow and quality of groundwater systems
Water - Marine	Changes in marine water quality, biodiversity and itegrity fo seabed and beaches
Land - Soil	Loss of soil from erosion, contamination of soils, depletion of minerals
Land - geomorphology	Impacts of aesthetic appearance of landscape
Land - flood management	Increase in risk of flooding
Land - Use	Impacts on land use
Land - biodiversity	Impacts on terrestrial biodiversity
Materials and Waste	Use of non-renewable resources and generation of waste products
Social	
Water - Consumptive	Impact to the safe consumtpive use of water (drinking,, recreation, irrigation)
Built Environment	Impacts to infrastructure
Safety	For all related activities
Nuisance	Noise and odor impacts, construction inconvinience
Access	Access to public and private spaces
Cultural Heritage	Impacts to cultural heritage sites or uses
Utility Reputation	Community attitudes of project or impacts from project
Education	Level of community understanding of options
Jobs	Increase or decrease in jobs (for example at a new water treatment plant)

Table 7: Potential guidelines for measurement of Option effects based on complexity

	Less Complex	Intermediate	More Complex
Assessment	Use checklist Describe qualitatively Provide some assessment of significance	Follow Less Complex assessment and add quantification as much as possible. Undertake simple environmental, social and economic impact assessments	Intermediate assessment and undertake detailed environmental, social and economic impact assessment
Consultation	Utility experts	Internal and External experts and stakeholders	Internal and external experts and stakeholder and major community consultation

Table 8: Example Scoring for Improved Water Age Options

Category of Effect	Weight	Do Nothing	Increased Reservoir Turnover	ASR Implementation	Reservoir Modifications
Financial		NPV	NPV	NPV	NPV
Financial Impact on Utility, NPV		-	(8,043,000)	(12,325,000)	(5,324,000)
Financial Impact on Others, NPV		(12,000,000)		(300,000)	
Local/Regional Economy, NPV				4,350,000	2,200,000
Environmental	54%	Score (-4 to 4)	Score (-4 to 4)	Score (-4 to 4)	Score (-4 to 4)
Air - Local	10%	-	1.1	1.2	2.3
Air - Global	5%	-	2.4	4.0	3.1
Water - Fresh	10%	-	2.2	3.2	3.1
Water - Ground	10%	-	-	4.0	-
Water - Marine	0%	-	-	-	-
Land - Soil	2%	-	-	(0.4)	(0.2)
Land - geomorphology	5%	-	-	(0.3)	(1.1)
Land - flood management	0%	-	-	-	-
Land - Use	5%	-	-	(0.3)	(0.6)
Land - biodiversity	2%	-	-	(0.2)	(0.3)
Materials and Waste	5%	-	-	(2.3)	(0.2)
Social	46%				
Water - Consumptive	10%	(4.0)	2.0	(2.0)	2.0
Built Environment	3%	-	-	(1.0)	(1.3)
Safety	10%	-	(0.2)	(0.2)	1.0
Nuisance	2%	-	-	(2.4)	(2.6)
Access	3%	-	-	(1.7)	(3.0)
Cultural Heritage	2%	-	-	-	-
Utility Reputation	10%	(4.0)	2.0	1.0	3.0
Education	3%	(4.0)	2.0	2.0	2.0
Jobs	3%	-	-	1.0	0.2
Weighted Score	100%	(0.9)	0.9	0.7	1.1
Cost	$	(12,000,000)	(8,043,000)	(8,275,000)	(3,124,000)

Questions?

Thank you!

Lee Odell, PE
Water Treatment Global Technology Lead
CH2M HILL

Solutions for Water Quality Issues in Your Water Storage Tank

DYK INCORPORATED ®

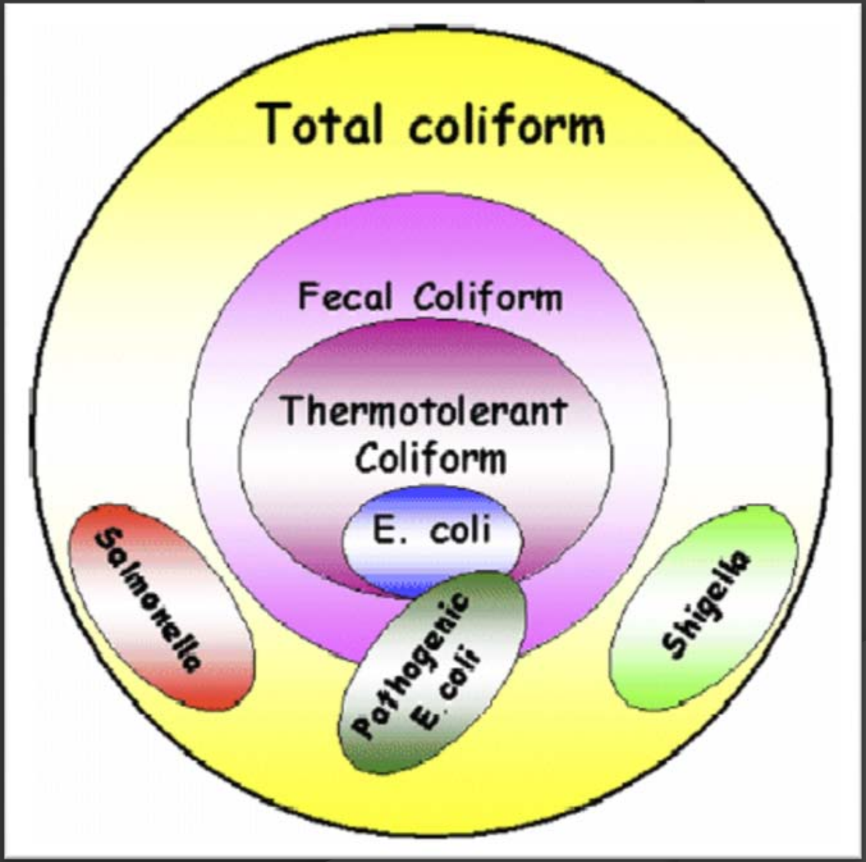
Presenter: Mark Moore
Concrete Tank Services

Importance of Water Quality

Vs.

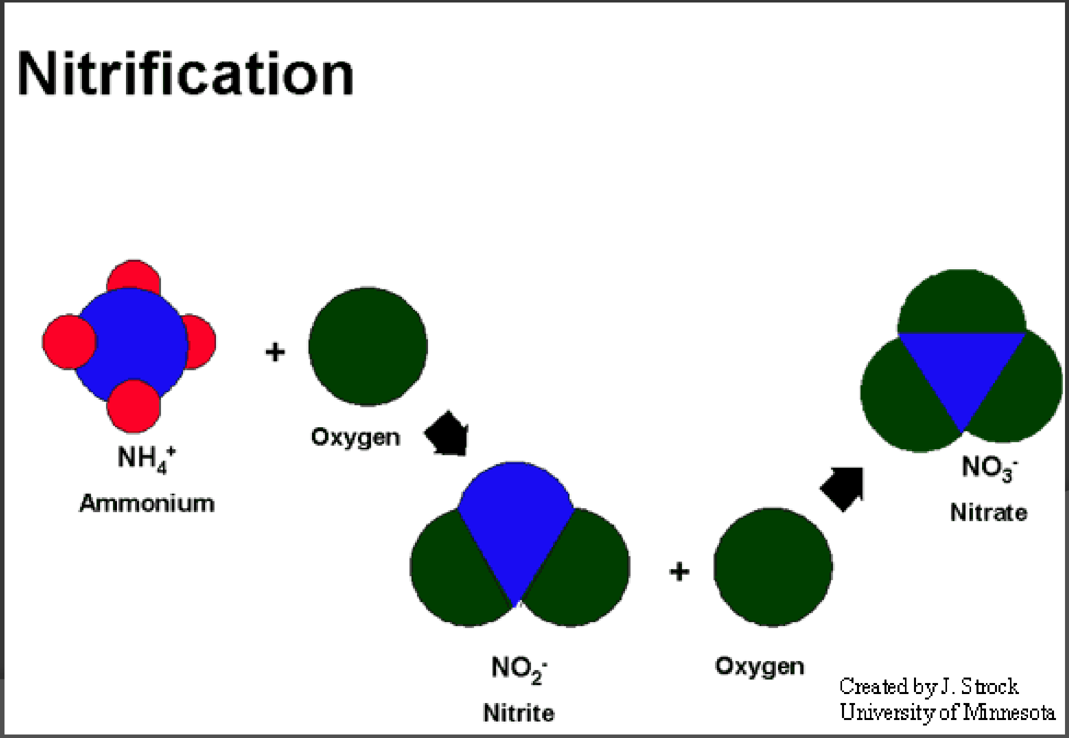
Water Quality Issues

- Microbiological
  - Coliform bacteria
    - Indication of possible contamination
    - E. Coli & Salmonella prevention
  - Sources
    - Environmental
    - Vermin
    - Ground water infiltration



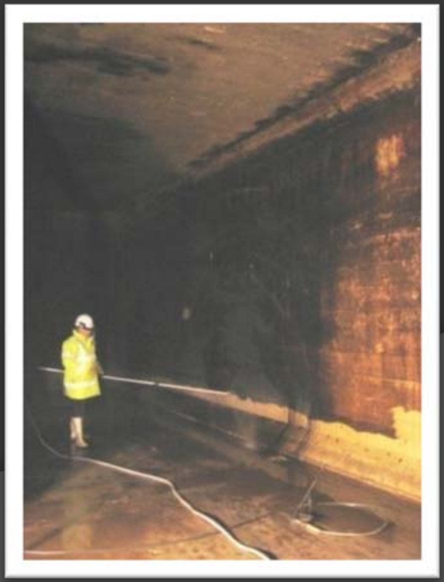
Water Quality Issues

- Microbiological
  - Nitrification (Chloramine Disinfection)
    - 2 step process creating nitrite & nitrate
    - Nitrite & nitrate can have harmful affects
      - Blue Baby Syndrome



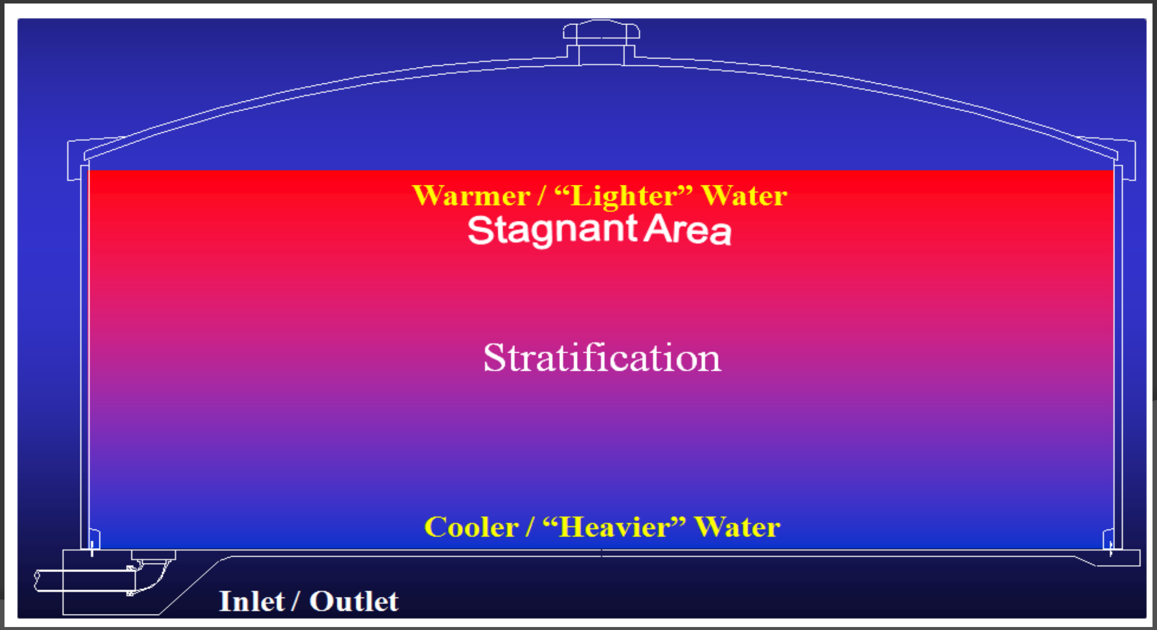
Water Quality Issues

- Physical
  - Sediment Buildup
    - Causes staining and discoloration
    - Water flow increase can stir up sediment, causing discoloration
    - Creates an environment for bacterial growth



Water Quality Issues

- Physical
  - Stratification
    - Thermocline
      - Creates layer of cooler “heavier water” and warmer “lighter water”
      - Inhibits mixing by creating barrier in water level



Water Quality Issues

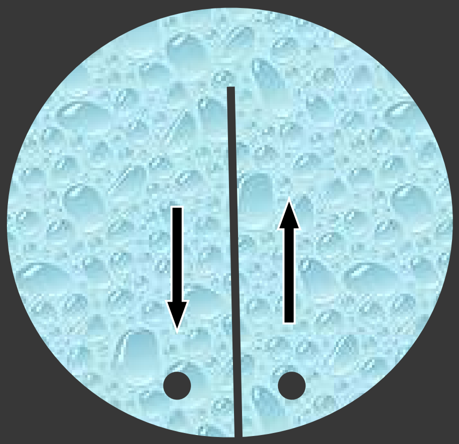
- Chemical
  - Disinfection by-products (DBP)
    - Reaction between disinfectant (typically chlorine) and organic matter in water creates certain acids.
    - These acids can reduce the pH in the water, causing the effectiveness of the chlorine to decrease.
  - Chlorine Residual Levels
    - High vs. Low
    - Taste & Odor

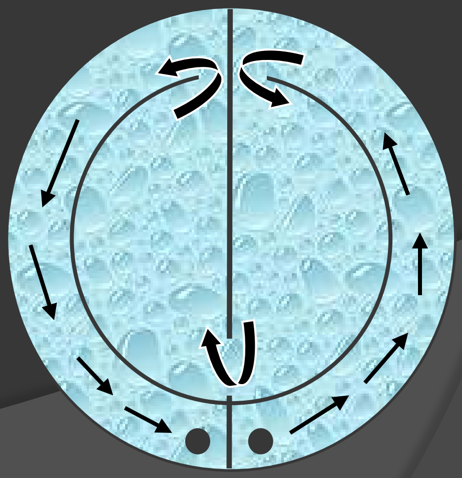
Solutions

Baffle Walls	• Fabric and/or Concrete
Mixing Systems	• Hydrodynamic vs Mechanical
Cleaning	• Chemical Application & Chlorine Disinfection

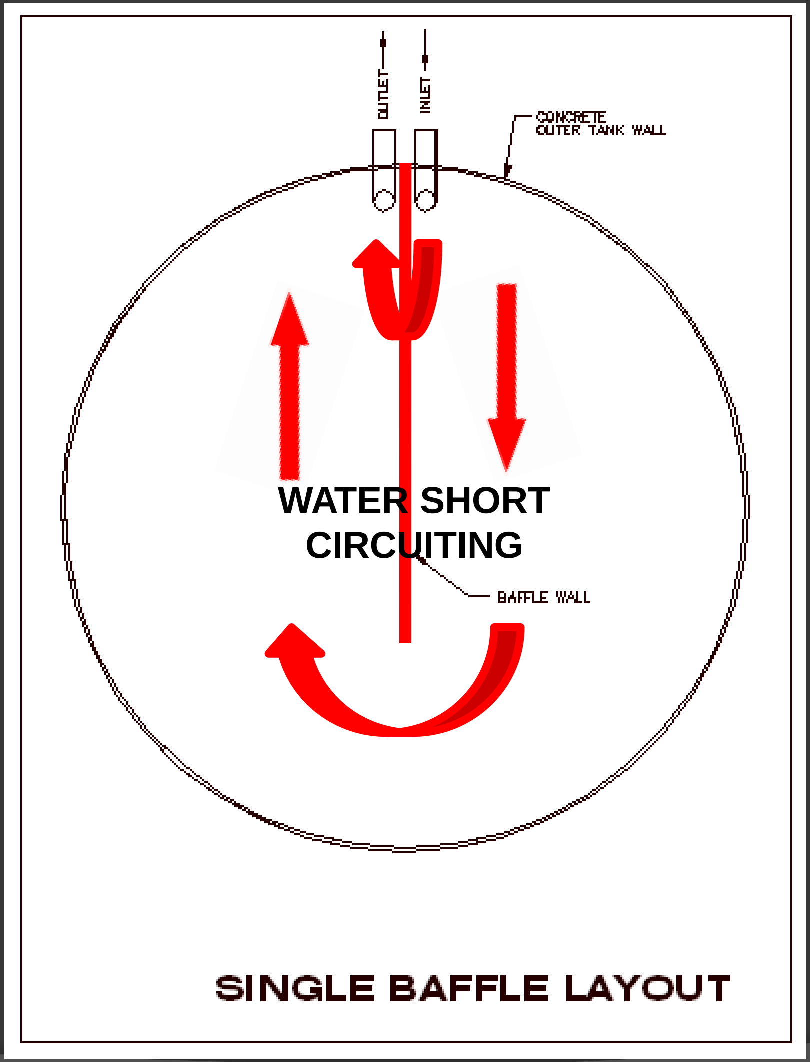
Baffle Walls

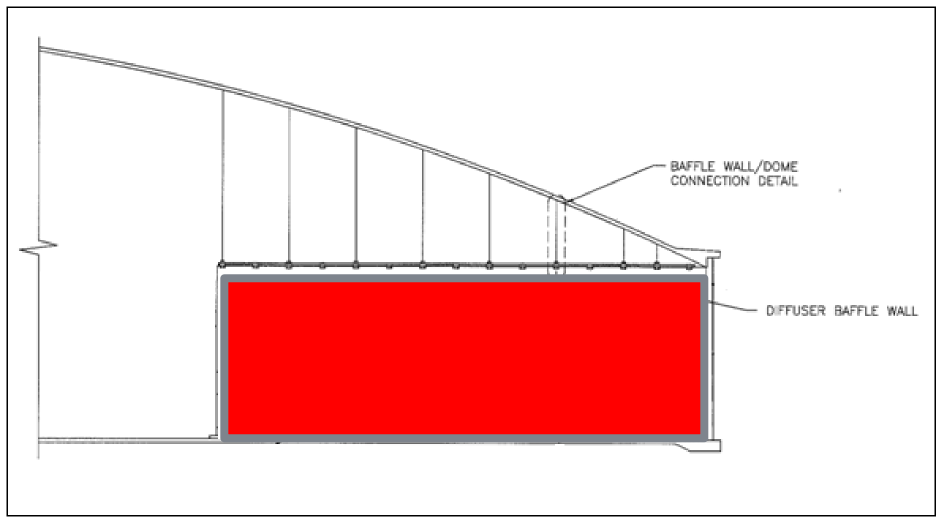
- Provides specific contact time (C_t) for water in tank
- Increases the efficiency of the tank (Plug Flow)
- Increases the path that the water travels from inlet to outlet
- Minimizes contact between entering water and water already in tank



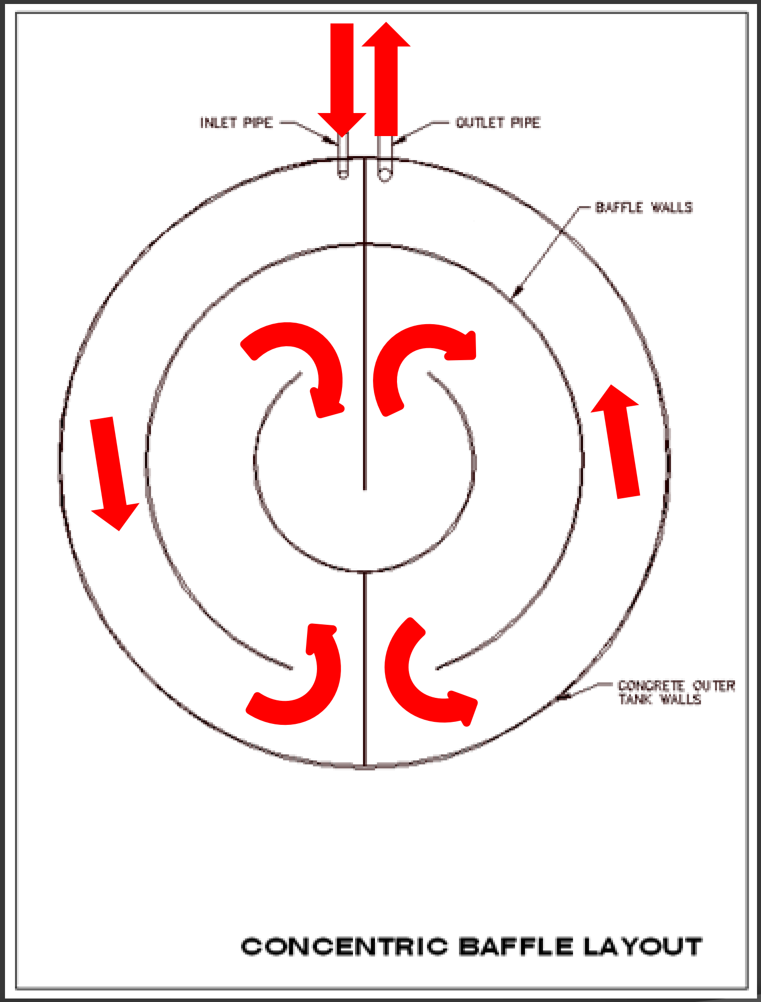


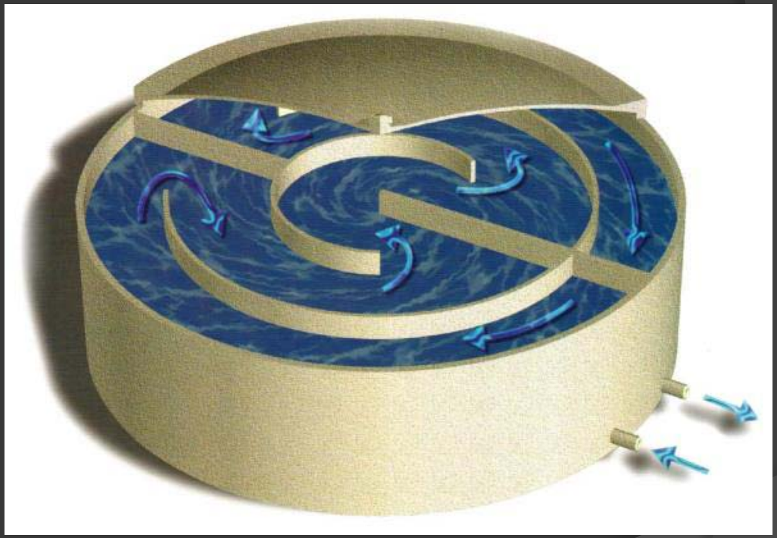
Single Curtain Baffle





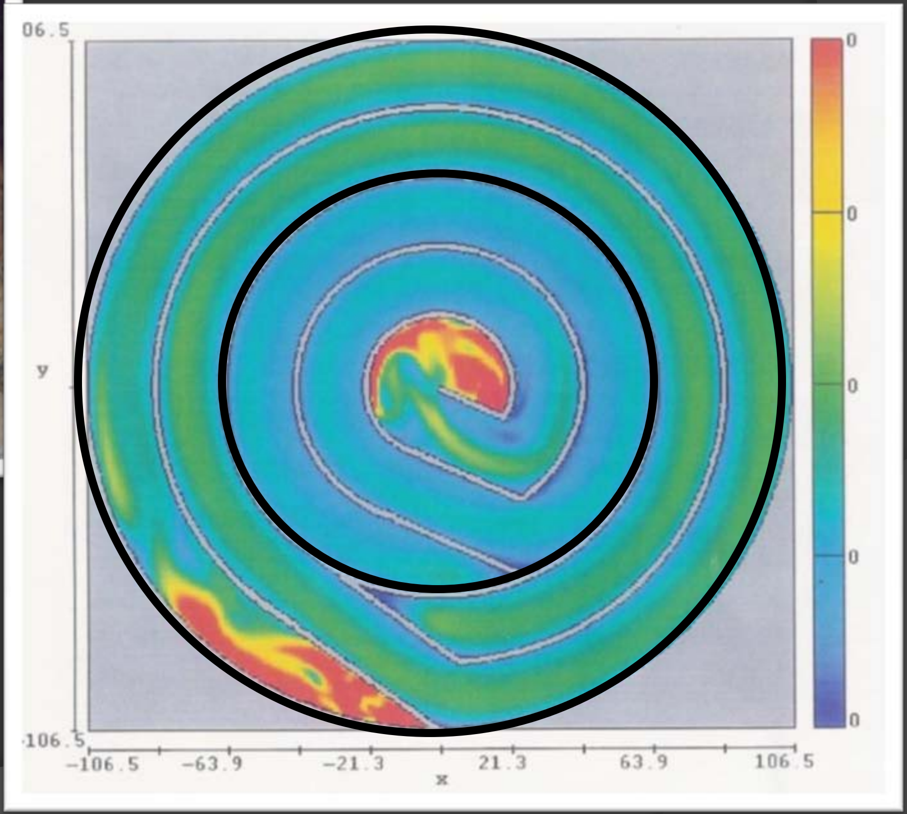
Fabric & Concrete Concentric C Baffles





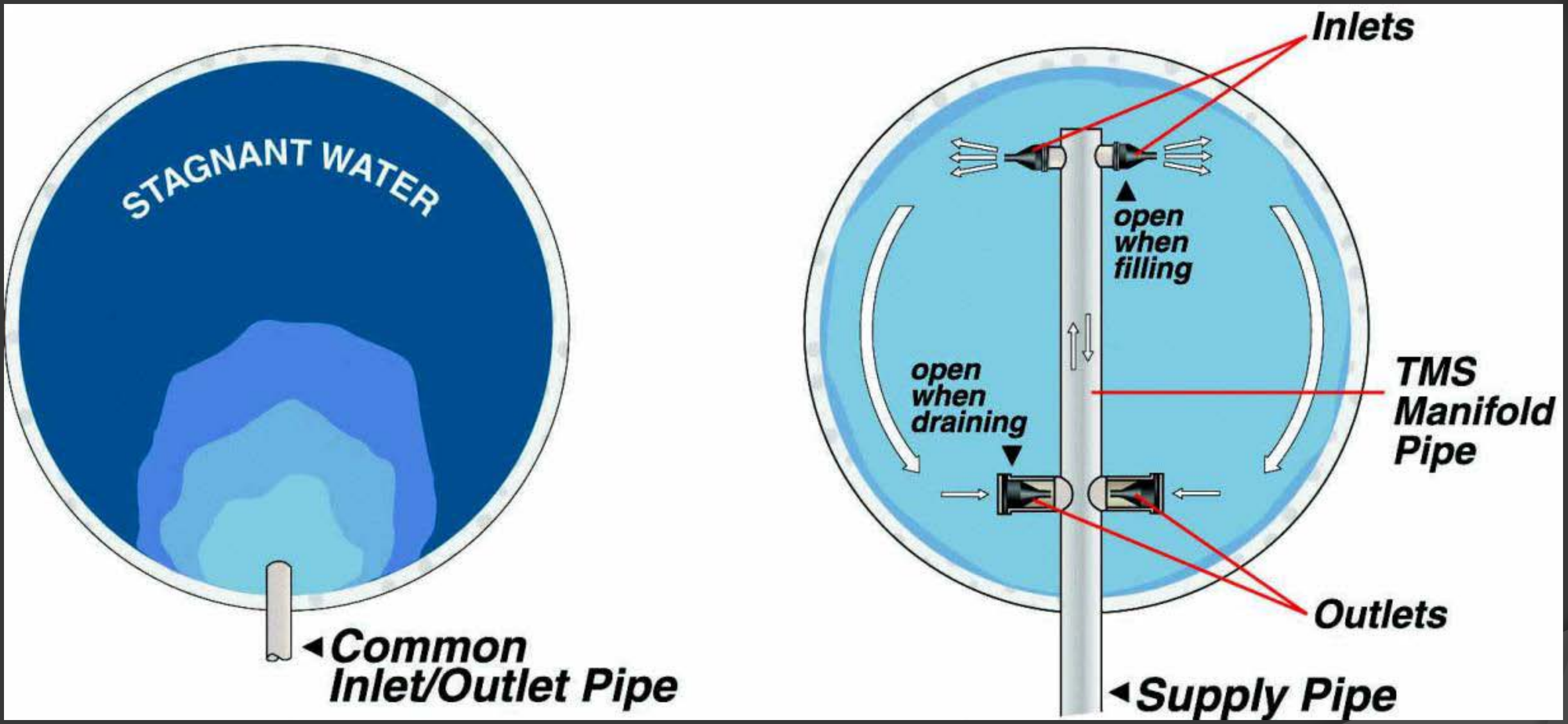
Concentric C Baffle

2.0 MG Tank within 5.0 MG Tank both with Interior Baffles



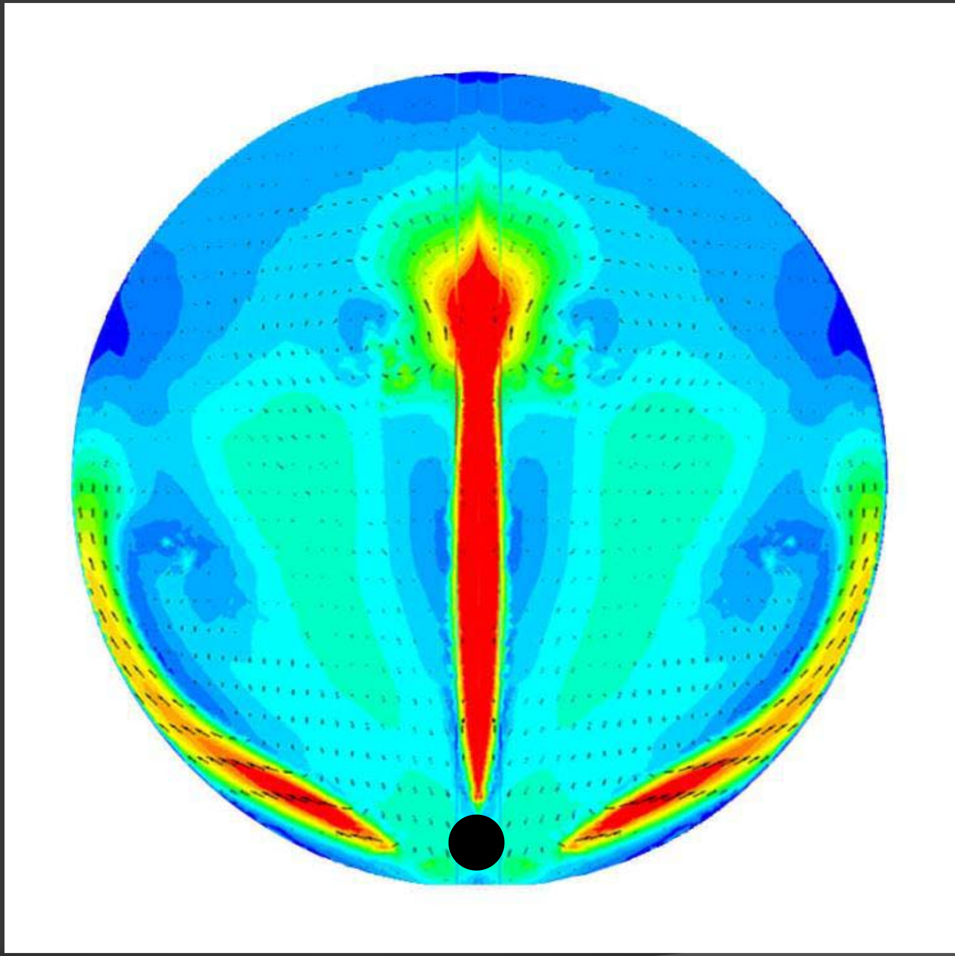
Cleveland Tracer Study-Velocity Magnitude

Hydrodynamic Mixing Systems



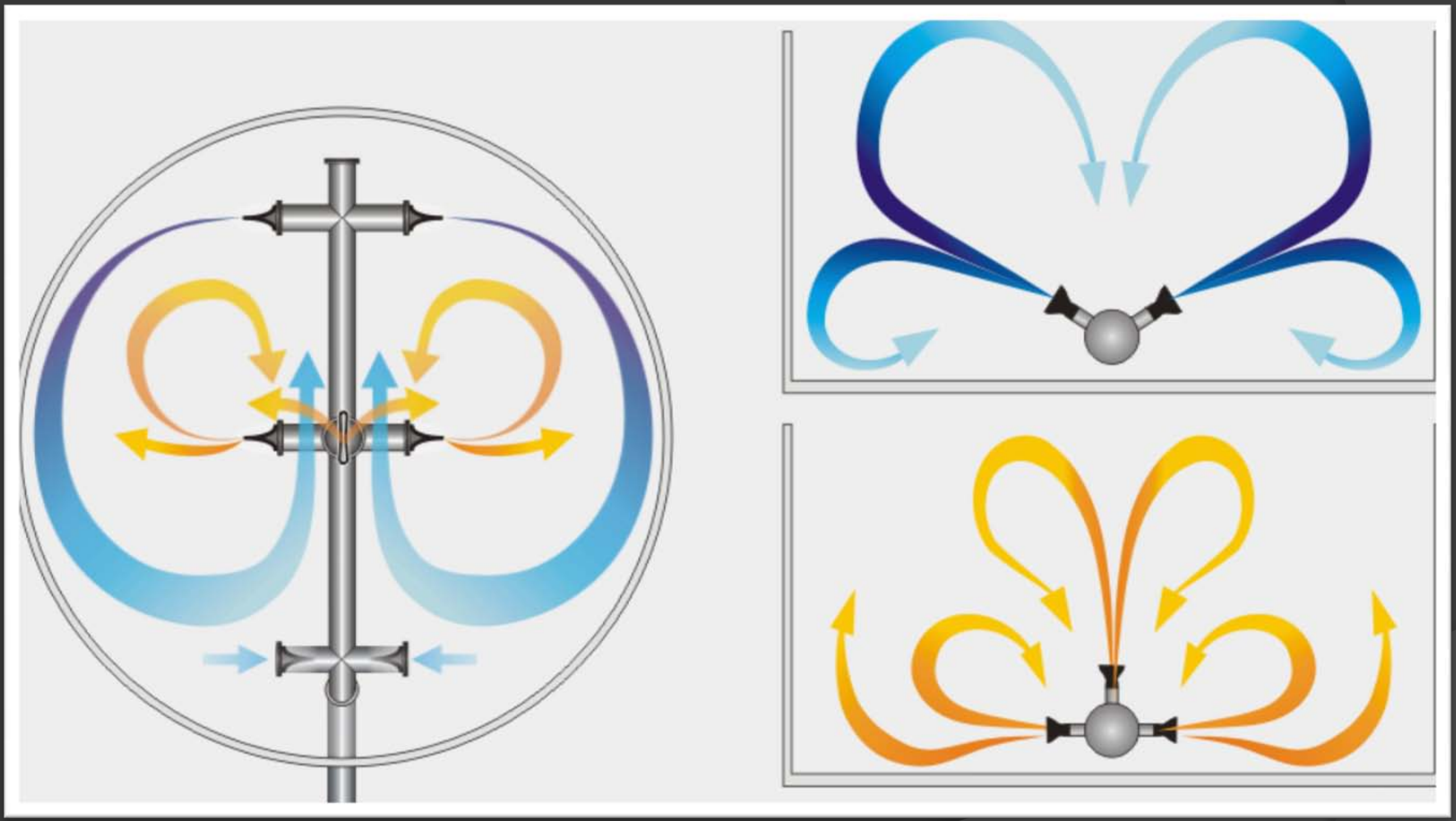
Tideflex Technologies

Hydrodynamic Mixing Systems



Velocity Gradient of a Vertical Mixing System Inside of a Water Tank

Inlet & Outlet Header with Inlet Jets

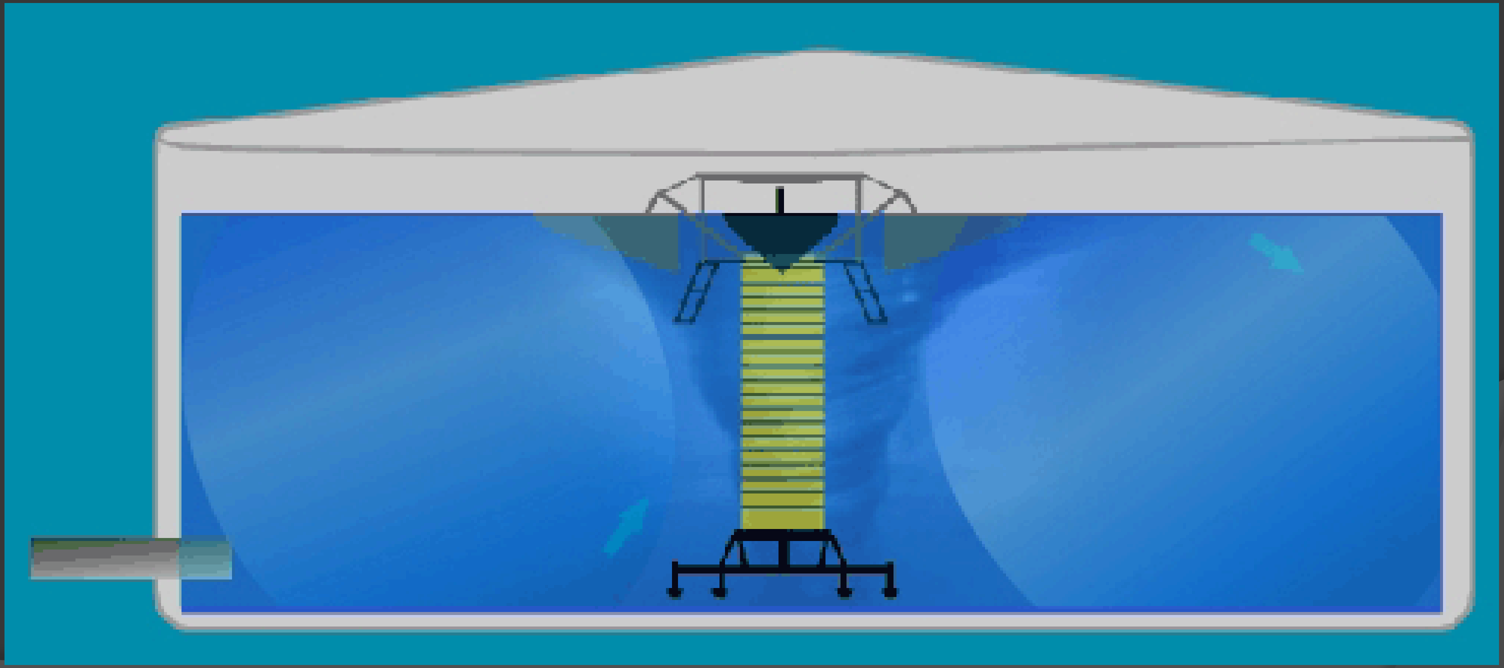


Brown & Caldwell

Hydrodynamic Mixing System Across Floor

Mechanical Mixing System

- Prevents stagnation, thermal stratification, nitrification and short circuiting.
- Provides complete mixing of influent and outflow.
- Can be solar powered.



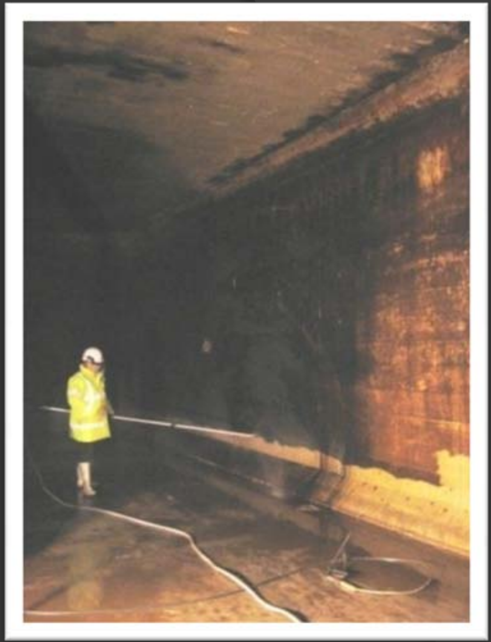
Solarbee, Inc.

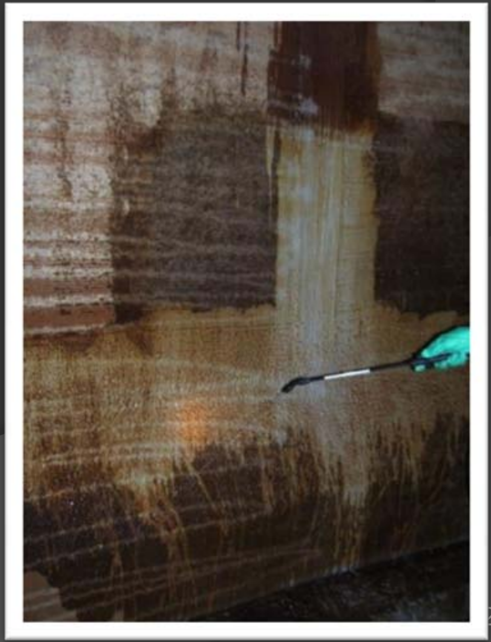
Hydrodynamic vs. Mechanical Mixing

- Hydrodynamic Mixing
  - Advantage: Zero Maintenance
    - No moving parts
  - Disadvantage: May require longer fill cycle for proper mixing (Inflow Dependent)
- Mechanical Mixing
  - Advantage: Length of fill cycle is not a factor
    - Constantly mixing
  - Disadvantage: Requires maintenance and power source

Tank Cleaning

- Chlorine Disinfection
  - Interior Chlorine Rinse
  - Routine testing and cleaning can prevent bacteria growth and potential health hazards
- Chemical Cleaning
  - Iron & Manganese Removal
    - Fe & Mg may be present in groundwater
  - Removes Biofouling
  - Chlorine Alternative – Less Harmful





Clearwell with Heavy Iron & Manganese Buildup

Biofouling and Iron & Manganese Buildup

What Have We Learned?

- Maintaining water quality is a critical issue
  - Entire communities are at risk
- Communities depend on clean water
  - 24/7 - 365 days a year
- Existing infrastructure can be retrofitted to ensure water system is safe and reliable

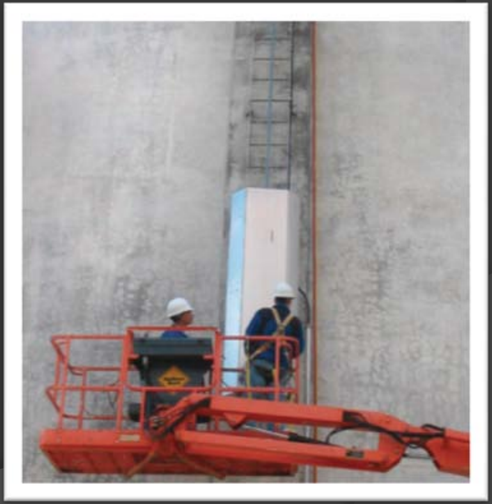
Vs.

Preventing Potential Issues

- Perform routine self inspections
  - Identify potential issues before they become major problems
- Professional Inspection every 5 years
  - Interior/Exterior
  - Should include inspection report sealed by a Professional Engineer

Preventing Potential Issues

- Self Inspection Checklists
  - Know what type you have
  - Screens intact and tight
    - All vents and overflows
  - Cracks in tank structure
  - Coating Failure
  - Wet or Damp areas
  - Concrete spalling
  - Ladders and safety climbs
  - Hatch functionality
    - lock and hinges



Retrofitting Existing Tanks

- It's never too late to retrofit a tank
  - Regulatory changes
  - Changing needs of a community
  - Water quality issues
  - Safety, Security and Access upgrades



QUESTIONS?