2024 Utility Technology Conference

Tennessee Association of Utility Districts
Vital for Tennessee's future

FOUNDATION INSTRUMENTS

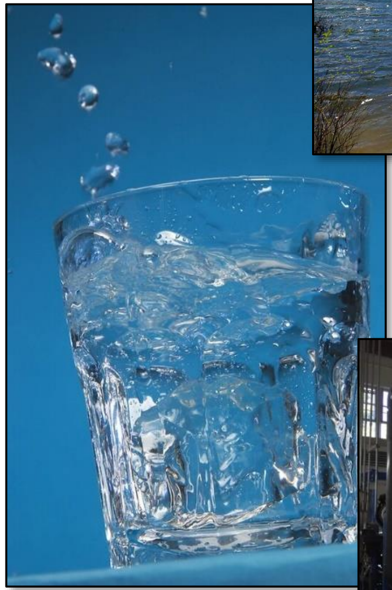
Keep Calm and Carry On… Being THM Compliant

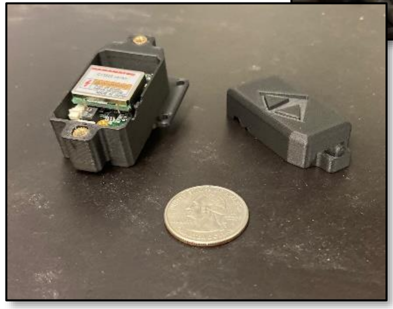
March 7, 2024

Paul Brister, Ph.D.

Foundation Instruments, Inc.

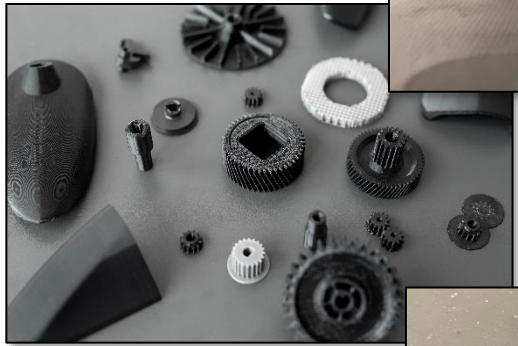
- Formed as a high-tech spinout from the University of Memphis in 2009
- Flagships products include analyzers for on-line, on-site and real-time monitoring of DBPs
- Leverage deep knowledge of drinking water chemistry and instrumentation to help utilities optimize and implement process improvements
- Focus on “making hard measurements easy”
- Diverse technical team including Analytical Chemists, Mechanical, Electrical, Software, and Computer Engineers
- Unique, sustainable business model

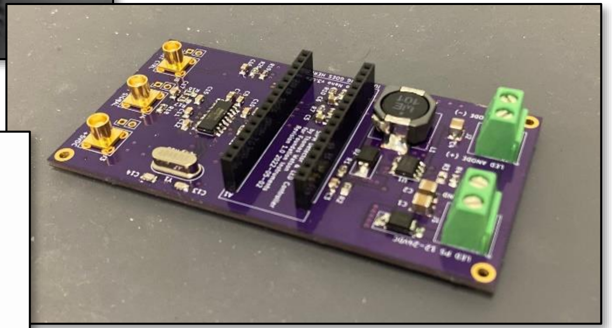



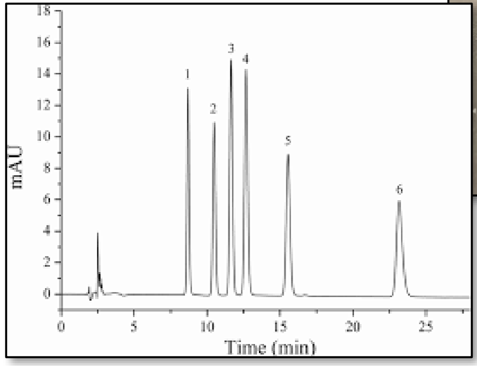


Core Capabilities

- *Instrumentation / Automation*
  - Deep analytical chemistry knowledge
  - Novel detection strategies
  - Expansion into other industries
- *3D Printing*
  - Continue to invest in 3D printing capabilities
  - Customization and optimization
  - Concept through to commercialization
- *Analytical Testing & Process Optimization*
  - Focus on DBP testing and analysis
  - Water treatment process mapping and optimization
- *Innovation*
  - New technology development







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Analyzers for Water Utilities

Remember…Our Goal is to Make Hard Measurements Easy

- Product line built around DBP analysis
- Current SBIR Phase II project focused on developing low-cost analyzers to reach small to mid-sized water treatment plants (THM-Meter)
- UofM Partnership

THM-Rapid Response

THM-Meter

HAA-Rapid Response

EZ-Titrator

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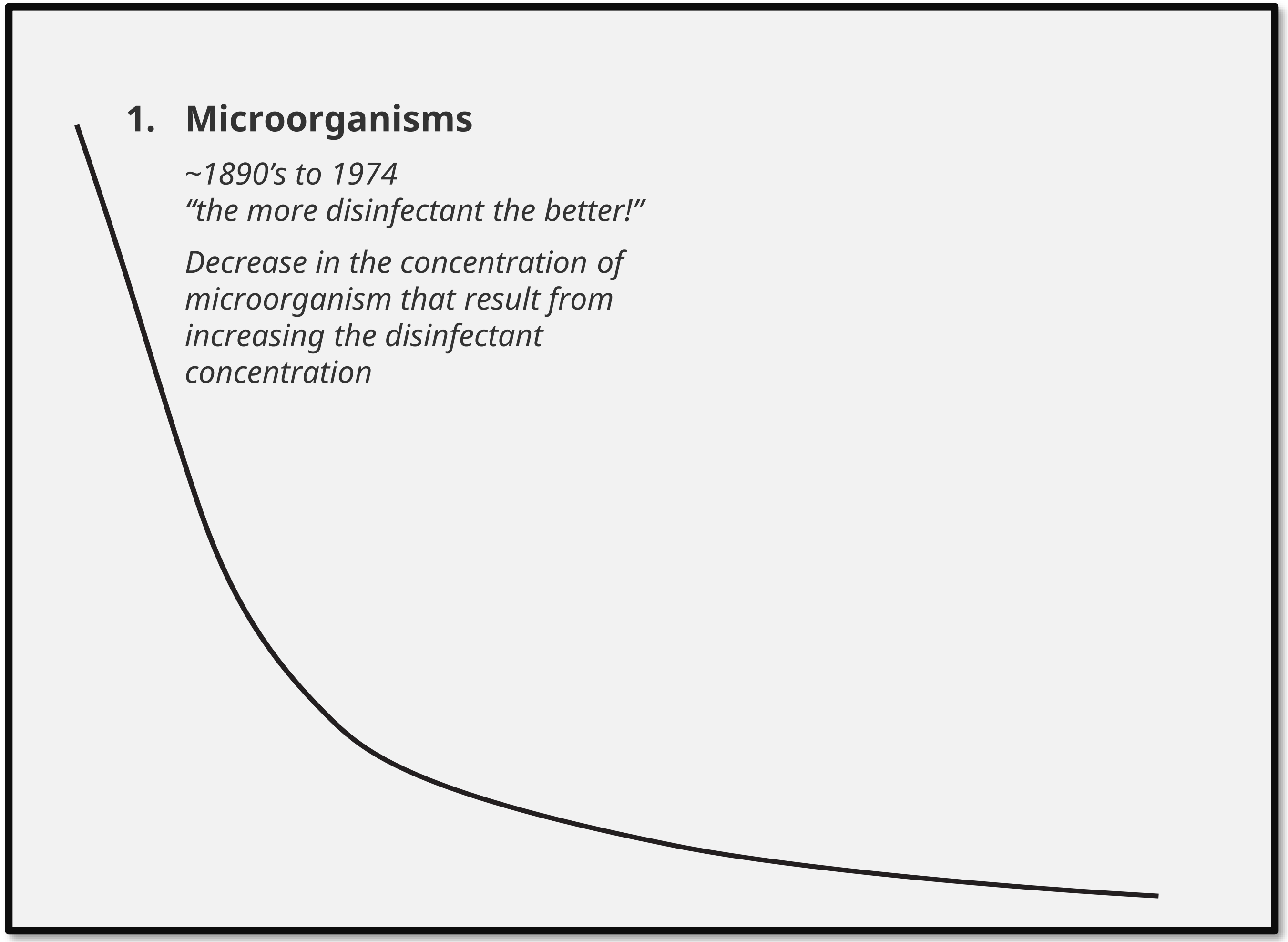
An Intro to Disinfection By-Products (DBPs)

Changing Strategies toward Drinking Water Disinfection



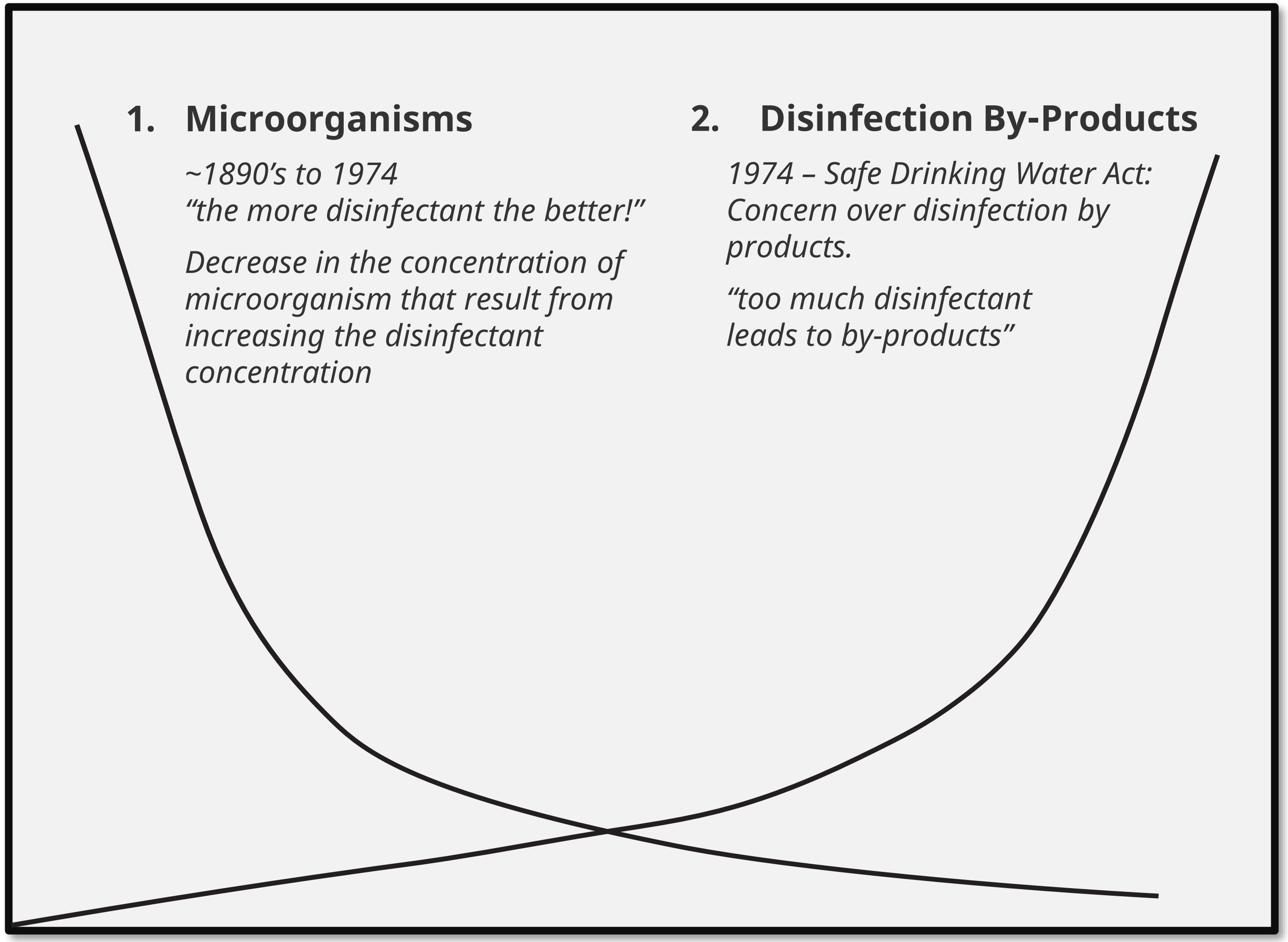
Concentration of Pathogenic Microorganisms

(concentration of organism increasing from bottom to top)

Concentration of Disinfectant (mg/L)

(chemicals such as chlorine gas, sodium hypochlorite, calcium hypochlorite, chlorine dioxide, and ozone that are used to disinfect drinking water; increasing going from left to right)

Changing Strategies toward Drinking Water Disinfection



Concentration of Pathogenic Microorganisms

(concentration of organism increasing from bottom to top)

Concentration of Disinfection By-Products (µg/L)

(Chemicals such as chlorinated hydrocarbons including Trihalomethanes and Haloacetic acids and bromate ion; concentration increasing from bottom to top of axis)

Concentration of Disinfectant (mg/L)

(chemicals such as chlorine gas, sodium hypochlorite, calcium hypochlorite, chlorine dioxide, and ozone that are used to disinfect drinking water; increasing going from left to right)

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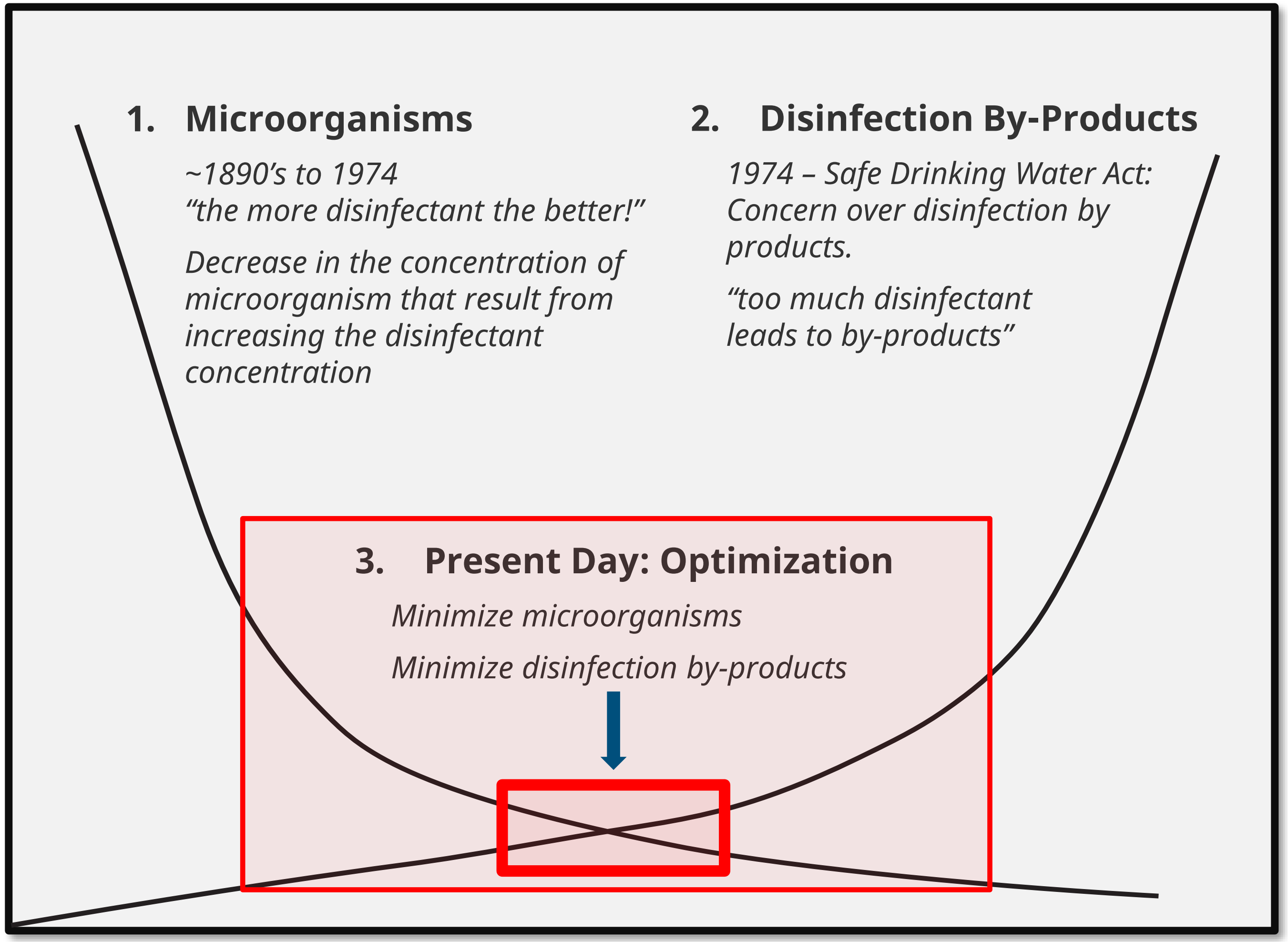
Changing Strategies toward Drinking Water Disinfection



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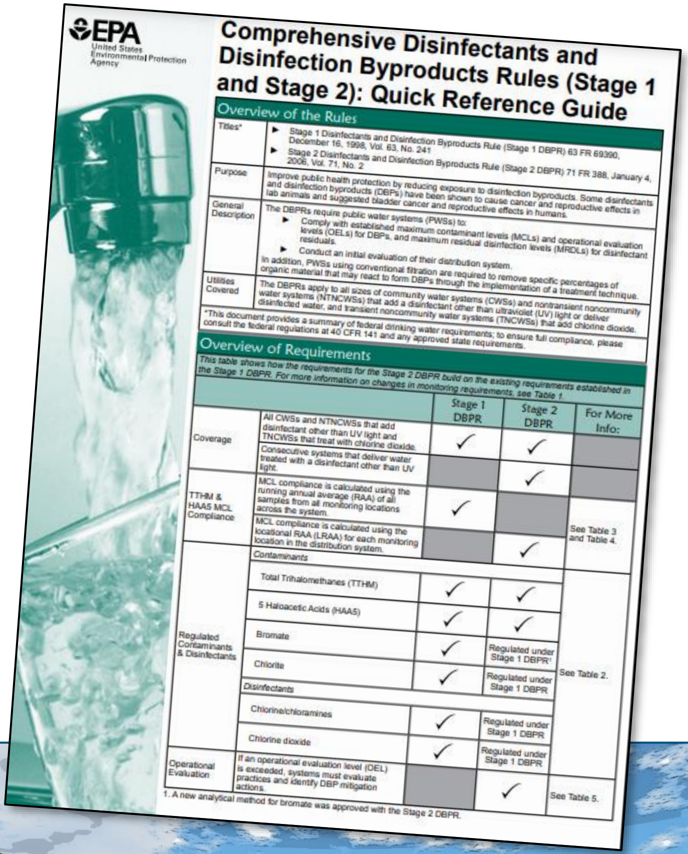
Background on DBPs

- Government regulations with regard to DBPs have become stricter
- Rules require public water systems to comply with maximum contaminant levels (MCLs) and operational evaluation levels (OELs) for DBPs
- Sampling based on source water type, population, and number of treatment plants, or wells
- Many utilities struggle each year to meet these regulations – especially Trihalomethanes (THMs) and Haloacetic Acids (HAAs)



EPA United States Environmental Protection Agency

Comprehensive Disinfectants and Disinfection Byproducts Rules (Stage 1 and Stage 2): Quick Reference Guide

Overview of the Rules

Titles*	► Stage 1 Disinfectants and Disinfection Byproducts Rule (Stage 1 DBPR) 63 FR 69390, December 16, 1998, Vol. 63, No. 241 ► Stage 2 Disinfectants and Disinfection Byproducts Rule (Stage 2 DBPR) 71 FR 388, January 4, 2006, Vol. 71, No. 2
Purpose	Improve public health protection by reducing exposure to disinfection byproducts. Some disinfectants and disinfection byproducts (DBPs) have been shown to cause cancer and reproductive effects in lab animals and suggested bladder cancer and reproductive effects in humans.
General Description	The DBPRs require public water systems (PWSs) to: ► Comply with established maximum contaminant levels (MCLs) and operational evaluation levels (OELs) for DBPs, and maximum residual disinfection levels (MRDLs) for disinfectant residuals. ► Conduct an initial evaluation of their distribution system. In addition, PWSs using conventional filtration are required to remove specific percentages of organic material that may react to form DBPs through the implementation of a treatment technique.
Utilities Covered	The DBPRs apply to all sizes of community water systems (CWSs) and nontransient noncommunity water systems (NTNCWSs) that add a disinfectant other than ultraviolet (UV) light or deliver disinfected water, and transient noncommunity water systems (TNCWSs) that add chlorine dioxide.

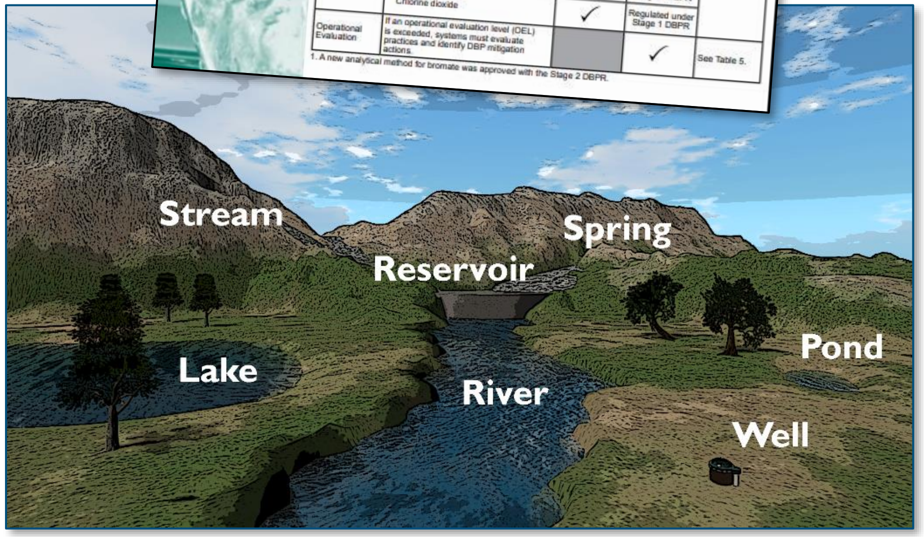
*This document provides a summary of federal drinking water requirements; to ensure full compliance, please consult the federal regulations at 40 CFR 141 and any approved state requirements.

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*			
	Total Trihalomethanes (TTHM)	✓	✓	
	5 Haloacetic Acids (HAA5)	✓	✓	
	Bromate	✓	Regulated under Stage 1 DBPR[1]	
	Chlorite	✓	Regulated under Stage 1 DBPR	See Table 2.
	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.



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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.

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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.

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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 dioxide	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]	

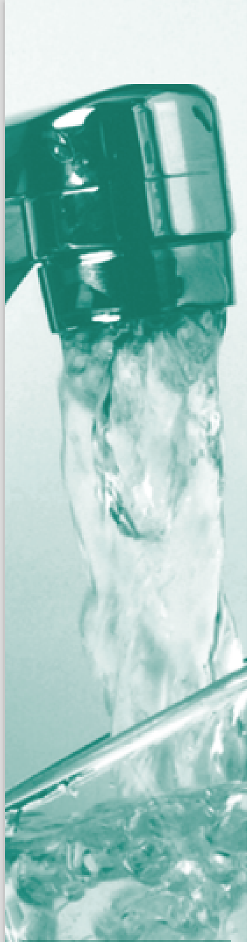
[1] All systems must monitor during the month of highest DBP concentrations. Systems on quarterly monitoring, except Subpart H systems serving 500 - 3,300, must take dual sample sets every 90 days at each monitoring location. Systems on annual monitoring and Subpart H systems serving 500 - 3,300 are 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.



For additional information on the DBPRs:

Call the Safe Drinking Water Hotline at 1-800-426-4791; visit the EPA web site at http://water.epa.gov/drink; or contact your state drinking water representative.

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.

Table 7. TOC Removal

Subpart H systems that use conventional filtration treatment are required to remove specific percentages of organic materials, measured as total organic carbon (TOC), that may react with disinfectants to form DBPs. Removal must be achieved through a treatment technique (enhanced coagulation or enhanced softening) unless a system meets alternative criteria. Systems practicing softening must meet TOC removal requirements for source water alkalinity greater than 120 mg/L $CaCO_3$.

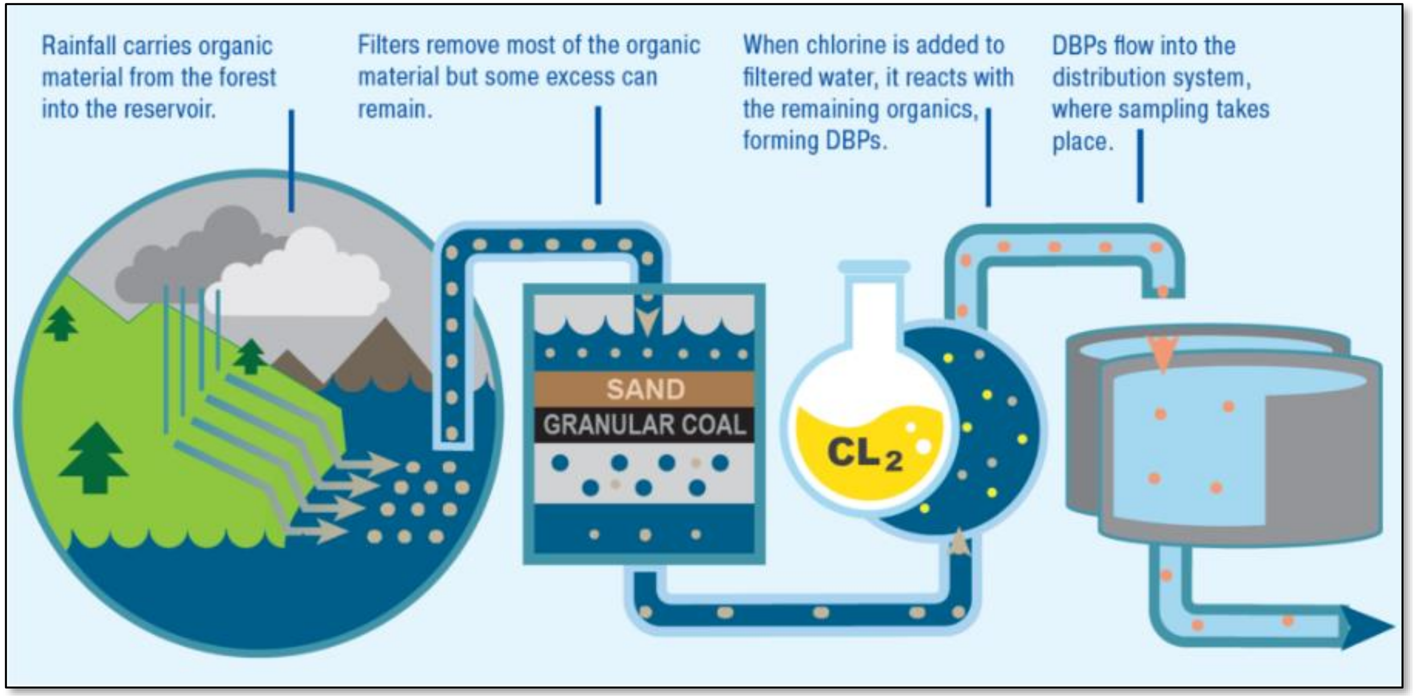
Source Water TOC (mg/L)	Source Water Alkalinity, mg/L as $CaCO_3$		
	0 - 60	> 60 to 120	> 120
> 2.0 to 4.0	35.0%	25.0%	15.0%
> 4.0 to 8.0	45.0%	35.0%	25.0%
> 8.0	50.0%	40.0%	30.0%

FOUNDATION INSTRUMENTS

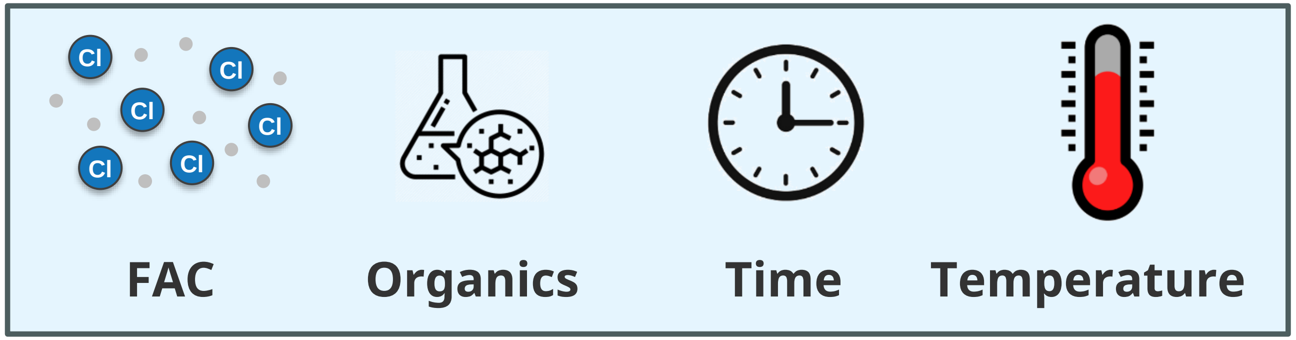
https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100C8XW.txt

What are DBPs and how do they form?

- The DBPs produced depend largely on which chemical disinfectant is used
- Chlorinated water -- (two common classes)
  - Trihalomethanes (THM4)
  - Haloacetic acids (HAA5)
- "Maximum Contaminant Levels" set by USEPA for finished water



Critical factors impacting THM formation:



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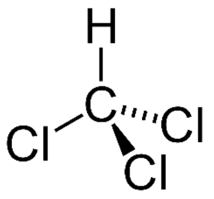
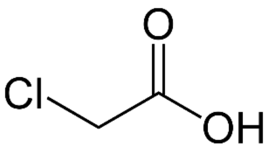
THMs and HAAs



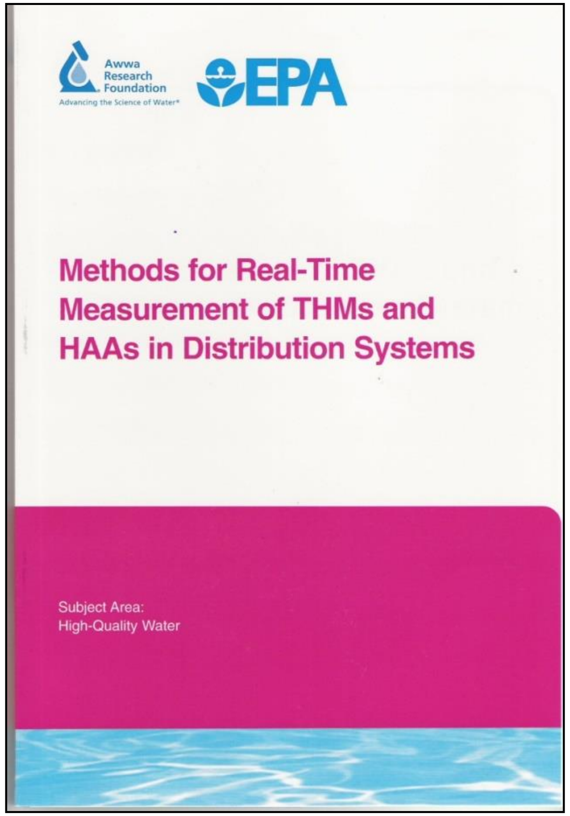
THM4	***MCL for Total-THM4 = 0.080 mg/L (80 µg/L)***		
$CHCl_3$ Chloroform	$CHBrCl_2$ Bromodichloro-methane	$CHBr_2Cl$ Dibromochloro-methane	$CHBr_3$ Bromoform



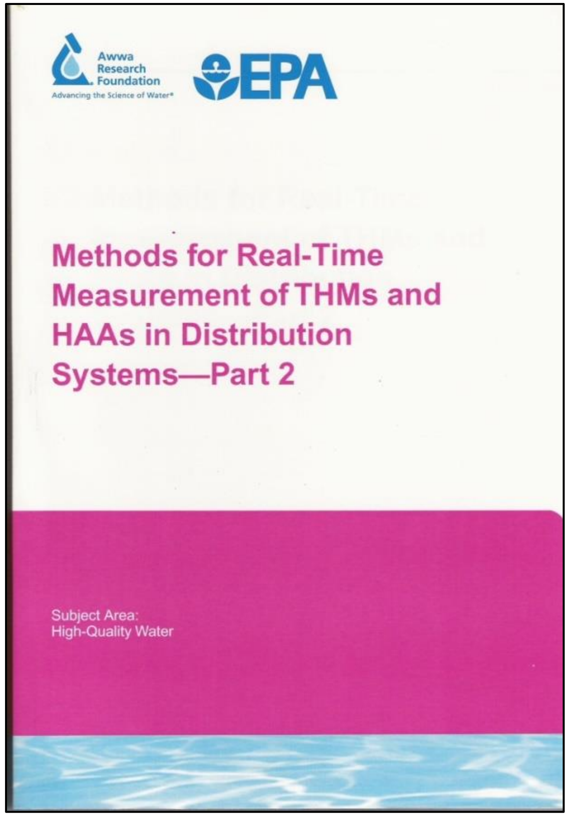
HAA5	***MCL for Total-HAA5 = 0.060 mg/L (60 µg/L)***			
CH_2ClCO_2H MCAA	$CHCl_2CO_2H$ DCAA	CCl_3CO_2H TCAA	CH_2BrCO_2H MBAA	$CHBr_2CO_2H$ DBAA

HAA9	***HAA5 plus four unregulated, but important HAAs***		
$CHBrClCO_2H$ BCAA	$CBrCl_2CO_2H$ BDCAA	CBr_2ClCO_2H DBCAA	CBr_3CO_2H TBAA

Water Research Foundation Project 2873



Emmert, G.L., Cao, G., Geme, G., Joshi, N. and Rahman, M. (2004) Methods for real-time measurement of THMs and HAAs in distribution systems. AWWARF and AWWA, Denver, CO.



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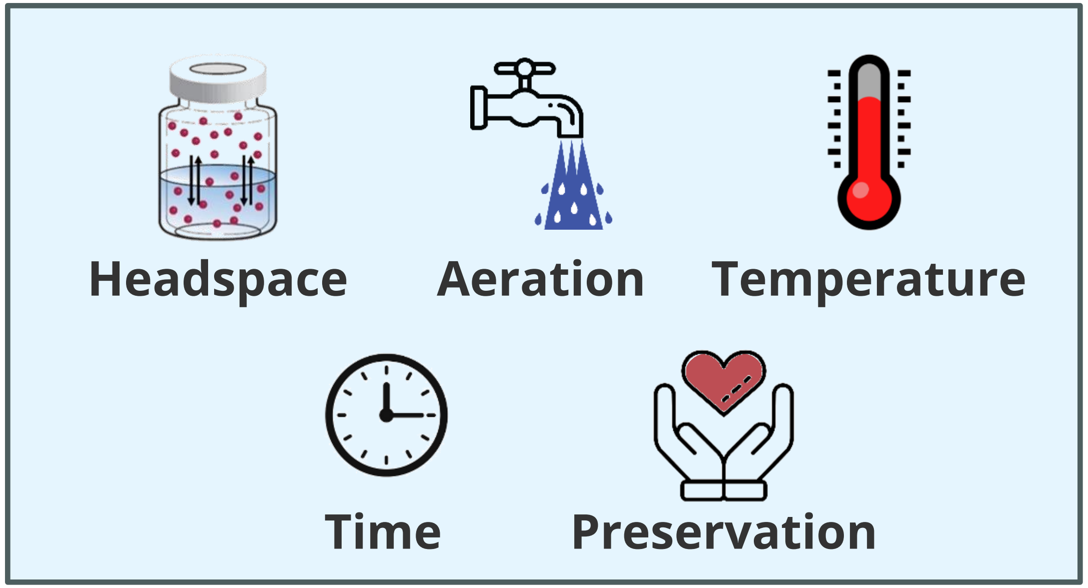
Does how I collect my THM sample really matter?

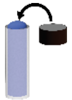
The best analytical tools are essentially worthless if performed on a sample that was improperly collected or handled

- This is especially true for THMs
- They really don't want to be in water (THMs vs HAAs)
- Think about how you remove THMs?
- I have collected organics and residual chlorine in a bottle…what will happen?

Critical factors impacting THM sampling:



Sampling Procedure Outline

	Sample collection should be done in an area free of excessive dust, rain, snow or other sources of contamination.
	Select a cold water faucet for sampling which is free of screens, aeration devices, hoses, purification devices or swiveled faucets. Faucets with screens and aeration devices can volatilize THMs causing a false reading.
	Run the faucet to thoroughly flush lines. Generally, 2 to 3 minutes will suffice. The water temperature will stabilize which indicates flushing is completed. Once the lines are flushed, reduce the flow to about 500 mL/min (a gentle thin stream).
	Fill the sample vials by running the gentle stream of water along the inner wall of the vial (to minimize the formation of air bubbles). Fill the sample vial approximately three fourths full and add 4 drops of 1:1 HCl. Continue to fill the sample vial to the brim forming a positive (convex) meniscus. ***Do not overflow the vial because you will lose the preservatives and possibly compromise your sample!***
	Replace the cap by gently setting it on the water meniscus. The thin Teflon side of the liner should be in contact with the water in the vial. Tighten the cap firmly, but do not overtighten. It is relatively easy to break the neck of the vial by twisting too hard.
	Be sure that there are NO AIR BUBBLES in the sample vials after they are filled and capped. Turn the vial over to check for bubbles. If there is a bubble larger than the size of a small pea, open the vial and add more water.
	Sample collection should be done one vial at a time. Legibly label each vial. Open → Fill → Close → Label → Repeat
	Place the sample into a cooler with ice for delivery or transport to the laboratory

What are the Options for Daily Process Control Strategies for WTPs?

- In-House Laboratories
- Contract Labs
- On-Site process control options

FOUNDATION INSTRUMENTS

“The only time I have problems with THMs and HAAs is in the summer.”

Paraphrased from almost everyone I speak with in the industry.

FOUNDATION INSTRUMENTS

“The only time I have problems with THMs and HAAs is in the summer.”

Paraphrased from almost everyone I speak with in the industry.

	Winter		*Summer*
Total THMs	20 ppb	Assume 1st order kinetics	40 ppb
Temp (°F)	58		76
Temp (°C)	14.4	10°C increase Doubles Rate	24.4

“The only time I have problems with THMs and HAAs is in the summer.”

Paraphrased from almost everyone I speak with in the industry.

My thoughts on this –

- The best time to reduce DBPs (THMs and HAAs) is in the Winter, Spring and Fall quarters
- During these quarters, everything is working in your favor
- During the Summer, the “chemistry” is stacked against you – you are rowing against the stream

FOUNDATION INSTRUMENTS

Should I really measure THMs all year?!?

	Winter	Spring	Summer	Fall	LRAA	Goal	
THMs	20.0	50.0		47.0		80.0	ppb
HAA5	15.0	37.5		35.3		60.0	ppb

Should I really measure THMs all year?!?

	Winter	Spring	Summer	Fall	LRAA	Goal	
THMs	20.0	50.0	200.0	47.0	79.3	80.0	ppb
HAA5	15.0	37.5	150.0	35.3	59.4	60.0	ppb

FOUNDATION INSTRUMENTS

Should I really measure THMs all year?!?

	Winter	Spring	Summer	Fall	LRAA	Goal	
THMs	20.0	50.0	200.0	47.0	79.3	80.0	ppb
HAA5	15.0	37.5	150.0	35.3	59.4	60.0	ppb

THMs	117.5	>MCL
HAA5	88.1	>MCL

Exceeds Operational Evaluation Limit!

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

FOUNDATION INSTRUMENTS

Should I really measure THMs all year?!?

	Winter	Spring	Summer	Fall	LRAA	Goal	
THMs	20.0	50.0	200.0	47.0	79.3	80.0	ppb
HAA5	15.0	37.5	150.0	35.3	59.4	60.0	ppb

THMs	117.5	>MCL
HAA5	88.1	>MCL

Exceeds Operational Evaluation Limit!

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.

Let’s do some basic monitoring and optimization…

	Winter	Spring	Summer	Fall	LRAA	Goal	
THMs	20.0	35.0		35.0		80.0	ppb
HAA5	15.0	26.3		26.3		60.0	ppb

FOUNDATION INSTRUMENTS

Let’s do some basic monitoring and optimization…

	Winter	Spring	Summer	Fall	LRAA	Goal	
THMs	20.0	35.0	131.0	35.0	55.3	80.0	ppb
HAA5	15.0	26.3	98.3	26.3	41.4	60.0	ppb

Let's do some basic monitoring and optimization…

	Winter	Spring	Summer	Fall	LRAA	Goal	
THMs	20.0	35.0	131.0	35.0	55.3	80.0	ppb
HAA5	15.0	26.3	98.3	26.3	41.4	60.0	ppb

THMs	79.3	<MCL
HAA5	59.4	<MCL

Below Operational Evaluation Limit!

No additional Reporting Requirements or Plans

Hmmmmmmm…

But…you are gaming the system…

Nope. I'm following the law as it is written.

The USEPA does not want to set you up to fail. The regulations on THMs and HAAs can be met but it all starts with DAILY PROCESS CONTROL

THMs and HAAs should be monitored just like other parameters – pH, Alk, Hardness, Cl Dose etc.

Hmmmmmmm…

Operators need to understand the DAILY “diastole and systole” of their water treatment plant.

Overall Compliance in the LRAA does not depend on the Summer Quarter (when you have little control over events).

The foundation of Overall Compliance in the LRAA is laid in the other three quarters – when you are more in control

During the Winter, Spring and Fall, your mitigation strategies are at peak efficiency – more bang for the buck!

FOUNDATION INSTRUMENTS

Need for an on-site THMs analyzer

- Allows for a real-time response
- Proactive intervention
- Control strategies optimized on the fly

THM-METER™

Economical Total THM Analyzer

The THM-METER™ analyzer provides an economical means to measure Total THM concentration at your plant or out in the distribution system

- Technology fills a void for low cost, easy-to-use THM monitoring
- Enables small to medium sized utilities to bring in modern technology to aid in delivering safe drinking water to their customers
- Technology designed to reach the water treatment plants that need it the most!

FOUNDATION INSTRUMENTS

THM-METER™

Economical Total THM Analyzer

Analyzer Specifications:

Total THM Concentration: 10 to 200 ppb

RSD: ±5 ppb

Run Time: <1 hour

Reagents: Reagent A + Reagent B + UHP Water

Size: 20 in x 12 in x 11 in (*l* x *w* x h)

Weight: 29.9 lbs

Approximate Cost per Sample: ~$5 - 7.50/sample

Sample Prep: Fill vial with water sample

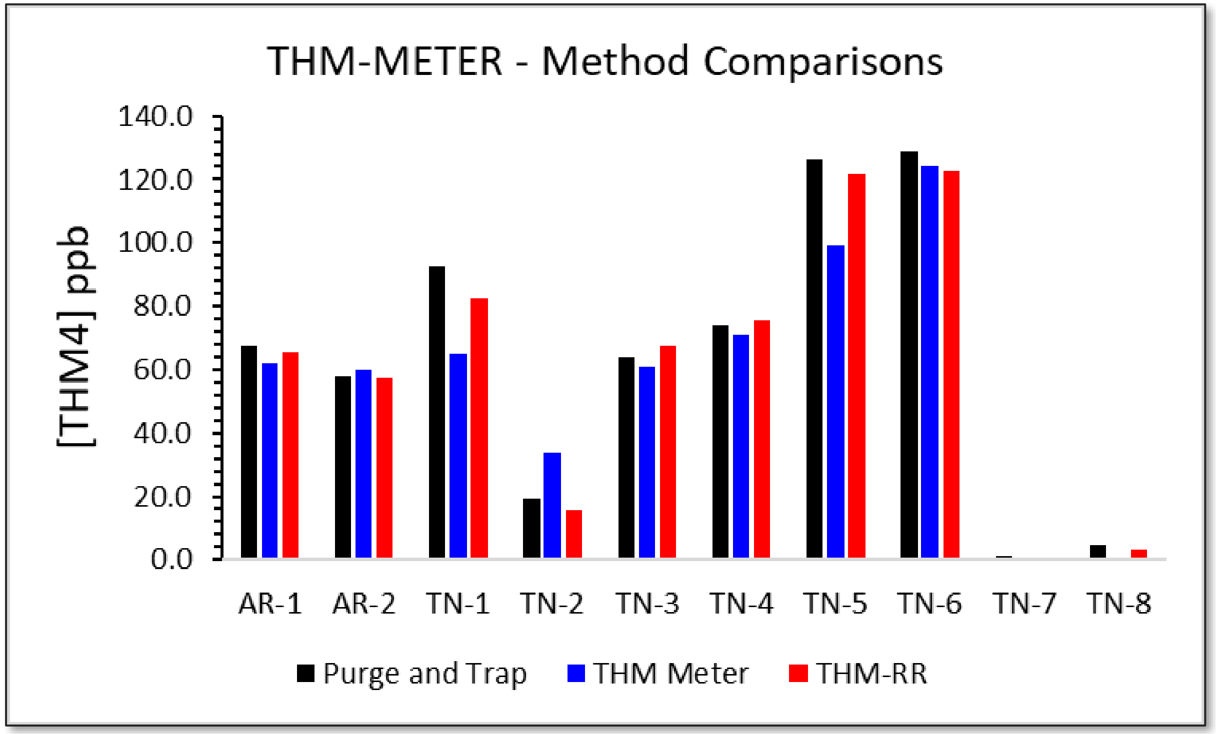
Skill Level: No specialized skills required

The THM-Meter works by reacting the THMs in the sample with proprietary reagents that generate a fluorescing compound that is proportional to the Total THMs in the sample.

THM-METER™ Method Comparison

The analyzer performance was compared with the GC-MS purge & trap method and the THM-RR instrument to assess field readiness

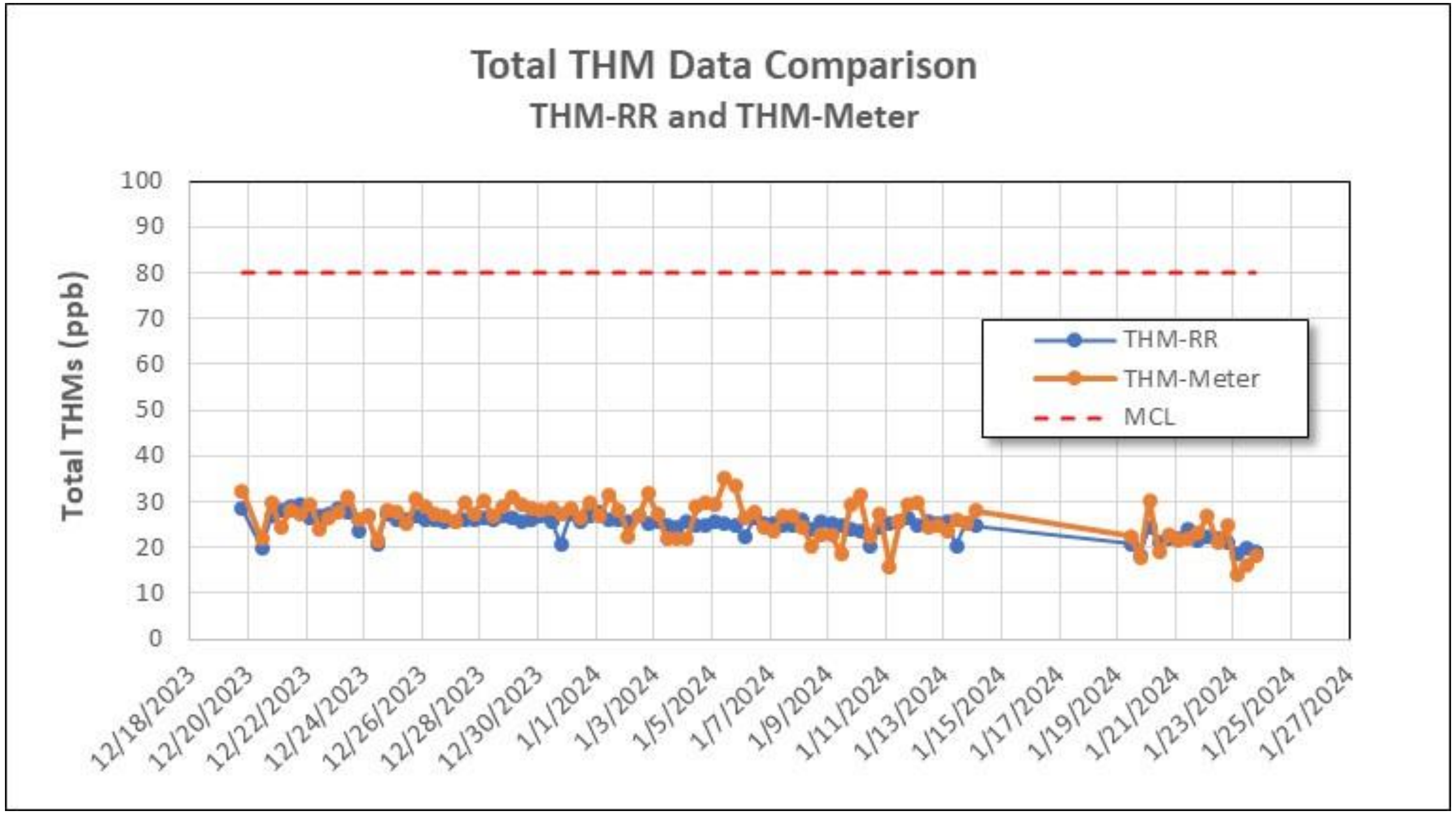
- Samples were collected from multiple locations and different water sources (ground, well, spring)
- Goal was to compare performance across validated THM analysis methods to assess system performance of the THM-METER
- The average bias between the THM-METER and established methods:
  - Purge & Trap: 6.9 ppb
  - THM-RR: 4.1 ppb



THM-METER™ Method Comparison

The analyzer was compared in online mode side-by-side to the THM-RR instrument to further assess system reliability and performance

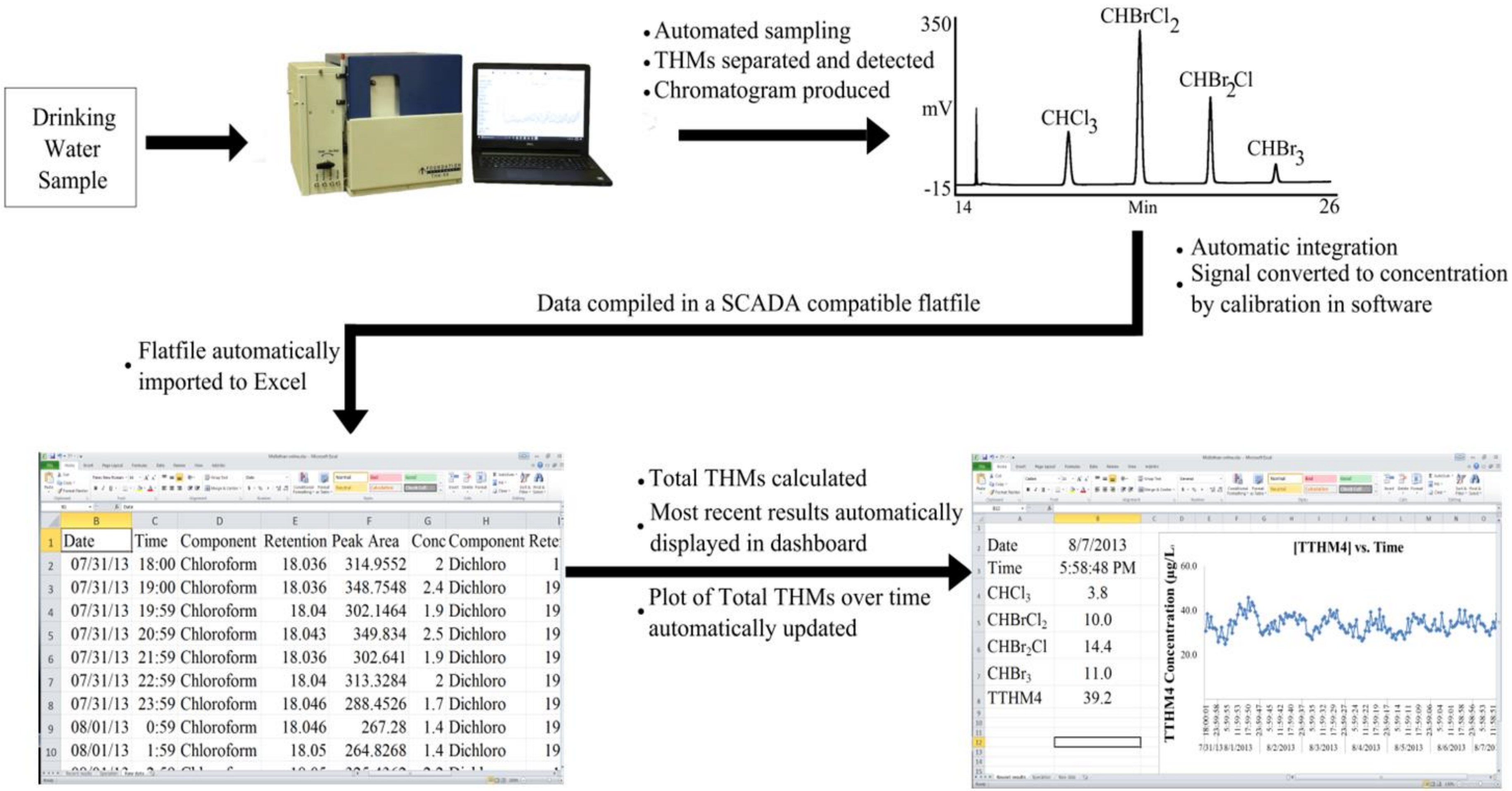
- Online sampling 3X daily over 6 weeks
- Sampled from same finished sampling adapter at same time points
- The average bias between the THM-METER and the THM-RR:
  - THM-RR: 1.2 ppb



THM-RR: Trihalomethane Rapid Response System

Commercialized version of the THM-RR with the RR-AutoCal Autosampler

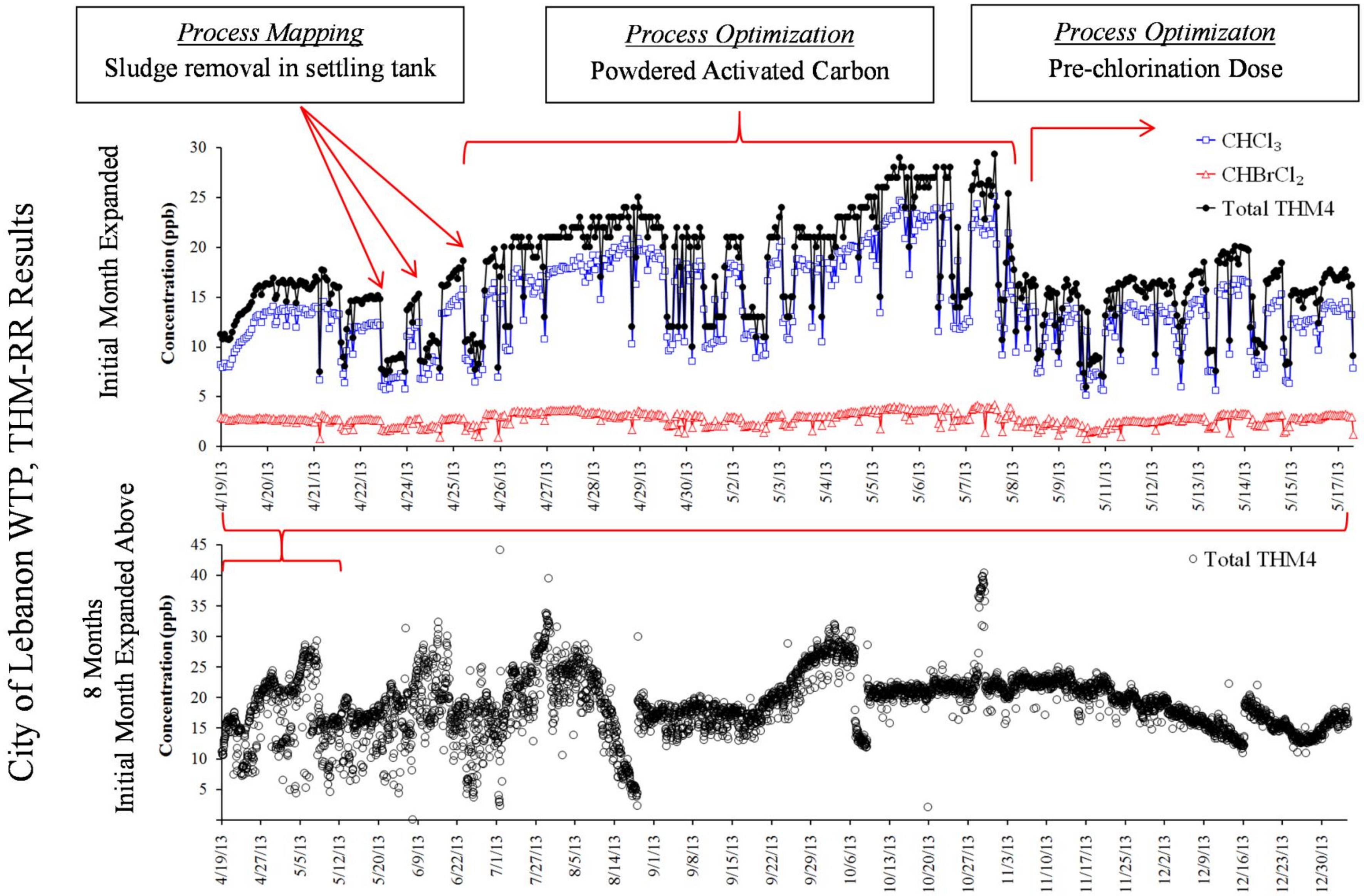
THM-RR: Fully automated sampling, data collection & reporting



FOUNDATION INSTRUMENTS

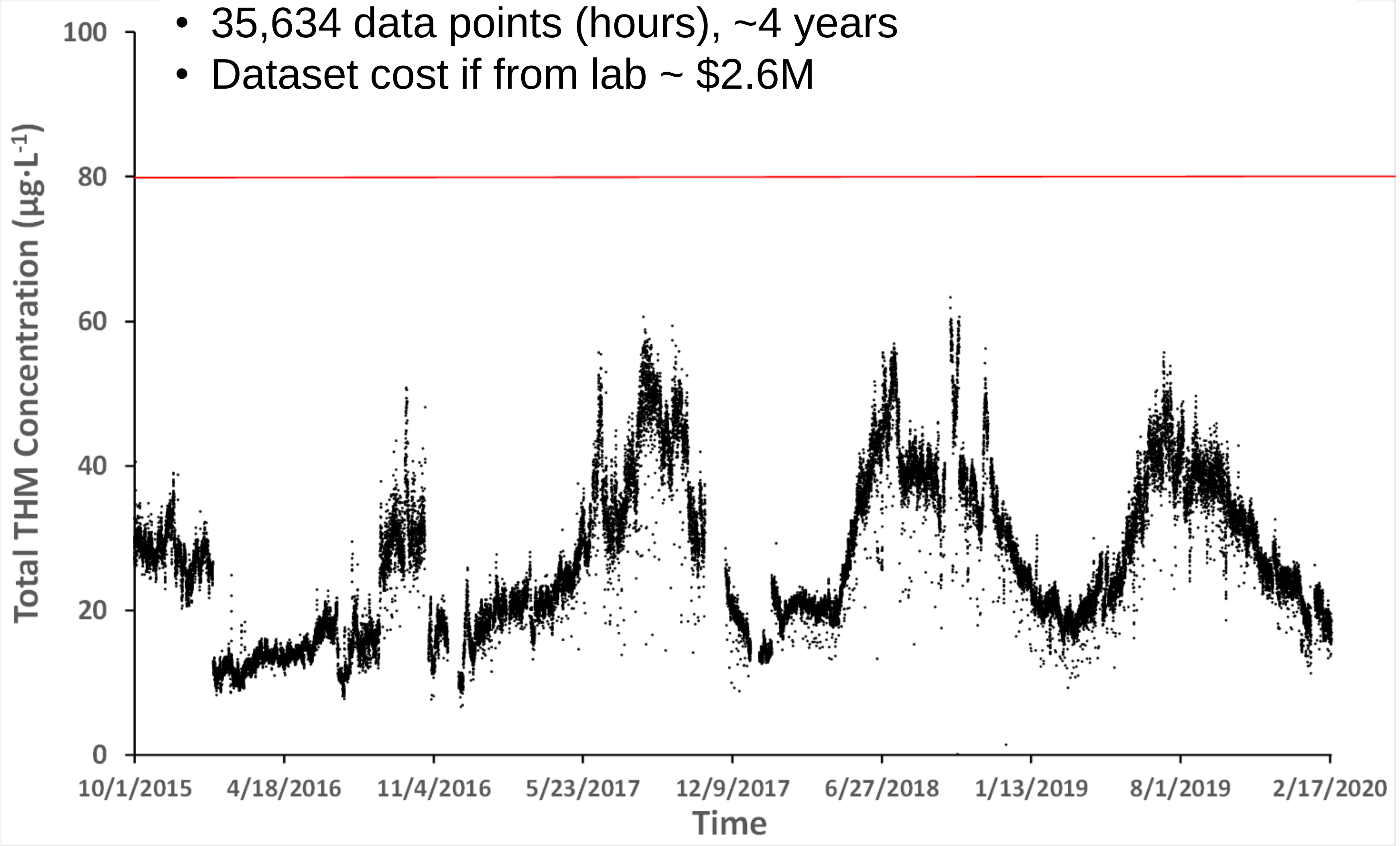
Quantification Range		
chloroform ($CHCl_3$)	0.06 – 60 $\mu g \cdot L^{-1}$ (ppb)	
bromodichloromethane ($CHBrCl_2$)	0.03 – 60 $\mu g \cdot L^{-1}$ (ppb)	
dibromochloromethane ($CHBr_2Cl$)	0.03 – 60 $\mu g \cdot L^{-1}$ (ppb)	
bromoform ($CHBr_3$)	0.1 – 60 $\mu g \cdot L^{-1}$ (ppb)	
Total THMs (TTHMs)	0.12 – 240 $\mu g \cdot L^{-1}$ (ppb)	
Accuracy and Precision		
@ 20 $\mu g \cdot L^{-1}$ (ppb)		
	Mean % Recovery	**%RSD**
chloroform ($CHCl_3$)	97	2
bromodichloromethane ($CHBrCl_2$)	101	2
dibromochloromethane ($CHBr_2Cl$)	97	1
bromoform ($CHBr_3$)	103	2
Total THMs (TTHMs)	99	1
@ 0.3 $\mu g \cdot L^{-1}$ (ppb)		
	Mean % Recovery	**%RSD**
chloroform ($CHCl_3$)	85	2
bromodichloromethane ($CHBrCl_2$)	81	2
dibromochloromethane ($CHBr_2Cl$)	77	1
bromoform ($CHBr_3$)	87	5
Total THMs (TTHMs)	83	2

THM-RR Process Optimization – Lebanon, TN



Extended On-line Monitoring Data (Lebanon, TN WTP)

- On-line monitoring data from Sept. 2015 to Feb. 2020
- 35,634 data points (hours), ~4 years
- Dataset cost if from lab ~ $2.6M



FOUNDATION INSTRUMENTS

HAA-RR™

Rapid Response Benchtop HAA Analyzer

The rapid response benchtop HAA-RR™ analyzer provides fast, reliable and accurate analysis of individual and total HAA concentrations.

- **Automated Operation**
  - Easy to use, results in 80 minutes
  - Optional auto sampler provides rapid unattended analysis for up to 12 samples
- **Comprehensive data**
  - HAA speciation data provided for HAA5 and HAA9
- **Operational Optimization**
  - Replaces reliance on external laboratories for performance control
  - Enables near-real time tracking and response for HAA control

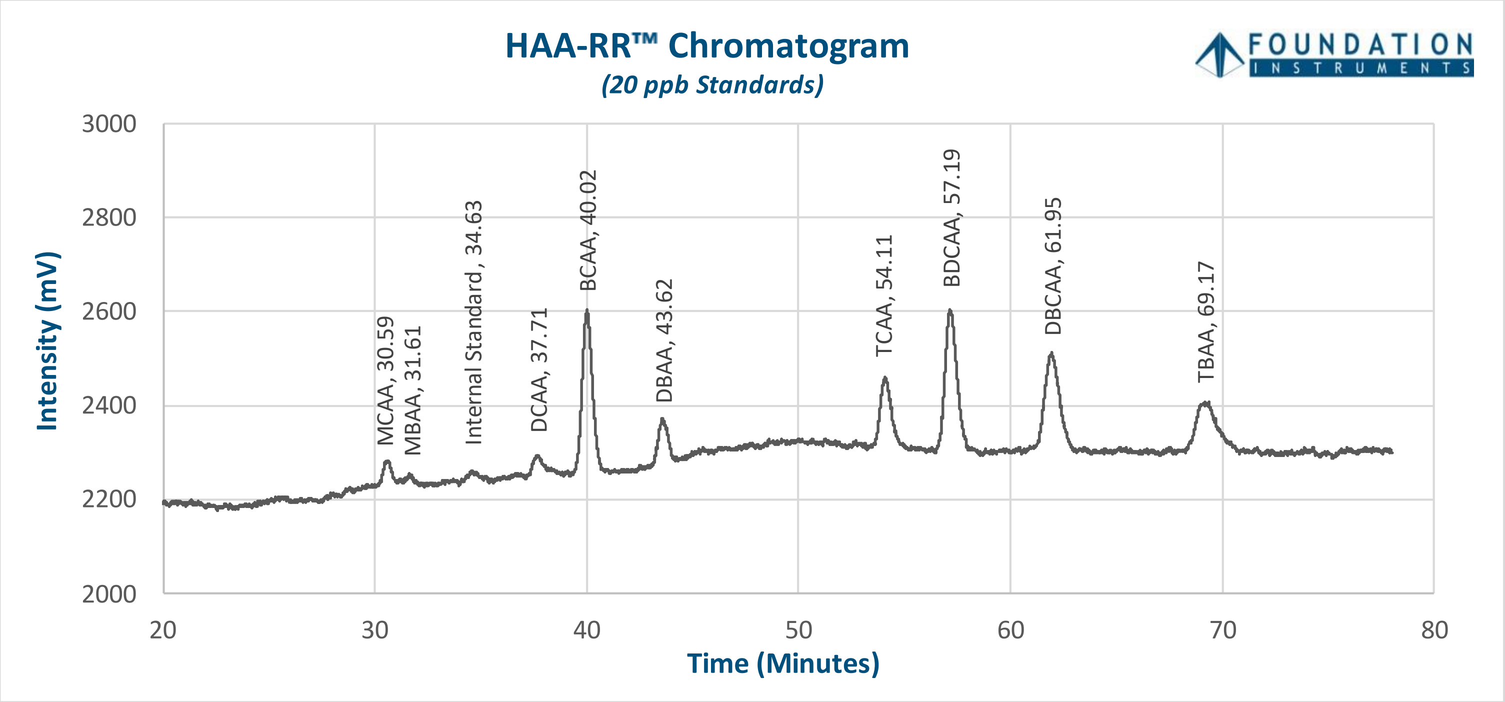
HAA-RR™

Rapid Response Benchtop HAA Analyzer

The HAA-RR™ system provides a means to collect on-site, near-real time HAA data to help utilities manage DBP levels

Potential Applications:

- Operators seeking to ensure cost-effective compliance with DBP regulations
- Utilities and engineers looking to undertake rapid evaluation of HAA treatment pilot systems, minimizing cost and time
- Utilities looking to undertake timely acceptance testing of a newly installed HAA treatment system



EZ-Titator™

Affordable Automated Titrator & Liquid Handling Devices

EZ-AutoPipet

- Minimize human error
- Automated separation of standards
- High accuracy & precision
- Use preloaded or custom methods
- Touchscreen interface

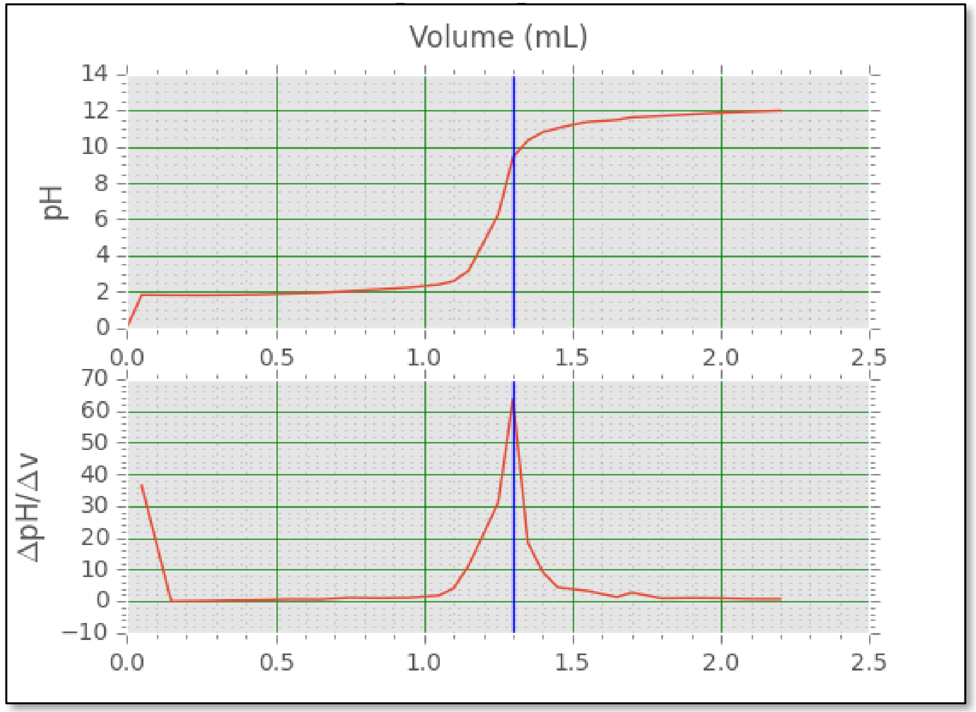
EZ-AutoTitrator

- Easy Alkalinity, Hardness, and pH measurements
- Minimizes human error in titrant delivery/endpoint detection
- Easy-to-read and use touchscreen interface
- Adaptable to other Potentiometric and indicator based titration methods

EZ-Titator™

Affordable Automated Titrator & Liquid Handling Devices

Potentiometric AND Colorimetric Titrations



- pH-based Titration
- To the equivalence point
- Full scale Titration to identify endpoint

Automated Endpoint Detection

- Hardness of Water - A classical “Hard to See” endpoint
- Reduces error in titrant delivery/endpoint detection between operators
- Fully automated endpoint detection

Analytical Testing & Consulting

Need THM/HAA data to better understand your disinfection byproduct levels?

- THM4, HAA5, HAA9
(EPA & non-EPA methods)
- VOCs (Purge & Trap)
- Chromatography (Liquid & Gas)
- Spectrophotometry
- Ion Chromatography
- Wet Chemistry Techniques
- Jar Testing (drinking water)
- Custom Analysis

FOUNDATION INSTRUMENTS

Other Projects and Opportunities

- Developing turn-key new product development support (concept through to commercialization) and additive manufacturing capabilities
- Lead analyzer to aid in the identification of lead service lines – goal is to develop a field deployable analyzer where you could test onsite
- Investigating analysis strategies for the determination of PFAS / PFOA as well as other emerging contaminants
- Seeking funding for automation of noninvasive cancer detection assay using selective biomarkers (partnership with UofM)
- Continue to research improved testing capabilities for disinfection byproducts in drinking water
- Working with the state to aid small utilities to improve DBP monitoring and compliance
- Looking for opportunities to work with other firms where we collaborate and/or develop new technologies to fill technology gaps

FOUNDATION INSTRUMENTS

Contact Information

Any Questions?

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