Distribution System Best Management Practices

Bureau of Safe Drinking Water Program
2026

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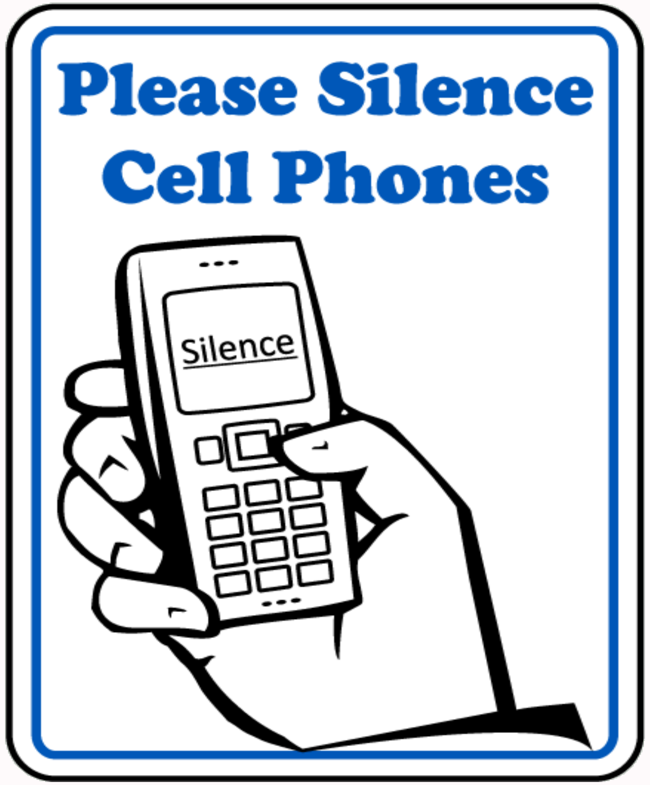
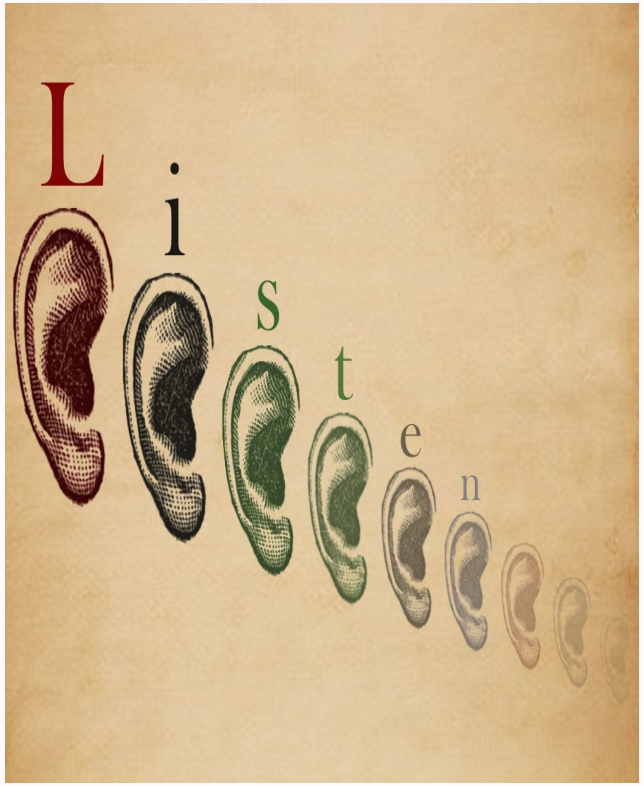
Welcome





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Agenda

- Water Quality Basics (Zack Kaufer)
  - Disinfection
  - DBPs: Formation & Impacts
  - Sampling Plans & Proper Sampling Techniques
  - Optimization, System Monitoring, BMPs & Regulation
- Increased Water Quality Monitoring and Special Studies (Stephanie Stoner)
  - Entry Point and In Plant Sample
  - Storage Tanks
  - Investigative Sampling
- BMPs - What to do about the problem areas (Stephanie Stoner)

Purpose of Distribution System Management

- Evaluate water quality from the treatment plant through the entire distribution system
- Sustain disinfectant residual and minimize DBP Formation
- Review findings of sampling results
- Encourage open discussion and problem-solving

Why Do Distribution Samples

Protect Public Health!

- By maintaining disinfectant barriers
- Reduce DBP formation (TTHM, HAA5)
- Prevent scaling, biofilm growth, and corrosion
- Support long-term system integrity

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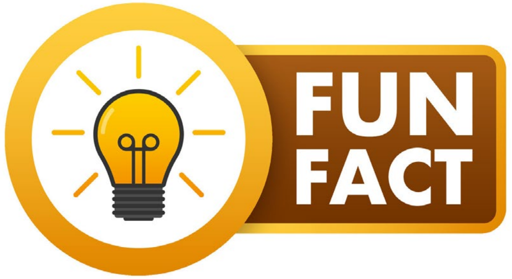
Disinfection Residuals

Chlorine DPD

Fun Fact: DPD Stands for - N,N-Diethyl-p-phenylenediamine. It is a chemical compound used primarily as a dye to detect chlorine levels.



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Chlorine DPD

- How it Works
- DPD reacts with Free - Total Chlorine (HOCl and OCl) to produce a pink color
- Intensity of the color is measured photometrically (commonly at 515 nm)

- HOCl = Hypochlorous Acid
- OCl = Hypochlorite Ion

Chlorine DPD

- Free chlorine must be read within ~1 min or reagent added
- Total chlorine requires a longer reaction time ~3-5 min before measurement
- Free chlorine pillows react only with hypochlorous acid / hypochlorite ions
- Total chlorine pillows have additional reagent to convert combined chlorine (chloramines) into a measurable form

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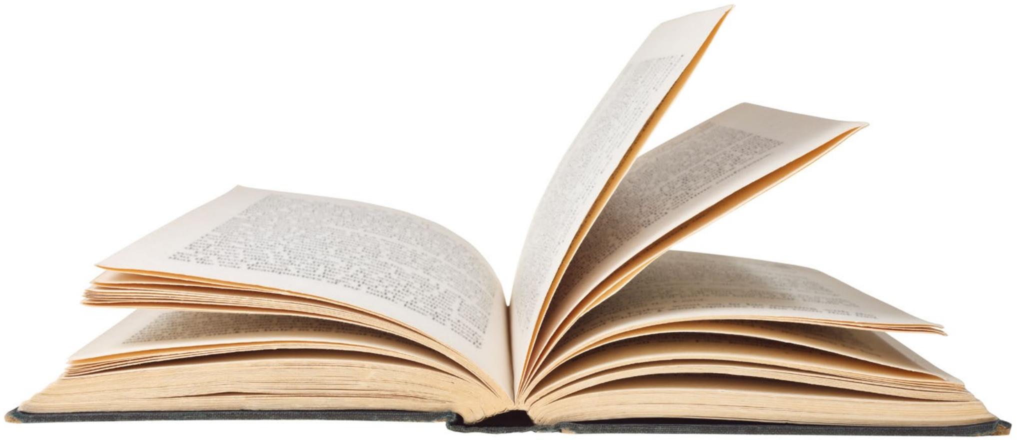
Video: Understanding Chloramination

Chloramination



Definition:

Chloramination is the addition of ammonia to chlorine to form chloramines (Primarily monochloramine)

Chloramination

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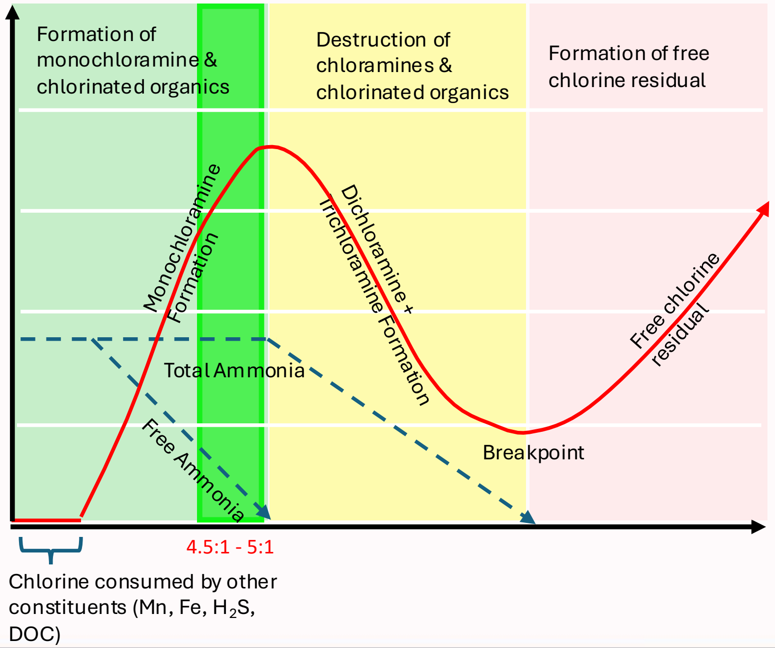
Purpose:

- Longer-lasting disinfectant residuals in distribution systems
- Reduced formation of regulated DBPs



Key Parameter:

- Free chlorine should be near zero (0) in a properly chloraminated system
- Confirm Proper chlorine to ammonia ratio
    - Typically 4.5:1 to 5:1 by weight
- Ensure ammonia is present to maintain chloramine formation
- Excess ammonia can lead to nitrification

Water Treatment Plant

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Causes Of Low Disinfectant Residuals

- High chlorine demand due to:
  - Natural organic matter (NOM)
  - Iron, manganese, sulfides
- Poor mixing or contact time
- Overfeeding ammonia (if chloraminated)
- pH fluctuation
- Temperature effects
  - Higher temperatures accelerate chlorine decay

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Distribution System

Causes Of Low Disinfectant Residuals

- Pipe corrosion or deposits reacting with chlorine
- Long residence times
- Seasonal temperature impacts
- Biofilm growth
- Nitrification (chloraminated systems)

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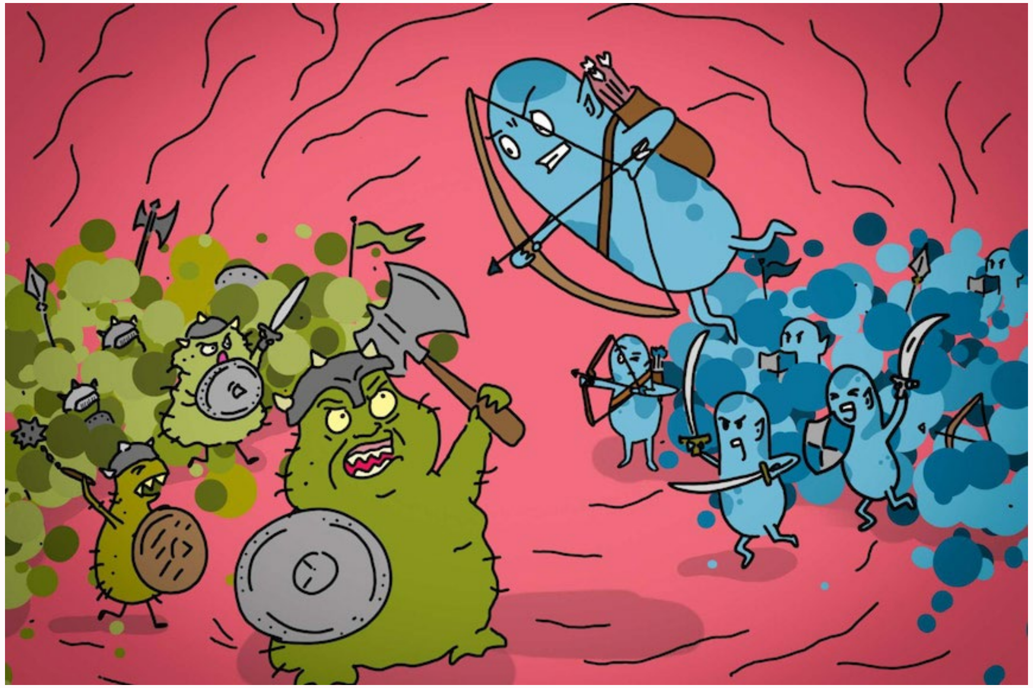
Booster Chlorination & Chloramination

- Used to maintain disinfectant residuals in remote or low-flow areas
- Chlorination adds free chlorine; Chloramination adds chlorine + ammonia to form chloramines
- Helps prevent microbial growth and maintain compliance



Booster Chlorination & Chloramination

Pros

- Maintains residuals in remote zones
- Reduces microbial regrowth
- Supports regulatory compliance
- Extends disinfectant effectiveness

Cons:

- Risk of DBP formation
- Requires precise monitoring
- May cause taste/odor issues if mismanaged

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DBPs

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Understanding DBPs

- What Are DBPs
  - DBPs are unintended chemical compounds formed during drinking water disinfection
  - They result when disinfectants like chlorine or chloramines react with natural organic matter (NOM) and bromide in source water
  - DBPs are regulated due to their potential health risks with long-term exposure

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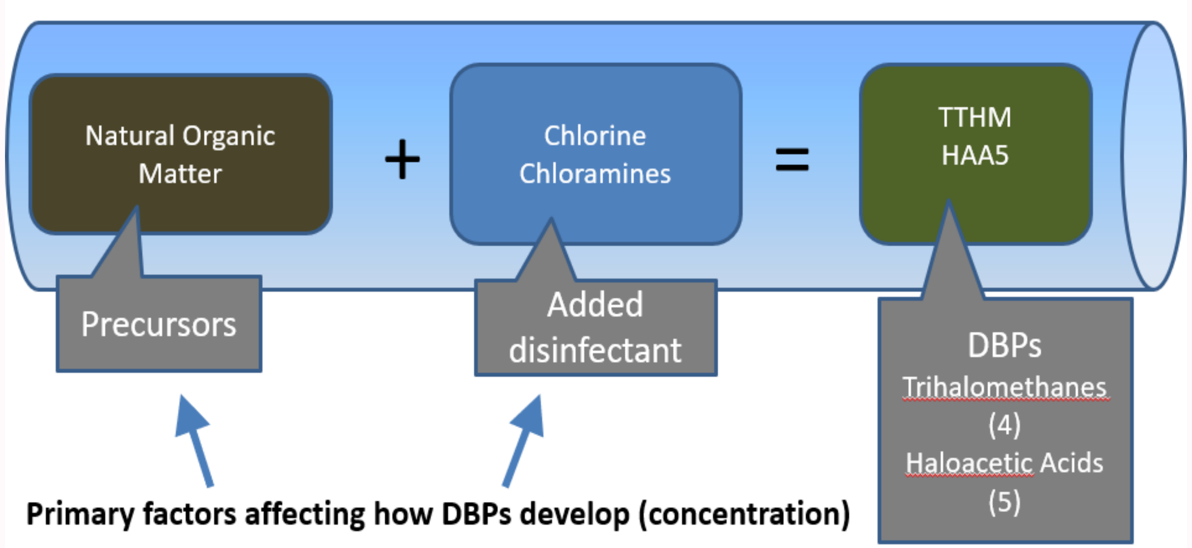
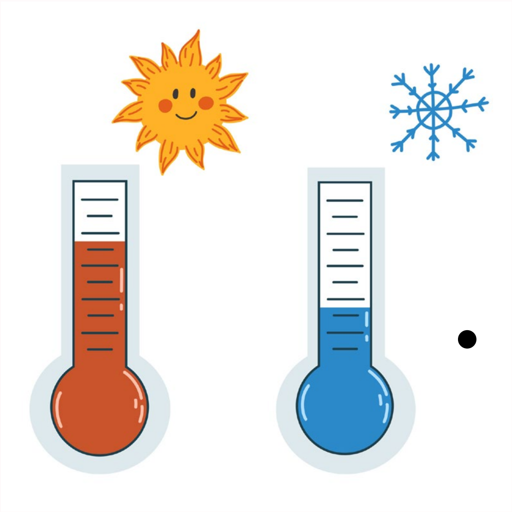
Understanding DBPs

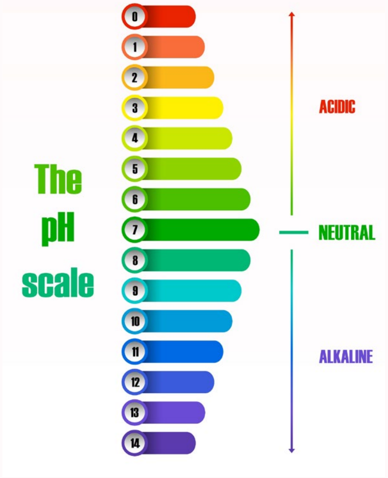


- How Do DBPs Form
  - Disinfectant (e.g., chlorine) is added to kill pathogens
  - They react with:
    - Natural Organic Matter
      - Decaying Vegetation
      - Algae
      - Soil Runoff
  - The chemical reaction produces DBPs as a byproduct of disinfection

Understanding DBPs



- What Influences DBP Formation
  - Water Age
  - Temperature
  - pH
  - Disinfectant Type & Dose
  - Organic Load of Source Water



Understanding DBPs

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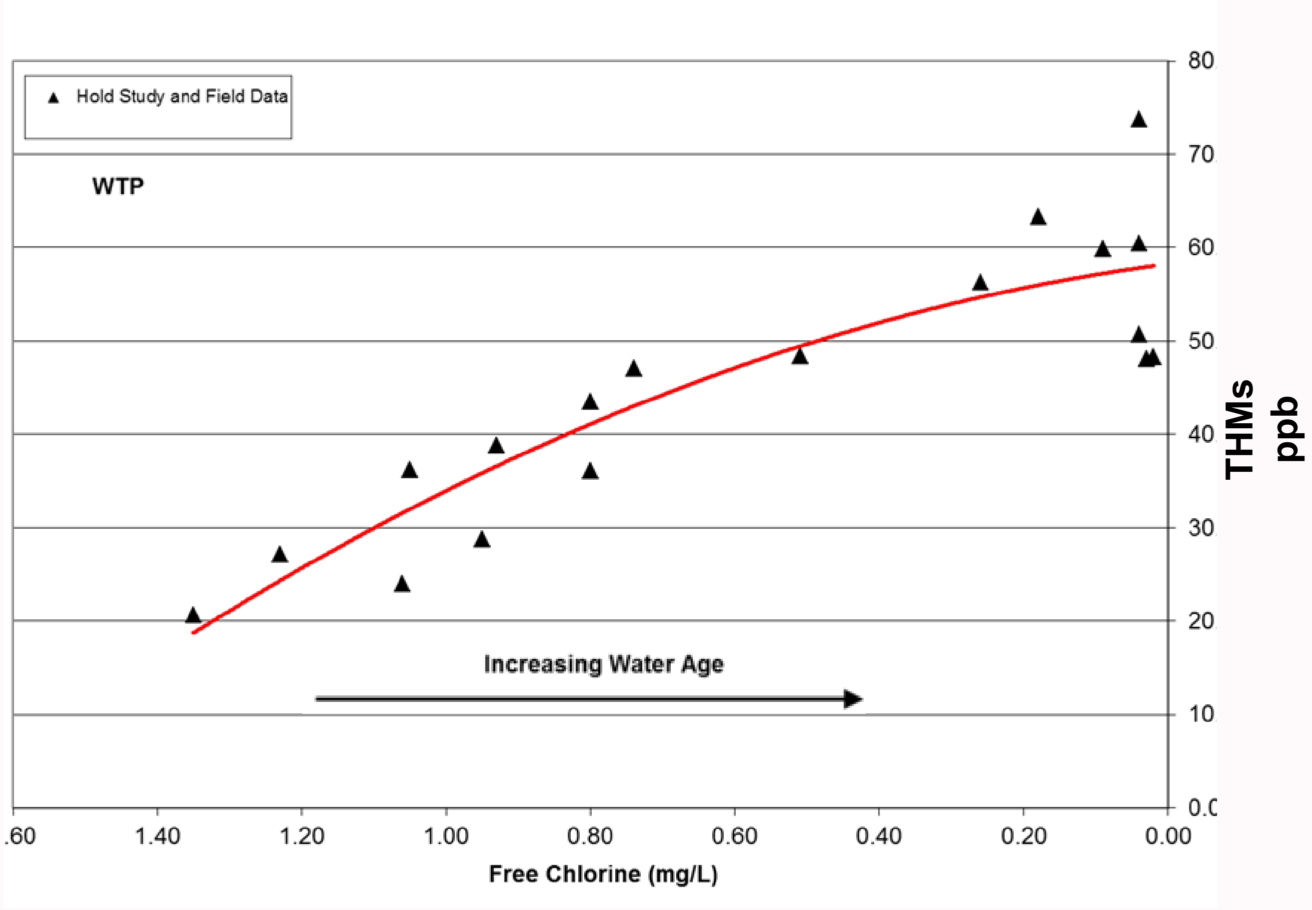

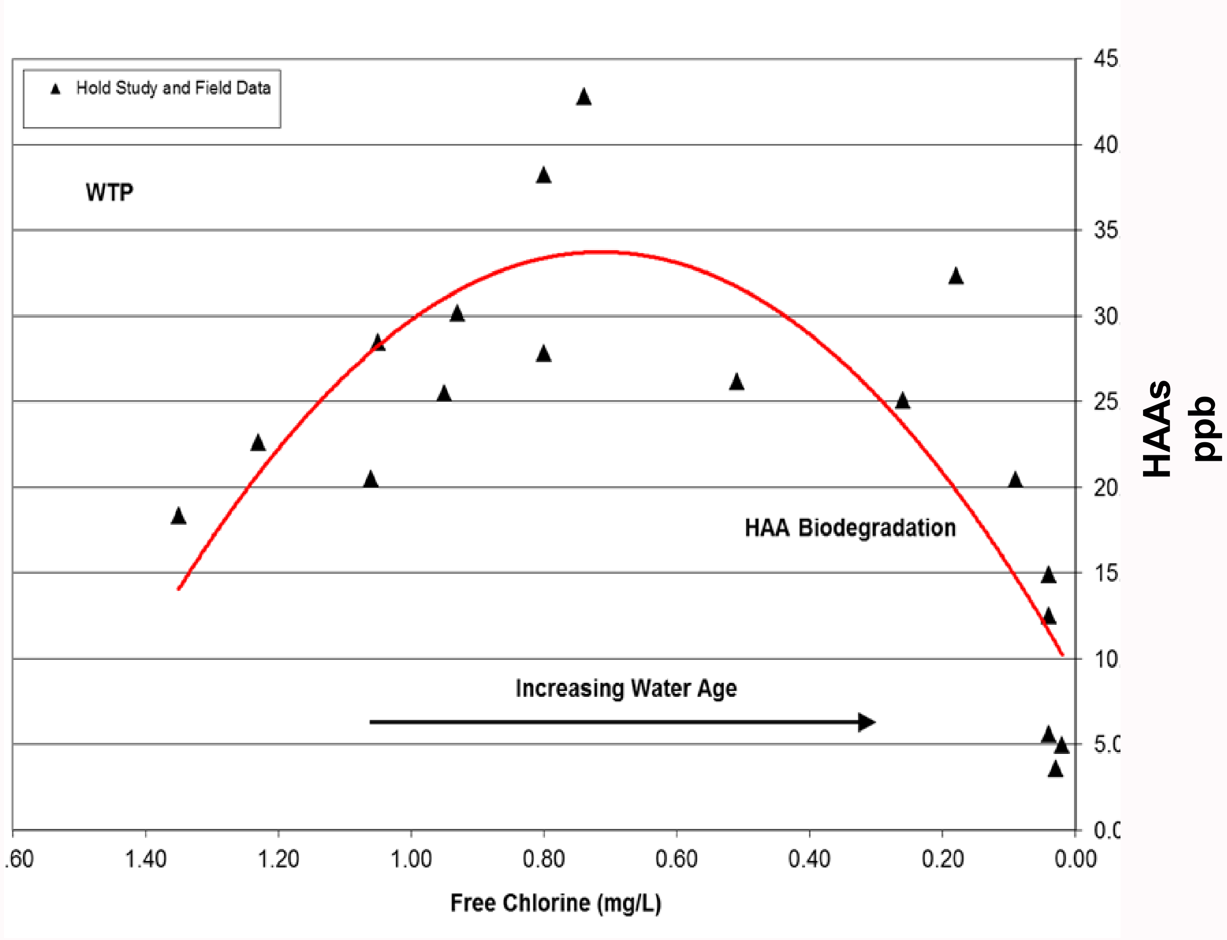

Effects Of DBP Formation

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- Health Risks: long-term exposure linked to cancer, reproductive issues, and developmental effects
- Water Quality Impacts: alters taste, odor, and chemical stability
- Operational Challenges: increases chlorine demand, complicates residual maintenance
- Infrastructure Stress: promotes corrosion, scaling, and biofilm growth

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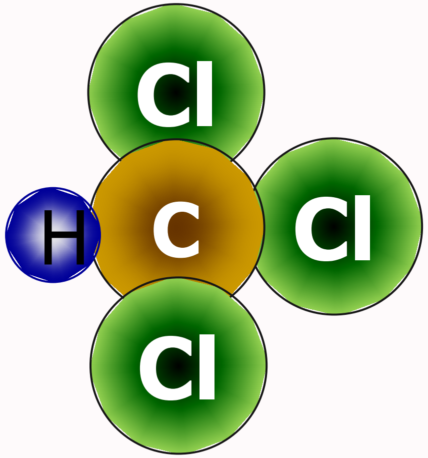
Regulated DBPs

Chloroform



- What are DBPs Made Of
- TTHM (Total Trihalomethanes)
  - Chloroform
  - Bromodichloromethane
  - Dibromochloromethane
  - Bromoform

Regulatory Limit = 80 µg/L
Optimization Entry Point = 20 µg/L
Optimization Distribution System = 70 µg/L

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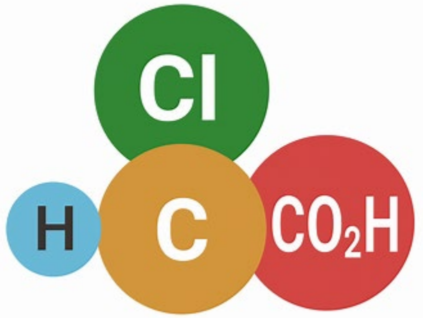
Regulated DBPs

- What are DBPs Made Of
- HAA5 (Haloacetic Acid)
  - Monochloroacetic Acid
  - Dichloroacetic Acid
  - Trichloroacetic Acid
  - Monobromoacetic Acid
  - Dibromoacetic Acid

Monochloroacetic Acid



Regulatory Limit = 60 µg/L
Optimization Entry Point = 15 µg/L
Optimization Distribution System = 50 µg/L

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Location Sample Plans

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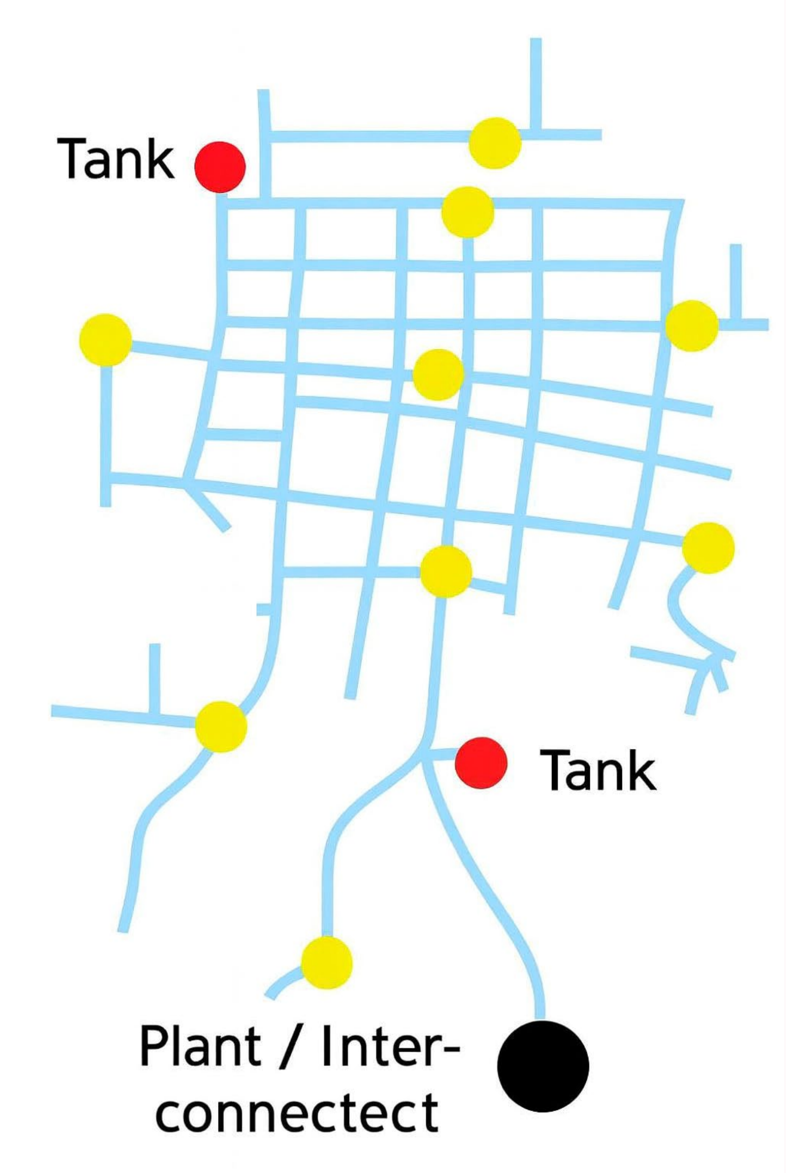
Sampling Location

Sample location = Yellow dots

Distribution main = Blue line

Tank = Red dot

Water plant / Interconnect = Black dot



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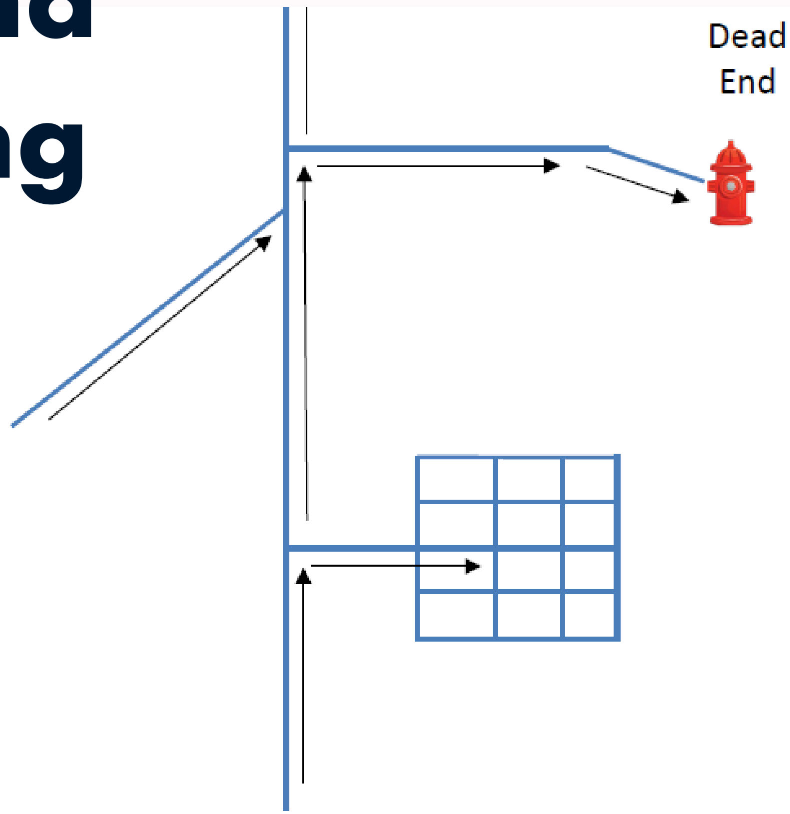
Dead-End Sampling



- High water age and stagnation risk
- Often aligned with MRT sites
- May require:
  - Spot flushing
  - Auto-flushers
  - Looping or booster chlorination

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Low Flow Zones

- Not true dead ends, but poor turnover
- Common in:
  - Oversized mains
  - Industrial zones with reduced demand
  - Looped systems with hydraulic imbalance

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Pipe Material

Material	Properties	System Impact
PVC / CPVC	Smooth, non-corrosive, low biofilm	Stable residuals, low DBP reactivity
Ductile Iron	Durable, may corrode without lining	Iron release can interfere with chlorine
Galvanized Steel	Prone to corrosion, rough interior	Promotes biofilm, residual decay
Asbestos Cement	Aging infrastructure, brittle	May leach under aggressive water chemistry
HDPE / Polyethylene	Flexible, inert, low biofilm	Minimal DBP contribution
Copper	Antimicrobial, may react with chlorine	Can alter pH and residual stability

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Pipe Material

- Corroded iron and steel pipes promote biofilm growth, increasing organic precursors for DBPs
- Rough surfaces trap organic matter, elevating chlorine demand
- Biofilms release proteins and amino acids that react with disinfectants to form TTHMs and HAA5s
- Plastic Pipes (PVC, HDPE) show lower DBP formation due to smooth surfaces and low reactivity

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Storage Tank: Water Quality

- Tanks influence disinfectant residual, DBP formation, and water age
- Key factors:
  - Turnover Rate (volume exchange)
  - Tank Mixing (thermal layering)
  - Sediment and biofilm accumulation
- Poor mixing = localized degraded chlorine and DBP spikes

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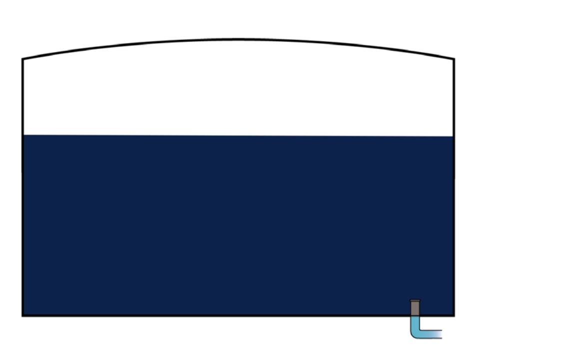
Storage Tank: Water Quality



- Turnover = time to exchange full tank volume
    - More Frequent Turnover = better residual, lower DBPs
    - Optimization turnover time ≤ 5 days
- Stratification (lack of mixing)
    - Cold water sinks, doesn’t mix
    - Warm weather increases temperature of top layer
    - Creates dead zones with aging water
- Seasonal effects amplify stratification

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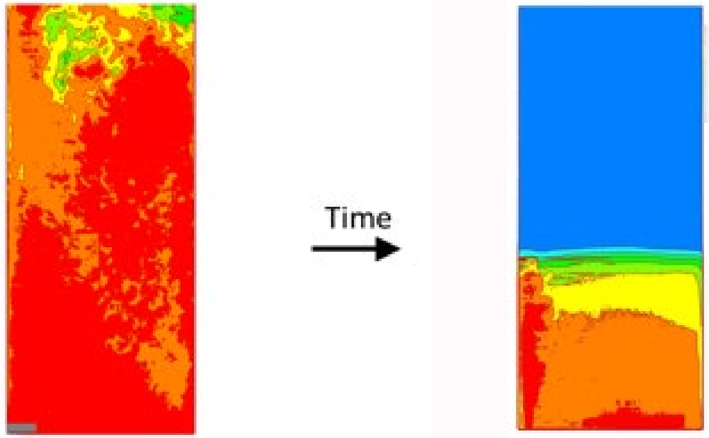
Storage Tank: Water Quality

- Mixing prevents stratification and dead zones
- Optimization mixing goal is ≥ 1.0
- Poor mixing = elevated TTHMs and HAA5s
- Sediment and biofilms increase chlorine demand
- AWWA recommends tank inspection every 3-5 years



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Water Quality Monitoring

	• pH, temperature, turbidity • DBPs: TTHM, HAA5
Chlorination	• Free chlorine and total chlorine • Iron, manganese (Interference risk)
Chloraminated Systems	• Monochloramine, free ammonia, total chlorine • Monitor for nitrification indicators • Chlorine-to-ammonia ratio

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Proper Sampling Techniques

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Protocol, SOP, and Consistency

- Use a written SOP for every sampling type
- Train all staff on consistent technique
- Document findings clearly and in a manner that can be repeated and looked up easily

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Bottle Prep and Handling

- Follow SOP
- Wear clean gloves and avoid touching bottle rims or caps
- Verify correct bottle type and preservative before sampling
- Check headspace requirements and fill bottles to the proper level
- Do not rinse preserved bottles
- Keep bottles sealed until sampling to prevent contamination
- Cap tightly and store samples immediately

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Proper Sampling Techniques

- Sampling must be consistent, representative, and compliant
- Follow SOPs for flushing, bottle handling, and timing
- Use Calculated Flush Time (CFT) to avoid over or under flushing
- Always rinse bottles without preservative (unless instructed otherwise)
- Ensure zero headspace in DBP bottles
- Include in-plant or interconnect sampling to pinpoint DBP formation

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Proper Sampling Techniques

- Hold Times – test parameters within required time limit
- Items like pH and chlorine must be measured in the field, not delayed
- Use clean, uncontaminated glassware to avoid false readings
- Match container to parameters, ensuring sample and container do not interact
- Preserve samples properly – chilled and protected

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Common Sampling Interferences

- Iron and Manganese can distort DPD chlorine readings
- Turbidity masks colorimetric readings
- Temperature affects reaction speed
- Biofilm alters chlorine demand
- Air bubbles skew DBP residual results

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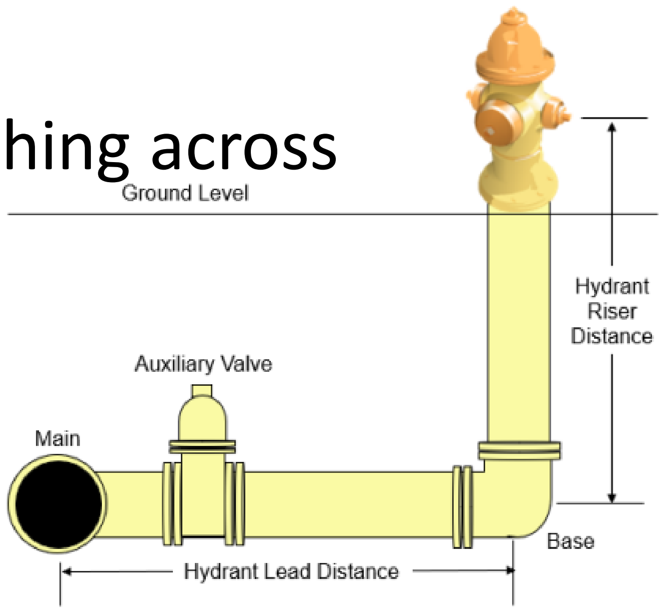
Flushing Sample Lines

- Flush long enough to get representative water from the main, but not so long you are pulling water from other zones
- EPA Calculated Flush Time / Volume (CFT / CFV)
    - Based on pipe diameter, length, and flow rate
    - Ensured consistent flushing across sites

EPA CFV / CFT guidance

EPA Hydrant Sampler & CFT for Hydrants



Flushing Sample Lines

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Calculate Flush Time			Flow Rate all Pipe Lengths	2	GPM				
Segment 1 Interior Diameter	12	Inces	Cubic Inches Per Minute	462		Sink	2 GPM	Flush Time per section to get formula to work	
Radius of pipe	113.0973					Hydrant	20 GPM	58.75186	
Length of Pipe Segment #1	20	Feet	Total Flush Time	58.75186	Minutes			#DIV/0!	
Length of pipe in inches	240	Inches						#DIV/0!	
Velocity of Water	4.084977							#DIV/0!	
Flow Time Minutes	58.75186							#DIV/0!	
Segment 2 Interior Diameter		Inces							
Radius of pipe	0								
Length of Pipe Segment #2		Feet							
Length of pipe in inches	0	Inches							
Velocity of Water	#DIV/0!								
Flow Time Minutes	#DIV/0!								

Maintenance Flushing Calculator				Multiple Flush Points	
		3.0	Target Velocity (ft/s)		
8	Pipe Diameter (in)	8	Pipe Diameter (Inches)	8	Pipe Diameter (in)
1,000	Pipe Length (ft)			1,000	Pipe Length (ft)
80	Flow Rate (gpm)	Minimum Flow Required Per Outlet		80	Total Flow Rate (gpm)
3.0	Target Velocity (ft/s)	469.982261		2	Number of flush points
				3.0	Target Velocity (ft/s)
Single Point Flush					
2,611.01	Pipe Volume (gal)				
0.51	Flow Velocity (ft/s)			2611.01	Pipe Volume (gal)
32.64	Flush Duration (min)			40	Flow Rate Per Point (gpm)
No	Meets Velocity Target?			0.26	Velocity Per Point (ft/s)
469.98	Needed gpm to reach Velocity			32.64	Flush Duration (min)
				No	Meets Velocity Target?
				469.98	Needed gpm to reach Velocity

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Optimization

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What is Optimization?

- Desire to exceed minimum regulatory standards
- Proactively improve treatment and distribution effectiveness
- Deliver the highest possible water quality
- Extend system lifespan
- Aids in compliance with future regulations

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Why Care About Optimization?

- Improve water quality and reduce health risks
- Improve safety margins and system resilience
- Reduction in reactive material(s)
    - Suspended solids
    - Dissolved components
        - Organic matter, Iron, Manganese, Ammonia
- Possible cost saving through
    - Reduction in chemical usage, extended life on filters, and increased life of distribution system

Optimization Goals:
Entry Point

- Entry Point Goals:
  - Giardia: ≥ 1.0 log inactivation post-filtration
  - TTHM ≤ 20 μg/L
  - HAA5 ≤ 15 μg/L

Optimization Goals: Distribution

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- Distribution System Goals:
  - Free Chlorine ≥ 0.50 mg/L
    - Required ≥ 0.2 mg/L at all locations
  - Tank Turnover ≤ 5 days
  - Tank Mixing: performance ratio ≥ 1.0
  - System Pressure > 50 PSI and < 125 PSI
  - TTHM ≤ 70 µg/L (MCL ≤ 80 µg/L)
  - HAA5 ≤ 50 µg/L (MCL ≤ 60 µg/L)

Regulatory Requirements

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- PA DEP Chapter 109.301-303
  - Defines monitoring frequency, sample location, and acceptable methods
- EPA Stage 2 DBPR (Disinfection Byproducts Rule)
  - Requires sampling for DBPs (TTHM & HAA5)
- DEP Monitoring Requirement Summary Sheets
  - Annual guidance documents summarizing required sampling by system type and size
- System-Specific Monitoring Plans
  - DEP required plans tailored to each system's layout and hydraulics

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Regulatory Requirements

PA DEP Chapter 109 Safe Drinking Water Regulations

DEP Drinking Water Management Portal

EPA Rules Summary Page

EPA DBPR

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Break

10:00

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Best Management Practices

Increased WQ Monitoring & Special Studies

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BMPs thru Increased WQ Monitoring & Special Studies

In-Plant

Entry Point (Start Here)

Distribution System

- Storage Tanks
- Investigative Distribution Sampling
  - Dead Ends; Areas of Low Use

Chloramines

Booster Disinfection

Consecutive Systems

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Increased Monitoring-Entry Point

Should focus be on filter plant or distribution system?

Start at the Entry Point

- Water quality = as good as it gets; does not improve as it ages or moves thru pipes/tanks
- Low disinfectant residuals will decrease
- High DBP concentrations will increase

Sample Entry Point DBPs

- At same time as distribution system samples
- Optimization = monthly

Entry Point Goals

- TTHM ≤ 20 µg/L
- HAA5 ≤ 15 µg/L

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Increased Monitoring-Entry Point

Entry Point Hold Study

How Reactive is the water? (you want stable water)

Water samples are collected and held for a period of time

- Duration depends on how fast/slow the chlorine is dropping
- Measures disinfectant decay & DBP formation in the water
- Does NOT assess pipe wall reactions, only water

EPA Hold Study Protocol

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Increased Monitoring-Entry Point

Hold Study

Reactivity – consider:

- How quick are disinfectant residuals dropping?
- How fast are DBPs forming?
- Does the WQ entering the distribution system meet the entry point goals?
- How long can the water age and still meet the distribution system goals?

Actual distribution system conditions = greater impact

Reactive, unstable entry point water may mean treatment plant optimization or changes are needed

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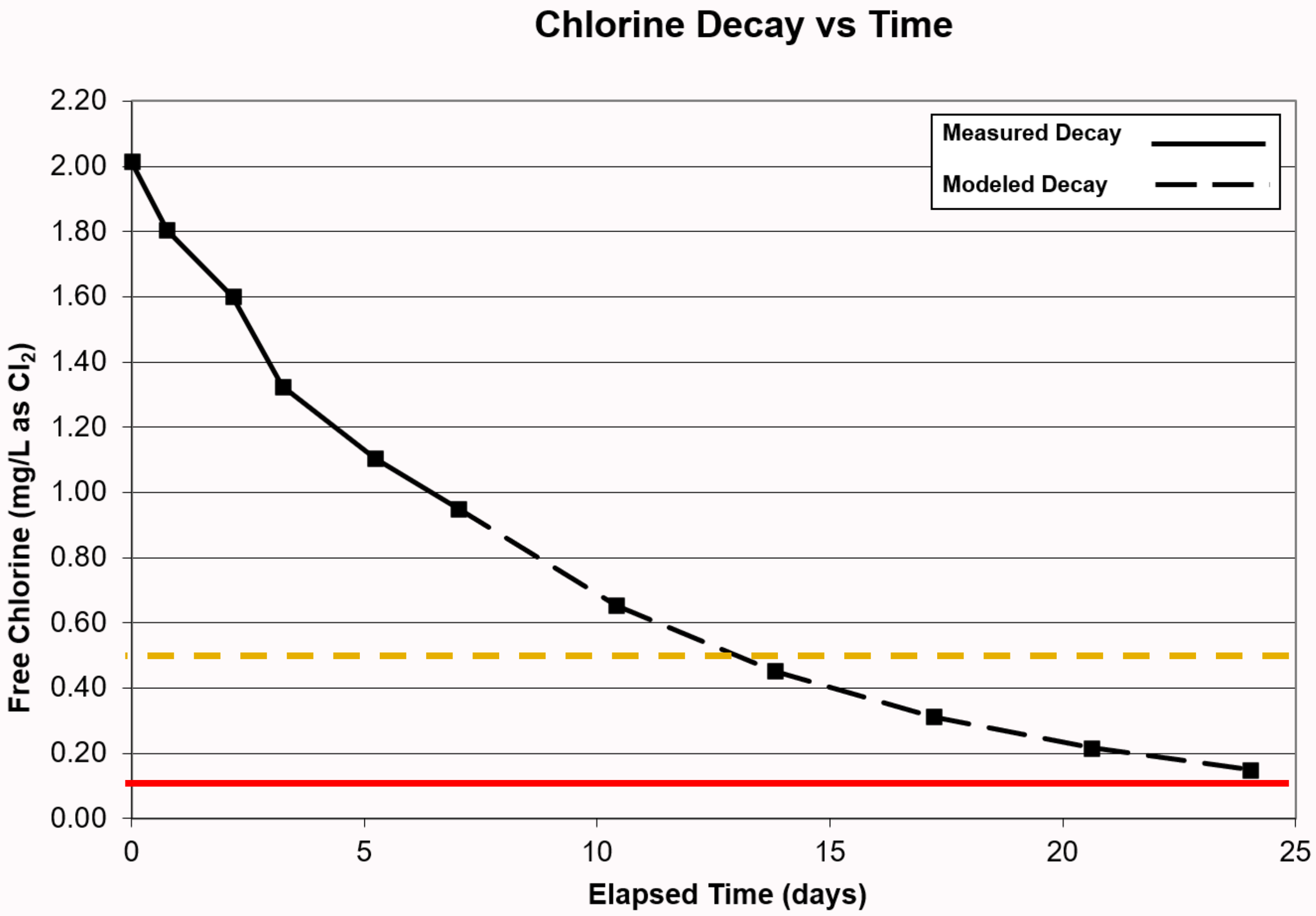
Increased Monitoring-Entry Point

Hold Study

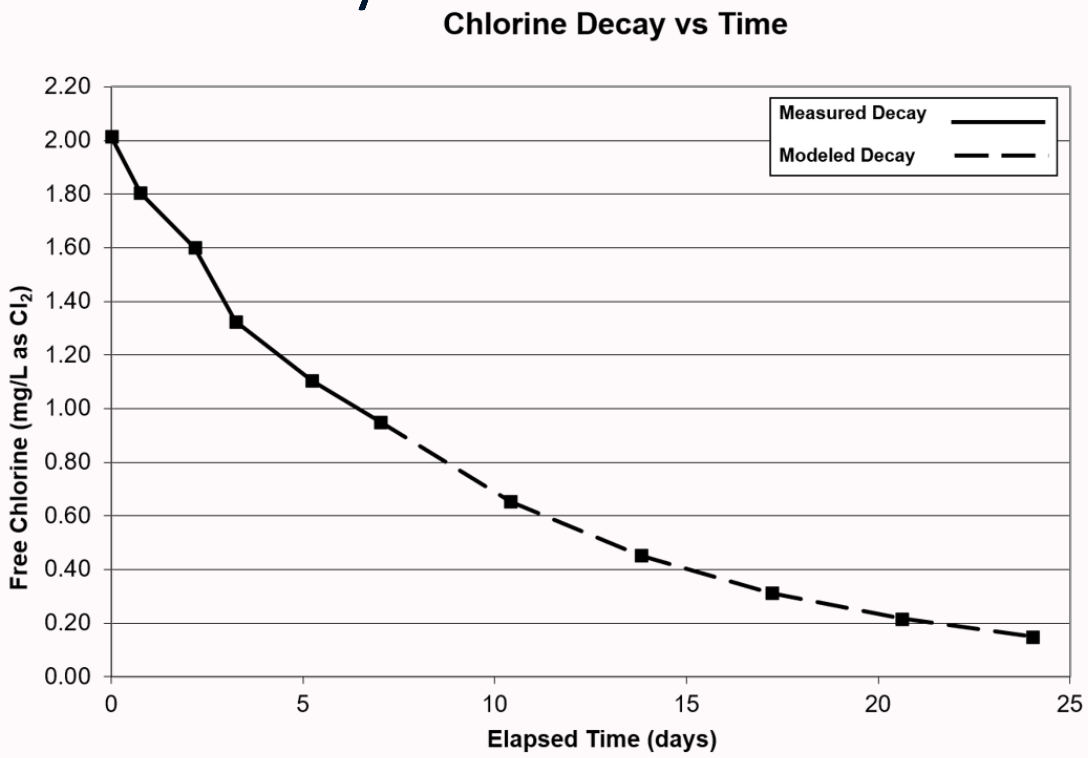
Data Trend/Graph

Hold Study Data Entry Spreadsheet to create graphs/modeling

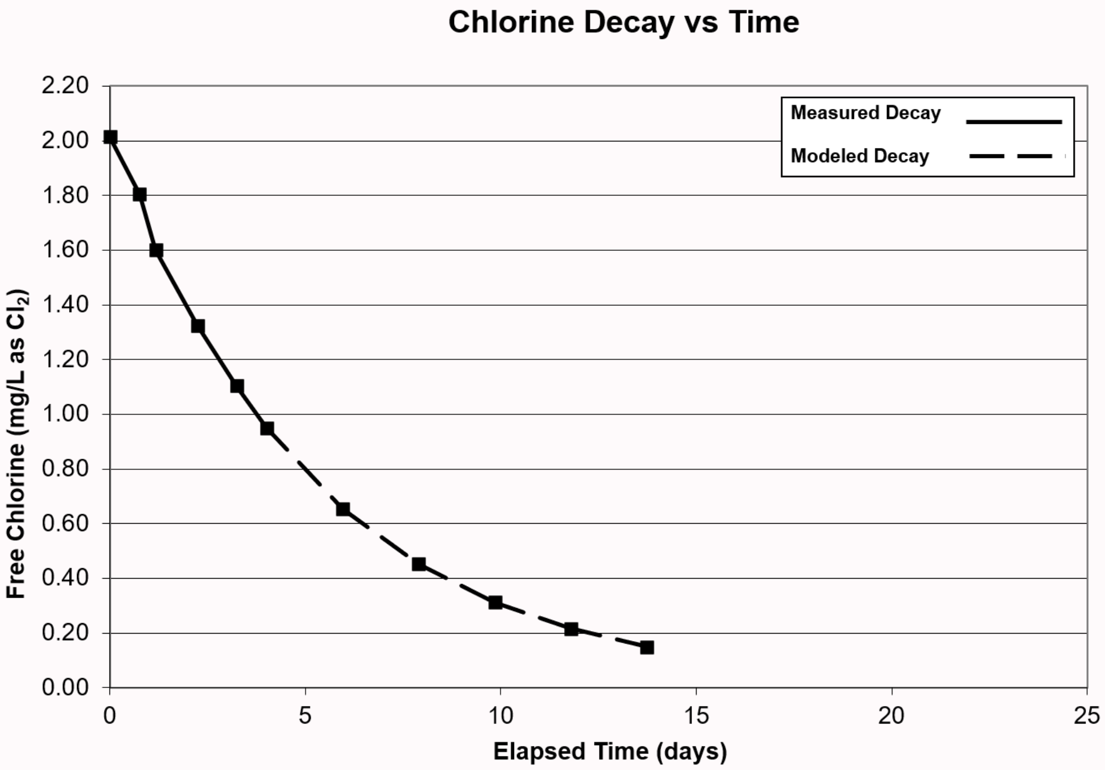


Question

Hold Study



System A



System B

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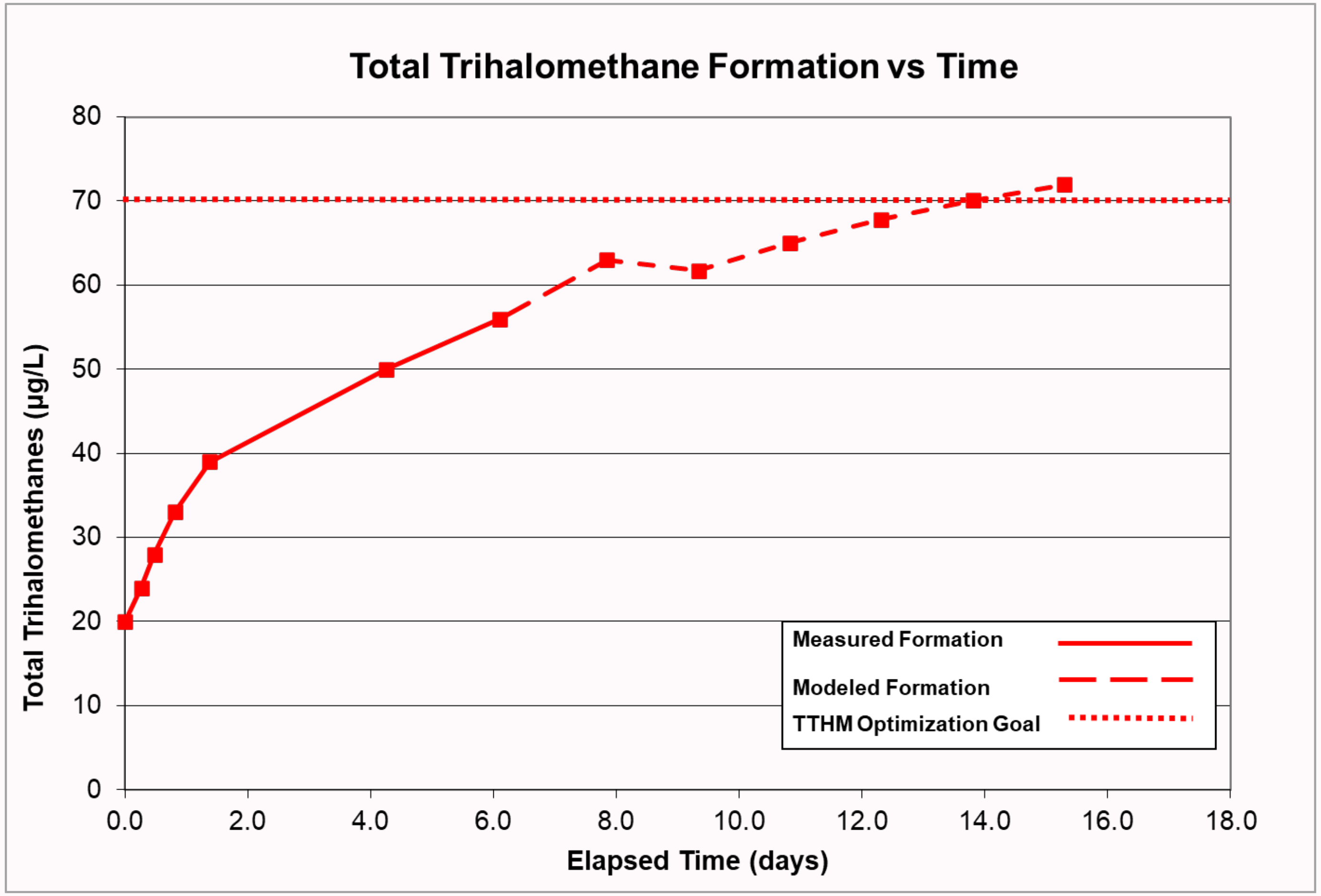
Increased Monitoring-Entry Point

Hold Study

Graphing/Trending TTHM Data



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What does Entry Point data tell you?

- Are the entry point DBPs above the optimization goals?

  Opt goals: TTHM = 20 µg /L   HAA5 = 15 µg /L

  Start with the filter plant

- Does the hold study show:

  Chlorine residual drops quickly <0.50 mg/L?

  DBPs exceed the optimization goal quickly?

  Focus on the filter plant

Filter Plant

- Where in the plant are most of the DBPs forming?
- Where is TOC (total organic carbon) being removed?

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Increased WQ Monitoring – In Plant

- Sample WQ: every step in the treatment process
  - ✓ Raw, mixed, settled, filtered, entry point
  - ✓ Consider partway thru settling if very large
  - ✓ Consider individual sed basins or filters

- Every step: pH, temp, TOC, UV254
- Every step after chlorine addition: chlorine residual (free & total), DBPs
- If chloraminating, every step after ammonia addition: monochloramine, total chlorine, free ammonia, nitrite

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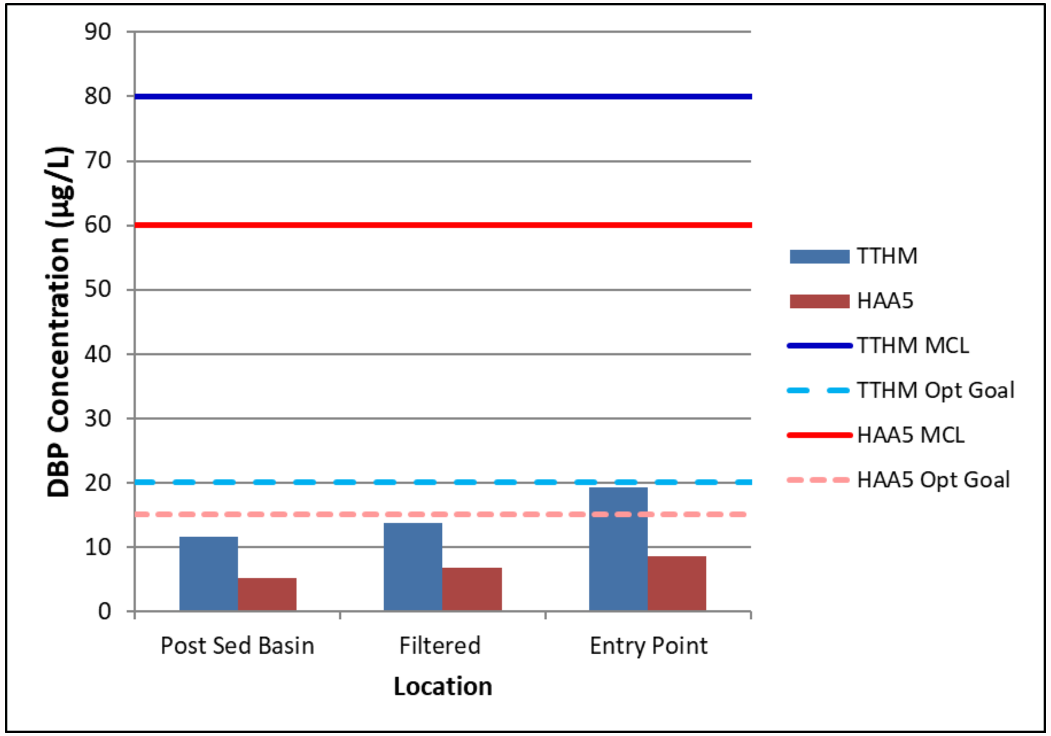
Increased WQ Monitoring – In Plant

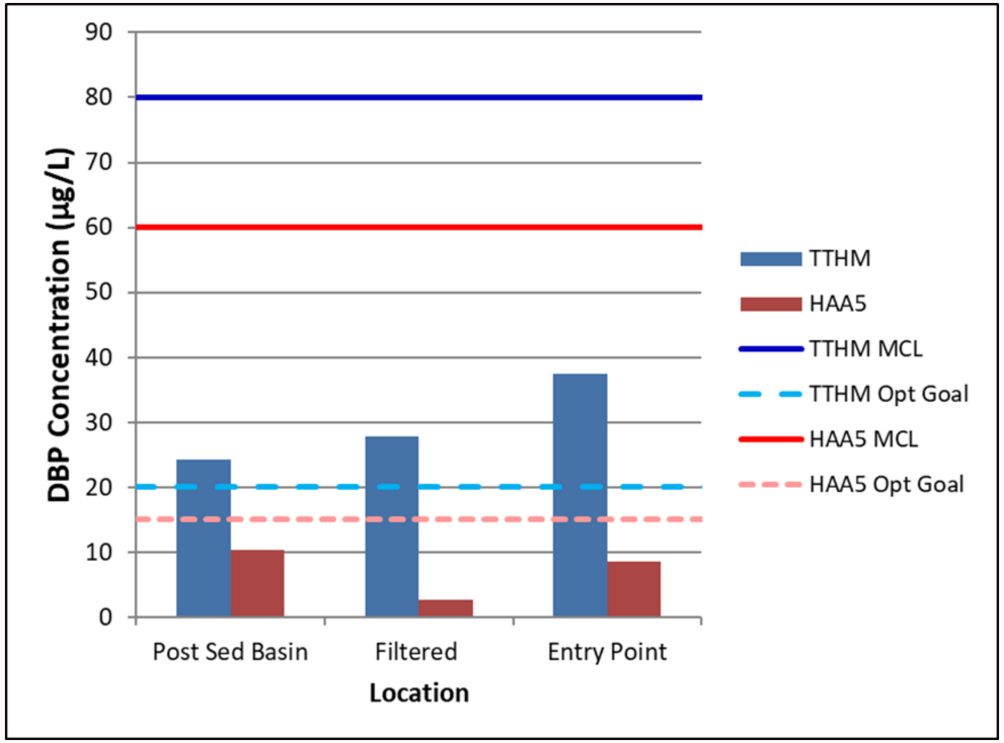
- General WQ: bromide, iron, manganese, alkalinity, fluoride, etc
  - ✓ System specific
- Frequency: depends on results, ease, cost
  - ✓ Daily (or more): chlorine, pH, temp, UV254, general WQ
  - ✓ Less frequently: TOC, DBPs, WQ that sent to lab
  - ✓ DBPs: if below the EP optimization goal = Quarterly

    If above the EP optimization goal = Monthly

Question



Focus on Distribution System first



Focus on Filter Plant first

Increased Water Quality Monitoring-Distribution System

If entry point sampling suggests the issue is NOT in the filter plant – focus on the distribution system

- Storage tanks
- Areas of low use
- Ends of the system
- Pump/booster stations
- Interconnects

Increased WQ Monitoring – Storage Tanks

What to monitor?

- Chlorine residuals, free & total
- DBPs
- Temperature, pH
- Sediment

Special Studies:

- ✓ Grab samples on inlet/outlet
- ✓ Online chlorine analyzer
- ✓ Overflow study
- ✓ Drain down
- ✓ In tank sampling-ground level
- ✓ Tank Assessment Software-mixing and turnover time

Increased WQ Monitoring – Storage Tanks

Grab Samples:

- If single inlet/outlet – sample when
  - Filling
  - Drawing-when tank is at it's lowest
- If separate inlet/outlet –
  - sample both the inlet and outlet

Chlorine residuals, DBPs, pH, temperature

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Increased WQ Monitoring – Storage Tanks

Continuous online chlorine analyzer

- Provides information/understanding
    - Chlorine residual
    - TTHM
        - Chlorine residual decreases typically correlate to TTHM increases
- Quicker response to low chlorine or sudden drop in chlorine

Permanent installation

Temporary/Department portable chlorine analyzer

Increased WQ Monitoring – Continuous Chlorine Monitoring

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Where

- Storage tanks
- Booster chlorine locations (before or after)
- Pump stations
- Interconnects
- Problem areas
- Any place with a sample tap, electric and a drain, including outside if secure

Increased WQ Monitoring – Continuous Chlorine Monitoring

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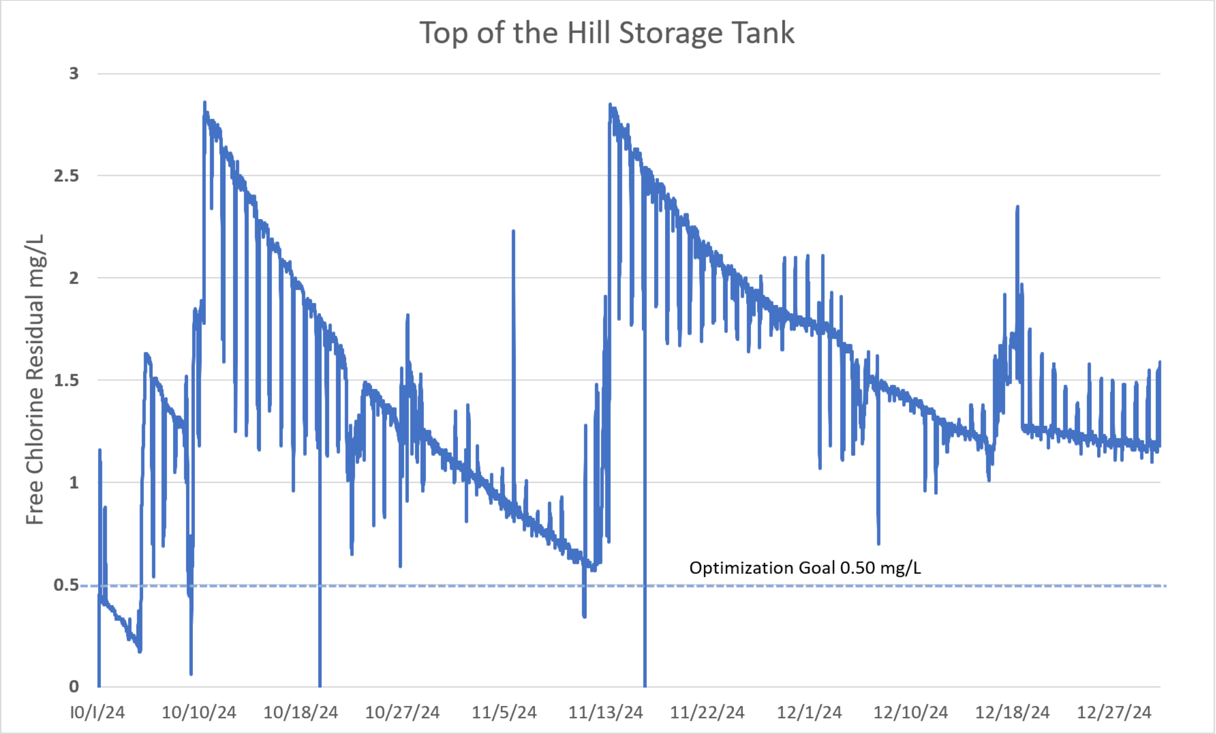
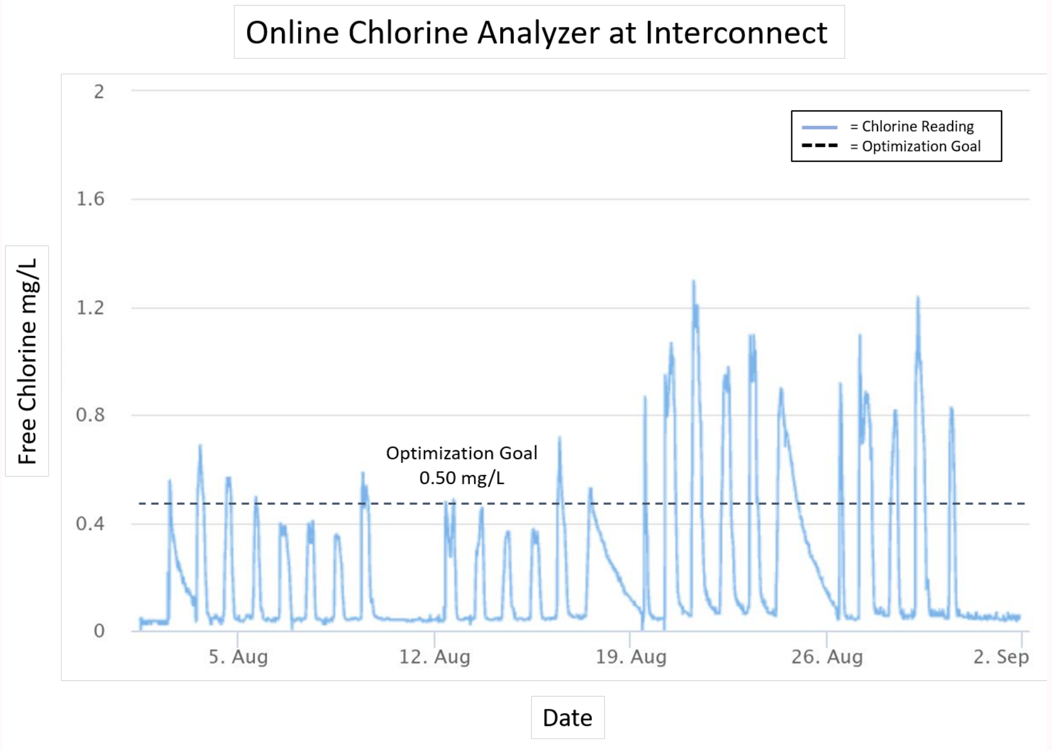
Storage Tank



Interconnect



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Increased WQ Monitoring – Storage Tanks

Overflow study

- Intentionally overflow tank to get water from top of tank
- Protocol in development; most complicated

Tank drain down

- When tank is drained for cleaning or inspection

In tank sampling – ground level tanks

- Use sample pump & hose marked in 1 ft increments

Sample entire water column, usually at 1 ft increments

Determine how long to overflow or drain 1 ft

Chlorine, temperature, pH, DBPs

Provides valuable info on WQ in tank & on stratification

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Storage Tank Assessment Study

EPA Storage Tank Assessment Study Protocol

Designed to estimate tank turnover time and mixing performance

Required inputs:

- Tank design data (volume, shape, inlet size, etc.)
- Tank level data (min/max levels over time)

Enter data into tank summary and worksheets

Date	Time	Min Level Ft	Max Level Ft
07/10/22	9:00 PM	33.90	
07/11/22	12:00 PM		38.90
07/12/22	11:00 PM	26.10	
07/13/22	7:00 AM		26.70
07/13/22	11:00 PM	18.60	
07/16/22	1:00 AM		43.20

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EPA Storage Tank Assessment Spreadsheet

Storage Tank Assessment Spreadsheet

Spreadsheet calculates

- Average turnover time
- Mixing performance ratio (measured/desired)

	Riverview	South End
Average Turnover Time (days)	2.3	9.3
Mixing Performance Ratio	1.58	1.72

Distribution System	Optimization Goals
Storage Tank Turnover	≤ 5 days
Storage Tank Mixing	Performance Ratio ≥ 1

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Storage Tank Assessment Spreadsheet

"Scenario Analysis" to test operational changes

	No Changes	Scenario A	Scenario B	Scenario C	Scenario D
Tank diameter	100	100	100	100	100
	0	0	0	0	0
~~Inlet Diameter~~	1.30	**1.30**	**1.30**	**1.30**	**1.30**
High/Max Level	37.85	**37.85**	**27.00**	**28.00**	**22.00**
Low/Min Level	28.27	**10.00**	**10.00**	**8.00**	**15.00**
H/D ratio	0.38	0.38	0.27	0.28	0.22
Actual Level Change	9.59	27.85	17.00	20.00	7.00
Dimensionless Mixing Time	10.20	10.20	10.20	10.20	10.20
Desired Level Change Needed for Good Mixing	5.58	2.74	2.74	2.36	3.59
Pressure Drop After Change in Min Water Level		7.9	7.9	8.8	5.7
Fill Rate/ Pumping Rate	446	446	446	446	446
Draw Rate/ Consumer Demand	228	228	228	228	228
Avg Fill Time	0.88	2.55	1.55	1.83	0.64
Avg Draw Time	1.81	4.98	3.04	3.58	1.25
Avg Volume Added During Fill	0.56	1.64	1.00	1.18	0.41
Avg Duration (fill +draw)	2.69	7.53	4.59	5.41	1.89
Avg Flow Rate	0.21	0.22	0.22	0.22	0.22
Avg Tank Vol	1.94	1.41	1.09	1.06	1.09
Mixing Performance Ratio (Measured/Desired)	**1.72**	**10.16**	**6.20**	**8.47**	**1.95**
Turnover Time	**9.3**	**6.5**	**5.0**	**4.9**	**5.0**

Storage Tank Assessment Spreadsheet

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Use when:

- Tanks operated in fill-draw
- Tanks volume-to-depth relationship is known

Do Not Use for:

- Flow-through tanks (simultaneous inflow/outflow)
- Tanks with non-uniform volume-depth geometry, irregular shape
- Tanks with baffles, mixers, or thermal stratification

Increased Water Quality Monitoring-Distribution System

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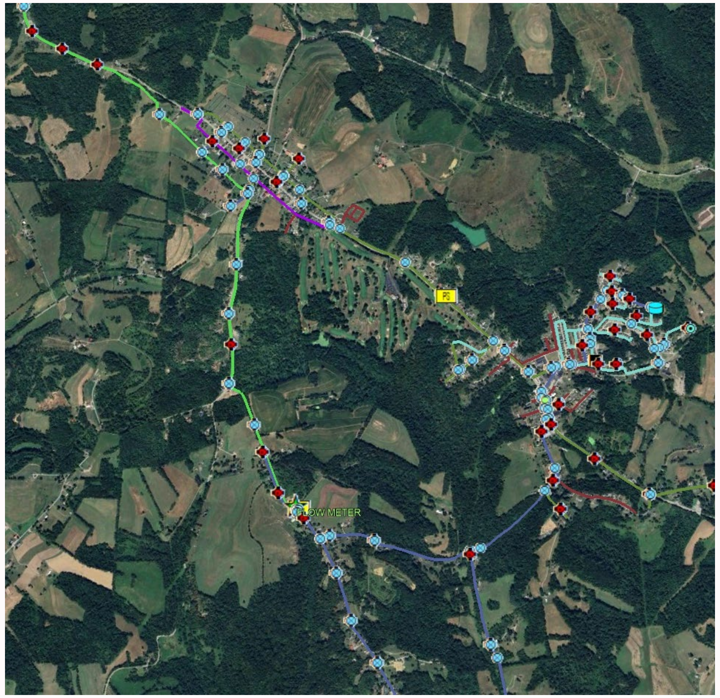
Investigative distribution system sampling

Up to date distribution system map



Identify critical locations

- Low chlorine
- High DBPs
- Dead ends; low use areas
- Booster stations
- Complaints
- Irregularities
- Interconnections

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Increased Water Quality Monitoring- Distribution System

Ensure water is from distribution system

- Not premise plumbing

Grab sampling

- Sampling station
- Hydrant sampler
- Time/Volume based flushing

    Consistent data = comparable results

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Increased Water Quality Monitoring- Distribution System

Calculated Flush Time or Calculated Flush Volume

Table 1: Calculated Flush Times (minutes) at 2 gpm for Various Line Sizes (inner diameter, ID, provided in inches)

Line Length (feet)	3/8" ID	½" ID	¾" ID	1" ID	1 ½" ID	2" ID	2 ½" ID	3" ID	4" ID
5	0.01	0.03	0.1	0.1	0.2	0.4	0.6	0.9	1.6
10	0.03	0.1	0.1	0.2	0.5	0.8	1.3	1.8	3.3
25	0.1	0.1	0.3	0.5	1.1	2.0	3.2	4.6	8.2
50	0.1	0.3	0.6	1.0	2.3	4.1	6.4	9.2	16.3
100	0.3	0.5	1.1	2.0	4.6	8.2	12.7	18.4	32.6

Note: some water systems and state primacy agencies have applied a **5-minute flush time** before sample collection. This may be excessive, appropriate, or insufficient depending on the circumstances at that sample point.

Table 2: Calculated Flush Volume (gallons) for Various Line Sizes (inner diameter, ID, provided in inches)

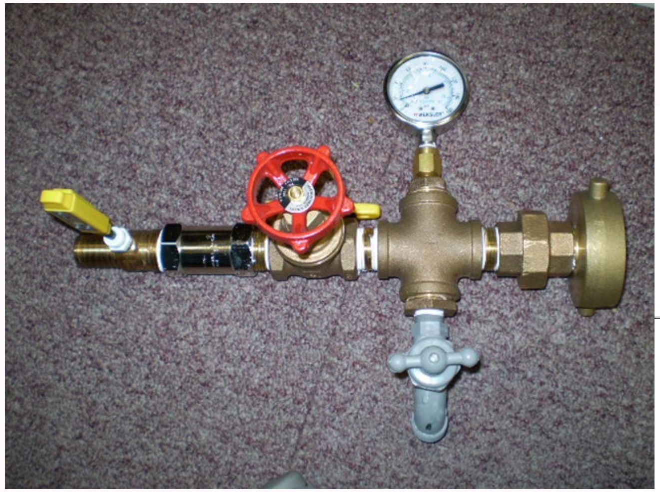
Line Length (feet)	3/8" ID	½" ID	¾" ID	1" ID	1 ½" ID	2" ID	2 ½" ID	3" ID	4" ID
5	0.03	0.1	0.1	0.2	0.5	0.8	1.3	1.8	3.3
10	0.1	0.1	0.2	0.4	0.9	1.6	2.5	3.7	6.5
25	0.1	0.3	0.6	1.0	2.3	4.1	6.4	9.2	16.3
50	0.3	0.5	1.1	2.0	4.6	8.2	12.7	18.4	32.6
100	0.6	1.0	2.3	4.1	9.2	16.3	25.5	36.7	65.3

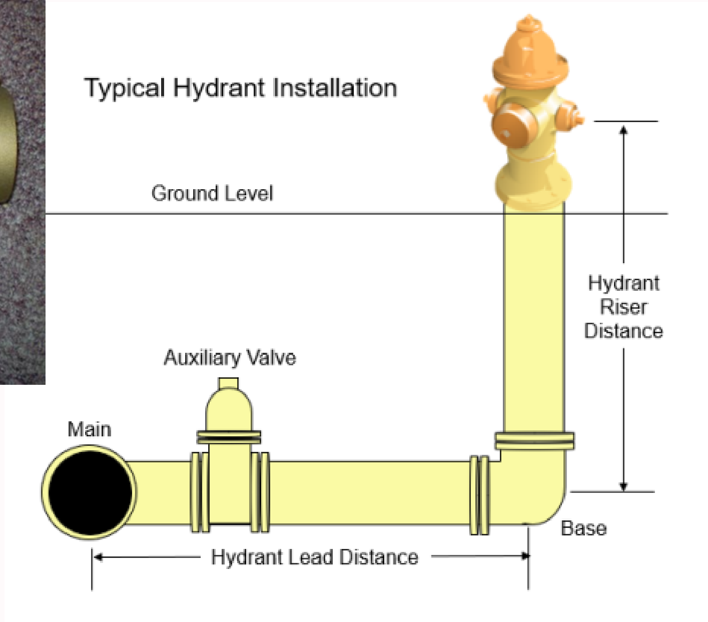
Note: this approach is not dependent on the sample tap flow rate, but a device for measuring volume is needed (i.e., appropriate volume).

EPA CFT/CFV guidance

Increased Water Quality Monitoring-Distribution System

Hydrant Sampler





Minimum Calculated Flush Times (minutes) at 20 gpm for various line sizes (inner diameter, ID, provided in inches).

Line Length (feet)	4" ID	6" ID	8" ID
5	0.5	0.5	1.0
10	0.5	1.0	1.5
15	0.5	1.5	3.0
20	1.0	1.5	3.0
25	1.0	2.0	3.5
30	1.0	2.5	4.0
35	1.5	3.0	5.0
40	1.5	3.0	5.5
45	1.5	3.5	5.5
50	2.0	4.0	6.5
60	2.0	4.5	8.0
70	2.5	5.5	9.5
80	3.0	6.0	10.5
90	3.0	7.0	12.0
100	3.5	7.5	13.5

EPA Hydrant Sampler Info: Parts & Procedure

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Increased Water Quality Monitoring-Distribution System

Parameters

- Free and total chlorine, pH, temp
- DBPs

Additional parameters if chloraminating

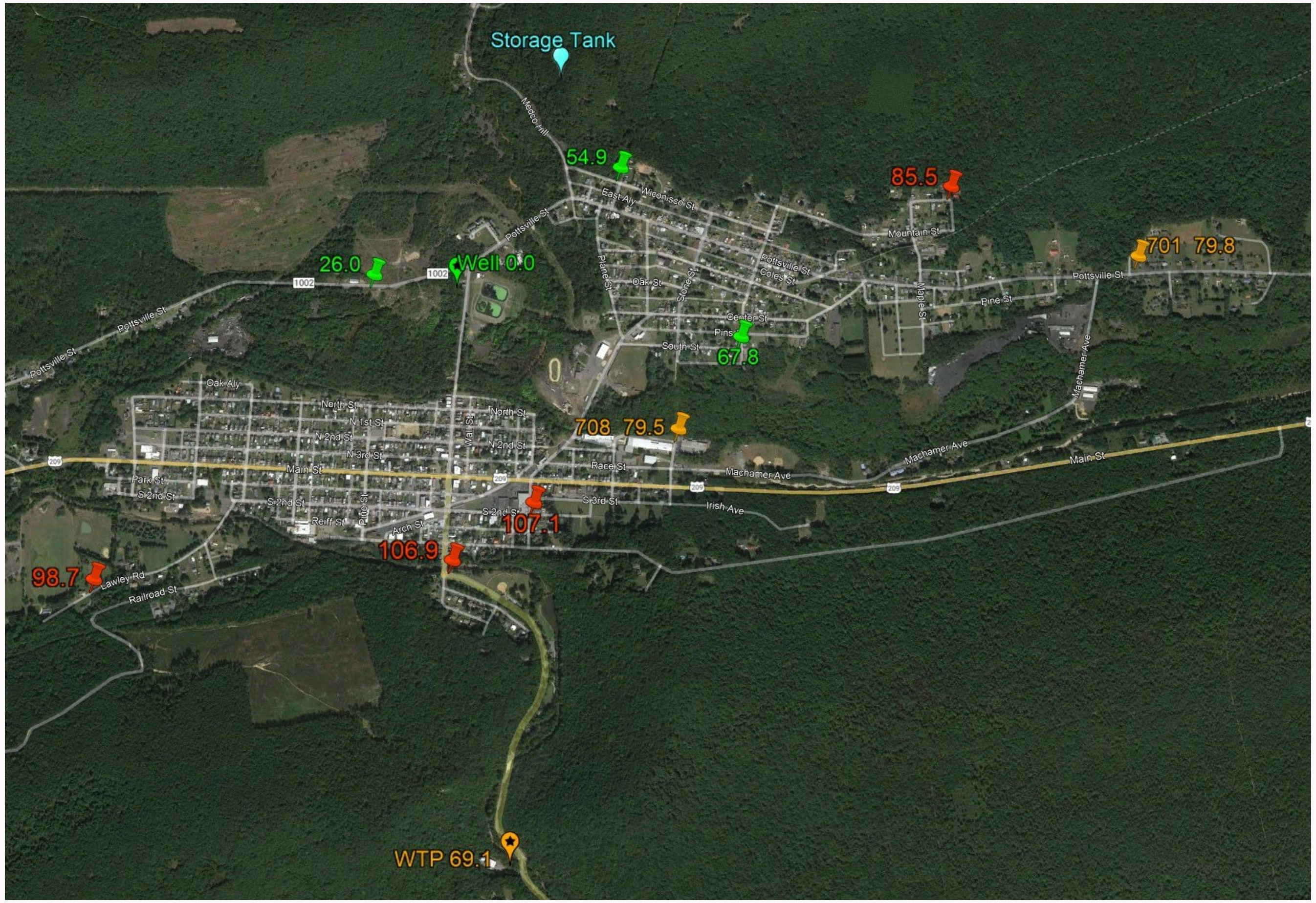
- Monochloramine, nitrite, free ammonia

Parameters specific to your system or the purpose of the investigation

- Alkalinity, fluoride, corrosion chemicals, hardness, specific conductivity

Increased Water Quality Monitoring-Distribution System

Mapping Results



Increased Water Quality Monitoring- Chloramines

Nitrification Control Plan (NCP)

In plant monitoring

Distribution system monitoring

Take action when prescribed in NCP

Required for systems chloraminating AND consecutives that purchase water from a system that is chloraminating

In Nitrification control plan pg 9 Action Plan triggers table	Total Chlorine (mg/L)	Monochloramine (mg/L)	Free Ammonia (mg/L)	Nitrite (mg/L)	Free Chlorine (mg/L)
Action 1 (normal)	1.5-2.5	1.5-2.5	<0.1	<0.02	<0.1
Action 2	1.0-1.5	1.0-1.5	0.1-0.5	0.02-0.05	0.1-0.5
Action 3	0.5-1.0	0.5-1.0	>0.5	0.05-0.10	>0.5
Action 4	<0.5	<0.5	>1	>0.1	>1

Increased WQ Monitoring-Booster Chlorine/Chloramine

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Boosting chlorine or chloramines

Best Case: Monitor before, then boost, then monitor after

Free chlorine boosting – free & total chlorine before and after

Chloramination boosting (chlorine & ammonia) - free & total chlorine, monochloramine, free ammonia, nitrite

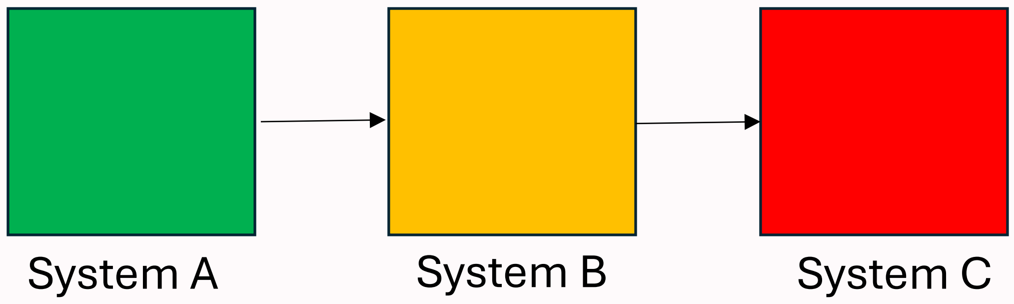
Consider also monitoring DBPs before and after

Increased Water Quality Monitoring-Consecutive Systems

High water age/old water

Low chlorine

High DBPs



Sample at interconnect

Chlorine residual-free and total

DBPs

Should the focus be within your distribution system or with the system you are receiving water from?

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Best Management Practices

What to do about the problem areas

BMPs – What to do about problems in the Filter Plant

Add chlorine after most of the organics have been removed

- This minimizes DBP formation
- Best case is to chlorinate after filtration
- If prechlorine is needed for CTs/log inactivation, minimize it as much as possible
  - Easier to meet CT requirements in warm weather - can you eliminate prechlorine in summer?
- If prechlorine is for something other than disinfection, consider alternative oxidants

Remove as many organics as possible

- Optimize pretreatment and settling/clarify steps to remove organics
- If you can't wait until organics are removed to add chlorine, waste/remove solids more frequently

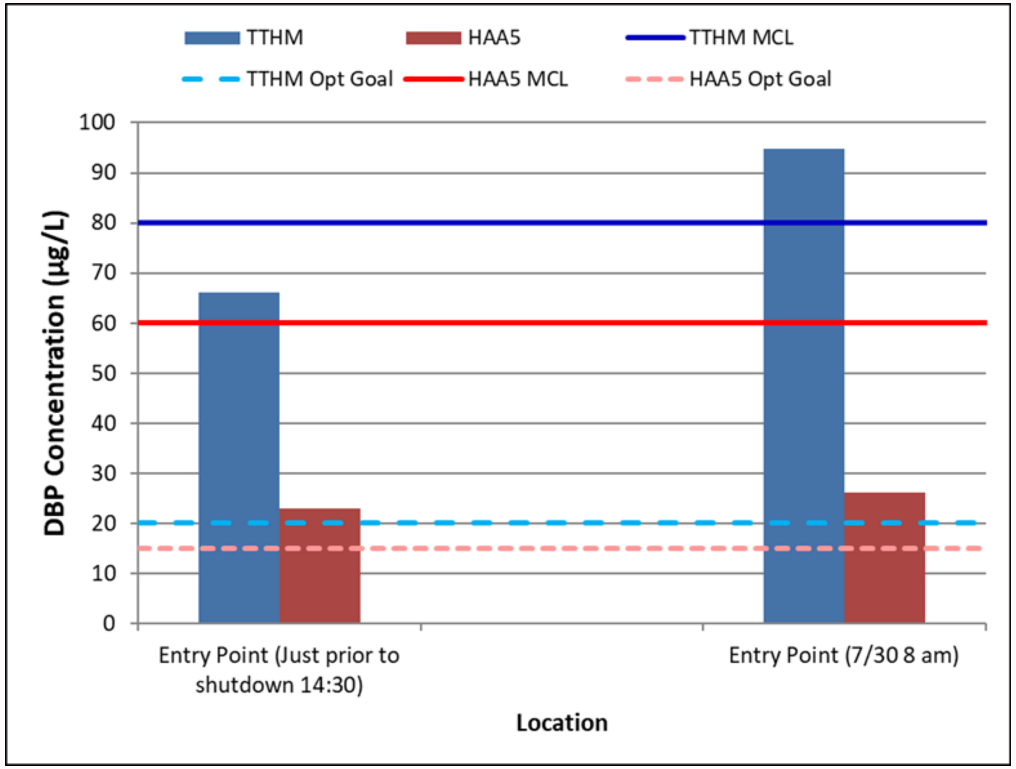
BMPs – What to do about problems in the Filter Plant

Optimize organics removal

- Use a preoxidant and/or powdered activated carbon (PAC)
  - Potassium or sodium permanganate
  - Chlorine Dioxide
  - Ozone

Continuous operation

- Water sitting in sed basin or clearwell overnight/plant offline can significantly increase in DBPs



BMPs – What to do about problems in Distribution Systems

Most problems are due to water age

Storage tanks

- Operational changes
    - Adjust high/low levels
    - Increase number of daily fill/draw cycles
    - Operate at a lower level; do not fill completely
- Decommission unneeded storage
- Mixers/aerators

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BMPs – What to do about problems in Distribution Systems

Flushing

- Manually flush entire system annually
- Manually flush problem areas more frequently
- Install Autoflushers in areas with persistent problems

- Flush to a chlorine target, instead of just until clean

BMPs – What to do about problems in Distribution Systems

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Booster chlorinate/chloraminate

- If chlorine residual is below regulatory requirement or optimization goal
- Can form additional DBPs
- Proper monitoring

Pipes

- Material
- Loop
- Properly size; don’t oversize

Pennsylvania
Department of
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Workshop
Anytown

10:00

Pennsylvania Department of Environmental Protection

Get In Touch

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The Department of Environmental Protection's mission is to protect Pennsylvania's air, land and water resources and to provide for the health and safety of its residents and visitors, consistent with the rights and duties established under the Environmental Rights Amendment (Article 1, Section 27 of the Pennsylvania Constitution).