Microbial and Disinfection Byproducts
Rule Revisions Working Group

Meeting 5: December 13, 2022, 11:00am-6:00pm ET

EPA

OFFICE OF GROUND WATER
AND DRINKING WATER

WELCOME

Rob Greenwood, Ross Strategic

Elizabeth Corr, DFO, U.S.EPA OGWDW

Eric Burneson, U.S. EPA OGWDW

OPENING REMARKS

Lisa Daniels & Andy Kricun, WG Co-Chairs

Segment 1: Agenda Review & Meeting Procedures

Rob Greenwood, Ross Strategic

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Today's Virtual Meeting: Zoom Controls

This meeting is **not** being recorded

The Zoom menu bar appears at the bottom of the Zoom window once the meeting begins.

If you don't see the menu bar, move your mouse slightly and the bar will appear.

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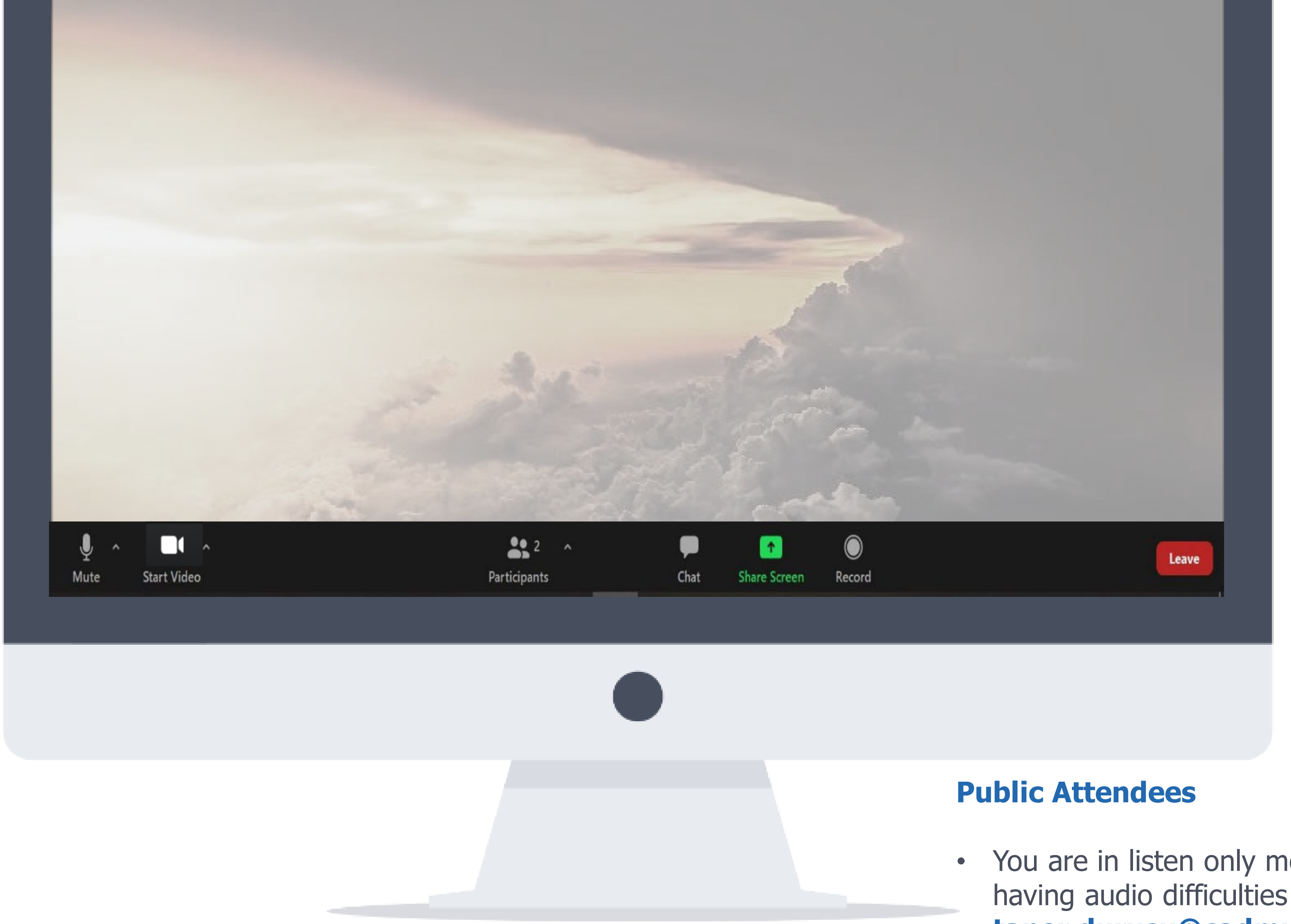

Public Attendees

- You are in listen only mode and will not be able to unmute. If you are having audio difficulties send an email to **taner.durusu@cadmusgroup.com**
- Any comments you may have can be sent to **MDBPRevisions@epa.gov** or to Public Docket: www.regulations.gov / Docket ID Number: EPA-HQ-OW-2020-0486

EPA AND FACILITATION TEAM

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Today's Agenda

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11:00-12:00	• Segment 1: Agenda Review and Meeting Procedures • Segment 2: Follow up on Problem Characterization Discussions on Opportunistic Pathogens, Disinfectant Residuals, Disinfection Byproducts, and Risk-Balancing/Interdependencies
	15 Minute Break (12:00 – 12:15 pm ET)
12:15-1:15	• Segment 2 continued
	60 Minute Lunch Break (1:15 – 2:15 pm ET)
2:15-3:30	• Segment 3: Environmental Justice in the MDBP Context
	15 Minute Break (3:30-3:45 pm ET)
3:45-6:00	• Segment 3 continued • Segment 4: Topic Areas for Possible Problem Characterization Findings • Segment 5: Meeting 6 Agenda & Next Steps

Segment 2: Follow up on Problem Characterization Discussions on Opportunistic Pathogens, Disinfectant Residuals, Disinfection Byproducts, and Risk-Balancing/Interdependencies

Presentations and Facilitated Discussion

December 13, 2022

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Problem Characterization on OP, Residuals, DBPs, and Interdependencies: Follow up Information

- Technical analysts who provided input to the responses on the following slides
  - Nancy Love – The University of Michigan
  - Andrew Jacque – Water Quality Investigations
  - Zaid Chowdhury – Garver
  - Susan Teefy – East Bay Municipal Utility District
  - Chris Owen – Hazen and Sawyer

Problem Characterization on OP, Residuals, DBPs, and Interdependencies: Follow up Information

- ## What are problems related to CT values?
  - The accuracy of CT values are sometimes questioned by water professionals. Some people think that there is too large safety factors are built into these values and that the safety factors may need to be reviewed.
  - CT Tables do not extend beyond a pH of 9. Some states have interpreted this to mean no CT credit is given above 9, whereas others allow it. There are studies available that include appropriate guidance (WRF 2019)
  - No EPA guidance is available regarding implementation of CT on a practical basis using modern equipment. For example, EPA guidance assumes CT is calculated once per day at peak flow rate. What happens if a water system calculates it continuously using online instruments? What constitutes a violation? One minute below the target? 95% of all daily readings? 99%? Different states have interpreted this differently.
- ## What problems are related to Public Notification?
  - Public Notification requirements don't consider modern communication mechanisms (social media, websites, "reverse 911")

Problem Characterization on OP, Residuals, DBPs, and Interdependencies: Follow up Information

- What unintended consequences are associated with source water contamination?
  - If the source water for a WTP is contaminated by upstream wastewater discharges, we could see trace contaminants that often pass through biological wastewater treatment processes. A few of the notable contaminants finding their way in to drinking water include nitrosamines, precursors for brominated and iodinated DBPs, pharmaceuticals, and PFAS. A reliable marker for wastewater contamination in drinking water sources is artificial sweeteners (sucralose) as these chemicals usually remain intact during the transport in rivers and canals.
  - Wild-fires in watersheds open up another category of contamination for drinking water. Several research projects are done in this area that demonstrate increased organic concentration in source (some of these could be DBP precursors and exert additional disinfectant demands during water treatment).
  - Nitrogenated DBP precursors include natural nitrogen sources, run-off, and wastewater.

Problem Characterization on OP, Residuals, DBPs, and Interdependencies: Follow up Information

- What water quality considerations are relevant for hydraulics?
  - Hydraulic conditions that significantly increase water age, could lead to additional DBP formation. Mixing of two different waters could result in reactions between components of the two sources that could result in formation of insoluble inorganic precipitants, decay of disinfectants (particularly when chloraminated distribution system water mixes with chlorinated groundwaters). It is advisable to thoroughly assess mixing two different types of waters.
  - Transient hydraulic conditions can dislodge biofilms and mineral scales to cause periodic release of metals bound in these materials (iron, manganese, arsenic, lead, copper, etc.) and of opportunistic pathogens.
  - Increased water age can lead to regrowth of opportunistic pathogens due to lower disinfectant residual and long exposure to growth-associated substrates that can create competition between types of microbes that proliferate. This is an area of research that is under-studied and we need more information to understand the phenomenon.
  - Sometimes a WTP can't be shut down. Complete depressurization leads to uncontrolled backflow/back-siphonage (most residential homes don't have backflow protection) and much more contamination. It is generally better to have water available, even if it is contaminated, for firefighting, toilet flushing, etc.

Problem Characterization on OP, Residuals, DBPs, and Interdependencies: Follow up Information

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- What are problems associated with nitrification?
  - Problems associated with nitrification in the DS vary depending upon conditions in the source water (surface and groundwater sources), type of treatment employed (conventional, membrane, ozone, etc.), disinfectant used, TOC concentration, ammonia concentration (in source or added for monochloramine feed), organic nitrogen concentration, water system configuration and premise plumbing conditions. Problems include:
    - A rapid loss of residuals (a very prominent indicator of nitrification).
    - A drop in pH resulting in red water issues due to oxidized iron dissolution from surfaces.
    - Accelerated corrosion of plumbing and other metallic equipment, especially in systems with low source water metal concentrations.
    - Growth of heterotrophic bacteria and biofilms.
    - Proliferation of ammonia oxidizers and an increase in nitrite/nitrate.
    - More growth of nitrifying bacteria. This may be amplified on point-of-use devices.
    - An increase in ammonia concentrations due to chloramine decay.
    - Nitrite formation which accelerate monochloramine decay.
    - Increases in chlorinated DBP (sometimes short-term due to a common response of localized breakpoint chlorination).

Problem Characterization on OP, Residuals, DBPs, and Interdependencies: Follow up Information

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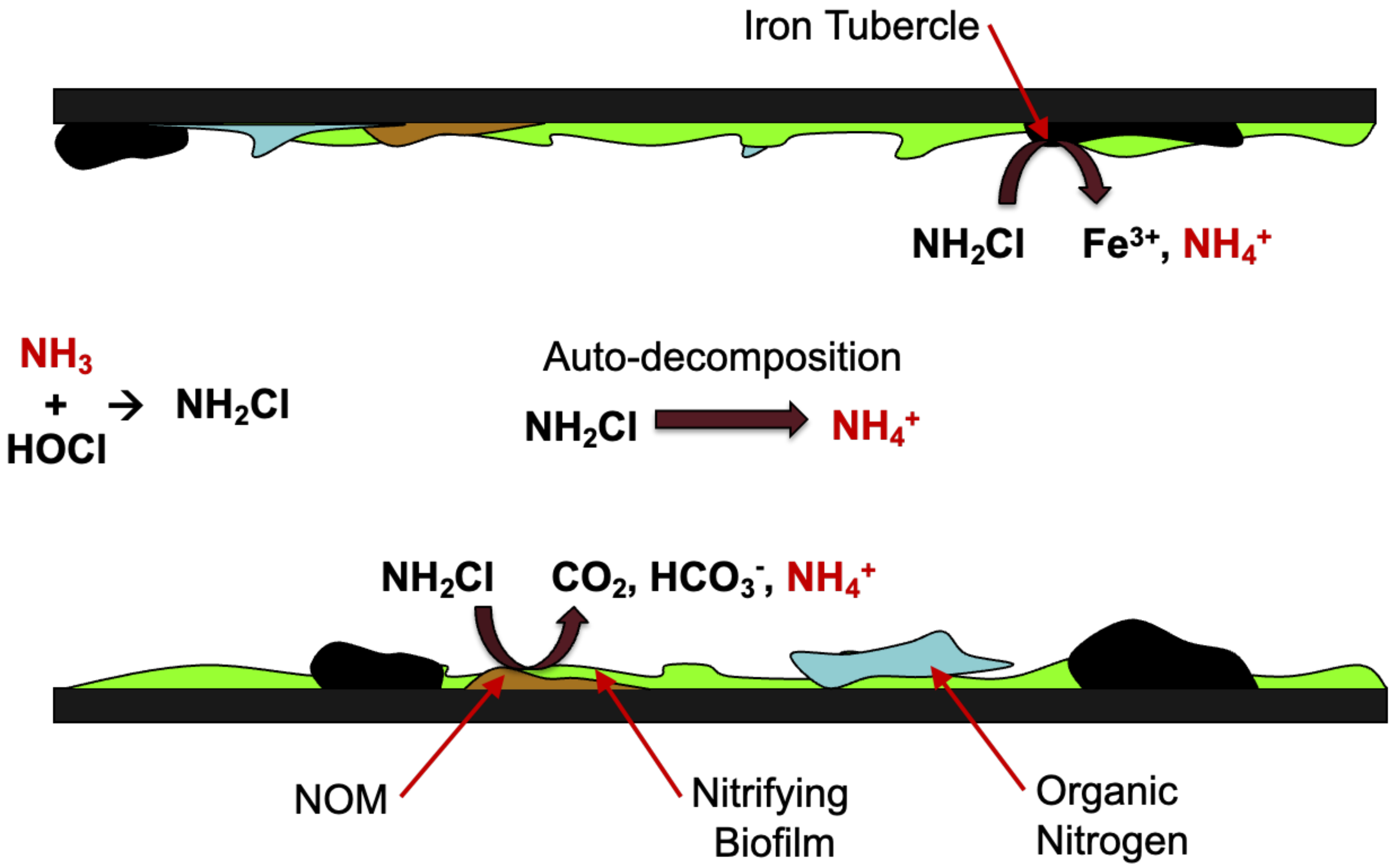
- ## What are problems associated with nitrification (cont.)?
  - Biofilms associated with nitrification have been shown to be "nitrosamine precursors" upon addition of monochloramine.
  - Nitrification is primarily a biofilm driven aerobic biological process that needs metallic cofactors for conversion of ammonia to nitrate (three step process), including iron, copper and molybdenum.
  - Nitrification is predominantly present in water storage structures but can be carried over into plumbing in well oxygenated waters.
  - Nitrification issues are more common in systems using monochloramine with too much excess ammonia. Nitrification has also been in water with elevated protein concentrations, which are not sampled for or regulated.
  - With no regulation of the amount of free ammonia that can be present, non-compliant nitrite concentrations can result at the consumer tap, which would not be caught by compliance monitoring.
  - When excess TOC is present, complete nitrification to nitrate is inhibited and nitrite concentrations can be developed in excess. Thick biofilms can perform the nitrogen cycle, including performing dissimilatory nitrate reduction to ammonia to keep the biofilm alive under low nutrient loading.


Iron Tubercle
NH2Cl
Fe3+, NH4+
NH3
+ → NH2Cl
HOCl
Auto-decomposition
NH2Cl → NH4+
NH2Cl
CO2, HCO3-, NH4+
NOM
Nitrifying Biofilm
Organic Nitrogen

Legionella Assessment and Risk

Joan B. Rose
Michigan State University
rosejo@msu.edu

Presentation to EPA's NDWAC Working Group on Microbial and Disinfection Byproduct Rules

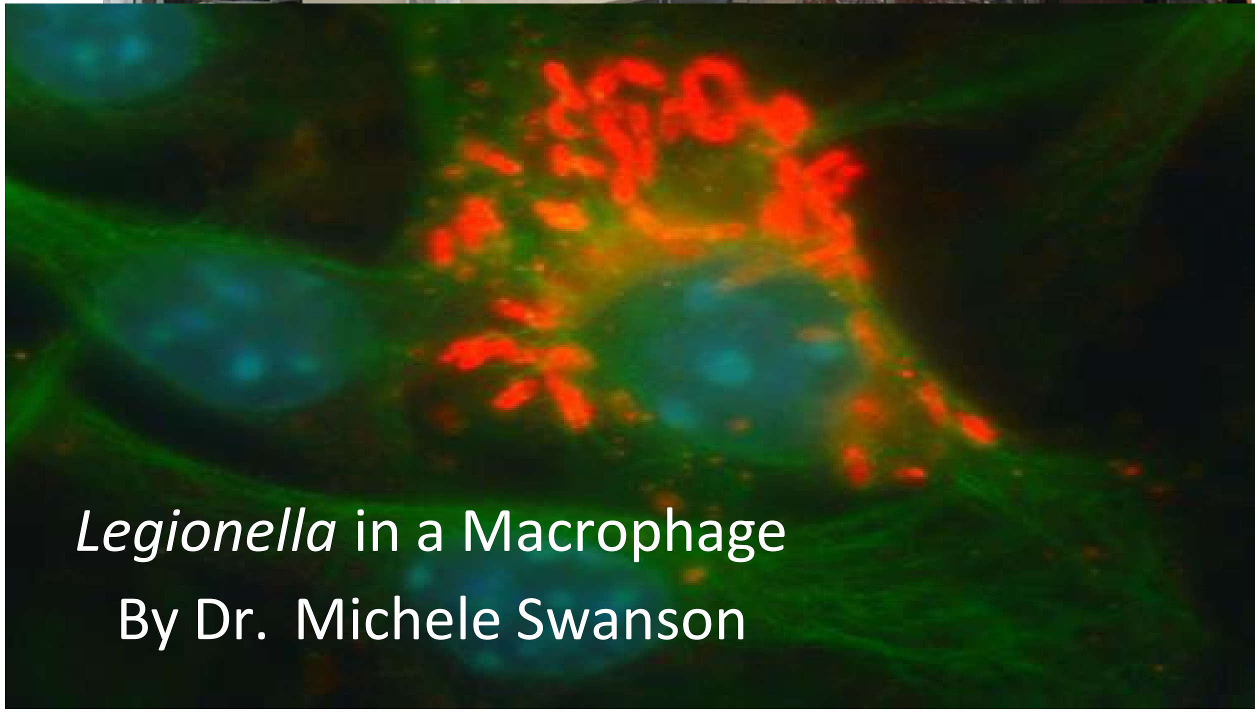
Presentation Outline

- Key Findings and Recommendations from the National Academies Report
- QMRA Framework
- Occurrence and Growth of Bacteria
- Implications for the Water Industry

The National Academies of Sciences, Engineering and Medicine Water Science and Technology Board

Management of *Legionella* in Water Systems 2019

The National Academies of Sciences, Engineering and Medicine
Water Science and Technology Board
Management of *Legionella*
in Water Systems

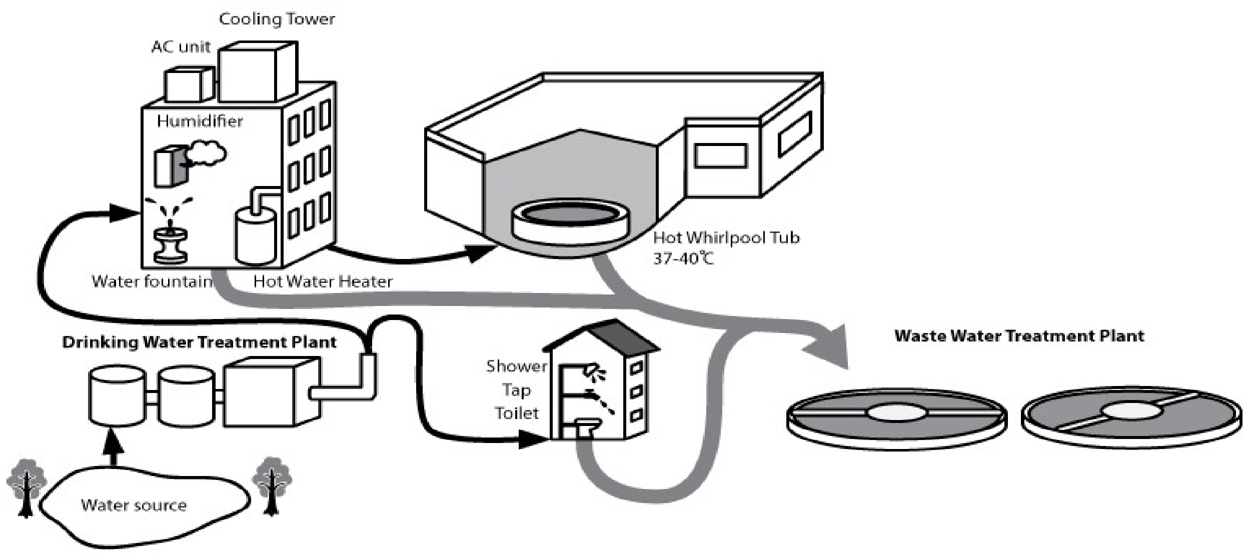


Legionella in a Macrophage
By Dr. Michele Swanson

Statement of Task

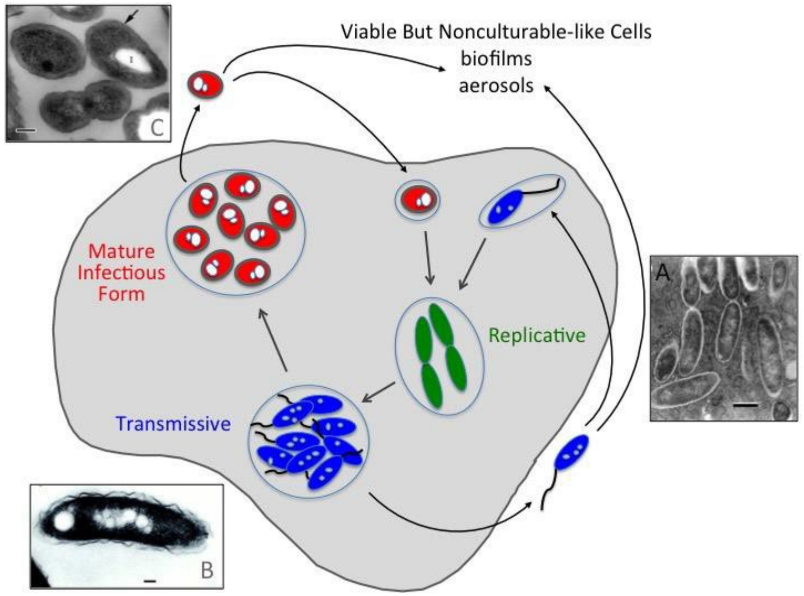
- **Ecology and Diagnosis**: Describe the microbial ecology of water supplies as it relates to *Legionella*. How can diagnosis be improved?
- **Transmission via Water Systems:** What are the primary sources of human exposure to *Legionella*? What features/characteristics of water systems make them likely to support growth of *Legionella?*
- **Quantification:** What is known about the concentration of *Legionella* in water systems *and* the prevalence of Legionnaires' disease over the last 20 years? Is there a minimum level of contamination required to cause disease?
- **Prevention and Control:** What are the most effective strategies for preventing and controlling *Legionella* amplification in water systems?
- **Policy and Training Issues:** What policies, regulations, codes, or guidelines affect the incidence, control, quantification, and prevention of Legionnaires' disease? How might they be built upon to better protect the public?

Chapter 1: INTRODUCTION



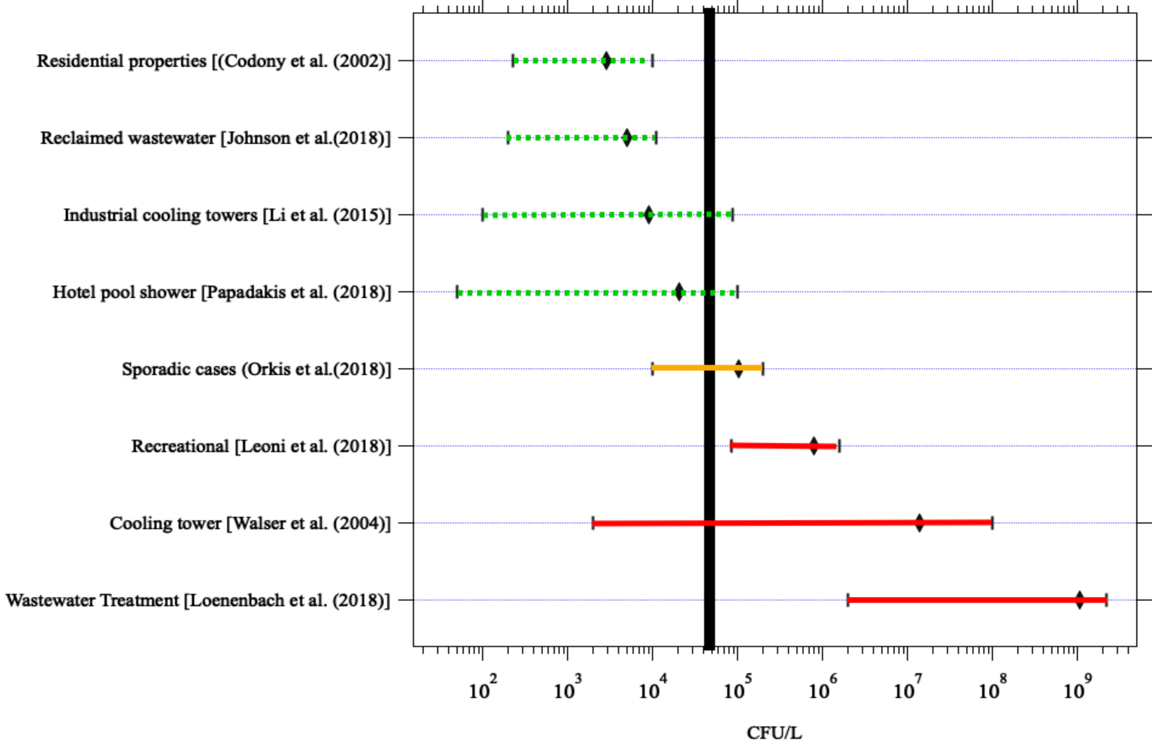
- *Legionella* was first documented as a cause of human disease in 1976, after an outbreak of pneumonia of unknown origin was described among members of the American Legion who had attended a conference at the Bellevue-Stratford Hotel in Philadelphia
- The history and evolution of knowledge on this waterborne disease is recorded to a large extent via outbreaks
- It is clear that the built environment is a major ecological niche for the bacteria and controls focus on biocides for cooling towers and hospitals

Chapter 2
DIAGNOSIS, ECOLOGY AND EXPOSURE PATHWAYS



- There are 61 known species of *Legionella*
- *L. pneumophila* is the most dominant; Others pathogenic species include *L. micdadei, L. bozemanii, L. dumoffi and L. longbeachae*
- The bacteria can exist in numerous forms. This includes transmissive, replicative, and mature infectious forms, as well as viable-but-nonculturable (VBNC)
- The primary growth habitat of *L. pneumophila* is within amoebae or other free-living protozoa associated with biofilms
- Studies are needed to understand the various forms, growth, virulence and role of free-living amoeba

Chapter 3: QUANTIFICATION OF *LEGIONELLA* AND LEGIONNAIRES' DISEASE



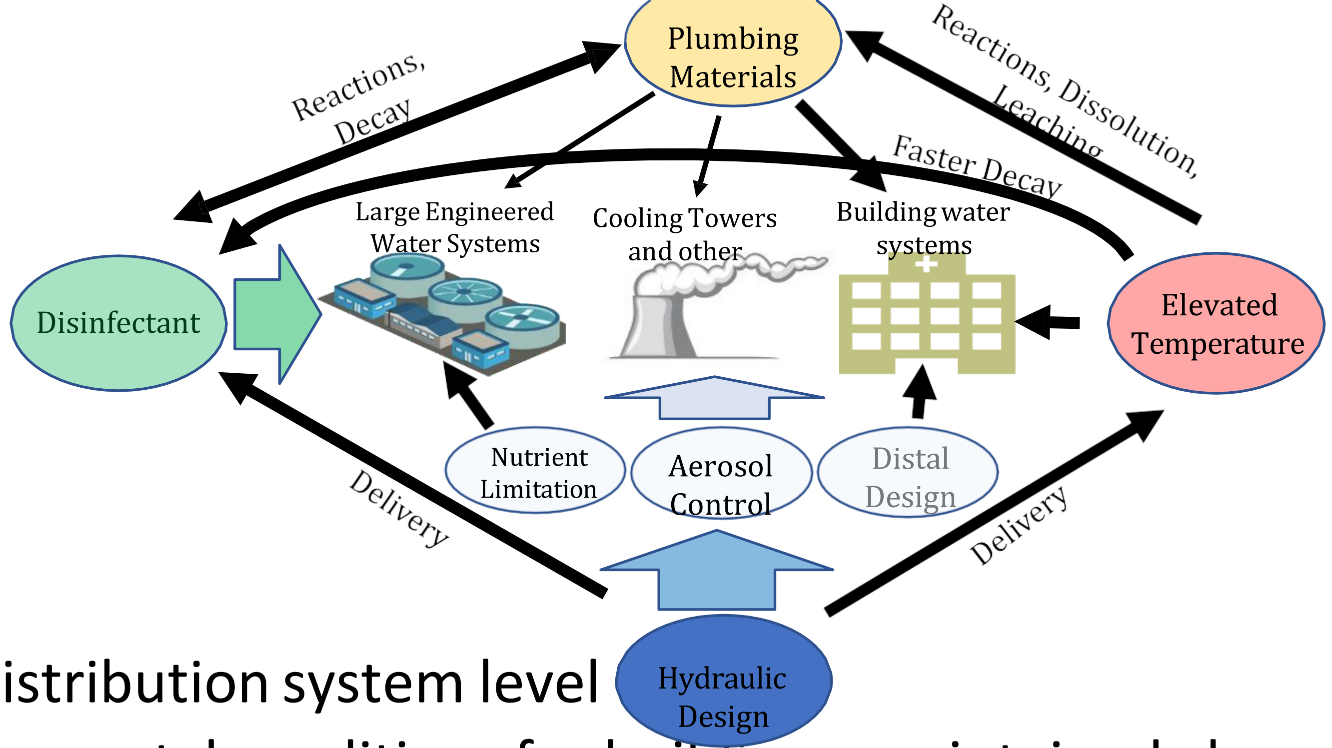
Many Purposes: Diagnosis, Outbreak investigation, Routine monitoring, Mitigation assessment, and Research

New investment in modified culture and molecular tools is needed

- **Regional Centers of Excellence** could serve as a backbone to strengthen the capacity of state health departments to detect and investigate cases of LD
- **Systematic comparison** of culture methods for *Lp* (and other pathogenic legionellae) ddPCR, qPCR, viability-qPCR, and reverse transcriptase qPCR needed.

Chapter 4:

STRATEGIES FOR *LEGIONELLA* CONTROL AND THEIR APPLICATION IN BUILDING WATER SYSTEMS



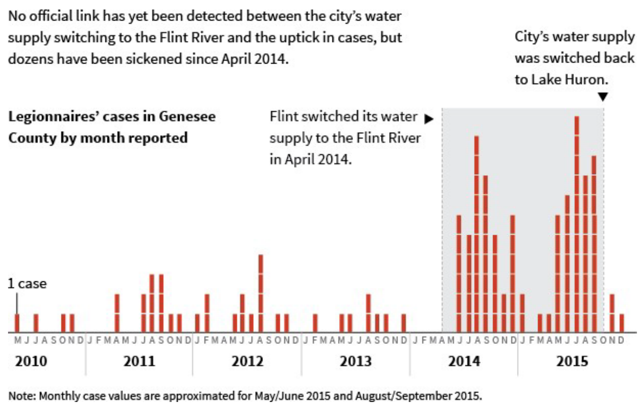
Includes approaches for the building and distribution system level

Temperature seen as one of the key environmental conditions for buildings, maintained above **60°C (140°F),** and the hot-water temperature to the distal points should exceed **55°C (131°F)**

For Engineered systems: Disinfection and hydraulics important; science of disinfection of the various forms of *Legionella* is unknown

The role of nutrients and pipe materials are not clear.

What causes *Legionella* to bloom?

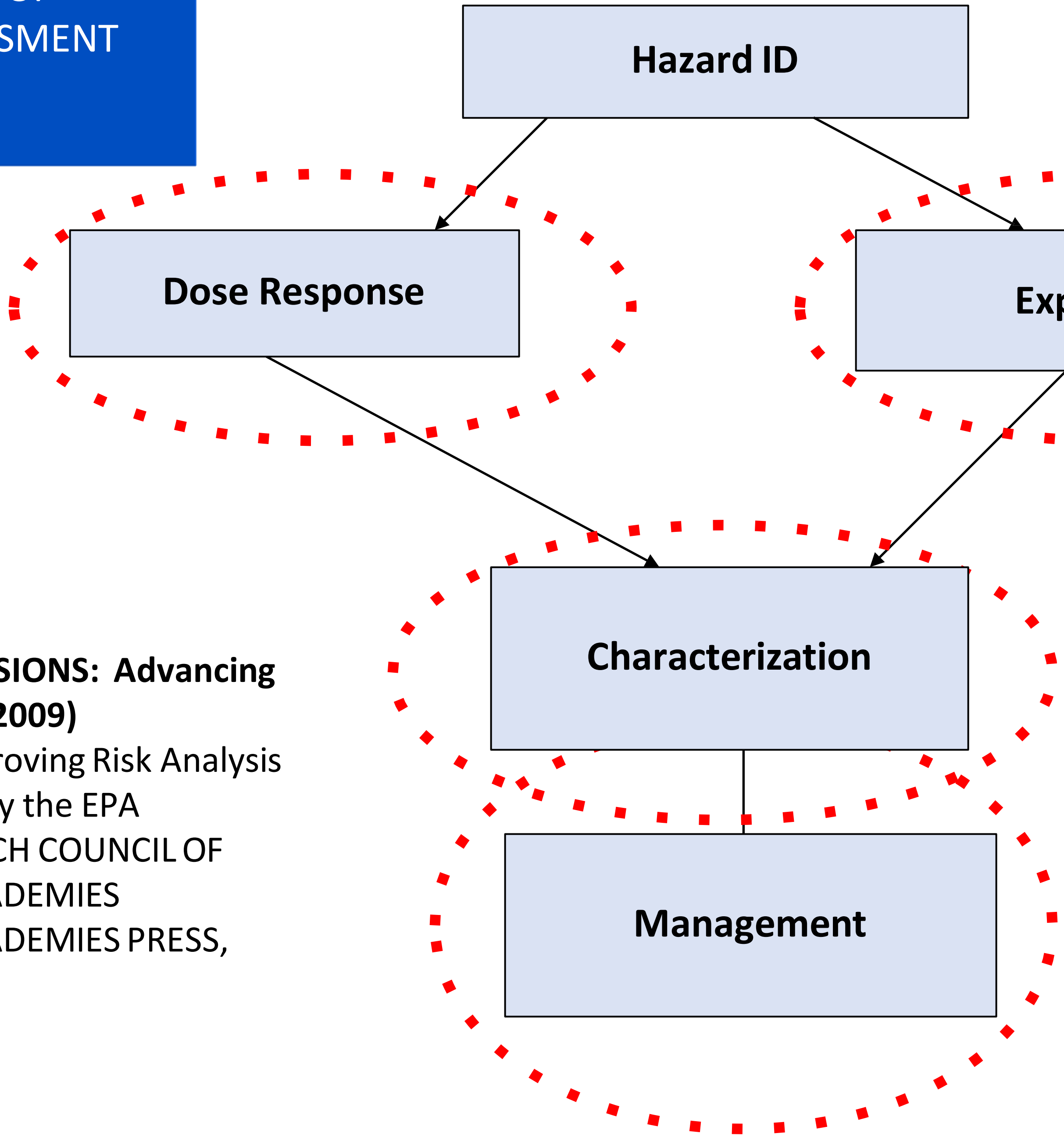


Chapter 5:
REGULATIONS AND GUIDELINES ON LEGIONELLA CONTROL IN WATER SYSTEMS

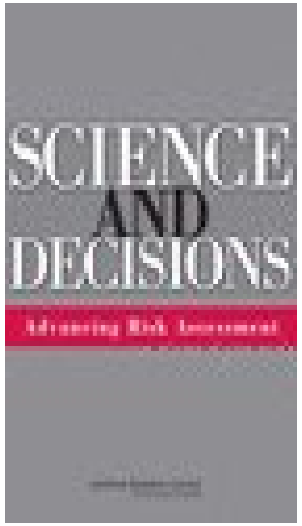
The Safe Drinking Water Act does not provide protection from Legionella

- The role of water utilities today
  - Responsive to SDWA
  - Providing DS disinfectant residual
  - Responsibility ends at the service connection
- Differences between premise plumbing and main distribution system (length, surface/volume ratio, water age)
- No evidence that residuals persist within buildings
- Do we need an "ICR" for distribution systems and buildings?

NATIONAL ACADEMY OF SCIENCES RISK ASSESSMENT PARADIGM

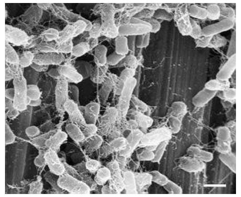


SCIENCE AND DECISIONS: Advancing Risk Assessment, (2009)
Committee on Improving Risk Analysis Approaches Used by the EPA
NATIONAL RESEARCH COUNCIL OF THE NATIONAL ACADEMIES
THE NATIONAL ACADEMIES PRESS, DC. www.nap.edu



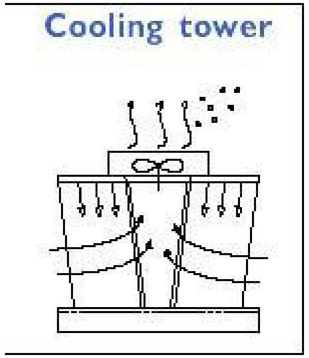
QMRA For SAFE DRINKING WATER

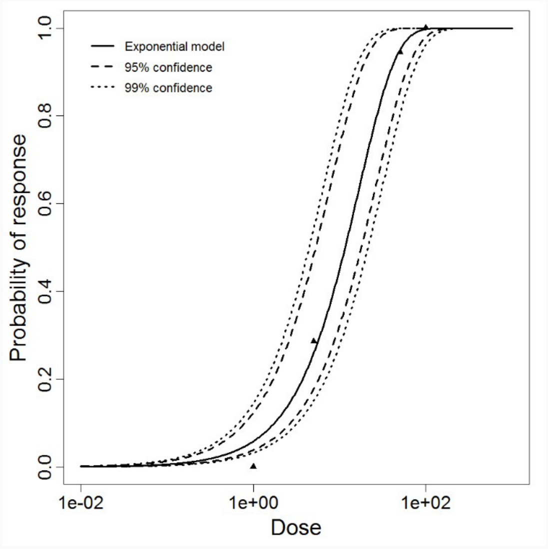
Hazards and impacts:
different species,
forms, Pontiac fever?



The Exposure

Sources of *Legionella*
Forms of bacteria
Regrowth
Aerosolization
Persistence





Exponential model plot, with confidence bounds around optimized model

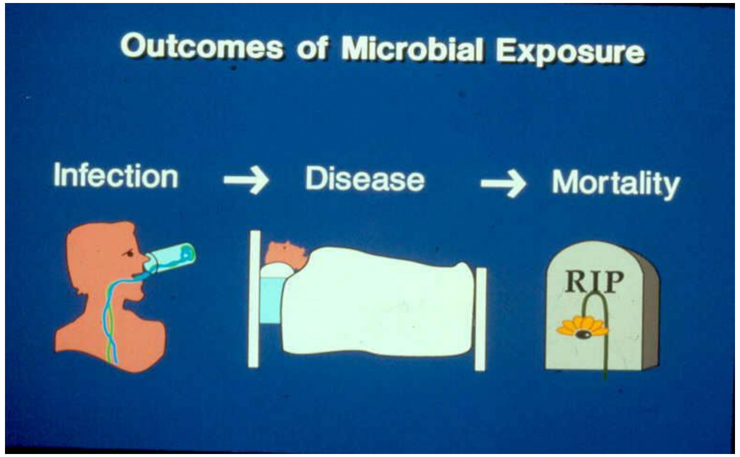
The Dose-response

Fitzgeorge et al. (1983) challenged Female Dunkin-Hartley Guinea-pigs with aerosols of *Legionella pneumophila* Strain 74/81.

11.6 ID_{50}

QMRAwiki:

The Risk Characterization



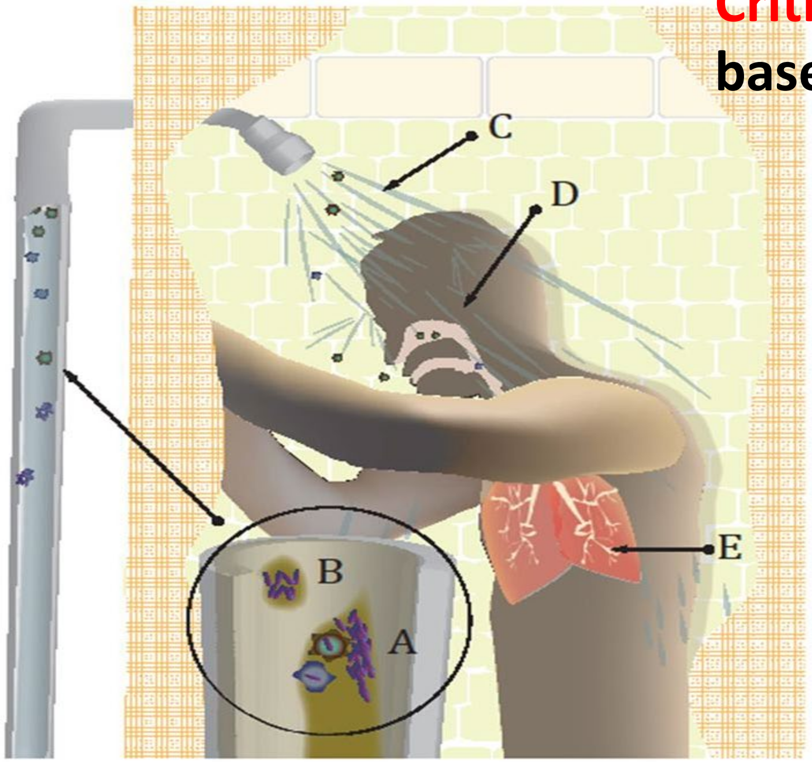
'Reverse' QMRA for critical *Legionella* densities

– informed Dutch, German & ASHRAE

Critical # in DW
10^6 – 10^8 CFU L^{-1}
based on QMRA model
Needs hosts to reach that

Aerosolization
Critical # 35 – 3,500 CFU m^{-3}
based on QMRA model

Inhalation



Biofilm colonization and detachment

Deposition
1-1,000 CFU in lung for potential illness

Schoen & Ashbolt (2011) Water Research 45(18): 5826-5836
American Soc Heating, Refrigerating & Air-Conditioning Eng

Source: Dr. Joan Rose http://www.nature.com/nature/journal/v523/n7562/fig_tab/nature14660_SV1.html

USE of QMRA

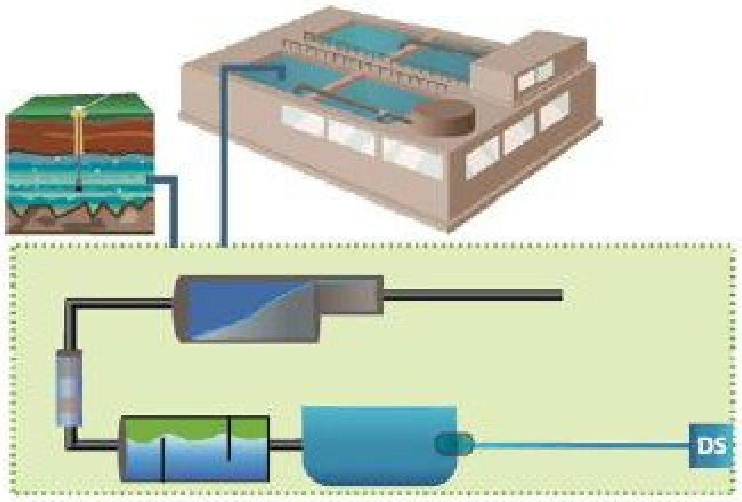
- Guidance on interpretation of monitoring results, e.g., including setting targets
- Training and education

Devices/Fixtures	Critical Average Lp Concentration (CFU/L)
Target Risk Value: 10^{-4} infections per person per year	
Conventional faucet	104,000
Conventional toilet	857,000
Conventional shower	1,410
Target Risk Value: 10^{-6} DALY per person per year	
Conventional faucet	1,060
Conventional toilet	8,830
Conventional shower	14.4

L. pneumophila concentrations in various plumbing fixtures that correspond to target risk levels. NOTE: Median estimates from a Monte Carlo simulation. SOURCE: Hamilton et al. (2019).

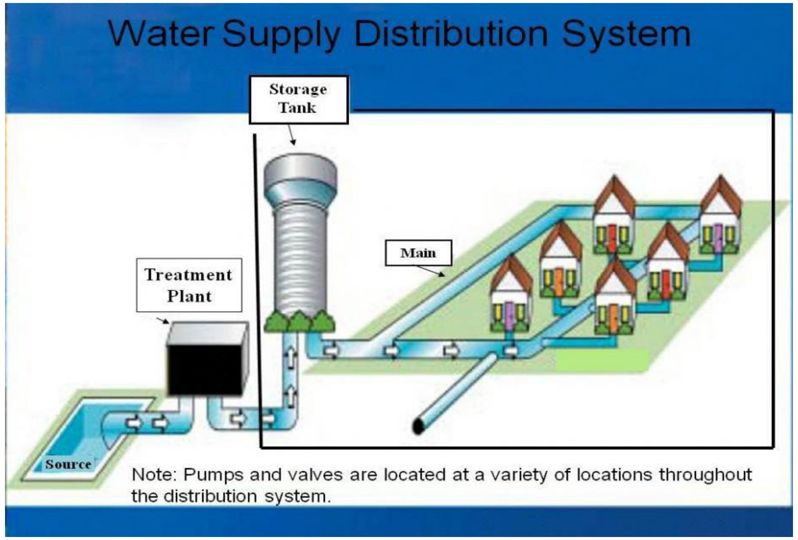
Legionella Environmental Occurrence

Treated Water



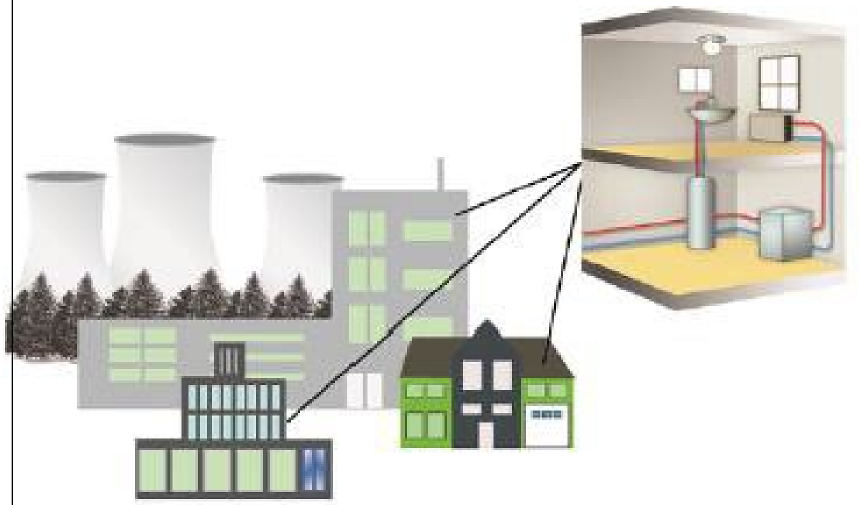
3×10^3 CFU/L

Distribution System



8×10^4 CFU/L

Premise Plumbing



6×10^5 CFU/L

Source: Papadakis et al. 2018; van Heijnsbergen et al. 2016; van Heijnsbergen et al. 2014

microorganisms

MDPI

Article

Water Age Effects on the Occurrence and Concentration of *Legionella* Species in the Distribution System, Premise Plumbing, and the Cooling Towers

Alshae R. Logan-Jackson [1,*] and Joan B. Rose [2]

Goal: To examine *Legionella* species from the water source to distributed water to cooling towers, a wholistic view of the water system

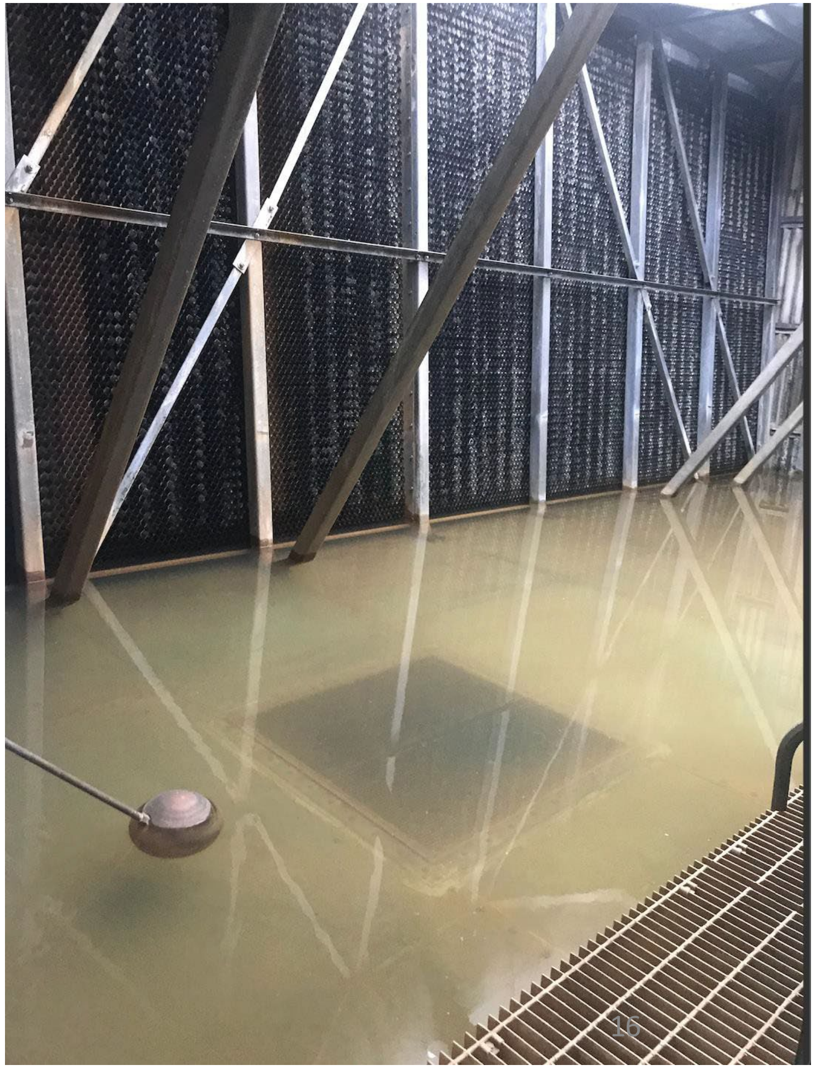
Summer 2019 : **Variability from Source to Tap, and Cooling Towers**

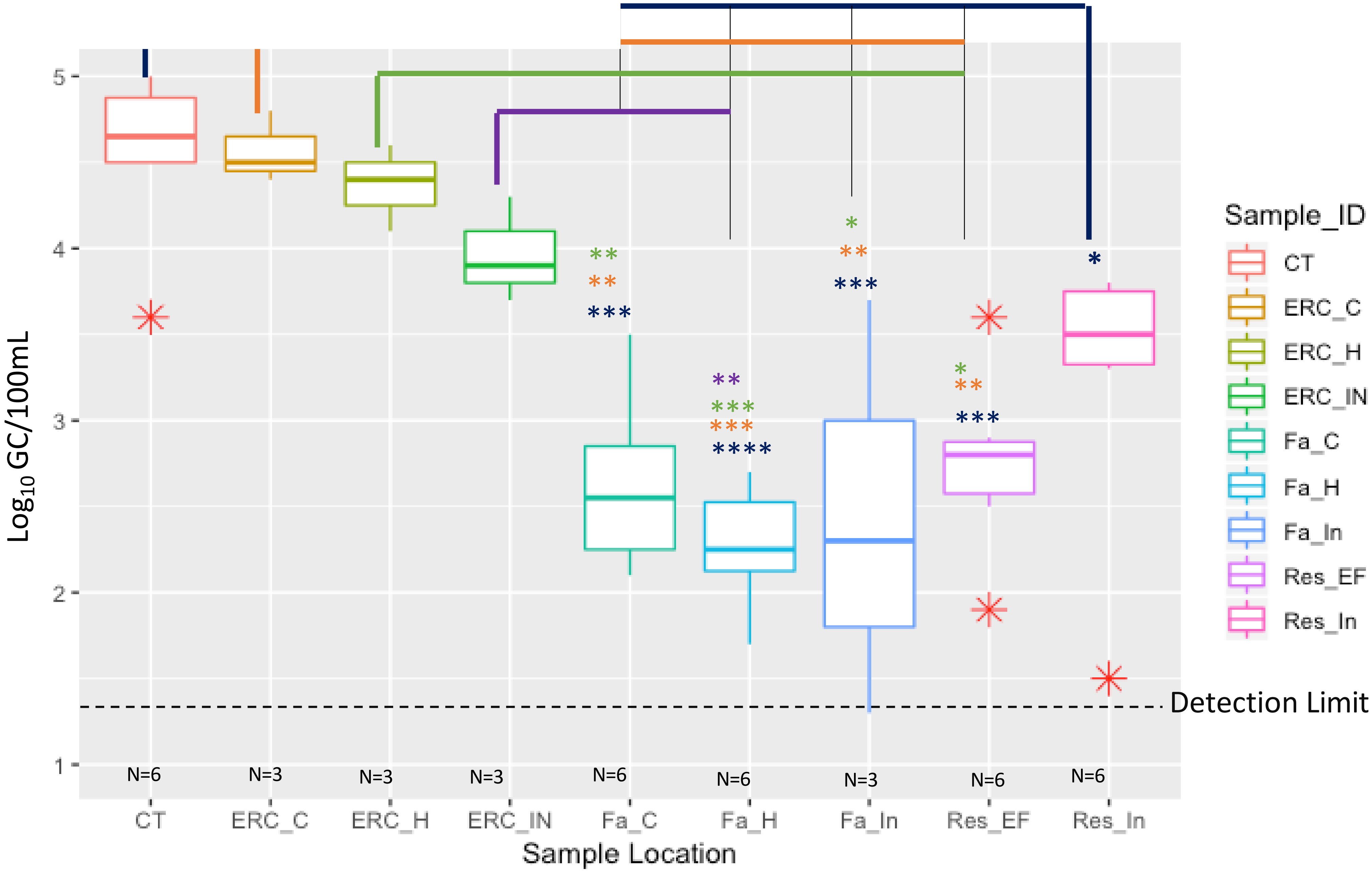
A total of 42 samples were collected:

Ground water and
Reservoir System
Influent: N= 6
Effluent: N= 6

F: N= 15
ERC: N= 9
Water samples

N = 6 Cooling tower samples



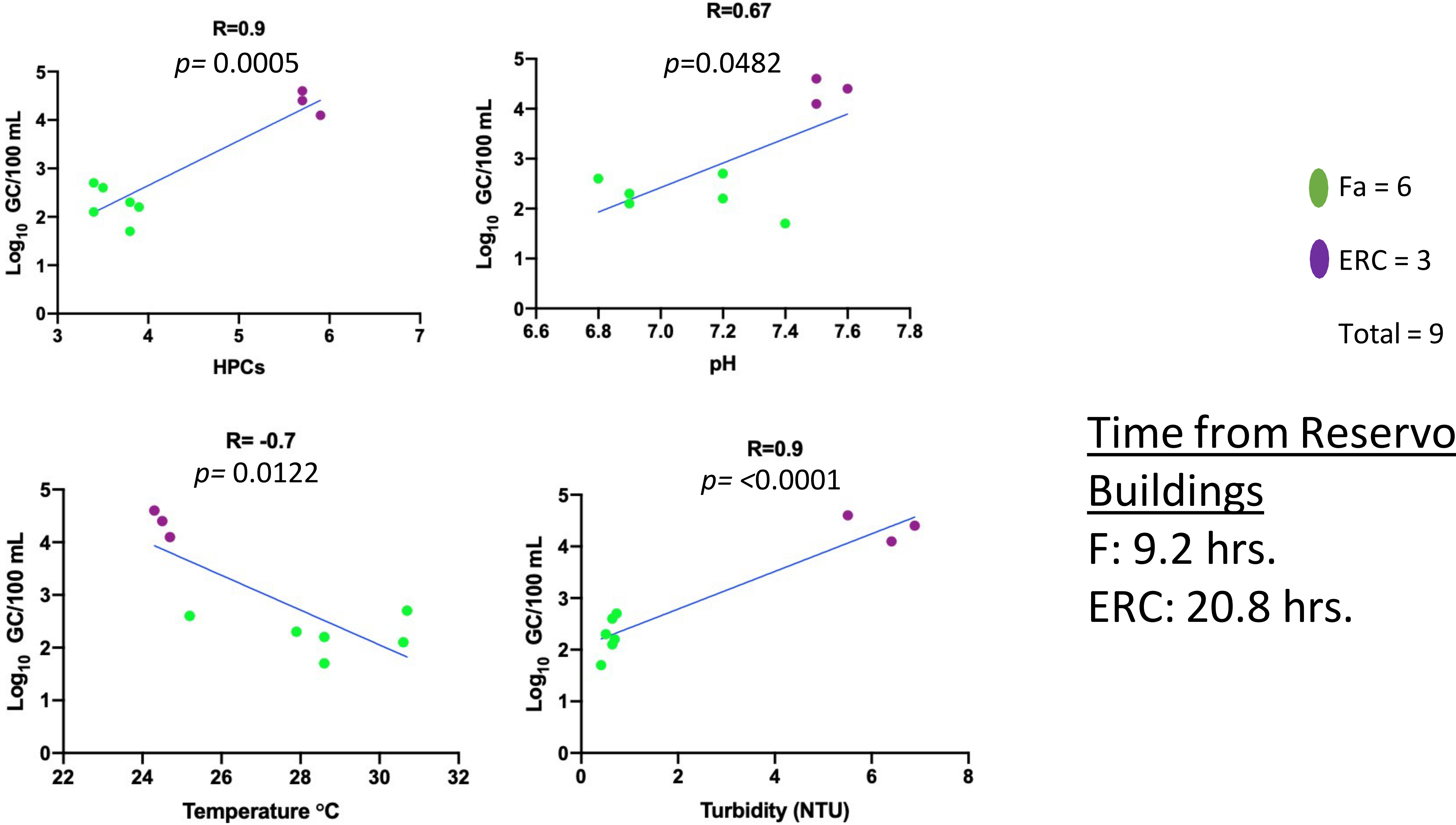


- Time from groundwater to the Reservoir (influent): 4.5 hours
- Time from the influent pipe to the effluent pipe: 3.4 hours

<u>Time from Reservoir to Buildings</u>

- F: 9.2 hours
- ERC: 20.8 hours
- Cooling Towers: not known

Pearson Correlation analyses of *Legionella* 23S rRNA and Water Quality Parameters in F and ERC Hot Water Samples



<u>Time from Reservoir to Buildings</u>

F: 9.2 hrs.

ERC: 20.8 hrs.

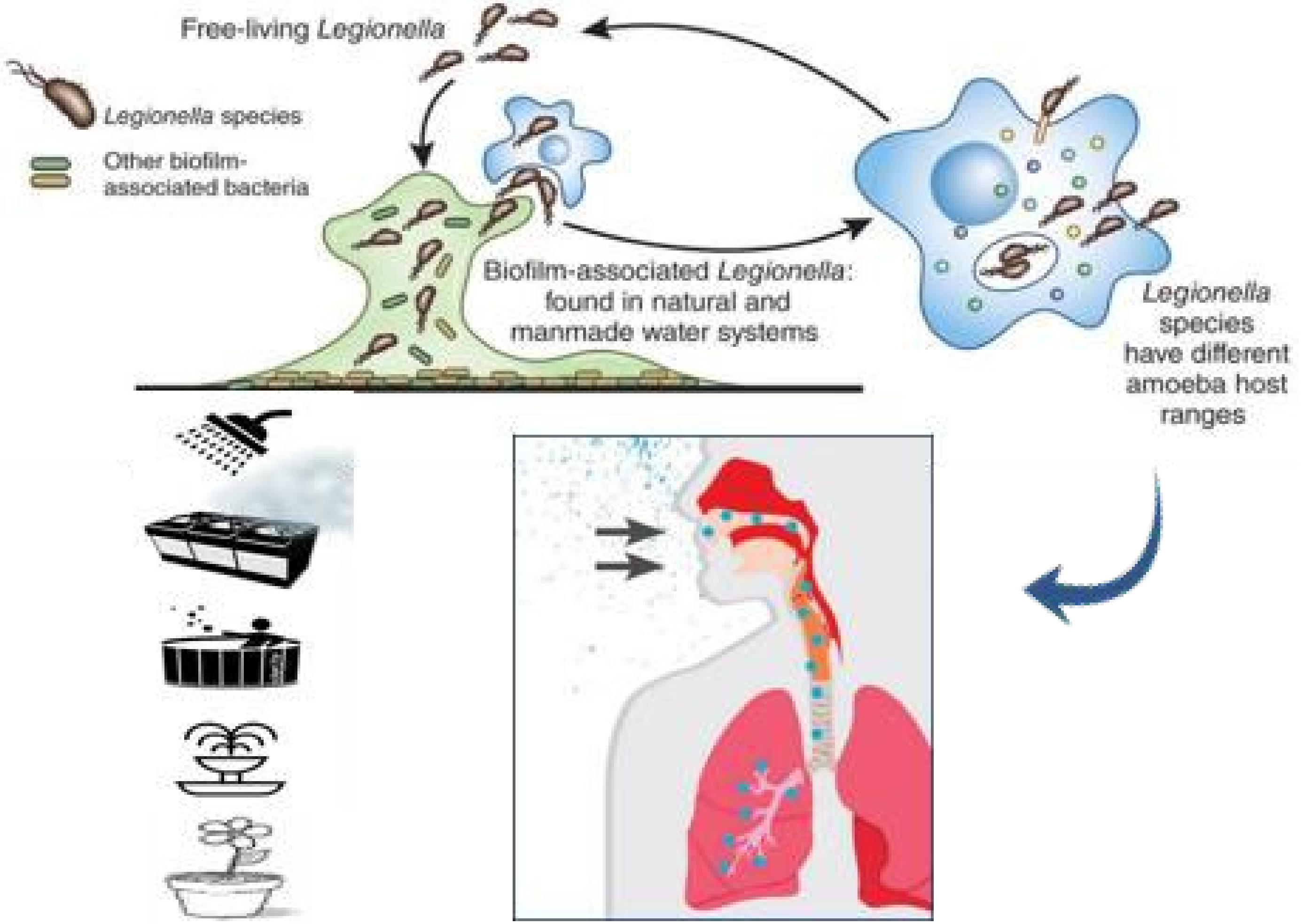
- *L. pneumophila, L. bozemanii, L.micdadei, L. longbeachae,* and *L.anisa,* were detected in the whole water supply system, and the concentration in the taps was approximately the same as the groundwater source (1.4 to 1.5 $\log_{10}$ GC/100 mL)
- *L. pneumophila, L. bozemanii, L.micdadei, L. longbeachae,* and *L.anisa* were detected in the cooling towers
    - Concentrations ranged from 1.5 to 2.9 Log_{10} GC/100mL
- Five specific *Legionella* species do not account for the total *Legionella* spp. (23S rRNA) in either of the water samples
- Only *L. bozemanii, L.micdadei* had a weak correlation with amoeba, in cooling towers

Implications for the Water Industry

The water industry is best positioned to support the following:

- Monitoring plan utilizing new tools to promote understanding of species, ecology and growth. Specialized studies and national surveys
- Understanding of hydraulics, water age, stagnation
- Investing in the science of disinfection
- Partnering with building owners to advance the understanding of occurrence and growth of *Legionella*

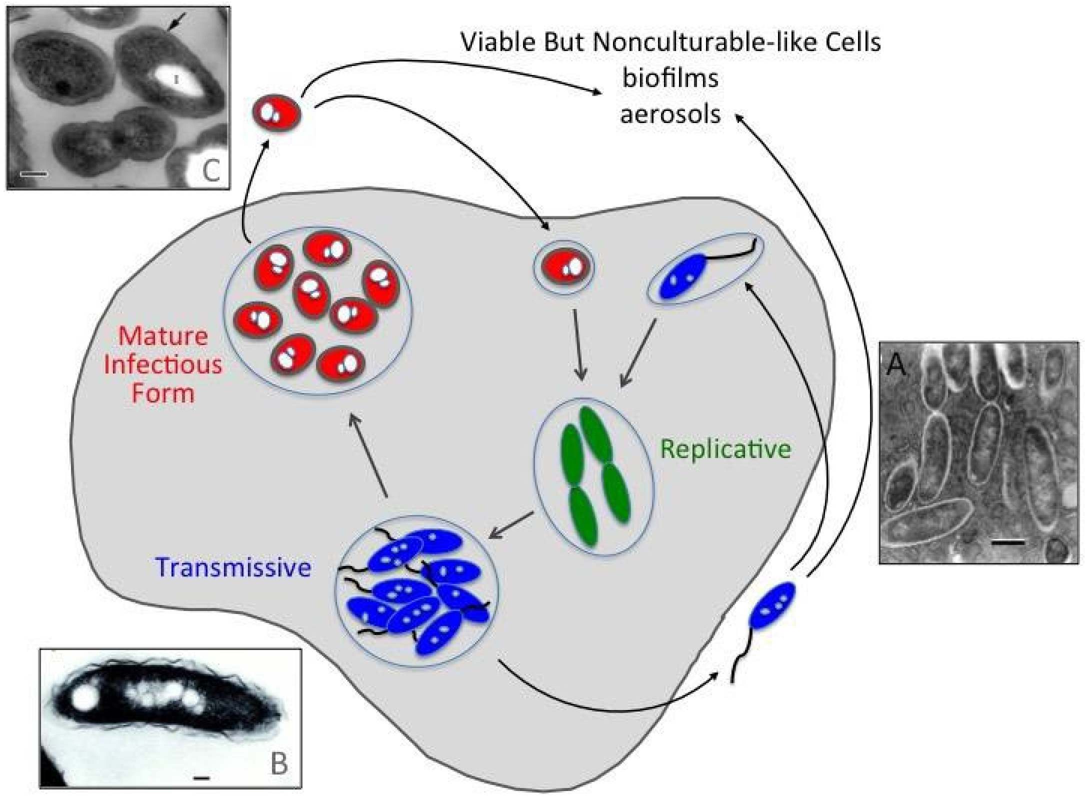
Questions?

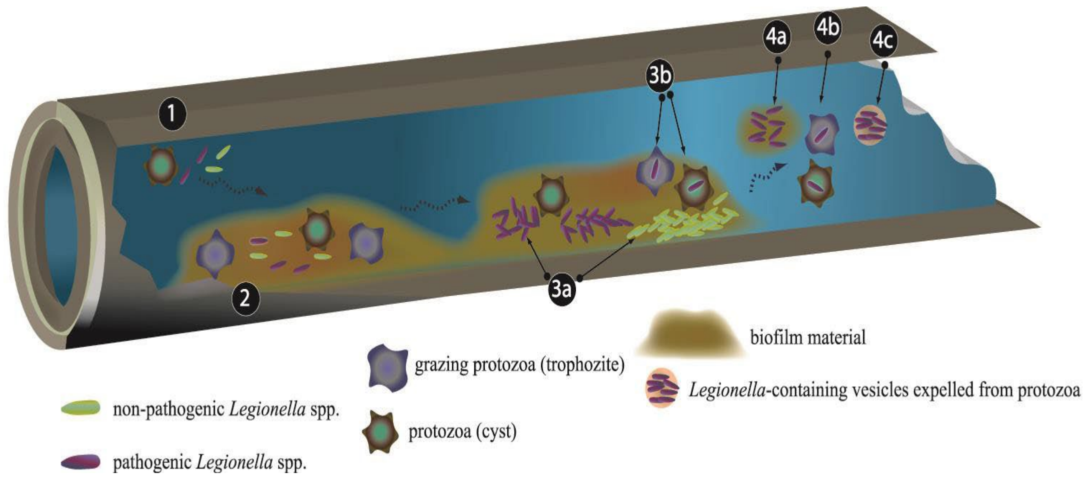


Free-living Legionella
Legionella species
Other biofilm-associated bacteria
Biofilm-associated Legionella: found in natural and manmade water systems
Legionella species have different amoeba host ranges

Ecology and Transmission

- The bacteria can exist in numerous forms. This includes transmissive, replicative, and mature infectious forms, as well as viable-but-nonculturable (VBNC)
- The primary growth habitat of *L. pneumophila* is within amoebae or other free-living protozoa associated with biofilms
- There are various forms of packaged *Legionella* that are released →
- Cell forms, and how they are packaged, differ in their infectivity, virulence, resistance to treatment, etc.





Chapter 2 Recommendations

- Protocols should be developed to generate, identify, enumerate, and report **distinct *Legionella* cell types**
- Whether *L. pneumophila* enters into a **VBNC state** that is both resilient and reversible remains an urgent question
- Ecological studies have almost **exclusively focused** on the growth, survival, and inactivation of ***L. pneumophila***
- Direct observations and metagenomic studies of microbial diversity are required to identify the **protozoa** that control pathogenic *Legionella*
- **How does *Legionella* cause Pontiac fever? Role of the aspiration pathway to total disease? Survival of *Legionella* in aerosols?**

Evolving Methods for Quantification of *Legionella*

Purpose: Diagnosis, Outbreak investigation, Routine monitoring, Mitigation assessment, and Research

- Urinary antigen test (UAT) which detects only *Lp1*
- Certified standard culture methods vs. New culture methods
- Quantitative PCR/droplet digital PCR

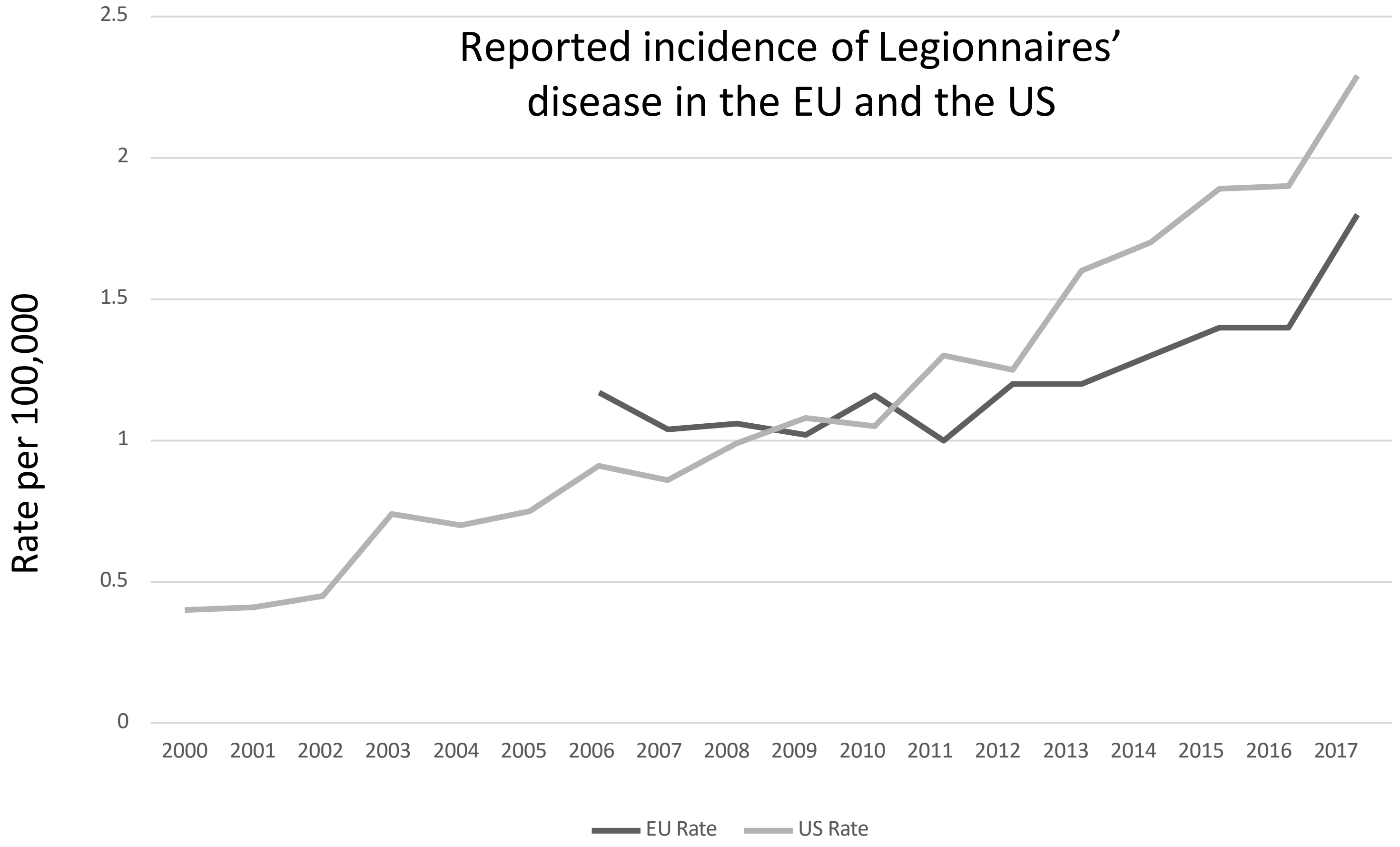
(*L spp., Lp, Lp1, L.anisa, L.micdadei, L.longbeachae, L.bozemanii*)

- Sequencing
- Associated amoeba

Legionella on
Charcoal Yeast Extract Agar

- **Most patients diagnosed as a result of a positive *Legionella* UAT**
- **The diagnosis of LD caused by *Legionella* spp. other than *Lp1* is very difficult with the current routine approaches**
- **Need evaluation, training, proficiency testing, national approaches for surveillance**
- **New investment in modified culture and molecular tools is needed**

Committee Estimate of Current Rate

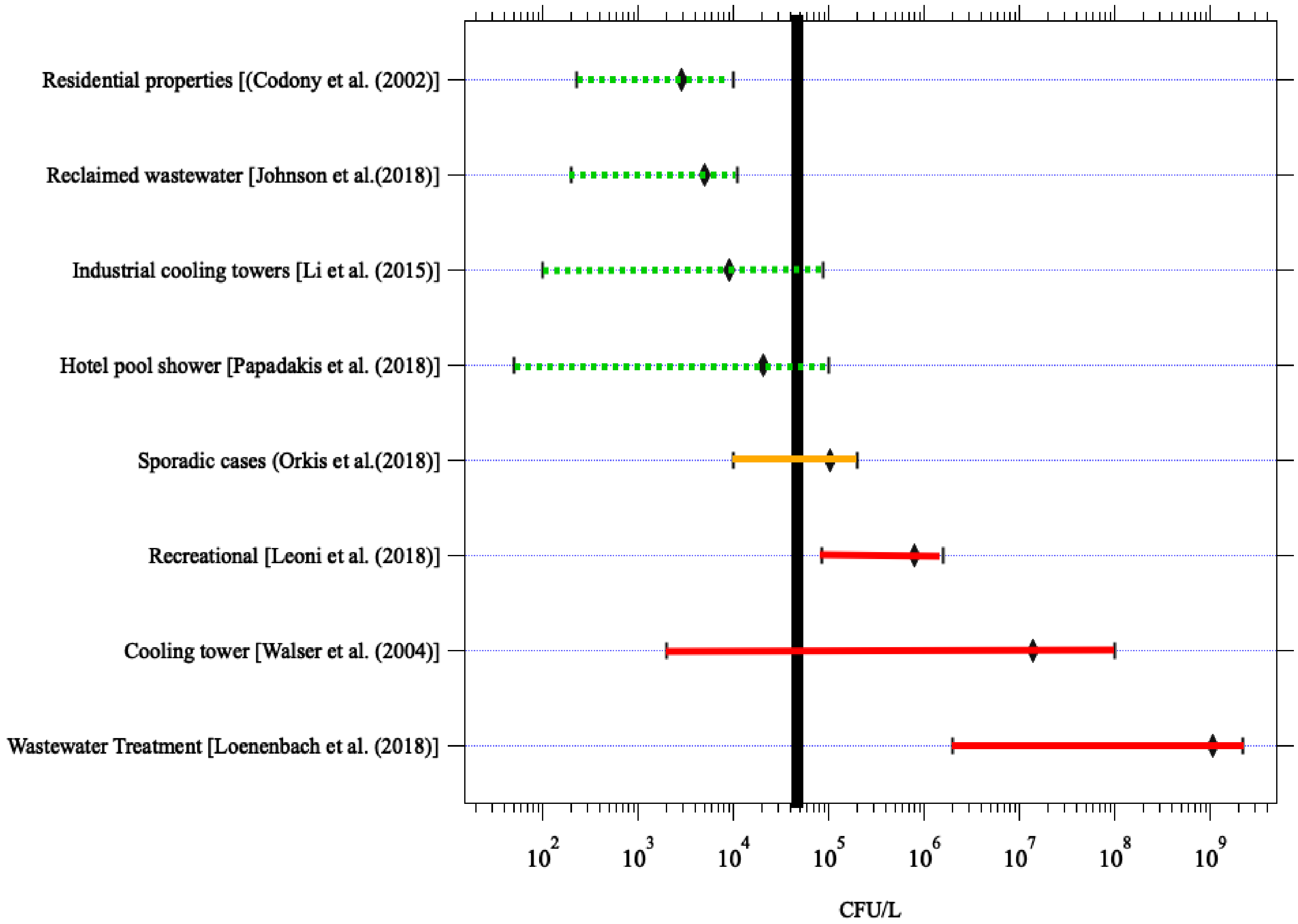


- Starting with the Etiology of Pneumonia in the Community (EPIC) study and making several adjustments to account for cases that would not have been captured, the Committee conservatively estimated that the number of persons with Legionnaires' disease ranges from **52,000 to 70,000 in the United States each year or a rate of 20.5 to 27.4/100,000**
- Estimate is 10 times higher than the current reported disease incidence (see graph above)
- This extent of underestimation of national reported data is supported by other studies

Range of Environmental Concentrations without and with Disease Outbreaks

A *Legionella* concentration of **5 x 10^4 CFU/L** should be considered an "action level", that is, a concentration high enough to warrant serious concern and trigger remediation.

A lower level may be necessary to protect at-risk individuals



Chapter 3 Recommendations

- Urgent need to **develop better clinical tools** that will capture more cases of Legionnaires' disease and identify pathogenic *Legionella* beyond *Lp1*
- Determining the most common sources of **sporadic disease** will require well-funded, population-based studies in multiple jurisdictions
- **Regional Centers of Excellence** could serve as a backbone to strengthen the capacity of state health departments to detect and investigate cases of LD
- **Systematic comparison** of culture methods for *Lp* (and other pathogenic legionellae) ddPCR, qPCR, viability-qPCR, and reverse transcriptase qPCR needed
- **Quantitative microbial risk assessment** is ready to determine concentrations that could be used to set standards/targets for routine monitoring, for determining the effectiveness cleanup, and for regulations

Control Strategies for *Legionella* in Various Water Systems

Strategy	Building Water Systems			Large Engineered Systems				Other Devices	
	Large Institutional Buildings	Green Buildings	Households	Potable Water Supply	Wastewater Treatment	Reclaimed Water Systems	Cooling Towers	Humidifiers	Hot Tubs
Temperature Control	√	X	√	?			?	√	
Disinfection	√	√	?	√	?	√	√		√
Manage Hydraulics	√	X	√	√		√	√	√	
Nutrient Limitation				?		√		√	
Plumbing Materials	√	√	√	?		√	√		
Distal Portion of Plumbing	√	X	√						
Aerosol Control	√	√	√		√		√		

Chapter 4 Recommendations

- For all types of buildings, hot-water heater temperature should be maintained above **60°C (140°F),** and the hot-water temperature to the distal points should exceed **55°C (131°F)**
- Compared to free chlorine, a **monochloramine** residual better controls *Legionella* risk from distribution systems AND building water systems, although the reasons are not yet clear
- Research is needed to better understand the **persistence of distribution system disinfectant residuals within building plumbing**
- Guidance about *Legionella* is needed for **homeowners,** especially consumers from at-risk segments of the population

Chapter 4 Recommendations con’t

- **Low-flow fixtures should not be allowed** in hospitals and long-term care facilities because of these buildings’ high-risk occupant populations
- **New designs** are needed to help advance control of *Legionella* in **cooling towers and humidifiers**, particularly use of temperature control in cooling towers
- **Green buildings and water and energy conservation** have worsened many of the problems with *Legionella*

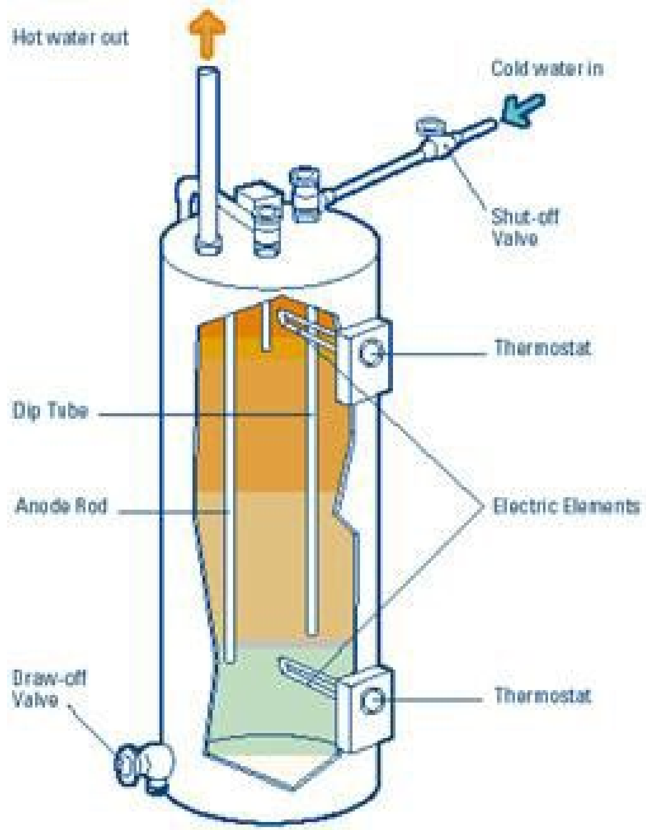
Current status of *Legionella* management in the U.S. today

1. *Legionella* **regulations** in the United States that require water management plans and/or monitoring of water systems for *Legionella* currently cover:

- Healthcare facilities in New York State
- Cooling towers in NYC and New York State
- Healthcare facilities within the VA system
- Hospitals/healthcare facilities receiving Medicare/Medicaid funds

2. **Voluntary** creation of water management plans using such guidance as ASHRAE 188. Success in reducing building risk has been shown to be related to presence of a *Water Management Plan*

3. All other buildings and private residences are potentially protected from *Legionella* only through the application of building and plumbing codes which are inadequate!



Water Management Plans

Water management plans capture what controls will be used in a building or for a device type to prevent growth of *Legionella.* Basic elements:

- Establish a program team
- Describe each water system
- Analyze where potential hazards may exist, develop, or propagate.
- Identification of control measures and where they should be applied.
- Monitor certain parameters (perhaps including *Legionella*) to determine if control measures are working.
- Confirm that the program is being implemented as designed (verification) and that the program effectively controls the hazard (validation).
- Document plan and analyses

Select International *Legionella* Regulations

Country/ Province	Buildings/Devices Covered	Preferred Treatment	Monitoring Thresholds (All Converted To CFU/L)
Netherlands	Priority premises (large buildings), swimming and bathing facilities, cooling towers	Temperature control, flushing, UV, filtration	>1,000 CFU/L, take response actions
Germany	Large buildings, cooling towers, swimming pools, bathing water, WWTPs	None, though temperature control and avoiding stag-nation evident in codes	>1,000 CFU/L, take response actions
England	Evaporative cooling systems, cooling towers, hot and cold water systems, spa/pool systems, healthcare facilities	Temperature control, biocides	100-1000 CFU/L, take response actions
France	Buildings except private residences, cooling towers	None apparent	<1,000 CFU/L target for public facilities <50 or 100 CFU/L target for prevention of nosocomial infections
Australia	Premise plumbing in healthcare and aged care facilities, cooling towers	Temperature control, biocides	> 10^6 CFU/L, take response actions
Canada	Cooling towers, open water systems, HVAC components, and hot- and cold-water systems in 360 government buildings	None	> 10^6 CFU/L, take response actions
Quebec	Cooling towers only	Biocides	$\geq 10^7$ to $<10^9$ CFU/L, take response actions

***Countries/Provinces that have evidence of lower environmental concentrations since regulations went into effect!**

Chapter 5 Recommendations

1. Expand the Centers for Medicare & Medicaid Services memo **to require monitoring for *Legionella*** in environmental water samples for all hospitals
2. **Register and monitor cooling towers**
3. Require **water management plans in all public buildings** including hotels, businesses, schools, apartments, government buildings
4. Require a temperature of **60°C (140°F)** at hot-water heaters and **55°C (131°F)** to the distal points (the point of connection to fixtures including thermal mixing values)
5. Require a **minimum disinfectant residual** throughout public water systems and concomitant monitoring for *Legionella*

National Waterborne Disease Outbreak Surveillance: A Deeper Dive into Community Water System Outbreaks

CDR Jasen Kunz, MPH – Drinking Water Lead
Megan Gerdes, MPH – Epidemiologist
Waterborne Disease Prevention Branch
Centers for Disease Control and Prevention

EPA National Drinking Water Advisory Council, Disinfection Byproducts Working Group

December 13, 2022

Overview

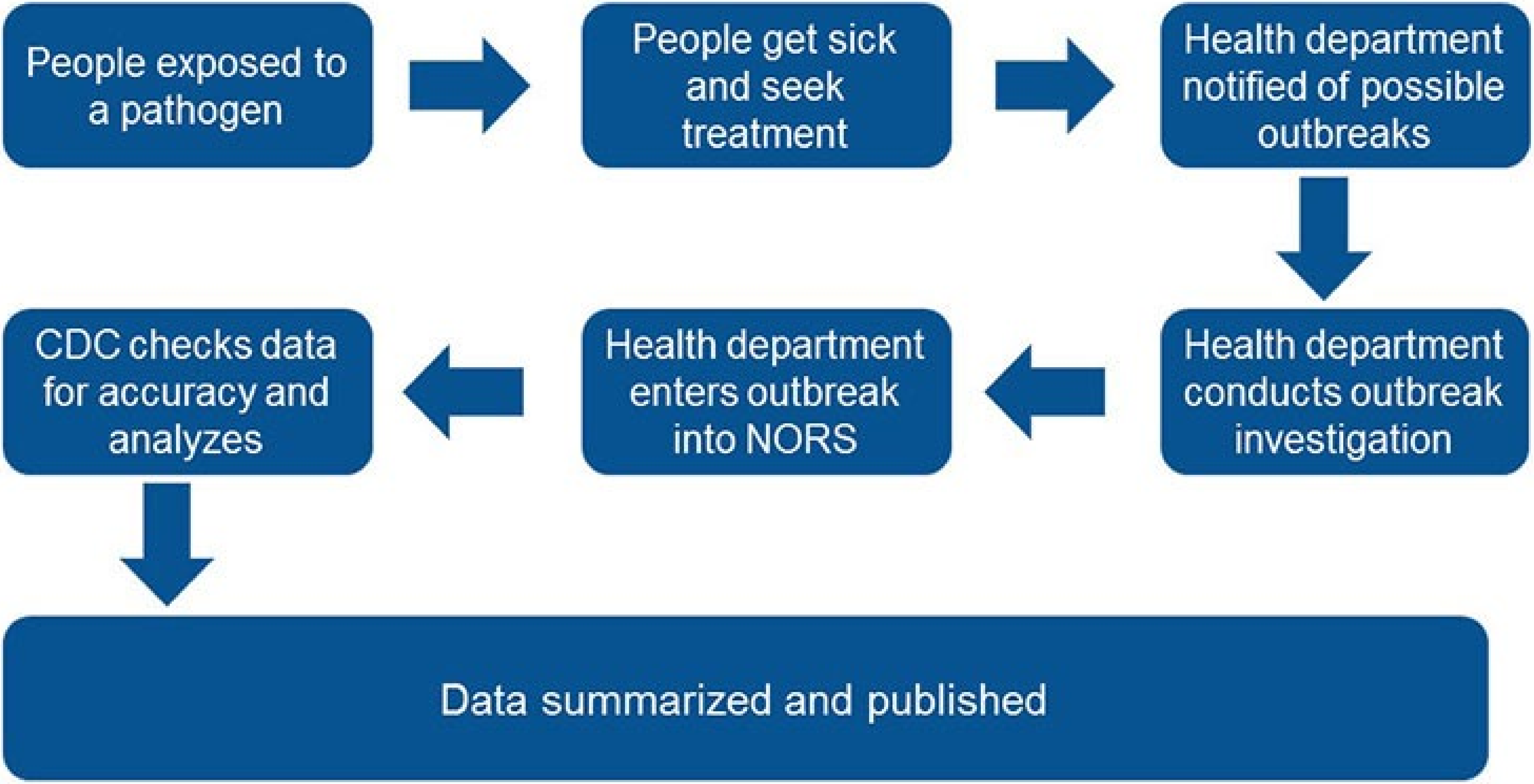
- Outbreak Surveillance
- Drinking Water-associated Outbreaks, 2015-2020
  - Water Systems
  - Settings
  - Contributing Factors
- Takeaways

Outbreak Surveillance

Surveillance for Waterborne Disease Outbreaks - NORS

- National Outbreak Reporting System
  - Foodborne, waterborne, and enteric animal contact, person-to-person, environmental disease outbreaks
- Waterborne outbreak reports can include information on:
  - Etiology
  - Type of water implicated (drinking water, recreational water, etc.)
  - Setting, water system and treatment, deficiencies in the system
  - Limitations
  - Reporting by states is voluntary
  - Outbreaks are likely underreported
  - Amount of information in reports is variable
  - Public health capacity to investigate outbreaks

Outbreak Data Are Reported to NORS and Summarized by CDC



2015-2020 Drinking Water-associated Outbreaks Reported to NORS

215 drinking water-associated outbreaks

- 2,212 illnesses
- 563 hospitalizations
- 88 deaths

170 outbreaks involved water from community **water systems**

- 1,178 illnesses
- 470 hospitalizations
- 70 deaths

156 (92%) were legionellosis outbreaks

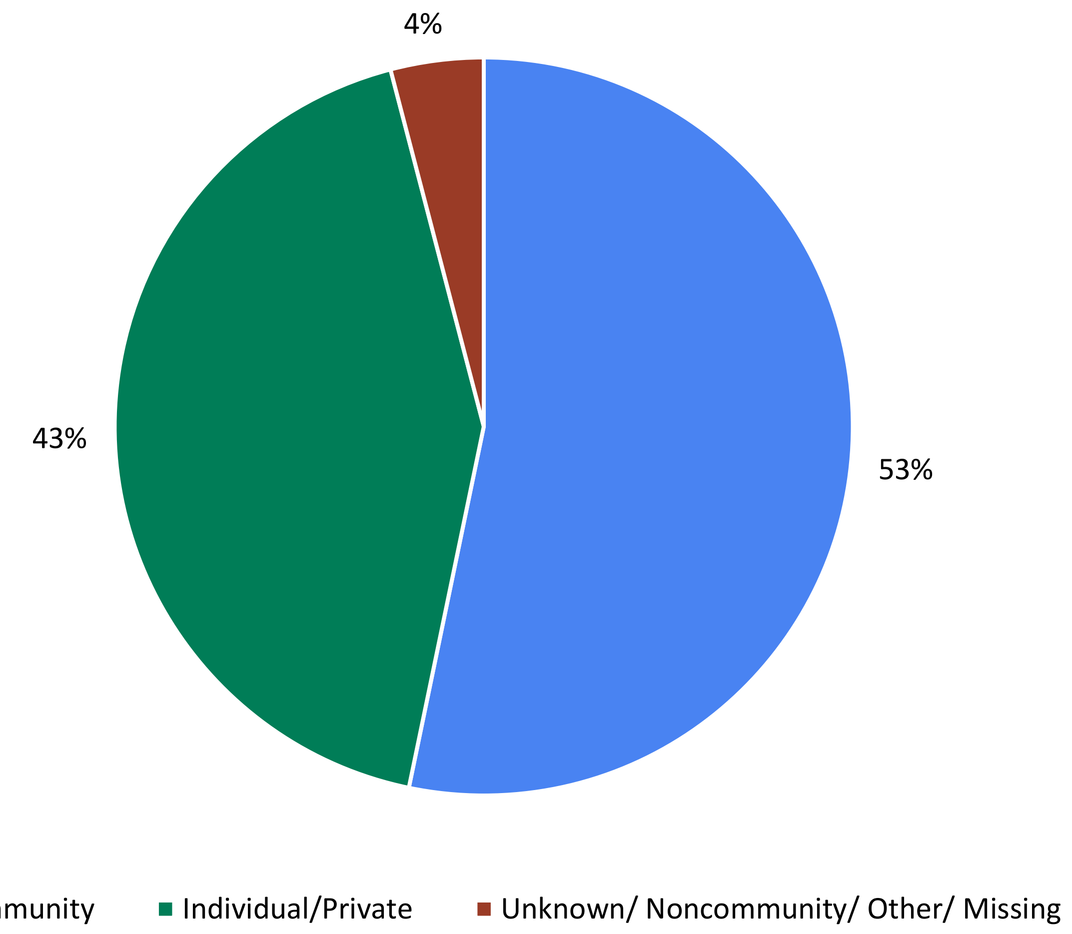
- 656 illnesses
- 456 hospitalizations
- 68 deaths

184 (86%) were legionellosis outbreaks

-786 illnesses
- 544 hospitalizations
- 86 deaths

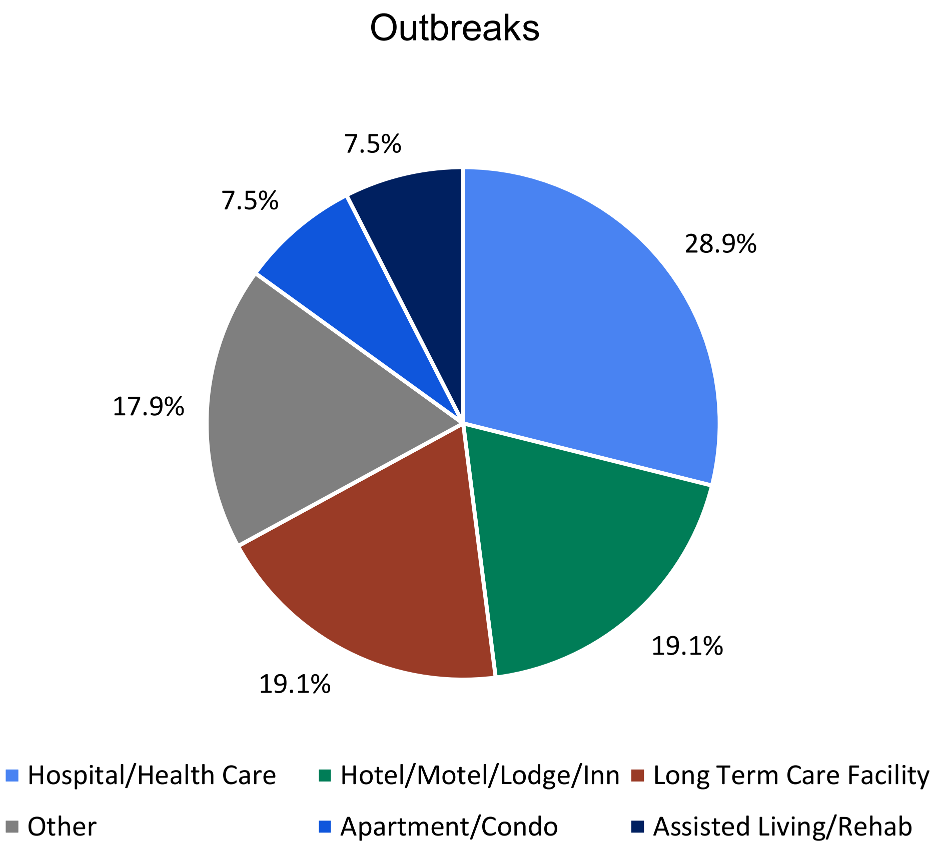
Drinking Water-associated Outbreaks, Community and Non-Community Water Systems, 2015-2020

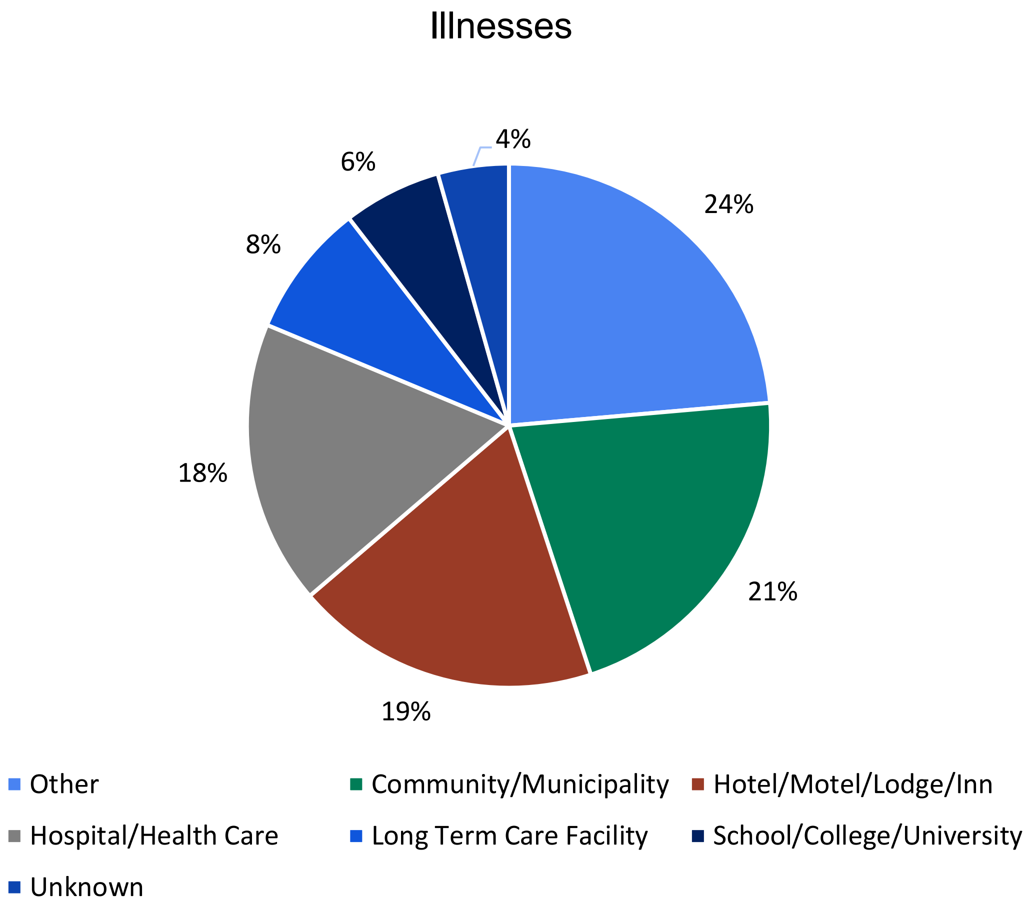
Most Drinking Water Outbreaks During 2015 – 2020 Are Associated with Community and Individual/Private Water Systems



N=2,121 illnesses

Drinking Water-related Outbreaks & Cases by Setting: Community and Non-Community Systems



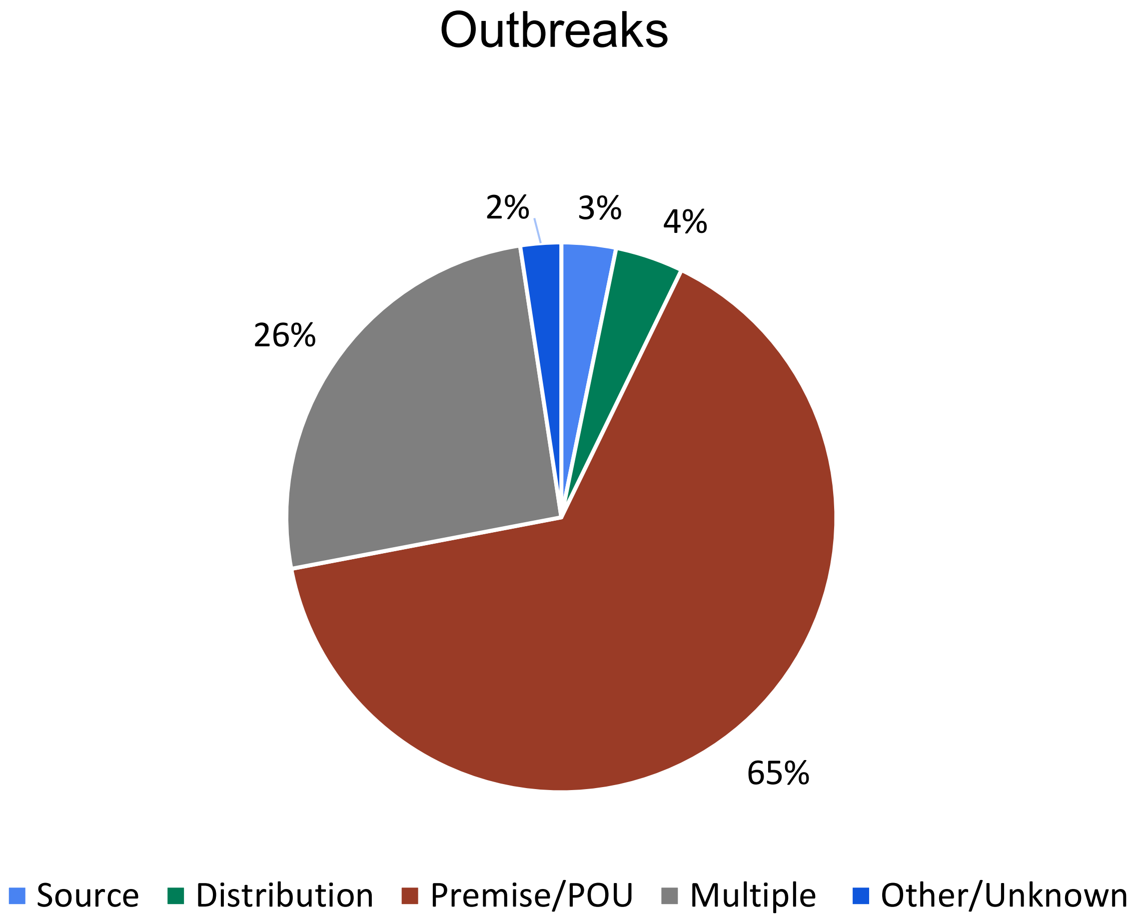


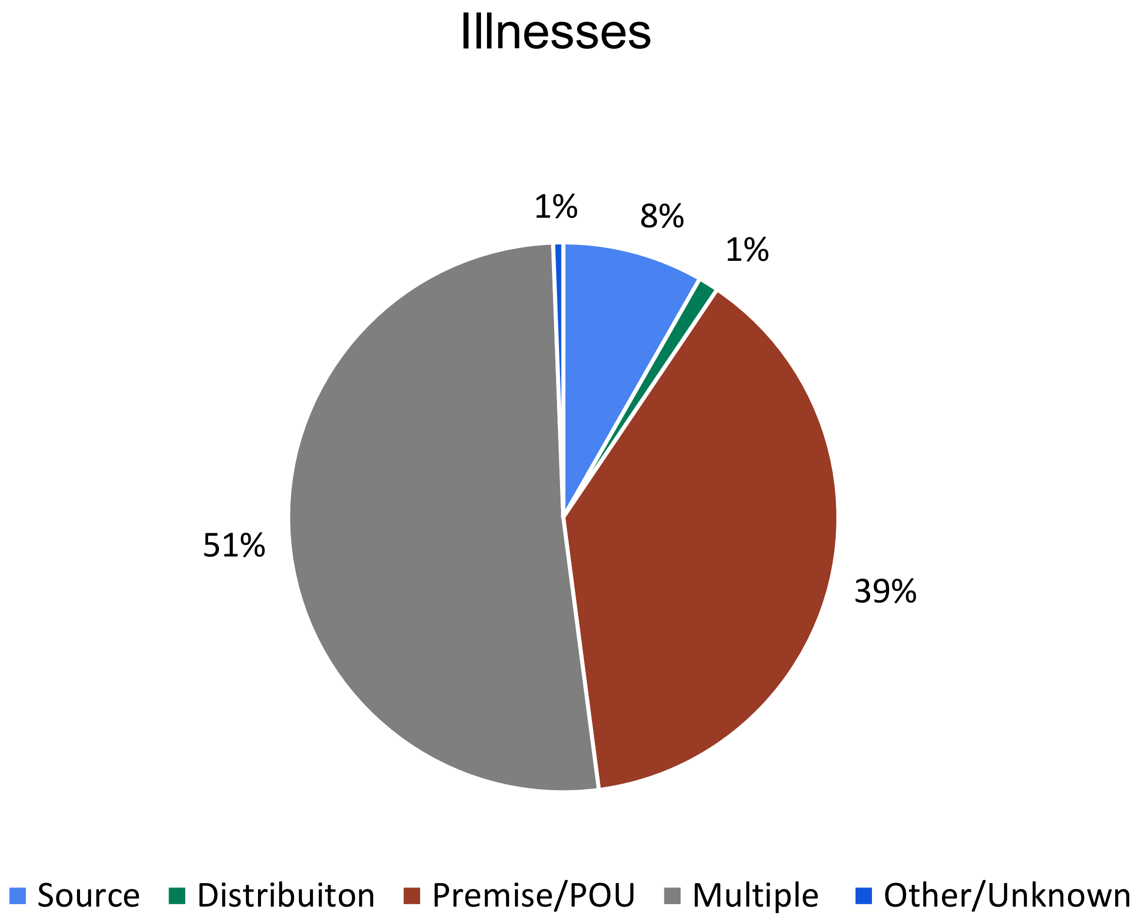
Contributing Factors

- Contributing factors can be reported for drinking water outbreaks and belong to one of four factor groups
  - Source, Treatment, Distribution, and Premise/POU
- There are 470 contributing factors for 148 drinking water-associated outbreaks from 2015-2020
  - 61% (288) are documented
  - 39% (182) are suspected

Factor Type	Contributing Factor Count
Source	49
Treatment	45
Distribution	68
Premise/POU	294

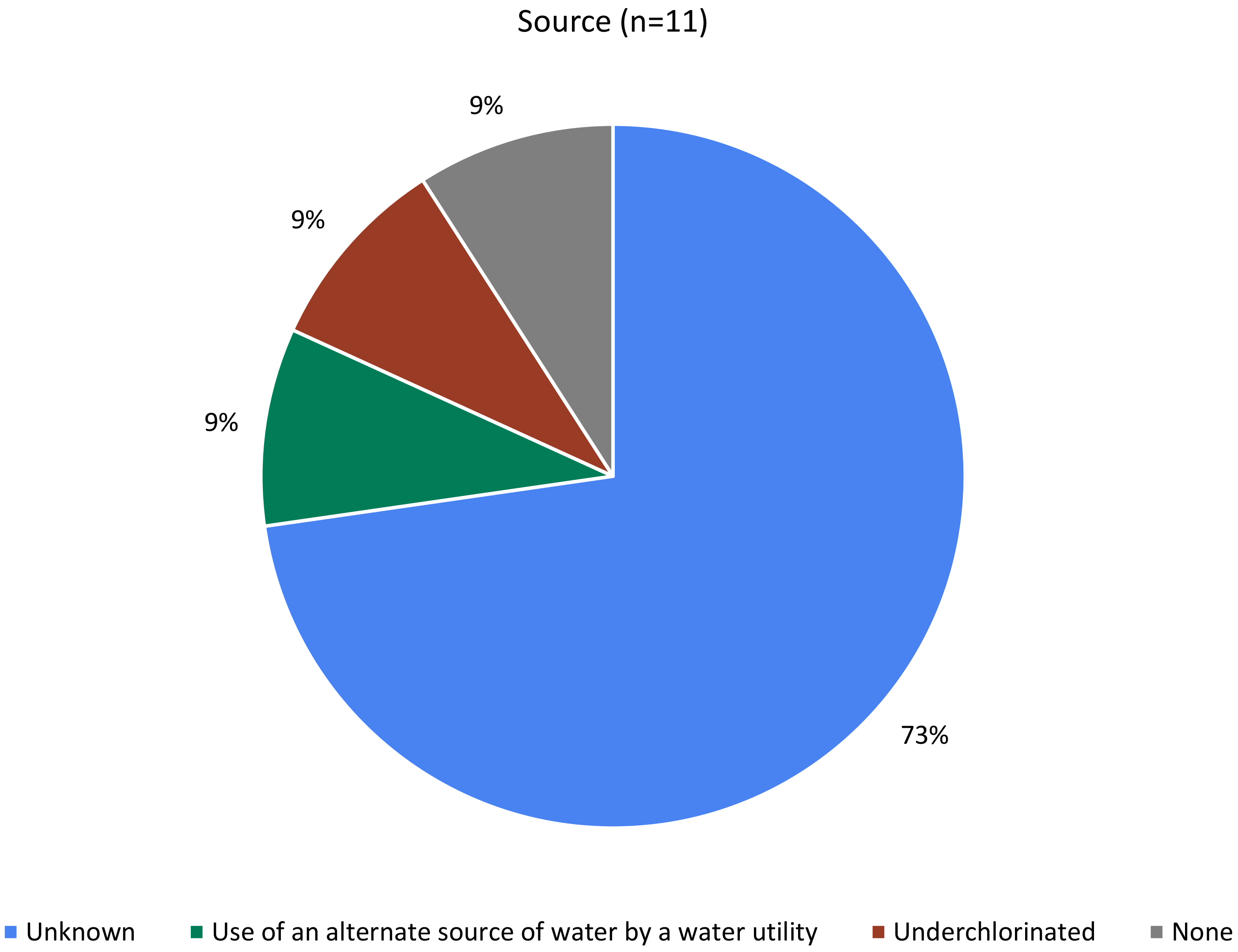
Contributing Factors Reported for Drinking Water-associated Outbreaks with Community and Noncommunity Water Systems – 2015 - 2020



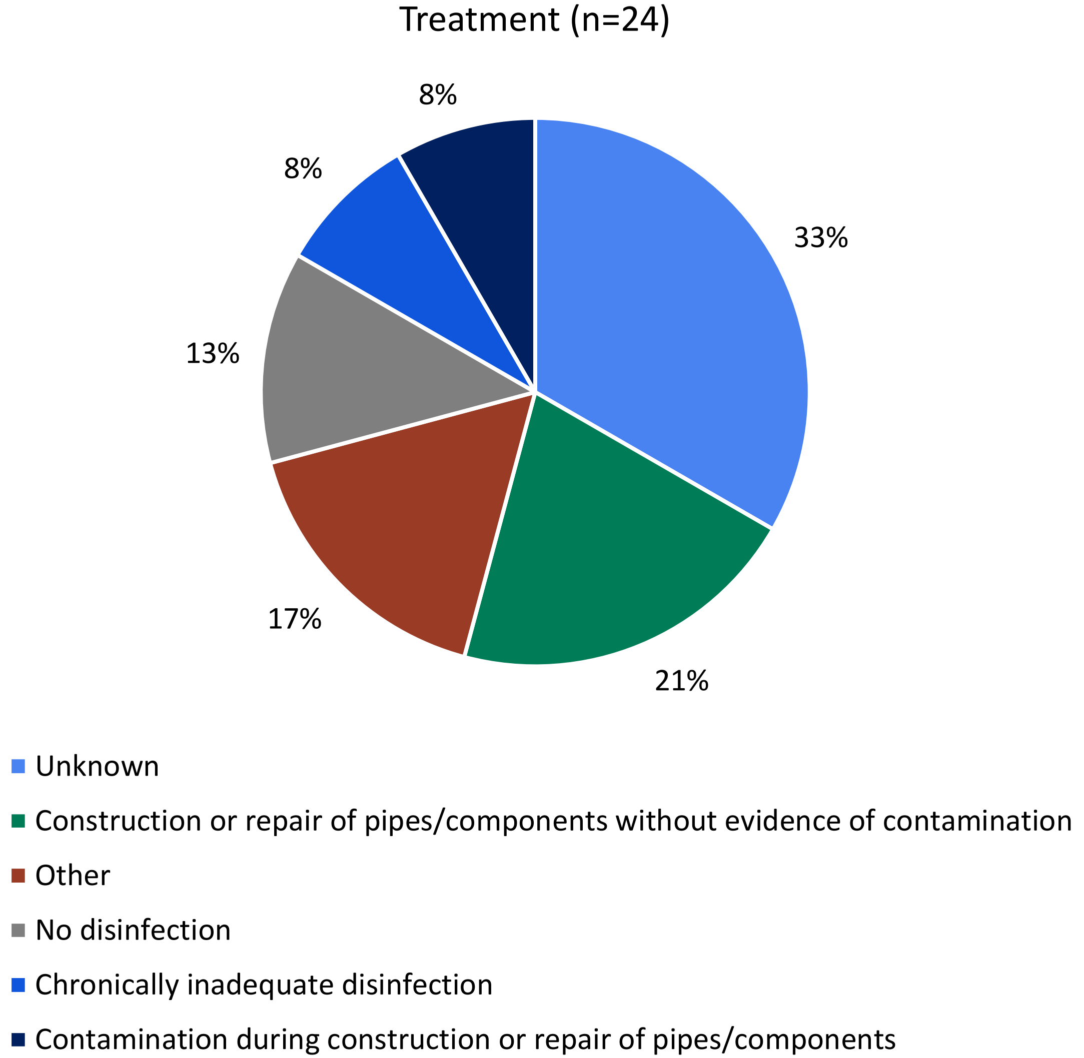


All Treatment factors had at least one other contributing factor listed and are included in “Multiple”

Source Related Contributing Factors Reported for Legionnaire’s Disease Drinking Water-associated Outbreaks with Community and Noncommunity Water Systems – 2015 - 2020

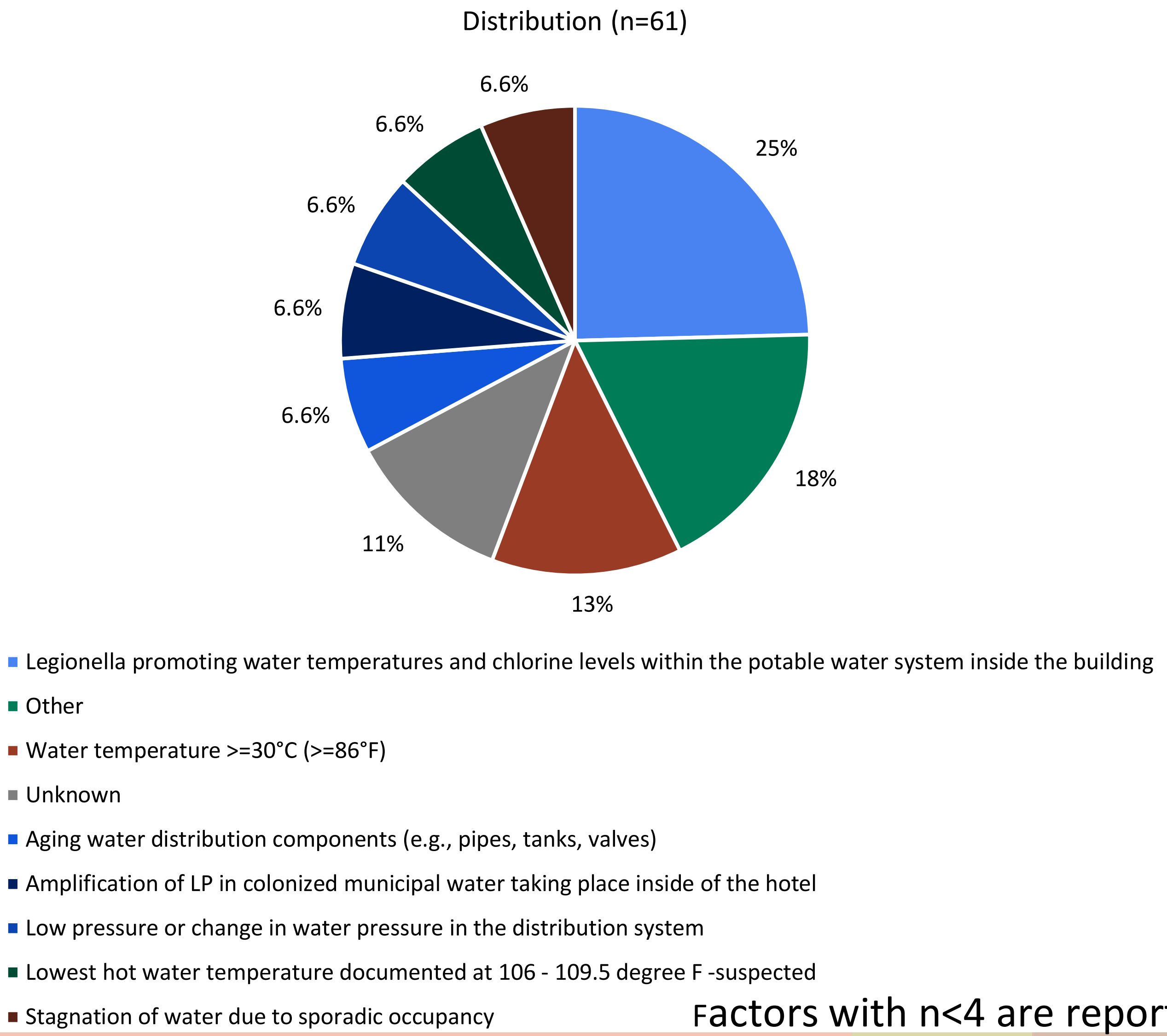


Treatment Related Contributing Factors Reported for Legionnaire's Disease Drinking Water-associated Outbreaks with Community and Noncommunity Water Systems – 2015 - 2020



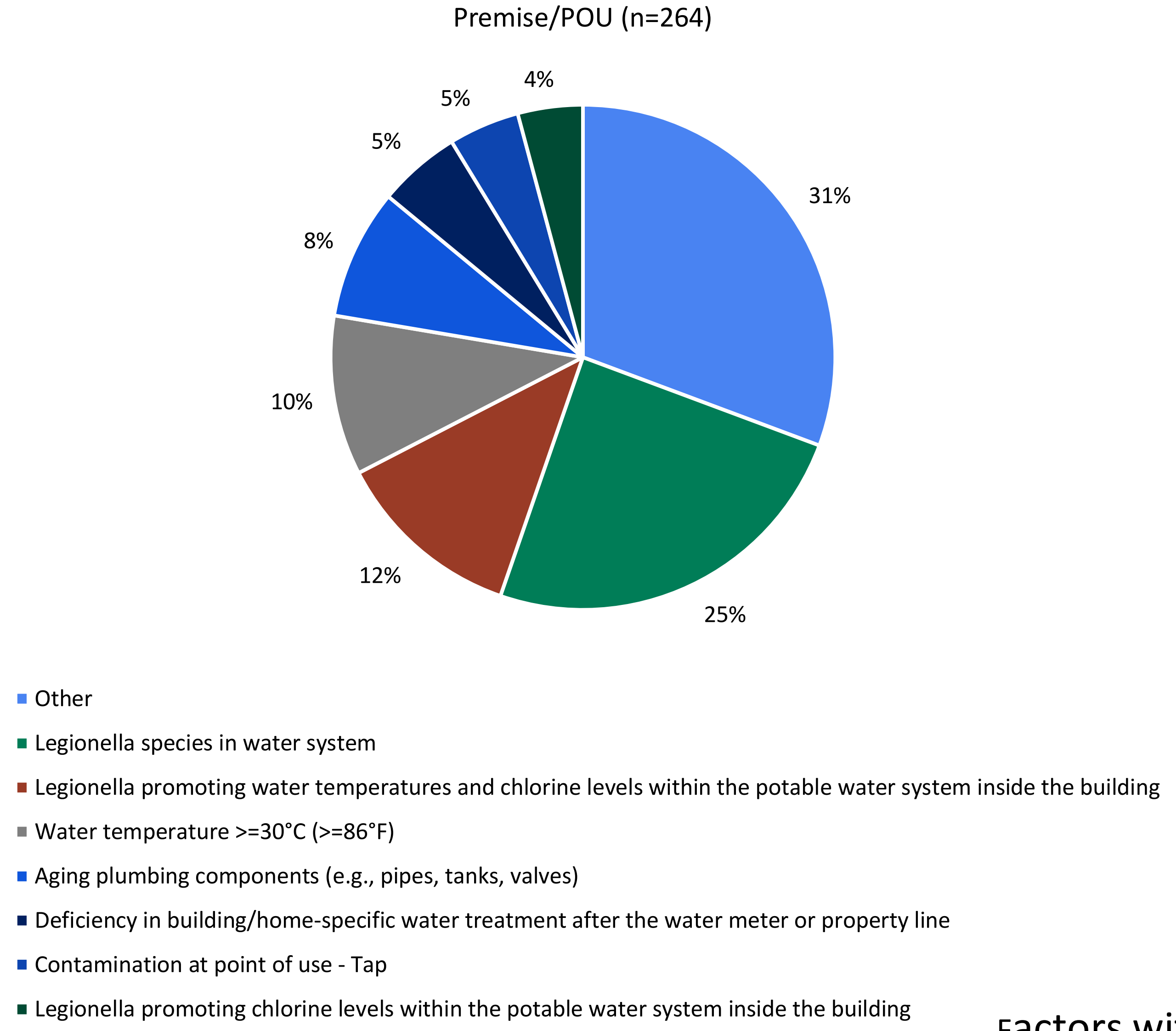
Factors with n=1 are reported in "Other"

Distribution Related Contributing Factors Reported for Legionnaire’s Disease Drinking Water-associated Outbreaks with Community and Noncommunity Water Systems – 2015 - 2020



Factors with n<4 are reported in "Other"

Premise Plumbing/Point of Use Related Contributing Factors Reported for Legionnaire's Disease Drinking Water-associated Outbreaks with Community and Noncommunity Water Systems – 2015 - 2020



Factors with n<10 are combined in other

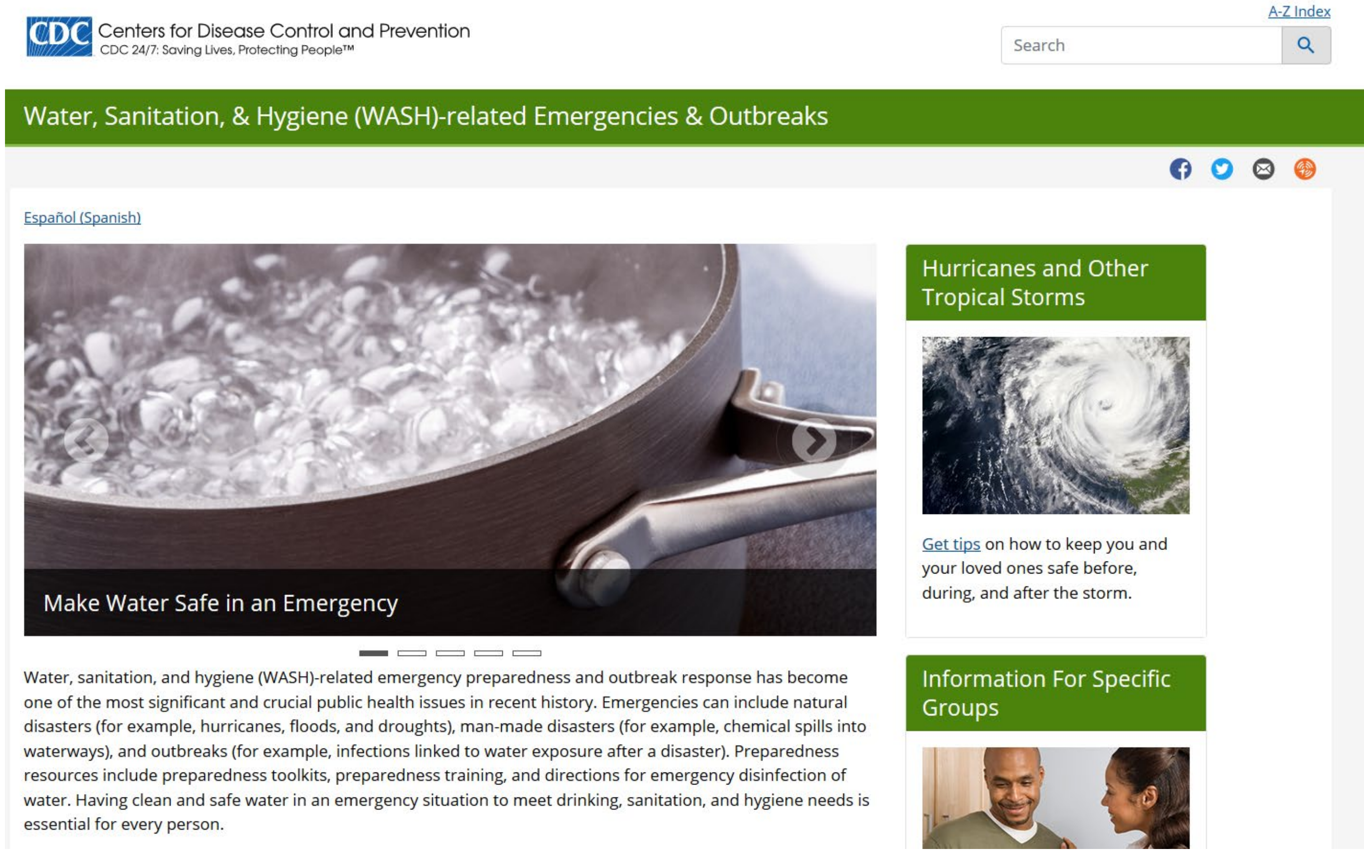
Takeaways

Takeaways

- Legionnaires' disease continues to lead as the cause of drinking water outbreaks
- Most drinking water-associated outbreaks have multiple contributing factors
- Distribution system level contributing factor information related to Legionnaires’ disease is infrequently captured
- *Legionella* promoting chlorine levels: most common premise plumbing contributing factor
  - Additional analysis needed to:
    - Determine what extent cold water is implicated
    - Determine disinfectant type (e.g., chlorine, monochloramine)

Thank you!

www.cdc.gov/healthywater
www.cdc.gov/healthywater/emergency



For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

15 Minute Break

12:00-12:15 pm ET

Segment 2: Continued

Presentations and Facilitated Discussion

December 13, 2022

EPA

OFFICE OF GROUND WATER AND DRINKING WATER

DBP Precursors: importance, occurrence and treatment

R. Scott Summers
Professor Emeritus
University of Colorado – Boulder
12-06-2022

Objectives

- Address working group questions and requests
- Place DBP precursors into perspective by evaluating DBP formation model equations
- Evaluate DBP precursor occurrence in source waters
- Assess DBP precursor (TOC) control by stage 2 DBP 3x3 TOC removal matrix
- Relate finished water DBP precursors to water quality in the distribution system

DBP formation models – free chlorine

Central tendency model

- DBP formation equation – empirical

$$DBP = A(TOC \times UVA)^a (Cl_2)^b (Br^-)^c (Temp)^d (pH)^e (time)^f$$

- TTHM formation equation

$$TTHM = 23.9(TOC * UVA)^{0.403} (Cl_2)^{0.225} (Br^-)^{0.141} (1.1560)^{(pH-7.5)} (1.0263)^{(Temp-20)} (time)^{0.264}$$

developed from bench-scale controlled experiments data

(R^2 = 0.92, R^2_{adj} = 0.92, n = 288)

$$DBP_{corr} = \frac{DBP_{pred}}{Correction\ Factor}$$

- Calibrated with full-scale ICR data, n= 300. Correction factor = 0.77, so the TTHM predicted values increased by a factor of 1.3 over bench-scale results
- Used to predict additional full-scale ICR data n= 667
- Additional equations for HAA5, TOX and all THM and HAA species

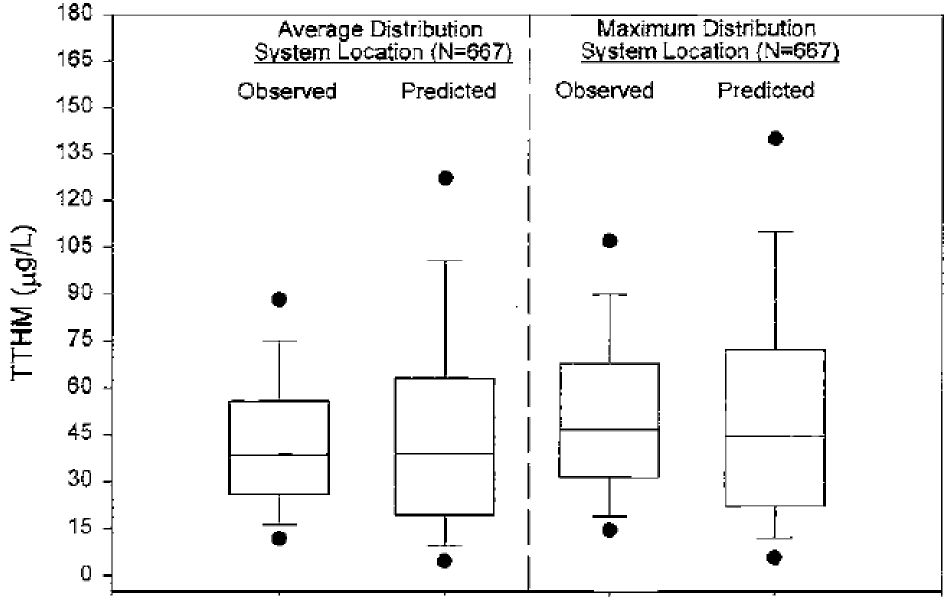


Figure 8.10 Distributions of observed and predicted TTHM values at distribution system locations with average and maximum detention times (after model calibration)

DBP precursor occurrence (ICR based)

	Surface Water*				
	10th	**25th**	**median**	**75th**	**90th**
TOC (mg/L)	1.4	2	2.7	3.8	5.3
Br (ug/L)	20	20	27	54	119
Temp (C)	7	11	16	22	26
UVA (/cm)	0.027	0.042	0.072	0.116	0.177
pH (-)	6.7	7.2	7.7	8.1	8.3
Distribution system time (hours)					
average	4	6	20	36	48
maximum	10	20	48	96	120

Updated data will be discussed through out this presentation

*ICR Book McGuire et al. (2002) Table 8.1 and Figure 7.1

DBP formation kinetics – **free chlorine**

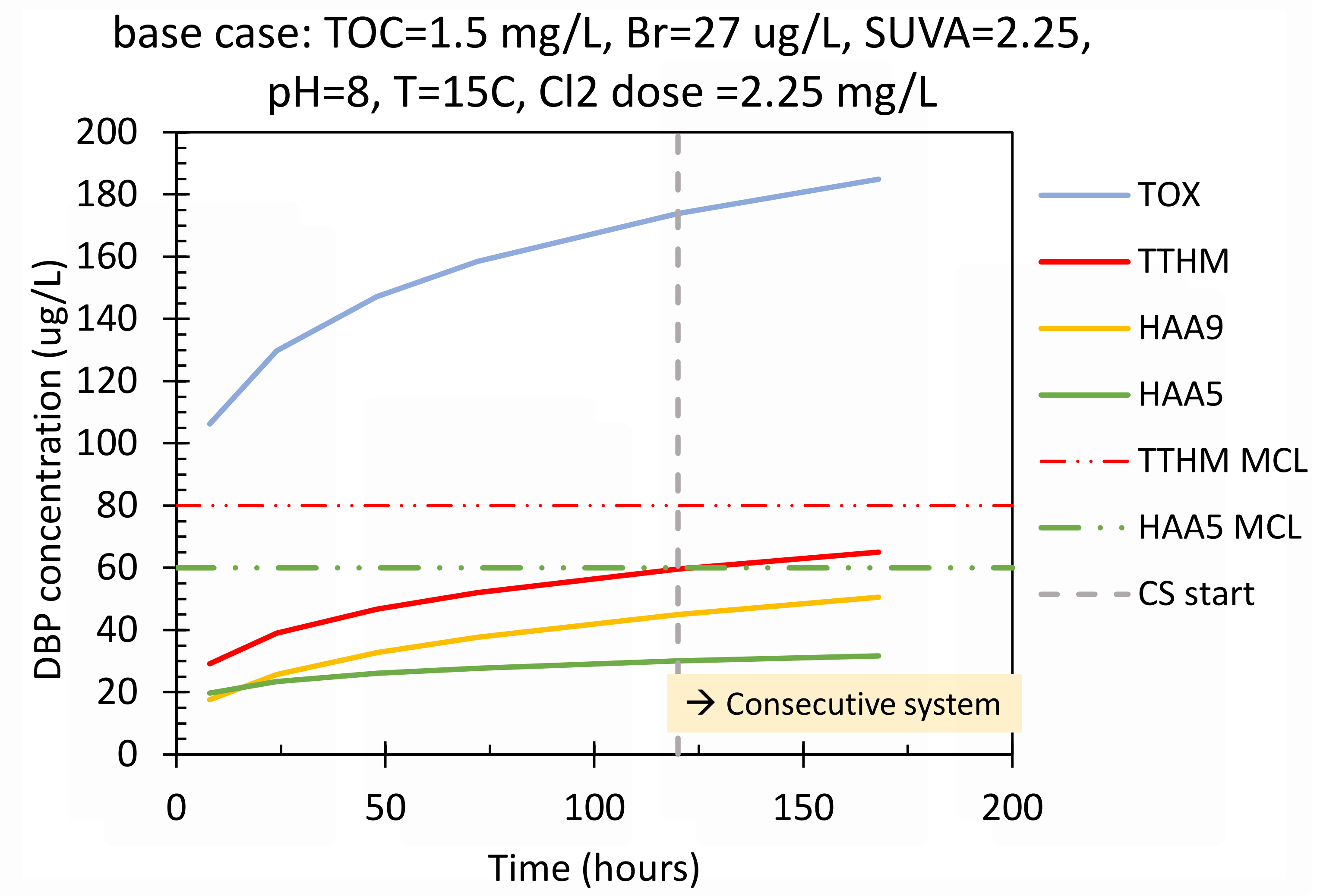
$$DBP = A(TOC \times UVA)^{a}(Cl_2)^{b}(Br^{-})^{c}(Temp)^{d}(pH)^{e}(time)^{f}$$

- Treated water TOC (mg/L)

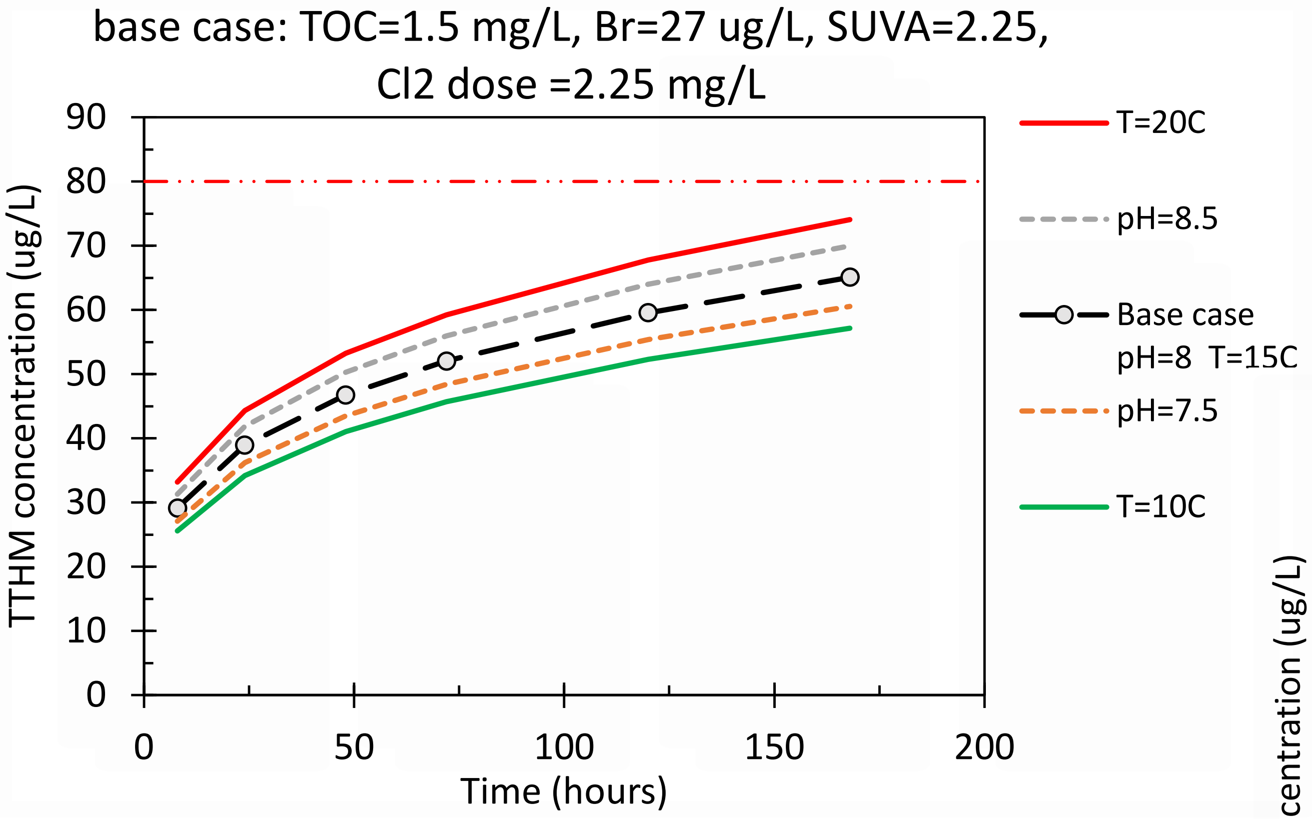
median	75th	90th
1.5	2.0	2.6

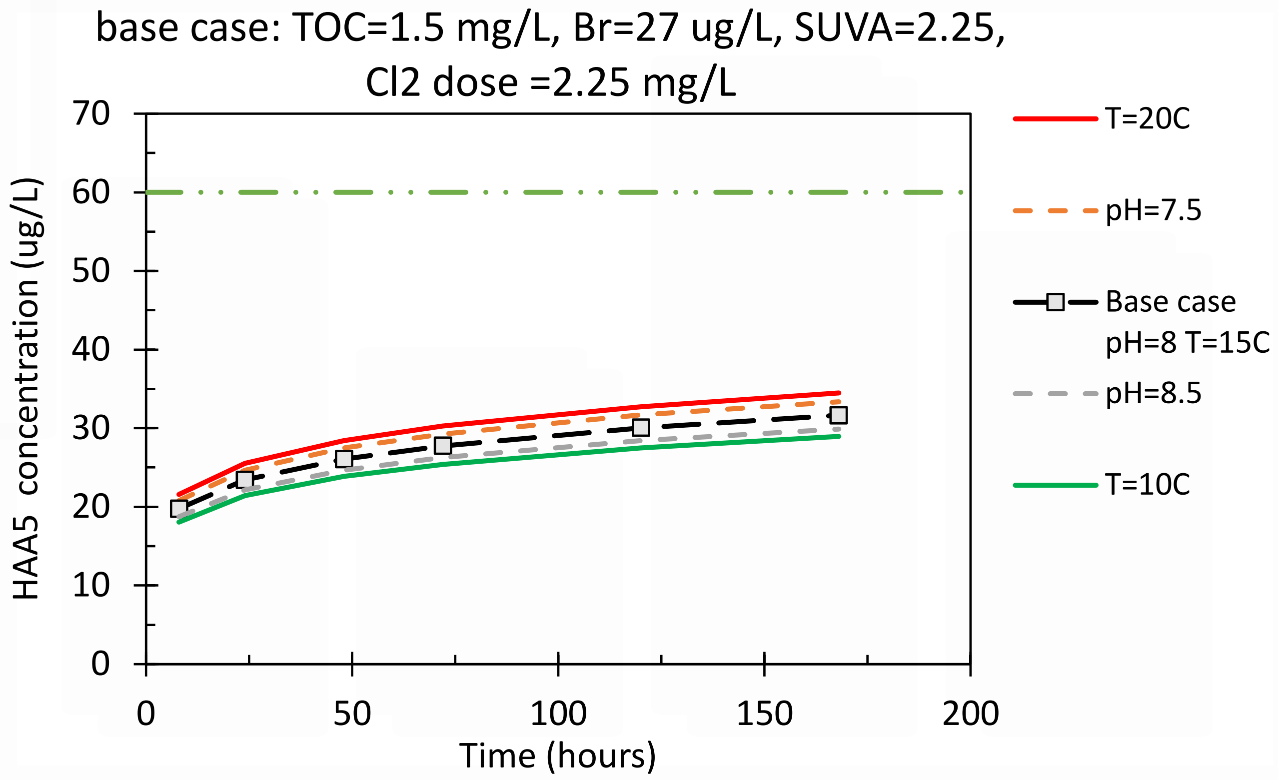
Base case

- TOC = 1.5 mg/L
- UVA = SUVA/TOC   SUVA=2.25
- Cl_2dose =1.5* TOC
- Br = 27 μg/L
- pH = 8
- Temp = 15 C
- Time = 8 to 168 hrs (up to 7 days)



Impact of temperature and pH on TTHM and HAA5 formation

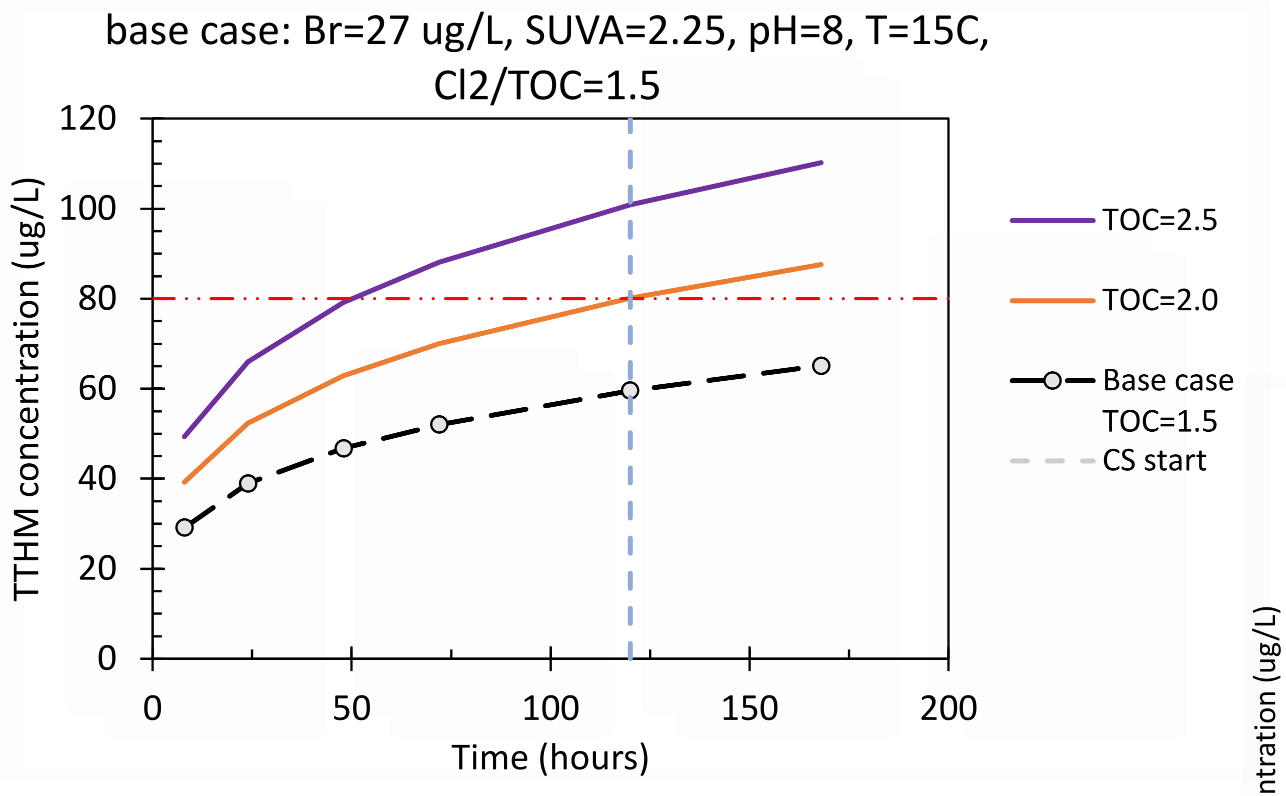


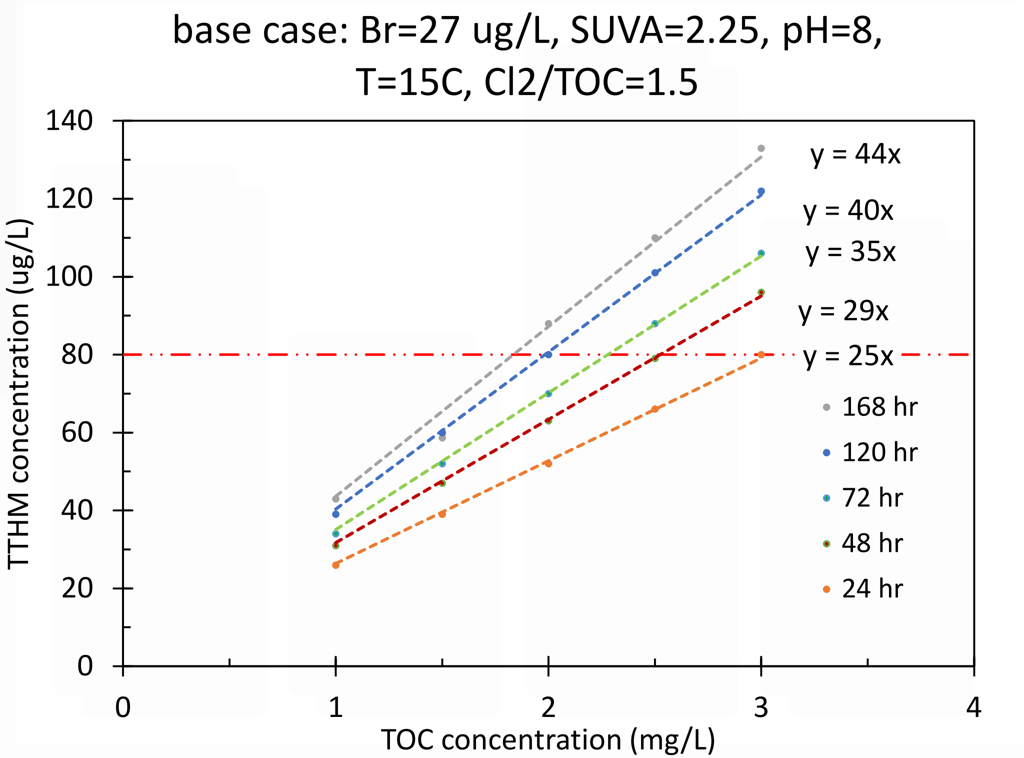


Impact of TOC on TTHM formation

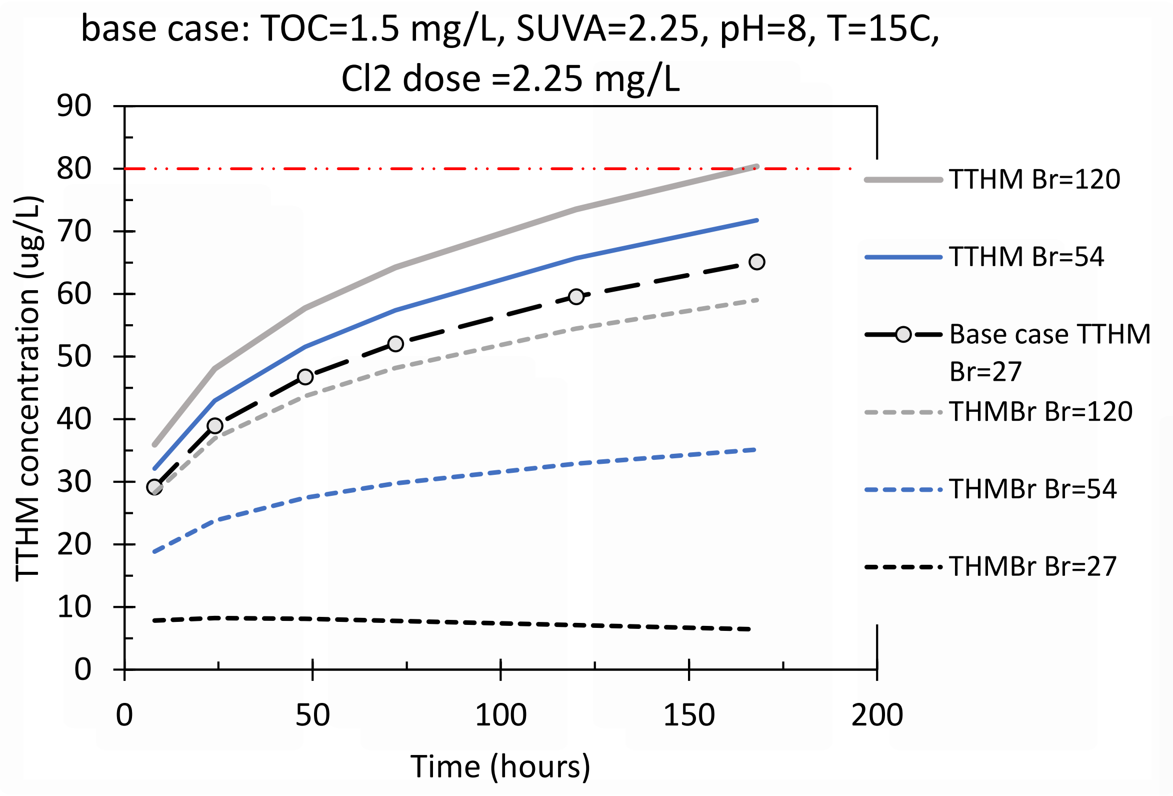
Maximum TOC above which MCL is exceeded

Time (hr)	Max TOC (mg/L)
24	3.2
48	2.8
72	2.3
120	2.0
168	1.8

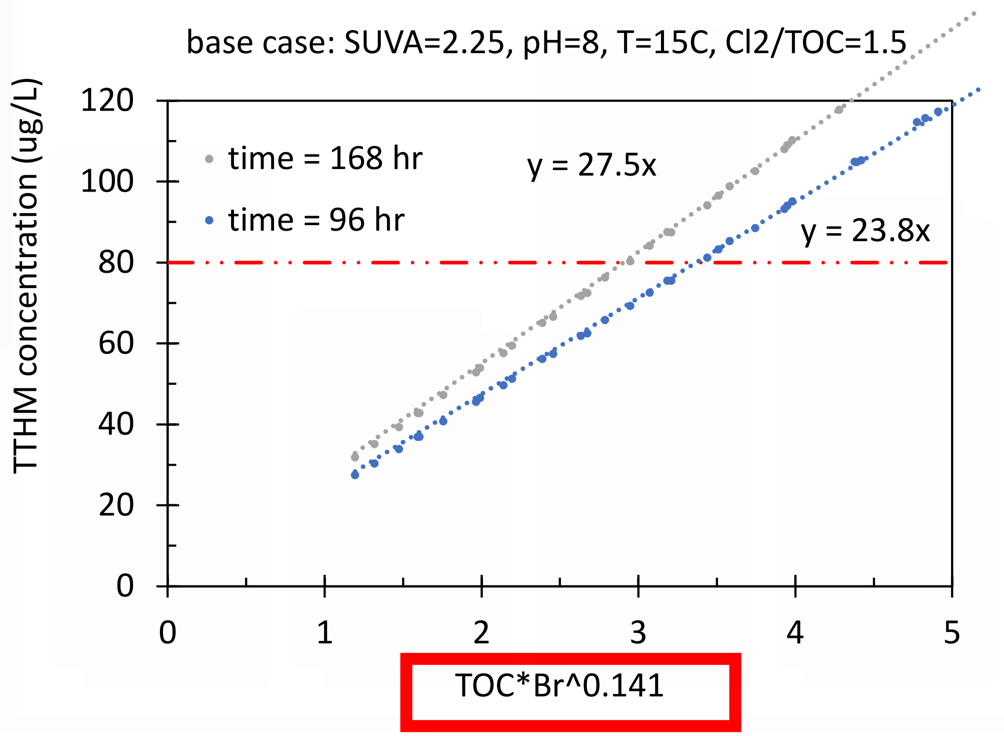




Impact of bromide and TOC*Br on TTHM formation



TOC*Br^0.141 =	**3.4**	**3.0**
Time (hr)	**96**	**168**
Br (ug/L)	**Max TOC**	**Max TOC**
27	2.1	1.9
54	1.9	1.7
120	1.7	1.5
220	1.6	1.4



Maximum TOC above which MCL is exceeded - f(Br)

Big impact of Br on THMBr

Issue Area: Precursor Occurrence and Their Effects on DBP Occurrence

Related Requests:

1. How well can we measure/characterize pre-cursors across system types and throughout the country?
2. Unintended consequences: Assessments of source water contamination and impacts on MDBP rules

Supporting Analysis:

1) Characterizing occurrence of source water Br and TOC by system size and source water type (with UCMR4)
2) Using a source water quality matrix (4x4 for Br vs TOC) to assess the usages of FCL vs CLM as a residual, and occurrence of high HAA9 and HAA6Br levels, respectively (with SYR4 ICR and UCMR4)

DBP precursor occurrence in source waters

Observations:

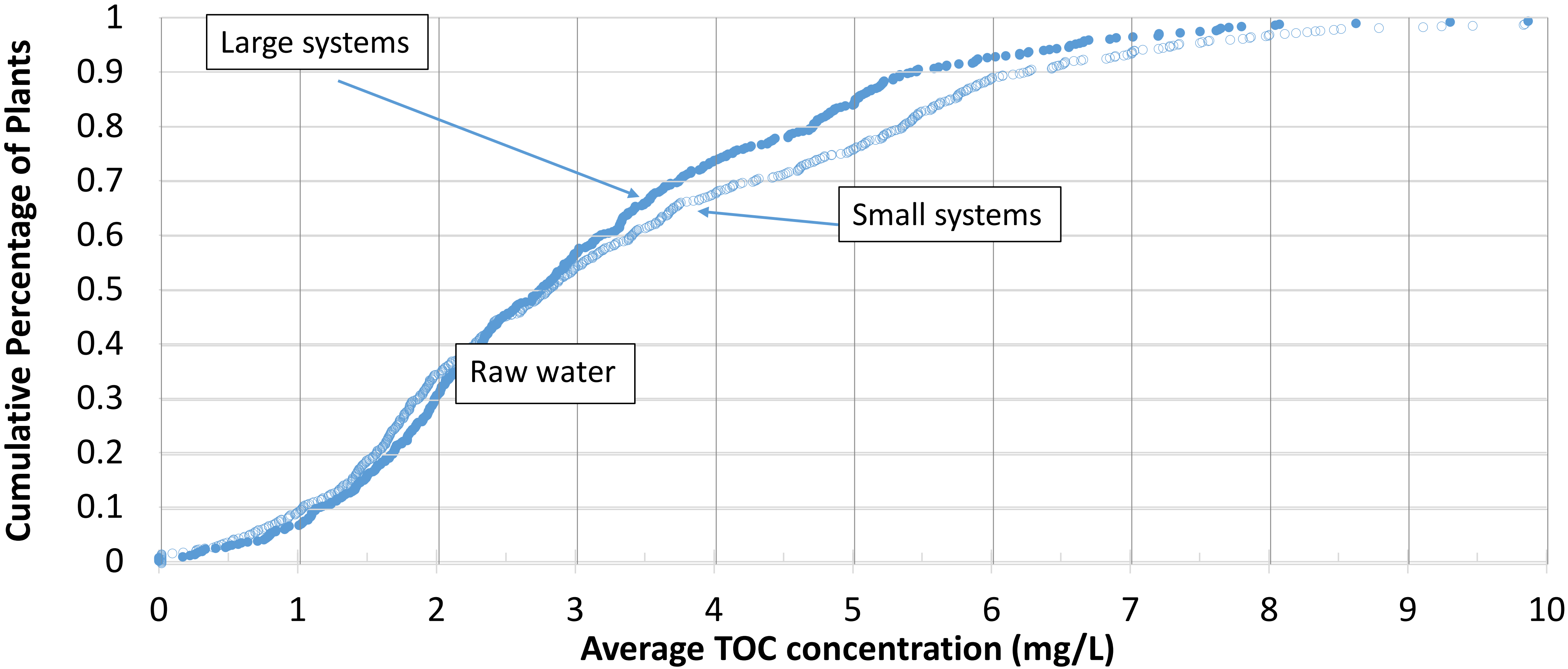
- TOC distribution
  - Surface waters - small systems were similar to that for large systems at the 50^{th}% ile (median), but much higher beyond the 75^{th}%ile
  - Ground waters - large systems were similar to that for small systems at the 50^{th}%ile (median), but much higher beyond the 75^{th}%ile

- Bromide distribution
  - Surface waters - ~30% higher for large systems
  - Ground waters – similar distributions
- GW systems have higher Br levels and lower TOC levels than SW systems

Raw surface water TOC: SYR4 ICR_2019

System Size	Year	Count of Plants	Median (mg/L)	Mean (mg/L)	90%ile (mg/L)	95%ile (mg/L)	% Plant Means > 2 mg/L	% Plant Means > 3 mg/L
Serving < 10,000	2019	661	**2.78**	3.37	**6.25**	**7.34**	65%	46%
Serving >= 10,000	2019	519	**2.75**	3.16	**5.42**	**6.57**	69%	43%
All	2019	1,180	2.77	3.28	5.93	7.02	67%	45%

Cumulative Distribution of TOC Plant Means Surface Water Plants: SYR4 ICR TOC Dataset



Bromide and TOC Levels in Source Water by Source Water Type and System Size (UCMR4)

Observations:

- GW systems have higher Br levels and lower TOC levels than SW systems
- In general, large systems have higher Br and TOC levels in source water than small systems

Statistics	Br Levels (µg/L)				TOC Levels (mg/L)			
	GW		SW		GW		SW	
	<10 k (N=409)	≥ 10 k (N=1,447)	<10 k (N=119)	≥ 10 k (N=1,460)	<10 k (N=409)	≥ 10 k (N=1,445)	<10 k (N=119)	≥ 10 k (N=1,460)
Median	42	53	17	22	0.5	0.5	2.3	2.6
90%ile	290	233	82	113	1.5	2.0	5.6	5.6
95%ile	486	426	141	203	2.2	4.0	6.0	6.8

Impact of DBP precursors on selection of treatment

Observations:

- Source water TOC concentrations impact the selection of treatment processes
- SW
  - >75% of the plants use **conventional** SW treatment (coagulation/flocculation/sedimentation/filtration(w or w/o biofilters)
  - Lower TOC values, <2 mg/L, allows the use of **non-conventional** treatment
- GW
  - >75% of the plants have TOC values < 0.6 mg/L, and use **non-conventional** treatment including no treatment and disinfection only
  - Higher TOC concentrations yield more advanced treatment

Source Water TOC by Treatment Type – all

UCMR4

Systems that Include Facility Types of…….	# Facilities	% Facilities	Mean of Facility Ave. TOC, mg/L	90%ile of Facility Ave. TOC, mg/L	95%ile of Facility Ave. TOC, mg/L	% Facilities ave. TOC > 2 mg/L	% Facilities ave. TOC > 3 mg/L
Conventional (softening or non-softening, **without biofiltration**, without advanced treatment)	2,275	**22%**	**2.51**	5.60	6.95	51%	32%
Conventional (softening or non-softening**, with biofiltration,** without advanced treatment)	84	0.8%	3.60	6.70	8.27	67%	56%
Non-Conventional (without advanced treatment, including direct filtration, in-line filtration, slow sand filtration, unfiltered, disinfection only, etc.)	705	**6.7%**	**0.87**	2.43	3.51	15%	6.4%
With advanced treatment (including GAC, ionic exchange, membrane)	166	1.6%	1.02	3.48	4.75	17%	12%
All Others[1]	6,316	**60%**	**0.33**	1.25	1.98	4.8%	2.2%
No Treatment Info Available	1,028	9.7%	0.69	2.35	3.14	13%	5.6%
Total	10,574	100%	0.91	2.98	4.45	17%	9.9%

Source Water TOC by Treatment Type – SW

UCMR4

Systems that Include Facility Types of…….	# Facilities	% Facilities	Mean of Facility Ave. TOC, mg/L	90%ile of Facility Ave. TOC, mg/L	95%ile of Facility Ave. TOC, mg/L	%Facilities ave. TOC > 2 mg/L	%Facilities ave. TOC > 3 mg/L
Conventional (softening or non-softening, **without biofiltration**, without advanced treatment)	1,451	**73%**	**3.18**	5.78	6.93	69%	44%
Conventional (softening or non-softening**, with biofiltration**, without advanced treatment)	69	3.5%	4.25	7.11	8.50	80%	67%
Non-Conventional (without advanced treatment, including direct filtration, in-line filtration, slow sand filtration, unfiltered, disinfection only, etc.)	132	**6.6%**	**1.96**	3.88	4.63	46%	23%
With advanced treatment (including GAC, ionic exchange, membrane)	25	1.3%	2.43	4.41	4.89	60%	36%
All Others[1]	205	10.3%	2.33	5.07	5.87	51%	32%
No Treatment Info Available	105	5.3%	3.02	5.12	6.30	70%	35%
Total	1,987	100%	2.99	5.60	6.63	66%	41%

Source Water TOC by Treatment Type – GW

UCMR4

Systems that Include Facility Types of…….	# Facilities	% Facilities	Mean Facility Ave. TOC, mg/L	90%ile Facility Ave. TOC, mg/L	95%ile Facility Ave. TOC, mg/L	%Facilities ave. TOC > 2 mg/L	%Facilities ave. TOC > 3 mg/L
Conventional (softening or non-softening, **without biofiltration**, without advanced treatment)	793	**9.3%**	**1.30**	3.93	7.07	18%	11%
Conventional (softening or non-softening, **with biofiltration**, without advanced treatment)	15	0.18%	0.58	1.47	2.21	7%	7%
Non-Conventional (without advanced treatment, including direct filtration, in-line filtration, slow sand filtration, unfiltered, disinfection only,)	566	6.6%	0.62	1.80	2.35	7%	3%
With advanced treatment (including GAC, ionic exchange, membrane)	141	1.7%	0.77	1.90	4.40	9.9%	7.8%
All Others[1]	6,101	**71%**	**0.26**	1.04	1.61	3.2%	1.2%
No Treatment Info Available	922	11%	0.43	1.50	2.23	6.5%	2.3%
Total	8,538	100%	0.40	1.37	2.06	5.3%	2.5%

Impact of DBP precursors on selection of distribution system disinfectant

- **All** disinfecting systems
  - free chlorine - 83% of all systems and 63% of population served
- Groundwater
  - free chlorine - 88% of all systems and 81% of population served
- Surface waters
  - free chlorine - 67% of all systems and 56% of population served

- High levels of source water TOC or Br levels may drive systems to use chloramines more frequently

UCMR4 and SYR4 ICR in 2019

Disinfecting CWSs with Different Residual Types: UCMR4 and SYR4 ICR in 2019

System Category	Disinfectant Residual Type	#Systems	#Population	% SW systems	% of SW population	%All Systems	% All Population
SW CWSs	Free Chlorine	7,816	123,472,631	67%	56%	18%	40%
	Chloramines	3,783	97,250,843	33%	44%	9%	32%
	all SW CWSs	11,599	220,723,474				
				% GW systems	**% of GW population**		
Disinfecting GW CWSs	Free Chlorine	27,816	71,146,728	88%	81%	65%	23%
	Chloramines	3,707	16,467,841	12%	19%	9%	5%
	all GW CWSs	31,523	87,614,569				
All Disinfecting CWSs	Free Chlorine	35,632	194,619,359			**83%**	**63%**
	Chloramines	7,490	113,718,684			**17%**	**37%**
All Disinfecting CWSs	ALL	43,122	308,338,043			100%	100%

* Collectively based on UCMR4 and SYR4 ICR in 2019

Co-Occurrence of TOC and Br in Source Water Affects Use of Chloramines as Residual by CWSs

Observation:

- High levels of TOC and Br were associated with high levels, > 50%, of chloramine use
- Some of systems with low levels of TOC and Br also used chloramines, i.e., chloramines used for reasons other than DBP control

		Systems using Chloramines (%)			
		System Avg **TOC**, mg/L			
	range	< 2	2-4	4-6	≥ 6
Sys Avg **Br**, µg/L	< 40	3.6%	17%	44%	61%
	40-80	6.4%	37%	56%	77%
	80-120	3.4%	43%	74%	91%
	≥ 120	6.3%	56%	90%	100%

Issue Area: Effects of Quality of Water Entering DS

Related Requests

1. How do the quality of water entering distribution systems and changes on disinfectant doses/residual levels affect formation/occurrence of DBPs with major concern in distribution systems (including organics in finished water)?

Supporting Analysis:

1) Assessing potential associations of finished water TOC levels versus residual levels, TC and EC positive rates, TTHM and HAA9 occurrence, and NDMA occurrence in DS, with the data from SYR4 ICR, UCMR4, SYR3 ICR, and UCMR2

Surface water: Raw and finished water TOC: SYR4 ICR_2019

System Size	Year	Count of Plants	Median (mg/L)	Mean (mg/L)	90%ile (mg/L)	95%ile (mg/L)	% Plant Means > 2 mg/L	% Plant Means > 3 mg/L
Raw Water								
Serving < 10,000	2019	661	**2.78**	3.37	**6.25**	**7.34**	65%	46%
Serving >= 10,000	2019	519	**2.75**	3.16	**5.42**	**6.57**	69%	43%
All	2019	1,180	2.77	3.28	5.93	7.02	67%	45%
Finished Water								
Serving < 10,000	2019	661	**1.58**	1.74	**3.25**	**3.75**	36%	14%
Serving >= 10,000	2019	519	**1.46**	1.56	**2.57**	**3.03**	25%	5.4%
All	2019	1,180	1.50	1.66	2.99	3.50	31%	10%

Finished water TOC impact on distribution system residual levels

Observation:

- Occurrence of **nondetectable** **free chlorine** levels **(FCL)** increased as finished TOC levels increased, more so among large systems.
- 50% of measurements had **FCL** residual levels < 1 mg/L, when TOC > 1.5 mg/L
- Finished water TOC **levels did not appear associated with TCL levels in DS**. Nearly all TCL measurements had detectable levels, regardless finished water TOC levels (data not shown)

	Monthly Sys Ave Finished Water TOC, mg/L	#Samples	%Samples at given levels of FCL, mg/L				
			Non-Detects	< 0.1	< 0.2	< 0.5	< 1
≥ 10k	<1	47,377	0.0%	0.4%	0.7%	7.7%	35%
	1-1.5	76,895	0.4%	4.3%	6.0%	11%	37%
	1.5-2	56,660	1.6%	9.7%	14%	21%	48%
	2-3	43,338	4.7%	14%	19%	26%	47%
	>=3	9,357	22%	27%	32%	37%	47%
< 10k	<1	4,880	0.0%	0.8%	1.0%	7.0%	35%
	1-1.5	5,415	0.0%	0.5%	1.4%	6.7%	38%
	1.5-2	5,737	0.4%	2.0%	4.3%	12%	47%
	2-3	6,016	2.9%	8.1%	12%	24%	56%
	>=3	2,971	4.7%	17%	24%	39%	63%

SW CWSs in 2018 and 2019, w ≥ 90%Completeness of residual records in SYR4 ICR

Finished Water TOC Levels Impact TTHM Levels in DS

Observations:

- TTHM levels were significantly lower at finished water TOC levels < 1 mg/L
- TTHM levels were only slightly affected by finished water TOC levels at ≥ 1 mg/L
- At a given finished water TOC range, small systems had higher TTHM levels

	Quarterly Sys Avg Finished Water TOC, mg/L	# Quarters	% Quarters	%Sys Quarterly Avg TTHM ≥ 64 µg/L	Mean of Quarter Avg TTHM, µg/L	Median of Quarterly Avg TTHM, µg/L
< 10k	<1	723	25%			
	1-1.5	461	16%	15%	49	38
	1.5-2	365	13%	19%	45	42
	2-3	716	25%	20%	46	44
	>=3	605	21%	25%	49	46
≥ 10k	<1	386	18%	5.2%	30	28
	1-1.5	490	23%	8.6%	35	32
	1.5-2	514	24%	9.5%	38	36
	2-3	526	25%	11%	37	34
	>=3	187	8.9%	11%	37	34

SW CWSs (Paired records of finished water TOC and TTHM in SYR4 ICR Data in 2018 and 2019)

Finished Water TOC Levels Impact HAA9 levels in DS

Observation:

- HAA9 levels were significantly lower at finished water TOC levels < 1 mg/L, as compared to those at TOC levels ≥ 1 mg/L.
- HAA9 levels were not affected by finished water TOC levels at ≥ 1 mg/L.

	Quarterly System Avg Finished Water TOC, mg/L	# Quarters	% Quarters (N=1,290)	%Sys Quarterly Avg HAA9 ≥ 60 µg/L	Mean of Quarter Avg HAA9, µg/L	Median of Quarterly Avg HAA9, µg/L
All System Sizes	<1	250	19%	0.4%	23	22
	1-1.5	338	26%	5.0%	33	30
	1.5-2	298	23%	6.0%	34	33
	2-3	297	23%	5.7%	32	30
	>=3	107	8.3%	7.5%	33	30

Due to relatively low number of system year-quarters (n=1,290) systems were not grouped by system size
SW CWSs (Common system year-quarters in SYR4 ICR and UCMR4 in 2018 and 2019)

Major Observations on Analysis of Precursor Occurrence and Effects on DBP Occurrence

DBP occurrence observations (data not shown)

FCL systems

- Majority exceeding 60 µg/L Max LAA **HAA9** threshold had relatively **low** bromide levels
- Relatively high HAA6Br levels rarely occurred at low levels of bromide (i.e., < 40 µg/L)

CLM systems

- no systems with TOC < 4 mg/L had Max LAA HAA9 ≥ 60 µg/L
- relatively high HAA6Br levels occurred only with extremely high levels of bromide in source water (i.e., >=120)

Issue Area: Effects of Quality of Water Entering DS

Related Requests

1. How effective has the required TOC removal criteria, a.k.a., the 3x3 matrix, been for conventional surface water treatment plants?

Supporting Analysis:

1) Assessment of TOC removal by conventional surface water using SYR4 2019 and 2018 paired data – raw and finished water

Raw Water TOC, mg/L		Raw Water Alkalinity, mg $CaCO_3$/L 0-60	>60 to 120	>120
2.0 < TOC <= 4.0	**Required %TOC removal**	**35%**	**25%**	**15%**
4.0 < TOC <= 8.0	**Required %TOC removal**	**45%**	**35%**	**25%**
TOC > 8.0	**Required %TOC removal**	**50%**	**40%**	**30%**

Required TOC removal criteria
3x3 matrix

Conventional SW treatment

Developed with the thought that 90% of the WTPs could meet the required removal

Alternative compliance criteria

- Raw water TOC or SUVA <2
- Finished water TOC or SUVA <2
- Diminishing return on jar tests – work with the state
- < 40/30 TTHM/HAA5 for FCL systems
- Raw TOC < 4, Raw water Alk > 60, and TTHM/HAA5 < 40/30.

Raw Water TOC, mg/L	System size	Serving >= 10,000		
	Summary (Total #Facility Years) =	**757**		
		Raw Water Alkalinity, mg $CaCO_3$/L		
		0-60	>60 to 120	>120
2.0 < TOC <= 4.0	#Facility Years	227	136	103
	Mean Removal	**49%**	**43%**	**35%**
	Required %TOC removal	35%	25%	15%
4.0 < TOC <= 8.0	#Facility Years	132	25	107
	Mean Removal	**63%**	**50%**	**47%**
	Required %TOC removal	45%	35%	25%
TOC > 8.0	#Facility Years	21	--	6
	Mean Removal	**71%**	**--**	**56%**
	Required %TOC removal	50%	40%	30%

SYR4 ICR_2019 and 2018
Conventional SW treatment

Mean removal is a delta of 14% to 22% higher than required removal

Raw Water TOC, mg/L	System size	**Serving >= 10,000**		
	Summary (Total #Facility Years) =	**757**		
		Raw Water Alkalinity, mg $CaCO_3$/L		
		0-60	>60 to 120	>120
2.0 < TOC <= 4.0	#Facility Years	227	136	103
	%Facility Years with %Removal < Required	**10%**	**10%**	**5%**
	Required %TOC removal	35%	25%	15%
	% Facility Years with Treated TOC > 2 mg/L	5%	11%	49%
	Mean Treated TOC, mg/L	**1.47**	**1.54**	**1.94**
4.0 < TOC <= 8.0	#Facility Years	132	25	107
	%Facility Years with %Removal < Required	**7%**	**4%**	**0%**
	Required %TOC removal	45%	35%	25%
	% Facility Years with Treated TOC > 2 mg/L	53%	76%	91%
	Mean Treated TOC, mg/L	**2.03**	**2.52**	**2.76**
TOC > 8.0	#Facility Years	21	--	6
	%Facility Years with %Removal < Required	5%	--	0%
	Required %TOC removal	50%	40%	30%
	% Facility Years with Treated TOC > 2 mg/L	76%	--	83%
	Mean Treated TOC, mg/L	**2.99**	**--**	**4.49**

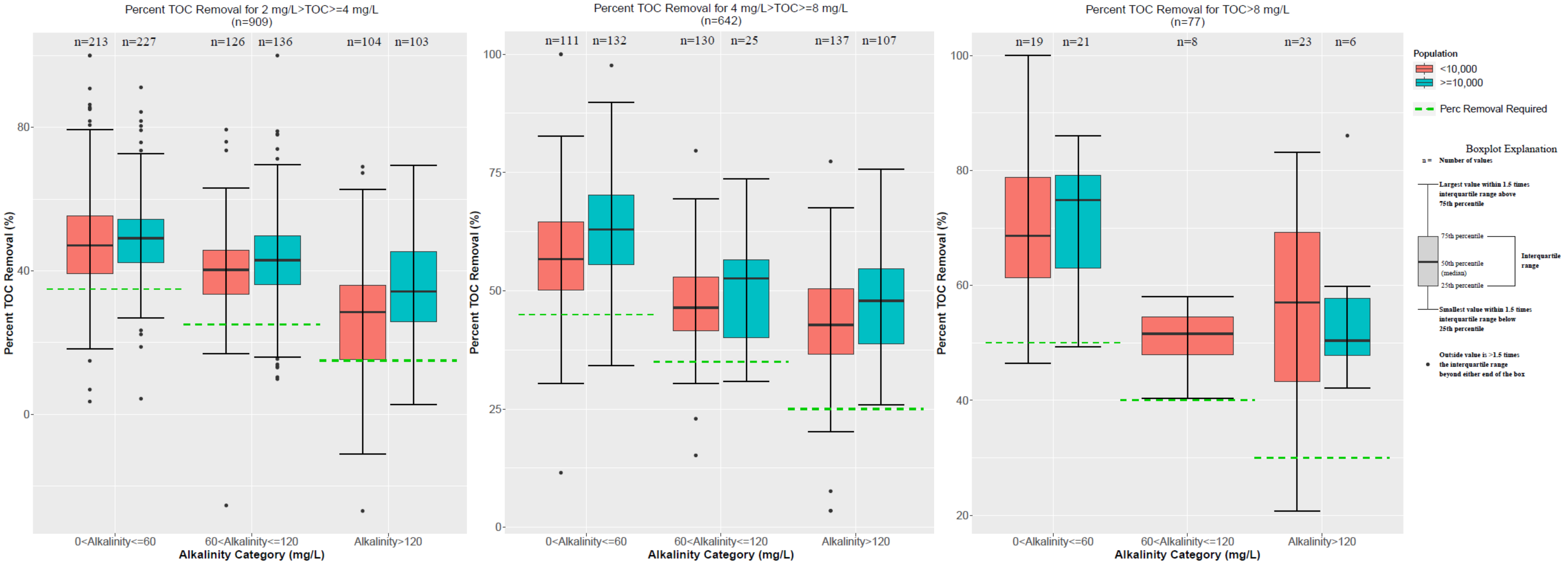
Overall 7% of facility years had %removal **achieved** less than **required** %removal.

Compliance for these facilities could have been achieved through alternative criteria

Raw Water TOC, mg/L	System size	Serving >= 10,000			**Serving < 10,000**		
	Summary (Total #Facility Years) =	757			**871**		
		Raw Water Alkalinity, mg $CaCO_3$/L			Raw Water Alkalinity, mg $CaCO_3$/L		
		0-60	>60 to 120	>120	0-60	>60 to 120	>120
2.0 < TOC <= 4.0	#Facility Years	227	136	103	213	126	104
	%Facility Years with %Removal < Required	10%	10%	5%	14%	7%	24%
	Mean Removal	49%	43%	35%	49%	40%	27%
	Required %TOC removal	35%	25%	15%	**35%**	**25%**	**15%**
	% Facility Years with Treated TOC > 2 mg/L	5%	11%	49%	9%	16%	70%
	Mean Treated TOC, mg/L	1.47	1.54	1.94	1.44	1.64	2.28
4.0 < TOC <= 8.0	#Facility Years	132	25	107	111	130	137
	%Facility Years with %Removal < Required	7%	4%	0%	6%	7%	4%
	Mean Removal	63%	50%	47%	58%	48%	43%
	Required %TOC removal	45%	35%	25%	**45%**	**35%**	**25%**
	% Facility Years with Treated TOC > 2 mg/L	53%	76%	91%	68%	96%	96%
	Mean Treated TOC, mg/L	2.03	2.52	2.76	2.26	2.89	3.24
TOC > 8.0	#Facility Years	21	--	6	19	8	23
	%Facility Years with %Removal < Required	5%	--	0%	11%	0%	4%
	Mean Removal	71%	--	56%	72%	51%	56%
	Required %TOC removal	50%	40%	30%	**50%**	**40%**	**30%**
	% Facility Years with Treated TOC > 2 mg/L	76% o Not	-- o	83%	79%	100%	100%
	Mean Treated TOC, mg/L	2.99	--	4.49	2.95	4.56	4.38

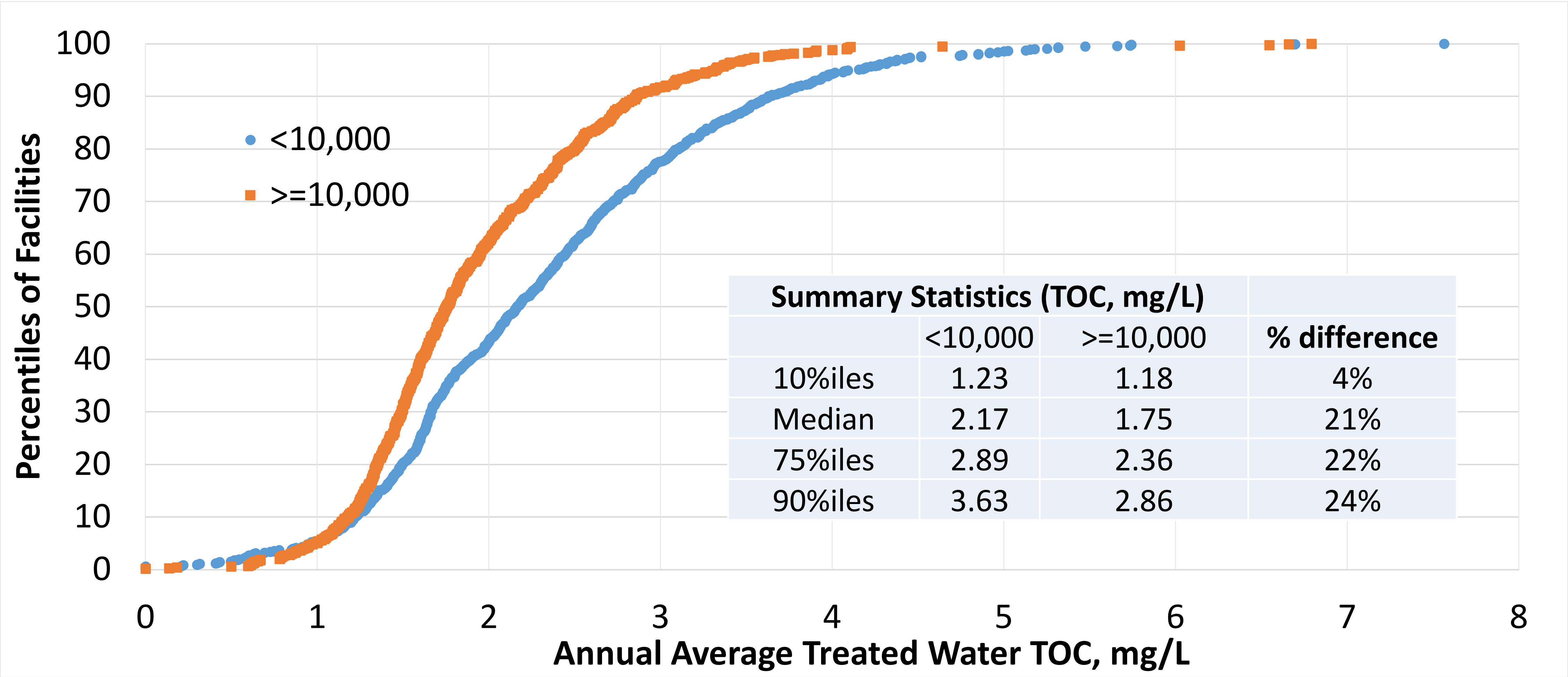
Overall 11% of facility years had % removal achieved less than required removal.

Conventional SW treatment
SYR4 ICR_2019 and 2018



Treated Water TOC Levels by System Size from SYR4 ICR Dataset

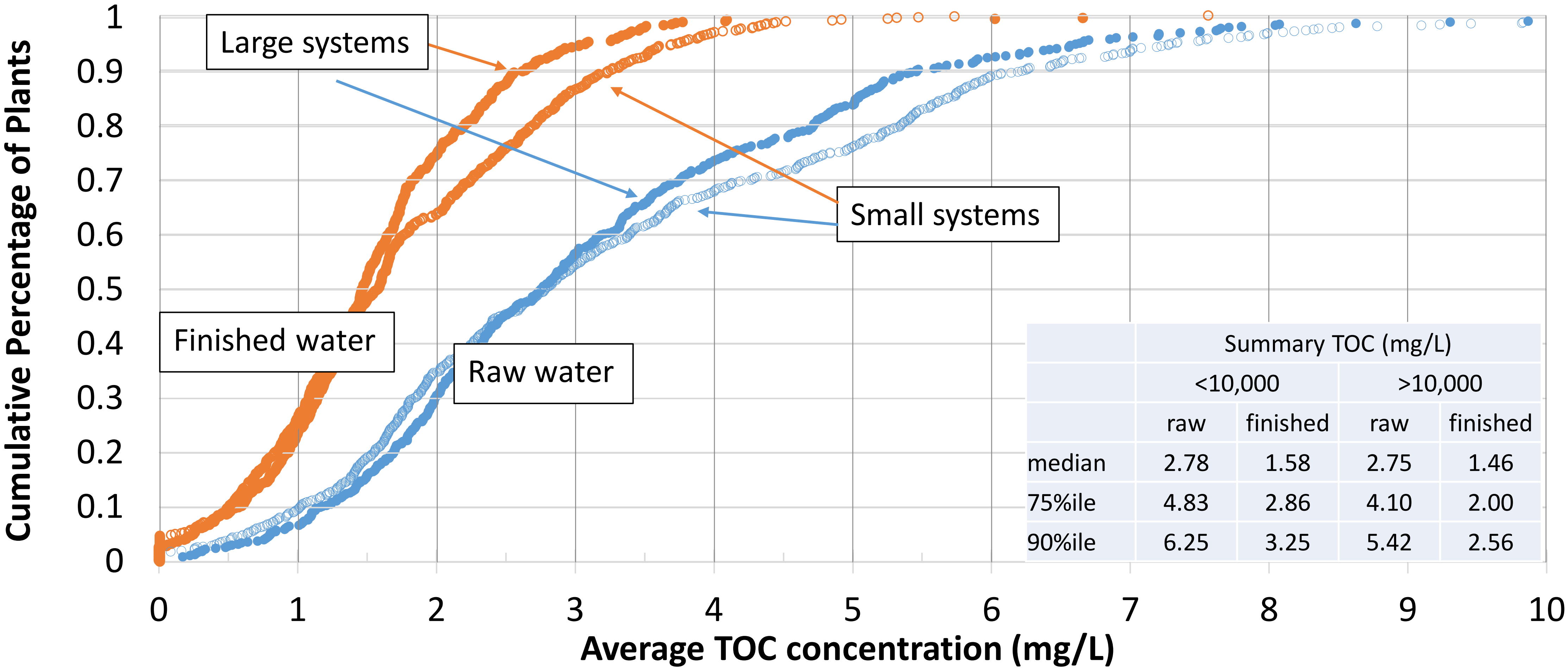
(Based on Paired TOC Data (n=871) from 2018-2019)



Summary Statistics (TOC, mg/L)			
	<10,000	>=10,000	**% difference**
10%iles	1.23	1.18	4%
Median	2.17	1.75	21%
75%iles	2.89	2.36	22%
90%iles	3.63	2.86	24%

Does not include raw water TOC < 2 mg/L)

Cumulative Distribution of TOC Plant Means Surface Water Plants: SYR4 ICR TOC Dataset 2019



	Summary TOC (mg/L)			
	<10,000		>10,000	
	raw	finished	raw	finished
median	2.78	1.58	2.75	1.46
75%ile	4.83	2.86	4.10	2.00
90%ile	6.25	3.25	5.42	2.56

Summary

- TOC and bromide concentrations strongly impact regulated DBP formation
- TOC and bromide strongly impact the selection of distribution system disinfectant – high levels favor chloramine use
- GW systems have higher source water Br levels and lower TOC levels than SW systems
- Occurrence of **non-detectable free chlorine** levels increased as finished TOC levels increased
- Low levels of TOC, 1 mg/L, was associated with lower concentrations of TTHMs and HAAs
- Overall only 7% of facility years had TOC %removal **achieved** that were less than **required** TOC %removal (alternative compliance criteria could be in effect)
- The distribution of TOC in both source water and finished water for small systems were:
  - **similar** to that for large systems at the 50^{th}%ile (median)
  - but much **higher** beyond the 75^{th}%ile

Facilitated Discussion

- Clarifying questions
- Do you have additions or refinements to the characterization of opportunistic pathogens or D/DBPs presented today or previously?

60 Minute Lunch Break

1:15 – 2:15 pm ET

Segment 3: Environmental Justice in the MDBP Context

Presentations, Facilitated Discussion

December 13, 2022

EPA

OFFICE OF GROUND WATER AND DRINKING WATER

Microbial and Disinfection Byproducts
Rule Revisions Working Group

Environmental Justice Considerations

Meeting 5: December 13, 2022, 11:00am-6:00pm ET

EPA
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Outline

- Environmental Justice Related Executive Orders
- Bipartisan Infrastructure Law
- EJ Considerations for Proposing a Drinking Water Regulation
- Additional Input

Aim and Purpose

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- Executive Order (E.O.) 12898 brings federal attention to the environmental and human health effects of federal actions on minority and low-income populations with the goal of achieving environmental protection for all communities.

- In addition, Executive Order 14008 places focus on consulting and partnering with Tribes; state, local, and territorial governments, and other federal agencies; community groups; scientists and adaptation experts; businesses; and other stakeholders to increase the resilience of the nation, with a particular focus on advancing environmental justice.

- EPA aims to deepen environmental justice practice within EPA programs to improve the health and environment of overburdened communities; work with partners to expand our positive impact within overburdened communities; and demonstrate progress on significant national environmental justice challenges.

Executive Order 12898 – Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations

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E.O. 12898 directs federal agencies to:

- Identify and address the disproportionately high and adverse human health or environmental effects of their actions on minority and low-income populations, to the greatest extent practicable and permitted by law;
- Develop a strategy for implementing environmental justice;
- Promote nondiscrimination in federal programs that affect human health and the environment, as well as provide minority and low-income communities access to public information and public participation.

Executive Order 14008 and Justice40

- In January 2021, Executive Order 14008 – Tackling the Climate Crisis at Home and Abroad announced the **Justice40** Initiative, which mandates that at least 40% of the overall benefits of certain federal programs flow to disadvantaged communities.

- Justice40 is a White House initiative to advance environmental justice across the entire government.

Justice40 Potential Investments and Benefits

Justice40 will provide recommendations on how certain Federal investments might be made toward a goal that **40 percent of the overall benefits flow to disadvantaged communities** and focuses on investments in many areas, including:

- the *remediation and reduction of legacy pollution* and;
- the *development of critical clean water infrastructure*.

EPA's Office of Ground Water and Drinking Water (OGWDW) related programs that may be addressed by Justice40 include the following:

- Drinking Water State Revolving Fund (including SRF funding for Emerging Contaminants)
- Small and Disadvantaged Communities Drinking Water Grant Program
- Small System Training and Technical Assistance Grant
- Water Infrastructure Improvements for the Nation's Small and Underserved Communities

Bipartisan Infrastructure Law

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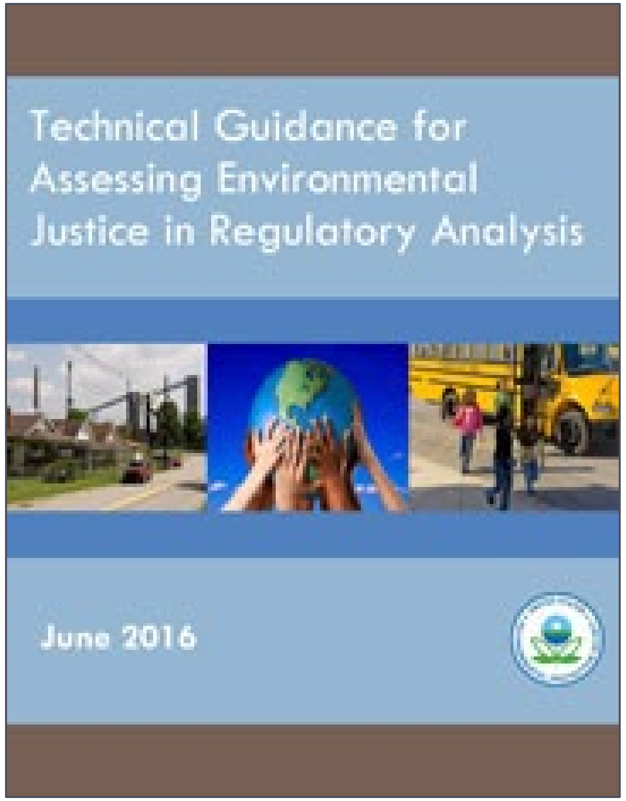
- The Bipartisan Infrastructure Law (BIL) provides for significant investments in safe drinking water infrastructure and drinking water programs.
- EPA is working to ensure the funds are available to drinking water systems, especially those serving disadvantaged communities.
- Examples of funds to potentially support implementation of drinking water regulations:
  - $11.7 billion: Funding to supplement the Drinking Water General State Revolving Loan Fund (DWSRF)
  - $4 billion: DW SRF Funding to specifically address emerging contaminants
  - $5 billion: Funding through the Small, Underserved, and Disadvantaged Communities Grants, which can be used to address and remediate emerging contaminants in drinking water within disadvantaged communities
  - $15 billion: Dedicated funding through the DW SRF for lead service line (LSL) identification and replacement.
  - Examples of eligible projects for all of these funds may include upgrades to distribution systems storage tanks or capital infrastructure improvement upgrades.

Technical Guidance for Assessing EJ in Regulatory Analysis

EPA is committed to ensuring the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

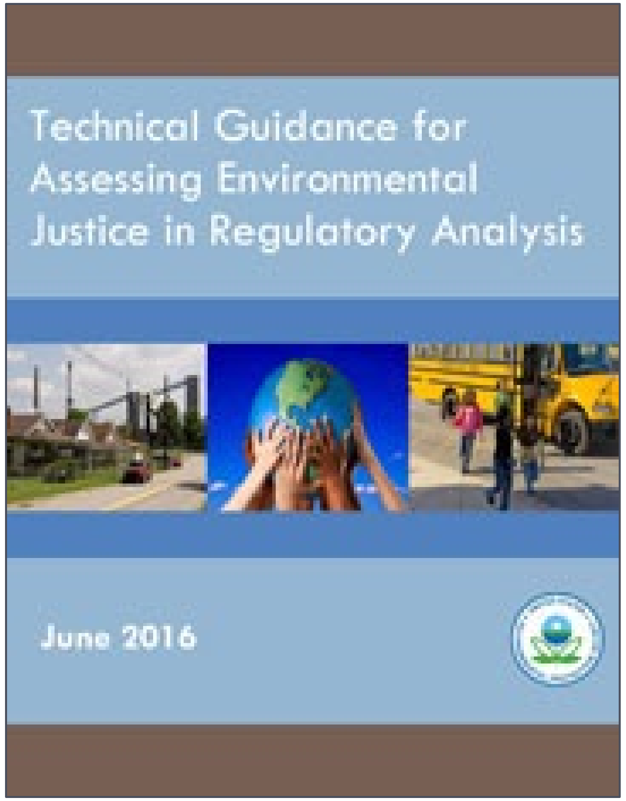
To directly support this commitment to EJ, EPA's *Technical Guidance for Assessing Environmental Justice in Regulatory Analysis* outlines particular technical approaches and methods to help EPA analyze potential EJ concerns for regulatory actions.



Technical Guidance for Assessing EJ in Regulatory Analysis

EPA's *Technical Guidance for Assessing Environmental Justice in Regulatory Analysis* recommends addressing three questions when analyzing potential EJ concerns for regulatory actions:

- Are there potential EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern in the baseline?
- Are there potential EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern for each regulatory option under consideration?
- For each regulatory option under consideration, are potential EJ concerns created or mitigated compared to the baseline?



Plan for Environmental Justice Analysis to inform MDBP Rule Revision

- Prior to proposing any MDBP rule revisions, EPA would conduct an Environmental Justice Analysis based on available information to evaluate the rule's impact on disadvantaged communities.
- During rule proposal, EPA would seek and consider comments before finalizing the analysis with the final rule.
- Dependent on data availability, EPA could consider:
  - Existing scientific literature and evaluations and relevant case studies
  - Historical concentrations of contaminants in drinking water served to disadvantaged communities
  - Historic exceedances/noncompliance of PWSs that serve disadvantaged communities, with respect to relevant NPDWR requirements
  - Demographic distribution of health benefits and incremental household costs anticipated to result from any proposed MDBP rule revisions
  - EPA can evaluate this information using tools such as EJScreen, other screening tools, and/or cost-benefit models.
- Input received by the NDWAC would be considered as EPA develops the analysis.

EJ Considerations for Proposing Drinking Water Regulations

- As part of its EJ analysis, EPA will consider whether population groups of concern (e.g., low-income populations) are disproportionately exposed to microbial contaminants and DBPs in drinking water.
    - A few examples exist in the published literature on small-scale analyses.

- EPA's analysis is expected to also evaluate whether population groups of concern are disproportionately affected by potential regulatory options for the MDBP rule revisions.

Seeking Public Input

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EPA plans to seek input to inform the development of proposed revisions to the MDBP drinking water rules from key stakeholders, organizations, and interested parties, including:

- Impacted communities through outreach meetings to discuss EJ considerations
- Science Advisory Board
- Small Business Advocacy Review Panel
- Tribal government officials
- State and local government officials
- National Drinking Water Advisory Council

EPA will consider the information gained from these engagements, and from the public comment process, during the regulatory development process.

Initial EJ Relevant Input from the NDWAC Working Group Meetings

- Understand levels of underlying health conditions, vulnerable populations, and the cumulative impacts of MDBP exposures;

- Consider utilizing spatial data to perform an accurate analysis of drinking water challenges and impacted communities and localities;

- Aim for a compliance analysis for MDBP rules, with focus on water utilities that serve disadvantaged communities, demographics of impacted communities, and the number of violations;

- Collate knowledge from residents of impacted communities; determine how they learned of violations; and review information provided to them.

Initial EJ Relevant Input from the NDWAC Working Group Meetings

- Perform literature reviews of relevant research on MDBPs and environmental justice.

- Assess linkages between small, and potentially understaffed systems and water quality violations;

- Find solutions to improve and provide well maintained infrastructure for EJ-communities at the system and premise levels;

- Ensure communities are aware of best practices and share practices that balance disinfection and DBPs.

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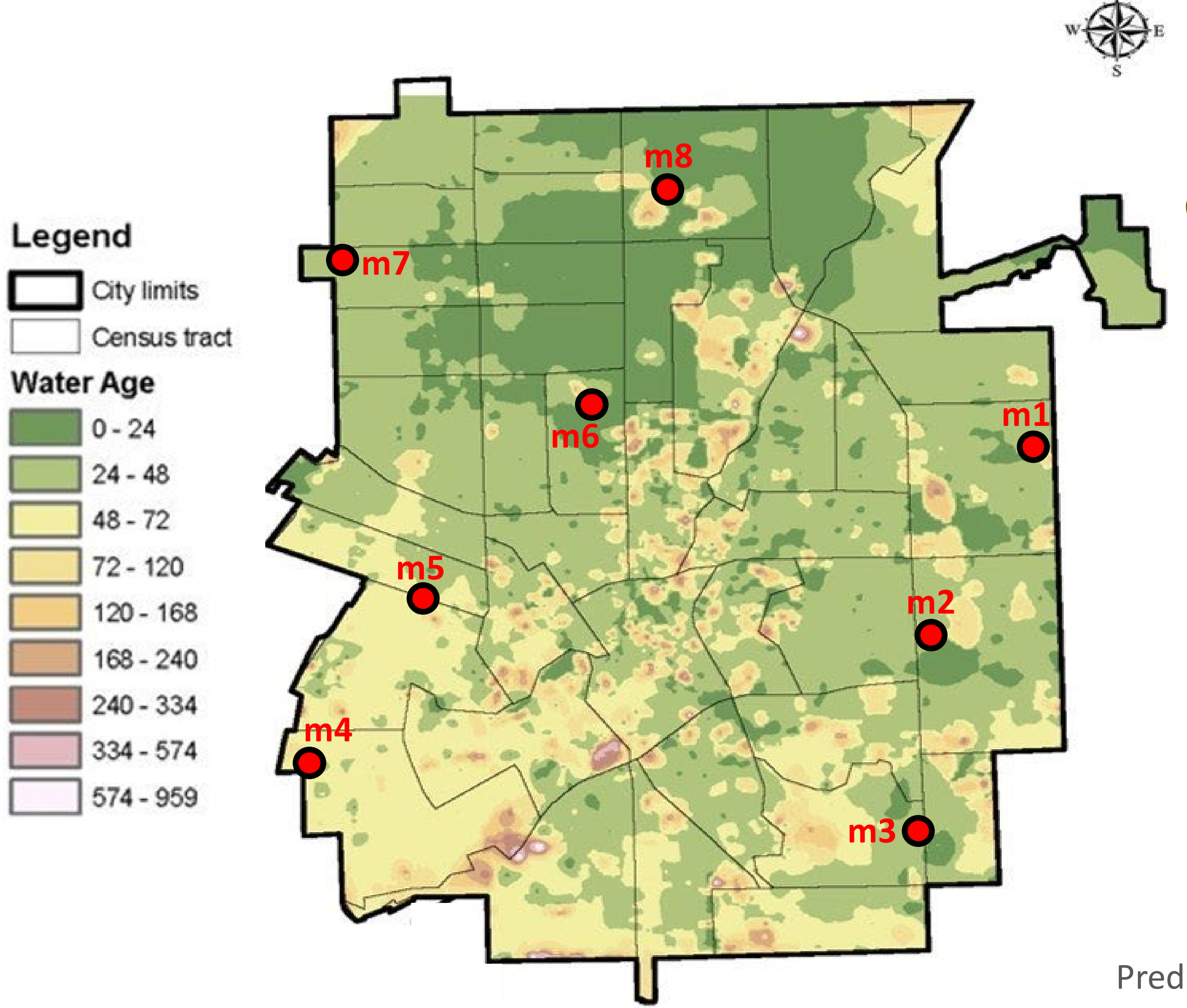
Questions?

Considerations for Bringing an Environmental Justice Lens into Water Quality Research and Design

Shawn P. McElmurry, PhD, PE
Dept. Civil & Environmental Engineering
Wayne State University

Nancy G. Love, PhD, PE, BCEE
Dept. Civil & Environmental Engineering
University of Michigan



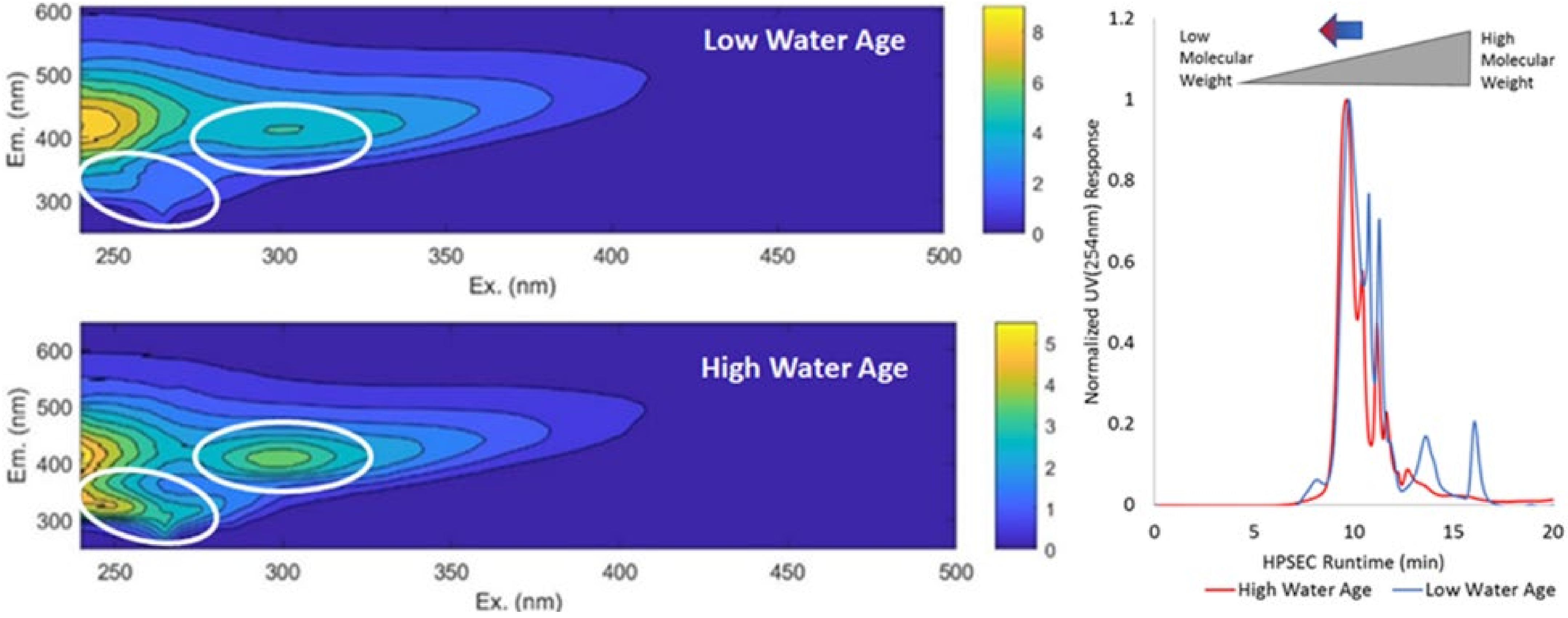
Flint has significant water storage occurring in under-maintained distribution system pipes and premise plumbing

- Chlorine residual monitoring points in distribution system during and preceding water crisis – largely driven by DBP monitoring requirements.

Analysis by: Shawn McElmurry, Sara Schwetschenau, Amir Kamjou, Harry Vaslo
Wayne State University

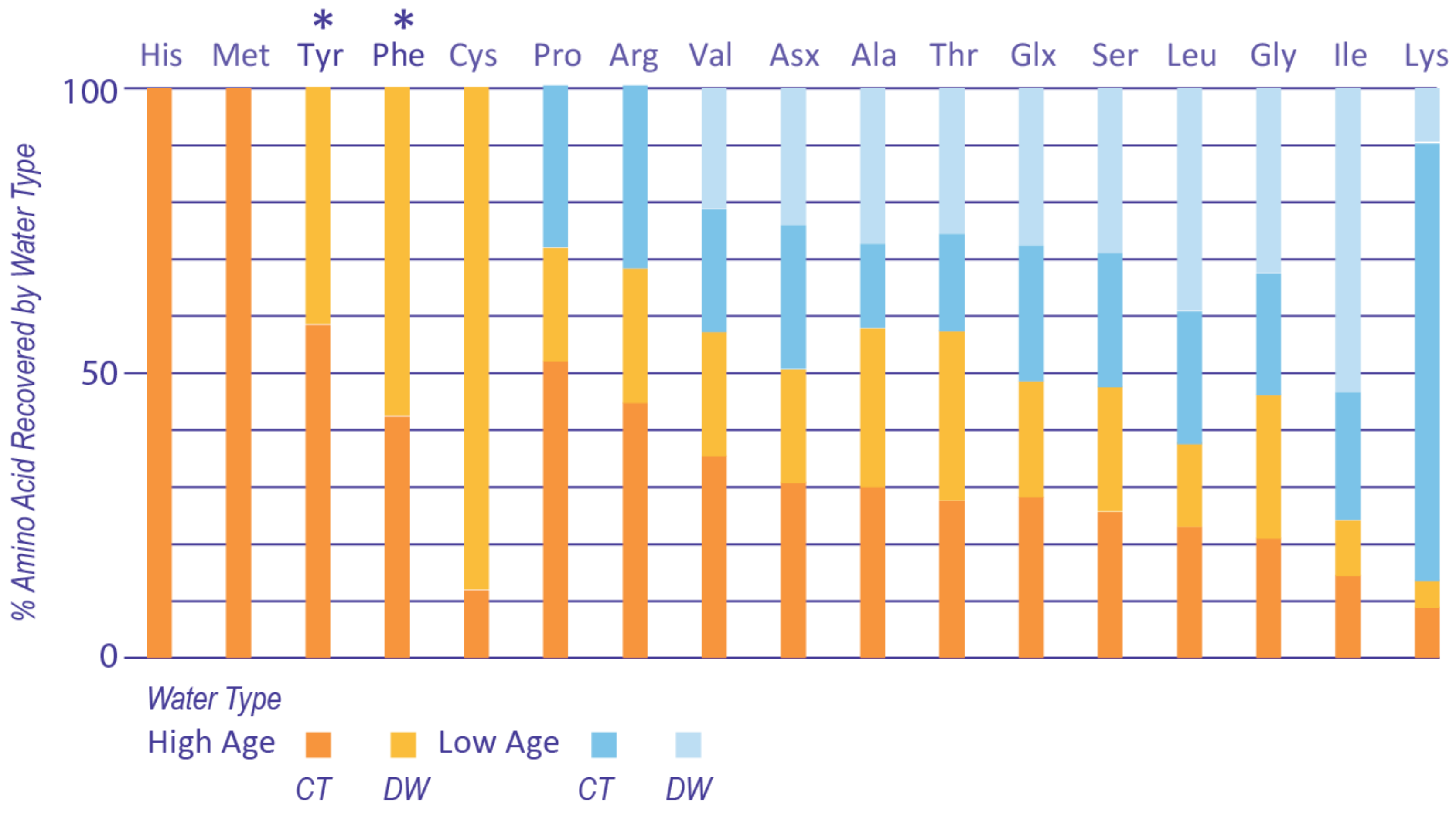
Predicted Water Age via an EPA, CitiLogics, and Arcadis calibrated EPANET model that was provided under a data sharing agreement with the City of Flint and further calibrated using data for the period of sampling (July-Sept 2016) that includes monthly water meter readings and data from 22,910 residential accounts, 1,722 commercial accounts, and 51 accounts associated with lawn irrigation

Dissolved organic matter evolves as it moves through drinking water distribution system



Unpublished Data: *Audrey Rose-Zarb[1], Brittany Brown Hicks[2], R. David Holbrook[3], Pei-Chung Lee[1], Nancy G. Love[2], Shawn McElmurry[1]*
[1]Wayne State University, [2]National Institute of Standards & Technology, [3]University of Michigan

Change in organic nitrogen has implications to emerging pathogens as well as DBP formation



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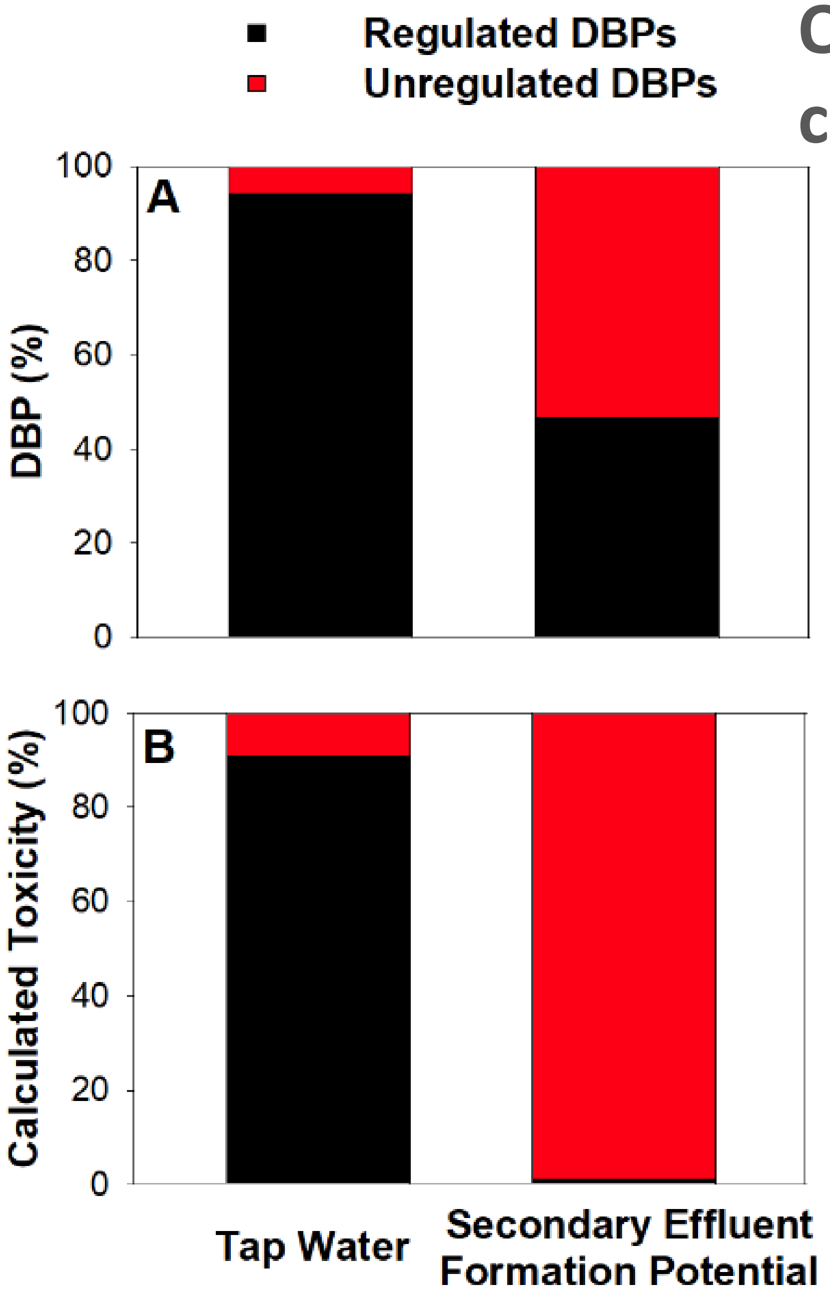
[1]Wayne State University, [2]National Institute of Standards & Technology, [3]University of Michigan

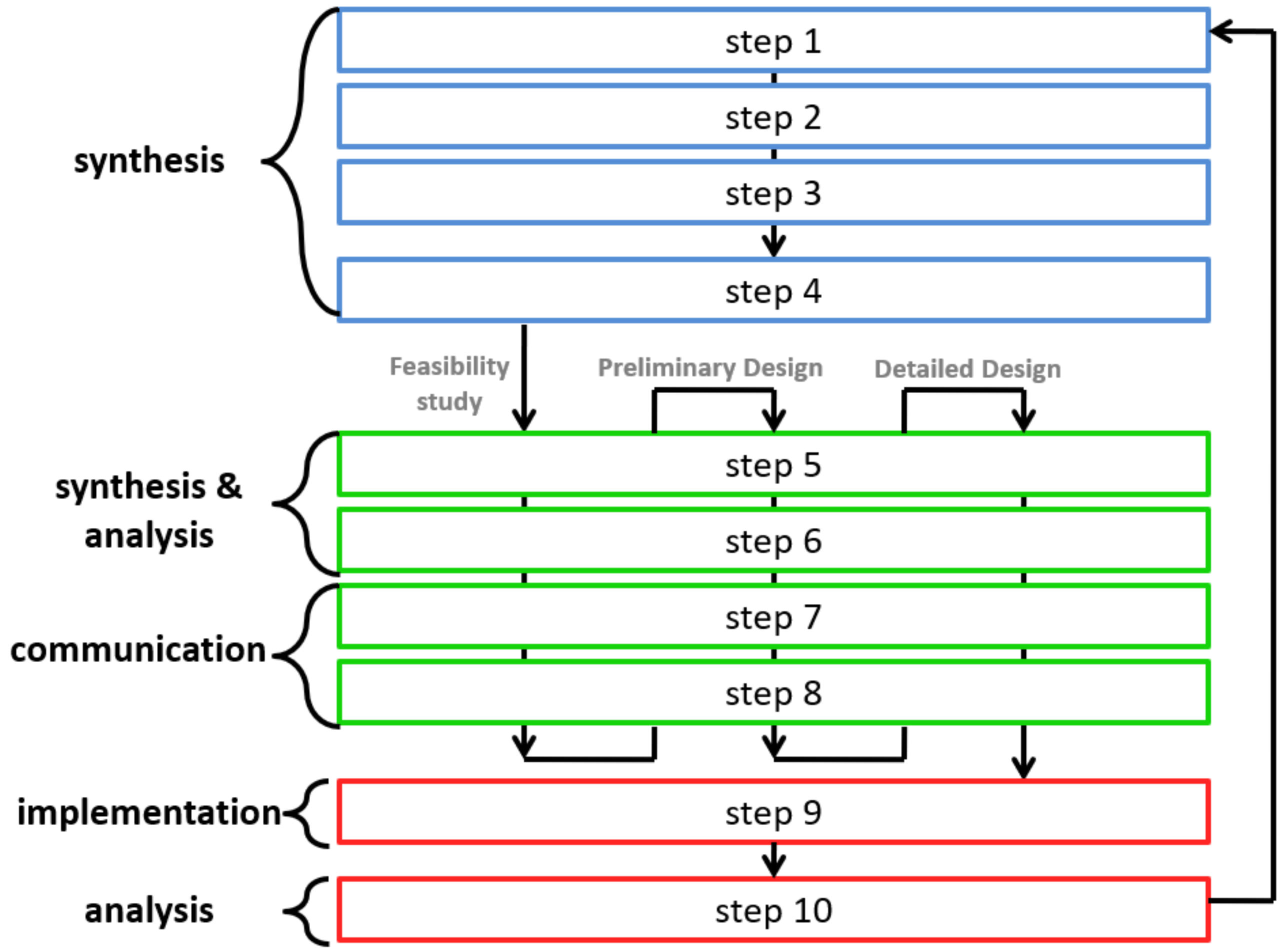
Organic carbon form influences the relative contribution of regulated and non-regulated DBPs

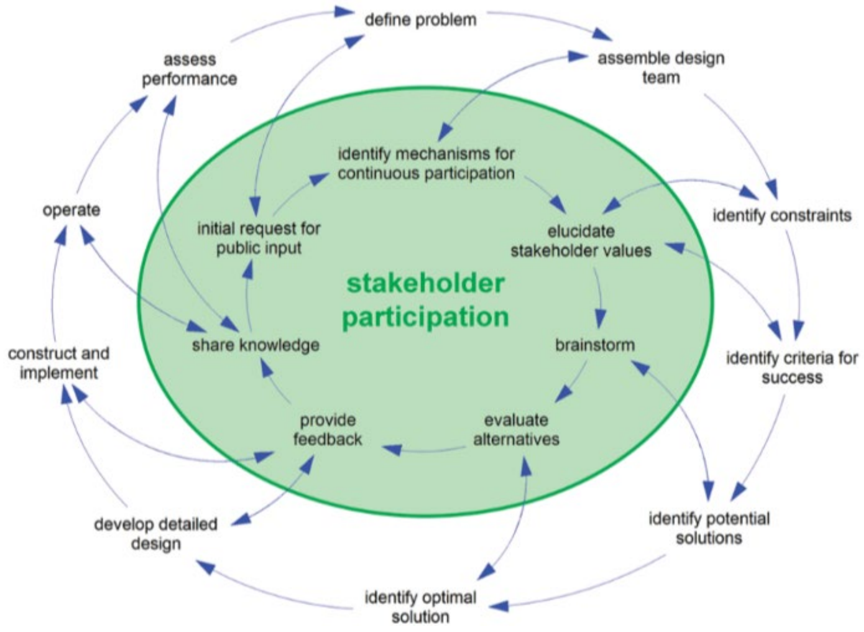


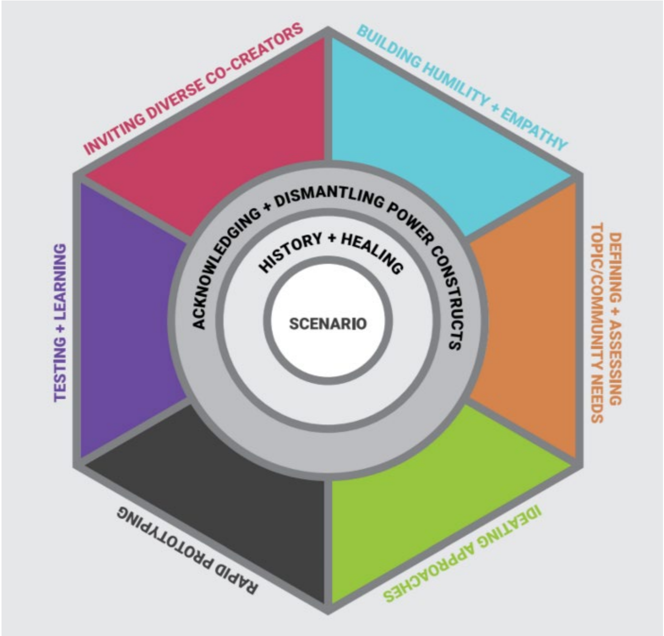
Contribution of regulated and unregulated DBPs on (A) a mass concentration basis & (B) calculated toxicity basis [20] in a tap water sample, and those formed from secondary effluent treated with 5 mg-Cl_2/L for 3 days. Regulated DBPs consist of THM4 and HAA5. Unregulated DBPs consist of 4 additional HAAs, HANs, HAMs, HALs, I-THMs, HKs, HNMs, and N-nitrosamines.

Unpublished data by Aleksandra Szczuka, University of Michigan.

The Evolution of Design…………..



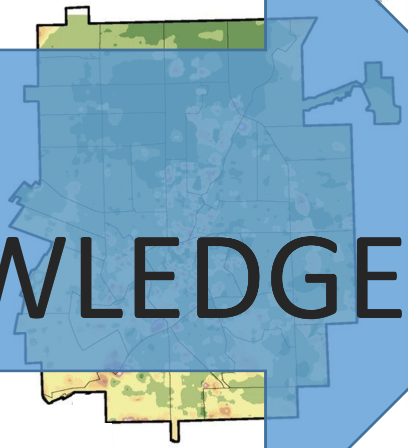




Adapted from Figure 5.1 –Holtzapple- Reece, *Foundations of Engineering, Second Edition. pg. 37*

Guest et al., ES&T, 2009

Akshat Srivastava, What is Equity-Centered Community Design? https://bootcamp.uxdesign.cc/what-is-equity-centered-community-design-4a49cb55003f



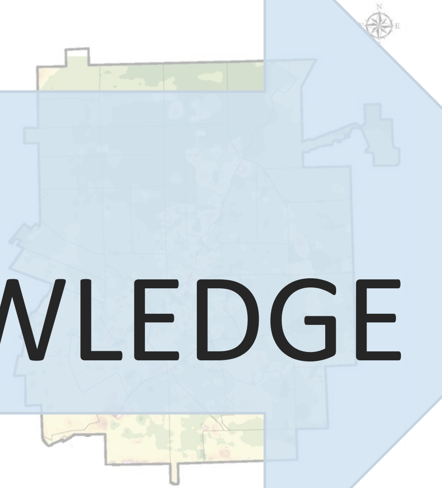
HISTORY & COMMUNITY KNOWLEDGE

DISPARATE AFFORDABILITY & ACCESS

WATER QUALITY IMPLICATIONS

HEALTH DISPARITIES

HISTORY & COMMUNITY KNOWLEDGE



DISPARATE AFFORDABILITY & ACCESS

WATER QUALITY IMPLICATIONS

HEALTH DISPARITIES

COMMUNITY ADVISORY PROCESS

DESIGN FOR ADAPTATION

EQUITABLE & DIVERSE WATER WORKFORCE

EQUITABLE RATE STRUCTURES

UNIVERSAL, HIGH QUALITY, MAINTAINED WATER INFRASTRUCTURE

COMMUNITY KNOWLEDGE, UNDERSTANDING, & PARTNERSHIPS

TRUSTED, AFFORDABLE & ACCESSIBLE WATER SERVICES

National Center for Environmental Health

Legionnaires' Disease Health Disparities: A Social Determinants of Health Perspective

Nakia S. Clemmons, MPH, REHS, CIC
Environmental Health Specialist

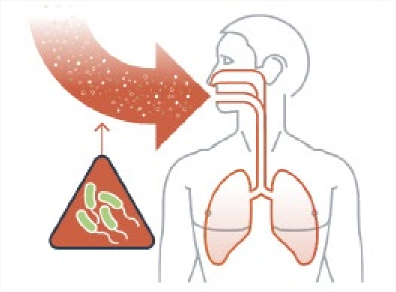
NDWAC Working Group Meeting
December 13, 2022

Presentation Outline

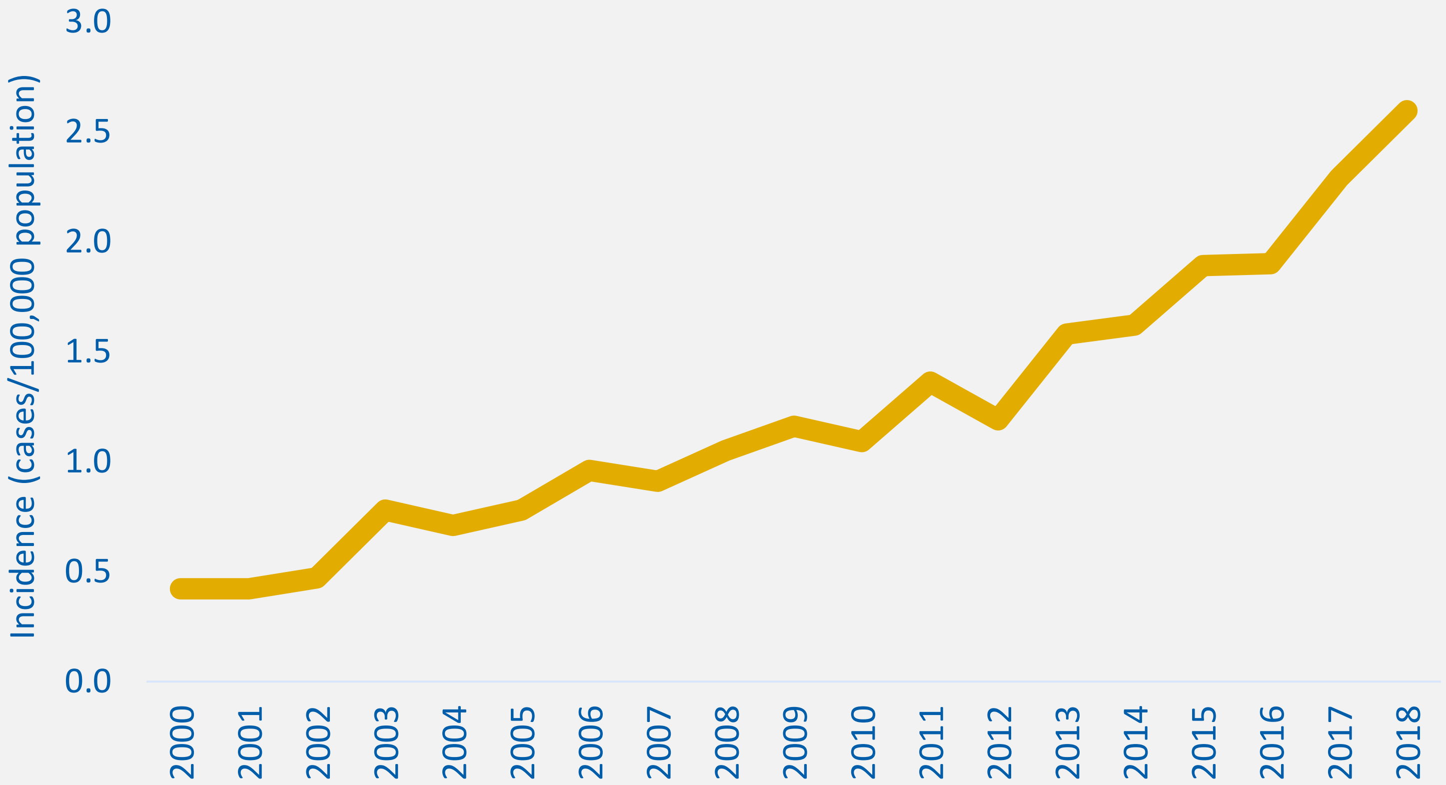
- **Legionnaires' Disease (LD) Burden**
- **Racial Disparities in LD Incidence & Social Determinants of Health**
- **Results and Findings**
- **Summary and Conclusions**

The Burden of Legionnaires' Disease (LD)

- **Causes severe pneumonia and usually requires hospitalization**
  - Deadly for 1 in 10 people infected
- **Inpatient cost estimates total over $433 million per year**
- **LD accounted for more than half of reported outbreaks associated with exposure to potable drinking water sources (e.g., showers, hot tubs) (2013-2014)**
- **Health Disparities:** LD incidence among Black or African American persons was more than double of White persons.



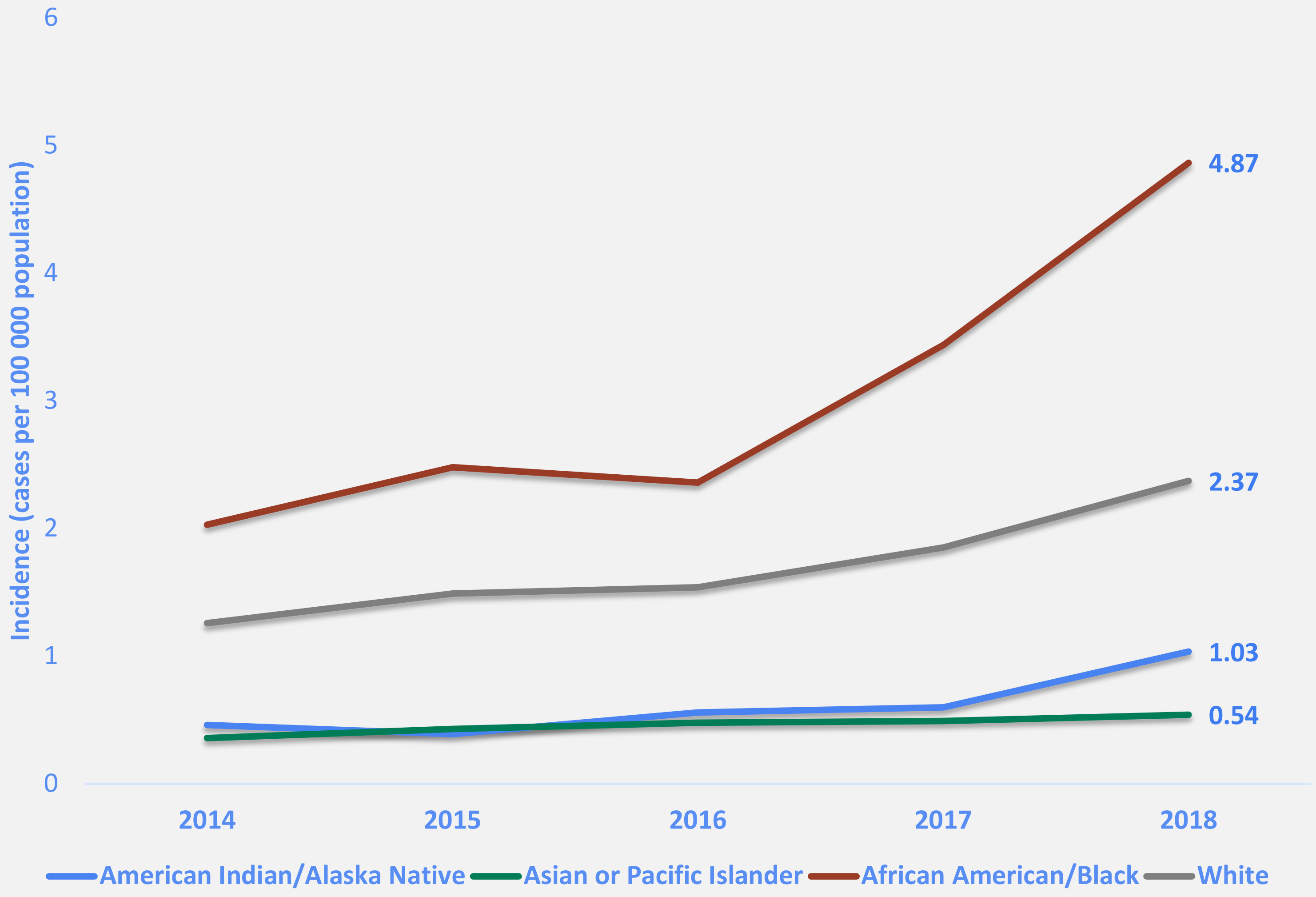
Legionnaires’ Disease is on the rise in the United States



Rate of reported LD cases increased 6-fold over 18 years

Centers for Disease Control and Prevention. National Notifiable Diseases Surveillance System: national notifiable infectious diseases and conditions, United States: weekly tables. 2020. Accessed March 1, 2020. https:// wonder. cdc. gov/ nndss/ nndss_weekly_ tables_ menu. asp

Racial Disparities in Legionnaires' Disease Incidence by Year and Race, U.S., 2014-2018

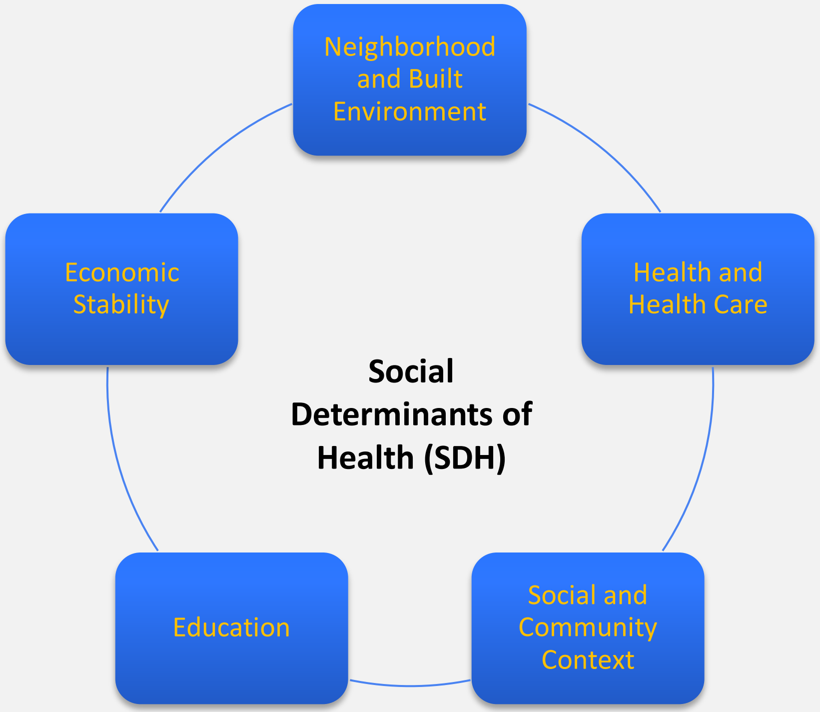


2018 Incidence Rate was more than double among Black or African American persons compared to White persons

Barskey A, Lackraj D, Tripathi PS, et al. *Legionnaires' Disease Surveillance Summary Report, United States: 2016-2017*. Centers for Disease Control and Prevention; 2020. Accessed March 1, 2020.

Disparities in Legionnaires' Disease Incidence

- **Black or African American persons and individuals with lower incomes are disproportionately impacted by Legionnaires' disease**
- **Objective of Study**
  - Explore underlying determinants to target interventions
  - Conduct narrative review of the health disparities for LD and respiratory related diseases



Healthy People 2020/30

Article Selection Process

The search terms used included Legionnaires, Legionella bacteria, Pontiac Fever, Legionellosis, extrapulmonary infection, racial/ethnic minority health, health care disparities and social determinants of health.

220 Articles identified through database (PubMed and Scopus) search

122 Articles excluded because unrelated to Legionnaires' disease, pneumonia, and health disparities

98 Full-text articles obtained for final review

79 Articles excluded:

- **77** Unrelated to social determinants of health or health disparities
- **2** Limited to children

19 Articles included in review

Preliminary Findings: Social Determinants of Health related to LD

Economic Stability	Lower Income/Poverty Employment & Working Conditions
Education	Lower Educational Attainment
Social and Community Context	Stress/Discrimination* Social Support/ Social Capital*
Health and Health Care	Comorbidities Healthcare Access
Neighborhood and Built Environment	Housing and community design Drinking water infrastructure* Air pollution*

Hunter CM, Salandy SW, Smith JC, Edens C, Hubbard B. Racial Disparities in Incidence of Legionnaires' Disease and Social Determinants of Health: A Narrative Review. Public Health Rep. 2022 Jul-Aug;137(4):660-671. doi: 10.1177/00333549211026781. Epub 2021 Jun 29. PMID: 34185609; PMCID: PMC9257508.

*Not frequently mentioned in reported articles

Economic Stability

- **Poverty levels may be associated with the highest incidence of Legionnaires' disease.**
  - New York City Legionnaires' disease incidence in areas with higher rates of poverty were 2.5 times higher than the areas with lower rates of poverty.
  - South Bronx Legionnaires' disease outbreak was found in areas of higher rates of poverty.

- **The role of occupation in 1,279 cases of community-acquired legionellosis:**
  - New Jersey found most cases were among people employed in hazardous or service industries (i.e., transportation, repair, protective services, cleaning, or construction).

Farnham A, Alleyne L, Cimini D, Balter S. Legionnaires' disease incidence and risk factors, New York, New York, USA, 2002-2011. *Emerg Infect Dis*. 2014;20(11):1795-1802. doi: 10. 3201/ eid2011. 131872
Gleason JA, Ross KM, Greeley RD. Analysis of population level determinants of legionellosis: spatial and geovisual methods for enhancing classification of high- risk areas. *Int J Health Geogr*. 2017;16(1):45. doi: 10. 1186/ s12942- 017- 0118-4

Education & Social and Community Context

- **Lower education level was associated with**
  - higher census-tract incidence of Legionnaires’ disease in New Jersey

- **No studies measured social and community context factors such as stress, discrimination, or social capital in the context of Legionnaires’ disease.**

Gleason JA, Ross KM, Greeley RD. Analysis of population level determinants of legionellosis: spatial and geovisual methods for enhancing classification of high-risk areas. *Int J Health Geogr*. 2017;16(1):45. doi: 10. 1186/ s12942- 017- 0118-4

Hunter CM, Salandy SW, Smith JC, Edens C, Hubbard B. Racial Disparities in Incidence of Legionnaires' Disease and Social Determinants of Health: A Narrative Review. Public Health Rep. 2022 Jul-Aug;137(4):660-671. doi: 10.1177/00333549211026781. Epub 2021 Jun 29. PMID: 34185609; PMCID: PMC9257508.

Health and Healthcare

- **A higher incidence of Legionnaires' may be associated with diabetes and invasive pneumococcal disease.**

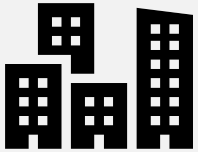
- **Immune compromising comorbidities were associated with community-acquired pneumonia and pneumonia related hospitalizations.**

- **Medicare comprised the largest percentage of primary payer for pneumonia-associated hospitalizations in New York City, followed by Medicaid.**

Farnham A, Alleyne L, Cimini D, Balter S. Legionnaires' disease incidence and risk factors, New York, New York, USA,2002-2011. *Emerg Infect Dis*. 2014;20(11):1795-1802. doi: 10.3201/ eid2011. 131872
Bush C, Mensah N, Fitzhenry R. Legionnaires' disease in New York City, 2007 to 2017. *Epi Data Brief*. 2018;106:1-17.
Hayes BH, Haberling DL, Kennedy JL, Varma JK, Fry AM,Vora NM. Burden of pneumonia- associated hospitalizations:United States, 2001-2014. *Chest*. 2018;153(2):427-437. doi: 10.1016/ j. chest. 2017. 09. 041
Jeon CY, Muennig P, Furuya EY, Cohen B, Nash D, Larson EL. Burden of present- on- admission infections and health care–associated infections, by race and ethnicity. *Am J Infect Control*. 2014;42(12):1296-1302. doi: 10. 1016/ j. ajic. 2014. 08.019
Feemster KA, Li Y, Localio AR, et al. Risk of invasive pneumococcal disease varies by neighbourhood characteristics: implications for prevention policies. *Epidemiol Infect*. 2013;141(8):1679-1689. doi: 10. 1017/ S095 0268 8120 0235X
Wortham JM, Zell ER, Pondo T, et al. Racial disparities in invasive streptococcus pneumoniae infections, 1998-2009. *Clin Infect Dis*. 2014;58(9):1250-1257. doi: 10. 1093/ cid/ ciu108

Neighborhood and Built Environment

- **In New Jersey, LD incidence increased with**
  - Percentage of vacant homes, rented homes, older homes
  - Older (pre-1950) housing



- **Proximity to construction sites and cooling towers may be associated with increased incidence**

- **Air pollution and LD is understudied**

Gleason JA, Ross KM, Greeley RD. Analysis of population level determinants of legionellosis: spatial and geovisual methods for enhancing classification of high- risk areas. *Int J Health Geogr*. 2017;16(1):45. doi: 10. 1186/ s12942- 017- 0118-4
Farnham A, Alleyne L, Cimini D, Balter S. Legionnaires' disease incidence and risk factors, New York, New York, USA,2002-2011. *Emerg Infect Dis*. 2014;20(11):1795-1802. doi: 10.3201/ eid2011. 131872
Koch K, Søgaard M, Nørgaard M, Thomsen RW, Schønheyder HC; Danish Collaborative Bacteremia Network. Socioeconomic inequalities in risk of hospitalization for community- acquired bacteremia: a Danish population- based case- control study. *Am J Epidemiol*. 2014;179(9):1096-1106

Discussion and Interventions

- There is a paucity of LD and SDHs articles related to **education, social and community context, neighborhood and built environment.**
- Community Health Workers and Environmental Health Practitioners can work together to comprehensively address health disparities related to SDH
- Outreach to organizations that have an interest in combatting
  - poor housing quality
  - comorbidities
  - air pollution
  - conditions that disproportionately affect people with lower incomes and people from racial & ethnic minority groups
- Future research

Summary

- **The disproportionately higher incidence of Legionnaires' disease among Black or African American persons and people with lower socioeconomic status (e.g., income, education, occupation) suggest a need for public health action.**
  - Incorporate SDH data sources with geocoded addresses from LD surveillance data
  - Use data sources to link environmental and socioeconomic variables
- **Our review revealed that income and comorbidities are commonly studied aspects of SDH**
- **Other SDH are areas for future study**
  - Job characteristics, education, social support, stress, health care access, health insurance type, and built environment are areas for future study.

References

1. Bush C, Mensah N, Fitzhenry R. Legionnaires' disease in New York City, 2007 to 2017. Epi Data Brief. 2018;106:1-17.
2. Feemster KA, Li Y, Localio AR, et al. Risk of invasive pneumococcal disease varies by neighborhood characteristics: implications for prevention policies. Epidemiol Infect. 2013;141(8):1679- 1689.
3. Chapman KE, Wilson D, Gorton R. Invasive pneumococcal disease and socioeconomic deprivation: a population study from the North East of England. J Public Health (Oxf). 2013;35(4):558- 569.
4. Gleason JA, Ross KM, Greeley RD. Analysis of population-level determinants of legionellosis: spatial and geovisual methods for enhancing classification of high-risk areas. Int J Health Geogr. 2017;16(1)45.
5. McLaughlin JM, Swerdlow DL, Khan F, et al. Disparities in uptake of 13-valent pneumococcal conjugate vaccine among older adults in the United States. Hum Vaccin Immunother. 2019;15(4):841- 849.
6. Schumacher A, Kocharian A, Koch A, Marx J. Fatal case of Legionnaires' disease after home exposure to Legionella pneumophila serogroup 3—Wisconsin, 2018. MMWR Morb Mortal Wkly Rep. 2020;69(8):207-211.
7. Orkis LT, Harrison LH, Mertz KJ, Brooks MM, Bibby KJ, Stout JE. Environmental sources of community-acquired Legionnaires' disease: a review. Int J Hyg Environ Health. 2018;221(5):764-774.
8. Wortham JM, Zell ER, Pondo T, et al. Racial disparities in invasive streptococcus pneumoniae infections, 1998-2009. Clin Infect Dis. 2014;58(9):1250-1257.

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TTY: 1-888-232-6348 www.atsdr.cdc.gov www.cdc.gov
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Facilitated Discussion

- Clarifying questions
- Based on your experience, do you have additions or refinements to the characterization of environmental justice considerations in the context of the MDBP rules?
- What additional information, perspectives, or experience will be helpful to further understand Environmental Justice in the MDBP context?

15 Minute Break

3:30-3:45 pm ET

Segment 3: Continued

Panel Discussion, Facilitated Discussion

December 13, 2022

OFFICE OF GROUND WATER
AND DRINKING WATER

Panel & Facilitated Discussion

- Chris Edens, CDC
- Blanca Surgeon, RCAC
- Ben Pauli, NEJAC
- Andy Kricun, NEJAC

Segment 4: Topic Areas for Possible Problem Characterization Findings

Presentations, Facilitated Discussion

December 13, 2022

OFFICE OF GROUND WATER AND DRINKING WATER

MDBP Problem Characterization
Possible Topics for Preliminary Findings

Presented By Facilitators & Co-Chairs

December 13, 2022

MDBP WG Meeting 5

Possible Topics for Preliminary Findings
Topic for Finding Statement 1: Drinking water system pathogen-related public health impacts – evidence and root causes related to water quality conditions in distribution systems and their relationship to outbreaks/illness. (NDWAC charge areas 1, 2)
Topic for Finding Statement 2: Premise plumbing pathogen-related public health impacts – evidence and root causes related to water quality conditions in premise plumbing and their relationship to pathogen-related outbreaks/illness. (NDWAC charge areas 1, 2)
Topic for Finding Statement 3: Distribution system water quality conditions related to pathogens – evidence and root causes of variable conditions and related vulnerabilities within the distribution system. (NDWAC charge areas 1, 2)

Possible Topics for Preliminary Findings

Possible Topics for Preliminary Findings
Topic for Finding Statement 4: Drinking water system DBP-related public health impacts – evidence and root causes related to DBPs in drinking water and their relationship to public health risks. (NDWAC charge areas 1, 2)
Topic for Finding Statement 5: Distribution system water quality conditions related to DBP formation – evidence and root causes of the potential for unaddressed public health risks. (NDWAC charge areas 1, 2)

Possible Topics for Preliminary Findings
Topic for Finding Statement 6: Source water conditions and related treatment requirements – evidence and root causes of challenges posed by source water quality. (NDWAC charge areas 1, 2)
Topic for Finding Statement 7: Storage tanks – evidence and root causes related to negative water quality impacts resulting from contaminant entry, formation, or growth due to improper or inadequate storage tank maintenance, operations, and management. (NDWAC charge areas 1, 2)
Topic for Finding Statement 8: Consecutive systems – evidence and root causes related to negative water quality impacts related to the unique circumstances of consecutive systems. (NDWAC Charge Areas 1, 2)

Possible Topics for Preliminary Findings
Topic for Finding Statement 9: Environmental justice impacts related to drinking water system water quality, maintenance, operations, and management in the context of pathogens and DBP risks. (NDWAC Charge Area 6)
Topic for Finding Statement 10: Areas that may introduce implementation or compliance challenges for drinking water systems/communities related to regulation and management of pathogens and DBPs. (NDWAC Charge Area 6)
Topic for Finding Statement 11: Data and analysis gaps.

Facilitated Discussion

- Clarifying questions
- Do you see any major gaps in the proposed topic areas?
- Do you see any opportunities for making refinements or clarification to the possible topic areas?

Segment 5: Meeting 6 Agenda & Next Steps

Co-Chairs Andy Kricun & Lisa Daniels
Rob Greenwood, Ross Strategic

EPA
OFFICE OF GROUND WATER
AND DRINKING WATER

Proposed Meeting 6 Topics & Next Steps

OFFICE OF GROUND WATER AND DRINKING WATER

- Implementation and Compliance Challenges
- Working Group Preliminary Problem Characterization Findings
- Introduction to Interventions Phase of Discussions

Facilitated Discussion

- Do you have additions or refinements to the proposed topics?
- What background materials, presentations, or other resources will be helpful to you to prepare for the Meeting 6 discussions?
- Mindful of time and resource limitations prior to the next meetings, what supplemental technical analyses would you like on the topics to help inform discussions?

CLOSING REMARKS

CO-CHAIRS LISA DANIELS AND ANDY KRICUN

MEETING CLOSURE

ELIZABETH CORR, U.S.EPA, DFO