MANAGING BACTERIA IN BUILDING WATER SYSTEMS

Frank Sidari III, PE, BCEE
Technical Director, SPL Consulting Services
Today’s Topic

1. Drinking Water Microorganisms
   a. Regulatory Perspective
   b. Drinking Water Microbiology

2. Risk Management
   a. Risk Assessment
   b. Mitigation Approaches
   c. Water Safety Plan
REGULATORY PERSPECTIVE
Drinking Water Regulations

• Safe Drinking Water Act (SDWA)
  ▪ Ensure safety and protect drinking water
  ▪ Applies to all public water systems
• EPA
  ▪ Authority to set standards
  ▪ Oversees local implementation
SDWA Primary Regulations

- **MCLG**
  - Maximum contaminant Level Goal
  - Below which no know or expected risk to health
  - Non-enforceable
- **MCL**
  - Maximum Contaminant Level
  - Highest level allowed using best available treatment technology
- **TT**
  - Treatment technology
  - Process intended to reduce the level of contaminant

<table>
<thead>
<tr>
<th>Organism</th>
<th>MCLG</th>
<th>MCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cryptosporidium</td>
<td>0</td>
<td>TT</td>
</tr>
<tr>
<td>Giardia lamblia</td>
<td>0</td>
<td>TT</td>
</tr>
<tr>
<td>Heterotopic Plate Count</td>
<td>n/a</td>
<td>TT</td>
</tr>
<tr>
<td>Legionella</td>
<td>0</td>
<td>TT</td>
</tr>
<tr>
<td>Total Coliforms</td>
<td>0</td>
<td>5.0%</td>
</tr>
<tr>
<td>Turbidity</td>
<td>n/a</td>
<td>TT</td>
</tr>
<tr>
<td>Viruses (enteric)</td>
<td>0</td>
<td>TT</td>
</tr>
</tbody>
</table>
PA Drinking Water Regulations

- Microbiological MCLs
  - Total Coliforms ...OR... Fecal Coliforms ...OR... *E. coli*
  - Turbidity 1 NTU

- Treatment Technology
  - Surface Water
    - Continuous disinfection (>0.2 mg/L) and filtration
    - >99.9% *Giardia lamblia*
    - >99.99% Enteric virus
    - >99% Cryptosporidium
  - Ground Water
    - Continuous disinfection

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### PRIMARY CONTAMINANTS

**Volatile Organic Chemicals (VOCs):**

- BENZENE: 0.055 mg/l
- CARBON TETRACHLORIDE: 0.055 mg/l
- 1,2-DICHLOROETHANE: 0.005 mg/l
- TETRACHLOROETHYLENE: 0.005 mg/l
- TOXylene: 1 mg/l

**Synthetic Organic Chemicals (SOCs):**

- ALDRIN: 0.002 mg/l
- BHC (Mixtures): 0.0002 mg/l
- CARBON TETRACHLORIDE: 0.002 mg/l
- C2F6: 0.007 mg/l
- 1,2-DICHLOROETHANE: 0.002 mg/l
- DIOXIN: 0.006 mg/l
- ETHYLENE DIOXIDE: 0.00005 mg/l
- ETHER: 0.01 mg/l
- ETHYLENE DIBROMIDE: 0.0055 mg/l
- ETHER: 0.01 mg/l

**Disinfection Byproducts:**

- TOTAL TRICHLOROMETHANE (TTHM): 0.80 mg/l
- HALOGENATED ACIDS (HAA): 0.06 mg/l
- MONOSUMERATIC ACID: 0.01 mg/l
- CHLORINE: 1.0 mg/l

**Disinfectants (MRDLs):**

- CHLORINE: 4.0 mg/l
- CHLORAMINE: 4.0 mg/l
- CHLOROFORM (GLO): 0.5 mg/l

**Radionuclides:**

- URANIUM: 30 µCi/l

**Inorganic Chemicals (IOC s):**

- ANTHRACENE: 0.006 mg/l
- ARSENIC: 0.01 mg/l
- ASBESTOS (fibers longer than 10µm): 7 million fibers/l
- BARITUM: 2 mg/l
- BERYL: 0.004 mg/l
- BERYL: 0.005 mg/l
- Cs: 0.1 mg/l
- COPPER: 1.0 mg/l
- CYANIDE: 0.2 mg/l

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**Microbiological Contaminants:**

- PRESENCE OR ABSENCE OF TOTAL COLIFORMS BASED ON NUMBER OR PERCENTAGE OF TOTAL COLIFORM POSITIVE SAMPLES/MONTH OR FECAL COLIFORM OR E. COLI POSITIVE ROUTINE OR CHECK SAMPLES
- Turbidity: 1 NTU (applicable only to unfiltered surface water sources)
EPA Contaminant Candidate List (CCL4)

- Currently not subject to any proposed or promulgated regulations

- Known or anticipated to occur in public water systems

### Microbial Contaminants - CCL 4

**Final CCL 4 Microbial Contaminants**

<table>
<thead>
<tr>
<th>Microbial Contaminant Name</th>
<th>Type</th>
<th>Diseases and Infections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adenovirus</td>
<td>Virus</td>
<td>Respiratory illness and occasionally gastrointestinal illness.</td>
</tr>
<tr>
<td>Caliciviruses</td>
<td>Virus (includes Norovirus)</td>
<td>Mild self-limiting gastrointestinal illness.</td>
</tr>
<tr>
<td>Campylobacter jejuni</td>
<td>Bacteria</td>
<td>Mild self-limiting gastrointestinal illness.</td>
</tr>
<tr>
<td>Enterovirus</td>
<td>Viruses including polioviruses, coxsackieviruses and echoviruses</td>
<td>Mild respiratory illness.</td>
</tr>
<tr>
<td>Escherichia coli (0157)</td>
<td>Bacteria</td>
<td>Gastrointestinal illness and kidney failure.</td>
</tr>
<tr>
<td>Helicobacter pylori</td>
<td>Bacteria</td>
<td>Found in the environment capable of colonizing human gut that can cause ulcers and cancer.</td>
</tr>
<tr>
<td>Hepatitis A virus</td>
<td>Virus</td>
<td>Liver disease and jaundice.</td>
</tr>
<tr>
<td>Legionella pneumophila</td>
<td>Bacteria</td>
<td>Found in the environment including hot water systems causing lung diseases when inhaled.</td>
</tr>
</tbody>
</table>
Commissioning New Building Water Systems

- **PA Building Code**
  - IPC 2015
  - Section 610
    - AHJ
    - AWWA C651/2
    - IPC Method
  - “bacteriological examination that contamination remains”

- **Contamination**
  - An impairment of the quality of the potable water that creates an actual hazard to the public health through poisoning or the spread of disease by sewage, industrial fluids or waste.
Commissioning New Building Water Systems

- ASHRAE Standard 188
  - Commissioning
    - AWWA C651/2
    - Comply with AHJ
Building Water Systems

- AWWA C651-14

Building Water System vs. Disinfecting Water Mains

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Building Water Systems

• AWWA C651-14
  ▪ “bacteriological quality…shall show the absence of coliform bacteria”
  ▪ “standard HPC may be required”
  ▪ “no coliforms and HPC <500 CFU/mL”
DATE:       June 02, 2017
TO:         State Survey Agency Directors
FROM:       Director
            Quality, Safety and Oversight Group (formerly Survey & Certification Group)
SUBJECT:    Requirement to Reduce *Legionella* Risk in Healthcare Facility Water Systems to
            Prevent Cases and Outbreaks of Legionnaires’ Disease (LD)

***Revised to Clarify Expectations for Providers, Accrediting Organizations, and Surveyors***
CMS
Opportunistic Waterborne Pathogens

Conducts a facility risk assessment to identify where *Legionella* and other opportunistic waterborne pathogens (e.g. *Pseudomonas, Acinetobacter, Burkholderia, Stenotrophomonas*, nontuberculous mycobacteria, and fungi) could grow and spread in the facility water system.

- *Legionella*
- *Pseudomonas aeruginosa*
- *Acinetobacter*
- *Burkholderia*
- *Stenotrophomonas*
- Nontuberculous mycobacteria (NTM)
- Fungi
Disclaimer #1
Microbiology

Engineer

Legionellogist
**Legionella Is Not Alone**

- *Legionella* bacteria are part of a community of microorganisms
  - a consortium

- They live synergistically
  - one benefiting the other for mutual survival
DRINKING WATER MICROBIOLOGY
Heterotrophic Plate Count (HPC)

• “standard plate count”, “total viable count”, “total count”, “total aerobic bacteria”

• HPC found in drinking water
  ▪ include a range of genera
  ▪ utilize organic carbon for growth
  ▪ can be detected by culture

• Naturally occurring and truly ubiquitous
  ▪ Water, food, surfaces, your body, soil, etc.
# HPC Common in Drinking Water

<table>
<thead>
<tr>
<th>Water Source</th>
<th>HPC (CFU/mL)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>NJ Drinking Water System</td>
<td>320 – 1,000,000,000</td>
<td>LeChevallier et.al., 1987</td>
</tr>
<tr>
<td>Dental Water Lines</td>
<td>&gt;3,000</td>
<td>Rice et.al., 2006</td>
</tr>
<tr>
<td>Hospital Hot Water</td>
<td>60,000</td>
<td>Sheffer et.al., 2005</td>
</tr>
<tr>
<td>Michigan Lakes</td>
<td>3,000 – &gt;100,000</td>
<td>Jones et.al., 1991</td>
</tr>
<tr>
<td>Tucson, AZ Tap Water</td>
<td>&gt;3,000</td>
<td>Pepper et.al., 2004, Chaidez and Gerba, 2004</td>
</tr>
<tr>
<td>Administration Building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot Water</td>
<td>24,700 – 144,000</td>
<td>Sheffer et.al., 2005</td>
</tr>
<tr>
<td>Hospital Hot Water</td>
<td>8,000 – 27,000</td>
<td>Zhang et.al., 2009</td>
</tr>
<tr>
<td>Hospital Hot Water</td>
<td>2,900 (average)</td>
<td>Duda et.al., 2014</td>
</tr>
<tr>
<td>Research Building</td>
<td>16,000 (average)</td>
<td>Siebel et.al., 2008</td>
</tr>
<tr>
<td>Apartment Building</td>
<td>300 – 300,000</td>
<td>Bagh et.al., 2004</td>
</tr>
<tr>
<td>New Office Building</td>
<td>1 – 100,000 CFU/cm² (biofilm)</td>
<td>Inkinen et.al., 2014</td>
</tr>
<tr>
<td>New University Building</td>
<td>&gt;10,000</td>
<td>Nguyen et.al., 2008, Nguyen et.al., 2012</td>
</tr>
</tbody>
</table>
Heterotrophic Plate Count Bacteria Testing

- Estimate of bacterial content
- Different measurement methods

Dip Slide 24 hr.
Dip Slide 72 hr.
Culture Plate 120 hr.
HPC and Coliform Methods Do Not Detect Legionella

IDEXX Colilert

HPC plate count media

Legionella BCYE media
HPC as an Indicator

- HPC cannot be used as an indicator bacteria for waterborne pathogens
  - No correlation between HPC and
    - Waterborne pathogens
    - Risk for disease
HPC as an Indicator

• HPC cannot be used as an indicator bacteria for waterborne pathogens

Lack of correlation between *Legionella* colonization and microbial population quantification using heterotrophic plate count and adenosine triphosphate bioluminescence measurement

Scott Duda • Julianne L. Baron • Marilyn M. Wagener • Radisav D. Vadic • Janet E. Stout
HPC as an Indicator

• HPC cannot be used as an indicator bacteria for waterborne pathogens
  ▪ **No correlation between HPC and**
    • Waterborne pathogens
    • Risk for disease

• Use to monitor changes in water quality or treatment efficacy
Table 2
HPC genera commonly found in drinking water

<table>
<thead>
<tr>
<th>Acinetobacter</th>
<th>Methylocmonas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actinomyces&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Micrococcus</td>
</tr>
<tr>
<td>Alcaligenes</td>
<td>Mycobacterium&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Aeromonas&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Morexella</td>
</tr>
<tr>
<td>Aeromonas hydrophila&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Nin&lt;sup&gt;+&lt;/sup&gt;</td>
</tr>
<tr>
<td>Arthrobacter</td>
<td>Proteus</td>
</tr>
<tr>
<td>Bacillus</td>
<td>Pseudomonas</td>
</tr>
<tr>
<td>Beggiatoa</td>
<td>P. cepacia</td>
</tr>
<tr>
<td>Citrobacter&lt;sup&gt;c&lt;/sup&gt;</td>
<td>P. fluorescens</td>
</tr>
<tr>
<td>Co&lt;sup&gt;-&lt;/sup&gt;</td>
<td>P. maltophilia</td>
</tr>
<tr>
<td>Dactylosporangium</td>
<td>Serratia liquefaciens</td>
</tr>
<tr>
<td>Enterobacter agglomerans</td>
<td>Sphaerotilus</td>
</tr>
<tr>
<td>Enterobacter cloacae</td>
<td>Sphingomonas</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>Staphylococcus</td>
</tr>
<tr>
<td>Flavobacterium</td>
<td>Streptococcus</td>
</tr>
<tr>
<td>Flavobacterium meningosepticum</td>
<td>Streptomyces</td>
</tr>
<tr>
<td>Gallionella</td>
<td>Yersinia enterocolitica</td>
</tr>
<tr>
<td>Hafnia alvei</td>
<td></td>
</tr>
<tr>
<td>Klebsiella pneumoniae</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Not on List of HPC

Misapplication of 500 CFU/mL

• EPA target for primary water treatment where disinfection is not applied
  ▪ HPC levels less than 500 CFU/ml after treatment
  ▪ Not a health based target

• Why 500 CFU/mL?
  ▪ Potential interference of HPC bacteria at higher levels with culture based analytical methods for coliform testing
  ▪ Analytical methods now suppress background HPC levels and interferences are no longer an issue in coliform testing.
Heterotrophic Plate Count (HPC) Bacteria Testing

• What do we know?
  - HPC method does not detect Legionella
  - HPC not correlated with Legionella
  - HPC cannot be used to predict risk for waterborne disease
  - HPC used in water safety programs
    - Monitor water treatment programs
    - Not to validate Legionella control
Fecal Pathogens

- *E. coli, Cryptosporidium, Giardia, enteric viruses, etc.*
- DW treatment (filtration/disinfection)
  - Removal and inactivation of pathogen
- Do not amplify after treatment
  - Require an animal host to reproduce
- Total Coliform used as an indicator of removal and/or water quality changes post-treatment
Opportunistic Pathogens

- *Legionella, Pseudomonas, Mycobacteria*, etc.
- DW treatment (filtration/disinfection)
  - May not remove or inactivate 100%
- Can amplify after treatment in distribution
  - Nutrients, lack of disinfectant, other organisms
- Total Coliform or HPC cannot be used as an indicator or presence/absence
Legionella vs. Opportunistic Pathogens

• Source/Reservoir
  - Legionella: Building Water Systems
  - OOP: Building Water, Surfaces, Air, Dust, Soil, Drains, Cleaning Solutions, etc.

• Infection Site
  - Legionella: Lungs
  - OPP: Lungs, Urinary Tract, IV, Eyes, Soft Tissue, Burns, Wounds, Blood, etc.

• Transmission
  - Legionella: Aspiration, Aerosolization
  - OPP: Aspiration, Aerosolization, Direct Contact, Medical Equipment, Medical Solutions, Environmental Contact

• Other
  - Different Growth Factors
  - Ability to survive outside of water
  - Susceptibility to disinfectants
Special (non-clinical) Media To Isolate Waterborne Pathogens

- **Pseudomonas**
  - M-PA-C Modified Pseudomonas agar
- **Burkholderia**
  - *Burkholderia cepacia* selective agar
- **Acinetobacter**
  - Leeds Acinetobacter medium
- **Stenotrophomonas**
  - Trypticase soy agar (TSA) with imipenem
- **Non-tuberculous mycobacteria (NTM)**
  - Middlebrook 7H10, Mitchison 7H11
RISK MANAGEMENT
Basic Components of a Building Risk Assessment

1. Site Characterization
2. Water System Evaluation
3. Water System Testing
4. Recommendations

A WSP cannot be done solely as a desk study. It must involve site visits to confirm the knowledge, information and schematics available to the utility. (WHO WSP)
What is the Purpose of a Building Risk Assessment?

- New construction ready for occupancy?
- Risk for Legionella or investigating suspected case?
- Risk for other pathogen or investigating suspected case?
Answer to Purpose for Assessment
Determines Approach

• New construction ready for occupancy?
  ▪ Coliforms/HPC – flushed cold water
  ▪ Legionella in healthcare – first draw hot water

• Risk for Legionella or investigating suspected case?
  ▪ Legionella first draw hot water from outlets
  ▪ Legionella from other equipment
  ▪ Swabs from fixtures around case patient

• Risk for other pathogen or investigating suspected case?
  ▪ First draw and/or flushed samples from potable water
  ▪ Hot or cold water from potable water
  ▪ Other water generating equipment
  ▪ Sanitary drains, surfaces, supplies, etc.
Building Water System Evaluation and Testing

- Process Flow Diagrams
- Water System Operation
- Field Assessment
  - System components
  - Source water quality
  - Temperature, pH, disinfectant residual
  - *Legionella*, other pathogens
  - Water chemistry
- Infection Prevention
  - Patients / Surveillance
  - Root Cause Analysis

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Why Test for Legionella in Building Water Systems?

• Water is the only reservoir for Legionella

• Testing...
   Establishes risk
   Validates water safety plan
   Validates clinical diagnostic method
   Supports need/efficacy of disinfection
Why Test for Opportunistic Pathogens in Building Water Systems?

• Water may not be the source of Opportunistic Pathogens

• Testing…
  - Supports infection prevention investigation or program
Before You Act, Ask

- *Legionella* in the water systems?
  - Pathogenic species? (serogroup 1)
  - Extent of colonization? (>30%)
- Confirmed case of Legionnaires’ disease?
- On-going clinical surveillance?
- Susceptible hosts in the facility?
- Engineering controls in place?
- Water system operating efficiently?
MITIGATION APPROACHES
Mitigation Options

• Shock (Short-Term) Disinfection
  ▪ Thermal
  ▪ Hyper-Chlorination
  ▪ Short Course Ionization

• Supplemental (Long-Term) Disinfection
  ▪ Supplemental Chlorination
  ▪ Chlorine Dioxide
  ▪ Copper Silver Ionization
  ▪ Monochloramine

• Barriers
  ▪ Point of Use Filters
  ▪ UV
Supplemental Disinfection

- Supplemental disinfection has long term impacts
- Recommendation for disinfection needs to be evidenced-based

# Selecting an Application Point

<table>
<thead>
<tr>
<th></th>
<th>Hot Water Treatment</th>
<th>Cold Water Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treats where Legionella growth typically occurs?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Treats where other pathogens may be present?</td>
<td>Maybe</td>
<td></td>
</tr>
<tr>
<td>Ability to maintain residual in <strong>hot</strong> water?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Treats the Fixture</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Equipment Size/Cost</td>
<td>Small/Low</td>
<td></td>
</tr>
<tr>
<td>Chemical Use</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Occupant exposure to disinfectant and by-products</td>
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Evidenced Based Approach

INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY  NOVEMBER 2014, VOL. 35, NO. 11

ORIGINAL ARTICLE

Evaluation of A New Monochloramine Generation System for Controlling Legionella In Building Hot Water Systems

Scott Duda, MS; \(^1\) Sheena Kandiah, MD, PhD; \(^2\) Janet E. Stout, PhD; \(^3\) Julianne L. Baron, BS; \(^4\)

Maintaining Legionella control in building water systems

Legionella and other waterborne pathogens can present a risk to consumers of potable water. In particular, building hot water systems have been established as the primary reservoir for bacteria linked to cases of Legionnaires' disease (LD). These systems provide ideal conditions for Legionella proliferation because of their elevated temperature and lack of disinfection residual. Control of Legionella in potable water systems has become a focus for healthcare facilities because they serve a population that is particularly susceptible to LD from underlying health conditions, such as suppressed immune systems.

CrossMark
Evidenced Based Approach

Long-Term Effects of Hospital Water Network Disinfection on *Legionella* and Other Waterborne Bacteria in an Italian University Hospital

Beatrice Casini, BSc, MS; Andrea Buzzigoli, BSc; Maria Luisa Cristina, BSc, PhD; Anna Maria Spagnolo, BSc, PhD; Pietro Del Giudice, MD; Silvio Brusaferro, MD; Andrea Posta, MD; Umberto Moscato, MD; Paola Valenzini, BSc, MS; Angelo Bagiani, MD; Guetano Privitera, MD

Preventive efficacy and cost-effectiveness of point-of-use water filtration in a subacute care unit

Charity Holmes, RN, BSc
Laguna Beach, Calif

Infections with *Pseudomonas* mortality in hospitals. Ventilation in the subacute care and cost-effectively red

Efficacy of Copper-Silver Ionization in Controlling Biofilm- and Plankton-Associated Waterborne Pathogens

Hsiu-Yun Shih and Yusein E. Lin

Graduate Institute of Environmental Education, National Kaohsiung Normal University, Kaohsiung, Taiwan

Received 9 September 2009/Accepted 6 January 2010
Example…
Evidenced Based Approach

• Copper Silver Ionization
  ▪ Legionella – very effective
  ▪ Mycobacterium avium – not as effective
  ▪ Pseudomonas – could be effective
Example…

Evidenced Based Approach

• Chlorine
  ▪ Legionella – not very effective
  ▪ Mycobacterium avium – not very effective

Chlorine, Chloramine, Chlorine Dioxide, and Ozone Susceptibility of *Mycobacterium avium*

ROBERT H. TAYLOR,¹ JOSEPH O. FALKINHAM III,¹* CHERYL D. NORTON,² AND MARK W. LECHEVALLIER²

Fralin Biotechnology Center, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061-0346,¹ and American Water Works Service Co., Inc., Belleville Laboratory, Belleville, Illinois 62220²

Received 20 August 1999/Accepted 13 January 2000

Resistance of *Legionella pneumophila* serotype 1 biofilms to chlorine-based disinfection

I.R. Cooper*, G.W. Hanlon
Regulatory Context

• Regulatory Context
  ▪ Adding treatment in the facility could impact chemical and microbial water quality

• Certain federal and state regulatory requirements may apply
  ▪ Different states with different interpretations on permitting
Water Safety and Management Program

- ASHRAE Standard 188
- First *Legionella* standard in the United States
- Establish minimum *Legionellosis* risk management requirements for building water systems.
ASHRAE Standard 188

- Written for
  - Legionella
  - Building Water System

- Different Control Measures
  - Temperature
  - Disinfectant
  - Circulation

- Different Mitigation Approaches

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**PROGRAM TEAM**—Identify persons responsible for Program development and implementation.

**DESCRIBE WATER SYSTEMS/FLOW DIAGRAMS**—Describe the potable and nonpotable water systems within the building and on the building site and develop water-system schematics.

**ANALYSIS OF BUILDING WATER SYSTEMS**—Conduct a systematic evaluation of hazardous conditions in the building water system, and determine where control measures shall be applied.

**CONTROL MEASURES**—Determine locations where control measures shall be applied and maintained in order to stay within established control limits.

**MONITORING/CORRECTIVE ACTIONS**—Establish procedures for monitoring whether control measures are operating within established limits and, if not, take corrective actions.

**CONFIRMATION**—Establish procedures to confirm the following:
  - The Program is being implemented as designed—verification
  - The Program controls the hazardous conditions throughout the building water system—validation

**DOCUMENTATION**—Establish documentation and communication procedures for all activities of the Program.
Other Pathogens and Water Safety

• Special attention to address both Legionella and Other Pathogens

• Water Safety needs to be in conjunction with infection prevention practices
Take-Aways

1. Drinking Water Microorganisms
   a. Regulatory Perspective
   b. Drinking Water Microbiology

2. Risk Management
   a. Risk Assessment
   b. Mitigation Approaches
   c. Water Safety Plan