

Legionella and Public Health: Importance of Water Management Approach

Nancy Hall
State Hygienic Laboratory
Coralville, IA

2018 SHL Lab Symposium
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Presentation Overview Topics

- *Legionella* bacteria and illness
- *Legionella* ecology and transmission
- *Legionella* growth factors
- *Legionella* outbreaks; lessons learned
- Water management team approach
- *Legionella* environmental sampling and testing

Legionella Cases Increasing

- *Legionella* cases increasing (~4-fold in US; ~3-fold in Europe)
- *Legionella* causes the most outbreaks in community water systems
 - 2007-2008: 60%
 - 2009-2010: 76%
 - 2011-12: 84%

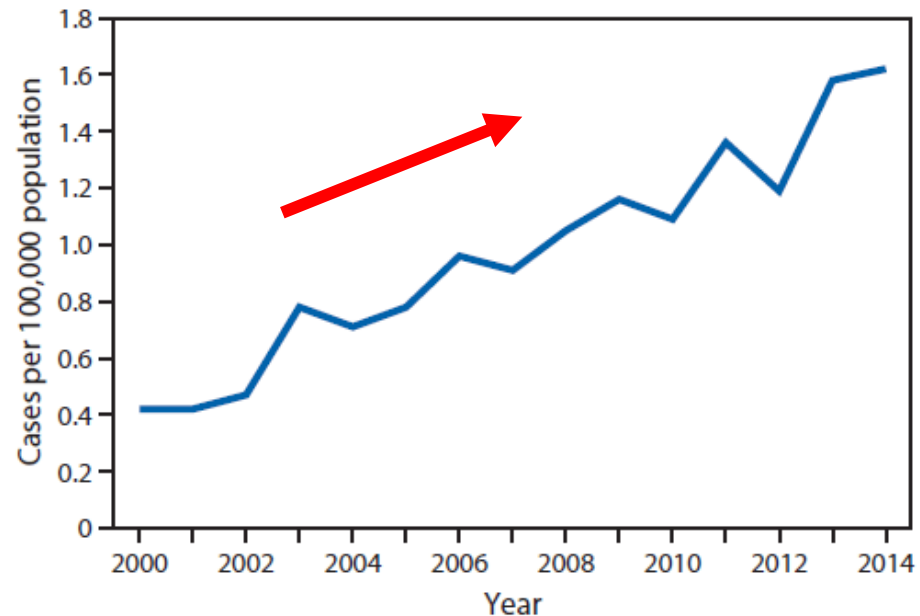


Fig 1. Cases of legionellosis per 100,000 population, by year US

Healthcare-associated Outbreaks

- LTCF second most frequent outbreak setting (27 CDC investigations, 2000-2014)
 - Hotels/motels – most frequent
- Healthcare-associated *Legionella* cases accounted for 85% of outbreak associated **deaths** (27 CDC investigations, 2000-2014)
- Illustrates disproportionate disease burden among hospitalized persons
- More likely to have risk factors of acquiring legionellosis

CDC Vital Signs Report. MMWR 62 (22):576-584, June 10, 2016

LEGIONNAIRES' DISEASE IN NURSING HOMES AND LONG-TERM CARE FACILITIES: AN EMERGING CATASTROPHE

Y.E. LIN^{1,3}, V.L. YU²

1. Department of Civil and Environmental Engineering; 2. Department of Medicine, University of Pittsburgh, PA, USA; 3. National Kaohsiung Normal University, Kaohsiung, Taiwan
Corresponding author: Victor L. Yu, MD, University of Pittsburgh, 3520 Fifth Ave. Suite 205, Pittsburgh, PA 15261, USA

Abstract: Outbreaks of Legionnaires' diseases in nursing homes and longterm care facilities have become increasingly cited in newspaper and television reports especially when deaths are involved. News reports can lead to unsubstantiated rumors and widespread disruption of services. A sense of panic can lead to adoption by the facility of expensive, short-term measures that are unscientific and expensive. The worst case scenario is that the measures will also be found to be useless. We present an evidence-based approach that has been successful and cost-effective in longterm care facilities. Environmental cultures of the drinking water for Legionella within the nursing home and longterm care facility is a necessary first step. Infection control personnel should make the key decisions in management of the outbreak. Healthcare facility managers and outside water treatment consultants often make costly and expensive recommendations that will be proven ineffective over time.

New CMS Guidelines: Focus on Water Management

- CMS S&C *Legionella* Memo June 2017
- Requirement to reduce *Legionella* risk in health-care facility water systems to prevent cases and outbreak of Legionnaires Disease

DEPARTMENT OF HEALTH & HUMAN SERVICES
Centers for Medicare & Medicaid Services
7500 Security Boulevard, Mail Stop C2-21-16
Baltimore, Maryland 21244-1850



Center for Clinical Standards and Quality/Survey & Certification Group

Ref: S&C 17-30-*Hospitals/CAHs/NHs*
REVISED 06.09.2017

DATE: June 02, 2017

TO: State Survey Agency Directors

FROM: Director
Survey and 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 Provider Types Affected*****

Memorandum Summary

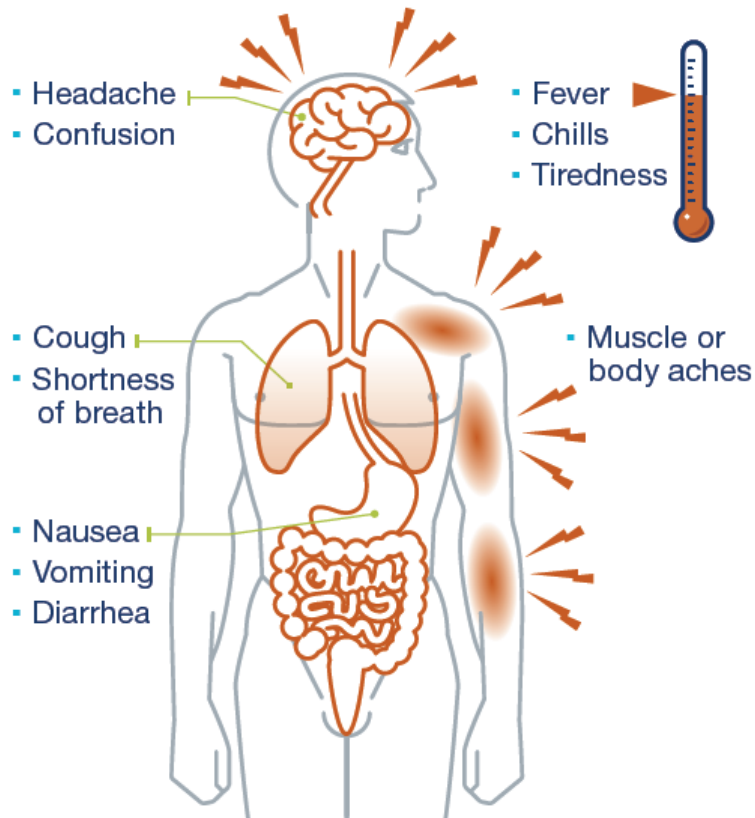
- **Legionella Infections:** The bacterium *Legionella* can cause a serious type of pneumonia called LD in persons at risk. Those at risk include persons who are at least 50 years old, smokers, or those with underlying medical conditions such as chronic lung disease or immunosuppression. Outbreaks have been linked to poorly maintained water systems in buildings with large or complex water systems including hospitals and long-term care facilities. Transmission can occur via aerosols from devices such as showerheads, cooling towers, hot tubs, and decorative fountains.
- **Facility Requirements to Prevent Legionella Infections:** Facilities must develop and adhere to policies and procedures that inhibit microbial growth in building water systems that reduce the risk of growth and spread of *legionella* and other opportunistic pathogens in water.
- **This policy memorandum applies to Hospitals, Critical Access Hospitals (CAHs) and Long-Term Care (LTC). However, this policy memorandum is also intended to provide general awareness for all healthcare organizations.**

Legionellosis

- **Illness caused by *Legionella* bacteria**
- **Two forms**
 - **Legionnaires Disease: severe form of pneumonia**
 - **Frequently leads to hospitalization**
 - **25% fatality rate when health-care related**
 - **Pontiac fever: self-limiting, flu-like symptoms**
- **Incubation period 2-10 days**

Signs and Symptoms

Legionnaires' disease symptoms



- cough, shortness of breath, fever, headache, lethargy, confusion, muscle aches, nausea, diarrhea, abnormal chest x-ray
- Not unique for LD; must test to confirm

Symptoms usually begin 2 to 10 days after being exposed to *Legionella*.



Legionellosis Transmission Pathway

- Not your classic waterborne pathogen
- Inhalation/ aspiration of aerosolized droplets of water contaminated with *Legionella* from man-made water systems



Legionnaires' disease, a type of severe pneumonia, is caused by breathing in small droplets of water that contain *Legionella*.

Legionellosis Risk Factors

- **Risk factors: >50 years age, underlying medical conditions: chronic lung or immunosuppression, travel, smoking**
 - **Residents in LTCFs have many of these risk factors**
- **Person to person transmission v rare (one case)**
- **3 transmission classifications: healthcare associated, travel-related or community-acquired**

Legionella Reservoir

- Commonly found in soil and water
- **Ubiquitous** in our freshwater environment worldwide; lakes, rivers, streams
- Exposure in this natural setting does not cause illness



Where *Legionella* Can Grow

Legionella can live and grow in these manmade devices:

- Water Distribution systems
 - Water heaters, hot and cold water storage tanks, showerheads and hoses, water filters, etc.
- Cooling Towers
- Decorative Fountains
- Whirlpool spas
- Ice Machines
- Humidifiers



Prerequisites for Legionellosis Transmission

1

Legionella Source/Manmade device
(water system, cooling tower or spa)



2

Amplification
(e.g. heat)



3

Aerosolization
(mist, v. small droplet size)



4

Susceptible Host
(immunosuppression)



Disease
(legionellosis)



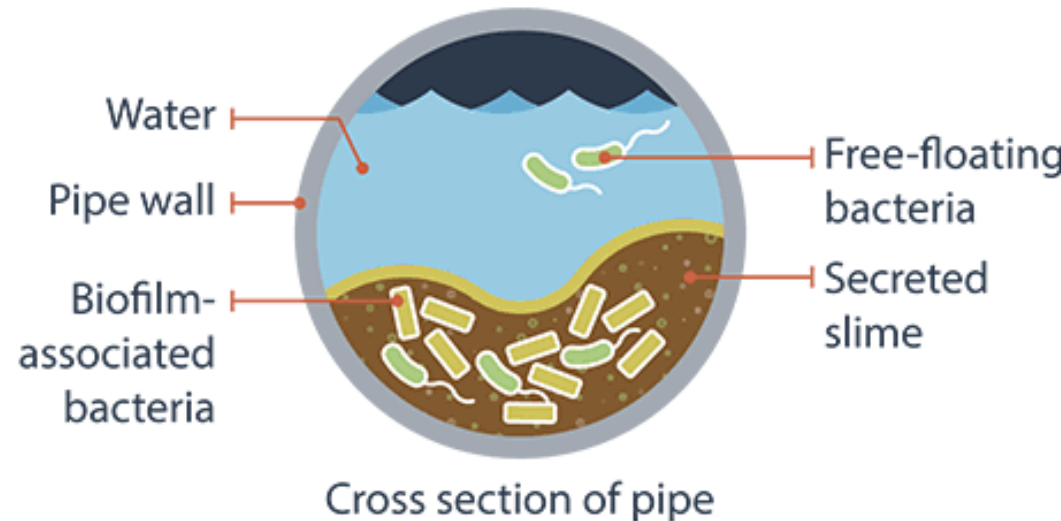
Survival Mechanisms in the Environment

Association with Biofilms

- Survives within biofilms
- Biofilm offers shelter and nutrients
- Evades biocide treatment

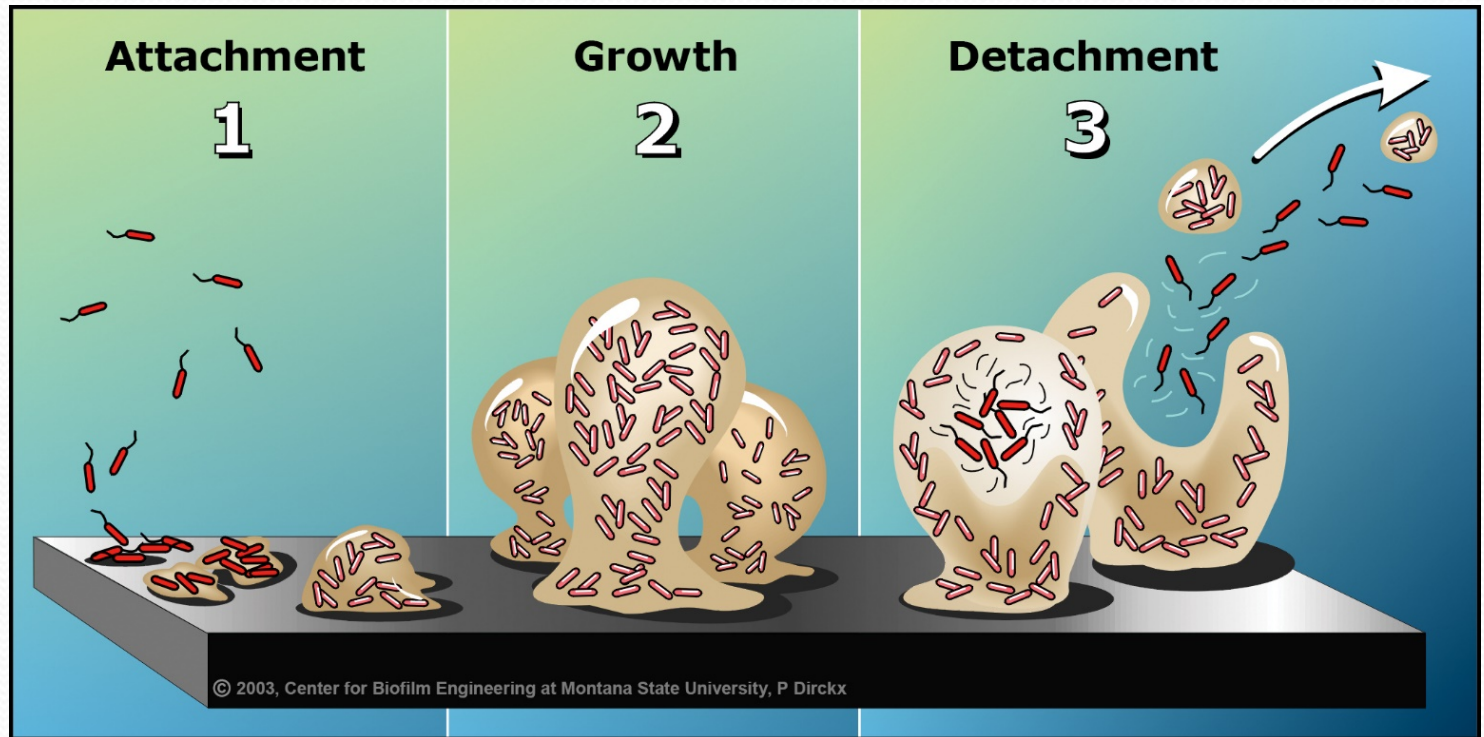


Legionella can live and grow in biofilm



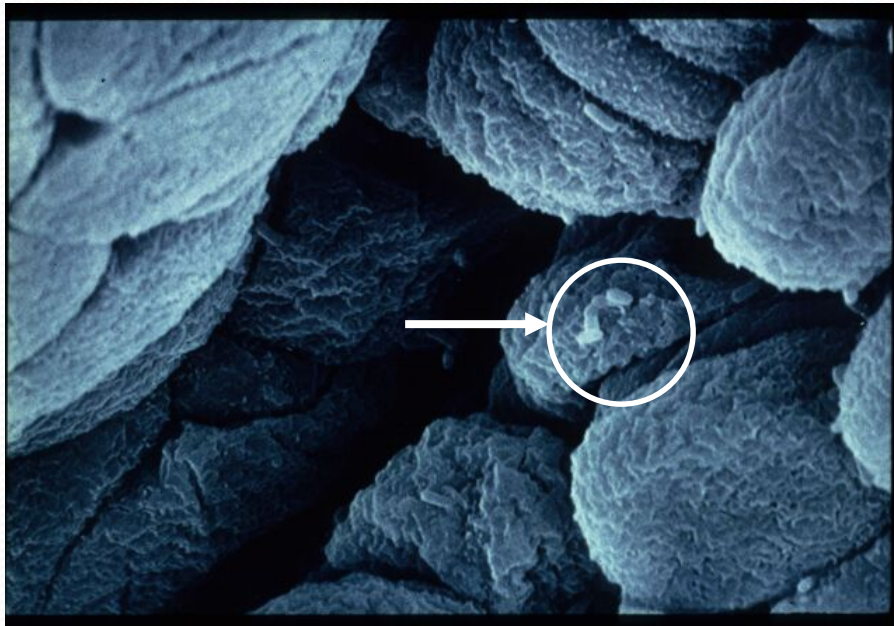
Control of biofilms – best control measure to prevent legionellosis

Biofilm Concept

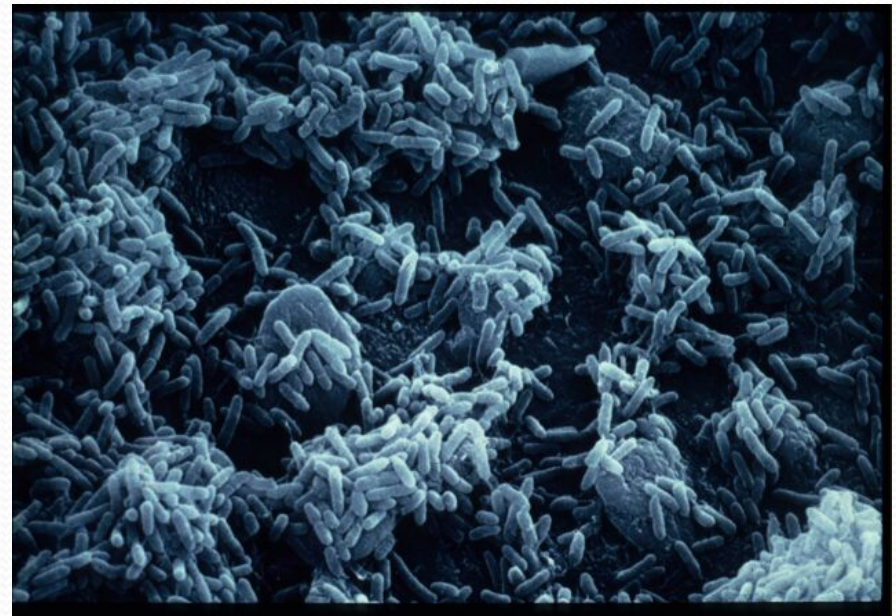


- group of microorganisms that stick to each other and onto a surface
- cells become embedded within a slimy extracellular matrix
- three dimensional structure
- represent a community lifestyle (“cities for microbes”)
- very resistant to disinfectants (and antibiotics)

Legionella Colonization



Legionella bacteria introduction



Heavy colonization and slime layer

Disinfectant levels must be CONSISTANTLY maintained to limit amplification

Factors that lead to *Legionella* Growth Man-made Aquatic Devices

- Ideal warm temperature
 - Optimum growth range: 25-42 °C (77-108F)
 - **Survives 50-55 °C (124F)**
 - **Death: >60 °C (140F)**
- Inadequate disinfect levels
- Water stagnation
- Scale and sediment
- Biofilm
- Construction/main breaks
- Changes in water quality

100 C

212 F

STEAM HUMIDIFICATION

90 C

80 C

HOT WATER RADIATORS

FAST DEATH RANGE

70 C

60 C

HOT WATER

SLOW DEATH RANGE

140 F

50 C

122 F

40 C

SPAS
COOLING TOWERS
SHOWER

OPTIMUM GROWTH RANGE

115 F

95 F

30 C

LEGIONELLA ACTIVE

20 C

SPRAY HUMIDIFIERS
EVAPORATIVE COOLERS

68 F

10 C

COOLING COILS

LEGIONELLA DORMANT

0 C

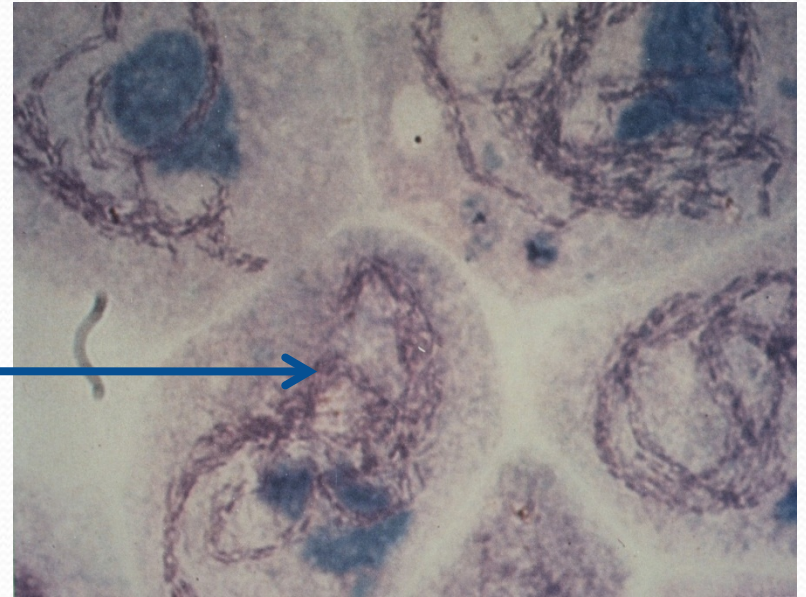
TAP WATER

32 F



Association with Amoebae

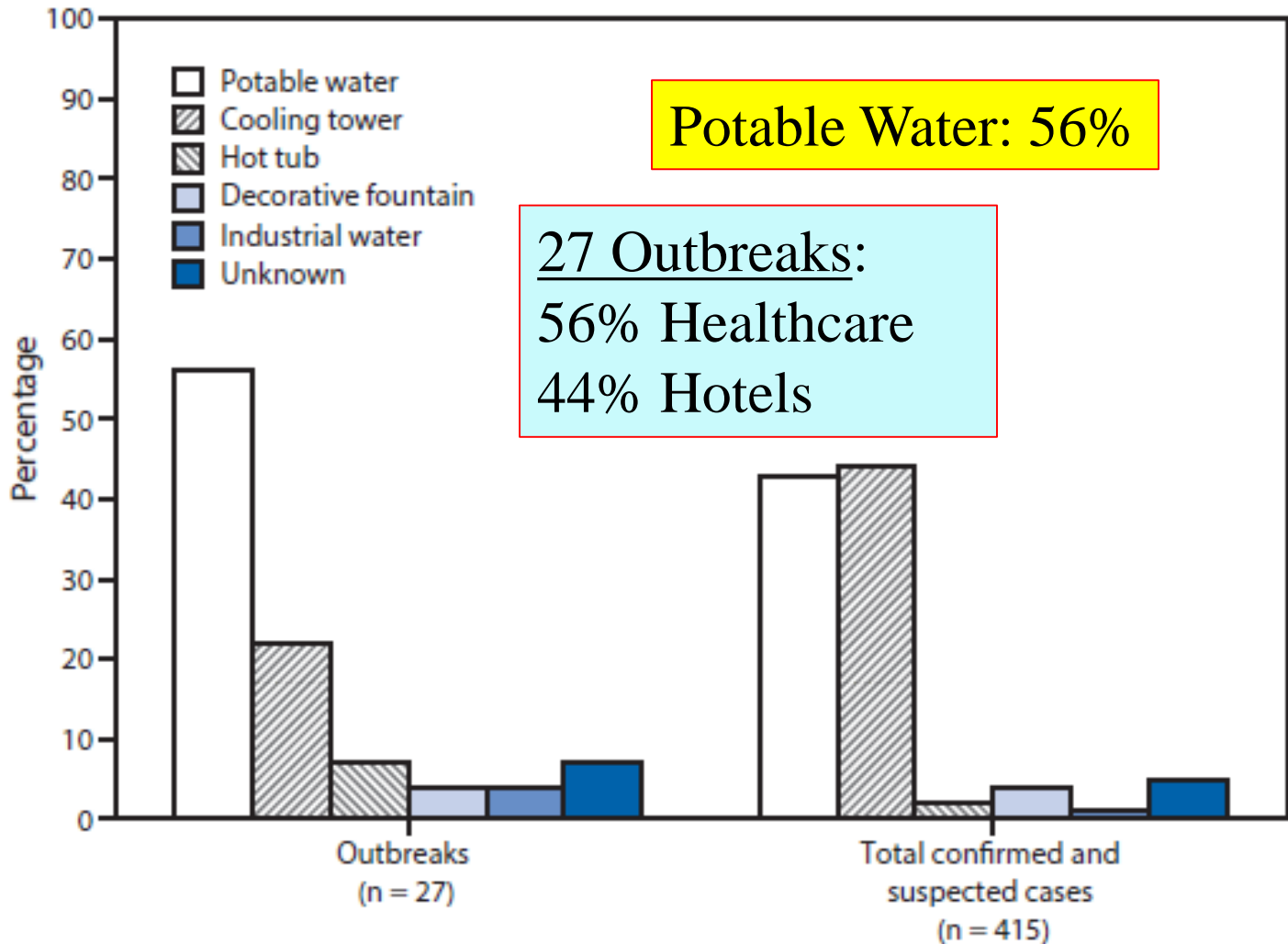
- Survives as intracellular parasites of free-living protozoa
- Ability to multiply intracellularly
- Explains how survives in environment
- Evades biocides



Legionella Taxonomy

- Family: *Legionellaceae*
- Genus: *Legionella*
- Species: ~60
 - *Legionella pneumophila* Serogroup 1 – accounts 80-90% reported cases in US
 - The name “*Legionella*” was derived from original outbreak at the 1976 American Legion Convention in Philadelphia; in Greek “pneumophila” means lung-loving
- Opportunist pathogen

Legionella Outbreaks CDC 2000-2014



Outbreak Deficiencies CDC 2000-2014

- **Most frequent deficiencies**
 - **Process failures (65%)**
 - 70% inadequate water disinfectant levels
 - 53% water temperatures in optimal *Legionella* growth range
- **Multiple common preventable maintenance deficiencies identified**
- **Highlights importance of comprehensive water management programs for water systems**

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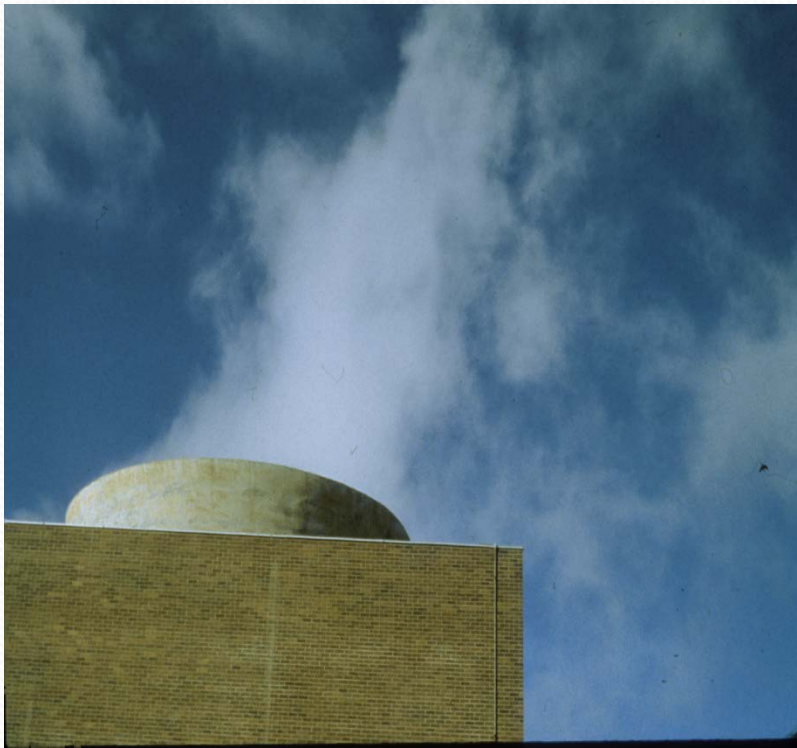
Legionella

Air Conditioning Systems



- Bellevue-Stratford Hotel, Philadelphia, PA
- August 1976 –thought possibly BT event
- Exposure to lobby
- 221 cases/ 34 deaths
- Epi data suggests **air conditioning** but scheduled for renovation – no samples available

Legionella Cooling Towers

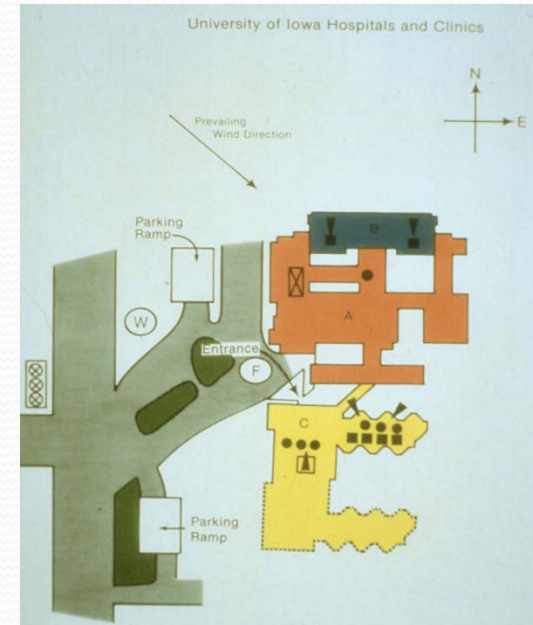


- Transmission source for legionellosis since the 70's
- *Legionella* cultured in up to ~50% of towers (PCR+ 84%)
- Many of the largest LD outbreaks assoc. w/ CT
 - 2015 New York Bronx (138 cases; 55 CTs; 16 deaths; medically vuln community)
 - **Improper maintenance**
 - New law governing operation and maintenance of NY CTs

Legionella

Potable Water Distribution System Outbreaks (Three Large Hospitals)

Location	Period	Cases
Los Angeles, CA	1977-80	175+
Pittsburgh, PA	1979-81	100+
Iowa City, IA	1981	24

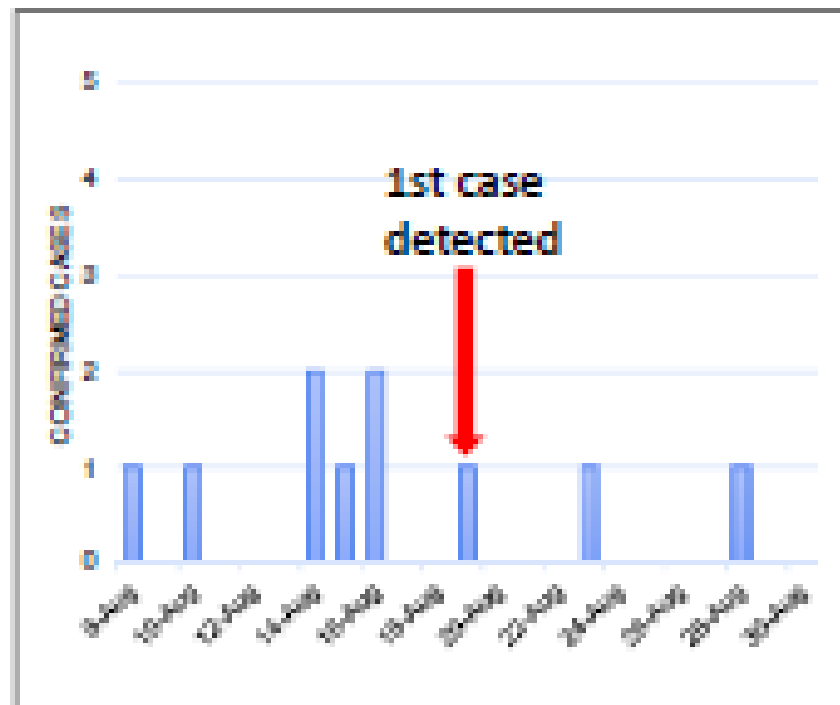


UIHC Cases in new hematology-oncology unit.

***Lpn1* isolated from one 2,000 gallon hot water storage tank and numerous water taps in unit**

Slovenia Nursing Home Outbreak 2010

- First case detected Aug 19; UA+ (Lpn1)
- Upon investigation, 9 residents had symptoms prior to Aug 19; none tested for LD
- LD confirmed in 10 patients
- Various *Legionella* species isolated from 64 enviro samples
 - Numerous closed pipes, no flow



Ref:Skaza, et al, (2012) Scadinavian J of Inf Dis, 44:4, 263-269

Symptoms	# Cases
Fever	10
Cough	7
Diarrhea	3
Confusion	3
Pneum x-ray	5

Legionella Whirlpool Major Outbreaks



Location	Period	Cases/Deaths
Cruise Ship	1994	50/0
Netherlands (indoor flower exhibition- whirlpool display)	1999	200/28

Source in Whirlpool

- *Legionella* was isolated from outbreak whirlpools
- Exposure to spas associated with disease
- Clinical and environmental isolates exact fingerprint match – confirmed source
- **Filters not properly maintained**
 - Low disinfectant levels
 - *Legionella* biofilm growth in filter



General *Legionella* in Water Prevention Strategies

- **Prevent amplification in manmade aquatic systems**
 - **Keep hot water hot (and cold water cold)**
 - **Keep water moving**
 - **Ensure adequate disinfection and temperatures correct**
 - **Maintain equipment (e.g. periodic sediment removal in tanks)**

Maintenance and Monitoring

How to meet the standards and regulations



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STANDARD

ANSI/ASHRAE Standard 188-2015

Legionellosis: Risk Management for Building Water Systems

Approved by the ASHRAE Standards Committee on May 27, 2015; by the ASHRAE Board of Directors on June 4, 2015; and by the American National Standards Institute on June 26, 2015.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

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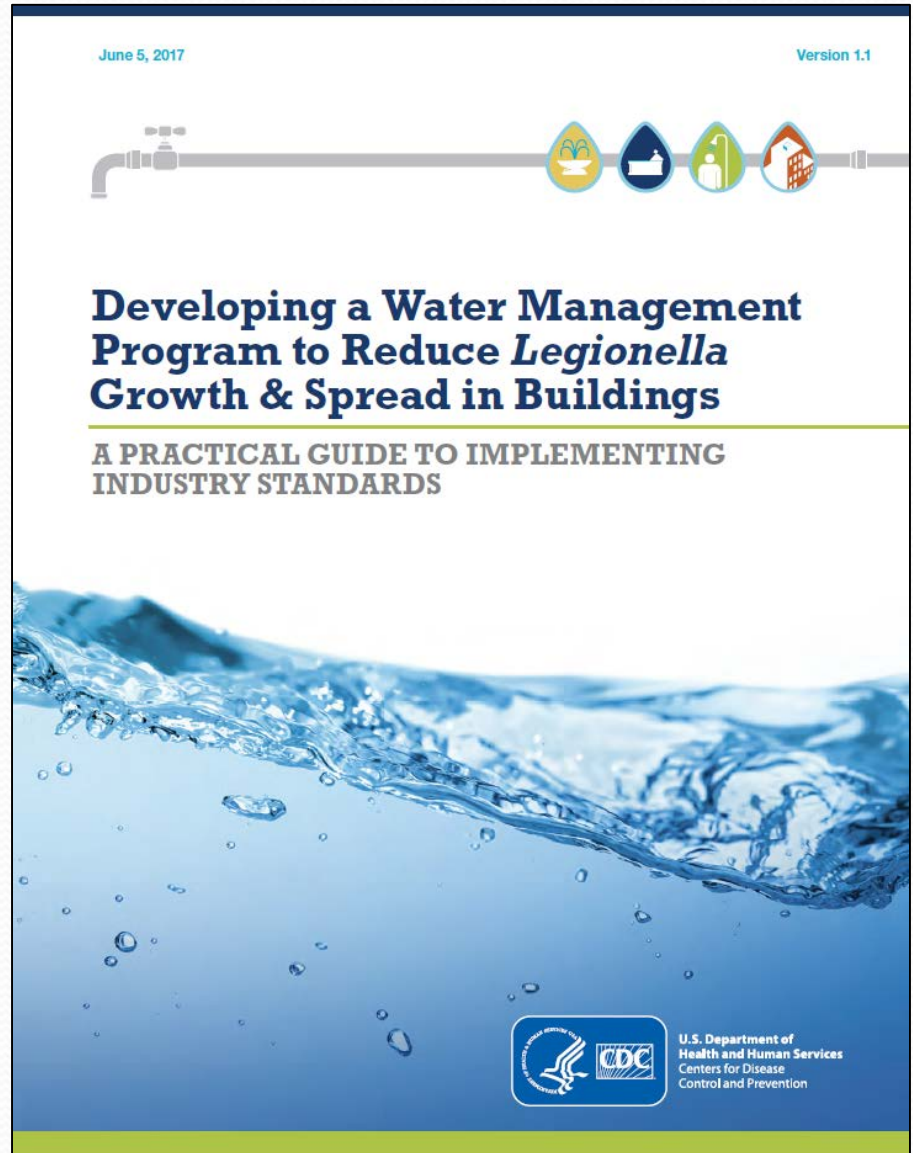
- **First Legionella standard in US; ASHRAE 188-2015**

ASHRAE Standard 188-2015

- Only available through membership or purchase
- **Purpose: establish minimum Legionellosis risk management requirements for building water systems**
- **Scope: design, construction, commissioning, operation maintenance, repair, replacement, expansion of new and existing building water systems.**
- **Describes principles of a water management program**
- **All elements are outlined in **CDC Toolkit****

CDC Tool Kit

<https://www.cdc.gov/legionella/maintenance/wmp-toolkit.html>



Toolkit Bottom Line

Water Management Program Steps

- Identify building systems when *Legionella* control measures are needed
- Assess risk of the hazardous conditions
- Apply control measures to reduce hazardous condition (prevent *Legionella* growth and spread)
- Make sure program is running as designed and effective

Per CDC Toolkit:

DEVELOPING A *LEGIONELLA* WATER MANAGEMENT PROGRAM

Identifying Buildings at Increased Risk

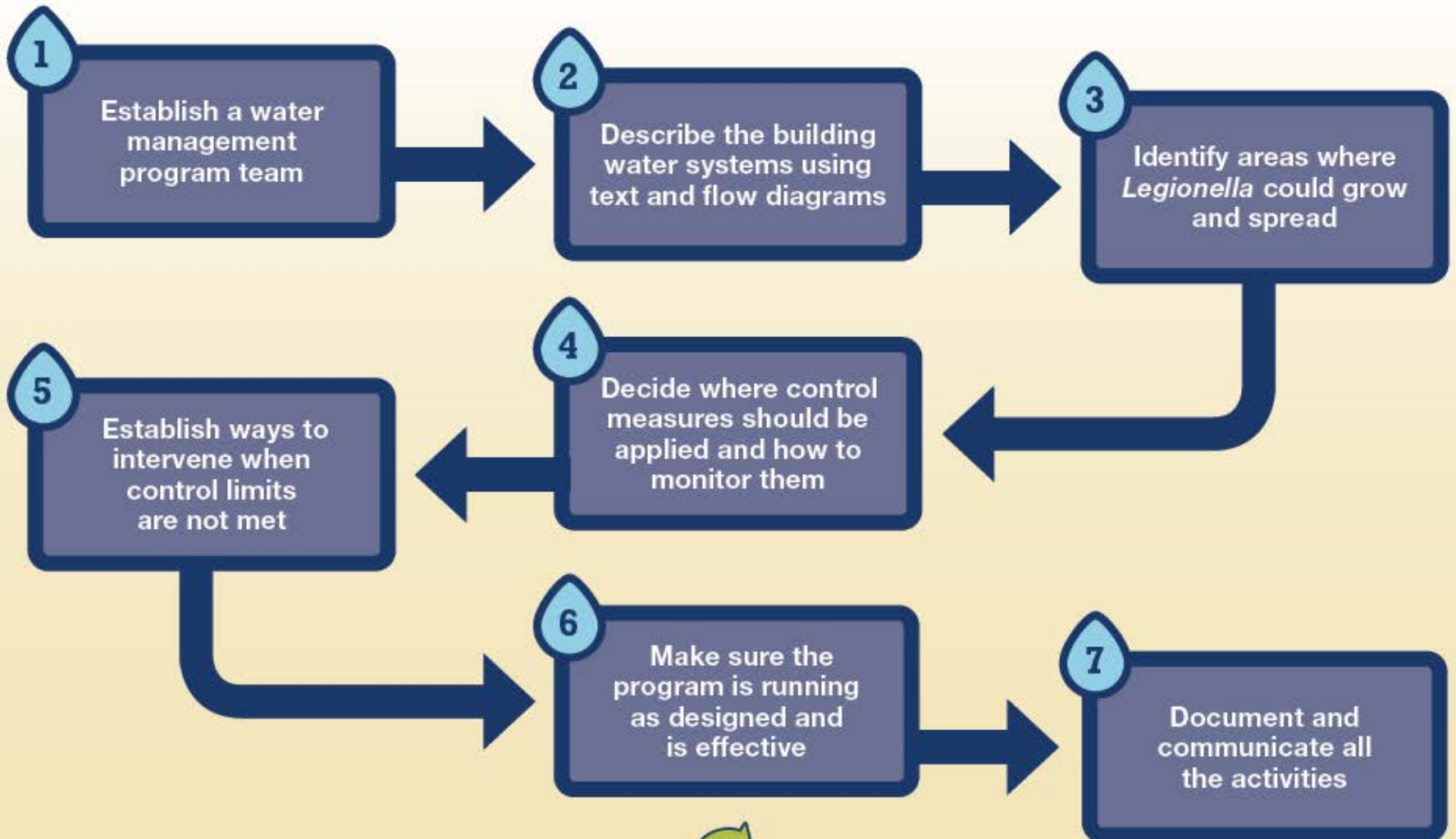
Survey your building (or property) to determine if you need a water management program to reduce the risk of *Legionella* growth and spread.

If you answer **YES to any of questions 1 through 4, you should have a water management program for *that building's* hot and cold water distribution system.**

Healthcare Facilities

- Yes ___ No ___ 1. Is your building a healthcare facility where patients stay overnight or does your building house or treat people who have chronic and acute medical problems[†] or weakened immune systems?
- Yes ___ No ___ 2. Does your building primarily house people older than 65 years (like a retirement home or assisted-living facility)?
- Yes ___ No ___ 3. Does your building have multiple housing units and a centralized hot water system (like a hotel or high-rise apartment complex)?
- Yes ___ No ___ 4. Does your building have more than 10 stories (including basement levels)?

Water Management Program Steps



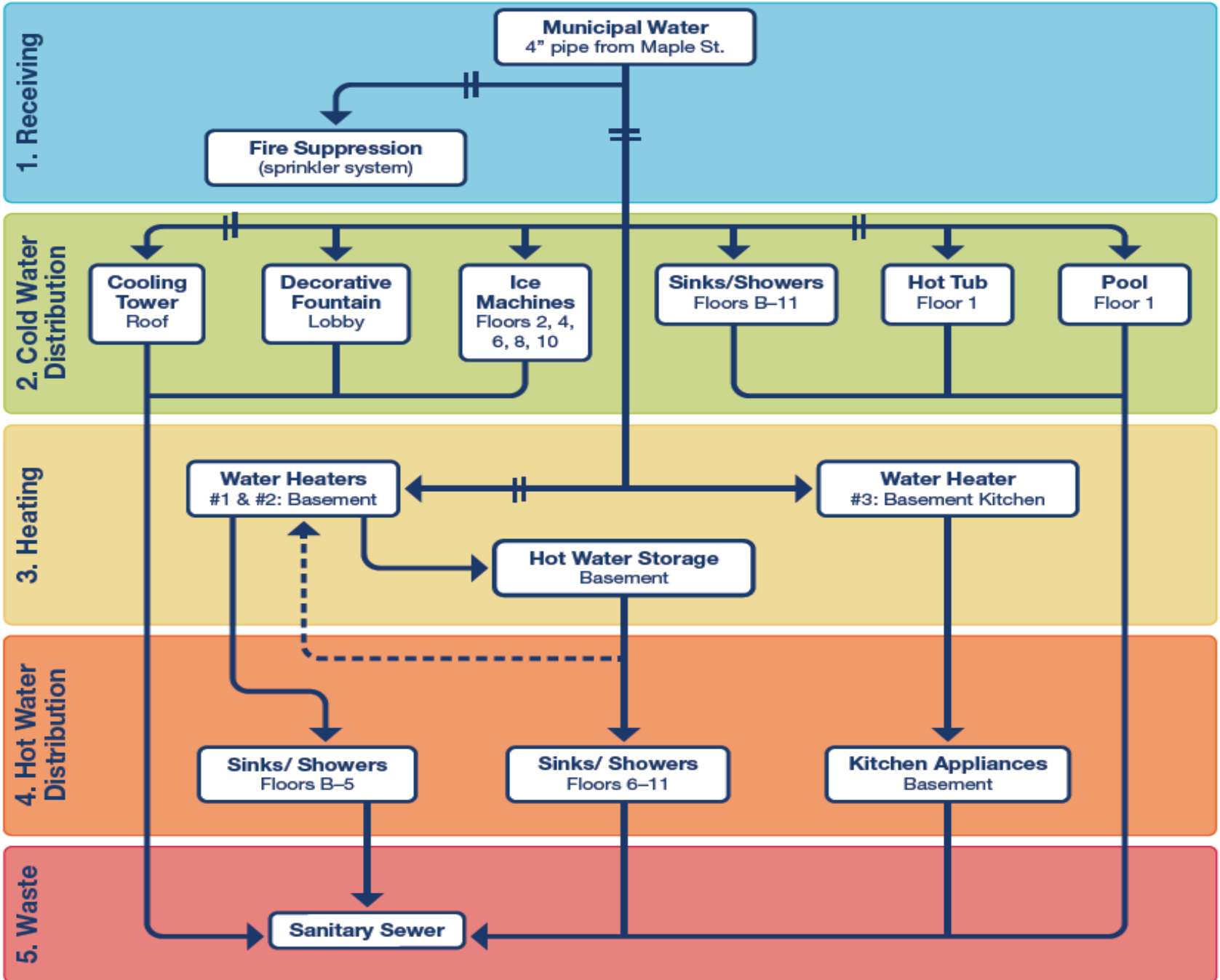
Build a team

- **Building owner or building manager/administrator**
- **Maintenance or engineering employees**
- **Contractors/consultants (e.g., water treatment professionals)**
- **Infection Preventionist**
- **Risk/Quality Management /Safety Officers and Accreditation specialist**
- **Consider Person with specific experience in *Legionella* bacteria in building water systems**

In some cases, you may need to train your in-house personnel or hire professionals with Legionella experience.

Describe Water System

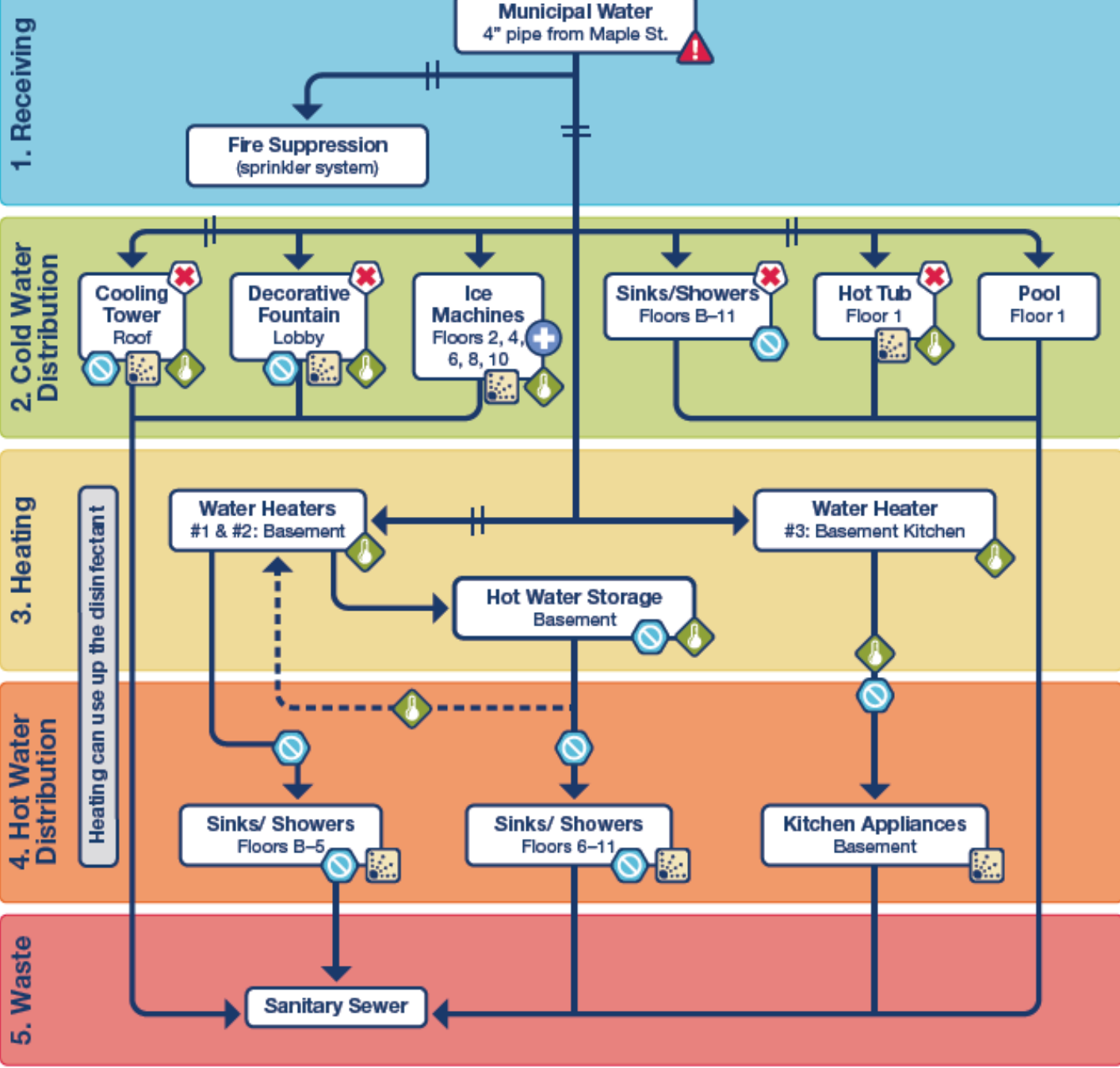
- **Develop a written description of the building or water distribution system(s)**
- **Develop a process flow diagram (keep it simple)**



Legend: || Backflow Preventer ← WaterFlow ← - - - Recirculating Return Flow □ Water Process

Identify Problem Areas: Control Points

- Where *Legionella* could grow and spread
- Identify areas where hazards could occur
 - Stagnation
 - Ideal temperature
 - Low or no disinfectant
 - Conditions for spread
 - water aerosolization- showers whirlpools, water features
 - External Hazards



- Temperature Permissive
- Stagnation
- No Disinfectant
- Conditions for Bacteria Spread
- Special Considerations for Healthcare Facilities
- External Hazards (eg., construction, main break)

Legend: || Backflow Preventer ← WaterFlow ←--- Recirculating Return Flow □ Water Process

Develop Control Measures, Limits and Corrective Actions

- Includes controls for each control point to reduce the risk of *Legionella* growth SUCH AS:
 - physical controls
 - temperature management
 - disinfectant level control
 - visual inspections
 - environmental testing for pathogens.

Chlorine Sample Procedure

- <http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Drinking-Water-Compliance/Training-Informational-Videos>

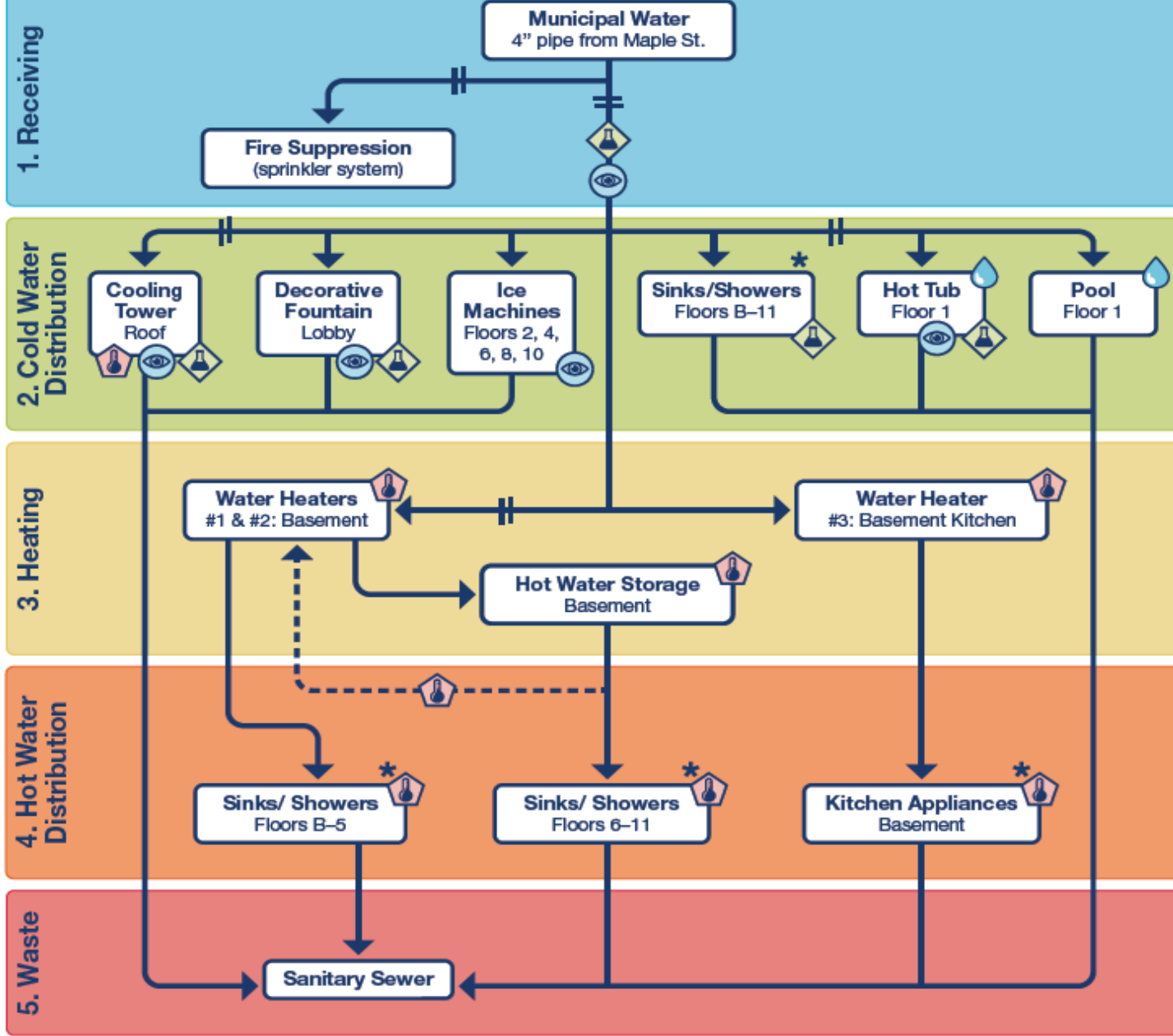
**IDNR YouTube
video; how to
measure chlorine
residuals**



Control Measures Examples

Make sure changes that may lead to Legionella growth are not occurring

- **System water quality (e.g. chlorine residuals) measured throughout system**
 - **No drop in chlorine levels**
- **Water heaters**
 - **maintained at appropriate temperatures.**
- **Decorative fountains**
 - **kept free of debris and biofilm.**
- **Cooling towers and hot tubs**
 - **Continuously maintained and regularly monitored.**
 - **Surfaces with any visible biofilm (i.e., slime) should be cleaned**



Legend: || Backflow Preventer ← WaterFlow ←--- Recirculating Return Flow □ Water Process



Visual Inspection



Check Disinfectant Levels



Check Temperature

* Monitoring at representative fixtures close to and far from the central distribution point is recommended. It is not necessary to routinely monitor water conditions at every tap.

Corrective Actions

Establish corrective actions when control limits are not met; examples below:

- **Biofilm growth seen in decorative fountain**
 - **Plan states to shut off fountain, drain, scrub with detergent; follow start up procedure and check disinfectant levels; document activities**
- **Unoccupied floor or wing**
 - **Plan states daily flushing of sinks at end of the hall; increases frequency of temp and chlorine monitoring (from weekly to daily); document activities**

Do you need to test for *Legionella*?

- Is CMS requiring routine environmental *Legionella* testing? **NO**
- But consider testing if:
 - Difficulty maintaining the building water systems within control limits
 - **Legionnaires' disease associated with the building water systems**

Laboratory Testing

- If testing is chosen to validate the effectiveness of the water management program
 - Laboratory should have environmental testing accreditation (e.g. TNI (The Nelac Institute) or ISO/IEC 17025:2005)
 - Laboratory demonstrate proficiency
 - CDC ELITE (Environmental *Legionella* Isolation Techniques Evaluation Program); two sets of proficiency samples/year; WSLH \$500/set
 - SHL has environmental testing accreditation and has been an ELITE member since its inception 2008

Sampling Compared to Coliform Collection (Drinking water)

Similarities

- **Method of sample collection can dramatically affect the results!**
- **Same sterile collection bottles containing 10% sodium thiosulfate for chlorine neutralizing**
- **Surveillance samples are collected from where you drink the water**
- **Trouble shooting similar: after positive; recommend strategic sampling**

Sampling Compared to Coliform Collection (Drinking water) Differences

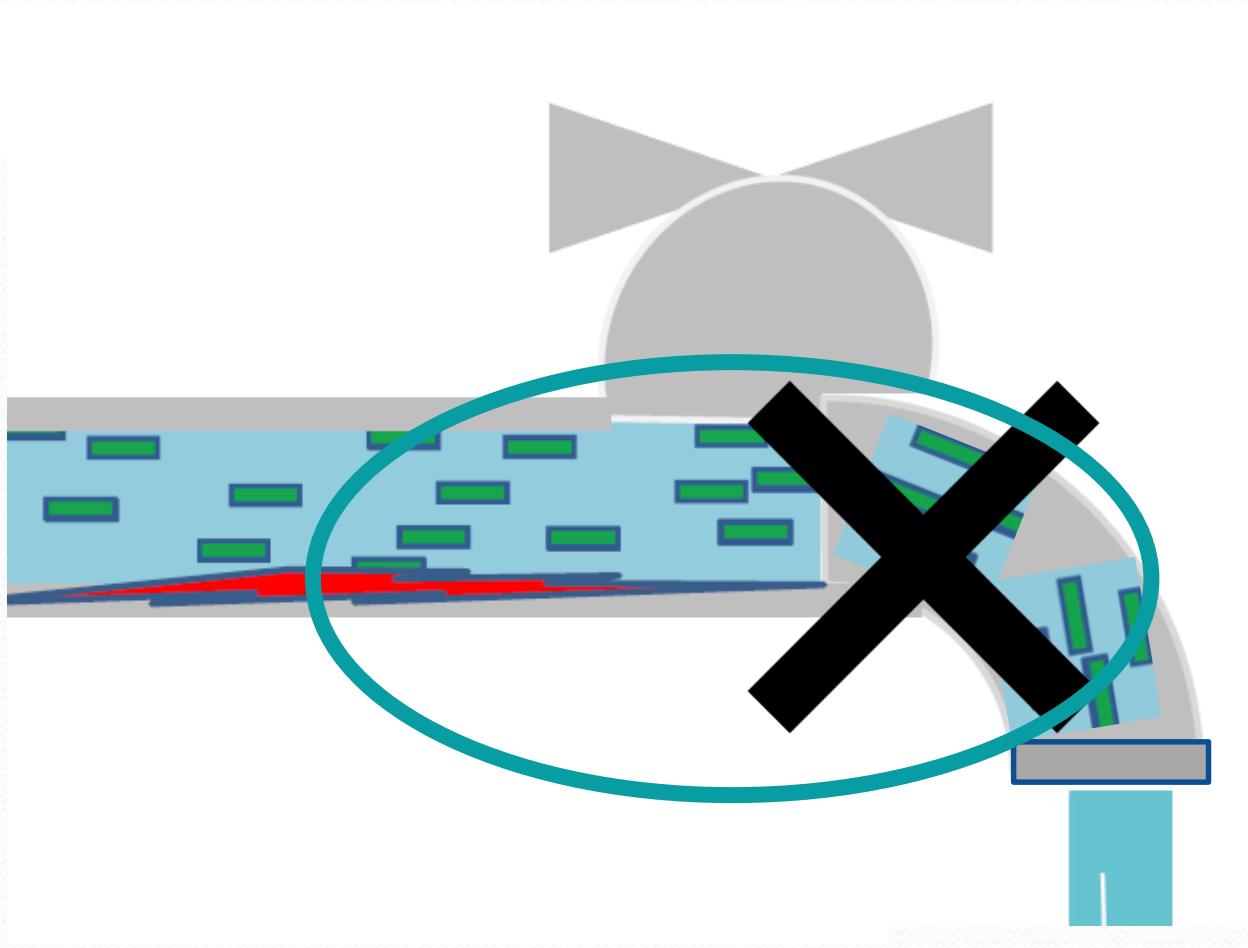
Coliform

- Sample volume: 100mL
- Cold water
- FLUSH for 2 min; evaluating distribution system lines; NOT distal end
- Remove aerator

Legionella

- 1000 mL for drinking water and 100 mL for cooling tower or decorative fountains
- Hot water
- Flush and/or no flush; depends what you are evaluating; line or distal end
 - CDC: collect biofilm swab then flush
 - U of Pittsburgh: no flush, first 1000 mL

Legionella Biofilm at Periphery





Centers for Disease Control and Prevention

Sampling Procedure and Potential Sampling Sites

Protocol for collecting environmental samples for *Legionella* culture during a **cluster or outbreak** investigation or when **cases of disease** may be associated with a facility.

Sampling should only be performed after a thorough environmental assessment has been done and a sampling plan has been made. This protocol describes how to take standard biofilm swab, bulk water, and filter samples from commonly sampled sites. This protocol may be used in conjunction with the following tools:



LEGIONELLA ENVIRONMENTAL ASSESSMENT FORM



SAMPLE DATA SHEET



LEGIONELLOSIS OUTBREAK INVESTIGATION VIDEOS:

Legionella Ecology and an Introduction to Environmental Health and Engineering

Conducting and Interpreting the Environmental Assessment

How to Make a Sampling Plan

How to Sample Potable Water

How to Sample Cooling Towers

How to Sample Spas and Fountains

<https://www.cdc.gov/legionella/downloads/cdc-sampling-procedure.pdf>

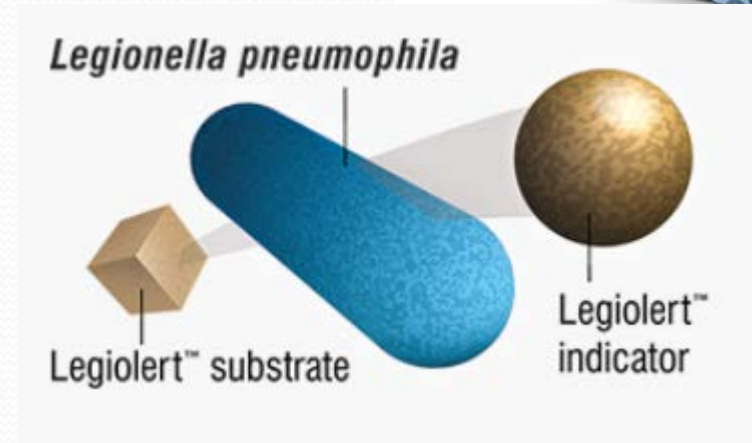
Legionella detection

- Filtration and culture-
CFU/mL (CDC or
SM9260J)
 - All species
- Filtration and PCR-
detection or no
detection
 - Lpn or *Legionella* sp
screen
- IDEXX Legiolert-
MPN/100mL
 - Only Lpn1



IDEXX Legiolert™

- Similar to colilert technology; defined substrate packets
- Differences
 - Temp: 39° C; inc 7 days
 - Different QT; must use QT Sealer PLUS
 - Humidity in incubator required
 - Positive: brown or turbidity



Legionella Speciation/Serogrouping

- Required for all VA Hospital positive samples
- Extremely important in health care setting for epi purposes; will guide diagnostic testing
- SHL *Legionella* speciation: Bruker MALDI-TOF MS
 - Lp serogrouping: DFA Microscopy



SHL MALDI-TOF MS

Legionella Research

CDC ELC AMD Project

- WGS study of *Legionella pneumophila* strain diversity over time in hospital premise plumbing: Wes Hottel, Valerie Reeb, Nancy Hall and Lucy DesJardin in collaboration with Brian Raphael, CDC
 - **Results: all strains from two facilities appeared to be genetically stable over time; one cluster of Lpn belonged to ST36 group, known to be assoc. with various outbreaks in US**

Standard



Standard 188—Legionellosis: Risk Management for Building Water Systems (ANSI Approved)

ASHRAE

Published 2015

www.techstreet.com/ashrae/products/1897561

Guidelines



Guideline 12—Minimizing the Risk of Legionellosis Associated with Building Water Systems

ASHRAE

Published 2000

www.techstreet.com/ashrae/products/232891

(currently under revision)



Legionellosis Guideline: Best Practices for Control of *Legionella*

Cooling Technology Institute

Published 2008

www.cti.org/downloads/WTP-148.pdf



Model Aquatic Health Code Guidance

Centers for Disease Control and Prevention

Published 2014

www.cdc.gov/mahc/index.html

Laboratory Resources



ELITE Program

Centers for Disease Control and Prevention and Wisconsin State Laboratory of Hygiene

wwwn.cdc.gov/ELITE/Public/EliteHome.aspx

In Summary

- **Legionellosis is on the rise and presents a serious risk of legionellosis in health-care facilities, esp LTC**
 - **Residents with many risk factors, legionellae ubiquitous in our water environment, grow and spread in man-made water systems**
- **CDC Tool Kit is a great tool.**
 - **Develop a team, assess hazard, develop/implement plan, evaluate/validate plan using CDC tool kit**

In Summary (continued)

- Remember preventing *Legionella* is like food safety
 - Keep the hot water hot and the cold water cold
 - regularly monitor temperature (and disinfectant)
 - Attention to maintenance (of water systems)
- Implementing good management plans at health care facilities will reduce the risk of *Legionella* growth and ultimately reduce disease

In Summary (continued)

- If *Legionella* testing necessary, SHL can help
 - either by performing the testing OR
 - if you are performing the testing, SHL can perform speciation/serogrouping
 - In addition, DNA fingerprinting is available for source tracking and confirmation



Any

Questions

