EPA's Office of Research and Development (ORD) and Office of Water invite you to a **free webinar**

Understanding End Water Quality in Hospitals and Other Large Buildings

A certificate for one continuing education contact hour will be offered for this webinar

Tuesday, April 28, 2015
2:00 to 3:00 pm EST

Use and effectiveness of various available technologies for the treatment and control of *Legionella*

The presentation will provide a brief overview on the EPA draft document "*Legionella*: Current Knowledge on Treatment Technologies" which will characterize the current body of knowledge regarding the use and effectiveness of various available technologies for the treatment and control of *Legionella*. The document will provide an overview on *Legionella*'s microbial, epidemiological and other characteristics as well as describe various control approaches for the prevention and remediation of *Legionella*. The information on treatment technologies will include a characterization of their effectiveness, water quality issues and recommended operational conditions based on the reviewed literature. The document could assist primacy agencies, affected facilities and system operators in their decision-making process regarding measures to control for *Legionella* in building water systems.

Presented by César Cordero – *EPA's Office of Water.* César joined the Standards and Risk Reduction Branch (SRRB) of the EPA Office of Ground Water and Drinking Water (OGWDW) in 2007. During his time in SRRB he has been involved in the review of the Revised Total Coliform Rule and the Long Term 2 Enhanced Surface Water Treatment Rule. He has also been involved in the development of the Contaminant Candidate Lists as well as helping address issues related to emerging waterborne pathogens. César has a B.S. in Industrial Microbiology and an M.S. in Biology, both from the University of Puerto Rico-Mayaguez.

Water quality issues in large buildings and emerging treatment technologies for premise plumbing-related pathogens

The Safe Drinking Water Act (SDWA) sets limits on water quality indicators for water in the distribution system. Once this distributed water enters a building or household, the responsibility of maintaining water quality shifts to the owners. The latest data for waterborne diseases indicates that premise plumbing-related outbreaks are increasing across the U.S. This fact, and the legal ramifications of waterborne outbreaks, are leading hospital and hotel owners to address water quality in their buildings. This presentation will discuss ORD's investigation of water quality issues in large buildings, with the goal of providing information to building owners on how water quality changes as it moves through complex premise plumbing systems. The evaluation of emerging treatment technologies designed specifically to control premise plumbing-related microbial pathogens will also be discussed.

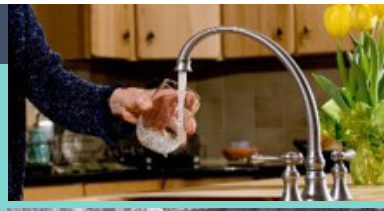
Presented by Mark Rodgers, Ph.D. – *EPA's Office of Research and Development.* Mark Rodgers is the Chief of the Microbial Contaminants Control Branch, in the EPA National Risk Management Research Laboratory. In this role he supervises microbiologists working on a diverse research program that includes the development of assays for determining sources of fecal contamination in source waters, the community composition of biofilms in drinking water distribution systems, the fate of pathogenic and indicator organisms in biosolids and the effectiveness of various conventional and emerging drinking water disinfectants.

Webinar Registration: https://attendee.gotowebinar.com/register/2867776279925225729

Who should attend?

State primacy agencies, tribes, community planners, technical assistance providers, academia and water systems interested in issues facing community water systems and solutions to help solve them.

In 2015, EPA's Office of Research and Development and Office of Water will host monthly webinars to discuss challenges and treatment solutions for small drinking water and wastewater systems.



EPA 2015 Monthly Webinar Series: Challenges and Treatment Solutions for Small Drinking Water and Wastewater Systems

All webinars will take place from 2:00 to 3:00 pm EST

January 27	Arsenic Treatment Technologies (COMPLETE)
February 24	Innovative Biological Treatment for Small Water Systems: Ammonia, Nitrites, and Nitrates (COMPLETE)
March 31	Small Water System Alternatives: Media and Membrane Filtration for Small Communities and Households (COMPLETE)
April 28	Understanding End Water Quality in Hospitals and Other Large Buildings
May 26	Current Water Treatment and Distribution System Optimization for Cyanotoxins
June 30	Biological and Microbial Aspects of Septic System Pollution
July 28	Corrosion Control for Drinking Water Systems
August 25	Distribution Operation Options for Small Systems to Address DBPs
September 29	UV Disinfections Systems – Treatment of Groundwater for Small/ Medium Sized Water Utilities
October 27	Decentralized High-Rate Wastewater Treatment of Peak Wet Weather Flows
November 24	Treatability Databases, Cost Models, and Other Tools for Water Systems
December 15	Reduction of Lead in Drinking Water

New!

Webinar recordings available on ASDWA's website:
http://www.asdwa.org/index.cfm?fuseaction=Page.viewPage&pageId=509&parentID=503&nodeID=1
(Certificates of completion cannot be given for viewing webinar recordings.)

2015 Monthly Webinar Series:

Challenges and Treatment Solutions for Small Drinking Water and Wastewater Systems

Presented by EPA's Office of Research and Development and Office of Water

April 28, 2015

TODAY'S TOPIC:

Understanding End Water Quality in Hospitals and Other Large Buildings

Webinar Support Phone Number: 1-800-263-6317

Audio Controls: Your audio is muted by the organizer

To Ask a Question: Type question in text box located in the lower section of your screen

A certificate for one continuing education contact hour will be offered for this webinar

If you did not request the credit at registration, send email request to webcastinfo@cadmusgroup.com or respond to your registration confirmation email

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Certificate of Completion for
One Contact Hour

Two Requirements:

1. You must be registered for the **live webinar** or be in a room with someone who is registered

2. You must attend for a minimum of **60 minutes**

Note

Certificates of completion cannot be given for webinar recordings viewed at a later time

Today's EPA Speakers:

César Cordero
Office of Water

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Contact: cordero.cesar@epa.gov

Mark Rodgers, Ph.D.
Office of Research and Development

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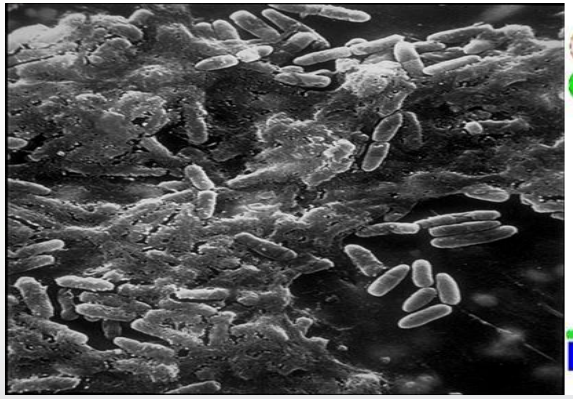
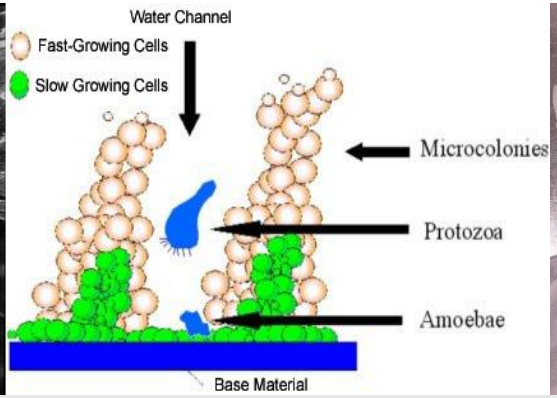
Contact: rodgers.mark@epa.gov

Understanding End Water Quality in Hospitals and other Large Buildings

Mark Rodgers
Water Supply and Water Resources Division
National Risk Management Research Laboratory
Office of Research and Development





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The Problem:

Hospital-Bred Infection Thought More Prevalent Than Estimated; Experts' Guesses on Incidence Range From 1% to 30% -- A.M.A. Finds Danger of Germs Is Exaggerated-1960

Infections Contracted in Hospitals Stir Concern- 1970

A Model V.A. Hospital on the Coast Is Plagued by Outbreaks of Legionnaire Disease; Effort to Find the Source-1978

Health Professionals Seek to Avert Risk of Hospital-Related Infections; Devices Cause Diseases Conducting a Study-1978

Swabs in Hand, Hospital Cuts Deadly Infections -2007

In Hospitals, Simple Reminders Reduce Deadly Infections-2008

2 patients die at UAB after testing positive for legionellosis- WBRC, May 27, 2014

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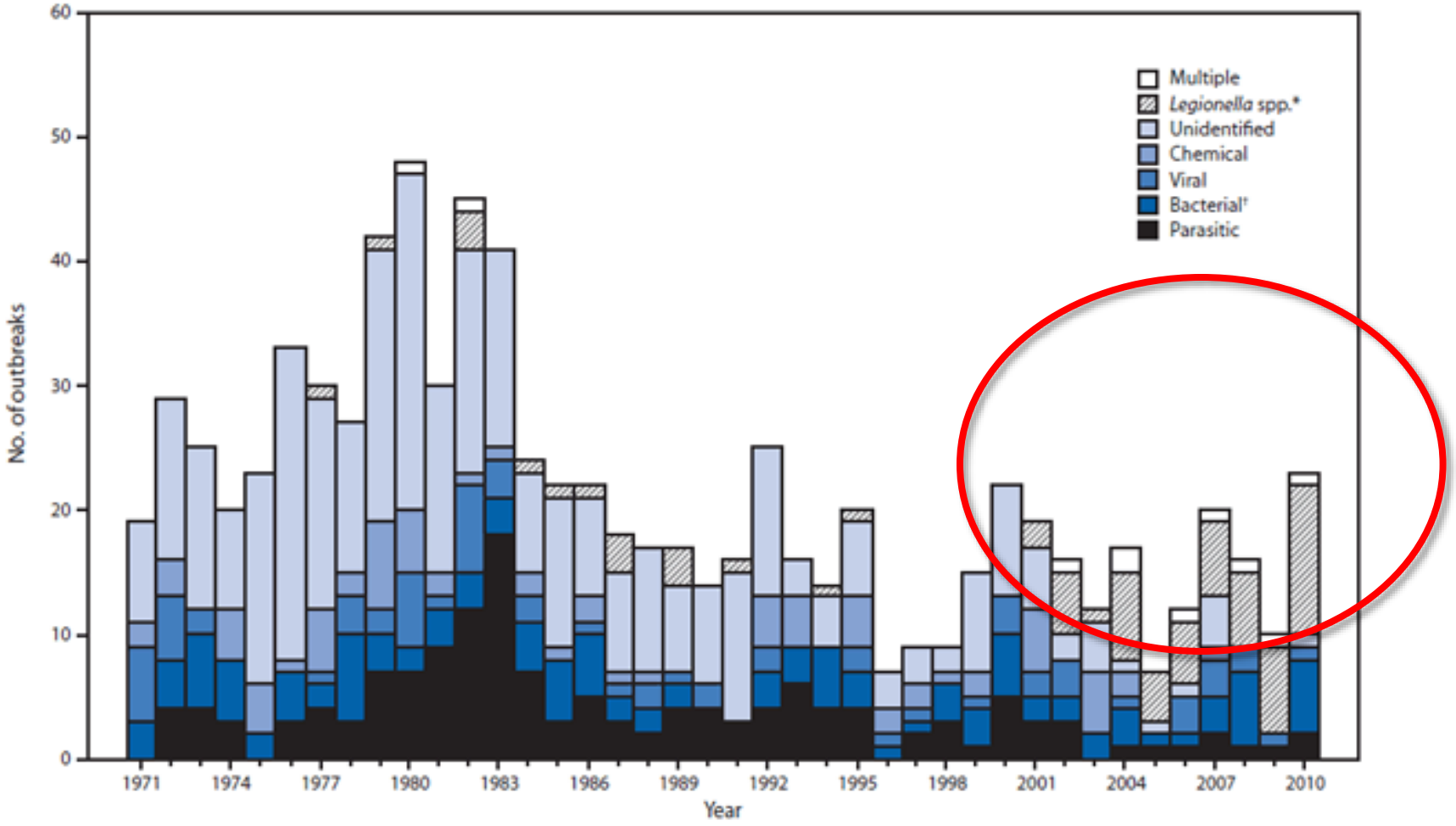
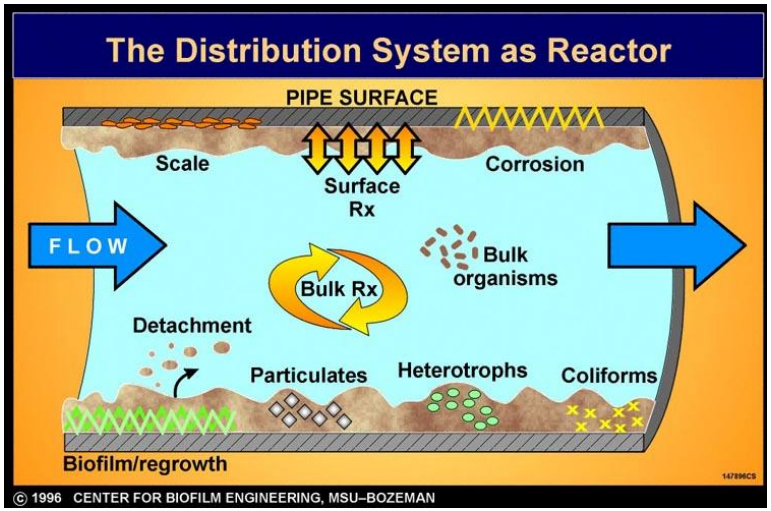
-Most outbreaks involved Legionella
-Most common deficiency- premise plumbing
-Few deaths in 2009-2010 (15), but all but one due to Legionella



Source-- 2013 MMWR 62:714

Premise plumbing systems are environments with naturally-occurring microbiota



- Drinking water treatment seeks to remove the majority of pathogens, but does not completely eliminate all bacteria.

- Bacterial pathogens come in two categories:
  - Those unable to grow in the environment-
    e.g. *E.coli, Salmonella*
  - Those able to grow in the environment-
    e.g. *Mycobacterium, Legionella*

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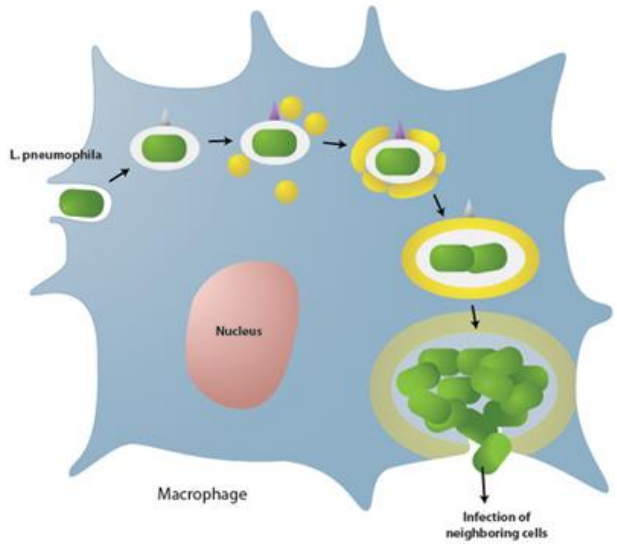
Macrophage



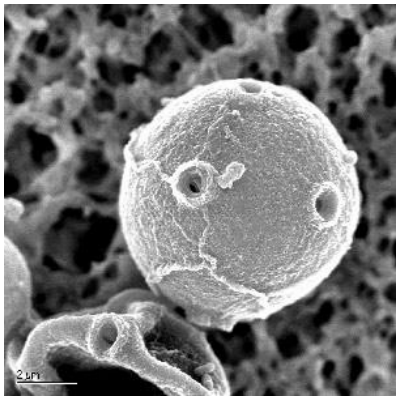
http://www.nih.gov/news/health/jun2011/nichd-16.htm

In humans- inside of macrophages

In biofilm communities- inside of free-living amoeba such as *Vermamoebae vermiformis*

Opportunistic pathogens:

Legionella pneumophila
Mycobacterium spp
Pseudomonas aeruginosa



Acanthamoeba cyst

For *L. pneumophila* sg1, 10^6- 10^8 CFU/L may be required for infection

Every building is a dead-end

- Variety of reactive pipe materials that interact with disinfectant and bacteria
  - -PVC, PEX, Galvanized, Copper, Brass, Solder, Old Lead
  - -Old plumbing versus new

- Variety of plumbing configurations, installation practices (good/bad), and maintenance (good/bad)

- Variety of water use patterns affect ***Water Age***
  - Water conservation→ increased water age
  - Temperature, Redox Potential, pH, Disinfectant Residual: Highly Variable

Modified from Dr. Marc Edwards

Borrowed from Dr. Simoni Triantafyllidou

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EPA Regulations

- Safe Drinking Water Act defines **Public Water Systems** as:
  - 15 connections or serve avg 25 people/day/>60days
    - Community, Non-community
- Most customer/connections are not a PWS, unless it:
  - Sells the water past the meter connection; or
  - Provides additional water treatment

- "providing drinking water is not the primary function of many small public water systems"

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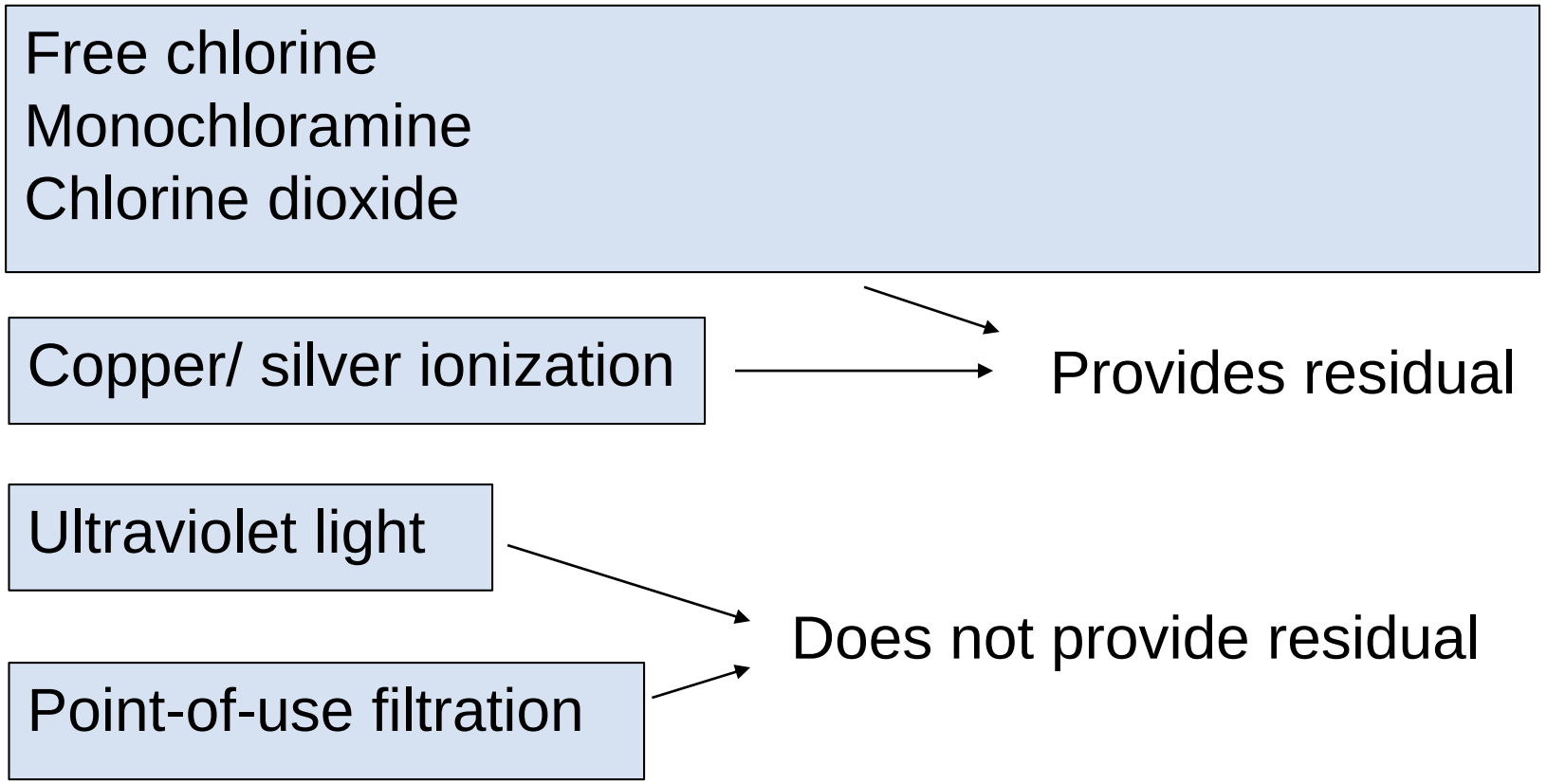
Premise plumbing treatment options



Copper/ Silver ionization

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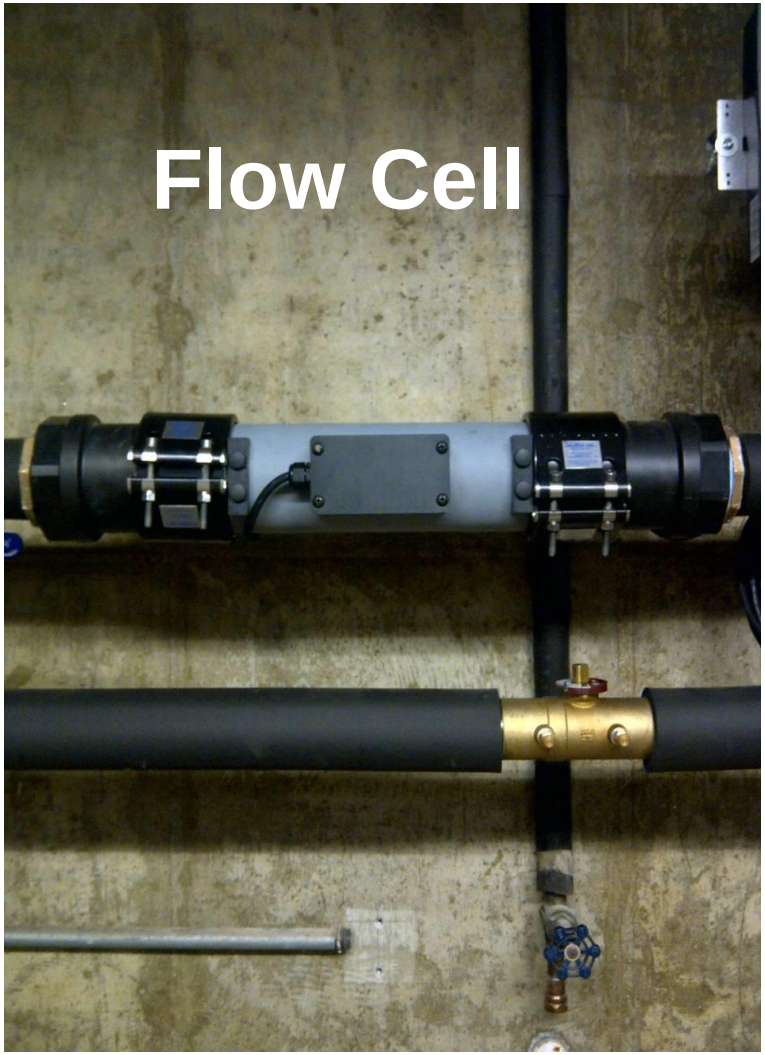
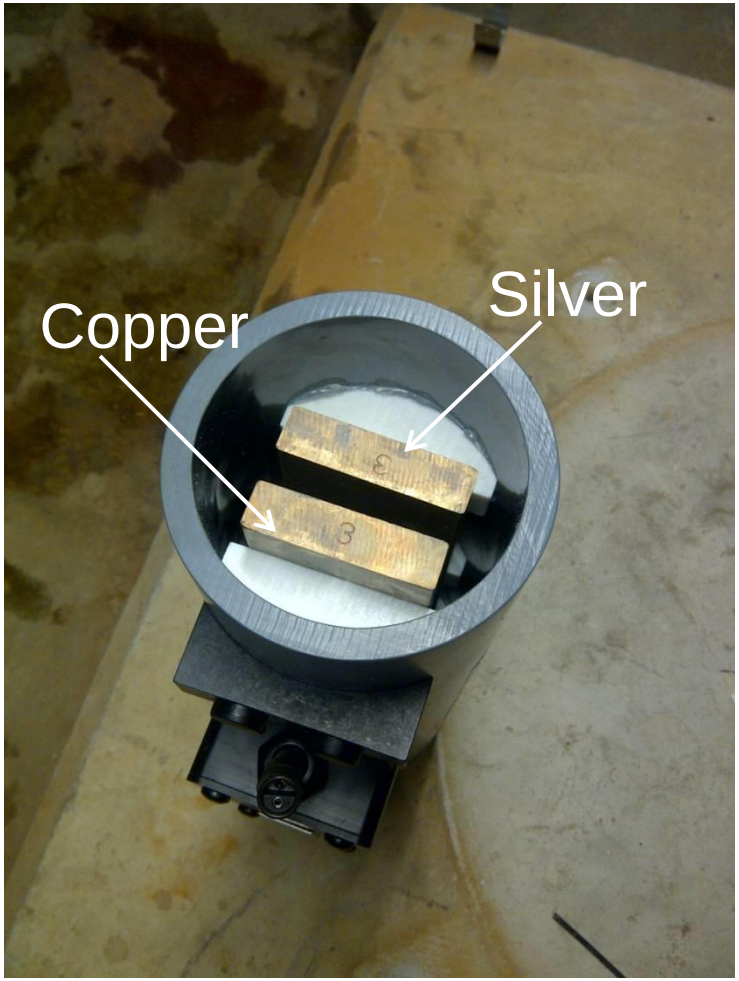
- Within Flow Cell are two metal bars
- Direct Current is applied across gap
- 30 sec pulses; reversing polarity
- Current increases as flow increases





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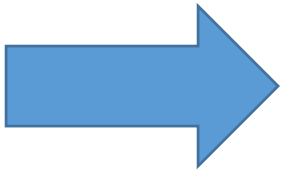
How to determine effectiveness of treatment?

- Among the many issues:
  - Where do you sample?
  - What type of sample?
  - For what do you monitor?
  - What are the best methods for determining the presence of pathogens?

“Representative” Sampling?

Variable end water quality possible between:

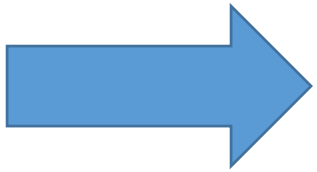
- Buildings
- Floors
- Water Outlets



Where to sample?

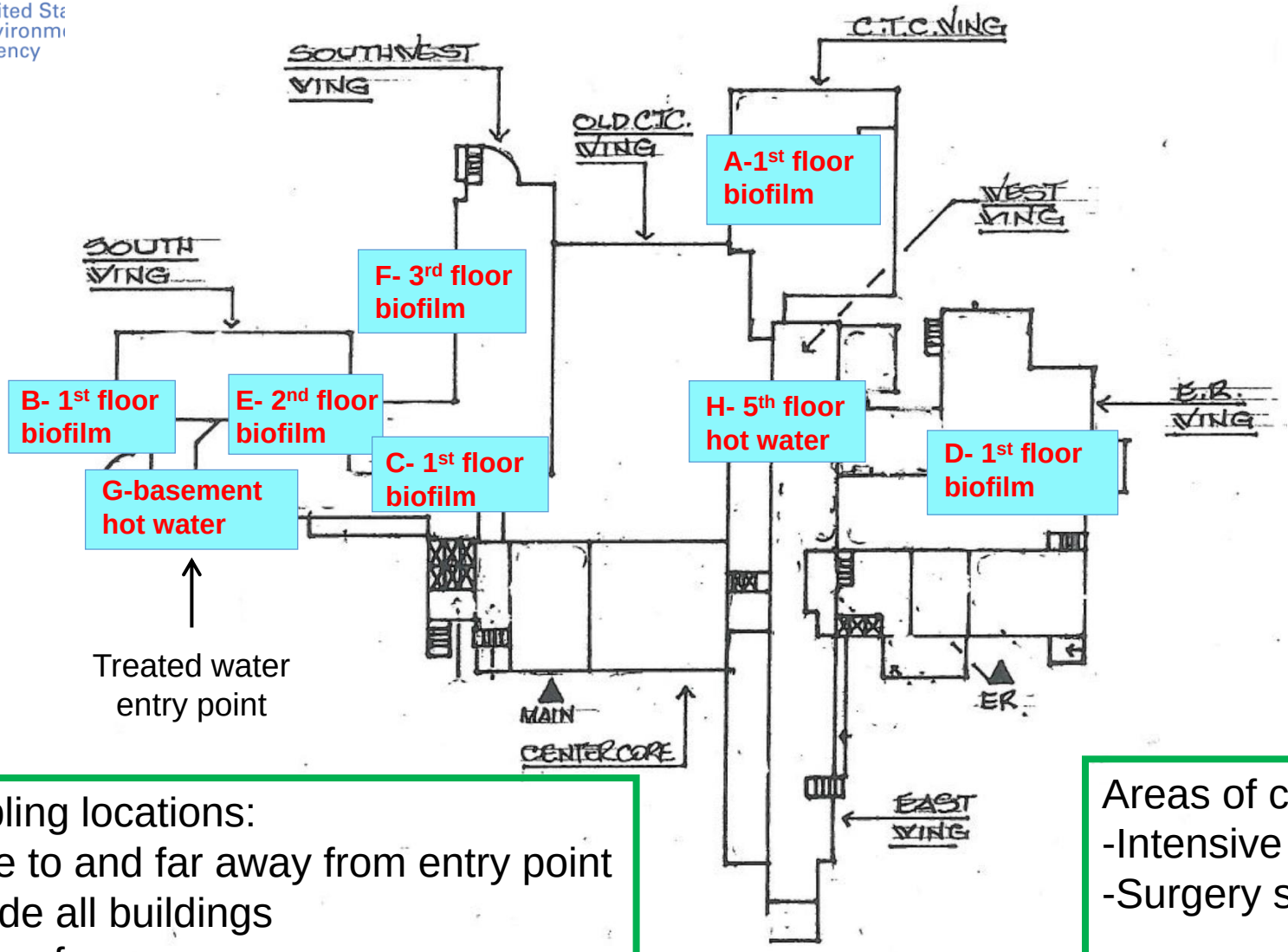
Different sample types give different types of information:

- Biofilm swabs vs bulk water
- Showerheads vs faucets
- First-draw vs flushed water
- Hot vs cold water



How to sample?

Hospital #1- Sampling Plan



Sampling locations:
-Close to and far away from entry point
-Include all buildings
-Areas of concern

Areas of concern:
-Intensive care
-Surgery suite

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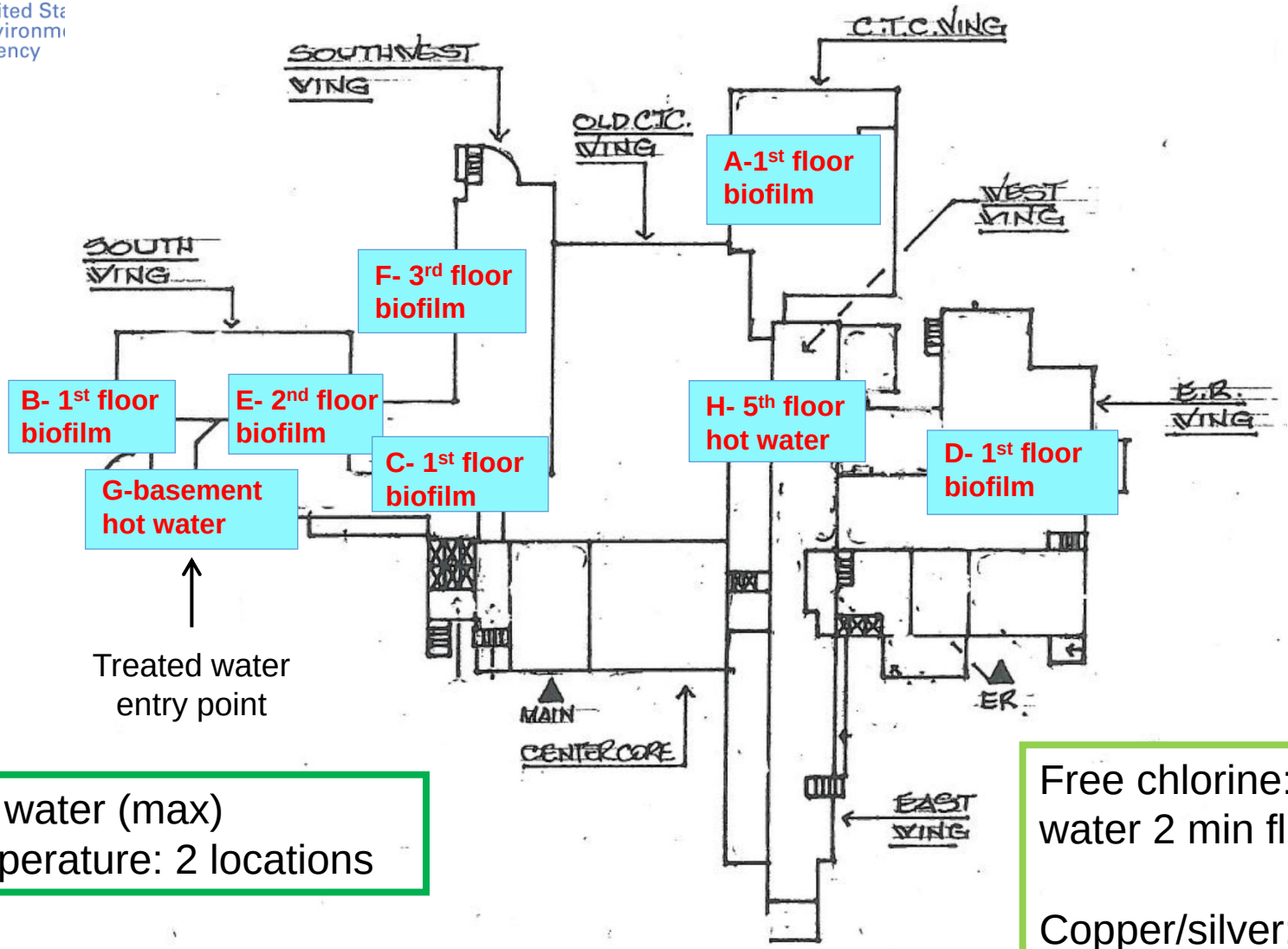
For what do you monitor?

- Control measures
  - Chlorine (total/ free)
  - Temperature (hot water)
  - Copper/ Silver (hot water)

  - Heterotrophic Plate Count bacteria (R2A agar)
  - *Legionella* (by culture)
  - *Mycobacterium* (by culture and PCR

Hospital #1- Sampling Plan



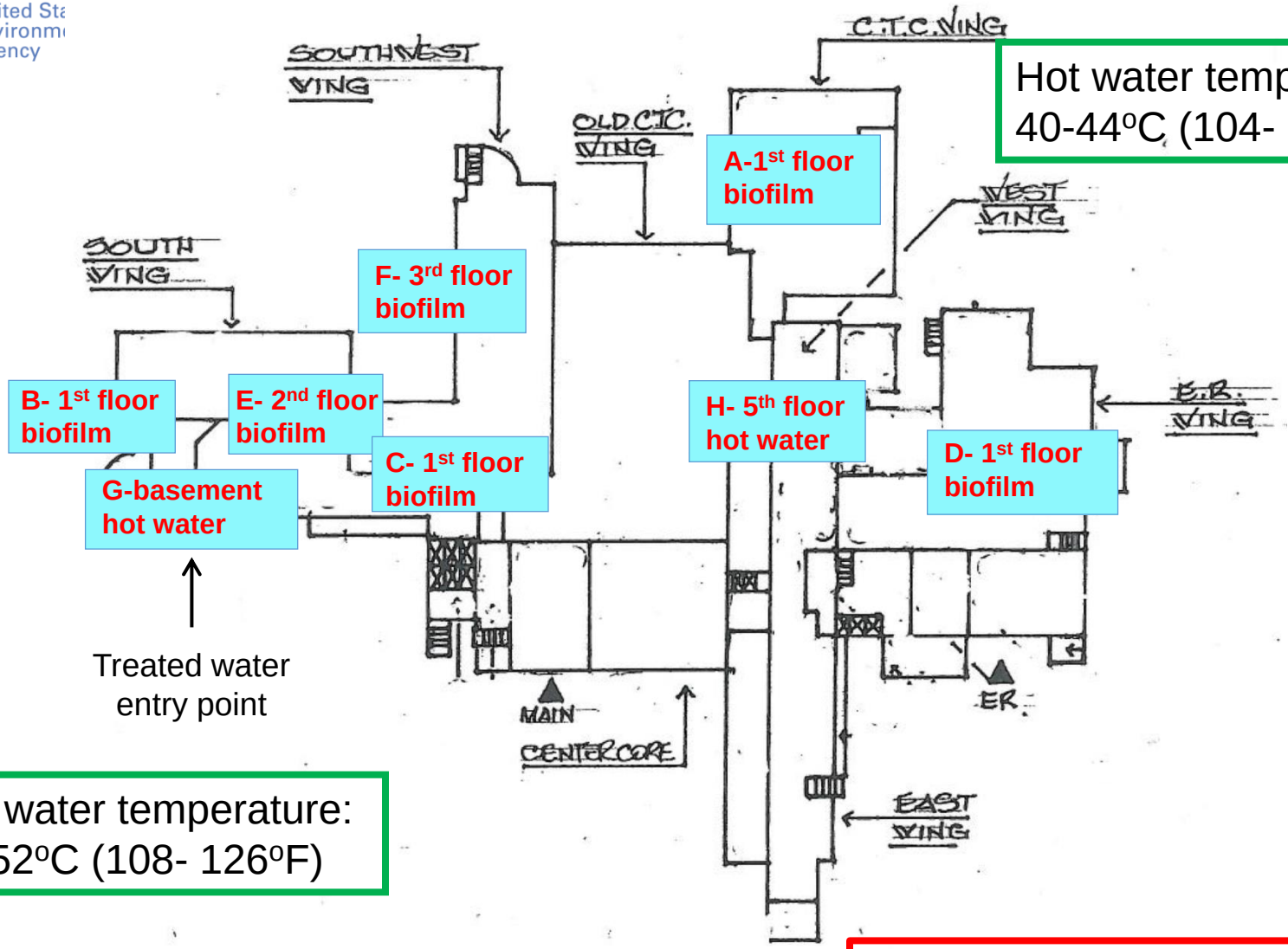
Hot water (max) temperature: 2 locations

Bacteria- faucet swabs, large volume hot water samples

Free chlorine: Cold water 2 min flush

Copper/silver: Hot water- 1st draw and 1min flush

Hospital #1

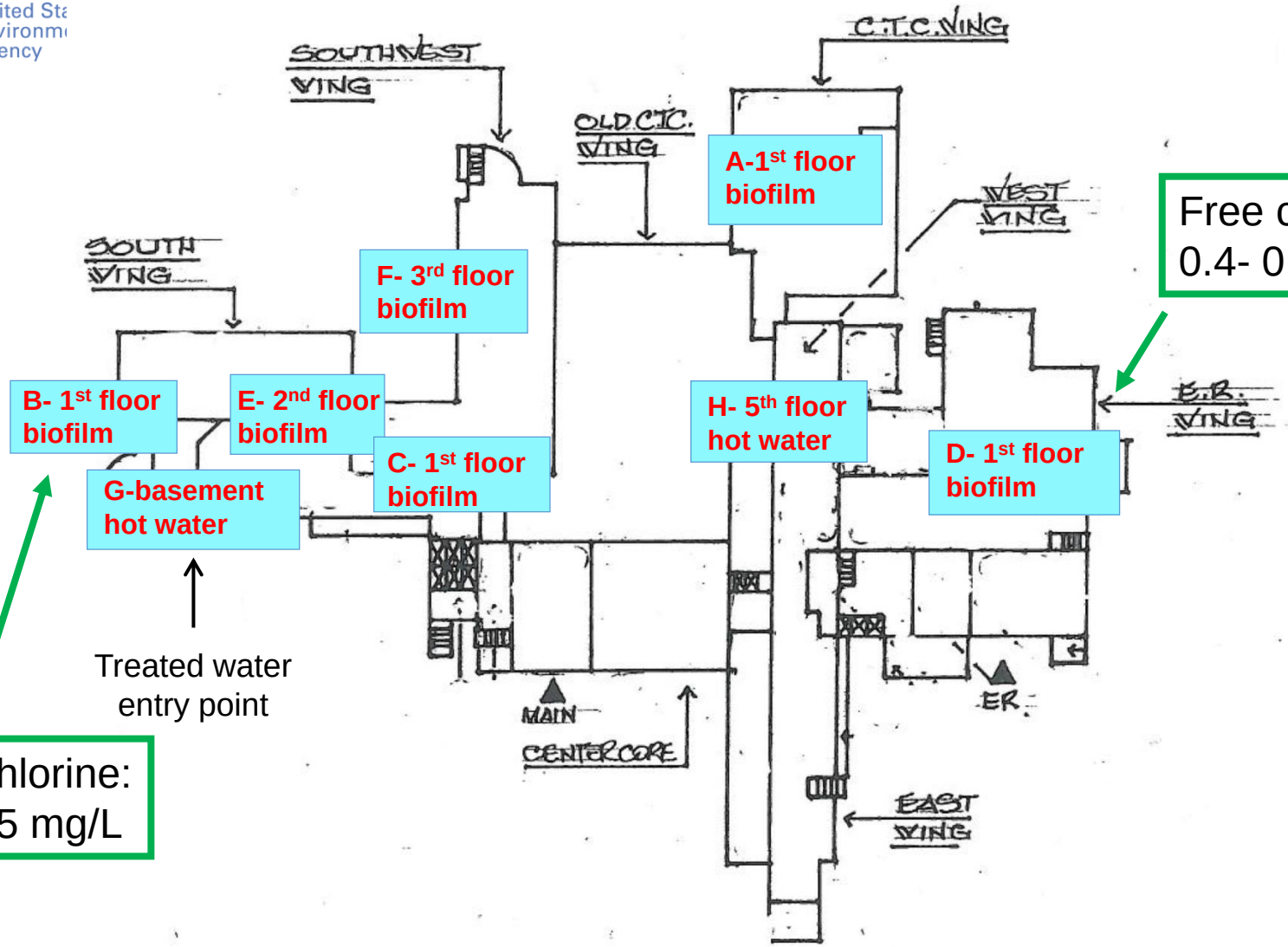


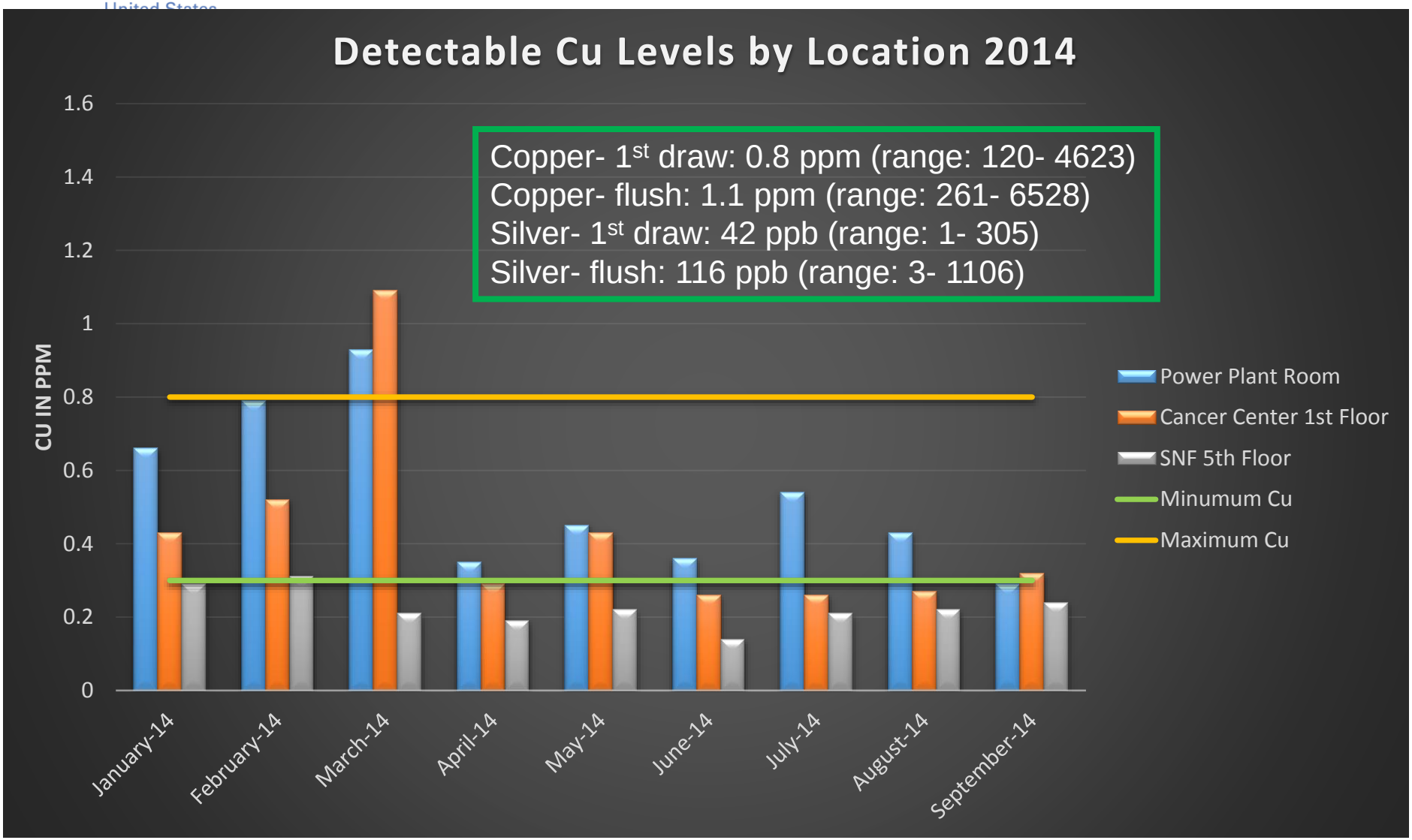
Hot water temperature: 40-44°C (104- 111°F)

Hot water temperature: 42-52°C (108- 126°F)

Legionella 24-46°C (77-115°F)

Hospital #1


SOUTHWEST WING
C.T.C. WING
OLD C.T.C. WING
WEST WING
SOUTH WING
E.R. WING
MAIN
CENTER CORE
ER
EAST WING
A-1st floor biofilm
F- 3rd floor biofilm
B- 1st floor biofilm
E- 2nd floor biofilm
C- 1st floor biofilm
G-basement hot water
H- 5th floor hot water
D- 1st floor biofilm
Free chlorine: 0.4- 0.8 mg/L
Treated water entry point
Free chlorine: 1.1- 1.5 mg/L

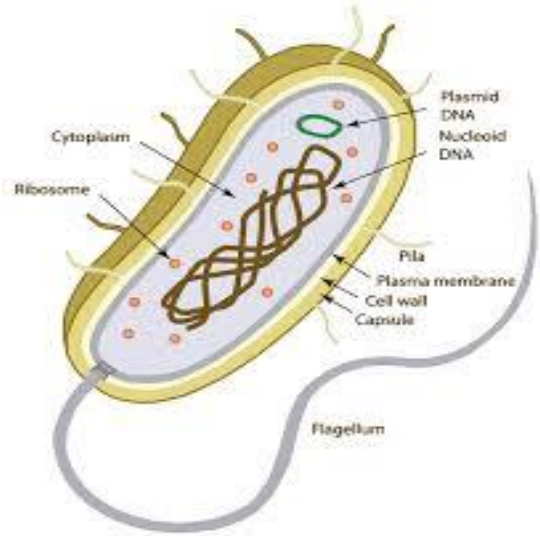

Detectable Cu Levels by Location 2014
Copper- 1st draw: 0.8 ppm (range: 120- 4623)
Copper- flush: 1.1 ppm (range: 261- 6528)
Silver- 1st draw: 42 ppb (range: 1- 305)
Silver- flush: 116 ppb (range: 3- 1106)
CU IN PPM
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
January-14
February-14
March-14
April-14
May-14
June-14
July-14
August-14
September-14
Power Plant Room
Cancer Center 1st Floor
SNF 5th Floor
Minumum Cu
Maximum Cu

Bacteria detection: culture and molecular methods

Culture method detects living (viable) **culturable** cells

***Legionella* bacteria growing in lab**

Molecular methods do not detect whole cells- rather these methods detect **parts of cells** which are **specific** to that organism



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Legionella pneumophila by culture in biofilm

2012 2013 2014

	June	Aug	Oct	Dec	Feb	April	June	Aug
3722	-	-	-	-	-	-	-	-
1607	-	-	-	-	-	-	-	-
A302	-	-	-	-	-	-	-	-
2614	+	+	-	-	-	-	-	-
ED 17	-	-	-	-	-	-	-	-
OR 10	+	-	-	-	-	-	-	-

Cu/Ag ionization treatment

Viable but non-culturable?

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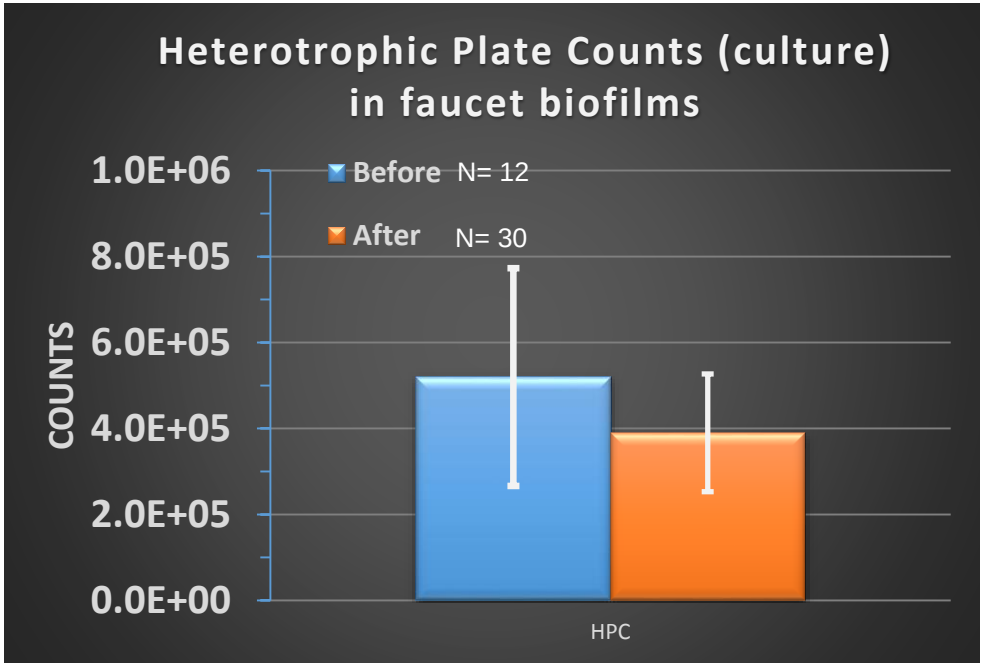
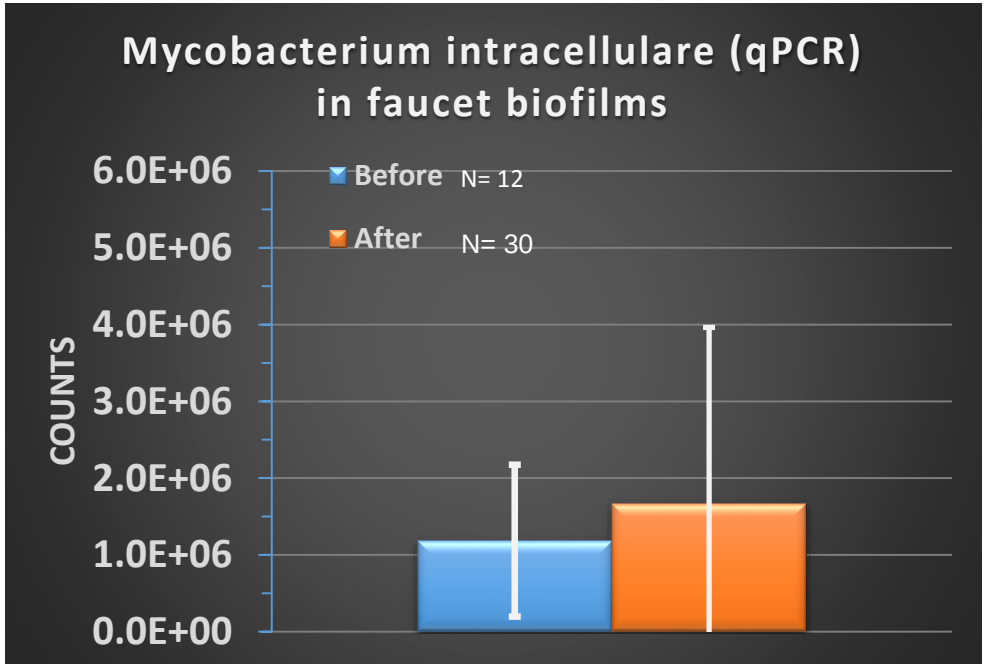
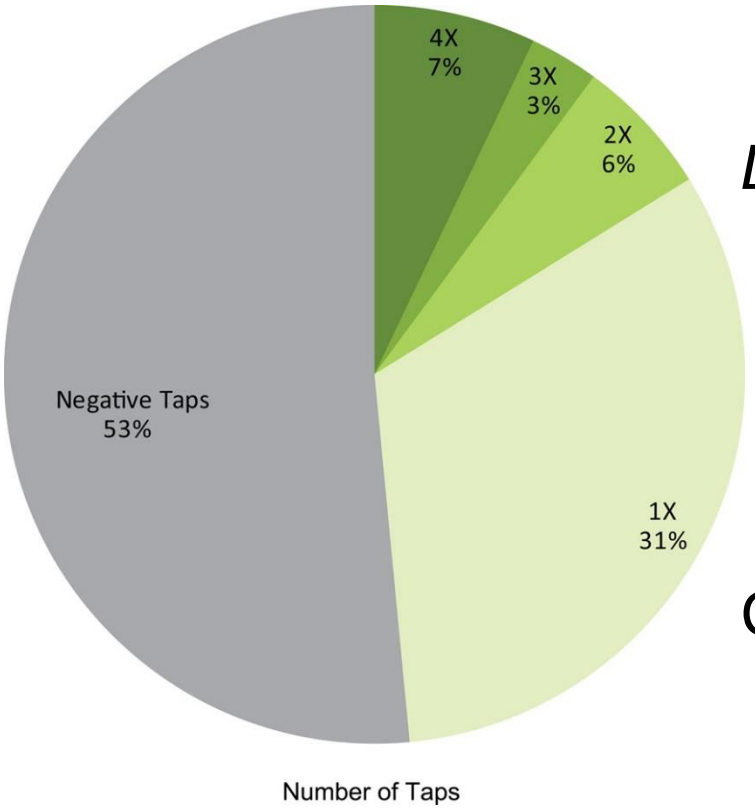


No impact on heterotrophic bacteria
or
Mycobacterium intracellular





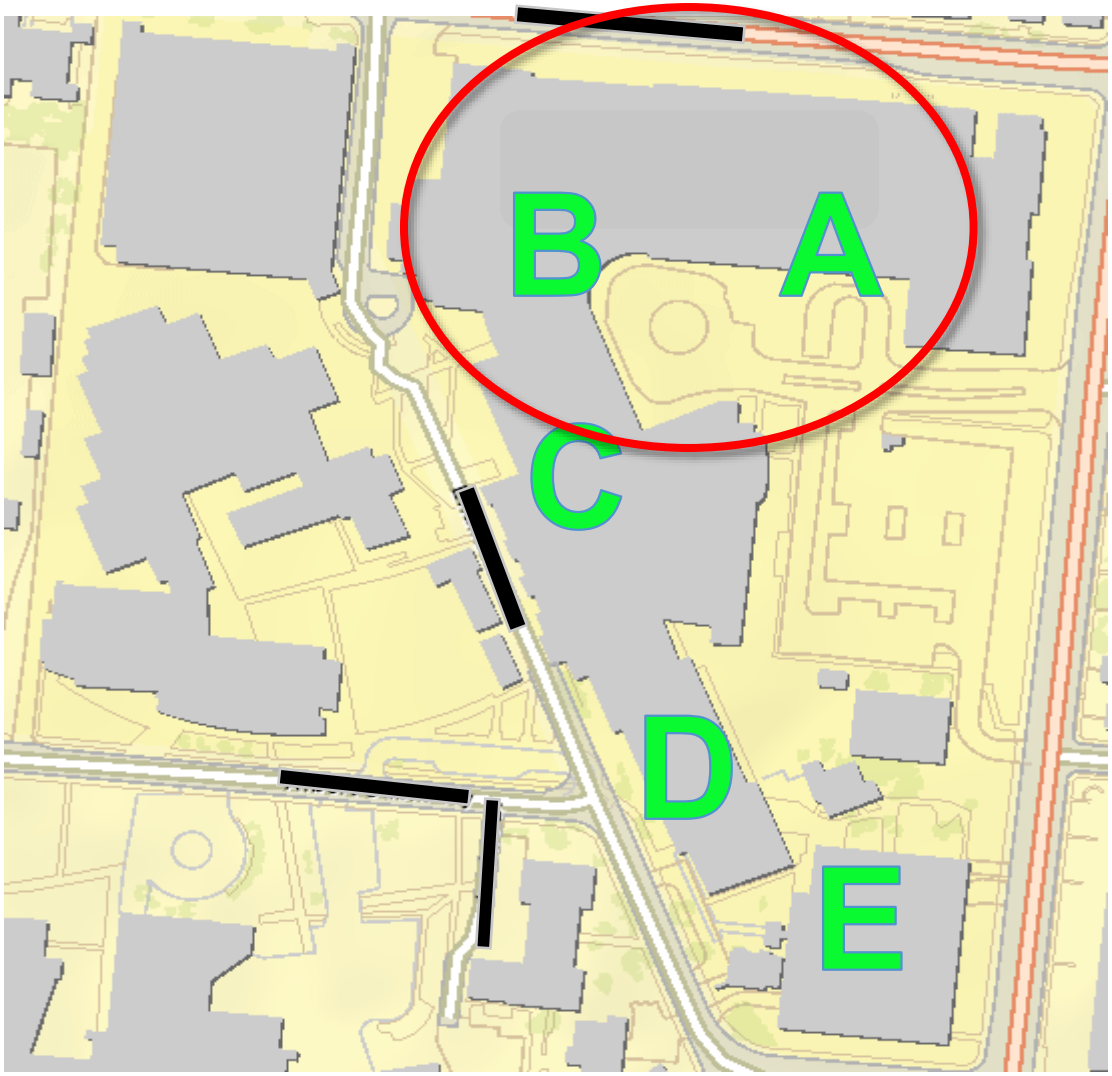
L. pneumophila sg1

Cold water samples

An unrelated EPA study of multiple taps sampled over time

Published in: Maura J. Donohue; Katharine O'Connell; Stephen J. Vesper; Jatin H. Mistry; Dawn King; Mitch Kostich; Stacy Pfaller; *Environ. Sci. Technol.* **2014,** 48, 3145-3152.
DOI: 10.1021/es4055115

Hospital project #2



Hospital #2- Sampling Plan

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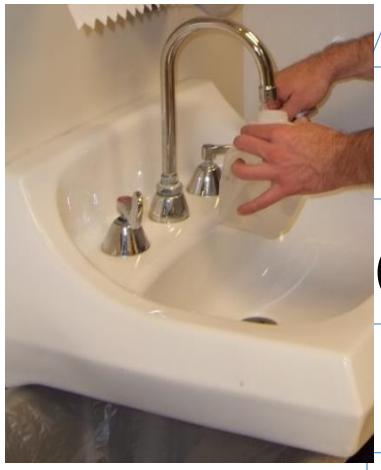
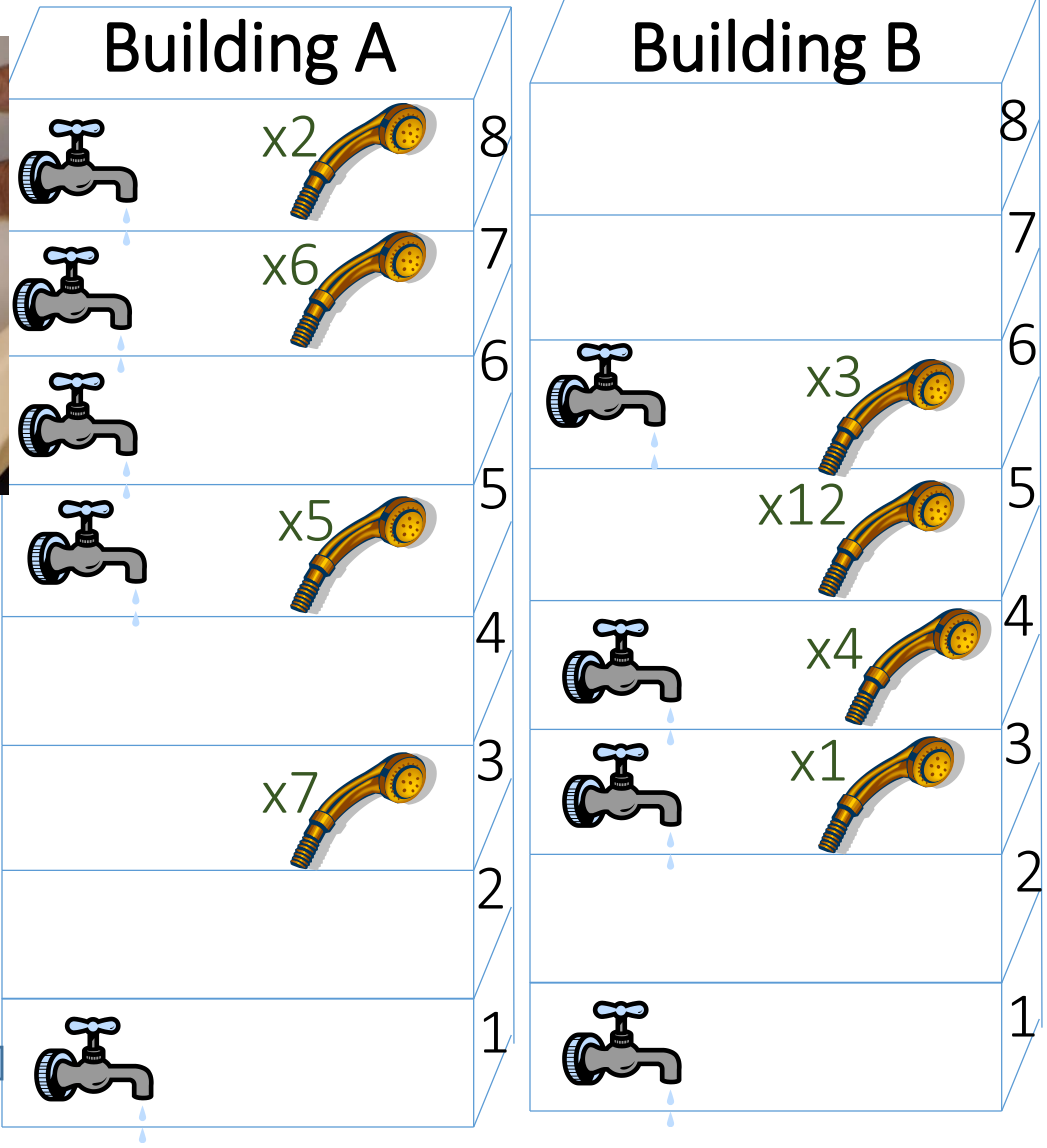
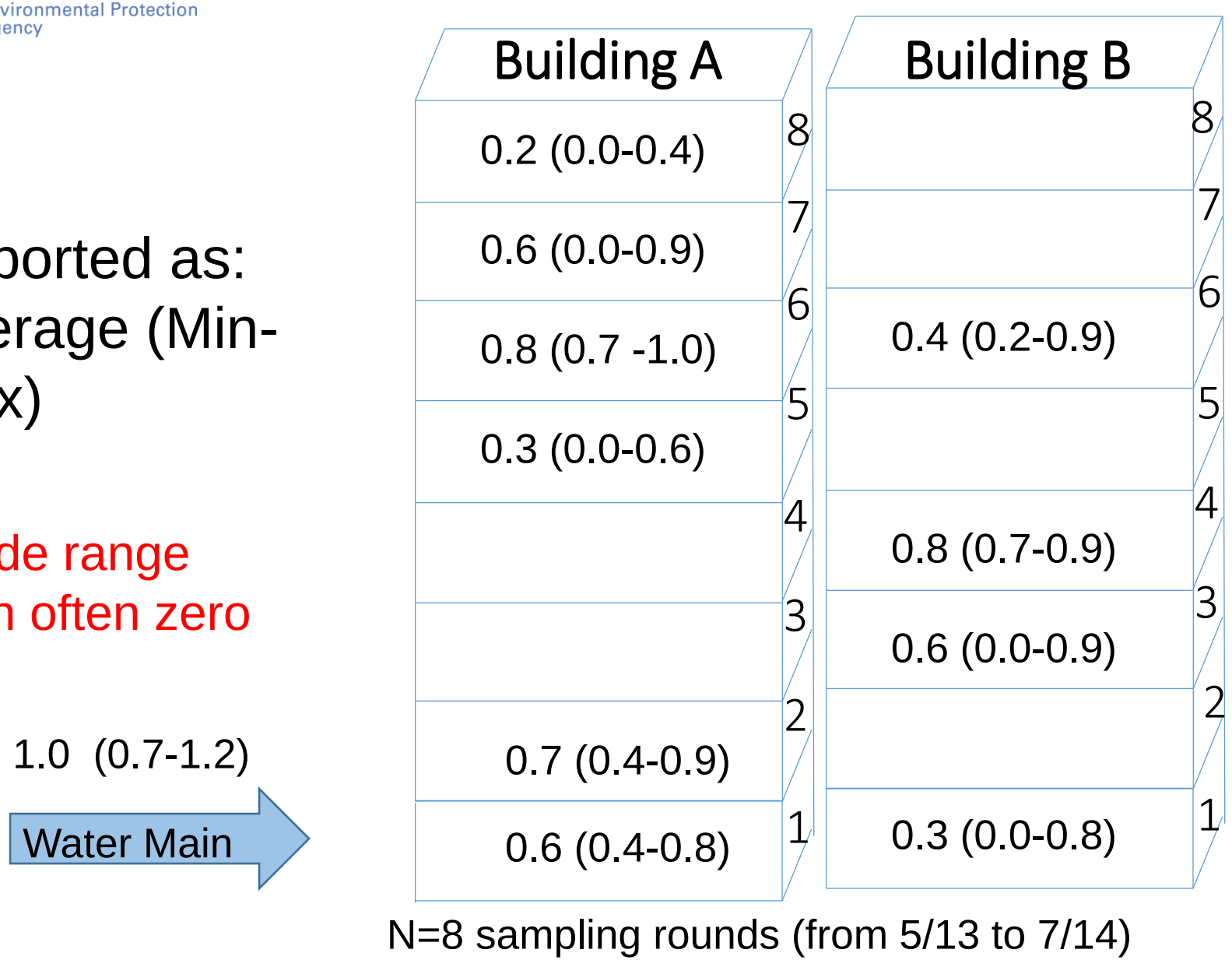




Free Chlorine (mg/L) in First-Draw Cold Water

Reported as: Average (Min-Max)

Wide range
Min often zero

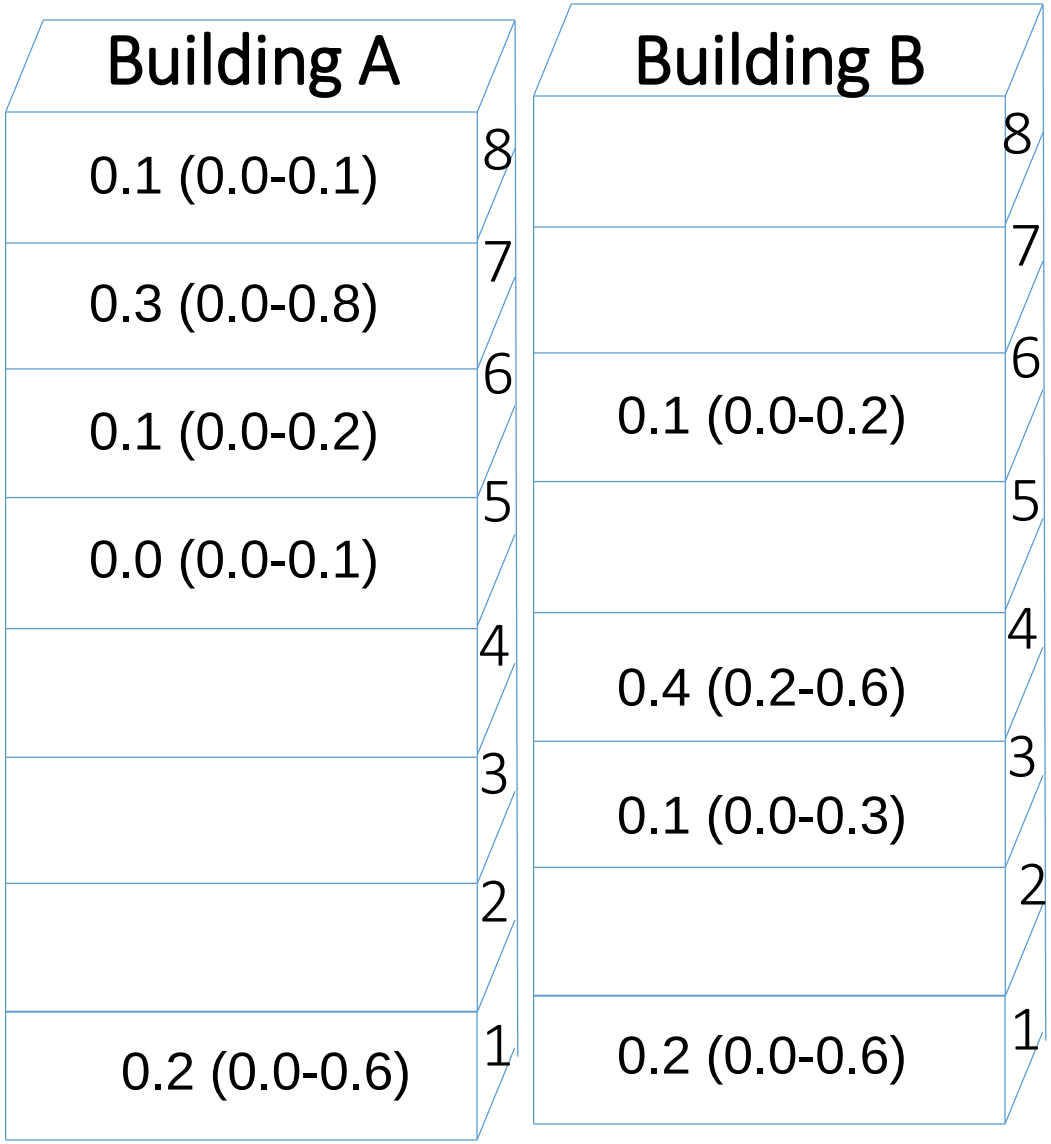


N=8 sampling rounds (from 5/13 to 7/14)

Free Chlorine in First Draw Hot Water

Reported as: Average (Min-Max)

As expected, very low



1.0 mg/L (0.7-1.2)

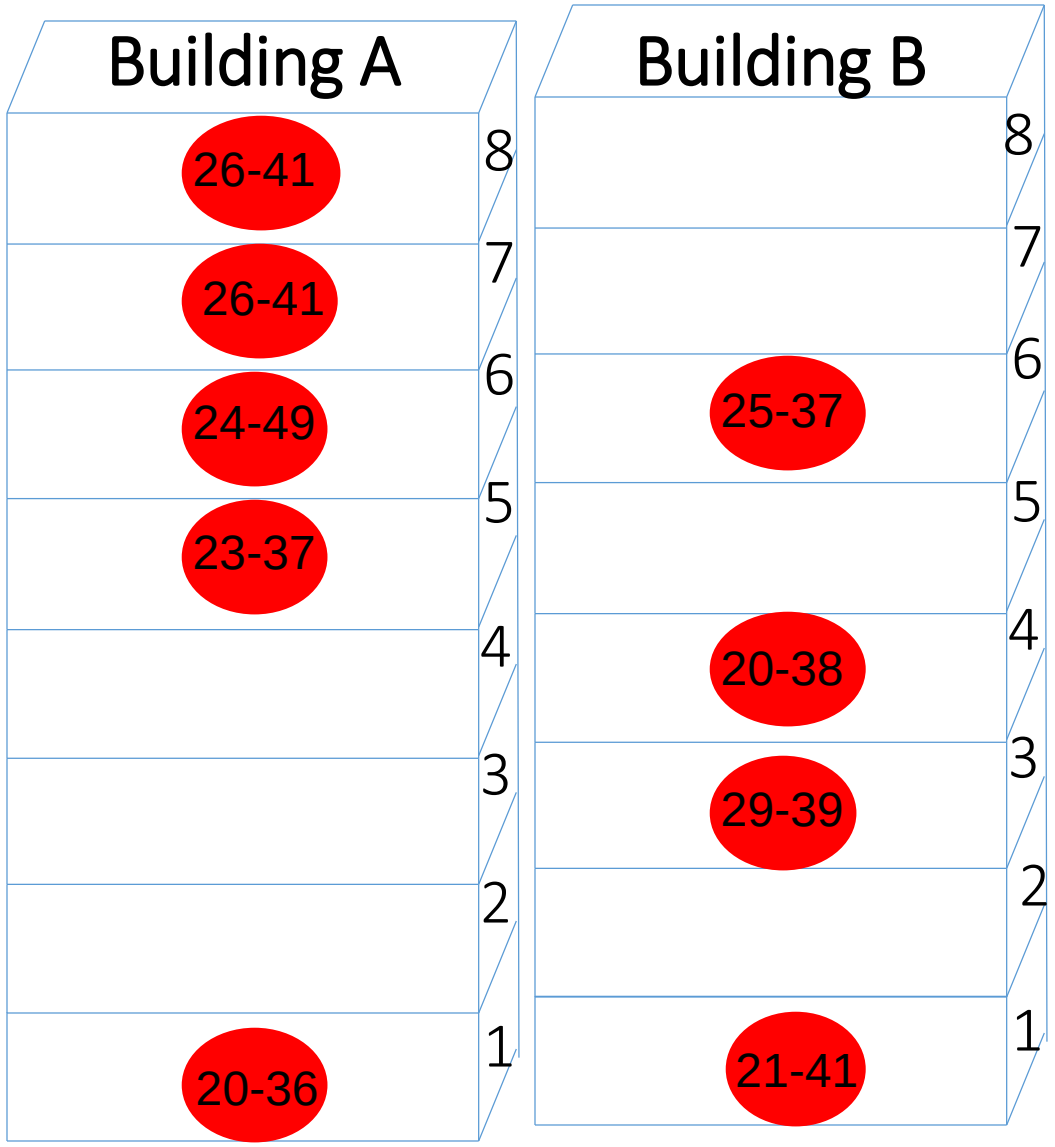
Water Main

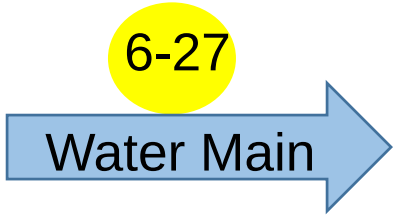
N=8 sampling rounds (from 5/13 to 7/14)

Temperature range (°C) in First-Draw Hot Water

For Legionella control:

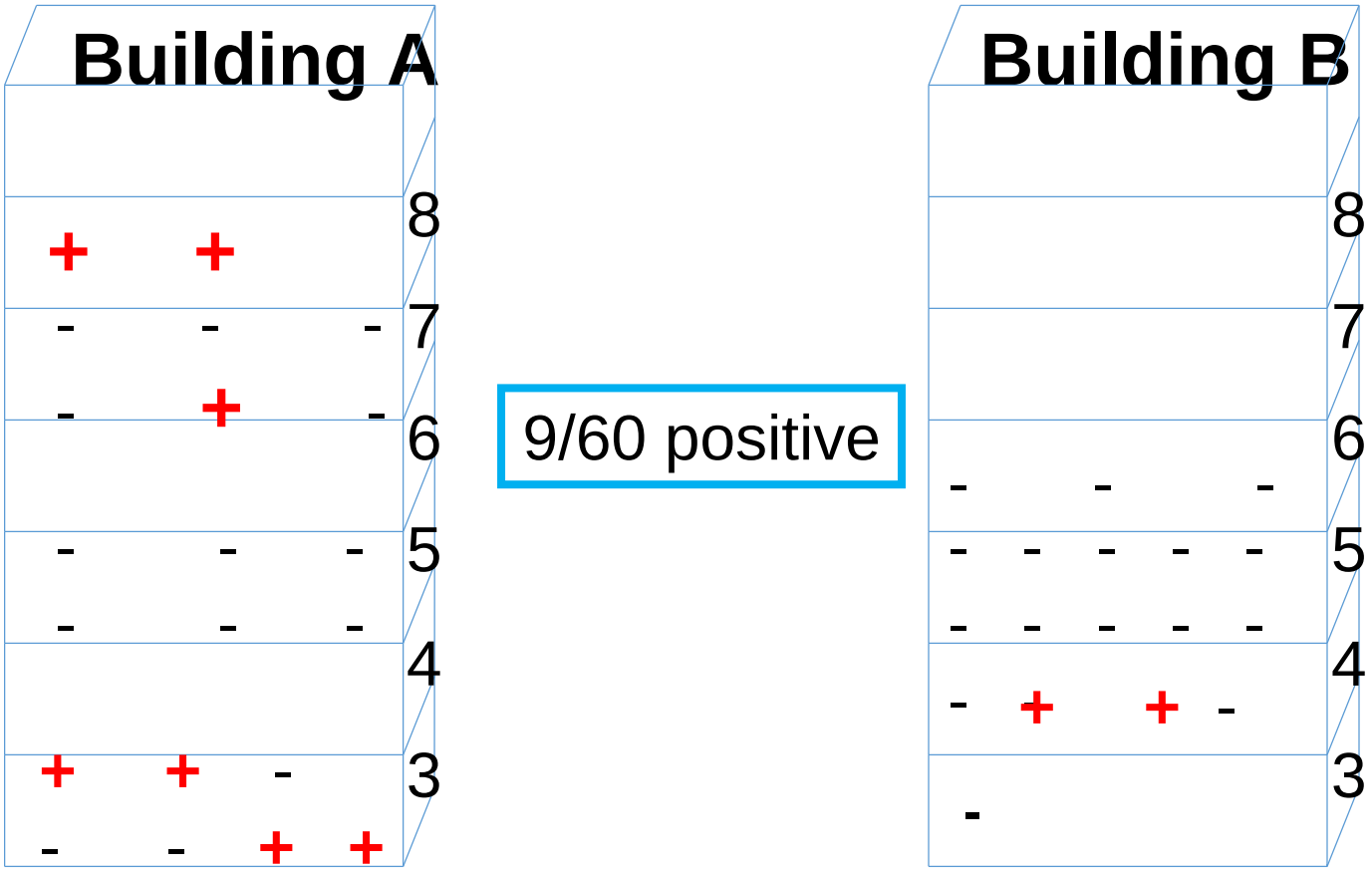
Growth permissive = <51C





N=8 sampling rounds (from 5/13 to 7/14)

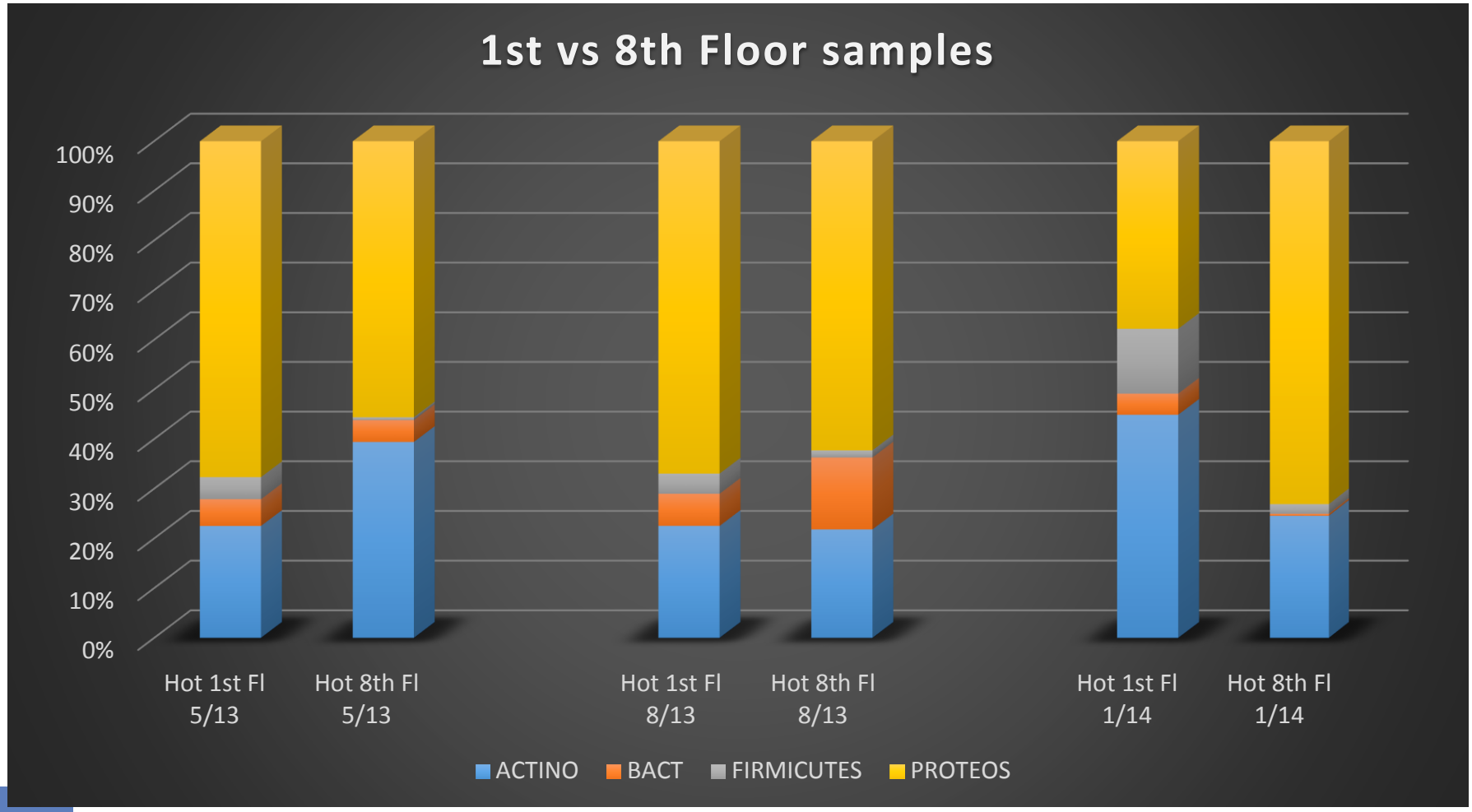
L. pneumophila serogroup 1 bacteria in showerhead biofilms



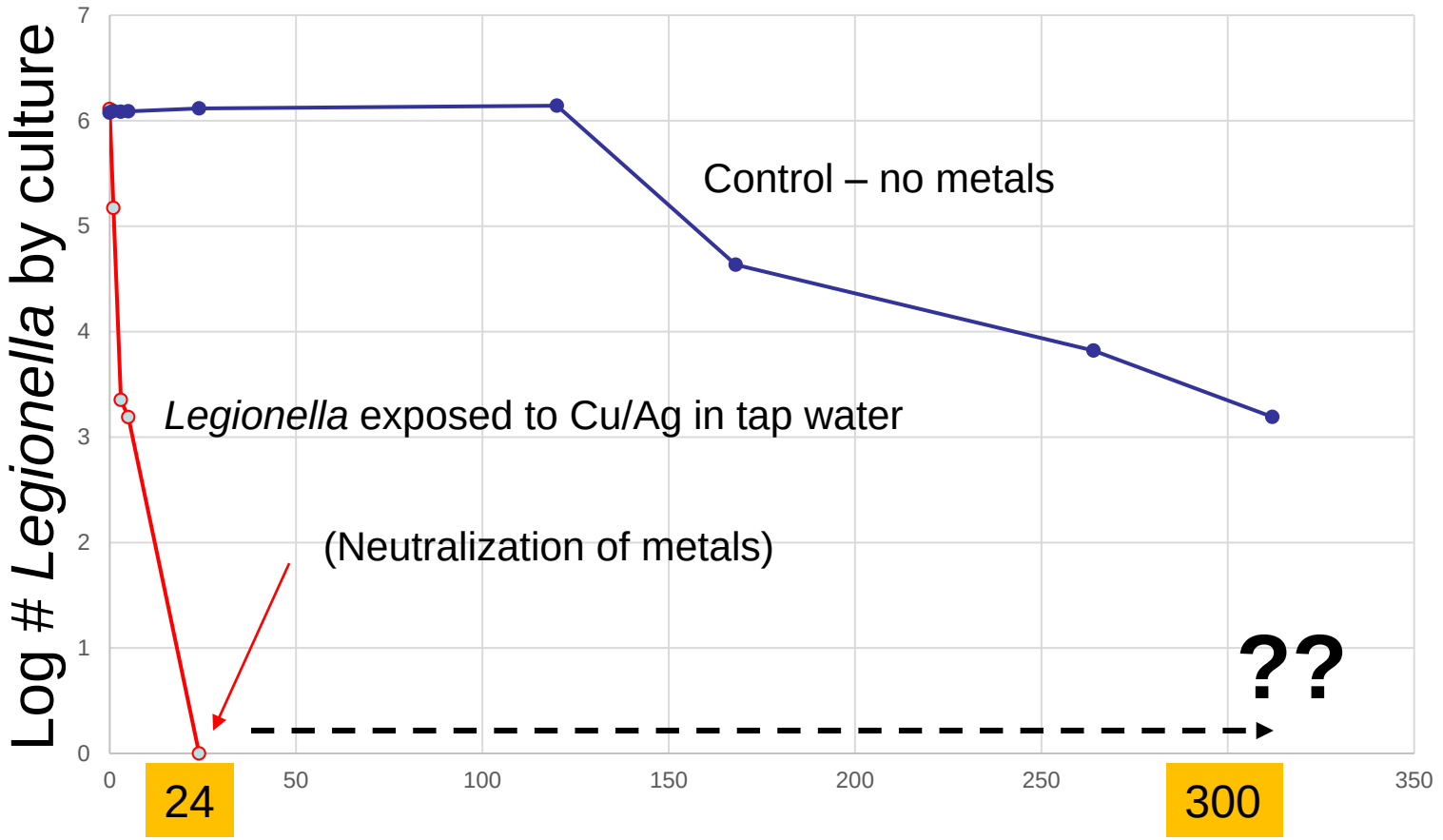
+ means positive *L. pneumophila* serogroup 1 [qPCR]

Microbial Water Communities

Sample location within building



Bench study with *Legionella* and Cu/Ag dosed hospital water



No evidence of recovery, yet

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Summary

- Expect for the water quality to change throughout a large building.
- Options exist for additional water treatment.
- Prepare a good plan for managing risks:
  - Assemble a team with staff with responsibilities that cover facilities management, maintenance, infection control, and clinical surveillance.
  - Understand the water systems in your building.
  - Identify the hazards that you wish to control.
  - Identify how you will control the hazards- where the controls will be applied and the control limits.
  - Decide how you will monitor for these controls.
  - Decide how you will validate the effectiveness of the controls.

Notice

The U.S. Environmental Protection Agency, through its Office of Research and Development, funded and managed, or partially funded and collaborated in, the research described herein. It has been subjected to the Agency's peer and administrative review and has been approved for external publication. Any opinions expressed in this paper are those of the author (s) and do not necessarily reflect the views of the Agency, therefore, no official endorsement should be inferred. Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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Thanks for your attention

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2015 Schedule

All webinars will take place from 2:00 to 3:00 pm EST

January 27	Arsenic Treatment Technologie (Recording available online)
February 24	Innovative Biological Treatment for Small Water Systems: Ammonia, Nitrites, and Nitrates (Recording available online)
March 31	Small Water System Alternatives – Media and Membrane Filtration for Small Communities and Households
April 28	Understanding End Water Quality in Hospitals and Other Large Buildings
May 26	Current Water Treatment and Distribution System Optimization for Cyanotoxins
June 30	Biological and Microbial Aspects of Septic System Pollution
July 28	Corrosion Control for Drinking Water Systems
August 25	Distribution Operation Options for Small Systems to Address DBPs
September 29	UV Disinfections Systems – Treatment of Groundwater for Small/ Medium Sized Water Utilities
October 27	Decentralized High-Rate Wastewater Treatment of Peak Wet Weather Flows
November 24	Treatability Databases, Cost Models, and Other Tools for Water Systems
December 15	Reduction of Lead in Drinking Water

Schedule and recordings available online:

http://www2.epa.gov/water-research/2015-small-systems-webinar-series

Legionella: Current Knowledge of Treatment Technologies

César E. Cordero
USEPA Office of Groundwater and Drinking Water
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Trends

- Infections/outbreaks continue- increased focus by CDC, EPA, state health programs.
- Response to outbreaks often includes adding point-of-entry treatment as a proactive measure.
  - Questions about efficacy of treatment and water quality impacts.

Approach

- A multi-agency taskforce participated in the data compilation.
  - Environmental Protection Agency (EPA)
  - Centers for Disease Control and Prevention (CDC)
  - State representatives (including Association of State Drinking Water Administrators (ASDWA))
- A subset of the multi-agency taskforce reviewed and summarized peer-reviewed literature.
- The public will have an opportunity to comment on the information.
- Independent external peer review.

Legionella Background

- *L. pneumophila* first found in 1976 after pneumonia outbreak at American Legion convention in PA.
- The genus *Legionella* includes >50 species, many of which are pathogenic.
- Documented occurrence in distribution system and premise plumbing.
- *Legionella* colonizes biofilms in plumbing (or other moist elements).
- Ability to parasitize protozoa such as amoebae and thermo-tolerance are important characteristics of their persistence, fate and transport under adverse environmental conditions.

Legionella Background (Cont.)

- **Legionellosis**
  - Legionnaires' disease (severe pneumonia)
  - Pontiac fever (milder flu-like symptoms)
- **Infection occurs primarily through inhalation or aspiration**
  - Showerheads, faucets, and hot tubs
  - Mist machines, decorative fountains, and cooling towers
  - Respiratory therapy devices and humidifiers
- **Waterborne disease outbreaks (2009-2010, reported by CDC)**
  - 19 of 33 waterborne disease outbreaks caused by *Legionella*
  - 11 of 19 *Legionella* outbreaks caused by environmental conditions within building water systems.

Preventative and Remediation Strategies

- **Hazard Analysis and Critical Control Point and Water Safety Plans**
  - Use a multiple barrier approach for protecting building water systems from hazards that may occur.
  - Case studies show effectiveness for controlling growth of pathogens in building water systems.

Preventative and Remediation Strategies (Cont.)

- **Chlorine**
  - Results of laboratory and pilot scale studies showed effectiveness but at wide range of dose and water quality conditions
  - Residual maintenance is important
  - Efficacy increases with increased temperature
  - Biofilms and inclusion of *Legionella* in amoeba shield organisms from chlorine
  - Potential water quality issues include disinfection byproducts (Trihalomethane (THM) and haloacetic acid (HAA)), taste and odors and corrosion

Preventative and Remediation Strategies (Cont.)

- **Monochloramine**
  - Laboratory studies showed wide range of inactivation under varying water quality conditions
  - Efficacy increases with increased temperature
  - Several studies concluded chloramine is more effective at penetration of biofilms than chlorine
  - Potential water quality issues include disinfection byproduct formation (nitrosamines), nitrification, and corrosion

Preventative and Remediation Strategies (Cont.)

- **Chlorine dioxide**
  - Laboratory and pilot scale testing showed effectiveness at low doses (<1 mg/l)
  - Effective against *Legionella* shielded in amoebae and at penetrating biofilms
  - Literature reports successful applications of chlorine dioxide disinfection systems in hospitals
  - Efficacy increased with increased water temperature
  - Potential water quality issues include formation of chlorite and chlorate, taste and odors, and corrosion

Preventative and Remediation Strategies (Cont.)

- **Copper-Silver Ionization (CSI)**
  - Laboratory studies indicate that copper ions (at 0.4 mg/L) and silver ions (at 0.04 mg/L) can reduce cultivability of *Legionella*
  - Literature reports successful applications in building water systems
  - Biofilms and inclusion of Legionella in amoeba shield the organism from CSI
  - *Legionella* strains appear to develop resistance to copper and silver
  - Potential water quality issues include high copper concentrations, and corrosion

Preventative and Remediation Strategies (Cont.)

- **UV Disinfection**
  - Has shown to be effective at decreasing and in some cases, eliminating *Legionella* from building water systems at low doses (40 mJ/cm2)
  - Only effective on water flowing through the reactor; when *Legionella* is already present in building water systems, supplemental treatment is required
  - Some UV reactors may not be tolerant of high temperatures (e.g. > 35^{o}C/ 95 ^{o}F) or certain chemical disinfectants.
  - Iron, manganese, calcium and magnesium may affect the quartz lamp sleeves decreasing UV output.

Preventative and Remediation Strategies (Cont.)

- **Point-of-Use Filtration**
  - Effectiveness demonstrated by several case studies
  - Dependent on pore size (≤ 0.2µm).
  - Depth filtration, including the use of silver-incorporated BAC filtration, not effective
  - Filters may clog and failure could lead to release of high levels of pathogens.

Preventative and Remediation Strategies (Cont.)

- **Emergency Disinfection**
  - Superheat-and-Flush Disinfection
    - Involves raising the hot water temperature to 71-77 ^{o}C while flushing each outlet for at least 30 minutes.
    - Has shown to be effective, particularly in hospital outbreak scenarios.
    - Regrowth is a major issue. May not provide long-term control unless combined with supplemental disinfection.
  - Shock Hyperchlorination
    - Involves injecting elevated chlorine concentration (20-50 ppm) for a specific contact time
    - Success for control of *Legionella* has been mixed
    - Legionella can be protected within *Acanthamoeba*, which can survive chlorine concentrations of 50 ppm.

Regulatory Context

- Adding treatment in the facility could impact chemical and microbial water quality
  - Certain federal and state regulatory requirements may apply.
- Consult with Primacy Agencies for specific requirements
  - For primacy agency contacts visit: http://water.epa.gov/drink/local/.
  - To identify the appropriate EPA regional office visit: http://www2.epa.gov/aboutepa/visiting-regional-office
- See EPA's Water Supply Guidance (WSG 90) for information on the approval process of alternative drinking water treatment technologies (http://water.epa.gov/lawsregs/guidance/sdwa/upload/wsg_90.pdf)

Next Steps

- Publish draft document – Summer 2015
- Public input
  - Public listening session/webinar – Summer 2015
- Independent external peer review – Late Summer 2015
- Publish final document – Fall 2015

Questions?