Ohio WEA-AWWA 2014 Technical Conference & Expo

Challenges in Maintaining Drinking Water Quality at Hospitals and Other Large Buildings

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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***
  - - Flow: Continuous Turbulent → Long Stagnation
  - - Temperature, Redox Potential, pH, Disinfectant Residual: Highly Variable

Variable end water quality possible between:

- Floors
- Water Outlets
- Hot and Cold water

} "Representative" sampling?

Hospitals deserve increased attention

- A recent outbreak of hospital-acquired pneumonia in Pittsburg, from waterborne *Legionella* bacteria, caused
  - Several fatalities and lawsuits
  - Congressional investigation
  - Extensive press coverage and criticism
  - Closer look at microorganisms in hospital water

http://www.cnn.com/2012/12/13/health/legionnaires-hospital-water/

Pittsburgh, Pennsylvania (CNN) -- Twenty-nine patients at the Veterans Administration hospital in Pittsburgh have been diagnosed with Legionnaires' disease since January 2011, raising questions about the institution's safety practices.

Five of the cases "are known to have acquired the disease from the hospital," the VA said. Another eight were infected elsewhere, and the source of the infection in 16 cases cannot been determined.

The spate of illnesses has led relatives of two veterans who died after contracting the disease, a type of pneumonia, to blame the hospital.

Hospitals deserve increased attention

CBS EVENING NEWS w/ SCOTT PELLEY FULL EPISO

By JENNIFER JANISCH / CBS NEWS / March 13, 2014, 6:21 PM

VA hospital knew human error caused Legionnaires' outbreak

Internal documents obtained last January by CBS News also indicated the Pittsburgh VA was failing to properly monitor and maintain its water system's Legionella prevention equipment, and that officials were told by a water treatment company that the hospital had legionella bacteria because "systems not being properly maintained."

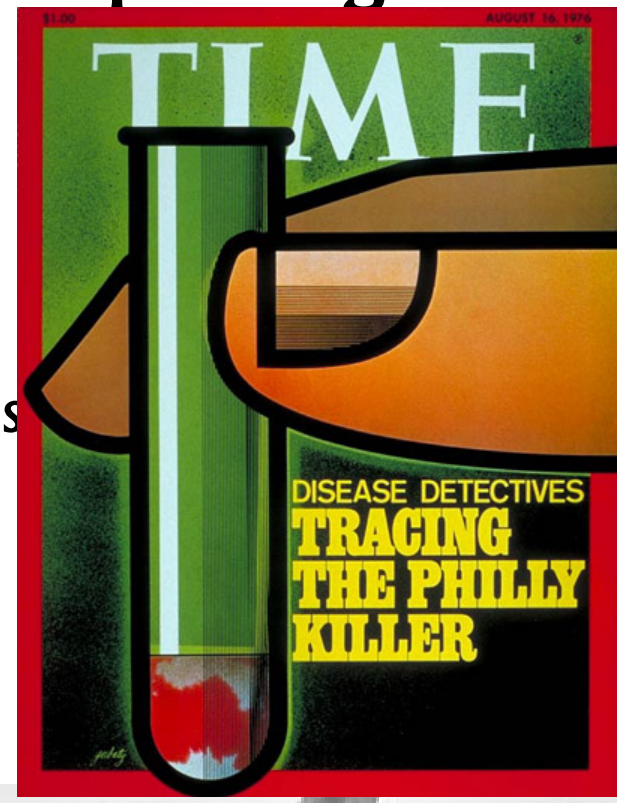
http://www.cbsnews.com/news/va-hospital-knew-human-error-caused-legionnaires-outbreak/

Ice machines were source of Legionnaires', May 2, 2014
http://www.post-gazette.com/news/health/2014/05/02/UPMC-Pittsburgh-hospital-ice-machines-Legionella-patients/stories/201405020165#ixzz312LpSUQx

Legionnaires' Disease Outbreak Linked to Hospital's Decorative Fountain, January 9, 2012
http://www.shea-online.org/View/ArticleId/124/Legionnaires-Disease-Outbreak-Linked-to-Hospital-s-Decorative-Fountain.aspx

Ice machines (ingestion)• Faucets (ingestion/inhalation)
Showerheads (inhalation) • Decorative fountains (inhalation)

Legionella is one opportunistic pathogen



Legionella pneumophila

→Pontiac fever

→Pneumonia, even death to susceptible individuals with risk factors

→Primary cause of waterborne disease in the USA

→ No enforceable regulations MCLG=0, TT, listed on CCL3

→ No consensus on endpoints for remediation

http://en.wikipedia.org/wiki/Legionella_pneumophila

Objectives

- Develop a sampling plan to monitor water quality in hospitals and potentially other large buildings
- Implement sampling plan in a hospital which was interested in participating
- Another hospital had already been sampled (different sampling plan), data were revisited
- Both hospitals chose to install in-building disinfection
- Understand implications of in-building disinfection:

  →End water quality before/after

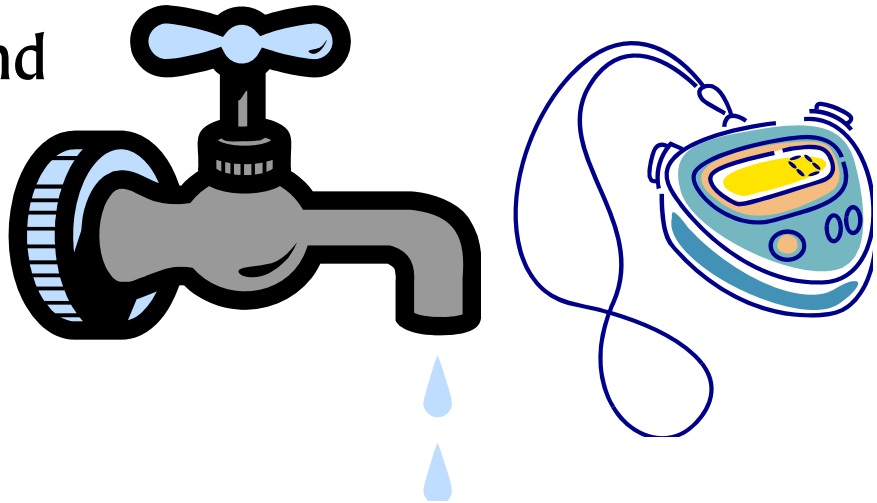
  →Regulatory requirements after

Case Study 1: Hospital Before In-building Disinfection

- Buildings A & B - Eight floors per building
- Receives treated surface water

  (pH= 8.6, Alkalinity=75 mg/L as $CaCO_3$, free chlorine=1 mg/L)
- Sample water faucets at 10 selected nurse break rooms of A & B:
  - once every few months (on-going)
  - 250 mL of **first-draw water** and

    1 L of **flushed water** (3 min)
  - hot water and cold water
  - water chemistry



Case Study 1: Hospital Before In-building Disinfection

- Initially sampled 40 showerheads from available patient/staff bathrooms:
  - depended on accessibility during visits
  - microbiological parameters in biofilms
  - 120 showerheads to be analyzed in total before/after in-building disinfection (on-going)

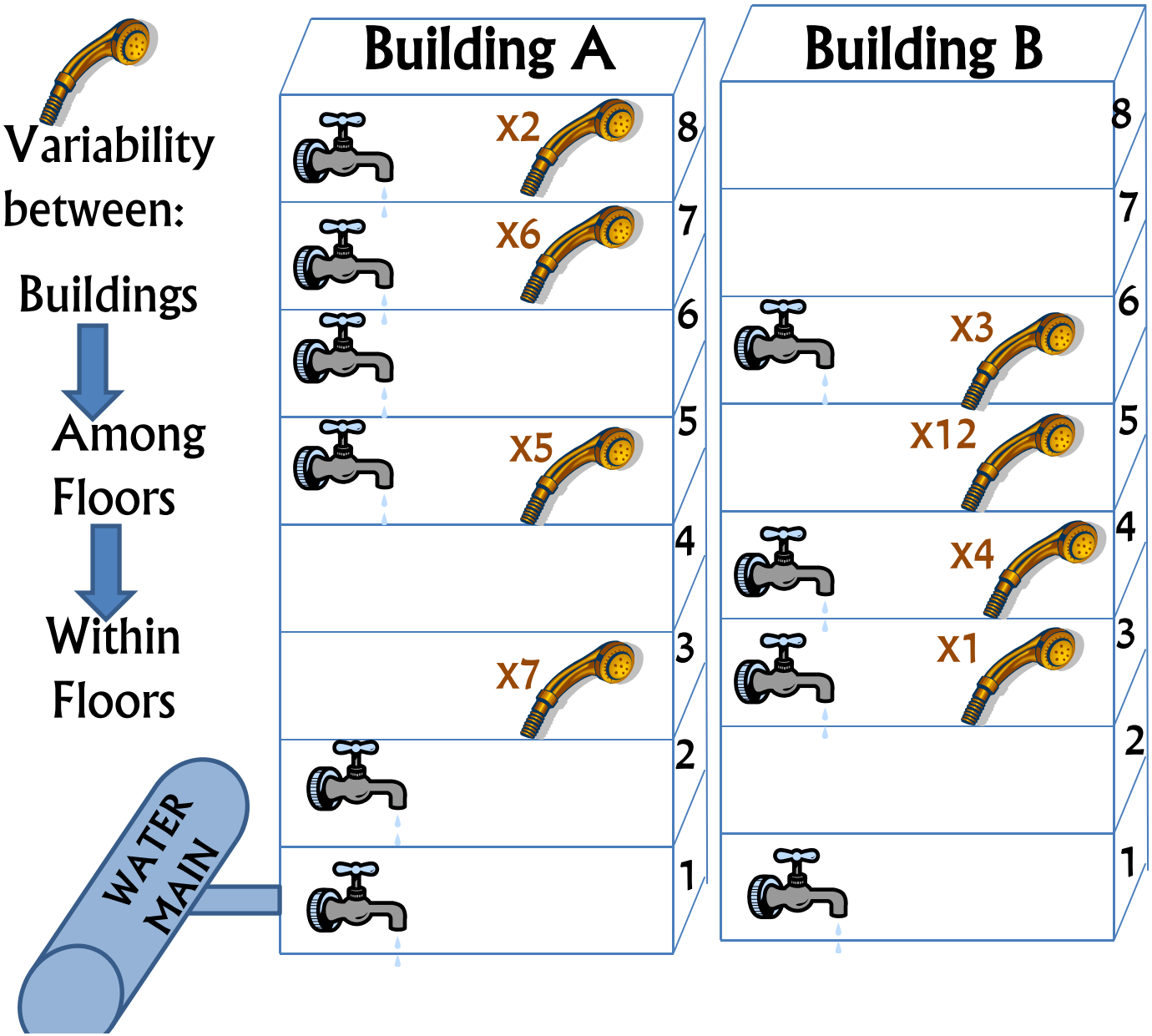
Case Study 1: Sampling Plan

Variability between:

Buildings

Among Floors

Within Floors



Variability between:

Buildings

Floors

First Draw and Flushed Water

Hot and Cold Water

Case Study 1: Collection of Tap Water

<u>On-site Water Parameters:</u>

- pH
- Temp.
- Chlorine

<u>Laboratory:</u>

Inorganic trace elements:

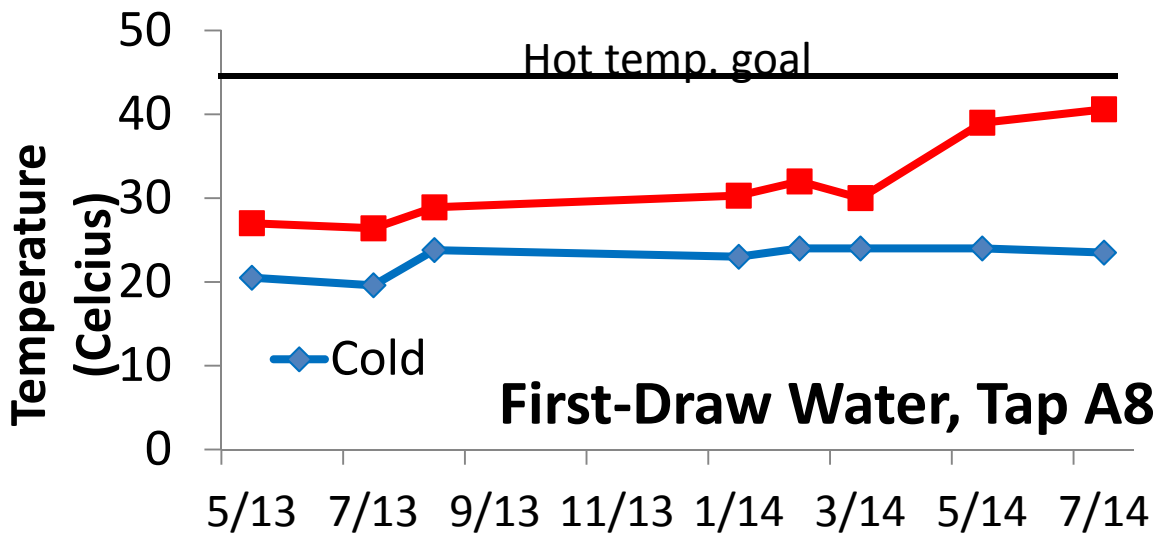
- ICP-MS
- ICP-AES

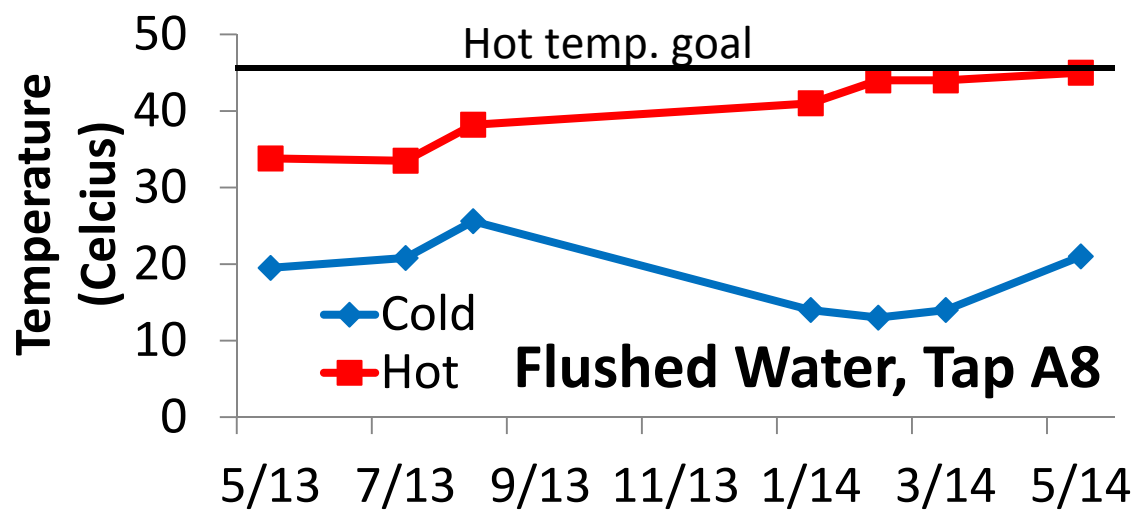
Case Study 1: Collection of Showerheads

<u>Microbiological Parameters</u>
(cultural assays and molecular):

- *Legionella* bacteria in biofilms
- Other pathogens (not discussed herein)

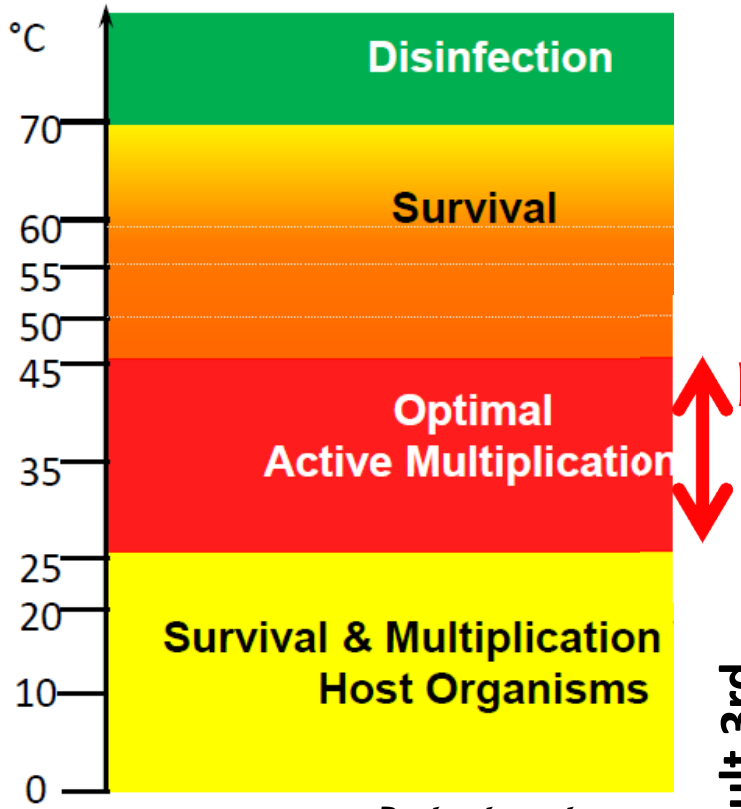
Case Study 1: Temperature variability





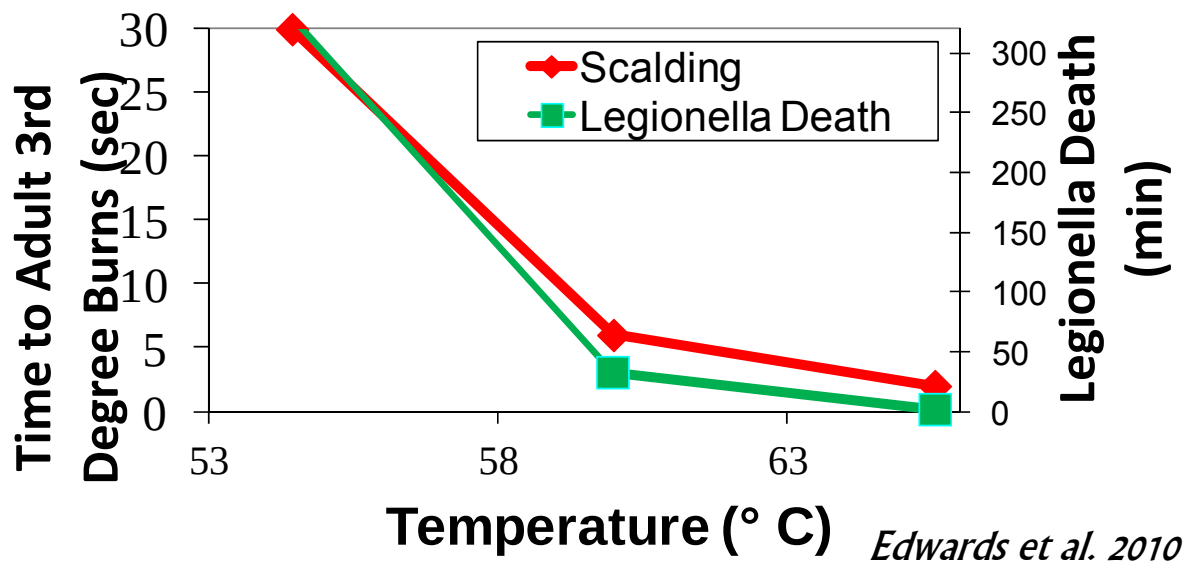
- Maintaining high enough hot water temperature to inactivate/kill pathogens is a first line of defense
- Not achieved in hot, first-draw water
- Flushed hot water warmer than first-draw hot water
- Tempering valves

Temperature cannot control *Legionella* and prevent scalding concurrently



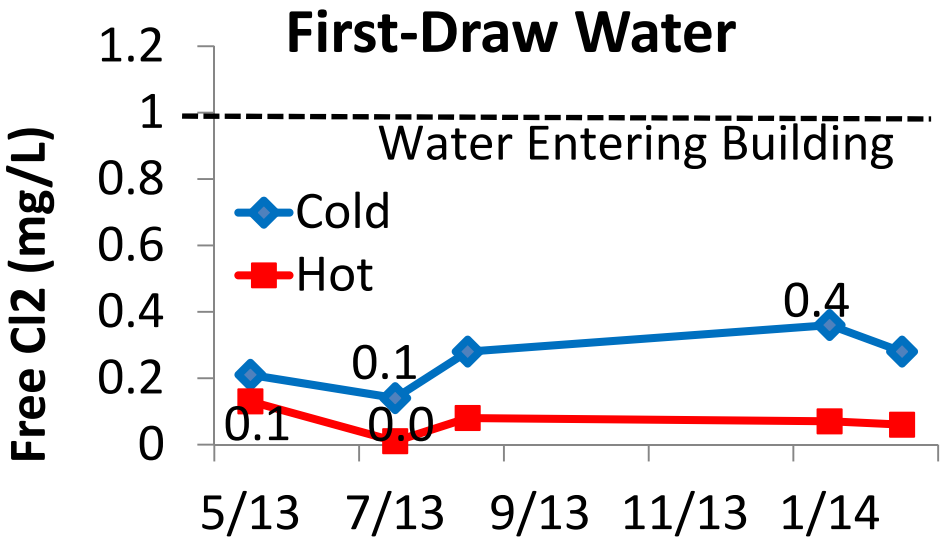
Bedard et al., 2013

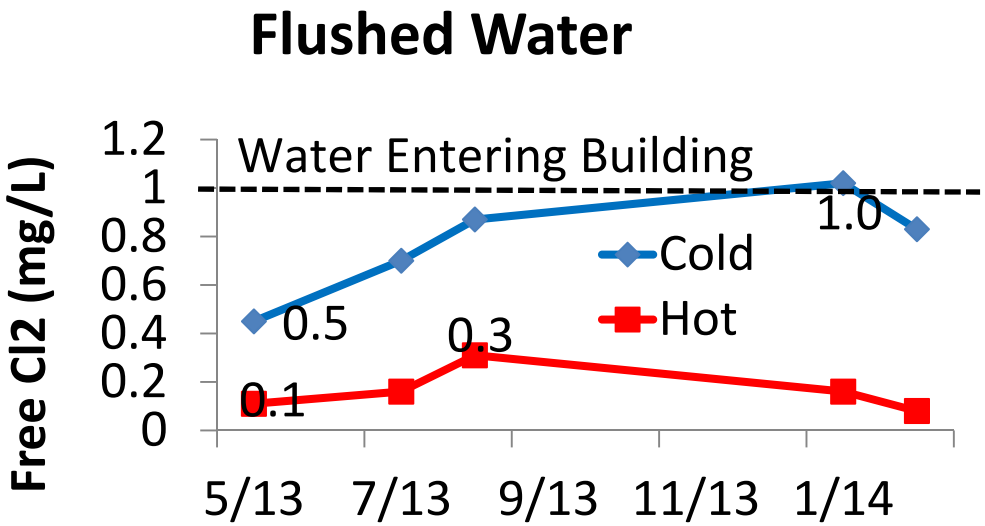
Hospital hot water in range that *Legionella* like



Edwards et al. 2010

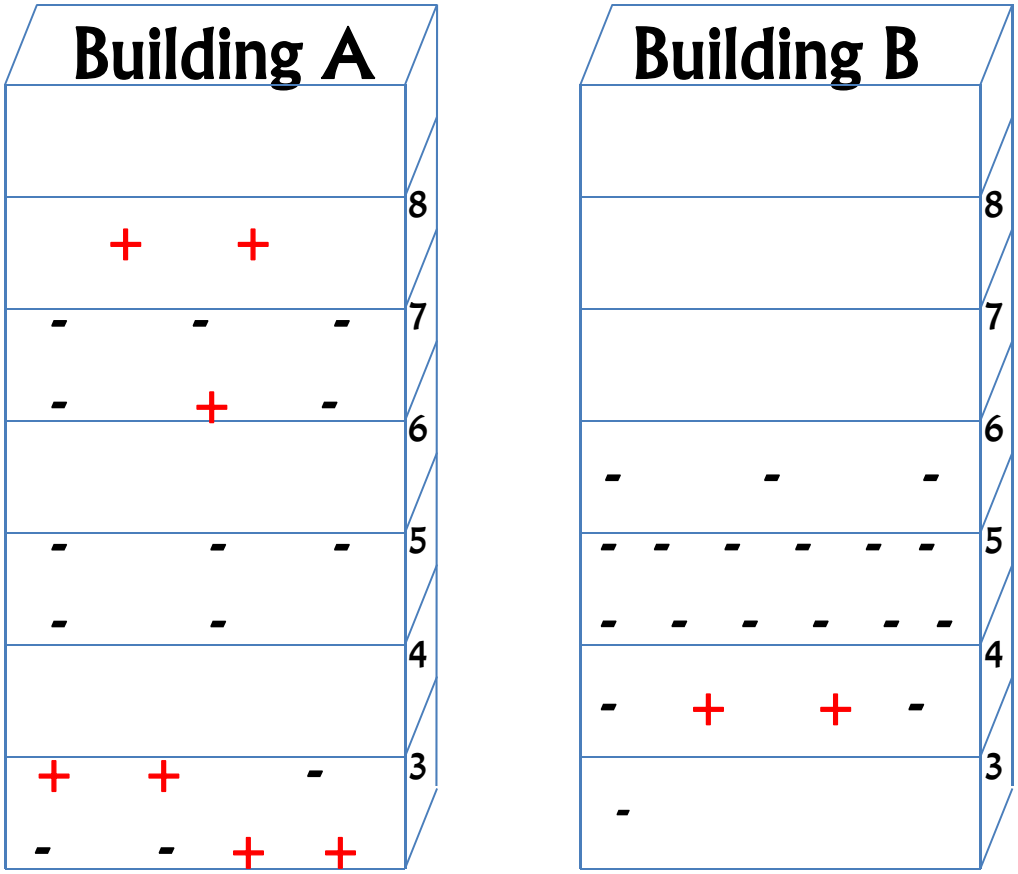
Case Study 1: Disinfectant variability





- Water entering the hospital loses much of its chlorine disinfectant within the hospital
- First-draw water has less disinfectant than flushed water
- Hot water has less disinfectant than cold water
- Are these levels sufficiently protective against pathogens?

Case Study 1: *Legionella* bacteria in showerhead biofilms



9/40 positive
L. pneumophila
serogroup 1 [qPCR]

- Some showerheads with less HPC counts (results not shown) tested positive
- Others with more HPC counts tested negative

Many hospitals nation-wide opt to <u>proactively</u> control pathogens by adding "in-building" disinfection

In-building disinfection

→ Thermal disinfection

Example: ASHRAE Guideline 12-2000

- Water always stored at > 60°C in water heater
  > 51°C in hot water lines
- Different instructions after outbreaks or for periodic thermal disinfection

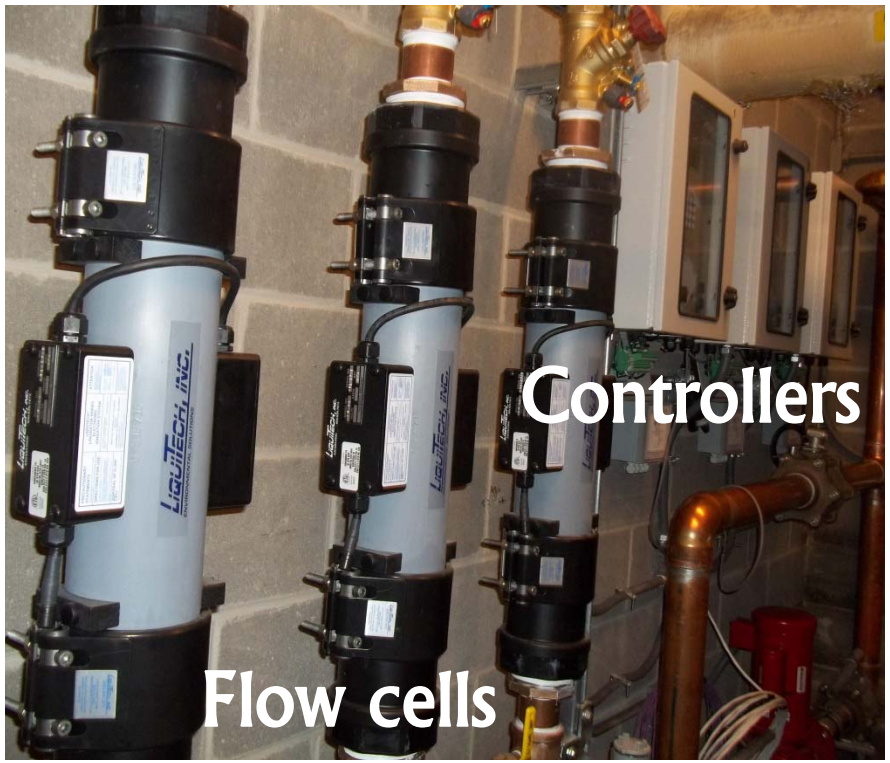
→ Chemical Disinfection

- Chlorine
- Chloramine
- Chlorine dioxide
- Copper-silver ionization
- UV irradiation
- Ozone

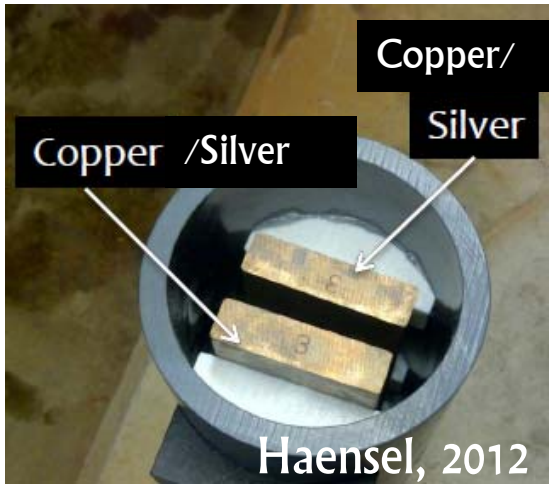
All methods have expected advantages/disadvantages

- EPA is preparing review document
- Water Research Foundation Report # 4379

Copper-Silver Ionization is one option



Inside a
"Fresh" Flow cell



Good
Maintenance
Needed

- Adds copper ions (Cu^{+2}) and silver ions (Ag^{+}) to water →biocides
- Only a fraction of copper and silver will remain in free ionic form depending on water chemistry

Case Study 2: Hospital with copper-silver ionization in hot water to control *Legionella*

- 6 faucets - biofilm swabs
- 4 faucets - first draw water and flushed water (1 min), hot only
- Microbiological parameters in swabs
- Metallic contamination and water chemistry in bulk water
- Before/after copper-silver ionization

Case Study 2: *Legionella* bacteria in faucet biofilms

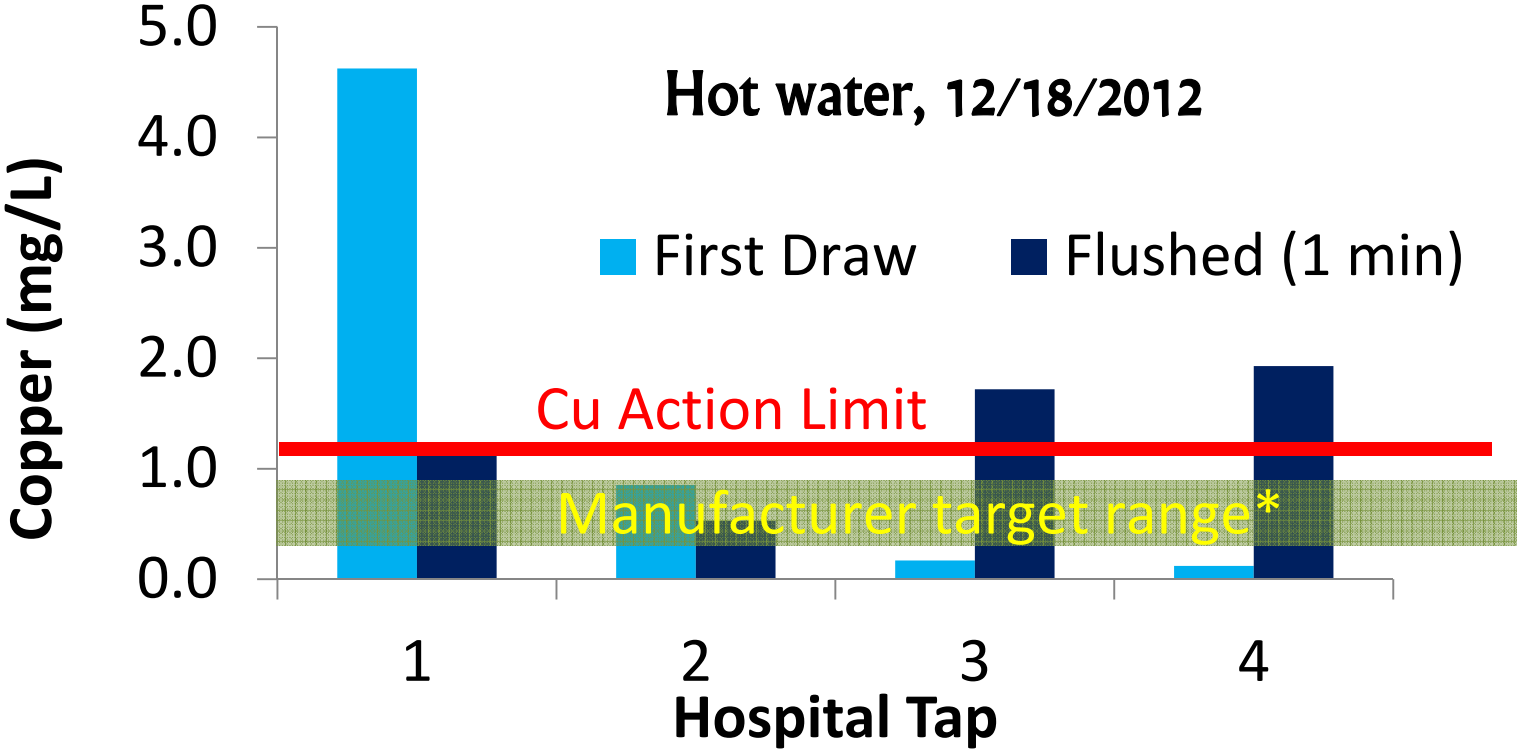
Activation of Cu-Ag unit →

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

+ means positive *L. pneumophila* [by culture]

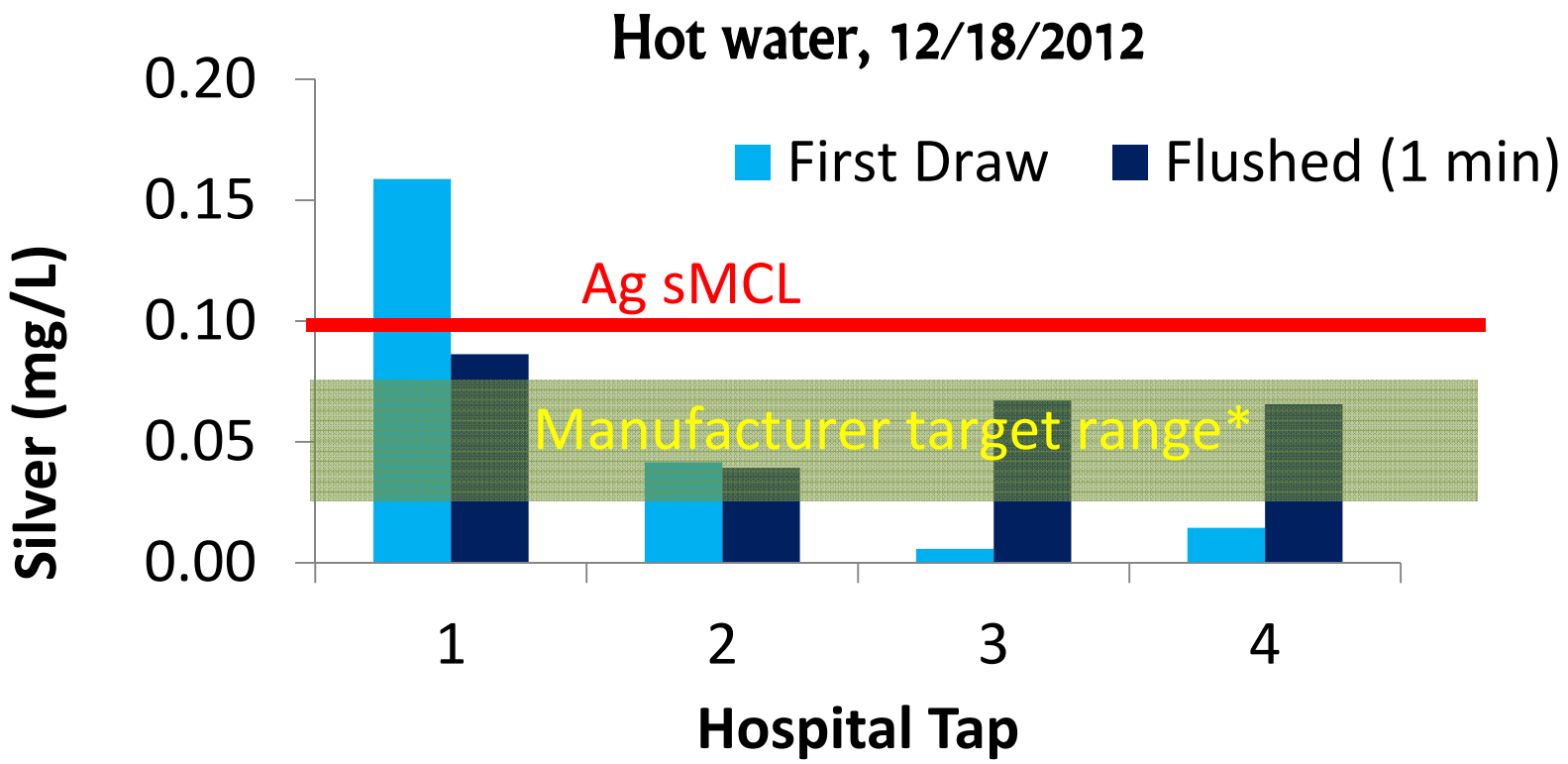
- Initial results optimistic
- Longer-term data are needed

Case Study 2: Copper in water



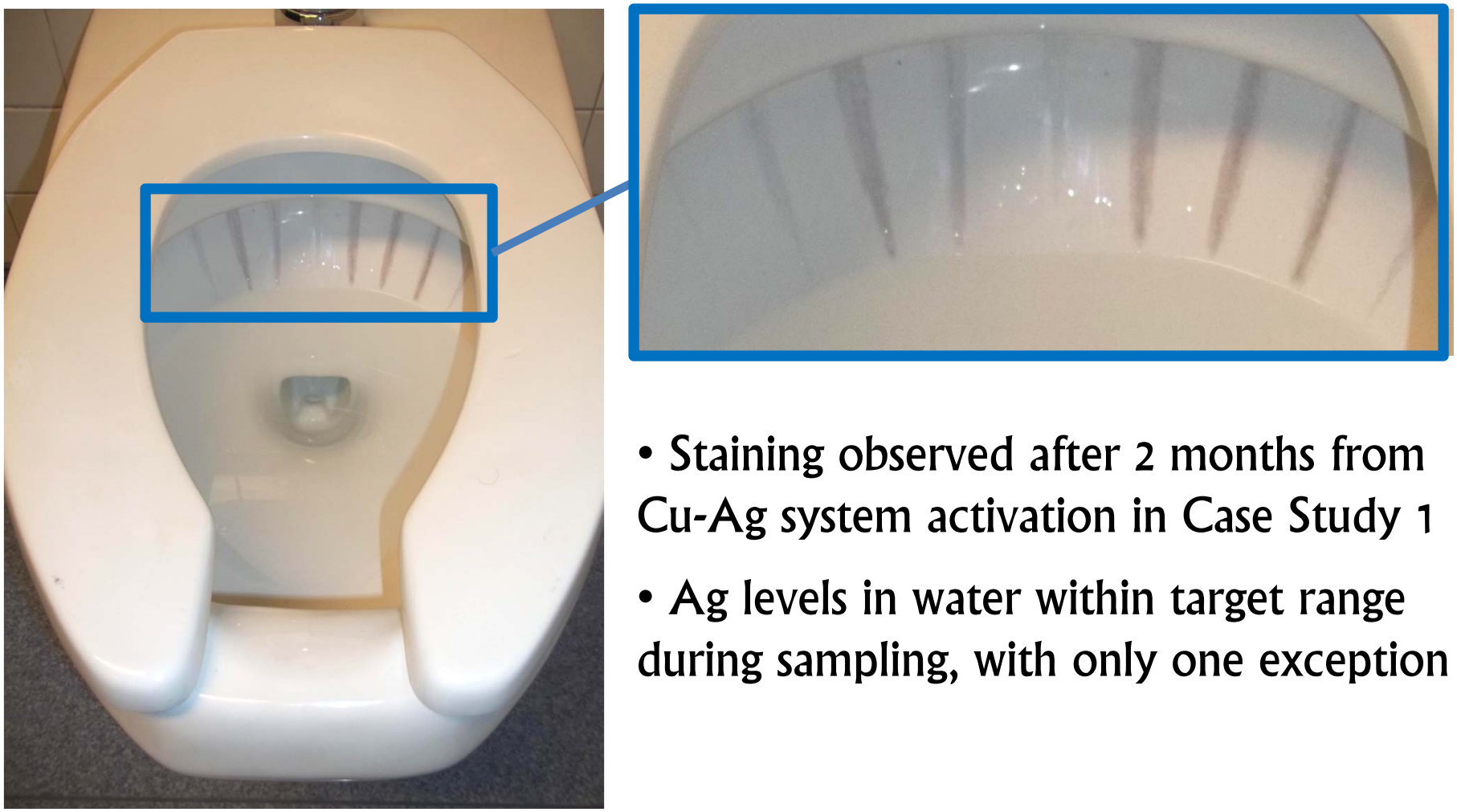
- Copper from ionization unit and from plumbing
- Copper levels variable between taps. Typically within desired ranges, but occasionally:
  - Some higher than Cu Action Limit (first-draw and flushed water)
  - Some lower than manufacturer target range in first-draw water

Case Study 2: Silver in water



- Silver from ionization unit only
- Silver levels variable between taps. Typically within desired ranges, but occasionally:
  - One tap higher than Ag secondary MCL in first-draw water
  - Some taps lower than Ag target range in first-draw water

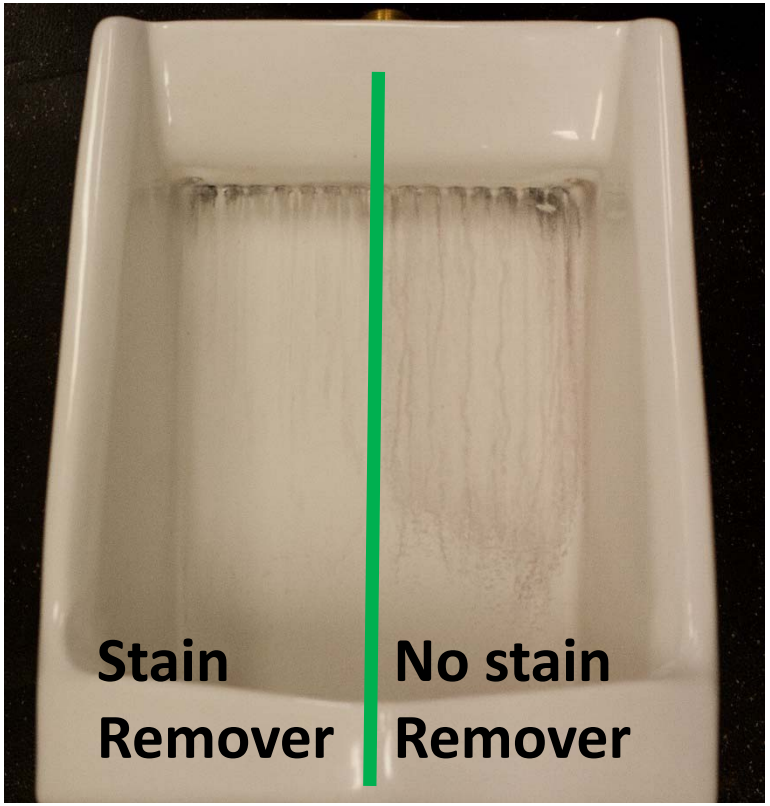
Undesirable staining



- Staining observed after 2 months from Cu-Ag system activation in Case Study 1
- Ag levels in water within target range during sampling, with only one exception

Undesirable staining

Undesirable staining



- Consulting firm removed stains with aggressive cleaner (hydrofluoric acid)

Undesirable staining

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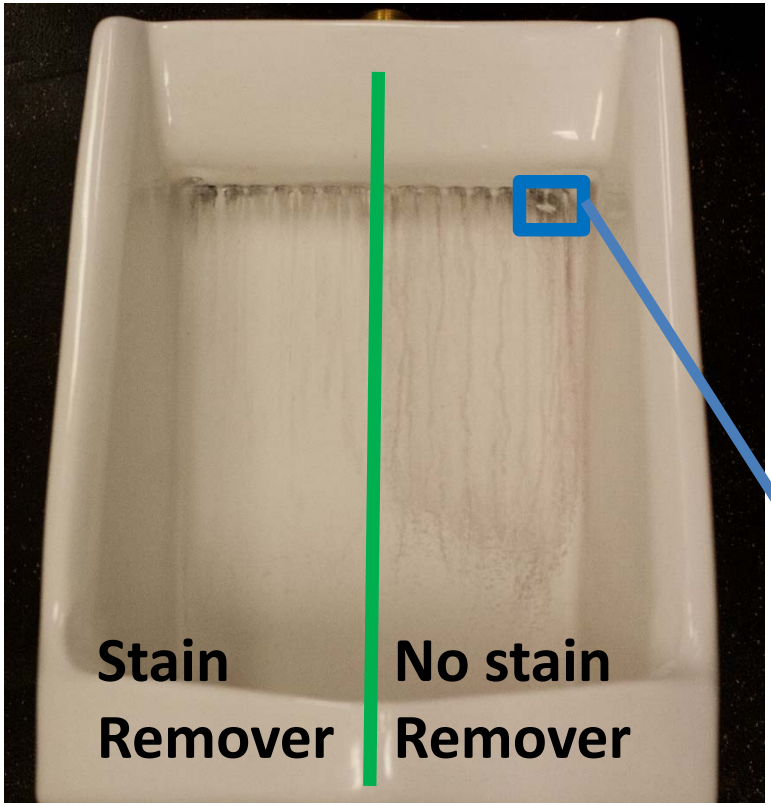
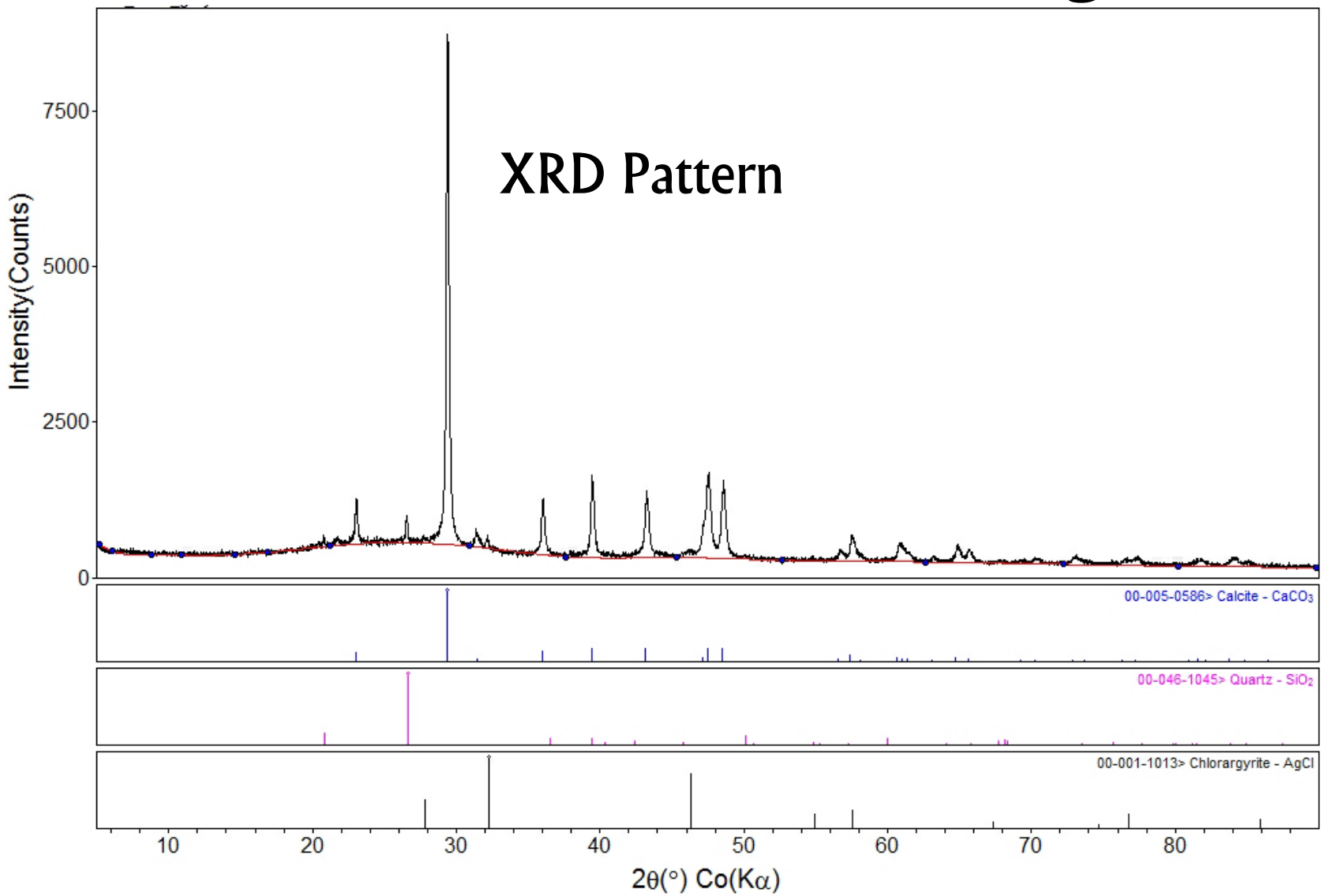
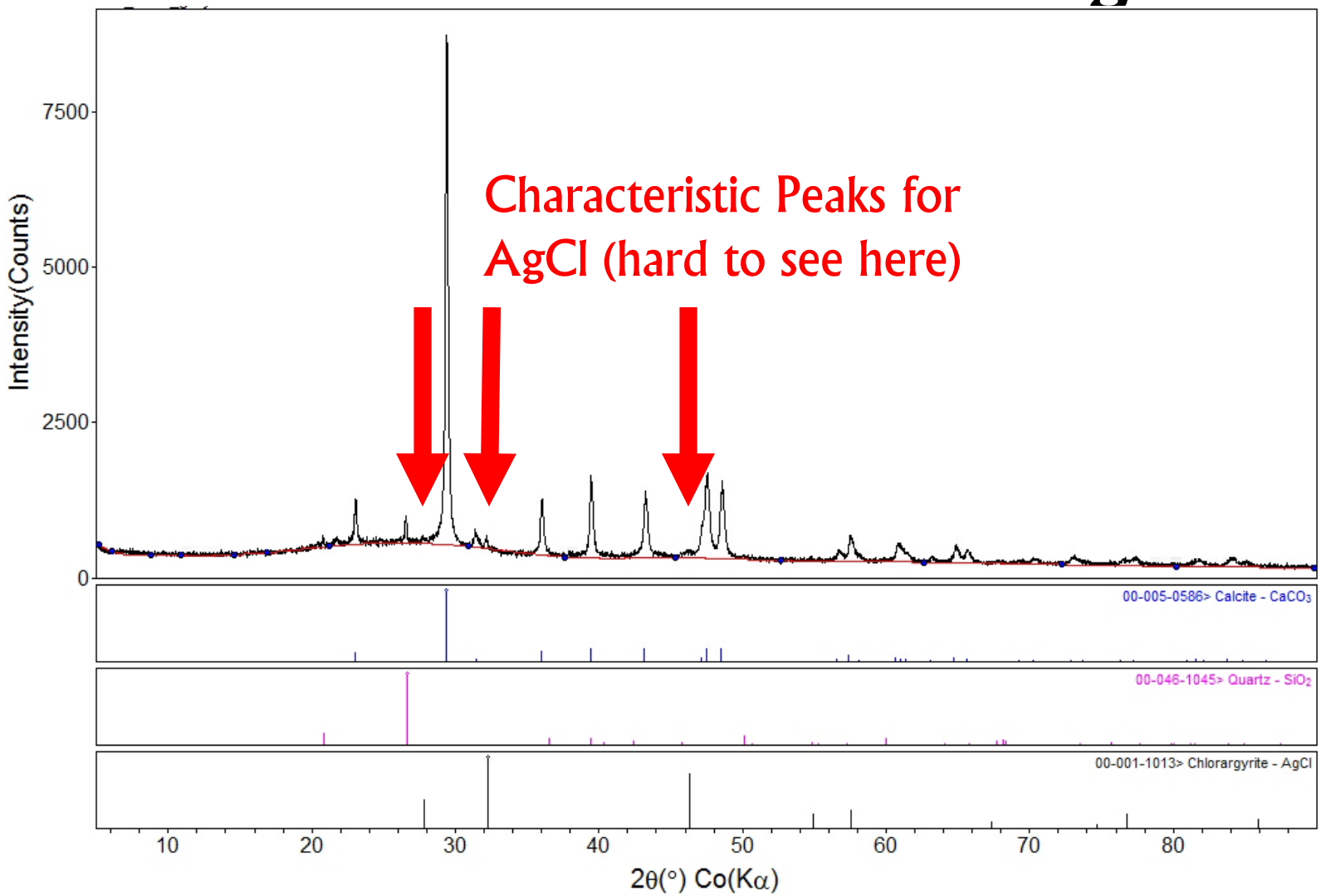


- XRD Analysis at EPA to identify precipitate

Undesirable staining



Undesirable staining



- AgCl identified as cause of staining
- Calcite and Quartz also identified (as expected)

In-building water treatment may alter the incoming water quality (intended and unintended)

How should it be monitored to ensure the safety of water?

Safe Drinking Water Act (SDWA) Provisions

A public water system (PWS):

→ Service connections ≥ 15, or

→ Individuals served ≥ 25

A PWS is not regulated if:

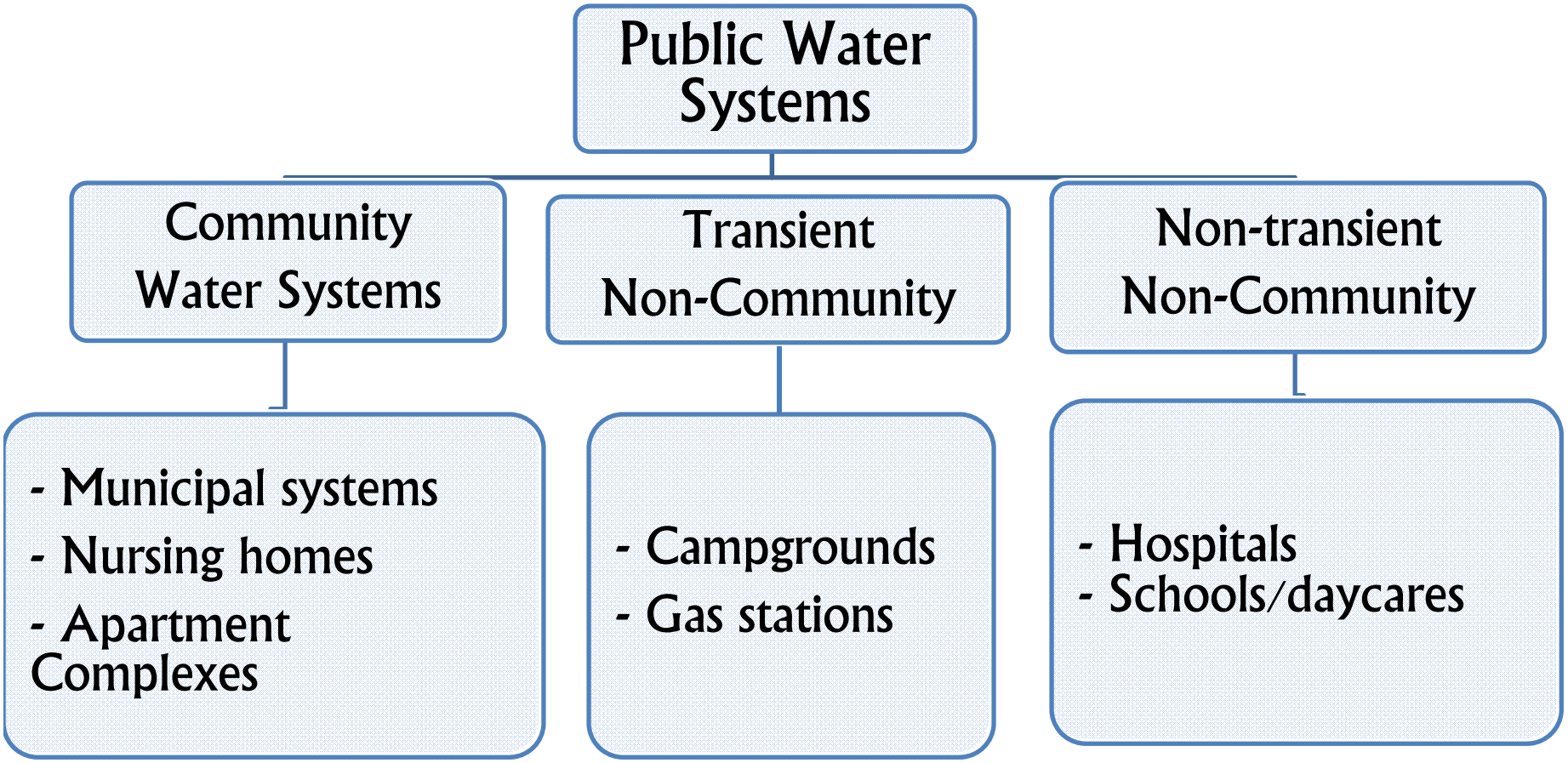
→ It has distribution and storage facilities, but

→ Does not have any collection and treatment facilities

Hospitals that receive water from a PWS:

→ Are subject to SDWA if they have their own additional treatment facilities

SDWA also applies to other large buildings



Schools, nursing homes, apartment complexes, casinos/resorts, etc. that meet the PWS definition, if they add their own in-building water "treatment"

SDWA requirements: Case Study 1

- Hospital had pre-existing softener for hot water line (not considered "treatment" under SDWA)

- In 2014 hospital activated Copper-Silver Ionization System for hot and cold water

→Non-Transient Non-Community (NTNC) PWS no longer exempt from SDWA requirement

SDWA requirements: Case Study 1

Primacy Agency
Ohio EPA

- Determined that based on specific treatment:
- Cu and Ag need to be monitored and reported
- No LCR, no Legionella, no TCR, no DBP testing required

Water Utility

- Operator in responsible charge
- Visit hospital 3 times/week to collect water samples for Cu and Ag (hot and cold water based on vendor recommendations)
- Monthly operating reports to the State

Hospital

- Daily grab monitoring for Cu
- Maintenance/proper operation of unit in coordination with water utility (monthly cleaning of metallic bars, replace/maintain valves/flow meters, etc.)

Vendor

- Advise on and check maintenance/proper operation of unit
- Replace metallic bars in flow cells

Summary

- *Legionella* colonized hospital showerheads, disinfectant residual was not sufficient and hot water temperature was not high enough
- Variability between first-draw and flushed water, hot and cold water, different floors and different buildings
- Hospital case study will be continued for longer-term

- Hospitals choose to proactively control possible disease outbreaks by selecting from a variety of "in-building" disinfection methods
- These may alter end drinking water and potentially affect primary or secondary drinking water contaminants- Cu/Ag ionization example presented here

- "In-building" treatment triggers requirements under the SDWA
- State of Ohio recently regulated a hospital with Cu-Ag ionization
- Other States' interpretation of SDWA may vary

Acknowledgments

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