American Water Works Association | ACE18 ANNUAL CONFERENCE & EXPOSITION

The Link between Fixture Water Use and Drinking Water Quality at a Net Zero Energy Residential Building

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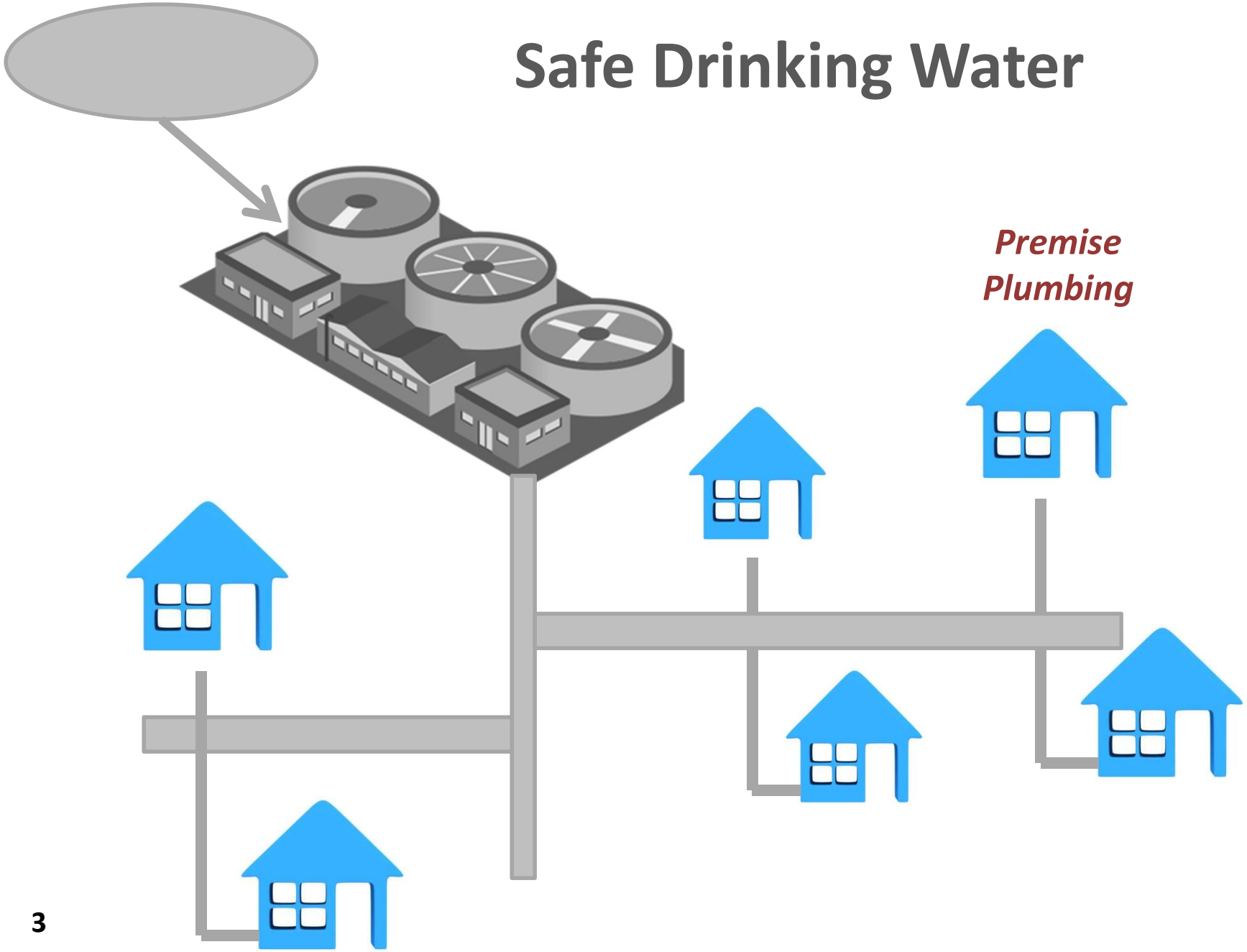
Outline

- ❑ Research Background & Significance
- ❑ Research Goal & Hypothesis
- ❑ Experimental Approach
- ❑ Result & Discussion
- ❑ Summary
- ❑ Future Work

Safe Drinking Water



Building Plumbing System



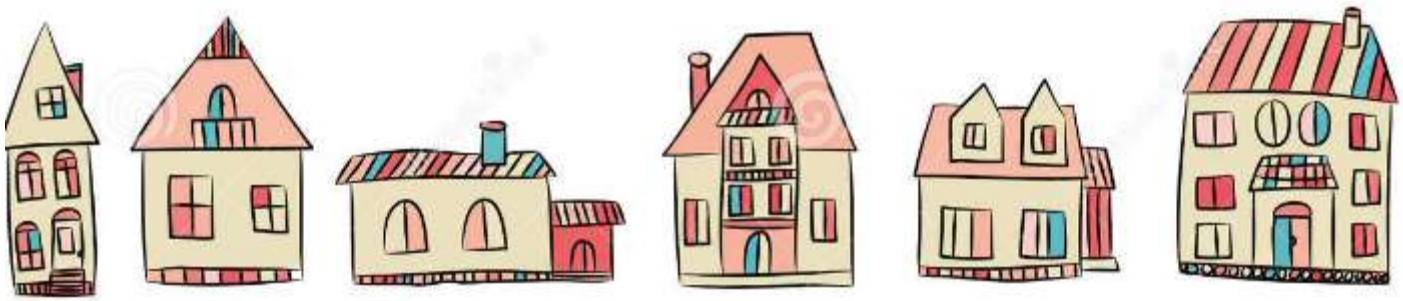




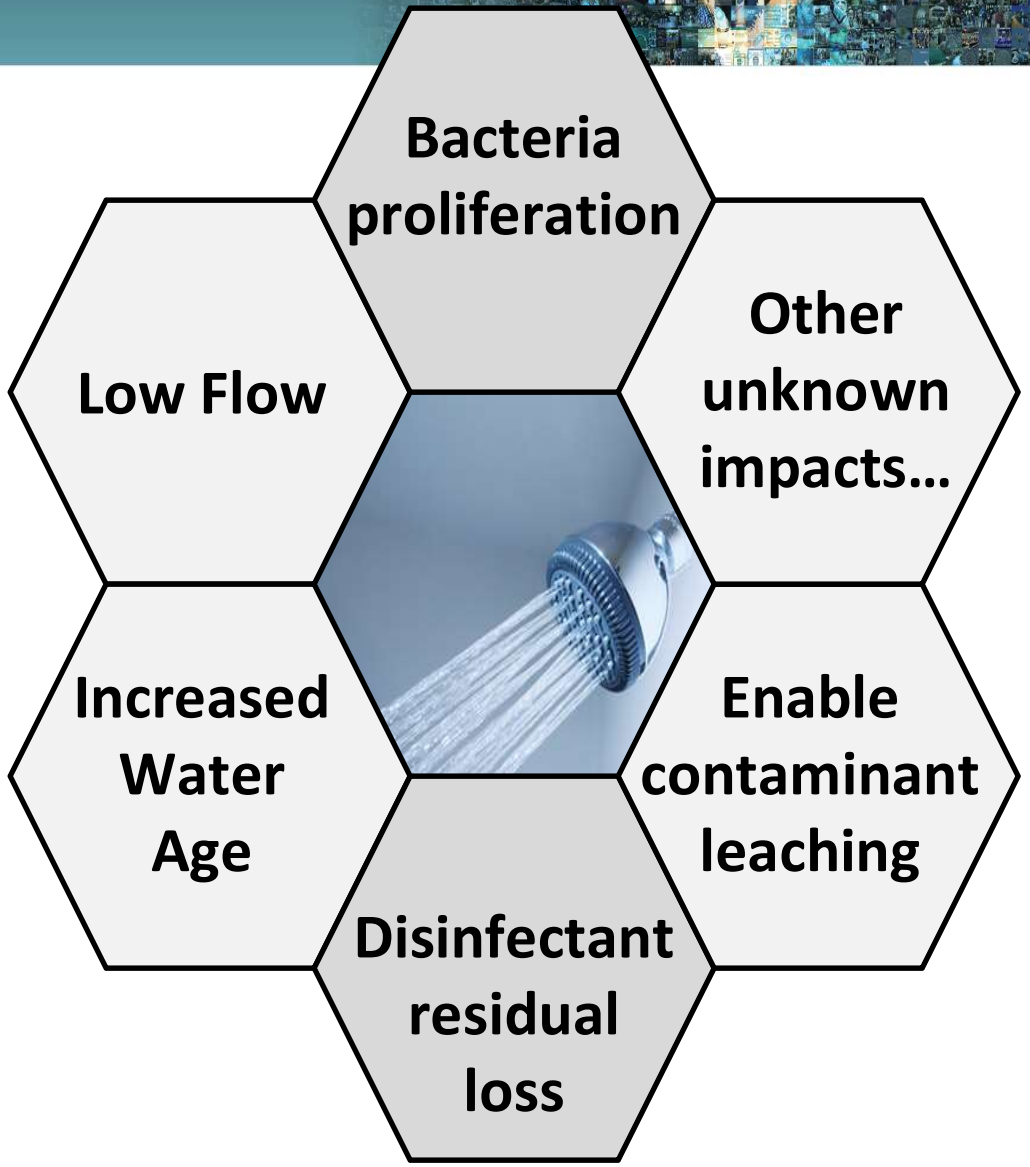



5-10 million miles of plumbing

Residential plumbing is critical for the health and safety of populations worldwide.



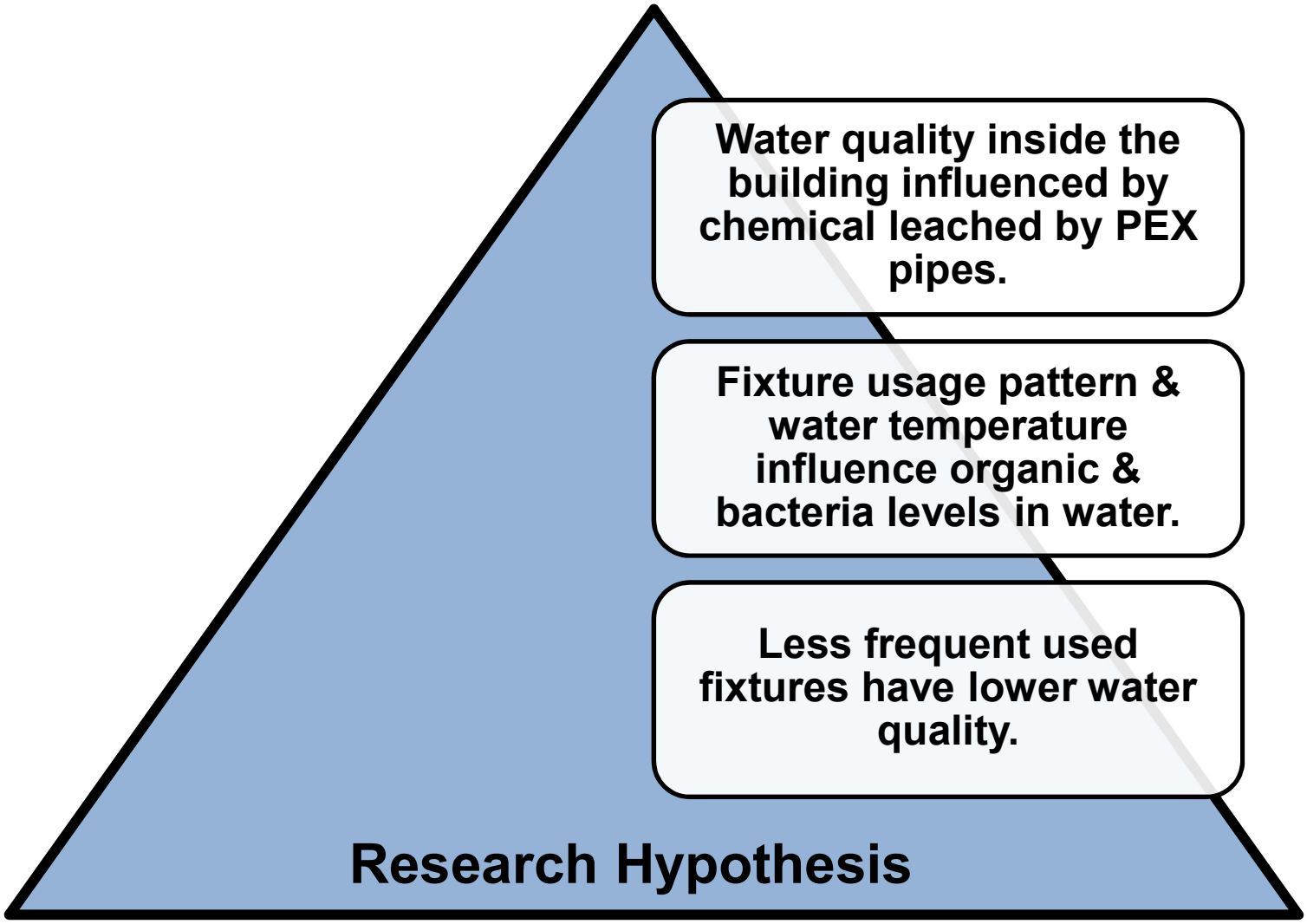
How Water Quality Impacted by Water Saving Practices & Low-flow Devices?



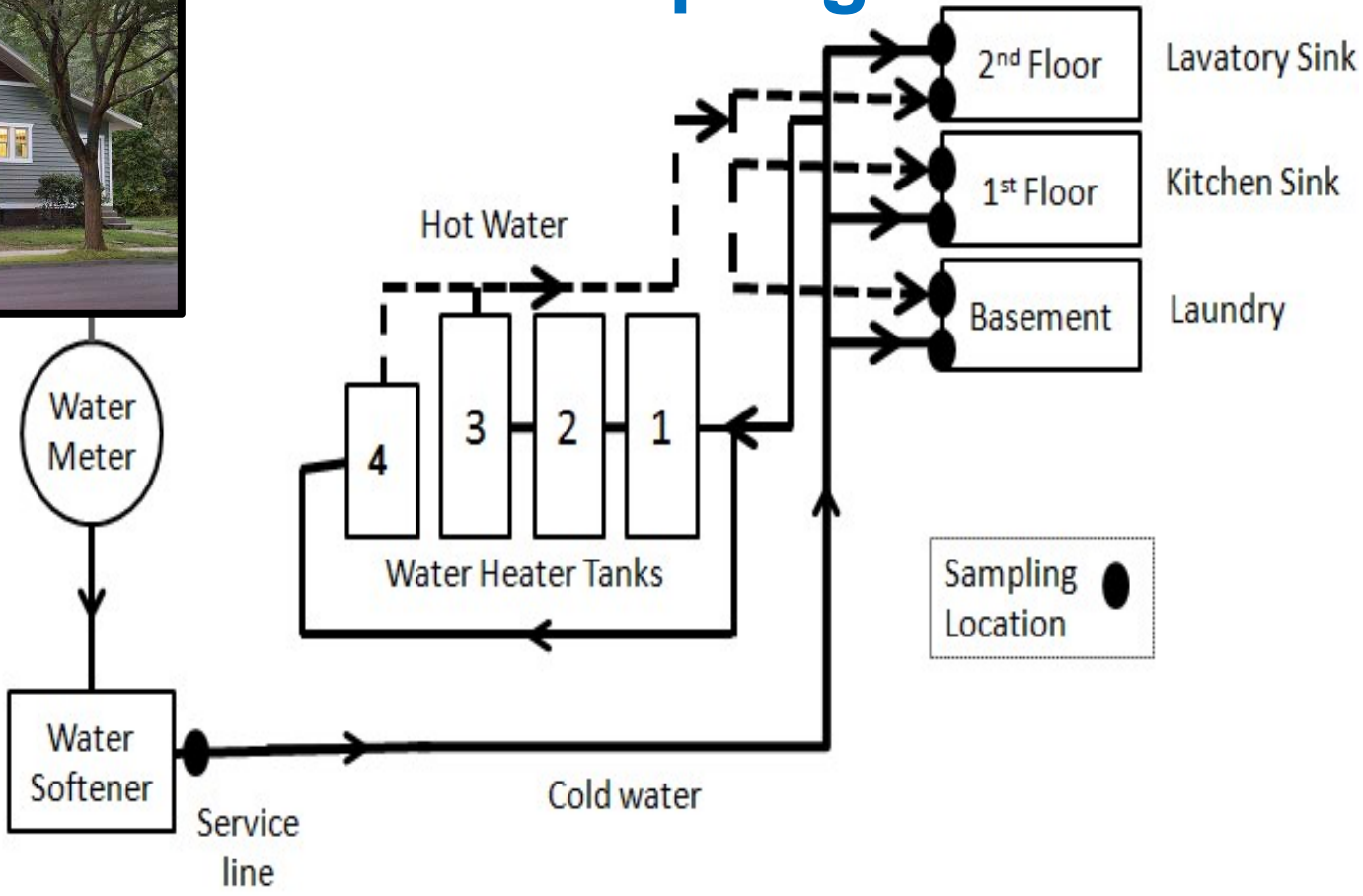
Water Quality has been Monitored at Several Residential Buildings

Location and Type of Buildings (Number)		Pipe Type / Plumbing Age (years)
USA	SFRBs (18)	nr/nr
	NZE SFRB (1)	PEX-a/ 0.5
	NZE SFRB & SFRB (2)	Cu, PEX/nr
	SFRB (3)	PEX-a, PEX-b/0.5-2
	Households (nr)	Cu, plastic/nr
CAN	SFRBs & Apartments (nr)	Cu, plastic/ <5, >10, >40
	SFRBs (6)	nr/nr
IT	SFRBs (nr)	Metal, plastic/nr
SWZ	Households (10)	nr/nr
DE	Households (1,674)	Cu/0.5-5
	Households (1,485)	nr
	SFRBs (nr)	Cu, plastic, galvanized steel/nr
	SFRBs (4)	Cu/nr

Goal: Better Understand the Link Between Water Use & Drinking Water Quality.



Water Sampling



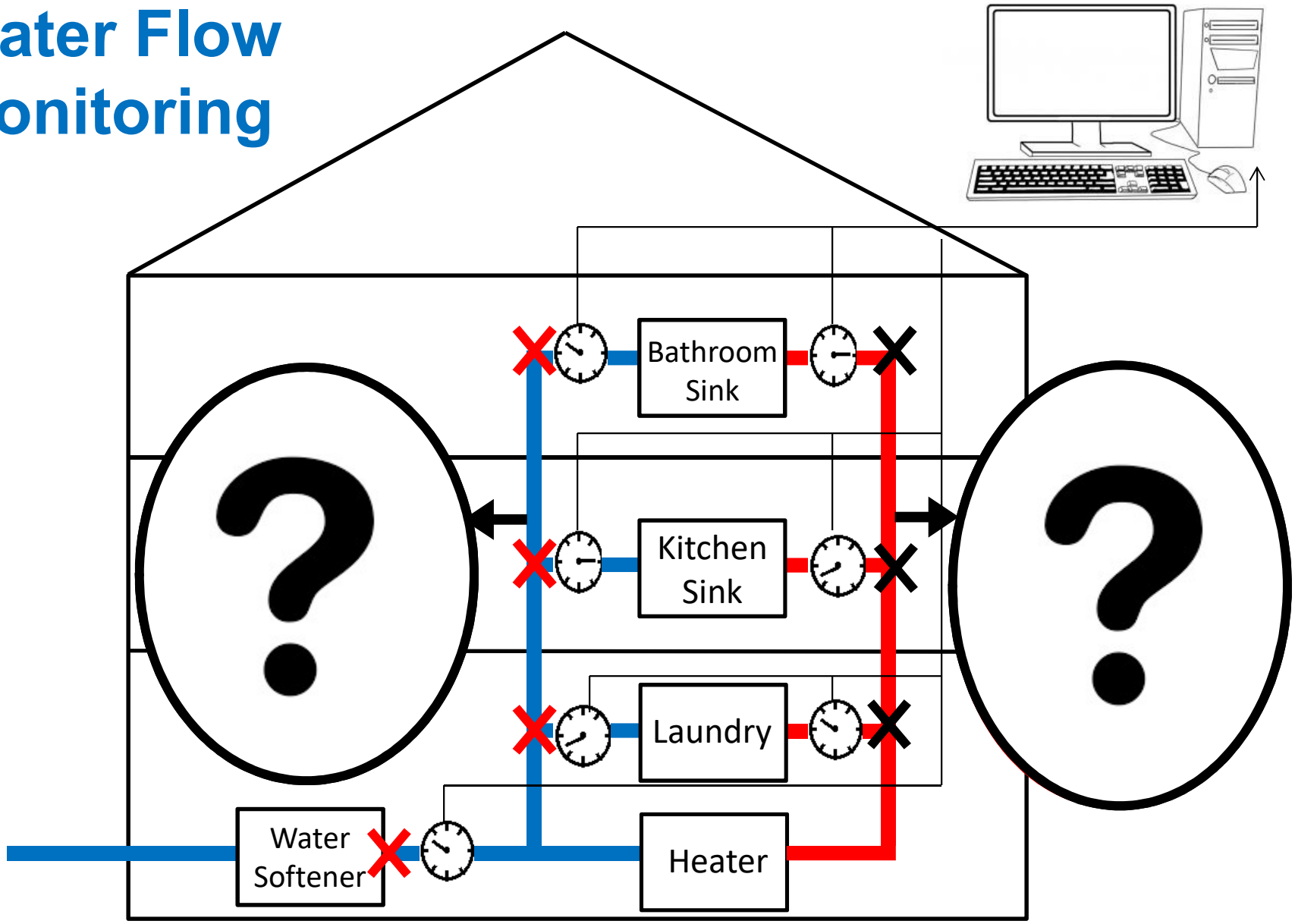
Water sampling (cold/hot) on day 3, 15, 30, 60 & 90

Water Quality Monitoring

Chemical Quality: Free chlorine, pH, Alkalinity, Total Organic Carbon (TOC),UV_{254} absorbance, Metals, Threshold Odor Number (TON)

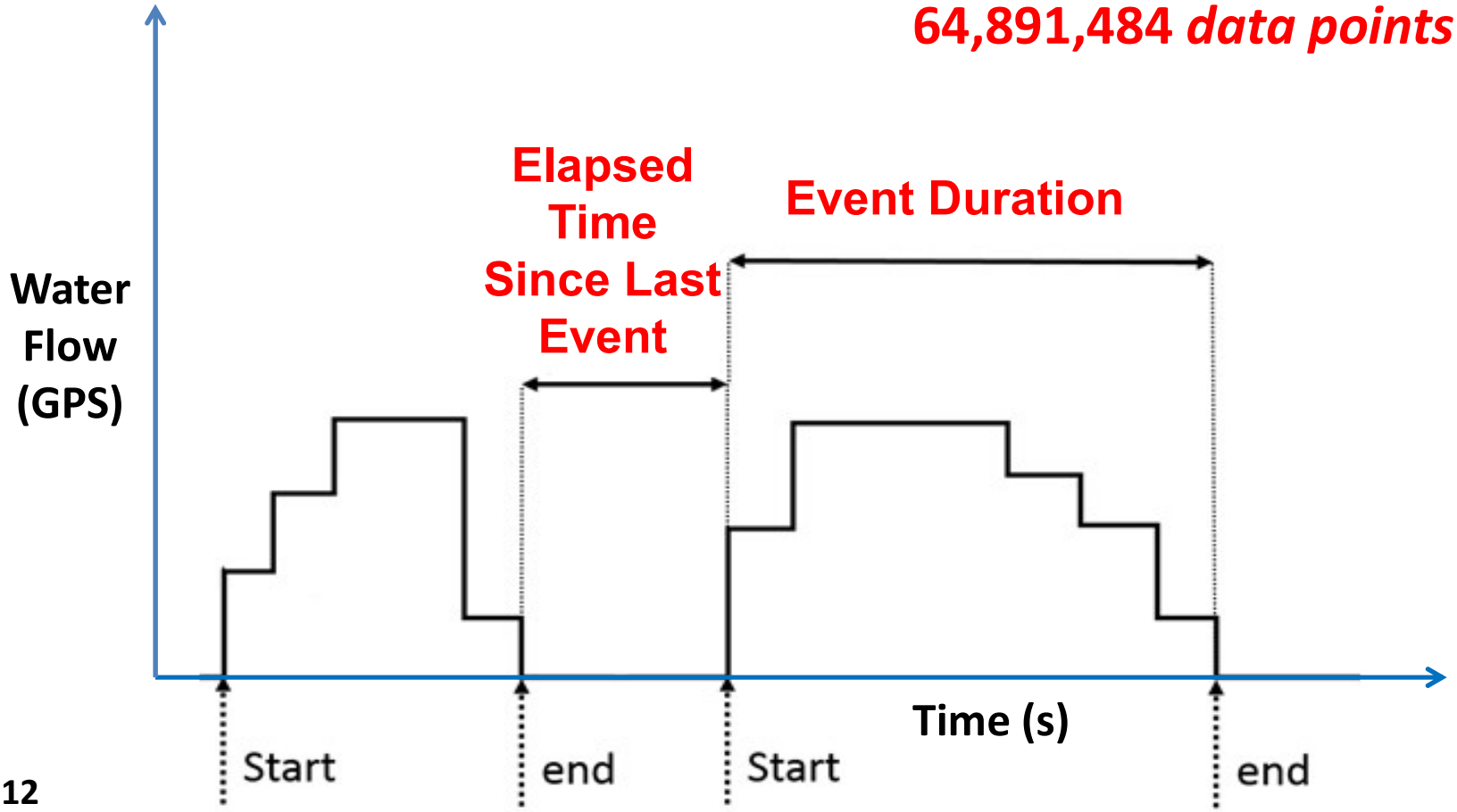
Bacterial Quality: Culture-based HPC & Culture-independent quantitative real-time PCR (qPCR)

Water Flow Monitoring



Water Usage Analysis

64,891,484 data points



Water Usage Patterns

Parameter / Fixture	Total Volume Used (m^3)	Number of Events	Average Elapsed Time (hr)	Maximum Elapsed Time (hr)
Service Line	5.2	3535	0.1	72
Basement-Cold	0.4	60	0.5	72
Basement-Hot	0.4	21	0.7	72
1st Floor-Cold	0.3	619	0.6	72
1st Floor-Hot	0.2	389	0.9	72
2nd Floor-Cold	0.1	145	2.0	72
2nd Floor-Hot	1.0	825	0.5	72

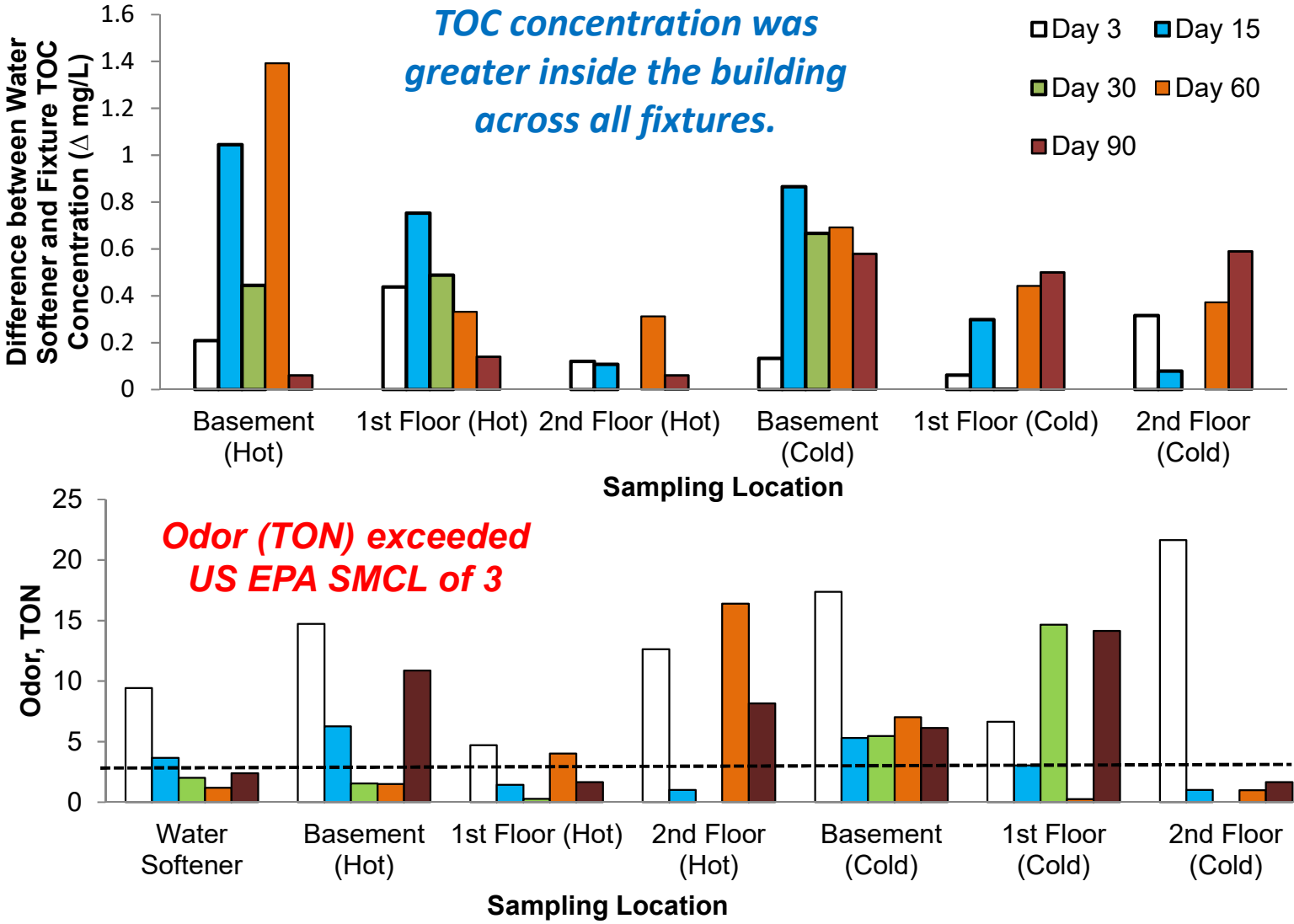
Water Usage Patterns

- During October to December the daily water usage varied between **0.169-0.245** m^3/d.

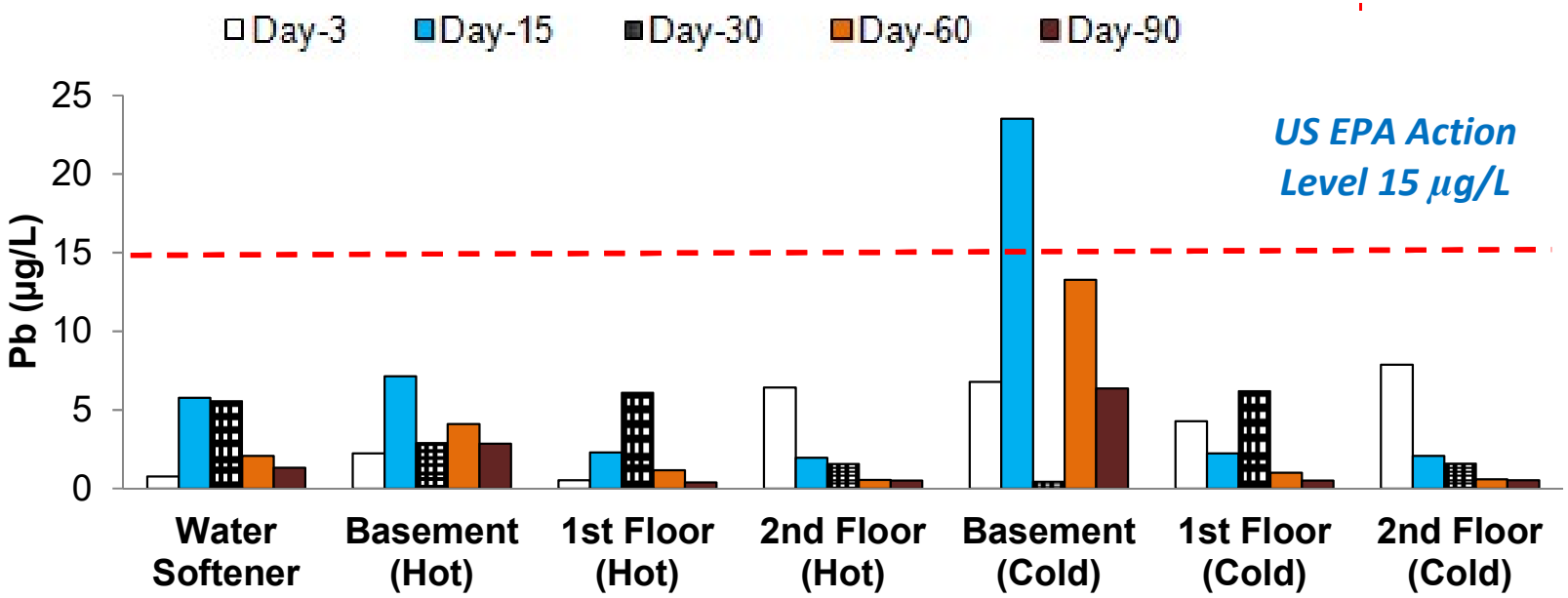
- **Basement fixture** was the least used (number of events at cold: 60-105, hot: 21-69) compared to the other fixtures in the building (number of events at cold: 145-856, hot: 326-2,230).

- During October to December the most frequently used fixture was the **2nd floor hot water** (bathroom sink, number of events per month 2,230).

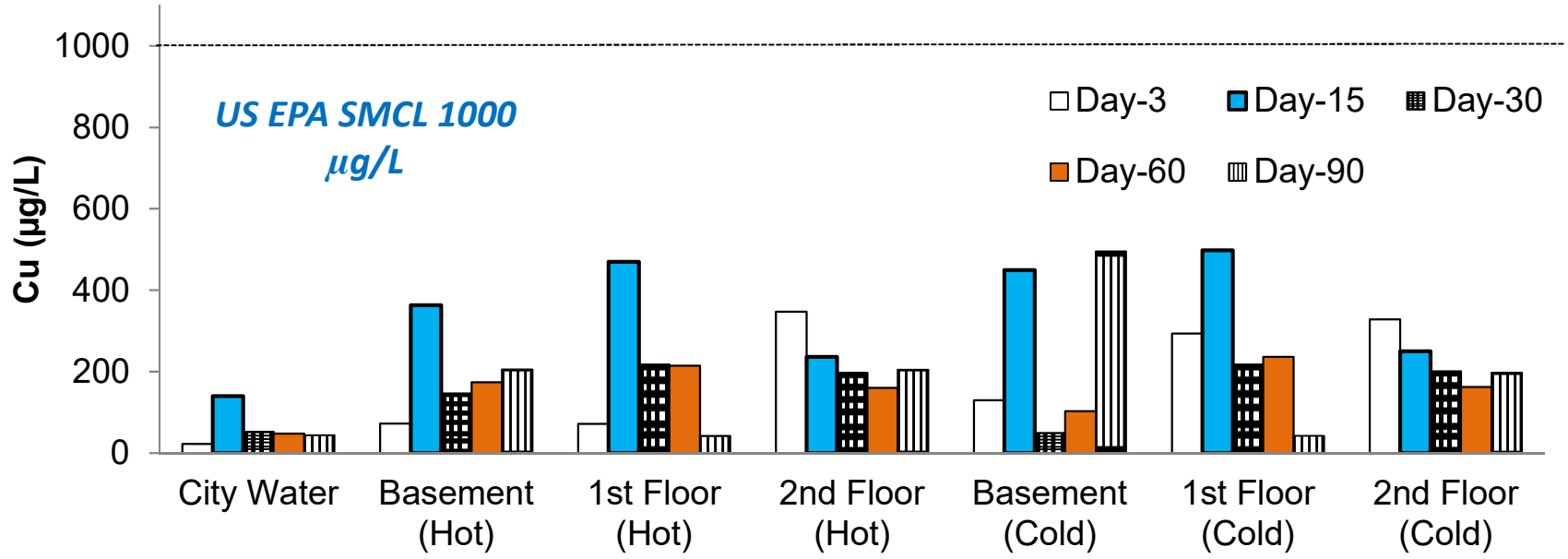
TOC Concentration Increased Inside the Building

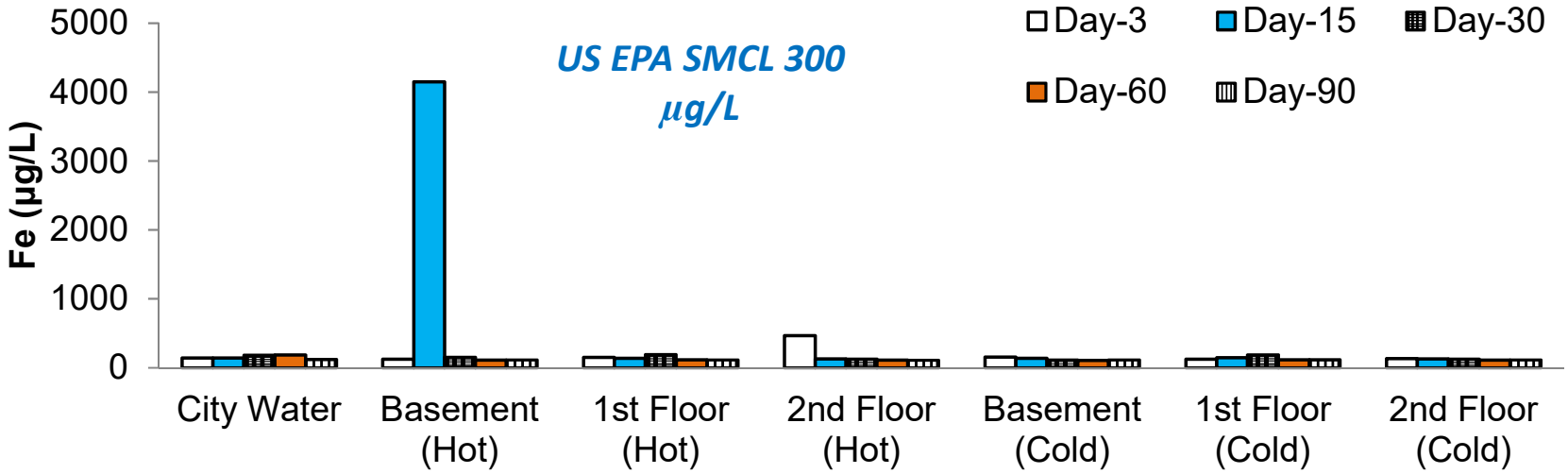


Several Heavy Metals with Health & Aesthetic Limits were Detected



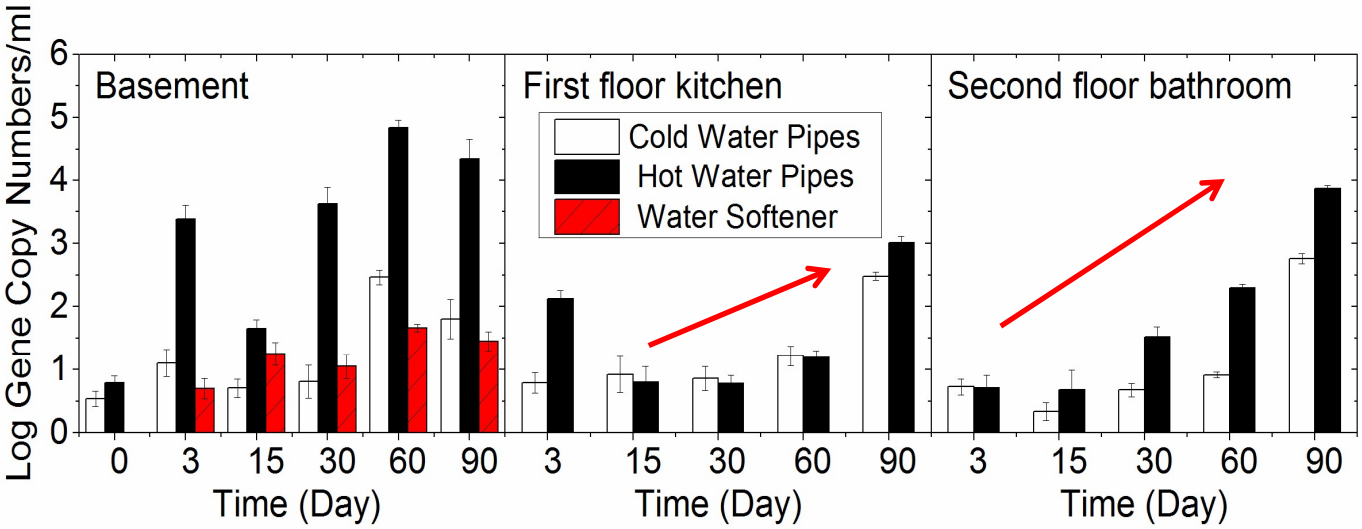
The **basement fixture brass needle valve** may have caused maximum Zn (5.9 mg/L), Fe (4.1 mg/L), and Pb (23 µg/L) levels compared to other fixture water samples.





Sampling Location

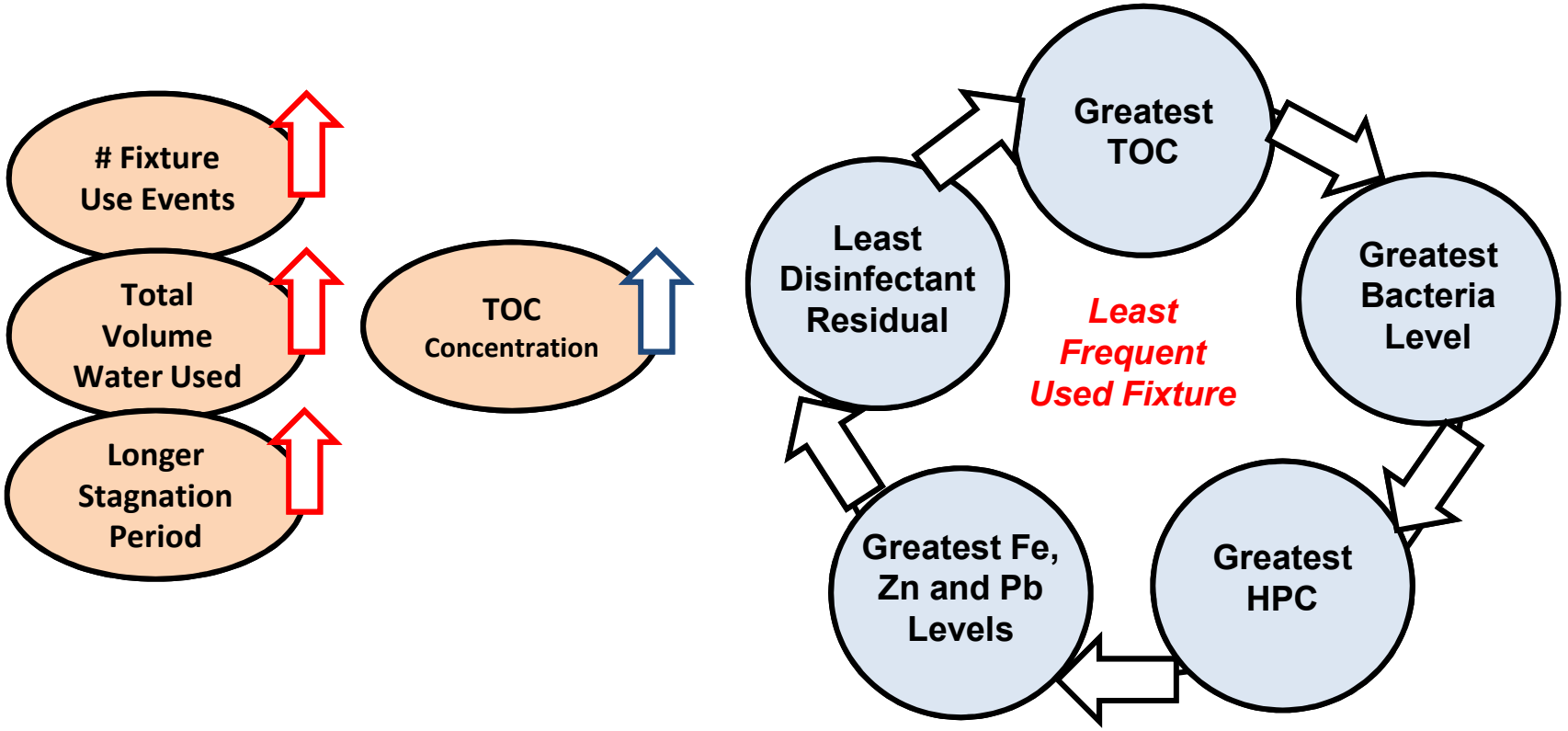
Both HPC & Gene Copy Number Increased at 1st & 2nd Floor



Greatest HPC level (856.7 CFU/mL) at day 90 basement hot water.

Positive correlations between TOC levels & bacterial gene copy numbers at water softener, 1st floor (cold), 2nd floor (cold/hot).

Water Use Influenced Chemical & Microbial Levels at each Fixture



Summary

- ❑ The maximum water stagnation time was 72.0 hr.
- ❑ Bacteria & organic carbon levels increased inside the plumbing system compared to the municipal tap water entering the building.
- ❑ A greater amount of bacteria was detected in hot water samples compared to cold water samples.
- ❑ At the basement fixture, where the least amount of water use events occurred, greater organic carbon, bacteria, and heavy metal levels were detected.

Future Research

Develop an integrated calibrated hydraulic water quality model for different plumbing designs.

Right Sizing Tomorrow's Water Systems for Efficiency, Sustainability, & Public Health

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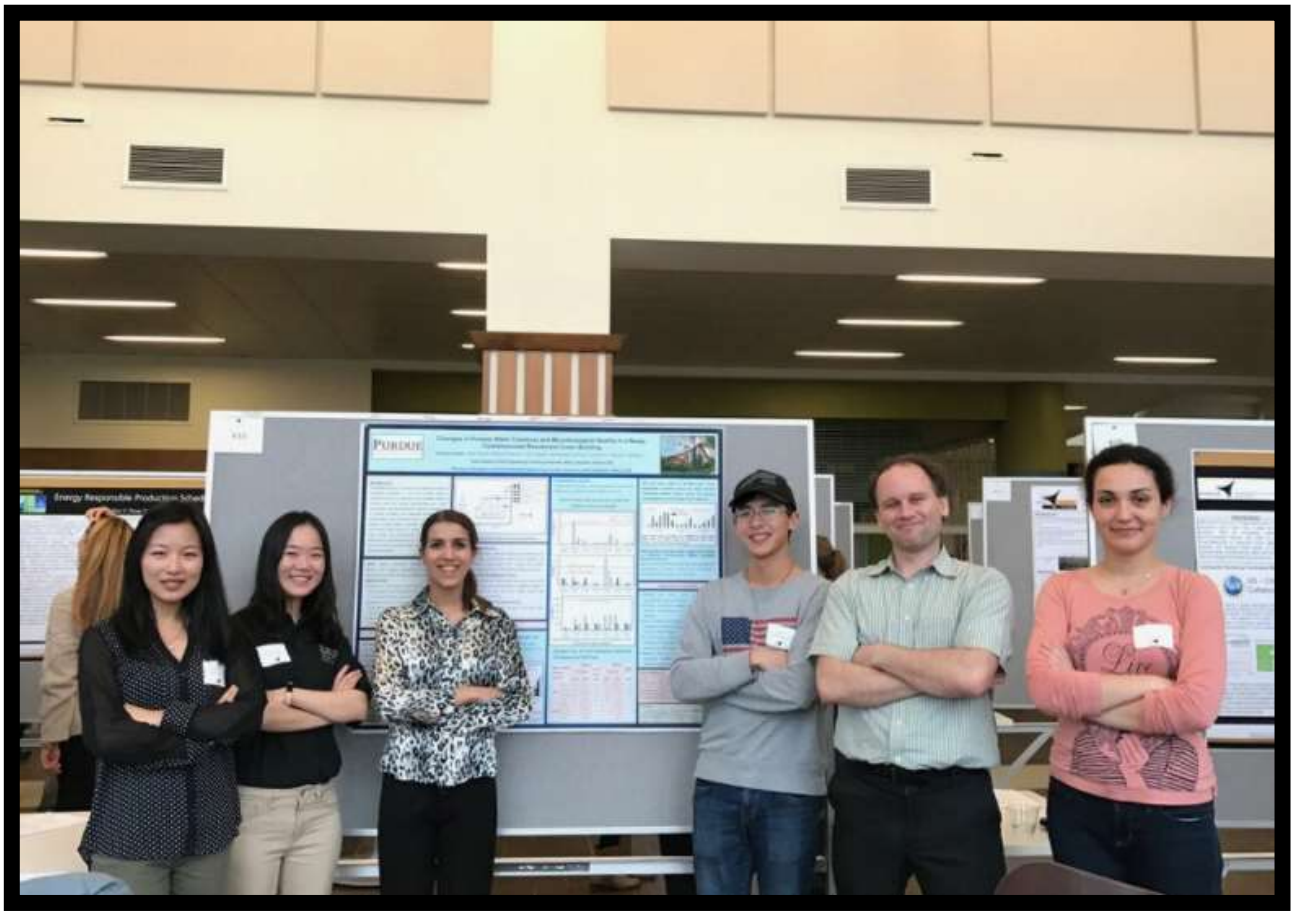
Question & Comments



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