UIUC Dormitory Water Filling Stations and Stagnation

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Presentation Outline

1. Background: Stagnation Effects
2. Objective of our Research
3. Methodology
4. Results of Sampling
5. Aspects of Design
6. Conclusion

Copper and lead pipes can corrode due to a number of chemical reactions, including with chlorine.

With Copper:

$$HOCl^{o} + H^{+} + Cu\,(s) \leftrightarrow Cu^{+2} + Cl^{-1} + H_2O$$

$$OCl^{-} + 2H^{+} + Cu\,(s) \leftrightarrow Cu^{+2} + Cl^{-1} + H_2O$$

With Lead:

$$Pb^{2+} + 2H_2O + Cl_2 \leftrightarrow PbO_2\,(s) + 4H^{+} + 2Cl^{-}$$

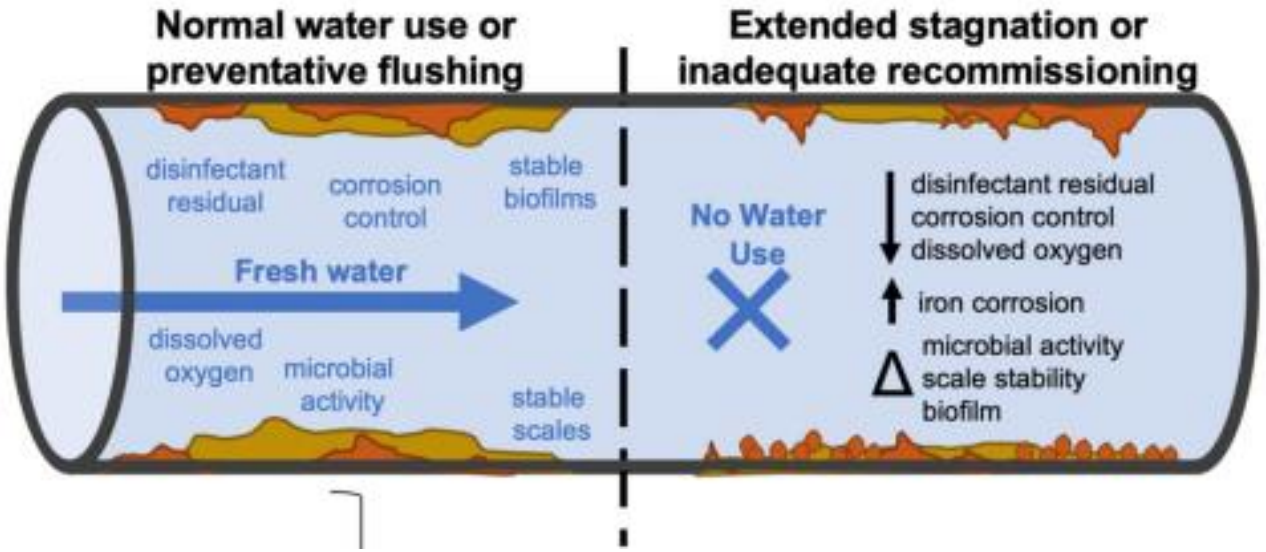
[12] Lytle, Darren A., Liggett, Jennifer. (2016). "Impact of water quality on chlorine demand of corroding copper." Water Research. https://www.sciencedirect.com/science/article/pii/S0043135416300318

[13] Courtesy of Gemma Clark, Lead Chemistry.

How stagnation impacts drinking water quality

- Stagnation can pose microbiological (Legionella, pneumophila, E.coli) and chemical (lead and copper) health concerns

- Lead and copper can become unstable during long periods of stagnation and leach into the water



Proctor et al, 2020

Research Questions, Goals, and Objectives

- To what extent does stagnation in pipes affect water quality
  - Specifically, what are the concentrations of lead, copper, and free chlorine?
  - Also, does age of the building matter?
- Do unfiltered versus filtered water stations impact the water quality?
- How does flushing help improve the water quality of stagnant water, and to what extent?

Variables

Discrete Decision Variables

- Filtration
  - -Filtered or unfiltered based on info from drinking water fountain logs
- Stagnation
  - -Stagnant or flushed based on the first second sample at each station
- Time of day
  - -Fixed sampling time, 7 am
- Building age
  - -ISR dorm (new) or FAR dorm (old)

Continuous Decision Variables

- Pollutant Concentrations
  - -Concentration of each pollutant of interest: lead, copper, free chlorine
  - -EPA guidelines
  - -15 micrograms/L for lead
  - -1,300 micrograms/L for copper
  - -4,000 micrograms/ L for free chlorine
- Flushing volume
  - -Volume of water to flush between first and second measurement
- Sample volume
  - -Total volume of sample taken

Two Sampling Locations & Two Teams

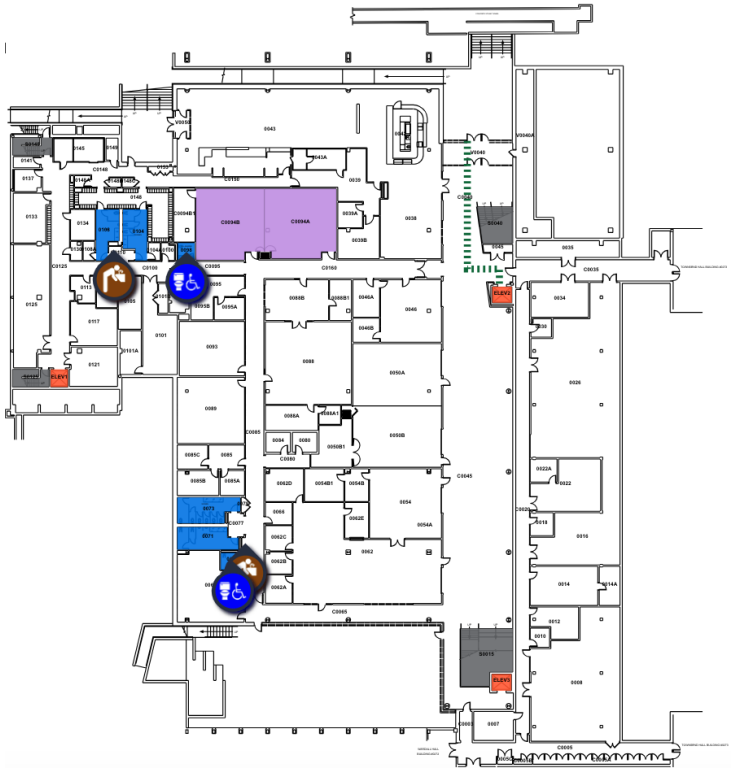
Old Building: FAR (built in 1964)

- **Filtered** Station**:** Basement Hallway
- **Unfiltered** Station**:** Basement Gym
- Alexis and Siari

https://uihistories.library.illinois.edu/virtualtour/residencehalls/farpar/

New Building: ISR-Townsend (renovated 2021)

- **Filtered** Station: bottle filler C-0077
- **Unfiltered:** Bathroom tap, Ground floor
- Aaron and Izabela



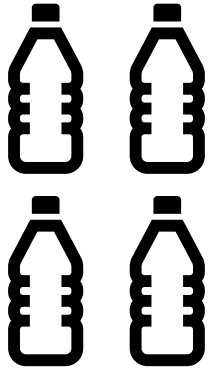
https://facilityaccessmaps.fs.illinois.edu/archibus/schema/ab-products/essential/workplace/index.html

Sampling Schedule

	Date	ISR	FAR	Chlorine Samples	Lead Samples	Copper Samples	Sum of Pb/Cu Samples
Week 1	4/2	X		X			
	4/3	X		X			-
Week 2	4/8	X		X*			-
	4/10	X		X			-
	4/11		X	X			-
	4/12	X	X	X	X	X	16
Week 3	4/17	X	X	X	X	X	32
	4/18	X	X	X	X	X	48

Sampling Process

7:00 AM—Two teams arrive at FAR and ISR



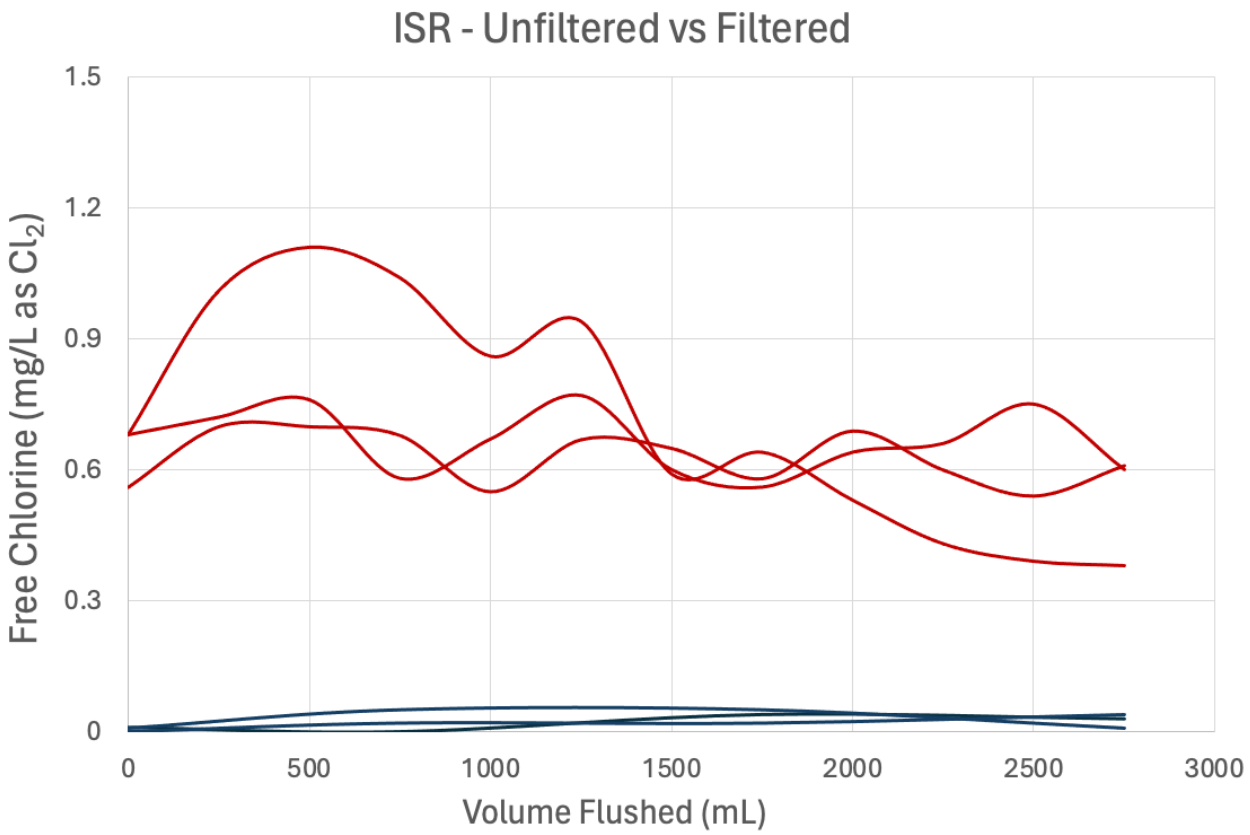
Each team takes 12 consecutive 250 mL samples from unfiltered and filtered fountains

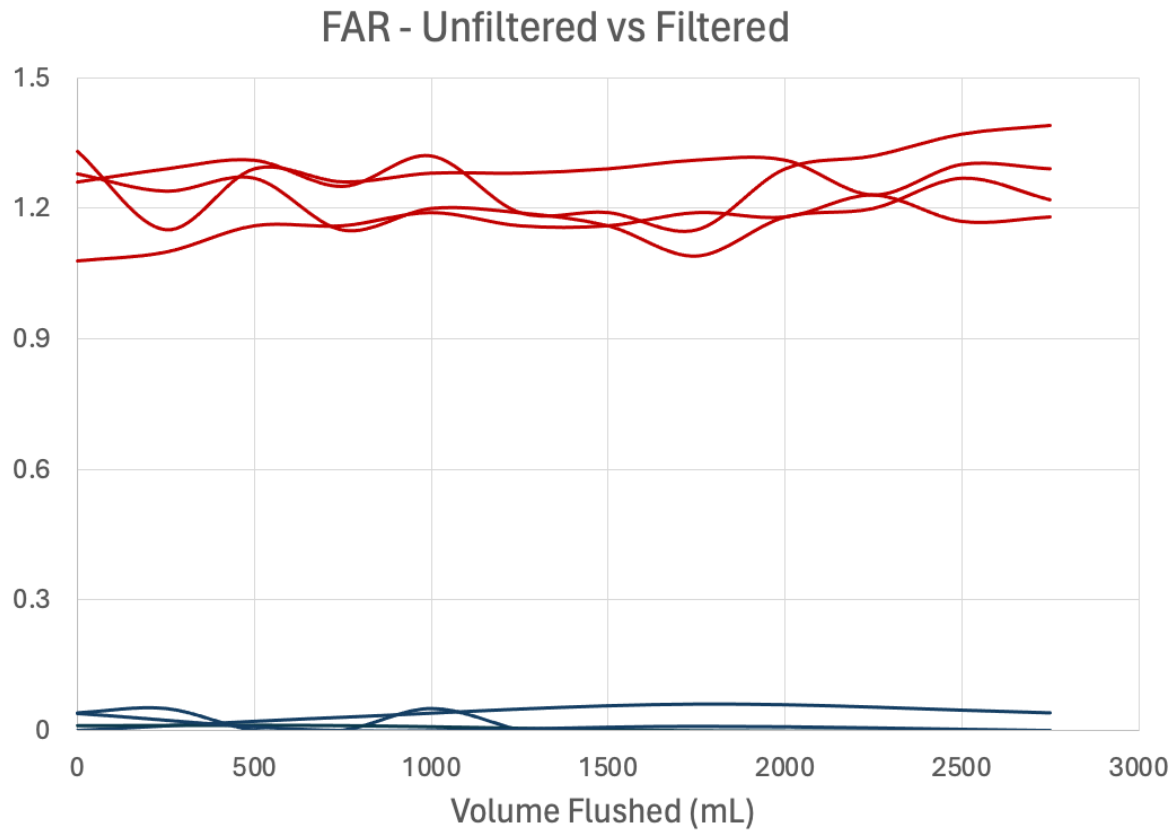
Perform Chlorine Measurements on site and record data in shared spreadsheet

(skip first week) Return samples to lab and perform sample prep for ICP-MS

Clean instruments used and prepare for next sampling day, reserve chlorine sampler

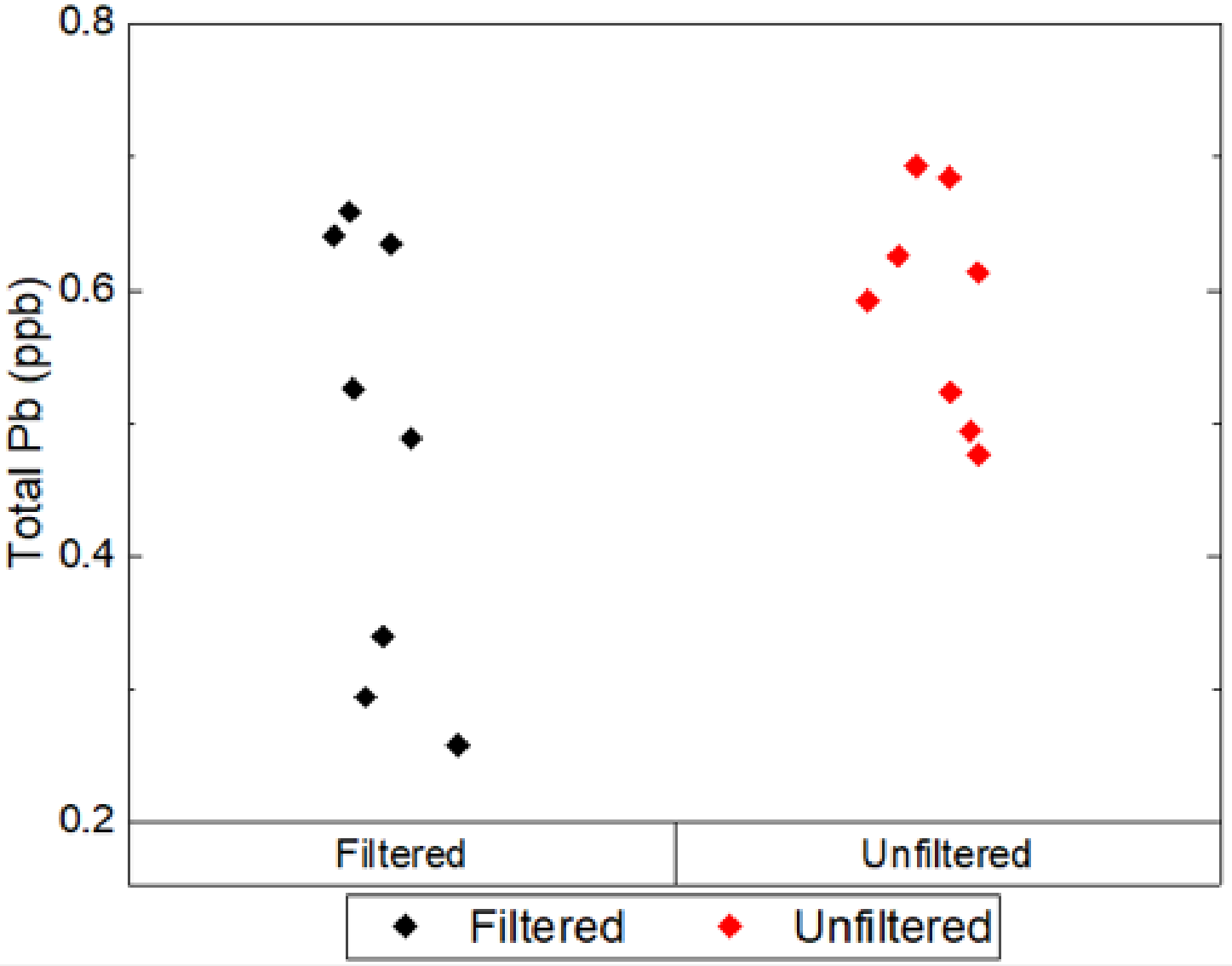
Residual Chlorine Curves





Unfiltered Filtered

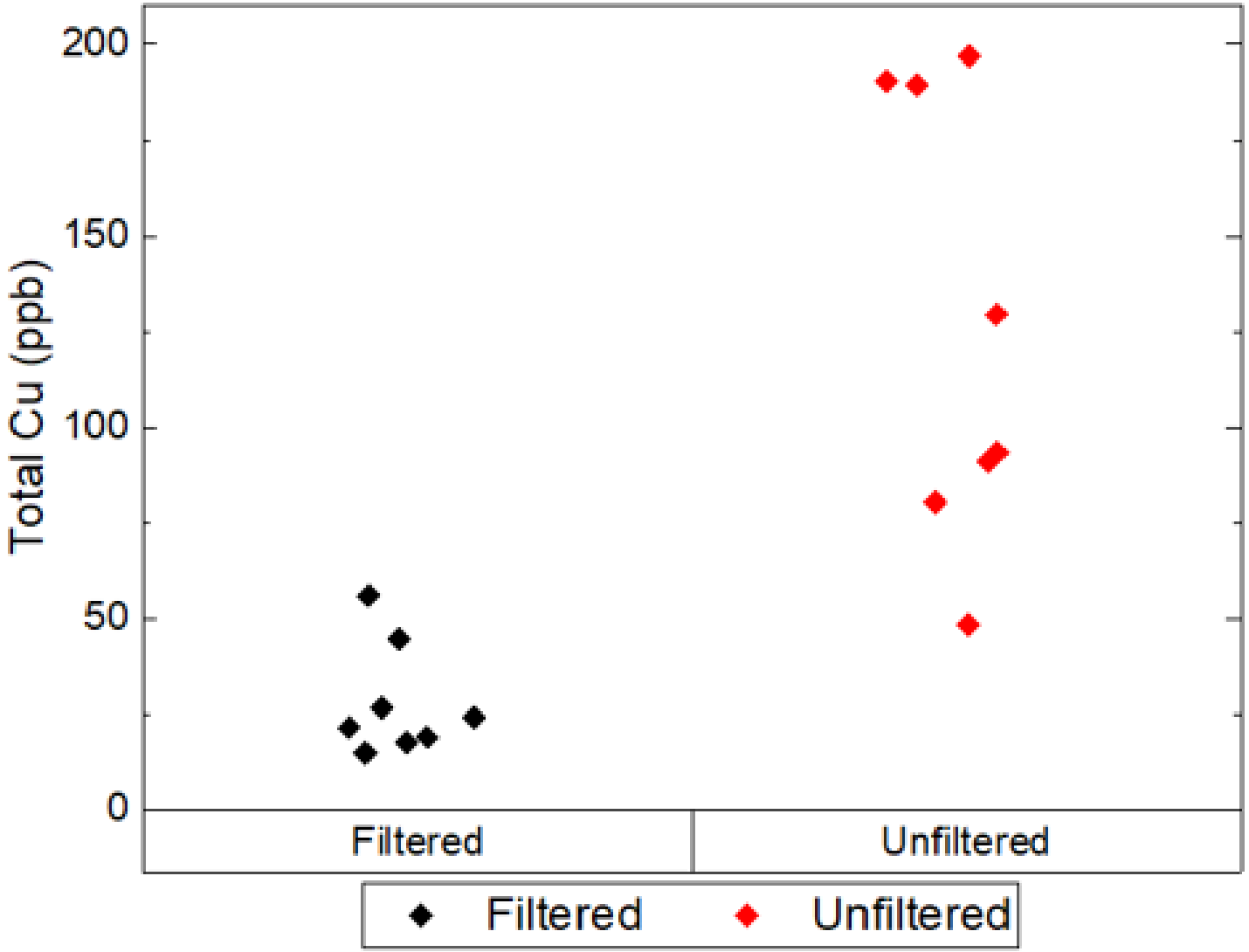
There was no statistical difference found between lead levels in filtered and unfiltered samples.



Fails t-test with 95% Confidence Interval, p = .14

No statistical difference

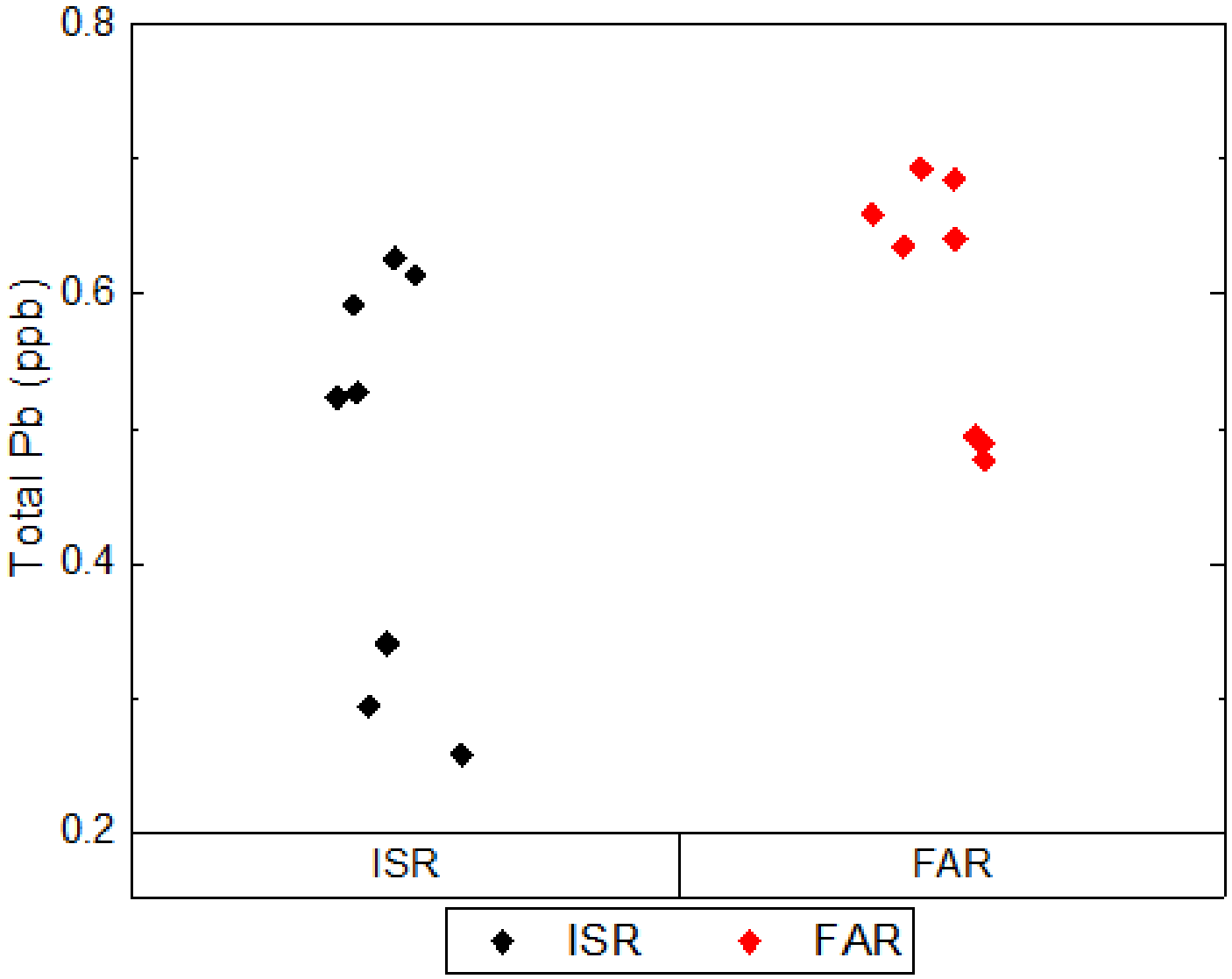
There was a statistically significant increase between copper levels from filtered to unfiltered samples.



Passes 1-tailed t-test with 97.5% Confidence Interval, p = .00041

Statistically significant increase

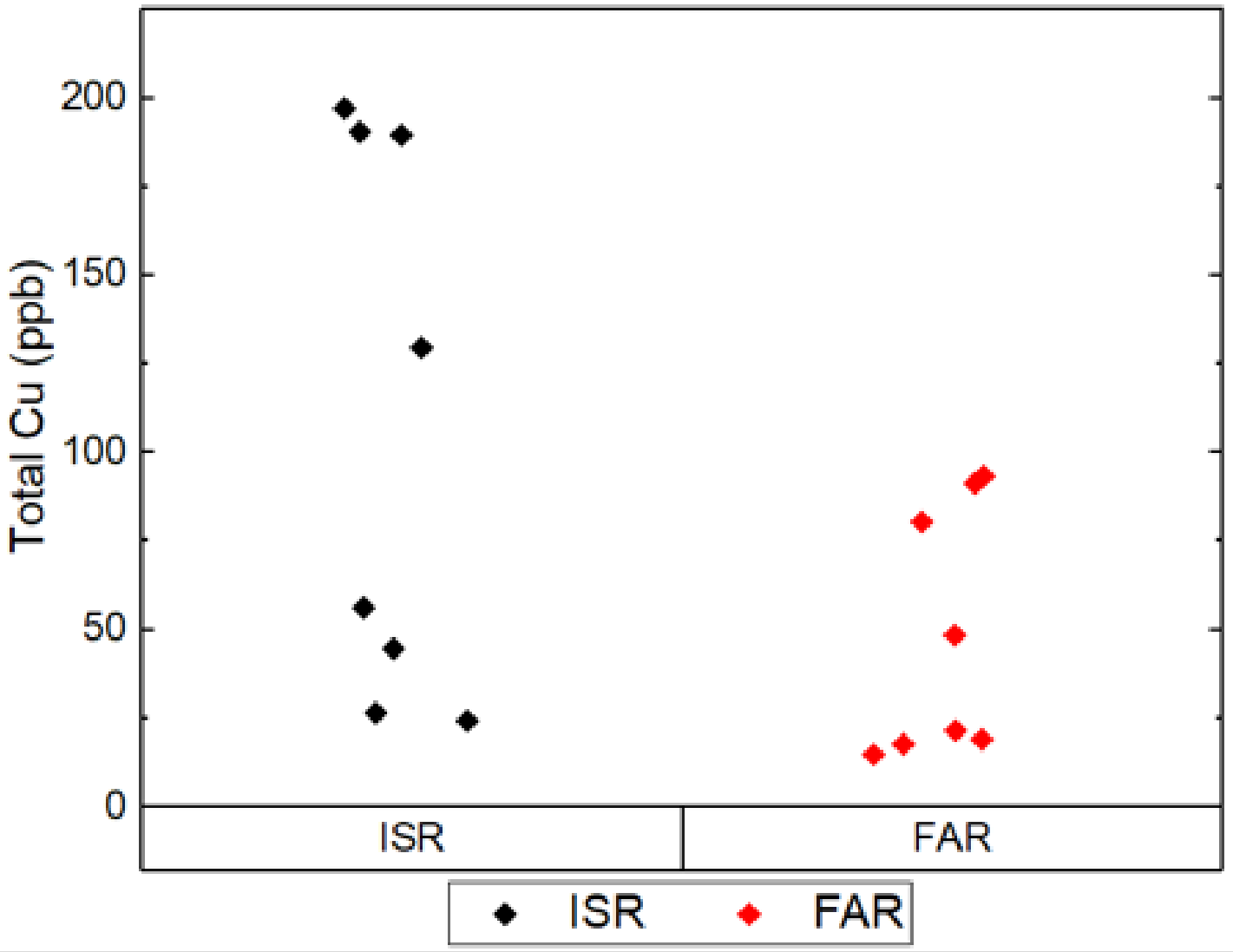
There was no statistical difference found between lead levels in FAR and ISR samples.



Fails t-test with 95% Confidence Interval, p = .087

No statistical difference

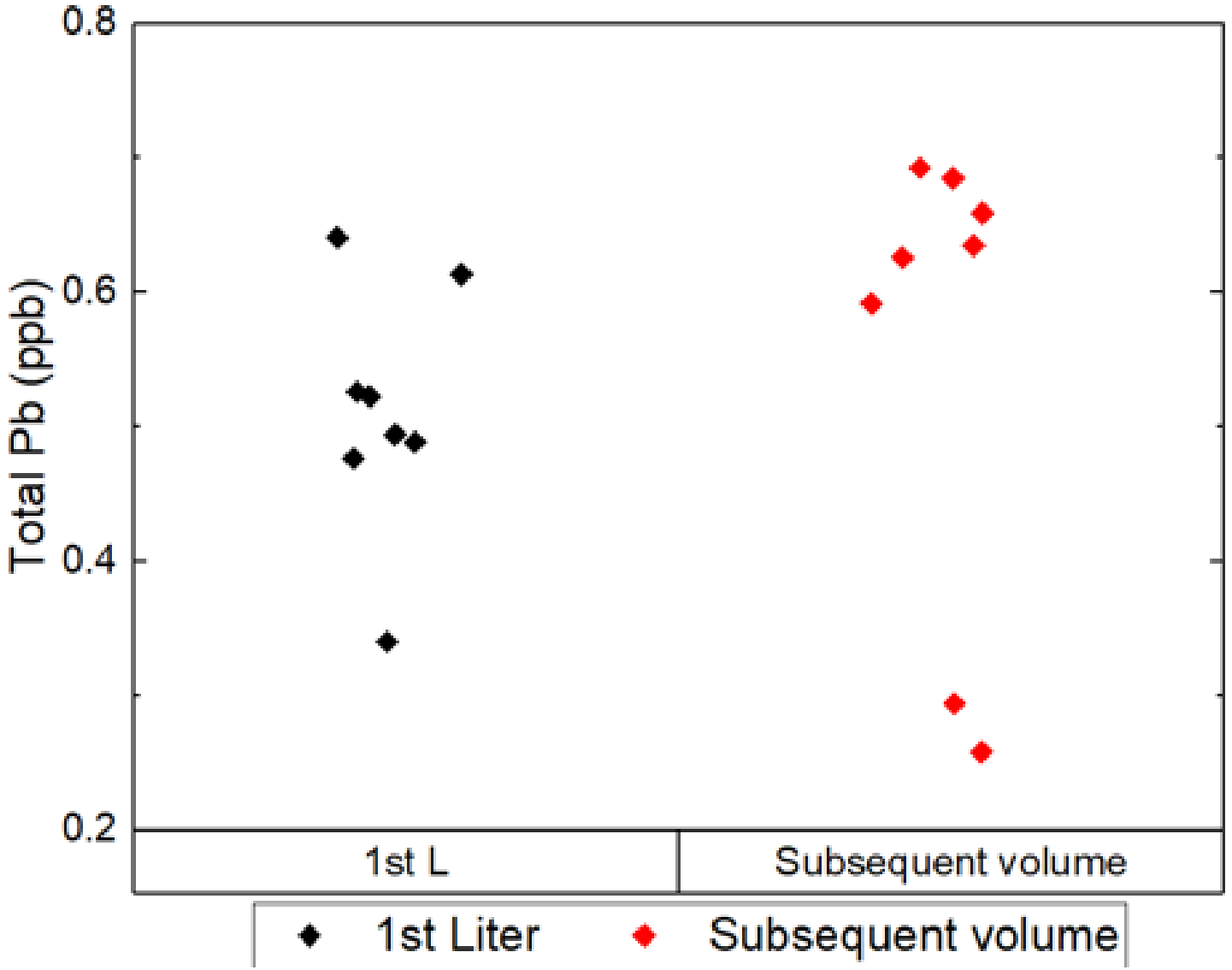
There was a statistically significant decrease between copper levels from ISR to FAR samples.



Passes 1-tailed t-test with 97.5% Confidence Interval, p = .0074

Statistically significant decrease

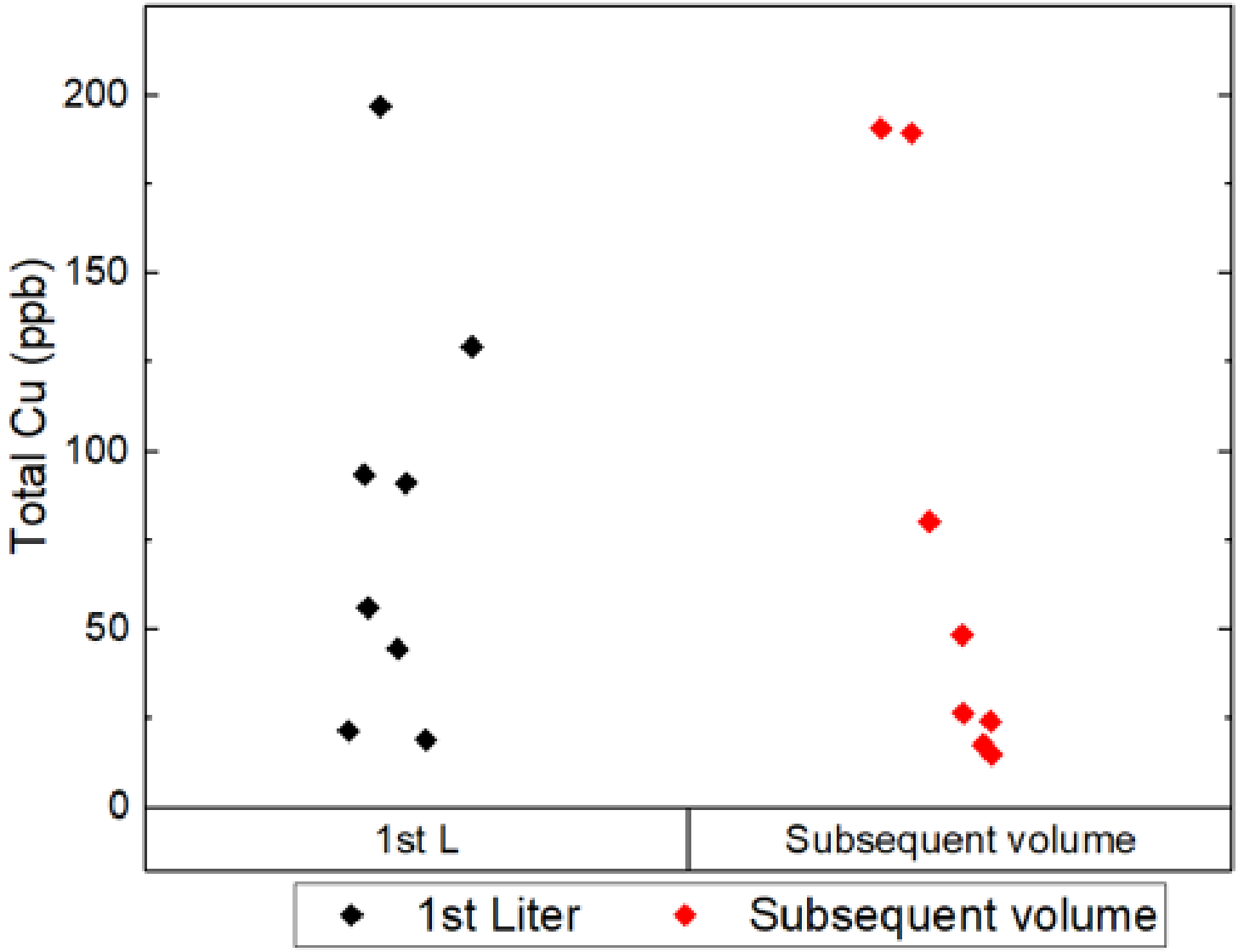
There was no statistical difference found between lead levels in the 1st liter and subsequent samples.



Fails t-test with 95% Confidence Interval, p = .47

No statistical difference

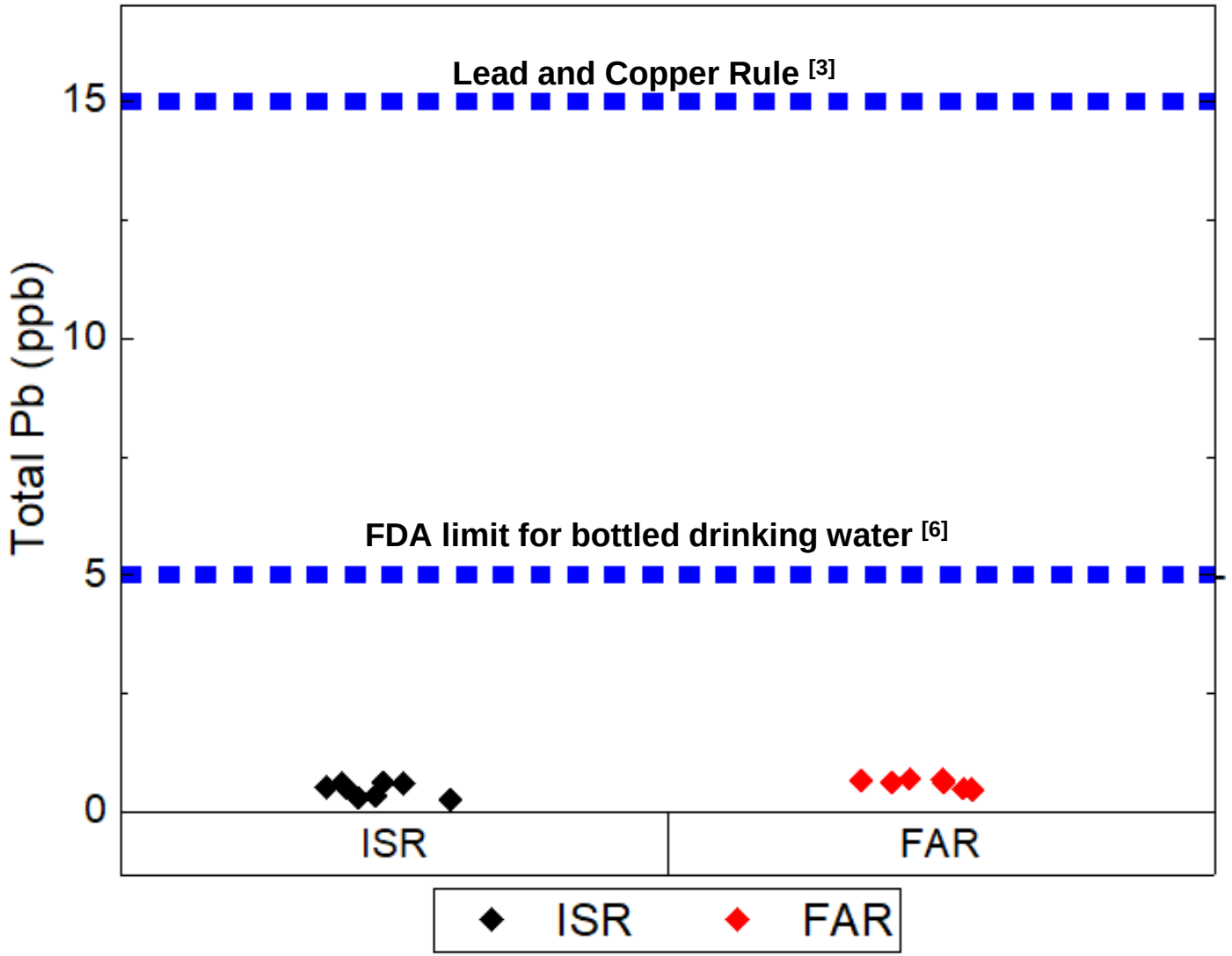
There was no statistical difference found between copper levels in the 1st liter and subsequent samples.



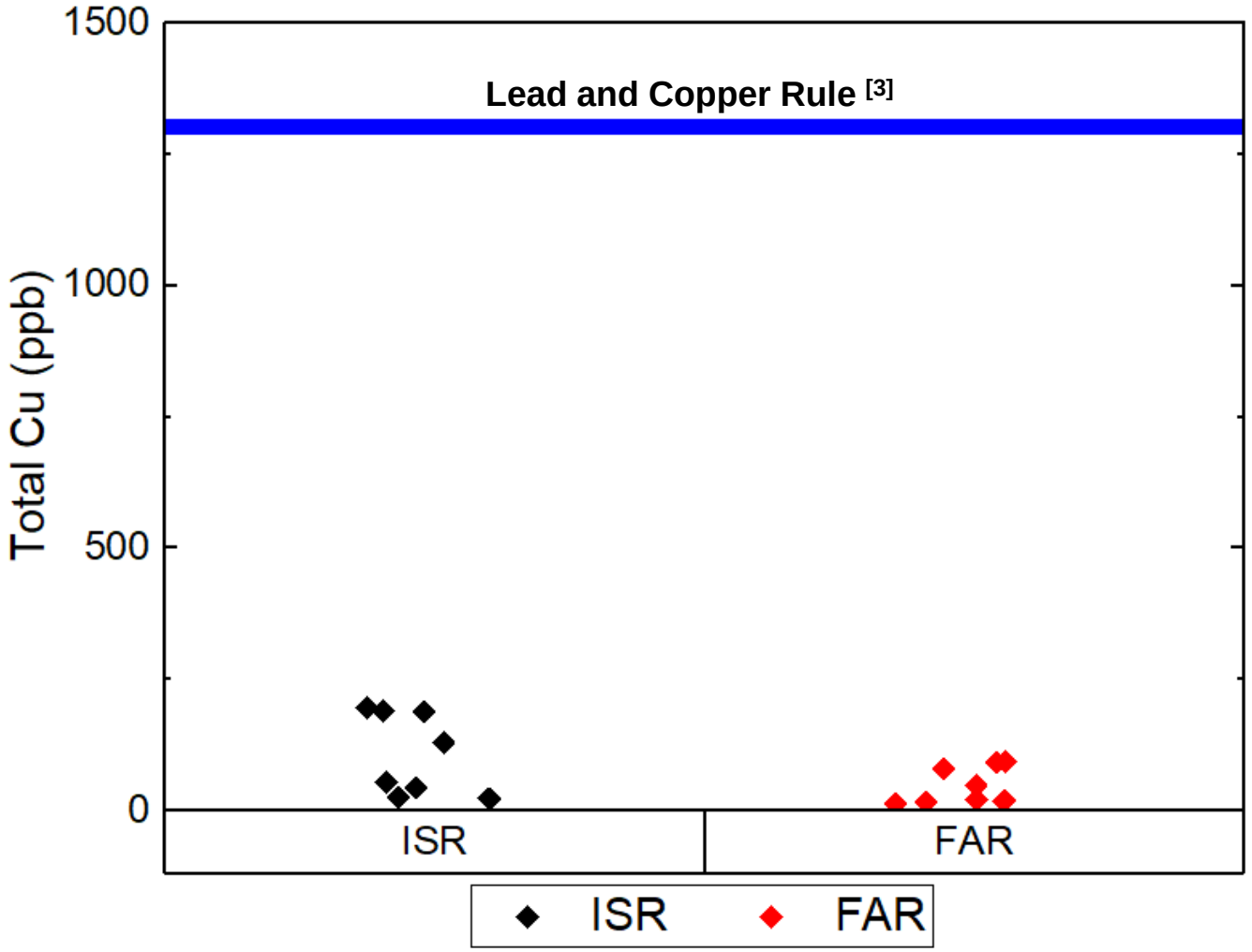
Fails t-test with 95% Confidence Interval, p = .52

No statistical difference

Lead Effects at this level



Copper Effects at this level



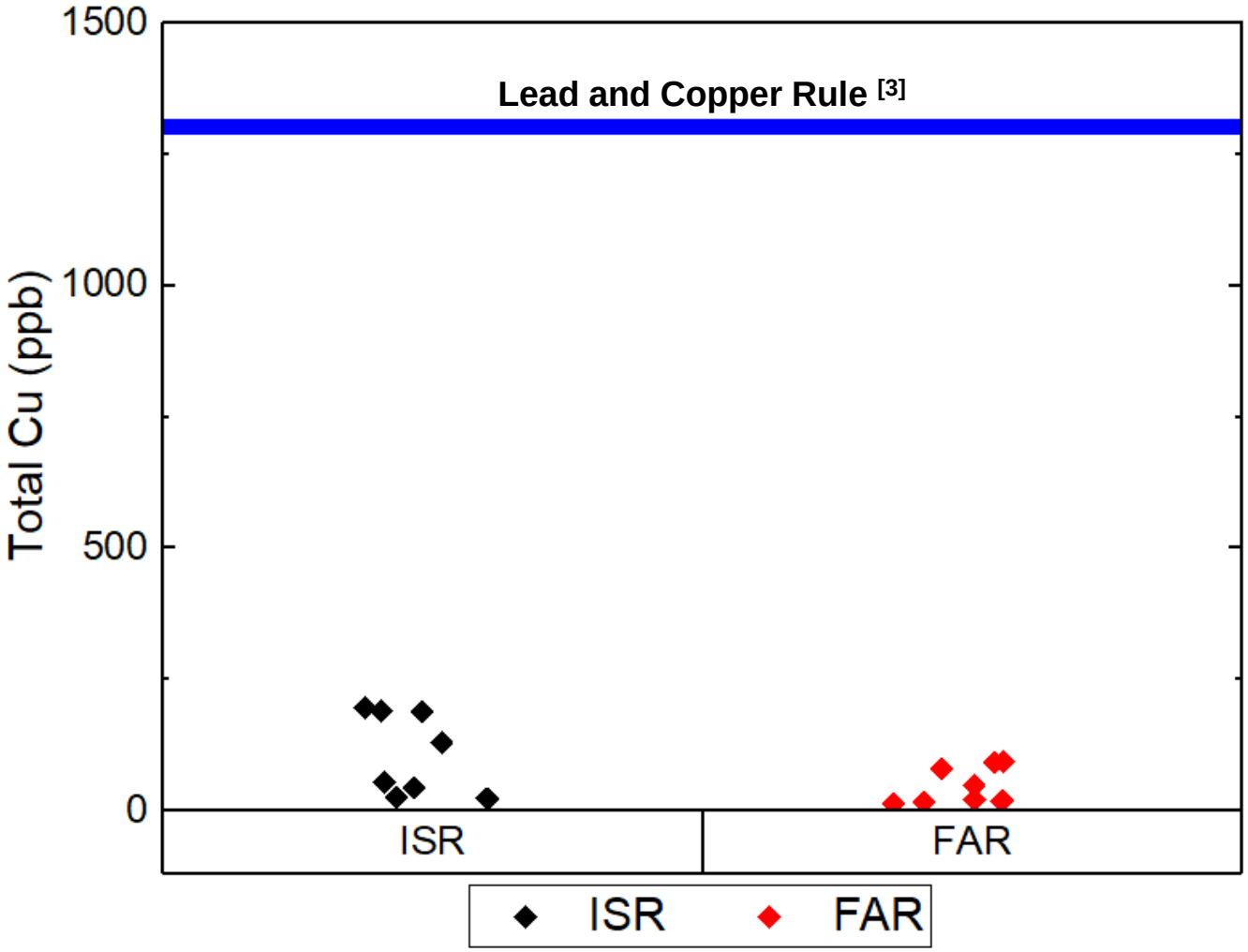
[1] *Reopening buildings after prolonged shutdown or reduced operation*. (n.d.). https://www.cdc.gov/nceh/ehs/water/legionella/building-water-system.html#:~:text=Stagnant%20or%20standing%20water%20in,%C2%B0%E2%80%9342%C2%B0C).

[2] Copper – ToxFAQs. (2022, April). ASTDR. https://www.atsdr.cdc.gov/toxfaqs/tfacts132.pdf

[3] *Lead and Copper rule*. (2023, November 28). US EPA. https://www.epa.gov/dwreginfo/lead-and-copper-rule

[4] National Institutes of Health Office of Dietary Supplements. "Copper." https://ods.od.nih.gov/factsheets/Copper-Consumer/

Copper Effects at this level



Life Stage	Recommended Amount
Birth to 6 months	200 mcg
Infants 7–12 months	220 mcg
Children 1–3 years	340 mcg
Children 4–8 years	440 mcg
Children 9–13 years	700 mcg
Teens 14–18 years	890 mcg
Adults 19 years and older	900 mcg
Pregnant teens and women	1,000 mcg
Breastfeeding teens and women	1,300 mcg

7 L ISR Unfiltered Water / day

Ages	Upper Limit
Birth to 12 months	Not established
Children 1–3 years	1,000 mcg
Children 4–8 years	3,000 mcg
Children 9–13 years	5,000 mcg
Teens 14–18 years	8,000 mcg
Adults	10,000 mcg

79 L ISR Unfiltered Water / day

[1] *Reopening buildings after prolonged shutdown or reduced operation*. (n.d.). https://www.cdc.gov/nceh/ehs/water/legionella/building-water-system.html#:~:text=Stagnant%20or%20standing%20water%20in,%C2%B0%E2%80%9342%C2%B0C).

[2] Copper – ToxFAQs. (2022, April). ASTDR. https://www.atsdr.cdc.gov/toxfaqs/tfacts132.pdf

[3] *Lead and Copper rule*. (2023, November 28). US EPA. https://www.epa.gov/dwreginfo/lead-and-copper-rule

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Design: Economics of Installing a New Fountain

Installation and maintenance LCA

Equipment Cost = $1500
Installation Cost = $500
Maintenance Cost = $0 (minimal)
*80 Bottle Filling Stations * $2000/station* = $160,000

https://www.elkay.com/products/details/51300C

Filter Replacement LCA

Filter Cost = $75/filter (replace once a year)

80 Bottle Filling Stations x $75/yr = $6,000/yr to replace filters

Total cost to provide filtered water = $220,000/10 years

Design: Economics of Distributing Pitcher Filters.

Pitcher Filters Distribution LCA:

Pitcher Cost = $36
Filter cost = $15.28
- Change 2x per year = $30.56

Maintenance Cost = $0

University housing accommodates 8,550 students
- Assume one pitcher per 2 students: 4,275 pitchers

$$4275\ (\$36\ pitcher + \$30.56\ filters) =$$

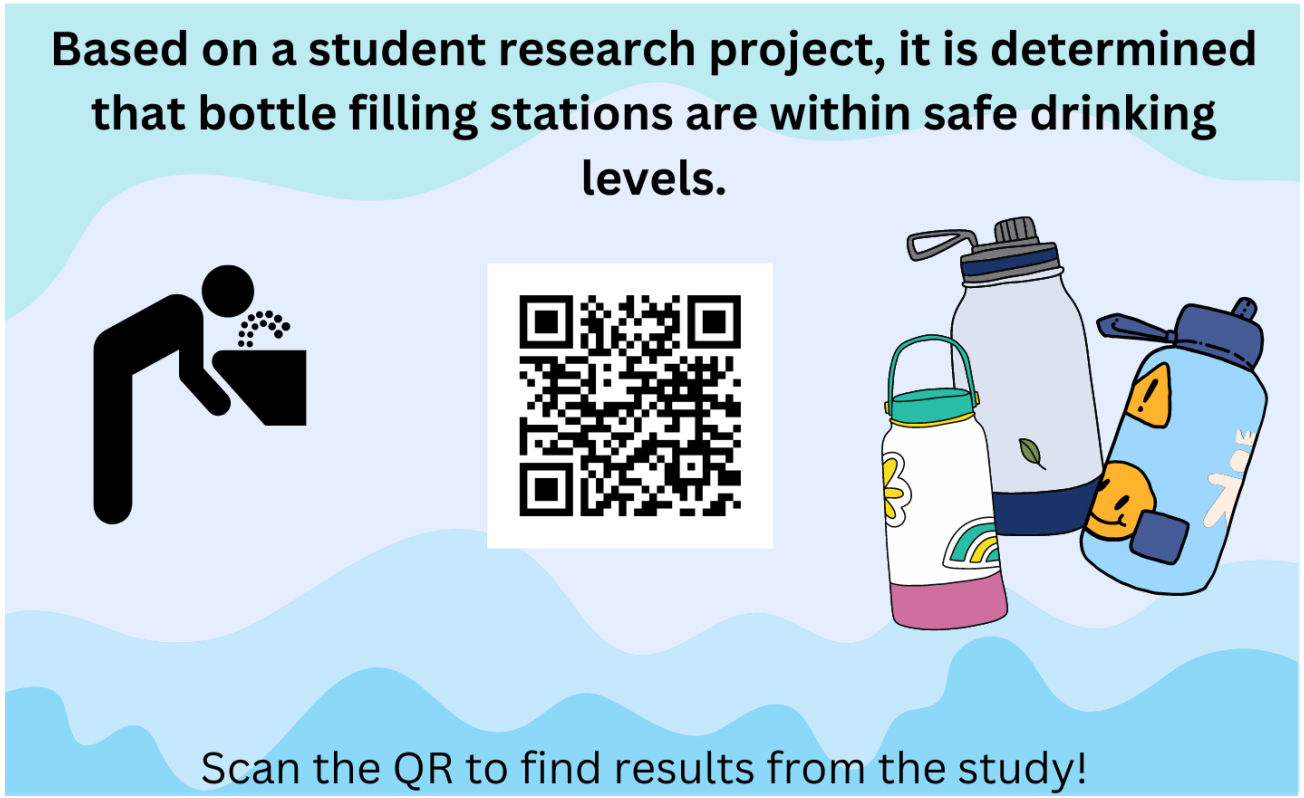
Total Cost for One Class Year: $280,000

Total Cost for 10 Class Years: $2.8 million

https://illinois.edu/about/facts.html

https://www.brita.com/products/denali-pitcher-elite/

Our sampling and data analysis will inform future design in the form of PSAs and educational resources.



Citations

[1] *Reopening buildings after prolonged shutdown or reduced operation*. (n.d.). https://www.cdc.gov/nceh/ehs/water/legionella/building-water-system.html#:~:text=Stagnant%20or%20standing%20water%20in,%C2%B0%E2%80%9342%C2%B0C).

[2] Copper – ToxFAQs. (2022, April). ASTDR. https://www.atsdr.cdc.gov/toxfaqs/tfacts132.pdf

[3] *Lead and Copper rule*. (2023, November 28). US EPA. https://www.epa.gov/dwreginfo/lead-and-copper-rule

[4] National Institutes of Health Office of Dietary Supplements. "Copper." https://ods.od.nih.gov/factsheets/Copper-Consumer/

[5] Rees, N., & Fuller, R. (2020). *The toxic truth: children's exposure to lead pollution undermines a generation of future potential*. UNICEF.

[6] U.S. Centers for Disease Control. (2023). "Lead Toxicity." https://www.atsdr.cdc.gov/csem/leadtoxicity/safety_standards.html

[7] World Health Organization. (2022). "Lead in drinking-water." https://iris.who.int/rest/bitstreams/1460455/retrieve

[8] Lanphear, B. P., Lowry, J. A., Ahdoot, S., Baum, C. R., Bernstein, A. S., Bole, A., ... & Trasande, L. (2016). Prevention of childhood lead toxicity. *Pediatrics*, *138*(1).

[9] UNICEF. (2020). "The Toxic Truth: Children's Exposure to Lead Pollution Undermines a Generation of Future Potential." https://www.unicef.org/sites/default/files/2020-07/The-toxic-truth-children%E2%80%99s-exposure-to-lead-pollution-2020.pdf

[11] Amazon.com. "Brita Elite Water Filter Replacements for Pitchers and Dispensers, Reduces 99% of Lead from Tap Water, Lasts 6 Months, 2 Count"

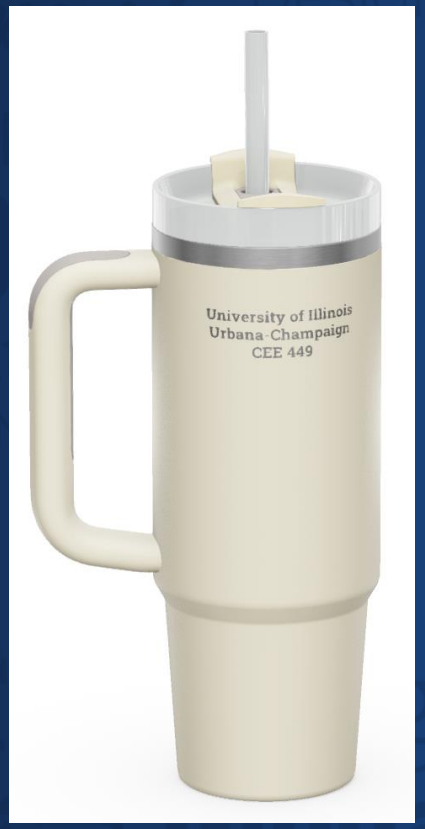
[12] Lytle, Darren A., Liggett, Jennifer. (2016). "Impact of water quality on chlorine demand of corroding copper." Water Research. https://www.sciencedirect.com/science/article/pii/S0043135416300318

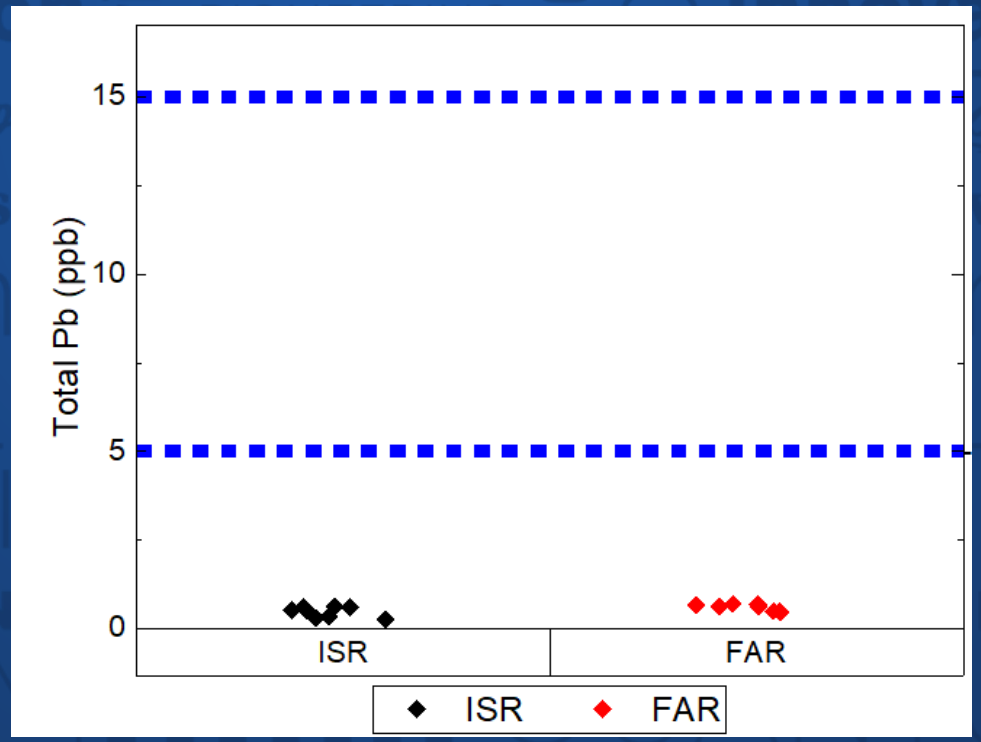
[13] Courtesy of Gemma Clark, Lead Chemistry.

[14] Proctor CR, Rhoads WJ, Keane T, et al. Considerations for large building water quality after extended stagnation. *AWWA Wat Sci*. 2020;e1186. https://doi.org/10.1002/aws2.1186

THANK YOU

QUESTIONS?





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