EXAMINING THE EFFICACY OF POU LEAD FILTERS UNDER EXTREME CORROSION CONDITIONS

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HUD Healthy Homes Technical Studies Grant Program

WATER LEAD LEVELS (WLLs)

15 ppb – EPA Action Limit

NOT a Health-Based Standard

10 ppb – NSF/ANSI 53 Lead Certification Filter Limit
from levels of 150 ppb

5 ppb – Bottled Water Standard

1 ppb – American Academy of Pediatrics (AAP) Goal

POUs DISTRIBUTED IN FLINT, MI

https://www.eclectablog.com/2016/01/photos-flint-a-poisoned-city-with-the-tenacity-strength-pride-to-never-quit-with-a-lot-of-help-from-its-friends.html

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Background   Motivation   Methods   Results   Key Takeaways

PUBLIC CONCERNS ABOUT EFFECTIVENESS

One heartbreaking dispatch from a family in Flint is capturing the attention of people everywhere

Julia Calderone, Tech Insider Feb. 1, 20

Flint, Michigan is in the midst of

Toxic levels of lead have been lea
switched its water source from La
an effort to save money.

Now, city officials are trying to cle
of water, filters, replacement cart
residents.

But there's one problem: Lead lev
filter that lead out, the Michigan

Nakeyja told Skolnik that after running her water through the government-issued filter, lead levels registered at 184 ppb (parts per billion) -- well above the level that the filter can handle, which is up to 150 ppb.

In fact, the city has seen lead levels in homes that range from 153 ppb to more than 4,000 ppb, the Detroit Free Press reports.

POUs WERE SUCCESSFUL IN FLINT, MI

Source: NBC

Our team's one sample evaluation:

The POU removed 99.85% of the water lead from the worst sample (13,200 ppb) resulting in filtered water with 20 ppb lead

POUs WERE SUCCESSFUL IN FLINT, MI

Source: NBC

Flint, MI Filter Challenge Assessment

n = 241
Highest Treated Water Lead = 1 ppb

Attachment: ATSDR Letter to U.S. EPA Administrator
June 22, 2016
Prepared by U.S. EPA in coordination with the Unified Command Group

Our team's one sample evaluation:

The POU removed 99.85% of the water lead from sample (13,200 ppb) resulting in filtered water with 20 ppb lead
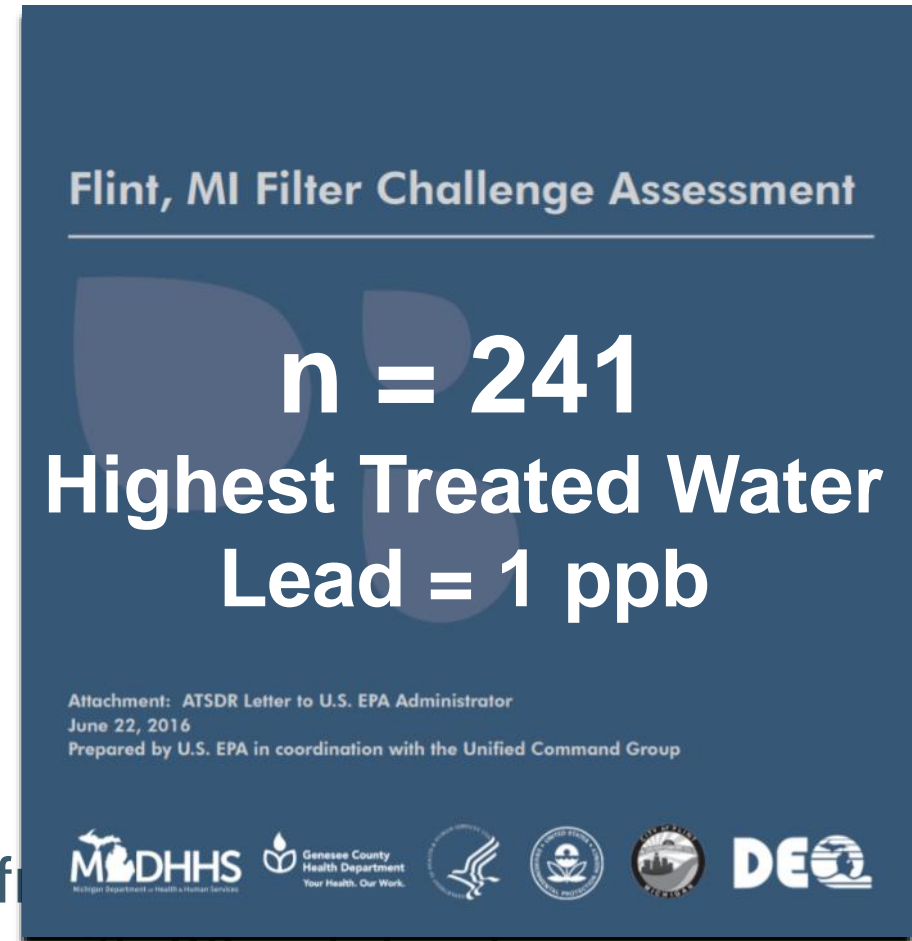
INVESTIGATING POUs LIMITATIONS

HUD GRANT PROJECT

MOTIVATION:

- Concerns about Pb exposure are increasing
- Filters are one solution for reducing lead levels, but all approaches have limitations
- Filters have been proven to work in EPA evaluation, but study was for new filters in Flint

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Background > Motivation > Methods > Results > Key Takeaways

INVESTIGATING POUs LIMITATIONS

HUD GRANT PROJECT

OBJECTIVES:

- Test NSF/ANSI 53 Certified Filters under extreme conditions
    - High levels of iron and lead
- Investigate effectiveness of operating the filter <u>past rated capacity</u>
- Determine filter failure modes

> Our goal was to push these filters PAST their BREAKING POINT

NSF/ANSI 53 LEAD CERTIFIED FILTERS ON THE MARKET

Pitcher Filters
Capacities: 15, 40, & 120 gallons

Dupont

ZeroWater

Brita Longlast

PUR Lead-Reduction

Faucet Filters
Capacities:100 & 200 gallons

PUR Basic   Brita Basic

Instapure F5   Culligan

Dupont Premiere

Dupont Deluxe

PUR Mineral Clear

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NSF/ANSI 53 LEAD CERTIFIED FILTERS ON THE MARKET

Pitcher Filters
Capacities: 15, 40, & 120 gallons

Faucet Filters
Capacities:100 & 200 gallons

Dupon...

PUR Basic   Brita Basic

ZeroW...   ...lligan

Brita Longlast

Dupont Premiere

PUR L...

PUR Mineral Clear

> **Total of 11 Filters**
> **4 pitchers and 7 faucets**

> **We do not disclose names in results**
> **they are coded - Brands A – K**

OUR DEFINITION OF FILTER FAILURE

1. Effluent lead levels exceed EPA Action Limit of 15 ppb
2. Premature Clogging   Adopted from NSF/ANSI 53

Flowrate is 4 X slower than the Initial Flowrate

WATER IN SMALL RURAL COMMUNITY SYSTEMS

Image Citation: Pieper, K (2018)

Are low-cost POUs still reliable options?

FILTER TIME

Soluble Lead Water

Pitcher Filter Brand X
Initial Gallon Time: 25 min
Failure Time = 25 X 4 = 100 min

Iron Particulate Water

Pitcher Filter Brand X
Initial Gallon Time: 100 min
Failure Time = 100 X 4 = 400 min

UNREASONABLY SLOW BEFORE CAPACITY

PITCHER FILTER SET-UP

- 3 Brands
- Duplicate filters
- 16-samples
- Up-to 200% rated capacity
- <u>30 minute rest after each gallon</u>
- Measure:
  - Flowrate
  - Concentrations

FAUCET FILTER SET-UP

- 7 Brands
- Duplicate filters
- 16-samples
- Up-to 200% rated capacity
- <u>40 minute ON/ 40 min OFF</u>
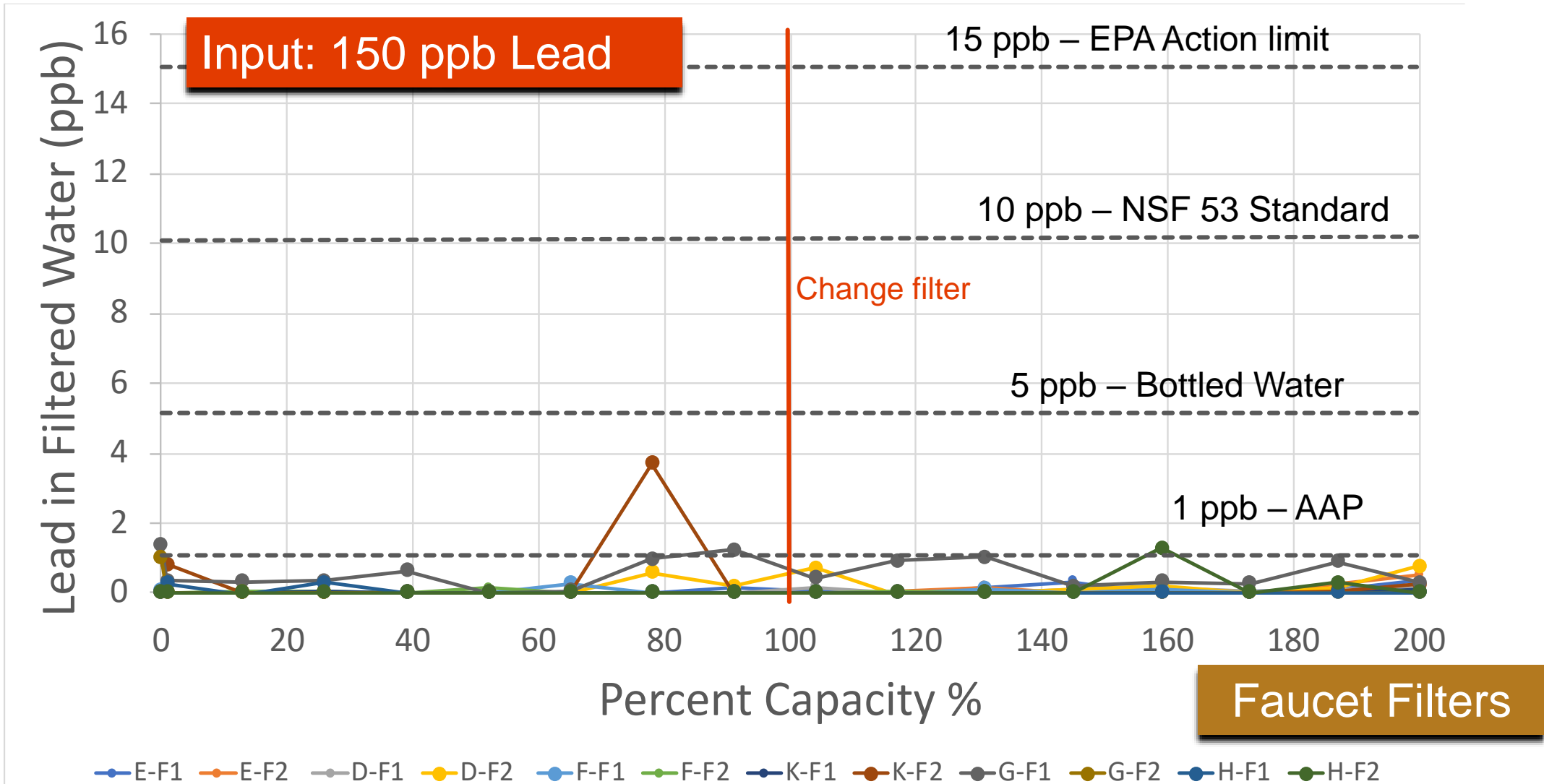- Measure:
  - Flowrate
  - Concentrations

FILTERS WORK IN REMOVING SOLUBLE LEAD
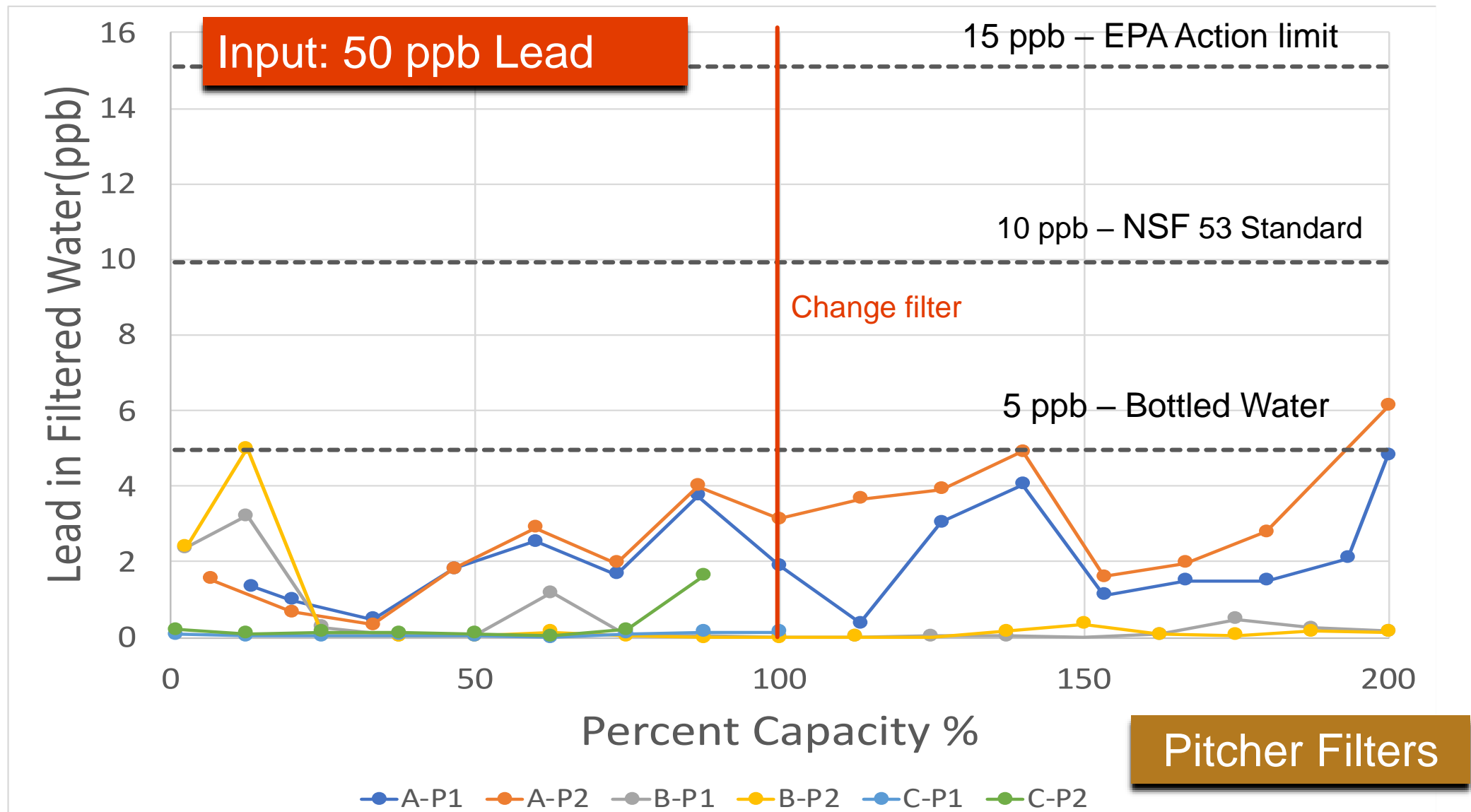

Input: 150 ppb Lead

15 ppb – EPA Action limit

10 ppb – NSF 53 Standard

Change filter

5 ppb – Bottled Water

1 ppb – AAP

Lead in Filtered Water (ppb)

Percent Capacity %

Faucet Filters

E-F1 E-F2 D-F1 D-F2 F-F1 F-F2 K-F1 K-F2 G-F1 G-F2 H-F1 H-F2

FILTERS WORK IN REMOVING PARTICULATE LEAD

Input: 50 ppb Lead

15 ppb – EPA Action limit

10 ppb – NSF 53 Standard

Change filter

5 ppb – Bottled Water

Pitcher Filters

Lead in Filtered Water(ppb) — Percent Capacity %

A-P1   A-P2   B-P1   B-P2   C-P1   C-P2

Background   Motivation   Methods   Results   Key Takeaways

MAIN CONCLUSIONS

POUs work majority of the time in our lab in reducing lead levels below EPA, NSF/ANSI 53, and Bottled Water Standards

POUs clog when exposed to soluble and particulate iron waters reducing filter capacity

Modes of Filter Failure: Overview

Structural

- Faucet Unit Leaks
- Pitcher Media Release Effluent

Performance

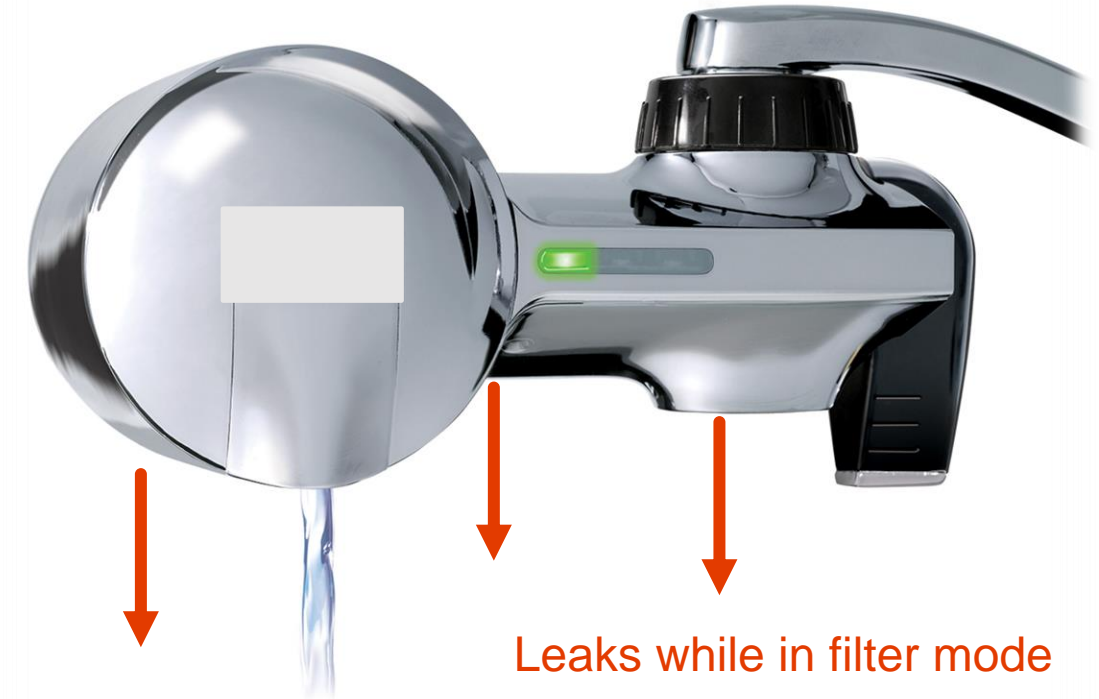- First Gallon
- Duplicate
- Particle Size – Challenge

Modes of Filter Failure:

Structural

- Faucet Unit Leaks

2 Brands eliminated because of <u>leaking prior to start of experiment</u>

Performed well in lead removal after we ordered new unit

**Disclaimer Not a real image from our lab this is just a diagram

Leaks while in filter mode

Modes of Filter Failure: Overview

Structural

- Faucet Unit Leaks
- Pitcher Media Release Effluent

Performance

- First Gallon
- Duplicate
- Particle Size – Challenge

Modes of Filter Failure:

Structural

- Pitcher Media Release Effluent

Brand eliminated because of
black carbon media leached out and took over 200 min to filter 1st gallon

Modes of Filter Failure: Overview

Structural
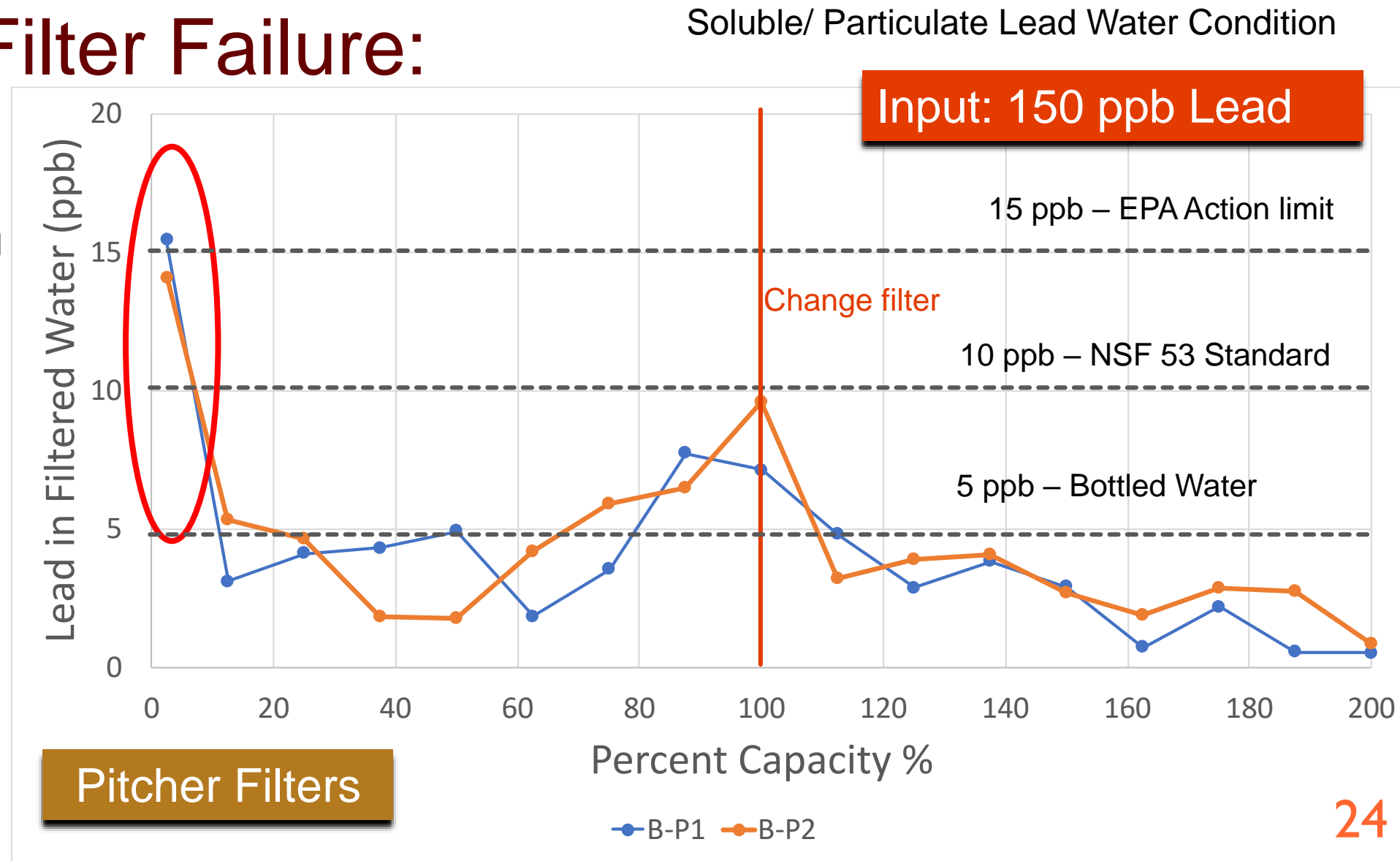
- Faucet Unit Leaks
- Pitcher Media Release Effluent

Performance

- First Gallon
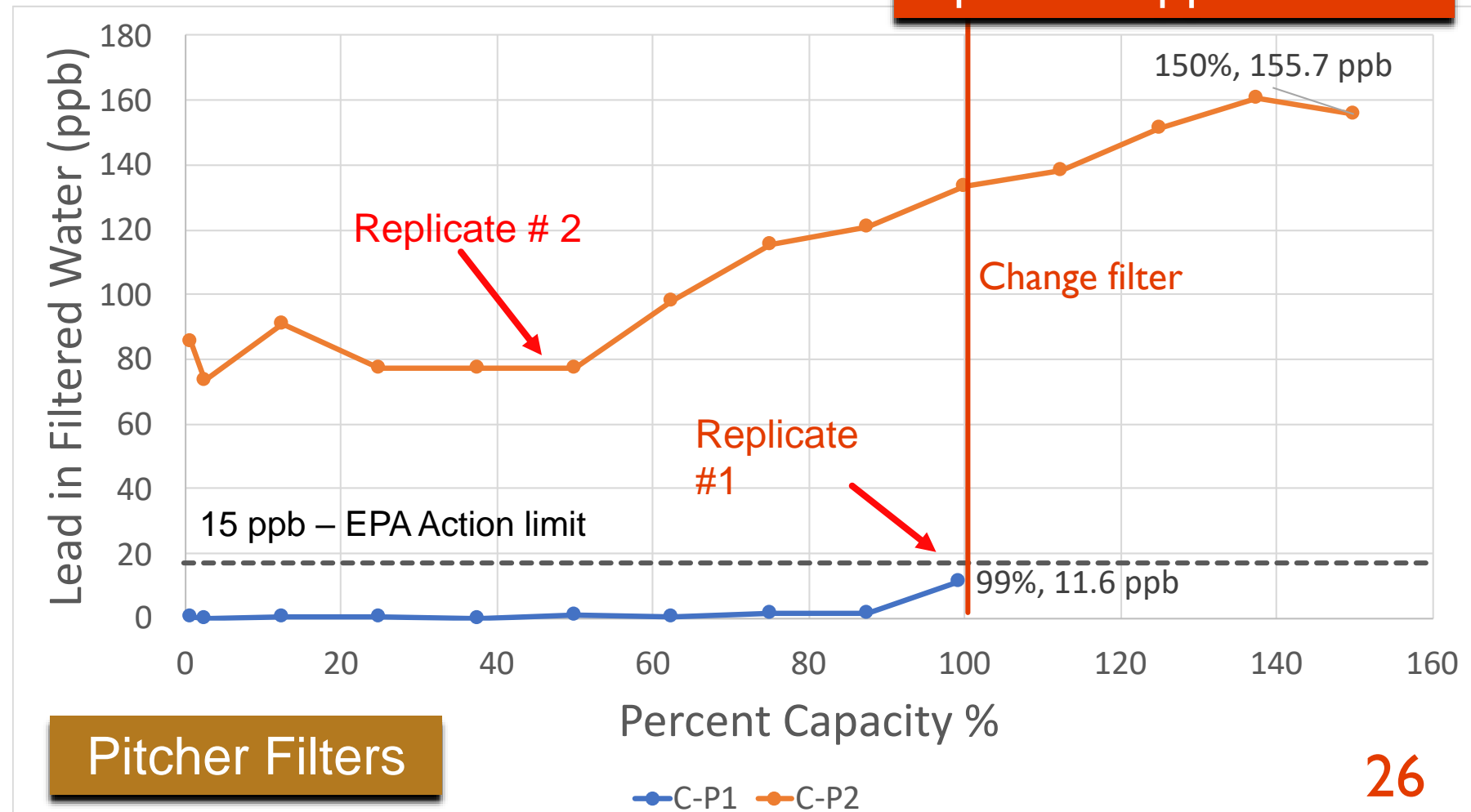- Duplicate
- Particle Size – Challenge

Modes of Filter Failure:

Performance

- First Gallon

Soluble/ Particulate Lead Water Condition

Input: 150 ppb Lead

15 ppb – EPA Action limit

Change filter

10 ppb – NSF 53 Standard

5 ppb – Bottled Water

Pitcher Filters

B-P1 B-P2

Y-axis: Lead in Filtered Water (ppb)
X-axis: Percent Capacity %

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Modes of Filter Failure: Overview

Structural

- Faucet Unit Leaks
- Pitcher Media Release Effluent

Performance

- First Gallon
- Duplicate
- Particle Size – Challenge

Modes of Filter Failure:

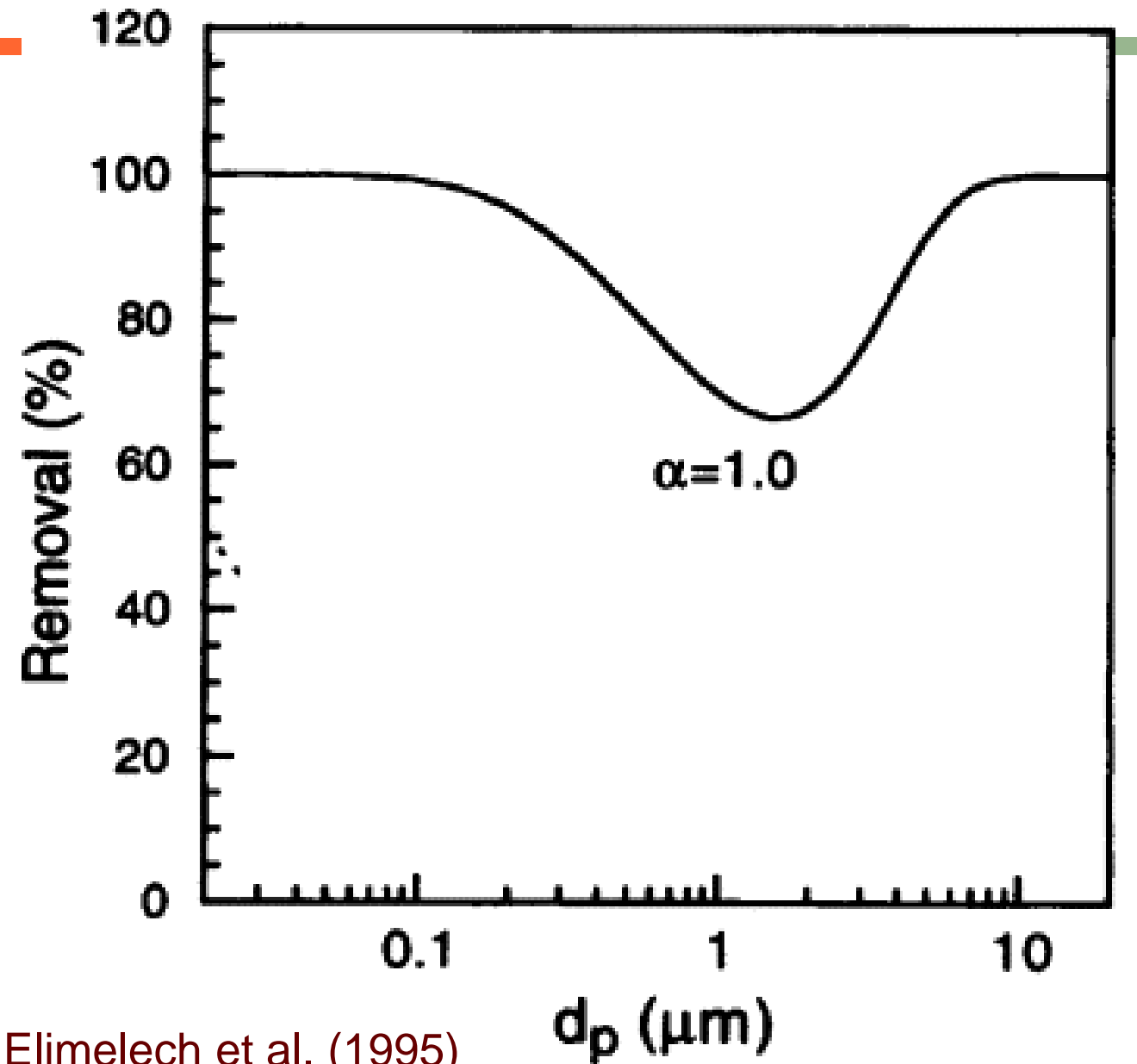## Performance

- Duplicate – Fast & Slow

Soluble Lead Water Condition
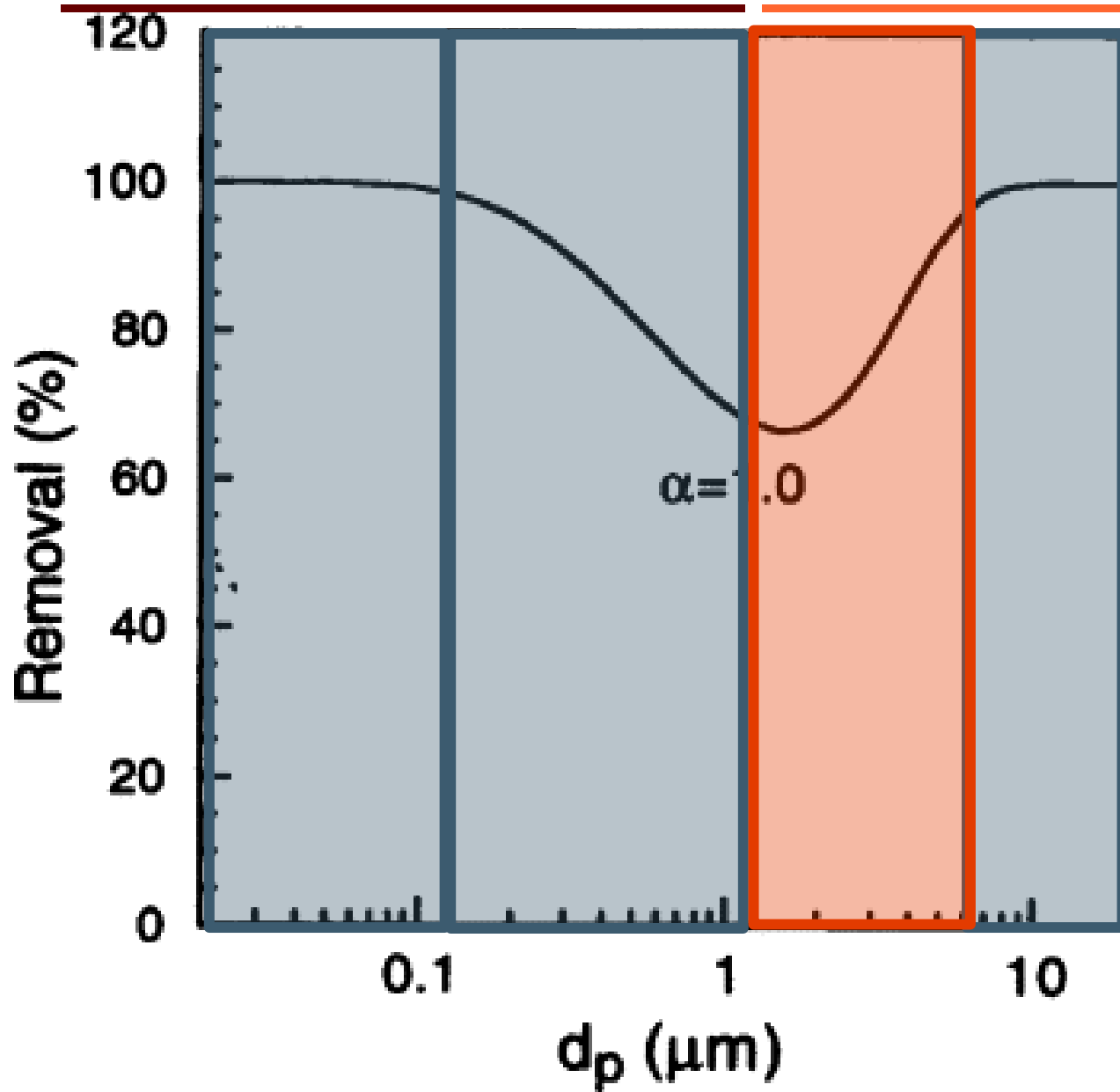

Input: 150 ppb Lead

150%, 155.7 ppb

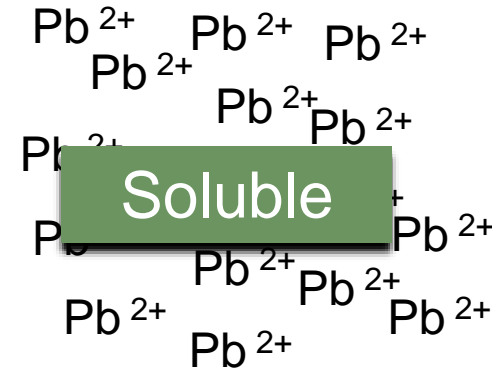Replicate # 2

Change filter

Replicate #1

15 ppb – EPA Action limit

99%, 11.6 ppb

Percent Capacity %

Lead in Filtered Water (ppb)

Pitcher Filters

C-P1   C-P2

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Theory Predicts: PARTICLE SIZE OF LEAD MAY IMPACT REMOVAL

Elimelech et al. (1995)

Removal (%) vs d_p (μm)

$\alpha = 1.0$

Soluble

Pb < 0.1 um

Fine

0.1 um < Pb < 1.2 um

Least likely to be removed

1.2 < Pb < 5 um

Sieved

5 um < Pb

Elimelech et al. (1995)

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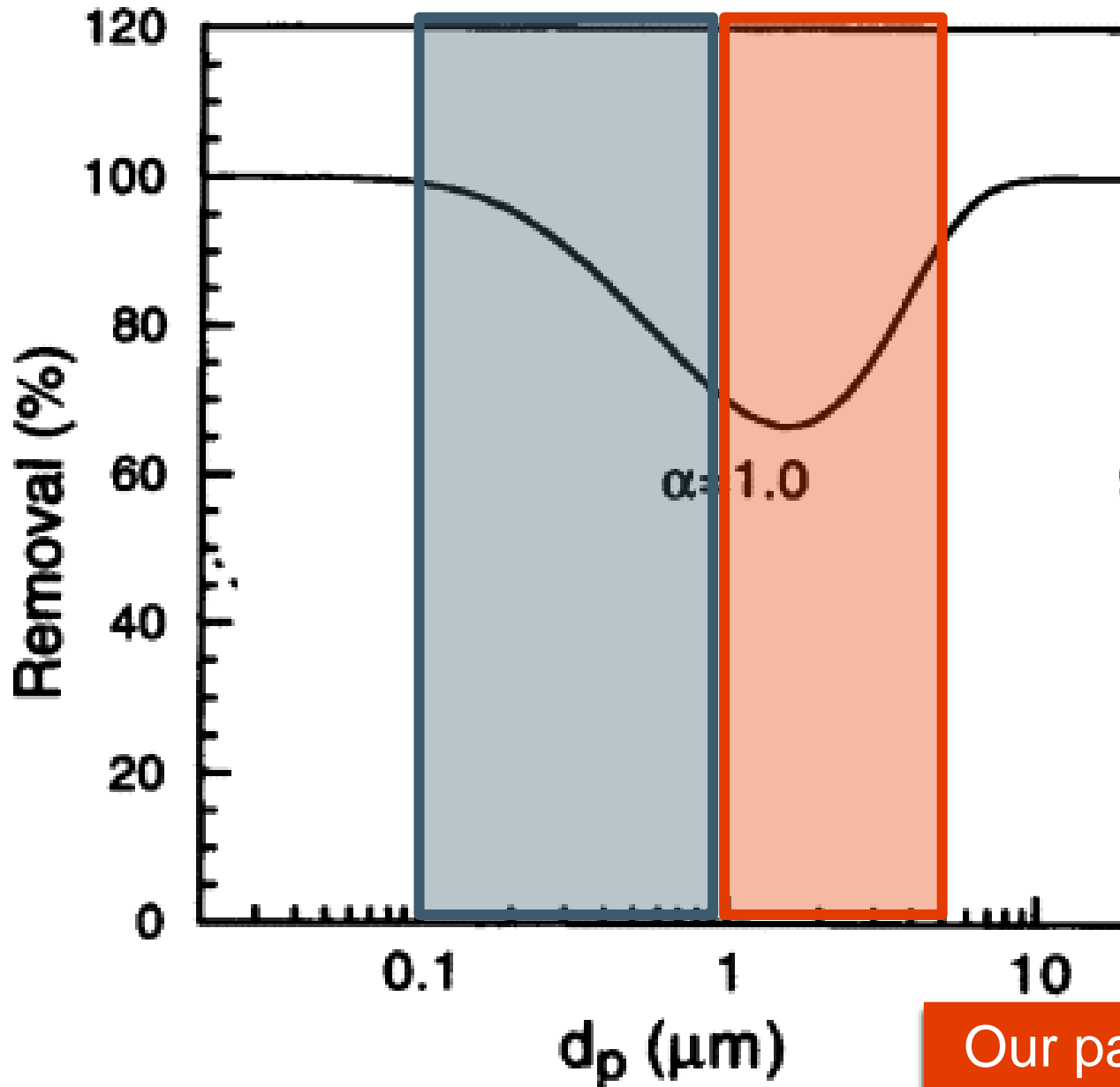
The NSF/ANSI 53 pH 8.5 Soluble-Particulate Challenge Water

Elimelech et al. (1995)

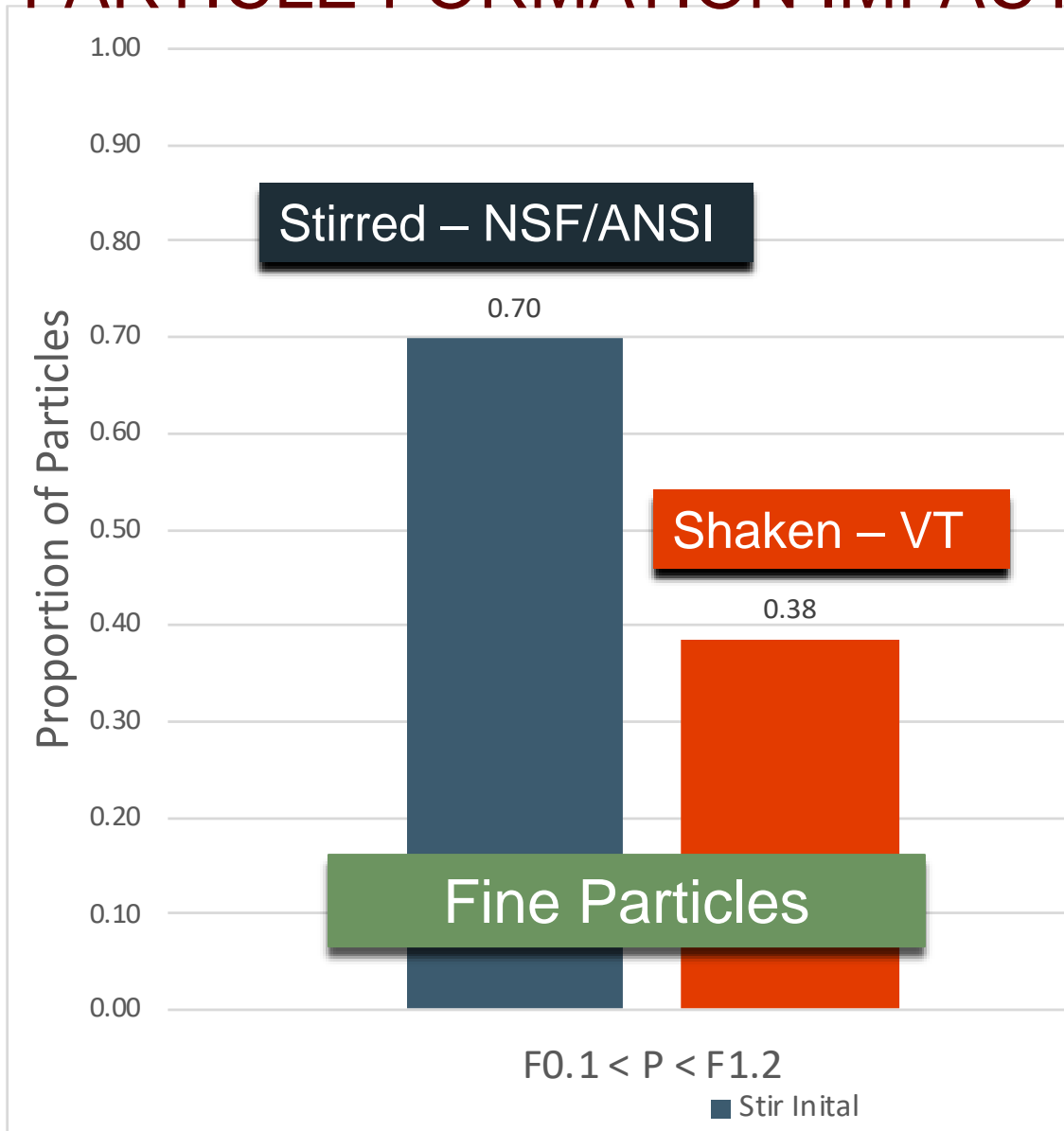|	NSF/ANSI	VIRGINIA TECH
Total Lead	150 ppb	150 -170 ppb
Total Particulate (Tp)	30 %	25-30%

Our particles are likely in the range that is harder to remove

Differences in Insoluble Lead Preparation

Remove portion

Oversaturate

Drain Line

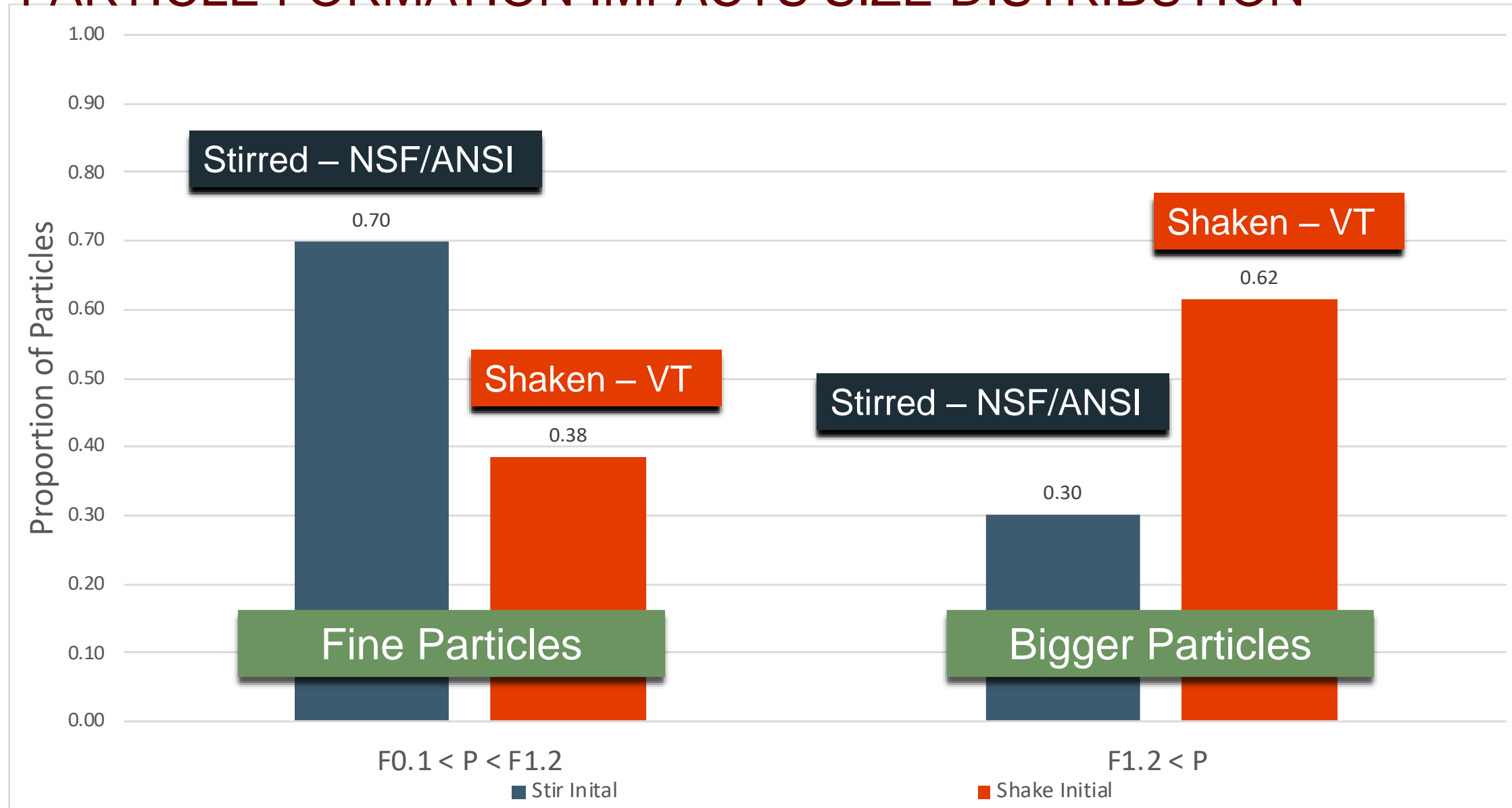Agitate for 60 seconds by…

Add back to tank

Shaking

OR

Stirring
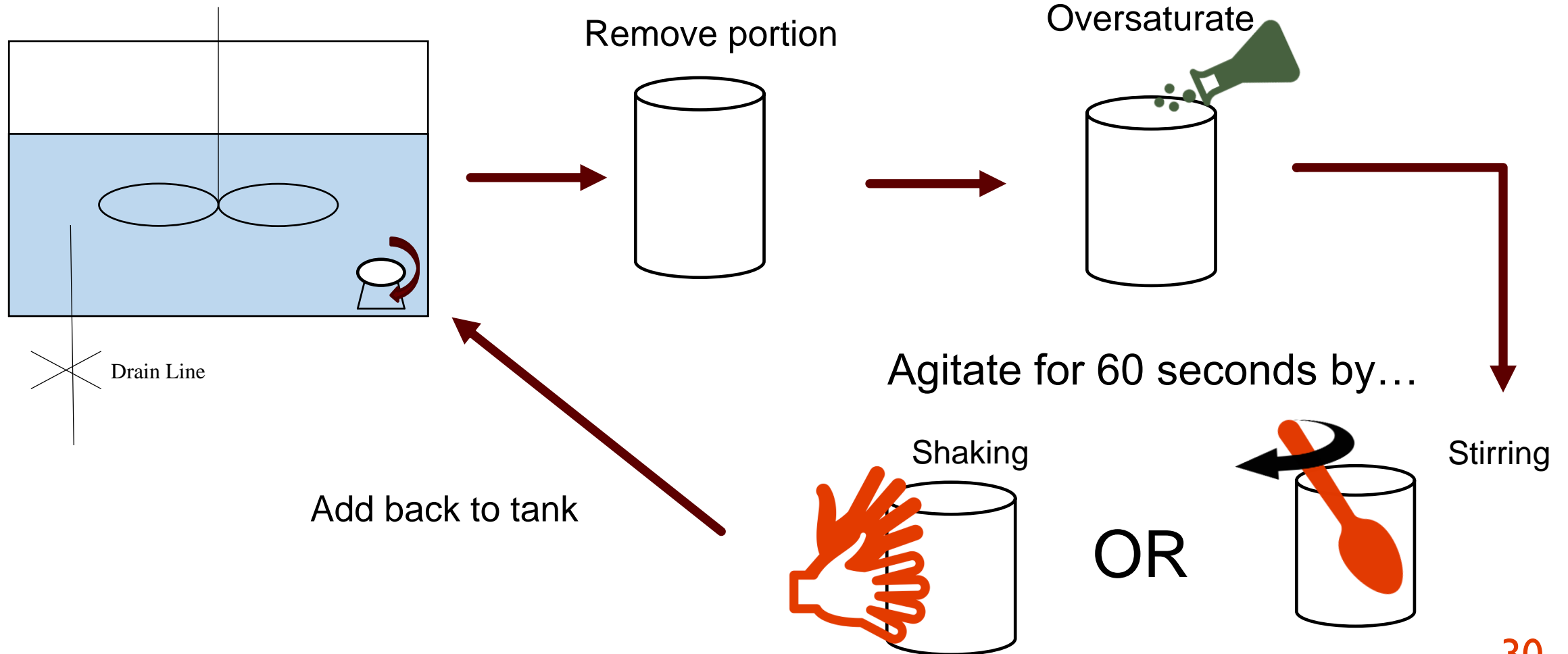
PARTICLE FORMATION IMPACTS SIZE DISTRIBUTION

PARTICLE FORMATION IMPACTS SIZE DISTRIBUTION

PARTICLE SIZE COULD BE THE REASON FOR FILTER PERFORMANCE

Input: 150 ppb

Still 80% Reduction at gal 78

Change filter

32 ppb

15 ppb – EPA Action Limit

10 ppb – NSF 53 Standard

Lead in Filtered Water (ppb)

Percent Capacity

Faucet Filters

D-F1   D-F2   F-F1   F-F2   K-F1   K-F2

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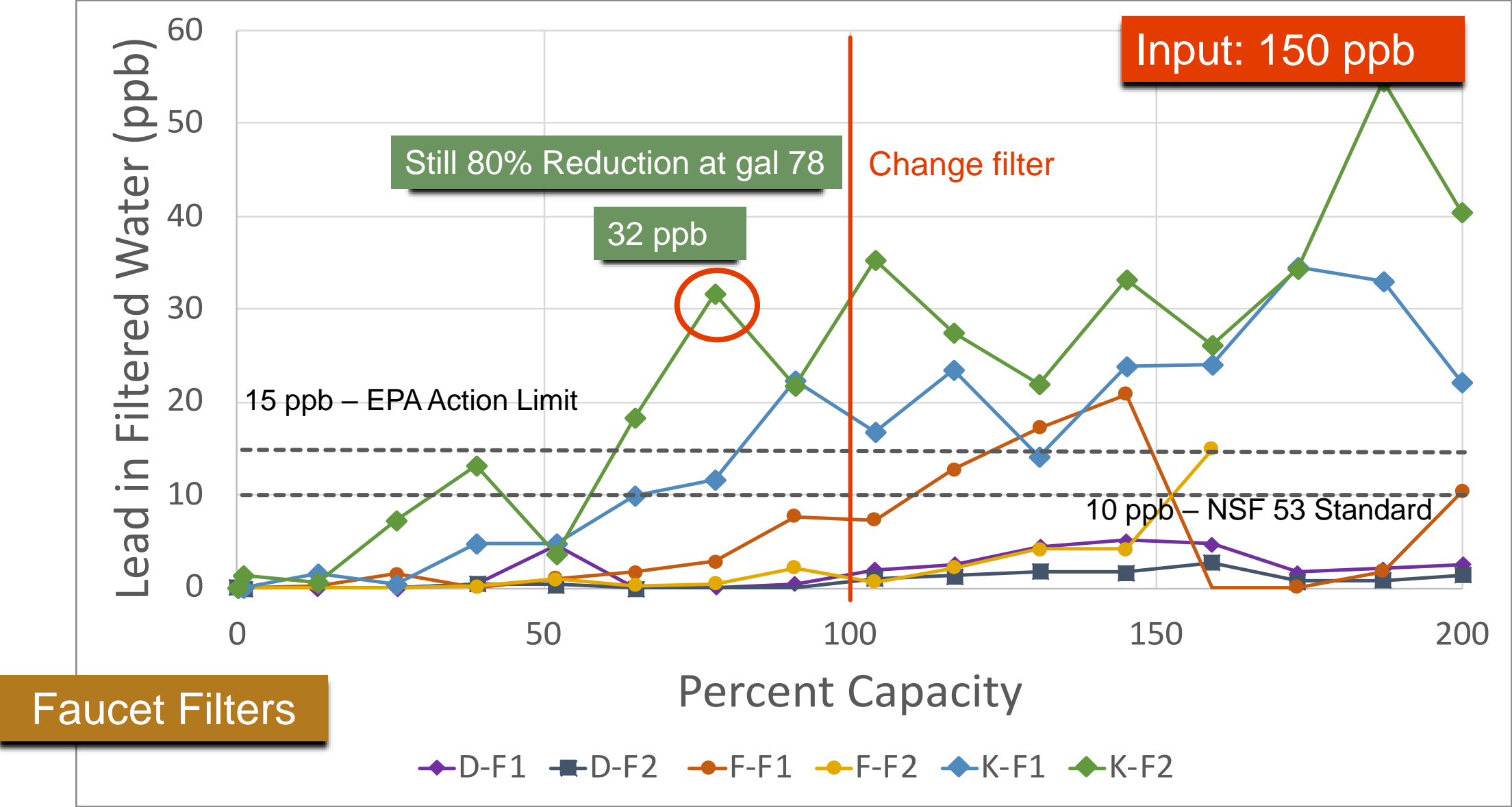
Newark's Drinking Water Problem: Lead And Unreliable Filters

August 13, 2019 · 3:21 PM ET

SASHA INGBER

Last fall, Newark gave out more than 40,000 water filters, even going door to door to reach families with lead service lines. The toxin is believed to have leached into drinking water through the old pipes between water treatment plants and people's homes. Free filters and cartridges would remove 99% of lead, the city of Newark said.

But recent test results introduced an element of doubt about that claim. A regional administrator at the EPA sent a letter Friday to city officials, saying tests on two homes suggested the filters "may not be reliably effective." Samples showed the filtered drinking water had lead levels exceeding 15 parts per billion, which is the federal and state standard, EPA regional administrator Peter Lopez said.

SHOTS - HEALTH
Where Lead Lu
Even Small Am

Source: NPR

A Newark, N.J., resident carries a case of bottled water distributed Monday at a recreation center. The Environmental

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Modes of Filter Failure: Overview

Structural

- Faucet Unit Leaks
- Pitcher Media Release Effluent

Leaking Unit – Replace It

Discard First Batch

Performance

- First Gallon
- Duplicate

Discard First Batch

QA/QC in Manufacturing

Modes of Filter Failure: Overview

Performance

- Particle Size ⟶ **Further Investigation**

MAIN CONCLUSIONS

POUs work majority of the time in our lab in reducing lead levels below EPA, NSF/ANSI 53, and Bottled Water Standards

FUTURE RESEARCH: Iron impacts filter performance, we are currently testing to see if it's presence impacts lead reduction

HUD PROJECT TEAM

Left to Right: Rusty, Jesika, Sarah, Paighton, Jeannie, and Ailene
June 26, 2019

CURRENT STUDENTS

Jesika McDaniel
Class 2021

Paighton Vanzant
Class 2020

Joseph Hector
Class 2021

Isabella Lerer
Class of 2022

Sarah Loomis
Class of 2022

Natalie Stone
Class of 2020

CURRENT STUDENTS

PREVIOUS STUDENTS

Co-Leading the Pitcher Study

Abby Simonpietri
Class of 2020

Becki Broyles
Class of 2020

Reilly Albert
Class of 2022

Ailene Edwards
UVA Class of 2023

Leila Husain
Class 2019
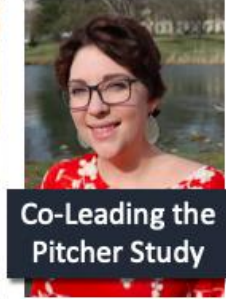
Rusty Rouillier
BS/MS Class of 2020

THANK YOU – QUESTIONS?

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