EVERETT

Jacobs Challenging today. Reinventing tomorrow.

Prove it! Demonstrating pathogen removal in a 10 gpm/sf gravity filtration pilot study

PNWS-AWWA Conference 2024

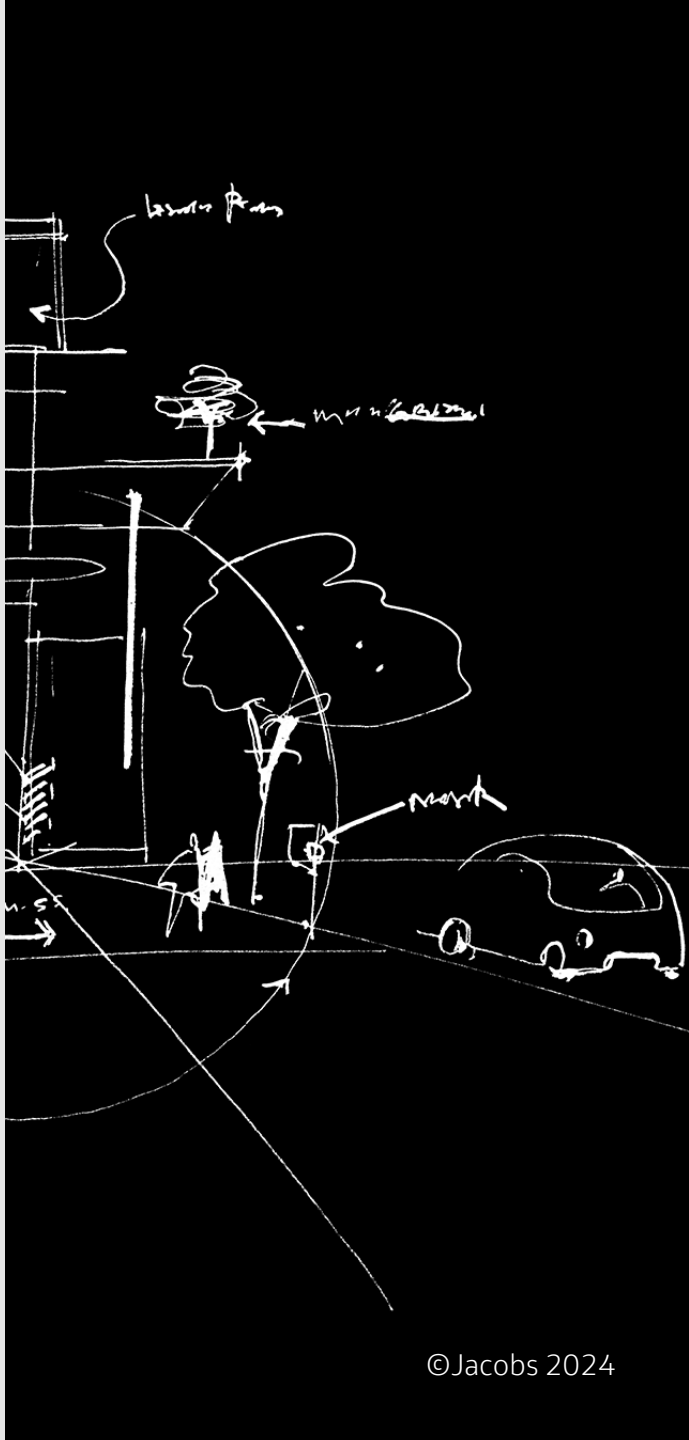
Enoch Nicholson and Benedicte Diakubama

Thursday May 2nd, 2024

11:30 AM

Agenda

- Acknowledgements
- Background and Pilot Study Objectives
- Planning and the 5 to 15 micron Monomedia Challenge
- Schedule and Results
- Conclusions and Lessons Learned



Acknowledgements

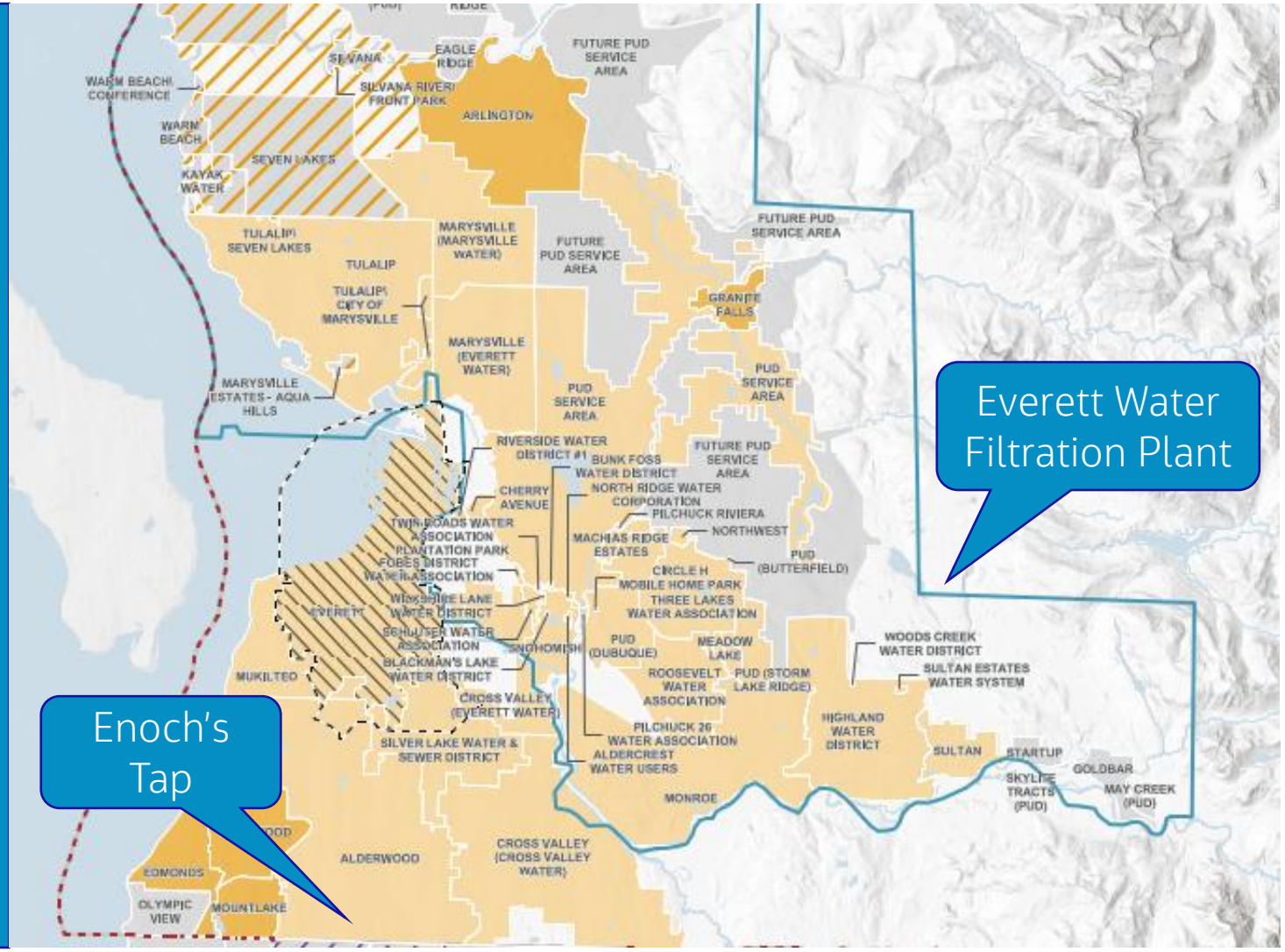
- City of Everett
  - Anna Thelen, Senior Environmental Specialist
  - James Rossi, Senior Water Treatment Plant Operator
  - Aaron Chan, Water Quality Analyst
  - Everett Water Filtration Plant Operators
- Jacobs
  - Talia Assi, Lead Process Engineer
  - Amy Gao, Project Manager

Background and Pilot Study Objectives

Everett Water System and Wholesale Customers

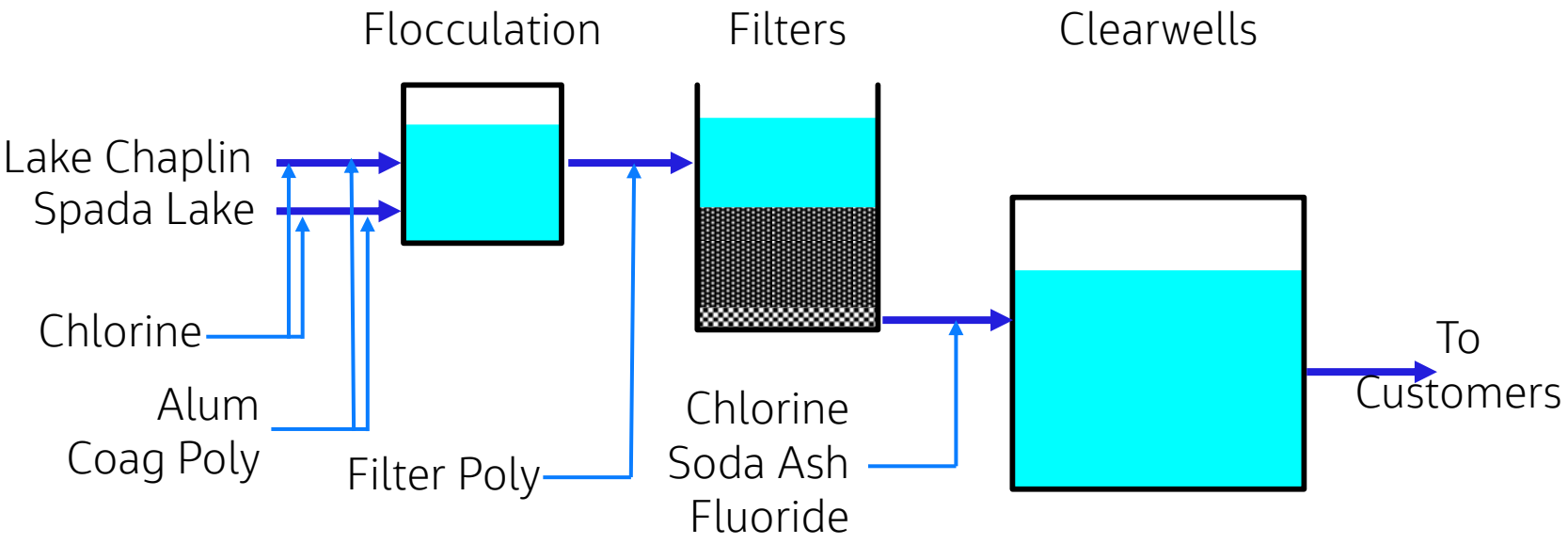
Everett Water System

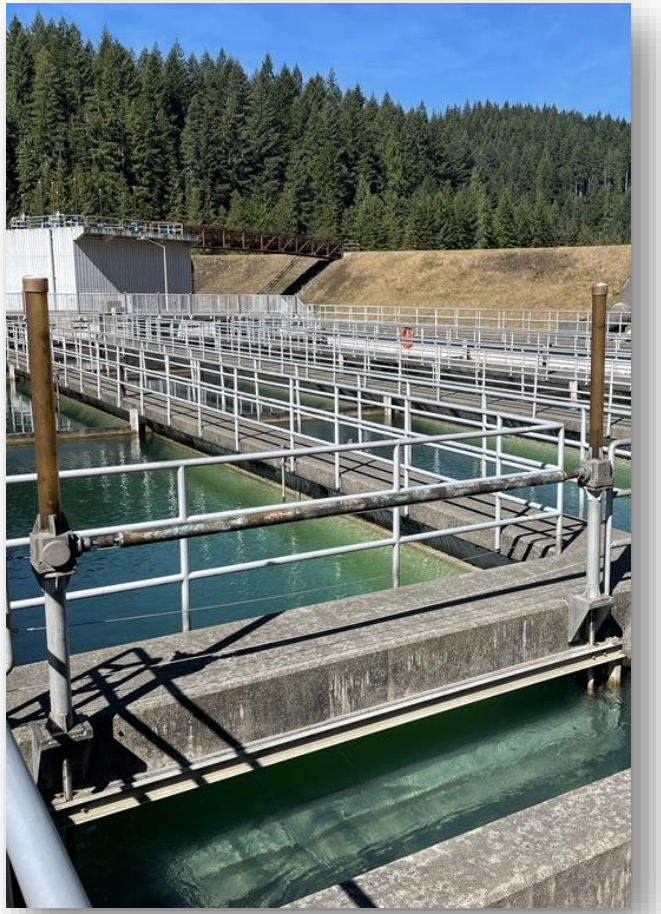
- 1 Water Filtration Plant
- 141 mgd peak day capacity
- 640,000 People Served
- 76% of county

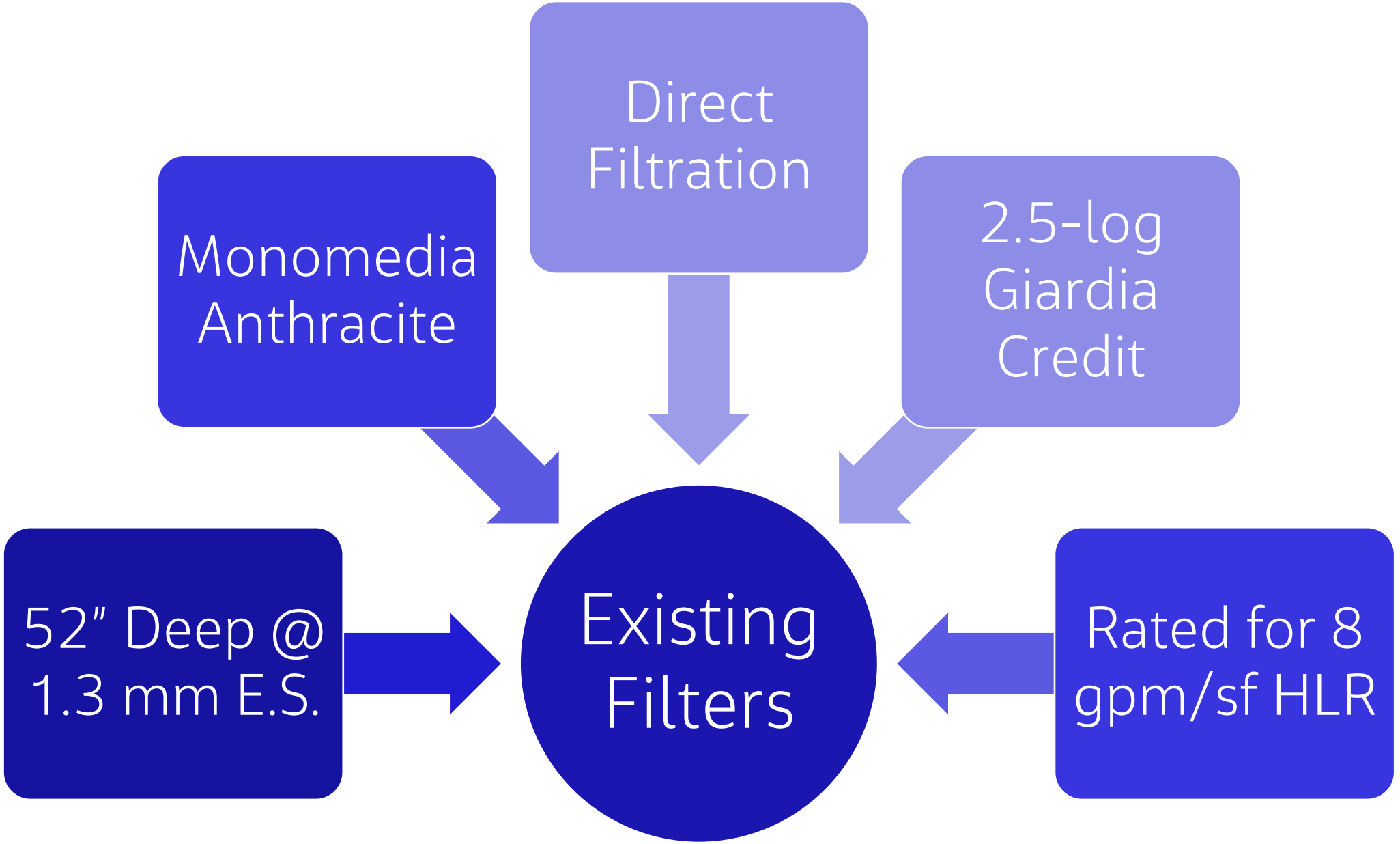


Source: City of Everett 2020 Water Comprehensive Plan, HDR Engineering

City of Everett Water Filtration Plant






Direct Filtration
Monomedia Anthracite
2.5-log Giardia Credit
52" Deep @ 1.3 mm E.S.
Existing Filters
Rated for 8 gpm/sf HLR

Testing Goals

Evaluate if existing filters are capable of operating at higher than 8 gpm/sf

Identify operational impacts associated with higher loading rates

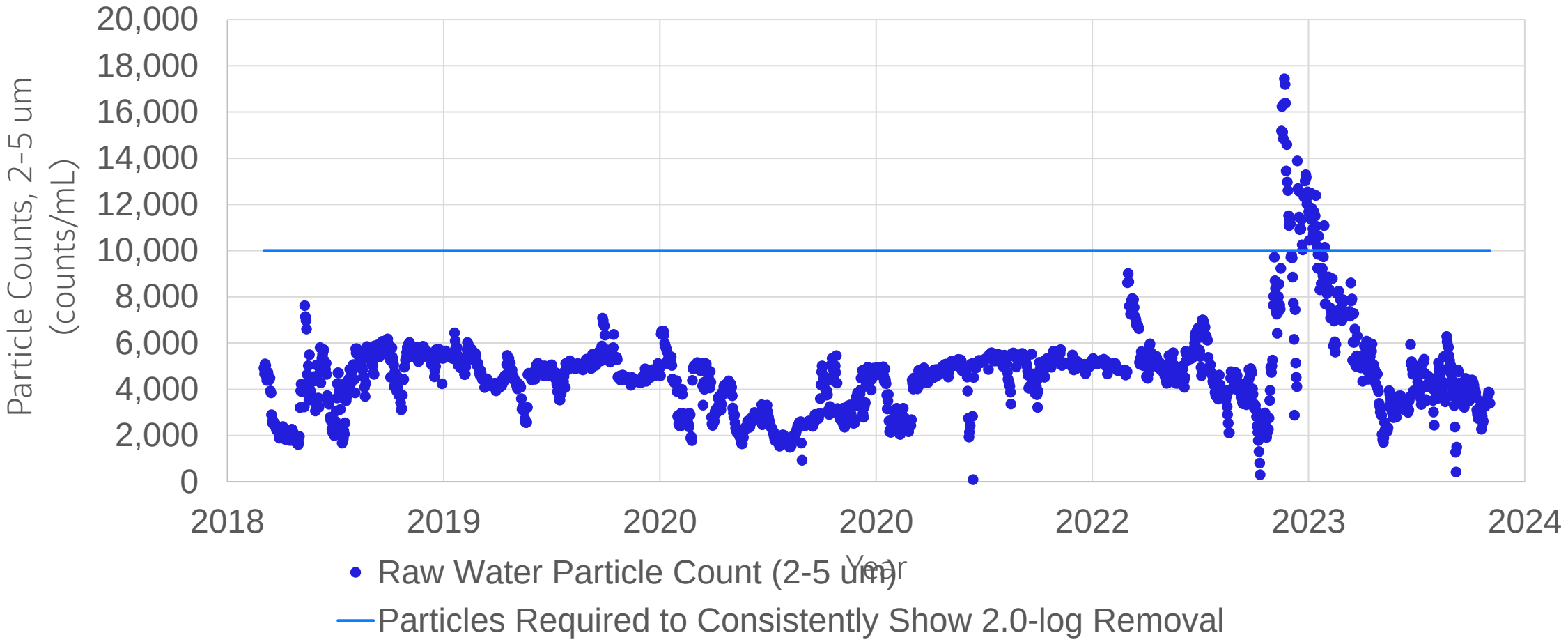
Gain Washington DOH approval if testing is successful

Test Plan and the 5 to 15 micron Monomedia Challenge

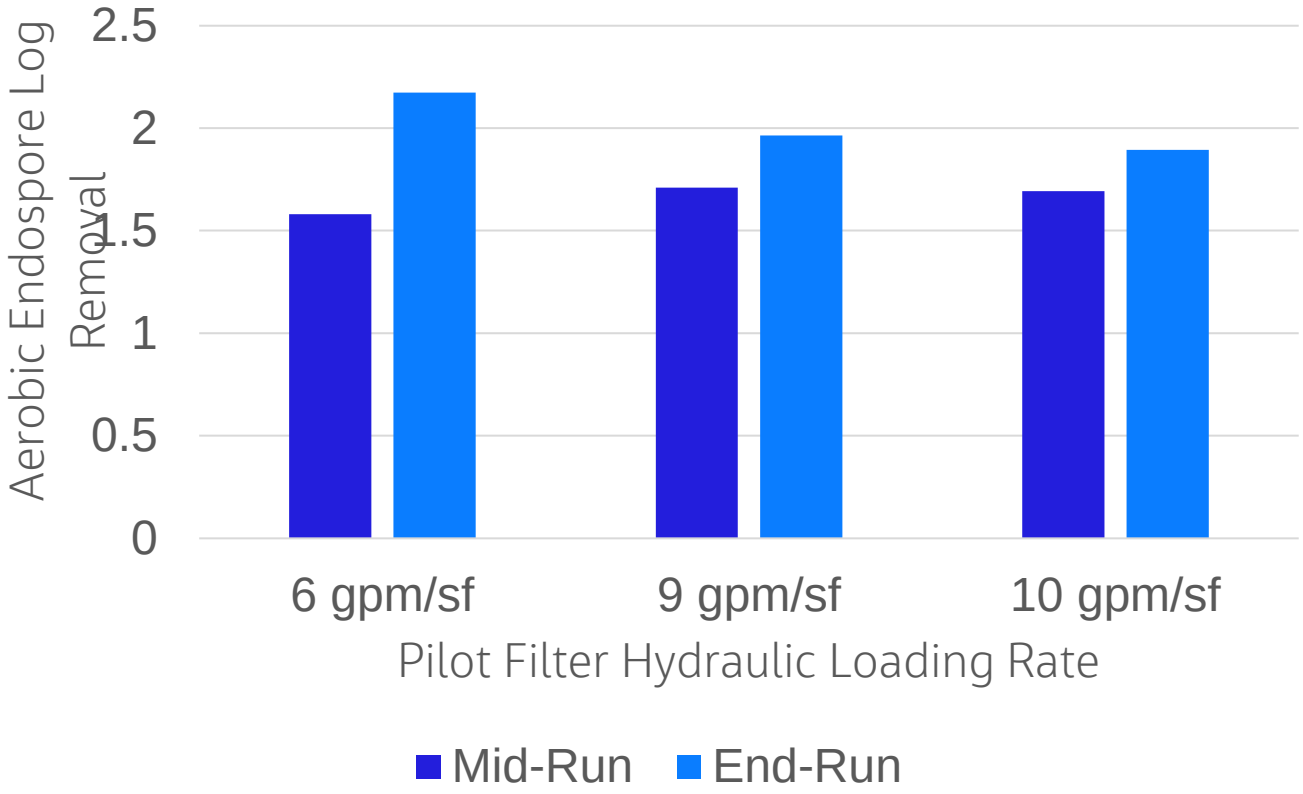
Pilot System Setup

- Manufactured by Intuitech, Inc
- Supply taken from floc basin effluent
- 3 column granular media filtration pilot
- Media taken from full scale filters

Clean water is clean water, but it's hard to show removal



Surrogate #1: Aerobic Endospores

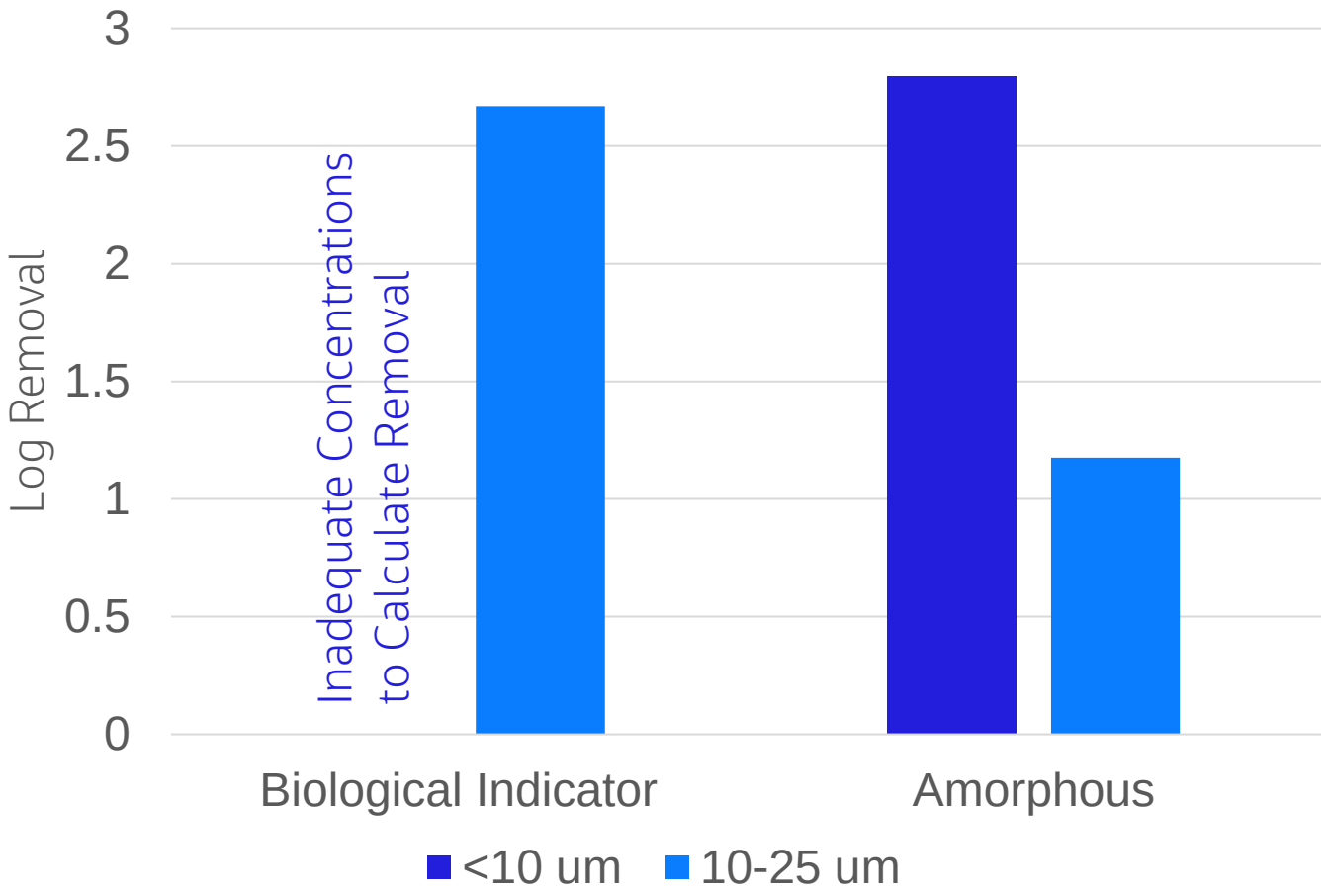


- Removal not equal to particle removal
- Matched literature that shows lower removal
- Lack of coagulation in pilot impacts filterability

Notes:
- Mid-Run: Stable Conditions, Low Effluent Particles
- End-Run: Early-stage turbidity and particle breakthrough

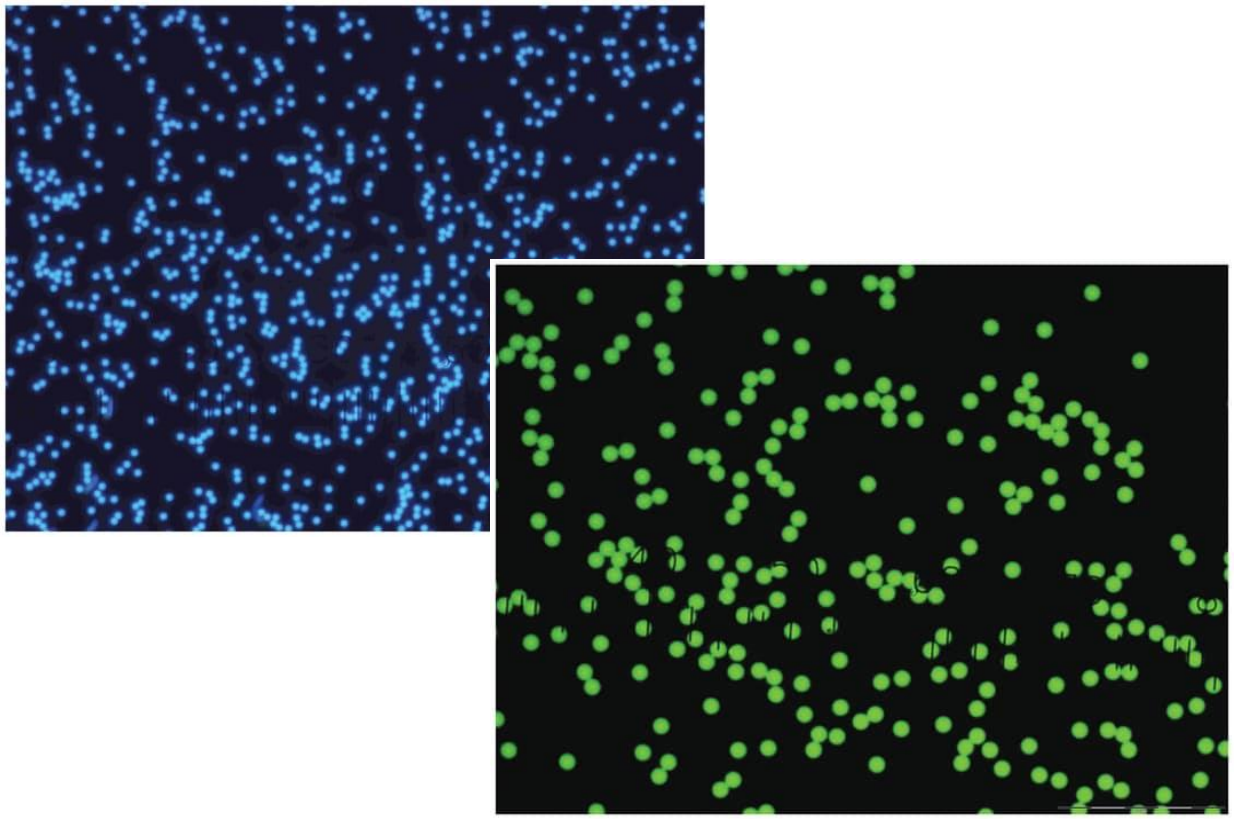
Surrogate #2: Microscopic Particulate Analysis (MPA)

- Absolute numbers did not demonstrate removal
- HOWEVER!
  Type of particles in finished water demonstrated removal
- Removal demonstration would have been subjective

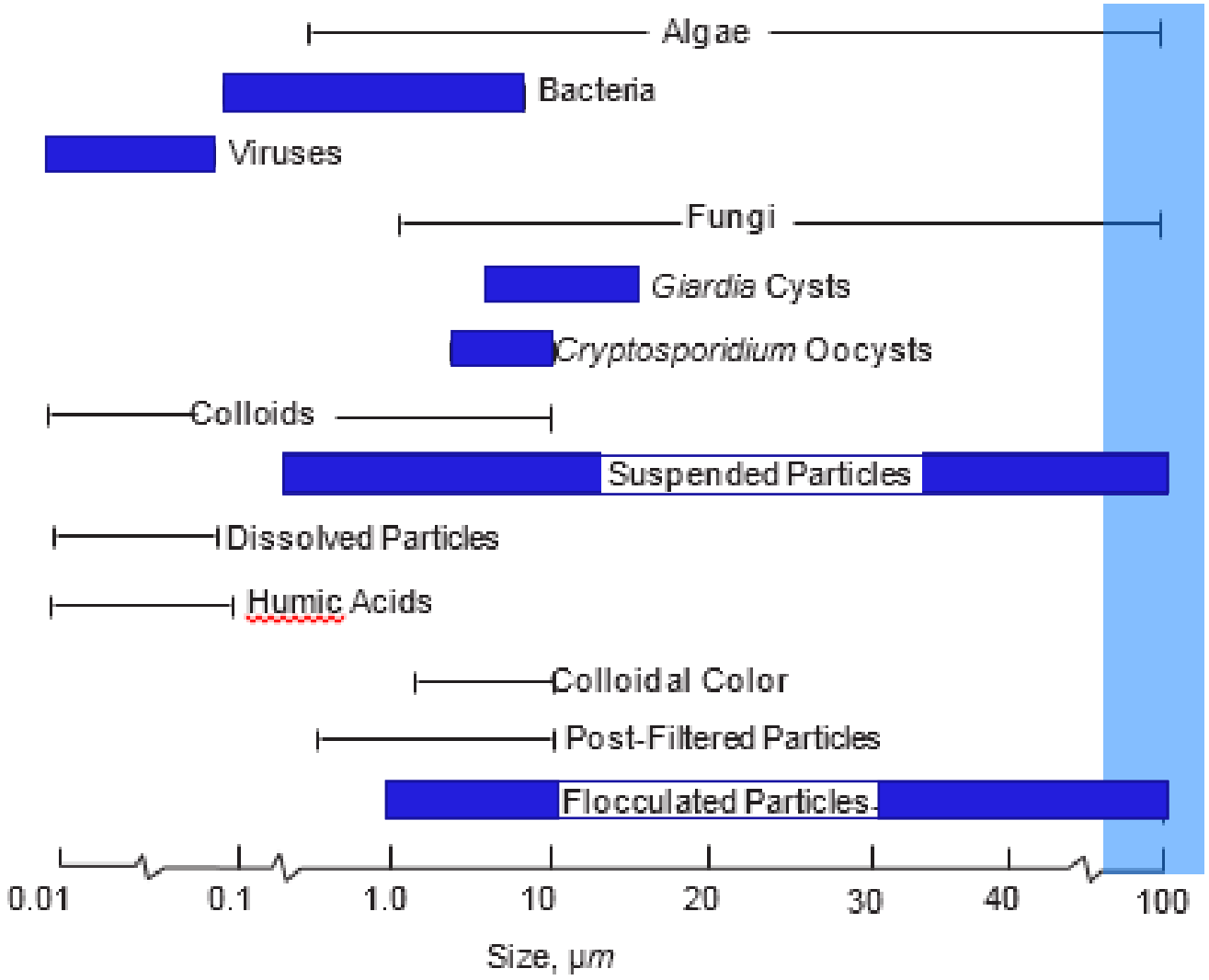


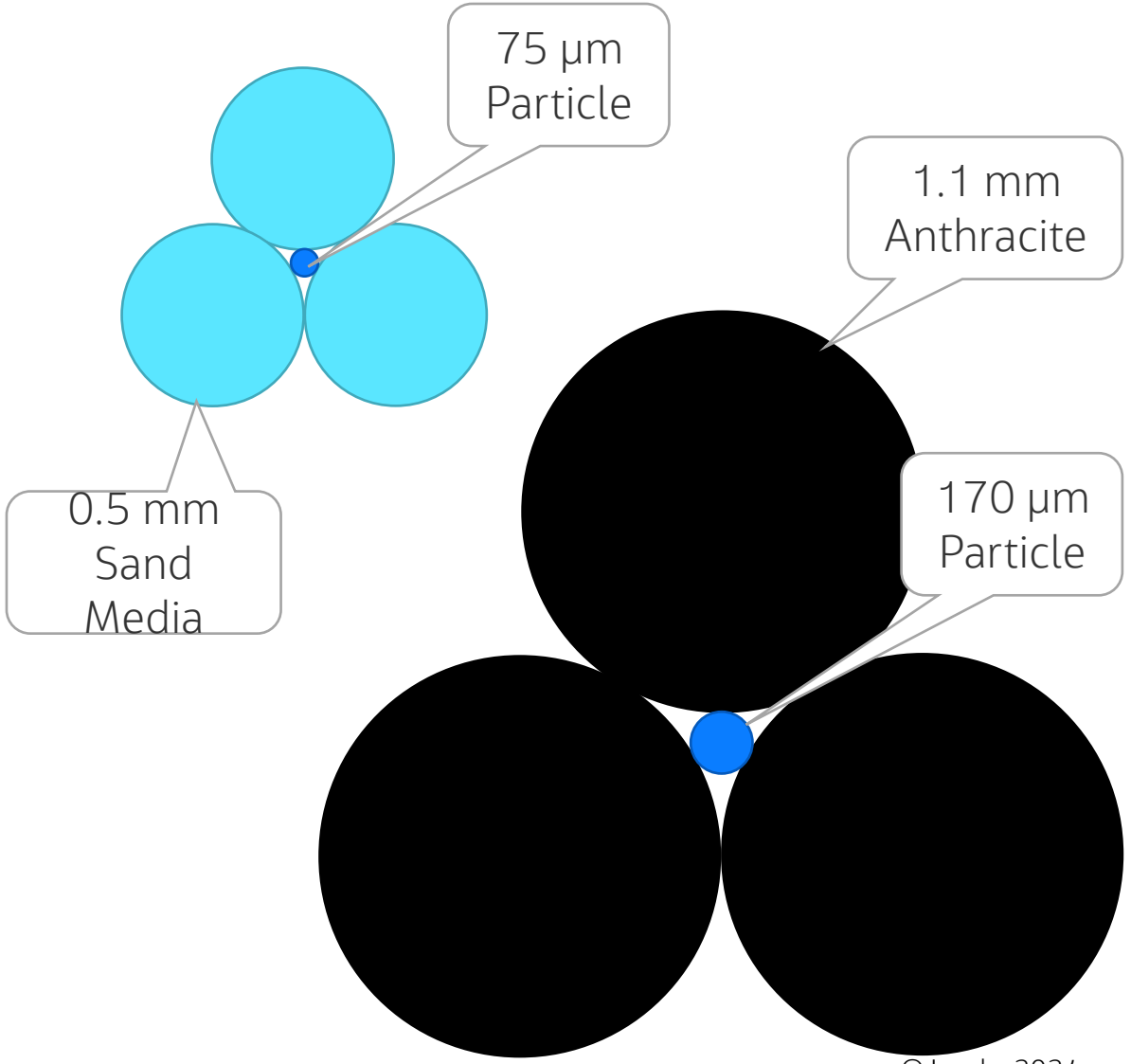
Surrogate #3: Fluorescent Microspheres

- Dyed polystyrene beads with specified diameters
- Expected similar results to Aerobic Endospores
- Not tested due to high cost of implementation



Fluorescent Microspheres courtesy of ThermoFisher


Algae
Bacteria
Viruses
Fungi
Giardia Cysts
Cryptosporidium Oocysts
Colloids
Suspended Particles
Dissolved Particles
Humic Acids
Colloidal Color
Post-Filtered Particles
Flocculated Particles
0.01
0.1
1.0
10
20
30
40
100
Size, µm


75 µm Particle
0.5 mm Sand Media
1.1 mm Anthracite
170 µm Particle

Pilot Test Plan

1 month
operation per season

20 runs
at each loading rate

6 gpm/sf
control filter

9 and 10 gpm/sf
test filters alternated each run

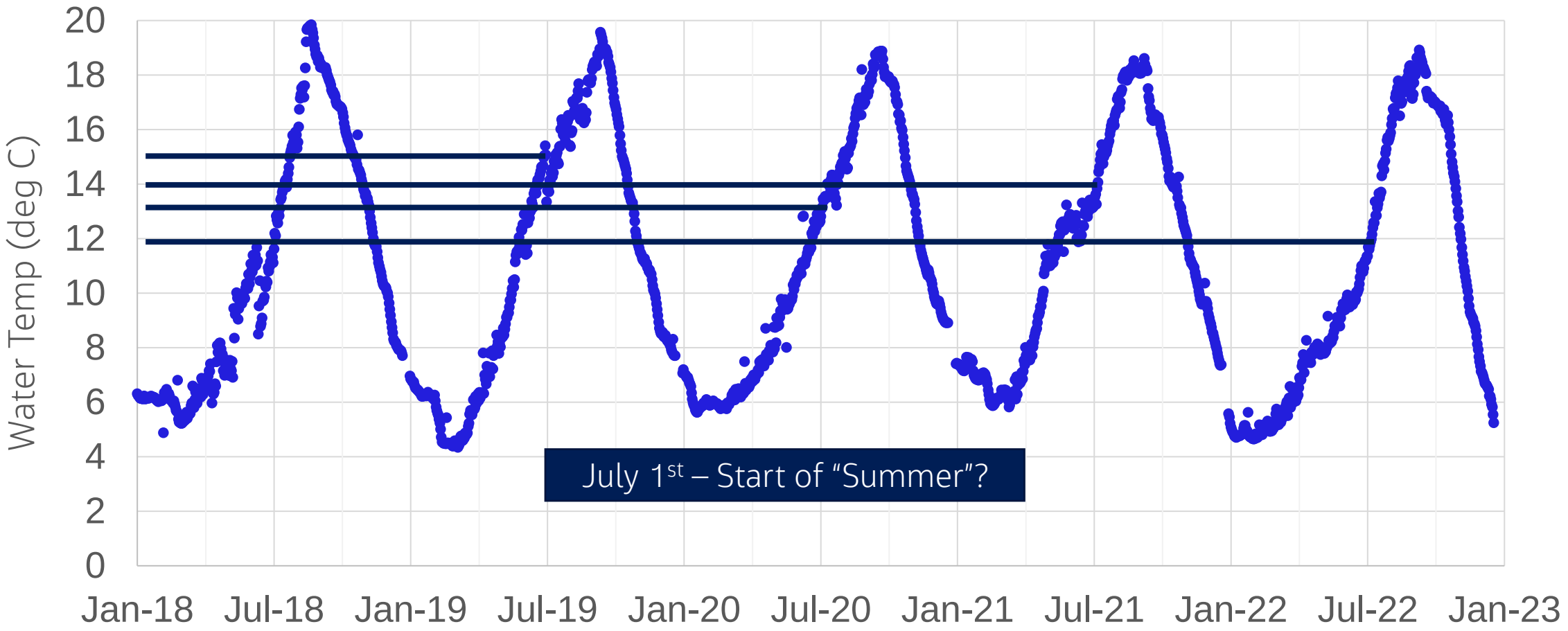
9 ft
terminal headloss

0.3 NTU
terminal turbidity

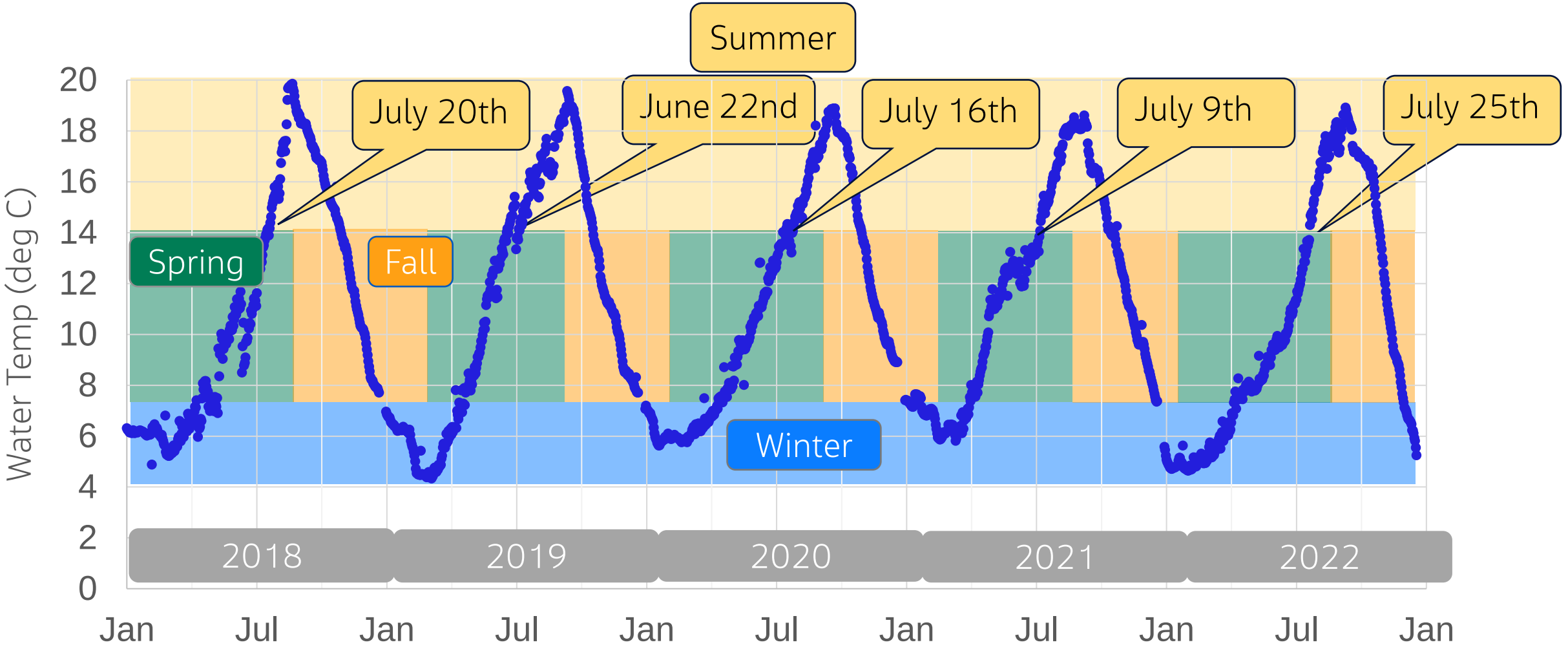
Parameter	Primary Criteria	Secondary Criteria*	Recording Period
Turbidity	≤ 0.1 NTU (95th Percentile)		Seasonal Average
2-5 um Particle Removal	2.0-log removal	≤ 60/mL	Filter Run Average
5-15 um Particle Removal	2.0-log removal	≤ 20/mL	Filter Run Average
* Discrete particle counts used only if direct calculation of removal is not possible			

Schedule and Results

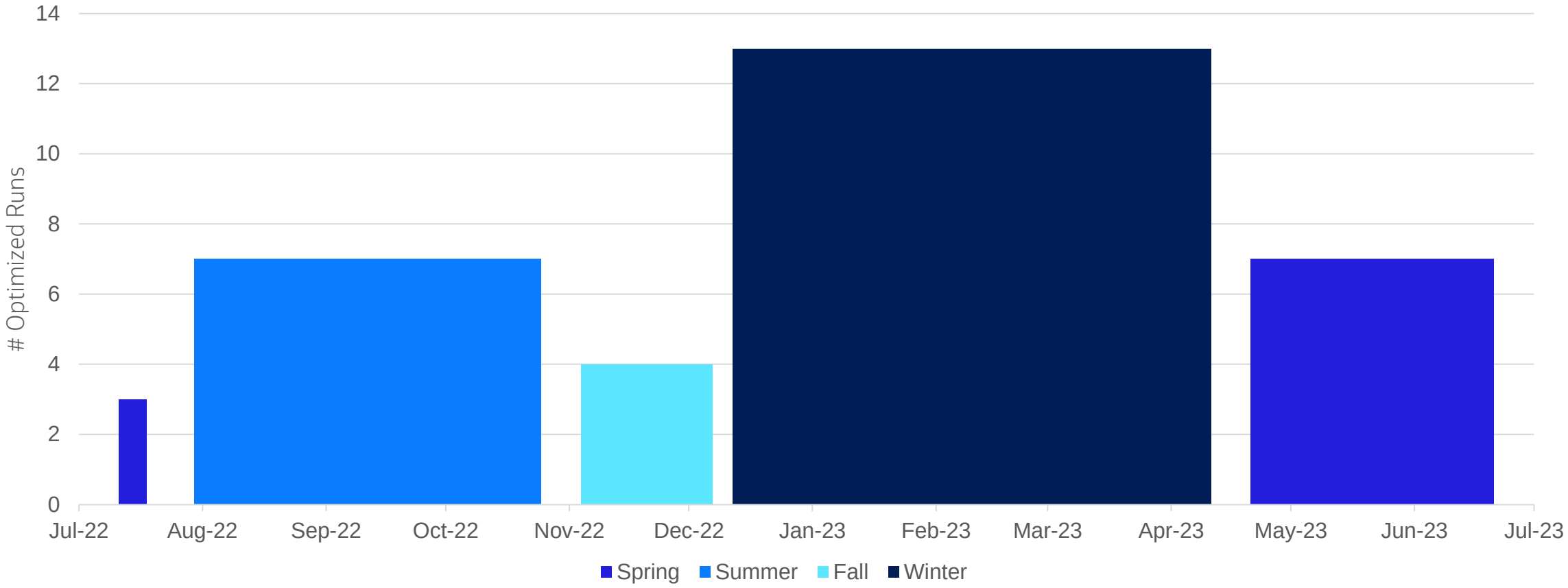
Water Seasons: A hot/cool approach to data analysis



Water Seasons: A hot/cool approach to data analysis



Pilot Testing Schedule

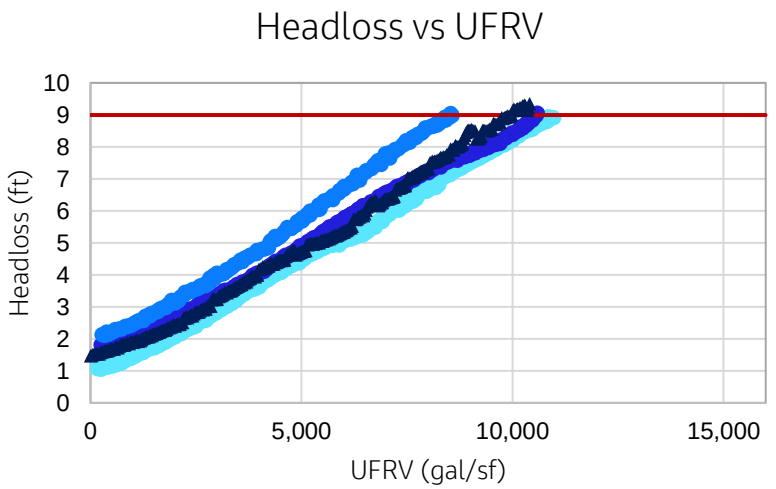


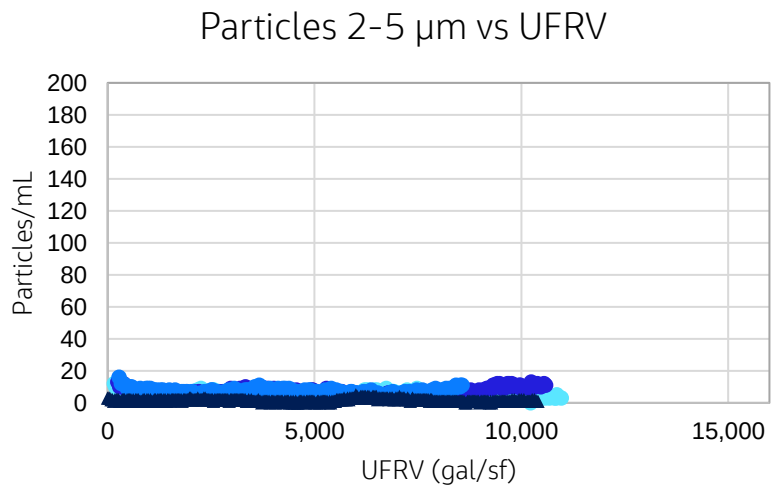
55 total runs over 1 year of operation

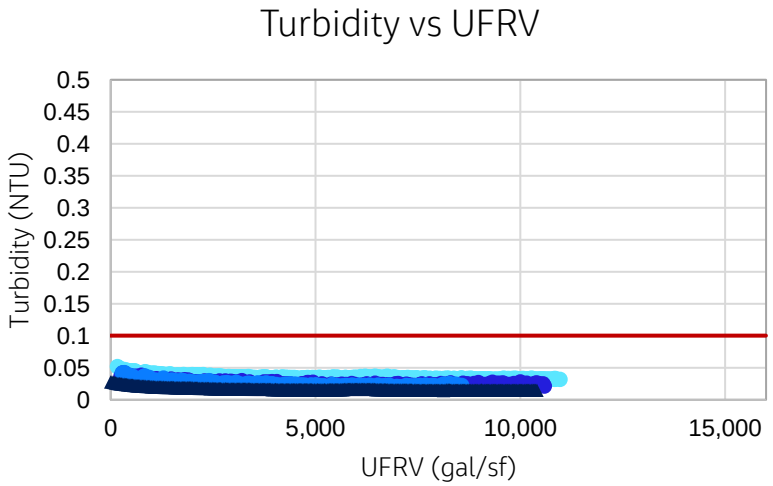
Example Optimized Run

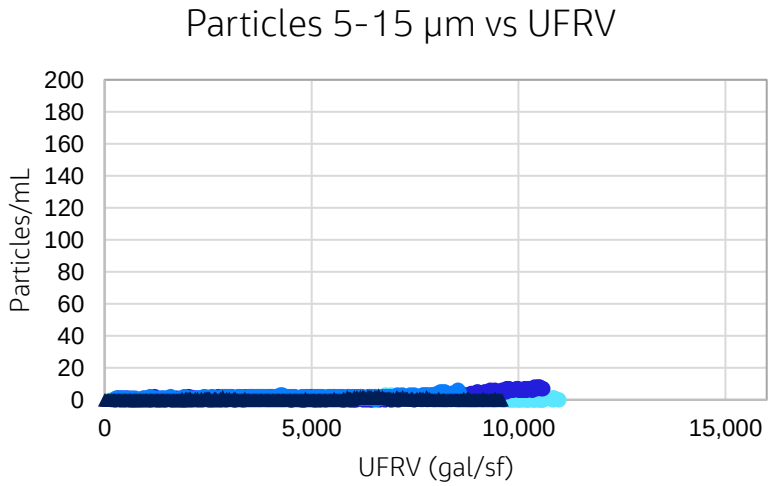
5/08/2023

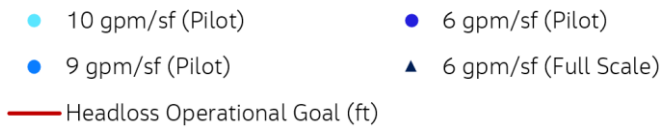
- All pilot filters terminated based on head loss
- All pilot filters met all particle log removal criteria for 2-5 and 5-15 um
- All pilot filters met operational goals for turbidity particle counts
- No turbidity or particle breakthrough at end of run
- All pilot filters UFRV run higher than expected/normal





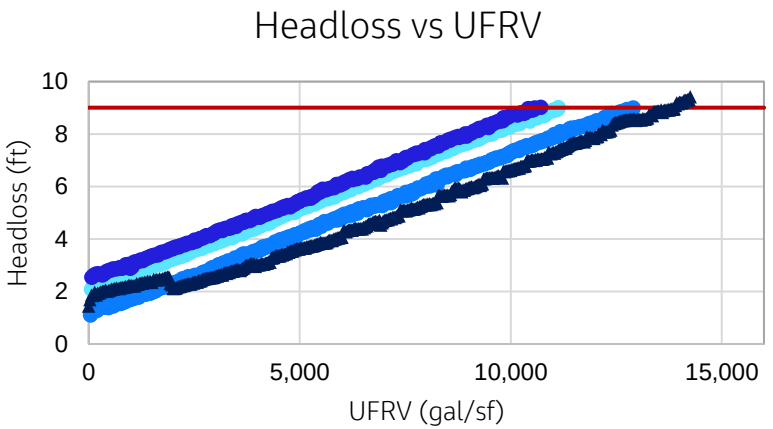


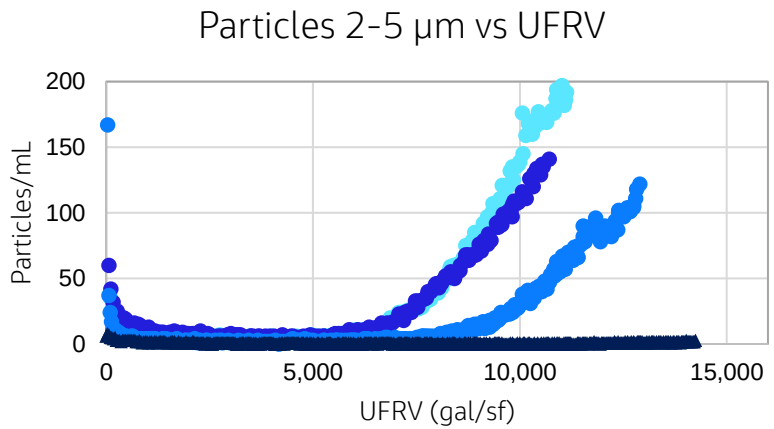


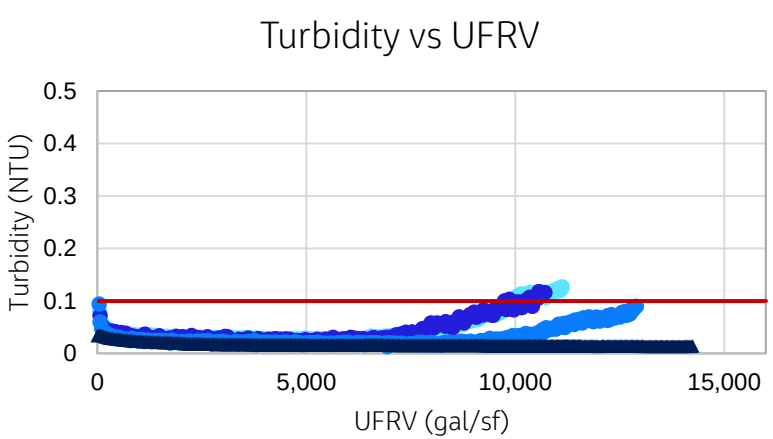


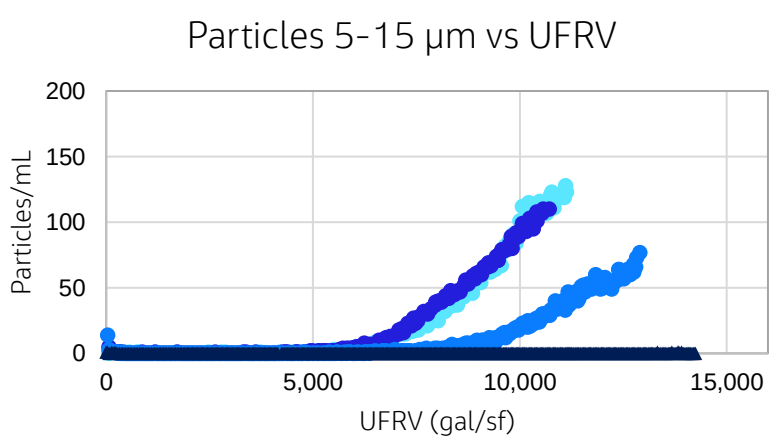
Representative Non-Optimized Run

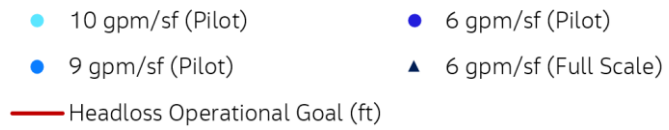
- Typical causes of non-optimized conditions:
  - Inadequate filter aid polymer dose
  - Pilot Equipment malfunction
  - Full-scale WFP not optimized for pilot particle removal





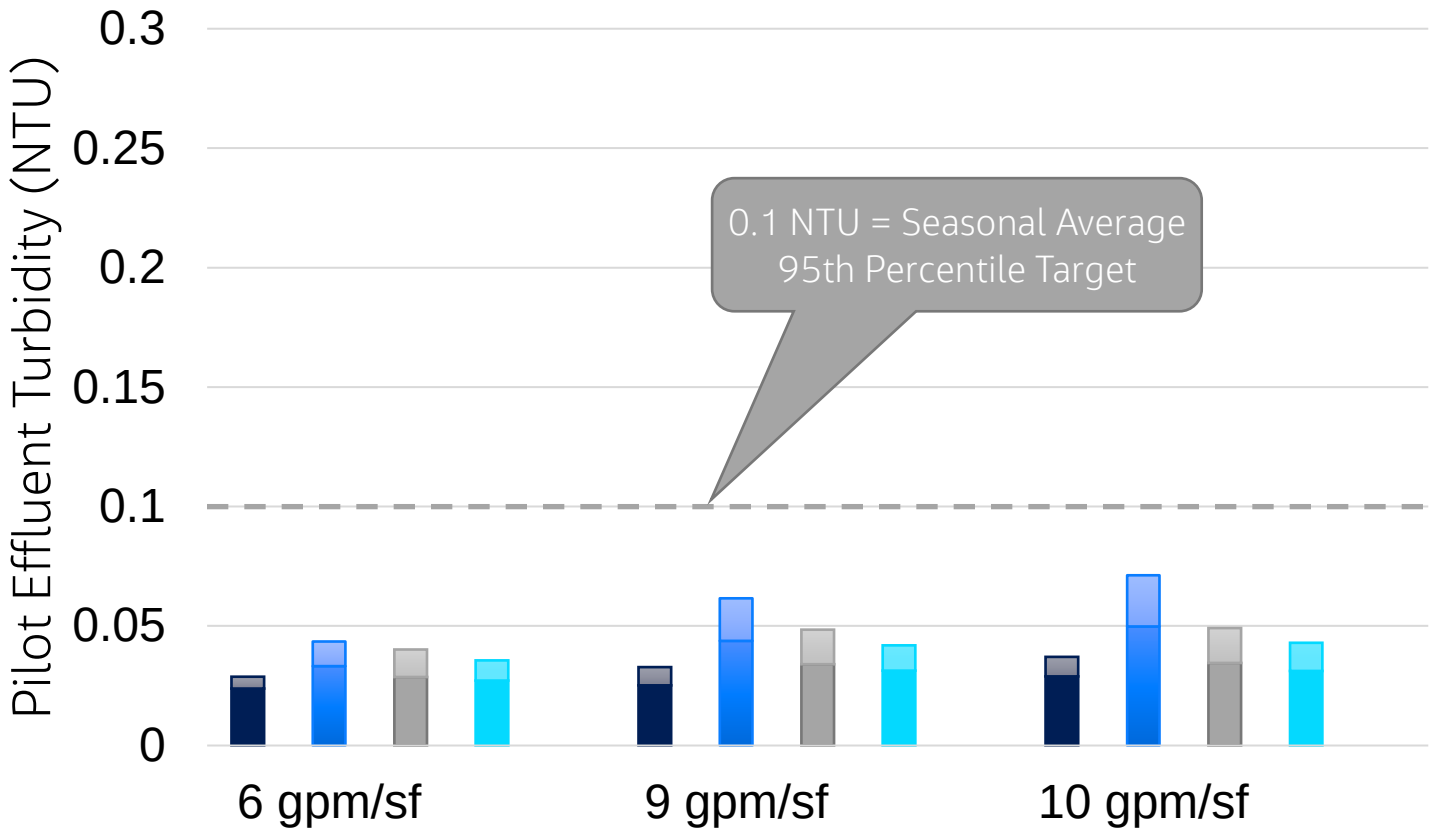






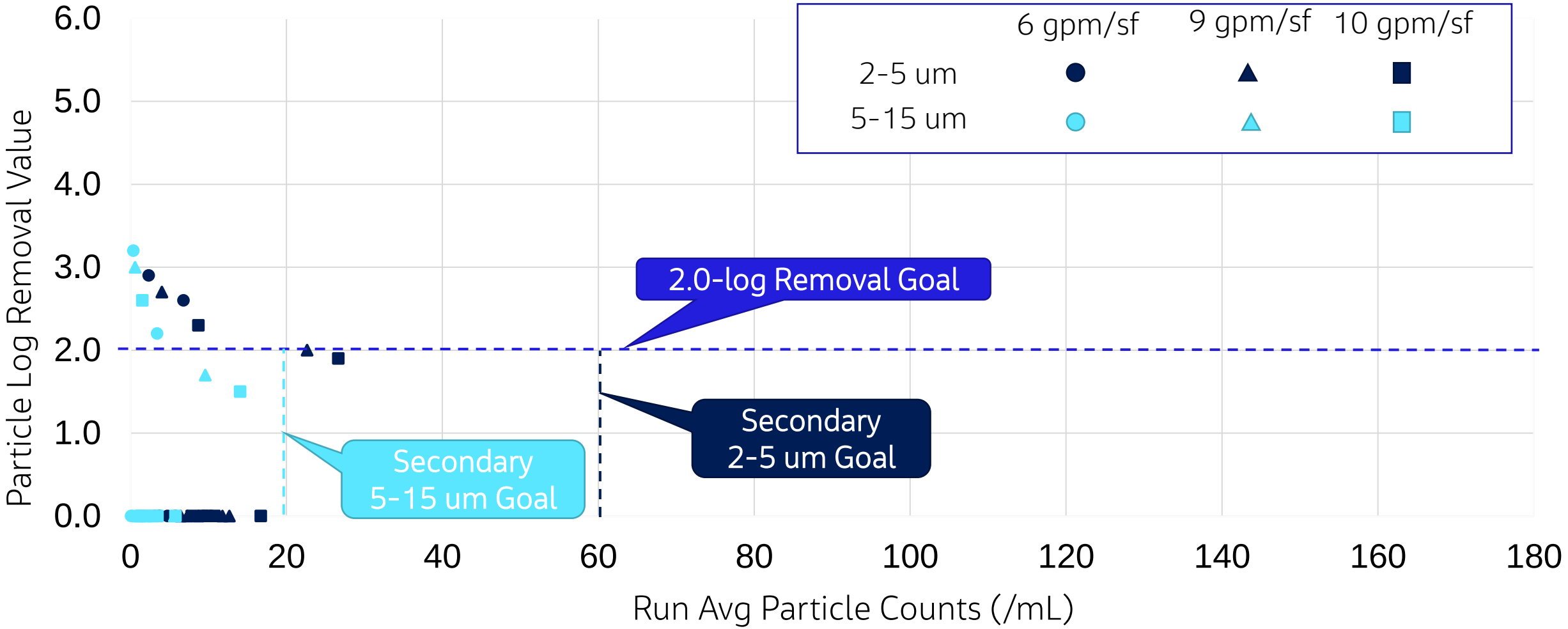
Pilot Turbidity

- Optimized runs only
- All filter loading rates met turbidity criteria
- Higher effluent turbidity in fall and winter
- Slight increase at higher loading rate likely due to sidewall effects



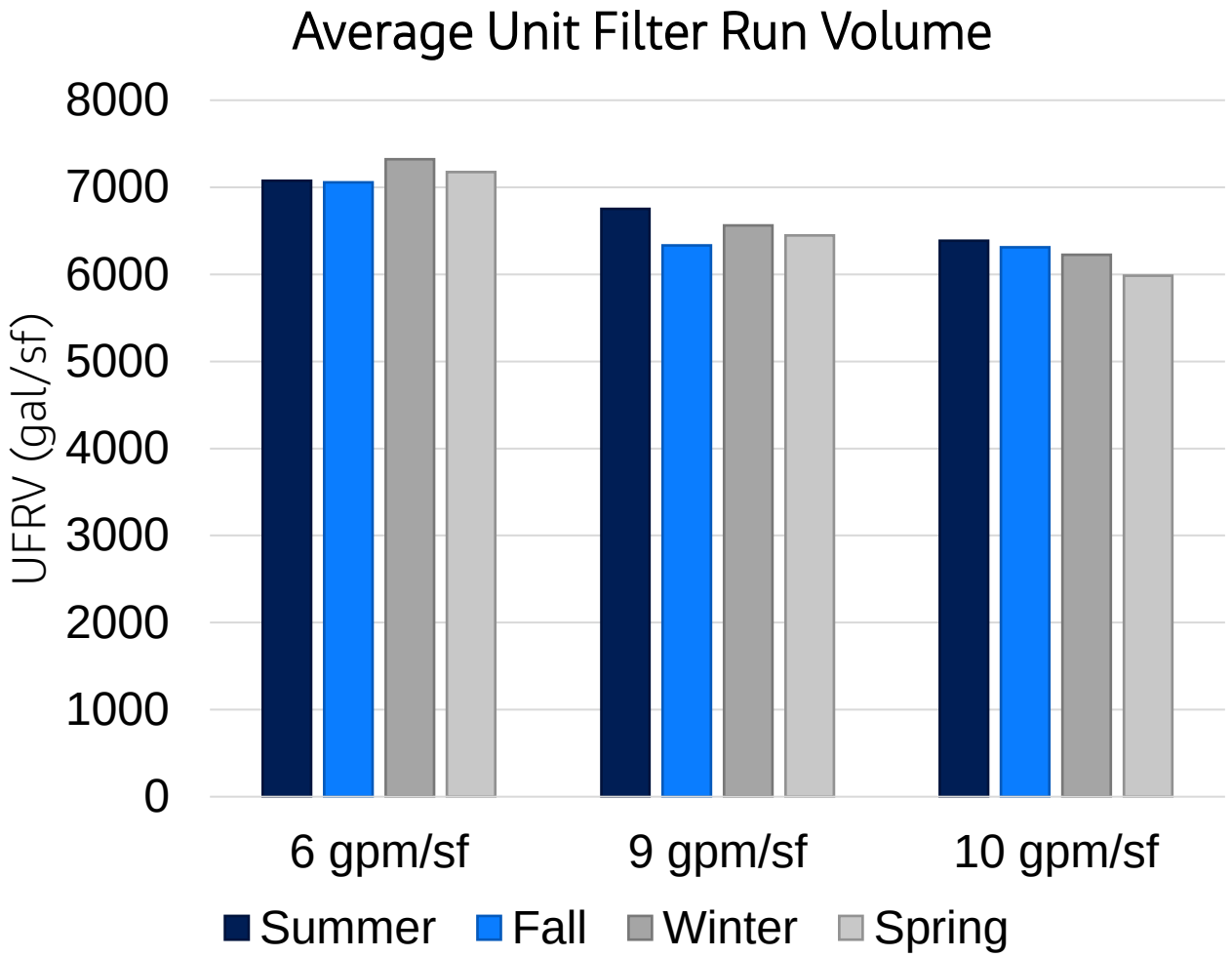
	Summer	Fall	Winter	Spring
Average Individual Run 95%				
Average Run Average				

Particle Acceptance Criteria - Summer

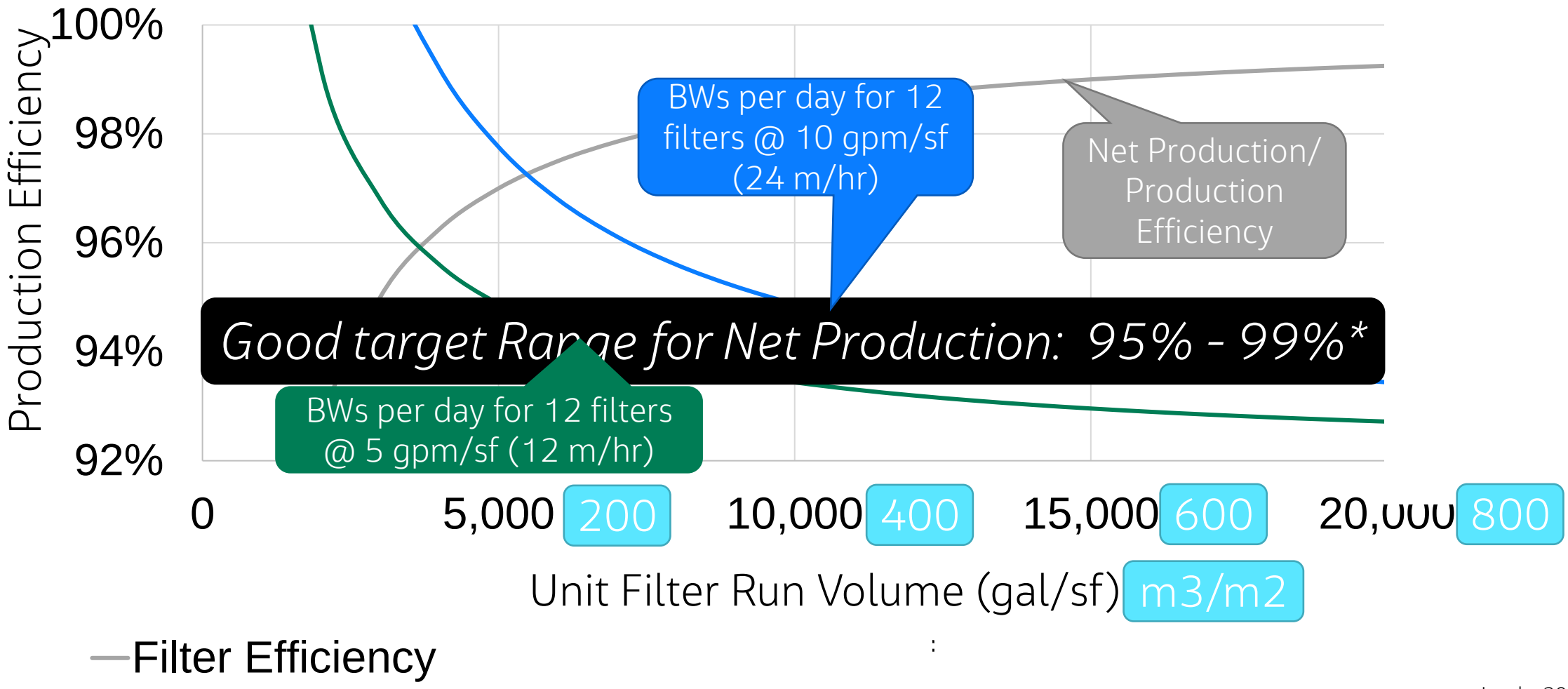


Pilot Filter Production Efficiency

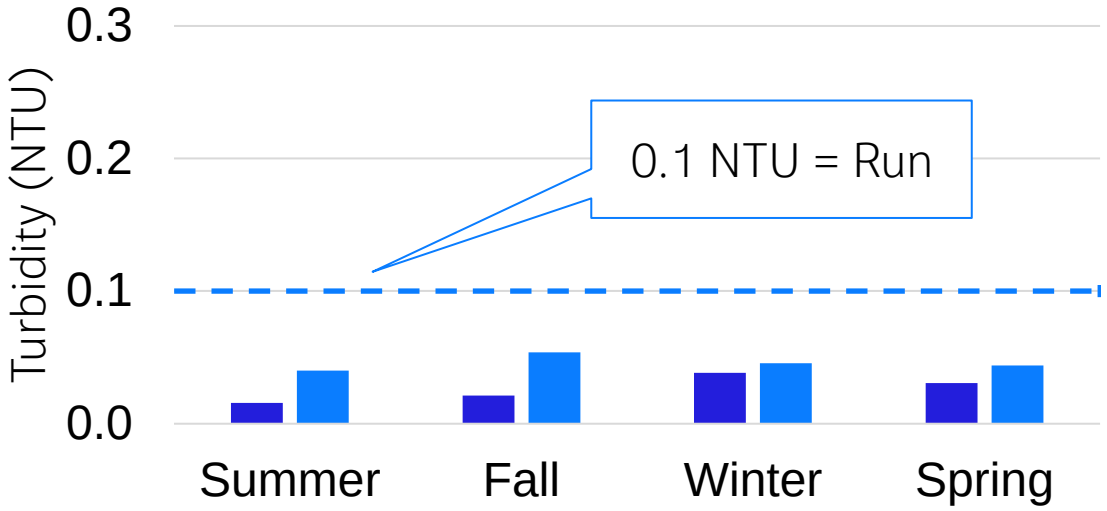
- Optimized runs only
- Average UFRV greater than 6000 gal/sf
- Minimal variability in UFRV between water seasons
- Highest UFRV is observed during the summer when higher capacity is expected

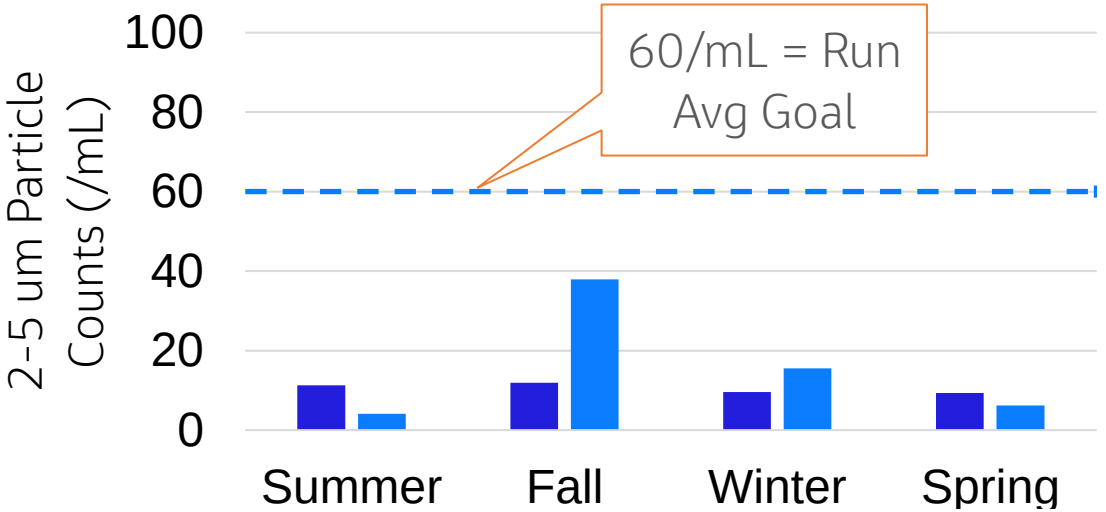


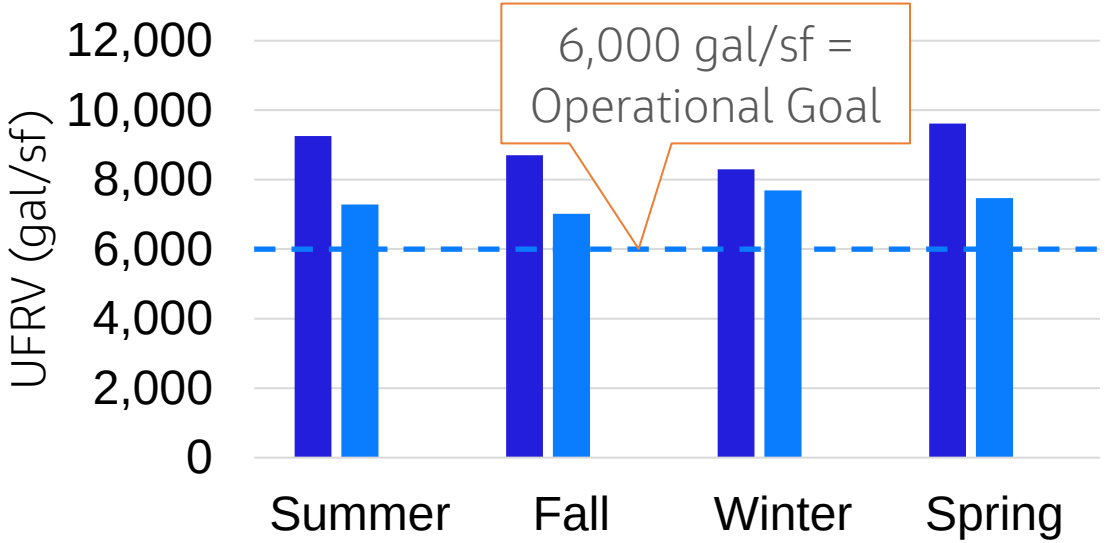
What's the Ideal Target UFRV?

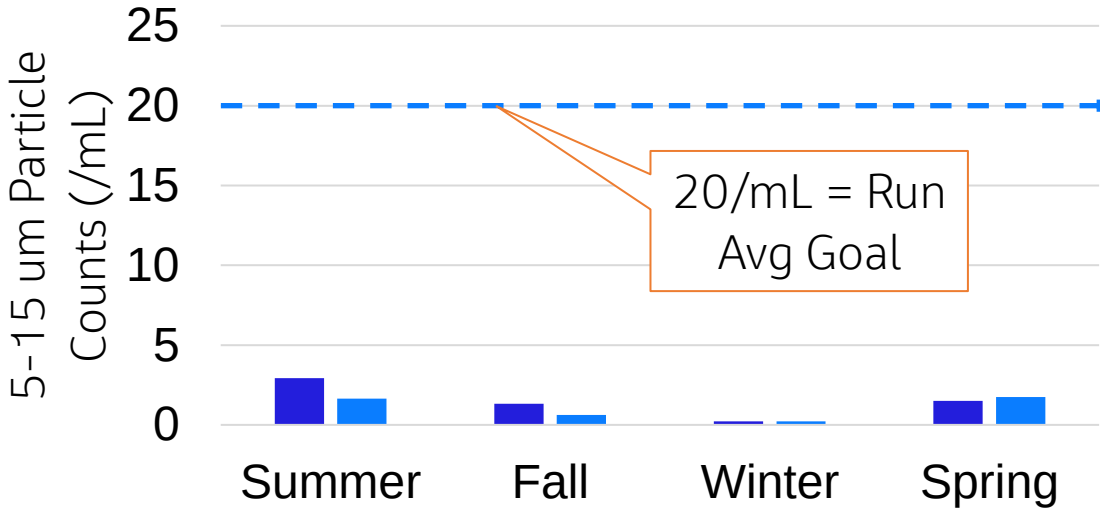


Full Scale Comparison Results





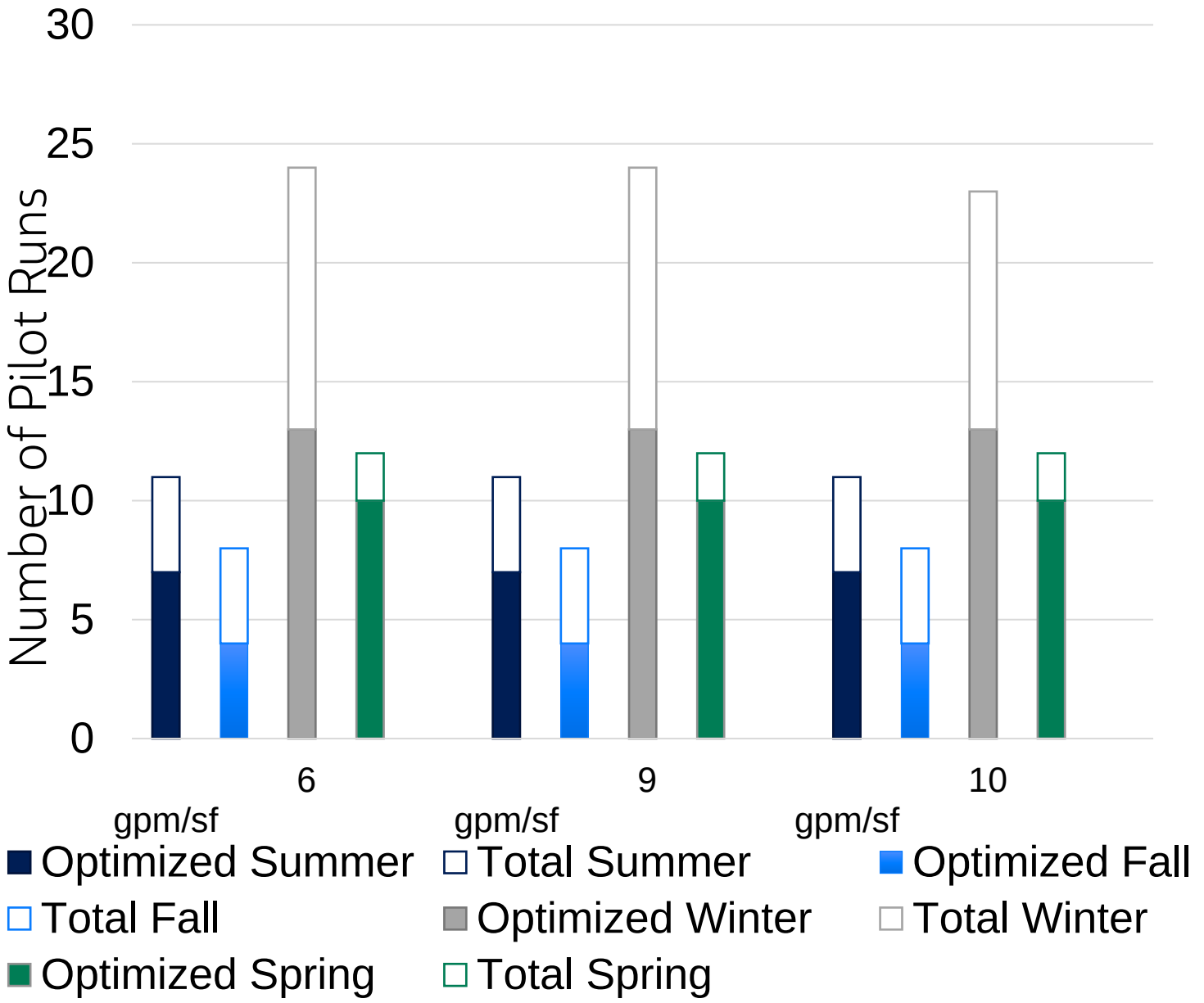




Conclusions and Lessons Learned

General Observations

- Loss of filter-aid polymer had lasting impact on pilot filter performance
- Loading Rate does not always correlate to filter performance
- “Optimized” coagulation window is narrower for pilot vs. full-scale
- Winter water required adjustment to full-scale coagulation and polymer dosing to optimize pilot performance
- Sidewall effects appear to have significant impact with monomedia pilot filters



Conclusion and Recommendation

- All loading rates demonstrated 2.0-log pathogen removal
- Requesting approval for up to 10 gpm/sf loading rates
- Higher loading rates to be tested at full-scale

Testing Results

0 runs
ended on turbidity breakthrough

100%
met particle removal

<0.1 NTU
95th percentile by Season

Thank you

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Challenging today.
Reinventing tomorrow.