How Long is Too Long? Evaluating Extended Biofilter Shutdown at Hayden Bridge (WRF Tailored Collaborative #4984)

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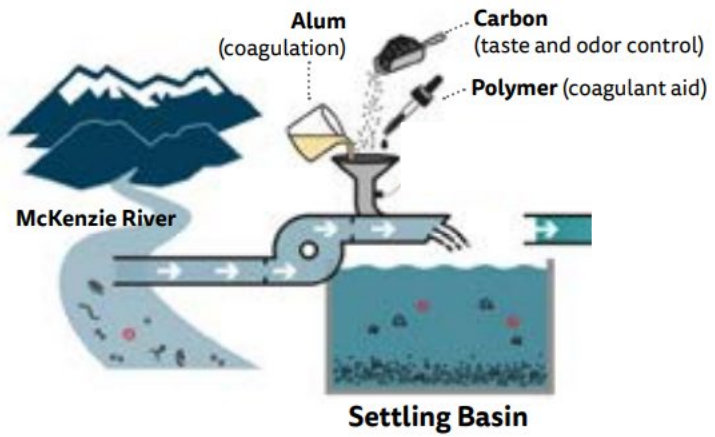
Hayden Bridge Filtration Plant

Conventional treatment plant

Convert from chlorine gas to on-site sodium hypo



Operational Considerations

Rated plant capacity is 88 MGD

- Daily production <40 MGD

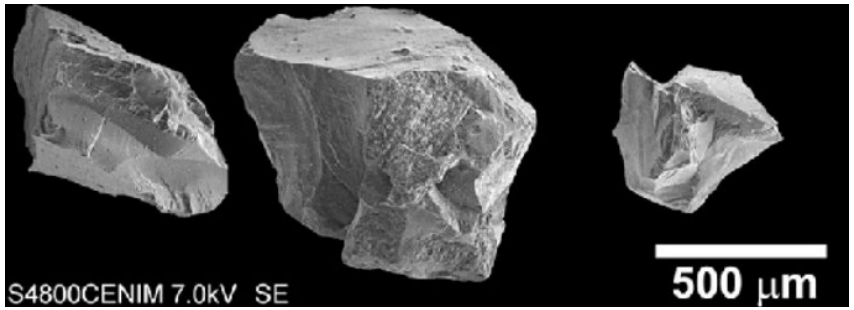
Rotate through 14 dual-media filters

- Shutdown following backwash
- 3-5 days during warm-water operation (>10°C)
- Up to 7 days during cold-water (<10°C)

Filter-to-waste occurs prior to production

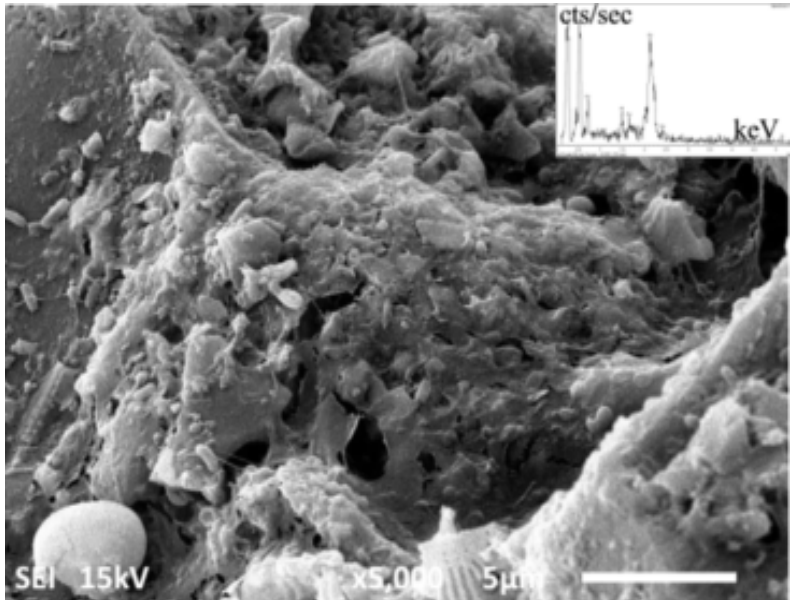
Our Definition of Biofiltration at EWEB

Filters operated without upstream disinfectant residual (no Cl)



Utilize existing anthracite media

Operation allows bacterial attachment and biofilm to form



Bacteria in biofilm may degrade, oxidize or consume substrates

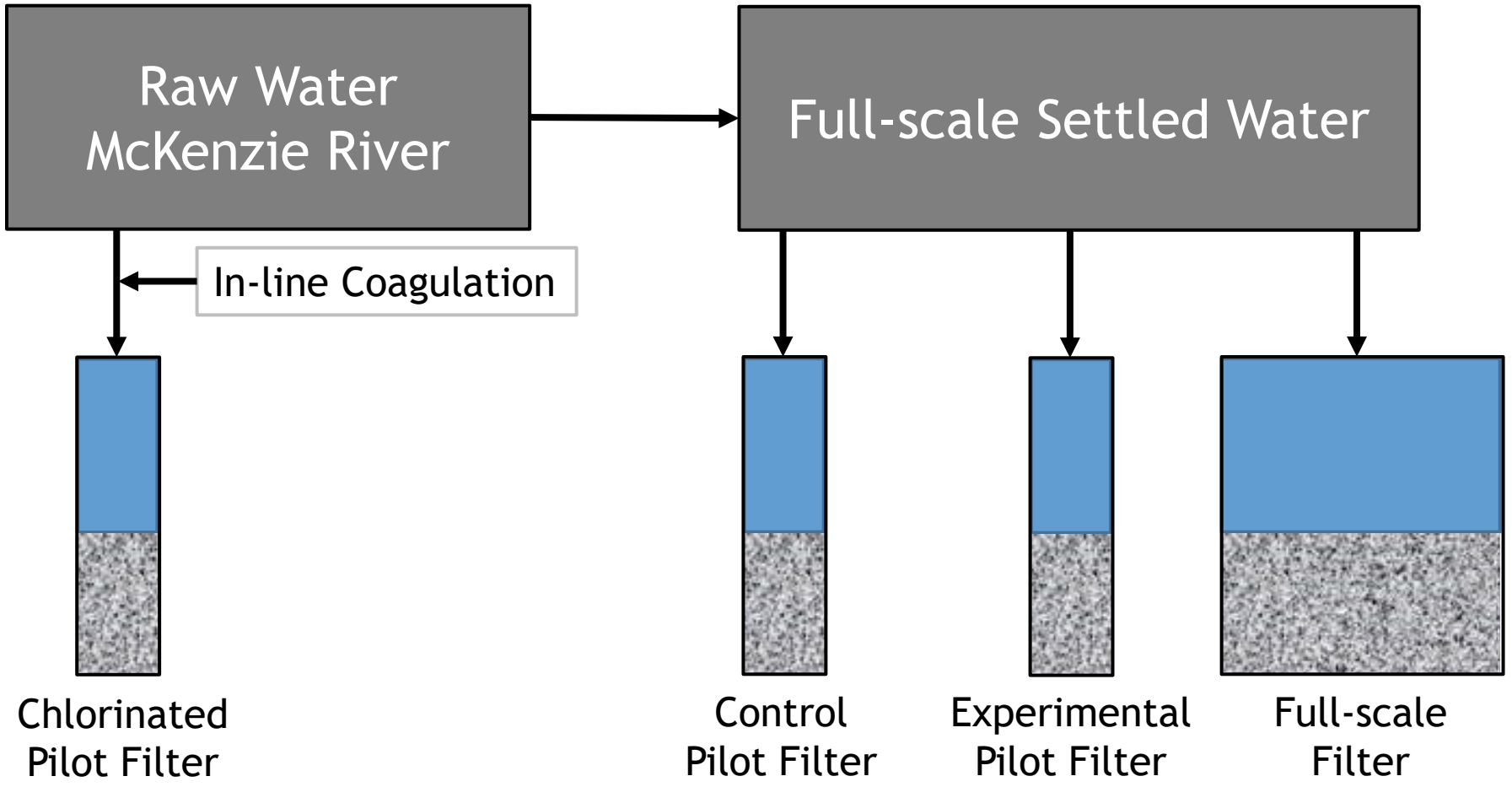
Project Objectives

1) Evaluate impact of removing pre-chlorination
   - Potential biomass development
   - Water quality and production

2) Identify effective monitoring parameters
   - Biomass, water quality and production

3) Examine biofilter shutdown up to 96 hours

HBFP Pilot Facility



HBFP Pilot Facility

Control and Chlorinated Pilot Filters

Experimental Pilot Filter

Filter Details

Full-scale filter

- Operated as necessary for production
- Chlorinated surface sweep

Chlorinated pilot filter

- Utilized for full-scale plant optimization
- Chlorinated backwash

Control pilot filter

- Operated continuously
- De-chlorinated backwash (ascorbic acid)

Experimental pilot filter

- De-chlorinated backwash (ascorbic acid)
- Shutdown duration increased on a two-week schedule

Phase 1: Filter Acclimation

Experimental filter commissioned December 2018

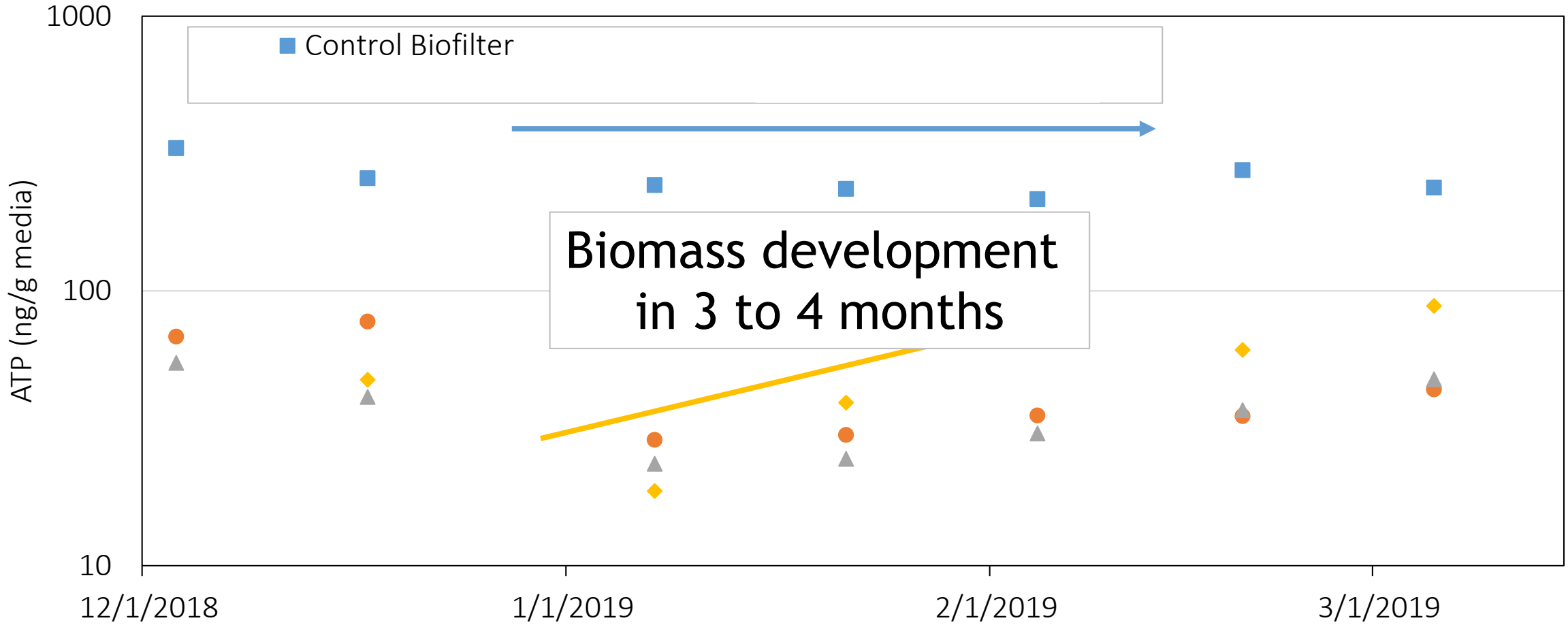
- Anthracite and sand from full-scale
- Operated continuously to mimic control filter
- Control and chlorinated filters previously operated

Evaluation of acclimation included:

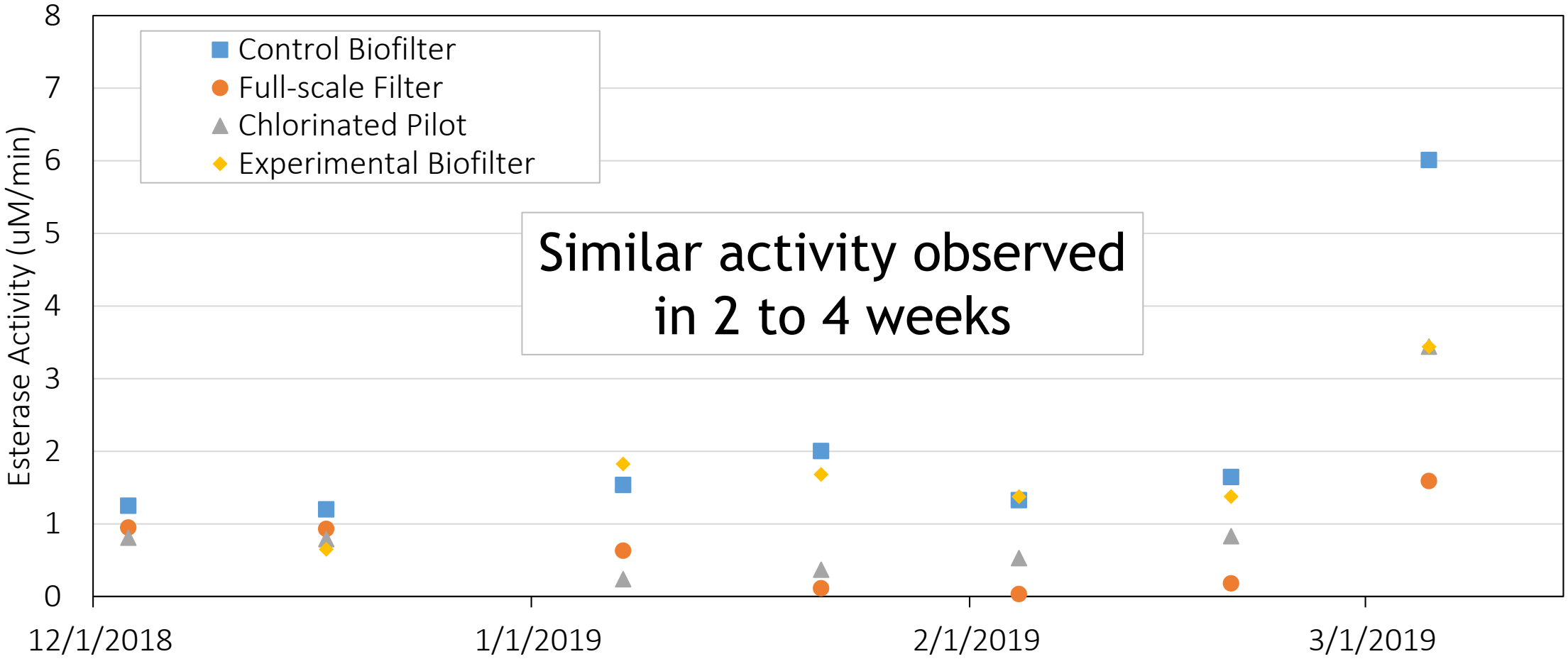
- Biomass development (via ATP)
- Biofilm activity (via enzyme activity)

Worst-case scenario (cold-water conditions <10°C)

Biomass Development



Biological Activity



Acclimation Summary

Biomass develops within 3 to 4 months of operation

- Cold-water may have slowed growth

Biological activity similar to control in <1 month

- Develops before biomass
- May be a better indicator of acclimation

Similar filtered water quality - January to March

- Relatively low organics removal (<5% DOC)

Warm-Water (>10°C) Shutdown Testing

Shutdown durations of 2 to 48 hours

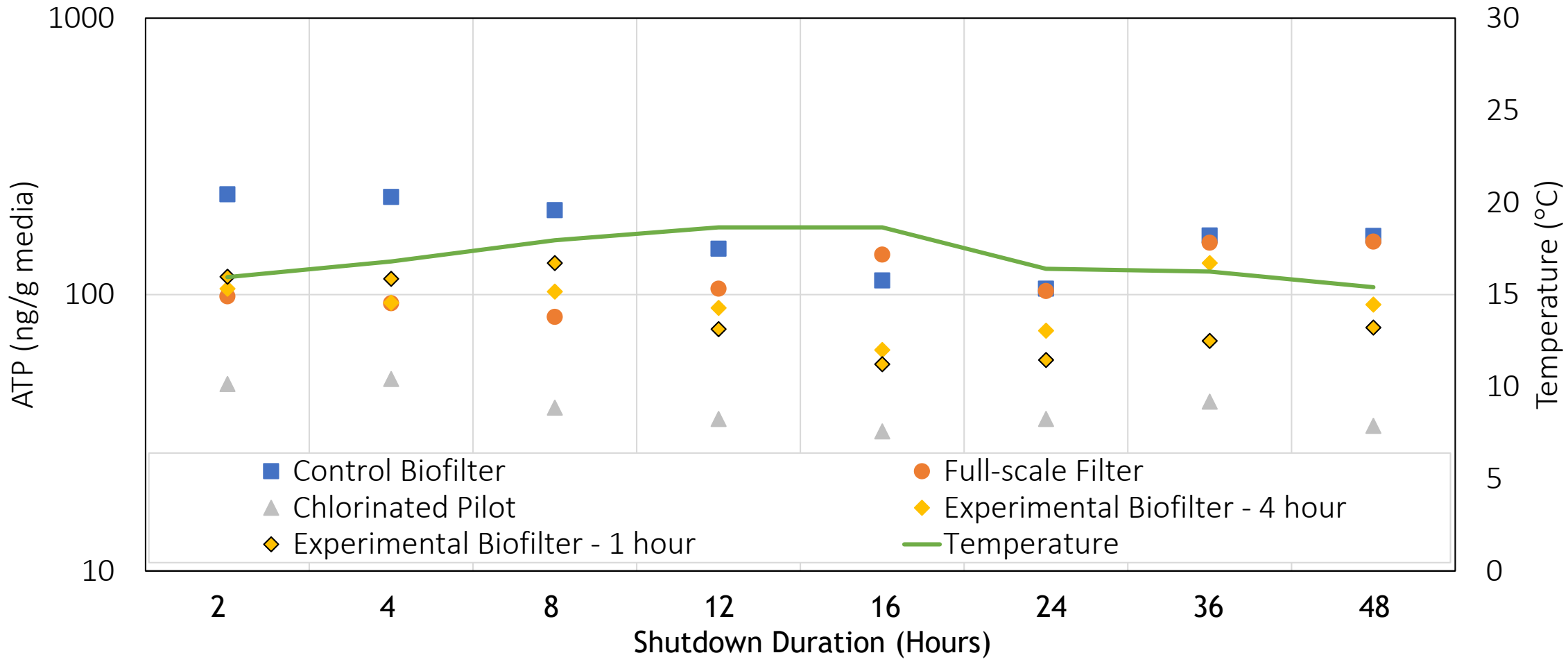
- Each condition evaluated for 2 weeks

Samples collected weekly

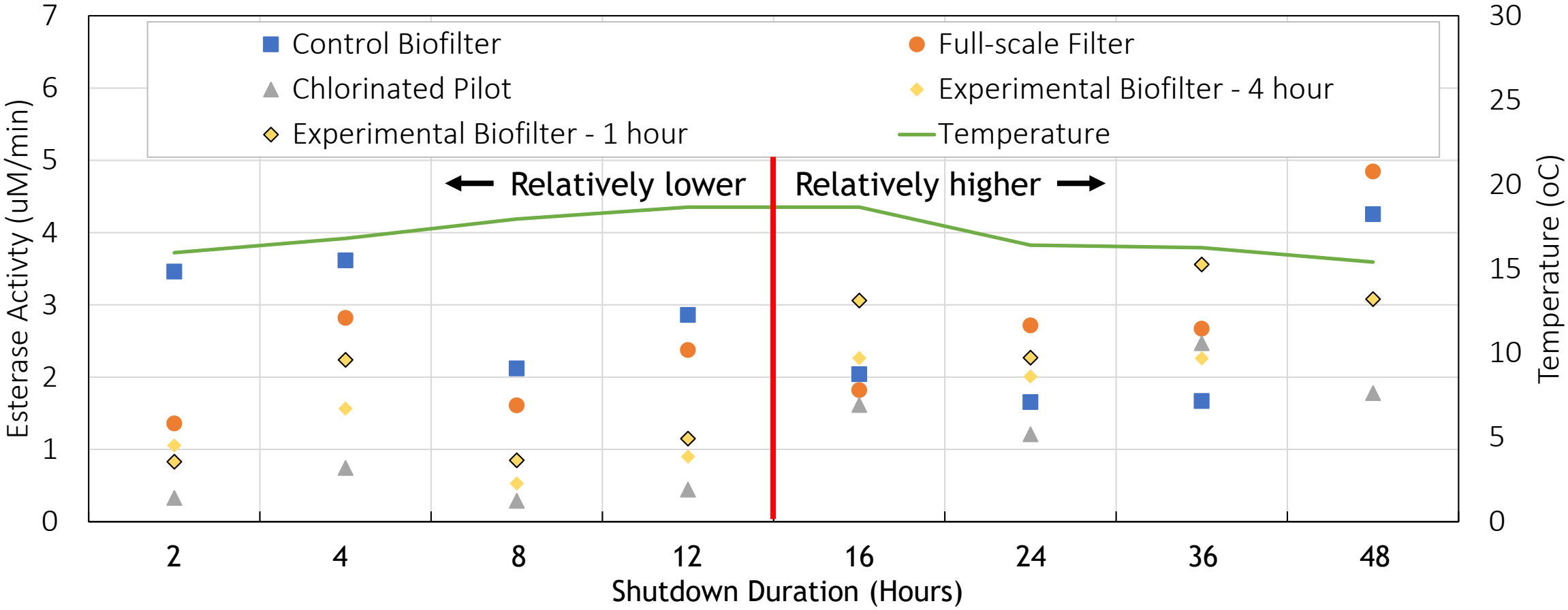
- Biomass characterization (ATP, enzyme activity)
- Organics (DOC, UV_{254}, THM FP, HAA FP)
- Water quality (DO, pH, turbidity)

Unit filter run volume calculated

Biomass Density - ATP



Biological Activity - Esterase



Summary of Biomass Characterization

Similar ATP trend observed between control and experimental filters

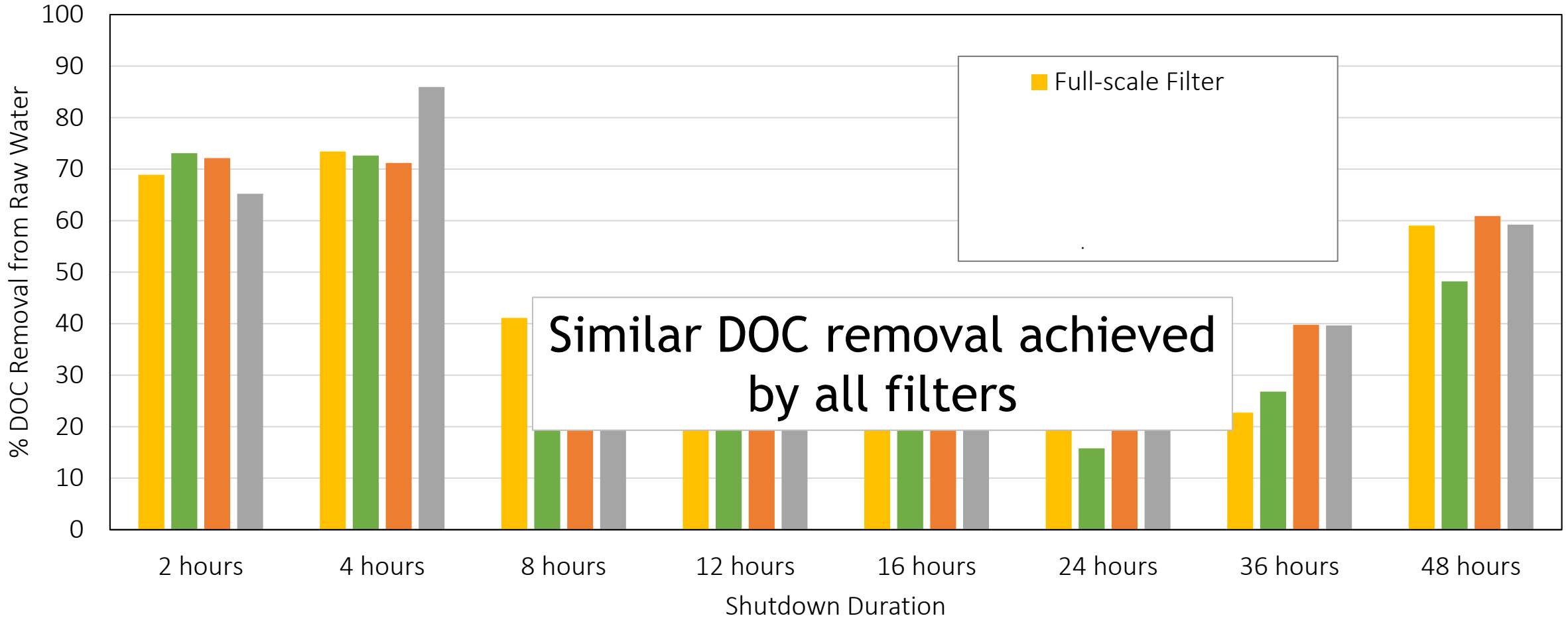
- Potentially related to substrate (i.e. carbon)

Esterase activity elevated with extended shutdown

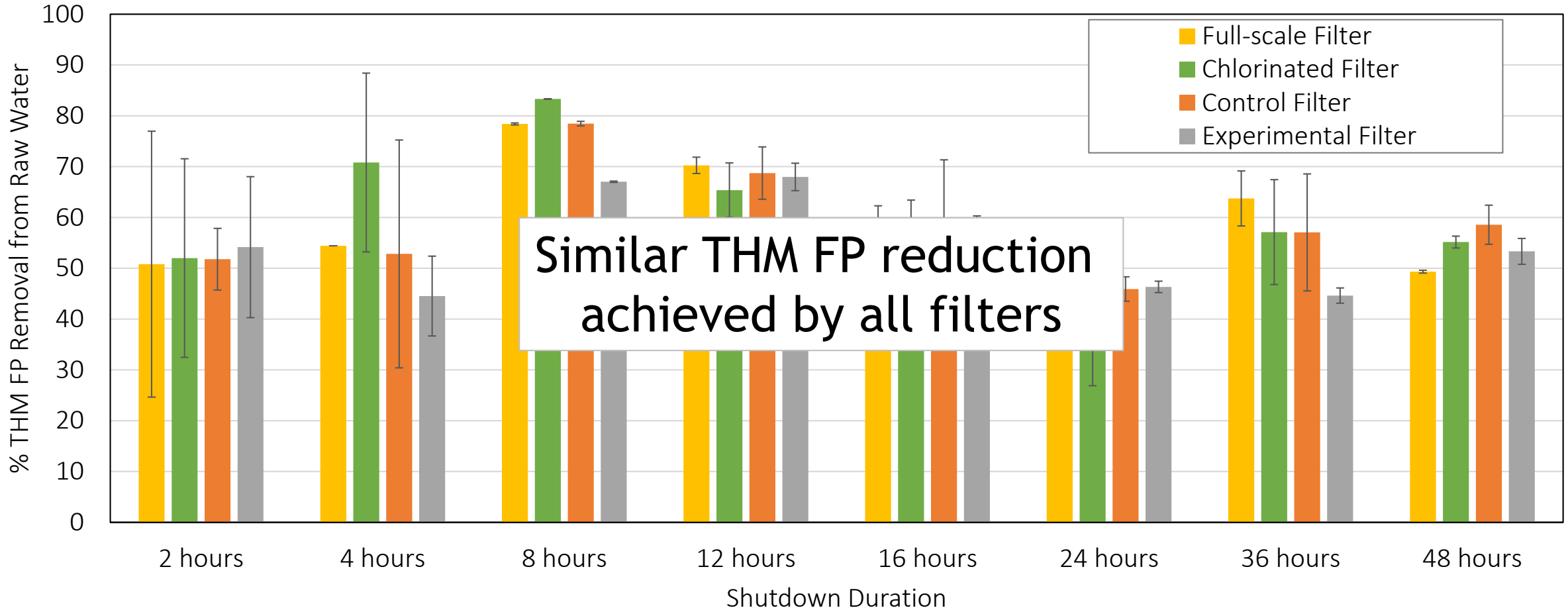
- Relatively more active biomass

No relationship to temperature observed

Organics Removal



THM FP Reduction



Summary of Water Quality Monitoring

Similar effluent water quality observed

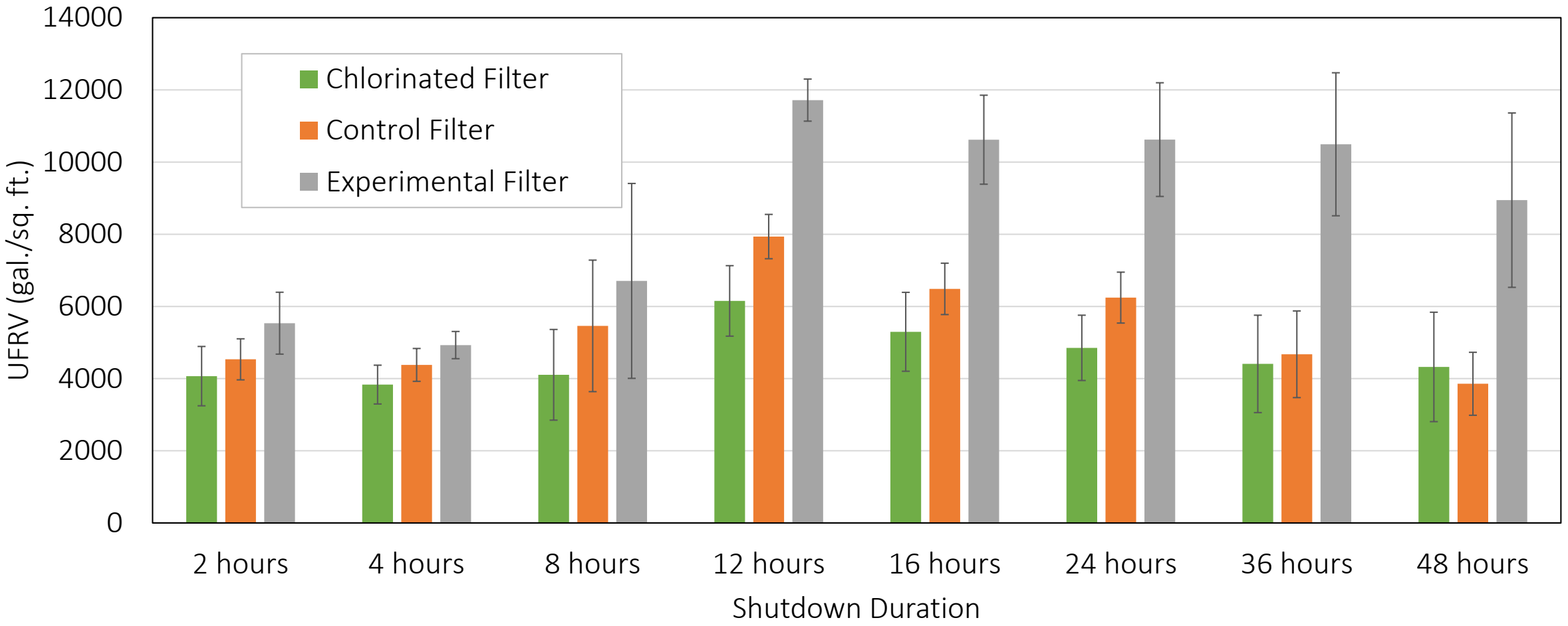
- No statistical difference between filters

Common monitoring parameters (e.g. pH, DO uptake, UV_{254}) poor indicators of performance

- Limited resolution
- No trends to regulated parameters

Biofilter shutdown did not impact performance

Filter Production



Summary of Warm-Water Testing

Shutdown >12 hours increased production

- Up to 100% improvement

Water quality was not impacted by shutdown

Extended shutdown improved biological performance relative to continuous operation

Full-scale biological operation viable

Cold-Water (<10˚C) Testing

Shutdown durations of 4 to 96 hours

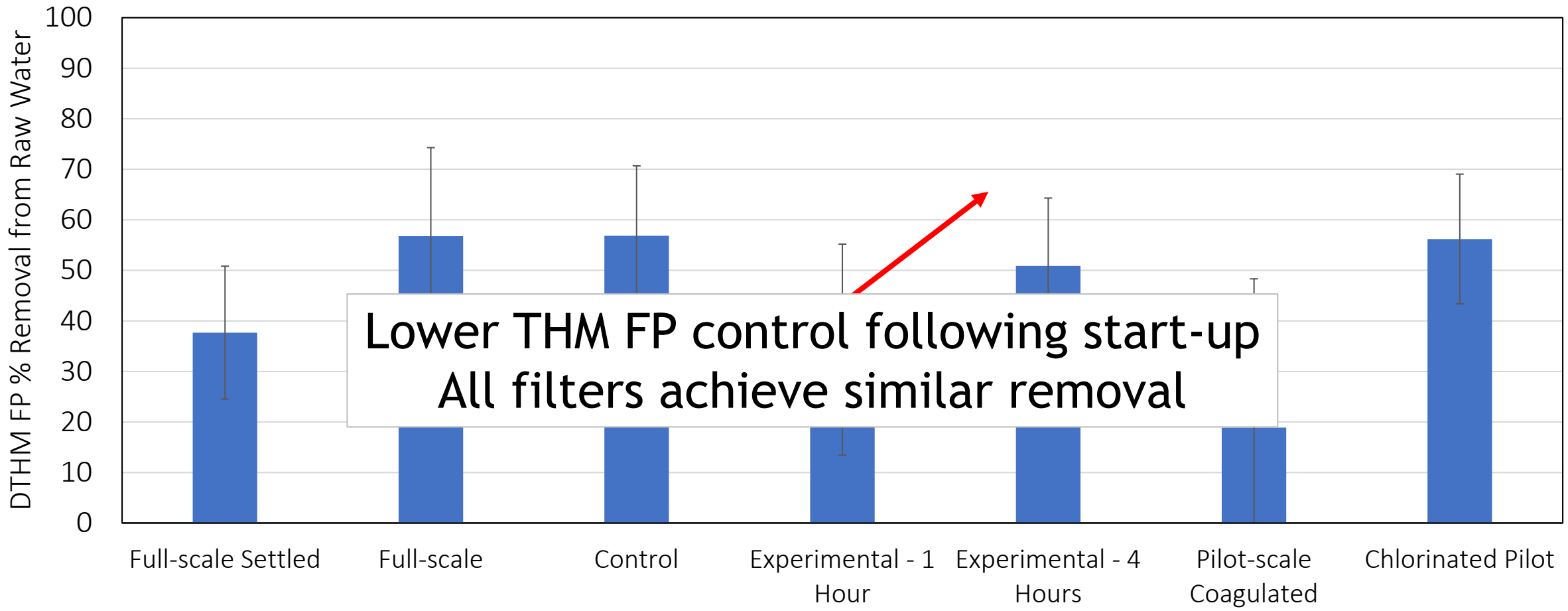
- Each condition evaluated for 2 weeks

Samples collected weekly

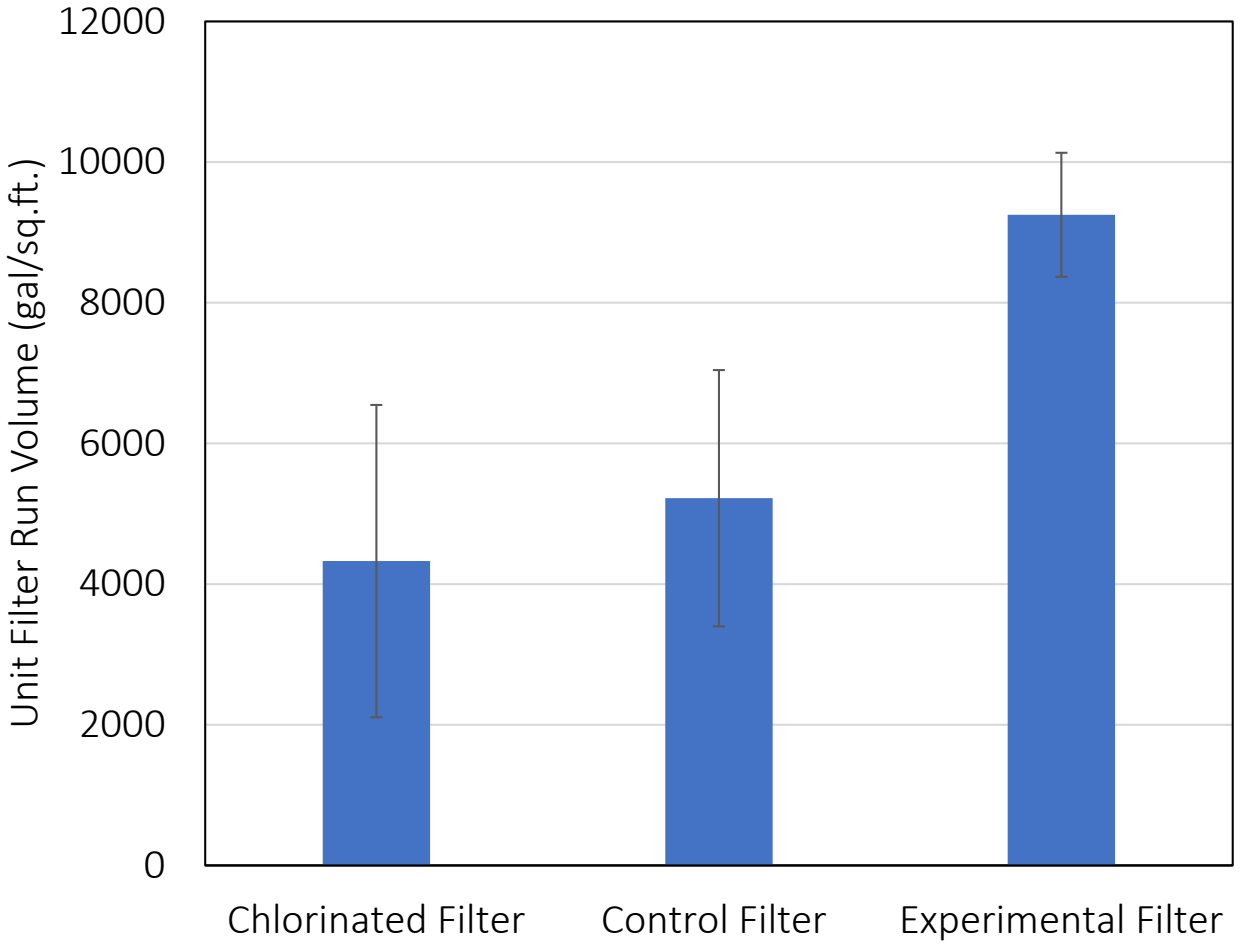
- Biomass characterization (ATP, enzyme activity)
- Organics (DOC, UV_{254}, THM FP, HAA FP)
- Water quality (DO, pH, turbidity)

Testing conducted November to March

THM FP Removal



Filter Production



Biofiltration improved UVRF by 20% on average

Average variability reduced by 18%

Shutdown increased UFRV by 77% and reduced variability by >50%

Summary of Cold-water Testing

Shutdown up to 96 hours did not impact:

- Biomass density
- Biological activity
- Organics reduction

Steady-state operation achieved within 4 hours

- Prevent simultaneous start-up of filters

Similar treatment provided during warm-water (>10˚) and cold-water (<10˚C) conditions

Project Summary

Elimination of pre-chlorination resulted in biological acclimation of filters

Biofilter shutdown in warm- (>10°C) and cold- (<10°C) water did not impair performance

- Some improvements observed (e.g. UFRV)

Enzyme activity – may be preferred monitoring parameter for biological processes

- Shorter shutdown limits effluent activity

Biofiltration Evolution

GAC Filter Caps

- Equip experimental filter with shallow GAC cap
- Improve biological growth and provide limited adsorption capability

Evaluation of algae and toxin removal

- GAC may improve toxin removal

Biofilter enhancement

- Promote biological activity and degradation

Next Steps – GAC Caps

6” caps added to experimental filter

- Corresponds to media depth added to alleviate existing media attrition

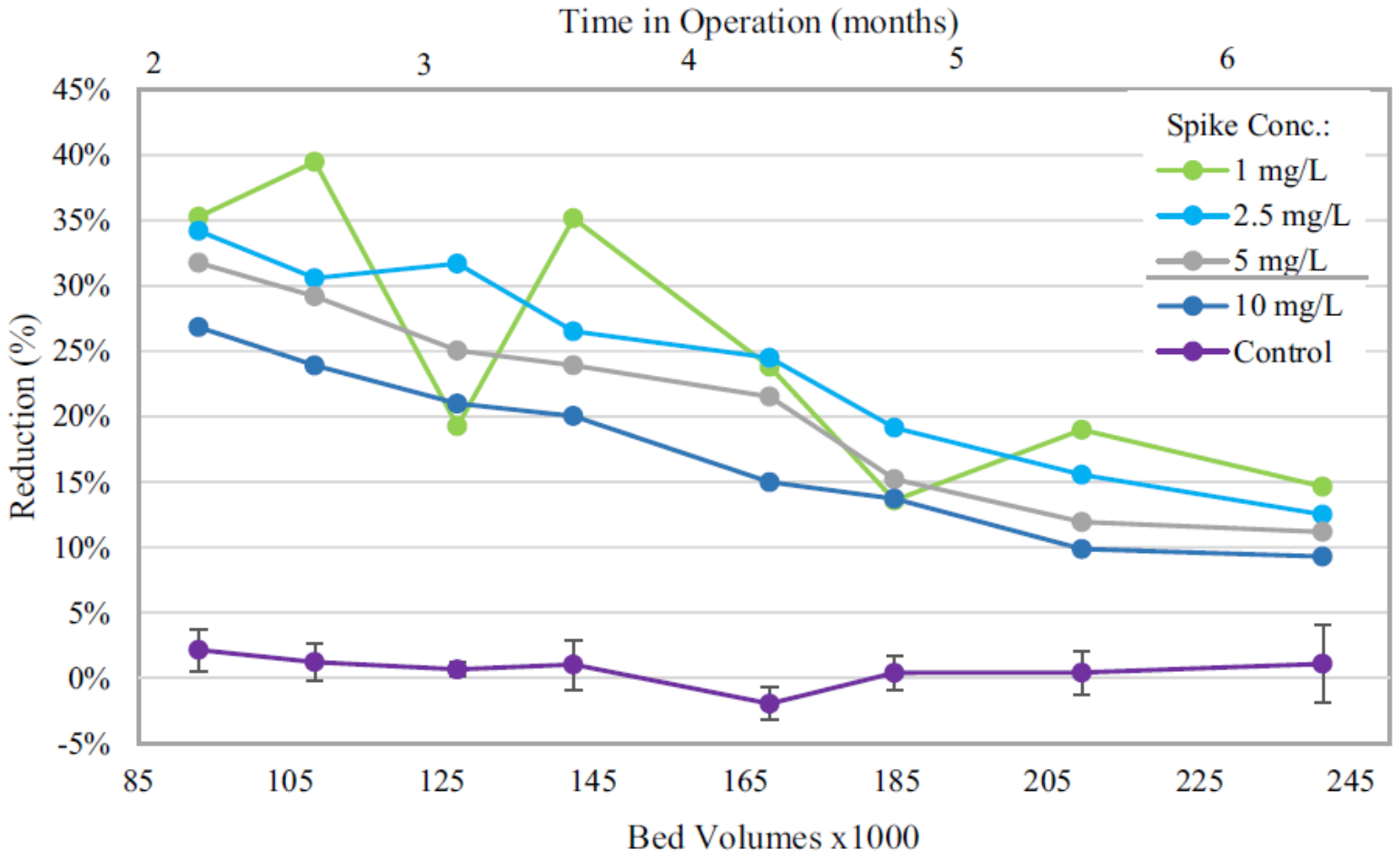
Project objectives included:

- Removal of organics (DOC, DBPs, etc)
- Chlorine demand
- Control of cyanotoxin surrogates

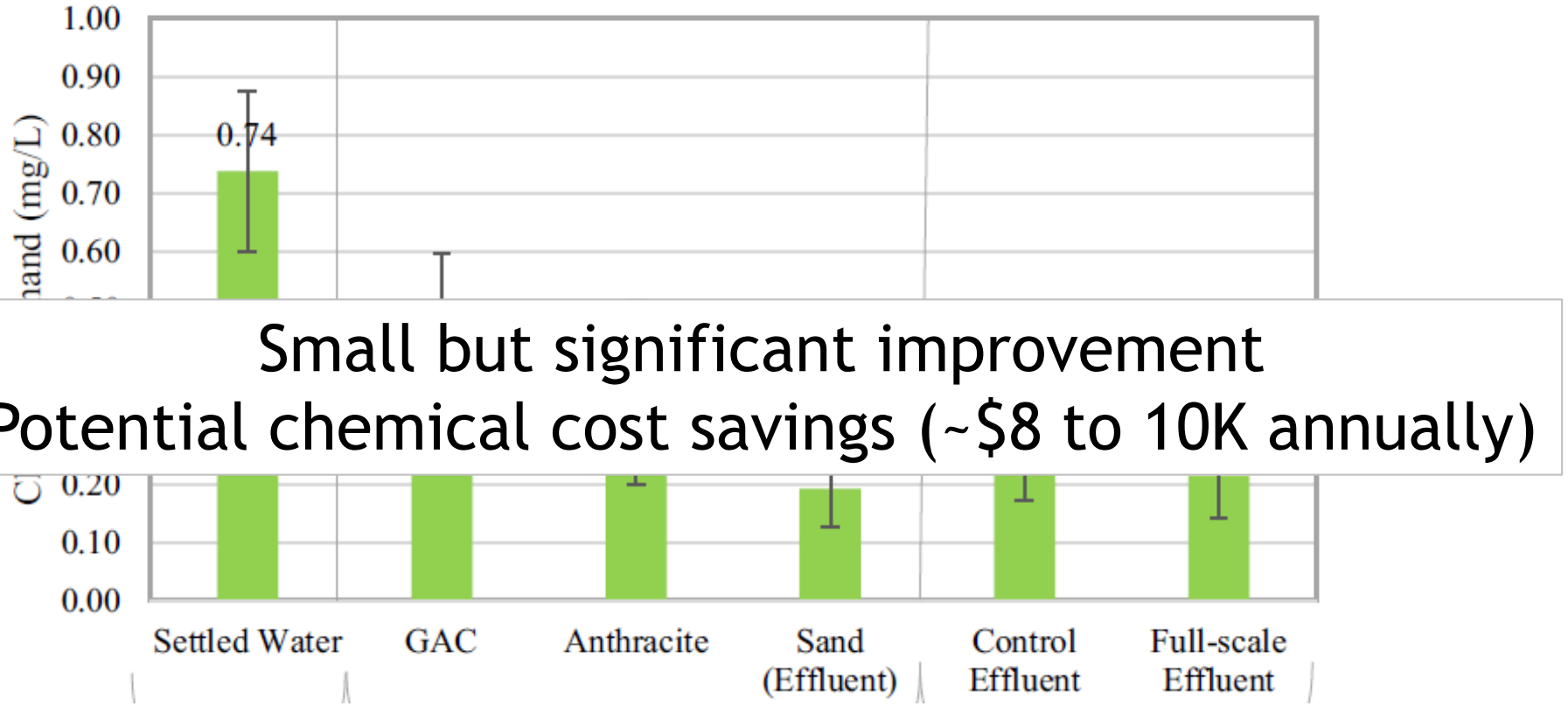
Justify anthracite replacement with GAC

- Cost-benefit analysis

Cyanotoxin Surrogate Removal



Organics Removal



Small but significant improvement
Potential chemical cost savings (~$8 to 10K annually)

Crowe, G.T., Almuhtaram, H., Andrews, R.C. & McKie, M.J. 2022. Granular Activated Carbon Caps – A Potential Treatment Barrier for Drinking Water Cyanotoxins. *Journal of Water Process Engineering,* 49. https://doi.org/10.1016/j.jwpe.2022.102977

Questions?

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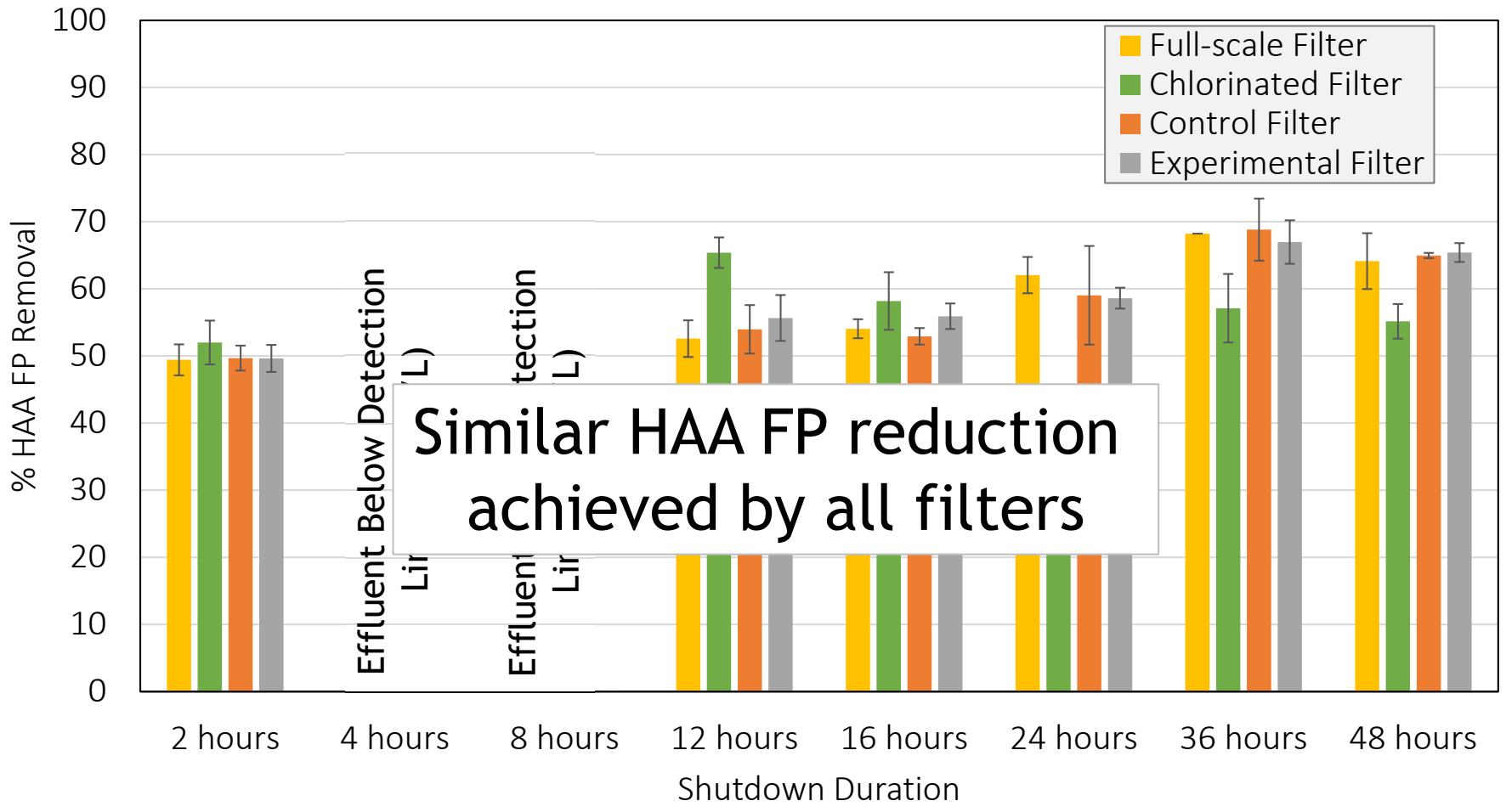
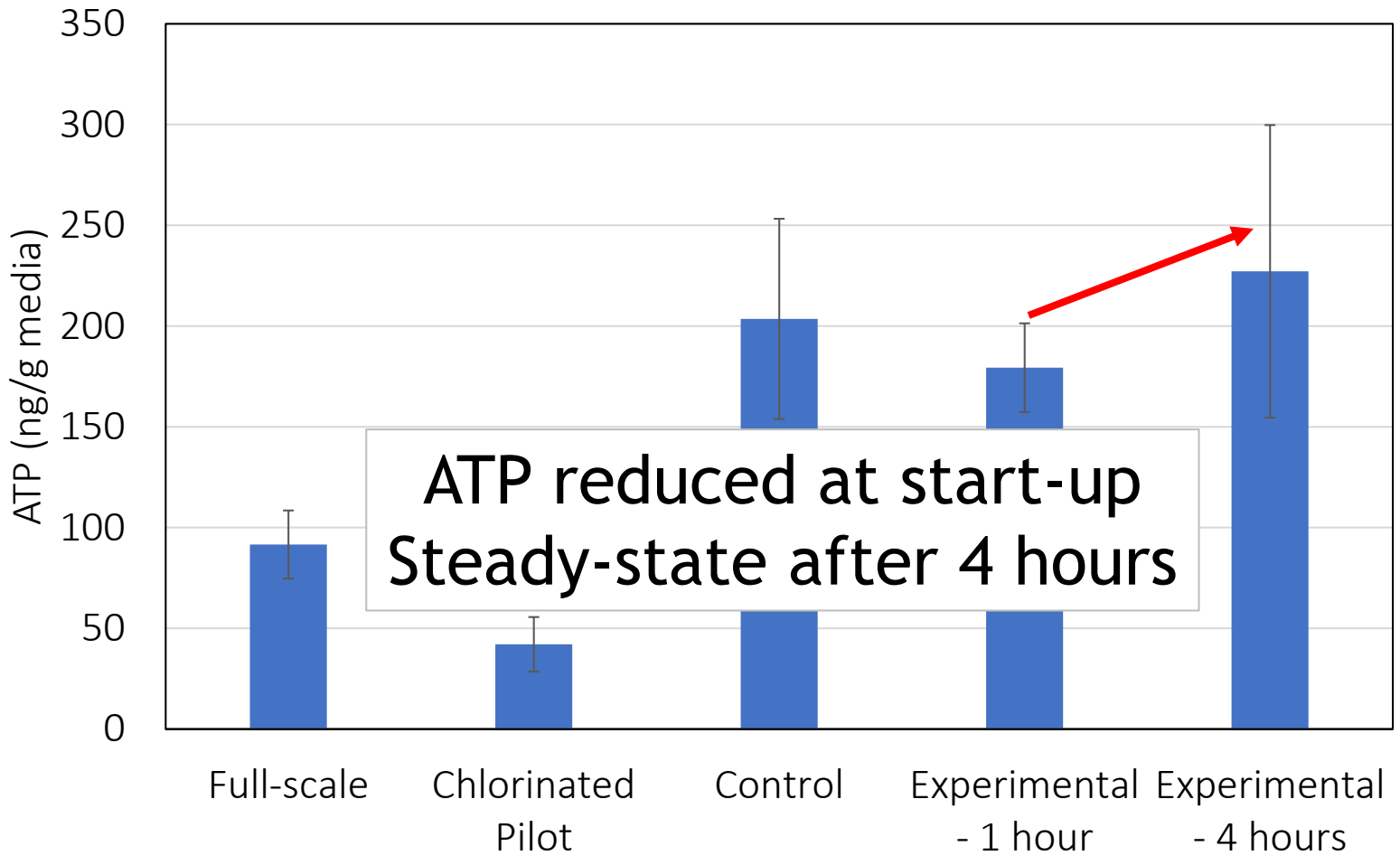
HAA FP Reduction



Biomass Density



HAA FP Removal