THE Water Research FOUNDATION

How Long is Too Long? Evaluating Extended Biofilter Shutdown WRF #4984

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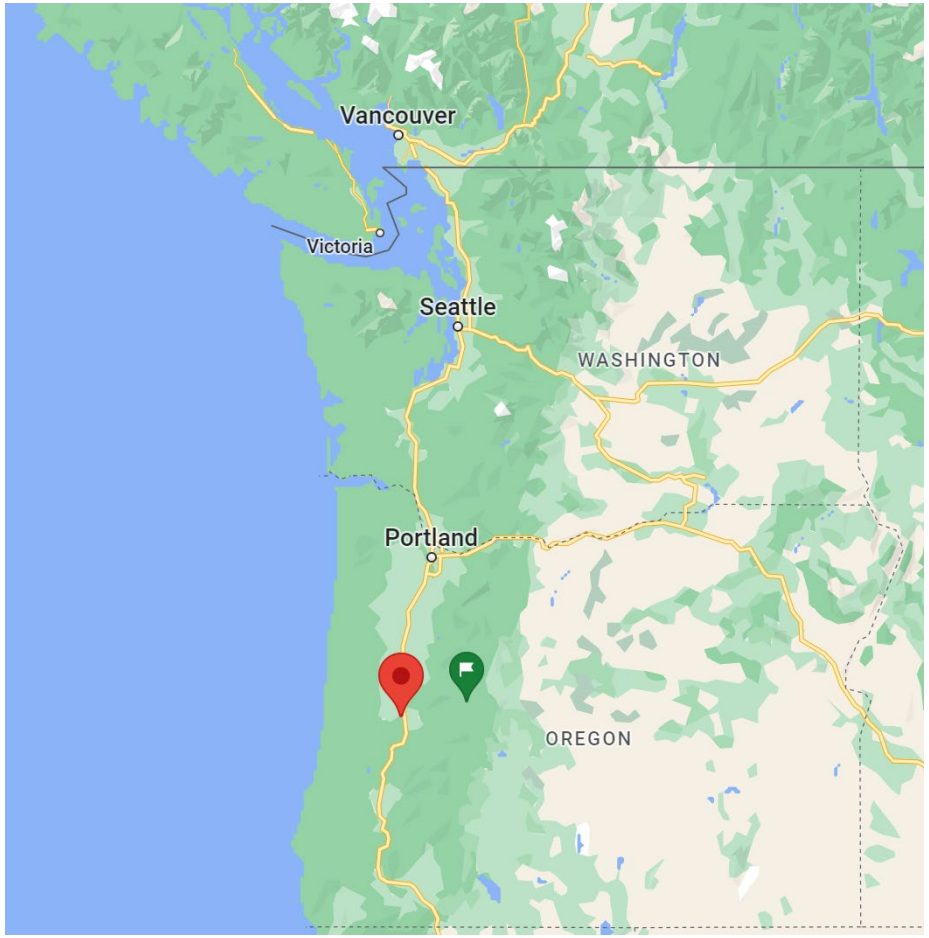
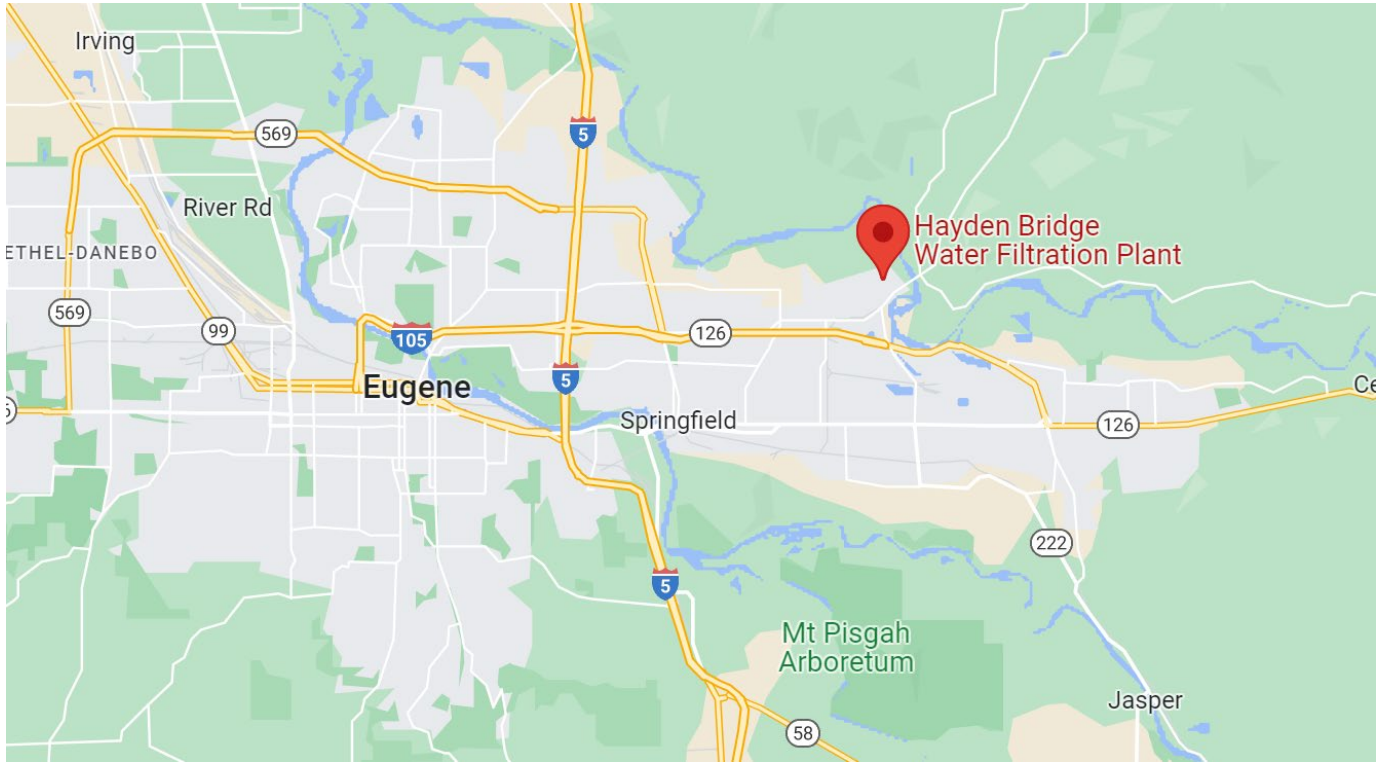
Hayden Bridge Filtration Plant



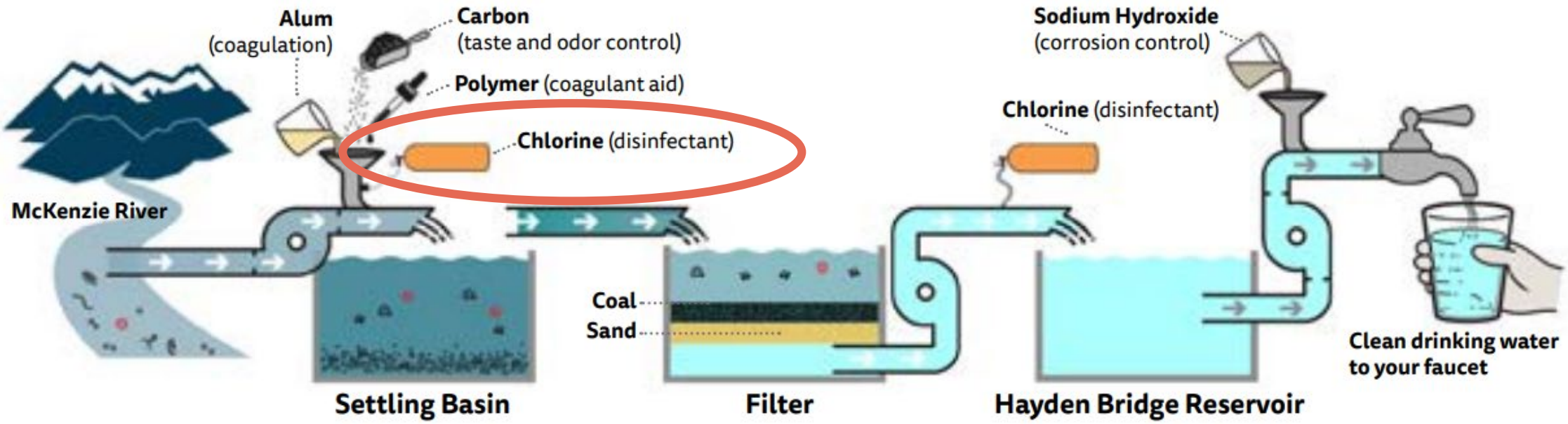


Hayden Bridge Filtration Plant

Hayden Bridge Filtration Plant

- Conventional treatment plant
- Maximum capacity 88 MGD (400 MLD)
  - Typical production <44 MGD (200 MLD)
- Use 5 to 7 of the 14 filters to meet demand
  - Filters placed out of service after backwash to cycle through all filters
  - Shutdown for 3 to 5 days during warm-water periods (>10°C)
  - Shutdown up to 7 days during cold-water periods (<10°C)
  - Filter to waste prior to production to meet turbidity target

Hayden Bridge Filtration Plant



EWEB Drivers for Research

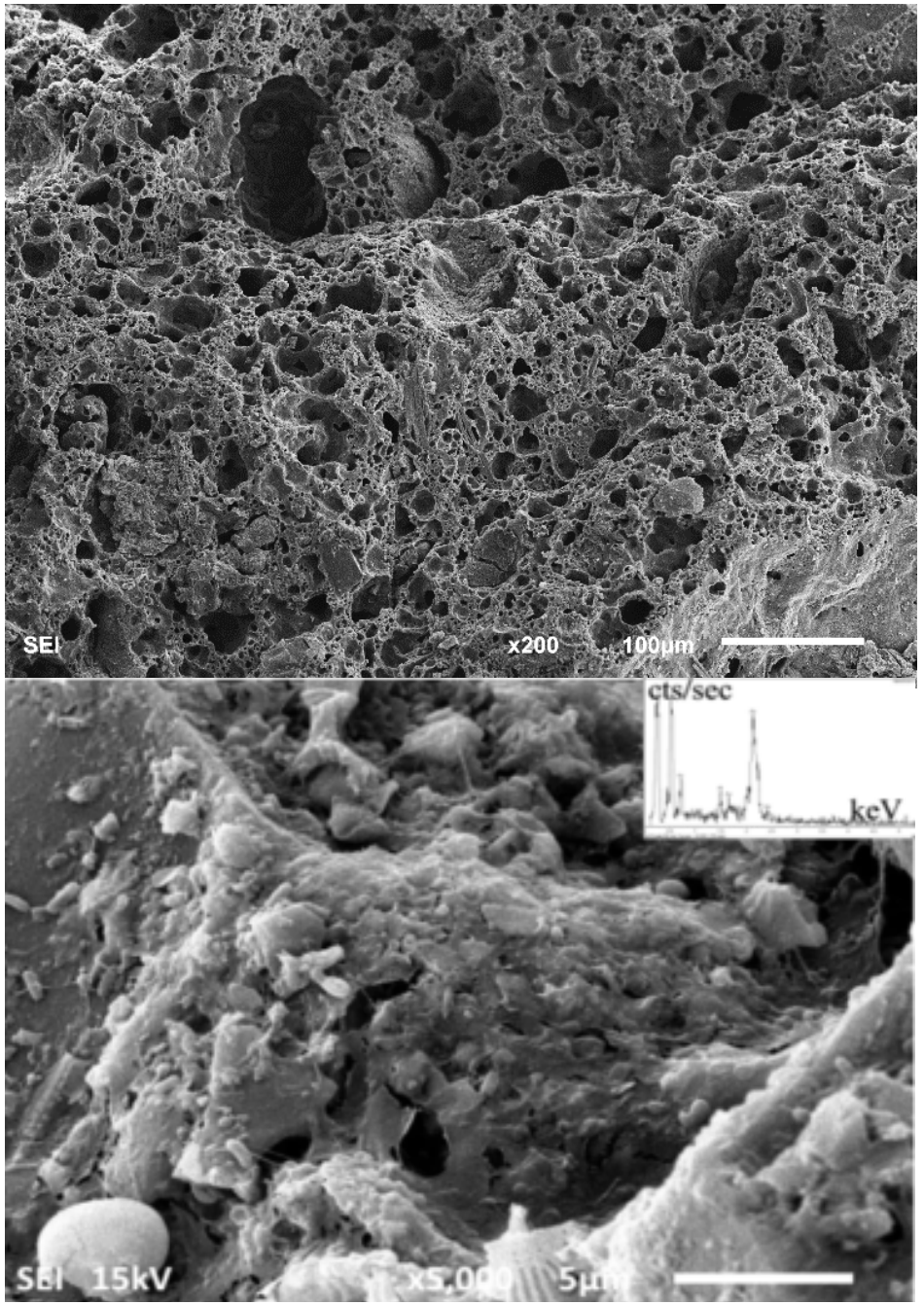
- Cost certainty and risk reduction
  - Reliance on few chlorine gas suppliers on the west coast
- Operational resiliency and flexibility
  - On-site sodium hypochlorite production facility planned
  - Emphasized the need for process optimization
- Give operators confidence with the new treatment approach
  - A culture of continuous improvement and understanding

WRF 4984 Objectives

- What happens when pre-chlorination stops?
- Is filter shutdown a viable operating strategy moving forward?
- How can plant operation be “optimized”?

What is Biofiltration?

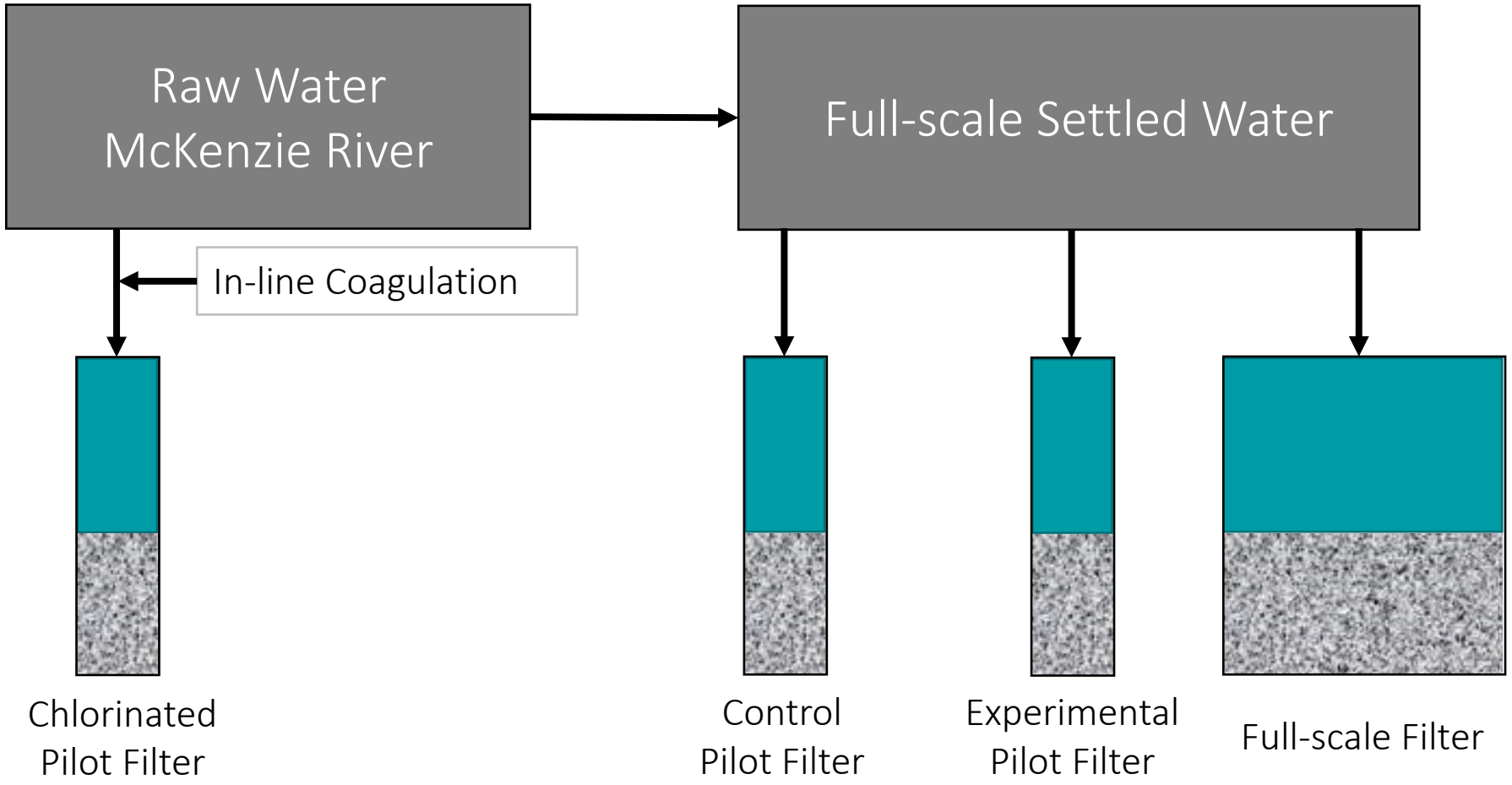
- Filters operated with limited exposure to oxidants
  - Preferably no exposure
- Naturally occurring bacteria attach and form a biofilm layer
- Bacteria degrade, oxidize or consume various substrates



Anticipated Benefits of Biofiltration

- Improved removal of organics
- Nutrient sequestration
- More “biostable” treated water
  - Lower regrowth potential
- Taste and odour control
  - Geosmin and MIB
- Reduced chemical usage
  - Pre-treatment and disinfectants

HBFP Pilot Facility



HBFP Pilot Facility

Control and Chlorinated Pilot Filters

Experimental Pilot Filter

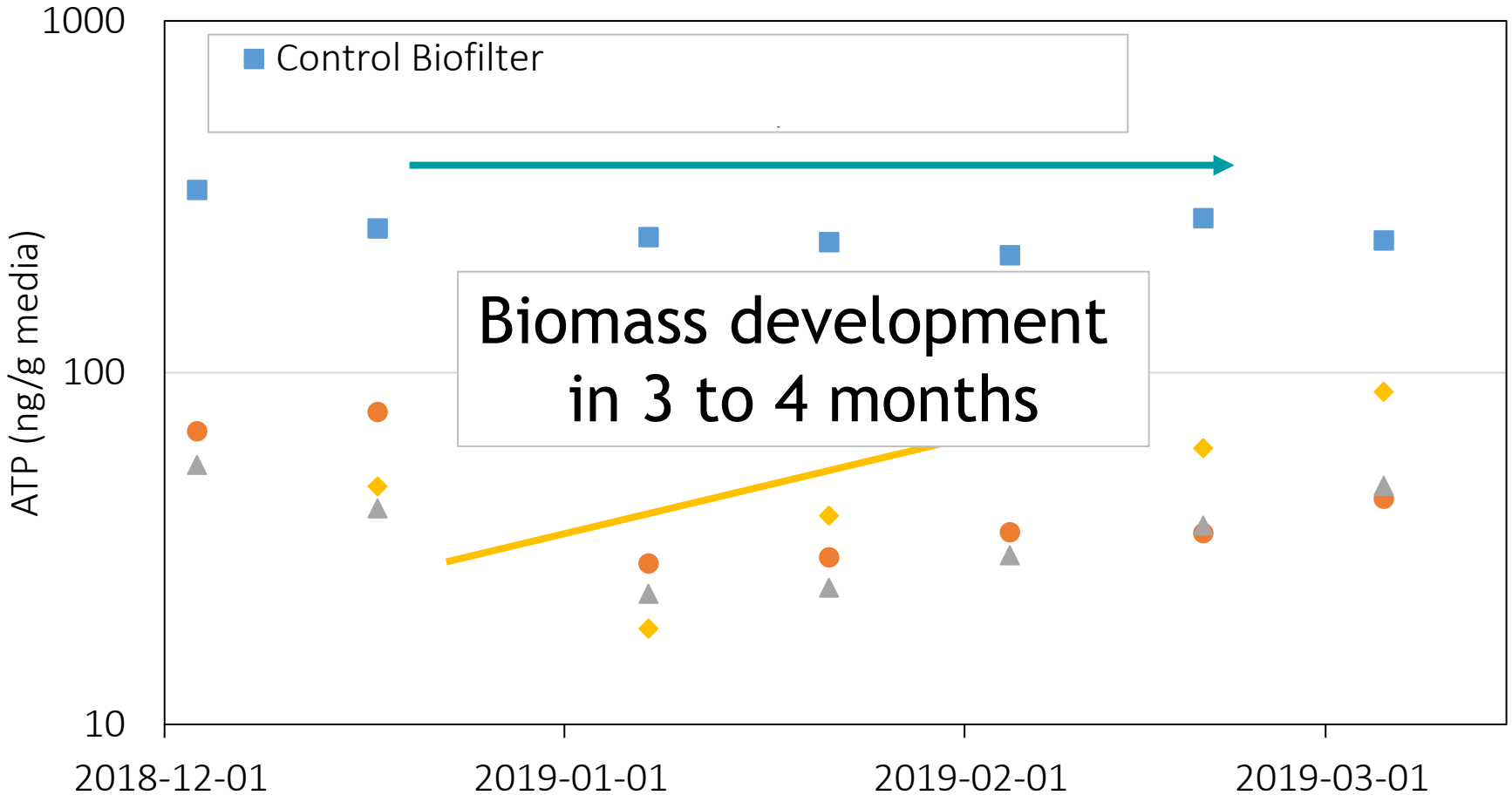
Parameters of Interest

- Organics
  - Dissolved organic carbon, $UV_{254,}$ THM and HAA Formation potential
- Inorganic nutrients
  - Nitrate, Nitrite, Ammonia, Phosphorus
- Biological characterization
  - ATP, enzyme activity
- Other parameters
  - Dissolved oxygen uptake, pH, filter run time, unit filter run volume

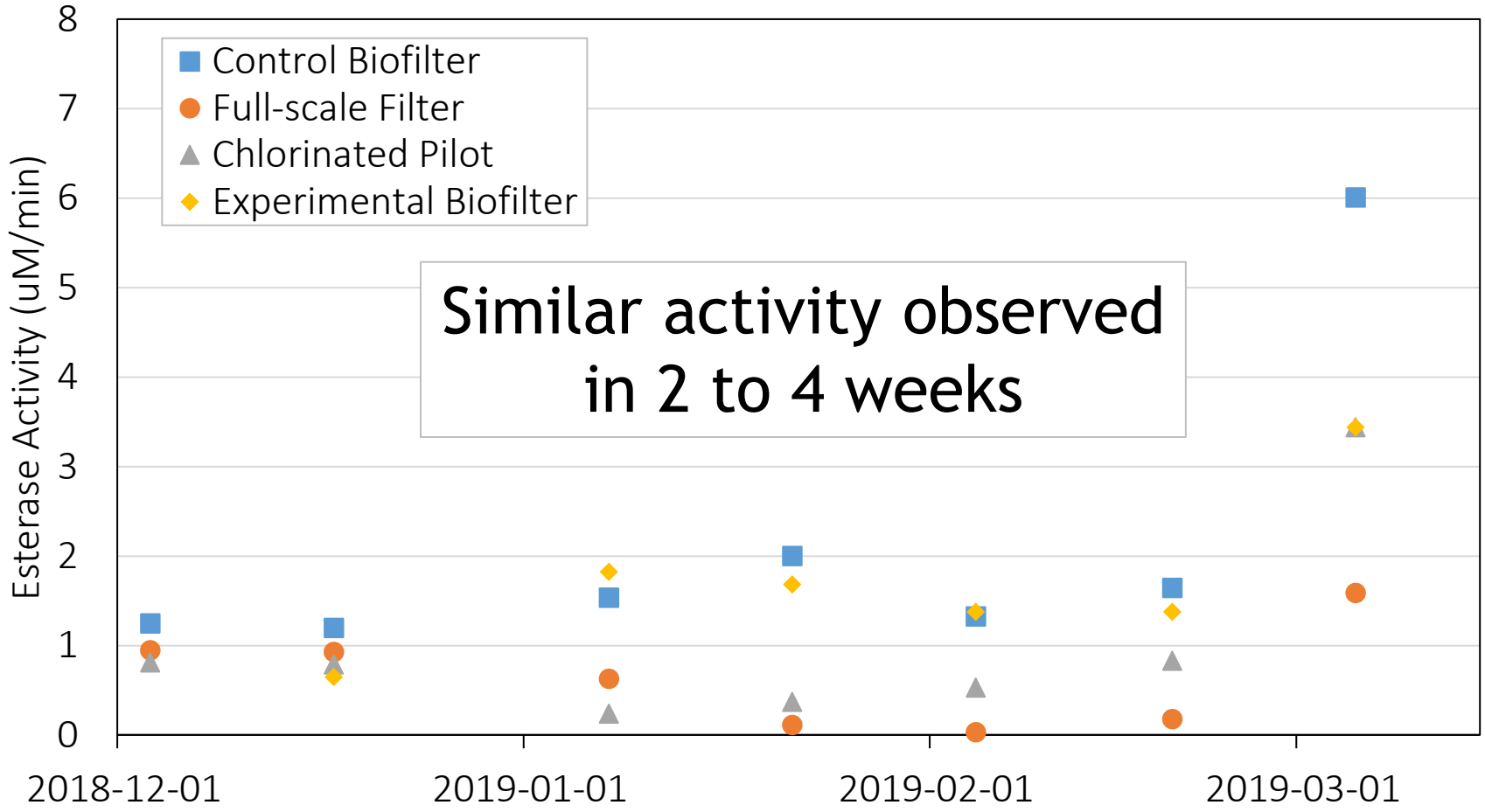
1) What Happens When Pre-chlorination Stops?

- Experimental filter commissioned in December 2018
  - Anthracite and sand from the full-scale filters
  - Operated continuously to mimic control filter
  - Control and chlorinated pilot filters in operation for many years prior
- Evaluation of filter acclimation included:
  - Biomass development (via ATP)
  - Biofilm activity (via enzyme activity)
- Trial conducted under worst-case conditions (cold-water <10°C)

Biomass Development



Biological Activity



Impacts of Stopping Pre-chlorination

- Filters became biologically active
- Similar amount of biomass after 3 to 4 months
  - Cold water may have slowed growth
- Biological activity was equivalent within 1 month
  - May be a better indicator of acclimation
- Filtered water quality was similar to the control
- Successful “proof of concept”

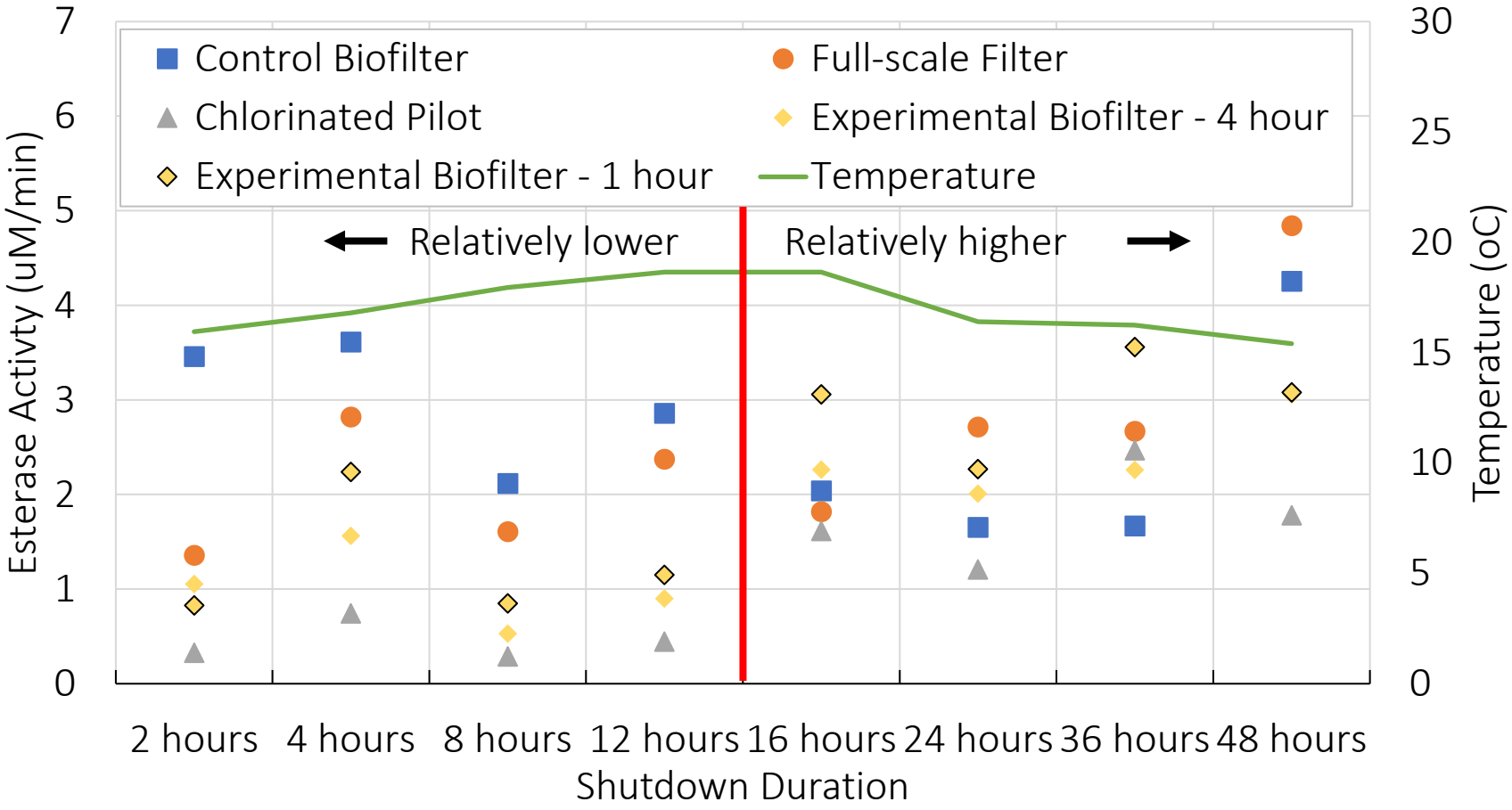
2) Evaluating the Impact of Biofilter Shutdown

- Microorganisms need nutrients to survive
  - Carbon, oxygen, trace minerals, etc.
- Filter shutdown limits the exposure to those nutrients
- Problem statement: What is the longest a filter could be shutdown and remain biological while achieving acceptable water quality?

Warm-water (>10°C) Shutdown Testing

- Evaluate filter performance with shutdowns from 2 to 48 hours
  - Each condition evaluated for 2 weeks
- Samples collected weekly and shipped to the U of T laboratory
  - Huge amount of coordination required
- Unit filter run volume to assess production

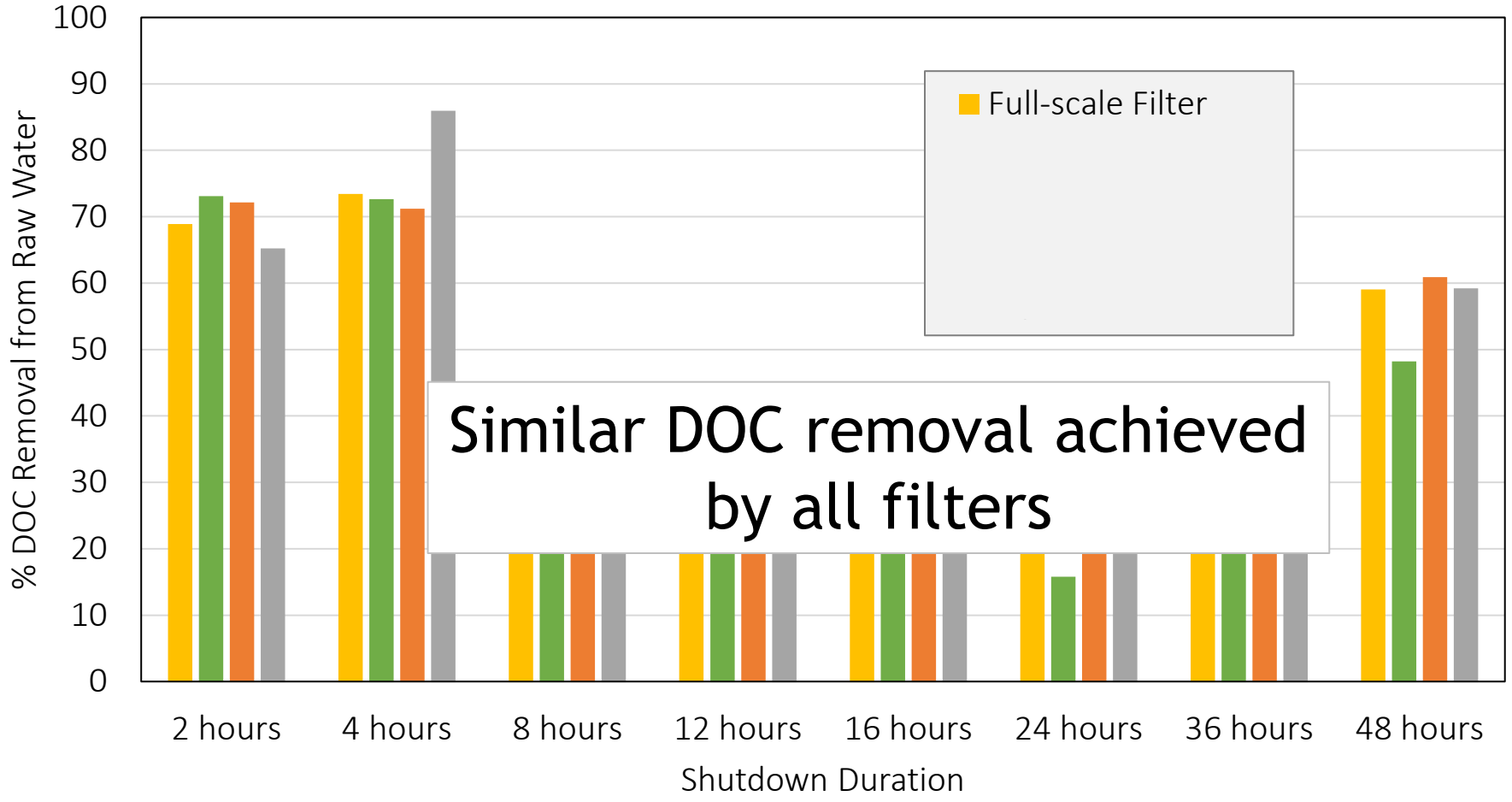
Enzyme Activity - Esterase



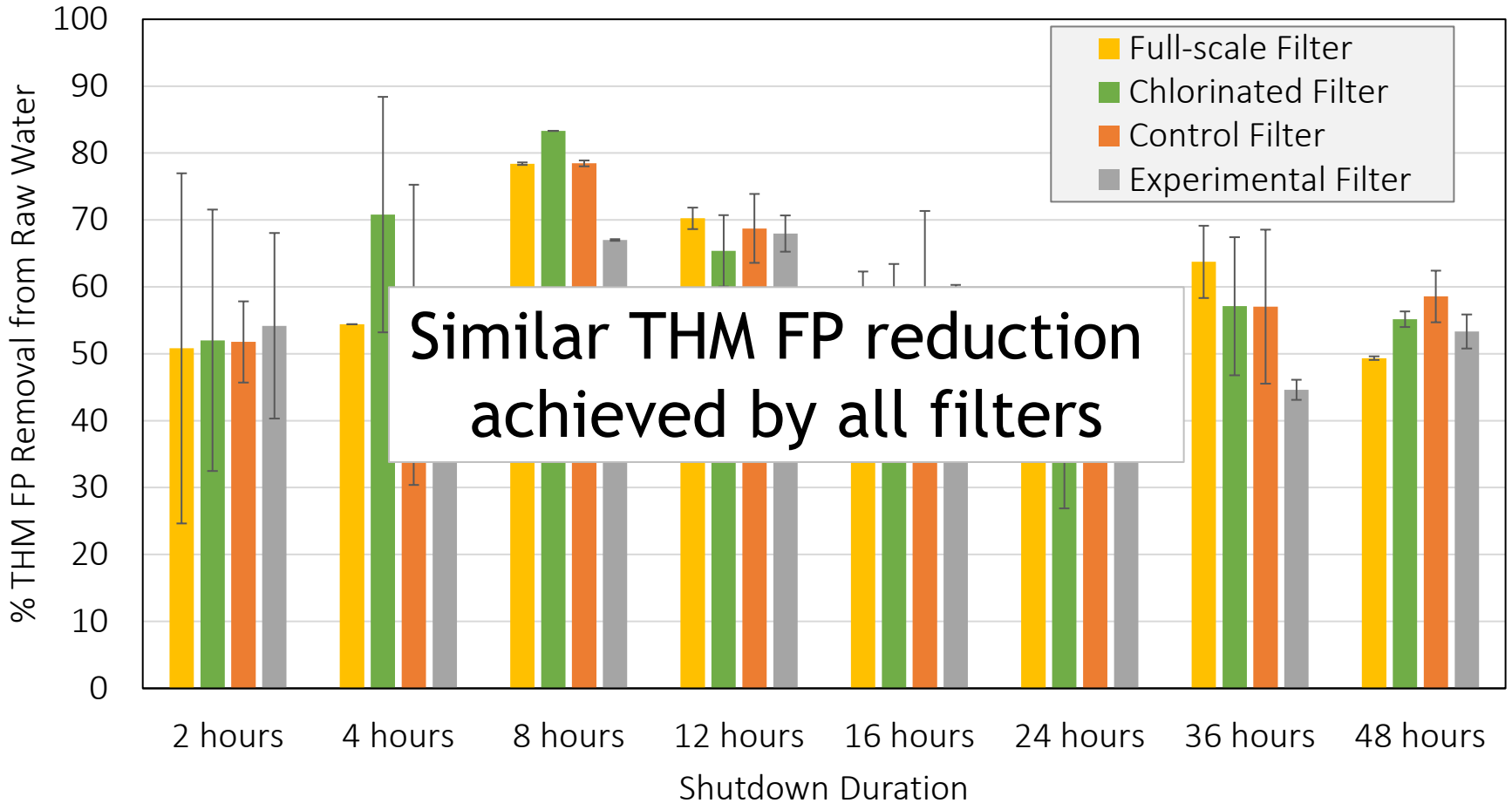
Summary of Biomass Characterization

- Similar ATP ***trend*** observed between control and experimental filters
  - Potentially related to changes in substrate (e.g. carbon)
  - Relatively lower experimental ATP may be due to less mature biofilm
- Esterase activity elevated with extended filter shutdowns
  - Relatively more active biomass
- No relationship to temperature observed

Organics Removal - DOC



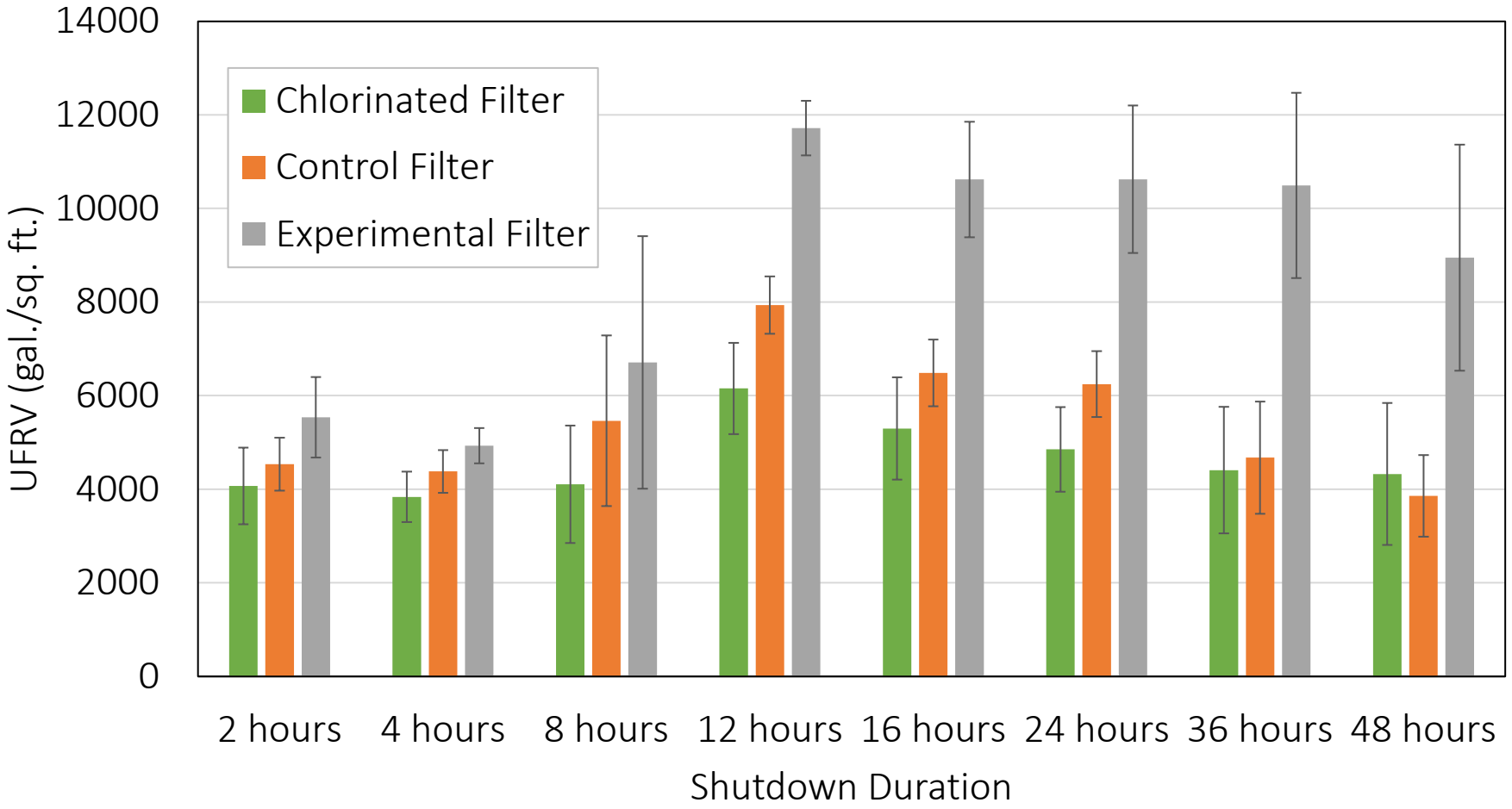
Organics Removal – THM FP



Summary of Water Quality Monitoring

- All filters achieved similar levels of organics removal
  - Likely limited removal achieved biologically – still achieves objective!
- Common biofiltration monitoring parameters (pH, DO uptake, UV_{254}) are poor indicators of performance at this location
- Filter shutdown duration did not affect performance
  - No changes to operation evident

Filter Production



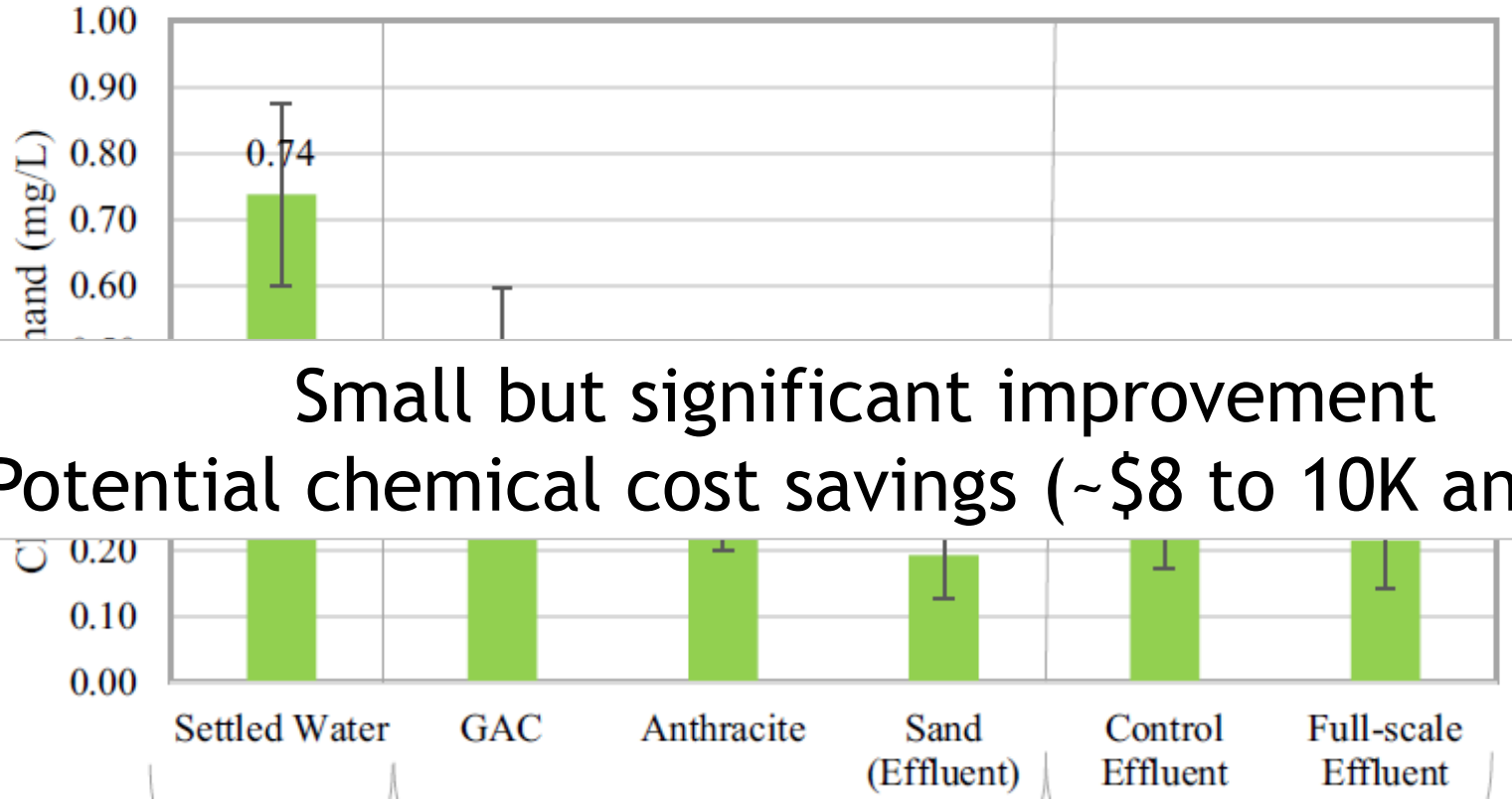
Major Project Findings

- Eliminating pre-chlorination resulted in biologically active filters
  - No changes in filtered water quality anticipated
- Filters without pre-chlorination had higher production capacities as measured by UFRV
  - Extended shutdown following backwash improved this further
- Full-scale elimination of pre-chlorination was a viable approach

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

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

Thank you!

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