

Green River Filtration Facility Biological Filtration Performance Evaluation

2018 PNWS-AWWA Section Conference

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 **Stantec**

Overview

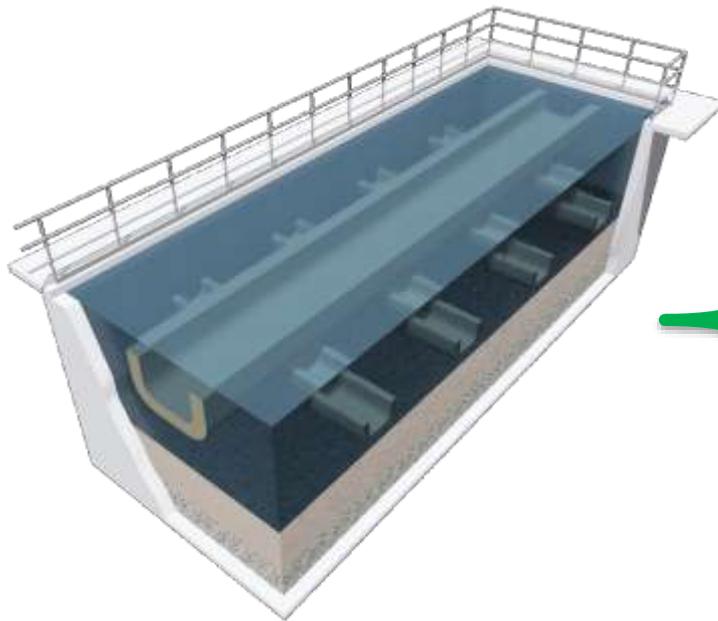
- **Biofiltration 101**
- **GRFF Overview and Filter Design**
- **Filter Performance**
- **Filter Inspections**
- **Baseline Biological Filtration Monitoring**

What is Biofiltration?



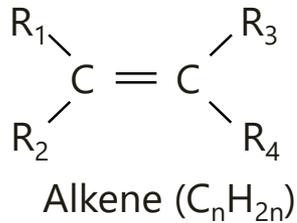
An operational practice of managing, maintaining, and promoting biological activity on granular media in the filter to enhance the removal of organic and inorganic constituents before treated water is introduced into the distribution system.

Biofilters work hard...for “free”

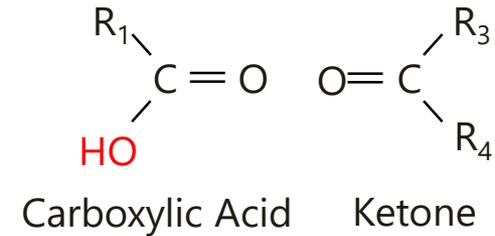
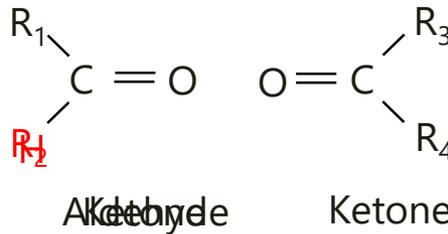
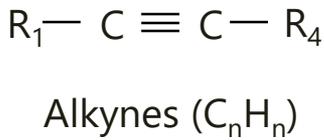
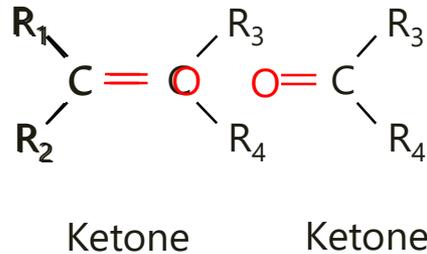


- Reduce T&O
- Reduce DBPs
- Reduce ammonia, iron, manganese
- Reduce regrowth potential
- Reduced corrosion potential
- Improved disinfectant stability

Upstream Ozone can improve biofiltration performance



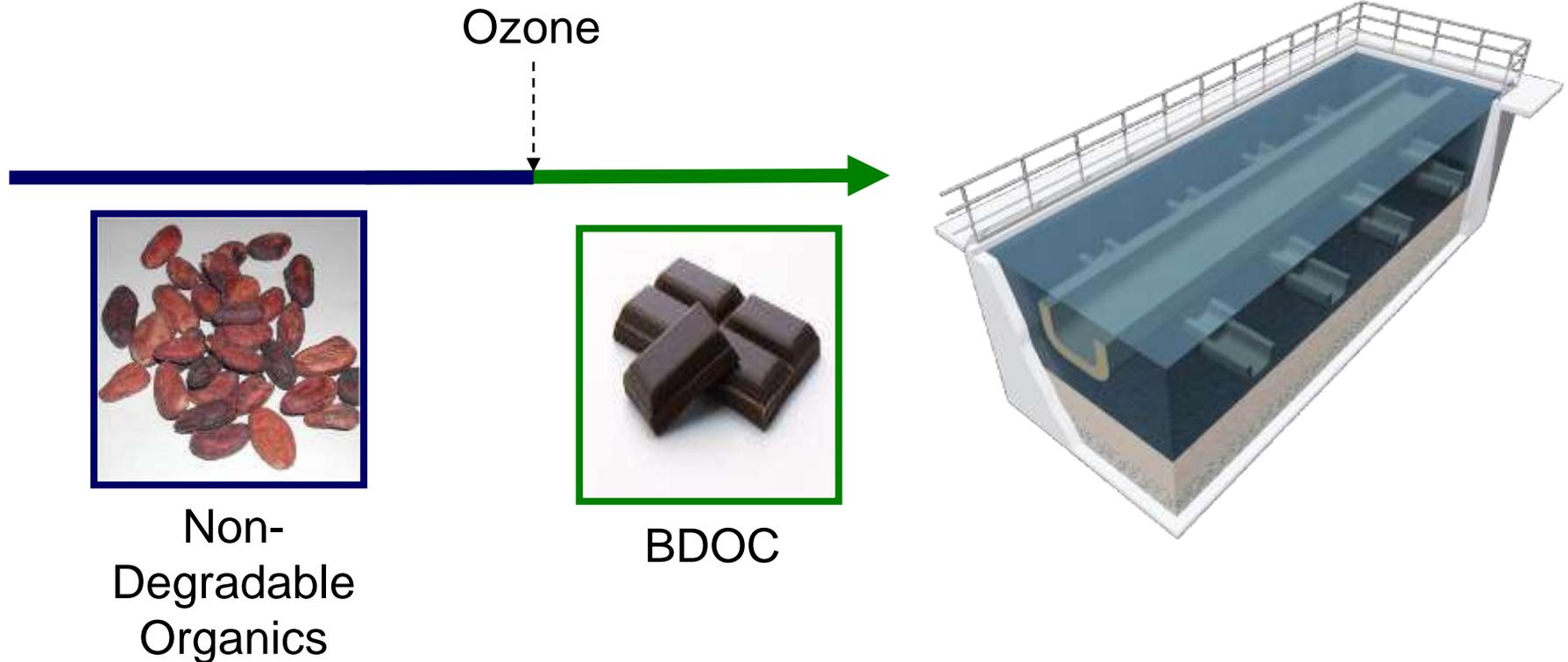
Ozone
→



- Larger compounds
- Abundant C-C bonds
- Less polarity
- Less hydrophilic

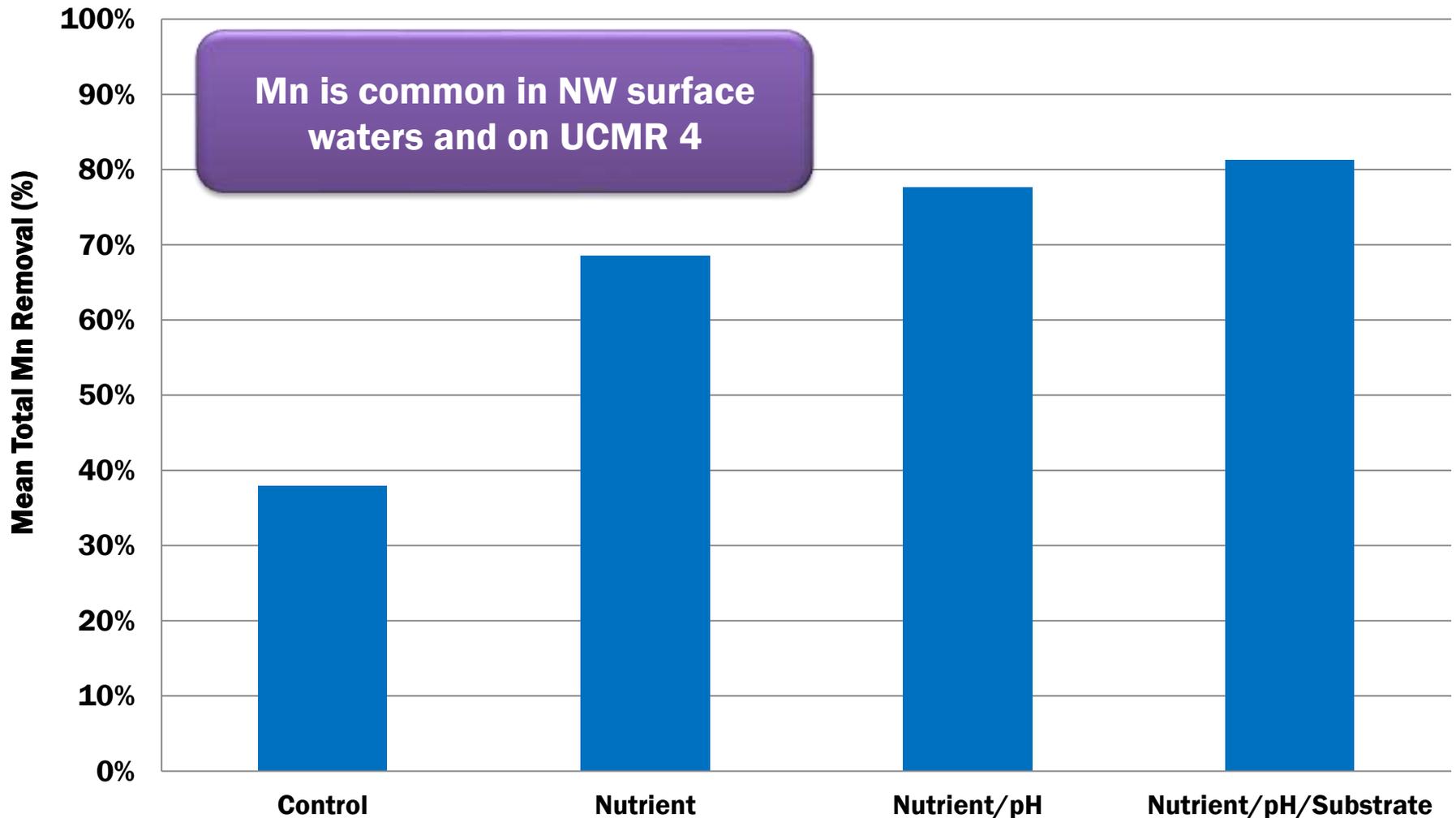
- Smaller compounds
- More C-O bonds
- Increased polarity
- Increased hydrophilicity

Ozone Increases Concentration of Microbial Food



So... you feed the bugs in the filters or feed the bugs in the distribution system

Biofiltration can achieve excellent Mn removal, even when the filter media contains legacy Mn



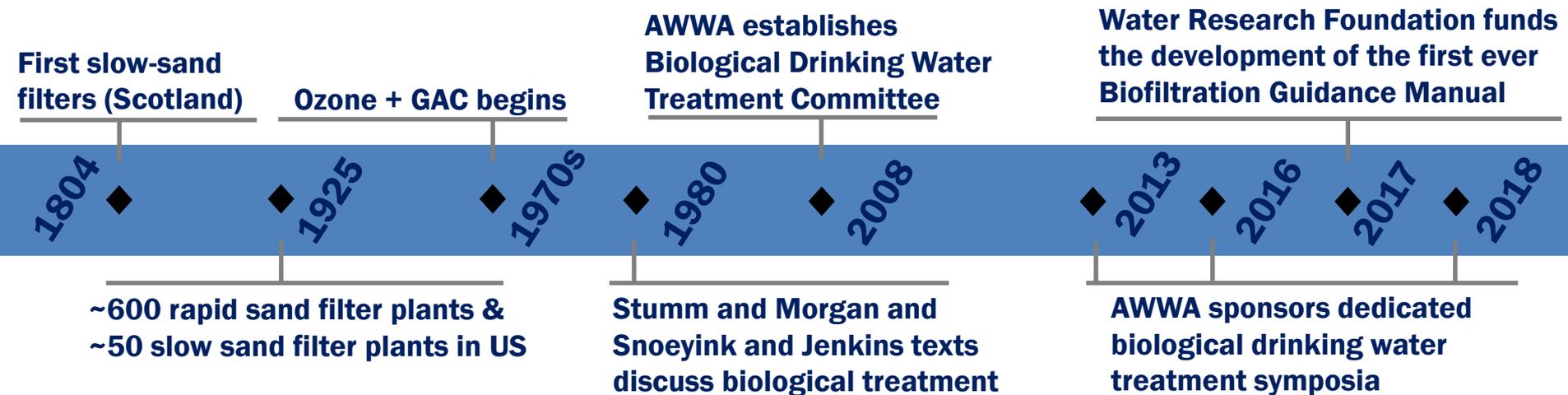
Biofiltration has been around awhile...



Prehistoric Bug Assessment



Contemporary Bug Assessment

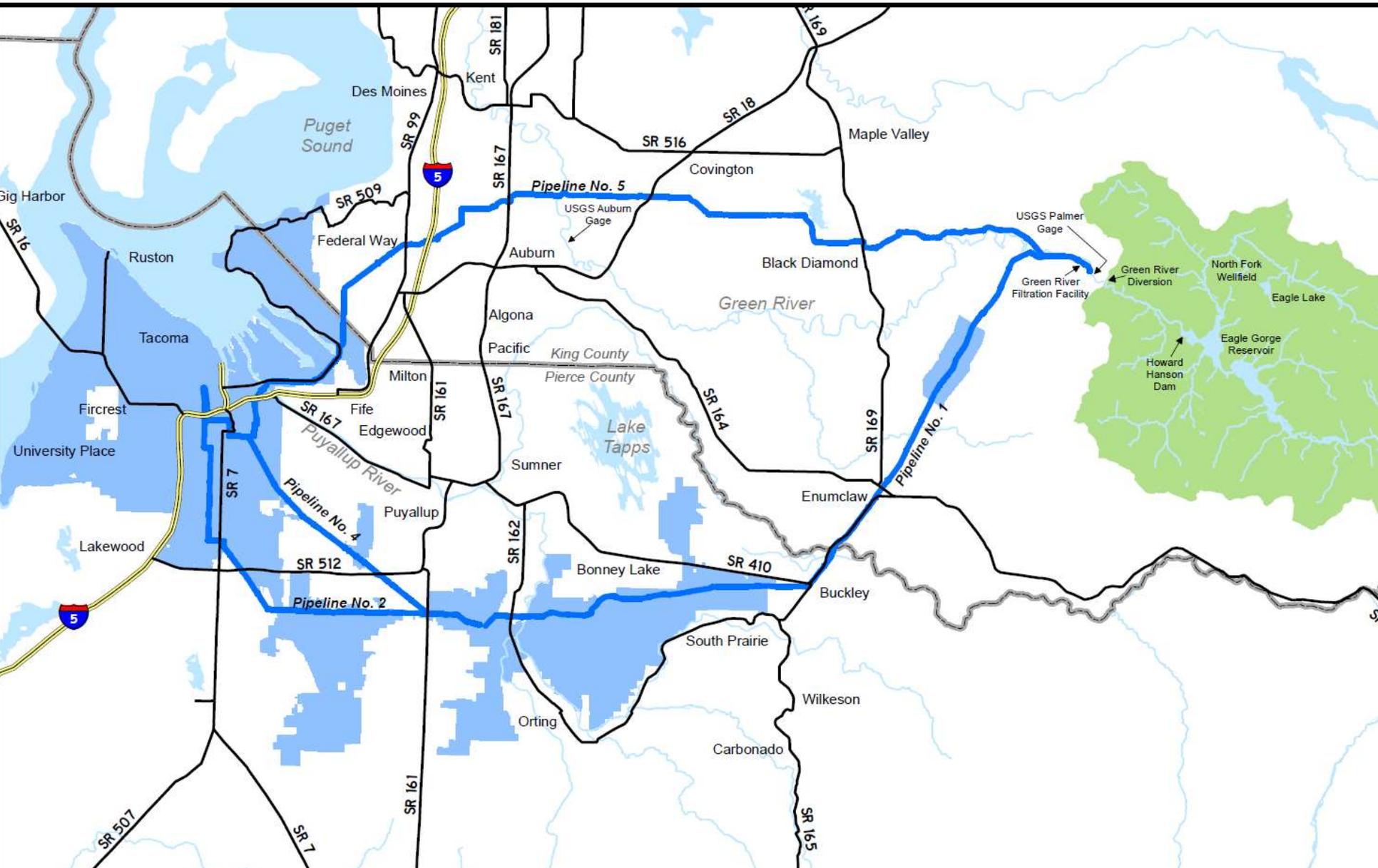




A Biofiltration Guidance Manual for Rapid-Rate Filtration Facilities (4719)



System Overview



Unfiltered for 102 years



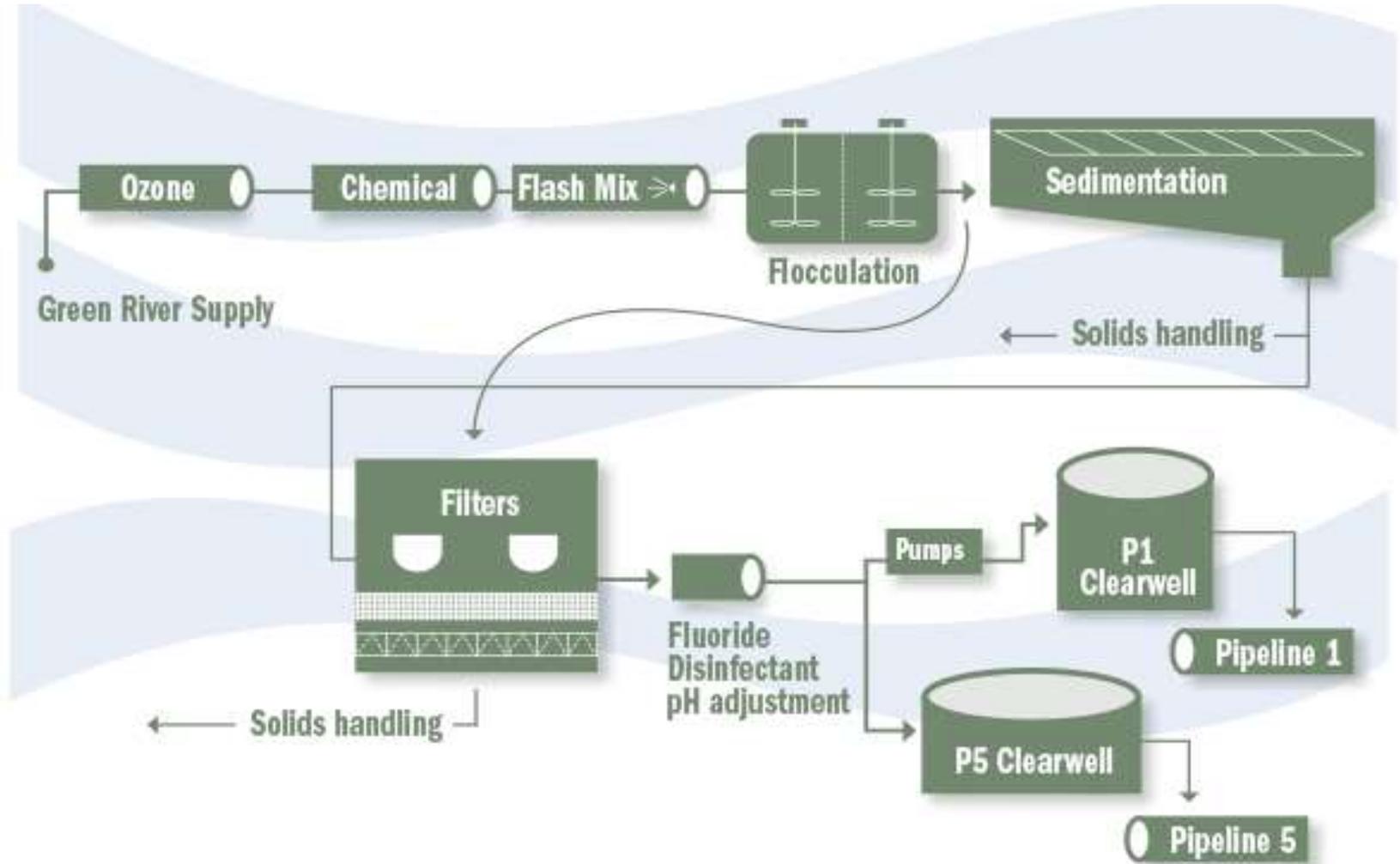
**Original Green River chlorination facility
- used through 1970s**

Green River Filtration Facility



Green River Filtration Facility
April 5, 2015

New Process Flow Diagram



Filter Specifications

Plant Capacity	150 MGD/168 MGD Ultimate
Filter Type	Constant Level and Constant Rate options
Total # of filters	8
Cell dimensions	42ft x 20ft
Cells per filter	2
Filter Area (each)	1680 ft²
Filter Area (total)	13,440 ft²
All 8 filters	7.7 gpm/sf (150 MGD) 8.7 gpm/sf (168 MGD)
One filter off-line	8.9 gpm/sf (150 MGD) 9.9 gpm/sf (168 MGD)
Approved maximum filtration rate	10 gpm/sf

Filter Media

Anthracite	
Depth	50 in
Effective size	1.32 ± 0.05
Uniformity coefficient	<1.4
Specific gravity	1.65

Sand	
Depth	20 in
Effective size	0.66 ± 0.03
Uniformity coefficient	<1.4
Specific gravity	2.63

Biological Filtration Decision

Passive biological filtration = No upstream chlorination, no nutrient addition

- **Some relatively high DBP levels when unfiltered (HAA5 ~40-70 ppb)**
- **Pre-ozonation already in place**
- **Improve overall water stability throughout system**
- **Potential to remove manganese**
- **Limit sodium hypochlorite requirements**
- **Common current industry practice**

Celebrate GRFF Completion – We're Filtered!



Now....how do we know if the filters actually work well or not?



GRFF Optimization Project

- **Requested consultant support in optimization efforts:**
 - Initial filter evaluation
 - Biological control
 - Chemical dosing and settled turbidity optimization
 - Seasonal manganese control
- **Parallel effort through Washington State DOH Performance Based Training**

Filter Performance

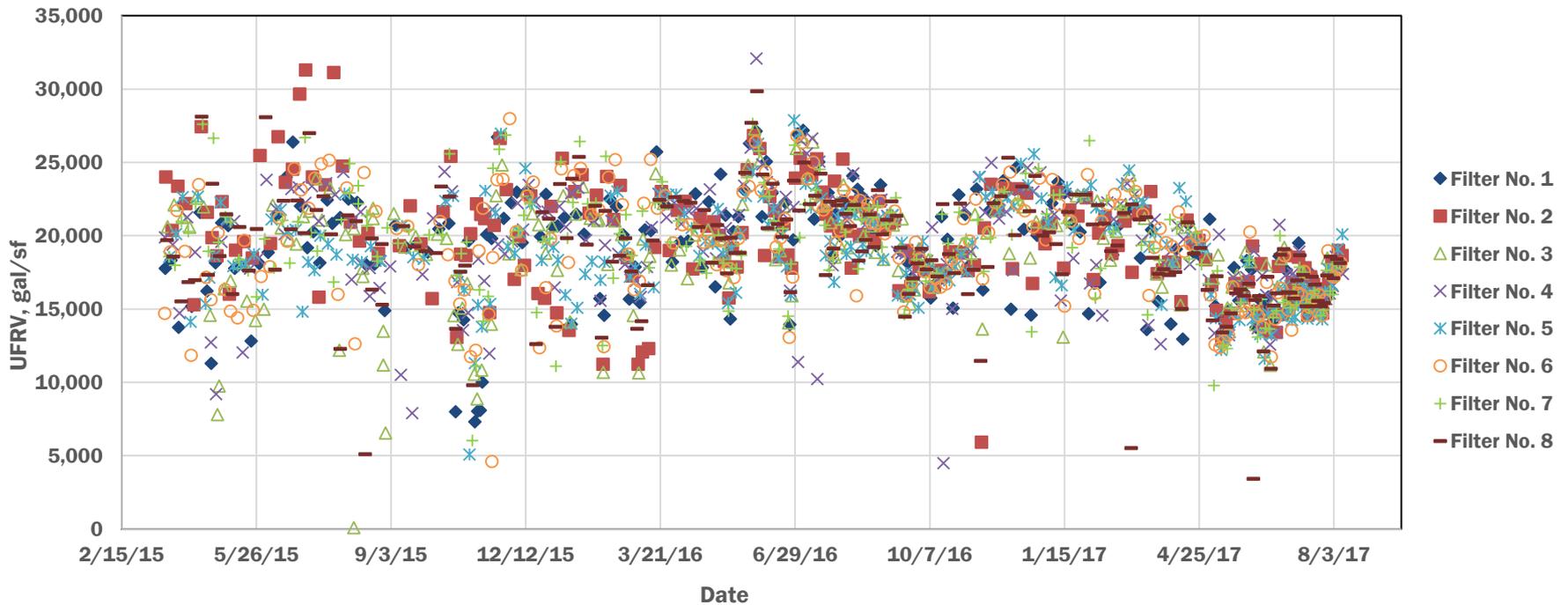
	No. of Runs	Average Filtration Rate (gpm/sf)	Average Reported Filtered Water Turbidity (NTU)	Average Filtered Water Particle Counts (#/mL)	Average Filter Run Times (hr)	Average Unit Filter Run Volume (gal/sf)	Average Head Loss Accumulation (ft/hr)
Filter No. 1	207	6.6	0.026	10.0	57	19,000	0.21
Filter No. 2	207	6.6	0.024	10.1	57	19,600	0.20
Filter No. 3	210	6.5	0.024	13.7	57	18,700	0.23
Filter No. 4	209	6.5	0.024	7.7	58	19,200	0.20
Filter No. 5	204	6.6	0.023	14.0	58	18,900	0.24
Filter No. 6	205	6.6	0.023	8.0	58	19,200	0.23
Filter No. 7	208	6.5	0.022	8.9	58	19,400	0.24
Filter No. 8	198	6.6	0.027	10.8	57	19,000	0.22

3/2015 – 8/2017

“Happy Filters” 

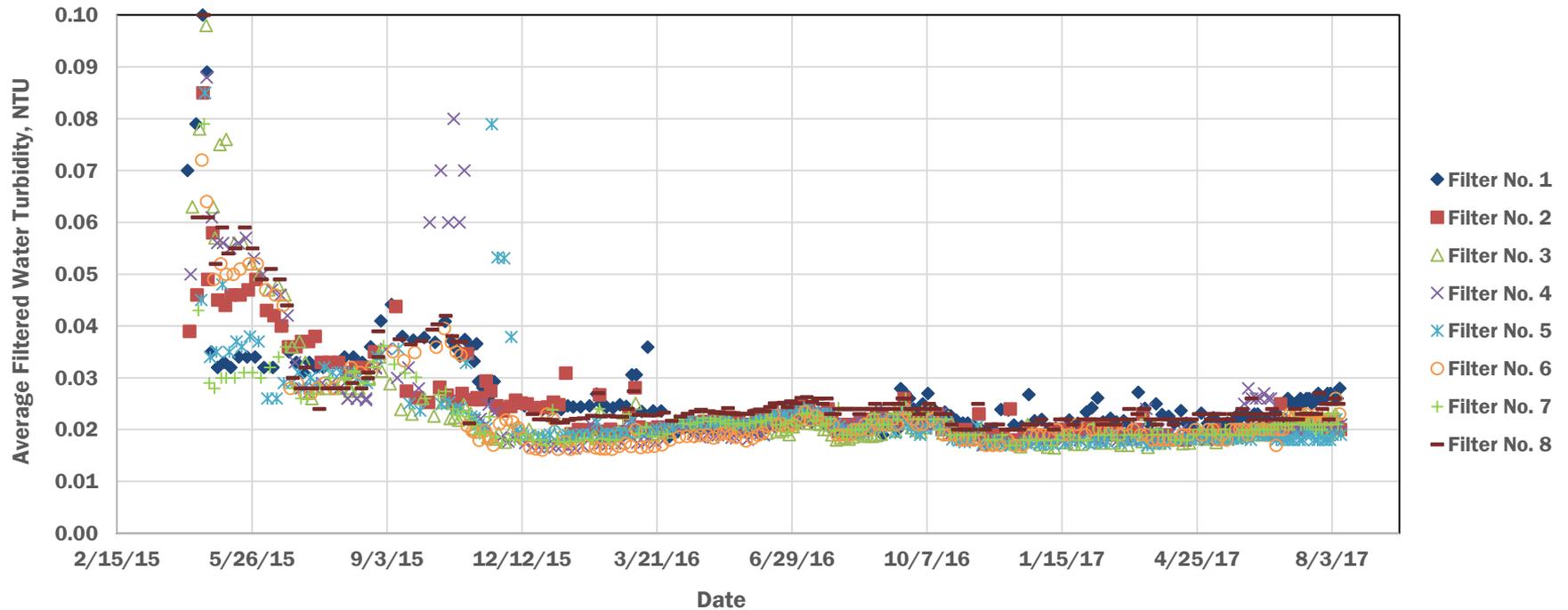
Filter Performance

Total Unit Filter Run Volume per Filter Run

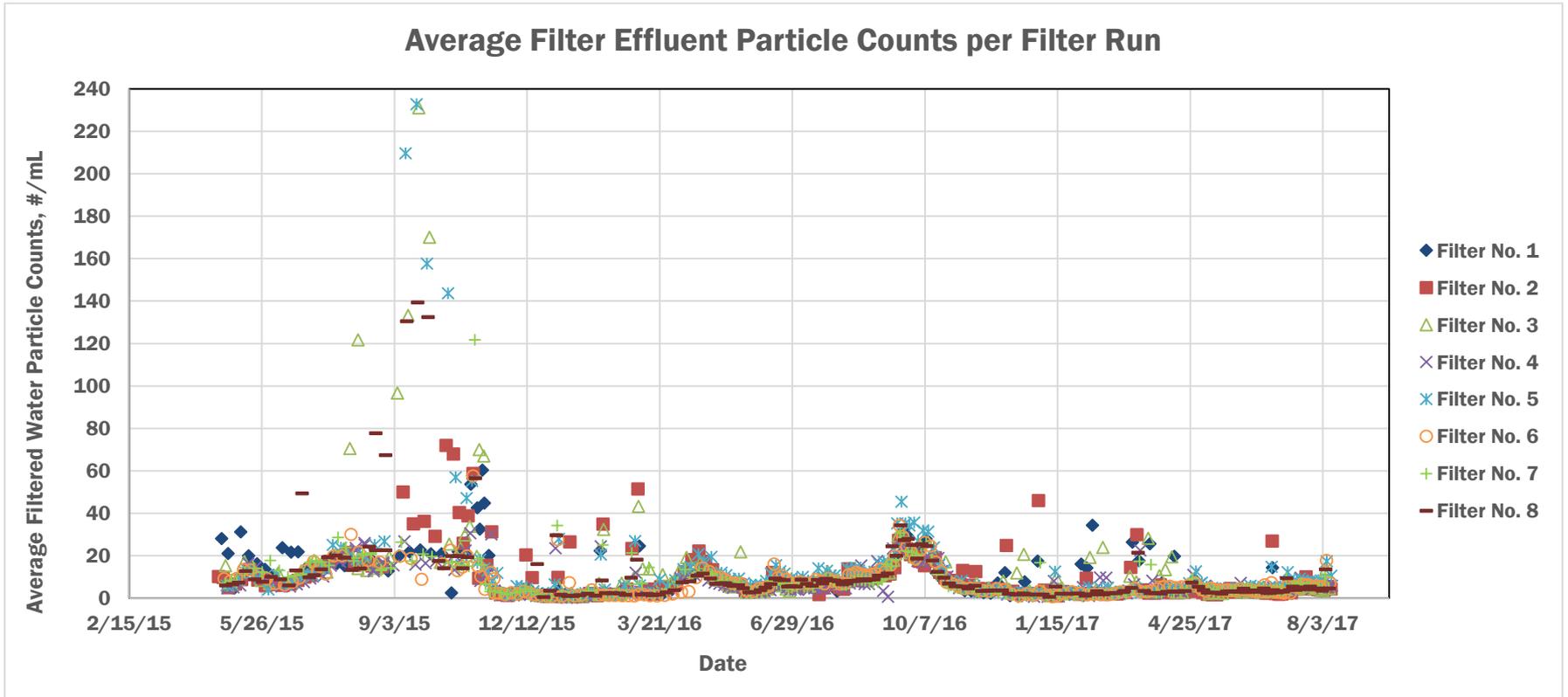


Filter Performance

Average Filter Effluent Turbidity per Filter Run

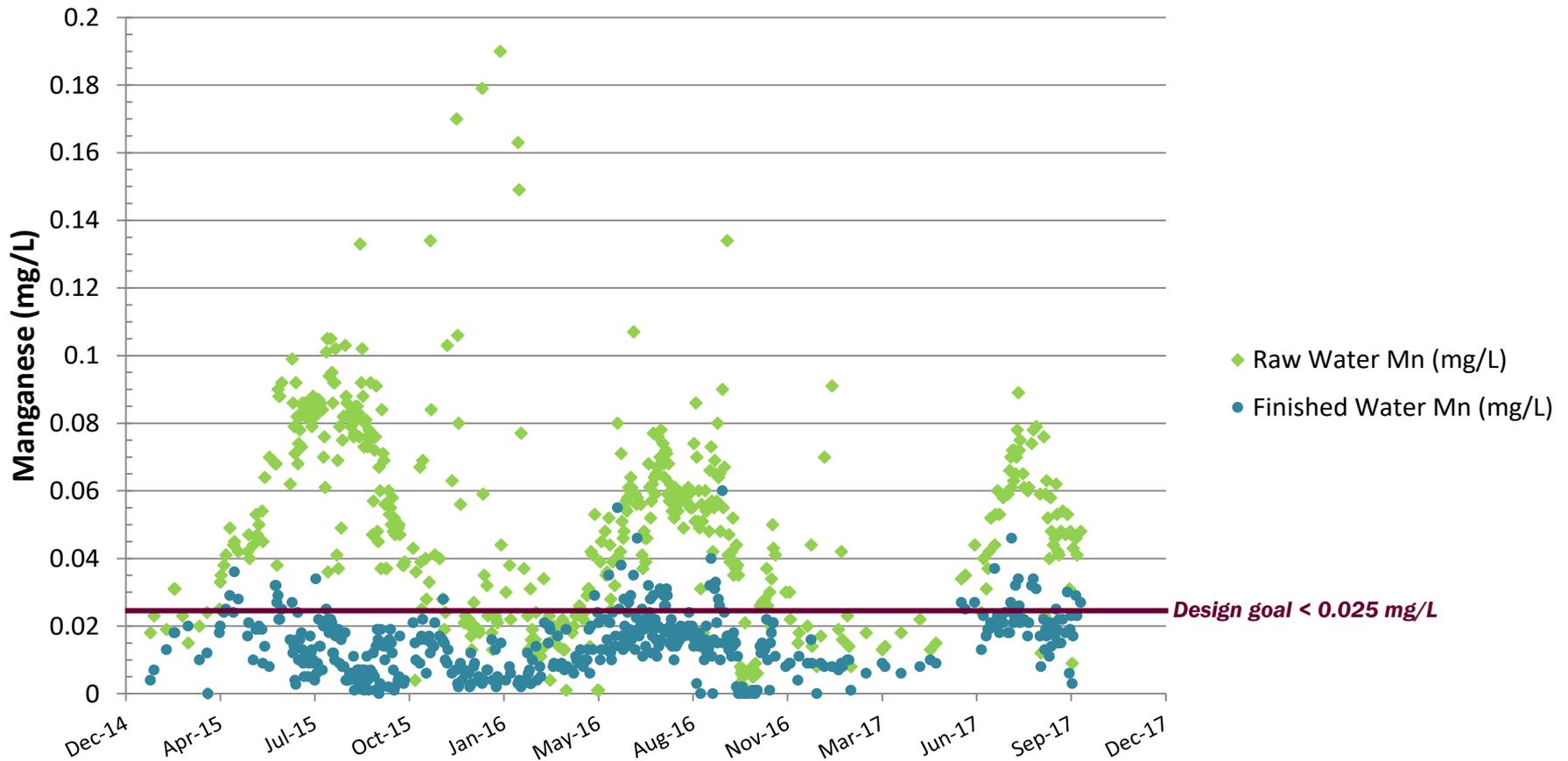


Filter Performance



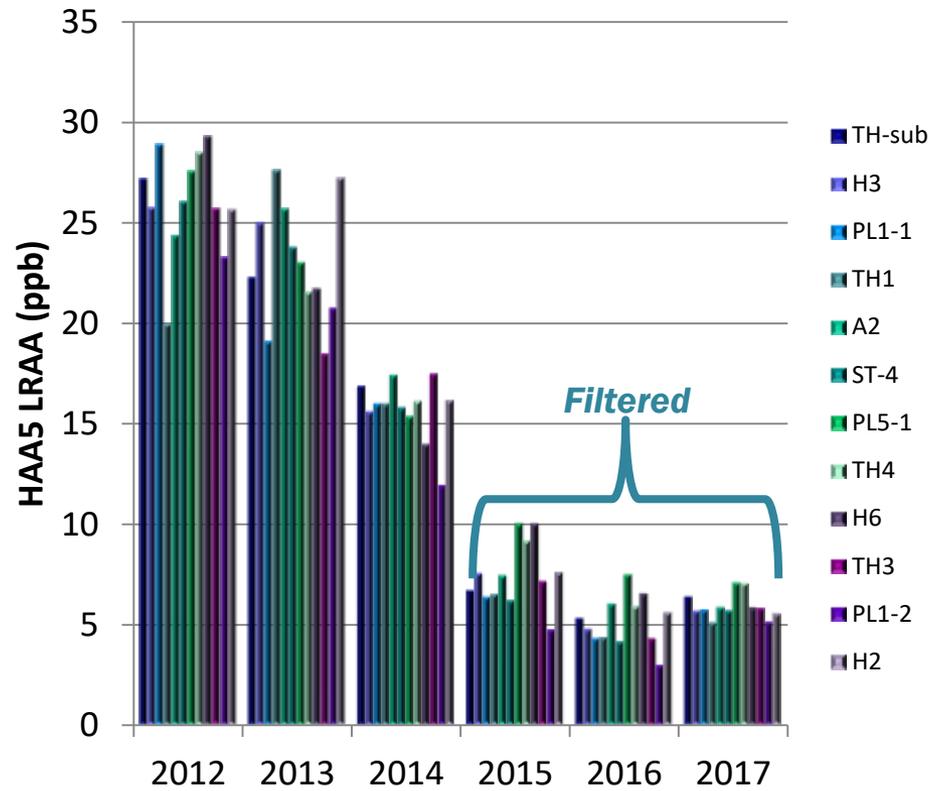
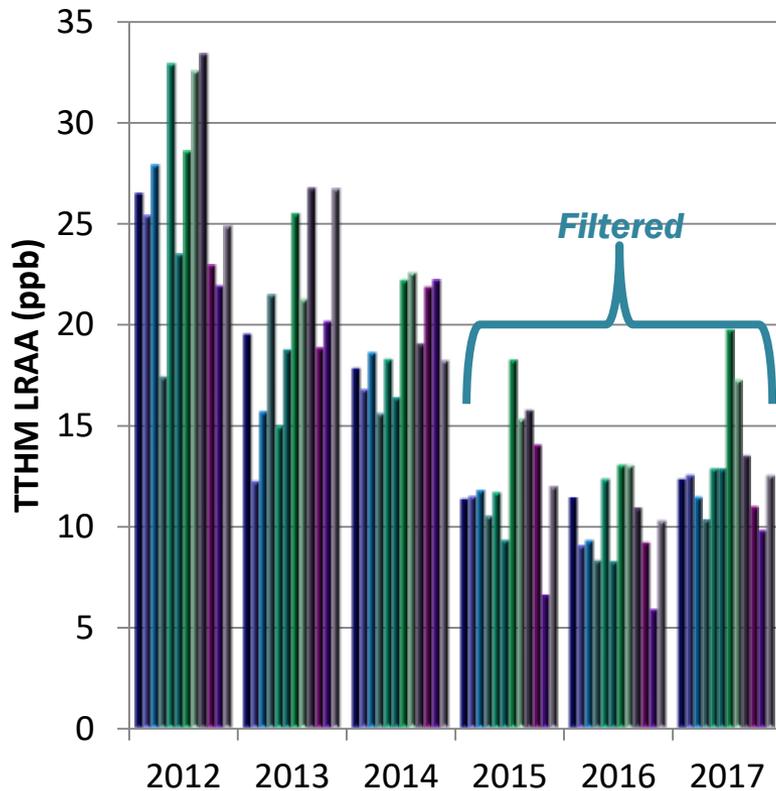
Filter Performance

Manganese Removal



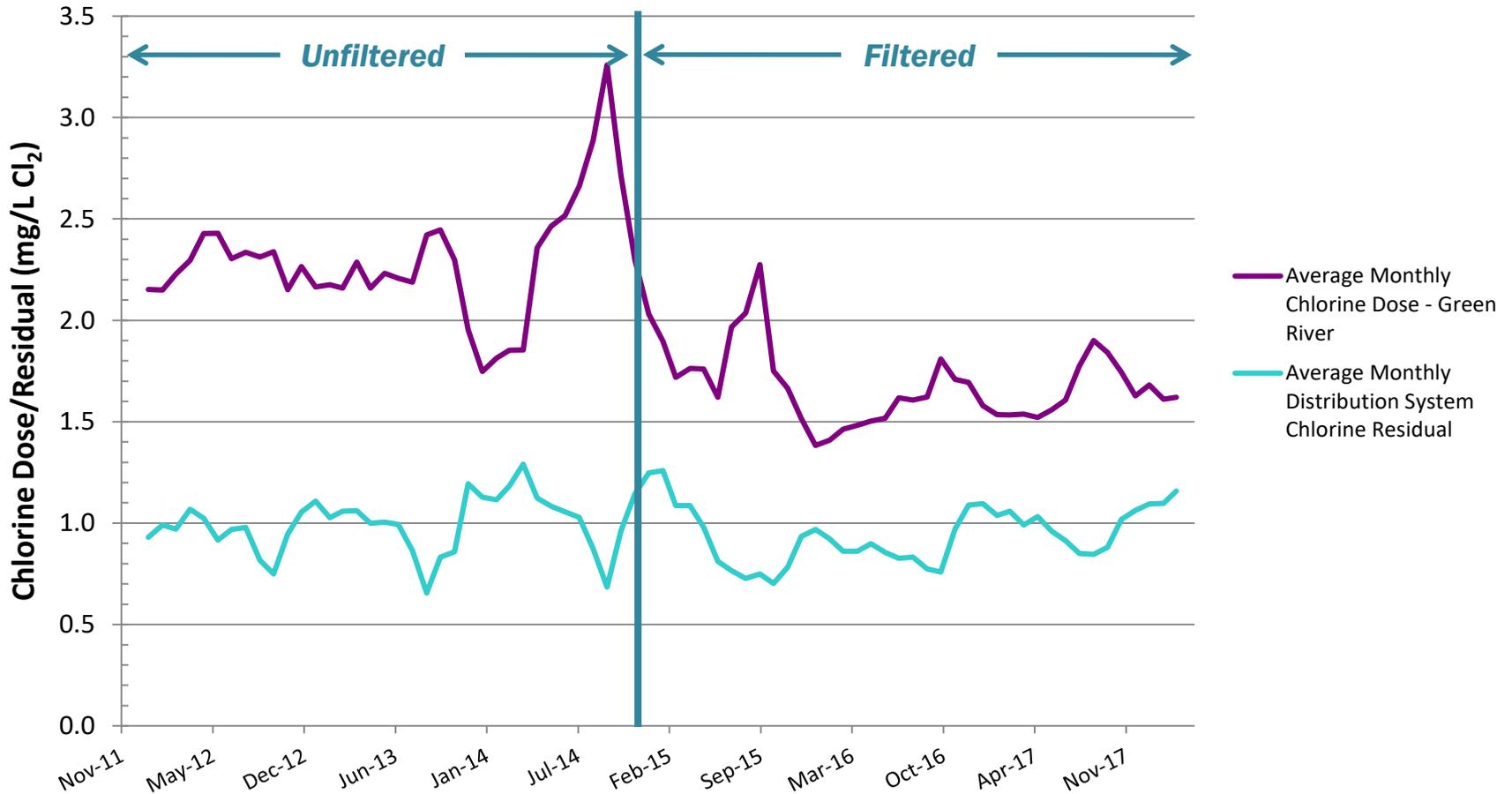
Filter Performance: Distribution System

Disinfection Byproducts

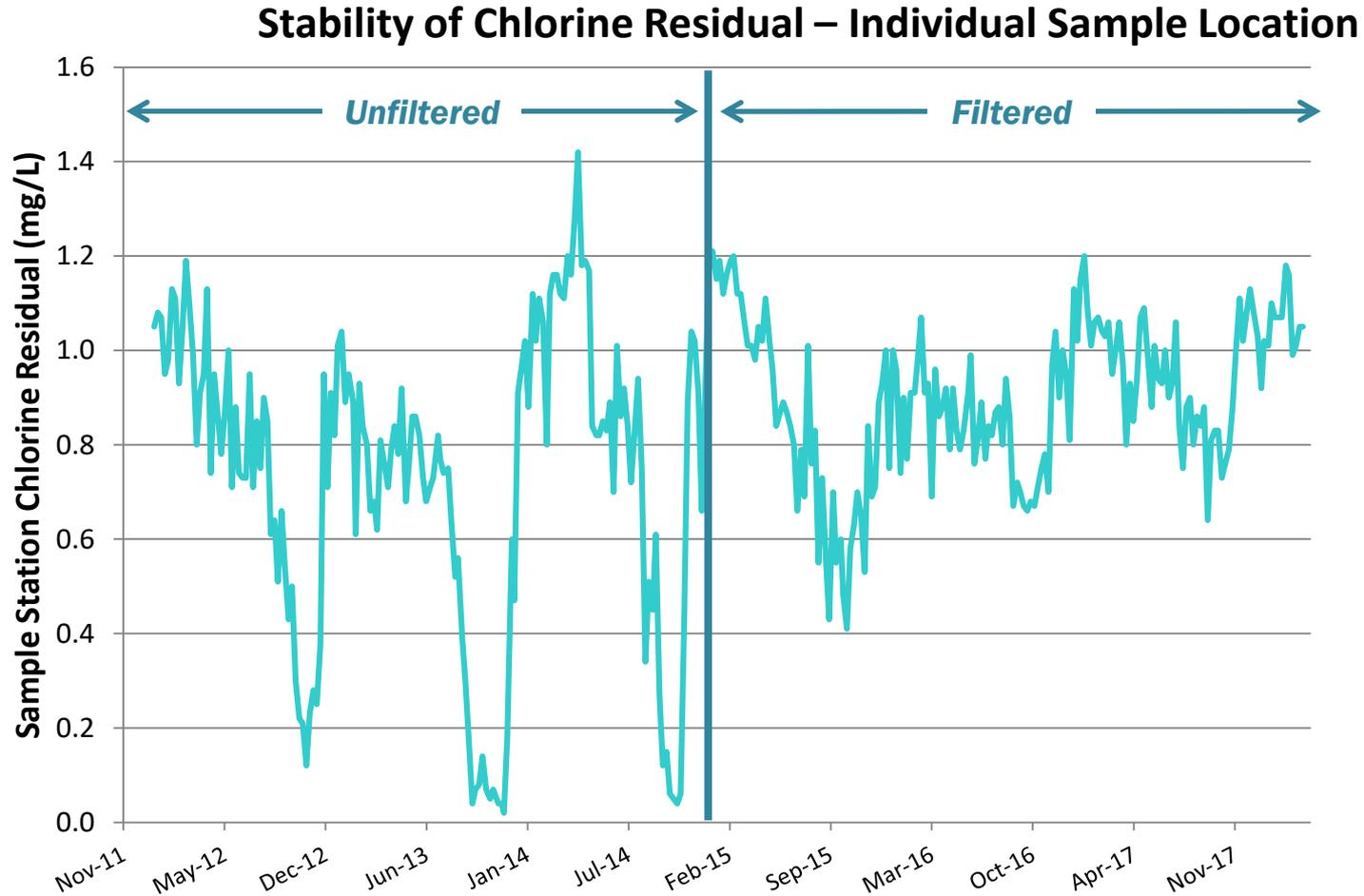


Filter Performance: Distribution System

Stability of Chlorine Residual – System Average

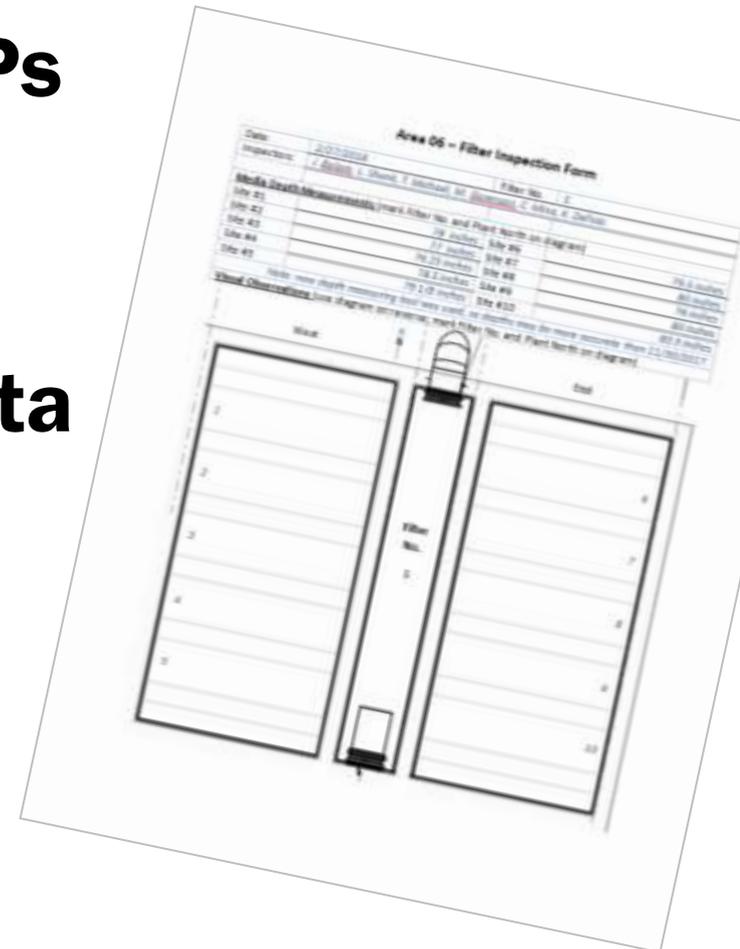


Filter Performance: Distribution System



Filter Inspections

- **Prepare and use Filter Surveillance Plan and SOPs for regular inspections – understand process**
- **Start building baseline data for comparison later**
- **First year: 2 filters x 4 inspections**



The image shows a 'Filter Inspection Form' titled 'Area 05 - Filter Inspection Form'. The form includes fields for 'Date', 'Inspector', 'Filter No.', and 'Filter No. 2'. It also has a section for 'Filter No. 1' and 'Filter No. 2' with columns for '1/2 inch', '3/4 inch', and '1 inch'. The form is tilted and shows a diagram of a filter with 'Inlet' and 'Out' labels. The diagram includes a central vertical pipe labeled 'Filter No. 1' and two side pipes labeled '1' and '2'. The form is partially filled out with handwritten text.

Filter Inspections: Filter Depth and Filter Bed Expansion

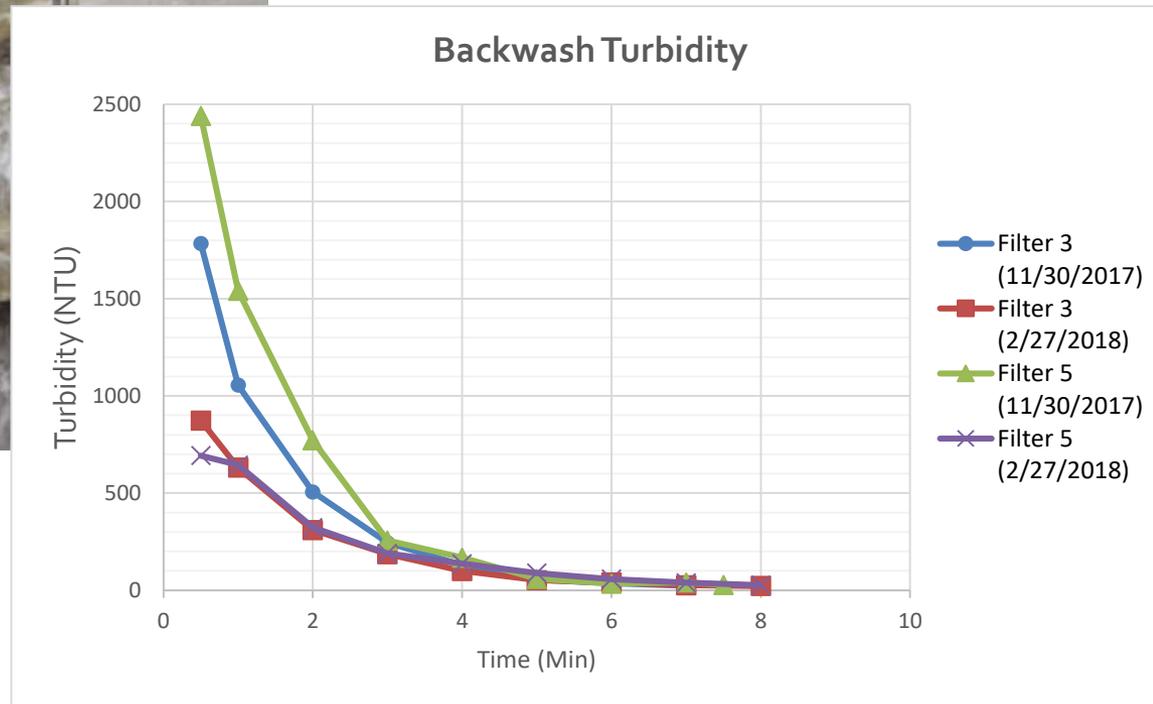


Try out new tools



20 – 21% bed expansion

Filter Inspections: Backwash Turbidity Profile

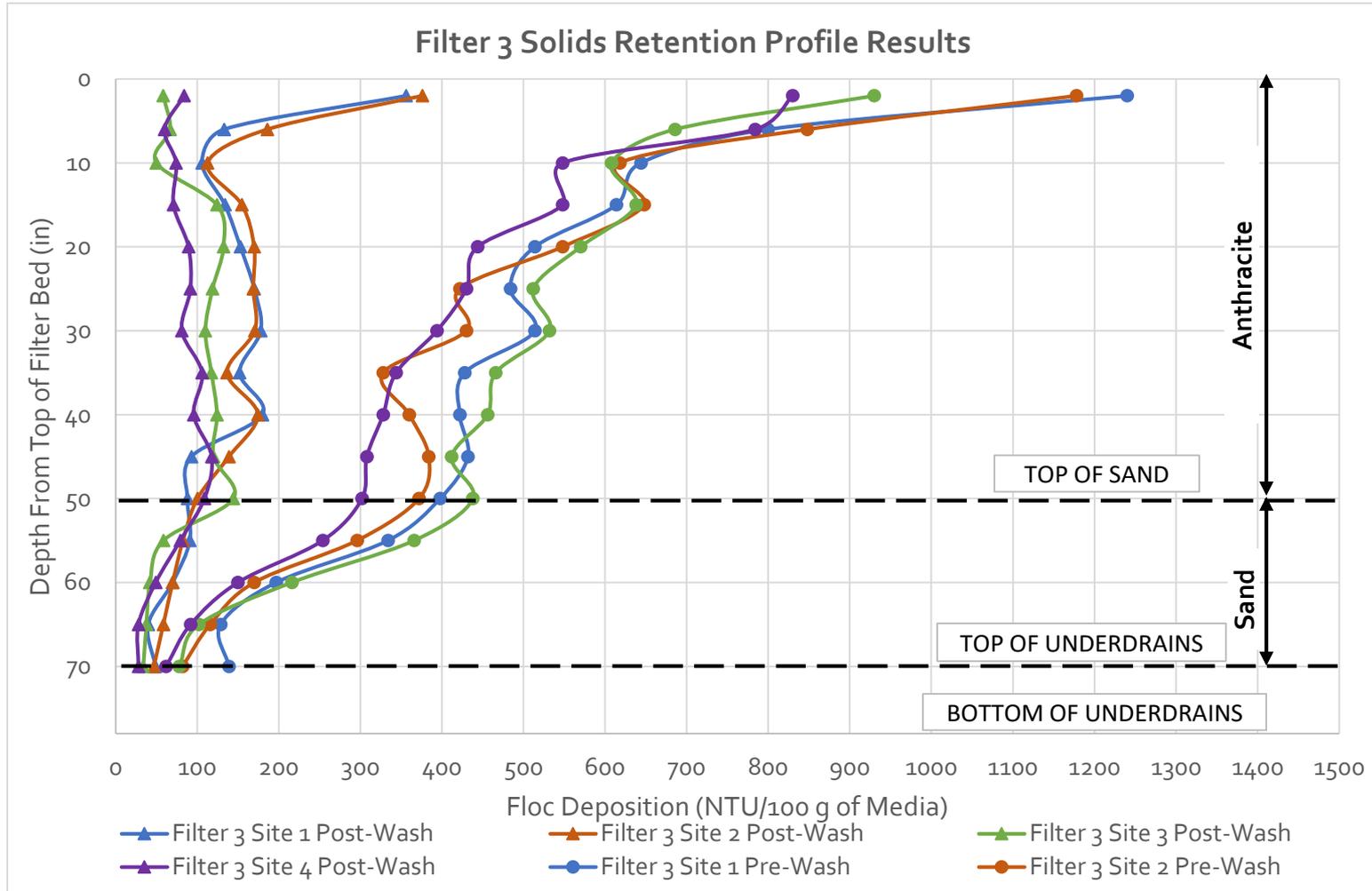


Filter Inspections: Filter Coring



- **Cores at 2 locations in each filter cell x 2 filters**
- **Sampled top 10" with pipe**
- **Sampled 15" – 70" with modified wheat thief**
- **Before and after backwash**
- **Over 200 bags of media!**

Filter Inspections: Solids Retention Profile



Baseline Biological Filtration Monitoring

- **Collect data to establish a baseline for biological filtration performance**
 - **Water Quality, Microbial, and Hydraulic**
- **Capture spectrum of performance under various conditions for 1 year**
 - **Conventional filtration/direct filtration**
 - **Warmest weather/coldest weather**

Baseline Biological Filtration Monitoring: Water Quality

- ***Water quality parameters***

Parameter	Indicates
Temperature	Conditions – biological activity reduced in colder water
pH	Conditions – pH outside of neutral range affects biological activity
Total organic carbon	Total carbon load entering filters
Dissolved organic carbon	Portion of carbon available for biological uptake
SUVA	Portion of carbon available for biological uptake
Biodegradable organic carbon	Max assimilable TOC/DOC available for removal across biofilters

2 filters, influent/effluent, 1-2 times per month, 1 year

Baseline Biological Filtration Monitoring: Water Quality

Parameter	Indicates
Ozonation byproducts (aldehydes, carboxylic acids)	If biologically unstable organic carbon generated by ozone process is being removed
Total/dissolved manganese	If removal is occurring and what fraction is available for biological removal
Geosmin/MIB	If removal is occurring
Ammonia	Whether biological activity is limited by lack of nutrients in water
Ortho-phosphate	Whether biological activity is limited by lack of nutrients in water

Baseline Biological Filtration Monitoring: Water Quality

- **Early results**

- **Primarily dissolved manganese, some removal through filters**
- **Some TOC/DOC removal through filters**
- **Some ammonia removal through filters**
- **Biological activity is phosphorus limited**
- **Very low or non-detect results for ozonation byproducts (influent and effluent)**
- **All cold water samples, <6 degrees C**

Baseline Biological Filtration Monitoring: Microbial

- **Adenosine triphosphate (ATP) is found in all forms of life, can provide assessment of biological activity**
- **Measure ATP based on light produced in reaction with Luciferase enzyme**
- **Measure ATP in top 6" of filter media before and after backwash at least 2x per month**



Baseline Biological Filtration

Monitoring: Microbial

- ***Microbial parameters (filter media)***

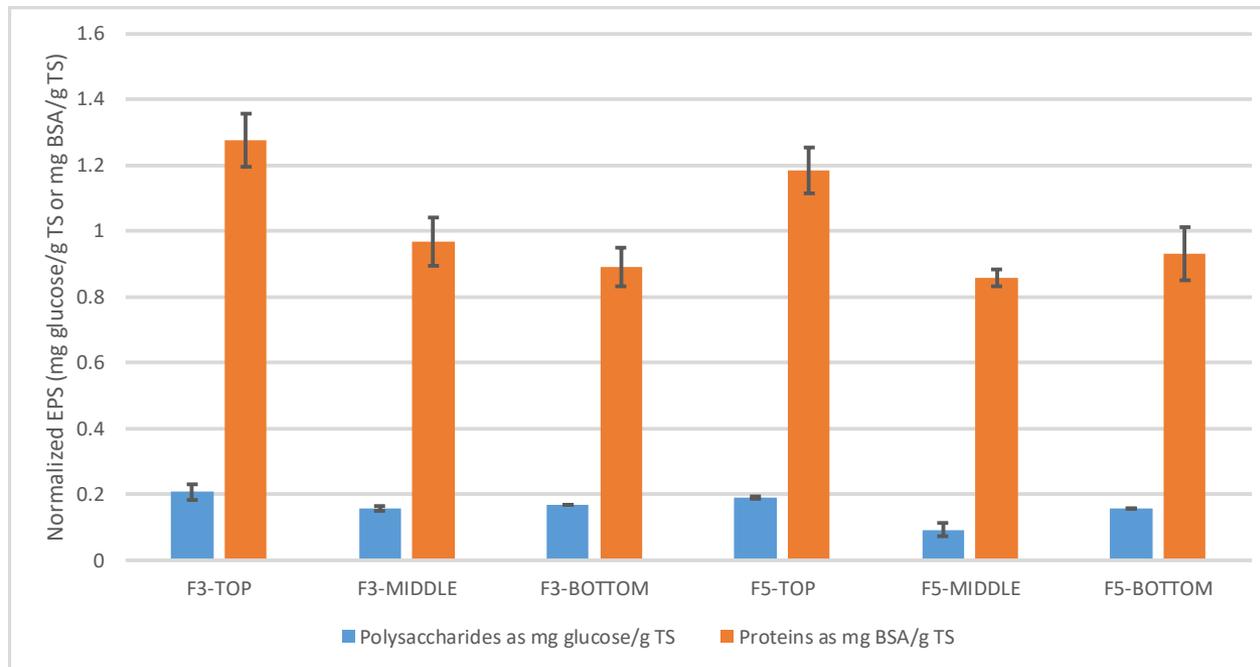
Parameter	Indicates
Extracellular polymeric substances (EPS)	Microbiological stress, including developing problems (i.e., clogging)
Microbial community morphology through SEM microscopy	Indirect clues to microbial stress
Microbial community structure	Shifts in genera that may correlate with changes in operating conditions or water quality
Adenosine triphosphate (ATP)	Overall microbiological activity

2 filters, 3 depths (composite top/middle/bottom), before backwash, 4 times, 1 year

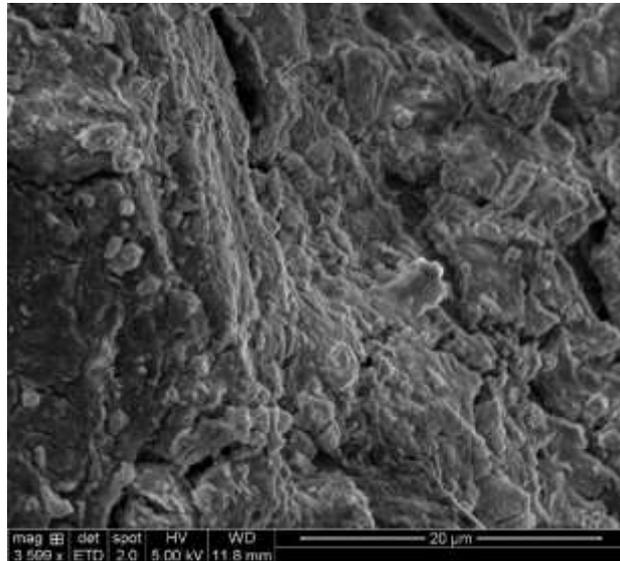
Baseline Biological Filtration Monitoring: Microbial

- **Initial results**
 - **EPS within expected range**
 - **ATP low but within reasonable range**
 - **Watch how microbial community shifts over the year**

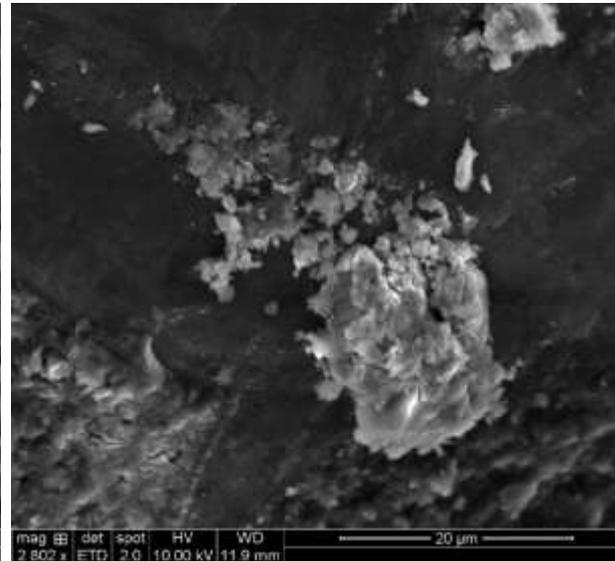
Baseline Biological Filtration Monitoring: Microbial



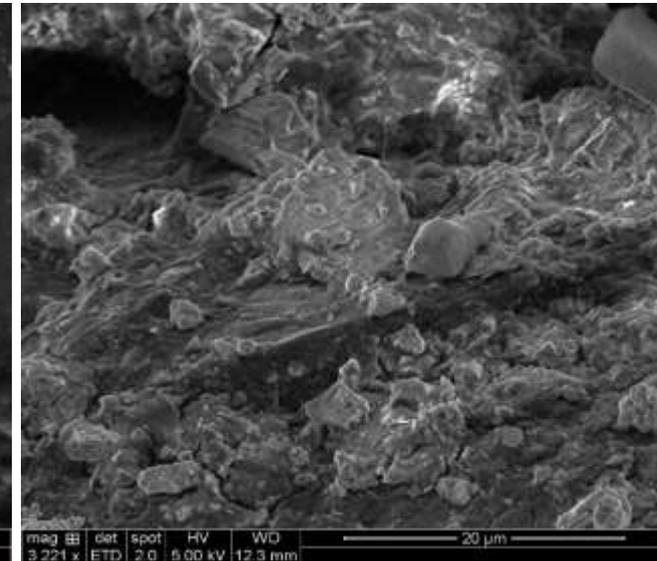
Baseline Biological Filtration Monitoring: Microbial



Top of filter

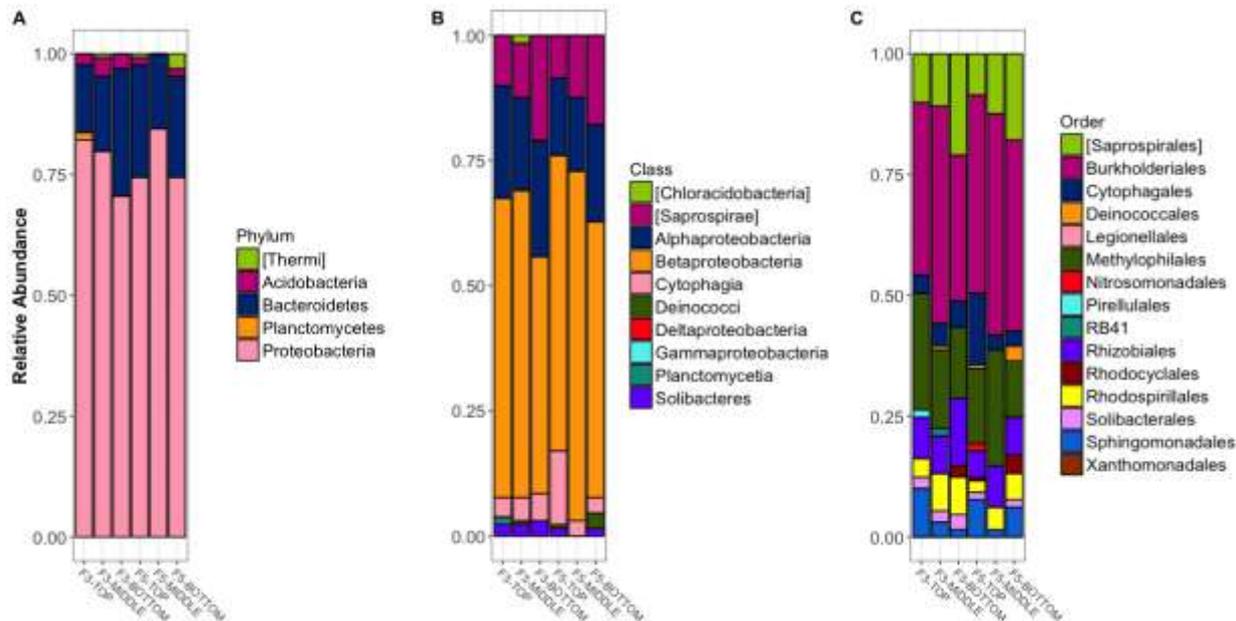


Middle of filter



Bottom of filter

Baseline Biological Filtration Monitoring: Microbial



Any potential unintended consequences in converting to biofiltration?

The image displays the North American Biofiltration Knowledge Base website interface. The header includes the Water Research Foundation logo and the title "North American Biofiltration Knowledge Base". A navigation menu contains links for Home, Library, Case Studies, My Facility, Knowledge Base Reports, and About. A text block explains that access is available to people affiliated with a subscribing organization of the Water Research Foundation (WRF), and provides an email address for access requests: Biofiltration.KnowledgeBase@arcadis-us.com. Below the text are four colored buttons with arrows pointing right: "Biofiltration Library" (orange), "Case Studies" (blue), "My Facility" (purple), and "Knowledge Base Reports" (red). Each button includes a brief description of its content. To the right, two sample reports are shown, titled "North American Biofiltration Knowledge Base Summary Report" and "North American Biofiltration Knowledge Base Planning Phase". Both reports feature various charts, including bar graphs, pie charts, and line graphs, along with tables and text sections. The background of the website interface is a blue water splash graphic.

Biofiltration sounds great and all, but what about ...

(Commonly expressed operational concerns)

- **Growth of macro-organisms**
- **Instrumentation fouling**
- **Decreased unit filter run volumes**
- **Growth and release of pathogens??**



Baseline Biological Filtration Monitoring: Next Steps

- **Complete remaining baseline monitoring in 2018**
- **Watch for indicators of potential issues, maintain baseline**
- **Identify additional specific performance goals and strategies to achieve those goals**
- **Develop ongoing monitoring strategy**

Acknowledgments

- **Tacoma Water - Water Quality Section staff**
- **The University of Texas at Austin Environmental and Water Resources Engineering**



Questions?

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