



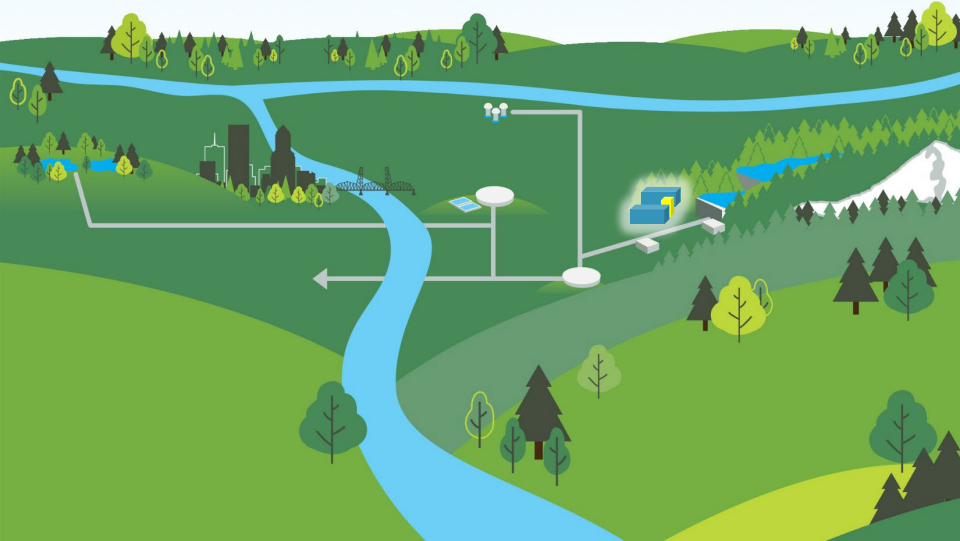
Building Treatment Resilience to Wildfires through Conventional Filtration Piloting

WRF 5168: Enhancing Drinking Water Treatment Resilience to Wildfire Events

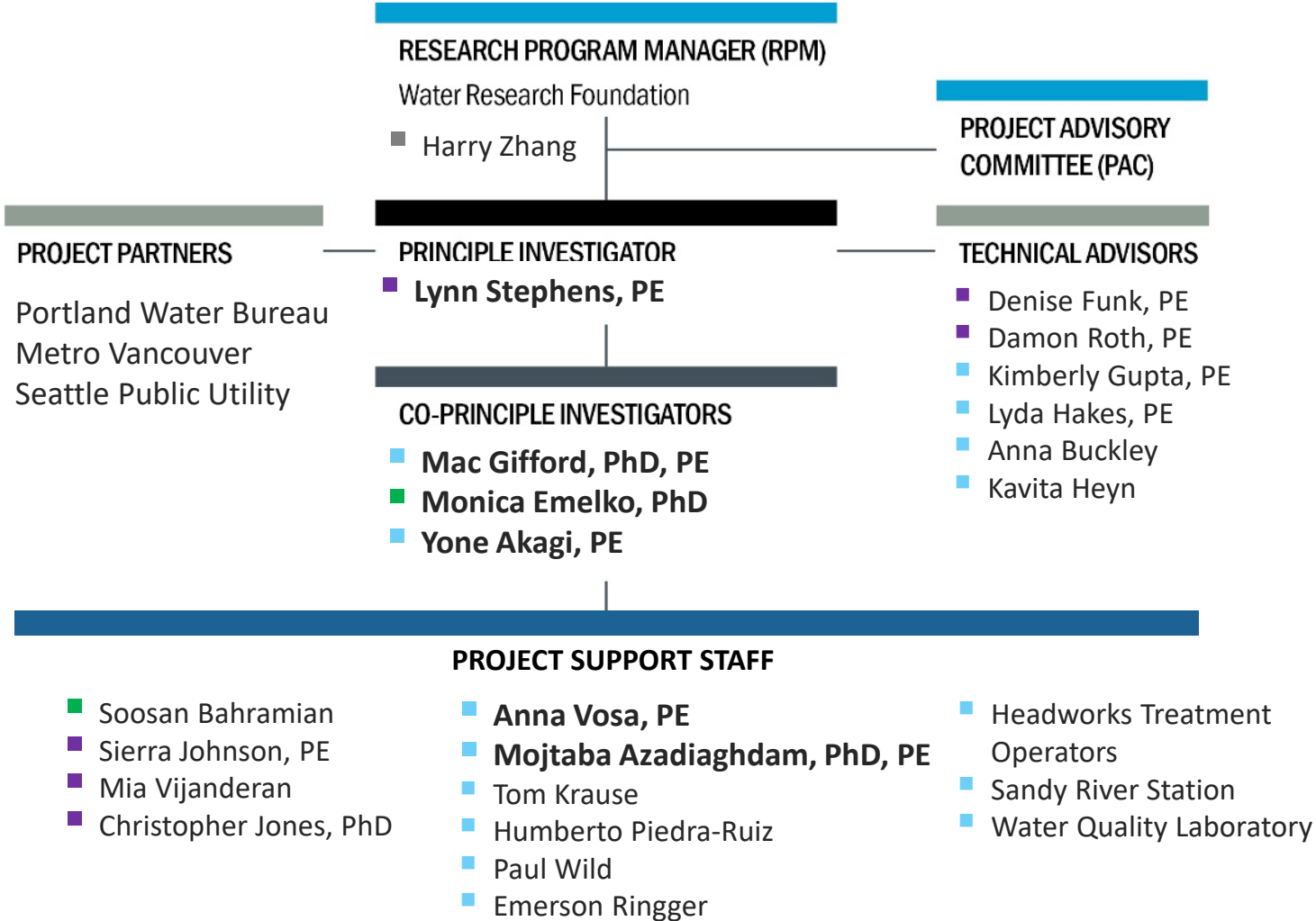
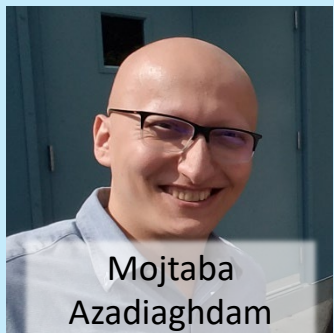
Mac Gifford, PhD, PE

Portland Water Bureau

May 8, 2025



WRF 5168 Team



Agenda

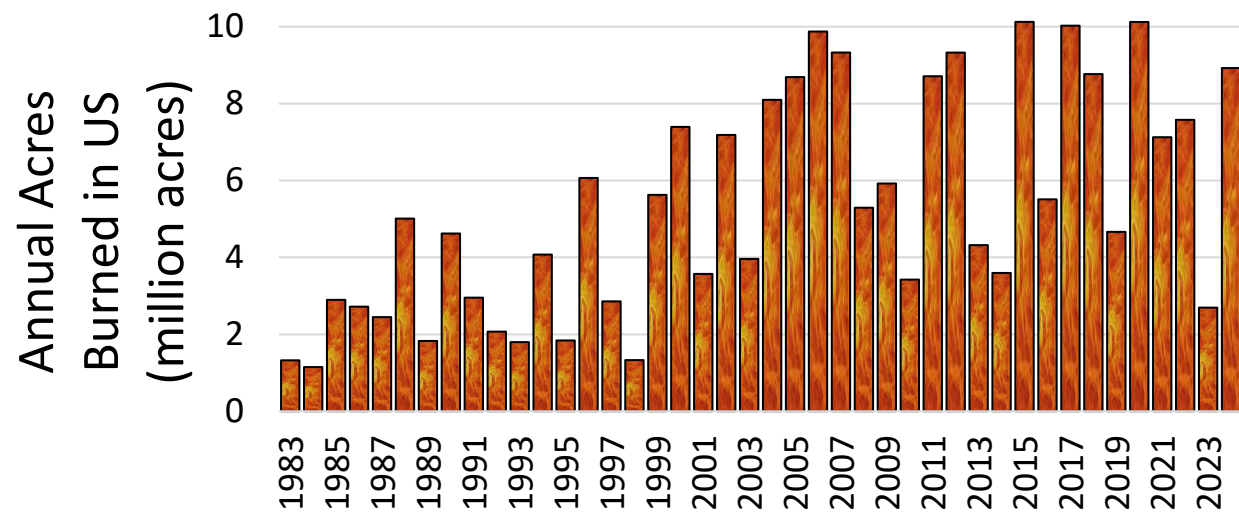
- Drivers for Studying Treatability After Wildfire
- Wildfire Ash Spiking
- Pilot Treatment
- Oxidation
- Coagulation
- Filtration
- Treatment Frameworks





Drivers for Studying Wildfire

Wildfire is more prevalent...



...even in places not historically at risk...



...including the Pacific Northwest.



Potential Water Quality Impacts

- **Changes to watersheds**
 - Increased runoff and erosion
 - Increased sediment loading
 - Increased nutrients
 - Increased algae, algal blooms, taste & odor
- **Changes to water quality**
 - Increases in pH and alkalinity
 - Increased turbidity
 - Increased metals
 - Increased organics with higher humic content
- **Challenges to treatability**
 - Increased chemical demand for coagulation and oxidation
 - Reduced filter efficiency
 - Increased solids loading
- **Challenges to distribution system**
 - Contamination from fire suppression or building materials
 - Increased disinfection byproducts



Wildfire Resilience Planning



Pre-Event Preparation

Watershed Management

Fire Mitigation

- Prevention
- Detection
- Preparation
- Suppression



Emergency Response

Collaboration

Mutual Aid Agreements

Secondary Supply

Public Outreach



Post-Fire Recovery

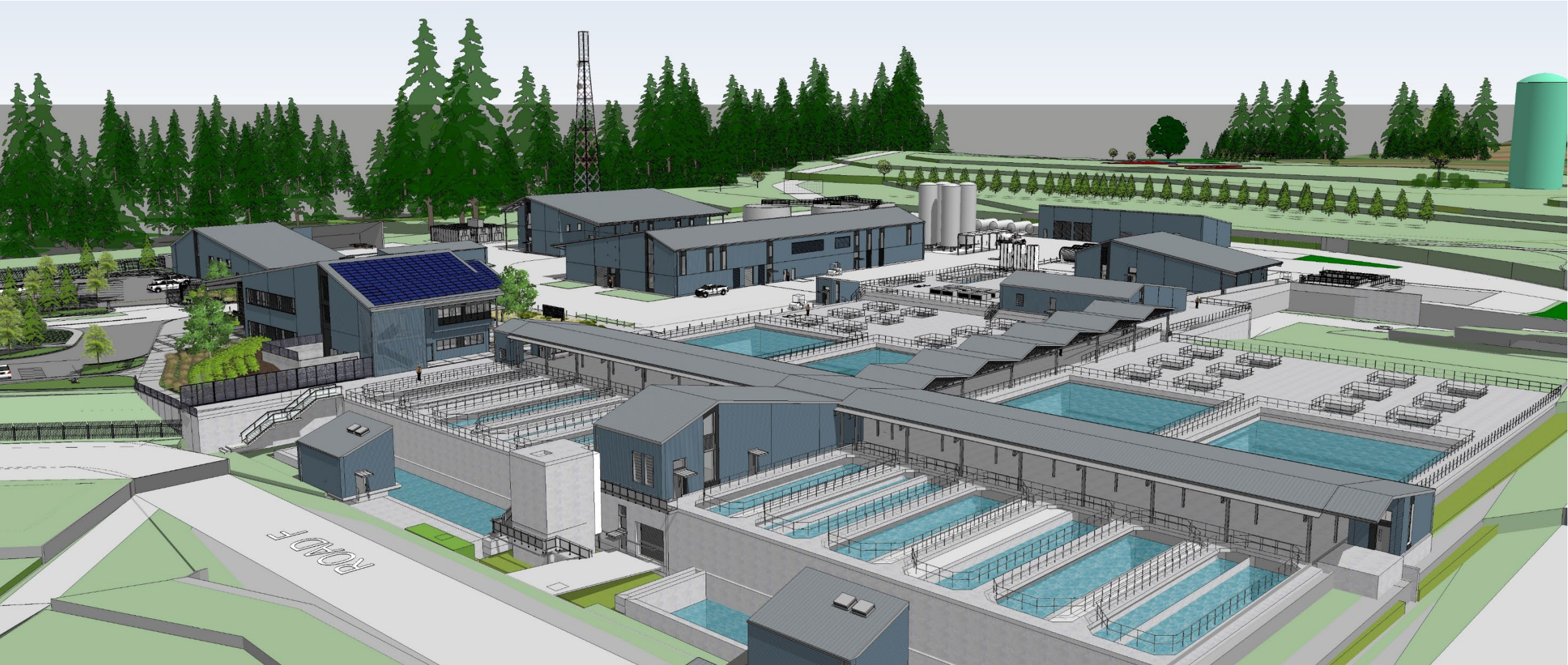
Forest Restoration

Water Treatment



About 1 million customers including 19 consecutive systems in Portland, Oregon

Filtration by 2027 to improve treatment resilience



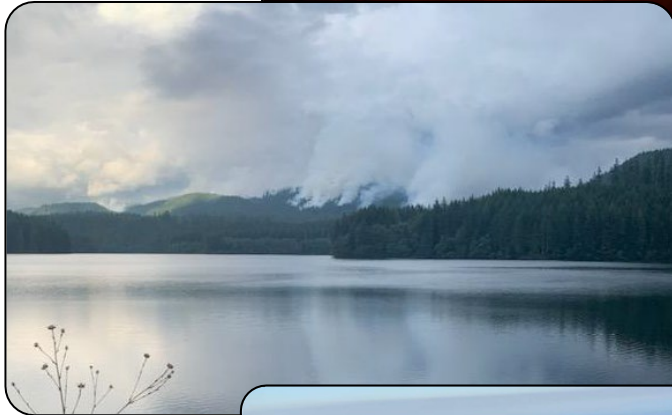
Learn more at portland.gov/bullrunprojects



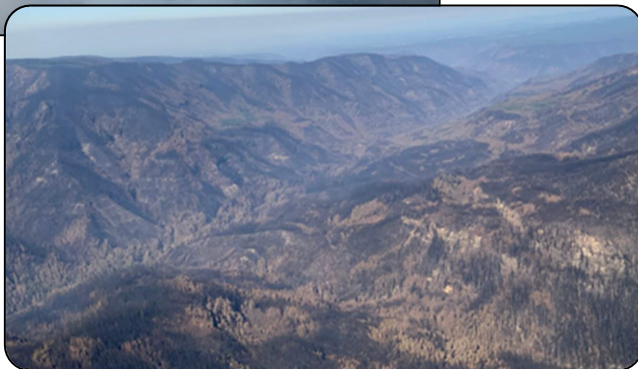
2022 Minnekhada Park Fire
Vancouver, BC
35 ac



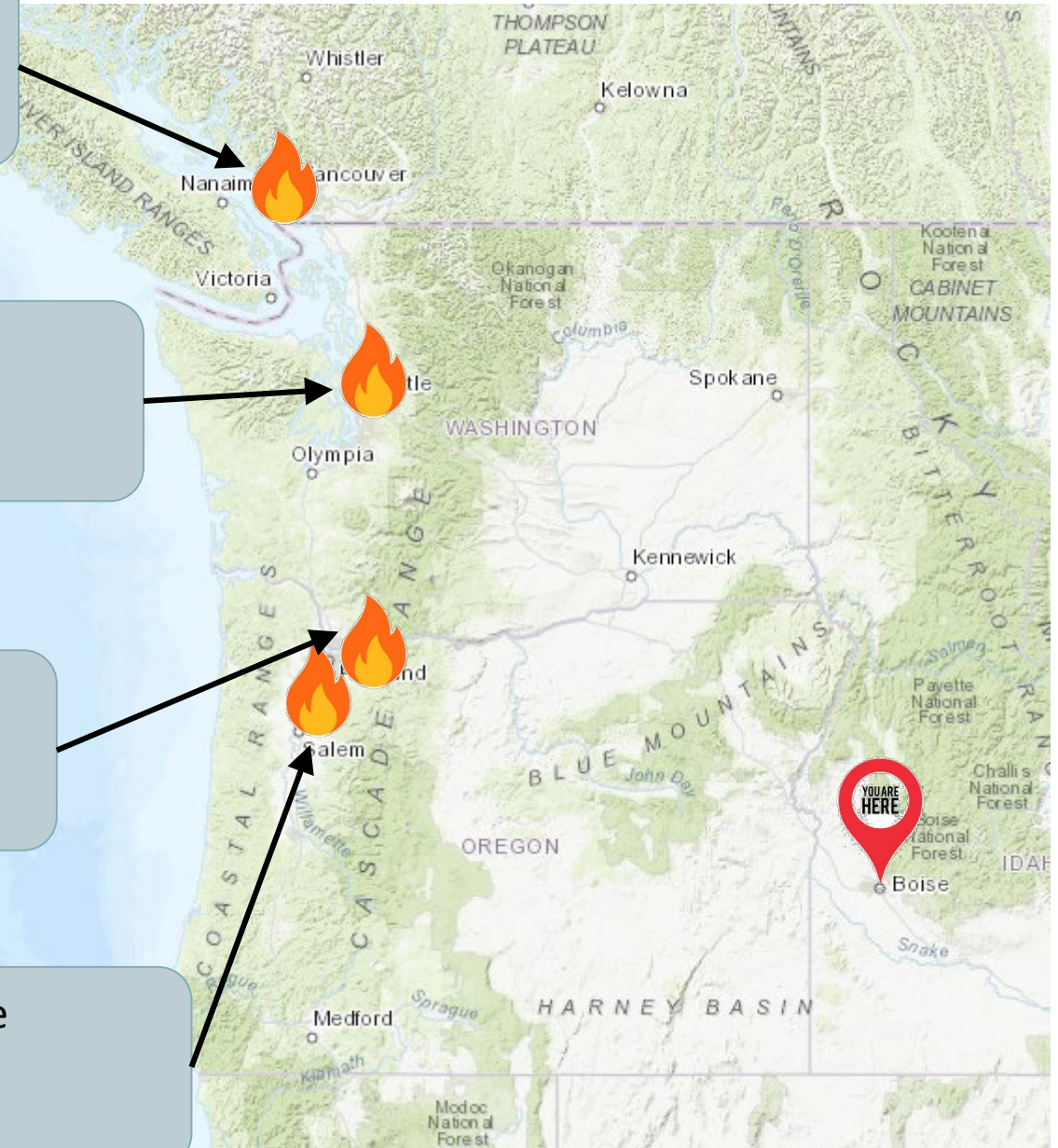
2022 Bolt Creek Fire
Seattle, WA
14,000 ac



2023 Camp Creek Fire
Bull Run Watershed, OR
2,050 ac



2020 Riverside Fire
Estacada, OR
140,000 ac

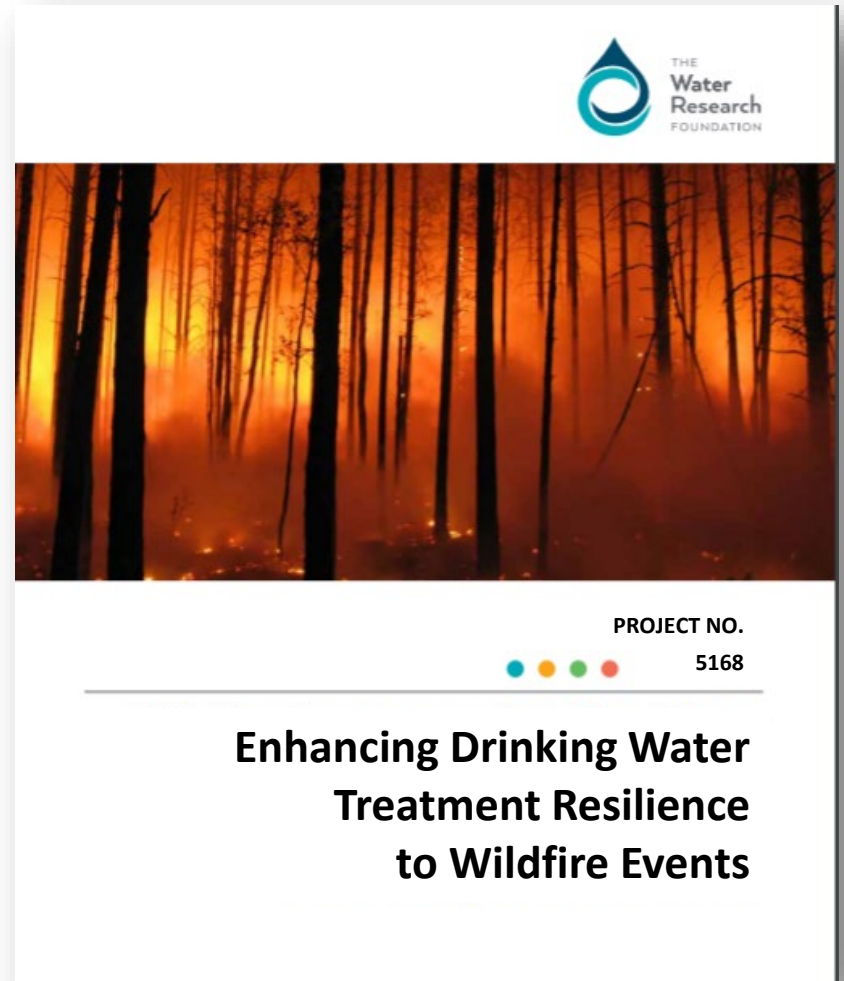


Ash Harvesting Riverside, Bolt Creek, Minnekhada Park Fires



WRF 5168 Study Objectives

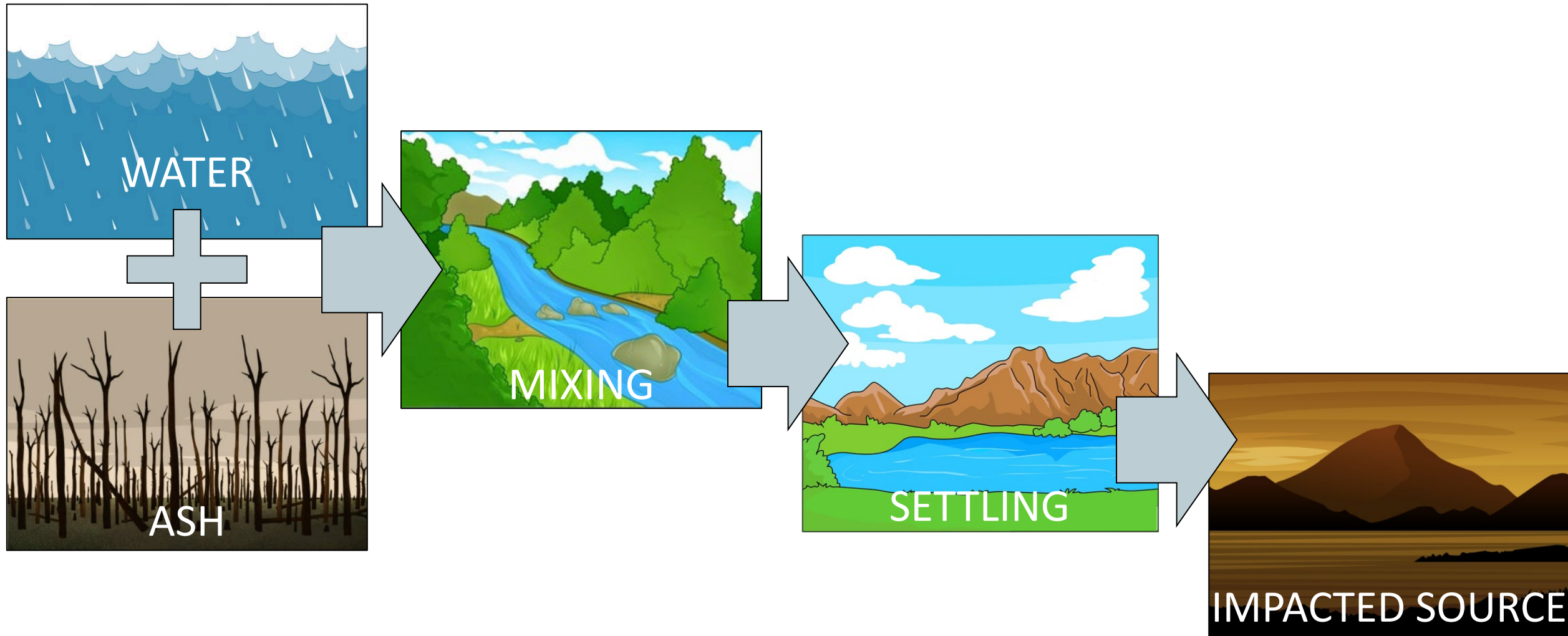
- Learn **operational treatment insights** on responding to degraded raw water quality like those that could happen after a wildfire.
- **Pilot-scale and side-by-side comparisons** of treatment strategies, specifically comparing conventional treatment with pre-ozonation and biofiltration compared to conventional treatment with pre-chlorination and filtration.
- **Demonstrate** how the designed treatment processes provide resilience to continue to meet water quality goals through a period of degraded source water quality representative of those that follow a wildfire.
- Provide design and operational **recommendations** that can be made in treatment and monitoring.



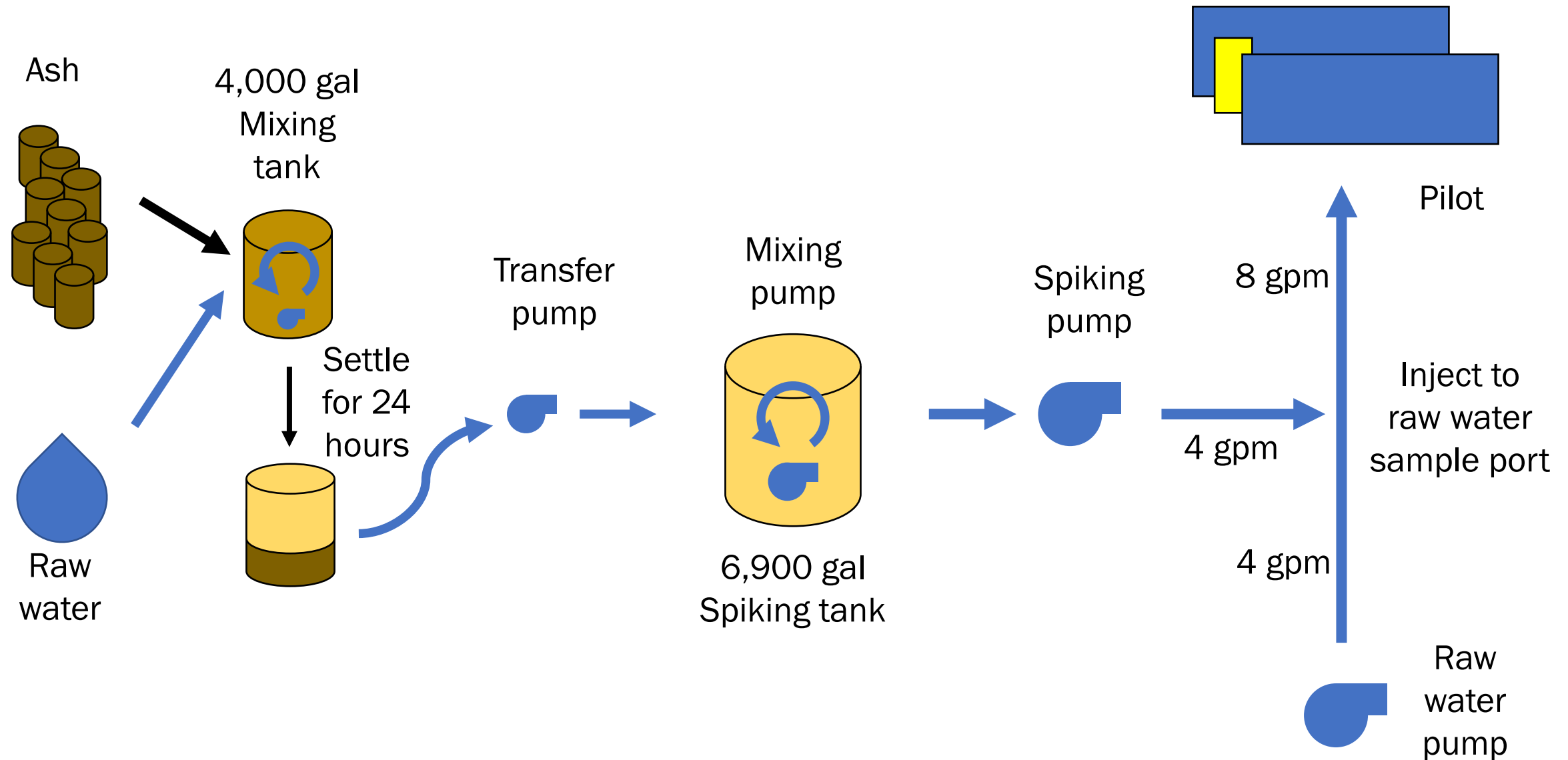
Wildfire Ash Spiking



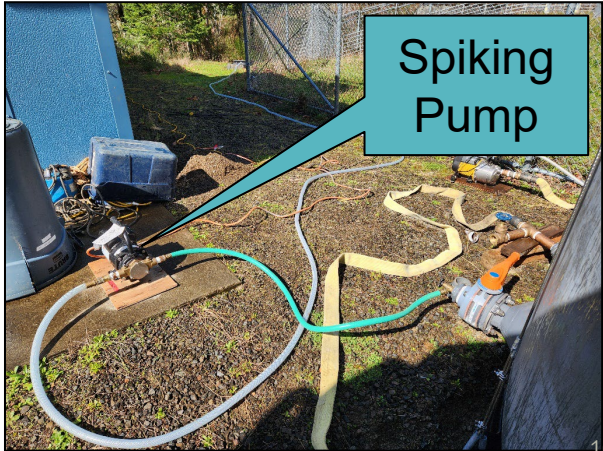
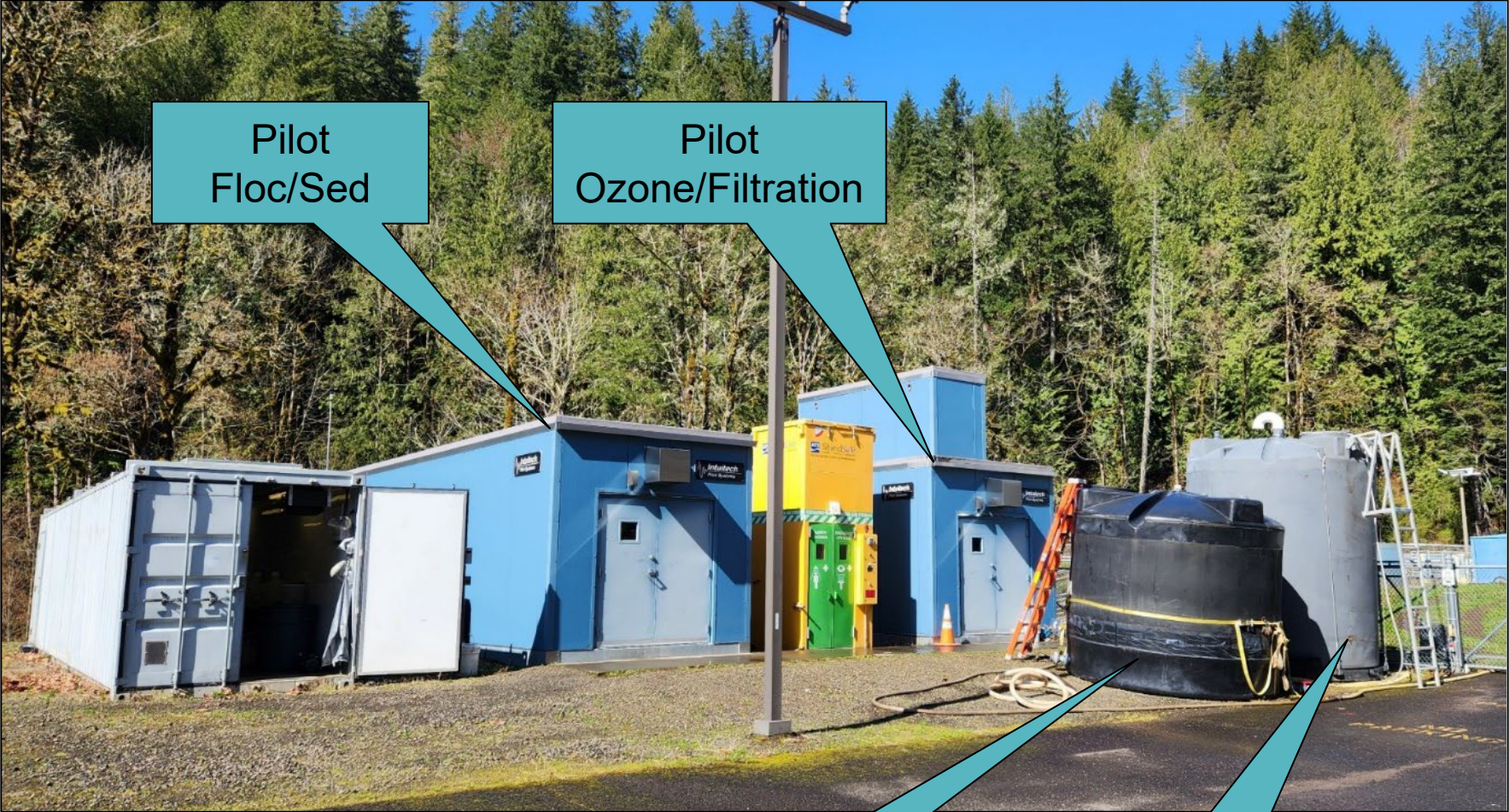
Wildfire impacts in natural systems



Ash slurry creation mimics natural process



Spiking Equipment



Ash & Water



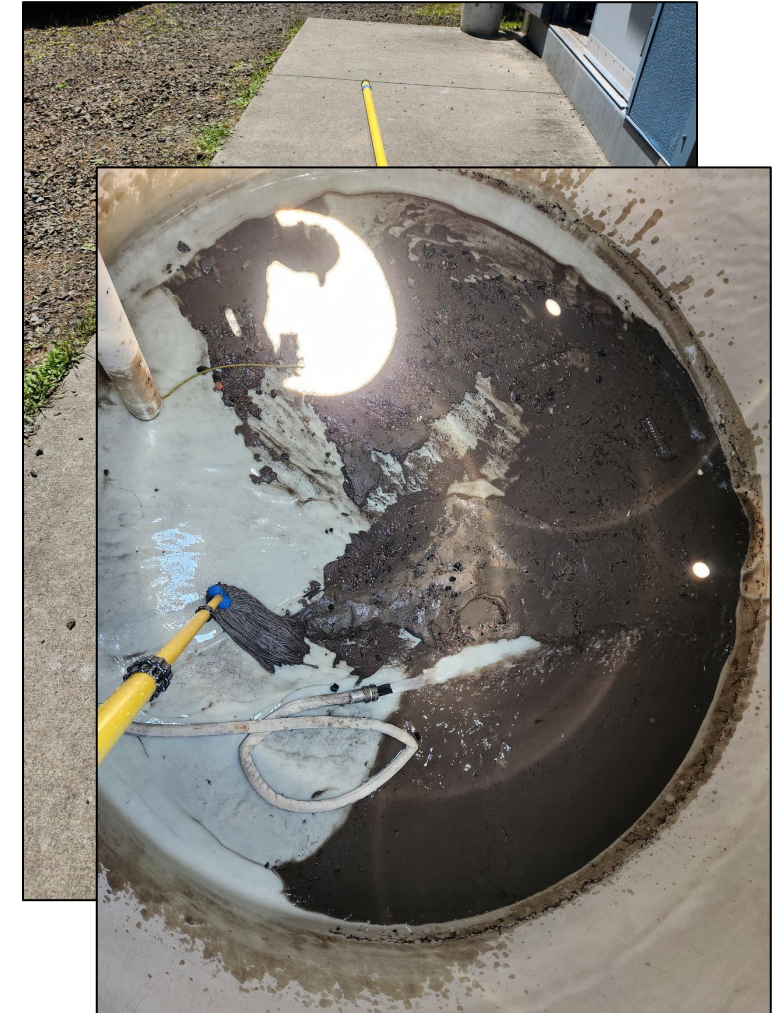
Mixing & Settling



SO. MUCH. MUD.



Gimmicks and Gadgets

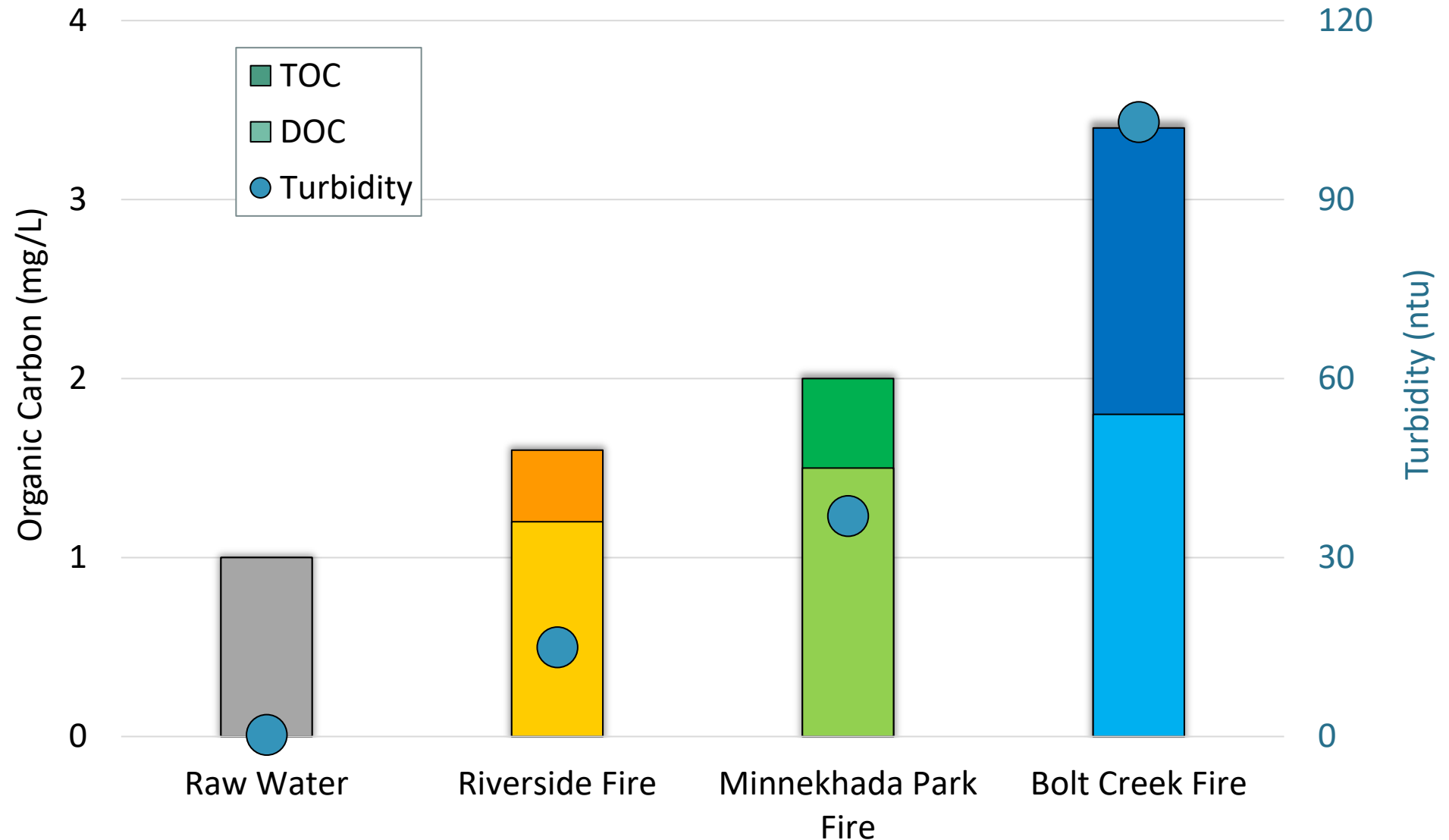


Successfully created ash-spiked water representing meaningful post-wildfire scenarios to test treatment

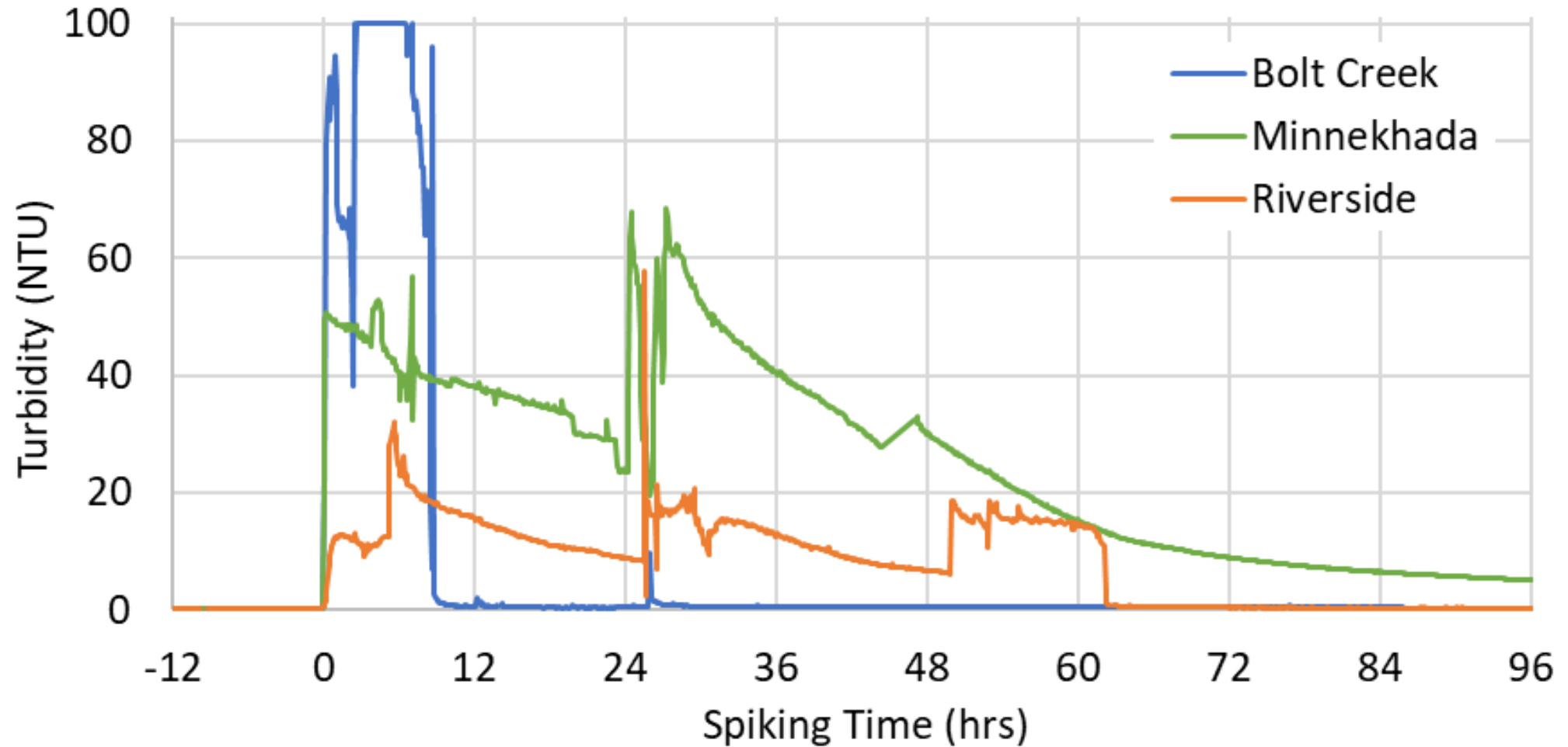
Round	Ash Used	Mixing Batches	Mixing Time	Settling Time	Volume of Spiked Water	Spiking Duration
Riverside	45 Buckets 700 Pounds	3	3 Days	3 hours	10,500 Gallons	60 Hours
Minnekhada	21 Buckets 325 Pounds	2	1.5 Days	8 Hours	8,000 Gallons	48 Hours
Bolt Creek	23 Buckets 235 Pounds	2	6 Days	2 hours	3,000 Gallons	10 Hours



Ash spiking creates meaningful scenarios that treatment systems must be ready to handle



Pilot Inlet Turbidity



	Location	Unspiked Raw Water	Riverside Spiked	Minnehada Spiked	Bolt Creek Spiked
Water Quality	Turbidity (NTU)	0.3	15	37	103
	Temperature (°C)	6	11	9	19
	pH	7.0		8.6	8.5
	Alkalinity (mg/L as CaCO ₃)	7		24	86
	Total Particle Counts (#/mL)	1,460		26,500	29,800
	Total Suspended Solids (mg/L)	<0.5		33	123
Organics	TOC (mg/L)	1.0	1.6	2.0	3.4
	DOC (mg/L)	1.0	1.2	1.5	1.8
	Apparent Color (Pt-Co)	10	200	426	1,179
	True Color (Pt-Co)	6		8	11
	UV ₂₅₄ (cm ⁻¹)	0.04		0.2	0.49
	Filtered UV ₂₅₄ (cm ⁻¹)	0.04		0.0	0.10
	SUVA (L/mg-m)	3.7	3.6	3.3	5.5
Metals & Nutrients	Total Aluminum (µg/L)	<50	1,020	2,230	8,140
	Total Arsenic (µg/L)		0.5	4.2	22.5
	Total Iron (µg/L)		572	1,365	2,595
	Total Manganese (µg/L)		271	435	429
	Total Phosphorus (mg/L)	<0.01	0.25	1.01	2.16
	Total Nitrogen (mg/L)	0.4	0.4	0.4	0.9

New SWTR
TOC removal
requirement

Exceed
secondary
MCLs

Exceeds
primary MCL

Changes lake
limnology

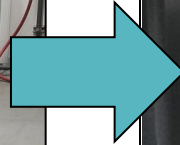


Pilot Treatment

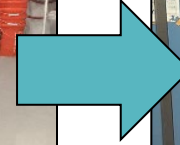
What the pilot includes



Oxidation

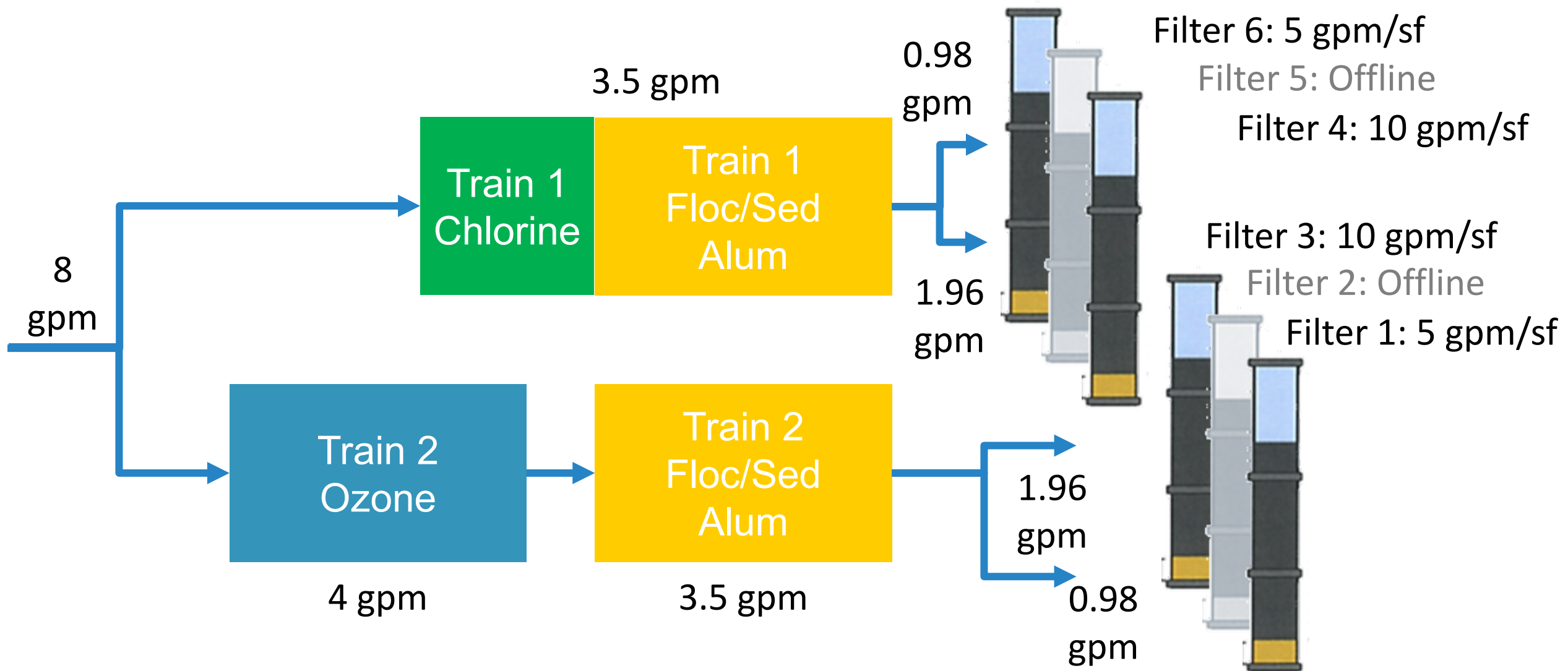


Flocculation/
Sedimentation



Filtration

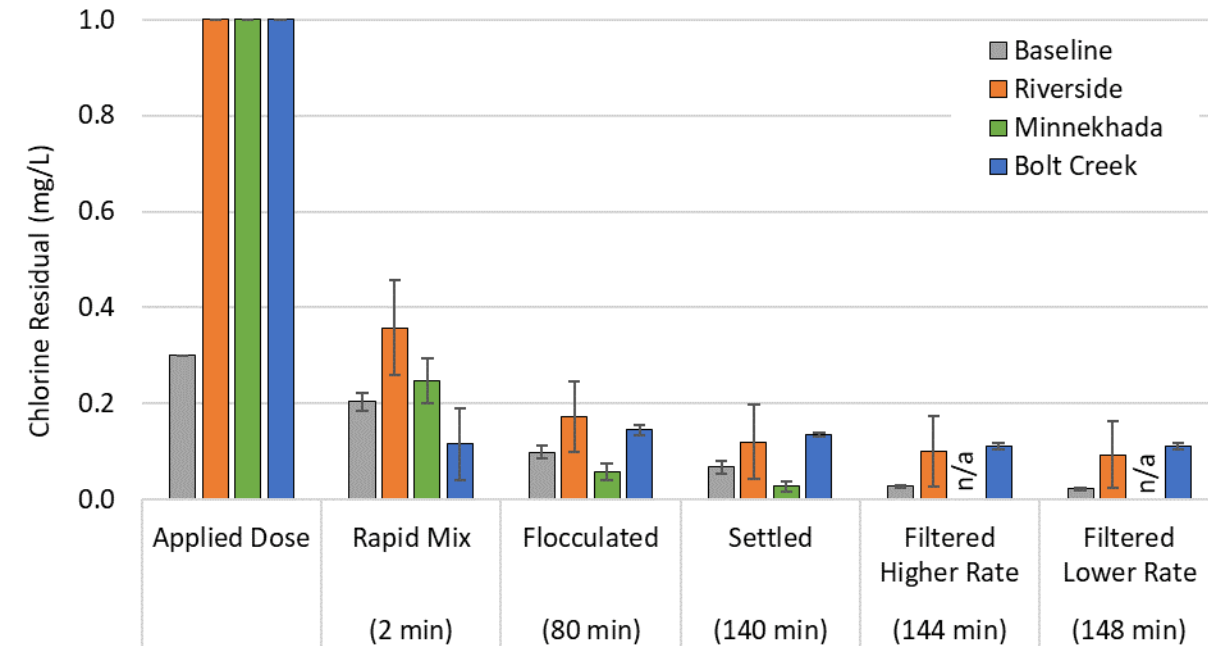
Process setup compares pre-oxidants and filtration rates



Pre-oxidation

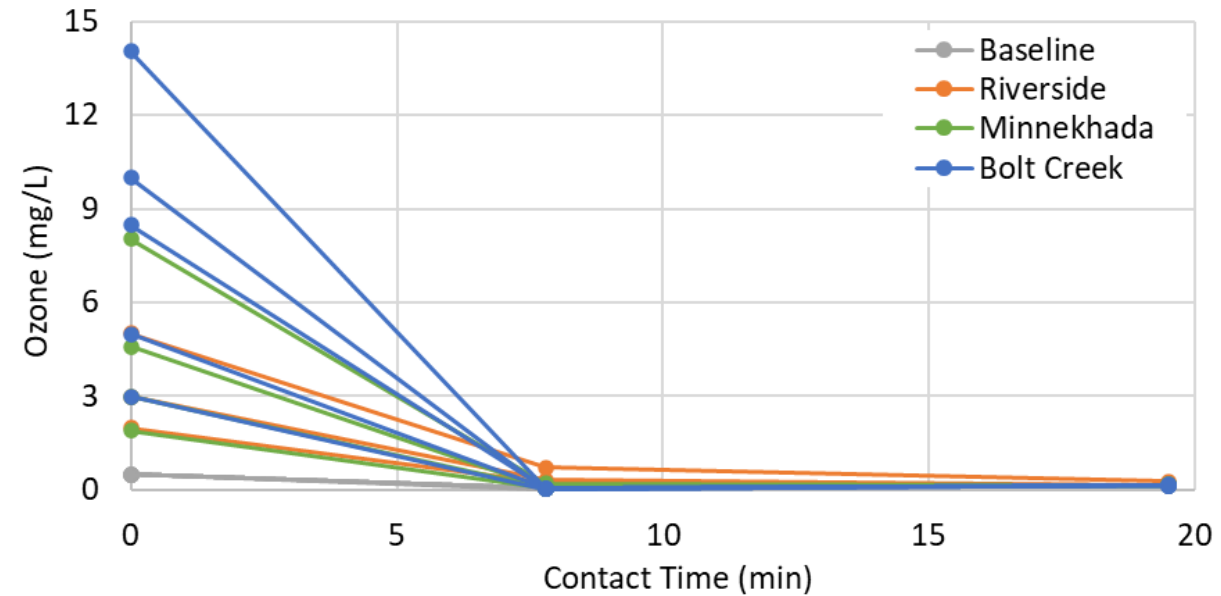


Pre-chlorine decay



- Most chlorine residual is consumed through flocculation and sedimentation.

Pre-ozone decay



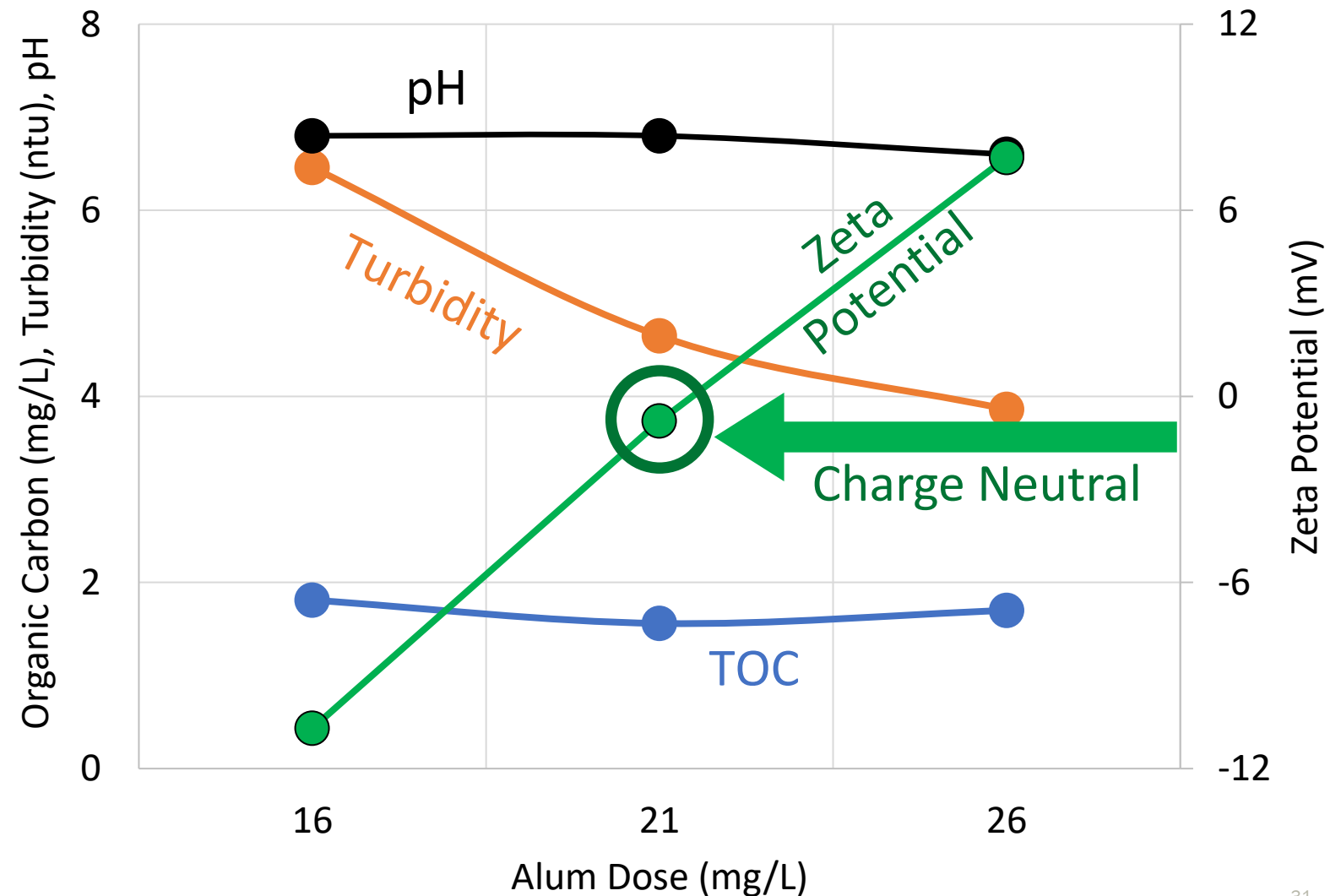
- Ozone completely consumed within 8 minutes of contact time.

Oxidant demand does not need to be fully met to produce downstream treatment benefits.



Coagulation

Use zeta-potential to quickly find correct coagulant dose in rapidly changing situations



Coagulation approach tailed to scenario

Coagulation

Add coagulant until zeta potential in rapid mix:
-3 mV – +1 mV



pH / Alkalinity

Add soda ash until settled water
pH > 6.5

Add acid until settled water
pH < 7.4



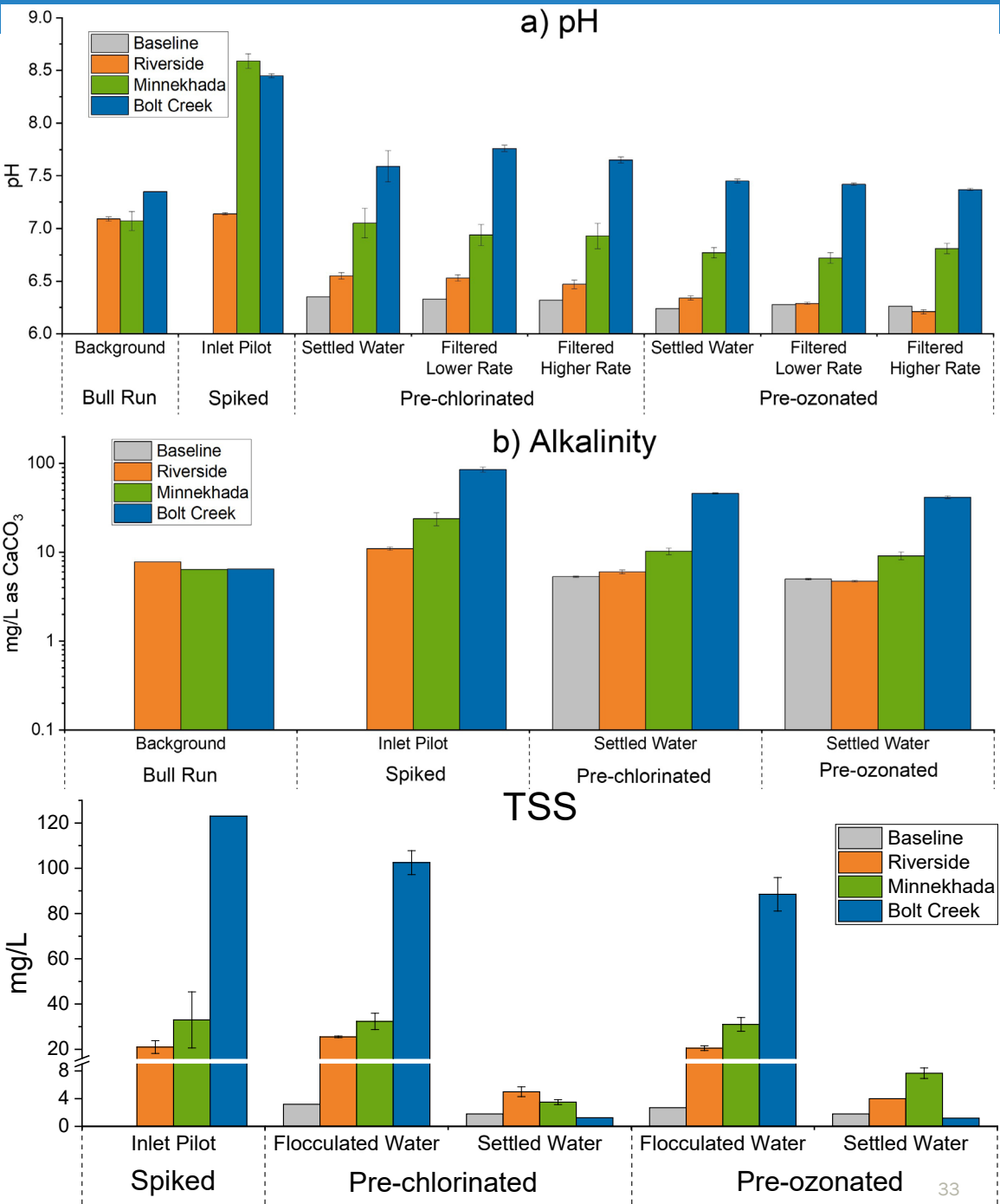
High Solids,
High Turbidity, or
Short Filter Runs

Add coagulant aid,
reduce coagulant:
0.3 mg/L polymer
replaces 1mg/L alum



Coagulation Results

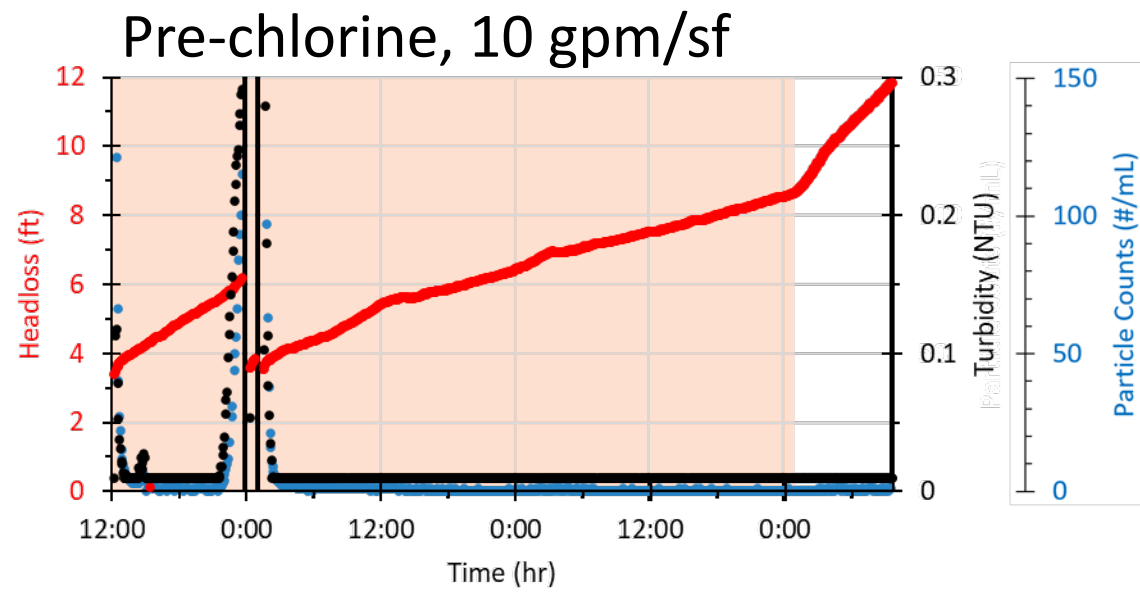
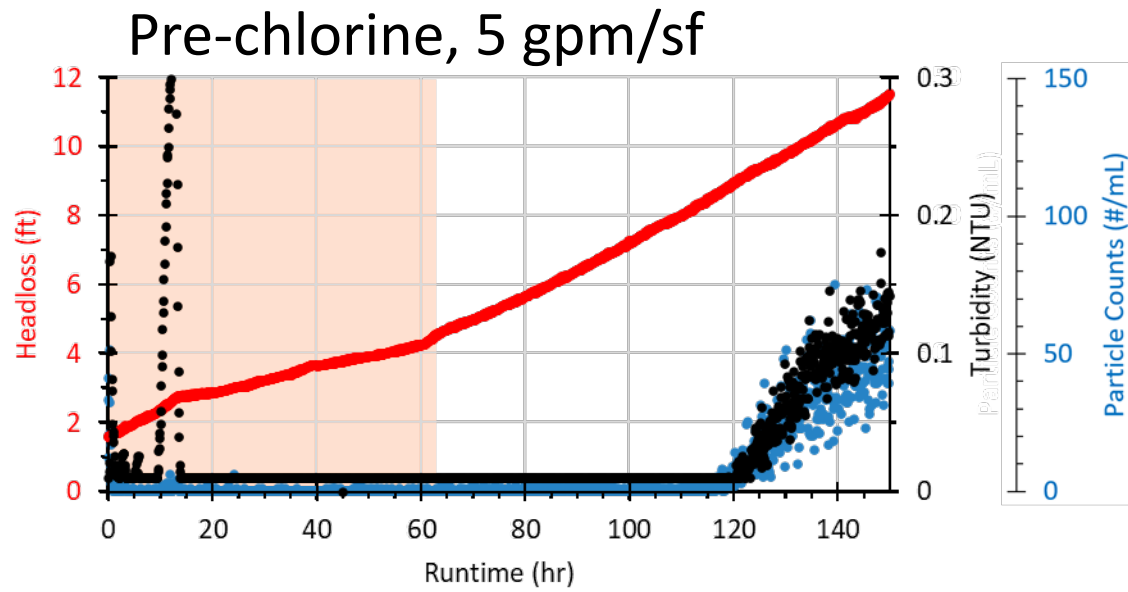
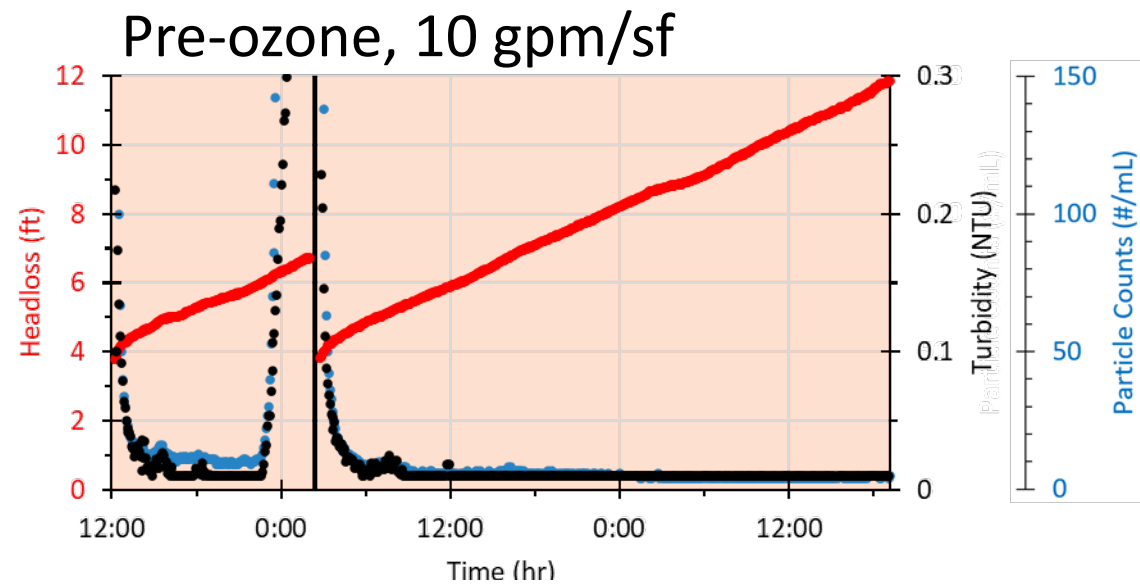
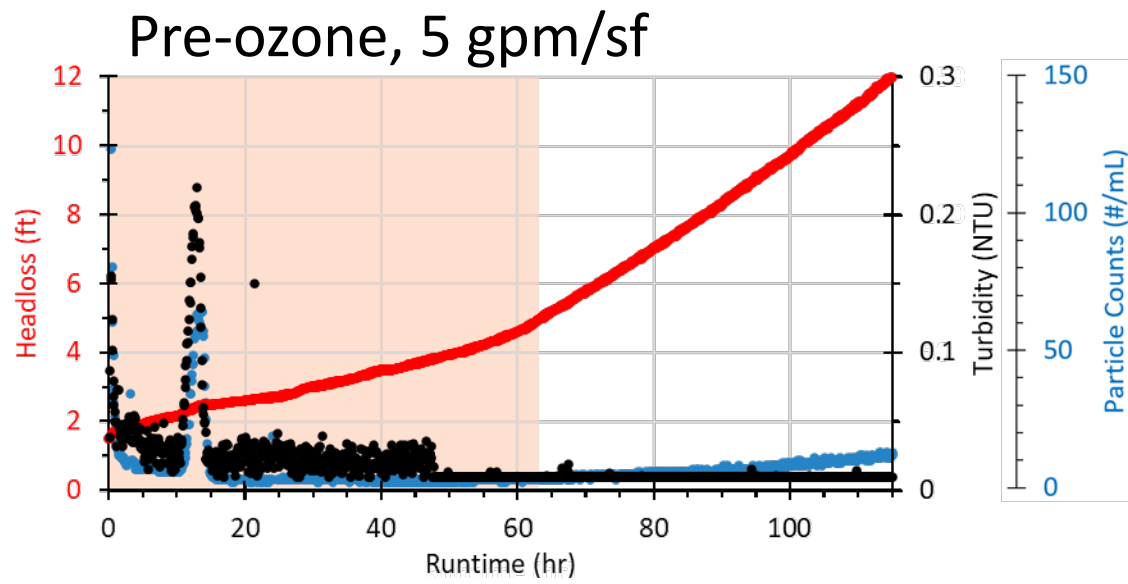
Scenario	Alum Dose (mg/L)	HCl Dose (mg/L)	Floc Aid Dose (mg/L)
Baseline	6	0	0
Riverside	15	0	0
Minnehada	19	3	0
Bolt Creek	15	25	0.025



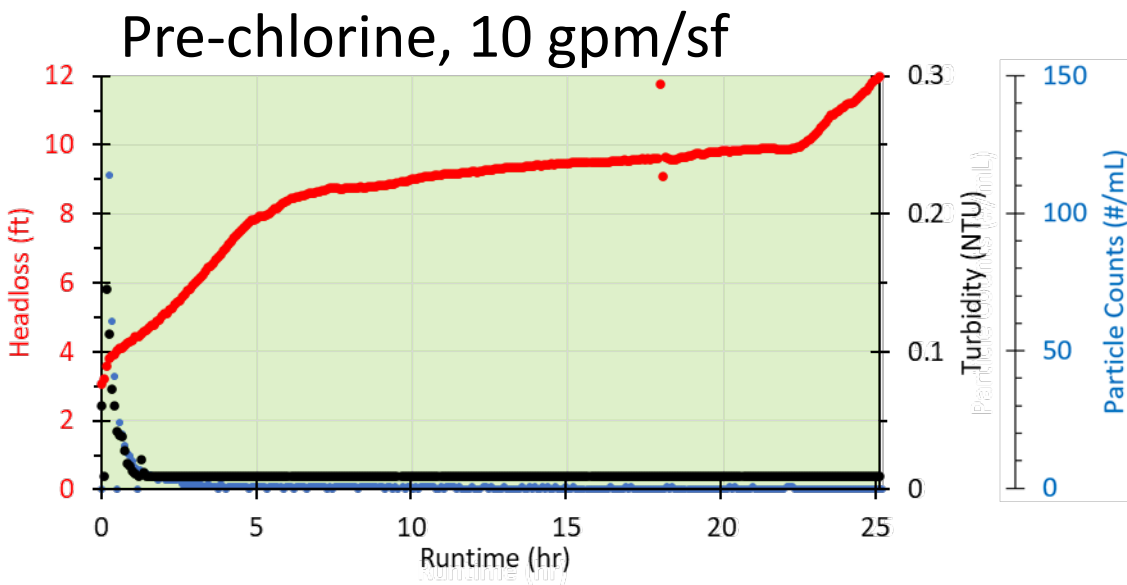
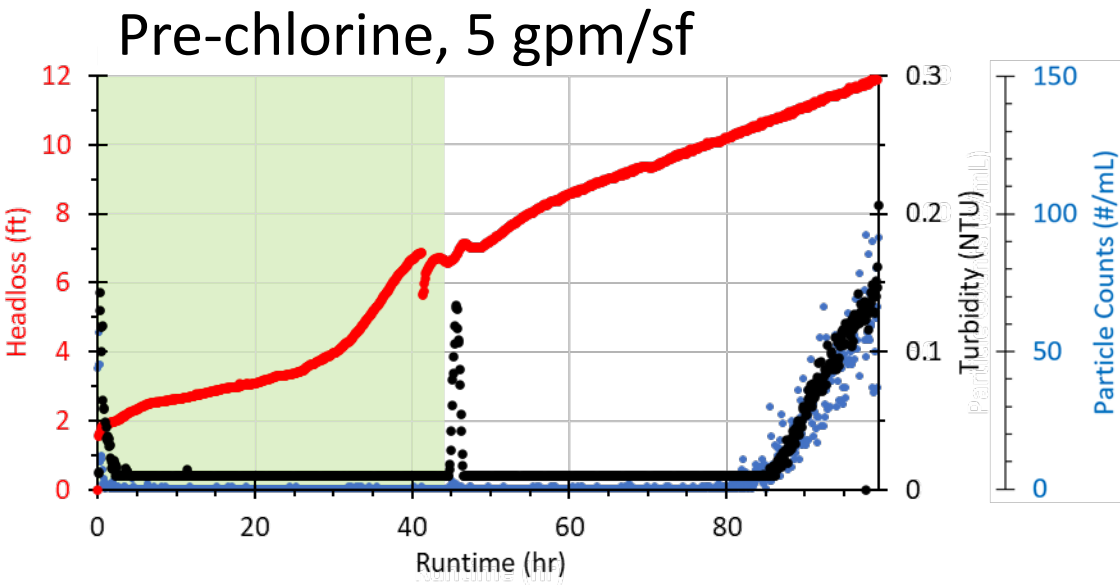
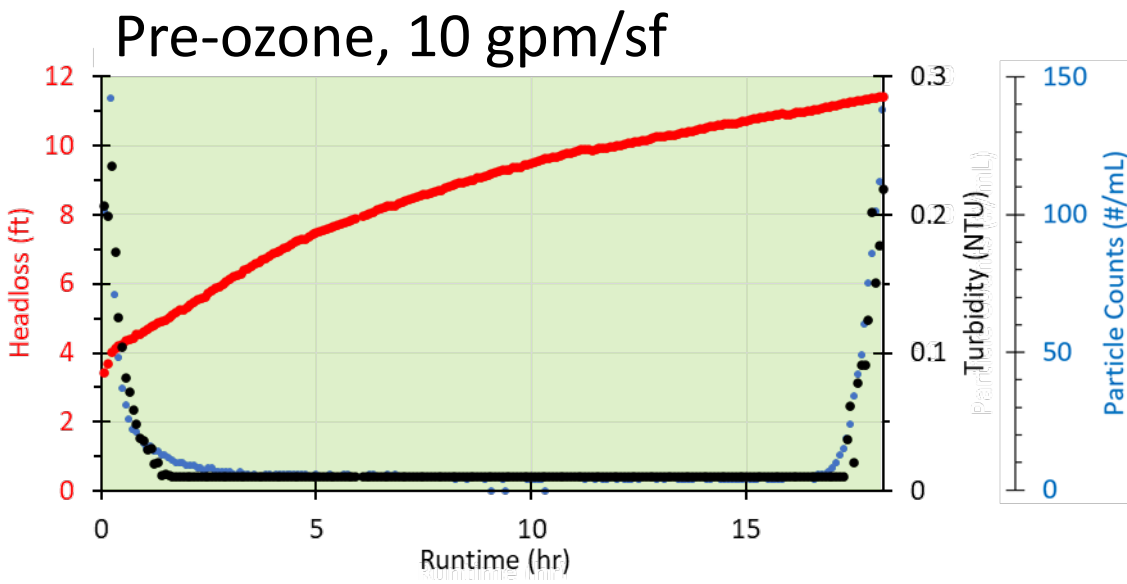
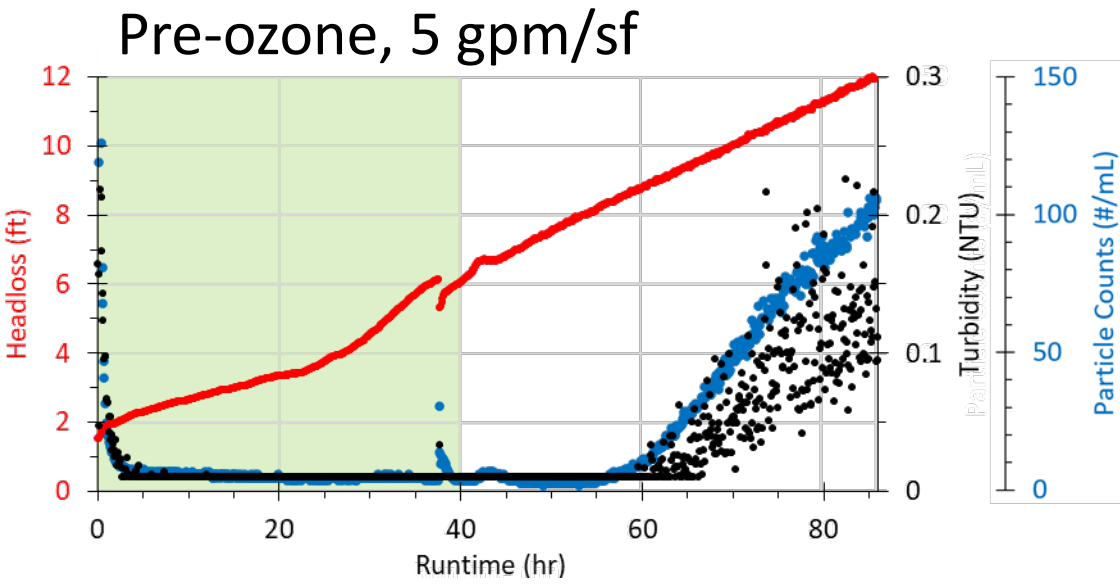


Filtration

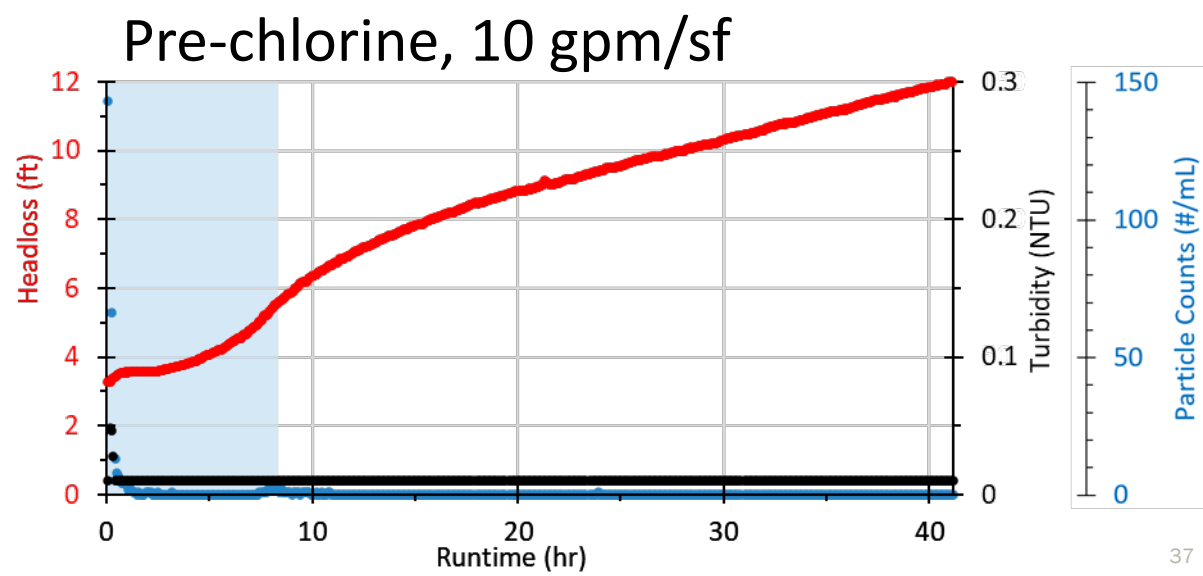
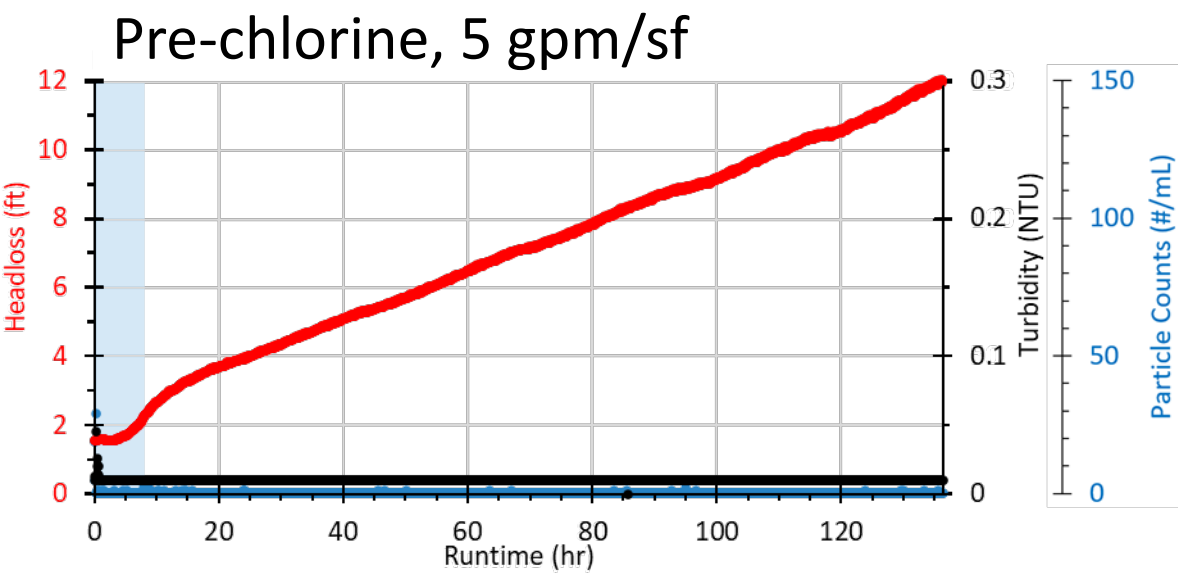
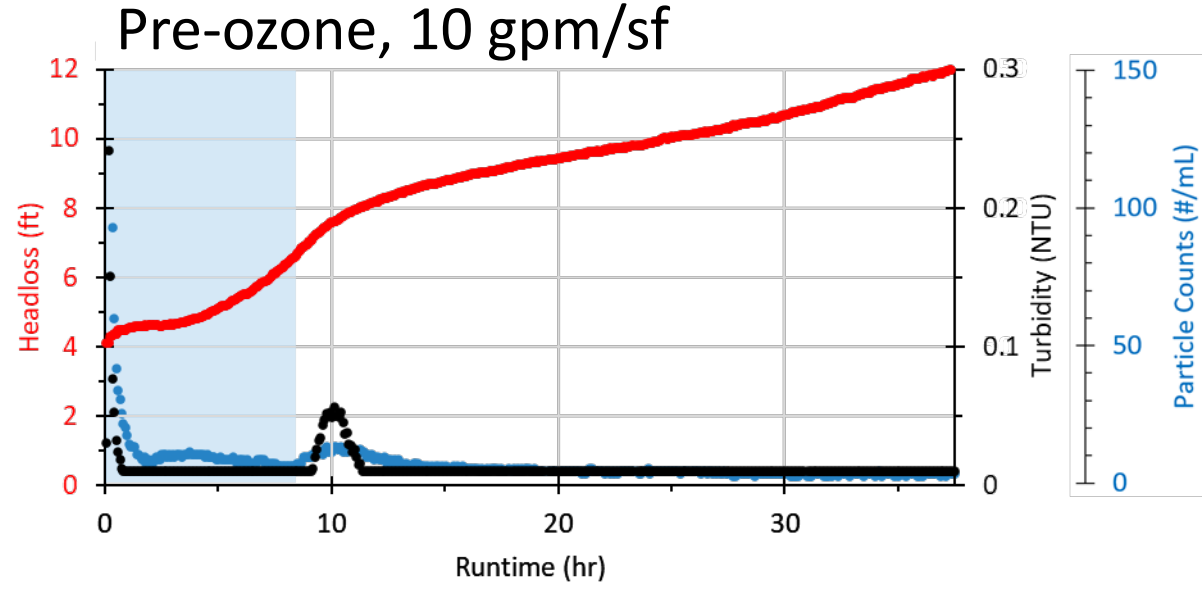
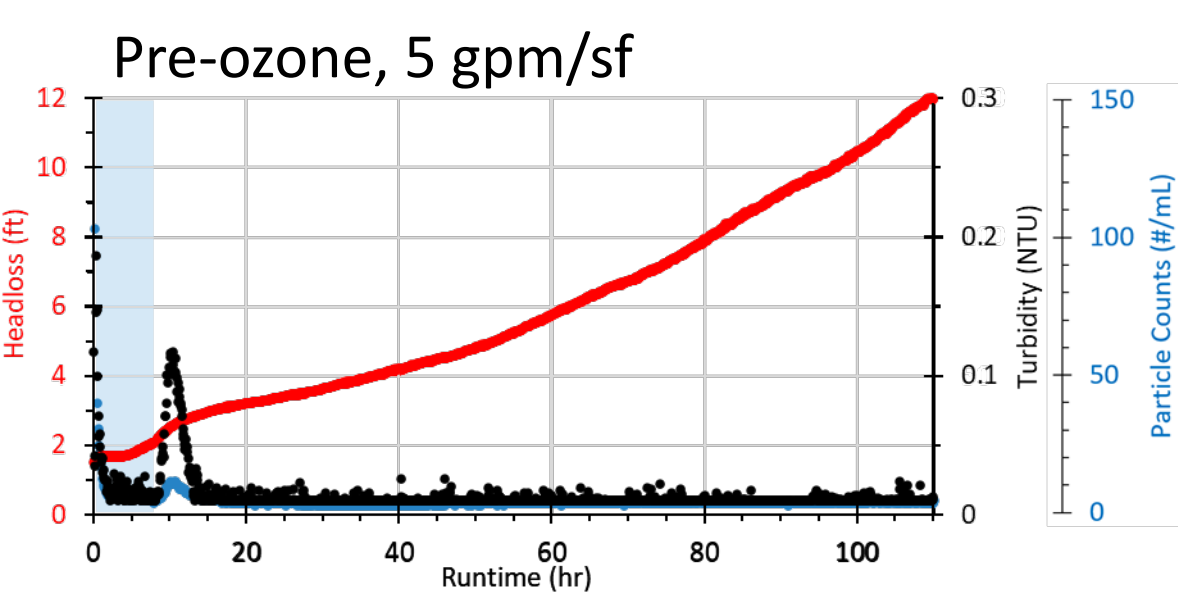
Riverside Filter Runs



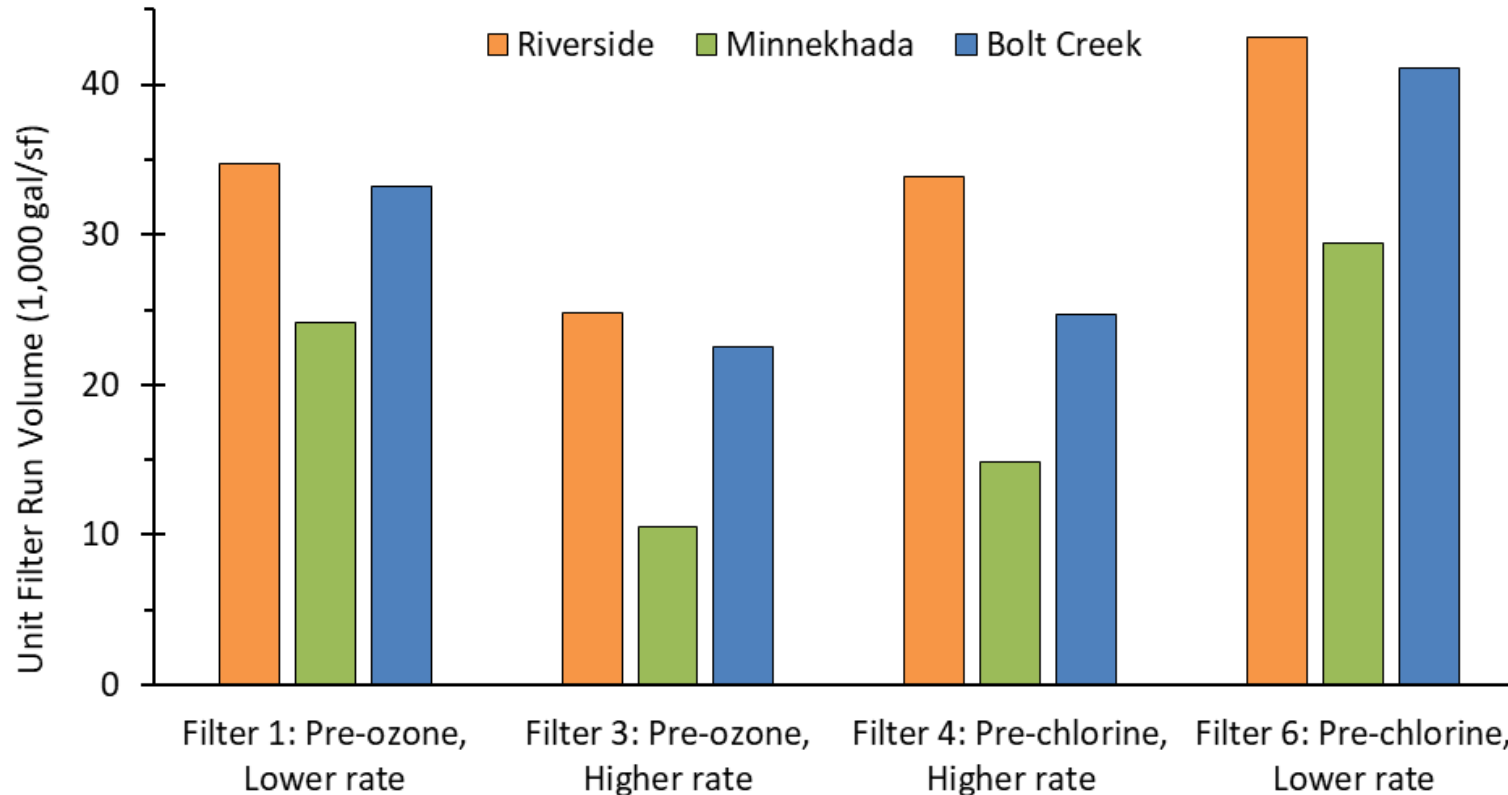
Minnekhada Filter Runs



Bolt Creek Filter Runs



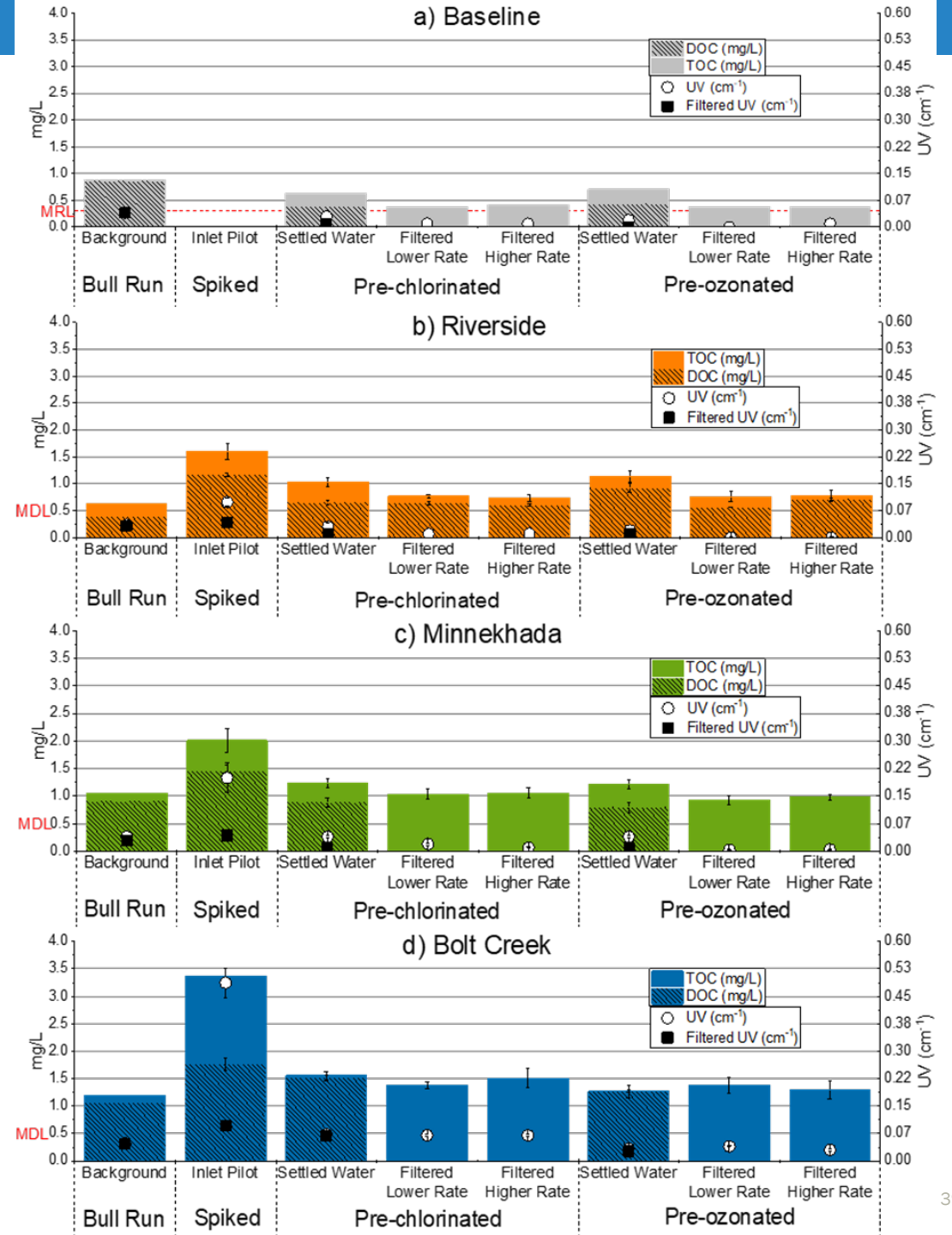
Compare Filtration Productivity



- Filters were 15-50% less productive during spiking compared to baseline conditions.
- Lower rate filters were 30-130% more productive than higher rate filters.
- Pre-chlorine filters were 10-40% more productive than the pre-ozone filters.

Organics

- Raw water organic carbon was primarily dissolved. Spiking increased both dissolved and particulate organic carbon.
- Treatment removed 30%-65% of organic carbon during spiking rounds, meeting SWTR regulatory requirements.
- After coagulation and settling, 15-30% of the organic carbon became particulate. Settling removed 10-25% of organic carbon.
- Pre-ozone filters removed nearly all particulate organic carbon and up to 30% dissolved organic carbon.
- Pre-chlorine filters removed nearly all particulate organic carbon and no dissolved organic carbon.



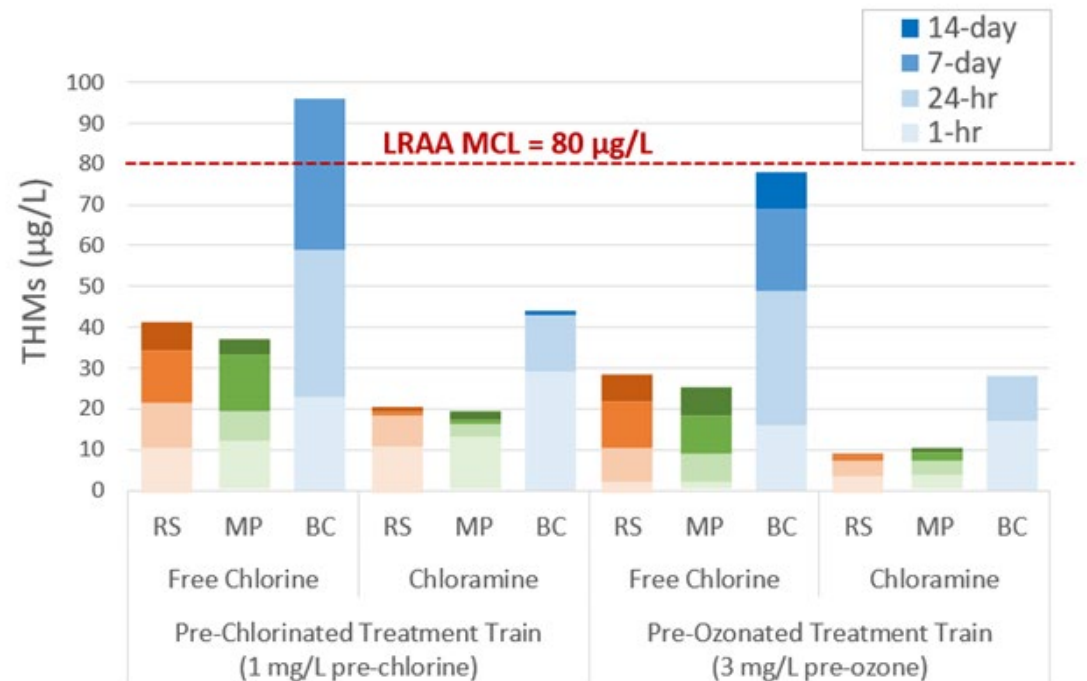
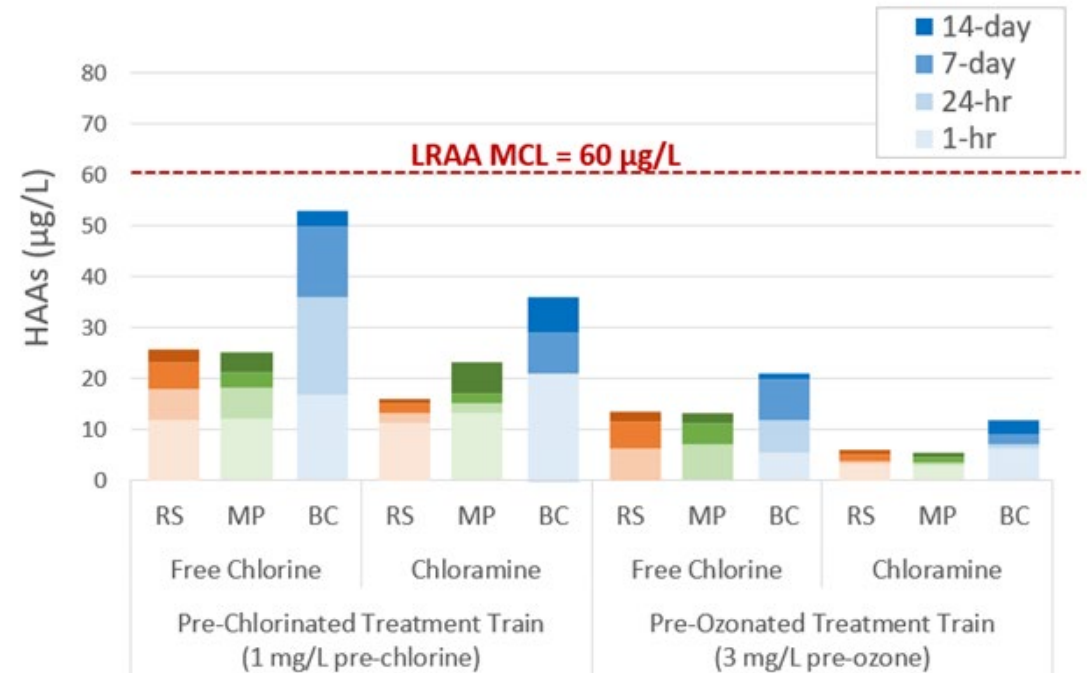
UFC DBPs

- Uniform Formation Conditions
 - Free-chlorine
 - 1 mg/L residual
 - 24 hours hold time
- Ash challenges coagulation pH and ability to remove DBP precursors
- Pre-chlorine train removed 50-60% of UFC-DBPs
- Pre-ozone train removed 75-85% of UFC-DBPs.
- No impact from filtration rate



SDS DBPs

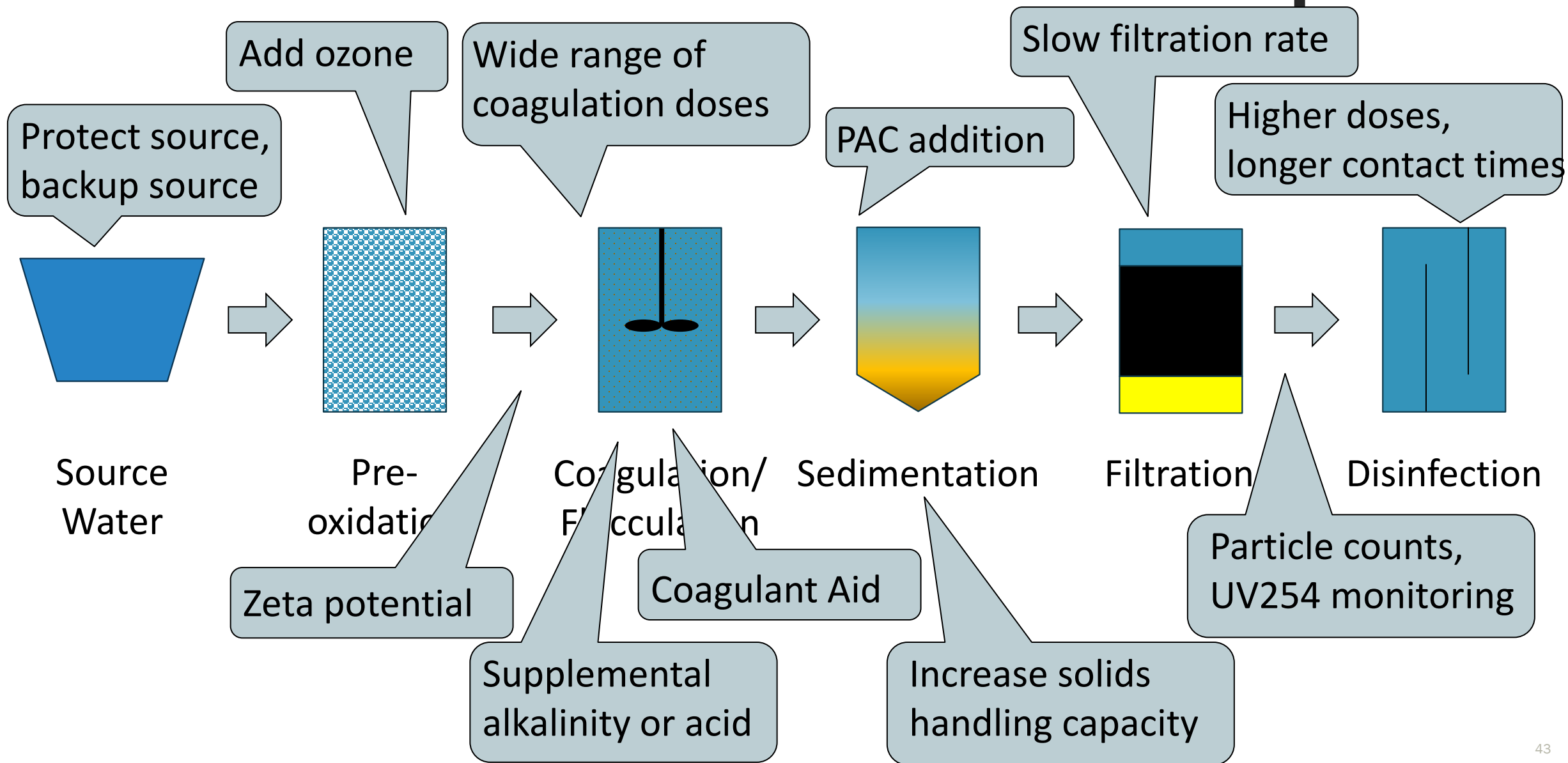
- Simulated Distribution System:
 - Realistic hold times up to 14 days
 - Compare 1 mg/L free chlorine and 3 mg/L combined chloramine residual
- SDS-DBPs formation rate
 - 30-50% within 1 hour
 - 60-80% form within 1 day
 - 90-100% form within 1 week.
- Pre-ozone train has 35-75% lower SDS-DBPs than the pre-chlorine train.
- Chloramine has 35-65% lower SDS-DBPs than free chlorine.











Treatment Resilience

Resilient Surface Water Treatment Options



Operational Tradeoffs

Compared to coagulating with alum only, if the challenge is ...	Then will it help to respond by... ?							
	Under-dose coagulant	Over-dose coagulant	Adding alkalinity	Adding coagulant aid	Switch from alum to ferric	Switch from alum to PACl	Start pre-chlorine	Start pre-ozone
Low settled water pH	Yes	No	Yes		No	Yes	No	No
Depleted alkalinity	Yes	No		Yes	No	Yes	-	-
Excessive solids production	Yes	No	No		No	Yes	No	No
Insufficient turbidity removal	No	Yes		Yes	-	-	Yes	Yes
Insufficient TOC removal	No	-	Yes	No		-	Yes	Yes
DBP formation	No	-	-	No	Yes	-	No	

Comparing Oxidants

Pre-chlorine treatment train

- Kept filter effluent particle counts below 15 #/mL
- Coagulant dose was 10%-15% lower than pre-ozone
- Filter runs were 10%-40% longer than pre-ozone

Pre-ozone treatment train

- Kept filter effluent particle counts below 15 #/mL
- Organic carbon was 10%-20% lower than pre-chlorine
- DBPs were 35%-75% lower than pre-chlorine
- Best rated taste & odor

Comparing Filtration Rates

10 gpm/sf filtration rate

- Able to meet filter effluent turbidity and particle count goals with UFRVs exceeding 10,000 gal/sf
- Responded more quickly to treatment adjustments.

5 gpm/sf filtration rate

- Able to meet filter effluent turbidity and particle count goals with UFRVs exceeding 10,000 gal/sf
- Increased filter productivity by 30%-130% compared to high rate filters.
- More resilient against process disruption.

Summary

- We all are susceptible to risk of drastic challenges from wildfire. Conventional treatment helps build resilience against difficult scenarios to continue to meet drinking water standards.
- Wildfire impacted water impacts treatment. Choice of coagulation approach brings tradeoffs for chemical demand, solids production, settled water pH, and organics removal.
- Reducing filtration rate from 10 gpm/sf to 5 gpm/sf increases resilience against process upsets, and increases filter run times and productivity.
- Pre-ozone further reduced regulated DBP formation, while pre-chlorine increased DBPs. Pre-chlorine increased filter run times and slightly decreased coagulant demand.



Learn More!

- Lynn Stephens: Utilization of Advanced Organics Characterization Methods to Understand Treatability to Wildfire Events
 - Thursday May 8th, 4:30pm, Room 120C
- Lyda Hakes: Even Greenfields get the Blues: Site Layout Challenges for the Bull Run Filtration Facility
 - Thursday May 8th, 4:30pm, Room 130
- Water Research Foundation 5168: Enhancing Drinking Water Treatment Resilience to Wildfire
 - Report finalized and will be published soon!
 - <https://www.waterrf.org/research/projects/enhancing-drinking-water-treatment-resilience-wildfire-events>



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Turjumaad iyo Fasiraad | Письмовий і усний переклад
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