

Long-term Resiliency of Salem's Geren Island WTF

PNWS AWWA Section Conference
April 27 2018

WATER
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OUR BUSINESS
OUR PASSION

CITY OF *Salem*
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Engineers...Working Wonders With Water®

Acknowledgements

- Dr. Robin Collins (UNH) & Dr. Jess Brown (Carollo) – Pilot Study Support
- WEST Consultants – Sediment Transport / Flood Mitigation
- MJA – Alternative Surface Water Intake
- GSI – Groundwater Development
- Carollo Engineers, Inc. – Project Coordination/Management



Our Agenda for Today

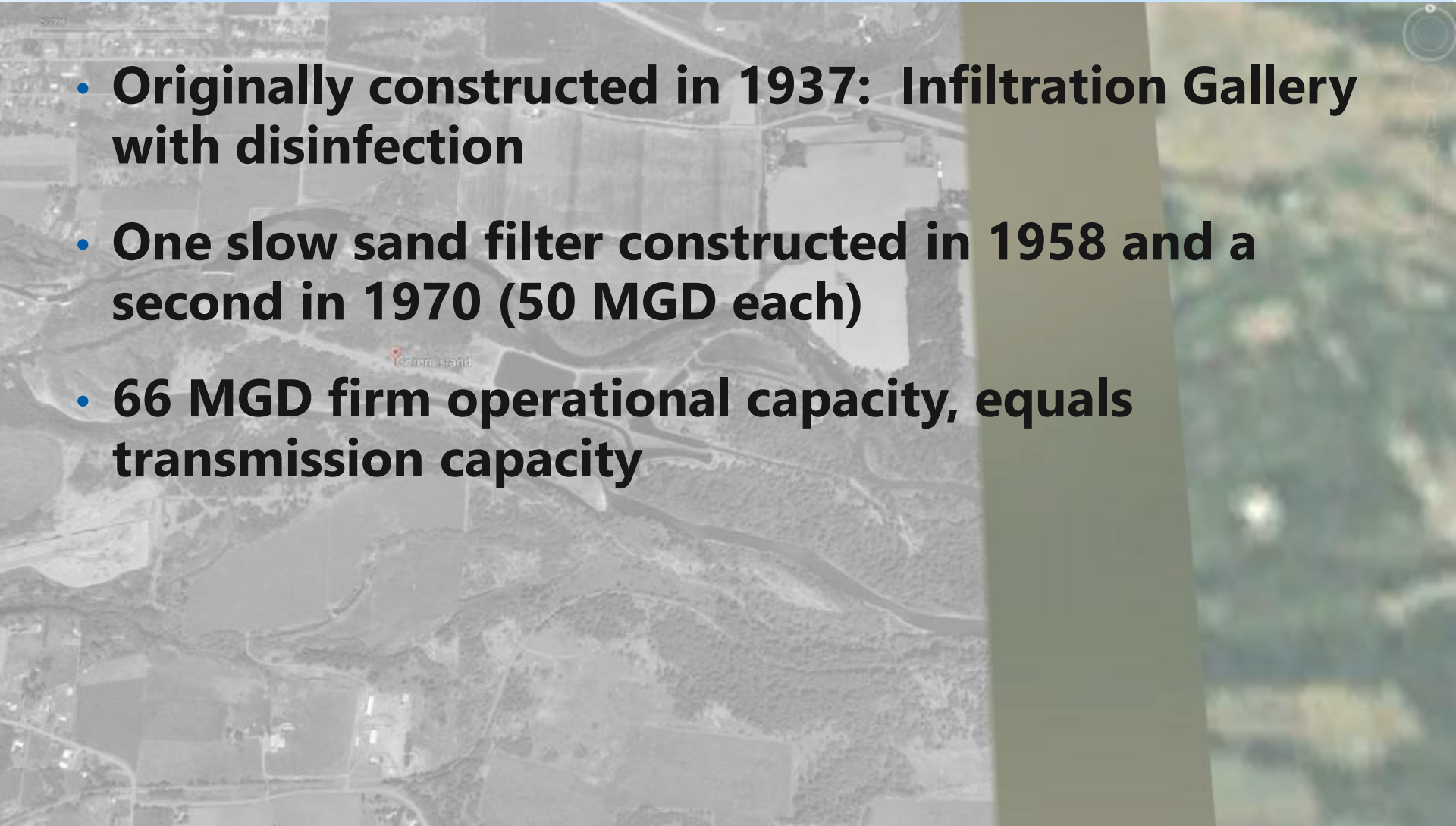
- Introduction and Overview
- Raw Water Quality Challenges
- Alternative Supplies
- Pilot Study Experimental Plan
- Pilot Results (to date)
- Summary and Next Steps






Introduction and Overview

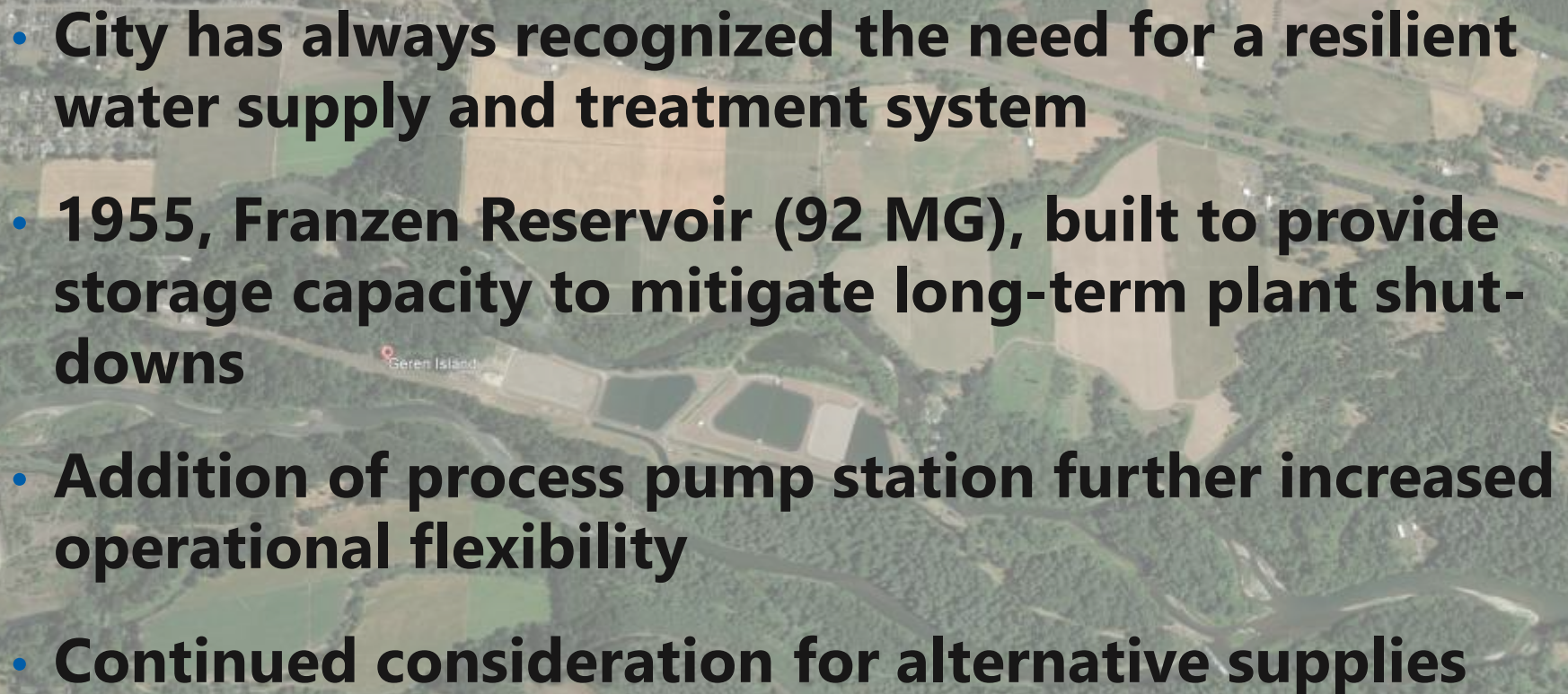
History of the Geren Island Water Treatment Facility

- **Originally constructed in 1937: Infiltration Gallery with disinfection**
 - **One slow sand filter constructed in 1958 and a second in 1970 (50 MGD each)**
 - **66 MGD firm operational capacity, equals transmission capacity**
- 
- An aerial photograph of the Geren Island Water Treatment Facility. The facility consists of several large, rectangular concrete basins and structures, some of which are filled with water. The surrounding area is a mix of open fields and some vegetation. A semi-transparent grey box is overlaid on the left side of the image, containing the text of the list. A small red location pin is visible on the map, labeled 'Geren Island'.

History of the Geren Island Water Treatment Facility

- **Treatment capacity expanded in 1998 through 2006; addition of two new filters**
 - **126 MGD design capacity**
 - **84 MGD firm operational capacity**
 - **Transmission capacity increased to 70 MGD**
- 
- An aerial photograph of the Geren Island Water Treatment Facility. The image shows a complex of large, rectangular concrete tanks and structures, interspersed with green trees and grassy areas. A winding road or path is visible through the facility. The overall scene is a mix of industrial infrastructure and natural landscape.

History of the Geren Island Water Treatment Facility

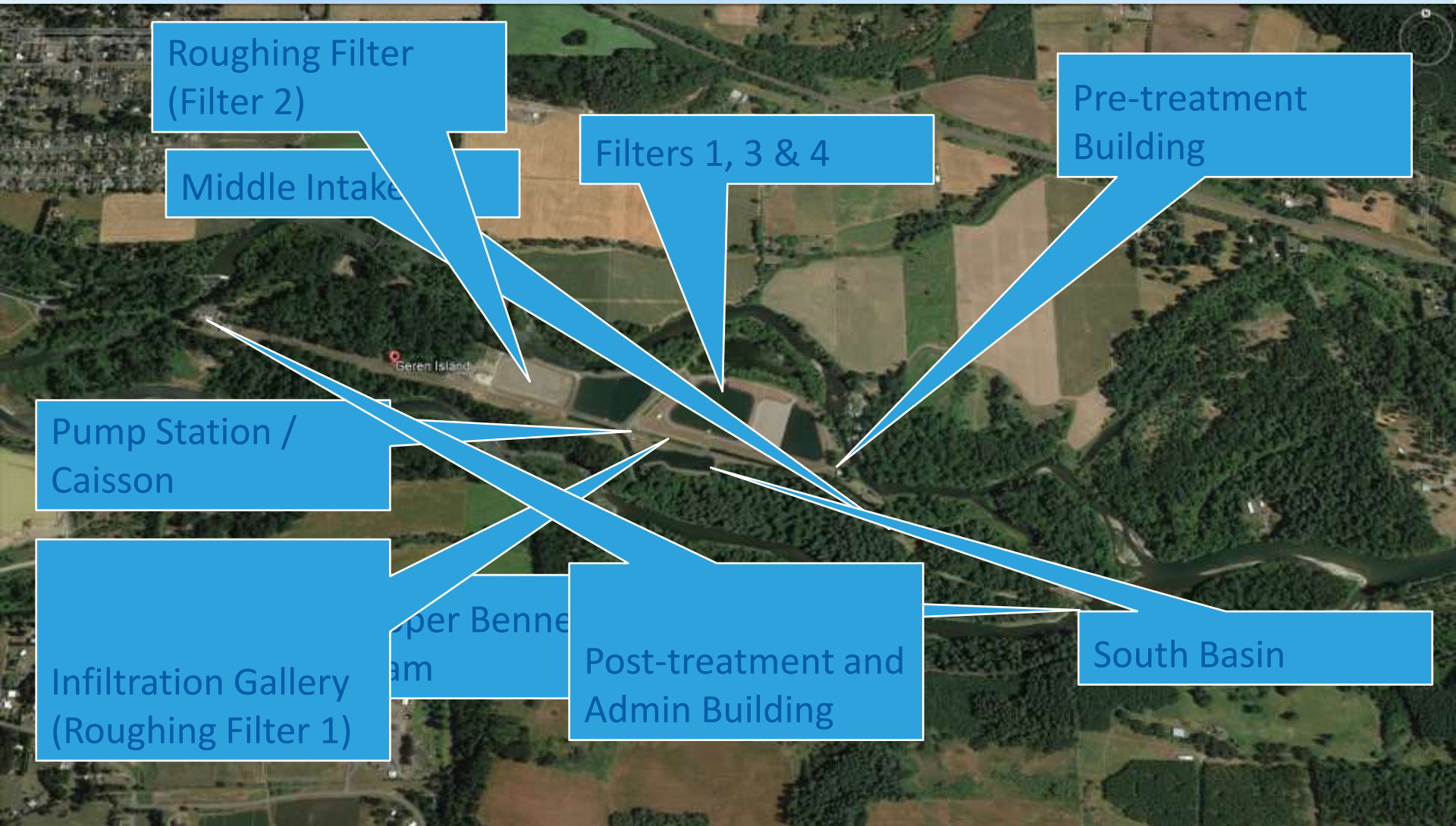
- **City has always recognized the need for a resilient water supply and treatment system**
 - **1955, Franzen Reservoir (92 MG), built to provide storage capacity to mitigate long-term plant shut-downs**
 - **Addition of process pump station further increased operational flexibility**
 - **Continued consideration for alternative supplies**
- 

History of the Geren Island Water Treatment Facility

- **Currently producing 25 MGD ADD / 50 MGD PDD**



Key Facilities - Geren Island Water Treatment Facility



Roughing Filter
(Filter 2)

Middle Intake

Filters 1, 3 & 4

Pre-treatment
Building

Pump Station /
Caisson

Infiltration Gallery
(Roughing Filter 1)

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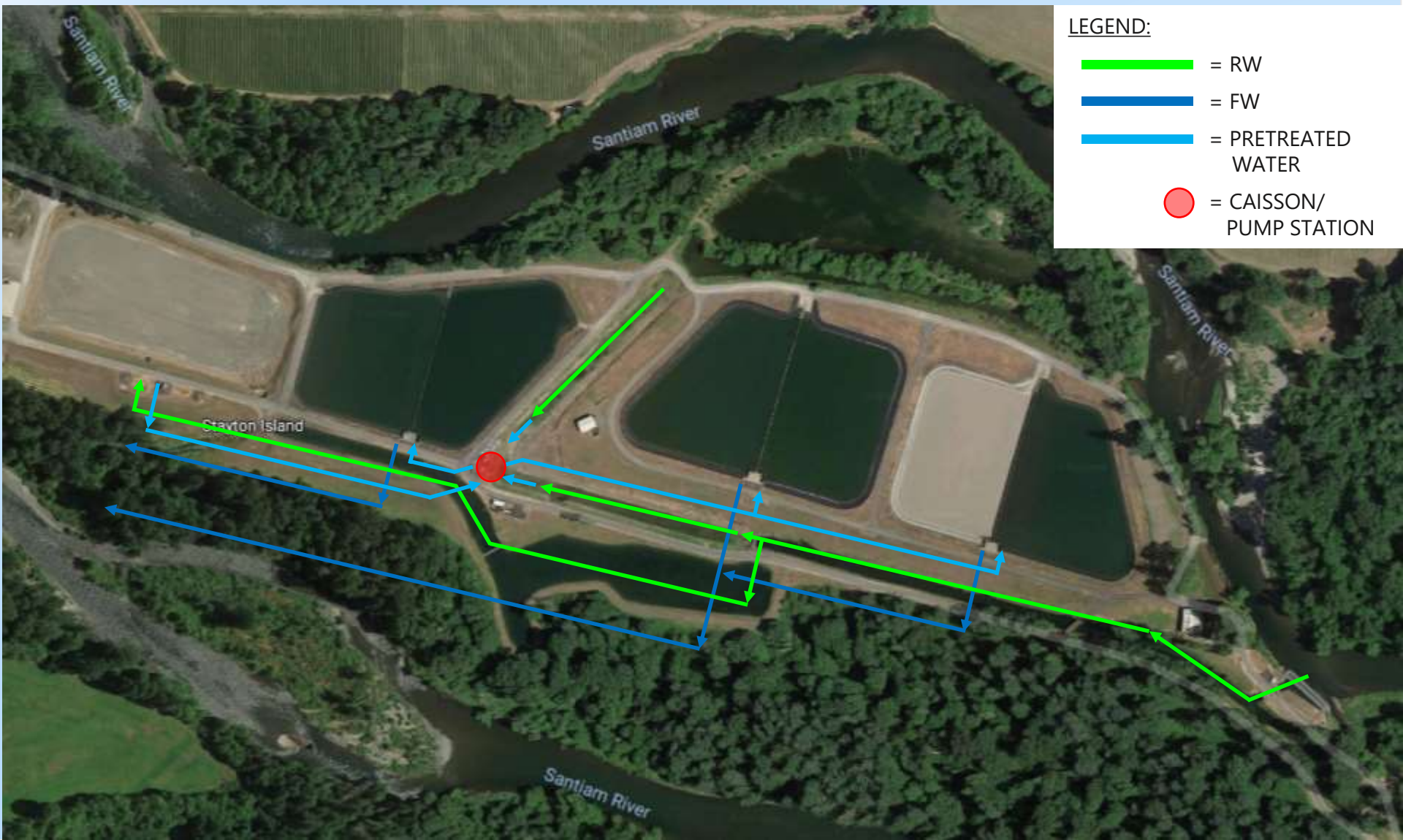
Post-treatment and
Admin Building

South Basin

Normal Operations Condition

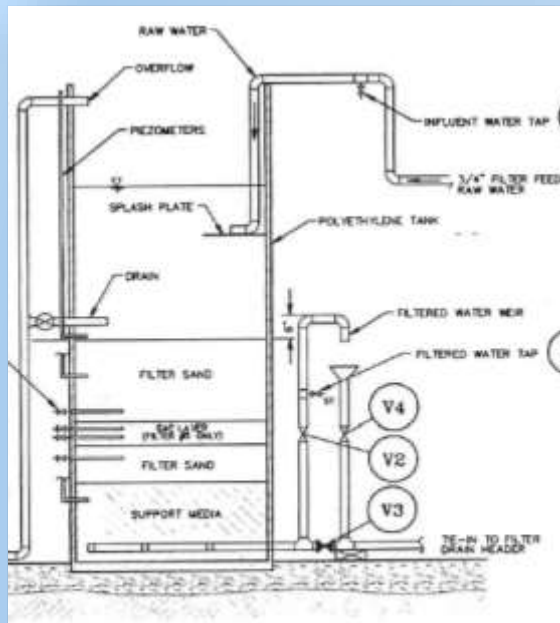


Elevated Turbidity Condition (>10 NTU)



Pilot Filter System built in 1990's to identify optimal media characteristics for SSFs

- Six pilot filters available
 - 10-foot tall polyethylene tanks
 - 4-foot diameter
 - Piezometers, sample taps, drains



- 36" of 0.3 mm sand media
- 24" gravel underdrain



Raw Water Quality Challenges

Historical RW Quality

Parameter	Units	Range	Average	Percentiles		
				5	50	95
Turbidity	NTU	0.03 – 51.8	2.23	0.43	1.15	6.58
Total Organic Carbon ⁽¹⁾	mg/L	0.05 – 1.59	0.85	0.7	0.75	1.04
pH	-	6.46 – 8.26	7.5	6.94	7.44	8.08
Temperature	°C	<1 - 27.6	13.1	7.67	11.4	21.5

Notes:

(1) TOC data only reported during the summer months.



Plant Performance Summary (cont.)

Turbidity / Particles	✓	✓	
Pathogens		✓	✓
Tastes and Odors		✓	

Based on historical water quality, slow sand filtration continues to be an appropriate technology for the Santiam River...unless the raw water quality changes.



Roughing
Filters



Slow Sand
Filters



Disinfection

Potential Changes in Raw Water Quality

Santiam River

Turbidity / Particles



Pathogens



Tastes and Odors



Human Caused Event



Elevated Turbidity



Algae / Algal Toxins



Recent fuel truck accident
Climate change
Increased day
species and turbidity
events concentrations in
the watershed
since 2013

Geren Island Algal Toxin Sampling Results

Year	Cylindrospermopsin (ELISA) (<0.10)					Cylindrospermopsin (LC/MS/MS) (<0.005)				
	No. of samples	No. of Detects	Min (µg/L)	Max (µg/L)	Average (µg/L)	No. of samples	No. of Detects	Min (µg/L)	Max (µg/L)	Average (µg/L)
2013	13	0	-	-	-	-	-	-	-	-
2014	4	2	0.06	0.238	0.149	33	32	0.03	0.15	0.0625
2015	-	-	-	-	-	28	23	0.01	0.12	0.0535
2016	-	-	-	-	-	15	9	0.04	0.13	0.07
2017	-	-	-	-	-	38	15	0.09	0.43	0.163



Treatment Improvements: Algae / Algal Toxin

	Saxitoxin	Anatoxin-a	Cylindrospermopsin	Microcystin
AOP	?	Y	Y	Y
Ozone	N	Y	Y	Y
Permanganate	N	Y	N	Y
Chlorine	Y	N	Y	Y
Chlorine Dioxide	?	N	N	N
Chloramines	?	N	N	N
	+/-			
Activated Carbon	-	Y	Y	Y
Biofiltration	N	Y	Y	Y
			+/-	+/-
UV	?	+/-	-	-
MF/UF	N	N	N	N
NF/RO	Y	Y	Y	Y

Treatment Improvements: Algae / Algal Toxin

- Current treatment approach
 - Avoidance: Can only sustain up to ~2-3 days in a row, based on system storage and ASR capacity
 - Dilution: When >30% groundwater is applied to SSFs, filters performance begins to degrade and may not meet water quality/performance goals.
 - Biological removal efficiency
 - Only capable of removing/reducing select algal toxins
 - Extended free chlorine oxidation
 - Only capable of oxidizing select algal toxins



Alternative Supplies

The City Currently has Two Alternatives to Surface Water

- Groundwater
 - 2 operational wells
 - 5 MGD capacity (3 MGD water right)
- 'Infiltration Gallery'
 - Groundwater collection between 5-10 MGD (w/out surface water)



Source Waters Have Low Nutrient Levels

Water Source	Biodegradable Dissolved Organic Carbon (mg/L)	Total Nitrogen (mg/L-N)	Orthophosphate (mg/L-P)	CNP Ratio
Surface Water	0.315	0.045	0.012	10:5.9:0.37
Infiltration Gallery	0.350	0.094	0.014	10:5.0:0.40
Groundwater	0.355	0.121	0.014	10:5.7:0.39

- Ideal C:N:P ratio is 10:1:0.3

Summary: Benefits of Groundwater Treatment

- Redundant Supply
- Resiliency against algae/algal toxin and other surface water contaminants
- Potentially avoids the need for costly 'surface water treatment improvements'



Pilot Study Experimental Plan

Pilot Overview and Objectives

- Identify treatment process improvements required to treat up to 34 MGD of groundwater water with no blending of surface water.
 - Identify Additional Water Quality Testing Required
 - Pilot Testing
 - Identify Treatment Changes Required
 - Estimate Capital and Operating Costs
 - Develop Summary TM

Pilot Testing Experimental Plan

- Experimental Plan Goals meet Task objectives.
 - ✓ – Determine Carbon, Nitrogen, and Phosphorus ratios of groundwater and surface water
 - ✓ – Prepare pilot filters for testing
 - ✓ – Allow pilot filters to ripen
 - ➔ – Identify rate limiting nutrient and treatment improvements
 - Perform challenge testing



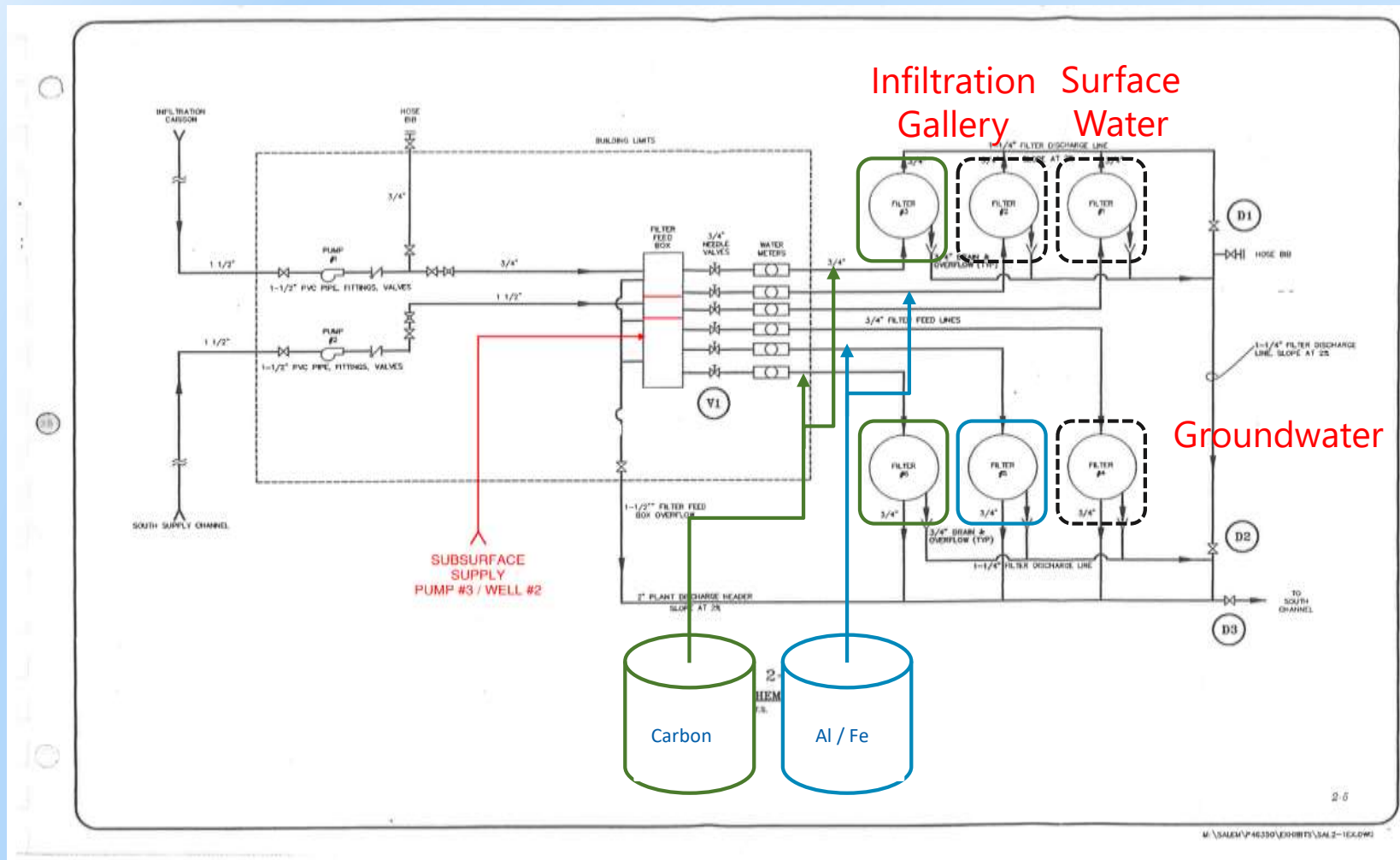
City of Salem
Geren Island Long-Term Water Supply Alternatives Analysis

Subsurface Water Treatment Improvements Pilot Testing Plan

DRAFT | June 2017



Experimental Set-up: Pilot Testing Schematic





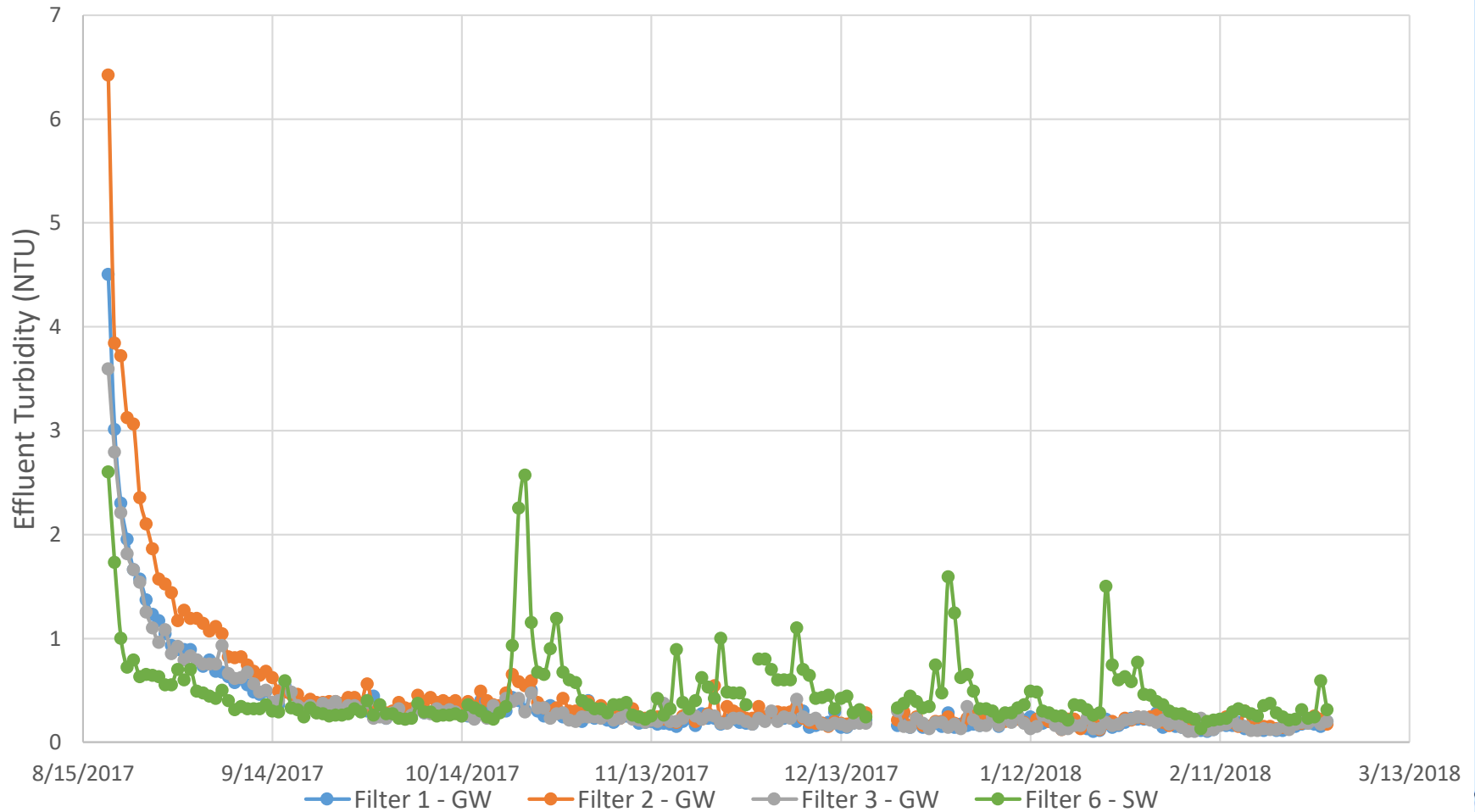
Pilot Results (to date)

Experimental Plan Overview

- Phase 1: Seed and Ripen Filters (current phase)
- Phase 2: Particle Destabilization and Rate Limiting Nutrient Testing
- Phase 3: Challenge Testing

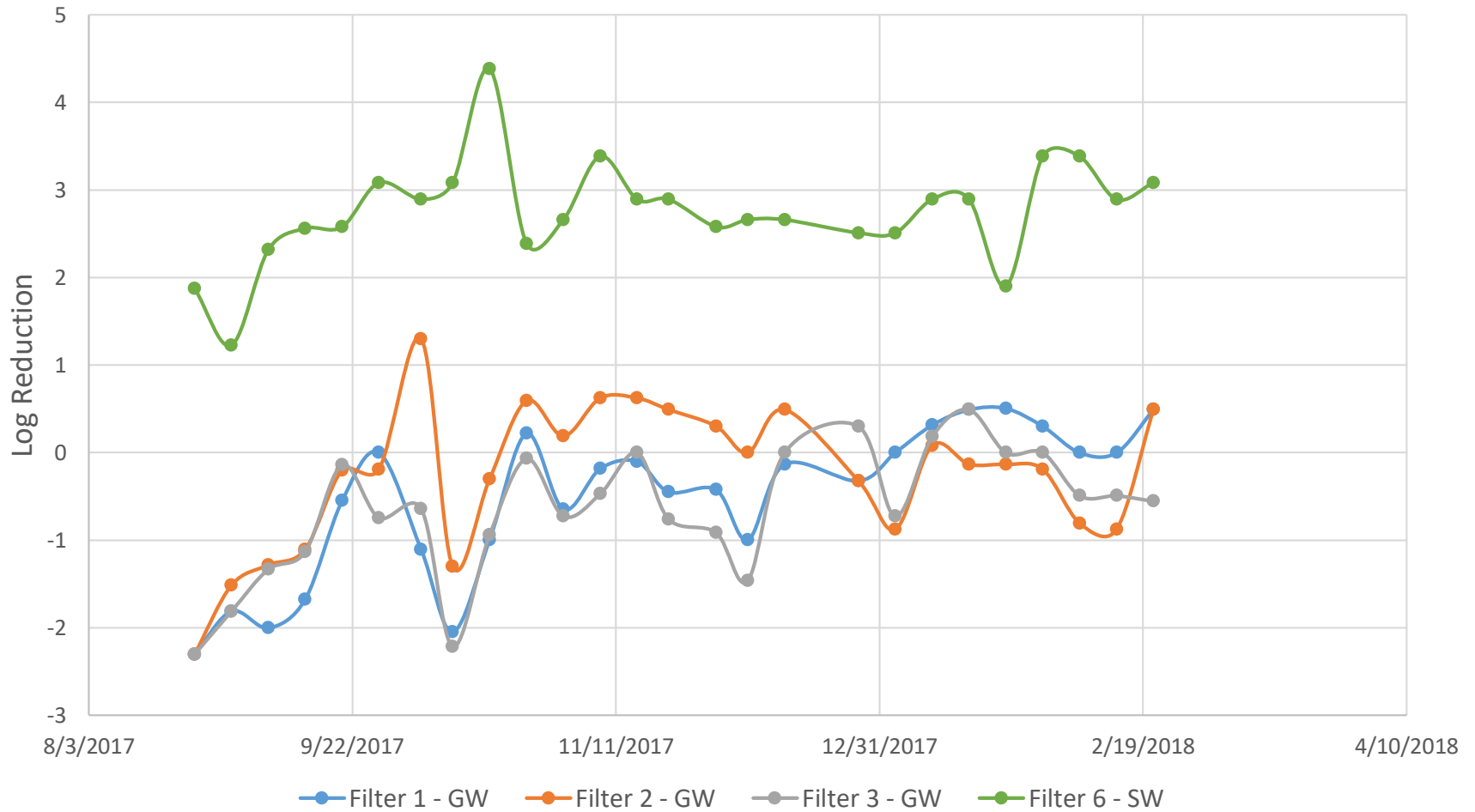
Filters have Ripened!

Pilot Filter Turbidity Removal - GW & SW



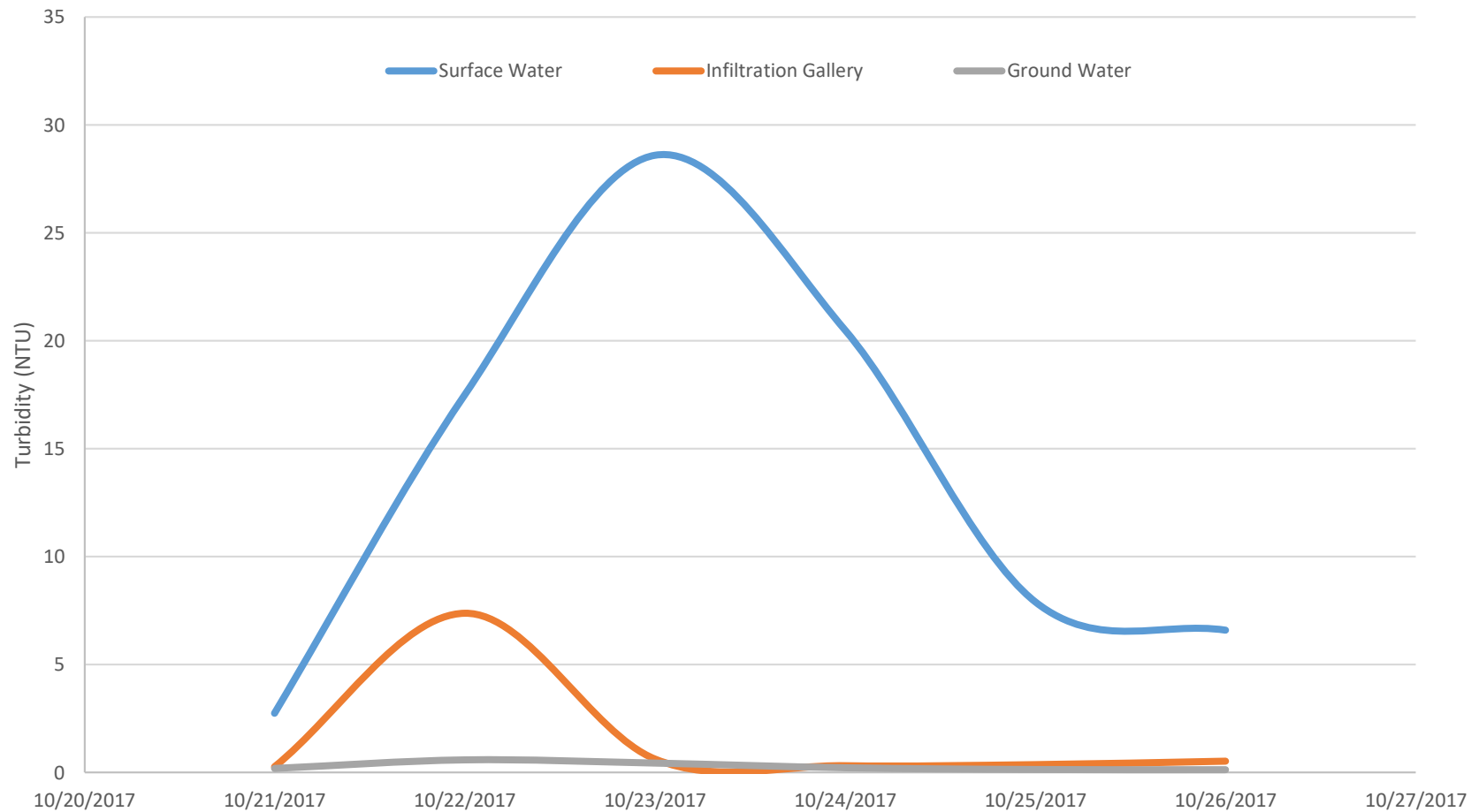
Filters have Ripened!

Pilot Filter Total Coliform Log Reduction (GW & SW)



Impacts of Elevated Turbidity Events in Surface Water

Raw Water Turbidity Following Rain Event



Phase 1: Seed and Ripen Filters

- Pilot Filters have been running since mid-August 2017
- Turbidity reduction meet FW Quality Goals
- Coliform concentrations in the effluent now meet FW Quality Goals

Challenge: Demonstrating 1-log reduction when we have low coliform in the untreated groundwater

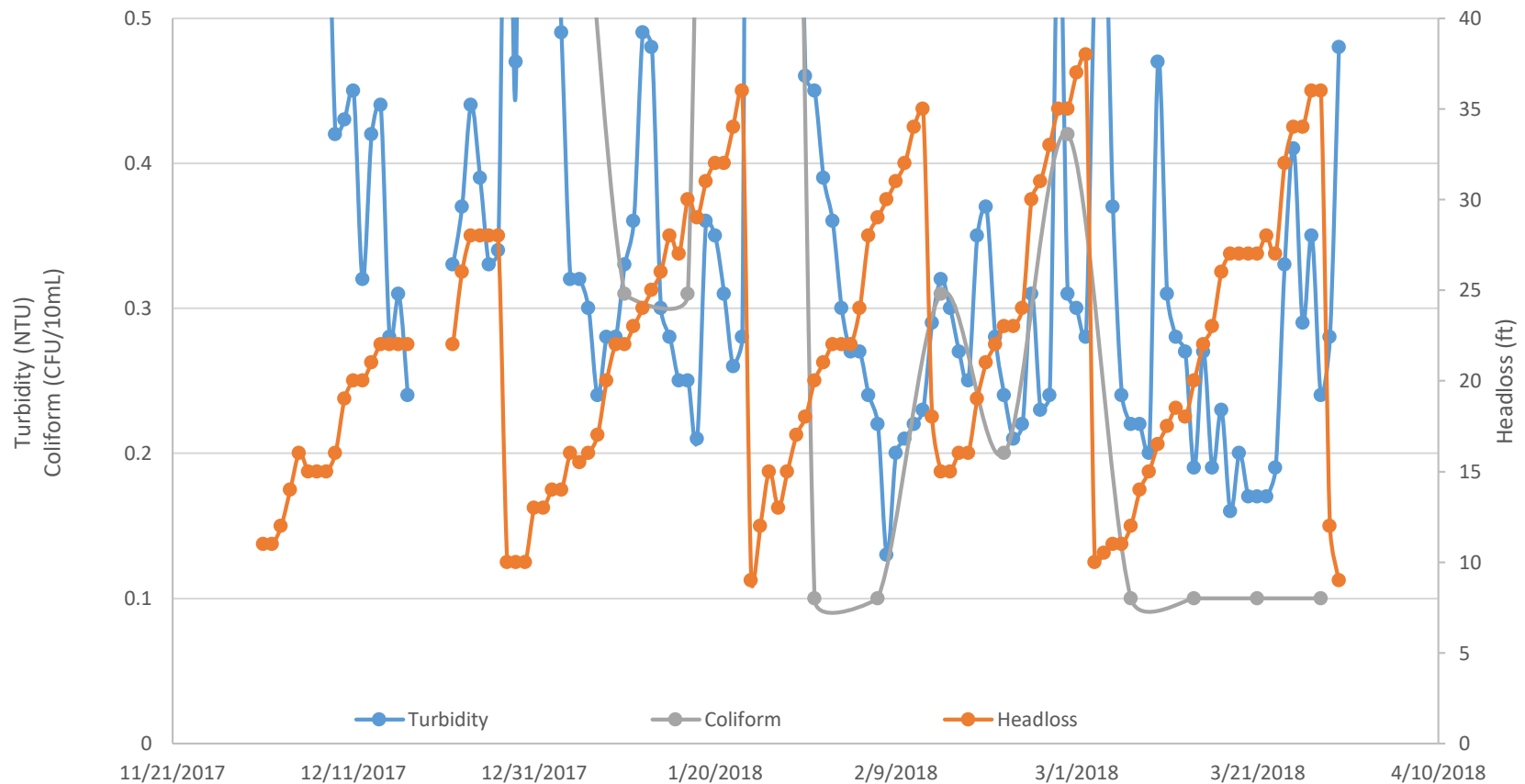
Phase 2: Particle Stabilization and Rate Limiting Nutrient Testing

- Goal is to identify which nutrient solutions may promote growth of beneficial bacteria within filters fed by groundwater.
 - Plant staff prepare nutrient solutions weekly

Pilot Filter	Source Water	Chemical Addition	Dose (mg/L as C/Fe/Al)
Filter No. 1	Groundwater	Acetic Acid	0.5
Filter No. 2	Groundwater	Ferric Chloride	0.2
Filter No. 3	Groundwater	Alum	0.2
Filter No. 4	Infiltration Gallery	TBD	N/A
Filter No. 5	Infiltration Gallery	TBD	TBD
Filter No. 6	Surface Water	n/a	TBD

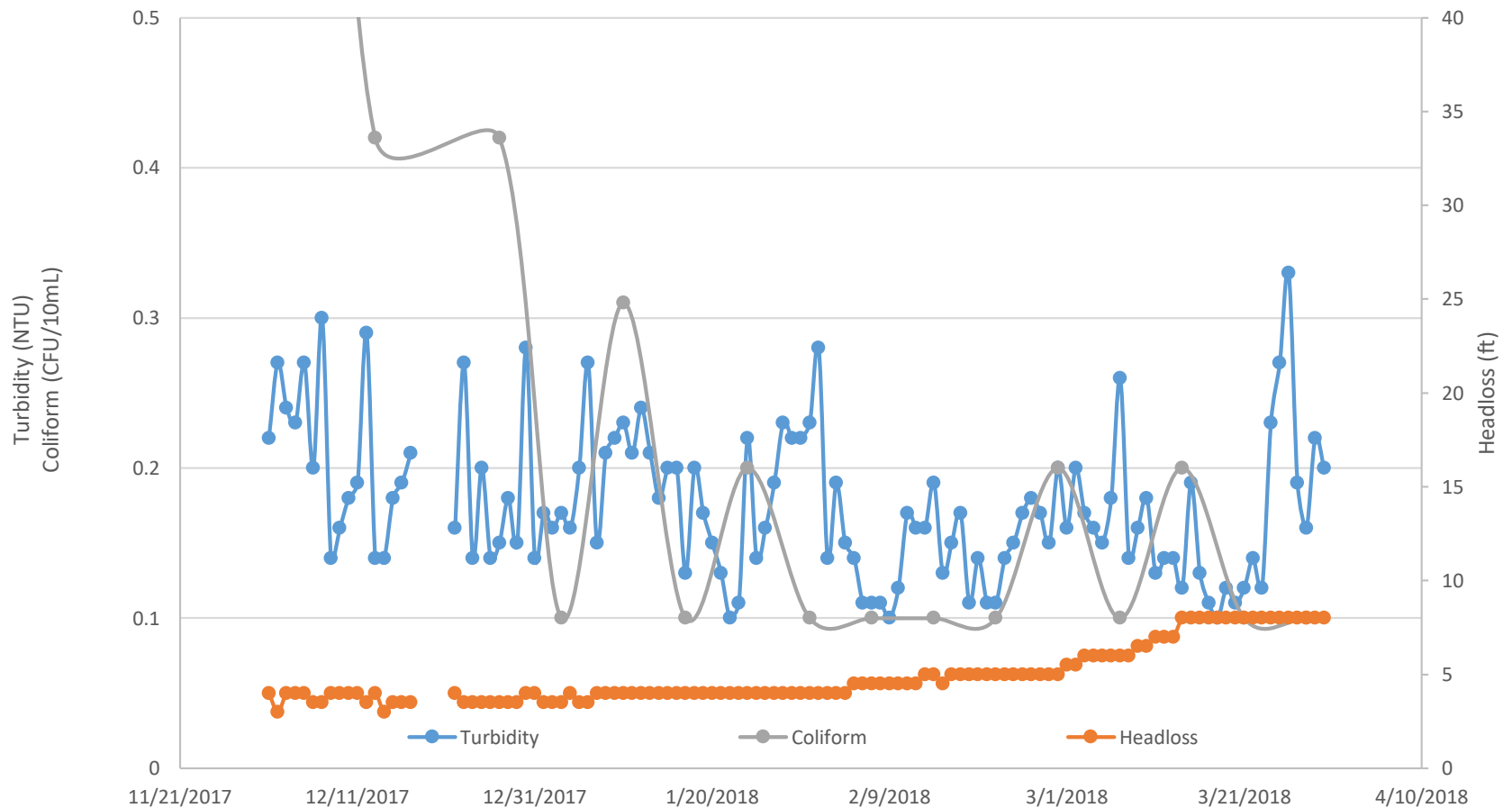
Surface Water Pilot Filter Performance Matches Full-scale Plant

Filter 6 SW - Headloss, Turbidity, and Coliforms



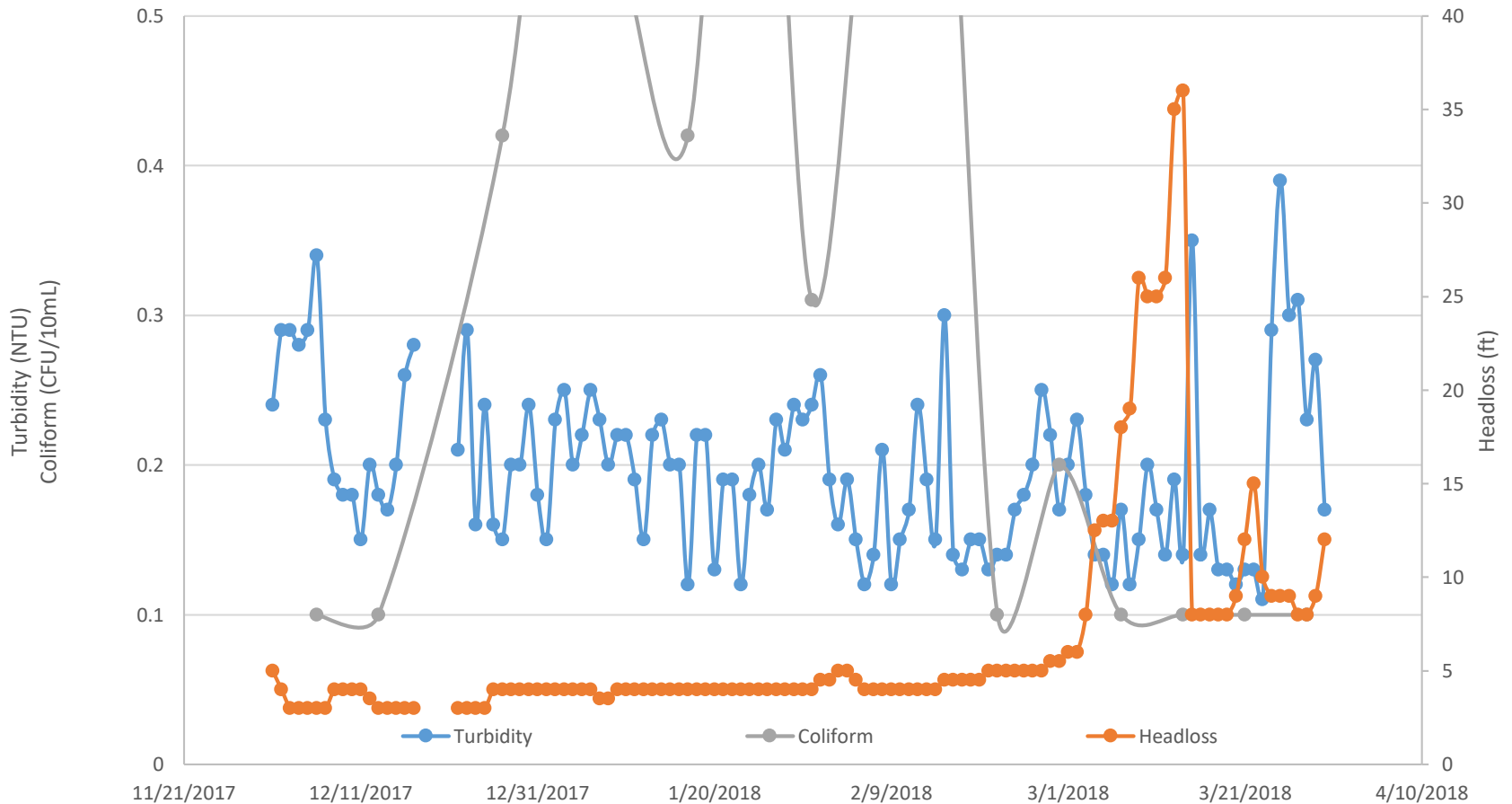
Carbon Appears to Have a Positive Impact

Filter 1 GW - Headloss, Turbidity, and Coliforms



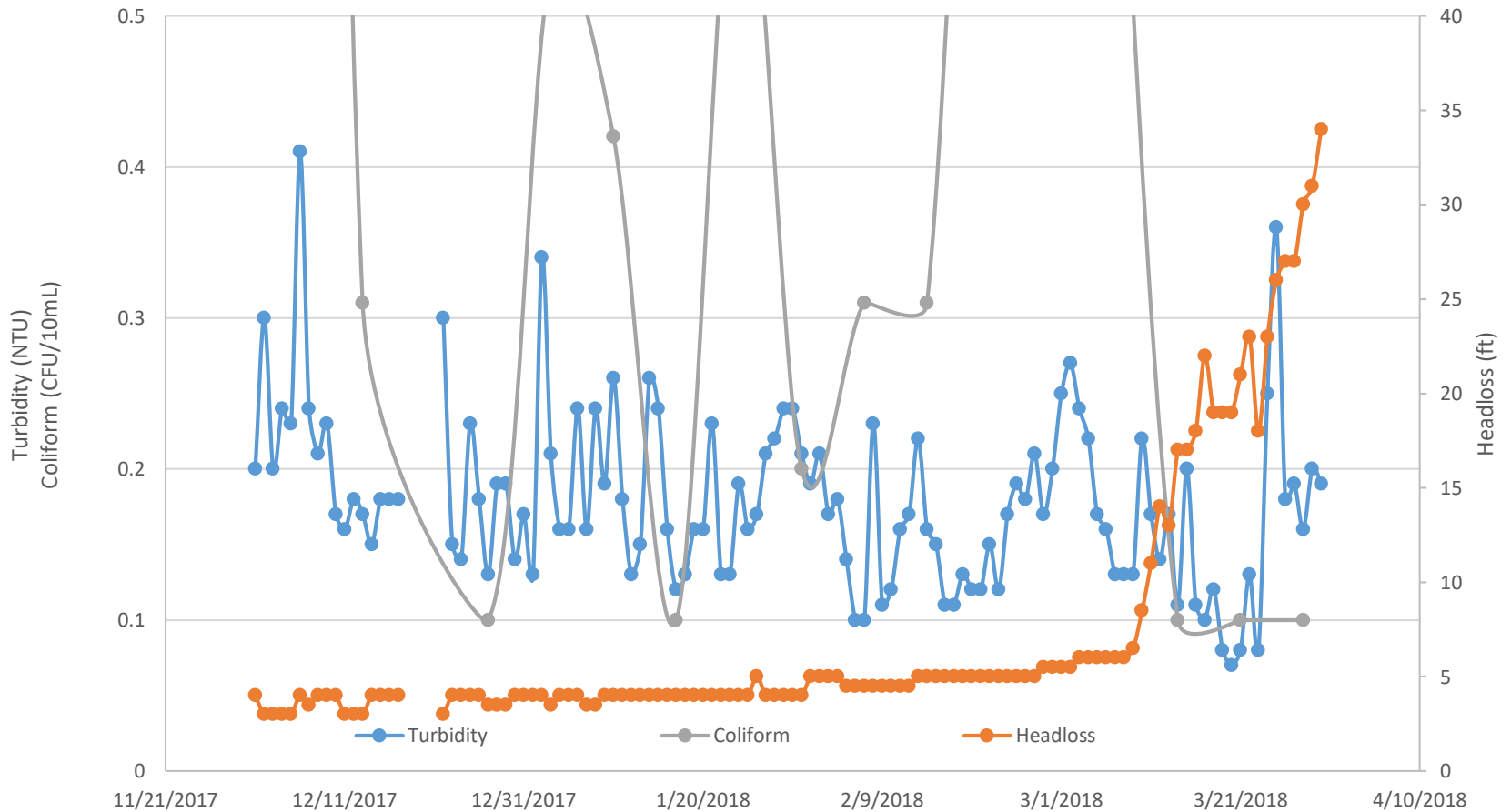
Alum also Improves Coliform Removal

Filter 2 GW - Headloss, Turbidity, and Coliforms



Ferric Results are Similar to Alum

Filter 3 GW - Headloss, Turbidity, and Coliforms

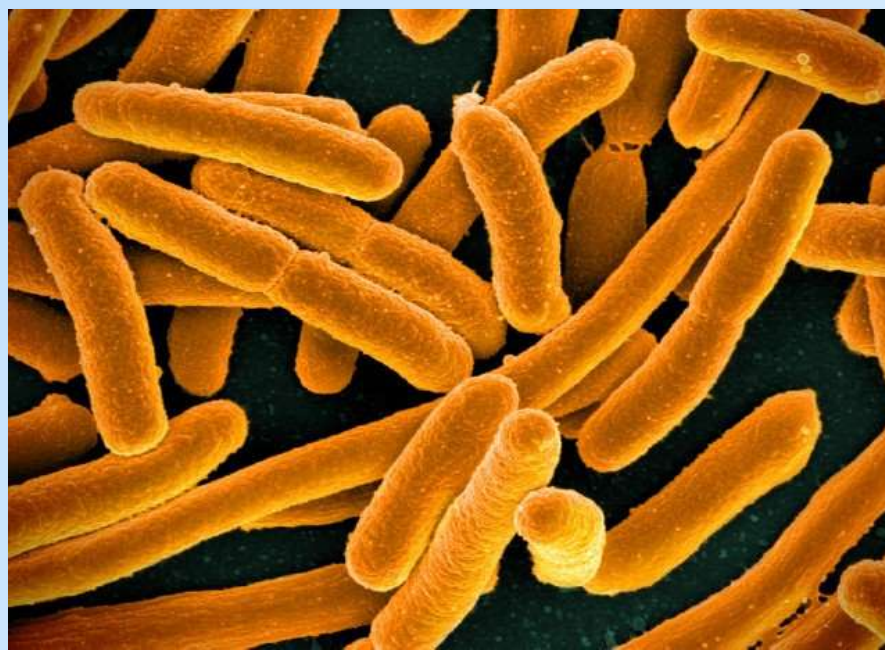




Summary and Next Steps

Phase 3: Challenge Testing

- Challenge pilot filters with inactivated E. coli once rate limiting nutrients have been identified and reproducible growth seen on groundwater filters.
- Testing will confirm that approach is viable to protect public health at full scale.





Questions?
tsherman@cityofsalem.net