City of Salem's Geren Island WTP

Cyanotoxin Response Summary

PNWS AWWA

May 2, 2019

carollo
Engineers...Working Wonders With Water®

CITY OF Salem
AT YOUR SERVICE

Acknowledgements

- City Leadership
- City Engineering, Operations, Maintenance and Contracts Staff
- Contractors of Record
- Oregon Health Authority
- Vendors
- Carollo Engineers

Agenda

- Background
- Cyanotoxin Treatment Technologies
- Near-term Response
  - Alternatives Analysis and Recommendations
  - Phased Implementation
- Long-term Solution
  - Alternatives Analysis
  - Recommendations
- Next Steps

Background

City of Salem's Water System

Slow Sand Filtration:

An elegant treatment approach

Slow Sand Filtration is an Appropriate Treatment based on 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.

May Detections Exceed Health Reference Levels

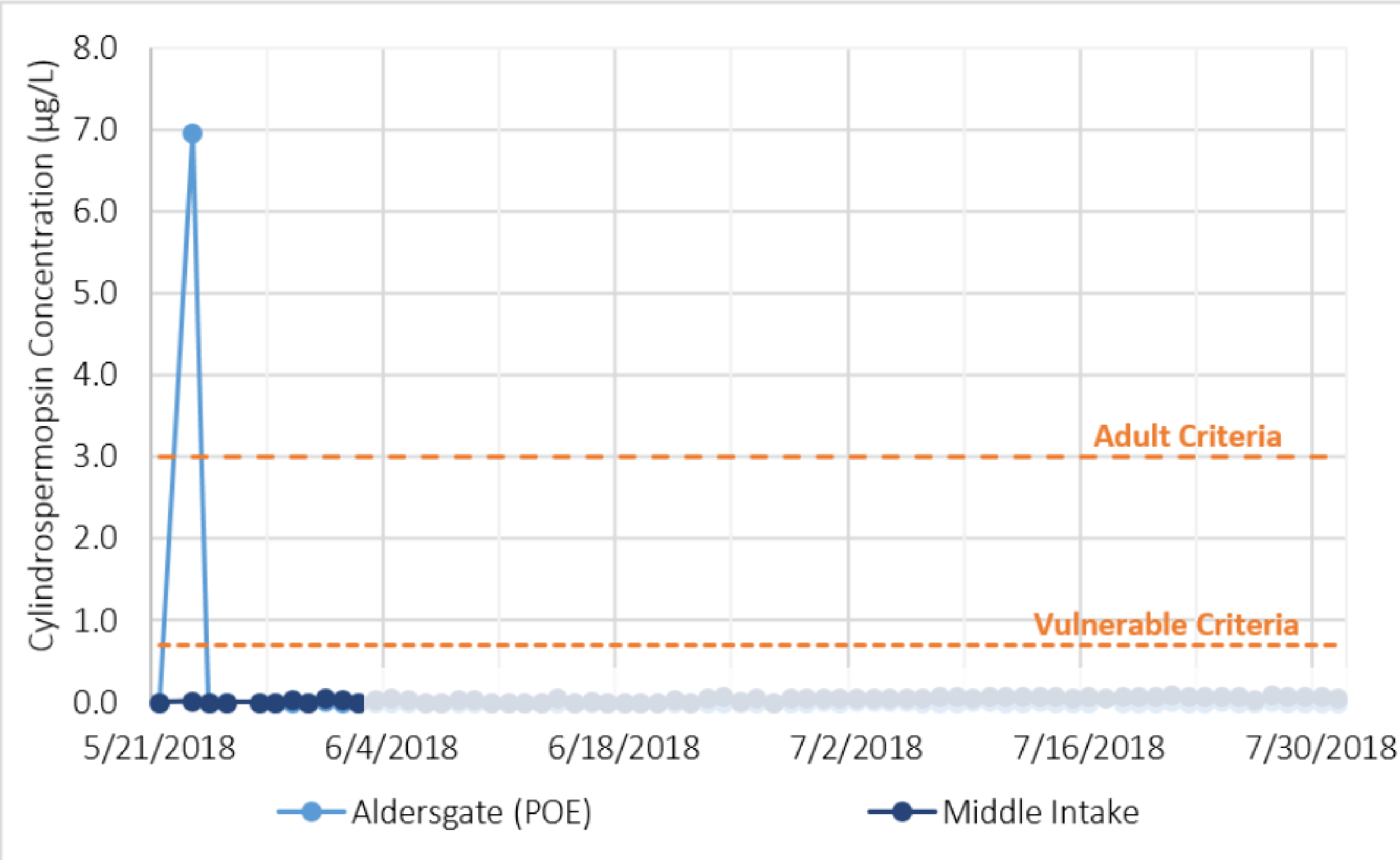


Figure 2.3 Cylindorspermopsin Concentrations at the GIWTF Intake and Aldersgate (POE)

May Detections Exceed Health Reference Levels

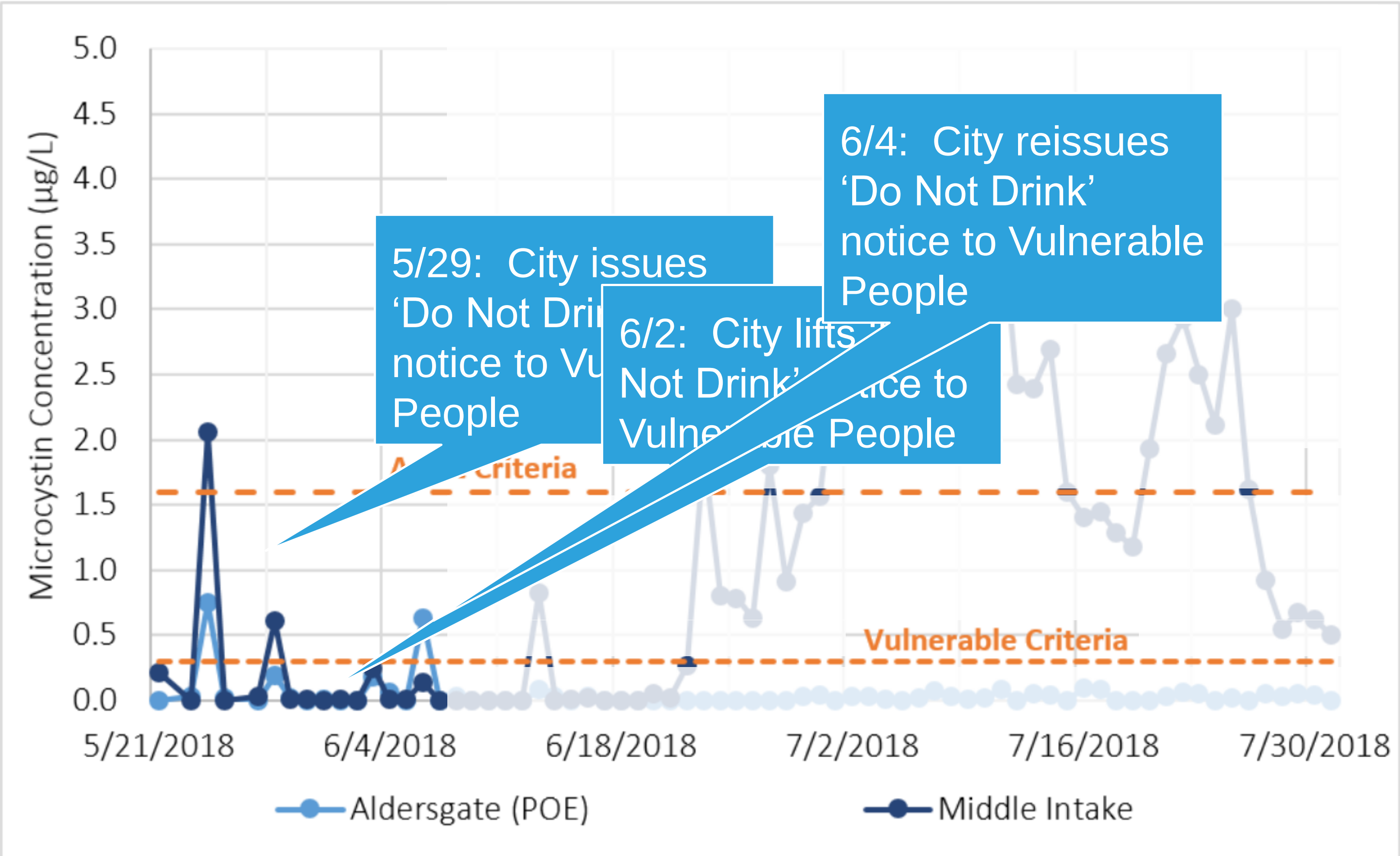


Figure 2.2 Microcystin Concentrations at the GIWTF Intake and Aldersgate (POE)

Cyanotoxin Treatment Technologies

Current Treatment Approach for Algae / Algal Toxins

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

Existing Plant Provides Multiple Barriers for Algae/ Cyanotoxins…

…But Needs a Supplement.

	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

Near-term Response: Alternatives Analysis and Recommendation

Removing Microcystin & Cylindrospermopsin: *Near-term Technology Screening*

Biodegradation

- ~~Biological filtration~~

EXISTING PLANT NOT SUCCESSFUL IN MAY

Oxidation

- ~~Free chlorine~~
- ~~Ozone~~
- ~~UV+AOP~~

NOT PROVEN RELIABLE IN MAY

REQUIRES SIGNIFICANT PLANNING, DESIGN AND CONSTRUCTION TIME

Adsorption

- Granular Activated Carbon (GAC)
- Powdered Activated Carbon (PAC)

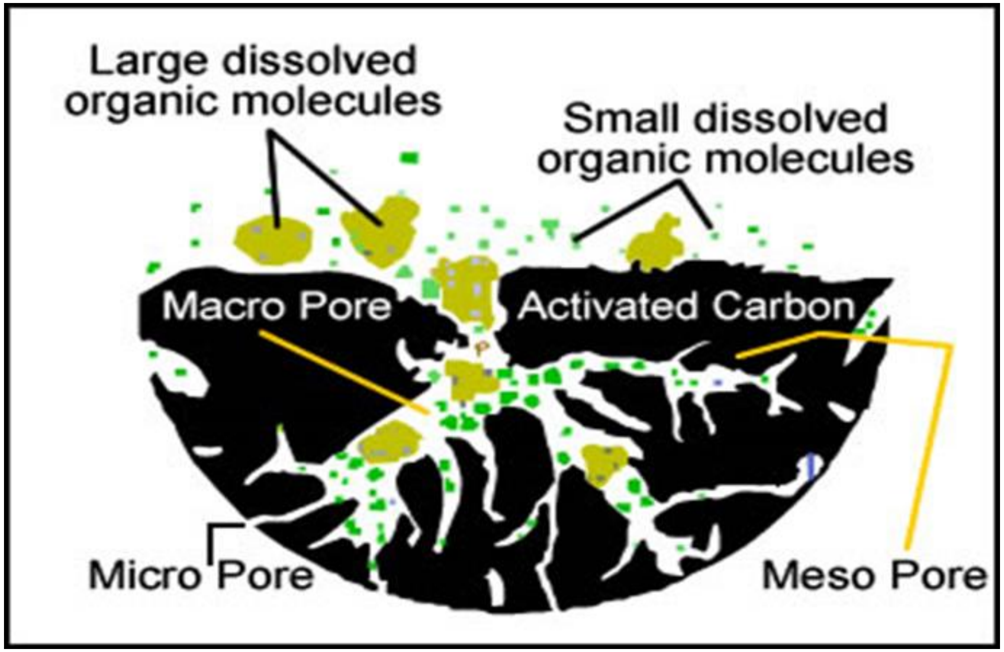
Removal

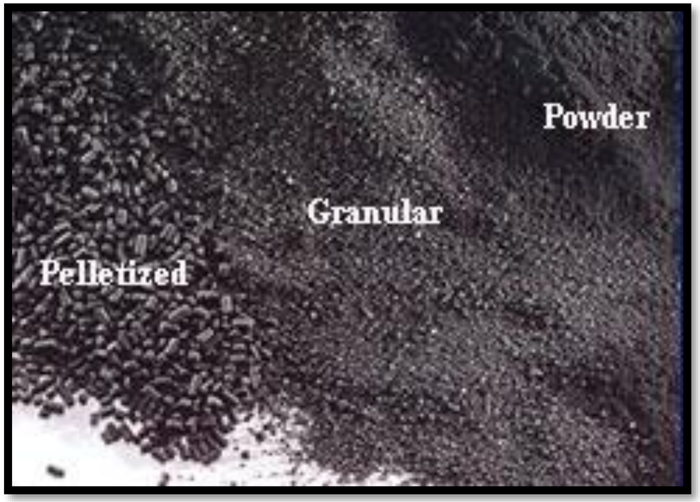
- ~~Nanofiltration, Reverse Osmosis~~

NO REGIONAL PRECEDENT

Adsorption: GAC and PAC

- Organic molecules are trapped within the pore spaces within the carbon matrix
- Adsorption occurs through ionic, polar and Van der Waals forces.
- ***PAC recommended for near-term implementation***



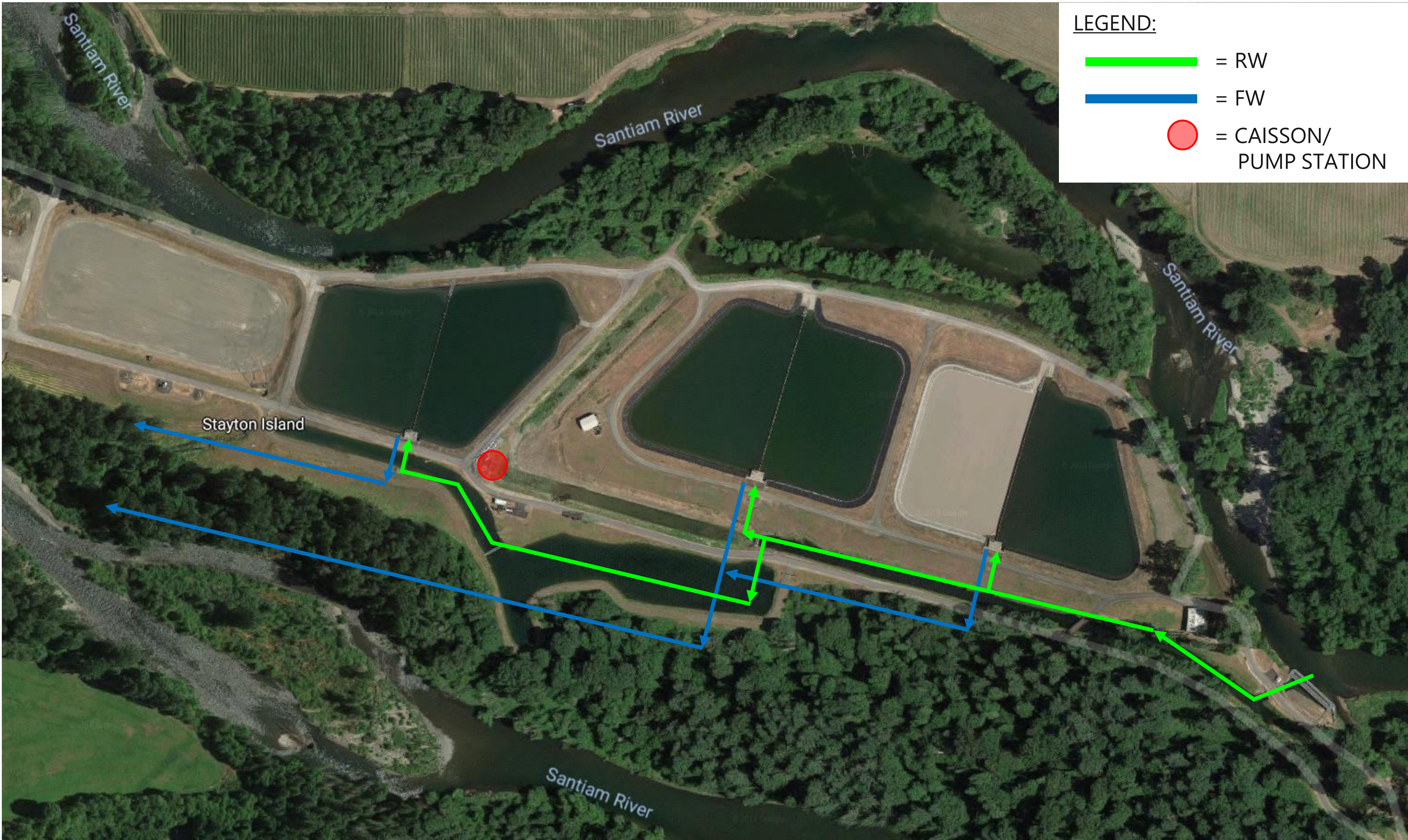


Risks and Other Issues for Consideration

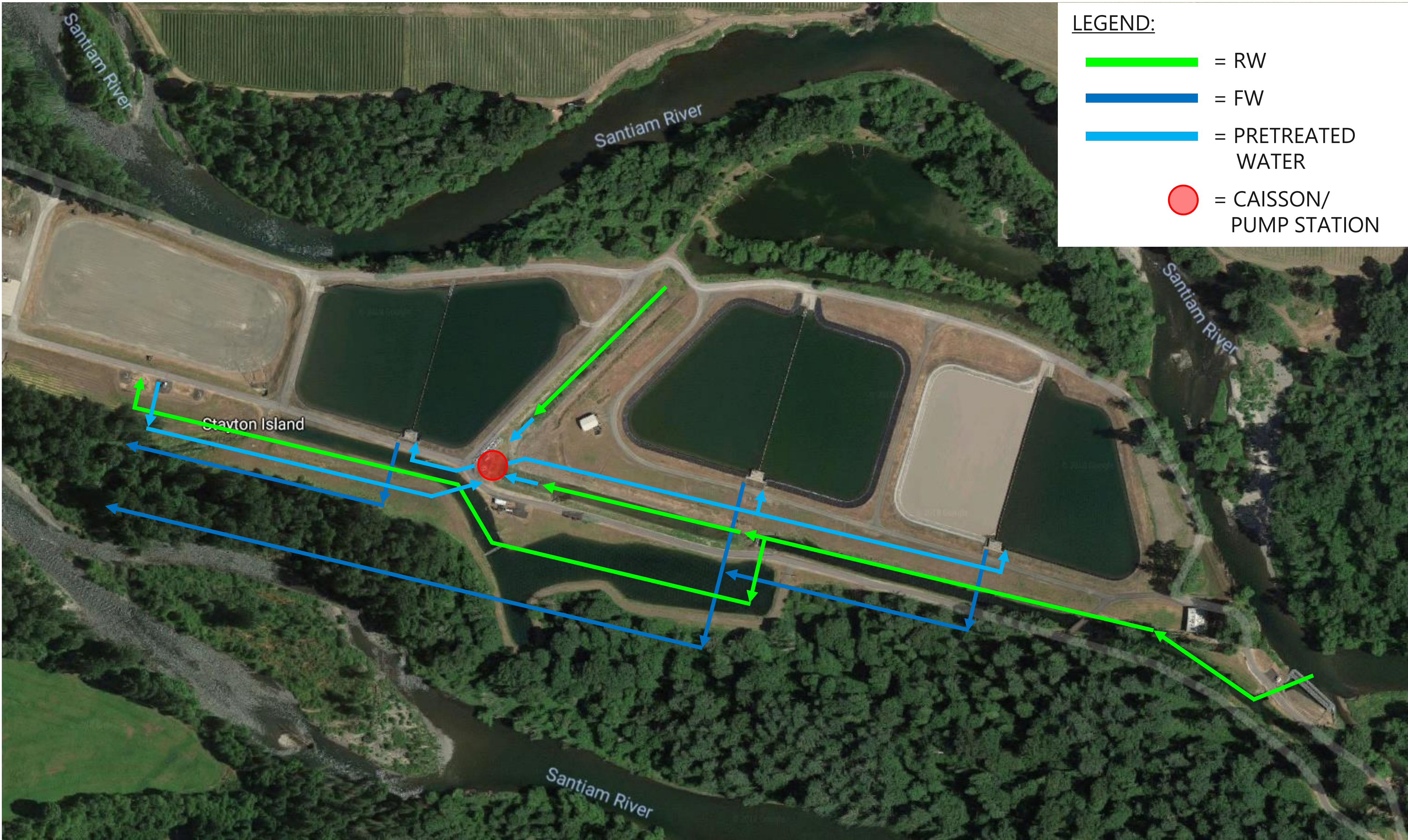
- Fine particles from PAC may plug filter media
- Lack of sufficient BDOC in post-carbon treated water may impact filter performance. A carbon 'supplement' may be required.
  - Pilot currently testing the use of acetic acid (vinegar); early data suggests a positive impact on filter performance when treating low-carbon groundwater.

Near-term Response: Phased Implementation

Normal Operating Conditions



Elevated Turbidity Conditions (>10 NTU)



Near-term Recommendations: Phased PAC approach to address issue and minimize risk

- Phase 0: Bench-scale testing
- Phase 1: Pilot-scale testing
- Phase 2: Demonstration-scale (single filter) testing
- Phase 3: Full-scale implementation

Phase 0: Bench Scale Testing

SCHEDULE: June 6 – June 14

Key Questions Were Answered:

1. How much PAC is required (mg/L) to be effective for algal toxin removal? (specifically MCN & CYL)
2. Are certain types of PAC better suited to removal than others?
3. Will the PAC settle on its own or is alum/polymer required?
4. If alum/polymer is required, how much to aid in rapid PAC settling?
5. Are we going to starve the slow sand filters?

Phase 1: Pilot-scale Testing

SCHEDULE: June 15 – June 25

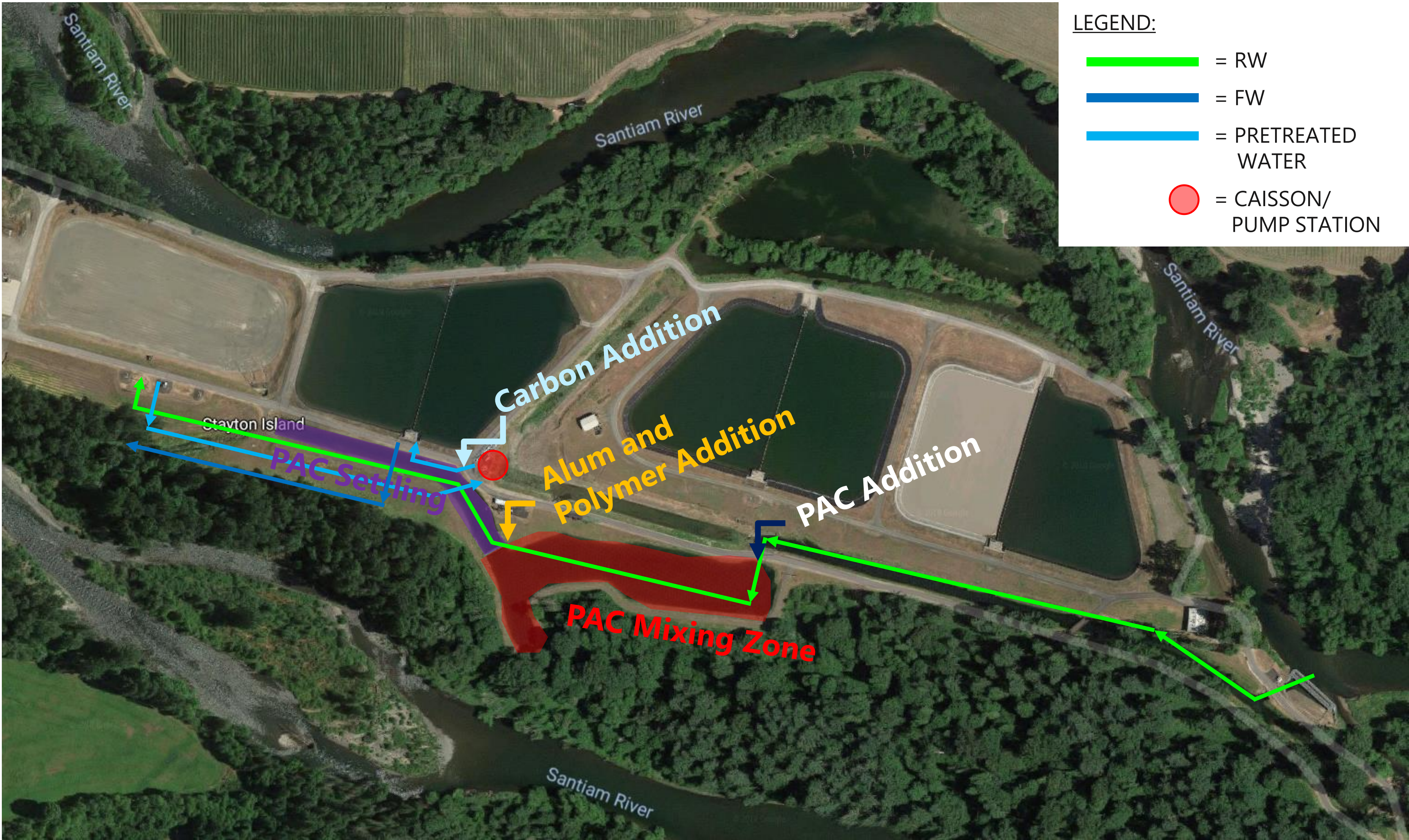
Key Questions Were Confirmed:

1. Confirm removal of algal toxins with bench-scale recommended PAC doses.
2. Determine extent of BDOC removal due to PAC addition.
3. Optimize carbon dose (acetic acid) to pilot filters
4. Identify and mitigate any regulatory performance issues (effluent turbidity, coliform, e-coli, etc.) as well as operational performance issues (headloss accumulation, etc.)

Phase 2: Demonstration-scale Implementation

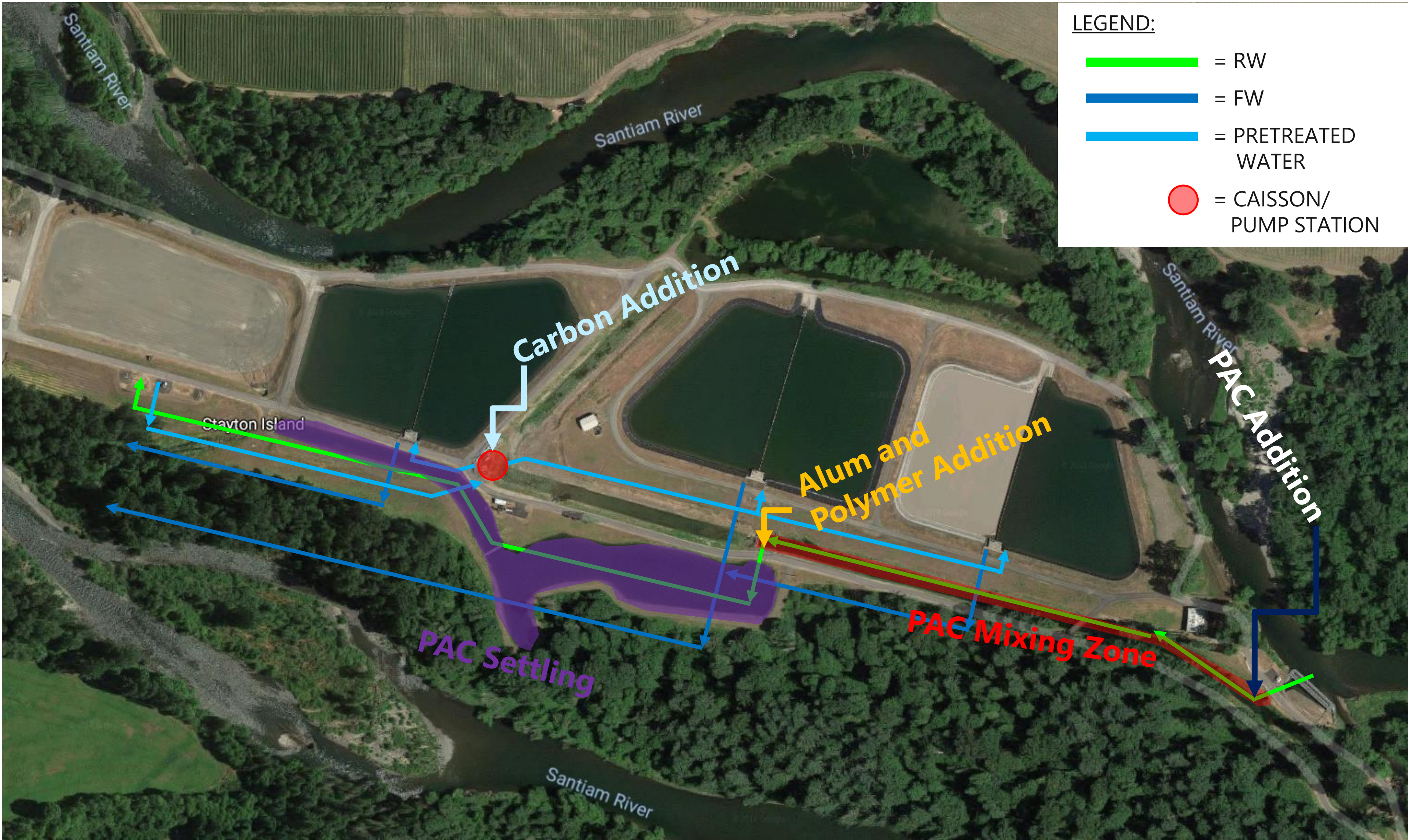
- SCHEDULE: June 26 – July 2
- Performance Similitude was Confirmed:
  - PAC adsorption
  - Ability to add, suspend, coagulate and settle PAC upstream of the roughing filter

Phase 2: Demonstration-scale Implementation



Phase 3: Full-scale Implementation

Normal operations configuration:

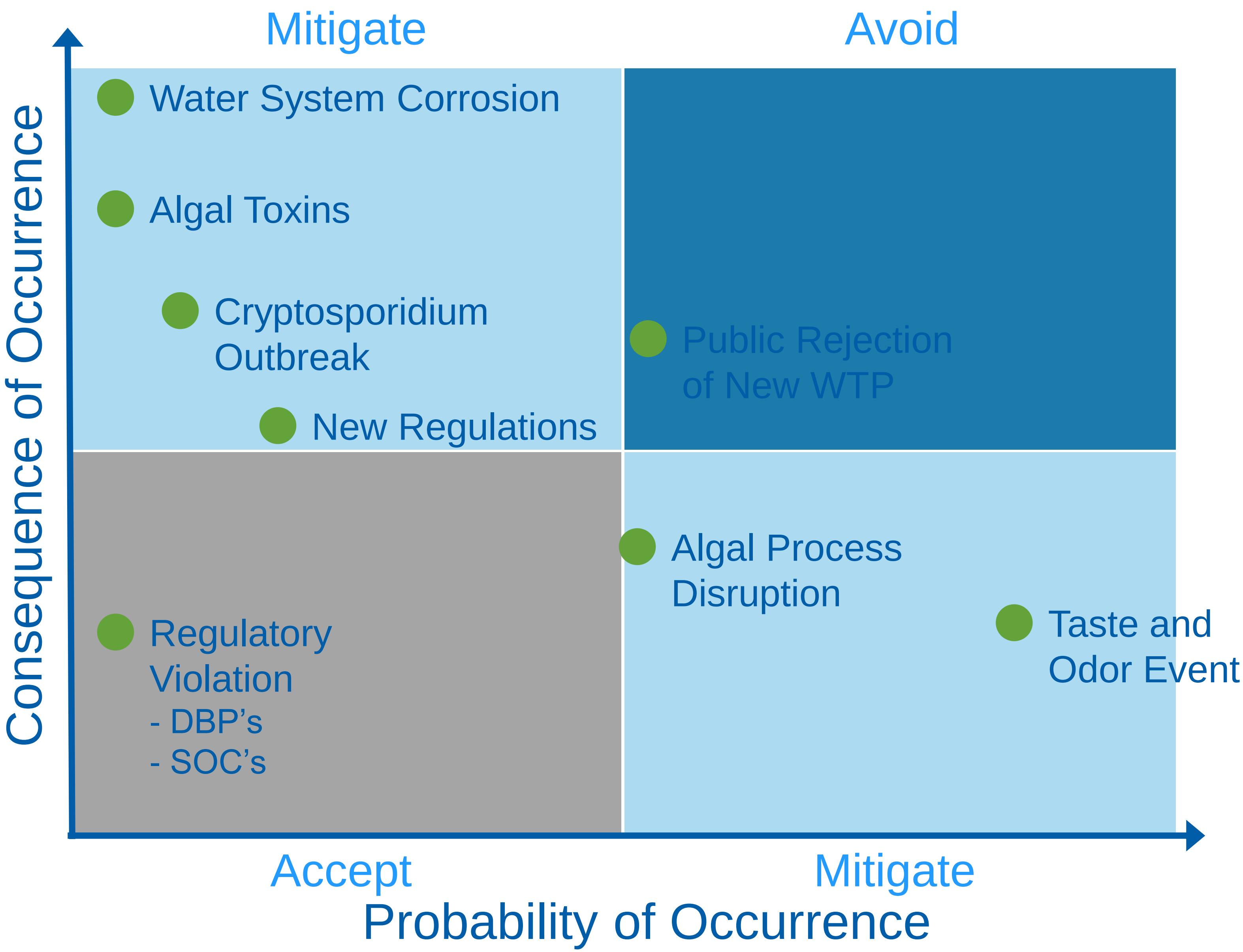


Short-Term Improvements

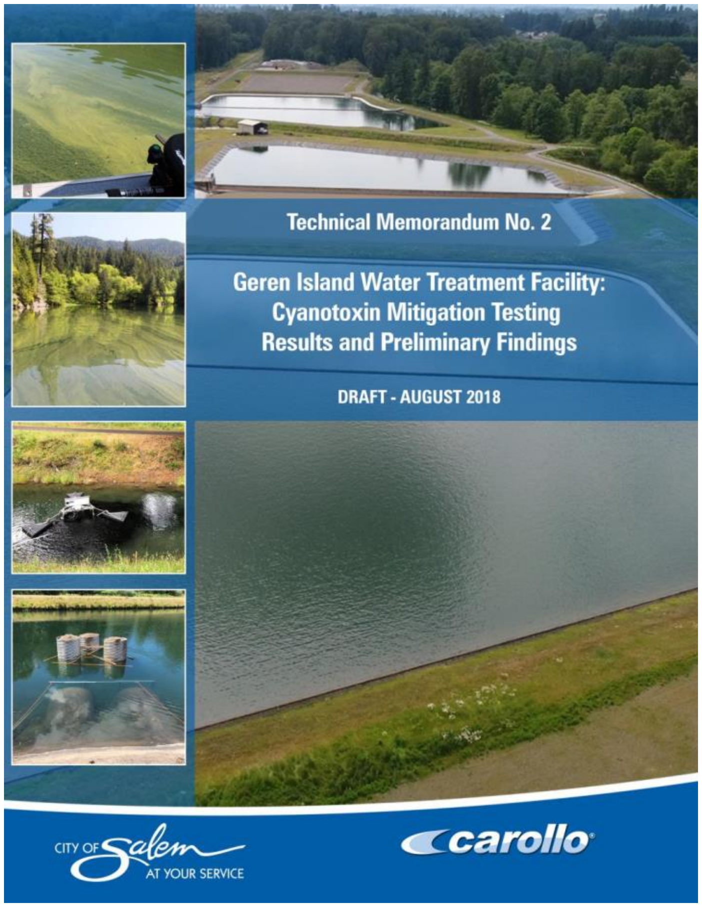
- Re-Sanding Roughing Filter No. 2
- Connect Groundwater Wells to Pump Station.
- Expansion of the South Basin
- Dechlorination Facilities at Points of Entry
- Slow Sand Filter Acetic Acid Dosing Improvements
- Flow Monitoring Improvements
- SCADA System Improvements

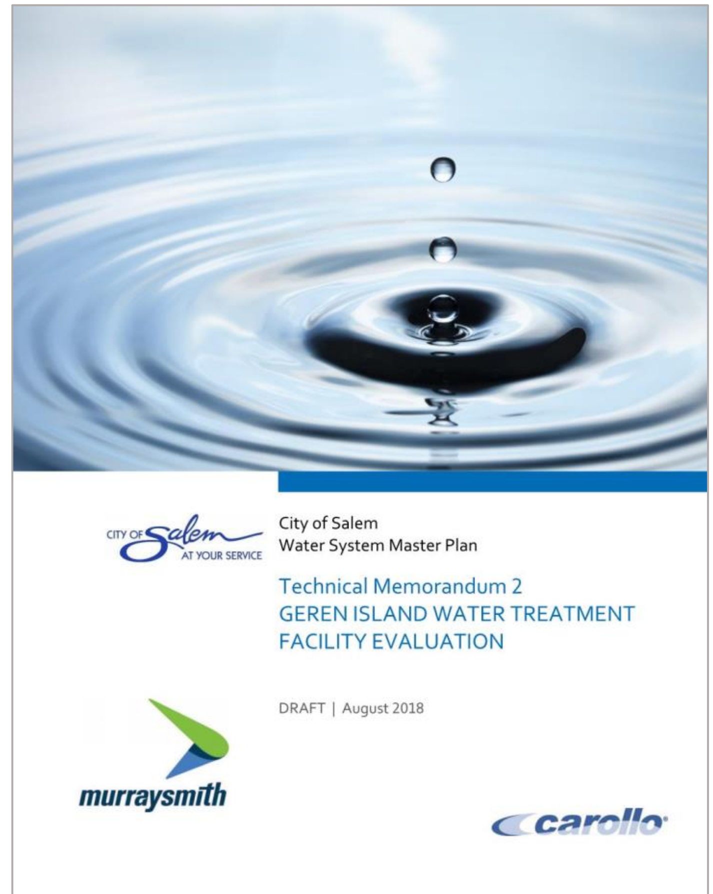
Long-term Solution

2018 has Changed the Way the Region Views Risks Associated with Algal Toxins

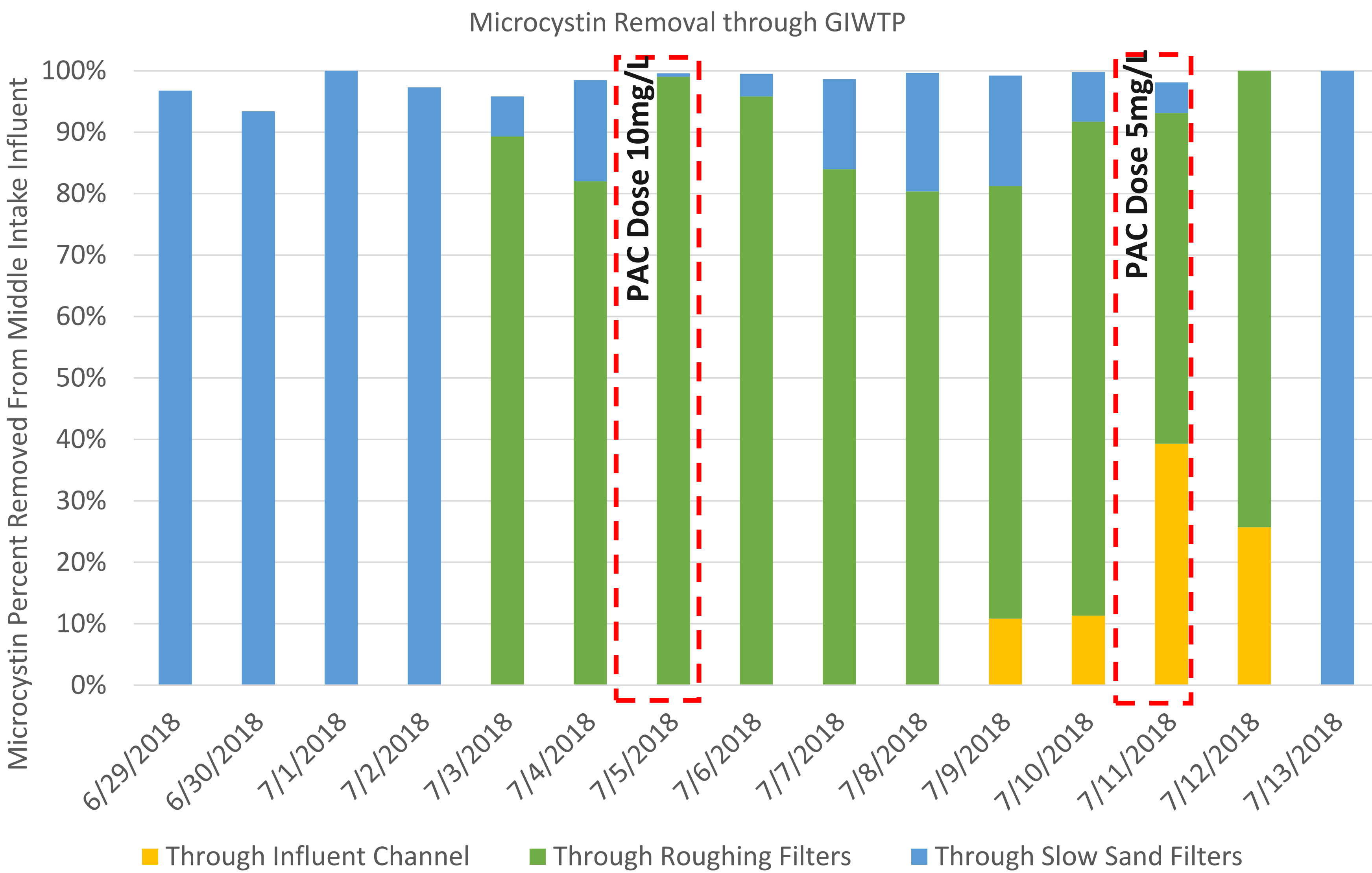


2-months of Intense Analysis Developed the Following Documents





Key Finding: Biological Filtration (Slow Sand) have Proven Ability to Removal Cyanotoxins



Key Finding: Biological Filtration Alone has not Proven to be a Reliable Barrier to Cyanotoxins

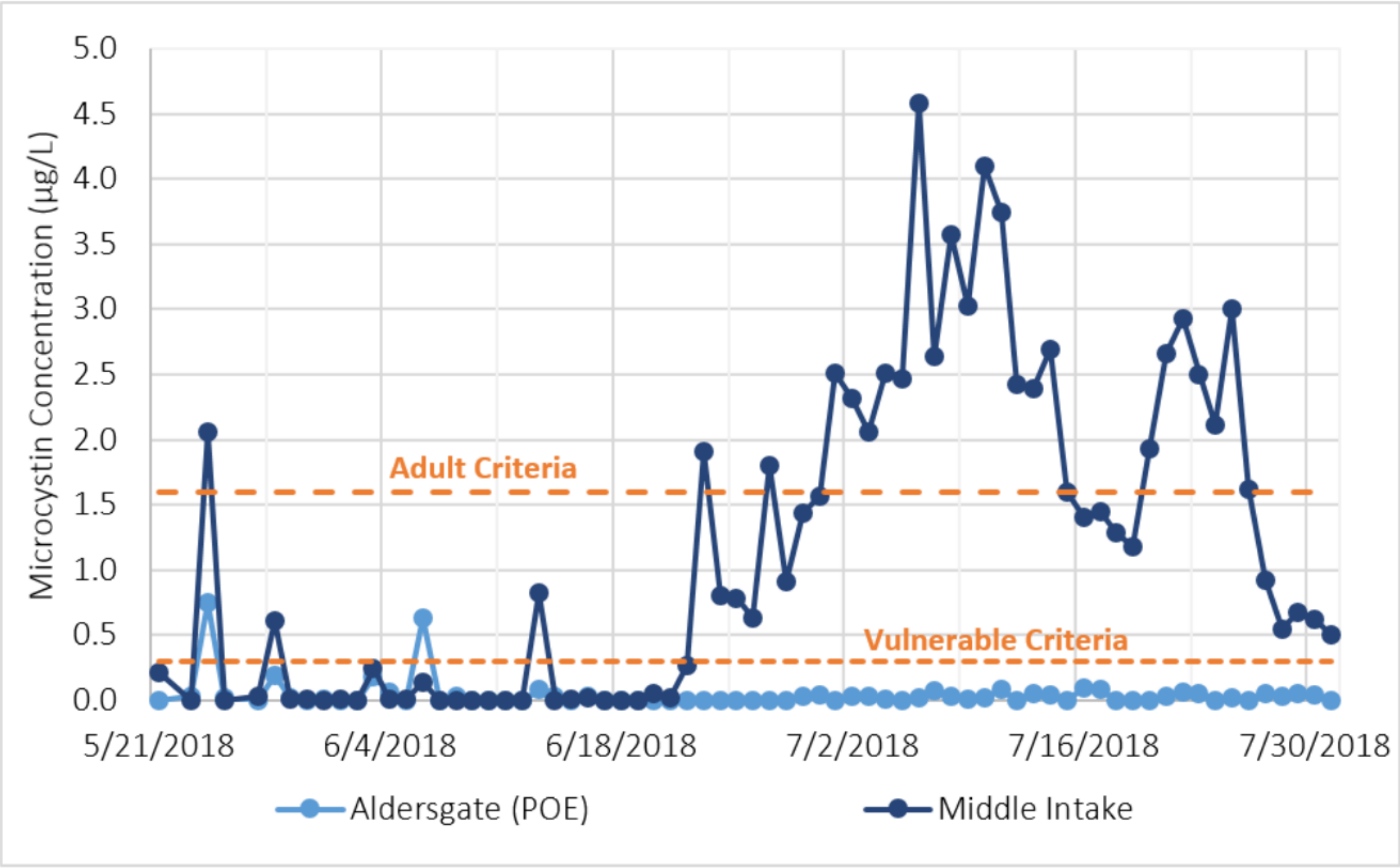


Figure 2.2 Microcystin Concentrations at the GIWTF Intake and Aldersgate (POE)

What is the Most Appropriate

Additional Barrier for Cyanotoxins?

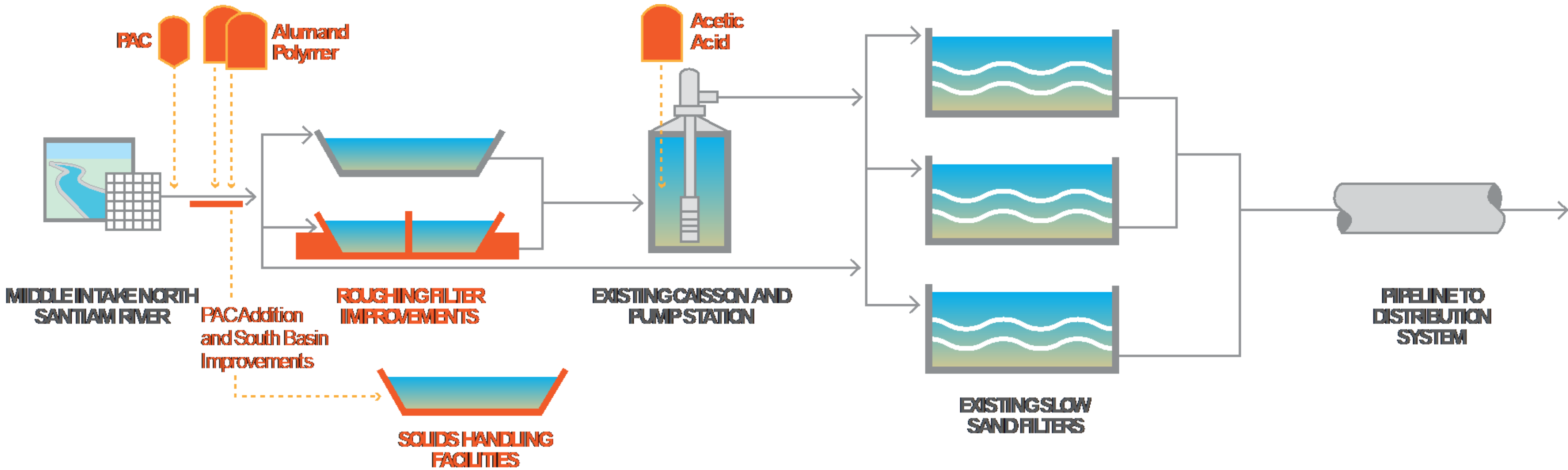
	Saxitoxin	Anatoxin-a	Cylindrospermopsin	Microcystin
Ozone	-	+	+	+
~~Permanganate~~	~~-~~	~~+~~	~~-~~	~~+~~
Chlorine (existing)	+	-	+	+
Activated Carbon	0	+	+	+
Biofiltration (existing)	-	+	+	+
Advanced Oxidation (UV+H_2O_2)	?	+	+	+
~~Nanofiltration/Reverse Osmosis~~	~~+~~	~~+~~	~~+~~	~~+~~

Five Processes Considered as an Additional Barrier for Cyanotoxins

1. PAC
2. Cl (‘Hyper’ Chlorination)
3. UV / AOP + GAC
4. GAC
5. O_3

Treatment System Alternatives:

#1 Roughing Filter + PAC



Benefits

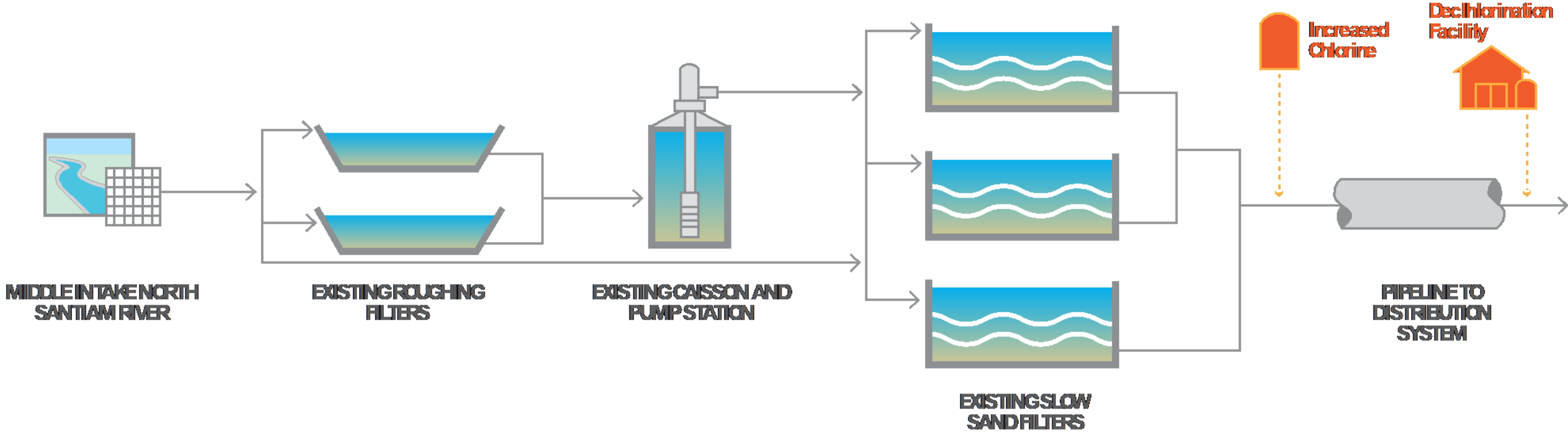
\+ Generally maintains existing systems / process operation

Right near-term solution; but not good fit for long-term

Challenges

- PAC is challenging to mix and settle
- Coagulant may upset roughing filters
- Additional food dose required for filter biological operation
- Significant labor required for dosing, dredging and dewatering
- PAC varies with type/dose; treatment difficult to monitor

Treatment System Alternatives:
#2 Roughing Filter + Cl (Hyper-chlorination)



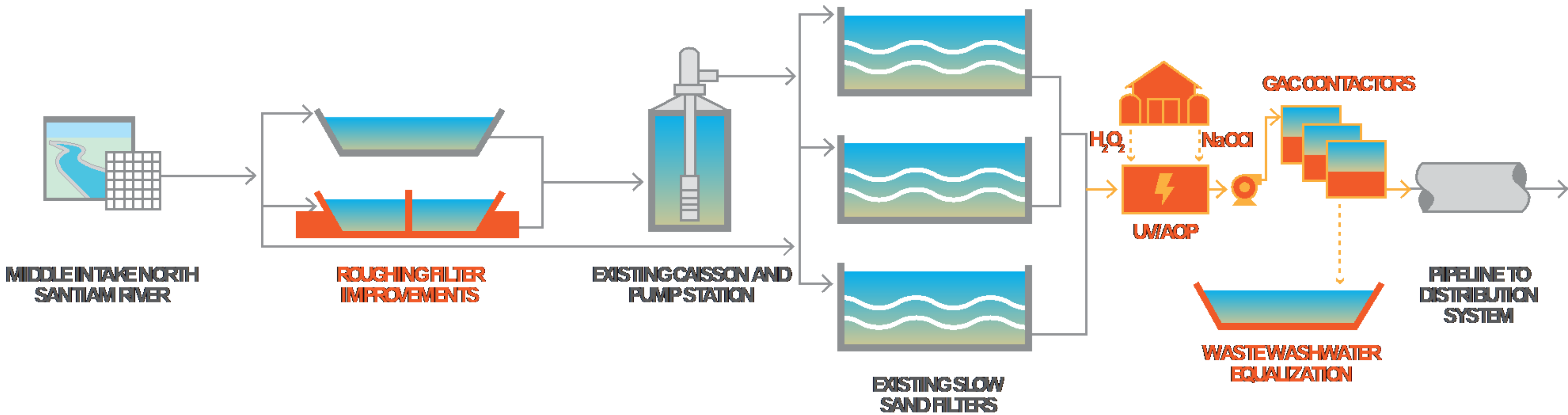
Benefits

+ Maximizes value of existing infrastructure
+ Allows SS Filters to ripen to algal toxins
+ Can be implemented quickly (i.e. if/when there is a 'hit' for toxins)

Challenges

- Treatment does not occur on-site; if not effective, no options to avoid water entering the distribution system
- Dechlorination would need to occur u/s of Turner turnout OR a new pump station would need to be installed at Franzen to back-feed Turner

Treatment System Alternatives:
#3 Roughing Filter + UV / AOP + GAC



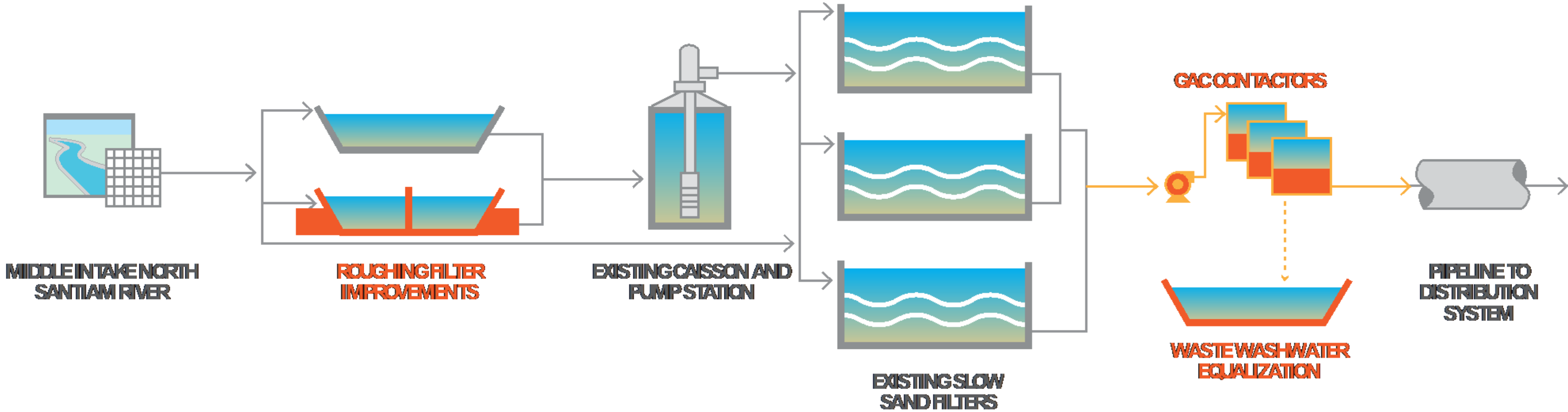
Benefits

+ Highly effective treatment for current and future contaminants
+ Allows SS Filters to ripen to algal toxins

Challenges

- Operationally complex
- New residuals treatment and waste stream (potential permit challenges)
- Energy intensive
- Chemically intensive

Treatment System Alternatives:
#4 Roughing Filter Improvements + GAC



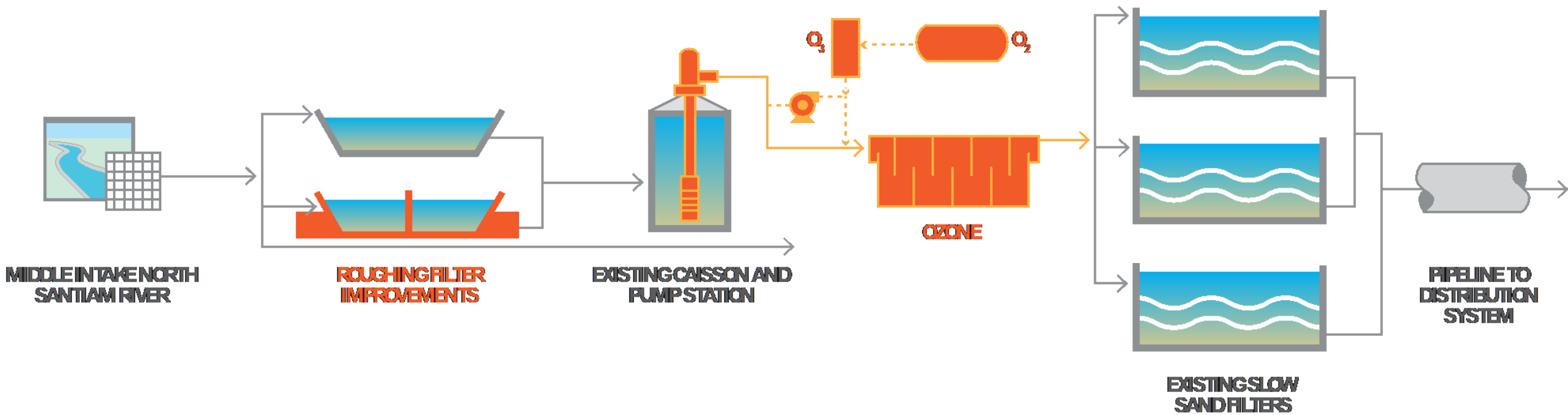
Benefits

+ Construction away from existing core plant facilities
+ Allows SS Filters to ripen to algal toxins

Challenges

- Additional pumping
- New residuals stream
- Difficult to monitor GAC remaining life, treatment effectiveness
- Treatment dependent on source/type of GAC
- GAC life dependent on background NOM

Treatment System Alternatives:
#5 Roughing Filter Improvements + Ozone



Benefits
+ Ozone is excellent for algal toxins
+ Ozone will provide food for filters; no need for additional substrate
+ Disinfection benefits; only screened option that provides an advanced barrier for emerging pathogens

Challenges
- New chemical required on-site
- Ideally located adjacent to existing core facilities, creating operations impacts during construction
- Doesn’t allow SS filters to acclimate to the algal toxins

Alternatives Analysis

Evaluation Criteria

- Decision between the processes should be made based on Cost and Risk Factors, including:

	criteria	description	weight	technology PAC	Cl[1]	UV/AOP+GAC	GAC	O3
Risk	proven performance		1	3	3	4	variability in types; breakthrough 4	5
	multiple barriers		1	1	since it's added d/s of the ss filters 5	since it's added d/s of the ss filters 5	since it's added d/s of the ss filters 5	1
	water quality	if everything is working great, which produces the best water quality	1	3	increased DBP; added chemicals. 2	5	works well, but won't taste as good as ozone 4	ozonated water tastes better 5
	adaptability	provides additional treatment benefits (CECs)	1	doesn't do as well with metals as GAC 3	1	5	addresses PFOA/PFOS and metals; no disinfection benefits 4	doesn't address PFOA/PFOS and metals; has disinfection benefits 4
	o&m complexity		1	solids handling 1	5	1	have to replace media 3	4
	Total			***11***	***16***	***20***	***20***	***19***

Risk Factors can Help Narrow the List

5 Excellent

3 Good

1 Fair

	Option				
	PAC	CL	UV/AOP +GAC	GAC	O3
Proven Performance	3	3	4	4	5
Multiple Barrier	1	5	5	5	1
Water Quality	3	1	4	4	5
Adaptability	3	1	5	4	4
O&M Complexity	1	5	1	3	4
Subtotal	**11**	**15**	**19**	**20**	**19**

One 'hole' in the Ozone Approach Which can be Filled w/ Chlorination

5 Excellent

3 Good

1 Fair

	Option				
	PAC	CL	UV/AOP +GAC	GAC	O3
Proven Performance	3	3	4	4	5
Multiple Barrier	1	5	5	5	1
Water Quality	3	1	4	4	5
Adaptability	3	1	5	4	4
O&M Complexity	1	5	1	3	4
Subtotal	**11**	**15**	**19**	**20**	**19**

One ‘hole’ in the Ozone Approach Which can be Filled w/ Chlorination

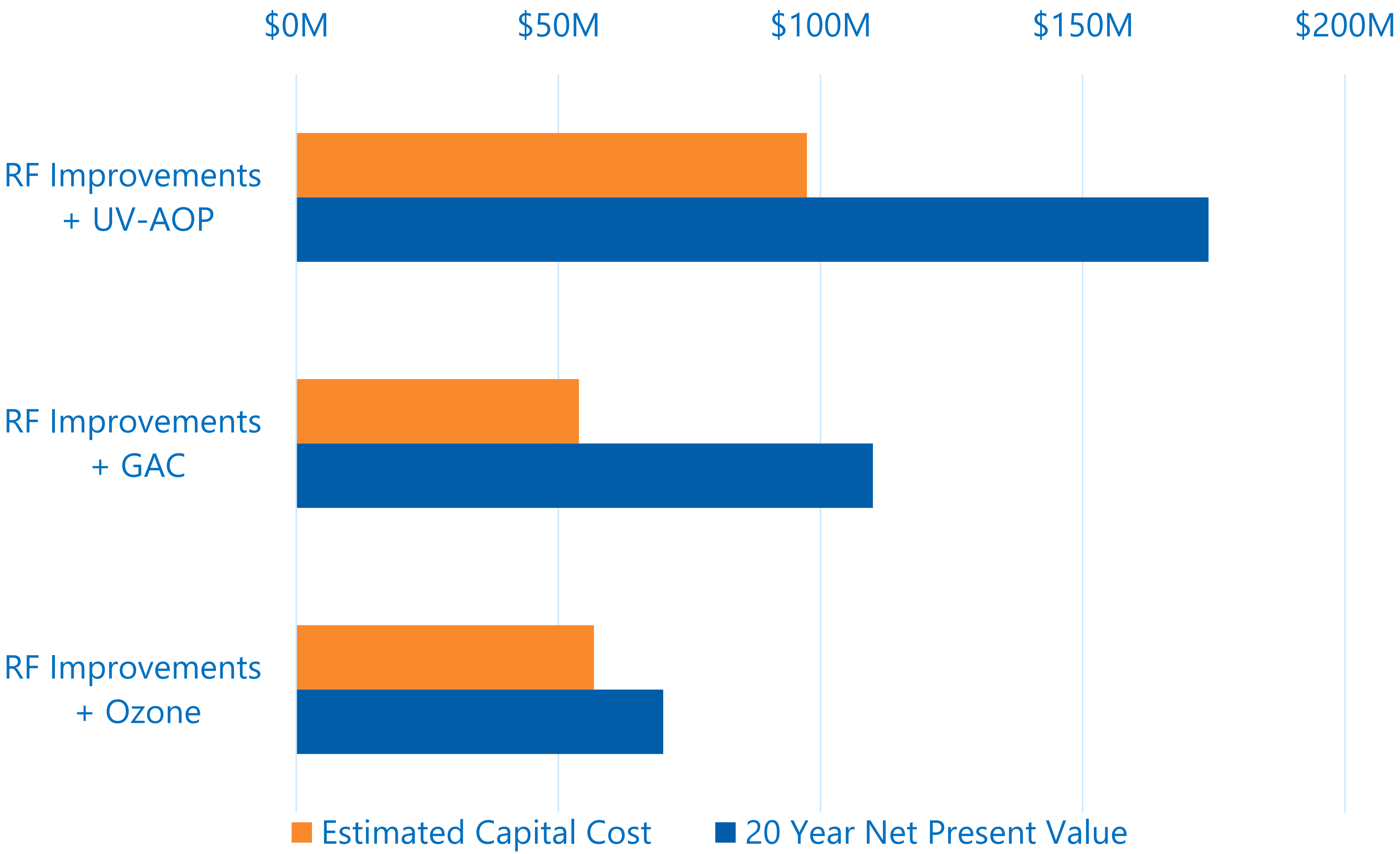
5 Excellent

3 Good

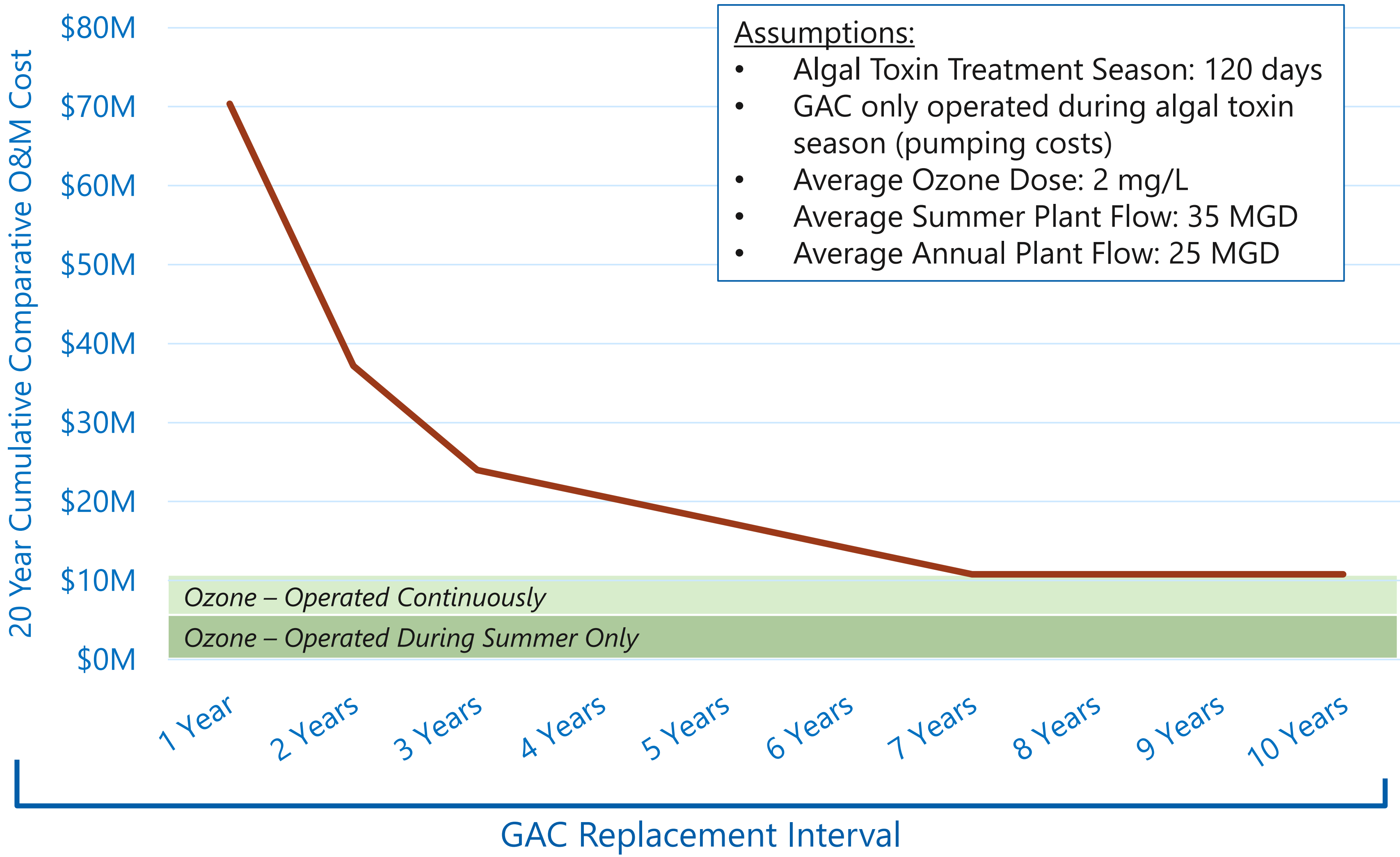
1 Fair

	Option				
	PAC	CL	UV/AOP +GAC	GAC	O3 + CL
Proven Performance	3	3	4	4	5
Multiple Barrier	1	5	5	5	**5**
Water Quality	3	1	5	4	5
Adaptability	3	1	5	4	4
O&M Complexity	1	5	1	3	4
Subtotal	**11**	**15**	**20**	**20**	**23**

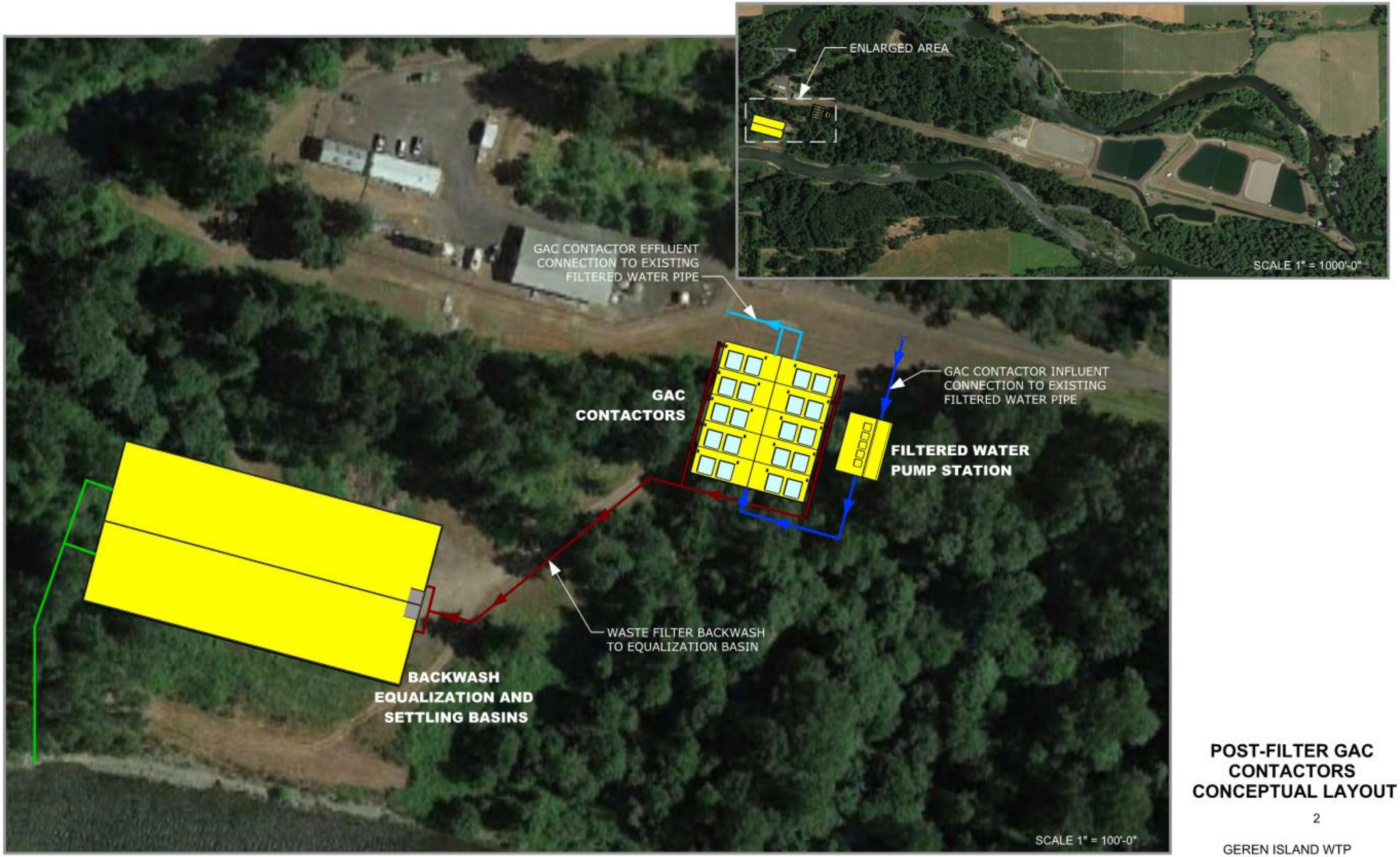
Cost Considerations can Further Narrow the List



O&M Cost Sensitivity to Operations



Implementation: Effluent GAC Contactors



POST-FILTER GAC CONTACTORS CONCEPTUAL LAYOUT

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GEREN ISLAND WTP IMPROVEMENTS
CITY OF SALEM

Implementation: Intermediate Ozone

INTERMEDIATE OZONE CONCEPTUAL LAYOUT

FIGURE 3

GEREN ISLAND WTP IMPROVEMENTS
CITY OF SALEM

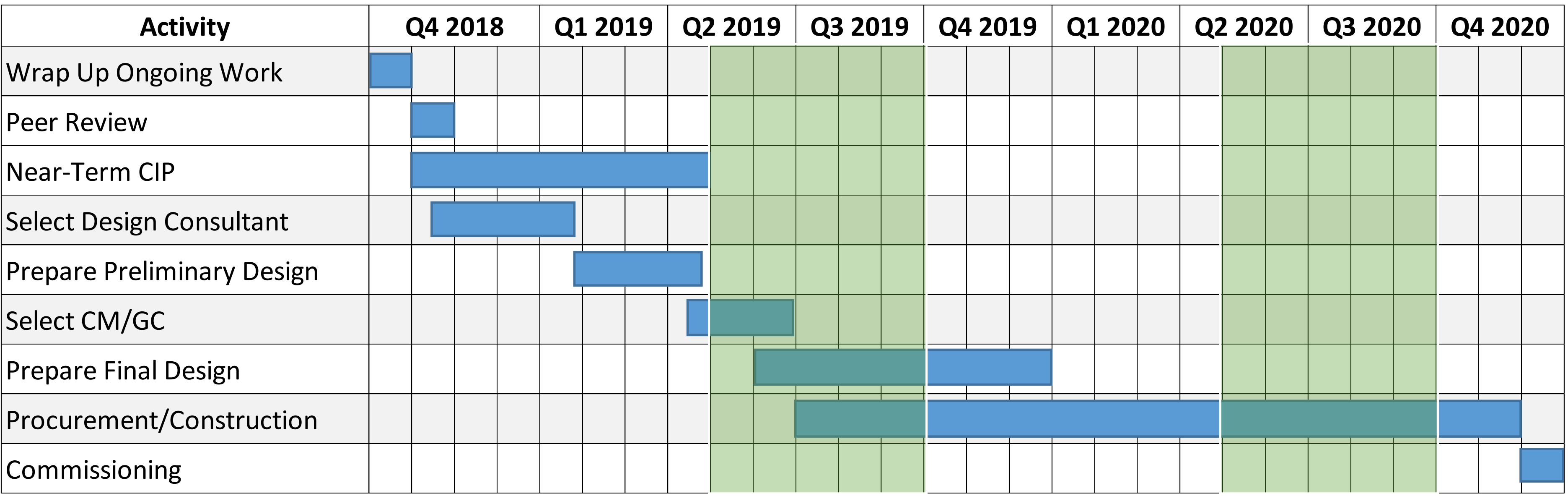
Recommendation

Strategy for Developing Recommendation

- Roughing Filters + GAC: 80% of Risk Score (20/25) for $90M - $110M
- ***Roughing Filters + Intermediate Ozonation: 92% of Risk Score (23/25) for $70M***

Next Steps

Measured Approach to Implementing Long-term Solution will Enhance Stakeholder Support



- Peer Review of the findings and recommendations
- City must operate on an ‘interim’ basis w/ PAC for next 2 algal seasons; near-term CIP to enhance reliability, increase capacity and provide operational flexibility is required

Questions