



June 26, 2023

Zuzanna Rand
Project Manager
Western Municipal Water District
14205 Meridian Parkway
Riverside, CA, 92518

Re: Amended Piloting Scope for PFAS Treatment

Dear Ms. Rand,

This letter describes the reasoning for the proposed modifications to the pilot phase for Design for PFAS Removal at WRRF project, as well as the proposed modifications to the piloting equipment, the proposed new schedule, and level of effort. It should be noted that water quality challenges related to the large spike in PFAS concentrations observed starting February 2023 will not be remedied with this revised treatment approach. We understand the cause(s) of the large PFAS spikes are being investigated by Western staff, with the expectation that the source(s) can be controlled.

Background

The piloting phase for the project began on April 6th, 2023 and was focused on investigating the performance of two adsorbent media (GAC and IX) for PFAS removal. The pilot influent water was supplied by tertiary filter #1 and was operated for 20 days, until severe fouling all throughout the pilot equipment rendered the pilot inoperable. Proliferation of algae within the pilot system contributed to severe bio-growth within the adsorption columns as well as fittings, valves and instruments (rotameters) in the system, leading to premature pressure buildup within the adsorbent bed. In the follow up discussions with the operators, algae occurrence events are seasonal and frequent at WRRF, predominantly forming in the equalization (EQ) basins that currently feed the tertiary cloth filters. The organic matter as well as nutrients, such as phosphorus and nitrogen present in tertiary wastewater, in the presence of sunlight, are promoters for the algae formation.

The organic matter present in the tertiary treated wastewater may also compete with PFAS for adsorption sites particularly on GAC. Adsorbed concentrations of organic matter can lead to rapid exhaustion of the GAC bed and frequent changeout that may ultimately limit the feasibility of GAC implementation. Identification of these pitfalls at the pilot scale prior to full scale implementation supports the value in this PFAS treatment piloting program for WMWD.

Technology for Amended Pilot Phase

Due to the foregoing fouling, an amended piloting phase is recommended to evaluate additional pretreatment approaches for PFAS treatment. Hazen's prior experience with similar wastewater applications, suggests that alternatives such as coagulation/flocculation may be effective pretreatment for reduction of dissolved nutrients that control algae growth, particularly phosphorus (up to 80%), which is

the limiting nutrient for algae reproduction. Moreover, coagulation/flocculation has the added benefit of reducing the total organic carbon (TOC, up to 30%), which is a foulant for any PFAS adsorptive media and competes with PFAS removal in the case of GAC. In alignment with the existing treatment infrastructure at WWRF, conventional coagulation/flocculation and filtration treatment technologies are proposed for the reduction of phosphorus and organic matter to prevent algae formation, reduce fouling, and prolong PFAS adsorption performance. The implementation of coagulation/flocculation at the WWRF could be most readily implemented compared with other treatment options (such as membranes systems), since WWRF already has the infrastructure for coagulation/flocculation and the cloth media filters are existing and in operation. To supplement the additional pilot pretreatment steps, Hazen will also manage algae proliferation in the adsorption columns by using opaque tubing and piping with supplemental UV blocking attachments to columns and tanks where needed. The amended pilot includes two pretreatment units, which will operate upstream of the pilot columns already at the site for PFAS removal (Figure 1):

- Coagulation/flocculation unit (provided by Intuitech);
- Cloth filter skid (provide by Aqua-Aerobic)

It should be noted that the coagulation/filtration treatment infrastructure already exists at the plant but has been disabled since 2016. Historical operation of the coagulation process included the use of alum coagulants, which was deemed operationally challenging. The amended pilot testing will reexamine coagulant addition for most suitable selection and dosage. We have proposed a set of preceding bench scale jar tests to rapidly evaluate coagulation and flocculation conditions to be validated in the piloting phase.

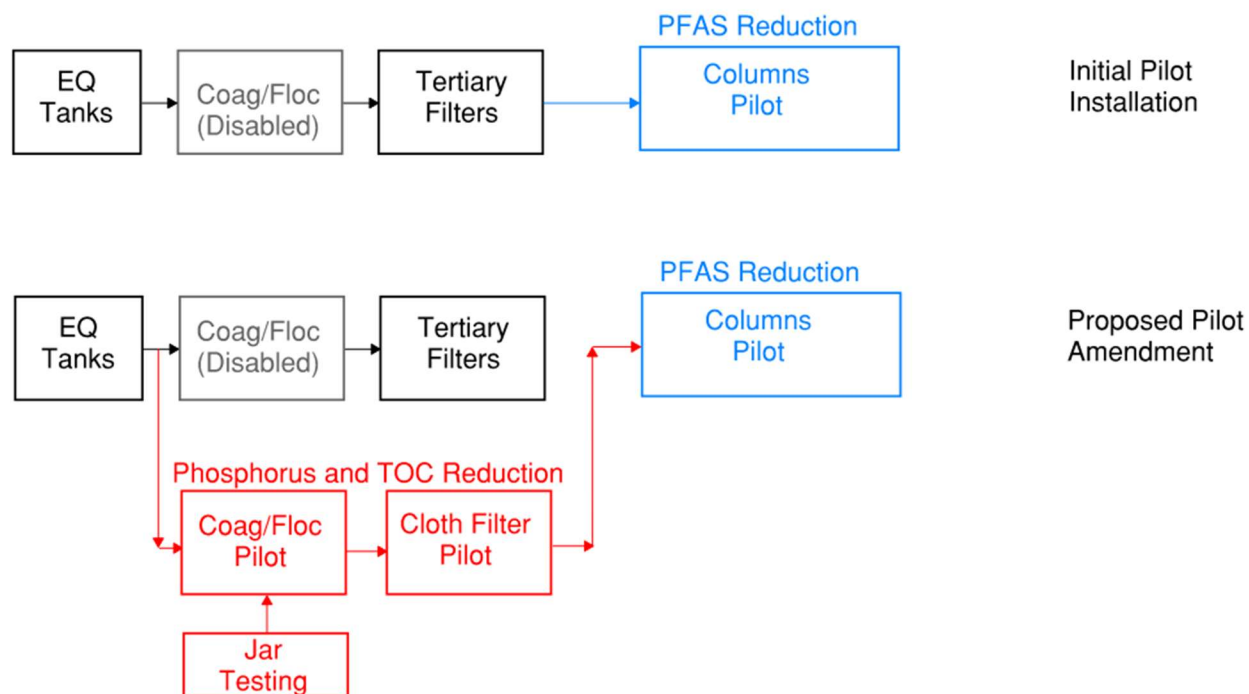


Figure 1. Initial and Amended Pilot System

Schedule and Level of Effort

The amended pilot testing phase is scheduled for three months and can commence once the PFAS levels in tertiary treated wastewater are down to the average concentration measured in December 2022-January 2023. At the time of preparing this memorandum, the new pilot units are available from vendors. The testing plan includes multiple components that were not included in the original piloting phase. These additional piloting units include:

- The procurement of additional pilot testing equipment to provide coagulation and flocculation and cloth filtration.
- A bench scale jar testing experimental plan to investigate appropriate coagulant selection and doses.

With additional piloting pretreatment stages, this amended piloting phase will require additional resources relative to the previously executed adsorption pilot. The added resources required include:

- An extension of the leased adsorption testing columns currently at the site.
- Additional time commitment from Hazen staff trips for routine pilot operation, maintenance, and sampling for field and laboratory testing.
- Additional analytical resources to characterize PFAS removal performance as well as the effectiveness of pretreatment approaches with analytes such as nitrogen and phosphorus species, total organic carbon, chemical oxidation demand, and others.
- Additional time required for data synthesis and reporting with expanded treatment processes and wastewater treatment process examination. In addition to the proposed experiments for this piloting campaign, Hazen's wastewater technical experts Dr. Wendell Khunjar and Dr. Gaya Ram Mohan will provide insight into potential wastewater process modifications that may be valuable in prolonging adsorbent bed life.

To reduce some of the analytical costs anticipated from this amended piloting campaign, we have proposed conducting a portion of the required lab analyses with field measurements using Hazen's portable ultraviolet transmittance meter and spectrophotometer. This approach will enable faster turnaround times and lower costs for frequently collected samples for nutrients and UV254.

Hazen is grateful for the opportunity to continue to work with WMWD to address PFAS treatment challenges. Enclosed is the proposed work breakdown structure and accompanied fee for this amended piloting phase. Please do not hesitate to contact us for further information regarding this proposed piloting campaign.

Best regards,

Silvana Ghiu, PhD, PE

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Western Municipal Water District Amended Piloting Phase Fee

<div>Hazen</div>		Hazen and Sawyer										
		Principal in Charge	Project Manager	Pilot Design Engineer	QA/QC	Pilot Engineer	Assistant Engineer	Technical Advisors				
		C. Miller \$329	S. Ghiu \$260	C. Murray \$150	N. Blute \$295	D. Rodriguez \$150	M. Bekhradan \$150	G. Ram Mohan & W. Khunjar \$260				
									TMH	Labor	ODC	Total
Task 600 - Amended Pretreatment and Adsorption Pilot Testing												
6.1 Proposal Development, Pilot Planning and Lab Coordination		7	21	36	7			18	89	\$19,908		\$19,908
6.2 Drafting the Testing Plan (ppt slides)			8	20	2			4	34	\$6,710		\$6,710
6.3 Jar Testing Plan			4	8	2	2	2	2	20	\$3,950		\$3,950
6.4 Jar Testing Execution			8	8	1	32	16	2	67	\$11,295	\$3,745	\$15,040
6.5 Amended Pilot Startup			16	8		24	16	4	68	\$12,400		\$12,400
6.6 Amended Pilot Testing			24	16		240	72	8	360	\$57,520	\$69,780	\$127,300
6.7 Amended Pilot Decommissioning						16	16		32	\$4,800		\$4,800
6.8 Data Compiling and Analysis		4	16	24	8	8	40	16	116	\$22,796		\$22,796
6.9 Modifications to existing WW treatment infrastructure (Algae)			4	8			8	48	68	\$15,920		\$15,920
6.10 TM Development		2	12	32	4		40	8	98	\$17,838		\$17,838
AMENDED PILOT TASK TOTAL		13	113	160	24	322	210	110	952	\$173,137	\$73,525	\$246,662
REMAINING BUDGET ON PILOT TASK 600										\$29,735	\$48,783	\$78,518
TASK 5 ADDITIONAL BUDGET										\$143,402	\$24,742	\$168,144

Details of the Other Direct Costs (ODC)

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Field and Lab Sampling Cost		
Pilot Sampling Cost	Included Analytes: PFAS, COD, TOC, UVT, pH, Alkalinity, Turbidity, NO3, NH3, TP, OP	\$ 18,000
Jar Testing Sampling Cost		\$ 1,700
Sampling Contingency		15%
Total Sampling Cost		\$ 22,655

Pilot Construction Materials

Coagulation/Floc/Sed Rental 17 weeks											\$ 35,978
Calgon Column Rental		Pilot column \$350/month starting July 6th									\$ 2,100
Piloting Supplies											\$ 1,500
Cloth Filter Rental											\$ 2,500
Mileage		140 miles RT	5 Trips Wk	12 Wk	\$.655/mile						\$ 5,502
Pilot Contingency											\$ 1,500
Jar Testing											
Hach and Turbidimeter Vials (disposal) + Jars + 2 trips for water collection											\$ 1,540
Coagulants											\$ 250
Pilot Construction Materials Cost											\$ 50,870