Pilot Update

Date	11/28/2022
Memo to	Sanjeev Tagra (HW)
Project name	Halifax Water DAF Pilot
Subject	JDK Pilot Update
From	CBCL
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Introduction

The following memo summarizes the pilot plant operations for July – November 2022. This memo includes information on the pilot plant operating conditions and water quality results.

Pilot Plant Operating Conditions

Table 1 provides a summary of the pilot plant conditions that were tested to date for the JDK DAF pilot.

Table 1: Summary of Variables Trialed

Parameter	Conditions Tested
Pilot Flow Rate	75 gpm
Floc Times	7 (1 stage), 14 (2 stage), 23 (3 stage)
Alum Dose	10-50 mg/L (as active product) 20-100 mg/L (volume basis)
$KMnO_4$ Dose	0-0.2 mg/L
$KMnO_4$ Oxidation Time	0 sec, 30 sec, 10 minutes
Filter Media	F1-GAC, F2- JDK Anthracite

Additional pilot plant parameters (held constant):

- Flocculation mixers set for rapid mix, flocculation tank 1 and flocculation tank 2 set at 80 rpm, 80 rpm and 40 rpm respectively (corresponds to mixing speeds of approx. $72s^{1}$, $78s^{-1}$, and $27s^{-1}$).
- Recycle flow rate held constant at approximately 9.9 gpm (recycle % of 10.9%-11.2%).

Table 2 provides a summary of the pilot plant operating conditions during the initial pilot plant operating period. The pilot plant spreadsheet (JDK DAF Pilot Plant Water Data) can be referred to for more detailed operating conditions.

Table 2: Pilot Plant Operating Conditions

Trial Start	Trial End	Alum Dose mg/L	Floc Time min	Coag. Type	KMnO4 Dose mg/L	Oxidation Time	Filter Feed gpm
2022-04-29	2022-05-12	40	23 min	Alum	0	~30 sec	5
2022-05-12	2022-05-13	40	23 min	Alum	0	~30 sec	5
2022-05-13	2022-05-16	50	23 min	Alum	0	~30 sec	5
2022-05-16	2022-05-16	40	23 min	Alum	0	~30 sec	5
2022-05-17	2022-05-17	40	23 min	Alum	0	~30 sec	5
2022-05-17	2022-05-25	50	23 min	Alum	0.15	~30 sec	5
2022-05-27	2022-05-31	40	23 min	Alum	0	~30 sec	5
2022-06-01	2022-06-01	40	23 min	Alum	0	~30 sec	5
2022-06-02	2022-06-03	40	23 min	Alum	0	~30 sec	5
2022-06-03	2022-06-03	40	23 min	Alum	0	~30 sec	5
2022-06-03	2022-06-03	60	7 min	Alum	0	~30 sec	5
2022-06-06	2022-06-07	40	23 min	Alum	0	~30 sec	5
2022-06-09	2022-06-09	40	23 min	Alum	0	~30 sec	5
2022-06-10	2022-06-10	40	23 min	Alum	0	~30 sec	5
2022-06-13	2022-06-13	40	23 min	Alum	0	~30 sec	5
2022-06-13	2022-06-13	60	23 min	Alum	0.05	~30 sec	5
2022-06-14	2022-06-14	40	23 min	Alum	0	~30 sec	5
2022-06-15	2022-06-15	40	23 min	Alum	0	~30 sec	5
2022-06-15	2022-06-15	50	14 min	Alum	0.05	10 min	5
2022-06-15	2022-06-15	50	14 min	Alum	0.1	10 min	5
2022-06-15	2022-06-15	50	14 min	Alum	0.15	10 min	5
2022-06-15	2022-06-15	50	14 min	Alum	0.2	10 min	5
2022-06-15	2022-06-16	50	14 min	Alum	0	10 min	5
2022-06-16	2022-06-16	40	23 min	Alum	0	~30 sec	5
2022-06-16	2022-06-16	50	14 min	Alum	0.1	10 min	5
2022-06-16	2022-06-16	50	14 min	Alum	0.15	10 min	5
2022-06-16	2022-06-16	50	14 min	Alum	0.2	10 min	5
2022-06-17	2022-06-17	40	14 min	Alum	0	10 min	5
2022-06-17	2022-06-17	15	14 min	Alum	0	10 min	5
2022-06-17	2022-06-17	15	14 min	Alum	0.05	10 min	5
2022-06-17	2022-06-17	15	14 min	Alum	0.1	10 min	5
2022-06-17	2022-06-17	15	14 min	Alum	0.15	10 min	5
2022-06-17	2022-06-17	15	14 min	Alum	0.2	10 min	5
2022-06-20	2022-06-20	50	14 min	Alum	0.1	10 min	5
2022-06-22	2022-06-22	50	14 min	Alum	0.05	10 min	5
2022-06-23	2022-06-23	50	14 min	Alum	0.2	10 min	5

Trial Start	Trial End	Alum Dose mg/L	Floc Time min	Coag. Type	KMnO4 Dose mg/L	Oxidation Time	Filter Feed gpm
2022-06-24	2022-06-24	35	14 min	Alum	0.15	10 min	5
2022-06-27	2022-06-27	80	7 min	Alum	0	~30 sec	5
2022-06-28	2022-06-29	40	7 min	Alum	0	~30 sec	5
2022-06-29	2022-07-04	50	7 min	Alum	0	~30 sec	5
2022-07-06	2022-07-06	90	7 min	Alum	0	~30 sec	5
2022-07-06	2022-07-06	100	7 min	Alum	0	~30 sec	5
2022-07-07	2022-07-07	40	7 min	Alum	0	~30 sec	5
2022-07-07	2022-07-11	50	7 min	Alum	0	~30 sec	5
2022-07-11	2022-07-11	50	7 min	Alum	0.3	~30 sec	5
2022-07-12	2022-07-15	50	7 min	Alum	0.15	~30 sec	5
2022-07-15	2022-07-15	50	7 min	Alum	0.15	~30 sec	5
2022-07-18	2022-07-19	50	7 min	Alum	0.15	~30 sec	5
2022-07-20	2022-07-21	50	7 min	Alum	0.15	~30 sec	5
2022-07-22	2022-07-22	30	23 min	Alum	0	~30 sec	5
2022-07-25	2022-07-26	40	23 min	Alum	0	~30 sec	5
2022-07-26	2022-08-04	40	23 min	Alum	0.15	~30 sec	5
2022-08-05	2022-08-11	40	23 min	Alum	0	~30 sec	5
2022-08-11	2022-08-17	40	7 min	Alum	0	~30 sec	5
2022-08-17	2022-08-26	40	14 min	Alum	0	~30 sec	5
2022-08-26	2022-09-22	40	14 min	Alum	0	~30 sec	2
2022-09-22	2022-10-12	40	7 min	Alum	0.15	~30 sec	2
2022-10-12	2022-10-12	40	23 min	Alum	0	~10 min	2
2022-10-12	2022-10-12	40	23 min	Alum	0.05	~10 min	2
2022-10-12	2022-10-12	40	23 min	Alum	0.1	~10 min	2
2022-10-12	2022-10-12	40	23 min	Alum	0.15	~10 min	2
2022-10-12	2022-10-12	40	23 min	Alum	0.2	~10 min	2
2022-10-13	2022-10-18	50	14 min	Alum	0	~30 sec	5
2022-10-19	2022-10-21	50	14 min	Alum	0.15	N/A	5
2022-10-25	2022-10-25	30	23 min	Alum	0.15	~30 sec	5
2022-10-27	2022-10-27	30	7 min	Alum	0.15	~30 sec	5
2022-10-28	2022-10-29	30	14 min	Alum	0.15	~30 sec	5
2022-11-01	2022-11-01	60	14 min	Alum	0.15	~30 sec	5
2022-11-01	2022-11-02	70	14 min	Alum	0	~30 sec	5
2022-11-02	2022-11-02	70	14 min	Alum	0.15	~30 sec	5
2022-11-03	2022-11-04	70	14 min	Alum	0	~30 sec	5
2022-11-04	2022-11-17	80	23 min	Alum	0	~30 sec	5
2022-11-18	2022-11-20	80	14 min	Alum	0	~30 sec	5

Pilot Plant Water Quality

The following section provides a summary of the key water quality parameters. To assess the performance of the pilot plant, Key Performance Indicators (KPIs) were selected during development of the Process Validation Protocol (PGM800.04 REP-001 (LM Process Validation Protocol)). The values for the KPIs were selected based on the current full scale WSP operations, required treated water quality and the proposed DAF system performance capabilities. The KPIs are presented in Table 3.

Table 3: Pilot Key Performance Indicators

Parameter	Target	Operating Range
Clarifier Turbidity	<0.2 NTU	0.2-0.5 NTU
Clarifier TOC/DOC	< 2 mg/L	2-3 mg/L
TOC Reduction	>60%	55-65%
Clarifier pH	6.0-6.8	
Clarifier UV254	>90% UVT	85-90% UVT
Filter Turbidity	<0.1 NTU	0.1-0.4 NTU
Filter TOC	< 2 mg/L	1.5-2.5 mg/L
Filter TOC Removal	20%	10-20%
Filter Total Manganese	<0.02 mg/L	0.015-0.025 mg/L
Filter Total Aluminum	<0.05 mg/L	0.025-0.075 mg/L
Filter UV 254	>92% UVT	90-95%
Filter Run Times	48 hrs	40-48 hrs
Filter Headloss	8 ft	6-8ft
Filter Unit Run Volume	10,000 gal/ft	7,500-10,000 gal/sf
Sludge Production Volume	<0.1% of total flow	
Sludge Solids Concentration	3%	

TOC

TOC data collected for the pilot and analyzed at the CWRS lab is presented in Figure 1 to Figure 4. Some preliminary commentary is provided below:

- Average raw water TOC over the operating period was 3.3 mg/L ±0.5 and average DAF TOC was 2.2 mg/L ± 0.3.
- Average TOC for F1(GAC) effluent during the operating period was 1.76 mg/L ± 0.05 and was 2.02 mg/L± 0.06 for F2 effluent.
- TOC percent reduction KPIs were not met for DAF or filter effluent as shown in Figure 2; however, the overall filter TOC KPI of 2.0 mg/L was met for 90% of F1 and 52% of F2 TOC results. All filter effluent samples measured were within the KPI TOC operating range (1.5-2.5 mg/L).
- 87% of DAF effluent TOC samples were within the targeted filtered TOC operating range (1.5-2.5 mg/L).
- Three staged flocculation with 23 minute floc time was able to provide approximately 40% TOC reduction in the DAF effluent. TOC % reduction for 7 min and 14 minute floc time varied between 20-40%.
- GAC media (F1) out performed the anthracite media (F2) for effluent filter TOC concentrations, however the margin between samples was often within 0.2 mg/L.
- Alum doses between 20-30 mg/L for each floc time trialed was shown to meet the filtered TOC KPI under warm water conditions.

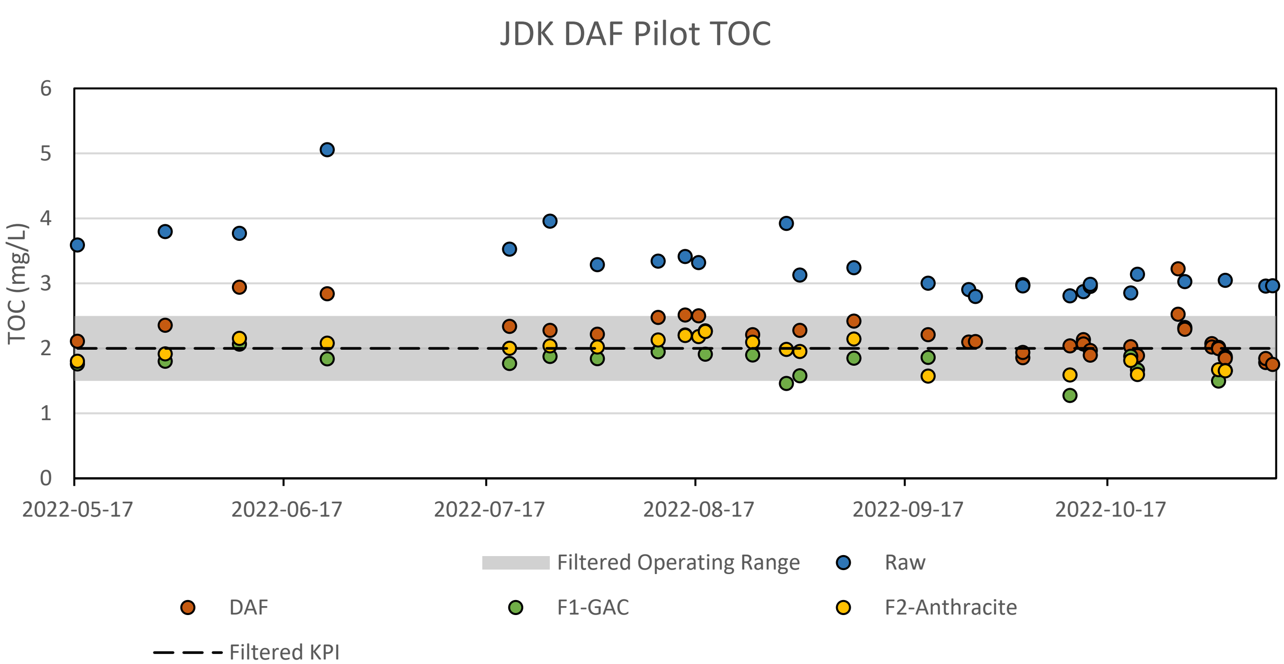

Figure 1: Pilot TOC Data May - November 2022

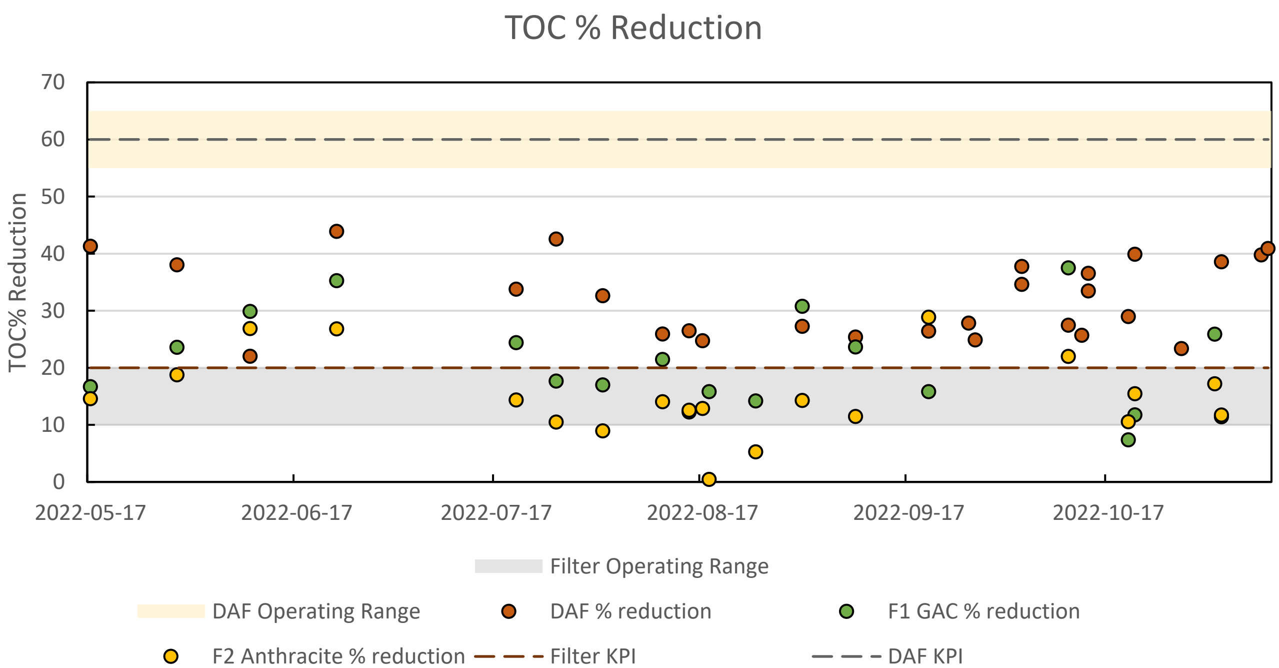

Figure 2: Calculated TOC % Reduction May-November 2022

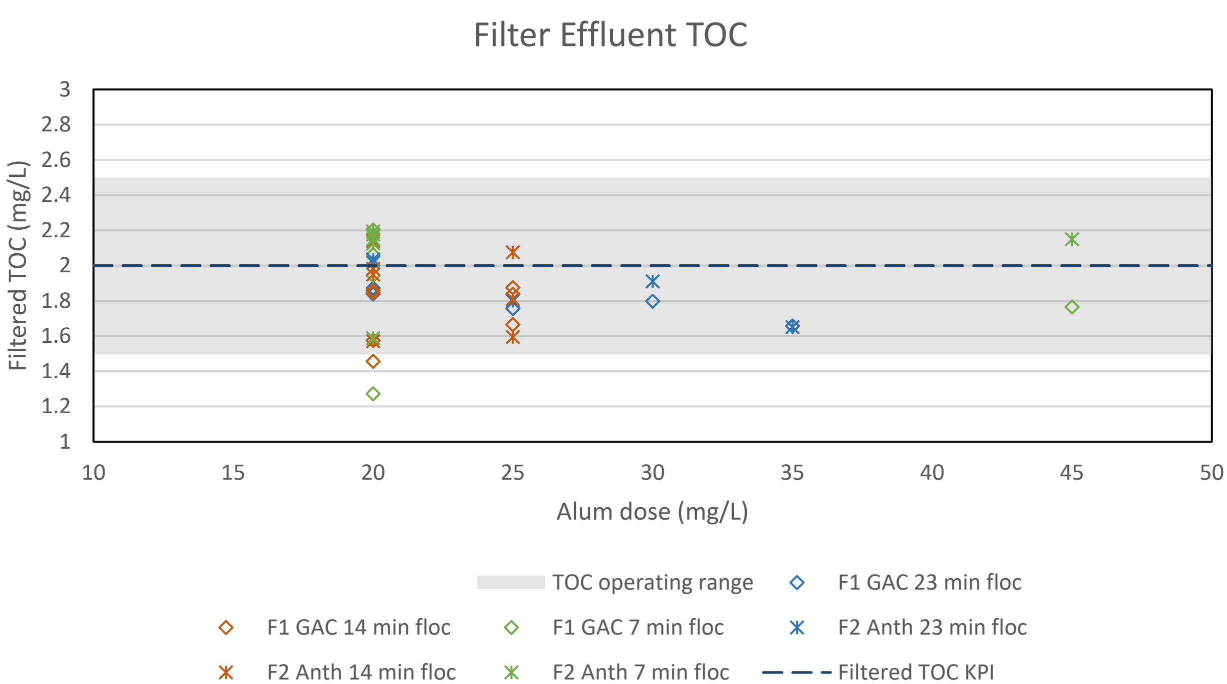

Figure 3: Filter Effluent TOC Compared to Floc Time and Alum Dose

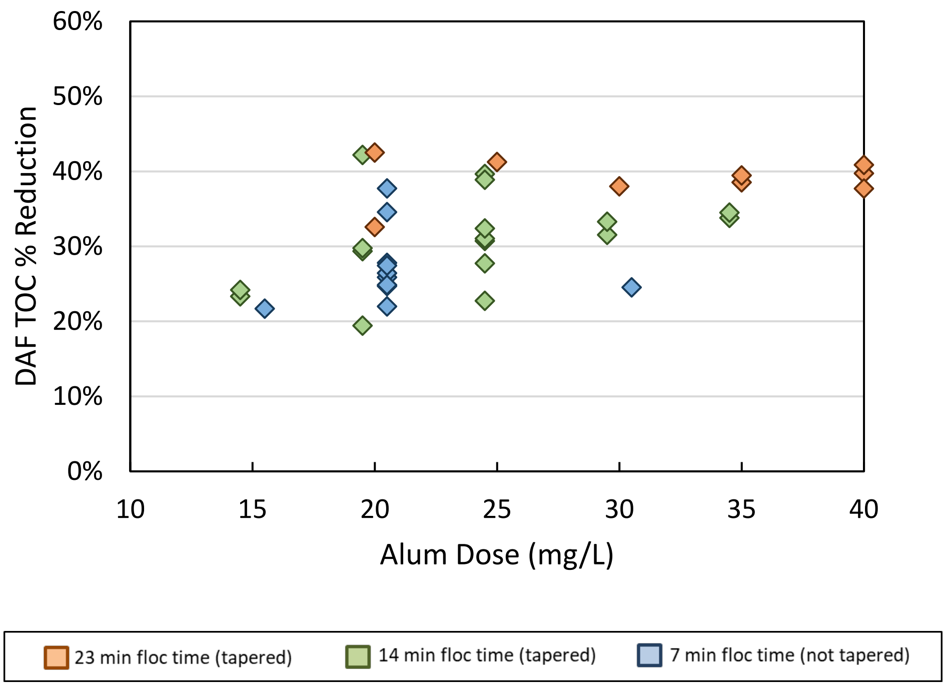

Figure 4: DAF Effluent TOC % Reduction by Floc Time and Alum Dose

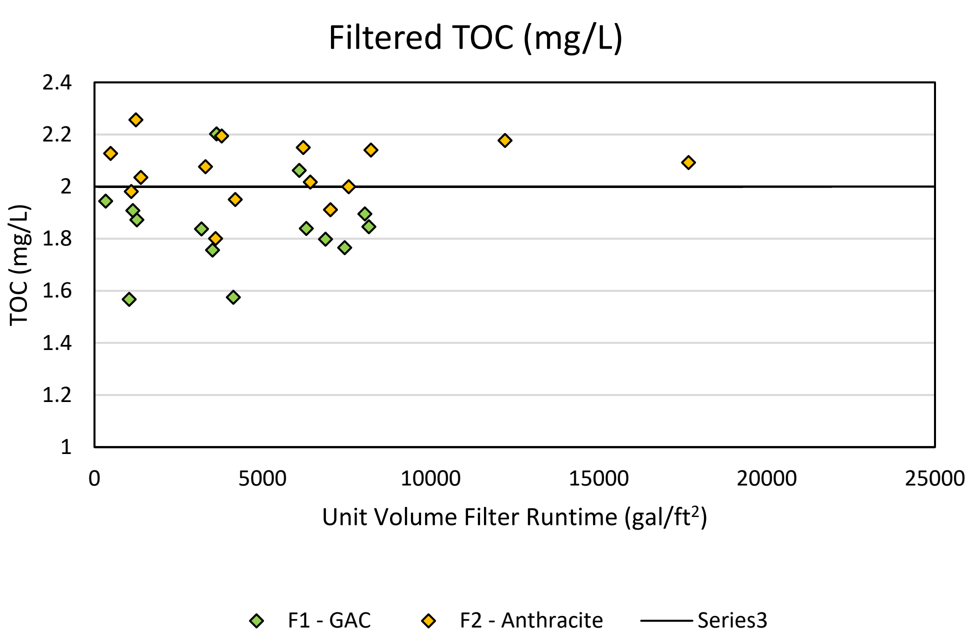

Figure 5: Filter Effluent TOC by Unit Volume Filter Runtime

UVT

For comparison with TOC data, UVT benchtop data collected daily is presented in Figure 6.

- UVT results mostly remained within or below the target range of 85-90% for DAF effluent and 90-95% for filter effluent except for conditions in late June/early July. This correlates with periods of operation where DAF pH fell below the operational range.
- Elevated UVT in early May corresponds to issues with calibration.

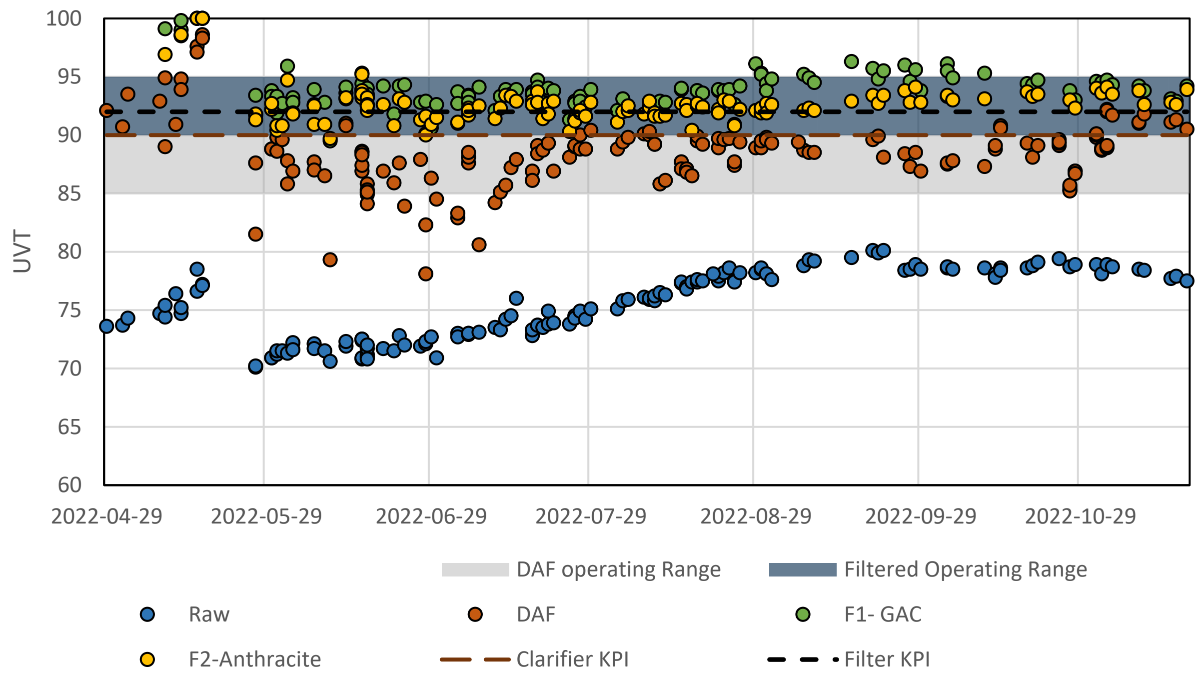

Figure 6: Benchtop UVT Results May-November 2022

Turbidity

Turbidity data is presented in Figure 7 to Figure 12, with some comments provided below:

- Turbidity data presented was collected during stable operating conditions and represents the daily operator check from online turbidimeters. Work is on-going to summarize historical SCADA trends and will be included in subsequent updates.
- Greatest turbidity removal was achieved with 23 minutes of flocculation time and alum dose between 30-40 mg/L. Optimized coagulant dose for turbidity removal was 25-35 mg/L.
- DAF was able to achieve effluent turbidity values ranging between 0.2-0.5 NTU consistently during warm weather conditions. DAF effluent turbidity below 0.2 NTU was achieved under several operating conditions.
- Filter turbidity breakthrough was generally experienced between UVFR of 7,500-10,000 gal/sf.
- Longer floc time provided higher DAF effluent quality, however, the shorter floc times were also able to achieve the KPI operating ranges (and in some instances the KPI target).

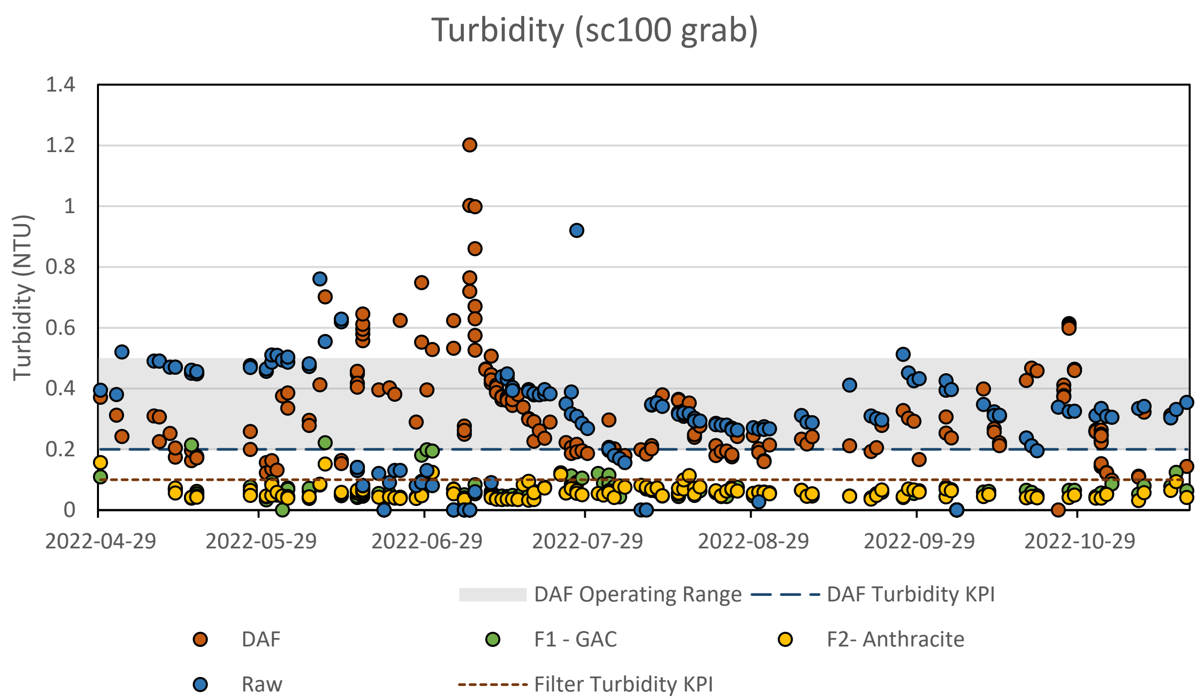

Figure 7: Turbidity (Daily Readings) May-November 2022

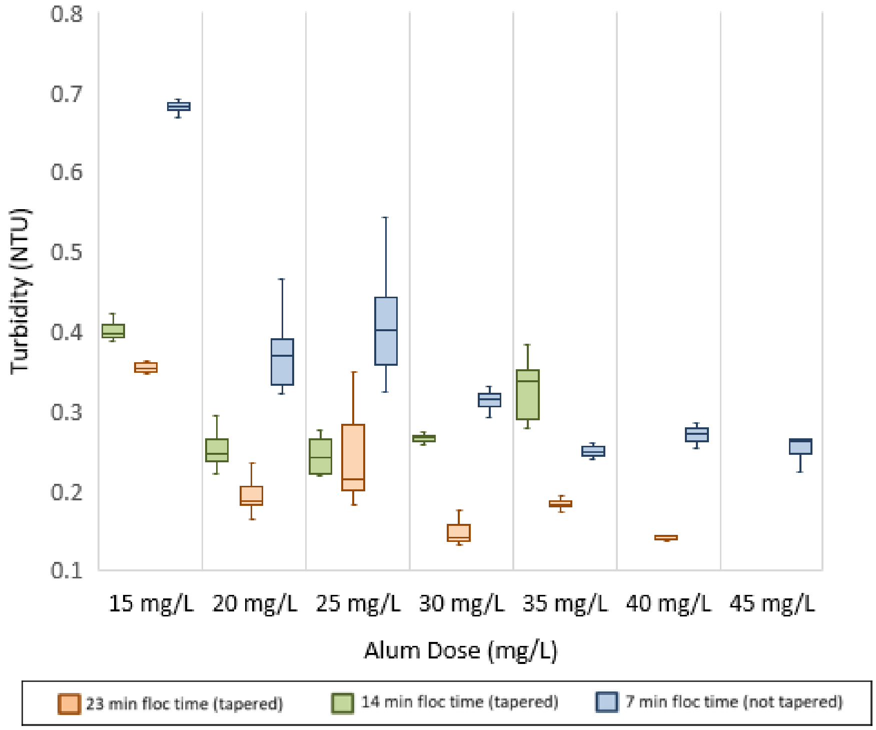

Figure 8: DAF Effluent Turbidity by Floc Time and Alum Dose

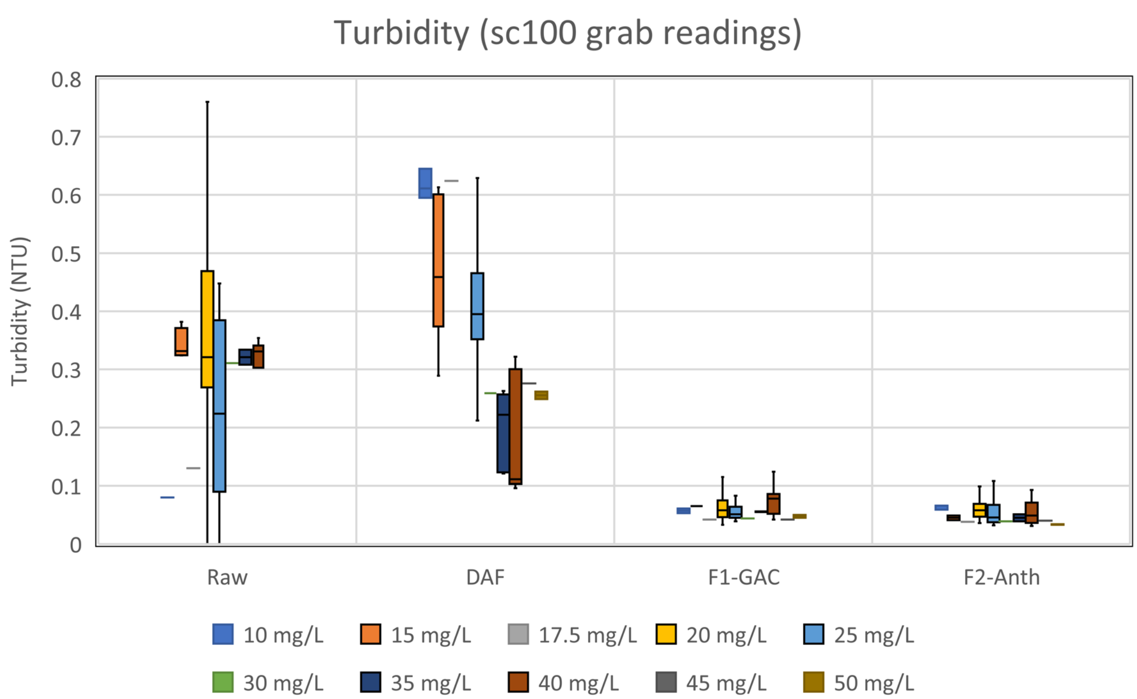

Figure 9: Turbidity Compared to Alum Dose

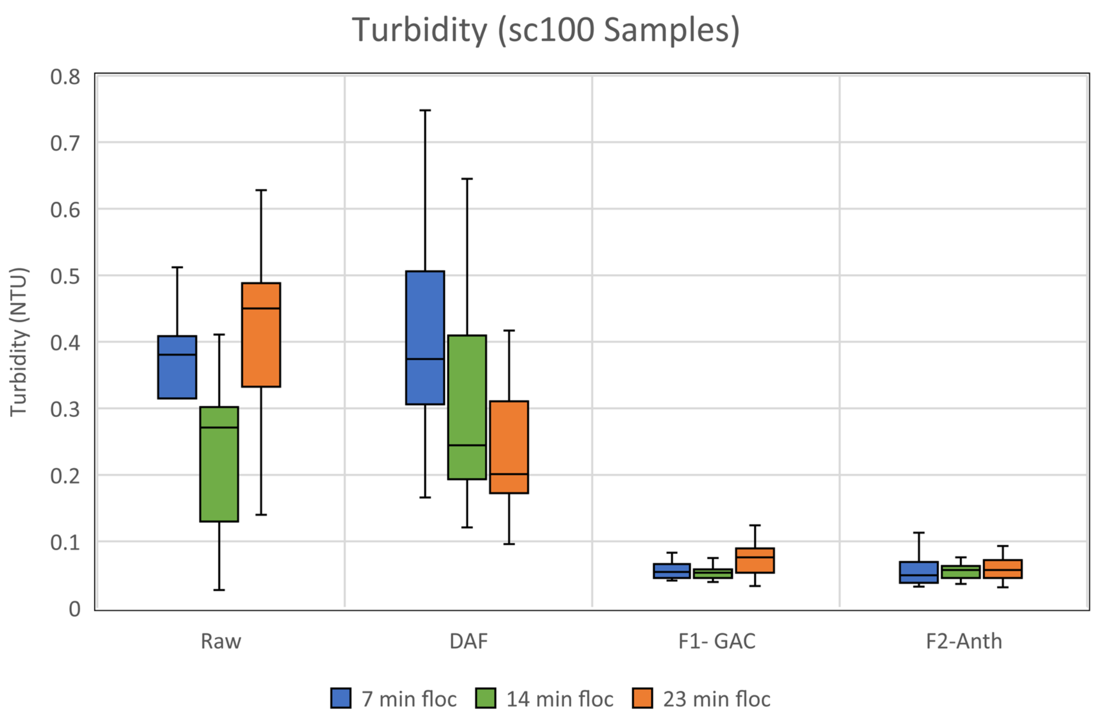

Figure 10: Turbidity Compared to Floc Time

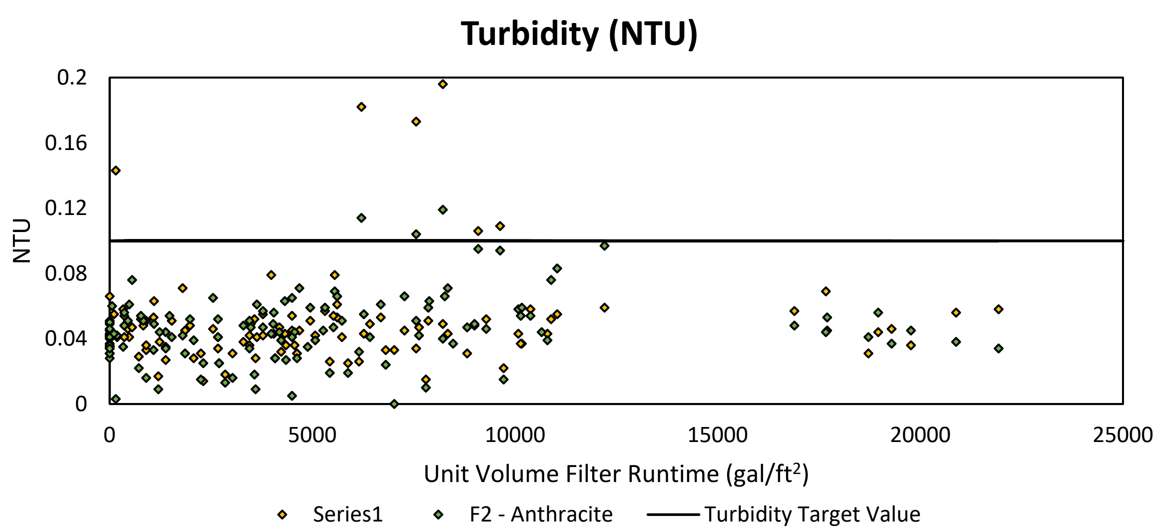

Figure 11: Filter Effluent Turbidity Compared to Unit Volume Filter Runtime

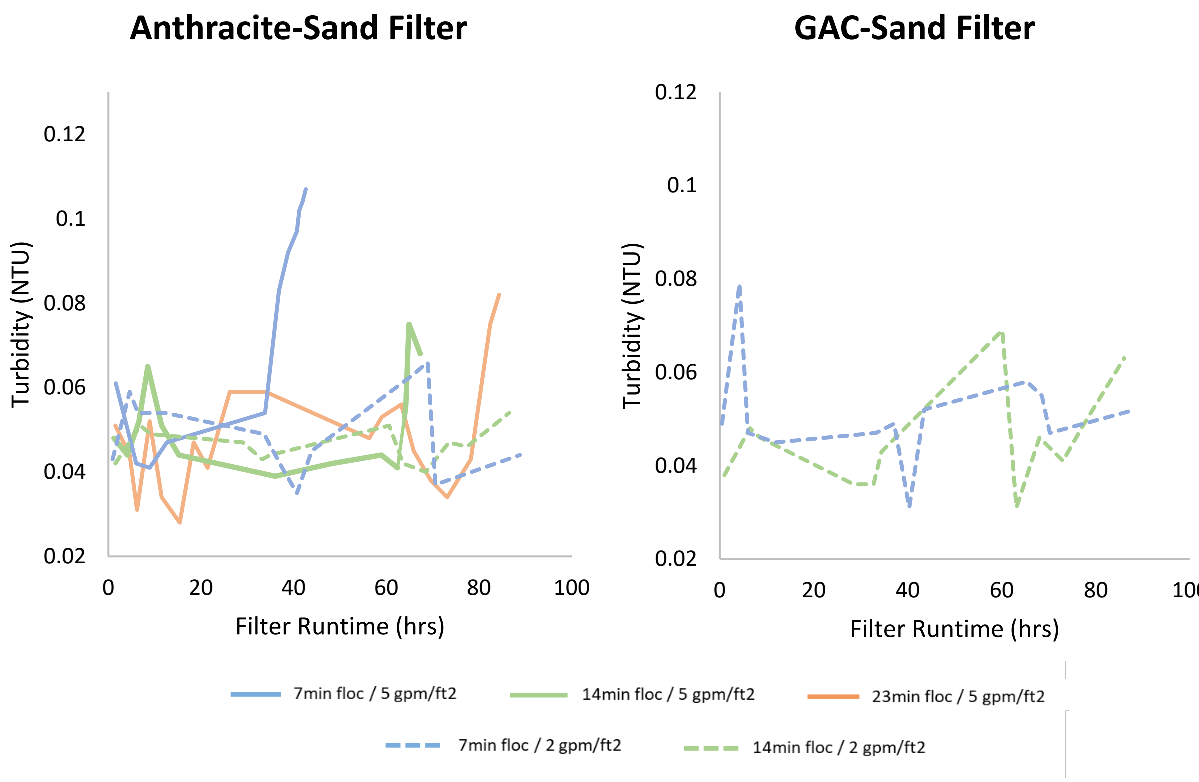

Figure 12: Filter Effluent Turbidity Compared to Filter Runtime

Disinfection By-Products

THM and HAA data is provided in Table 4.

- THM and HAA formation potential testing completed at CWRS. Additional samples were collected and extracted but are in process of being analyzed (and will be provided in subsequent updates).
- DBPFP results for both THM and HAA in the filter effluents was below the MAC of 100 ug/L and 80 ug/L respectively.

Table 4: DBPFP Results

	13-Jun-22		02-Aug-22	
	TTHM* (ug/L)	HAA9 (ug/L)	TTHM (ug/L)	HAA9 (ug/L)
Raw	73.2	152.5	149.8	114.5
DAF	247.8	40.1	70.9	38.0
F1	66.3	22.1	33.0	24.2
F2	90.0	26.5	62.8	25.1

*Samples noted by CWRS as potential chlorine dose issue.

Manganese

Manganese data is presented in Figure 13 to Figure 15. Initial comments on the data are provided below:

- Trials were completed to evaluate manganese removal at pilot scale. Due to limitations of the pilot, reaction times of 30 seconds and 10 minutes were tested. Modifications are underway to allow for 2 minutes of reaction time to be trialed.
- With 10 minute oxidation time, both filter effluents were able to achieve total manganese concentrations below the target limit. This was not consistently achieved with the shorter oxidation time of 30 seconds.
- Minor improvements of oxidation with 30 seconds vs no oxidant added.
- With increases in filter effluent concentrations through September and October, it is anticipated that the filter media is releasing manganese back into the water.
- Further testing to be completed throughout the fall as the lake experiences turnover.

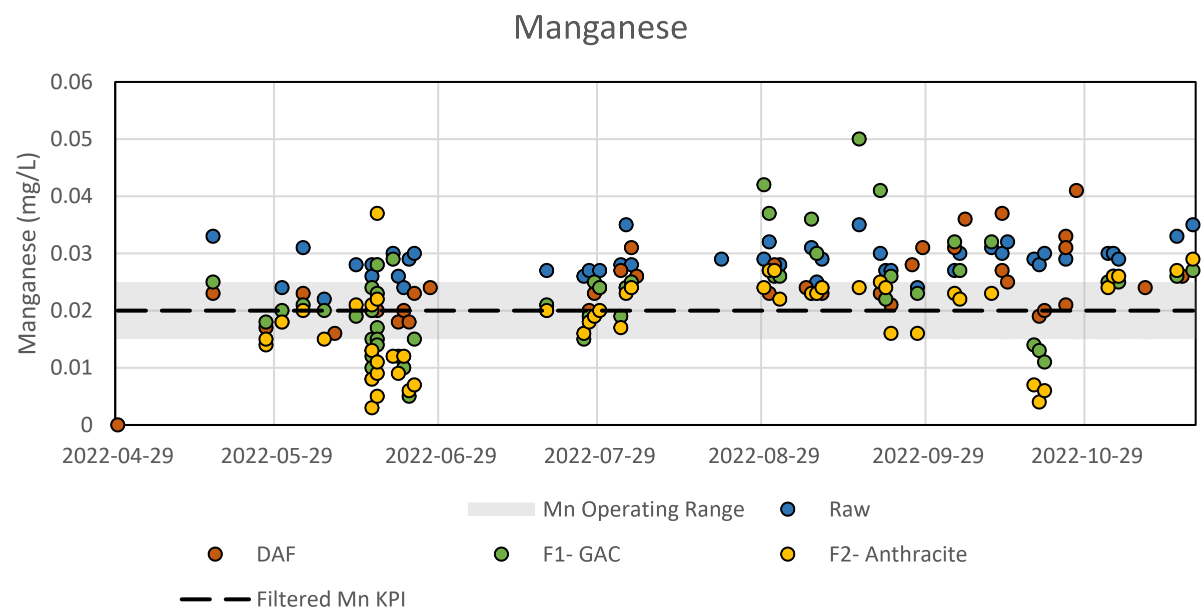

Figure 13: Manganese Results (Hach) from May-November 2022

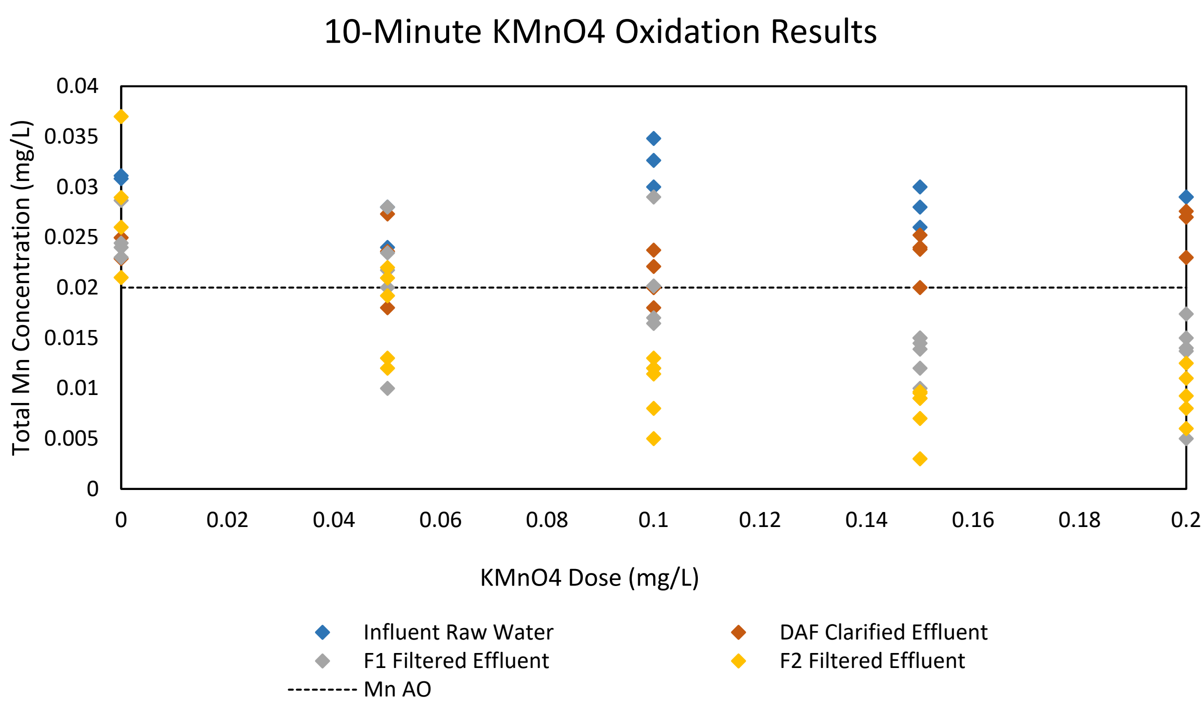

Figure 14: 10 min KMnO4 Trial

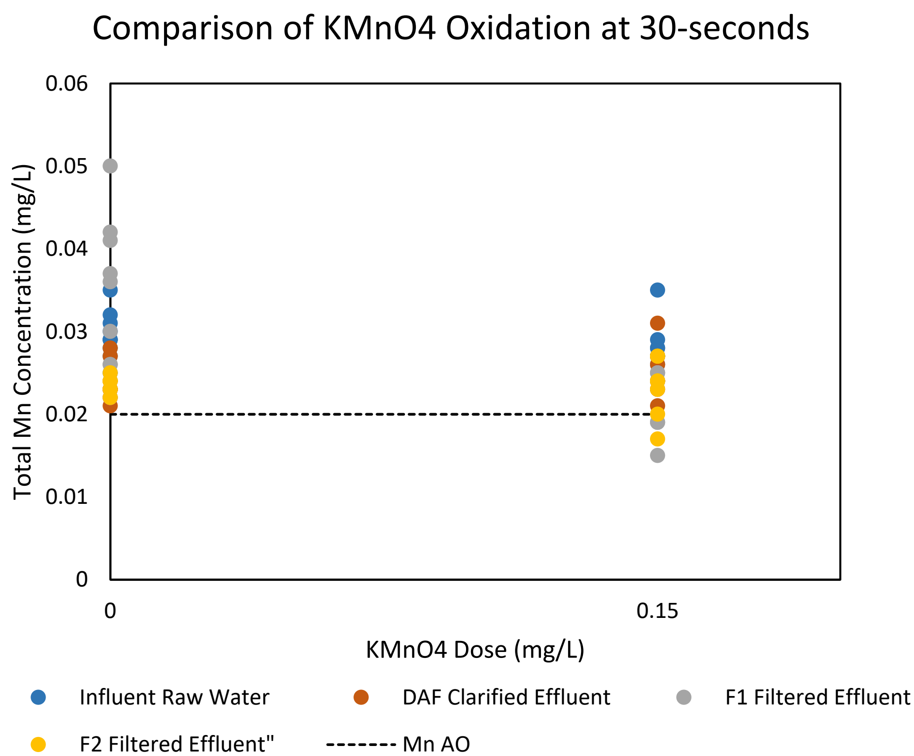

Figure 15: KMnO4 Oxidation at 30 seconds