Attachment W: Judge and Spiro Tunnels Mining - Influenced Water Treatment Evaluation: Draft Pilot Testing Report

DRAFT PILOT TESTING REPORT

Judge and Spiro Tunnels Mining-Influenced Water Treatment Evaluation: Draft Pilot Testing Report

Prepared for

Park City Municipal Corporation

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Acronyms and Abbreviations

BV	Bed Volume
DDW	(Utah) Division of Drinking Water
DWQ	(Utah) Division of Water Quality
EBCT	Empty Bed Contact Time
ES	Effective Size
MCL	Maximum Contaminant Level
MIW	Mining-Influenced Water
MRL	Minimum Reporting Limit
ND	Laboratory Detection Limit (Non-Detect)
O&M	Operations and Maintenance
ORP	Oxidation Reduction Potential
QJWTP	Quinns Junction Water Treatment Plant
RCRA	Resource Conservation and Recovery Act
SCO	Stipulated Compliance Order
SDP	Stream Discharge Permit
SMCL	Secondary Maximum Contaminant Level
SW	Settled Water
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UC	Uniformity Coefficient
UFRV	Unit Filter Run Volume
UPDES	Utah Pollutant Discharge Elimination System
USEPA	United States Environmental Protection Agency
UV 254	Ultraviolet Absorbance at 254 Nanometers
WET	Whole Effluent Toxicity

Executive Summary

This Pilot Testing Report summarizes the results of pilot testing from April 2016 through the completion of the pilot study in October 2016. The information gathered through the pilot study supports the Judge and Spiro Tunnels Mining-Influenced Water (MIW) Water Treatment Evaluation project.

This pilot study was conducted to support the design of the full-scale MIW treatment plant. This document includes a definition of pilot testing objectives and identification of the key questions that were identified to be answered during pilot testing. This document presents data and key findings from the pilot study to address the identified key questions. A key finding of this pilot study was that both tunnel waters can be treated utilizing the same treatment process.

The preferred treatment approach for the MIW facility is as follows:

- Pre-oxidation with chlorine
- Rapid mix/flocculation/sedimentation at elevated pH of 8.2
- Granular media filtration using deep-bed pyrolusite (manganese dioxide ore) media
- Post-filter adsorption with titanium dioxide media at a pH of 6.5 to 7.6

These treatment processes meet the pilot study operational goals and produce treated water that meets Park City Municipal Corporation (PCMC)'s water quality goals. Following these treatment steps, water used for drinking water will be conditioned, disinfected, and pumped to the distribution system. Water for stream discharge will be dechlorinated and discharged.

From the pilot testing results described in this document, the preferred treatment train offers the following advantages for PCMC:

- The preferred treatment train, with a settled water pH set point of 8.2, consistently meets drinking water maximum contaminant levels (MCLs) and stream discharge permit limits for regulated metals.
- The preferred treatment train is capable of meeting all other relevant drinking water limits, including the requirements of the Surface Water Treatment Rule consistent with conservative planning by PCMC.
- The preferred treatment train can effectively treat Judge Tunnel water alone, Spiro Tunnel water alone, and any ratio of blended Judge and Spiro water.
- The preferred treatment train is robust and can withstand variations in turbidity, short-term loss of chemical feeds, and rapid changes in operating parameters.
- The preferred treatment train provides multiple barriers for the metals of concern.

The pilot granular media filters with deep-bed pyrolusite media performed comparably at filter loading rates from 5 to 12 gallons per minute per square foot (gpm/sf). A high quality filtered water was produced across this range of filter loading rates.

SECTION 1

Introduction and Purpose

This pilot study provided key results to support the design of the full-scale MIW treatment plant. This Pilot Testing Report includes a definition of pilot testing objectives and identification of the key questions that were identified to be answered from pilot testing. This document presents data and key findings from the pilot study to address the identified key questions.

1.1 Background Information

PCMC has been issued Utah Pollutant Discharge Elimination System (UPDES) permits for the discharge of waters from Judge and Spiro Tunnels. PCMC entered into a Stipulated Compliance Order (SCO), concurrent with the issuance of the permits, which established schedules and certain terms and conditions for bringing the tunnel water discharges into compliance with the UPDES permits. PCMC (and other entities) currently use the mine tunnel waters for municipal drinking water, irrigation, and snowmaking. The Judge and Spiro Tunnels MIW Treatment Evaluation developed plans for meeting drinking water requirements and the SCO requirements for the tunnel waters. Pilot testing represented a key step in finalizing the selection of the preferred treatment process for Judge Tunnel water, Spiro Tunnel water, and combined tunnel water flows.

1.2 Purpose of Pilot Testing

In order to demonstrate proof of performance (i.e., validating full treatment train effectiveness and updating desktop cost estimates) for treatment of Judge and Spiro Tunnel waters for drinking water and/or stream discharge, PCMC commissioned this pilot study. Pilot testing focused only on the best options from the evaluation of alternatives and benefit-cost analysis completed previously (“Desktop Evaluation Study,” CH2M HILL, July 2015). Pilot operational parameters were set based on the chemical doses that provided effective treatment results during previous bench-scale testing (Water Quality & Treatment Solutions, September 2016). Pilot testing provided verification of design parameters and set the stage for conceptual, preliminary, and final design of the MIW treatment facilities.

Specifically, pilot testing built on the previous project decisions, and the main liquids treatment process tested at pilot-scale consisted of pre-oxidation, flocculation, sedimentation, filtration, and adsorption.

1.3 Finished Water Quality Goals and Targets

Pilot testing provided performance data on removal of each of the metals of concern, as identified in Table 1-1. The metals shown in Table 1-1 are those that have been measured at concentrations of at least 50 percent of the drinking water MCL or that are specifically limited as part of the UPDES discharge limits for the two mine tunnel waters.

Table 1-1: Metals of Concern for PCMC's Mining-Influenced Waters

Judge Tunnel	**Spiro Tunnel**
Antimony (MCL and stream discharge)	Antimony (MCL and stream discharge)
Arsenic (MCL)	Arsenic (MCL and stream discharge)
Cadmium (MCL and stream discharge)	Cadmium (MCL and stream discharge)
Lead (MCL and stream discharge)	Lead (MCL)
Mercury (MCL and stream discharge)*	Mercury (MCL and stream discharge)*
	Selenium (MCL and stream discharge)*
	Thallium (MCL and stream discharge)
Zinc (stream discharge)	Zinc (stream discharge)

Note: *indicates all concentrations measured are less than the relevant limits, so removal through treatment is not required.

In addition to the constituents shown in Table 1-1, treatment targeted the removal of iron and manganese to levels well below the secondary MCLs. In both tunnel waters, there are also stream discharge limits for total suspended solids and pH, and pilot data provided data to compare to these requirements. Pilot testing provided performance data for the removal of turbidity and other parameters of interest for treatment performance and regulatory requirements. Finally, pilot testing provided representative treated water samples for use in Whole Effluent Toxicity (WET) testing.

For the pilot study, the most stringent stream discharge permit (SDP) limit from the Judge or Spiro permit was considered in setting the treatment goals shown in Table 1-2. The treatment goals for the pilot were assumed to be 75 percent of the lower permit value between the drinking water MCL and the most stringent SDP limit. For manganese, the treatment goal was 20 percent of the secondary MCL, consistent with the goal established by PCMC for their Quinns Junction Water Treatment Plant (QJWTP).

Table 1-2: Treatment Goals

Analyte[a]	**MCL or SMCL**	**SDP Limit**	**Treatment Goal**
Antimony, Total	6	5.6	4.2
Arsenic, Total	10	10	7.5
Cadmium, Total	5	0.42	0.32
Thallium, Total	2	0.24	0.18
Zinc, Total	5,000	198	149
Selenium, Total	50	4.6	3.5
Mercury, Total	2	0.012	0.009
Iron, Total	300	NA	225
Manganese, Total	50	NA	10

[a] All concentrations are in µg/L.

1.4 Key Questions to Be Addressed by Pilot Testing

The key questions that were identified to be addressed during pilot testing were as follows:

- Does the optimum treatment approach from the previous decision evaluation and bench-scale testing perform as expected, meeting PCMC water quality goals, including drinking water MCLs and stream discharge limits for Judge Tunnel water, Spiro Tunnel water, and combined tunnel water?
- Does the same treatment approach perform acceptably under varying seasonal water quality? How does the treatment process perform during periods of miner activity in the tunnel? How does the process respond to or recover from an upset?
- Does pilot testing identify any limitations of the treatment approach that must be addressed in full-scale facility design and/or operations? Are there key findings from pilot study operations that help to familiarize operators with the treatment approach?
- To what extent is each metal of interest removed through each treatment step? Does this information support blending and bypass treatment alternatives that could be used to reduce the capital and operations and maintenance (O&M) cost of the full-scale treatment facility?
- Does the optimum treatment approach pass the required WET tests and allow regulatory approval of WET testing results?
- Do adsorption media performance and media capacity match projections and allow for selecting a preferred type of media?
- From the solids and discharge streams, how do the residuals settle and dewater? Do residuals pass the toxicity characteristic leaching procedure (TCLP)? What are the estimated solids quantities by water source and blend ratio?
- What chemical doses are required to stabilize finished water for the distribution system?
- What are the updated and/or refined design criteria for full-scale (i.e., flocculation time, filter loading rates, empty bed contact time for adsorption, chemical doses)? Does the data generated during pilot testing demonstrate these design criteria to Utah’s Division of Drinking Water (DDW) and/or the Division of Water Quality (DWQ)?
- What are the chemical and energy costs for the full-scale facility? How much truck traffic will be associated with chemicals, solids, and media replacement during full-scale plant operation?
- What are the updated and/or refined construction and O&M costs for full-scale?

1.5 Summary of Pilot Testing Tasks

The completed pilot testing tasks were as follows:

- Task 1 – Bench-Scale Testing
- Task 2 – Pilot Plant Commissioning
- Task 3 – Treatment for Metals Removal
- Task 4 – Challenge Testing and WET Test #1
- Task 5 – Adsorption Testing to Assess Exhaustion and WET Test #2

This final report is based on data, observations, and results from Tasks 2 through 5. The work summarized in this Pilot Testing Report is based on pilot testing results through October 31, 2016, the final day of testing for Tasks 2 through 5. The results from bench-scale testing performed for Task 1 have been summarized separately (WQTS, September 2016).

In the coming months, PCMC plans to continue adsorption testing on Spiro Water Treatment Plant filtrate. Any additional conclusions from this testing will be summarized in a separate report.

The Pilot Testing Protocol (CH2M Hill, March 2016), presented in Appendix G, contains additional testing details, descriptions of pilot equipment, pilot schedule, and experimental methods.

SECTION 2

Summary of Judge and Spiro Raw Water Quality

This pilot study provides key information to support the design and construction of a facility that must ultimately be able to treat Spiro Tunnel Water, Judge Tunnel Water, and a blend of the two waters. The initial phase of the MIW plant is likely to be able to treat all available Judge Tunnel water and up to a 4:1 blend of Spiro-to-Judge water. Future phases may require treating Spiro Tunnel water alone or treating a higher blend of Spiro-to-Judge water.

Testing included multiple water sources: Spiro Tunnel water alone, Judge Tunnel water alone, a 2:1 blend of Spiro-to-Judge water, and a 4:1 blend of Spiro-to-Judge water.

Box-plots have been created to illustrate the range of data compiled during pilot testing. Figure 2-1 provides a key for reading the box plots included herein. As shown, the box plots provide an illustration of the range of results encountered for a given parameter.

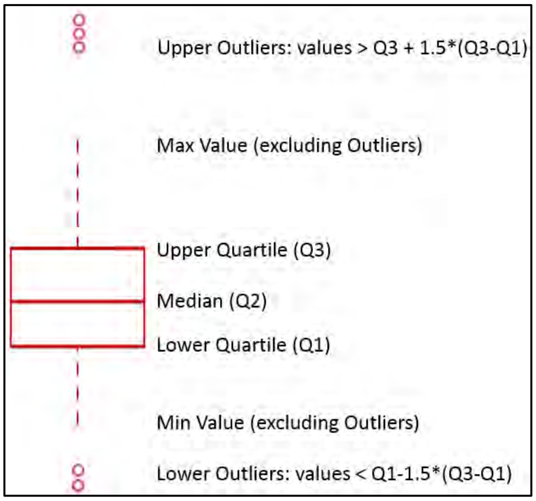


Figure 2-1: Definition of a Box Plot

2.1 Raw Water Metals Concentrations

Over the course of the pilot study, Judge Tunnel raw water and Spiro Tunnel raw water were routinely analyzed for the metals of concern. Figures 2-2 through 2-10 and Tables 2-2 and 2-3 provide a summary of the data for the Judge and Spiro Tunnel raw waters for the metals of concern. The data presented represents raw water samples collected between April 7 and October 31, 2016. The number of samples collected during this time varied between metals. Table 2-1 presents the number of raw water samples collected per metal.

The April 13 sample for antimony, arsenic, cadmium, iron, manganese, thallium, and zinc for Judge raw water was omitted due to laboratory errors.

Table 2-1: Number of Raw Water Samples Collected from April 7 through October 31, 2016

Analyte	Number of Judge Samples Collected	Number of Spiro Samples Collected[a]
Antimony, Total	49	45
Arsenic, Total	57	53
Cadmium, Total	60	56
Iron, Total	57	53
Manganese, Total	60	56
Thallium, Total	60	56
Zinc, Total	60	56
Selenium, Total	38	35
Lead, Total	38	38

[a] Excludes 9 upset samples shown in Table 2-7.

Each graph shows the drinking water MCL, SDP, and method detection limit (identified as ‘ND’ for nondetect).

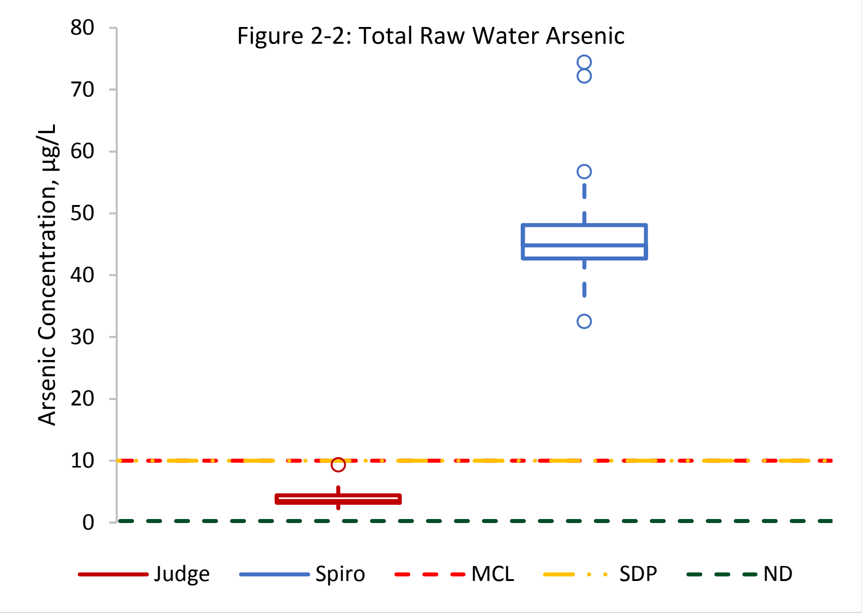


Figure 2-2: Total Raw Water Arsenic

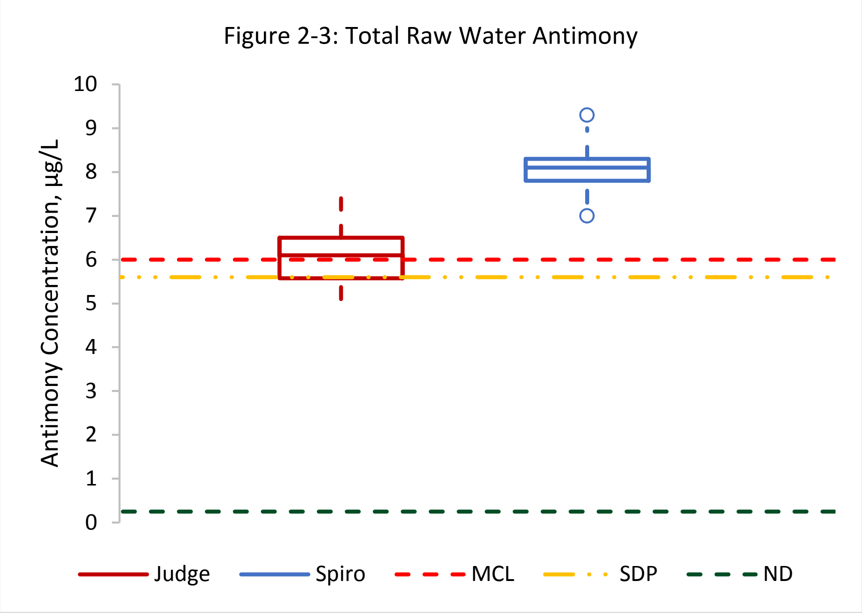


Figure 2-3: Total Raw Water Antimony

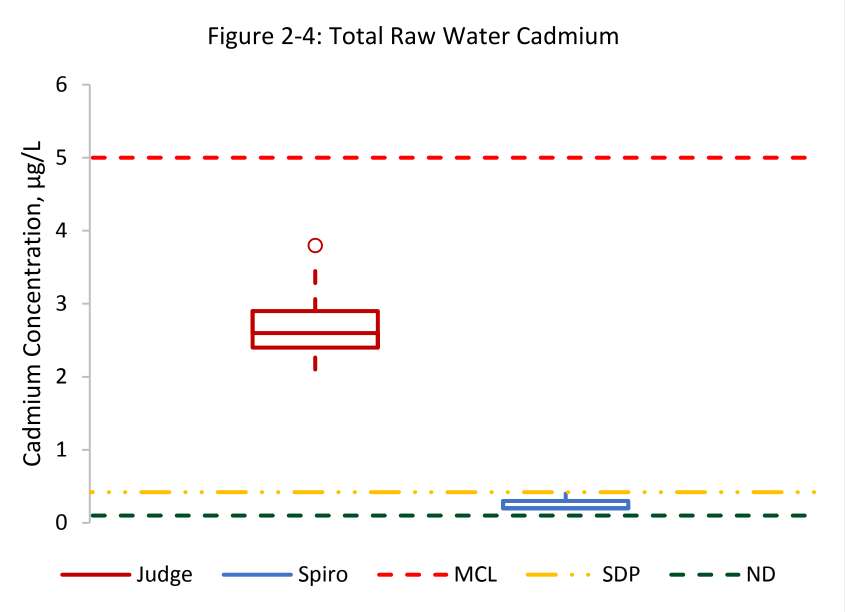


Figure 2-4: Total Raw Water Cadmium

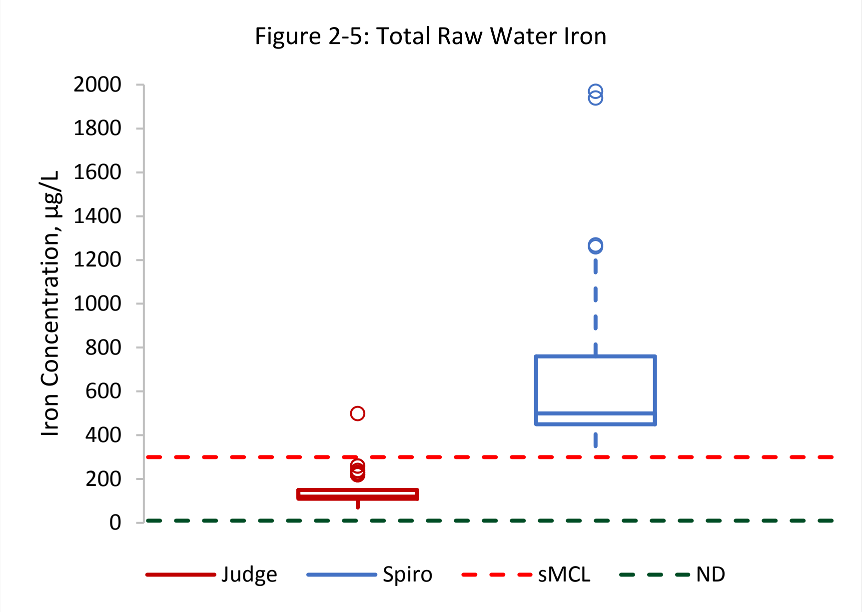


Figure 2-5: Total Raw Water Iron

Figure 2-6: Total Raw Water Manganese

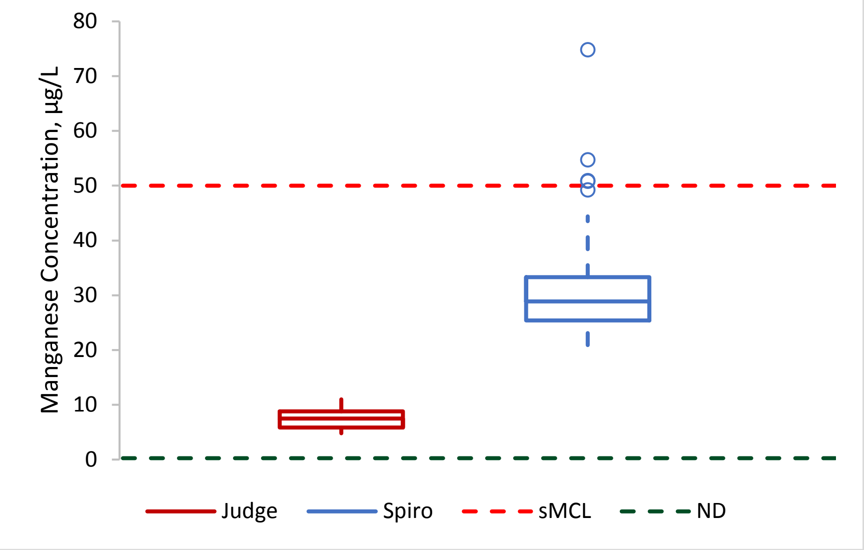


Figure 2-7: Total Raw Water Lead

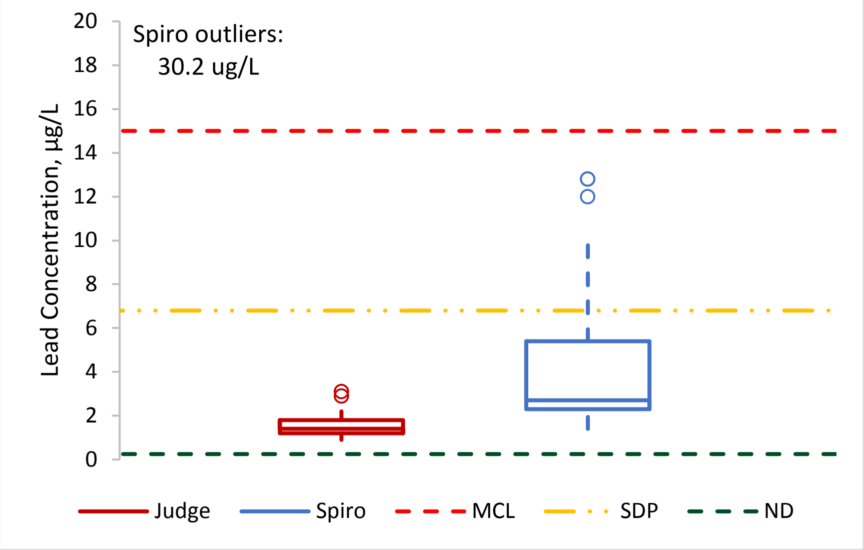

Spiro outliers:
30.2 ug/L

Figure 2-8: Total Raw Water Thallium

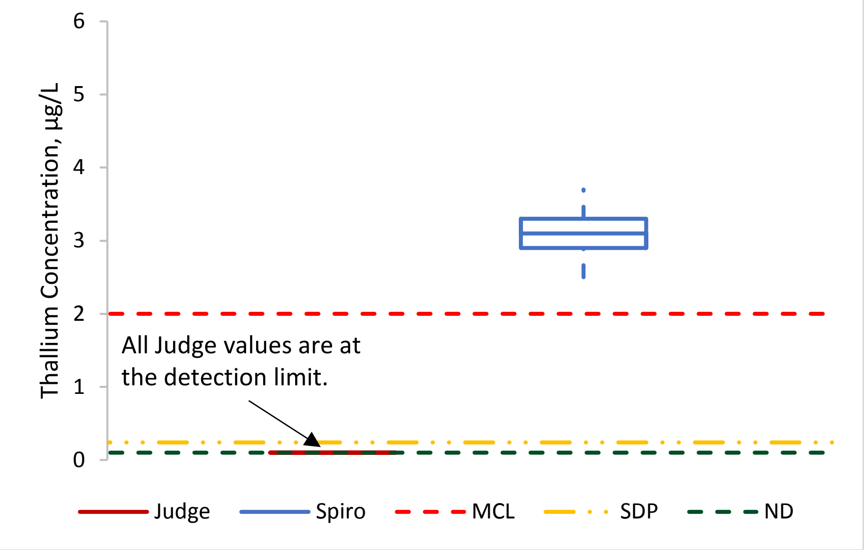
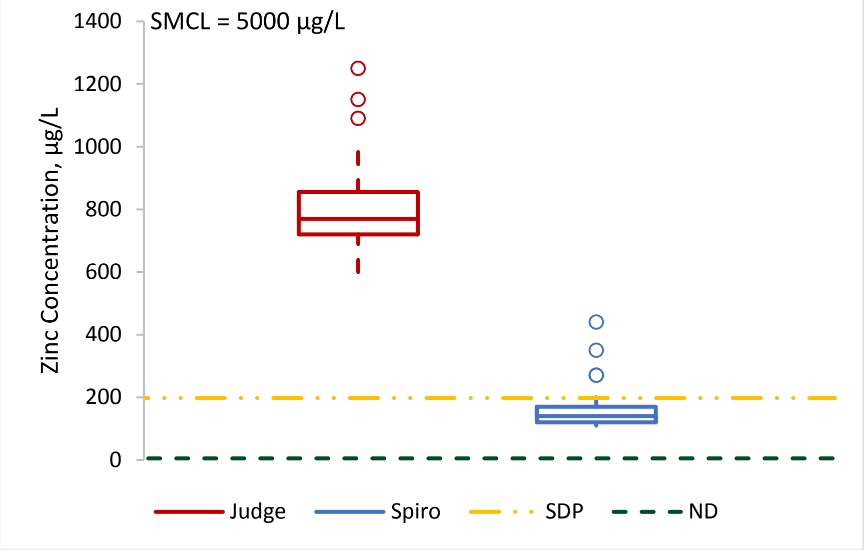
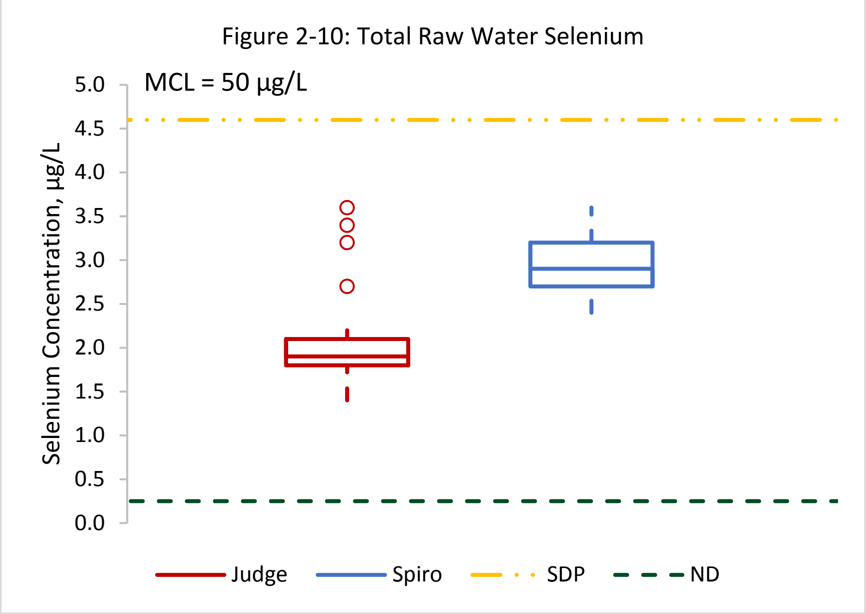
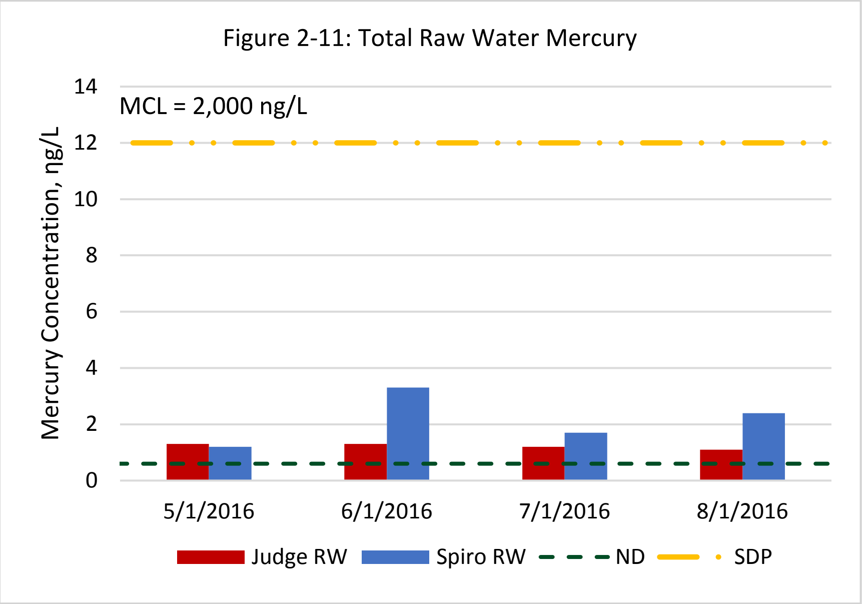

All Judge values are at the detection limit.

Figure 2-9: Total Raw Water Zinc


SMCL = 5000 µg/L



Due to the sampling complexity and costs of analysis, only four samples of low-level mercury were taken on the raw water sources in normal conditions. Six additional low-level mercury samples were collected during a period of high turbidity in the Spiro Tunnel; these results are discussed further in Section 3.3. Figure 2-11 illustrates the mercury levels in Spiro and Judge Tunnel over the course of the pilot study.



Based on the raw water data gathered during the pilot study:

- Spiro Tunnel water contains raw water total arsenic at levels approximately 4 to 5 times the stream water discharge permit limit while Judge Tunnel water has total arsenic levels of about 50 percent of the stream water discharge permit limit. The stream discharge permit limit and the MCL for arsenic are the same value. Thus, arsenic removal is required from Spiro Tunnel water.
- Spiro Tunnel water contains raw water antimony at levels approximately 1.3 times the drinking water MCL while Judge Tunnel water has antimony levels approximately at the MCL. The stream

discharge permit limit is slightly lower than the MCL. Removal of antimony is required from both tunnel water sources.

- Judge Tunnel water contains raw water cadmium at levels approximately 5 times the stream discharge permit limit but 50 percent of the drinking water MCL. Spiro Tunnel water has trace amounts of cadmium, at concentrations approximately 50 percent of the stream discharge permit limit. Thus, cadmium removal is required from Judge Tunnel water.
- Spiro Tunnel water contains iron at levels greater than the secondary MCL. Additionally, iron concentrations in Spiro Tunnel water range widely and include some outliers. Judge Tunnel water iron levels were below the secondary MCL. There is no stream discharge permit limit for iron.
- Spiro Tunnel water and Judge Tunnel water had observed values of manganese below the secondary MCL. Spiro Tunnel water had approximately three times more manganese than Judge Tunnel water. Both sources had outliers associated with manganese levels. There is no stream discharge permit limit for manganese.
- On occasion, Spiro Tunnel water may contain lead at levels above the stream discharge permit limit. There is a large spread in the Spiro Tunnel water lead levels as compared to the other metals sampled, including an outlier of 30.2 µg/L. This outlier is greater than the MCL and the stream discharge permit limit. Judge Tunnel water lead levels were below the MCL and the stream discharge permit limit. Removal of lead is required from Spiro Tunnel water.
- Spiro Tunnel water contains thallium at more than 12 times the stream water discharge permit limit. Additionally, the level exceeds the drinking water MCL. Judge Tunnel water did not contain thallium, with all samples at or below the detection limit. Removal of thallium is required from Spiro Tunnel water.
- Spiro Tunnel water contains zinc at levels that are typically below the stream discharge permit limit. However, there were three outliers above the stream discharge permit limit. Judge Tunnel water contains zinc levels at 3 to 4 times the stream discharge permit limit. The secondary MCL is 10 times the stream discharge permit limit, and zinc in both sources is below the drinking water limit. Removal of zinc is required from Judge Tunnel water.
- Spiro Tunnel water contains selenium at approximately 65 percent of the stream discharge permit limit. Judge Tunnel water contains selenium at approximately 45 percent of the stream discharge permit limit. Since the MCL is 10 times the stream discharge limit, selenium in both sources is below the drinking water MCL.
- Spiro Tunnel water and Judge Tunnel water both have very low levels of detectable mercury. Spiro Tunnel water has slightly higher values, which are still less than 30 percent of the stream discharge permit limit. Judge Tunnel water values are closer to 10 percent of the stream discharge permit limit. Mercury in both sources is well below the drinking water MCL.

As part of the Desktop Evaluation Summary: Judge and Spiro Tunnels Mining-Influenced Water Treatment Evaluation (CH2M Hill, July 2015), historic mine tunnel metal concentration data in both raw water sources was analyzed and summarized. The data collected during this pilot study is within similar ranges as previously observed and there have been no discernible patterns for seasonal variances experienced during the pilot study. Appendix E includes time-series plots showing both historic data and data collected in the pilot study.

Table 2-2: Summary of Judge Tunnel Metal Concentrations[a,b]

Analyte	Minimum	Lower Quartile[c]	Median	Upper Quartile[c]	Maximum	MCL or SMCL	SDP	ND[e]
Antimony (µg/L)	5.1 (4.9)	5.6 (5.3)	6.1 (5.9)	6.5 (6.3)	7.4 (7.0)	6	5.6	0.25
Arsenic (µg/L)	2.3 (1.1)	3.2 (1.6)	3.5 (1.8)	4.4 (2.0)	9.3 (5.0)	10	10	0.25
Cadmium (µg/L)	1.9 (1.7)	2.4 (2.2)	2.6 (2.4)	2.9 (2.7)	3.8 (3.4)	5	0.42	0.1
Iron (µg/L)	70 (10)	110 (10)	120 (10)	150 (10)	500 (220)	300	NA	10
Lead (µg/L)	0.9 (0.25)	1.2 (0.25)	1.4 (0.25)	1.8 (0.25)	3.1 (1.00)	15	6.8	0.25
Manganese (µg/L)	4.4 (4.3)	5.9 (5.9)	7.5 (7.4)	8.8 (8.7)	12.5 (11.8)	50	NA	0.25
Selenium (µg/L) [d]	1.4 (1.3)	1.8 (1.7)	1.9 (1.8)	2.1 (1.9)	3.6 (3.8)	50	4.6	0.25
Thallium (µg/L)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)	0.1 (0.2)	2	0.24	0.1
Zinc (µg/L)	590 (290)	720 (640)	770 (700)	855 (800)	1,250 (1,050)	5,000	198	5

Notes:

[a] Total and dissolved concentrations are presented. Dissolved concentrations are shown in parentheses.

[b] Total metals concentrations are as presented in Figure 2-2 through Figure 2-10.

[c] The lower quartile represents the 25th percentile of data and the upper quartile represents the 75th percentile of data.

[d] Dissolved concentrations may be greater than total concentrations due to a variable number of total and dissolved samples.

[e] ND indicated values not detected at the corresponding Minimum Reporting Limit (MRL). ND limit was quantified as 50% of the Minimum Reporting Level for analysis.

Table 2-3: Summary of Spiro Tunnel Metal Concentrations[a,b]

Analyte	Minimum	Lower Quartile[c]	Median	Upper Quartile[c]	Maximum	MCL or SMCL	SDP	ND[e]
Antimony (µg/L)	7.0 (6.5)	7.8 (7.3)	8.1 (7.5)	8.3 (7.8)	9.3 (8.5)	6	5.6	0.25
Arsenic (µg/L)	32.5 (12.3)	42.7 (14.7)	44.8 (19.1)	48.1 (21.0)	74.4 (44.4)	10	10	0.25
Cadmium (µg/L)	0.1 (0.1)	0.2 (0.2)	0.2 (0.2)	0.3 (0.2)	0.4 (0.3)	5	0.42	0.1
Iron (µg/L)	350 (10)	450 (10)	500 (20)	760 (40)	1,970 (430)	300	NA	10
Lead (µg/L)	1.4 (0.25)	2.3 (0.25)	2.8 (0.25)	6.3 (0.25)	30.2 (1.00)	15	6.8	0.25
Manganese (µg/L)	20.9 (17.5)	25.4 (20.4)	28.8 (21.7)	33.3 (24.0)	74.8 (33.9)	50	NA	0.25
Selenium (µg/L)	2.4 (2.3)	2.7 (2.6)	2.9 (2.7)	3.2 (3.1)	3.6 (3.5)	50	4.6	0.25
Thallium (µg/L) [d]	2.5 (2.4)	2.9 (2.9)	3.1 (3.0)	3.3 (3.2)	3.7 (3.8)	2	0.24	0.1
Zinc (µg/L)	90 (90)	120 (110)	140 (120)	170 (140)	440 (390)	5,000	198	5

[a] Total and dissolved concentrations are presented. Dissolved concentrations are shown in parentheses.

[b] Total metals concentrations are as presented in Figure 2-2 through Figure 2-10.

[c] The lower quartile represents the 25th percentile of data and the upper quartile represents the 75th percentile of data.

[d] Dissolved concentrations may be greater than total concentrations due to a variable number of total and dissolved samples.

[e] ND indicated values not detected at the corresponding Minimum Reporting Limit (MRL). ND limit was quantified as 50% of the Minimum Reporting Level for analysis.

2.2 Raw Water Turbidity

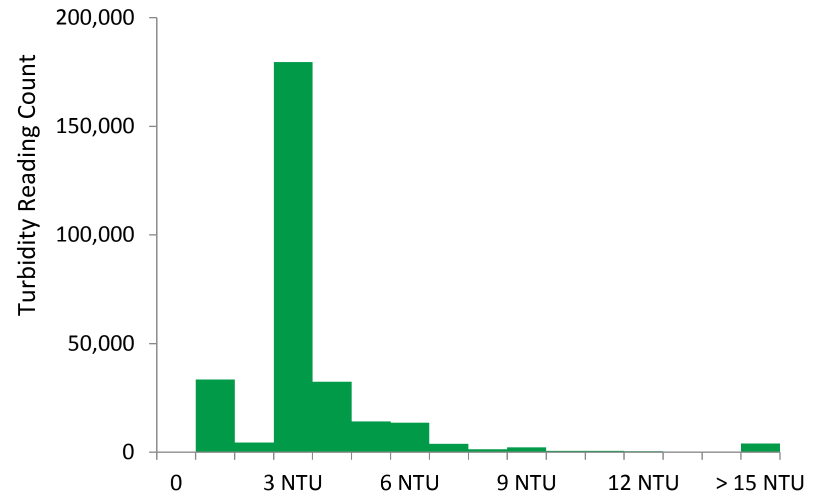
On-line instruments measured raw water turbidity at the pilot plant and the full-scale Spiro Water Treatment Facility where the pilot study was conducted. Turbidity was measured at the following locations:

- Judge Tunnel – PCMC maintains the Judge Tunnel turbidimeter. This meter is located near the entrance to Judge Tunnel and data was logged to the PCMC SCADA system.
- Judge Pilot Plant – The pilot team maintained the Judge Pilot Plant turbidimeter. It was installed on the pilot equipment and measured Judge Tunnel water turbidity as flow entered the pilot equipment skids. A surface scatter style turbidimeter was used to better evaluate high turbidity events. The pilot data logger recorded data from this meter.
- Spiro Bulkhead – PCMC maintains the Spiro Bulkhead turbidimeter. This meter is located at the Spiro Water Treatment Facility and measures the turbidity from the Bulkhead Pipeline flow as it enters the facility. Data collected from this instrument was archived in the PCMC SCADA system.
- Spiro Portal – PCMC maintains the Spiro Portal turbidimeter. This meter is located at the Spiro Water Treatment Facility and measures the turbidity from the Portal Pipeline flow as it enters the facility. Data collected from this instrument was archived in the PCMC SCADA system.
- Spiro Pilot Plant – The pilot team maintained the Spiro Pilot Plant turbidimeter. It was installed on the pilot equipment and measured Spiro Tunnel water pumped from the Spiro Water Treatment Facility raw water wet well as flow entered the pilot equipment skids. This flow represents a mixture of both Spiro Bulkhead and Spiro Portal waters. A surface scatter style turbidimeter was used to better evaluate high turbidity events. The pilot data logger recorded data from this meter.
- Influent Turbidity – The pilot team maintained the Pilot Plant Influent turbidimeter. This low range turbidimeter was located on the influent to the rapid mix of the Flocculation-Sedimentation unit. The pilot data logger recorded data from this meter.

Over the course of the pilot study, the pilot study team monitored the relationship between the Judge Tunnel, Spiro Bulkhead, Spiro Portal, and the Influent Turbidimeter to ensure the Influent Turbidimeter readings were in line with the full-scale turbidities. During raw water turbidity spikes, the raw water turbidity exceeded the measurement capacity of the Judge Tunnel, Spiro Bulkhead, Spiro Portal, and the Influent turbidimeters. For example, 99.9 NTU is the maximum value that could be measured by the Influent Turbidimeter. In the cases of high turbidities, the Spiro Pilot Plant and Judge Pilot Plant surface scatter-style turbidimeters measured turbidities up to 4000 NTU.

The Judge and Spiro sources represent a very high quality water source in terms of turbidity. Figure 2-12 presents a histogram of the pilot influent turbidity over the course of the pilot.

Figure 2-12: Influent Turbidity Histogram



As illustrated in Figure 2-12, the influent turbidity histogram demonstrated the following:

- Turbidity was less than or equal to 3 NTU 75% of the time
- Turbidity was less than or equal to 6 NTU 95% of the time
- Turbidity was less than or equal to 15 NTU 99% of the time.

Therefore, for the purposes of analyses, an “upset” for both Judge Tunnel and Spiro Tunnel waters occurred when turbidity spiked over 15 NTU.

Table 2-4 provides the percent of measured values that exceeded 15 NTU for the Judge Tunnel, Spiro Tunnel, and Spiro Bulkhead as measured by PCMC equipment for the duration of the pilot study.

Table 2-4: Percent of Turbidity Measurements above 15 NTU

Location of turbidity instrument	Percent of measured values that exceeded 15 NTU
Judge Tunnel	1.2%
Spiro Bulkhead	1.9%
Spiro Portal	0.4%

2.3 Tunnel Water Upset Conditions

Both tunnels have historically experienced high-turbidity events. For example, Spiro Tunnel water turbidity exceeded 200 NTU in May 2015 for over 24 hours. Tunnel collapses in the mine tunnel system or miner maintenance in the tunnels cause these spikes. Under current operations, it is not necessary for PCMC to treat the water during these high turbidity events. In the future, PCMC expects to treat tunnel water through these spikes.

2.3.1 Judge Tunnel Water Upset Conditions

A key goal of this pilot study was to capture the raw water quality (and treatment implications) of these events. The Judge Tunnel water flows through a storage tank and flows by gravity to the Spiro Water Treatment Plant. This conveyance system has the effect of some muting of turbidity events seen in the tunnel. While the Park City Operations team was in Judge Tunnel performing tunnel maintenance in

June and July 2016, they collected samples of Judge Tunnel water to simulate an upset condition. Analysis and bench top testing was performed on these samples.

Table 2-5 presents water quality data from the three Judge Tunnel water upset conditions. Metals are presented in total and dissolved concentrations, with the dissolved concentration presented in parentheses.

Table 2-5: Summary of Judge Tunnel Upset Samples[a]

Parameter	Median Judge Values over Course of Pilot[b]	Upset Sample 1	Upset Sample 2	Upset Sample 3
Sample Date	N/A	6/30/16	7/14/16	7/21/16
Turbidity (NTU)	1.8	93.5	88.0	51.0
Antimony (µg/L)	6.3 (6.0)	22.4 (8.3)	5.3 (1.5)	2.8 (1.3)
Arsenic (µg/L)	3.5 (1.8)	112 (20.6)	76 (4.8)	50.5 (1.8)
Cadmium (µg/L)	2.6 (2.4)	10.4 (2.8)	5.4 (1.9)	4.4 (1.6)
Iron (µg/L)	120 (10)	21,000 (2,240)	7,700 (270)	8,300 (10)
Lead (µg/L)	1.65 (0.25)	3,300 (386)	625 (19.3)	319 (0.25)
Manganese (µg/L)[c]	7.7 (7.8)	712 (45.7)	485 (43.9)	198 (31.7)
Mercury (ng/L)	1.3	N/A	333	N/A
Selenium (µg/L)	1.9 (1.8)	2.7 (1.4)	1.8 (1.1)	1.0 (1.0)
Thallium (µg/L)	0.1 (0.1)	0.4 (0.1)	0.1 (0.1)	0.1 (0.1)
Zinc (µg/L)	805 (700)	2,200 (580)	1,010 (440)	910 (400)

a- Total and dissolved concentration presented. Dissolved concentration are shown in parentheses.

b- Median metals concentrations as presented in Figure 2-2 through Figure 2-10.

c- Manganese dissolved concentrations may be greater than total concentrations due to variable number of total and dissolved samples.

Table 2-5 represents raw, untreated Judge Tunnel water in an upset condition. In the upset condition, there is an increase in total metals concentrations for most metals. The exceptions are selenium and thallium, each of which are present in only trace amounts in the Judge Tunnel water. The most significant increases in dissolved concentrations were in iron, arsenic, lead, and manganese.

A single data point of 333 ng/L mercury concentration during a Judge Tunnel upset was collected. This sample indicated that total mercury increased nearly 300 fold in an upset condition, compared to the median mercury concentration of 1.3 ng/L. It is assumed that this represents an increase in particulate mercury and this contaminate will be removed through coagulation, sedimentation, and filtration.

A jar test performed on Judge Tunnel Upset Sample 3 water indicated that this water could be successfully treated using oxidation, precipitation, coagulation, and sedimentation. Table 2-6 presents the jar test treatment results for Judge Upset Sample 3. The sample was treated with 1.5 mg/L of chlorine as a pre-oxidant, 18 mg/L of caustic soda to elevate the pH to 8.2, 10 mg/L of ferric chloride, and 2 mg/L of polymer, and then the sample was allowed to settle for 30 minutes. Filtration was simulated with 0.45 micron filter paper. For reference, the MCL or SMCL and the SDP limit are presented for each analyte. Mercury was not analyzed in this jar test, but was evaluated further during Spiro Tunnel turbidity upsets in September 2016.

Table 2-6: Summary of Judge Tunnel Upset Jar Test Settled Water and Filtered Water Samples

Analytes[b]	**Judge Tunnel Upset Raw Water**[a]	**Judge Tunnel Upset Settled Water**[a]	**Judge Tunnel Upset Filtered Water**[a]	**MCL or SMCL**	**SDP**
Antimony	2.8 (1.3)	1.3	1.3	6	5.6
Arsenic	50.5 (1.8)	3.4	1.4	10	10
Cadmium	4.4 (1.6)	0.6	0.2	5	0.42
Iron	8,300 (10)	770	10	300	NA
Lead	319 (0.25)	8.9	0.25	15	6.8
Manganese	198 (31.7)	21.5	8.7	50	N/A
Selenium	1.0 (1.0)	1.2	1.2	50	4.6
Thallium	0.1 (0.1)	0.1	0.1	2	0.24
Zinc	910 (400)	150	10	5,000	198

a- Total and dissolved concentration presented. Dissolved concentration in parentheses.
b- All values are in µg/L.

2.3.2 Spiro Tunnel Water Upset Conditions

Upset conditions occurred in Spiro Tunnel water during the pilot study. The pilot plant treated Spiro Tunnel Upset water through the entire treatment train, allowing for evaluation of the removal efficiency of each process and the necessary chemical doses to achieve successful treatment.

Table 2-7 presents water quality results from nine upset samples in Spiro Tunnel water at turbidities ranging from 44 to 994 NTU. Metals are presented in total and dissolved concentrations, with dissolved concentrations presented in parentheses. The results from the upset samples show that total metals concentrations for all metals except selenium and thallium were higher than the median concentration. However, dissolved metals concentrations were generally at or below the median metals concentration for all metals. The high percentage of metals in particulate form allowed for removal of most particulate metals through clarification.

Section 4.1 presents a treatment profile for four upset events. The treatment train maintained effective treatment through the proposed treatment train throughout all upsets experienced.

Table 2-7: Summary of Spiro Tunnel Upset Samples[a]

Parameter	Median Spiro Values over Course of Pilot[b]	Upset Sample 1[c]	Upset Sample 2	Upset Sample 3[c]	Upset Sample 4	Upset Sample 5[c]	Upset Sample 6	Upset Sample 7	Upset Sample 8	Upset Sample 9[c]
Sample Date	N/A	9/20/16	9/20/16	9/20/16	9/21/16	9/21/16	9/28/16	9/28/16	9/28/16	9/28/16
Turbidity (NTU)	3.6	43.5	66	80	55	53	164	389	640	994
Antimony (µg/L)	8.1 (7.5)	12.7 (8.0)	13.5 (7.6)	16.1 (8.5)	13.8 (8.1)	13.3 (8.1)	54.1(7.5)	91.3 (7.4)	115 (7.9)	156 (7.9)
Arsenic (µg/L)	42.7 (14.7)	224 (12.5)	270 (18.5)	341 (18.7)	242 (37.7)	256 (13.1)	487 (3.3)	820 (2.5)	1,040 (2.5)	1,320 (2.4)
Cadmium (µg/L)	0.2 (0.2)	0.8 (0.2)	0.9 (0.2)	1.2 (0.2)	0.9 (0.2)	0.9 (0.2)	4.3 (0.3)	7.9 (0.3)	10.6 (0.3)	15.1 (0.3)
Iron (µg/L)	500 (20)	6,620 (10)	8,930 (160)	10,200 (120)	7,280 (840)	7,800 (20)	48,900 (10)	96,000 (10)	135,000 (10)	192,000 (10)
Lead (µg/L)	32.8 (0.25)	51.8 (0.25)	61.2 (1.1)	61.9 (0.8)	56.1 (5.0)	39.6 (0.25)	299 (0.25)	509 (0.25)	598 (0.25)	684 (0.25)
Manganese (µg/L)	28.8 (21.7)	238 (17.8)	264 (17.0)	417 (23.1)	265 (26.9)	198 (26.7)	342 (20.4)	648 (18.4)	938 (17.5)	1,480 (14.3)
Mercury (ng/L)	NA	13.2	26.4	29.7	N/A	15.6	92.1	91.7	179.0	128.0
Selenium (µg/L)	2.9 (2.7)	2.8 (2.8)	2.8 (2.6)	2.9 (3.1)	3.1 (2.6)	2.9 (3.1)	4.0 (3.0)	4.5 (3.0)	4.6 (3.4)	4.9 (3.2)
Thallium (µg/L)	3.1 (3.0)	3.7 (3.3)	3.6 (3.2)	4.0 (3.7)	130 (3.4)	3.6 (3.4)	3.6 (2.7)	4.2 (2.4)	4.4 (2.5)	4.4 (2.4)
Zinc (µg/L)	140 (120)	330 (100)	390 (90)	420 (90)	330 (130)	340 (110)	1,620 (130)	3,130 (150)	4,660 (140)	6,590 (170)

a- Total and dissolved concentration presented. Dissolved concentrations are shown in parentheses.

b- Median metals concentrations as presented in Figure 2-2 through Figure 2-10.

c- Indicates samples for which a treatment profile is presented in Section 4.1.

2.4 Other Raw Water Quality Parameters

During pilot operations, laboratory analyses were conducted on-site on raw water samples from Judge and Spiro Tunnels to establish a baseline of raw water quality data. Table 2-8 presents a summary of raw water data for alkalinity, hardness, ultraviolet absorbance at 254 nanometers (UV 254), oxidation reduction potential (ORP), and conductivity between April 7 and October 31, 2016. Appendix E contains time series graphs for each parameter.

Table 2-8: Summary of Raw Water Quality Results from April 7 through October 31, 2016

Analytes	Judge Raw Water				Spiro Raw Water			
	Number of Samples	**Lower Quartile**	**Median**	**Upper Quartile**	**Number of Samples**	**Lower Quartile**	**Median**	**Upper Quartile**
Alkalinity[a]	33	120	130	140	34	160	160	160
Hardness[a]	41	190	210	230	43	470	480	500
UV 254[b,c]	31	0.003	0.004	0.005	31	0.001	0.002	0.002
ORP[d]	53	275	300	341	54	258	296	344
Conductivity[e]	110	374	406	460	108	798	850	874
Total Dissolved Solids (TDS)[f]	6	257	264	310	6	633	642	665

a- Measured in mg/L $CaCO_3$

b- Measured in absorbance with a 1 cm pathlength.

c- Two samples were omitted due to laboratory errors.

d- Measured in mV

e- Measured in µS/cm

f- Measured in mg/L TDS

As shown, the Spiro Tunnel raw water has higher hardness and conductivity compared to Judge Tunnel water. Both waters are very low in organic content, as indicated by the UV 254 results. Both Spiro and Judge Tunnel waters have similar oxidation-reduction potentials. Alkalinity is moderately high in both raw waters.

Pilot Plant Treatment Process

Treatment at the pilot plant consisted of pre-oxidation in a pipeline contactor, pH adjustment, clarification (i.e., rapid mixing, flocculation, and sedimentation), granular media filtration, and post-filter adsorption. This treatment scheme is presented graphically in Figure 3-1 and pictures of the pilot plant treatment train are shown in Figures 3-2 through 3-5.

A detailed pilot study schedule was provided in the Pilot Testing Protocol (Appendix G). Table 3-1 summarizes the duration of treatment for Spiro Tunnel water, Judge Tunnel water, as well as the duration of testing with the 2:1 Spiro to Judge and the 4:1 Spiro to Judge blends.

Table 3-1: Summary of Pilot Source Water

Source Water for Treatment	Treatment Duration (through October 31, 2016)
Spiro only	6 weeks (includes 4 weeks of pilot plant commissioning, April 7 through May 14, 2016)
Judge only	2 weeks (May 14 through May 26, 2016)
2:1 Spiro to Judge Blend	5 weeks (May 27 through July 4, 2016)
4:1 Spiro to Judge Blend	17 weeks (July 5 through October 31, 2016)

Bench testing results, reported by Water Quality and Treatment Solutions (WQTS, September 2016), supported the establishment of initial chemical doses and operation set points. The initial bench testing work provided results for jar tests at pH 9.0 and pH 7.5. While the pilot plant was being fed with Spiro Tunnel water only and then with Judge Tunnel water only, pH was varied between 7.5 and 9.0 to determine an optimal treatment set point. From the bench testing report, pH had the greatest effect on zinc and cadmium removal.

As illustrated in the previous section, Spiro Tunnel water zinc and cadmium concentrations are normally below the stream discharge permit limit. From May 8 through May 14, 2016, settled water pH was varied from 7.1 to 8.2 while the pilot plant was exclusively treating Spiro Tunnel water. From the investigation, treatment objectives were achieved during the pH variation. Elevated pH provided the most advantageous conditions for converting dissolved manganese to particles through the sedimentation basin. However, when treatment through pyrolusite filtration was compared for pH ranging from 7.1 to 8.2, metals removal from Spiro Tunnel water alone was comparable at all pH values tested.

A similar test was performed on Judge Tunnel water alone from May 19 through May 26, 2016. Since zinc and cadmium removal varied the most with pH change at bench scale, pH was varied from 7.5 to 8.4 during this time. The greatest removal of zinc and cadmium occurred for Judge Tunnel water between pH 8.2 to 8.4 through clarification and filtration. Figures 3-6 and 3-7 summarize the results of this test.

Figure 3-1: Mining-Influenced Water Treatment Schematic

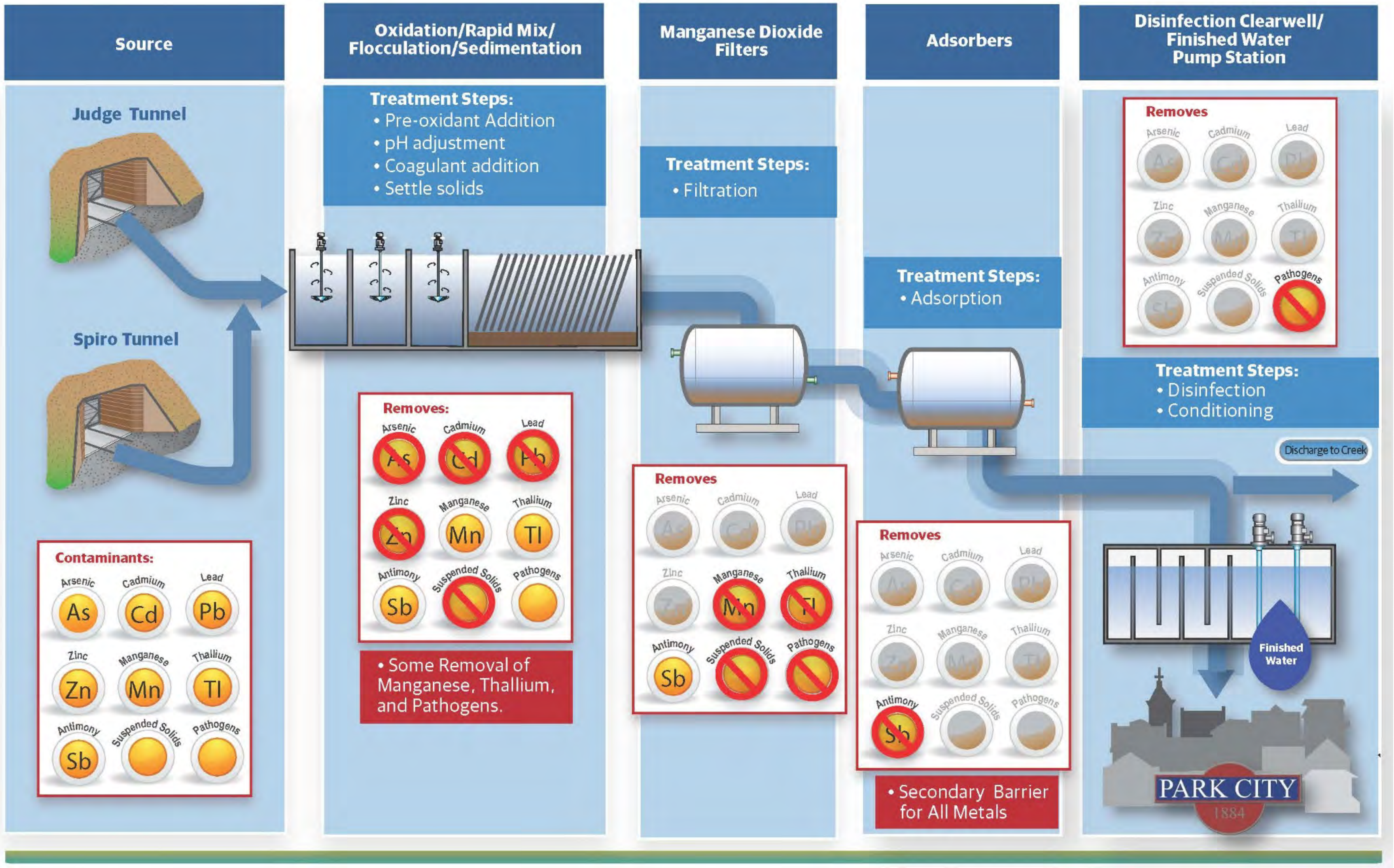


Figure 3-2: Oxidation and Adsorption Skid

Figure 3-3: Flocculation and Sedimentation Skid

Figure 3-4: Flocculation and Sedimentation Skid From Above

Figure 3-5: Filtration Skid

Figure 3-6: Effect of Settled Water pH on Cadmium Removal in Judge Tunnel Water

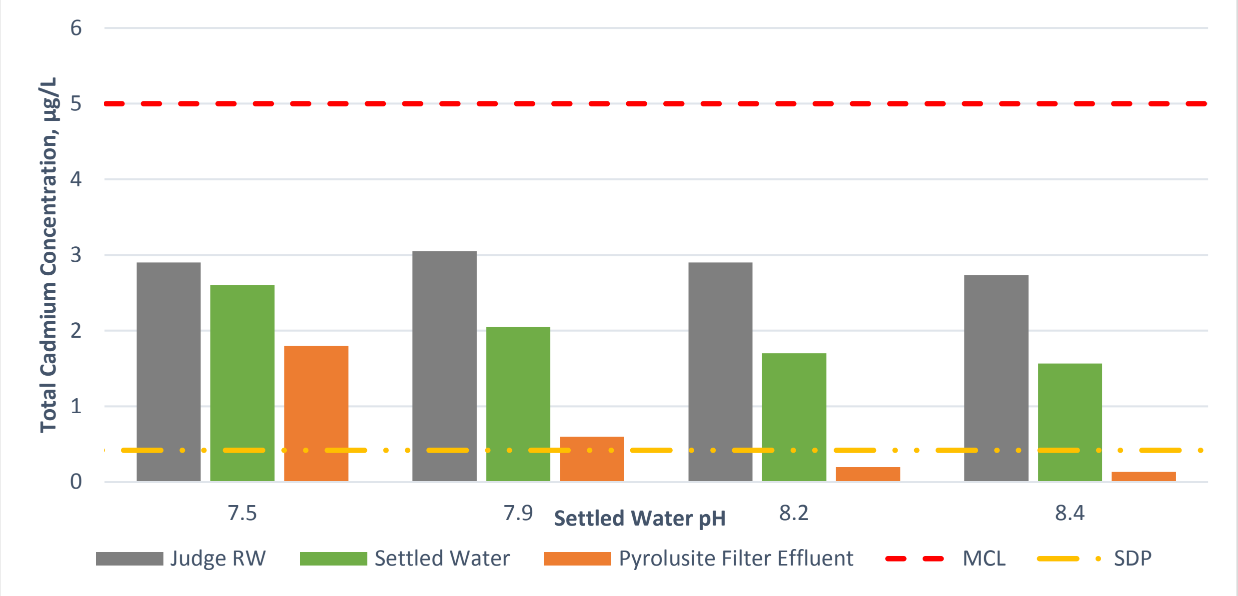
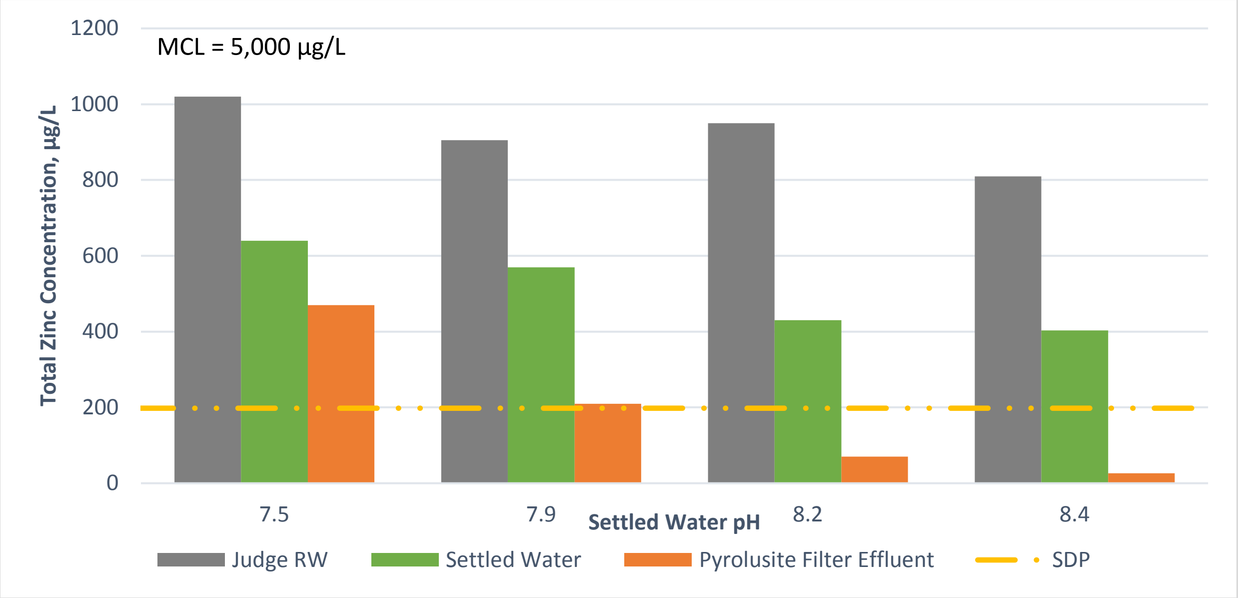


Figure 3-7: Effect of Settled Water pH on Zinc Removal in Judge Tunnel Water



The following inferences were made based on the results presented in Figure 3-6 and Figure 3-7:

- Clarification and filtration with pyrolusite media removes zinc and cadmium to levels below the stream discharge permit level at pH 8.2 and above.
- Treatment to remove cadmium and zinc improved as the settled water pH increased from 7.5 to 8.4.
- The additional treatment benefit from increasing the settled water pH from 8.2 to 8.4 was minimal.

Based on these findings, the decision was made to operate the pilot plant at the settled water pH of 8.2. The target pH remained at 8.2 with both the 2:1 and 4:1 Spiro to Judge blends to simplify operations and to provide full zinc and cadmium removal through any change in blend ratio.

Due to the high hardness of Spiro Tunnel water, when operating the pilot plant at pH 8.5 or greater, softening started to occur. The softening resulted in an accumulation of calcium particles through flocculation and sedimentation, which led to a decrease in turbidity removal through clarification. Scale from the precipitated calcium particles coated the pH probes and turbidimeters, which required frequent cleaning to maintain accurate readings. Therefore, pilot plant operation at the target pH of 8.2 also limited the potential for softening and associated scaling.

Oxidant dose, coagulant dose, and coagulant aid polymer dose were also investigated. Both tunnel waters exerted a very low oxidant demand. Operationally, a free chlorine residual of 0.3 mg/L or greater was maintained in the filter effluent. Higher chlorine residuals provided no additional treatment benefit.

Coagulant and coagulant aid polymer dose were selected through jar testing and pilot scale performance verification. Ferric chloride was used for the coagulant and Nalclear® 7766 Plus anionic polymer (30 percent active) was used for the coagulant aid polymer.

The optimal dose of ferric chloride was found to be 8 to 10 mg/L as $FeCl_3$, and the optimal dose of Nalclear® 7766 Plus was found to be 0.75 mg/L based on the performance of downstream pyrolusite filters. For the polymer, an important regulatory limit is the 1 mg/L maximum allowable polyacrylamide dose. Based on the product information, this dictated the maximum allowable polymer dose as product of 3.3 mg/L. Appendix C contains additional information regarding Nalclear® 7766 Plus.

SECTION 4

Key Observations and Findings

This section will discuss key observations and findings of the pilot study. The following aspects of the treatment process are discussed:

- Metals removal through oxidation, clarification, and filtration (Section 4.1)
- Metals removal through adsorption (Section 4.2)
- Whole Effluent Toxicity (WET) testing (Section 4.3)
- Turbidity removal through oxidation, clarification, and filtration (Section 4.4)
- Filter performance (Section 4.5)
- Solids dewatering and dewatering filtrate water quality (Section 4.6)
- Disposal of granular filtration media (Section 4.7)
- Operational considerations (Section 4.8)
- Challenge tests (Section 4.9)
- Taste test (Section 4.10)

4.1 Metals Removal Through Oxidation, Clarification, and Filtration

The pilot treatment approach performed as expected, meeting PCMC water quality goals for metals, including drinking water MCLs and stream discharge permit limits for Judge Tunnel water, Spiro Tunnel water, and combined tunnel water.

From the preliminary alternatives evaluation and cost estimates, as detailed in the Desktop Summary Evaluation (CH2M Hill, July 2015), it was determined that the greatest single effect on the ongoing operations and maintenance (O&M) cost of the facility was the replacement frequency of the adsorption media. Reducing the metals load on the adsorption media increases the bed volumes that can be treated before media replacement is needed. Therefore, a key treatment objective of the pilot study was to remove the most metals possible through oxidation, clarification, and filtration.

Over the course of the pilot study, the pilot operations team conducted pilot runs with varied operating conditions. Figure 4-1 through Figure 4-9 illustrate the metals concentrations through these pilot runs in the pilot plant influent, settled water (SW), and after filtration through 42 inches of pyrolusite media. Values shown as filter effluent represent either filtration through a single 42-inch pyrolusite filter media column or the blend of two 42-inch pyrolusite media columns. Experimental pilot filter runs, such as the pilot filter runs associated with optimizing zinc and cadmium removal through varying settled water pH in Spiro Tunnel and Judge Tunnel waters, was excluded from the results presented in Figure 4-1 through Figure 4-9. Table A-1, presented in Appendix A, summarizes the pilot filter runs, which make up the results presented in these figures.

Figure 4-1 through Figure 4-9 indicate that oxidation, clarification, and filtration with the deep bed pyrolusite media removed cadmium, iron, manganese, lead, and thallium to the laboratory method detection limit. Arsenic was removed to less than the MCL and less than the stream discharge permit limit to values close to its laboratory method detection limit. Zinc was removed to levels below the MCL and stream discharge permit limit and to values close to its laboratory method detection limit. For reference, Appendix G presents laboratory methods in the Pilot Testing Protocol. All results shown were generated at a target pH of 8.2 in clarification.

Antimony and selenium were not removed through oxidation, clarification, and filtration with pyrolusite. Mercury sampling in the settled water and filtered water was not performed due to the low levels of mercury in both the Judge Tunnel and Spiro Tunnel raw water sources.

Figure 4-1: Total Arsenic

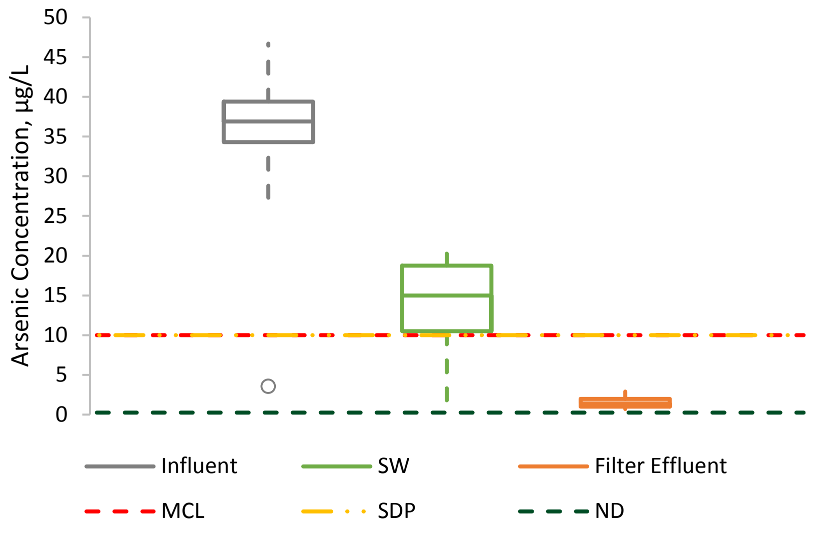


Figure 4-2: Total Antimony

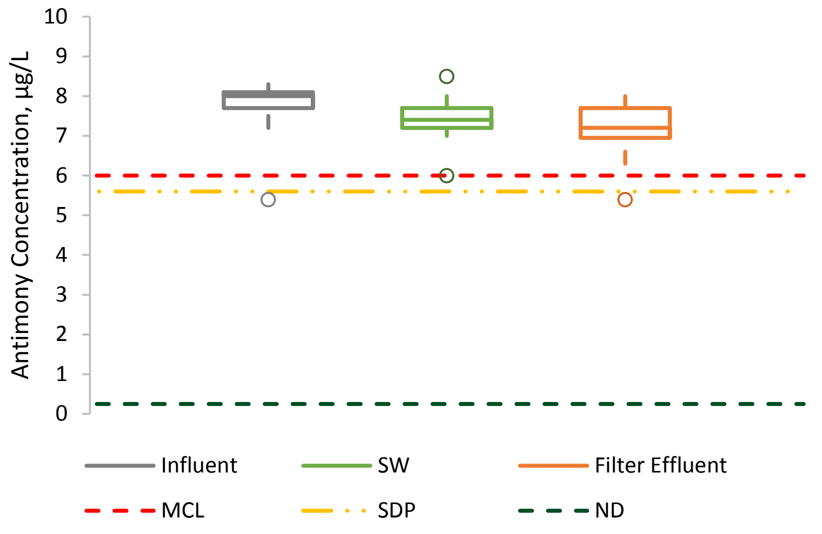


Figure 4-3: Total Cadmium

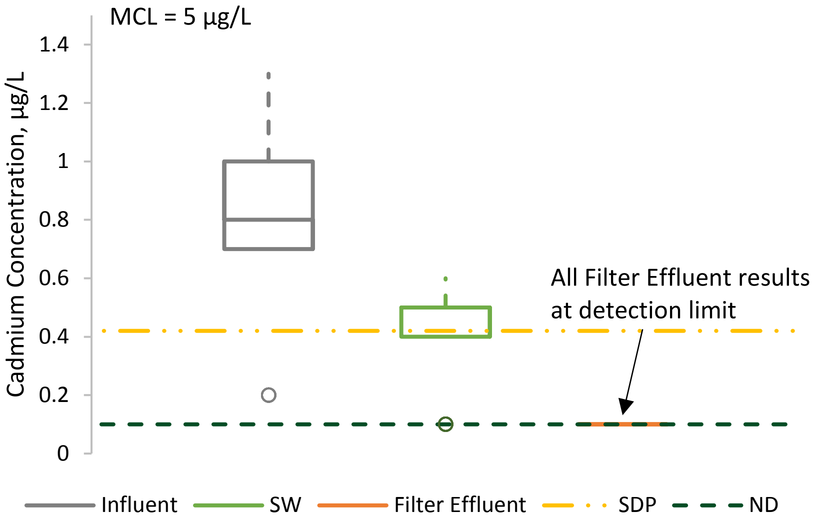


Figure 4-4: Total Iron

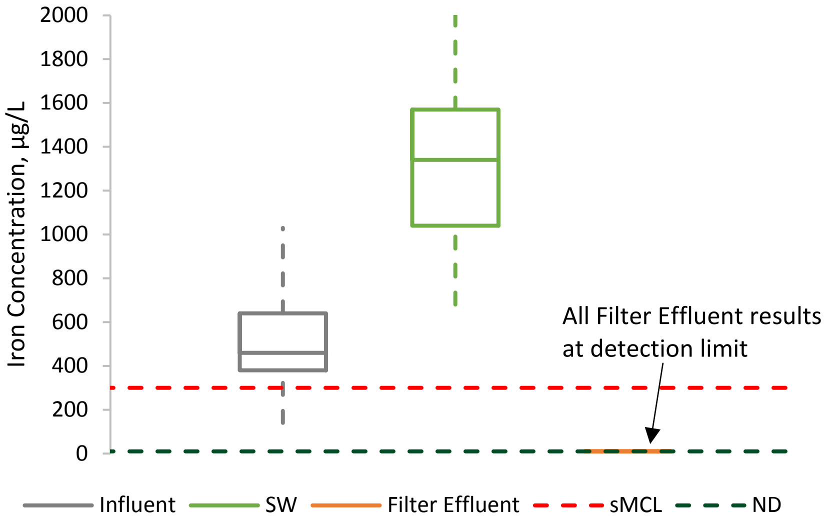


Figure 4-5: Total Manganese

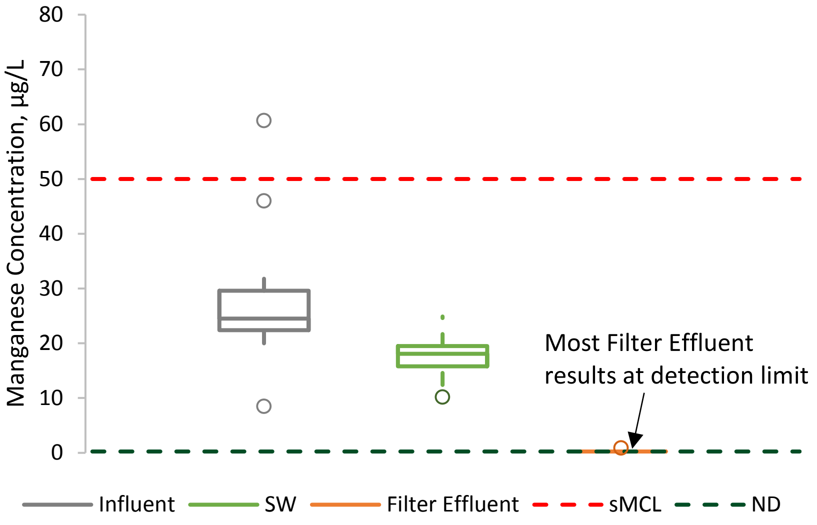
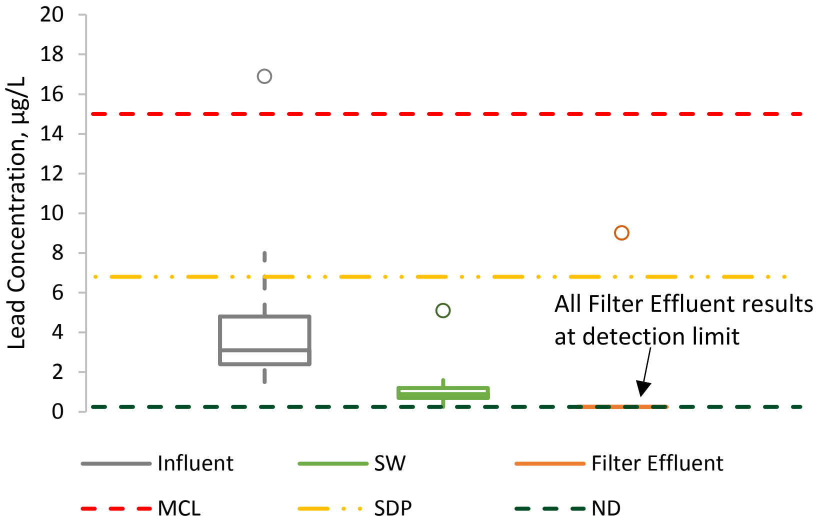


Figure 4-6: Total Lead



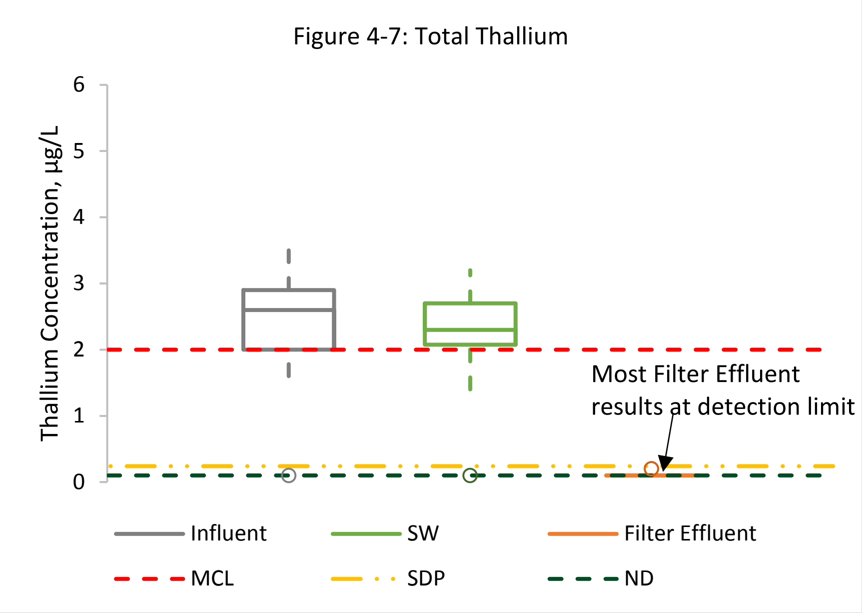


Figure 4-7: Total Thallium

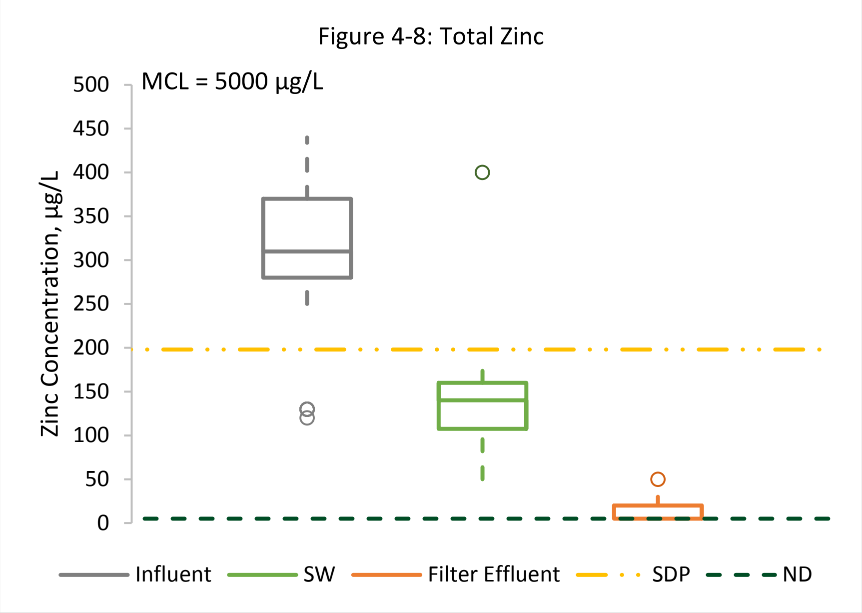


Figure 4-8: Total Zinc

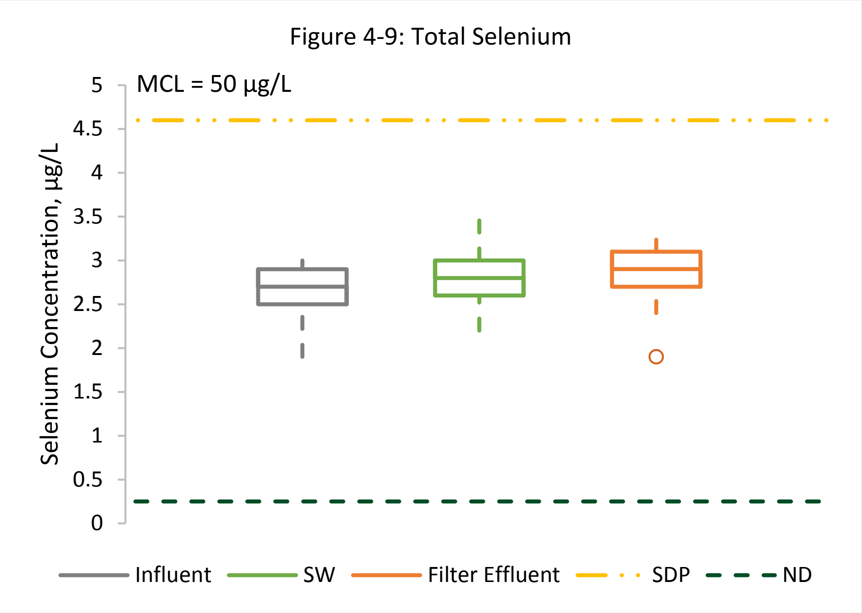


Figure 4-9: Total Selenium

Metals removal through oxidation, clarification, and filtration was also evaluated through four of the turbidity spikes discussed in Section 2.3. In the turbidity spikes, samples were taken at the influent, settled water, filter effluent, and adsorption effluent as the turbidity spike moved through the pilot plant.

Through the turbidity spikes, the treatment train successfully removed metals to levels below the stream discharge permit limit through clarification, filtration, and adsorption. Figures 4-10 through 4-18 provide data for all four turbidity spikes through the treatment process compared to typical metals removal data. Sample collection was staggered by the calculated residence time of each unit process to track the spike through the pilot plant. In each of these figures, each line represents a single sample set; the gray lines represent data collected during normal operation and the red lines represent data collected during a Spiro Tunnel turbidity spike. During treatment of the turbidity upset samples, concentrations of metals were similar to those achieved during normal operation after the sedimentation process.

Six raw water mercury samples collected during the turbidity spikes had mercury levels above stream discharge permit levels. Although no mercury samples were taken through the treatment train, two high turbidity water samples were clarified in a jar test and filtered through a 0.45-micron paper filter to obtain settled water and filtered water samples for mercury analysis. Results shown in Table 4-1 indicate that mercury would be expected to be removed to below the stream discharge permit limit through clarification and filtration.

Figure 4-10: Antimony Removal Through Turbidity Spikes

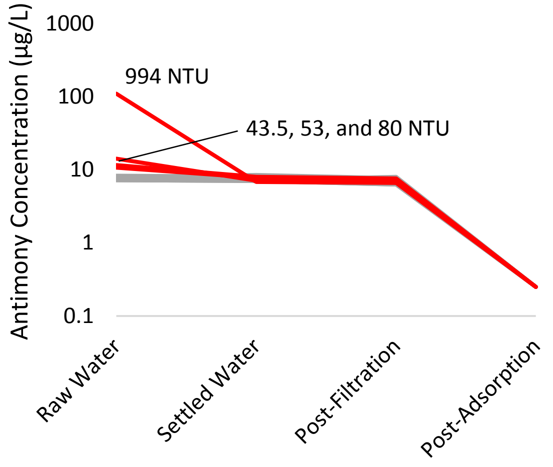
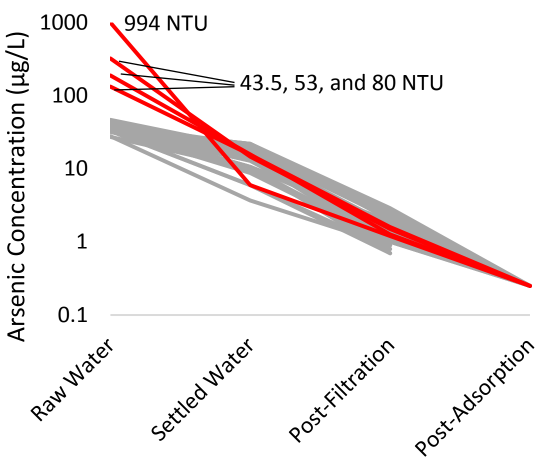


Figure 4-11: Arsenic Removal Through Turbidity Spikes



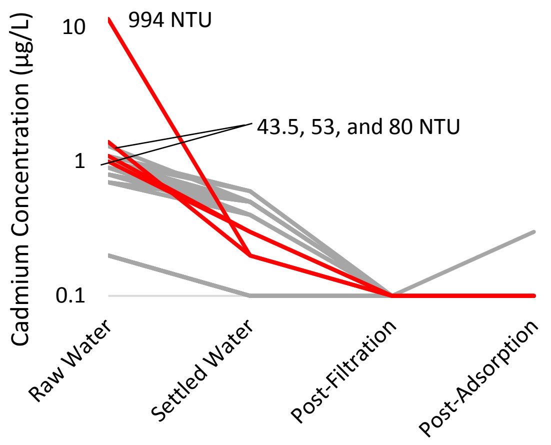


Figure 4-12: Cadmium Removal Through Turbidity Spikes

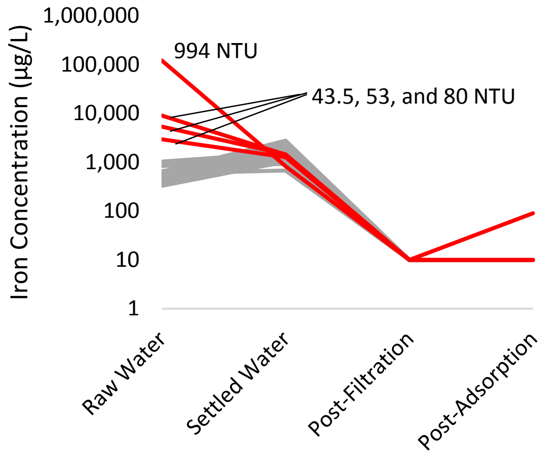


Figure 4-13: Iron Removal Through Turbidity Spikes

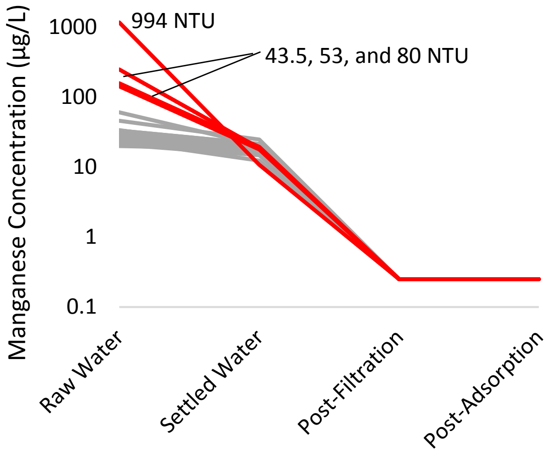


Figure 4-14: Manganese Removal Through Turbidity Spikes

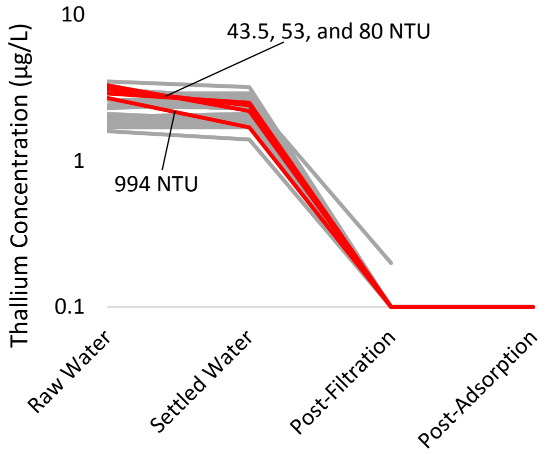


Figure 4-15: Thallium Removal Through Turbidity Spikes

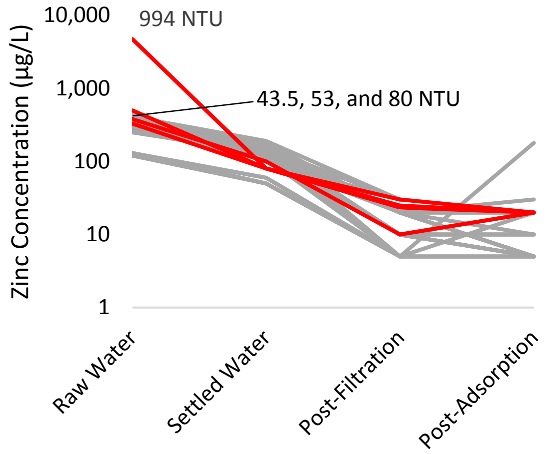


Figure 4-16: Zinc Removal Through Turbidity Spikes

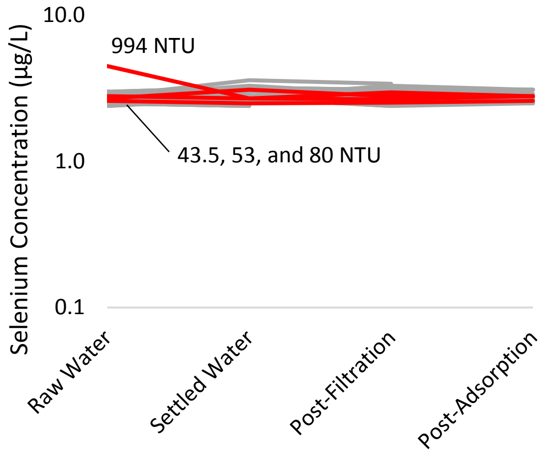


Figure 4-17: Selenium Removal Through Turbidity Spikes

Figure 4-18: Lead Removal Through Turbidity Spikes

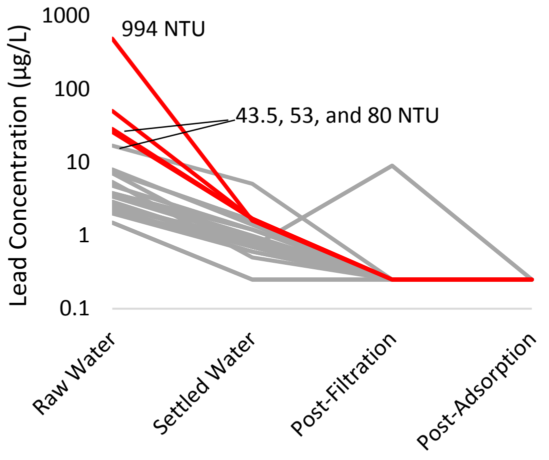


Table 4-1: Spiro Tunnel Upset Raw Water, Settled Water, and Filtered Water Mercury Concentrations

	Spiro Tunnel Upset, 730 NTU			Spiro Tunnel Upset, 850 NTU				
Analyte	**Raw Water**[a,b]	**Settled Water**[a]	**Filtered Water**[a]	**Raw Water**[a,b]	**Settled Water**[a]	**Filtered Water**[a]	**MCL or SMCL**	**SDP**
Mercury (ng/L)	19.4	0.25	0.25	93.7	0.25	0.25	2,000	12

a- All concentrations presented are total mercury concentration. Values represent a sample of Spiro Tunnel upset water taken during the “999 NTU” turbidity spike on September 28, 2016.

4.2 Metals Removal Through Adsorption

In the pilot plant treatment train, filtered water from two 42-inch pyrolusite filters was collected in a common filter effluent basin and fed to the adsorption process. The loading rates of these filters varied, but for the majority of time one filter operated at 10 gpm/sf and one filter operated at 6 gpm/sf. Filtered water turbidity remained below 0.1 NTU throughout operation. If a filter effluent reached 0.1 NTU, the filter would automatically backwash.

Adsorption was identified as the primary mechanism for antimony removal. Through bench-scale testing, three adsorption media were recommended for the pilot study, as follows:

- Titanium dioxide media: Metsorb®, provided by Graver Technologies.
- Ferric oxide media: Bayoxide® E33, provided by AdEdge Technologies.
- Ferric hydroxide media: GFH®, provided by Evoqua Water Technologies.

More detailed information about each adsorption media can be found in Appendix C.

Adsorption media exhaustion curves developed during pilot operation show antimony concentration versus bed volumes (BVs) treated for the column midpoint and column effluent sample points.

There were several phases of testing with the adsorption columns. They are summarized below.

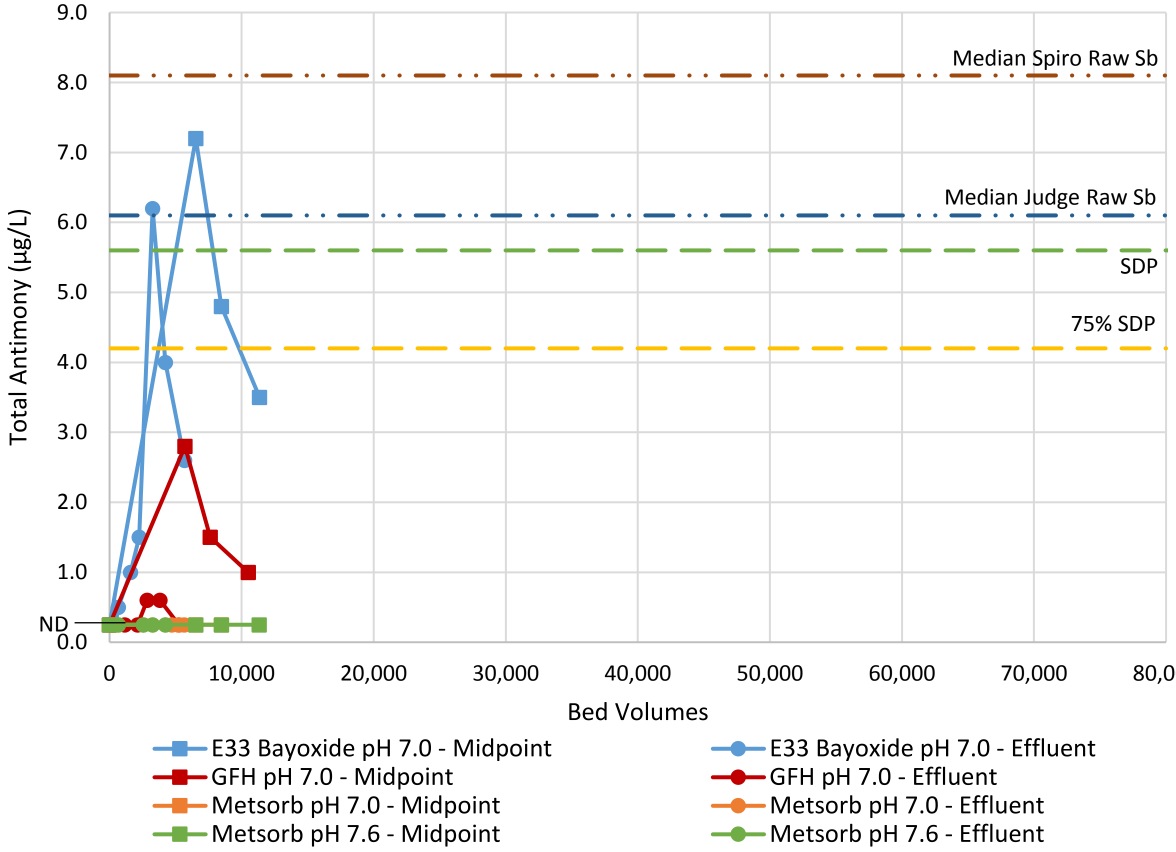
4.2.1 Trial 1

During the initial trial, four test conditions were evaluated:

- Adsorption Column 1: Metsorb® at pH 7.0
- Adsorption Column 2: Bayoxide® E33 at pH 7.0
- Adsorption Column 3: GFH® at pH 7.0
- Adsorption Column 4: Metsorb® at pH 7.6

Samples were collected at the midpoint and the effluent of each column. The two sample points represented empty bed contact times (EBCTs) of 3.0 and 6.0 minutes. During this initial trial, the pH rose from the target of 7.0 to a pH of 8.0 due to difficulties encountered with the acid feed. When the pH increased, there was an immediate increase in the antimony levels detected in the Bayoxide® E33 and GFH® products. This effect can be seen in Figure 4-19 from 3,000 to 5,500 bed volumes for the effluent series and between 6,000 to 11,000 bed volumes for the mid-point series. The pH increase did not have a detectable effect on the Metsorb® columns.

Figure 4-19: Antimony Removal through Adsorption Trial 1



4.2.2 Trial 2

Based on the observation of pH effect in Trial 1, the test conditions were modified during the second trial. Trial 2 represents a continuation of Trial 1 for all columns, with all columns containing the same media as Trial 1. Trial 2 test conditions included:

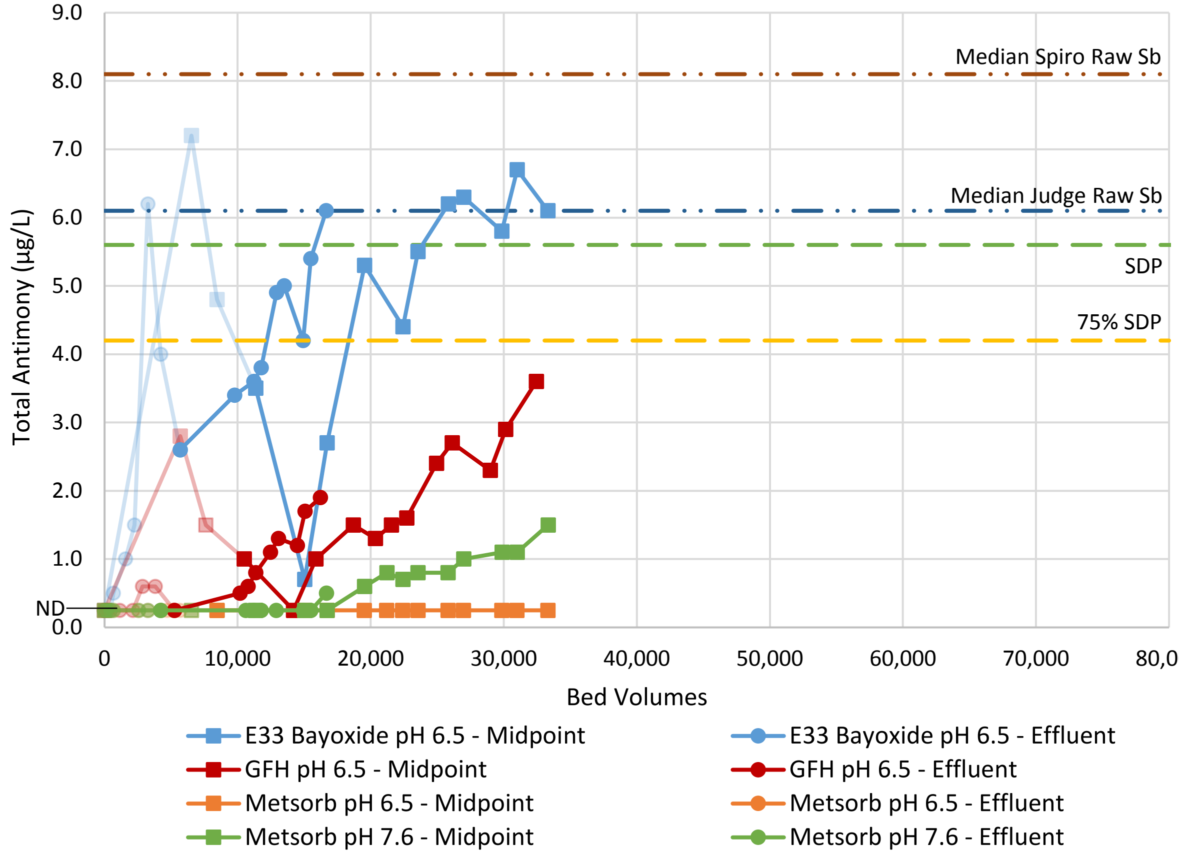
- Adsorption Column 1: Metsorb® at pH 6.5
- Adsorption Column 2: Bayoxide® E33 at pH 6.5

- Adsorption Column 3: GFH® at pH 6.5
- Adsorption Column 4: Metsorb® at pH 7.6

Additionally, the loading rate on the column was increased. Samples were collected at the midpoint and the effluent of each column. The two sample points represented EBCTs of 2.5 and 5.0 minutes.

During the second trial, a correction in the removal of antimony through the Bayoxide® E33 and GFH was observed. This indicated that antimony removal is influenced by pH. Since the stream discharge permit limit pH range is between 6.5 and 9.0, pH was not adjusted below 6.5. Figure 4-20 shows antimony concentrations at the midpoint and effluent of all adsorption columns. The shaded lines represent results from Trial 1 and the non-shaded lines represent results from Trial 2.

Figure 4-20: Antimony Removal through Adsorption Trial 2



Though removal increased for Bayoxide® E33 and GFH at the more acidic pH values during Trial 2, both media continued to show breakthrough, as indicated by Figure 4-20. The Bayoxide® E33 media was the first media whose effluent exceeded PCMC's goal of 75 percent of the SDP. Based on the pilot data, Bayoxide® E33 media at pH 6.5 would need to be changed every 12,000 to 18,000 bed volumes.

The GFH media continued to show breakthrough as well. Through extrapolation, it was estimated that GFH media at pH 6.5 would need to be changed every 29,000 to 50,000 bed volumes.

4.2.3 Trial 3 – Antimony Removal with Metsorb® Titanium Dioxide Media

On August 17, 2016, new Metsorb® media replaced both the Bayoxide® E33 and GFH® media. Test conditions for the Trial 3 were modified with the media replaced to the following:

- Adsorption Column 1: Metsorb® at pH 6.5 (same media as Trial 1 and 2)
- Adsorption Column 2: Metsorb® at pH 6.5 (new media)

- Adsorption Column 3: Metsorb® at pH 7.6 (new media)
- Adsorption Column 4: Metsorb® at pH 7.6 (same media as Trial 1 and 2)

Based on finished water quality modeling, for the purpose of the pilot study, it was assumed that finished water would leave the future MIW treatment plant at approximately pH 7.6 to achieve a target calcium carbonate precipitation potential (CCPP). To evaluate the treatment benefits of depressing to pH 6.5 for adsorption and then elevating the pH back to 7.6, test columns were run at both pH 6.5 and pH 7.6 for comparison. These conditions were maintained through the remainder of the pilot study.

Antimony levels in the effluent of both Metsorb® columns operating at pH 6.5 stayed below the laboratory detection limit throughout the duration of the pilot study. Metsorb® columns operating at pH 7.6 saw detectable levels of antimony at both the effluent and the mid-point sample points of the Metsorb® columns.

At the conclusion of this pilot study, in the column mid-point at pH 7.6, antimony levels reached a maximum of 2.6 µg/L at 37,000 bed volumes, which is less than half of the stream discharge permit limit.

Results for the Metsorb® media at pH 6.5 are presented in Figure 4-21. Since most of the data points in Figure 4-21 were at the laboratory detection limit, few quantifications can be drawn, other than the adsorption media life will be much longer than originally anticipated, resulting in significant O&M cost savings for PCMC. However, if the data from the mid-point of Adsorption Column 1 with Metsorb® at pH 6.5 were extrapolated to 75 percent of the SDP, it would result in approximately 170,000 bed volumes between media changes.

Figure 4-22 presents results for the Metsorb® media at pH 7.6. There is no data after approximately 35,000 bed volumes for the midpoint of the Metsorb® column at pH 7.6. In August 2016, half of the Metsorb® media was unintentionally removed from the column. The flow rate to the column was adjusted to maintain an effluent EBCT of 5 minutes, but samples could no longer be taken from the midpoint sample point. From the data in Figure 4-22, media replacement is expected between 66,000 and 91,000 bed volumes at pH 7.6. This indicates that there is a significant improvement that could be obtained by lowering to pH 6.5 for adsorption. Further cost comparisons using the results will be completed during conceptual design.

Near the end of the pilot study, the two Metsorb® columns at pH 7.6 were operated at pH 6.5 for three days to determine if lowering the pH would increase adsorption media life. The columns were returned to pH 7.6 after three days and were sampled again to determine any effects on the adsorption media exhaustion curve shape. Figure 4-22 shows that antimony concentrations were reduced by up to 1.6 µg/L when pH dropped, indicating that reducing adsorption feed pH from 7.6 to 6.5 can increase metals removal. The figure also shows that antimony concentrations returned to previous values once pH was returned to 7.6.

Figure 4-21: Antimony Removal through Metsorb at 6.5 pH

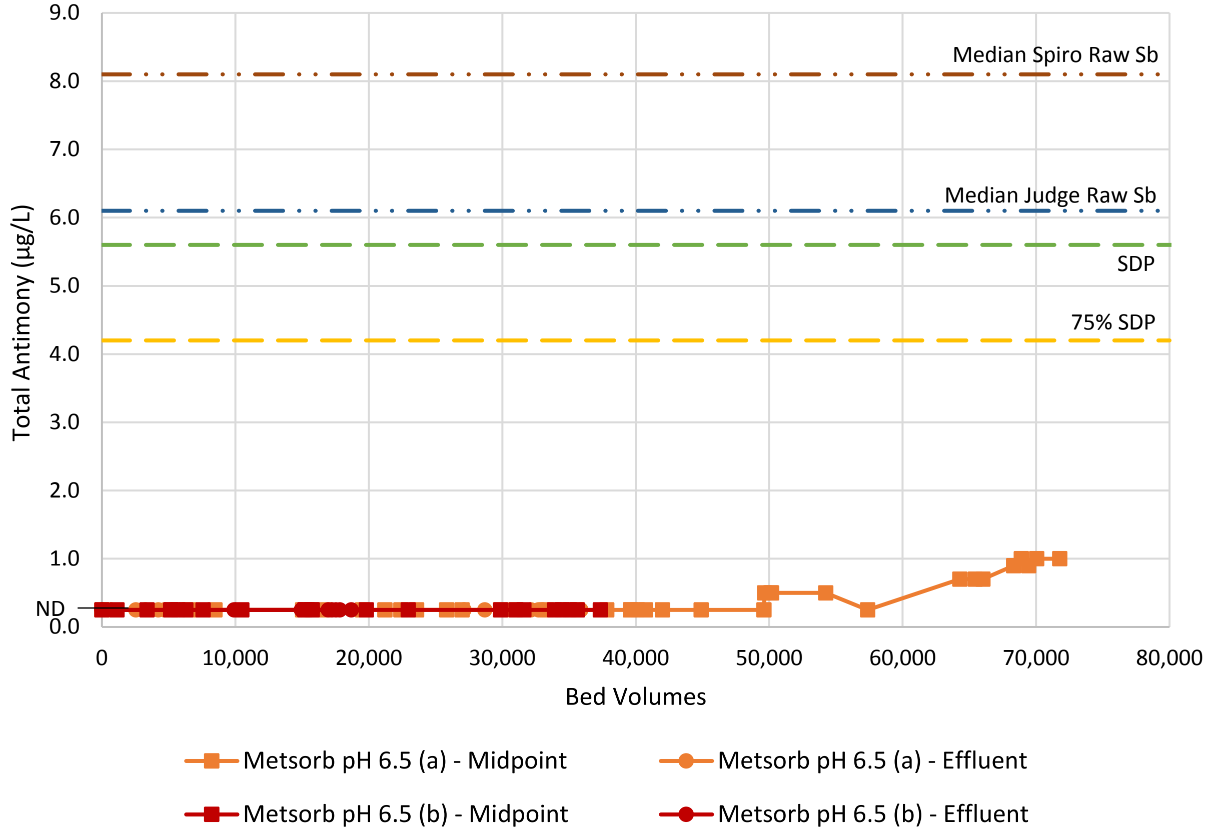
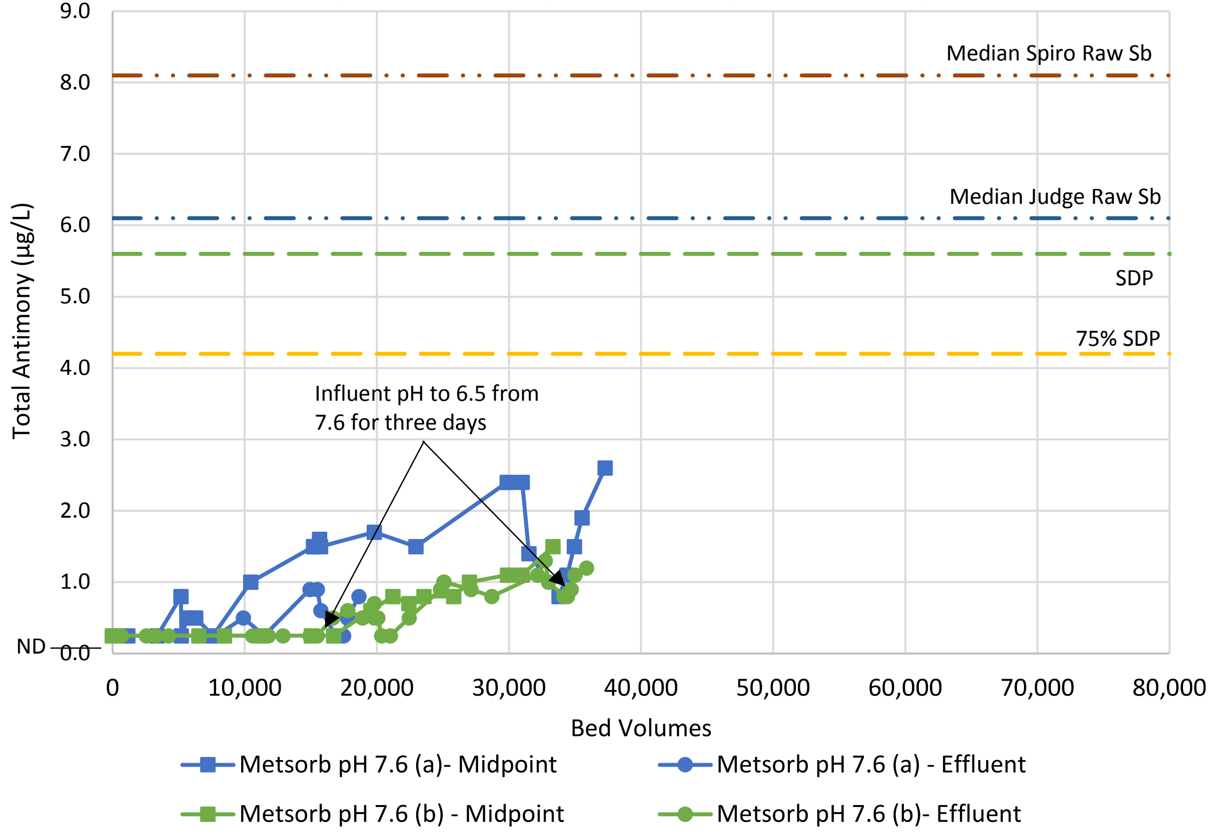


Figure 4-22: Antimony Removal through Metsorb at 7.6 pH



4.2.4 Additional Considerations

In addition to antimony, several other metals were sampled regularly in the adsorption columns' effluent. All adsorption midpoint and effluent samples for all adsorption media saw no detection of either lead or thallium throughout the pilot study.

Arsenic and cadmium were detected once at the midpoint and arsenic was detected once at the effluent of the first Metsorb® column at pH 6.5. All arsenic and cadmium detections from the first Metsorb® column at pH 6.5 were above the respective laboratory detection limits, but less than the MCL and SDP limits. Iron was detected once at both the midpoint and effluent of the GFH® column, twice at the effluent of the Bayoxide® E33 column, and once at the midpoint of the second Metsorb® column at pH 6.5. Manganese was detected once at both the midpoint and effluent of the first Metsorb® column at pH 6.5, once at the midpoint of the second Metsorb® column at pH 6.5, twice at both the midpoint and effluent of the GFH® column, twice at the effluent of the Bayoxide® E33 column, and twice at both the midpoint and effluent of the first Metsorb® column at pH 7.6. Most iron and manganese detections were below their respective SMCLs and all detections corresponded with either the period of difficulty with pH adjustment in the adsorption feed or the turbidity spikes seen in September 2016. Selenium was not removed through adsorption and was typically measured between 2.5 and 2.9 µg/L in the adsorption column effluent.

Zinc was detected often at both the midpoint and effluent of the Metsorb® columns at pH 6.5 and at the midpoint and effluent of the GFH® and Bayoxide® E33 columns at pH 6.5. Zinc was also detected at the midpoint and effluent of the Metsorb® columns at 7.6 pH when the pH was reduced to 6.5 for several days. Most zinc detections were below the stream discharge permit limit. However, three zinc samples were detected at levels near or above the SDP limit during periods of very low influent pH. The first Metsorb® pH 7.6 column influent dropped to pH 2 for several hours in early July and the influent to the GFH®, Bayoxide® E33, and Metsorb pH 6.5 columns dropped to pH 3 for approximately 10 hours in mid-July due to an experimental error. After these occurrences, the influent pH issue was resolved and no further influent pH issues occurred. These results indicate that there may be a zinc release potential with all adsorption media used under very low pH conditions. If pH 6.5 or 7.6 is maintained, then the zinc release is not expected to be of concern.

The following conclusions can be made based on the data gathered on metals removal through adsorption:

- Adsorption with titanium dioxide media, ferric oxide media, and ferric hydroxide media removed antimony to below the stream discharge permit limit level. The media replacement frequency was estimated at:
  - 66,000 to 170,000 bed volumes for titanium dioxide media
  - 22,000 to 18,000 bed volumes for ferric oxide media
  - 29,000 to 50,000 bed volumes for ferric hydroxide media
- Antimony was removed by all media at an EBCT of 2.5 minutes.
- Antimony removal at a pH of 6.5 will result in the ability to treat significantly more bed volumes before exhaustion compared to operation at pH 7.6.
- Lowering pH from 7.6 to 6.5 for three days increased antimony removal in both pH 7.6 Metsorb® columns. Media exhaustion curves for both pH 7.6 Metsorb® columns returned to pre-6.5 pH levels once pH was returned to pH 7.6.

Both GFH® and Bayoxide® E33 media were tested with the Toxicity Characteristic Leaching Procedure (TCLP) after removal from the process to verify proper disposal requirements. Metsorb® adsorption media will undergo the TCLP after further testing of the media (as described in Section 6) is completed.

TCLP results for GFH® and Bayoxide® E33, shown below in Table 4-2, are below the TCLP regulatory limits as defined by the Resource Conservation and Recovery Act (RCRA) limits for hazardous solid waste by an order of magnitude or more. These results indicate that both media can be considered non-hazardous waste.

Table 4-2: GFH and Bayoxide® E33 Media TCLP Results

Analyte[a]	**GFH Media**	**Bayoxide® E33 Media**	**RCRA Limit**
Mercury, TCLP	0.0007	0.0007	0.2
Arsenic, TCLP	0.25	0.25	5
Barium, TCLP	0.28	0.17	100
Cadmium, TCLP	0.025	0.025	1
Chromium, TCLP	0.025	0.025	5
Lead, TCLP	0.1	0.1	5
Selenium, TCLP	0.001	0.025	1
Silver, TCLP	0.025	0.025	5

a- All values are total measurements in µg/L.

4.3 Whole Effluent Toxicity (WET) Testing

Two WET tests were conducted throughout the pilot study: one in the spring, during the time that has historically coincided with higher flow conditions, and one in the fall, during the time that has historically coincided with lower flow conditions. These tests matched the regulatory compliance requirements of the UPDES permits. Both WET tests used Metsorb® titanium dioxide media effluent. The first WET test used a blend of 2:1 Spiro-to-Judge water at an adsorption influent pH of 7.0 and the second WET test used a blend of 4:1 Spiro-to-Judge water at an adsorption influent pH of 6.5. The pilot treated water passed the first and second WET tests for survival and reproduction of *Ceriodaphnia dubia* (water flea) and *Pimephales promelas* (fathead minnows). Appendix D contains a summary of results from both WET tests.

As previously discussed, Spiro Tunnel water has a hardness of 470 to 500 mg/L as $CaCO_3$ and, when blended with Judge Tunnel water, has a hardness of 370 to 445 mg/L as $CaCO_3$, depending on the blend ratio. The control water used in the WET test had a hardness of approximately 100 mg/L as $CaCO_3$. Therefore, PCMC had an additional control sample of 400 mg/L as $CaCO_3$ hardness synthetic water tested during the first WET test to determine if elevated hardness levels alone could affect the survival and reproduction of either *Ceriodaphnia dubia* or *Pimephales promelas.* The high hardness control WET test passed for survival and reproduction of *Pimephales promelas* as well as survival of *Ceriodaphnia dubia* but failed for reproduction of *Ceriodaphnia dubia*.

Elevated levels of total dissolved solids (TDS) in the water can interfere with the WET test results. In the first WET test, conductivity ranged from 745 to 812 µS/cm in the sample pilot effluent water and 1,155 to 1,222 µS/cm in the synthetic high hardness water. Using conductivity as a surrogate, the synthetic high hardness water had higher levels of (TDS) than the pilot effluent sample water. This indicates that if the TDS of the tunnel water were to rise significantly, there may be an increased risk of not passing a future WET test.

WET testing for Spiro and Judge Tunnel raw waters was considered but ultimately not pursued because the UPDES permit does not require WET tests on raw water. Furthermore, any raw water WET test results were not expected to impact the current process selection.

4.4 Turbidity Removal Through Oxidation, Clarification, and Filtration

Both Spiro Tunnel and Judge Tunnel are classified as groundwater sources for drinking water. However, PCMC has decided to establish more conservative drinking water quality goals that match the USEPA's Surface Water Treatment Rule for conservative planning. Specifically, this pilot study gathered data to demonstrate that this facility conforms to Utah Admin Code Rule R309-525 for Facility Design and Operation: Conventional Surface Water Treatment.

The pilot process of clarification and filtration represents a conventional surface water treatment process. The 42 inches of pyrolusite media column must be approved through R309-525-15 (4) (e.):

> *R309-525-15. Filtration.*
>
> > *(4) Media Design.*
> >
> > > *(e) Other Media Compositions and Configurations: Filters consisting of materials or configurations not prescribed in this section will be considered on experimental data or available operation experience.*

Pyrolusite is a manganese dioxide ore typically used in drinking water treatment. Pilot testing was performed using a deep bed filter with 42 inches of two types of pyrolusite media with 0.43 to 0.5 mm effective size (ES) and 1.48 to 1.56 uniformity coefficient (UC) pyrolusite. Appendix C includes a sieve analysis of the pyrolusite media that confirms the ES and UC of the media. This media configuration has performed exceptionally well in terms of turbidity removal and metals removal.

Loading rates for pyrolusite filter runs ranged from 5 gpm/sf to 12 gpm/sf throughout the course of the pilot study. From April 29 through October 31, 2016, this media configuration operated through various upstream conditions and set points, with 247 filter runs completed during optimal operating conditions. All but five of 247 filter runs in optimal conditions terminated due to the accumulation of 20 feet of headloss. The five filter runs that terminated due to reaching 0.1 NTU effluent turbidity did so during a period of elevated influent turbidity near the end of the pilot study. During pilot operations, the filter runs were stopped if any filter effluent measured 0.1 NTU for over 15 minutes or when the filter reached 29 feet of headloss, the maximum reachable headloss for each filter at the pilot plant. All UFRV calculations were based on 20-feet of headloss accumulation, which occurred prior to the terminal headloss of 29 feet. Typical filter effluent turbidity from the deep-bed pyrolusite filters was 0.023 NTU.

During the majority of the pilot testing period, the raw water turbidity was very low. From April 1 to October 31, 2016, the MIW pilot plant influent saw thirteen turbidity spikes, and the most severe spike saw raw water turbidity reach 999 NTU. A turbidity reading of over 15 NTU was defined as a "turbidity spike" for both Judge Tunnel and Spiro Tunnel waters. Table 4-3 presents a summary of the turbidity spikes seen through the pilot study. During the highest of these spikes, settled water turbidity briefly reached a maximum of 7.6 NTU. Throughout these spikes, the 42-inch pyrolusite media maintained an effluent turbidity of less than 0.1 NTU at all times. During the highest turbidity spikes, filter run length decreased in duration through the 42-inch pyrolusite media due to faster headloss accumulation when polymer doses were increased above 1.0 mg/L. However, the unit filter run volumes (UFRVs) of the filter runs during the turbidity spikes were comparable to other filter runs during normal operation. Filter performance is discussed in Section 4.5.

Thus, the deep bed pyrolusite filters saw minimal effects of the turbidity upsets experienced through the pilot plant and the filters maintained filter effluent turbidities of less than 0.1 NTU. Throughout the seven turbidity spikes, the deep bed pyrolusite filter performance indicated that both the Long-Term 2 Enhanced Surface Water Treatment Rule and the DDW Alliance's most stringent filtered water turbidity goals of less than 0.15 NTU 95 percent of the time will be met during elevated inlet turbidity conditions.

The periods of elevated turbidity showed that the pilot plant can produce high quality finished water in high turbidity upset conditions up to turbidities of 994 NTU. At full-scale, further optimization of chemical dosing and process operation through clarification is recommended during high turbidity events.

Table 4-3: Summary of Turbidity Spikes

Date of Turbidity Spike	Maximum Spiro Raw Water Turbidity (NTU)	Maximum Settled Water Turbidity (NTU)	42-inch Pyrolusite Filter Loading Rates (gpm/sf)	Ferric Chloride Dose Range (mg/L)	Polymer Dose Range (mg/L)
5/3/2016	146	7.6	5 and 6	10	0.75
5/27/2016	54	6.5	2	12 – 30	0.75 – 1.0
6/16/2016	37	2.8	5 and 6	8	1.0 – 1.5
8/11/2016	15	3.1	6 and 12	8	0.75
8/17/2016	73	4.1	6	8	0.75
9/19/2016	49	4.2	6, 8, and 10	10 – 20	0.75 – 1.0
9/20/2016	84	3.9	6, 8, and 10	10 – 12	1.0
9/21/2016	91	3.5	6, 8, and 10	8 – 12	0.75 – 1.5
9/26/2016	20	3.2	6, 8, and 10	8 – 10	0.75 – 2.0
9/27/2016	24	3.4	6, 8, and 10	8	0.75 – 1.0
9/28/2016	999	7.5	6, 8, and 10	8 - 15	0.75 – 3.0
9/29/2016	37	4.3	6, 8, and 10	8 - 10	1.0 – 2.0
10/5/2016	19	7.1	6, 8, and 10	10	1.0 – 2.0

Figure 4-23 through Figure 4-25 present Spiro raw water turbidity, pilot influent turbidity, settled water turbidity, and filter effluent turbidity through three turbidity spikes seen at the pilot plant. Filters “PY-01,” “PY-02,” and “PY-07” all contained 42 inches of 0.43 to 0.50 mm ES pyrolusite. “PY-01” and “PY-02” contained one type of pyrolusite media and “PY-07” contained a different type of pyrolusite media. Appendix C shows the pyrolusite media sieve analysis for both media types. Pilot influent turbidity was measured at the inlet of the flocculation and sedimentation pilot skid and varied from Spiro raw water turbidity based on the Spiro to Judge blend at the time of spike.

In addition to the filters with 42 inches of pyrolusite, three other media profiles were tested. Specific information on each media type is shown below in Section 4.5. Media profiles tested included 60 inches of anthracite over 12 inches of sand, 40 inches of anthracite over 20 inches of pyrolusite, and 24 inches of pyrolusite. Table 4-4 presents a comparison of metals removal and turbidity removal performance of the four media profiles. When compared, the 42 inches of pyrolusite filter media performed the best in terms of metals removal of all filter media profiles. The 42 inches of pyrolusite filter media also consistently terminated due to headloss accumulation and did not typically terminate due to reaching 0.1 NTU filter effluent turbidity.

Table 4-4: Comparison of Filter Media Profiles

Parameter	**42-inch Pyrolusite**	**60-inch Anthracite over 12-inch Sand**	**24-inch Pyrolusite**	**40-inch Anthracite over 20-inch Pyrolusite**[b]
Metals Removal	Full removal of thallium	Partial removal of thallium	Partial removal of thallium	Partial removal of thallium
UFRV (gal/sf)[a,c]	11,600	6,000 – 17,000	5,500 – 13,000	23,100
Termination	Headloss	Turbidity	Headloss/ Turbidity	Turbidity
Median Turbidity (NTU)[c]	0.023	0.02 – 0.06	0.02 – 0.05	0.016

a- Unit Filter Run Volume calculated based on the volume of water produced per square foot of filter area from the conclusion of filter-to-waste through termination of the filter run. Filter run termination could be from either headloss or turbidity.

b- Anthracite over pyrolusite media was evaluated at a polymer dose of 2 mg/L, which was found to be the optimal polymer dose for maximizing filter run lengths with this media configuration.

c- Single UFRV and turbidity values represent the median value and a range of UFRV or turbidity values represents the range for that media.

For each filter run, a filter effluent turbidity and headloss profile was created. As per the Pilot Testing Protocol, filter runs ended at either 0.1 NTU filtered water turbidity or if filter headloss accumulation exceeded 20-feet.

The following conclusions can be drawn from the turbidity performance during the pilot study as well as Figure 4-23 through Figure 4-25 and Figures F-1 through F-247 in Appendix F:

- 42 inches of 0.43 to 0.50 mm ES pyrolusite performed the best of all filters tests, providing robust metals removal as well as excellent turbidity removal.
- In 247 filter runs of optimized treatment conditions, most runs with 42 inches of pyrolusite media terminated on headloss, always maintaining a filtered water turbidity of less than 0.1 NTU. Five filter runs terminated on turbidity during periods with elevated influent turbidity.
- Filter runs terminated after 20 feet of headloss accumulation with turbidities in the 0.02 to 0.05 NTU range.

Figure 4-23: Turbidity Spike of 146 NTU (maximum) on May 3, 2016, Filter Loading Rates of 5 and 6 gpm/sf

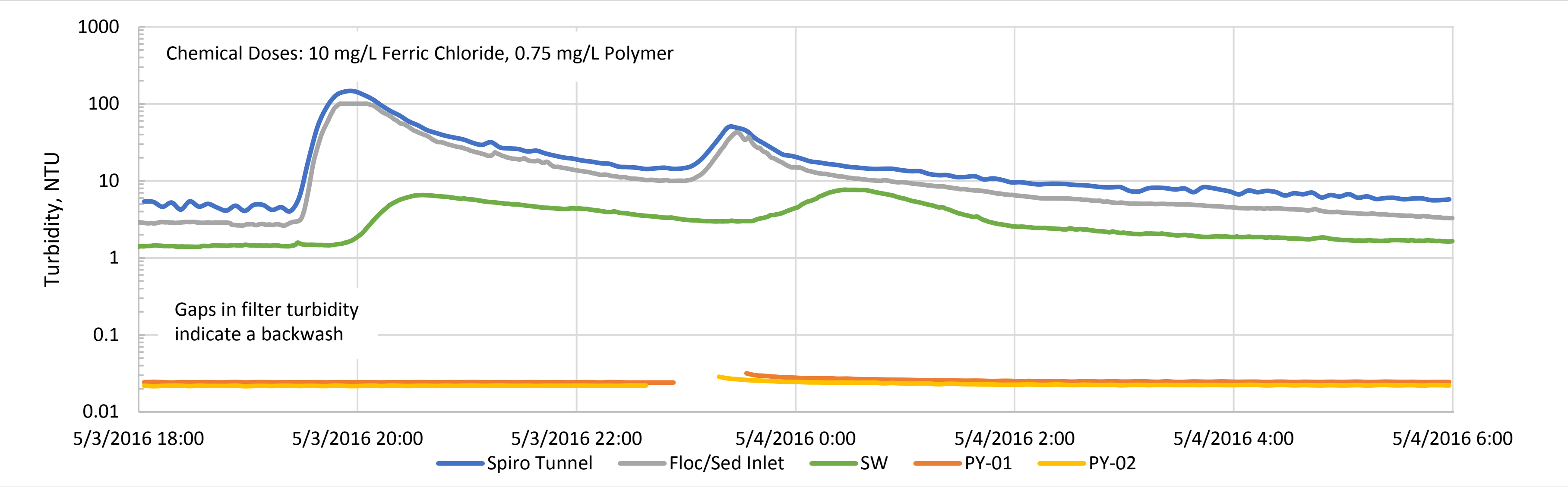


Figure 4-24: Turbidity Spikes of 45, 65, and 91 NTU (maximum) on September 19 through 22, 2016, Filter Loading Rates of 6, 8, and 10 gpm/sf

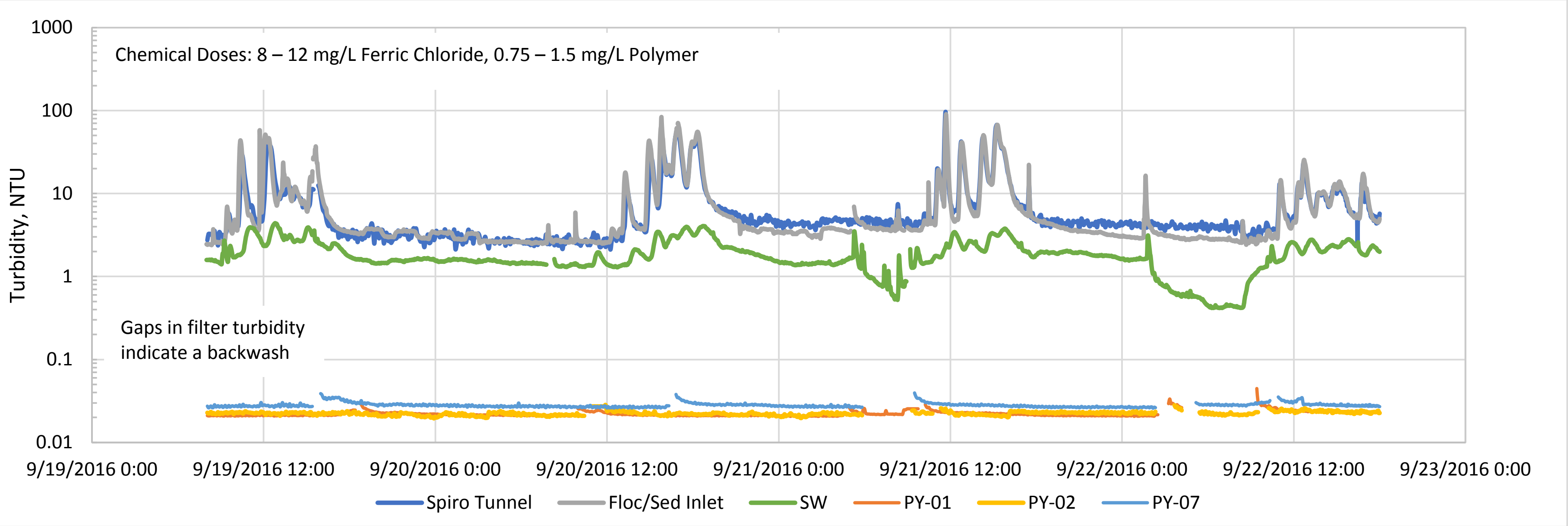
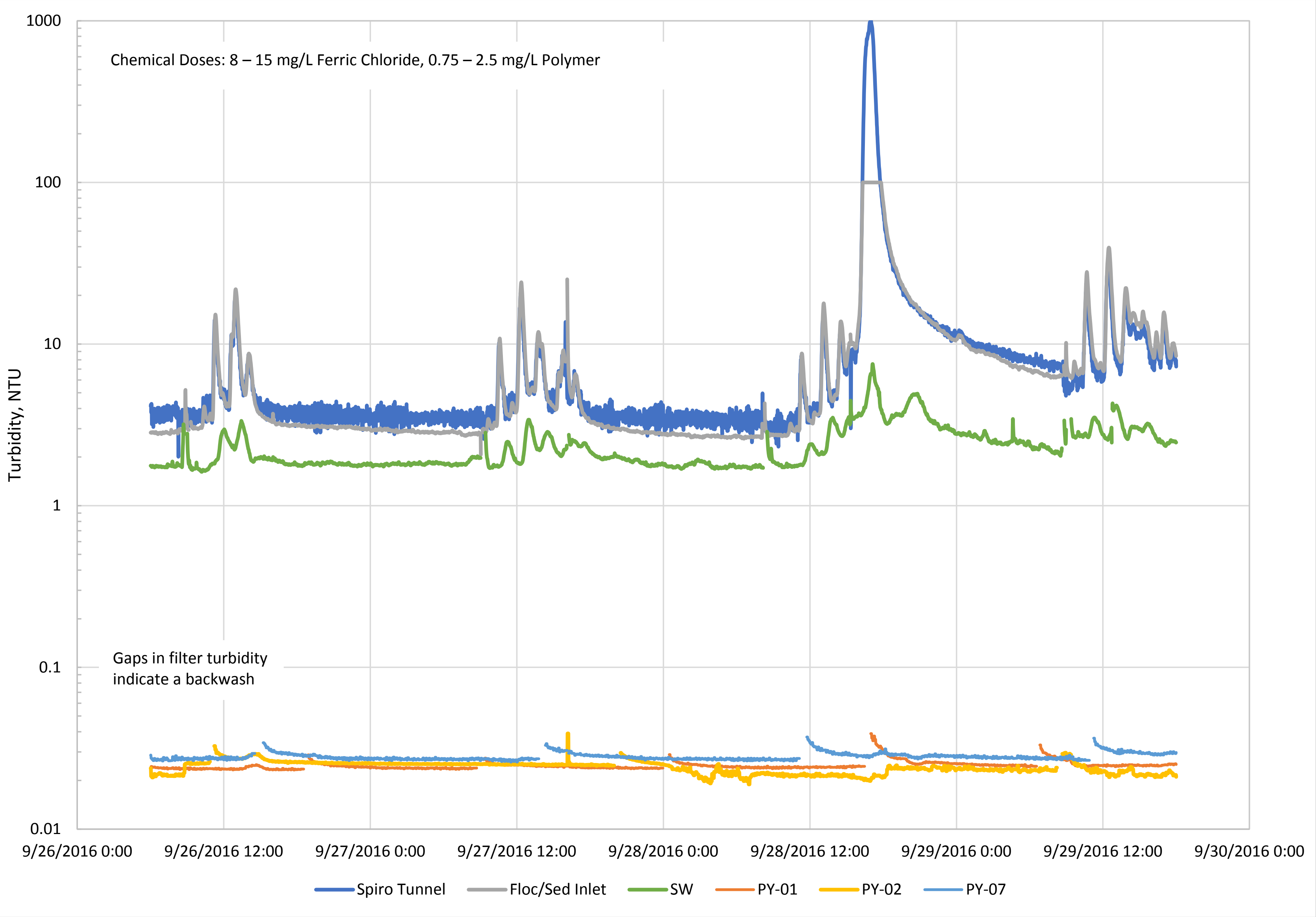


Figure 4-25: Turbidity Spikes of 20, 21, 999, and 38 NTU (maximum) on September 26 through 29, 2016, Filter Loading Rates of 6, 8, and 10 gpm/sf



4.5 Filter Performance

Throughout the pilot study, evaluations of metals and turbidity removal of four filter media profiles aided in the selection of the best filter media to be used for full-scale operations. The four filter media profiles and number of filter runs performed are as follows:

- 501 filter runs using three separate filter columns with 42 inches of 0.43 to 0.50 mm ES pyrolusite media from two different media suppliers
- 134 filter runs using two separate filter columns with 60 inches of 1.25 to 1.35 mm ES anthracite over 12 inches of 0.55 to 0.65 mm ES sand
- 42 filter runs using one column with 40 inches of 1.25 to 1.35 mm ES anthracite over 20 inches of 0.43 mm ES pyrolusite
- 16 filter runs using one column with 24 inches of 0.43 mm ES pyrolusite media

Of the 501 runs performed with the pyrolusite media, 247 filter runs occurred during optimal treatment conditions and their effluent turbidity and UFRV analysis is included below. The first 42 filter runs for both the pyrolusite column PY-01 and the pyrolusite column PY-02 were excluded because they were during the pilot commissioning phase. Other excluded filter runs included those occurring during mechanical difficulties and during experimental periods (e.g., loss of chemical feed, changes in upstream conditions, insufficient or excess polymer). Table 4-5 presents a summary of filter runs PY01-43 though PY01-251, filter runs PY02-43 through PY02-165, and filter runs PY07-01 through PY07-83. Appendix F includes filter run profiles for these 248 pyrolusite filter runs. The filter runs that are shown and that were included in the data summary that follows are those 247 filter runs that constitute “steady state” filter runs with optimized treatment conditions.

The data summarized below in Table 4-5 and illustrated in Figure 4-26 and Figure 4-27 are based on filter runs from three 42-inch pyrolusite filter columns. The filter analysis used 13 filter runs at 5 gpm/sf, 66 filter runs at 6 gpm/sf, 60 filter runs at 8 gpm/sf, 99 filter runs at 10 gpm/sf, and 9 filter runs at 12 gpm/sf. One single filter run at 7 gpm/sf was also performed with a UFRV of 14,078 gallons per square foot (gal/sf) and a median turbidity during the run of 0.019 NTU.

Table 4-5: Summary of Filter Performance

Filter Loading Rate	Number of Runs Analyzed	***Lower Quartile***[a,b]		***Median***[b]		***Upper Quartile***[a,b]	
		UFRV	**Median Filter Effluent Turbidity**	**UFRV**	**Median Filter Effluent Turbidity**	**UFRV**	**Median Filter Effluent Turbidity**
5 gpm/sf	13	12,098	0.018	14,220	0.021	15,127	0.021
6 gpm/sf	66	7,449	0.022	9,730	0.023	12,303	0.025
8 gpm/sf	60	6,653	0.023	8,076	0.024	9,992	0.027
10 gpm/sf	99	5,901	0.020	8,084	0.021	9,164	0.024
12 gpm/sf	9	10,498	0.020	10,986	0.020	11,159	0.020

a- The lower quartile represents the 25th percentile of data and the upper quartile represents the 75th percentile of data.
b- UFRV values are in gallons per square foot (gal/sf), and median filter effluent turbidity values are in NTU.

Figure 4-26: Filter Run UFRV

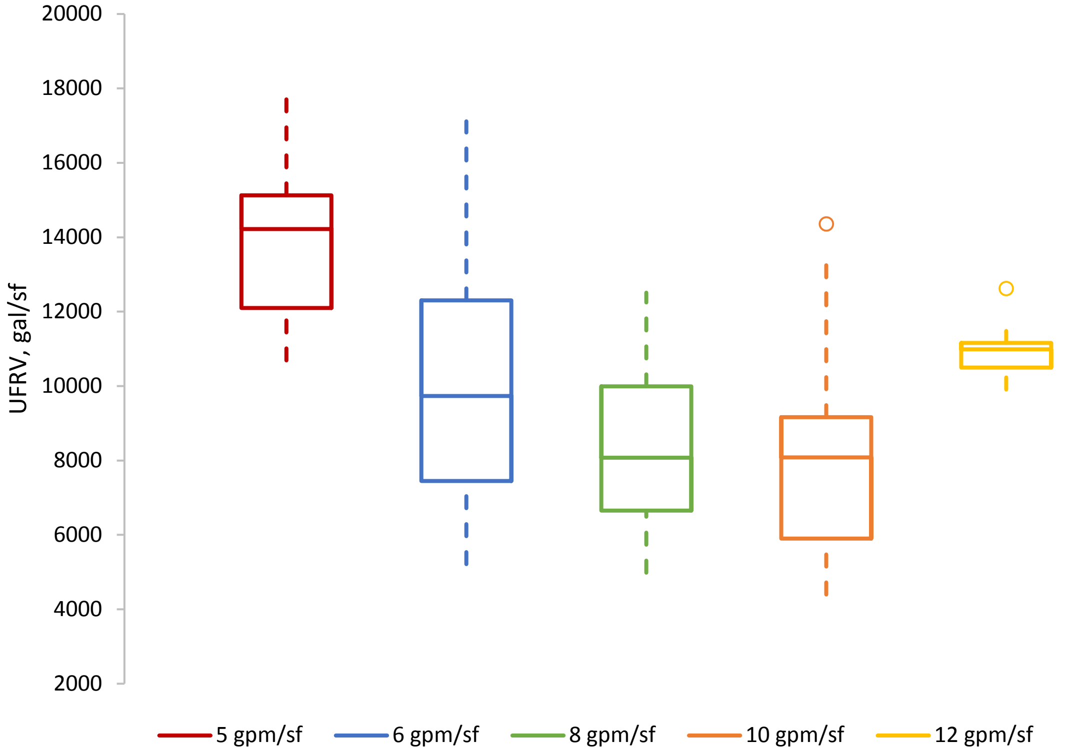
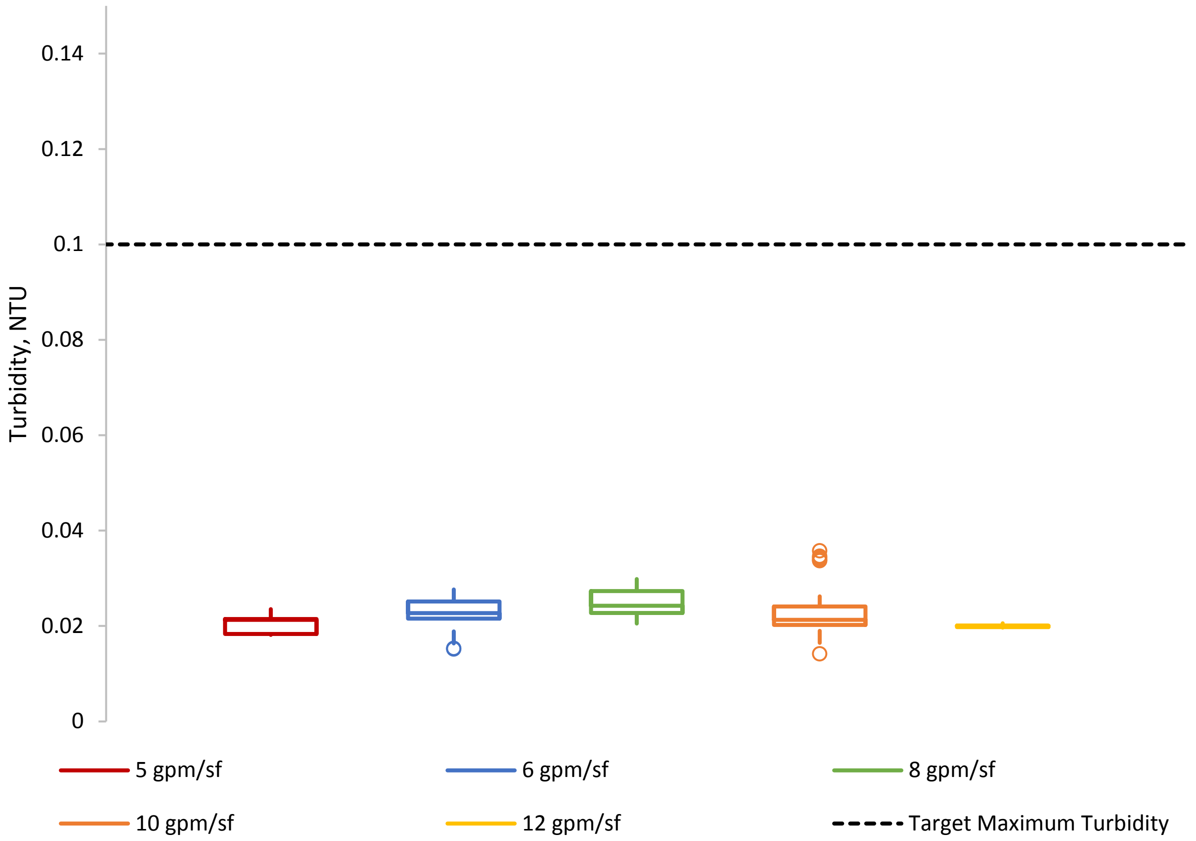


Figure 4-27: Median Turbidity of Filter Runs



From Figure 4-27 and Table 4-5, filtered water turbidity varied minimally between all filter loading rates tested from 5 to 12 gpm/sf, with a filtered water turbidity between 0.018 and 0.028 NTU for most filter runs. Figure 4-27 shows that all filter runs with the 42-pyrolusite filter media far exceeded the goal of less than 0.1 NTU filter effluent turbidity. Additionally, most optimized filter runs terminated due to headloss, regardless of filter loading rate. Five filter runs terminated due to turbidity in October 2016 during a period of elevated influent turbidity.

Figure 4-26 and Table 4-5 indicate UFRVs between 4,400 gal/sf and 18,000 gal/sf. The figure also shows that UFRVs were slightly higher at a 5 gpm/sf filter loading rate compared to UFRVs at filter loading rates of 6, 8, 10, and 12 gpm/sf. However, UFRV represents an operational consideration, and the implications of the slightly lower UFRV will be factored in with the future construction cost for different loading rates in selecting a design value. Metals removal data also showed equivalent removal of manganese and thallium across all filter loading rates.

4.6 Solids Dewatering and Dewatering Filtrate Water Quality

Throughout pilot testing, pilot operators routinely drained settled solids from the clarifier and discharged them to the sanitary sewer. Periodically, samples of the clarifier underflow were collected for settling tests and simulated thickening in a 30-gallon container. The thickening simulation achieved solids concentrations of 2.0 to 3.3 %. Samples of the thickened solids were collected in order to send to Andritz Separation for analysis of alternative dewatering processes.

Additionally, two settling tests were conducted in an unstirred 2000-mL graduated cylinder and indicated that minimal additional settling occurred in samples with no polymer addition. For example, in the first settling test, only 100 mL of clear supernatant was observed after 3 hours and in the second test, only 135 mL of clear supernatant was observed after 3 hours.

In October 2016, sludge grab samples were taken while draining sludge from the clarifier. Three sludge samples were taken each day for six days. The sludge samples drawn included a sample at the initial draw of sludge from the clarifier, a composite sample of the total daily sludge volume, and a sample at the final draw of sludge before the water ran clear. These 18 sludge samples were measured for total suspended solids (TSS) to compare the initial and final TSS concentration to the composite sample TSS concentration. Figure 4-28 indicates that the composite samples can be used as an estimate of all solids wasted from the pilot sedimentation basin, since the TSS concentration of the composite was close to the average of the initial and final sample TSS concentrations. Therefore, the metals concentrations in the composite sludge samples, shown below in Table 4-6, will be used to estimate percent of metals captured through clarification. Concentrations of radionuclides including uranium, gross alpha, gross beta, radium-226, and radium-228 a single composite sludge sample will also be included in Table 4-6 after data is received.

After sampling, the composite sludge samples settled for 24 hours, and the resulting supernatant was sampled for metals concentrations. Table 4-7 shows the metals in the supernatant and composite sludge samples. The supernatant metals concentrations were lower than the sludge metals concentrations by more than an order of magnitude, which confirms the sludge contains most of the metals by mass.

From TSS analyses of the initial draw sludge samples, the samples ranged from 0.8 to 1.6 percent solids, indicating that some thickening occurred in the floc/sed pilot unit. Composite sludge samples ranged from 0.4 to 0.7 percent solids. During conceptual design, more typical values for percent solids will be used for conservatism of solids process design.

Figure 4-28: Percent Solids at Beginning, Middle, and End of Solids Collection

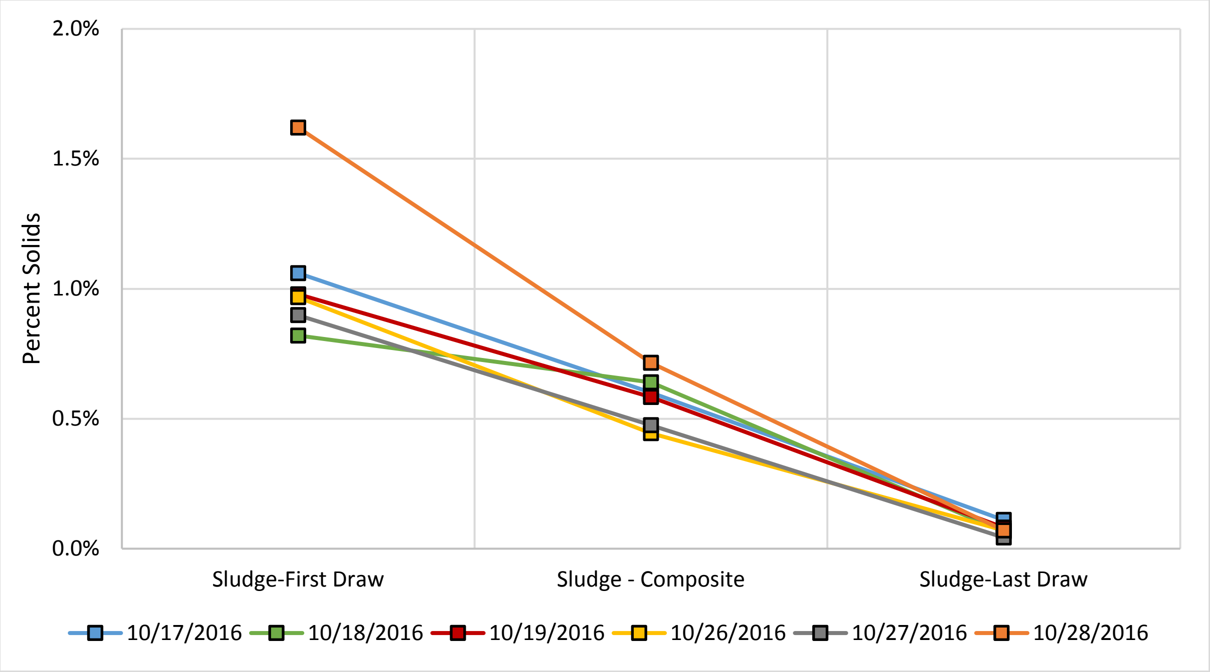


Table 4-6: Summary of Metals Present in Composite Sludge Samples

	Sample Number						
Analyte[a,b]	**1**	**2**	**3**	**4**	**5**	**6**	**Average**
Antimony	0.11	0.20	0.13	0.10	0.17	0.14	**0.14**
Arsenic	12.0	17.0	16.3	12.7	22.0	15.3	**16.0**
Cadmium	0.167	0.266	0.262	0.193	0.322	0.219	**0.238**
Iron	1,700	2,400	2,310	1,730	2,550	1,870	**2,093**
Lead	0.83	1.28	1.14	0.76	1.39	0.93	**1.06**
Manganese	9.38	14.80	13.10	8.99	16.00	11.30	**12.26**
Selenium	0.53	0.89	0.94	0.64	1.15	0.79	**0.82**
Thallium	0.13	0.08	0.10	0.05	0.11	0.10	**0.10**
Zinc	71.3	116.0	113.0	81.5	136.0	96.4	**102.4**

a- All values represent the total concentration in mg/L.

b- Results reported in mg/kg solids. Assumed sludge density of 1 kg/L to calculate metals concentrations

Table 4-7: Comparison of Sludge and Supernatant

Analyte	Composite Sludge Average[a]	Supernatant Average[a]
Antimony	0.140	0.007
Arsenic	16.0	0.014
Cadmium	0.238	0.0014
Iron	2,093.0	1.2
Lead	1.06	0.005
Manganese	12.26	0.025
Selenium	0.82	0.035
Thallium	0.100	0.006
Zinc	102.4	0.13

a- All values represent the total concentration in mg/L.

After simulating solids thickening in a 30-gallon experimental gravity thickener, in July 2016, Andritz Separation analyzed a 5-gallon sample of the thickened sludge for alternative dewatering processes. The sample submitted to Andritz had a TSS concentration of 3.4 percent solids.

Supernatant from the experimental gravity thickener and filtrate from the Andritz-simulated dewatering equipment underwent metals analysis with the intent of providing information on recycling to the head of the treatment process. Table 4-8 presents a comparison of the median pilot influent, supernatant from the experimental pilot gravity thickener, and filtrate from Andritz simulations of a belt filter press, plate and frame filter press, and Andritz' Buchner funnel simulation of gravity thickening. The belt filter press and simulated gravity thickening filtrate had the highest metals concentrations due to the lower solids capture efficiency in these tests. The pilot treatment train effectively treated the same metals that are present in the supernatant and filtrate, so the treatment process will be able to remove them if the streams are processed through the treatment facility.

Table 4-9 presents a summary of the results of the laboratory dewatering simulation tests. Screening tests without polymer indicated the sludge would be difficult to dewater. The sample contained a fine particle distribution, with over 94 percent of the measured TSS less than 45 microns in diameter. At full-scale, it is expected that polymer addition will be employed during thickening and dewatering.

Table 4-8: Comparison of Influent, Supernatant, and Filtrate Metals

Analyte[a]	Pilot Influent Median	Average Pilot Sludge Supernatant	Belt Filter Press Filtrate	Plate & Frame Press Filtrate	Buchner Funnel Filtrate (Gravity Thickening)
Antimony	8.0 (7.5)	N/A	10.8	1.8	12.6
Arsenic	35.7 (14.6)	24.5 (1.5)	349	1.7	419
Cadmium	0.8 (0.7)	2.6 (1.6)	8.9	1.2	10.6
Iron	440 (15)	3,330 (60)	41,200	20	55,900
Lead	3.8 (0.25)	7.3 (0.25)	92	<0.5	117
Manganese	24.5 (18.6)	63.4 (40.1)	1,460	1,120	1,610
Selenium	2.7 (2.5)	N/A	3.7	2.8	3.5
Thallium	2.4 (2.4)	2.5 (2.4)	3.5	<0.2	3.0
Zinc	300 (280)	1,263 (733)	3,680	580	467

a- All values are in µg/L. Dissolved values are in parentheses.

Table 4-9: Dewatering Simulation Test Results

Dewatering Process	Polymer	Polymer Dose[a] (active lbs/ton TSS)	Estimated Cake Dryness (%TSS)	Solids Capture (%)
Centrifuge	A210P (anionic)	18.9	25±2	98
	E30 (cationic)	12.7	24±2	
Belt Filter Press	A210P (anionic)	18.9	16±1	95
Plate & Frame Press	A210P (anionic)	16.8	22.3	99

a- A210P and E30 polymers are NSF 61 approved for use in drinking water.

The plate and frame press required a 4-mm thick pearlite filter precoat to capture solids and form a solids cake. The precoat supported the high solids capture efficiency for the plate and frame press.

Chemtech Ford Laboratories analyzed solids cakes from the belt filter press, plate and frame press, and gravity thickener simulation for TCLP analysis. The centrifuge simulation did not produce enough cake for TCLP analysis due to the small sample volume in the centrifuge tubes. Table 4-10 presents the TCLP results for the solids cake samples. Results for each sample were below the TCLP regulatory limits, which indicates that non-hazardous waste classification applies to the dewatered solids.

Table 4-10: Solids Cake TCLP Metals Results

Analyte[a]	**Belt Filter Press**	**Plate & Frame Press**	**Gravity Thickener**	**RCRA Limit**
Arsenic, TCLP	<0.50	<0.50	<0.50	5
Barium, TCLP	0.58	0.57	0.64	100
Cadmium, TCLP	0.129	0.126	0.145	1
Chromium, TCLP	<0.050	<0.050	<0.050	5
Lead, TCLP	0.05	0.06	0.05	5
Selenium, TCLP	0.43	0.47	0.27	1
Silver, TCLP	<0.05	<0.05	<0.05	5
Mercury, TCLP	<0.002	<0.002	<0.002	0.2

a- All values are in mg/L.

4.7 Disposal of Granular Filtration Media

The pyrolusite granular filtration media was submitted for TCLP testing after the conclusion of the pilot. Table 4-11 shows TCLP results for the media. Comparing the results to the RCRA limits indicates that spent media can be disposed of as non-hazardous waste.

Table 4-11: Granular Filtration Media TCLP Results[a]

Analyte[a]	**Pyrolusite TCLP Results**	**RCRA Limit**
Arsenic, TCLP	0.35	5
Barium, TCLP	0.18	100
Cadmium, TCLP	0.028	1
Chromium, TCLP	0.010	5
Lead, TCLP	<0.20	5
Selenium, TCLP	<0.5	1
Silver, TCLP	<0.05	5
Mercury, TCLP	<0.0020	0.2

a- All values are in mg/L.

4.8 Operational Considerations

A key component of this pilot evaluation was to determine operations control points and design criteria for the full-scale facility. In this section, key operational considerations are addressed for the following treatment processes:

- Oxidation (Section 4.8.1)
- Settled water pH adjustment (Section 4.8.2)
- Flocculation and sedimentation (Section 4.8.3)

- Filter operation (Section 4.8.4)
- Adsorption pH adjustment (Section 4.8.5)
- Finished water stabilization (Section 4.8.6)
- Disinfection considerations (Section 4.8.7)

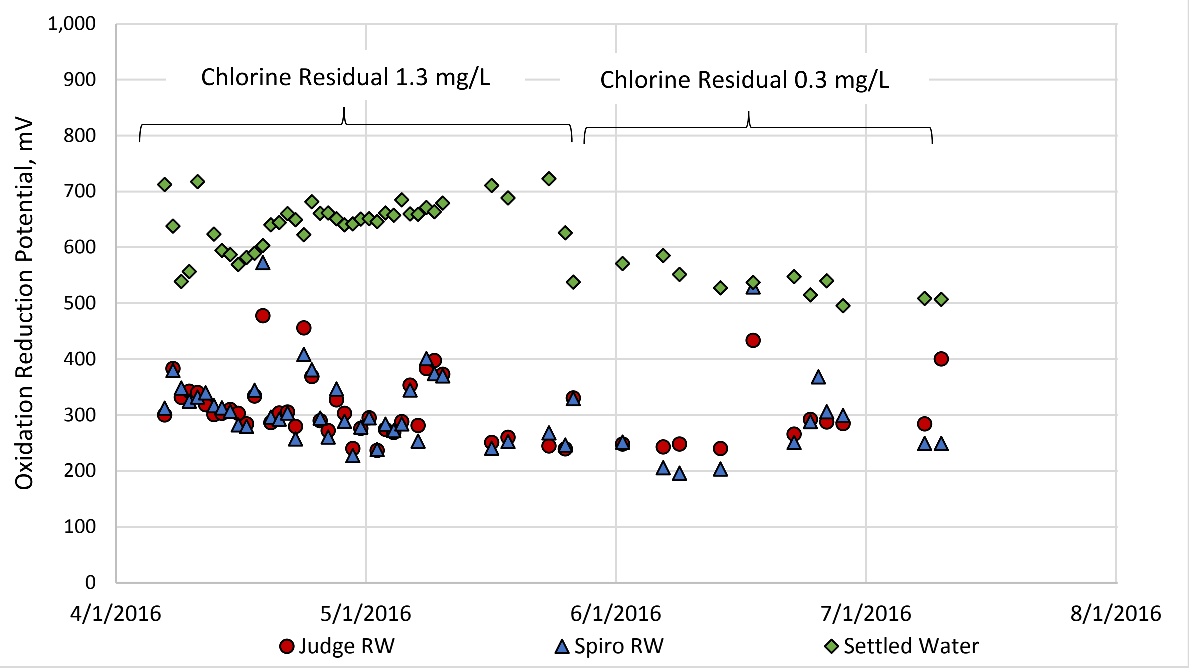
4.8.1 Oxidation

Over the course of the pilot study, the chlorine residual concentration was monitored at the filter effluent. For the first half of pilot operations, a chlorine addition point upstream of the rapid mix basin allowed for two minutes of contact time before the addition of caustic soda, ferric chloride, and polymer in the rapid mix basin. In August 2016, the pilot operations team moved the chlorine addition point to the rapid mix basin along with the other chemicals. This change in chlorine addition point did not affect metals removal through the treatment train.

During the first two months of the pilot study, the pilot operations team targeted a free chlorine residual of 1.3 mg/L in the filters to ensure adequate oxidation of manganese on the filters for thallium and manganese removal. The target residual was reduced to 0.3 mg/L when the adsorption columns were brought on-line. Adsorption media vendors recommended minimizing the chlorine residual on the media to limit degradation of the media binder. However, no data was provided on the maximum chlorine residual or the effects of chlorine residual on adsorption media life.

A comparison of metals data at both a 1.3 mg/L and 0.3 mg/L chlorine residual indicated that a higher chlorine residual did not offer additional treatment benefit. Therefore, an oxidation reduction potential (ORP) of 500 mV at a chlorine residual of 0.3 mg/L, as shown in Figure 4-29, indicates sufficient oxidation to aid in downstream metals removal.

Figure 4-29: Raw Water and Settled Water Oxidation Reduction Potential



4.8.2 Settled Water pH Adjustment

As discussed previously, the pilot operations team targeted a pH of 8.2 through sedimentation for optimal removal of zinc and cadmium. Table 4-12 presents the caustic soda dose range needed to maintain settled water pH within a range of pH 8.1 and 8.3.

Based on the measured alkalinity and hardness of the Judge Tunnel and Spiro Tunnel sources, as the amount of Spiro Tunnel water in the blend increased, the caustic soda dose increased to maintain the target settled water pH of 8.2.

Table 4-12: Caustic Dose Range to Achieve 8.1 to 8.3 Settled Water pH[a]

Water Source	Minimum Dose	Median Dose	Maximum Dose
Spiro Only	22.6	24.0	26.6
4:1 Spiro to Judge Blend	7.5	18.5	29.1
2:1 Spiro to Judge Blend	14.6	18.2	26.9
Judge Only	10.3	11.8	16.7

a- All results are in mg/L.

When treating Spiro Tunnel water only, the pilot operations team observed that softening occurred through flocculation and sedimentation at a pH of approximately 8.5. Therefore, the maximum pH through flocculation and sedimentation was controlled to be less than 8.4. When softening occurred, turbidity performance deteriorated through both sedimentation and filtration due to the calcium particles. Scale also built up on the instruments (pH probes and turbidimeters), which resulted in inaccurate readings.

4.8.3 Flocculation and Sedimentation

The pilot plant used a small-scale rapid mix/flocculation/sedimentation pilot skid. The skid included 3-stage flocculation, with flocculation time from 30 to 45 minutes (depending on flowrate), and variable speed flocculation mixers. Following flocculation, treatment used an inclined lamella plate settling basin with an adjustable number of lamella plates. The S100 flocculation/sedimentation skid has the following design parameters:

- The maximum flowrate for the S100 unit is 6.2 gpm.
- Rapid Mix Volume: 5 gallons (at 6.2 gpm, 1.3 minutes rapid mix time).
- Flocculation Basin 1, 2, and 3 Volume: 60 gallons per stage (at 6.2 gpm, 9.7 minutes per stage).
- Sedimentation Basin Volume: 130 gallons (at 6.2 gpm, 21.0 minutes).
- Sedimentation Basin Settling Area: 40.5 sf (at 6.2 gpm there is an effective surface loading rate of 0.15 gpm/sf with all 25 plates installed).

The rapid mix energy was set at 500 sec^{-1}. The mixing energy for three stages of flocculation was set as follows: Stage 1 at 60 sec^{-1}, Stage 2 at 40 sec^{-1}, Stage 3 at 20 sec^{-1}.

The number of lamella plates in the skid can be adjusted by removing plates. Initially, twelve of the available 25 plates were removed. With 13 of the available 25 plates used, the setting area was 21.1 square feet and the effective surface loading rate was 0.29 gpm/sf. During Pilot Plant Commissioning, a settled water turbidity of less than 2 NTU could not be maintained and the twelve removed plates were installed. This decreased the effective surface loading rate of the pilot equipment to 0.15 gpm/sf at 6.2 gpm. The skid operated at this condition for the remainder of the pilot study. It was decided that the most important operating guideline for the clarifier was to produce representative settled water quality.

Full-scale design, assuming plate settling, will follow Utah Administrative Code R309-525-13. Sedimentation, which states, “Sedimentation With Tube Settlers shall be a maximum rate of 2 gal/sq. ft./min of cross-sectional area, unless higher rates are successfully shown through pilot plant or in-plant demonstration studies.” At this point, no pilot data is being presented to illustrate a loading rate in excess of 2 gal/sq. ft/min of cross-sectional area. Previous full-scale design experience will be the basis for the MIW treatment facility design criteria if a lamella plate clarifier is selected for implementation.

Ferric chloride was used as the primary coagulant throughout the pilot study. No other coagulants were evaluated during the pilot study since ferric chloride worked effectively and provided dual benefits for metals removal and turbidity removal. Jar testing and pilot scale demonstration verified the coagulant dose of 8 to 12 mg/L that was used throughout normal operations in the pilot study. The dose varied during normal operation to both meet the settled water turbidity goal of <2 NTU and to optimize filter UFRVs for different filter media.

Similar to the coagulant dose, a range of polymer doses aided in clarification and filtration to both meet the settled water turbidity goal of <2 NTU and to optimize filter UFRVs. Jar testing provided an initial range of polymer doses, which were then confirmed at the pilot scale. Polymer dose in the pilot plant ranged from 0.5 to 2.0 mg/L.

4.8.4 Filter Operation

Following the flocculation and sedimentation skid, the pilot plant include a small-scale filtration skid. The F300 filter skid includes four filter columns in parallel, each with a dedicated feed pump. The filter skid has the following design parameters:

- Maximum total flow rate: 8.0 gpm
- Individual filter flow loading rate range: 2.0 gpm/sf to 12.2 gpm/sf
- Filter column diameter: 6 inches

The maximum flow rate of 6.2 gpm of the flocculation/sedimentation skid limited the filter skid to a maximum flow rate of approximately 5.5 gpm.

Criteria for filter runs were previously discussed in Section 4.4. At the termination of each filter run, the filters underwent a backwash. Backwashes for each filter varied for each media. Each backwash cycle consisted of air scour, followed by air scour combined with backwash, backwash (water only), and filter-to-waste. Filter-to-waste required a time setting, which was established as 30 minutes in order to keep any high turbidity water from entering the CFE basin and adsorption media.

As previously discussed, filter loading rates ranged from 5 to 12 gpm/sf during normal operation. Due to the limiting total influent flow of 5.5 gpm, if two filters were operating at filter loading rates above 8 gpm/sf, one filter was set at 2 gpm/sf to ensure adequate flow to all filters.

4.8.5 Adsorption pH Adjustment

The target pH for adsorption columns was discussed in Section 4.2. One column of Metsorb® media treated water at pH 7.6, which would need no pH adjustment for distribution. The E33, GFH®, and second Metsorb® media columns treated water, first at pH 7.0 and then at pH 6.5. The addition of sulfuric acid to the adsorption influent decreased pH to achieve pH targets of 7.6, 7.0, and 6.5.

To accommodate two target pH values, the CFE basin fed two adsorption feed pipes, which fed the adsorption columns. Sulfuric acid fed into each feed pipe at the CFE basin effluent. To reach pH 7.6, 0.05 and 0.1 percent dilute sulfuric acid solutions were used, and to reach pH 7.0 and 6.5, 0.5 and 1 percent dilute sulfuric acid were used. An online pH probe measured influent pH on the pH 7.0 and 6.5 feed line, which allowed for more accurate acid dose adjustments to reach the target pH. Table 4-13 shows the average sulfuric acid doses required to reach each pH value.

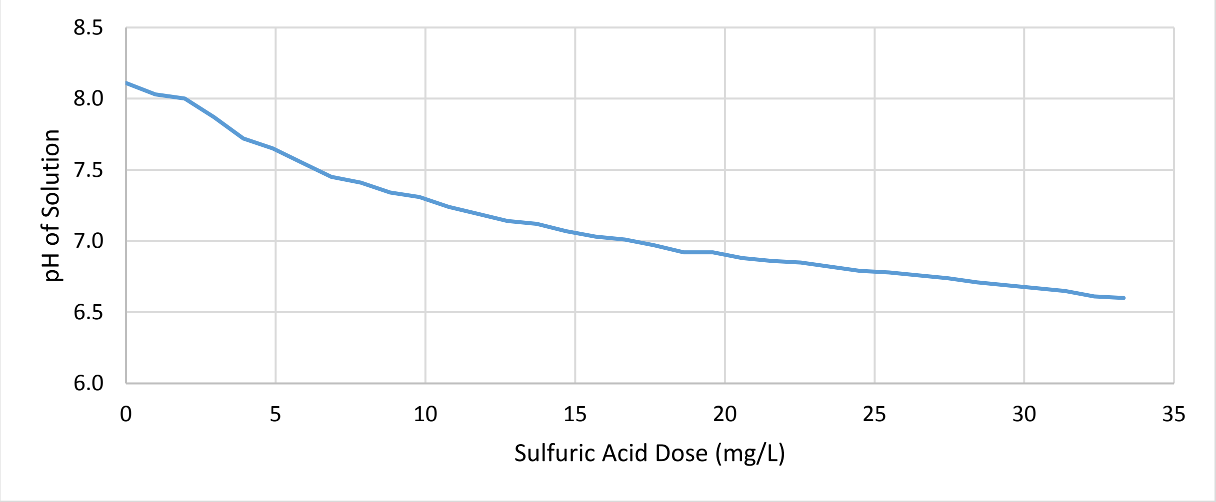
Table 4-13: Average Sulfuric Acid Doses Used to Reach Adsorption Influent pH of 7.6, 7.0, and 6.5[a]

Water Source	**Average Sulfuric Acid Dose to achieve pH 7.6**	**Average Sulfuric Acid Dose to achieve pH 7.0**	**Average Sulfuric Acid Dose to achieve pH 6.5**
2:1 Spiro to Judge Blend	5.9	16.7	37.2
4:1 Spiro to Judge Blend	4.4	NA	43.4

a- All doses are in mg/L

Combined filter effluent during a period of using a 2:1 blend ratio of Spiro to Judge waters was used for an acid titration to determine necessary dose for various target pH values. The addition of one percent dilute sulfuric acid to filter effluent water in 0.1 mL increments reduced pH as shown below in Figure 4-30. Filter effluent water had an initial pH of 8.1 and 33.3 mg/L sulfuric acid addition adjusted pH to 6.6.

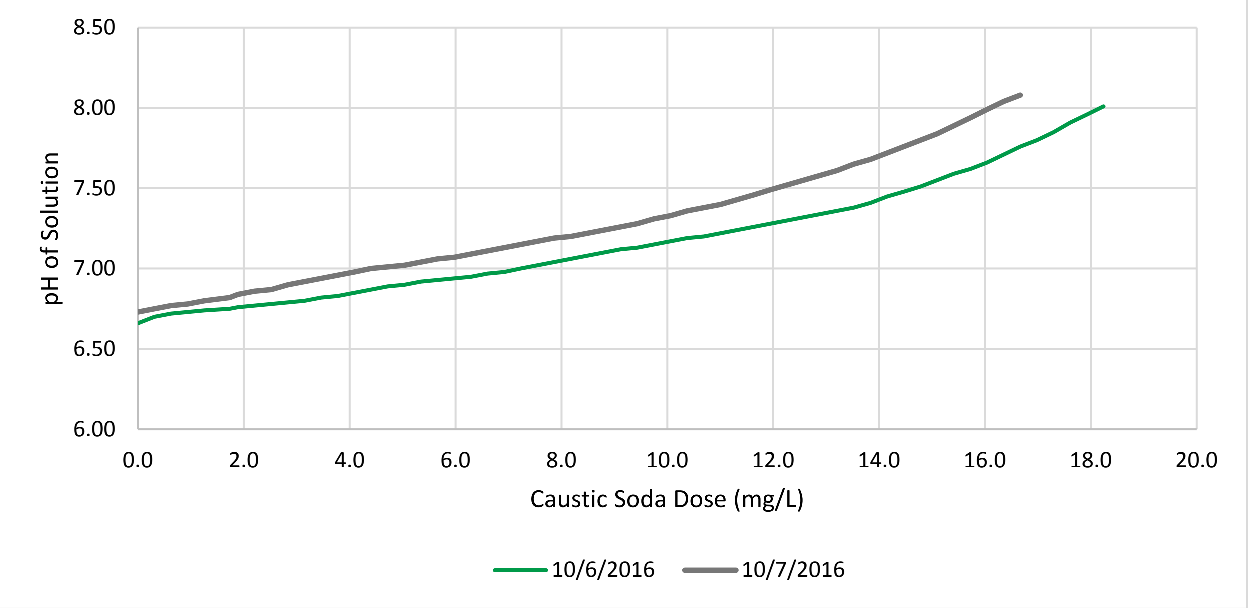
Figure 4-30: Acid Titration with Filter Effluent



4.8.6 Finished Water Stabilization

Effluent from the pH 6.5 Metsorb® titanium dioxide column was used for a titration test using caustic soda before the conclusion of the pilot study. Alkalinity and pH were measured initially, and pH was measured continuously as caustic soda (25% concentration) was added to one liter of adsorption effluent in 0.1 mL increments. A second sample of adsorption effluent was then pH adjusted to 7.6 and alkalinity measured. The first and second CCPP stabilization curves are shown in Figure 4-31. Initial pH and alkalinity of the adsorption effluent in the first test were 6.66 and 95 mg/L as $CaCO_3$, respectively, and the alkalinity of effluent at pH 7.6 was 140 mg/L as $CaCO_3$. In the second CCPP test, the initial pH was 6.73 and initial alkalinity was 100 mg/L as $CaCO_3$. Alkalinity at pH 7.6 was 140 mg/L as $CaCO_3$.

Figure 4-31: Finished Water Stability Test



4.8.7 Disinfection Considerations

The pilot operations team conducted a chlorine residual decay test during the pilot study to aid in the future design of the chlorine disinfection basin for the full-scale water treatment plant. For the test, the operations team collected two liters of pH 6.5 Metsorb® titanium-dioxide adsorption media effluent, and adjusted pH to 7.6, and then dosed with a 1.24% sodium hypochlorite solution to obtain a chlorine residual of 1.5 mg/L. Chlorine residual and pH of the water were measured at two-hour increments for six hours and then measured again after 24 hours. Table 4-14 below indicates that there was minimal decay of chlorine residual after a 24-hour period.

Table 4-14: Chlorine Decay Test Results

Time[a]	Chlorine Residual[b]	pH
0	1.64	7.70
2	1.63	7.69
4	1.57	7.73
5.5	1.56	7.77
24	1.42	8.00

a- Time measured in hours
b- Chlorine residual measured in mg/L Cl_2

4.9 Challenge Tests

One key objective for the MIW pilot plant operation was to perform various challenge tests in order to understand the robustness of the treatment process, particularly with regard to risk of stream discharge compliance issues. Between August and September 2016, the pilot operations team performed testing through several challenges to demonstrate treatment in less than ideal conditions. The challenge tests conducted included:

- Filter challenge tests
- A 48-hour shutdown and a 72-hour shutdown

- Periods of ceasing to add chemicals used at the pilot plant, including caustic soda, sodium hypochlorite, ferric chloride, and polymer
- Elevated turbidity in the source waters (as described previously)

4.9.1 Filter Challenge Tests

Filter challenge tests included a high loading rate “stress test” and a test in which the filter loading rate was changed rapidly. These tests were conducted to identify any changes in filtered water quality that could occur if the filter loading rate changed to accommodate a higher or lower plant flowrate.

In the high loading rate stress test, one 42-inch pyrolusite filter’s loading rate was changed from 10 to 12 gpm/sf for approximately 4 days to evaluate both turbidity removal and metals removal. Filter performance remained constant throughout the high rate stress test. While at 12 gpm/sf, the pyrolusite filter achieved UFRVs between 10,000 and 12,600 gal/sf and maintained a median filter run turbidity of 0.02 NTU, both of which were consistent with performance at a 10 gpm/sf loading rate. Additionally, the pyrolusite filter completely removed manganese and thallium during the high loading rate stress test. It should be noted that the filter loading rate of 12 gpm/sf represented the highest possible filter loading rate with the pilot equipment.

Turbidity removal of the pyrolusite filters was also evaluated when loading rates were changed mid-run. For each 42-inch pyrolusite filter, loading rates were changed for two hours and then returned to the previous loading rate. The first 42-inch pyrolusite filter was changed from 10 to 5 gpm/sf, the second pyrolusite filter changed from 6 to 10 gpm/sf, and the third pyrolusite filter changed from 8 to 11 gpm/sf. All filter loading rate changes were made two hours into their respective filter runs and lasted for 2 hours before returning the filters to their original loading rates. Filter effluent turbidity and filter run UFRVs remained similar for all pyrolusite filters throughout the duration of the test.

4.9.2 Shutdown Challenge Tests

The pilot operations team conducted a 48-hour shutdown test in late August 2016 and a 72-hour shutdown test in early September 2016 to determine any effect on water quality when bringing the treatment processes back online after a period without treatment. In each test, the pilot plant processes were shutdown for the time period indicated, with no flow through several unit process. At the end of the 48-hour shutdown test, flow was returned to the pilot plant. Sampling through the treatment process immediately followed the end of the shutdown test after placing the filters and adsorption columns back in service.

Both metals removal and turbidity removal were evaluated in the 48-hour shutdown test. For this test, water continued to run through the flocculation/sedimentation skid throughout the test, but water to all filters and adsorption media was turned off. Sodium hypochlorite, caustic soda, ferric chloride, and polymer continued to be fed to the oxidation and flocculation/sedimentation skids throughout the test. Samples were taken through the process before shutdown.

After bringing the pilot plant back online after the shutdown, filters operated normally for 15 minutes before backwashing. Sampling of all filter effluent occurred at 5 minutes and 12 minutes after each filter came back online as well as 15 minutes after backwashing the filters. Metals removal remained consistent through all 42-inch pyrolusite columns before and after the 48-hour shutdown test.

The 40-inch anthracite over 20-inch pyrolusite column saw no change in metals removal before and after the test except for the removal of thallium. Thallium was detected in the effluent at levels greater than the stream discharge permit level after 5 minutes and 12 minutes of filter operation after coming back online. The anthracite over pyrolusite filter effluent was not sampled after backwashing.

The 72-hour shutdown test focused on turbidity performance through sedimentation and filtration as well as time to bring the pilot plant back online. No sampling for metals occurred before or after the

72-hour shutdown. In this test, no water flowed through clarification, filtration, or adsorption over a 72-hour period. The pilot plant was brought back online incrementally, with flow to flocculation and sedimentation increased from 3 to 6 gpm after 2.5 hours of operation. Settled water turbidity dropped to below 1.5 NTU after 30 minutes of operation and remained below 1.5 NTU throughout the startup period. All filters were backwashed immediately after startup. Effluent turbidity of all filters dropped below 0.03 NTU within 20 minutes of normal operation after backwash and remained there throughout the filter runs. The Metsorb® media saw an increase in antimony removal two days after the shutdown, most likely due to the resting period during the 72-hour shutdown.

4.9.3 Chemical Drop Tests

The chemical drop tests consisted of ceasing to add a treatment chemical for a period of approximately 12 to 16 hours to demonstrate the effect on treatment of an interruption in dosing of each treatment chemical. Tests were conducted individually, dropping caustic soda, sodium hypochlorite, ferric chloride, and polymer over a number of tests. For the tests, the pilot operations team turned off each chemical, except polymer, overnight and brought them back online the next morning. Before returning the chemical feed, sampling through the process occurred to determine any effects on metals removal.

Polymer was unintentionally halted several times throughout the course of the study for up to 12 hours at a time. An evaluation of turbidity removal during these periods is shown below.

4.9.3.1 Caustic Soda

When the caustic soda feed was stopped, pH in the settled water basin dropped to 7.4 from pH 8.2. Through filtration, pH dropped from 8.0 to 7.5. Adsorption influent pH dropped slightly from pH 6.5 to pH 6.4 in the low-pH adsorption columns and from pH 7.6 to 7.4 in the ambient-pH adsorption columns.

Due to the pH-dependent nature of cadmium and zinc removal, the loss of caustic soda resulted in elevated cadmium and zinc levels through clarification and filtration. Zinc levels through the pyrolusite effluent exceeded the SDP and cadmium levels through the pyrolusite effluent reached values near the SDP, showing the importance of maintaining a pH of 8.0 or above through filtration. During the test, pyrolusite filter effluent had approximately four times the cadmium and ten times the zinc concentrations that would typically be loaded onto the Metsorb® titanium-dioxide adsorption media. Both cadmium and zinc were removed to levels at or near the detection limit through Metsorb® media. Table 4-15 shows cadmium and zinc concentrations through the process during the test compared to median concentrations from pilot study data. These results demonstrate the criticality of the multiple metals removal barriers provided with post-filter Metsorb® adsorption.

Table 4-15: Cadmium and Zinc Removal Without Caustic Soda Feed

Sample Locations	**Cadmium**[c,d]		**Zinc**[c,d]	
	Without Caustic Soda	Median Value	Without Caustic Soda	Median Value
Laboratory Detection Limit	0.1	0.1	5	5
Influent	0.8 (0.7)	0.8 (0.7)	310 (260)	310 (280)
Settled Water	0.6 (0.5)	0.5 (0.2)	250 (190)	140 (40)
Post-Filtration[a]	0.4	0.1	210	20
Post-Adsorption[b]	ND	ND	20	10
MCL	5	5	5000	5000
SDP	0.42	0.42	198	198

a- Concentration reported is the average of all filter effluent concentrations in similar operating conditions.

b- Concentration reported is the maximum concentration of all adsorption effluent samples to provide the most conservative estimate.

c- All values are in µg/L. Dissolved concentrations are in parentheses.

d- A value of ND indicates a concentration below the laboratory detection limit.

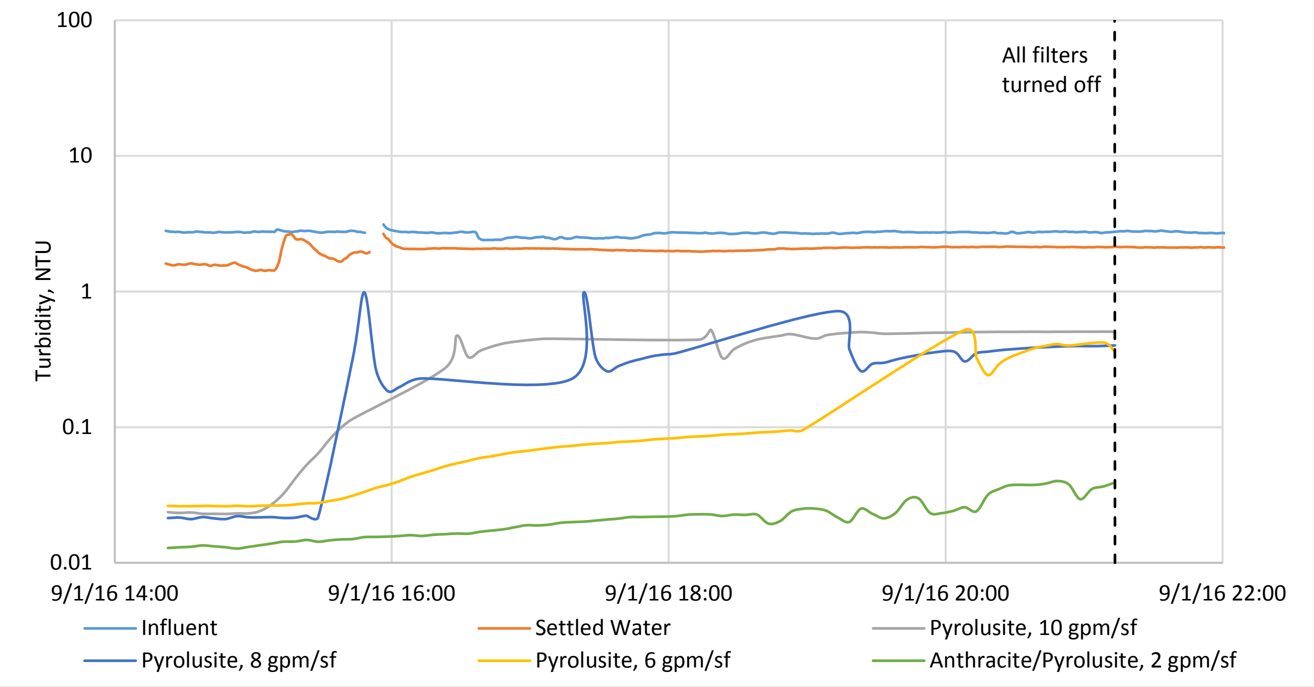
4.9.3.2 Sodium Hypochlorite

The loss of sodium hypochlorite was expected to affect both the pre-oxidation process and the pyrolusite filter media performance. Removal of manganese and thallium through pyrolusite media relies on the media retaining a positive chlorine residual. Despite the temporary stop in chlorine dosing, the pyrolusite filters completely removed thallium and manganese to below the laboratory detection limit throughout the interruption of 18 hours in chlorine dosing. Longer periods without chlorine dosing may have a greater impact. Continuous chlorine dosing is recommended at full-scale.

4.9.3.3 Ferric Chloride

The loss of ferric chloride affected both metals removal and turbidity performance. Without ferric chloride, settled water turbidity increased to 2.5 NTU after 50 minutes. Figure 4-32 shows that the 42-inch pyrolusite filters at 10 gpm/sf and 8 gpm/sf filter loading rates operated for approximately one hour before they could no longer maintain effluent turbidities of less than 0.1 NTU. The 42-inch pyrolusite filter at 6 gpm/sf operated for approximately four hours before consistently reaching effluent turbidities above 0.1 NTU. The 40-inch anthracite over 20-inch pyrolusite filter was operating at a 2 gpm/sf loading rate and was turned off after seven hours of operation along with the other filters. It reached a maximum effluent turbidity of 0.04 NTU at seven hours of operation without ferric chloride. The loss of ferric chloride also resulted in a reduction of arsenic and lead removal through clarification.

Figure 4-32: Turbidity Removal through Clarification and Filtration during Ferric Drop Test



4.9.3.4 Polymer

Polymer feed to the pilot was unintentionally stopped five times throughout May and June, 2016. In all five instances, the polymer feed stopped overnight and the pilot operators saw that the polymer was not feeding into the rapid mix basin the next morning. The exact time that the polymer stopped feeding to the system is unknown in all five instances. After discovering the loss of polymer feed, the pilot operators reinstated polymer feed by repositioning the feed tube in the peristaltic feed pump and by trimming the feed tubing inlet or outlet to remove any clogging of polymer in the tubing. All five instances occurred while a small diameter polymer feed tube was used; it was replaced with a larger diameter tubing in June 2016 and polymer feed was able to run continuously after the switch. During polymer stoppage, settled water turbidity increased from less than 2.0 NTU to a maximum of 3.3 NTU. Pyrolusite filter run times and UFRVs decreased slightly and median filter effluent turbidities increased slightly during periods of polymer loss. All pyrolusite filter runs terminated due to headloss accumulation during the periods of polymer feed loss. Filter run UFRVs and median filtered water turbidities for the filter runs during loss of polymer feed are indicated as black squares on the filter run summaries shown below in Figure 4-33 and Figure 4-34. The plots below show that pyrolusite filters can still produce low turbidity filtered water without a polymer feed for a period of 12 hours or less.

Figure 4-33: Filter Run UFRV during Polymer Drop

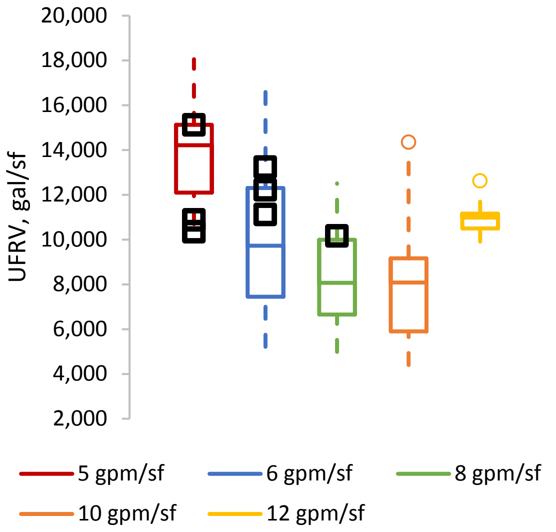
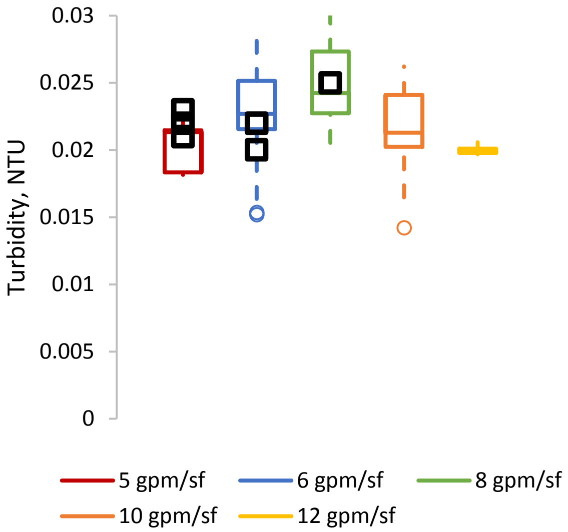


Figure 4-34: Median Turbidity of Filter Runs during Polymer Drop



4.9.3.5 Summary of Chemical Drop Tests

The chemical drop tests indicated that, in an emergency, interruptions to caustic soda, sodium hypochlorite, and polymer dosing can be tolerated for up to 12 hours without a significant impact on finished water quality. For stream discharge, zinc concentrations may become critical if caustic soda dosing is interrupted. The tests also indicated that the process can continue to operate for a short period of time without ferric chloride until an operator is able address the loss in chemical feed.

4.10 Taste Test

At the conclusion of the pilot study, adsorption effluent at both a 2:1 Spiro to Judge blend ratio and a 4:1 Spiro to Judge blend ratio were collected and compared to the taste of two water sources from Salt Lake City and two sources from the Park City distribution system. Effluent from one pH 6.5 Metsorb® column was sampled for the adsorption effluent samples. Both samples were pH adjusted to pH 7.6 and disinfected with sodium hypochlorite at a chlorine residual of 1.5 mg/L after 30 minutes of contact time to provide more than 0.5 log reduction in *Giardia* and a much more than the SWTR's 2.0-log reduction in viruses. All samples were taken the day before the test and refrigerated to maintain a similar temperature. A facilitator numbered the samples and served them to six taste testers in order to maintain a blind taste test. Figures 4-36 and 4-37 show the taste testers trying the various waters. The taste testers ranked the samples from best to worst and rated them on an absolute scale. Figure 4-35 presents the average rating given to each sample and indicates that all sample waters were observed to be fairly similar in taste. The Metsorb® effluent with a 2:1 Spiro to Judge blend received the highest rating, followed by water collected from the CH2M office near Salt Lake City. After the waters were ranked from best to worst, it was found that the Metsorb® effluent with a 2:1 Spiro to Judge blend was ranked the highest, while the Metsorb® effluent with a 4:1 Spiro to Judge blend was in the middle of the pack.

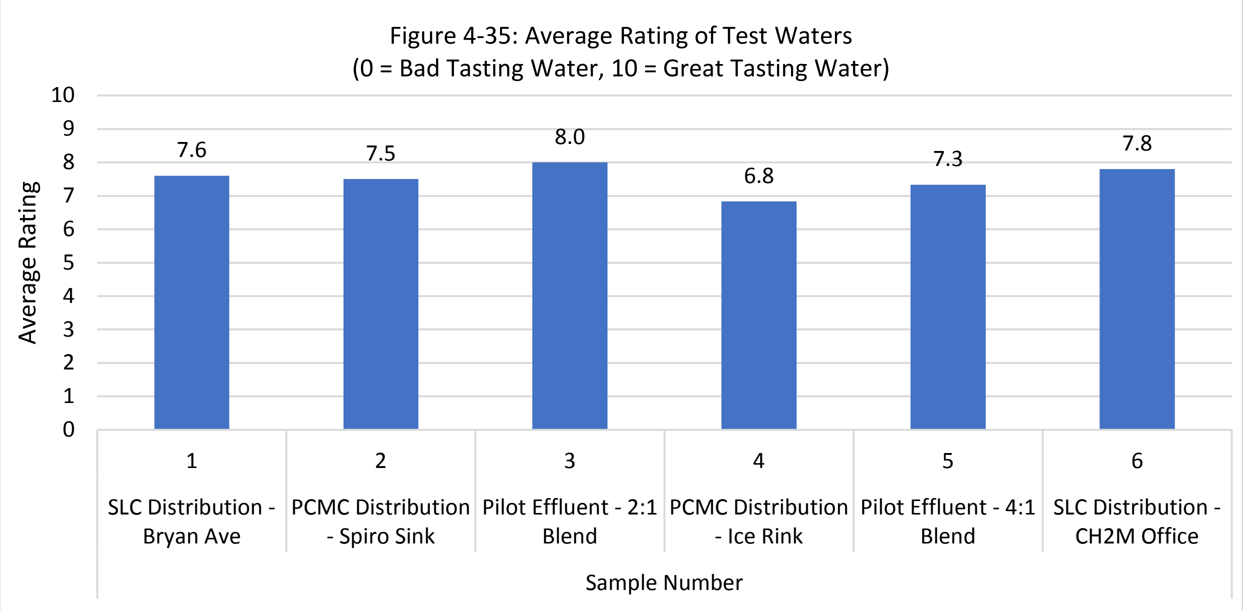


Figure 4-36 and 4-37: Members of the pilot study team from Park City and CH2M tasting waters from the pilot plant and from Park City and Salt Lake City distribution systems.

SECTION 5

Key Questions Addressed by Pilot Testing

The key questions that were identified in the Pilot Testing Protocol to be addressed during pilot testing are shown again in this section, followed by a response to each question.

1. *Does the optimum treatment approach from the previous decision evaluation and bench-scale testing perform as expected, meeting PCMC water quality goals, including drinking water MCLs and stream discharge limits for Judge Tunnel water, Spiro Tunnel water, and combined tunnel water?*

   Yes, the optimum treatment approach performs better than expected and meets PCMC water quality goals including drinking water MCLs and stream discharge limits for Judge Tunnel water, Spiro Tunnel water, and combined tunnel water.

2. *Does the same treatment approach perform acceptably under varying seasonal water quality? How does the treatment process perform during periods of miner activity in the tunnel? How does the process respond to or recover from an upset?*

   Testing has demonstrated that the treatment approach performed acceptably throughout the 7 month study, including during all turbidity spikes encountered (see Section 4.4 and Figures 4-23 through 4-25) and during all seasonal variations encountered during testing from April through October, 2016.

3. *Does pilot testing identify any limitations of the treatment approach that must be addressed in full-scale facility design and/or operations? Are there key findings from pilot study operations that help to familiarize operators with the treatment approach?*

   Pilot testing has indicated some key boundary conditions for future full-scale operation, particularly with regard to pH through clarification and the pH of adsorption. Key observations include the following:

   - When treating Judge or blended Judge and Spiro water, targeting settled water pH of 8.2 was required for effective zinc and cadmium removal to below the stream discharge permit limit. Refer to Figure 3-2, Figure 3-3, and Section 3.0.
   - Softening occurred at pH 8.5, as noted in Section 3.0 and 4.8. At full-scale, care should be taken to keep pH at 8.2 but not to allow pH to rise to levels that can result in softening due to the solids production, scaling, and ultimately the maintenance requirements associated with softening.
   - Adsorptive media performance is better (longer media life to exhaustion) at lower pH. An operating strategy to optimize life-cycle costs will be developed as the project progresses.
   - Polymer feed and ferric chloride coagulant feed are important to the continued production of high quality settled water and to achieve the operational goals for filter performance.

   To enhance the involvement of the PCMC operations group, the following tasks were undertaken during pilot testing:

   - To initiate operator involvement in learning about the pilot process and its O&M requirements, the PCMC operations team operated and maintained the pilot plant over the weekends, beginning in July.
   - The PCMC operations team also attended an information session on O&M of the pilot facilities, including the theory behind the operating conditions in the pilot plant and the importance of metals removal through treatment.

- During September 2016, the PCMC operators performed pilot plant O&M for a week of operations.
- PCMC operators provided key input in responding to raw water turbidity events in September 2016.

4. To what extent is each metal of interest removed through each treatment step? Does this information support blending and bypass treatment alternatives that could be used to reduce the capital and O&M cost of the full scale treatment facility?

Metals removal through treatment is described in Section 4.1 (through clarification and filtration) and Section 4.2 (through adsorption). As shown, all drinking water limits, stream discharge permit limits, and PCMC water quality goals have been met. Additional challenge testing, described in Section 4.9, has been performed to verify the performance of the multi-barrier treatment approach for metals removal.

The data collected and summarized herein can be used to perform different bypass and blending analyses during conceptual design. The available test results from the pilot testing indicate that there is the potential for development of a partial bypass of the adsorption process followed by downstream blending. Further evaluation of this approach will occur in conceptual design and will be based on balancing water quality and life-cycle costs.

5. Does the optimum treatment approach pass the required WET tests and allow regulatory approval of WET testing results?

As described in Section 4.3, the pilot treated water passed the first and second WET tests for survival and reproduction of *Ceriodaphnia dubia* (water flea) and *Pimephales promelas* (fathead minnows). The tests were conducted under the required seasonal conditions.

6. Does adsorption media performance and media capacity match projections and allow selecting a preferred type of media?

The following are key findings related to adsorption:

- Preliminary estimates for full-scale O&M costs were based on replacement of Metsorb® media after 15,000 bed volumes. This estimate was increased to 30,000 bed volumes following bench-scale testing. Projections of the adsorption media data indicate that longer media life (higher bed volumes) are expected to be realized. The test results show that media life will be maximized if pH is lowered to 6.5 for adsorption.

7. *From the solids and discharge streams, how do the residuals settle and dewater? Do residuals pass the toxicity characteristic leaching procedure (TCLP)? What are the estimated solids quantities by water source and blend ratio?*

   As described in Section 4.6, the pilot plant residuals settle and dewater effectively with polymer addition. Residuals passed the TCLP test. The data generated will be used in conceptual design and future updates to facility construction and O&M cost estimates.

8. *What chemical doses are required to stabilize finished water for the distribution system?*

   As described in Section 4.8.6, titrations with acid for pH reduction before adsorption and base to achieve finished water quality targets were conducted on pilot plant effluent during the pilot study.

9. *What are the updated and/or refined design criteria for full-scale (i.e., flocculation time, filter loading rates, empty bed contact time for adsorption, chemical doses)? Does the data generated during pilot testing demonstrate these design criteria to DDW and/or DWQ?*

The updated design criteria for full-scale will be developed during conceptual design based on the pilot testing results. The data generated during pilot testing has been collected with the objective of being sufficient to demonstrate design criteria to DDW and/or DWQ. As described herein, filter performance has been shown to be equivalent for filter loading rates from 5 to 12 gpm/sf.

10. *What are the chemical and energy costs for the full-scale facility? How much truck traffic will be associated with chemicals, solids, and media replacement during full-scale plant operation?*

    The data gathered during pilot testing on water quality, chemical doses, and solids generation will be used to update chemical and energy costs for the full-scale facility during conceptual design. This information will be used to quantify truck traffic for future full-scale plant operation.

11. *What are the updated and/or refined construction and O&M costs for full-scale?*

    The construction and O&M costs for the full-scale facility will depend on a number of process decisions that will be made during conceptual design, and the pilot testing results summarized in this document will represent key information to support these decisions.

SECTION 6

Continuing Pilot Tests

As a continuation of this pilot study, Park City Municipal Corporation plans to operate the adsorption columns further by feeding filtered Spiro Tunnel water through the adsorption media. This will allow for adsorption media exhaustion curves to be extended to actual media exhaustion.

Several other pending test results will also become available following distribution of this Draft Pilot Testing Report. The sample results anticipated to become available in the future include the results of germanium sampling in the raw water and adsorption effluent and radionuclides sampling in the solids.

Appendix A
Summary of Pilot Runs Included in Metals Removal Analysis

Table A-1: Summary of Pilot Runs Included in Metals Removal through Oxidation, Clarification, and Filtration Analysis

Sample Date	Pilot Run Identifier[e]	Pilot Source Water[a]	Chlorine Dose (mg/L)[e]	Caustic Soda Dose (mg/L)[e]	Ferric Chloride Dose[b,e] (mg/L)	Coagulant Polymer Dose[c,e] (mg/L)	Settled Water pH[e]	Filter Effluent Free Chlorine Residual[e,f]	Filter Loading Rate[f]	Filter Effluent Turbidity[e,f]
4/29/2016[d]	PY02-43	Spiro	2.75	25.6	10.0	0.54	8.3	1.22	5	0.039
4/29/2016[d]	PY01-43	Spiro	2.75	25.6	10.0	0.54	8.3	1.22	5	0.083
5/2/2016	PY01-45	Spiro	2.75	22.7	10.0	0.75	8.2	1.28	5	0.021
5/2/2016	PY02-45	Spiro	2.75	22.7	10.0	0.75	8.2	1.31	5	0.022
5/3/2016	PY02-45	Spiro	2.75	23.4	10.0	0.75	8.2	1.23	5	0.022
5/4/2016	PY02-46	Spiro	2.75	25.3	10.0	0.75	8.1	1.34	6	0.022
5/4/2016	PY01-46	Spiro	2.75	25.3	10.0	0.75	8.1	1.26	6	0.024
5/5/2016	PY01-47	Spiro	2.75	25.3	10.0	0.75	8.0	1.32	5	0.025
5/5/2016	PY02-47	Spiro	2.75	25.3	10.0	0.75	8.0	1.32	5	0.023
5/6/2016	PY01-47	Spiro	2.75	25.3	10.0	0.75	8.0	1.44	5	0.024
5/6/2016	PY02-47	Spiro	2.75	25.3	10.0	0.75	8.0	1.44	5	0.022
5/16/2016	PY02-54	Judge	2.75	11.8	8.0	0.75	8.1	1.28	6	0.022
6/1/2016	PY01-60	2:1	0.85	19.7	10.0	0.82	8.3	0.41	5	0.022
6/1/2016	PY02-60	2:1	0.85	19.7	10.0	0.96	8.3	0.40	6	0.023
6/2/2016	PY02-61	2:1	0.85	19.7	10.0	1.25	8.3	0.41	6	0.023
6/2/2016	PY01-61	2:1	0.85	19.7	10.0	1.25	8.3	0.39	5	0.021
6/3/2016	PY02-61	2:1	0.85	19.7	10.0	1.25	8.3	0.41	6	0.022
6/3/2016	PY01-61	2:1	0.85	19.7	10.0	1.25	8.3	0.42	5	0.022
6/6/2016	PY01-62	2:1	0.85	14.6	8.0	1.00	8.3	0.38	5	0.021
	PY02-63							0.39	6	0.022
6/7/2016	PY01-62	2:1	0.85	17.3	8.0	1.00	8.3	0.38	5	0.021

Sample Date	Pilot Run Identifier[e]	Pilot Source Water[a]	Chlorine Dose (mg/L)[e]	Caustic Soda Dose (mg/L)[e]	Ferric Chloride Dose[b,e] (mg/L)	Coagulant Polymer Dose[c,e] (mg/L)	Settled Water pH[e]	Filter Effluent Free Chlorine Residual[e,f]	Filter Loading Rate[f]	Filter Effluent Turbidity[e,f]
	PY02-63								6	0.022
6/8/2016	PY01-63	2:1	0.85	17.3	8.0	1.00	8.2	0.36	5	0.021
	PY02-64								6	0.022
6/9/2016	PY01-63	2:1	0.85	17.3	8.0	1.00	8.2	0.29	5	0.021
	PY02-64								6	0.022
6/17/2016	PY01-66	2:1	0.40	17.1	8.0	1.00	8.1	0.21	5	0.021
	PY02-68								6	0.023
6/24/2016[d]	PY01-68	2:1	0.40	18.2	8.0	1.00	8.2	0.23	5	0.018
	PY02-71								6	0.023
6/30/2016[d]	PY02-74	2:1	0.40	18.2	8.0	1.00	8.3	0.24	6	0.023
	PY01-71								5	0.018
7/5/2016	PY02-76	4:1	0.40	18.1	8.0	1.00	8.2	0.25	6	0.024
7/11/2016	PY02-79	4:1	0.40	18.0	8.0	1.00	8.2	0.21	6	0.024
	PY01-77							N/A	10	0.018
8/11/2016	PY01-120	4:1	0.70	15.6	8.0	0.64	8.2	0.29	12	0.020
8/15/2016	PY01-126	4:1	0.70	14.5	8.0	0.75	8.3	0.36	12	0.020
8/19/2016	PY02-105	4:1	0.70	14.0	8.0	0.75	8.2	0.36	6	0.025
8/19/2016	PY07-02	4:1	0.70	14.0	8.0	0.75	8.2	0.34	8	0.021
8/19/2016	PY01-134	4:1	0.70	14.0	8.0	0.75	8.2	0.39	10	0.021
8/23/2016	PY02-108	4:1	0.70	15.5	8.0	0.75	8.2	0.36	6	0.025
8/23/2016	PY07-06	4:1	0.70	15.5	8.0	0.75	8.2	0.33	8	0.020

Sample Date	Pilot Run Identifier[e]	Pilot Source Water[a]	Chlorine Dose (mg/L)[e]	Caustic Soda Dose (mg/L)[e]	Ferric Chloride Dose[b,e] (mg/L)	Coagulant Polymer Dose[c,e] (mg/L)	Settled Water pH[e]	Filter Effluent Free Chlorine Residual[e,f]	Filter Loading Rate[f]	Filter Effluent Turbidity[e,f]
8/23/2016	PY01-140	4:1	0.70	15.5	8.0	0.75	8.2	0.40	10	0.020
8/26/2016	PY01-144	4:1	0.70	15.5	8.0	0.75	8.2	0.41	10	0.021
8/26/2016	PY02-110	4:1	0.70	15.5	8.0	0.75	8.2	0.36	6	0.025
8/26/2016	PY07-09	4:1	0.70	15.5	8.0	0.75	8.2	0.33	8	0.021
9/7/2016	PY01-153	4:1	0.70	17.9	8.0	0.75	8.2	0.35	10	0.021
9/7/2016	PY02-114	4:1	0.70	17.9	8.0	0.75	8.2	0.32	6	0.026
9/7/2016	PY07-16	4:1	0.70	17.9	8.0	0.75	8.2	0.26	8	0.021
9/12/2016	PY01-161	4:1	0.70	17.4	8.0	0.75	8.3	0.40	10	0.021
	PY02-118								6	0.027
10/6/2016	PY01-198	4:1	0.70	19.0	12.0	1.5	8.2	0.39	10	0.034
	PY02-141								6	0.019
10/13/2016	PY01-214	4:1	0.28	20.0	12.0	1.5	8.2	0.11	10	0.024
	PY02-148								6	0.022
10/20/2016	PY01-228	4:1	0.70	17.8	12.0	1.5	8.1	0.43	10	0.026
	PY02-154								6	0.020
10/31/2016	PY01-250	4:1	0.60	21.3	12.0	1.0	8.3	0.34	10	0.019
	PY02-164								6	0.026

a- Blend ratios expressed in Spiro to Judge Ratio.

b- Ferric chloride dose expressed as active ferric chloride.

c- Polymer dose expressed as polymer product (Nalclear 7766 plus – 30 percent active).

d- Indicates a filter effluent sample without a paired influent or settled water sample.

e- Values indicate dose or measurement at the time of the sample taken, and are not representative of the entire filter run. See Appendix F for graphs of all filter runs used for filter analysis.

f- For entries with multiple Pilot Run Identifiers, filter loading rate is provided for the singular run and filter effluent turbidity represents the mean value for that run. Chlorine residual is provided for the singular run if available and is otherwise provided for the combined filter effluent sample.

Appendix B

Water Quality Parameters Through Pilot Treatment Processes

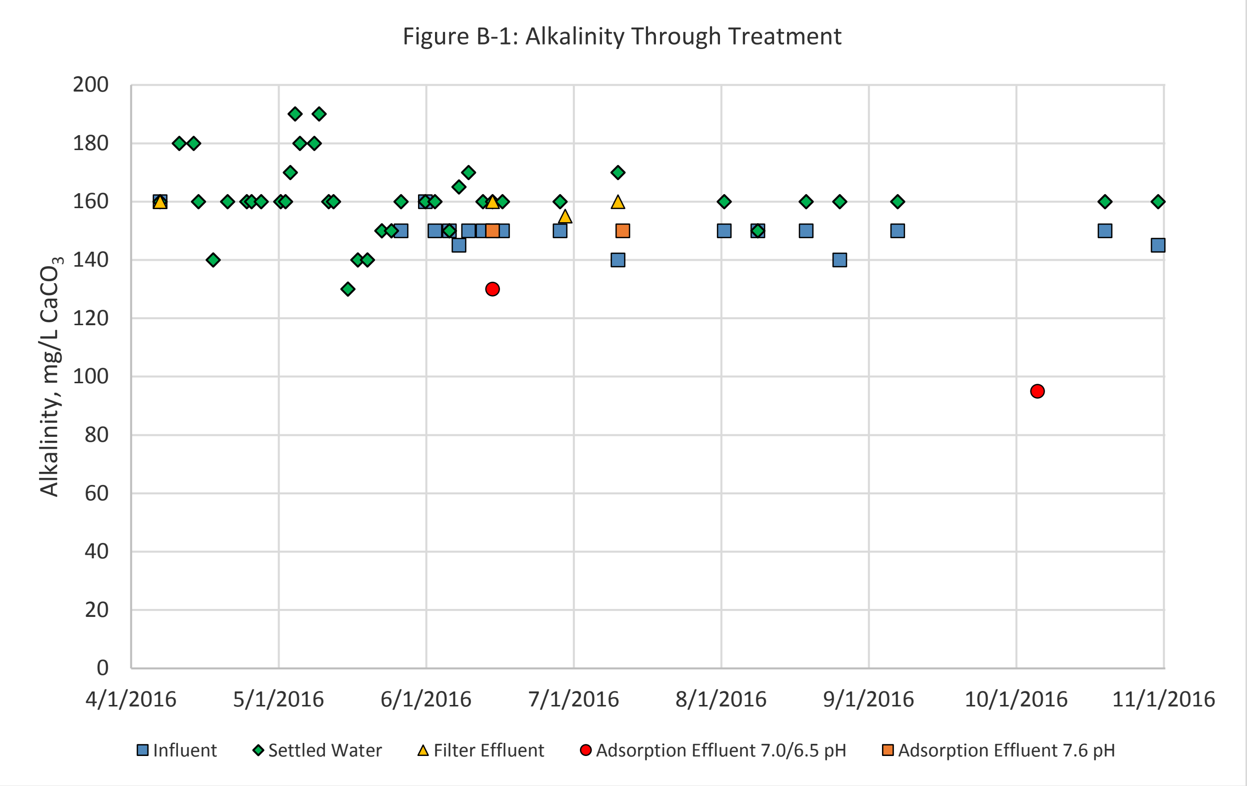


Figure B-1: Alkalinity Through Treatment
Alkalinity, mg/L CaCO3
200
180
160
140
120
100
80
60
40
20
0
4/1/2016
5/1/2016
6/1/2016
7/1/2016
8/1/2016
9/1/2016
10/1/2016
11/1/2016
Influent
Settled Water
Filter Effluent
Adsorption Effluent 7.0/6.5 pH
Adsorption Effluent 7.6 pH

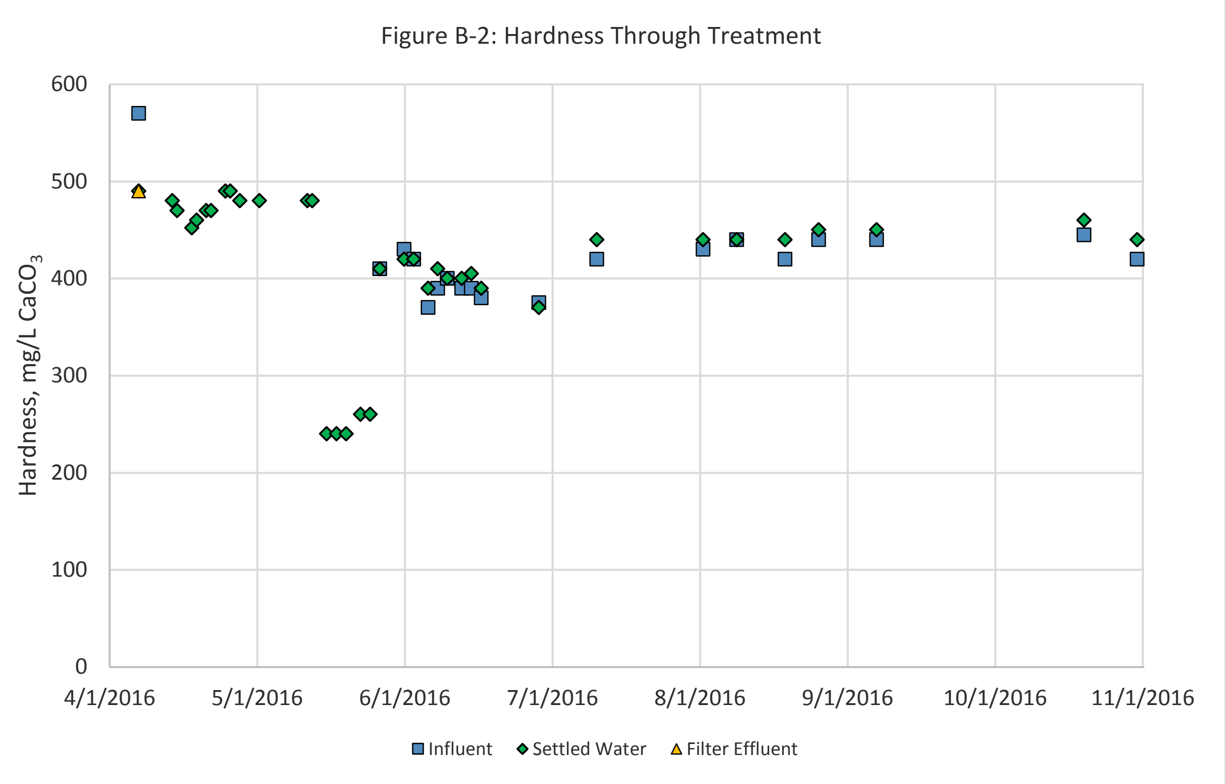


Figure B-2: Hardness Through Treatment
Hardness, mg/L CaCO3
600
500
400
300
200
100
0
4/1/2016
5/1/2016
6/1/2016
7/1/2016
8/1/2016
9/1/2016
10/1/2016
11/1/2016
Influent
Settled Water
Filter Effluent

Figure B-3: Conductivity Through Treatment

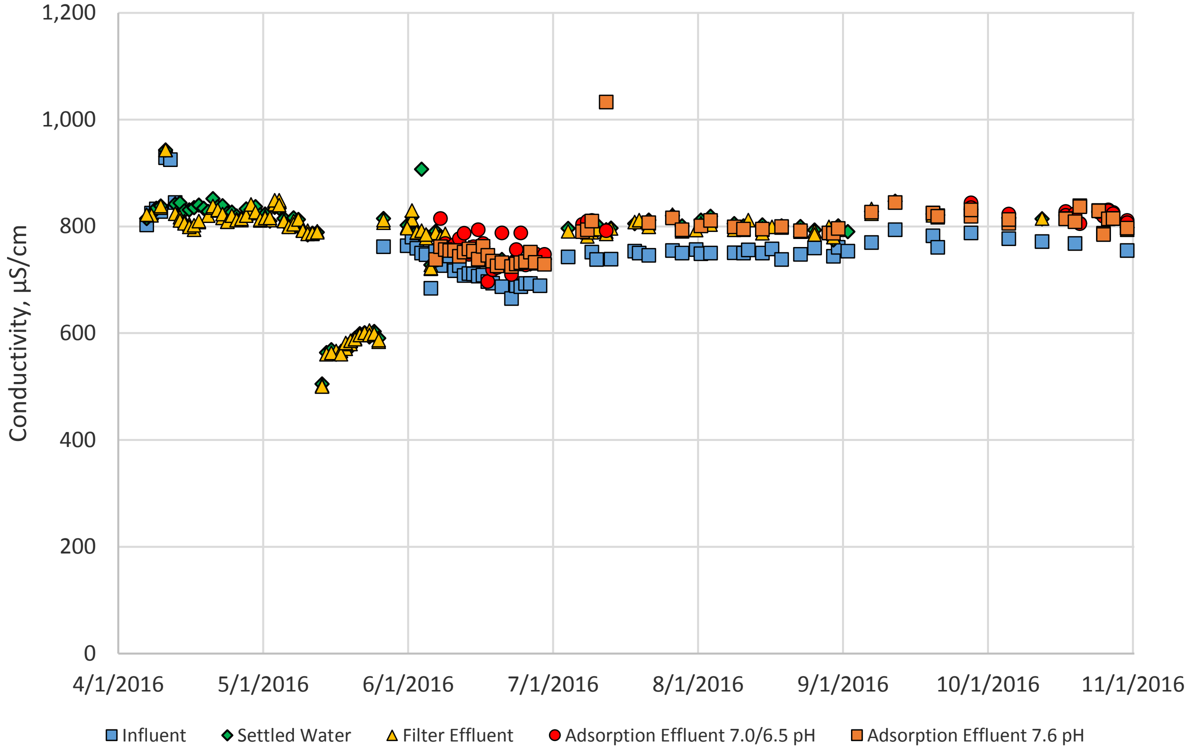
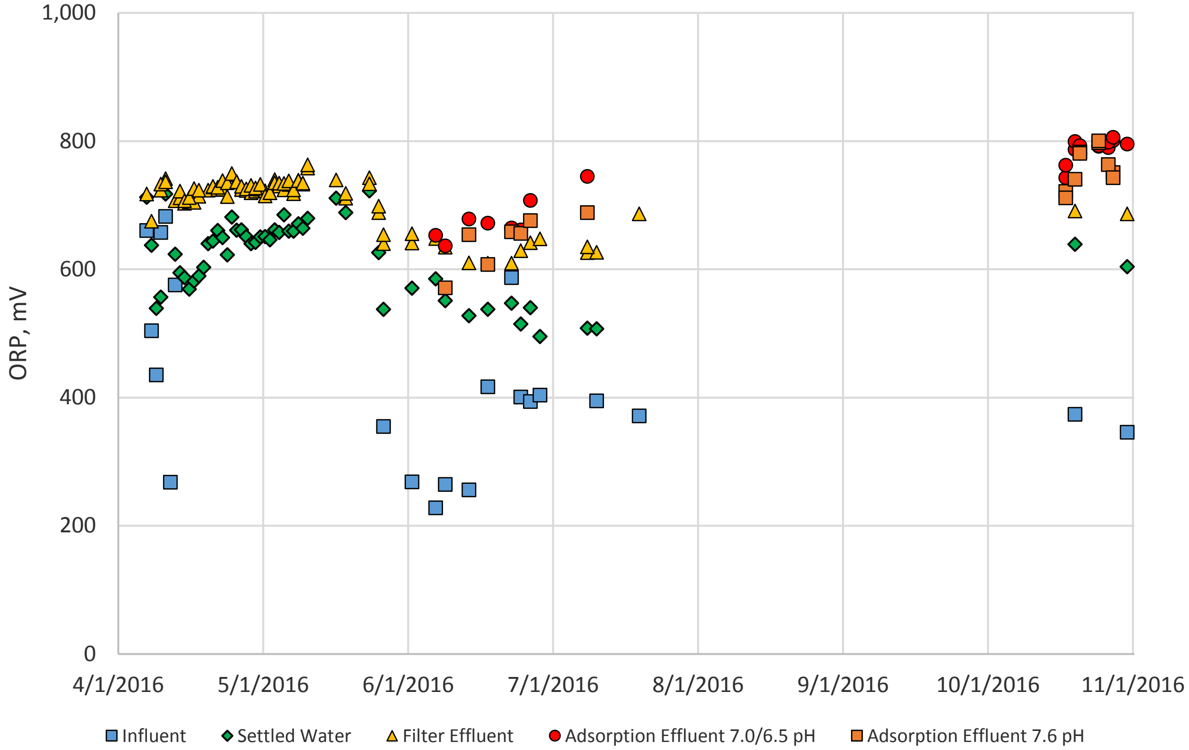


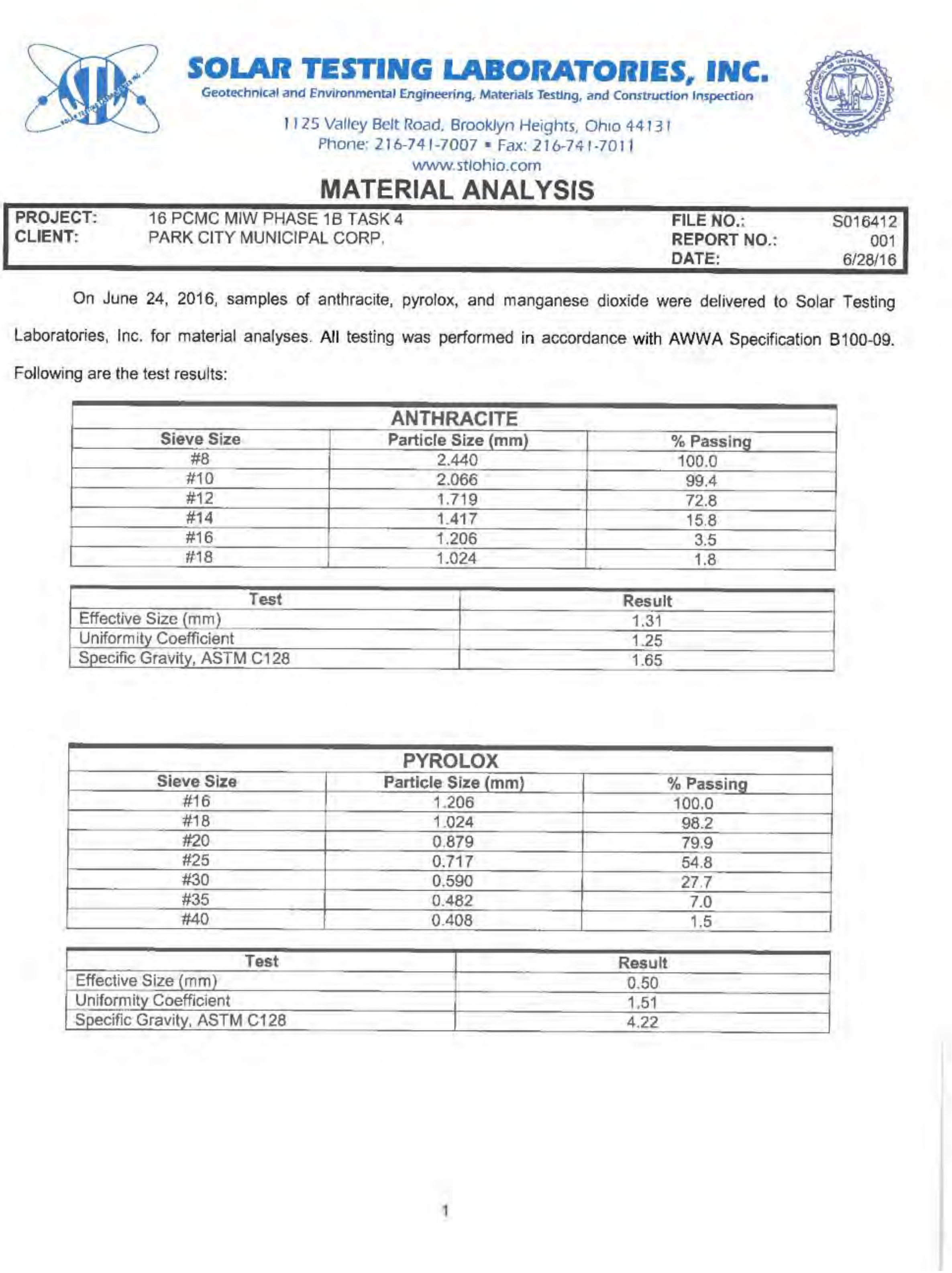
Figure B-4: ORP Through Treatment



Appendix C

Pilot Plant Design Parameters

Filter Media Sieve Analysis



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Phone: 216-741-7007 ▪ Fax: 216-741-7011
www.stiohio.com

MATERIAL ANALYSIS

PROJECT: 16 PCMC MIW PHASE 1B TASK 4
CLIENT: PARK CITY MUNICIPAL CORP.
FILE NO.: S016412
REPORT NO.: 001
DATE: 6/28/16

On June 24, 2016, samples of anthracite, pyrolox, and manganese dioxide were delivered to Solar Testing Laboratories, Inc. for material analyses. All testing was performed in accordance with AWWA Specification B100-09. Following are the test results:

ANTHRACITE

Sieve Size	Particle Size (mm)	% Passing
#8	2.440	100.0
#10	2.066	99.4
#12	1.719	72.8
#14	1.417	15.8
#16	1.206	3.5
#18	1.024	1.8

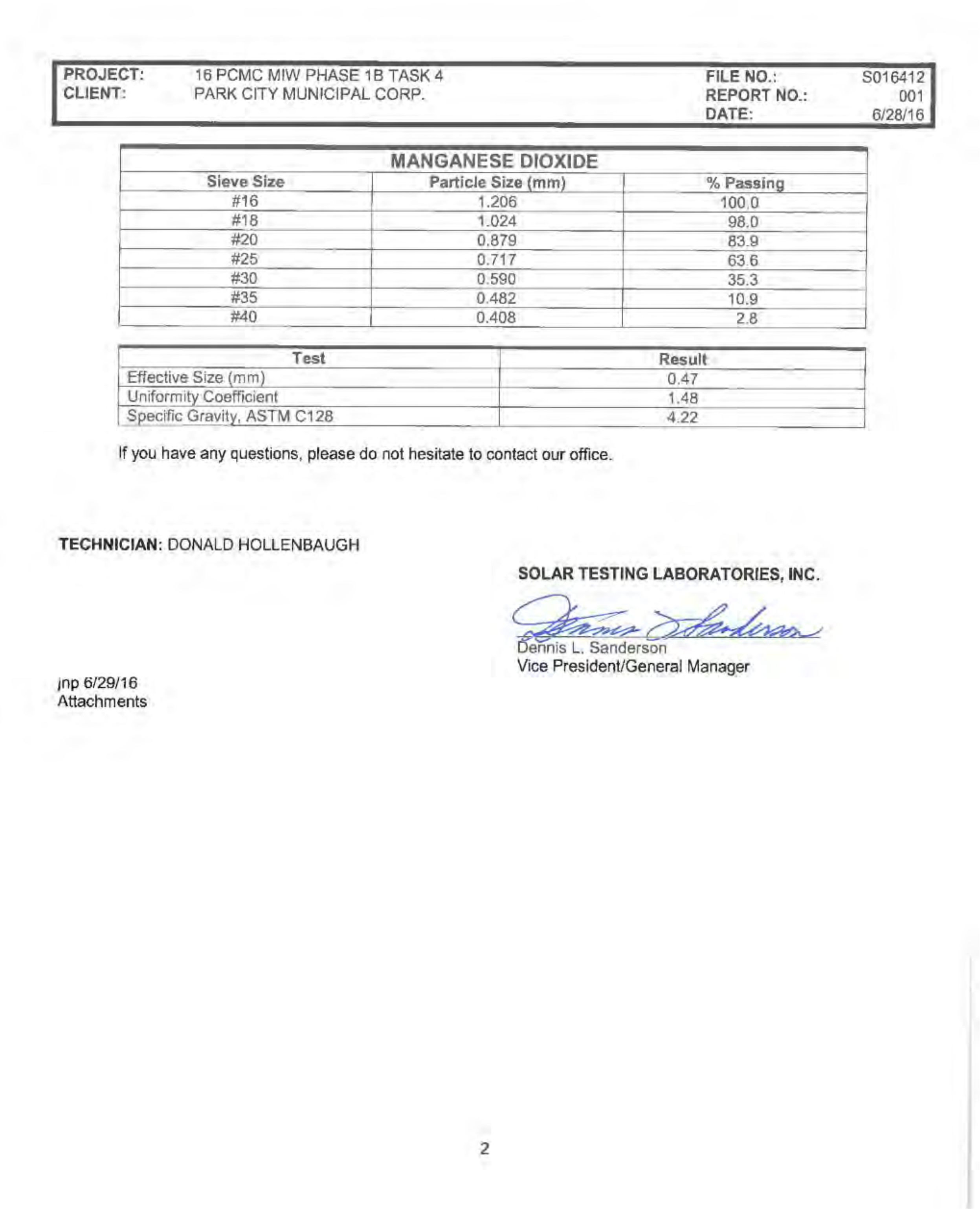
Test	Result
Effective Size (mm)	1.31
Uniformity Coefficient	1.25
Specific Gravity, ASTM C128	1.65

PYROLOX

Sieve Size	Particle Size (mm)	% Passing
#16	1.206	100.0
#18	1.024	98.2
#20	0.879	79.9
#25	0.717	54.8
#30	0.590	27.7
#35	0.482	7.0
#40	0.408	1.5

Test	Result
Effective Size (mm)	0.50
Uniformity Coefficient	1.51
Specific Gravity, ASTM C128	4.22

1



PROJECT:	16 PCMC MIW PHASE 1B TASK 4	**FILE NO.:**	S016412
CLIENT:	PARK CITY MUNICIPAL CORP.	**REPORT NO.:**	001
		DATE:	6/28/16

MANGANESE DIOXIDE

Sieve Size	Particle Size (mm)	% Passing
#16	1.206	100.0
#18	1.024	98.0
#20	0.879	83.9
#25	0.717	63.6
#30	0.590	35.3
#35	0.482	10.9
#40	0.408	2.8

Test	Result
Effective Size (mm)	0.47
Uniformity Coefficient	1.48
Specific Gravity, ASTM C128	4.22

If you have any questions, please do not hesitate to contact our office.

TECHNICIAN: DONALD HOLLENBAUGH

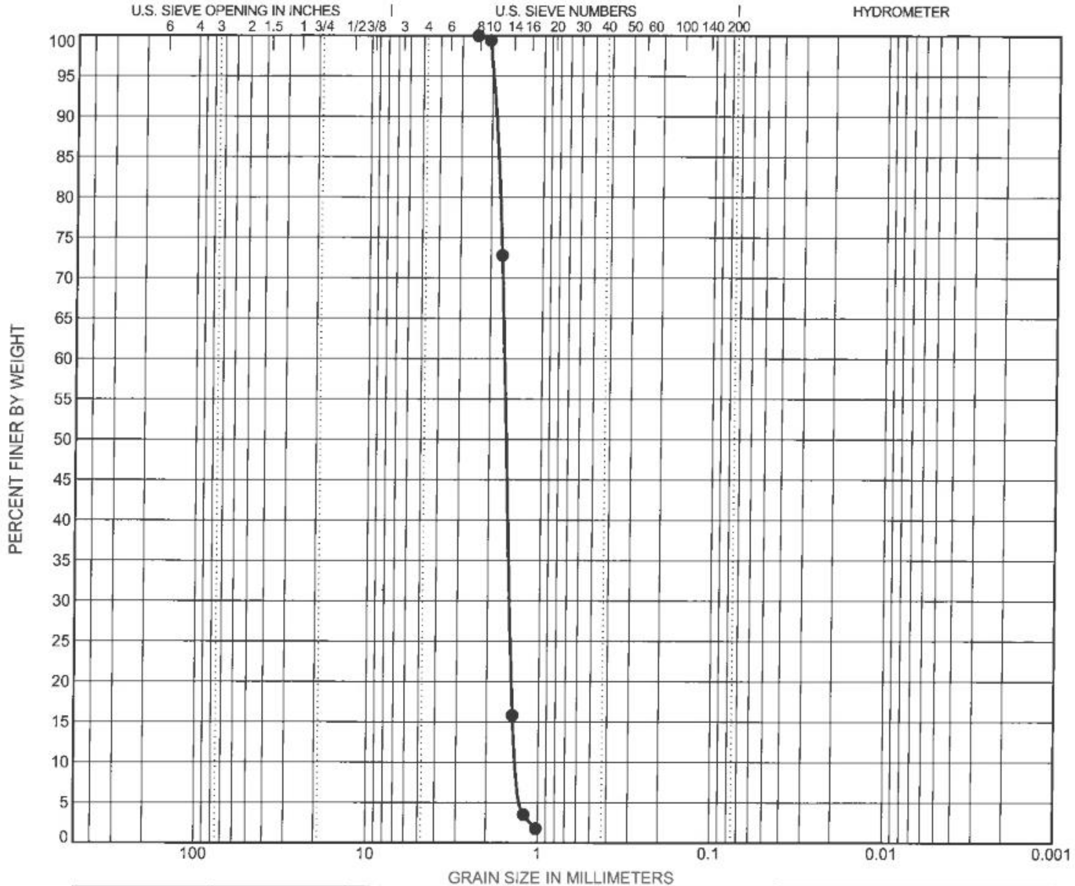
SOLAR TESTING LABORATORIES, INC.

Dennis L. Sanderson
Vice President/General Manager

jnp 6/29/16
Attachments

REPORT NO. ________

GRAIN SIZE DISTRIBUTION TEST REPORT



% +3"	%Gravel	%Sand	%Silt	%Clay
0.0	5.3			

LL	PI	D90	D60	D50	D30	D15	D10	Cc	Cu
		1.936	1.646	1.591	1.487	1.402	1.313	1.02	1.25

REMARKS	USCS	AASHTO

PROJECT NUMBER S016412

PROJECT NAME 16 PCMC MIW PHASE 1B TASK 4

LOCATION ________

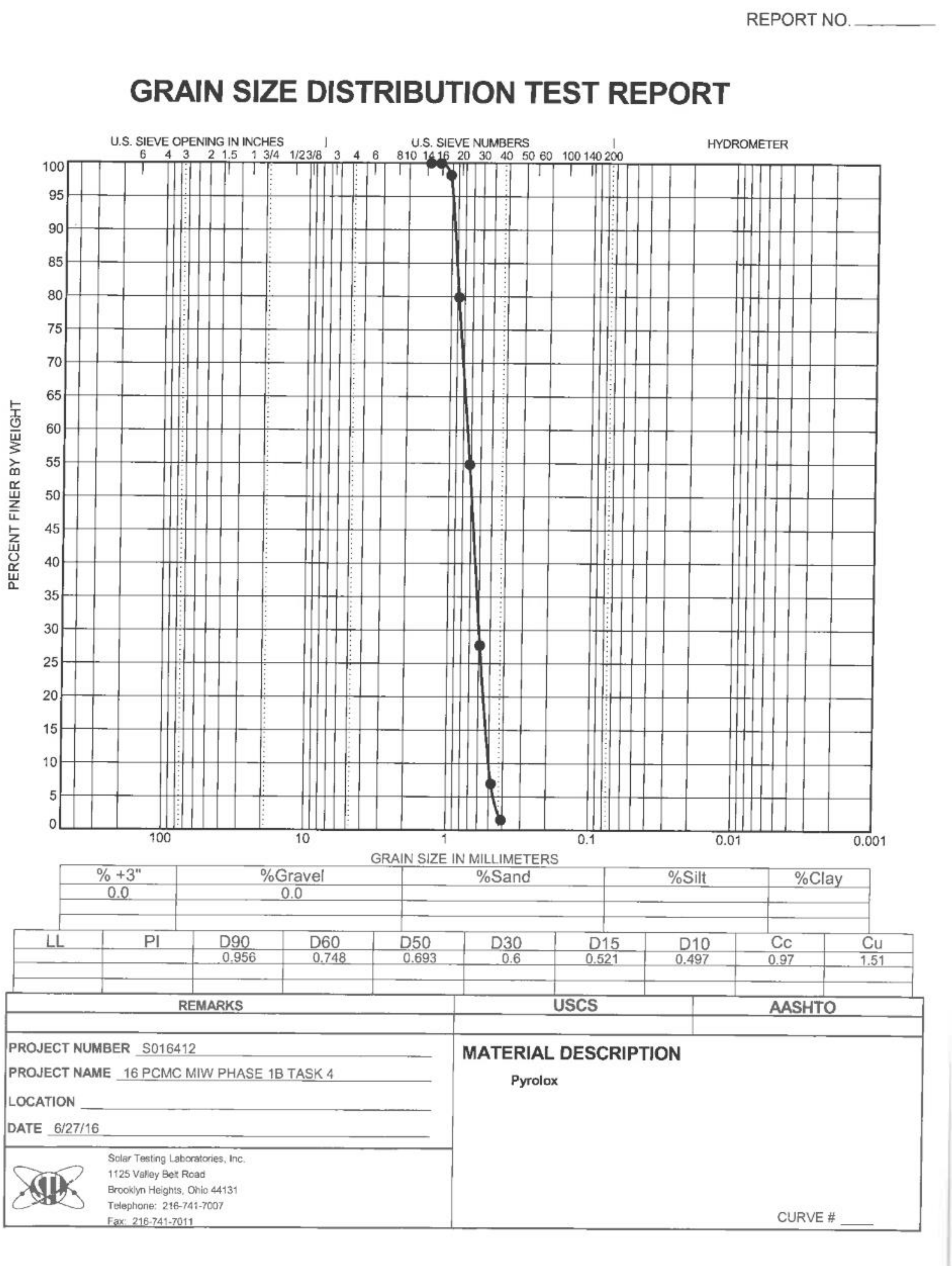
DATE 6/27/16

Solar Testing Laboratories, Inc.
1125 Valley Belt Road
Brooklyn Heights, Ohio 44131
Telephone: 216-741-7007
Fax: 216-741-7011

MATERIAL DESCRIPTION

Anthracite

CURVE # ____



REPORT NO. ________

GRAIN SIZE DISTRIBUTION TEST REPORT

% +3"	%Gravel	%Sand	%Silt	%Clay
0.0	0.0			

LL	PI	D90	D60	D50	D30	D15	D10	Cc	Cu
		0.956	0.748	0.693	0.6	0.521	0.497	0.97	1.51

REMARKS	USCS	AASHTO

PROJECT NUMBER S016412

PROJECT NAME 16 PCMC MIW PHASE 1B TASK 4

LOCATION ________

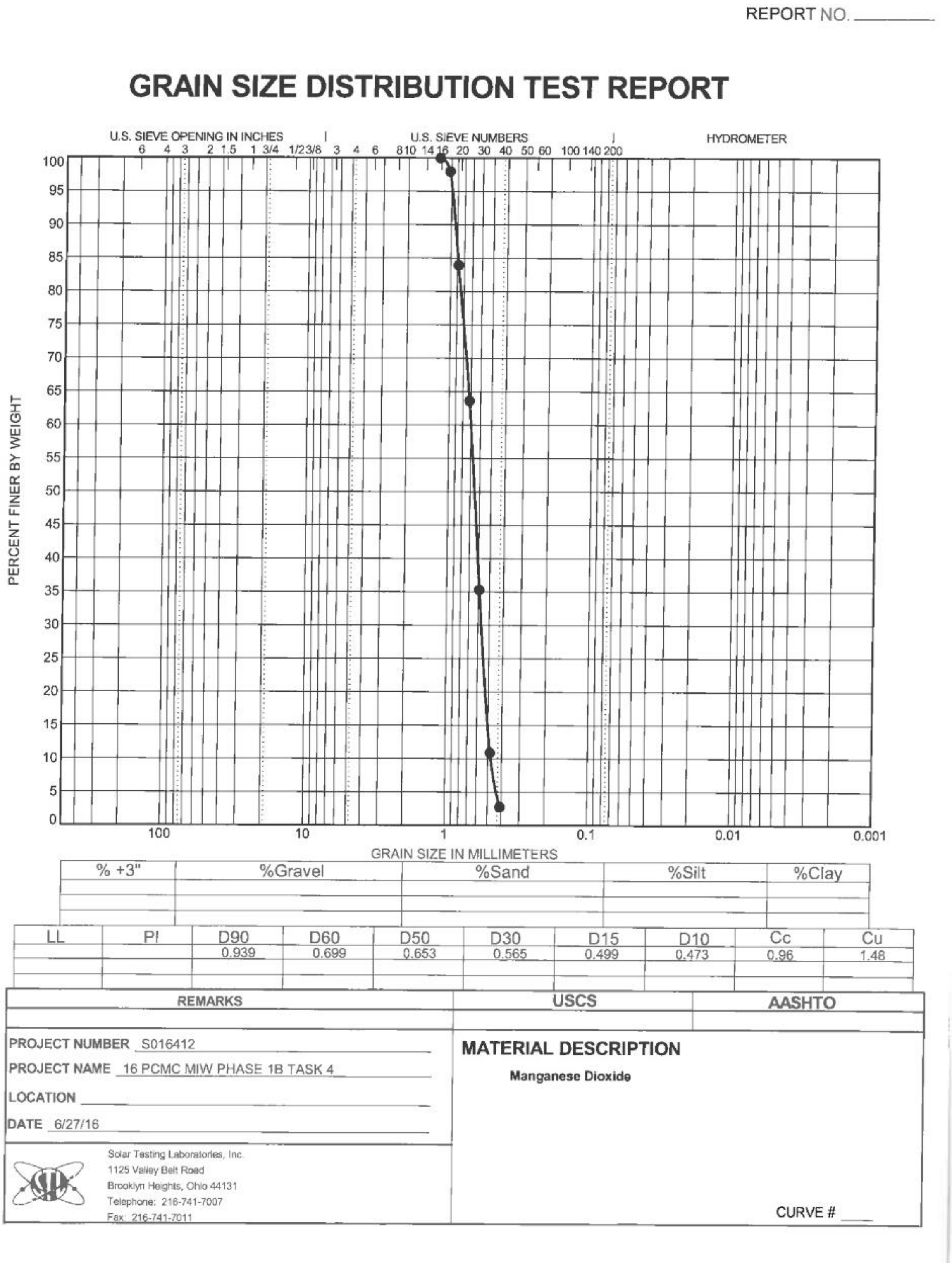
DATE 6/27/16

Solar Testing Laboratories, Inc.
1125 Valley Belt Road
Brooklyn Heights, Ohio 44131
Telephone: 216-741-7007
Fax: 216-741-7011

MATERIAL DESCRIPTION

Pyrolox

CURVE # ____



REPORT NO. ________

GRAIN SIZE DISTRIBUTION TEST REPORT

% +3"	%Gravel	%Sand	%Silt	%Clay

LL	PI	D90	D60	D50	D30	D15	D10	Cc	Cu
		0.939	0.699	0.653	0.565	0.499	0.473	0.96	1.48

REMARKS	USCS	AASHTO

PROJECT NUMBER S016412

PROJECT NAME 16 PCMC MIW PHASE 1B TASK 4

LOCATION ________

DATE 6/27/16

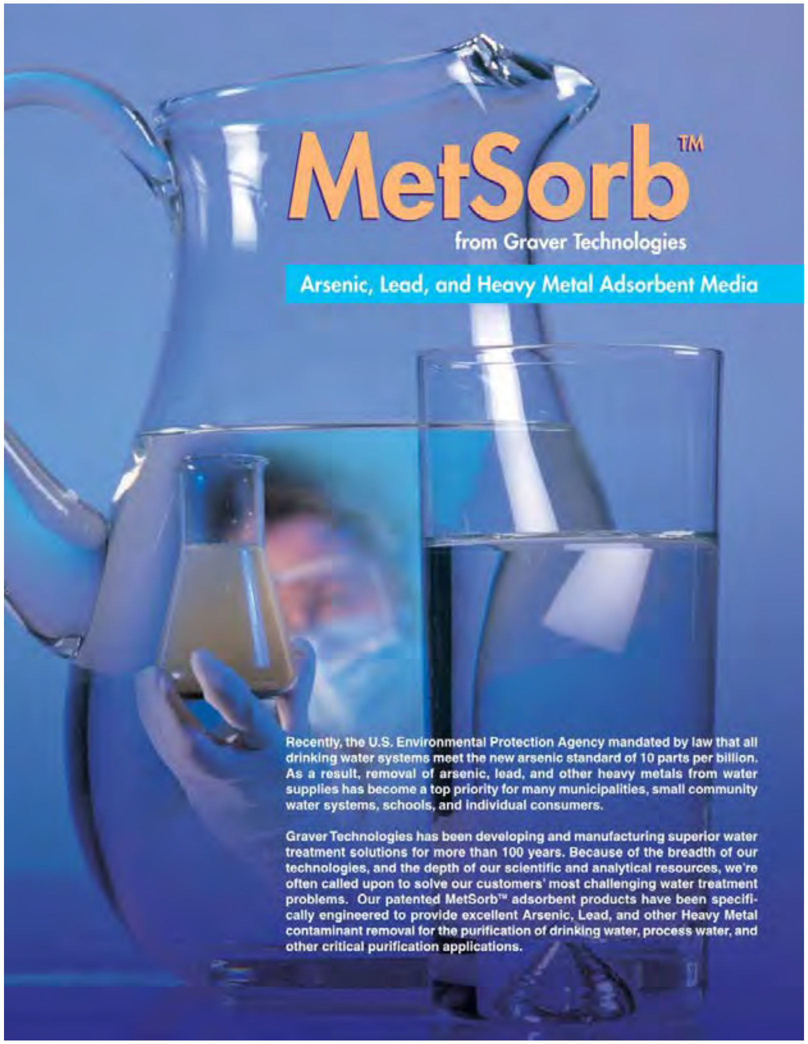
MATERIAL DESCRIPTION

Manganese Dioxide

Solar Testing Laboratories, Inc.
1125 Valley Belt Road
Brooklyn Heights, Ohio 44131
Telephone: 216-741-7007
Fax: 216-741-7011

CURVE # ____

Metsorb®, GFH®, and Bayoxide® E33 Adsorption Media Information Sheets



Recently, the U.S. Environmental Protection Agency mandated by law that all drinking water systems meet the new arsenic standard of 10 parts per billion. As a result, removal of arsenic, lead, and other heavy metals from water supplies has become a top priority for many municipalities, small community water systems, schools, and individual consumers.

Graver Technologies has been developing and manufacturing superior water treatment solutions for more than 100 years. Because of the breadth of our technologies, and the depth of our scientific and analytical resources, we're often called upon to solve our customers' most challenging water treatment problems. Our patented MetSorb™ adsorbent products have been specifically engineered to provide excellent Arsenic, Lead, and other Heavy Metal contaminant removal for the purification of drinking water, process water, and other critical purification applications.

MetSorb™ Adsorption Media

MetSorb™ HMRG is a highly effective granular adsorbent that removes arsenic III & V, and a wide variety of heavy metals including Lead, Cadmium, Copper, Chromium+6, Selenium, and Zinc from aqueous sources. MetSorb adsorbent technology utilizes a patented Titanium compound to adsorb both forms of arsenic as well as a wide range of contaminants in water. The increased surface area afforded by Titanium coupled with advanced pore volume provides excellent kinetics of adsorption.

MetSorb maintains a higher capacity and a lower level of ion interference than competitive iron and alumina based products.

The media is long-lasting and upon exhaustion, has consistently tested nonhazardous for disposal classification.

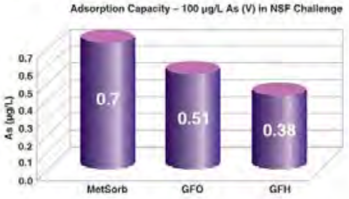
The media is NSF Standard 61 approved, and has received regulatory approval from agencies across the United States and Canada.

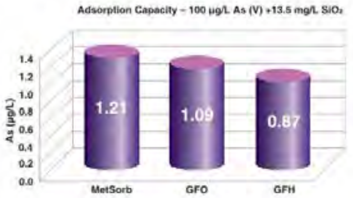
MetSorb Features and Benefits

- Removes As (III) and As (V) to <1.5 µg/L (non-detect)
- High adsorbent capacity for arsenic and lead (>10 mg As per gram of METSORB)
- Extremely Fast Kinetics: Empty Bed Contact Times (EBCT) between 1.5 - 3 minutes
- Reduced equipment footprint
- Simple installation and start-up
- Reduced (in some cases eliminated) frequency of backwash
- Nonhazardous disposal as solid waste–passes EPA TCLP (Toxicity Characteristic Leach Procedure)
- No regeneration Chemicals Required
- Removing Arsenic in millions of gallons of drinking water daily

Typical MetSorb Properties

Media Chemical Designation	Crystalline Titanium Oxide (TiO_2) (Anatase)
Physical Form/Color	White Granular Solid
Moisture Content	< 7%
Particle Size	-16 mesh / + 60 mesh
Surface Area	200–240 m^2/gram
Bulk Density	0.65 grams per cc (40 lbs / ft^3)
Pore Volume	0.34–0.44 cm^3/gram
Avg. Pore Size	64 - 84 Angstroms





Results of AWWA Research Foundation Study *"Adsorbent Treatment Technologies for Arsenic Removal"*, 2005

www.gravertech.com

MetSorb™ Application

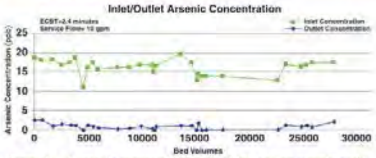
MetSorb adsorbent media is applicable in a wide range of water treatment processes, from large-scale municipal systems to small-scale residential treatment units. Regardless of the system size, there are operational design parameters that must be considered to ensure effective, trouble-free performance of the MetSorb adsorbent media.

Groundwater or surface water is simply pumped in a down-flow mode through a single or multiple fixed bed pressure vessel containing the MetSorb media. The multiple pressure vessel design is either assembled in Parallel Flow or Series Flow when additional adsorption protection is deemed necessary. Flow to each vessel is measured and totalized to record the volume of water treated. Pressure differential through each vessel is also monitored. Periodic back-washing is typically performed at start-up and every 8-10 weeks thereafter depending on usage and water quality.

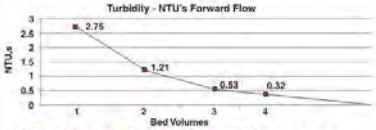
Dual vessels containing MetSorb plumbed in series for added consumer protection

Operational Design Parameters

Service Flow Rate	8-10 gpm/ft²
Flow Direction	Downward Flow
EBCT	1.5-3 Minutes
Typical Pressure Drop	< 5 psi
Backwash Flow Rate	8-10 gpm/ft²
Backwash Volume	5-7 Bed Volumes
Typical Freeboard	35 - 40%
Minimum Bed Depth	2 Feet
Maximum Feed Temperatue	150°F



Example of arsenic removal from drinking water supply well



Stability of MetSorb allows fast cleanup after backwash, placing in service flow promptly

MetSorb Disposal

MetSorb is operational in numerous locations across the US and Canada providing much experience in managing the exhausted media. Arsenic (or "heavy metal") laden MetSorb HMRG 16/60 has been evaluated using both the EPA TCLP (CFR 40-RCRA Regs.) and California WET methods and has been found to be nonhazardous and safe for landfill disposal. Since each application differs, however, we recommend exhausted MetSorb HMRG 16/60 be evaluated following all federal, state, and local regulations regarding necessary approvals for landfill disposal.

NOTES:

- Graver recommends treatment system monitoring to determine media breakthrough and changeout.
- Pre-filtration for particulates can greatly reduce frequency of backwash.
- High levels of iron and magnesium can influence efficiency of MetSorb adsorption.
- EBCT of 3 minutes is recommended for challenging water qualities.
- Backwash water discharged to sewer or POTW. Direct discharge according to state and local regulations.

Graver Technologies is a Member of the Marmon Group of Companies, an international corporation with over $6 Billion in annual sales. Graver Technologies has the technical resources and financial strength that make us the perfect partner for your business, whether it's around the corner or around the world.

Locations

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Industrial Filtration Products
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Telephone: 585-624-1330
Fax: 585-624-1205

Europe Sales Office
Stuttgart, Germany
Telephone: 49-711-3154-7160
Fax: 49-711-3154-7170

China Sales Office
RM 16D, Bldg. B
No. 1118
Changshou RD
Shanghai, China 200042
Telephone: (86) 21 5238 6576-608
Fax: (86) 21 5238 6579

Member of:

NSF

American Water Works Association

Water Quality Association **Rural Water Association**

Graver Technologies

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www.gravertech.com

Granular Ferric Hydroxide (GFH) for Trace Metal Removal, in Accordance with DIN EN 15029

A) Application for GFH

GFH is a high performance adsorbent based on the chemistry of ferric hydroxide. It is manufactured in a special patented process. **GFH** can be treated and customized for the removal of different contaminants from water.

GFH is customized for the removal of trace metal in various applications, like pump and treat at contaminated sites, treatment of scrub water from incineration, industrial wastewater and landfill leachates.

GFH can adsorb the following compounds:
Arsenic III - Arsenic V - Antimony - Lead - Copper - Molybdenum - Selenium IV – Vanadium

B) Specification

Chemical Composition

Active Substance: $Fe(OH)_3$ and ß-FeOOH:	55 – 60 %
Water Content:	40 – 45 %

Adsorption density for arsenic > 55g/kg

The adsorption density of **GFH** for the individual contaminants depends on pH and the water chemistry.

Physical data:

Grain size:	0.30 – 2.0 mm
Percentage < 0,30 mm:	< 10 %
Percentage > 2 mm:	< 10 %
Density of grains:	1.5 – 1.7 kg/dm^3
Bulk density:	1.05 – 1.2 kg/dm^3
Specific surface:	> 220 m^2/g (dry substance)

(The density values are given for **GFH** with a water content of 45 %)

C) Application

Adsorbers for the application of **GFH** are pressure filter vessels or gravity filters with filter nozzles, a support gravel layer, and a connector for the removal of spent adsorbent.

Filtering rate:	5 – 20 m/h
Recommended backwashing rate at 12°C:	26 – 28 m/h (only water backwashing)
Recommended freeboard:	30 – 50 % of bed depth
Empty bed contact time (EBCT):	$\geq$ 3 minutes

D) Maximum ratings

Bed depth:	1.6 m
Filtering rate:	22 m/h
Backwashing rate:	35 m/h
Max. tolerable head loss:	0.5 bar
Max. operating temperature:	+ 60 °C

E) Transport and storing conditions

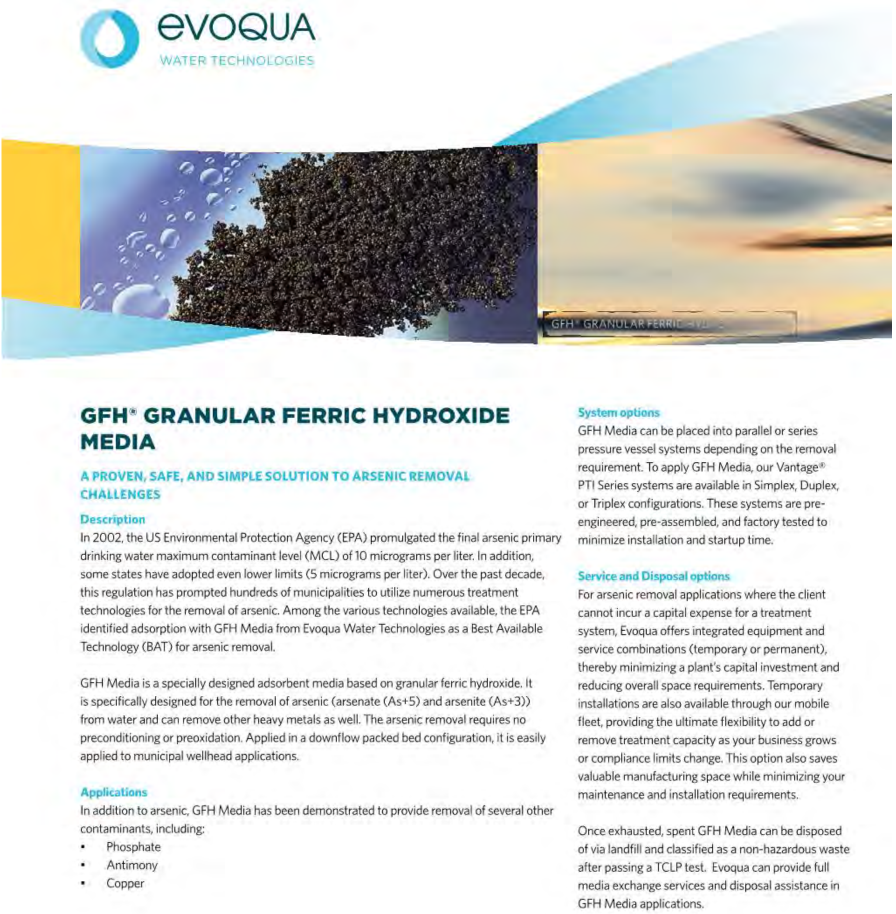
Storage temperature (average):	-10° + + 30 °C
Storage period:	12 months

Packaging	Plastic drums or big bags

2430 Rose Place
Roseville, MN 55113

Tel: +1 (651) 638-1300
Fax: +1 (651) 846-4394

Page 1 of 1



GFH® GRANULAR FERRIC HYDROXIDE MEDIA

A PROVEN, SAFE, AND SIMPLE SOLUTION TO ARSENIC REMOVAL CHALLENGES

Description

In 2002, the US Environmental Protection Agency (EPA) promulgated the final arsenic primary drinking water maximum contaminant level (MCL) of 10 micrograms per liter. In addition, some states have adopted even lower limits (5 micrograms per liter). Over the past decade, this regulation has prompted hundreds of municipalities to utilize numerous treatment technologies for the removal of arsenic. Among the various technologies available, the EPA identified adsorption with GFH Media from Evoqua Water Technologies as a Best Available Technology (BAT) for arsenic removal.

GFH Media is a specially designed adsorbent media based on granular ferric hydroxide. It is specifically designed for the removal of arsenic (arsenate (As+5) and arsenite (As+3)) from water and can remove other heavy metals as well. The arsenic removal requires no preconditioning or preoxidation. Applied in a downflow packed bed configuration, it is easily applied to municipal wellhead applications.

Applications

In addition to arsenic, GFH Media has been demonstrated to provide removal of several other contaminants, including:

- Phosphate
- Antimony
- Copper

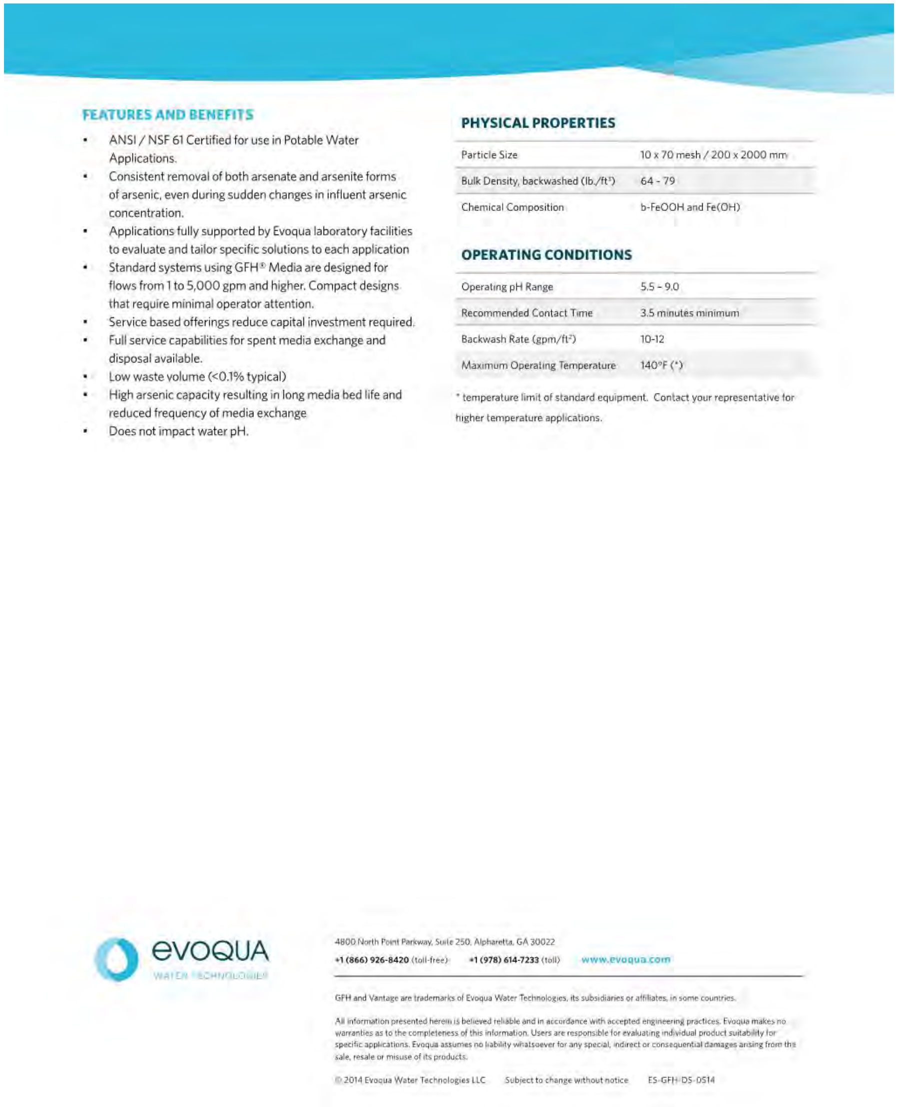
System options

GFH Media can be placed into parallel or series pressure vessel systems depending on the removal requirement. To apply GFH Media, our Vantage® PTI Series systems are available in Simplex, Duplex, or Triplex configurations. These systems are pre-engineered, pre-assembled, and factory tested to minimize installation and startup time.

Service and Disposal options

For arsenic removal applications where the client cannot incur a capital expense for a treatment system, Evoqua offers integrated equipment and service combinations (temporary or permanent), thereby minimizing a plant's capital investment and reducing overall space requirements. Temporary installations are also available through our mobile fleet, providing the ultimate flexibility to add or remove treatment capacity as your business grows or compliance limits change. This option also saves valuable manufacturing space while minimizing your maintenance and installation requirements.

Once exhausted, spent GFH Media can be disposed of via landfill and classified as a non-hazardous waste after passing a TCLP test. Evoqua can provide full media exchange services and disposal assistance in GFH Media applications.



FEATURES AND BENEFITS

- ANSI / NSF 61 Certified for use in Potable Water Applications.
- Consistent removal of both arsenate and arsenite forms of arsenic, even during sudden changes in influent arsenic concentration.
- Applications fully supported by Evoqua laboratory facilities to evaluate and tailor specific solutions to each application
- Standard systems using GFH® Media are designed for flows from 1 to 5,000 gpm and higher. Compact designs that require minimal operator attention.
- Service based offerings reduce capital investment required.
- Full service capabilities for spent media exchange and disposal available.
- Low waste volume (<0.1% typical)
- High arsenic capacity resulting in long media bed life and reduced frequency of media exchange
- Does not impact water pH.

PHYSICAL PROPERTIES

Particle Size	10 x 70 mesh / 200 x 2000 mm
Bulk Density, backwashed (lb./ft^3)	64 - 79
Chemical Composition	b-FeOOH and Fe(OH)

OPERATING CONDITIONS

Operating pH Range	5.5 - 9.0
Recommended Contact Time	3.5 minutes minimum
Backwash Rate (gpm/ft^2)	10-12
Maximum Operating Temperature	140°F (*)

* temperature limit of standard equipment. Contact your representative for higher temperature applications.

evoqua
WATER TECHNOLOGIES

4800 North Point Parkway, Suite 250, Alpharetta, GA 30022
+1 (866) 926-8420 (toll-free) **+1 (978) 614-7233** (toll) www.evoqua.com

ADVANT EDGE

Bayoxide® E33 Adsorption Media – Arsenic Reduction

AdEdge Technologies' Bayoxide® E33 media is the industry standard for arsenic reduction that reduces up to 99% of total arsenic, including both arsenic (III) and arsenic (V). This revolutionary new iron-based granular adsorption media has 4 to 10 times the capacity of many adsorption medias. AdEdge's product is specifically designed for commercial and residential POE and small systems to meet the EPA arsenic standard of 10 ppb. Developed in the mid-nineties, this ferric oxide-based product has been successfully used in large-scale drinking water applications since 1999. The new E33 media can be discarded when spent and requires no chemicals or regeneration. It has become the premier product of choice for POE whole-house drinking water treatment systems for reliable, cost-effective, proven reduction of arsenic.

✓ Removal of up to 99% of total Arsenic in water, including As (III) & As (V) with no wasting of water.	✓ NSF 61 product listing (see AdEdge for listing site/product details) ✓ Effective over broad water chemistry.
✓ Spent media discarded as non-hazardous household waste.	✓ Simple application for whole house POE applications for arsenic removal.
✓ Reliable performance, low maintenance ✓ Adaptable add-on to water softening or other existing equipment.	✓ 2 - 2.5 times lighter than other iron-based media; easily backwashable; arsenic not released or discharged in backwash water.
✓ No salt, chemicals or regeneration needed	✓ Imparts no harmful chemicals into the treated product water.

TECHNICAL SPECIFICATIONS

E33 provides cost effective centralized arsenic treatment with a typical life of 2-3+ years before replacement. The media exhibits high operating capacity across a wide range of pH, influent arsenic concentrations and flow rates. It is simple to apply in standard POE vessels with typical flow rates of 2-10 gallons per minute. Once the media is exhausted, E33 can be discarded as a non-hazardous waste (specific state requirements should be consulted). Media is easy to handle and can be stored and shipped dry.

Physical Properties	E33 Media
Matrix	Iron Oxide Composite
Physical Form	Dry granular media
Color	Amber
Particle Size Distribution	10x35 mesh
Moisture Content	< 15% by wt.
Packaged	Dry

ADVANT EDGE
AdEdge Technologies, Inc.,
5152 Belle Wood Court, Suite A,
Buford, GA 30518 (866) 823-3343 (678) 835-0057 Fax
www.advantedgewater.com

AdVantEdge 02-11

Arsenic Removal Performance (POE)	
Arsenic concentration range [1,2]	10 – 100+ ppb
Arsenic species reduced	As (III) and As (V)
Removal efficiency	Up to 99%
Estimated media life	2 to 3+ years
Expected life bed volumes [3]	15,000 to 125,000
Spent media disposal [4]	Non-hazardous waste
Empty bed contact time	3 minutes typical

Notes:
1. Typical arsenic contamination in U.S. < 50 ppb.
2. Capable of removing higher As concentrations. Consult AdVantEdge for applications above 100 ppb.
3. Actual bed volumes based on water quality.
4. Reference US EPA TCLP protocol

Use of E33 media in typical point-of-entry system installation. Picture courtesy of Aquamech, Inc.

WATER QUALITY CRITERIA

Parameter	Value [1]
pH range [2]	5.5 - 8.5
Arsenic [3]	< 100 ug/L
Iron	< 0.3 mg/L
Manganese	< 0.05 mg/L
Phosphate	< 0.5 mg/L
Silica	< 30 mg/L
Sulfate	< 100 mg/L
Sulfides	< detect mg/L
TSS	< 5 mg/L
Fluoride	< 1 mg/L
Hardness	< 300 mg/L
Turbidity	5 NTU

Notes:
1. Recommendations for best performance.
2. Water > 8.5 pH may require pH adjustment for best results. Contact AdVantEdge for technical support.
3. For all applications, complete AdVantEdge POE profile sheet to pre-qualify site for proper use; consult AdVantEdge Authorized dealer or distributor for details
4. Pretreat for tannins if present prior to adsorption

RESIDENTIAL SIZING PARAMETERS

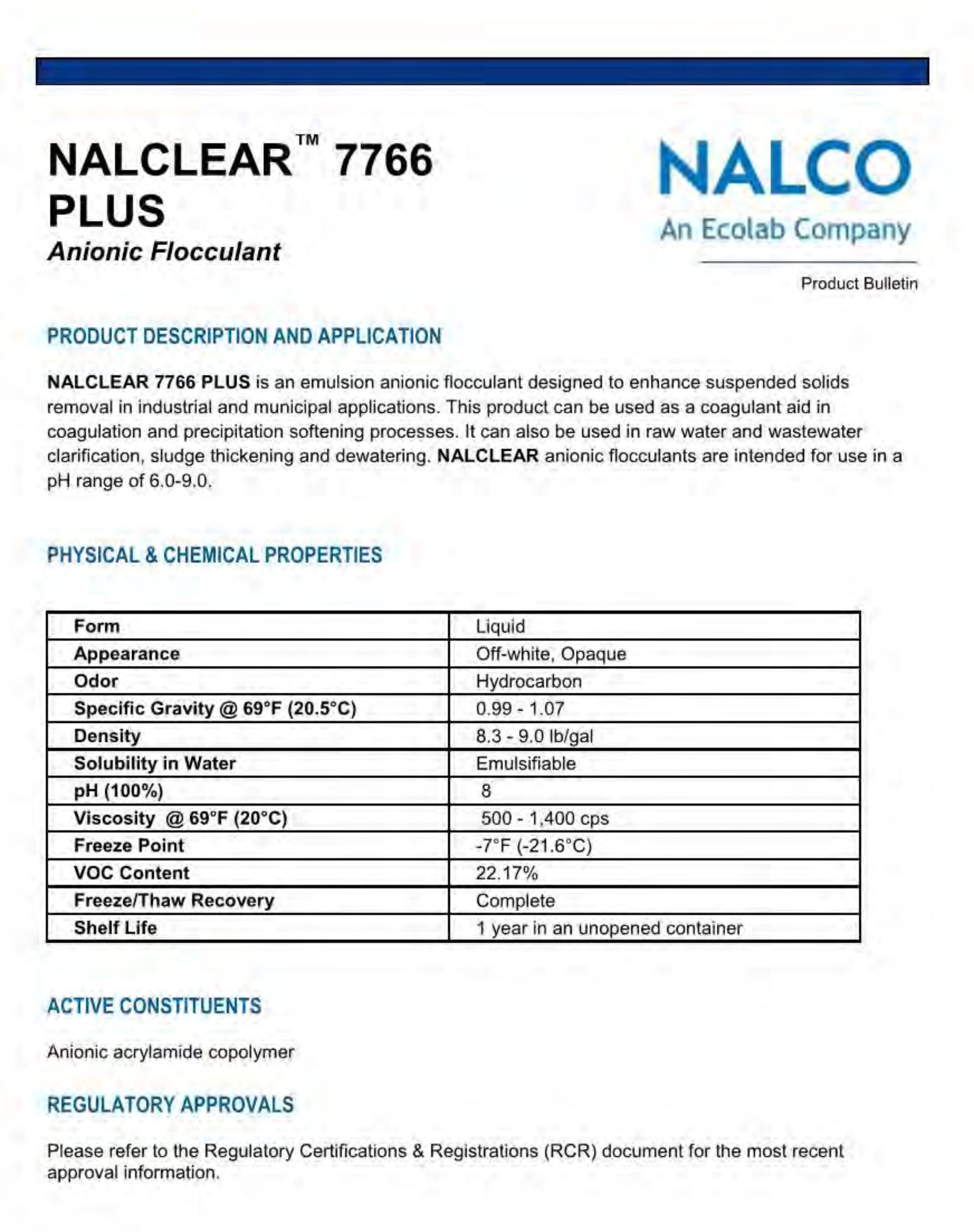
System Design Parameters	5 GPM dual tank	5 GPM single tank	10 GPM single tank
Typical Tank size (inches)	10 x 42	12 x 52	14 x 65
Media Volume (cubic feet)	(2) 1-ft³ ea	2 ft³	4 ft³
Operation mode	2 in series	Single tank	Single tank
Media Type	E33S	E33S	E33S
Underbedding	gravel	gravel	gravel
Typical Freeboard (%)	40	40	40
Backwash flow rate (gpm/ft²)	4	5	10
Backwash cycles (per month)	2x	2x	2x
Est. gallons per day [3]	300	300	500
Est. gallons to breakthrough [2]	374,000	374,000	561,000
Estimated time to media changeout[1]	2-3+ years	2-3+ years	2-3+ years
Max flow rate (gpm)	5	6	10

Notes:
1. Media life based on gallon usage and water profile (Above is example only; example assumes 40 ppb
2. arsenic, 25,000 bed volumes); will vary by individual site based on water quality and usage
3. AdVantEdge recommends effluent testing and monitoring program to determine media breakthrough.
4. Average gallons per day will be site and usage specific.

ADVANT EDGE
AdEdge Technologies, Inc.,
5152 Belle Wood Court, Suite A,
Buford, GA 30518 (866) 823-3343 (678) 835-0057 Fax
www.advantedgewater.com

AdVantEdge 02-11

Nalclear® 7766 Plus Product Bulletin



NALCLEAR™ 7766 PLUS

Anionic Flocculant

NALCO
An Ecolab Company

Product Bulletin

PRODUCT DESCRIPTION AND APPLICATION

NALCLEAR 7766 PLUS is an emulsion anionic flocculant designed to enhance suspended solids removal in industrial and municipal applications. This product can be used as a coagulant aid in coagulation and precipitation softening processes. It can also be used in raw water and wastewater clarification, sludge thickening and dewatering. **NALCLEAR** anionic flocculants are intended for use in a pH range of 6.0-9.0.

PHYSICAL & CHEMICAL PROPERTIES

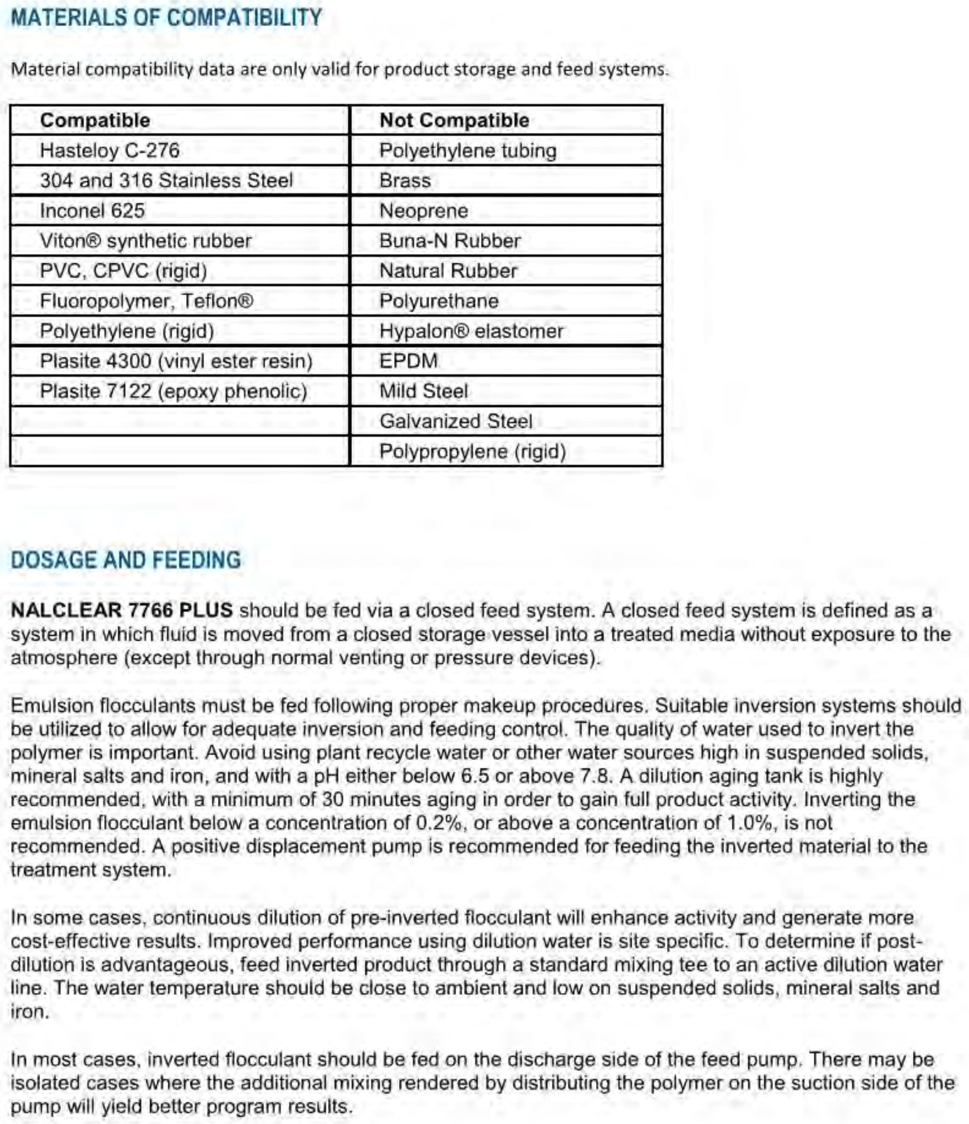
Form	Liquid
Appearance	Off-white, Opaque
Odor	Hydrocarbon
Specific Gravity @ 69°F (20.5°C)	0.99 - 1.07
Density	8.3 - 9.0 lb/gal
Solubility in Water	Emulsifiable
pH (100%)	8
Viscosity @ 69°F (20°C)	500 - 1,400 cps
Freeze Point	-7°F (-21.6°C)
VOC Content	22.17%
Freeze/Thaw Recovery	Complete
Shelf Life	1 year in an unopened container

ACTIVE CONSTITUENTS

Anionic acrylamide copolymer

REGULATORY APPROVALS

Please refer to the Regulatory Certifications & Registrations (RCR) document for the most recent approval information.



MATERIALS OF COMPATIBILITY

Material compatibility data are only valid for product storage and feed systems.

Compatible	Not Compatible
Hasteloy C-276	Polyethylene tubing
304 and 316 Stainless Steel	Brass
Inconel 625	Neoprene
Viton® synthetic rubber	Buna-N Rubber
PVC, CPVC (rigid)	Natural Rubber
Fluoropolymer, Teflon®	Polyurethane
Polyethylene (rigid)	Hypalon® elastomer
Plasite 4300 (vinyl ester resin)	EPDM
Plasite 7122 (epoxy phenolic)	Mild Steel
	Galvanized Steel
	Polypropylene (rigid)

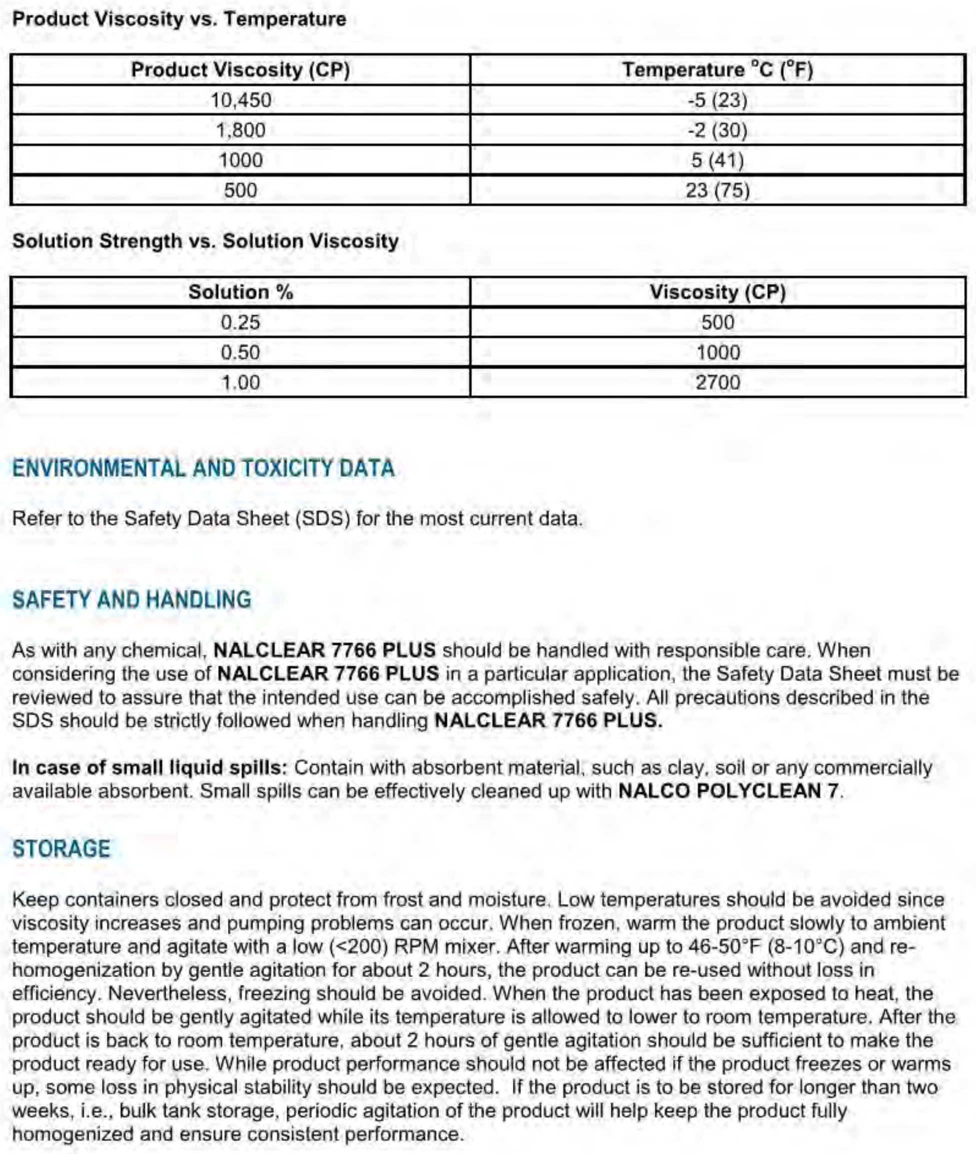
DOSAGE AND FEEDING

NALCLEAR 7766 PLUS should be fed via a closed feed system. A closed feed system is defined as a system in which fluid is moved from a closed storage vessel into a treated media without exposure to the atmosphere (except through normal venting or pressure devices).

Emulsion flocculants must be fed following proper makeup procedures. Suitable inversion systems should be utilized to allow for adequate inversion and feeding control. The quality of water used to invert the polymer is important. Avoid using plant recycle water or other water sources high in suspended solids, mineral salts and iron, and with a pH either below 6.5 or above 7.8. A dilution aging tank is highly recommended, with a minimum of 30 minutes aging in order to gain full product activity. Inverting the emulsion flocculant below a concentration of 0.2%, or above a concentration of 1.0%, is not recommended. A positive displacement pump is recommended for feeding the inverted material to the treatment system.

In some cases, continuous dilution of pre-inverted flocculant will enhance activity and generate more cost-effective results. Improved performance using dilution water is site specific. To determine if post-dilution is advantageous, feed inverted product through a standard mixing tee to an active dilution water line. The water temperature should be close to ambient and low on suspended solids, mineral salts and iron.

In most cases, inverted flocculant should be fed on the discharge side of the feed pump. There may be isolated cases where the additional mixing rendered by distributing the polymer on the suction side of the pump will yield better program results.



Product Viscosity vs. Temperature

Product Viscosity (CP)	Temperature °C (°F)
10,450	-5 (23)
1,800	-2 (30)
1000	5 (41)
500	23 (75)

Solution Strength vs. Solution Viscosity

Solution %	Viscosity (CP)
0.25	500
0.50	1000
1.00	2700

ENVIRONMENTAL AND TOXICITY DATA

Refer to the Safety Data Sheet (SDS) for the most current data.

SAFETY AND HANDLING

As with any chemical, **NALCLEAR 7766 PLUS** should be handled with responsible care. When considering the use of **NALCLEAR 7766 PLUS** in a particular application, the Safety Data Sheet must be reviewed to assure that the intended use can be accomplished safely. All precautions described in the SDS should be strictly followed when handling **NALCLEAR 7766 PLUS.**

In case of small liquid spills: Contain with absorbent material, such as clay, soil or any commercially available absorbent. Small spills can be effectively cleaned up with **NALCO POLYCLEAN 7**.

STORAGE

Keep containers closed and protect from frost and moisture. Low temperatures should be avoided since viscosity increases and pumping problems can occur. When frozen, warm the product slowly to ambient temperature and agitate with a low (<200) RPM mixer. After warming up to 46-50°F (8-10°C) and re-homogenization by gentle agitation for about 2 hours, the product can be re-used without loss in efficiency. Nevertheless, freezing should be avoided. When the product has been exposed to heat, the product should be gently agitated while its temperature is allowed to lower to room temperature. After the product is back to room temperature, about 2 hours of gentle agitation should be sufficient to make the product ready for use. While product performance should not be affected if the product freezes or warms up, some loss in physical stability should be expected. If the product is to be stored for longer than two weeks, i.e., bulk tank storage, periodic agitation of the product will help keep the product fully homogenized and ensure consistent performance.

REMARKS

If you need assistance or more information on this product, please call your nearest Nalco representative.

For more news about Nalco, an Ecolab company, visit our website www.nalco.ecolab.com

For **Medical and Transportation Emergencies** involving Nalco products, please see the Safety Data Sheet for the phone number.

ADDITIONAL INFORMATION

Nalco An Ecolab Company

Subsidiaries and Affiliates in Principal Locations Around the World

Appendix D
WET Testing Results

Summary of MIW Pilot WET Testing

PREPARED FOR:	Park City Municipal Corporation
PREPARED BY:	CH2M
DATE:	November 4, 2016
PROJECT NUMBER:	659671.03.31

MIW Pilot WET Tests

Under the Utah Pollutant Discharge Elimination System (UPDES) permits for the Judge and Spiro Tunnels, two chronic Whole Effluent Toxicity (WET) tests were to be performed during the permit term on effluent from a pilot scale treatment plant of representative effluent from the blended Judge and Spiro feed waters. The blended feeds were to be representative of actual ratios of feed waters from the two tunnels that could likely result in the future treatment plant. One WET test was to be performed during the spring high flow period and the other during the fall low flow period, approximately six months after the initial test. The chronic test was to be run on both *Ceriodaphnia dubia* (water flea) and *Pimephales promelas* (fathead minnow).

Both WET tests were completed, as specified in the permits, at the PCMC MIW pilot plant and are summarized herein. The high flow WET test was conducted in June 2016 and the low flow WET test was conducted in October 2016. In both WET tests, the pilot plant effluent passed the survival and reproduction criteria for both *Ceriodaphnia dubia* (water flea) and *Pimephales promelas* (fathead minnow). Results from each WET test can be found in Attachments B through D.

The WET samples were taken of a representative blend of tunnel water treated with the following treatment train:

- Oxidation with sodium hypochlorite
- Chemical conditioning with sodium hydroxide to achieve approximately 8.2 pH in the settled water
- Ferric chloride and polymer addition for coagulation
- Filtration through 42 inches of manganese dioxide media
- Adsorption through a titanium dioxide media at pH 7.0 and pH 6.5

The titanium dioxide adsorption column was fed by a combined filter effluent basin, which collected water from two manganese dioxide filters. The loading rates of the two filtration columns were 5 gpm/sf and 6 gpm/sf for the first WET test, and 6 gpm/sf and 10 gpm/sf for the second WET test. The titanium dioxide adsorption had an empty bed contact time of six minutes for the first WET test and five minutes for the second WET test.

Composite samples of effluent were taken on days 1, 3, and 5 of each test. The complete WET testing protocol can be found Attachment A.

Due to a laboratory control error on the first WET test, the *Ceriodaphnia dubia* test was repeated after the initial test. No laboratory errors were encountered through the second WET test. Operating conditions for the first and second WET tests are presented below.

High flow WET test:

The high flow WET test was completed from June 12 – 16, 2016. Results can be found in Attachment B. Pilot plant operating conditions during the WET test were:

Table D-1: High Flow WET Test Conditions

Parameter	Value
Source Water Blend	2:1 Spiro to Judge Blend
Pilot Plant Influent Turbidity Range	3.8 – 8.0 NTU
Sodium Hypochlorite Dose	0.4 mg/L
Sodium Hydroxide Dose Range	17.1 – 17.9 mg/L
Ferric Chloride Dose	8 mg/L
Polymer Dose	1 mg/L
Settled Water pH Range	8.11 – 8.38
Manganese Dioxide Filter Loading Rates	5 and 6 gpm/sf
Titanium Dioxide Adsorption Column EBCT	6 minutes
Titanium Dioxide Adsorption Column pH Range	6.79 – 7.03

The high flow WET test resulted in a finding of “pass” for the survival and reproduction of fathead minnows and a pass for the survival of *Ceriodaphnia dubia*.

A laboratory control error for reproduction of *Ceriodaphnia dubia* invalidated the *Ceriodaphnia dubia* part of the test. A follow-up *Ceriodaphnia dubia* WET test was repeated soon after.

High flow WET test repeat for *Ceriodaphnia dubia*:

The repeat of the high flow WET test was completed from June 26 – 30, 2016. Results for this test can be found in Attachment C.

No changes to the treatment train nor the operational set point were made between the first WET test and the repeated test. This WET test was only conducted on *Ceriodaphnia dubia*. Pilot plant operating conditions for the second WET test are outlined below:

Table D-2: Conditions During High Flow WET Test Repeat for *Ceriodaphnia dubia*

Parameter	Value
Source Water Blend	2:1 Spiro to Judge Blend
Pilot Plant Influent Turbidity Range	1.80 – 3.77NTU
Sodium Hypochlorite Dose	0.4 mg/L
Sodium Hydroxide Dose	18.2 mg/L
Ferric Chloride Dose	8 mg/L
Polymer Dose	1 mg/L
Settled Water pH Range	8.23 – 8.25
Manganese Dioxide Filter Loading Rates	5 and 6 gpm/sf
Titanium Dioxide Adsorption Column EBCT	6 minutes
Titanium Dioxide Adsorption Column pH Range	6.92 – 7.02

The repeated high flow WET test resulted in a pass for survival and reproduction of *Ceriodaphnia dubia.*

Low flow WET test:

The low flow WET test was completed from October 9 - 13, 2016. Results can be found in Attachment D. Pilot plant operating conditions during the WET test were:

Table D-3: Conditions During Low Flow WET Test

Parameter	**Value**
Source Water Blend	4:1 Spiro to Judge Blend
Pilot Plant Influent Turbidity Range	2.5 – 16.4 NTU
Sodium Hypochlorite Dose	0.7 mg/L
Sodium Hydroxide Dose Range	13.0 – 21.8 mg/L
Ferric Chloride Dose Range	10 - 12 mg/L
Polymer Dose Range	1.0 – 1.5 mg/L
Settled Water pH Range	7.94 – 8.42
Manganese Dioxide Filter Loading Rates	6 and 10 gpm/sf
Titanium Dioxide Adsorption Column EBCT	5 minutes
Titanium Dioxide Adsorption Column pH Range	6.32 – 6.62

The low flow WET test resulted in a pass for the survival and reproduction of fathead minnows and *Ceriodaphnia dubia*.

Attachment A – WET Testing Protocol

WET Testing Protocol PCMC Pilot Study

PREPARED FOR:	MIW Operations Team
DATE:	June 6, 2016

Below is the protocol to be used at the Mining Influence Water Pilot test. This protocol adherers to UPDES chronic WET testing requirements.

Testing Requirements:
WET testing requirements are established in Table 2 of the UPDES permit

a. Conduct two tests during the permit term. Tests must be performed on effluent from the pilot plant treating blended feeds representative of the tunnel flows. One test will be conducted during high flow (spring) and the other approximately 6 months later (low flow condition).
b. Chronic tests must be run on two species, Ceriodaphnia dubia and fathead minnows. The chronic test duration is 7 days.
c. Test is pass/fail, based on IC25 > 100% effluent. The IC25 is the dilution that results in a 25% reduction compared to the control. The specifics on calculating the IC25 for each species are in the EPA WET test procedure. In chronic tests, Ceriodaphnia are monitored for survival and reproduction, and fathead minnows for survival and growth. A copy of the UPDES permit should be provide to the toxicity testing lab so they see the exact permit language.

Testing Dates:
1st WET testing date: June 12th, 2016
2nd WET testing date (approximate): November 13th, 2016

Representative Flow:
The WET testing will be performed on blended feeds representative of the tunnel flows. The blended feed will included 2 parts Spiro water and 1 part Judge water.

Testing Laboratory:
Water Environmental Testing
235 W 400 S
American Fork, UT 84003

Sampling Conditions and Volume:
The WET testing shall be taken from a continuously running treatment piloting. Samples will be taken at the effluent of the treatment process to simulate stream discharge.

Nine gallons of pilot treated water will be required for this test, delivered in three samples of 5-gallon composite sample volume. Composite samples will be taken on Sunday, Tuesday, and Thursday and kept on ice until they are delivered to the laboratory the following morning.

For each of the 5-gallon composite samples, four equal value samples will be collected over a 6 hour sampling period. Once the sampling has begun, a 0.75 gallon sample will be taken at time stamp 0 hour, 2 hour, 4 hour, and 6 hour.

Samples will be collected in new, clean plastic containers. Before collecting the sample for the lab, the container will be rinsed with effluent. The container will be filled completely with no headspace. Once collected, samples must be cooled to 0 to 6 C until used for the testing.

The sample will be taken from the effluent tap of the titanium dioxide adsorption column. The flow rate for the column is 0.082 gallons per minute. Each sampling event (0hr, 2hr, 4hr, and 6hr) will require slightly more than 15 minutes of continuous flow to collect 1.25 gallons.

After the required volume for the WET test is collected, a paired sample for metal testing will be taken. A 25% aliquot of a one-liter sample will sampled after the WET Sample has been taken at sampling event. This sample will be sent to Chemtech-Ford for metals analysis.

At the time of the sample, field pH, temperature, and Total Chlorine Residual will be recorded.

WET Testing Conditions:

The permit limit is an IC25 >100% effluent. A dilution series of 100%, 75%, 50%, 25%, and 12.5% effluent, will be performed. Dilution water is to be moderately hard dilution water (80-100 mg/L as $CaCO_3$).

Control Sample:

The hardness of the blended effluent is approximately 400 mg/L as $CaCO_3$. The moderately hard dilution water (80-100 mg/L as $CaCO_3$) commonly used to grow test organisms will be used as the control sample. A second control sample of hardness 400 mg/L as $CaCO_3$ will be tested in addition to the moderately hard dilution water.

Pilot Plant Conditions:

The pilot plant will be operated at the same conditions during the 5-day sampling period. Pilot plant operating conditions will be confirmed 1-2 days before WET samples are collected. Pilot conditions are expected to be as follows:

- Raw water: 2:1 Spiro to Judge Blend
- Settled water turbidity: Less than 2 NTU, ferric and polymer dose will vary with incoming raw water quality as needed to meet settled water turbidity goal.
- Filter water turbidity: Less than 0.1 NTU
- Filter water chlorine residual: 0.3-0.5 mg/L as Total Residual Chlorine measured at filter effluent
- Filtration Media: Pyrolusite
- Filtration Loading Rate: 5-6 gpm/sf
- Adsorption Media: Titanium dioxide
- Adsorption Empty Bed Contact Time: 6 minutes

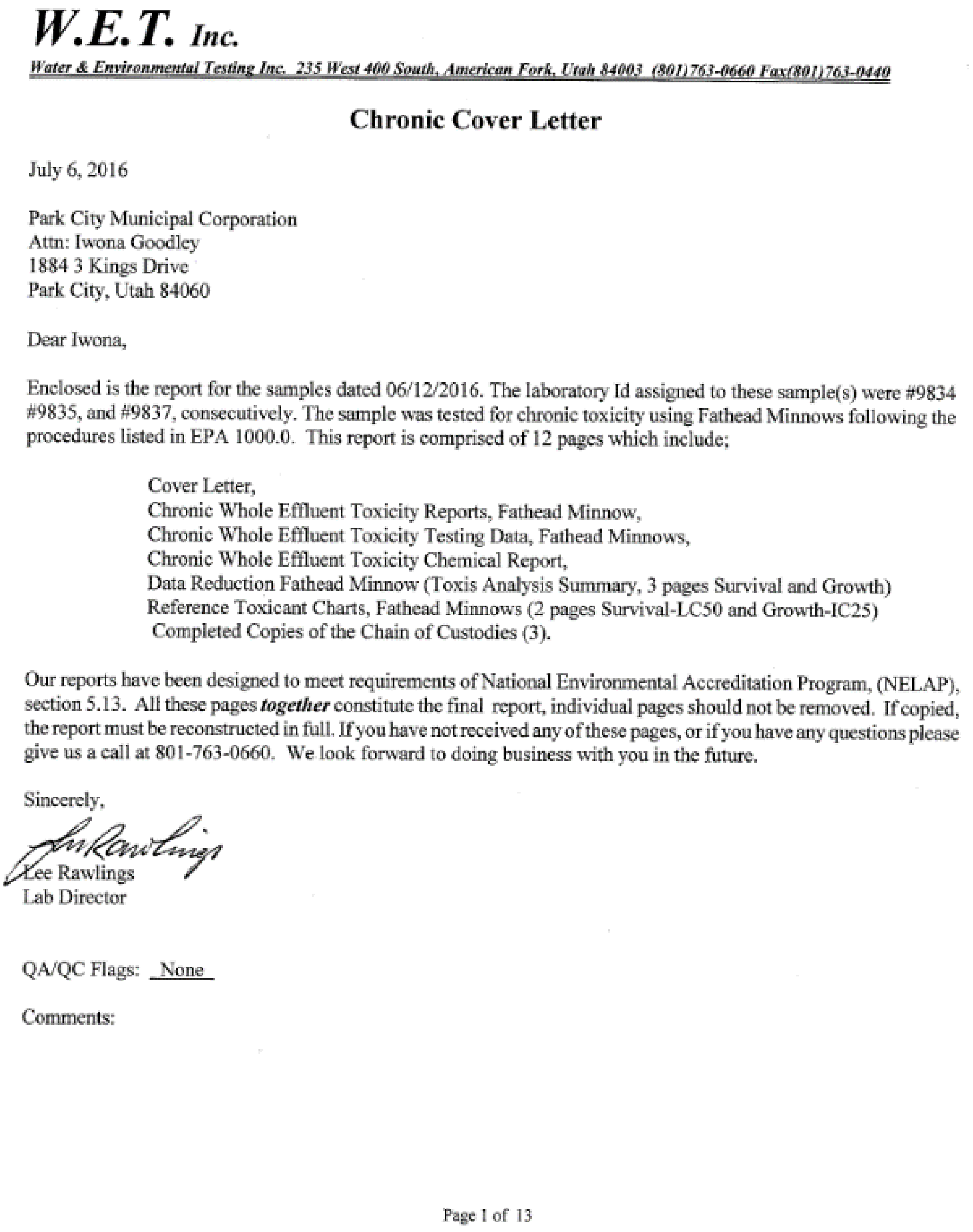
Additional Sample Analysis:

On each day when WET samples are collected, a paired composite sample will be analyzed for:

- Arsenic
- Antimony
- Cadmium
- Lead
- Selenium
- Thallium
- Zinc
- Hardness
- Alkalinity
- Total Dissolved Solids
- Total Residual Chlorine
- Specific Conductivity
- pH
- Ammonia

Sample bottles with the appropriate preservatives will be provided by Chemtech Ford.

Attachment B – High Flow WET Test Results



W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Cover Letter

July 6, 2016

Park City Municipal Corporation
Attn: Iwona Goodley
1884 3 Kings Drive
Park City, Utah 84060

Dear Iwona,

Enclosed is the report for the samples dated 06/12/2016. The laboratory Id assigned to these sample(s) were #9834 #9835, and #9837, consecutively. The sample was tested for chronic toxicity using Fathead Minnows following the procedures listed in EPA 1000.0. This report is comprised of 12 pages which include;

Cover Letter,
Chronic Whole Effluent Toxicity Reports, Fathead Minnow,
Chronic Whole Effluent Toxicity Testing Data, Fathead Minnows,
Chronic Whole Effluent Toxicity Chemical Report,
Data Reduction Fathead Minnow (Toxis Analysis Summary, 3 pages Survival and Growth)
Reference Toxicant Charts, Fathead Minnows (2 pages Survival-LC50 and Growth-IC25)
Completed Copies of the Chain of Custodies (3).

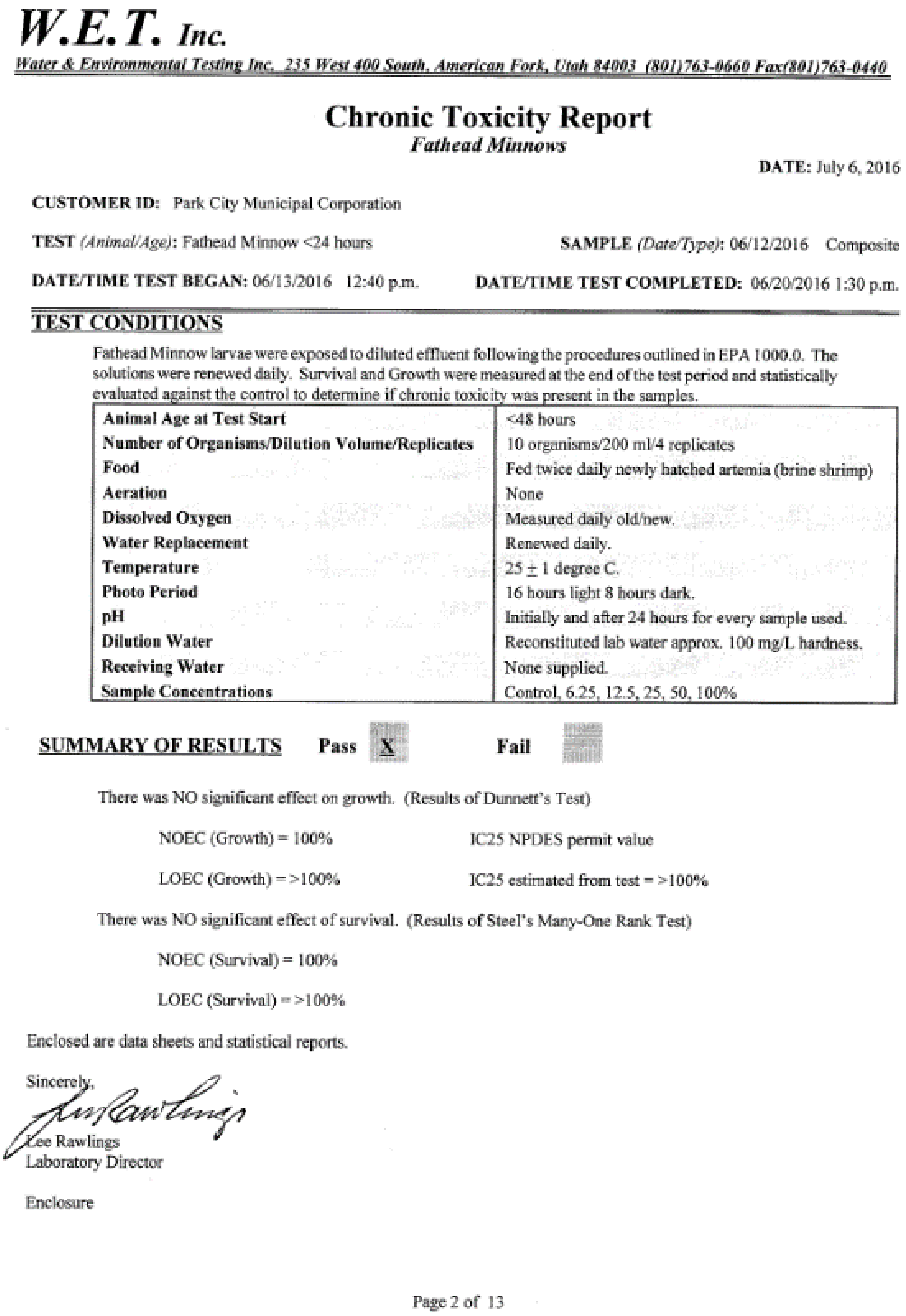
Our reports have been designed to meet requirements of National Environmental Accreditation Program, (NELAP), section 5.13. All these pages ***together*** constitute the final report, individual pages should not be removed. If copied, the report must be reconstructed in full. If you have not received any of these pages, or if you have any questions please give us a call at 801-763-0660. We look forward to doing business with you in the future.

Sincerely,

Lee Rawlings
Lab Director

QA/QC Flags: _None_

Comments:



W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Toxicity Report

Fathead Minnows

DATE: July 6, 2016

CUSTOMER ID: Park City Municipal Corporation

TEST *(Animal/Age)***:** Fathead Minnow <24 hours

SAMPLE *(Date/Type)***:** 06/12/2016 Composite

DATE/TIME TEST BEGAN: 06/13/2016 12:40 p.m.

DATE/TIME TEST COMPLETED: 06/20/2016 1:30 p.m.

TEST CONDITIONS

Fathead Minnow larvae were exposed to diluted effluent following the procedures outlined in EPA 1000.0. The solutions were renewed daily. Survival and Growth were measured at the end of the test period and statistically evaluated against the control to determine if chronic toxicity was present in the samples.

Animal Age at Test Start	<48 hours
Number of Organisms/Dilution Volume/Replicates	10 organisms/200 ml/4 replicates
Food	Fed twice daily newly hatched artemia (brine shrimp)
Aeration	None
Dissolved Oxygen	Measured daily old/new.
Water Replacement	Renewed daily.
Temperature	25 ± 1 degree C.
Photo Period	16 hours light 8 hours dark.
pH	Initially and after 24 hours for every sample used.
Dilution Water	Reconstituted lab water approx. 100 mg/L hardness.
Receiving Water	None supplied.
Sample Concentrations	Control, 6.25, 12.5, 25, 50, 100%

SUMMARY OF RESULTS

Pass X **Fail**

There was NO significant effect on growth. (Results of Dunnett's Test)

NOEC (Growth) = 100%

IC25 NPDES permit value

LOEC (Growth) = >100%

IC25 estimated from test = >100%

There was NO significant effect of survival. (Results of Steel's Many-One Rank Test)

NOEC (Survival) = 100%

LOEC (Survival) = >100%

Enclosed are data sheets and statistical reports.

Sincerely,

Lee Rawlings
Laboratory Director

Enclosure

Page 2 of 13

W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Toxicity Testing

Fathead Minnow

Customer ID: ID: Park City Municipal Corporation

Final Mean Weight mg/fish: Control 0.44 6.25% 0.51 12.5% 0.51 25% 0.54 50% 0.51 100% 0.50

Percent Lethality: Control 0% 6.25% 0% 12.5% 0% 25% 2.5% 50% 0% 100% 2.5%

IC25 value required by NPDES permit: ____

IC25 estimated from the test: >100%

Sample Type/Date: 06/12/2016 4:00 p.m.
06/14/2016 3:30 p.m.
06/16/2016 6:00 p.m.

Analyses Dates/Times Beginning 06/13/2016 12:40 p.m.
Ending 06/20/2016 1:30 p.m.

Initial Organism Age: <24 hours

Dilution Water/Control = EPA formula for moderately hard synthetic fresh water approximately 100 mg/L hardness.

FATHEAD MINNOWS
Replicates

	Number of Organisms/Percent Survival				Mean Weight after 7 days (mg/fish)				
Sample	A	B	C	D	A	B	C	D	Mean Weight
Control	10/100%	10/100%	10/100%	10/100%	0.46	0.42	0.42	0.45	0.44
6.25	10/100%	10/100%	10/100%	10/100%	0.56	0.52	0.44	0.52	0.51
12.5	10/100%	10/100%	10/100%	10/100%	0.55	0.44	0.54	0.53	0.51
25.0	9/90%	10/100%	10/100%	10/100%	0.49	0.57	0.55	0.53	0.54
50.0	10/100%	10/100%	10/100%	10/100%	0.53	0.53	0.46	0.54	0.51
100	9/90%	10/100%	10/100%	10/100%	0.39	0.52	0.50	0.59	0.50

Concentration (%)

Max/Min	Control	6.25	12.5	25.0	50.0	100
Dissolved Oxygen	7.4/5.1	7.5/4.5	7.6/4.8	7.5/5.0	7.9/4.6	8.4/4.6
Temperature (°C)	25.2/24.6	25.2/24.6	25.2/24.6	25.2/24.6	25.2/24.6	25.2/24.6
Ph	8.26/7.42	8.00/7.27	7.99/7.29	7.72/7.45	7.81/7.24	8.03/7.12

Dilution Water (Average) Hardness: 108 mg/L **Alkalinity:** 80 mg/L **Conductivity:** 404 umhos/cm

Laboratory Director: Lee Rawlings **Laboratory:** Water & Environmental Testing, Inc.

Signature: Lee Rawlings

Date: 7/6/16

Comments: ____

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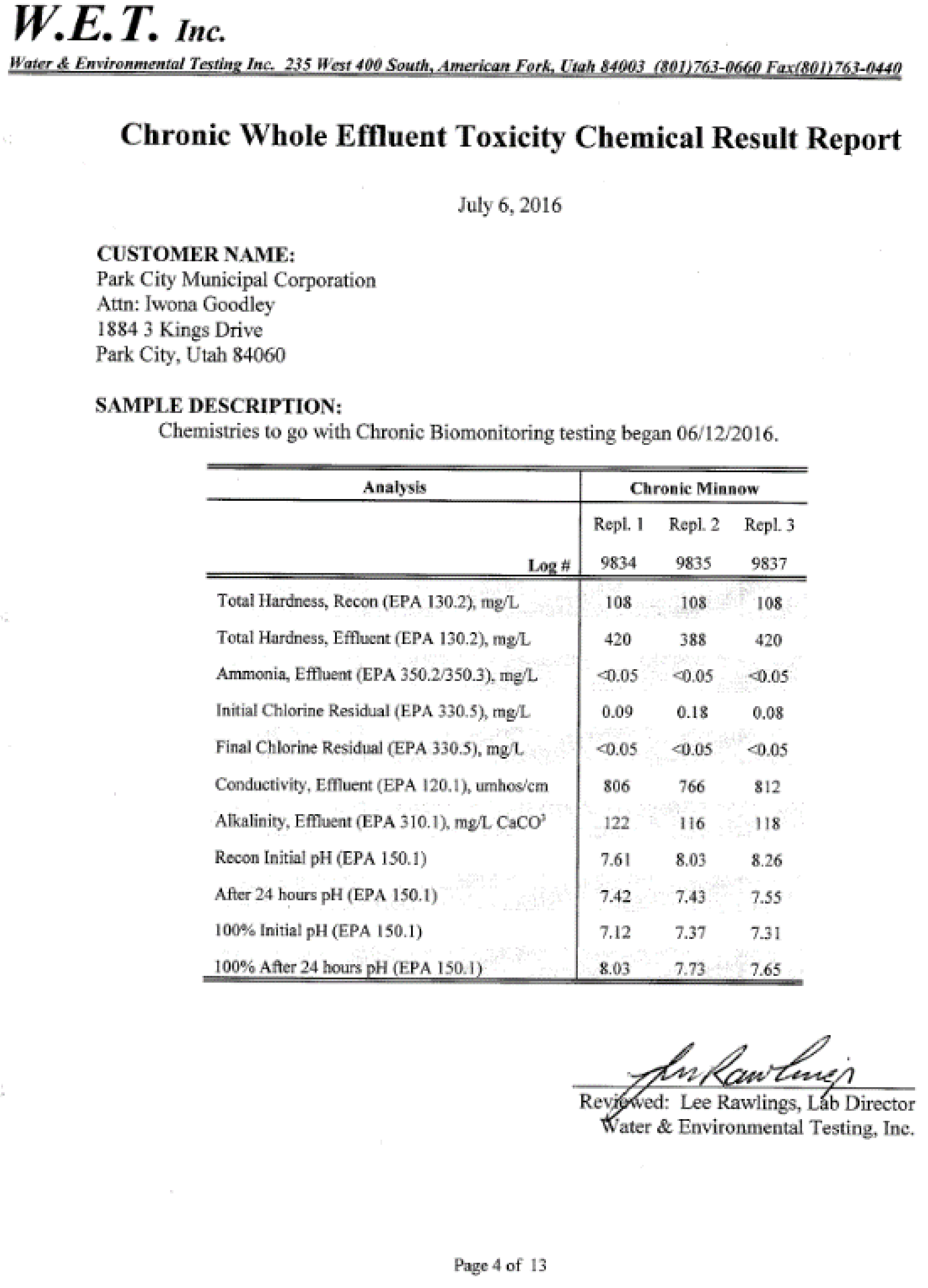

W.E.T. Inc.
Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Whole Effluent Toxicity Chemical Result Report

July 6, 2016

CUSTOMER NAME:
Park City Municipal Corporation
Attn: Iwona Goodley
1884 3 Kings Drive
Park City, Utah 84060

SAMPLE DESCRIPTION:

Chemistries to go with Chronic Biomonitoring testing began 06/12/2016.

Analysis	Chronic Minnow		
	Repl. 1	Repl. 2	Repl. 3
Log #	9834	9835	9837
Total Hardness, Recon (EPA 130.2), mg/L	108	108	108
Total Hardness, Effluent (EPA 130.2), mg/L	420	388	420
Ammonia, Effluent (EPA 350.2/350.3), mg/L	<0.05	<0.05	<0.05
Initial Chlorine Residual (EPA 330.5), mg/L	0.09	0.18	0.08
Final Chlorine Residual (EPA 330.5), mg/L	<0.05	<0.05	<0.05
Conductivity, Effluent (EPA 120.1), umhos/cm	806	766	812
Alkalinity, Effluent (EPA 310.1), mg/L $CaCO^3$	122	116	118
Recon Initial pH (EPA 150.1)	7.61	8.03	8.26
After 24 hours pH (EPA 150.1)	7.42	7.43	7.55
100% Initial pH (EPA 150.1)	7.12	7.37	7.31
100% After 24 hours pH (EPA 150.1)	8.03	7.73	7.65

Lee Rawlings
Reviewed: Lee Rawlings, Lab Director
Water & Environmental Testing, Inc.

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Larval Fish Growth and Survival Test-7 Day Survival

Start Date:	6/13/2016 12:40	Test ID:	PC6-16cf	Sample ID:	Park City 6-16 chronic fathead
End Date:	6/20/2016 13:30	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	PP-Pimephales promelas
Comments:					

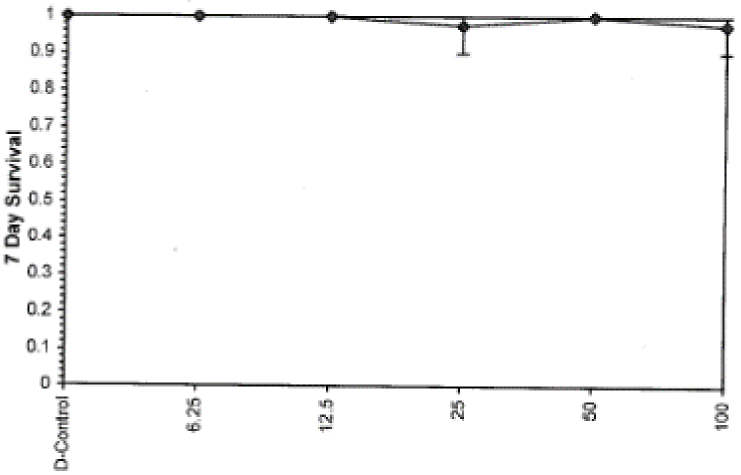
Conc-%	1	2	3	4
D-Control	1.0000	1.0000	1.0000	1.0000
6.25	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000
25	0.9000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	0.9000	1.0000	1.0000	1.0000

			Transform: Arcsin Square Root					Rank	1-Tailed
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical
D-Control	1.0000	1.0000	1.4120	1.4120	1.4120	0.000	4		
6.25	1.0000	1.0000	1.4120	1.4120	1.4120	0.000	4	18.00	10.00
12.5	1.0000	1.0000	1.4120	1.4120	1.4120	0.000	4	18.00	10.00
25	0.9750	0.9750	1.3713	1.2490	1.4120	5.942	4	16.00	10.00
50	1.0000	1.0000	1.4120	1.4120	1.4120	0.000	4	18.00	10.00
100	0.9750	0.9750	1.3713	1.2490	1.4120	5.942	4	16.00	10.00

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.61382	0.916	-2.1359	5.27706
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs D-Control				

Dose-Response Plot



Reviewed by:

Larval Fish Growth and Survival Test-7 Day Growth

Start Date:	6/13/2016 12:40	Test ID:	PC6-16cf	Sample ID:	Park City 6-16 chronic fathead
End Date:	6/20/2016 13:30	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	PP-Pimephales promelas
Comments:					

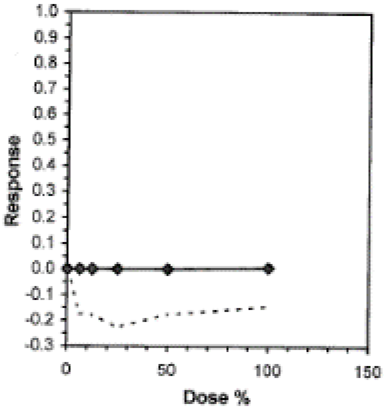
Conc-%	1	2	3	4
D-Control	0.4600	0.4170	0.4150	0.4540
6.25	0.5640	0.5190	0.4420	0.5240
12.5	0.5520	0.4430	0.5350	0.5270
25	0.4850	0.5700	0.5630	0.5250
50	0.5250	0.5300	0.4620	0.5360
100	0.3850	0.5220	0.4950	0.5940

			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	0.4365	1.0000	0.4365	0.4150	0.4600	5.455	4				0.5024	1.0000
6.25	0.5122	1.1735	0.5122	0.4420	0.5640	9.952	4	-2.089	2.410	0.0874	0.5024	1.0000
12.5	0.5143	1.1781	0.5143	0.4430	0.5520	9.457	4	-2.144	2.410	0.0874	0.5024	1.0000
25	0.5358	1.2274	0.5358	0.4850	0.5700	7.314	4	-2.737	2.410	0.0874	0.5024	1.0000
50	0.5132	1.1758	0.5132	0.4620	0.5360	6.714	4	-2.117	2.410	0.0874	0.5024	1.0000
100	0.4990	1.1432	0.4990	0.3850	0.5940	17.381	4	-1.724	2.410	0.0874	0.4990	0.9932

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.93271		0.916		-0.6617	0.92269
Bartlett's Test indicates equal variances (p = 0.40)					5.13428		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test Treatments vs D-Control	100	>100		1	0.08738	0.20019	0.00466	0.00263	0.16981	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



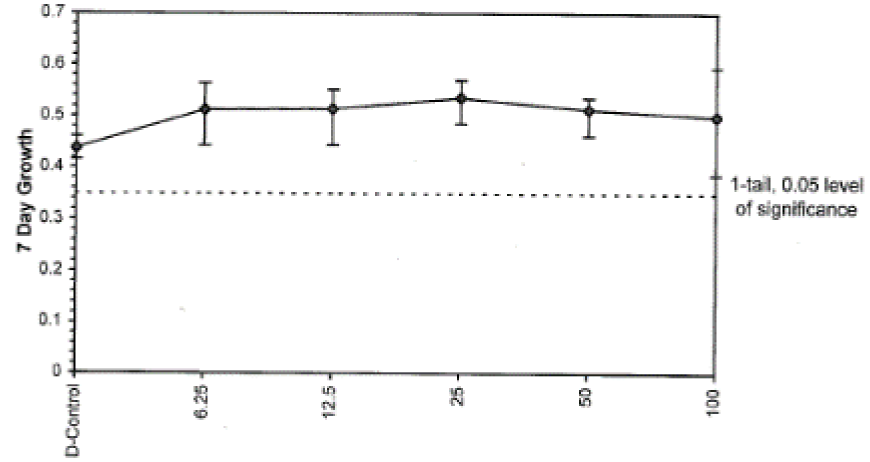
ToxCalc v5.0.32

Reviewed by:

Larval Fish Growth and Survival Test-7 Day Growth

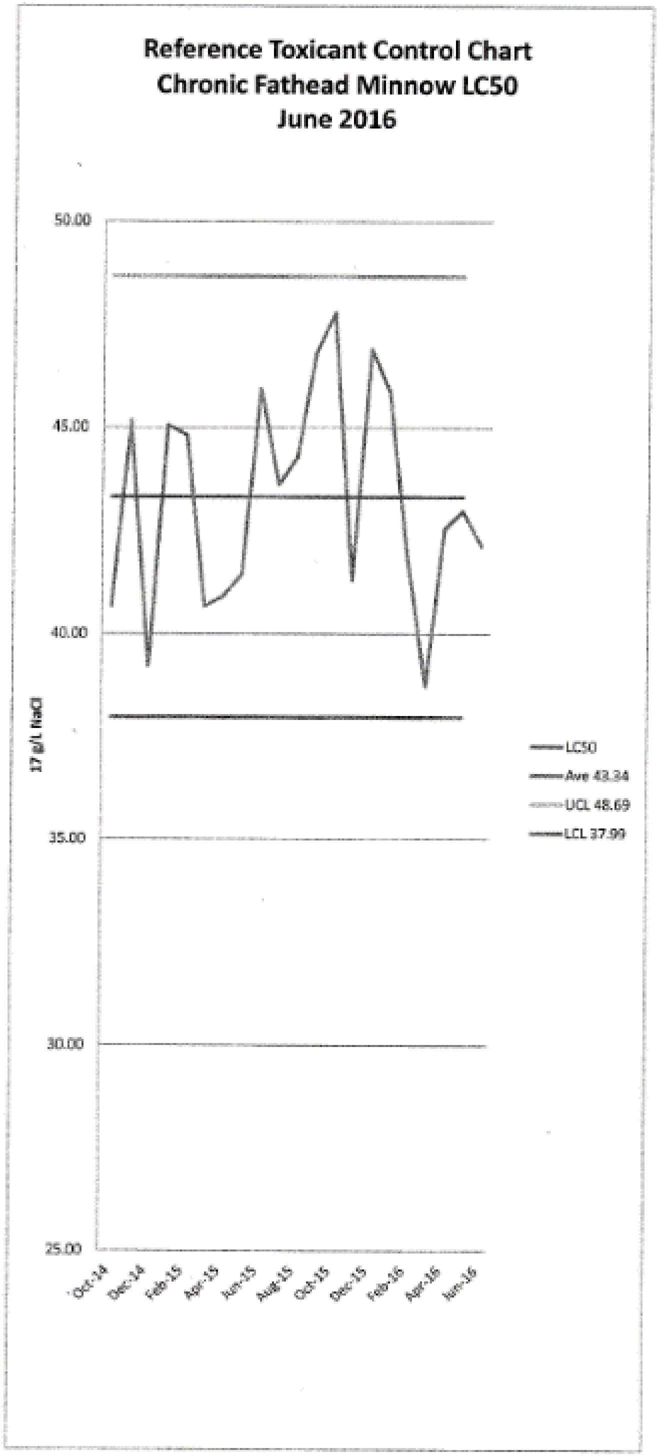
Start Date:	6/13/2016 12:40	Test ID:	PC6-16cf	Sample ID:	Park City 6-16 chronic fathead
End Date:	6/20/2016 13:30	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	PP-Pimephales promelas
Comments:					

Dose-Response Plot



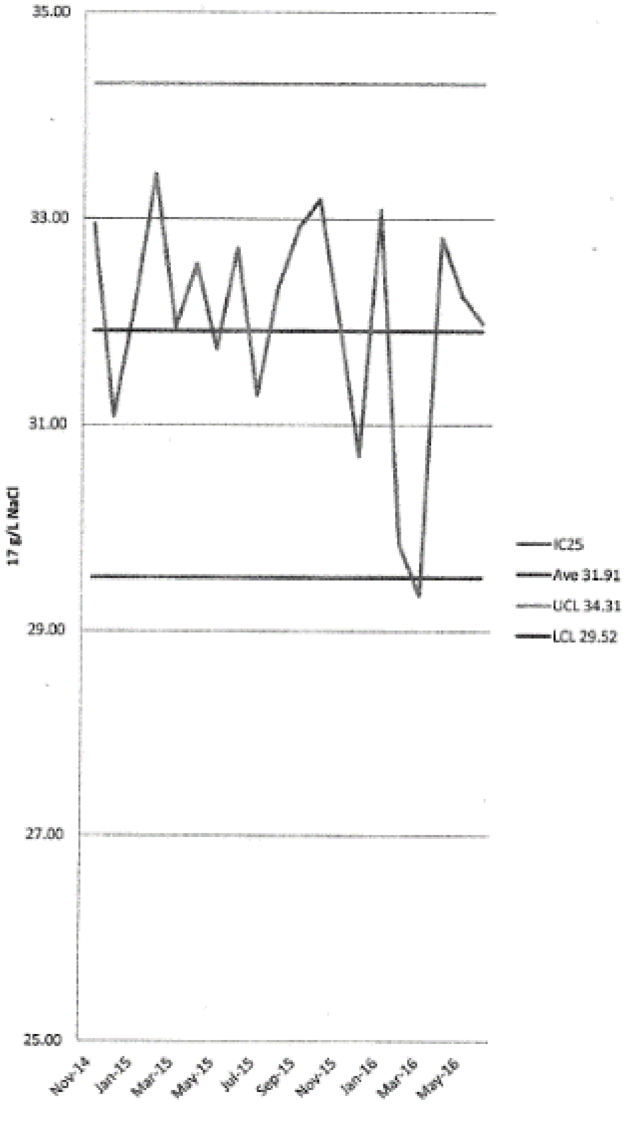
ToxCalc v5.0.32

Reviewed by: GR



Reference Toxicant Control Chart
Chronic Fathead Minnow LC50
June 2016

Reference Toxicant Control Chart
Chronic Fathead Minnow IC25
June 2016



W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Cover Letter

August 18, 2016

Park City Municipal Corporation
Attn: Iwona Goodley
1884 3 Kings Drive
Park City, Utah 84060

Dear Iwona,

Enclosed is the report for the sample dated 06/12/2016. The laboratory Id assigned to these sample(s) are #9834, #9835, and #9837, consecutively. The sample was tested for chronic toxicity using Ceriodaphnia dubia following the procedures listed in EPA 1002.0. This report is comprised of 11 pages which include;

Cover Letter,
Chronic Whole Effluent Toxicity Reports Data Ceriodaphnia dubia,
Chronic Whole Effluent Toxicity Testing Data Ceriodaphnia dubia,
Chronic Whole Effluent Toxicity Chemical Report,
Data Reduction Ceriodaphnia dubia (Toxis Analysis Summary, 2 pages survival and growth)
Reference Toxicant Charts, Ceriodaphnia dubia (2 pages Survival-LC50 and Growth-IC25)
Completed Copies of the Chain of Custodies (3).

The work represented here along with the report format have been designed to meet requirements of National Environmental Accreditation Program, (NELAP), section 5.13. All these pages ***together*** constitute the final report, individual pages should not be removed. If copied, the report must be reconstructed in full. If you have not received any of these pages, or if you have any questions please give us a call at 801-763-0660. We look forward to doing business with you in the future.

Sincerely,

Lee Rawlings
Lab Director

QA/QC Flags: Yes Quality Control Failure. Control did not meeting the minimum reproduction requirement of 15 young/adult. The test will need to be repeated.

Comments:

W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Whole Effluent Toxicity Report

Ceriodaphnia

DATE: August 18, 2016

PERMITTEE NAME: Park City Municipal Corporation

TEST (Animal/Age): Ceriodaphnia dubia <8 hours

SAMPLE (Date/Type): 06/12/2016 Composite

DATE/TIME TEST BEGAN: 06/13/2016 6:15 p.m.

DATE/TIME TEST COMPLETED: 06/21/2016 3:07 p.m.

TEST CONDITIONS

Ceriodaphnia dubia neonates were exposed to diluted effluent as specified by EPA 1002.0. At the end of the test period Survival and Reproduction were measured and compared statistically against a control to determine if Chronic Toxicity was present in the samples.

Animal Age at Test Start	<8 hours.
Number of Organisms/Dilution Volume/Replicates	1 organism/15 ml/10 replicates.
Food	Fed daily 0.1 ml YTC and Algae.
Aeration	None required.
Dissolved Oxygen	Measured daily old/new.
Water Replacement	Renewed daily.
Temperature	25 ± 1 degree C.
Photo Period	16 hours light 8 hours dark.
pH	Measured initially and at 24 hours for each sample.
Dilution Water	Reconstituted lab water approx 100 mg/L hardness.
Receiving Water	None Received
Sample Concentrations	Control, 6.25, 12.5, 25, 50, 100%

SUMMARY

Results: Pass Fail

There was NO significant effect on reproduction. (Results of Dunnett's T Test)

NOEC (Reproduction) = QC failure

IC25 required by NPDES permit =

LOEC (Reproduction) = QC failure

IC25 estimated from test data = QC Failure

There was NO significant effect on survival. (Fisher's Exact Test)

NOEC (Survival) = 100

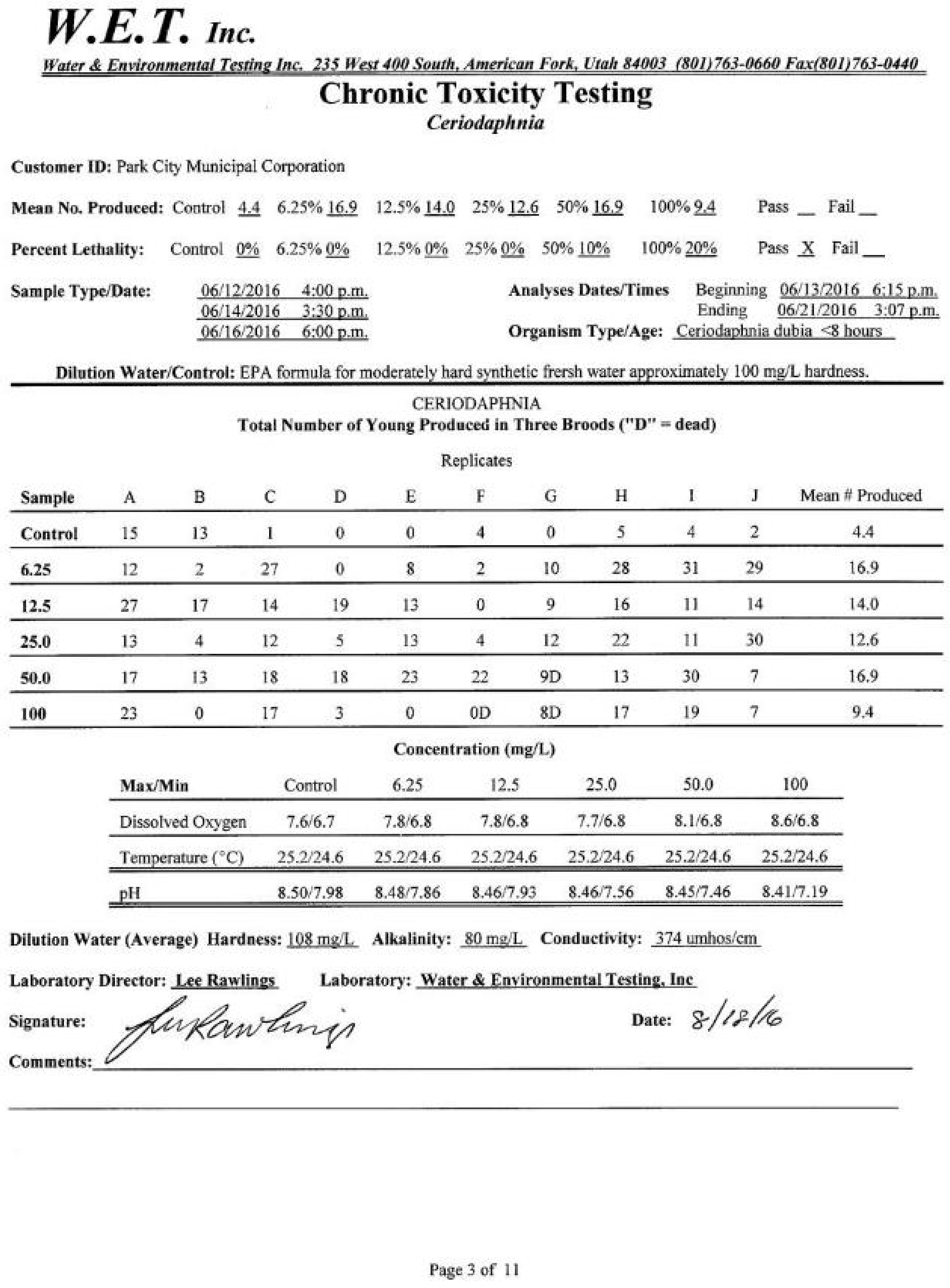
LOEC (Survival) = >100

Enclosed are data sheets and statistical reports.

Sincerely,

Lee Rawlings

Lee Rawlings
Lab Director
Enclosure



W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Toxicity Testing

Ceriodaphnia

Customer ID: Park City Municipal Corporation

Mean No. Produced: Control 4.4 6.25% 16.9 12.5% 14.0 25% 12.6 50% 16.9 100% 9.4 Pass __ Fail __

Percent Lethality: Control 0% 6.25% 0% 12.5% 0% 25% 0% 50% 10% 100% 20% Pass X Fail __

Sample Type/Date:
06/12/2016 4:00 p.m.
06/14/2016 3:30 p.m.
06/16/2016 6:00 p.m.

Analyses Dates/Times Beginning 06/13/2016 6:15 p.m.
Ending 06/21/2016 3:07 p.m.

Organism Type/Age: Ceriodaphnia dubia <8 hours

Dilution Water/Control: EPA formula for moderately hard synthetic frersh water approximately 100 mg/L hardness.

CERIODAPHNIA

Total Number of Young Produced in Three Broods ("D" = dead)

Replicates

Sample	A	B	C	D	E	F	G	H	I	J	Mean # Produced
Control	15	13	1	0	0	4	0	5	4	2	4.4
6.25	12	2	27	0	8	2	10	28	31	29	16.9
12.5	27	17	14	19	13	0	9	16	11	14	14.0
25.0	13	4	12	5	13	4	12	22	11	30	12.6
50.0	17	13	18	18	23	22	9D	13	30	7	16.9
100	23	0	17	3	0	0D	8D	17	19	7	9.4

Concentration (mg/L)

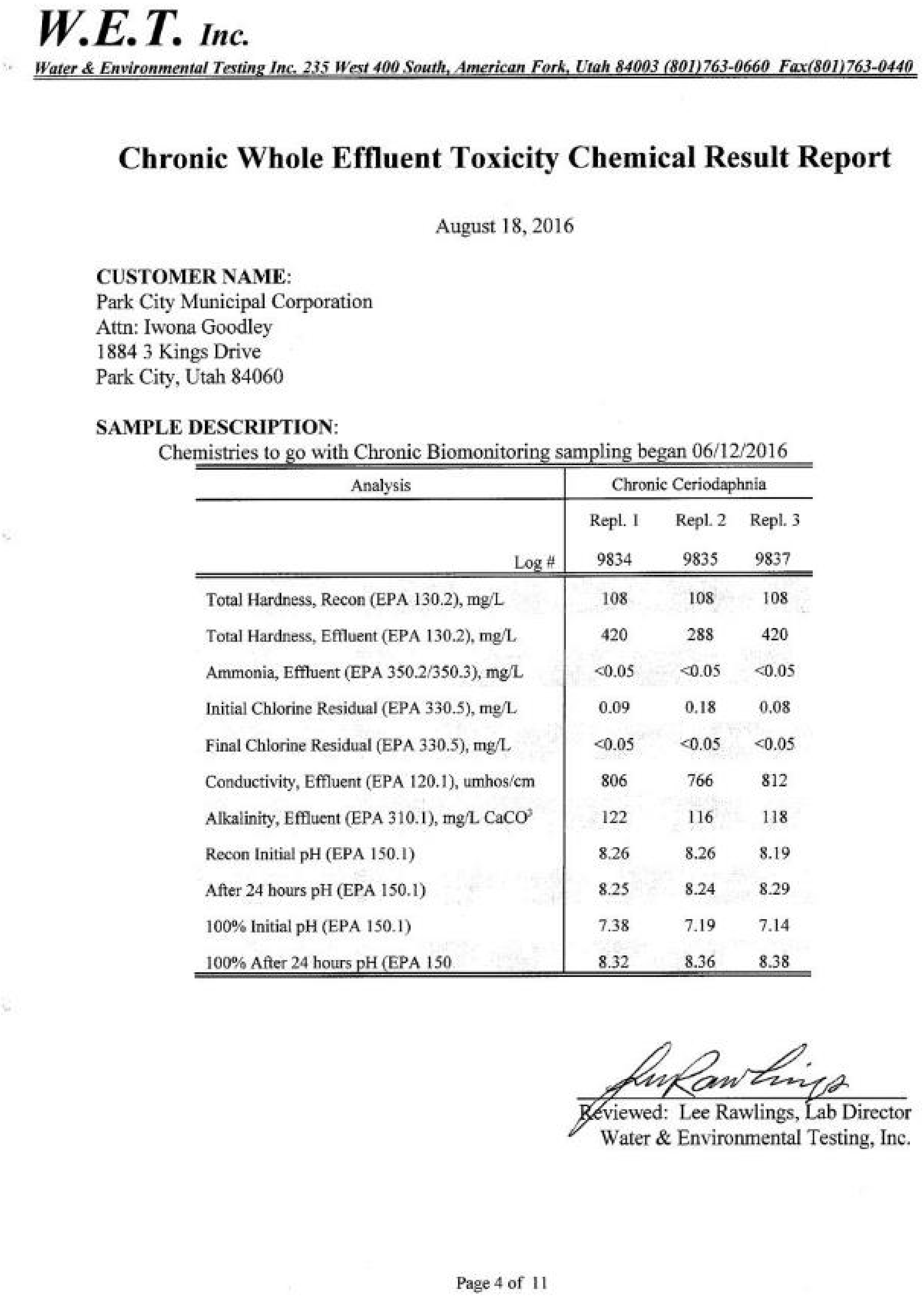
Max/Min	Control	6.25	12.5	25.0	50.0	100
Dissolved Oxygen	7.6/6.7	7.8/6.8	7.8/6.8	7.7/6.8	8.1/6.8	8.6/6.8
Temperature (°C)	25.2/24.6	25.2/24.6	25.2/24.6	25.2/24.6	25.2/24.6	25.2/24.6
pH	8.50/7.98	8.48/7.86	8.46/7.93	8.46/7.56	8.45/7.46	8.41/7.19

Dilution Water (Average) Hardness: 108 mg/L **Alkalinity:** 80 mg/L **Conductivity:** 374 umhos/cm

Laboratory Director: Lee Rawlings **Laboratory:** Water & Environmental Testing, Inc

Signature: Lee Rawlings **Date:** 8/18/16

Comments:



W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Whole Effluent Toxicity Chemical Result Report

August 18, 2016

CUSTOMER NAME:

Park City Municipal Corporation
Attn: Iwona Goodley
1884 3 Kings Drive
Park City, Utah 84060

SAMPLE DESCRIPTION:

Chemistries to go with Chronic Biomonitoring sampling began 06/12/2016

Analysis	Chronic Ceriodaphnia		
	Repl. 1	Repl. 2	Repl. 3
Log #	9834	9835	9837
Total Hardness, Recon (EPA 130.2), mg/L	108	108	108
Total Hardness, Effluent (EPA 130.2), mg/L	420	288	420
Ammonia, Effluent (EPA 350.2/350.3), mg/L	<0.05	<0.05	<0.05
Initial Chlorine Residual (EPA 330.5), mg/L	0.09	0.18	0.08
Final Chlorine Residual (EPA 330.5), mg/L	<0.05	<0.05	<0.05
Conductivity, Effluent (EPA 120.1), umhos/cm	806	766	812
Alkalinity, Effluent (EPA 310.1), mg/L $CaCO^3$	122	116	118
Recon Initial pH (EPA 150.1)	8.26	8.26	8.19
After 24 hours pH (EPA 150.1)	8.25	8.24	8.29
100% Initial pH (EPA 150.1)	7.38	7.19	7.14
100% After 24 hours pH (EPA 150	8.32	8.36	8.38

Reviewed: Lee Rawlings, Lab Director
Water & Environmental Testing, Inc.

Page 4 of 11

Ceriodaphnia Survival and Reproduction Test-7 Day Survival

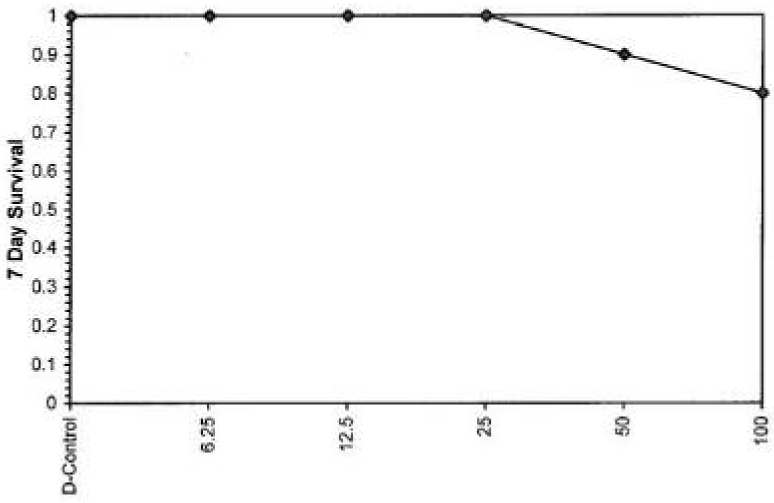
Start Date:	6/13/2016 18:15	Test ID:	PCM8-16cc	Sample ID:	Park City Mun 8-16 chronic cero
End Date:	6/21/2016 15:07	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6	7	8	9	10
D-Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6.25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000

Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical
D-Control	1.0000	1.0000	0	10	10	10		
6.25	1.0000	1.0000	0	10	10	10	1.0000	0.0500
12.5	1.0000	1.0000	0	10	10	10	1.0000	0.0500
25	1.0000	1.0000	0	10	10	10	1.0000	0.0500
50	0.9000	0.9000	1	9	10	10	0.5000	0.0500
100	0.8000	0.8000	2	8	10	10	0.2368	0.0500

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test Treatments vs D-Control	100	>100		1

Dose-Response Plot



Page 1 ToxCalc v5.0.32 Reviewed by:

Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	6/13/2016 18:15	Test ID:	PCM8-16cc	Sample ID:	Park City Mun 8-16 chronic cero
End Date:	6/21/2016 15:07	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6	7	8	9	10
D-Control	15.000	13.000	1.000	0.000	0.000	4.000	0.000	5.000	4.000	2.000
6.25	12.000	2.000	27.000	0.000	8.000	22.000	10.000	28.000	31.000	29.000
12.5	27.000	17.000	14.000	19.000	13.000	0.000	9.000	16.000	11.000	14.000
25	13.000	4.000	12.000	5.000	13.000	4.000	12.000	22.000	11.000	30.000
50	17.000	13.000	18.000	18.000	23.000	22.000	9.000	12.000	30.000	7.000
100	23.000	0.000	17.000	3.000	0.000	0.000	8.000	17.000	19.000	7.000

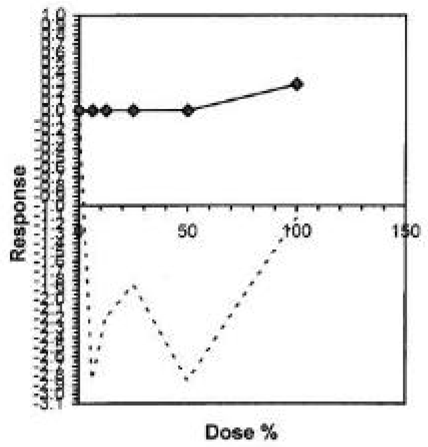
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	4.400	1.0000	4.4000	0.0000	15.0000	122.718	10				12.960	1.0000
6.25	16.900	3.8409	16.9000	0.0000	31.0000	69.871	10	-3.377	2.287	8.4638	12.960	1.0000
12.5	14.000	3.1818	14.0000	0.0000	27.0000	49.830	10	-2.594	2.287	8.4638	12.960	1.0000
25	12.600	2.8636	12.6000	4.0000	30.0000	64.823	10	-2.215	2.287	8.4638	12.960	1.0000
50	16.900	3.8409	16.9000	7.0000	30.0000	41.227	10	-3.377	2.287	8.4638	12.960	1.0000
100	9.400	2.1364	9.4000	0.0000	23.0000	94.249	10	-1.351	2.287	8.4638	9.400	0.7253

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Kolmogorov D Test indicates normal distribution (p > 0.05)	0.87418	0.895	0.19987	-0.5376
Bartlett's Test indicates equal variances (p = 0.29)	6.21132	15.0863		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test Treatments vs D-Control	100	>100		1	8.46376	1.92358	232.187	68.5	0.0098	5, 54

Linear Interpolation (200 Resamples)

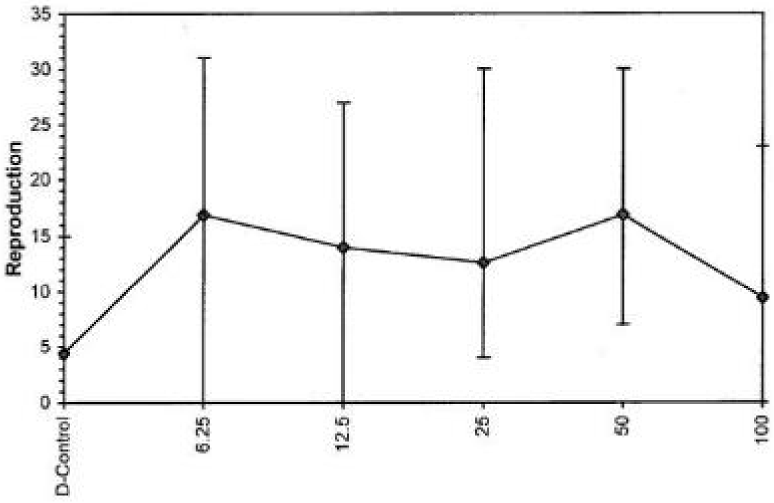
Point	%	SD	95% CL	Skew
IC05	59.101			
IC10	68.202			
IC15	77.303			
IC20	86.404			
IC25	95.506			
IC40	>100			
IC50	>100			



Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	6/13/2016 18:15	Test ID:	PCM8-16cc	Sample ID:	Park City Mun 8-16 chronic cero
End Date:	6/21/2016 15:07	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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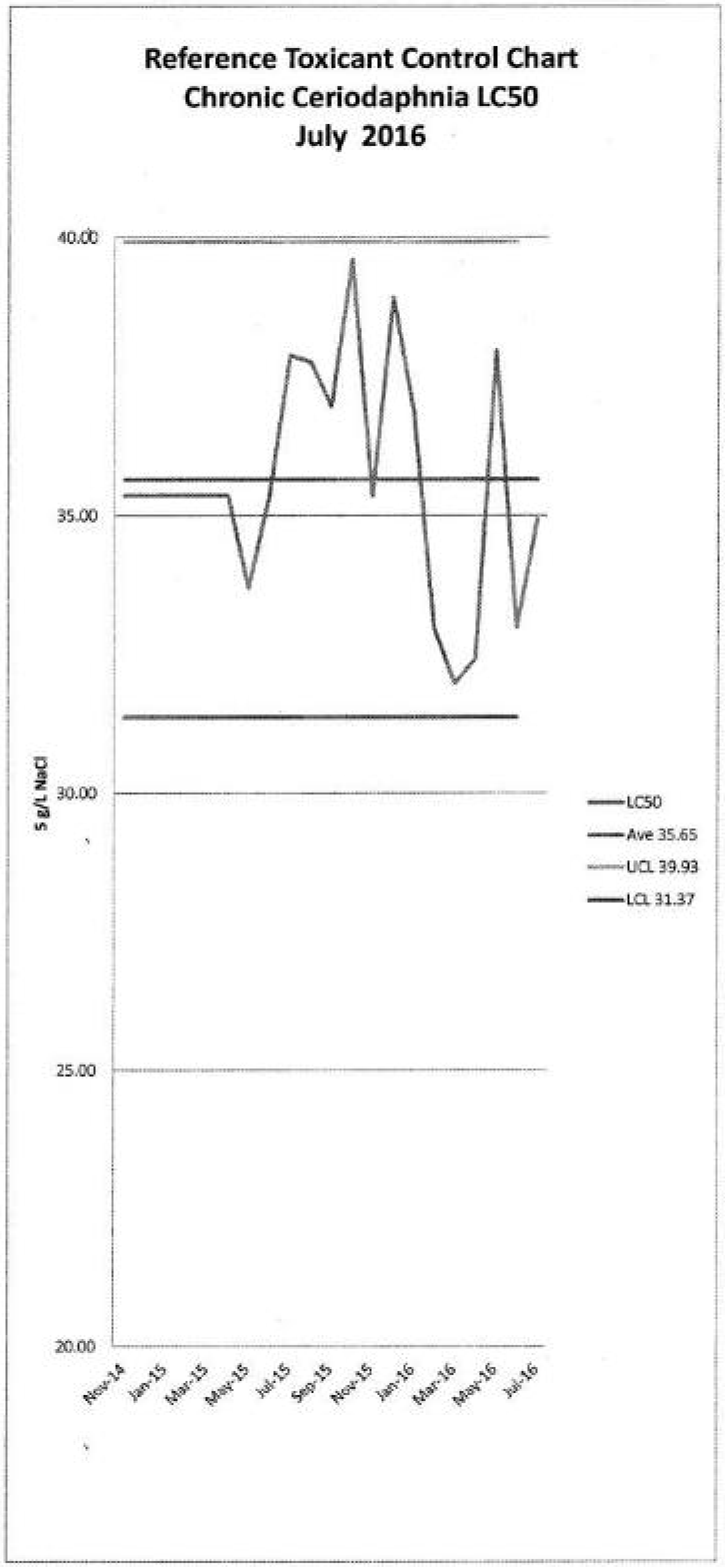
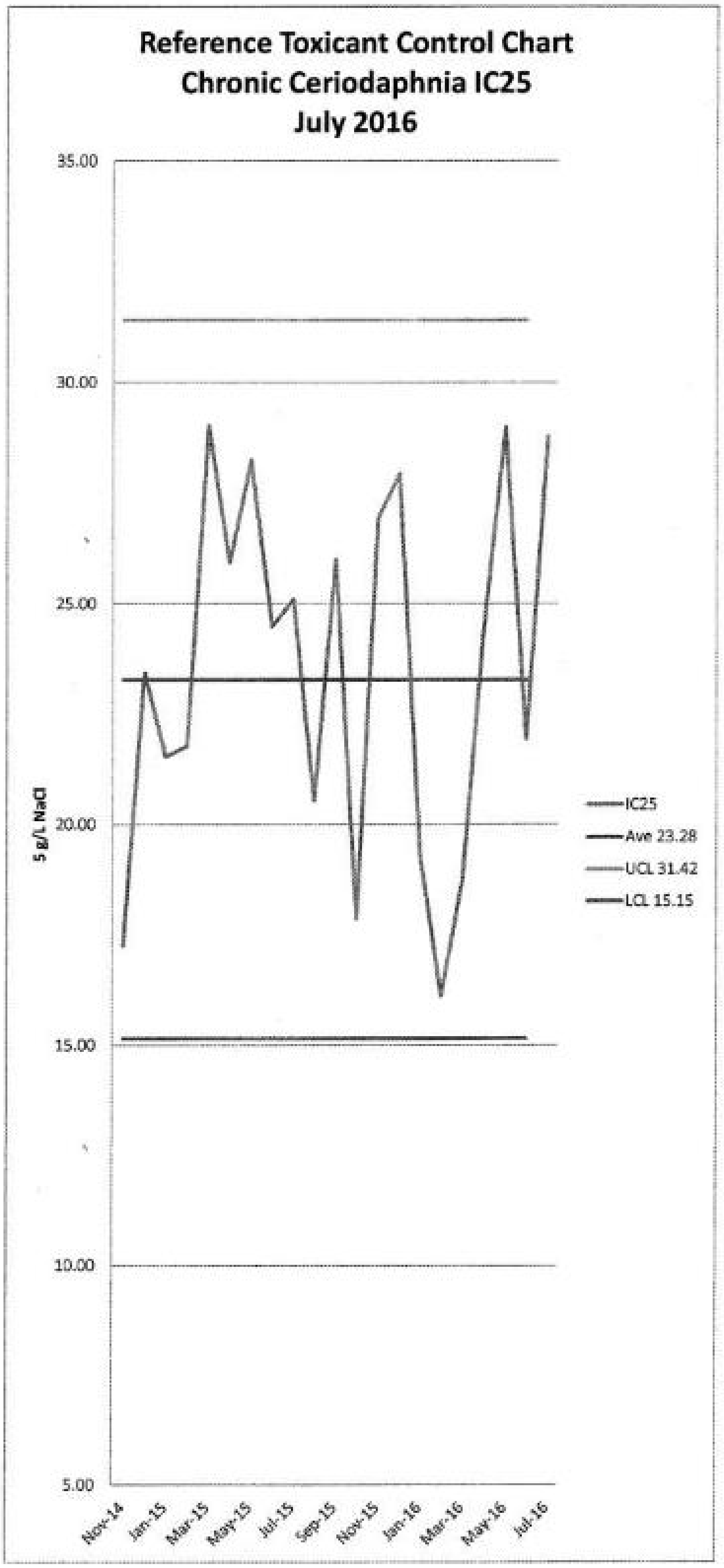


Reference Toxicant Control Chart
Chronic Ceriodaphnia LC50
July 2016


Reference Toxicant Control Chart
Chronic Ceriodaphnia IC25
July 2016
35.00
30.00
25.00
20.00
15.00
10.00
5.00
5 g/L NaCl
Nov-14
Jan-15
Mar-15
May-15
Jul-15
Sep-15
Nov-15
Jan-16
Mar-16
May-16
Jul-16
IC25
Ave 23.28
UCL 31.42
LCL 15.15

Certificate of Analysis

Park City Municipal Corporation
Michelle De Haan
PO Box 1480
Park City, UT 84060

PO#: **WEPCP 0330-051481**
Receipt: **6/13/16 12:40 @ 0.80 °C**
Date Reported: 6/14/2016
Project Name: **16 PCMC MIW PHASE 1B TASK 3**

Sample ID: **34AD2 (Adsorb 1 Eff)-Composite**
Matrix: **Drinking Water**
Lab ID: **16F0664-01**

Source Code:
Field pH:
Field Temp: °C
Field Cond.: µmhos/cm
Latitude:

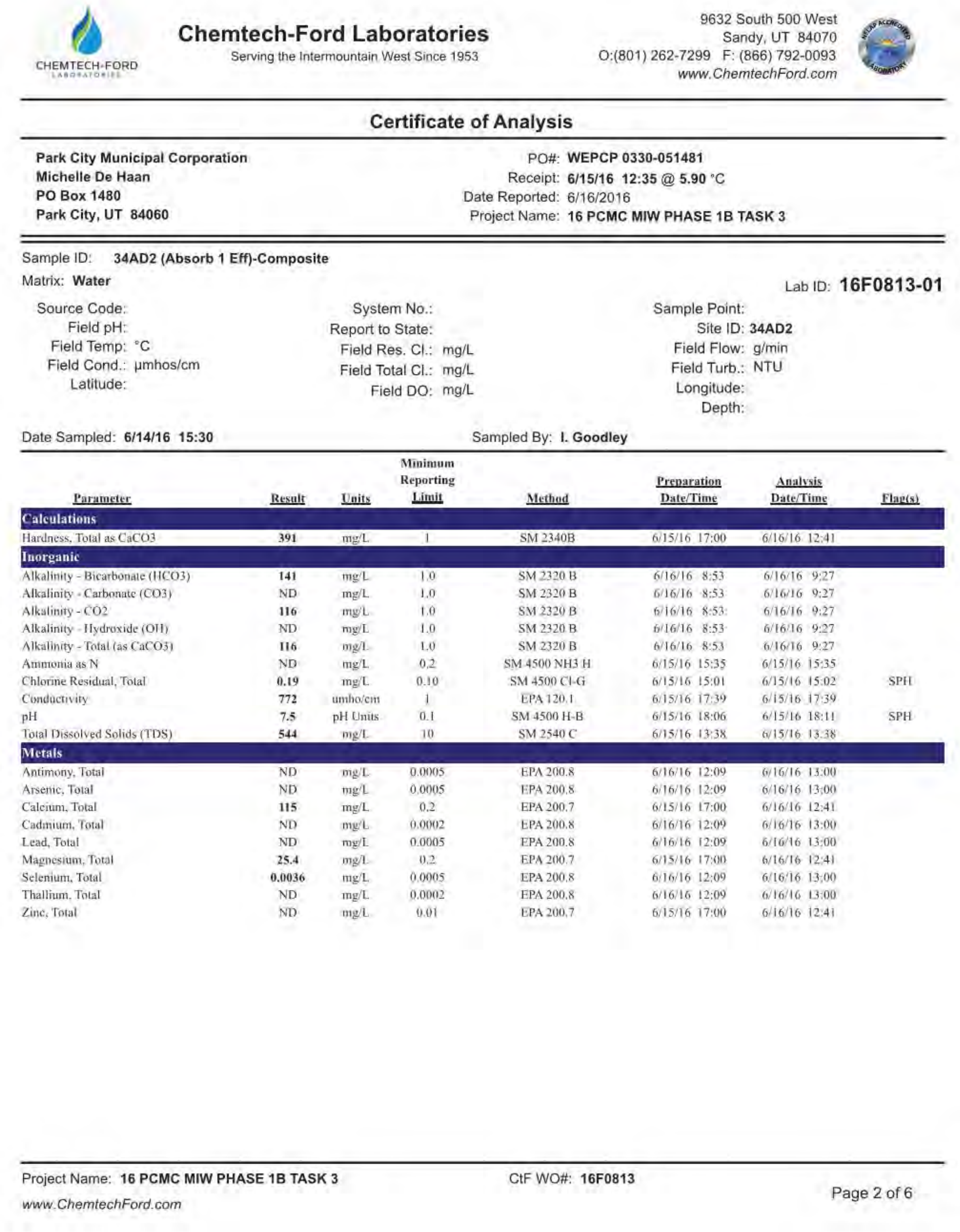
System No.:
Report to State:
Field Res. Cl.: mg/L
Field Total Cl.: mg/L
Field DO: mg/L

Sample Point:
Site ID: **34AD2**
Field Flow: g/min
Field Turb.: NTU
Longitude:
Depth:

Date Sampled: **6/12/16 16:00**

Sampled By: **I. Goodley**

Parameter	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Calculations							
Hardness, Total as CaCO3	**460**	mg/L	1	SM 2340B	6/13/16 18:00	6/14/16 14:59	
Inorganic							
Alkalinity - Bicarbonate (HCO3)	**156**	mg/L	1.0	SM 2320 B	6/13/16 12:48	6/14/16 10:14	
Alkalinity - Carbonate (CO3)	ND	mg/L	1.0	SM 2320 B	6/13/16 12:48	6/14/16 10:14	
Alkalinity - CO2	**128**	mg/L	1.0	SM 2320 B	6/13/16 12:48	6/14/16 10:14	
Alkalinity - Hydroxide (OH)	ND	mg/L	1.0	SM 2320 B	6/13/16 12:48	6/14/16 10:14	
Alkalinity - Total (as CaCO3)	**128**	mg/L	1.0	SM 2320 B	6/13/16 12:48	6/14/16 10:14	
Ammonia as N	ND	mg/L	0.2	SM 4500 NH3 H	6/14/16 8:30	6/14/16 8:30	
Chlorine Residual, Total	**0.10**	mg/L	0.10	SM 4500 Cl-G	6/13/16 15:45	6/13/16 15:45	SPH
Conductivity	**814**	umho/cm	1	EPA 120.1	6/13/16 15:07	6/13/16 15:08	
pH	**7.6**	pH Units	0.1	SM 4500 H-B	6/13/16 16:57	6/13/16 16:58	SPH
Total Dissolved Solids (TDS)	**590**	mg/L	10	SM 2540 C	6/13/16 10:54	6/13/16 10:54	
Metals							
Antimony, Total	ND	mg/L	0.0005	EPA 200.8	6/14/16 12:00	6/14/16 12:42	
Arsenic, Total	ND	mg/L	0.0005	EPA 200.8	6/14/16 12:00	6/14/16 12:42	
Calcium, Total	**138**	mg/L	0.2	EPA 200.7	6/13/16 18:00	6/14/16 14:59	
Cadmium, Total	ND	mg/L	0.0002	EPA 200.8	6/14/16 12:00	6/14/16 12:42	
Lead, Total	ND	mg/L	0.0005	EPA 200.8	6/14/16 12:00	6/14/16 12:42	
Magnesium, Total	**28.2**	mg/L	0.2	EPA 200.7	6/13/16 18:00	6/14/16 14:59	
Selenium, Total	**0.0033**	mg/L	0.0005	EPA 200.8	6/14/16 12:00	6/14/16 12:42	
Thallium, Total	ND	mg/L	0.0002	EPA 200.8	6/14/16 12:00	6/14/16 12:42	
Zinc, Total	ND	mg/L	0.10	EPA 200.7	6/13/16 18:00	6/14/16 15:19	



Certificate of Analysis

Park City Municipal Corporation
Michelle De Haan
PO Box 1480
Park City, UT 84060

PO#: **WEPCP 0330-051481**
Receipt: **6/15/16 12:35 @ 5.90 °C**
Date Reported: 6/16/2016
Project Name: **16 PCMC MIW PHASE 1B TASK 3**

Sample ID: **34AD2 (Absorb 1 Eff)-Composite**
Matrix: **Water**
Lab ID: **16F0813-01**

Source Code:
Field pH:
Field Temp: °C
Field Cond.: µmhos/cm
Latitude:
System No.:
Report to State:
Field Res. Cl.: mg/L
Field Total Cl.: mg/L
Field DO: mg/L
Sample Point:
Site ID: **34AD2**
Field Flow: g/min
Field Turb.: NTU
Longitude:
Depth:

Date Sampled: **6/14/16 15:30**
Sampled By: **I. Goodley**

Parameter	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Calculations							
Hardness, Total as CaCO3	**391**	mg/L	1	SM 2340B	6/15/16 17:00	6/16/16 12:41	
Inorganic							
Alkalinity - Bicarbonate (HCO3)	**141**	mg/L	1.0	SM 2320 B	6/16/16 8:53	6/16/16 9:27	
Alkalinity - Carbonate (CO3)	ND	mg/L	1.0	SM 2320 B	6/16/16 8:53	6/16/16 9:27	
Alkalinity - CO2	**116**	mg/L	1.0	SM 2320 B	6/16/16 8:53	6/16/16 9:27	
Alkalinity - Hydroxide (OH)	ND	mg/L	1.0	SM 2320 B	6/16/16 8:53	6/16/16 9:27	
Alkalinity - Total (as CaCO3)	**116**	mg/L	1.0	SM 2320 B	6/16/16 8:53	6/16/16 9:27	
Ammonia as N	ND	mg/L	0.2	SM 4500 NH3 H	6/15/16 15:35	6/15/16 15:35	
Chlorine Residual, Total	**0.19**	mg/L	0.10	SM 4500 Cl-G	6/15/16 15:01	6/15/16 15:02	SPH
Conductivity	**772**	umho/cm	1	EPA 120.1	6/15/16 17:39	6/15/16 17:39	
pH	**7.5**	pH Units	0.1	SM 4500 H-B	6/15/16 18:06	6/15/16 18:11	SPH
Total Dissolved Solids (TDS)	**544**	mg/L	10	SM 2540 C	6/15/16 13:38	6/15/16 13:38	
Metals							
Antimony, Total	ND	mg/L	0.0005	EPA 200.8	6/16/16 12:09	6/16/16 13:00	
Arsenic, Total	ND	mg/L	0.0005	EPA 200.8	6/16/16 12:09	6/16/16 13:00	
Calcium, Total	**115**	mg/L	0.2	EPA 200.7	6/15/16 17:00	6/16/16 12:41	
Cadmium, Total	ND	mg/L	0.0002	EPA 200.8	6/16/16 12:09	6/16/16 13:00	
Lead, Total	ND	mg/L	0.0005	EPA 200.8	6/16/16 12:09	6/16/16 13:00	
Magnesium, Total	**25.4**	mg/L	0.2	EPA 200.7	6/15/16 17:00	6/16/16 12:41	
Selenium, Total	**0.0036**	mg/L	0.0005	EPA 200.8	6/16/16 12:09	6/16/16 13:00	
Thallium, Total	ND	mg/L	0.0002	EPA 200.8	6/16/16 12:09	6/16/16 13:00	
Zinc, Total	ND	mg/L	0.01	EPA 200.7	6/15/16 17:00	6/16/16 12:41	

CHEMTECH-FORD LABORATORIES

Chemtech-Ford Laboratories
Serving the Intermountain West Since 1953

9632 South 500 West
Sandy, UT 84070
O:(801) 262-7299 F: (866) 792-0093
www.ChemtechFord.com

Certificate of Analysis

Park City Municipal Corporation
Michelle De Haan
PO Box 1480
Park City, UT 84060

PO#: **WEPCP 0330-051481**
Receipt: **6/17/16 12:18 @ 3.10 °C**
Date Reported: 6/27/2016
Project Name: **16 PCMC MIW PHASE 1B TASK 4**

Sample ID: **34AD2 (Adsorb 1 Eff)-Composite**
Matrix: **Drinking Water**
Lab ID: **16F0961-01**

Source Code:
Field pH:
Field Temp: °C
Field Cond.: µmhos/cm
Latitude:

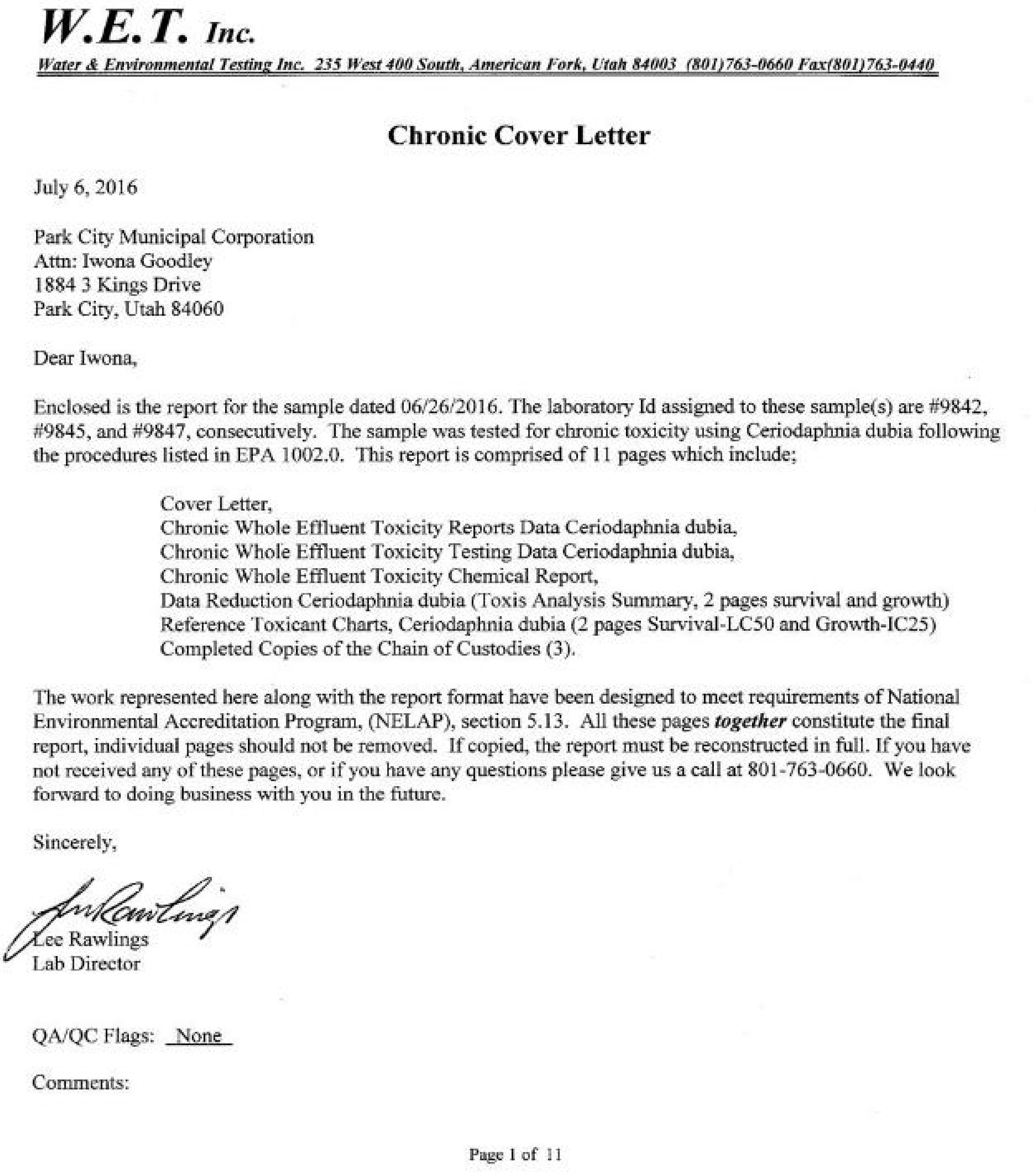
System No.:
Report to State: **N**
Field Res. Cl.: mg/L
Field Total Cl.: mg/L
Field DO: mg/L

Sample Point:
Site ID:
Field Flow: g/min
Field Turb.: NTU
Longitude:
Depth:

Date Sampled: **6/16/16 18:00**
Sampled By: **Erinn Kunik**

Parameter	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Calculations							
Hardness, Total as CaCO3	**450**	mg/L	1	SM 2340B	6/17/16	6/19/16	
Inorganic							
Alkalinity - Bicarbonate (HCO3)	**145**	mg/L	1.0	SM 2320 B	6/22/16	6/22/16	
Alkalinity - Carbonate (CO3)	ND	mg/L	1.0	SM 2320 B	6/22/16	6/22/16	
Alkalinity - CO2	**116**	mg/L	1.0	SM 2320 B	6/22/16	6/22/16	
Alkalinity - Hydroxide (OH)	ND	mg/L	1.0	SM 2320 B	6/22/16	6/22/16	
Alkalinity - Total (as CaCO3)	**119**	mg/L	1.0	SM 2320 B	6/22/16	6/22/16	
Ammonia as N	ND	mg/L	0.2	SM 4500 NH3 H	6/19/16	6/19/16	
Chlorine Residual, Total	ND	mg/L	0.10	SM 4500 Cl-G	6/17/16 14:57	6/17/16 14:58	SPH
Conductivity	**801**	umho/cm	1	EPA 120.1	6/17/16	6/17/16	
pH	**7.1**	pH Units	0.1	SM 4500 H-B	6/17/16 11:08	6/17/16 11:09	SPH
Total Dissolved Solids (TDS)	**580**	mg/L	10	SM 2540 C	6/17/16	6/17/16	
Metals							
Antimony, Total	ND	mg/L	0.0005	EPA 200.8	6/17/16	6/20/16	
Arsenic, Total	ND	mg/L	0.0005	EPA 200.8	6/17/16	6/20/16	
Calcium, Total	**134**	mg/L	0.2	EPA 200.7	6/17/16	6/19/16	
Cadmium, Total	ND	mg/L	0.0002	EPA 200.8	6/17/16	6/20/16	
Lead, Total	ND	mg/L	0.0005	EPA 200.8	6/17/16	6/20/16	
Magnesium, Total	**27.7**	mg/L	0.2	EPA 200.7	6/17/16	6/19/16	
Selenium, Total	**0.0038**	mg/L	0.0005	EPA 200.8	6/17/16	6/20/16	
Thallium, Total	ND	mg/L	0.0002	EPA 200.8	6/17/16	6/20/16	
Zinc, Total	ND	mg/L	0.01	EPA 200.7	6/17/16	6/19/16	

Attachment C – High Flow WET Test Repeat for *Ceriodaphnia dubia* Results



W.E.T. Inc.
Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Cover Letter

July 6, 2016

Park City Municipal Corporation
Attn: Iwona Goodley
1884 3 Kings Drive
Park City, Utah 84060

Dear Iwona,

Enclosed is the report for the sample dated 06/26/2016. The laboratory Id assigned to these sample(s) are #9842, #9845, and #9847, consecutively. The sample was tested for chronic toxicity using Ceriodaphnia dubia following the procedures listed in EPA 1002.0. This report is comprised of 11 pages which include;

Cover Letter,
Chronic Whole Effluent Toxicity Reports Data Ceriodaphnia dubia,
Chronic Whole Effluent Toxicity Testing Data Ceriodaphnia dubia,
Chronic Whole Effluent Toxicity Chemical Report,
Data Reduction Ceriodaphnia dubia (Toxis Analysis Summary, 2 pages survival and growth)
Reference Toxicant Charts, Ceriodaphnia dubia (2 pages Survival-LC50 and Growth-IC25)
Completed Copies of the Chain of Custodies (3).

The work represented here along with the report format have been designed to meet requirements of National Environmental Accreditation Program, (NELAP), section 5.13. All these pages ***together*** constitute the final report, individual pages should not be removed. If copied, the report must be reconstructed in full. If you have not received any of these pages, or if you have any questions please give us a call at 801-763-0660. We look forward to doing business with you in the future.

Sincerely,

Lee Rawlings
Lab Director

QA/QC Flags: None

Comments:

Page 1 of 11

W.E.T. *Inc.*
Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Whole Effluent Toxicity Report
Ceriodaphnia

DATE: July 6, 2016

PERMITTEE NAME: Park City Municipal Corporation

TEST (Animal/Age): Ceriodaphnia dubia <8 hours

SAMPLE (Date/Type): 06/26/2016 Composite

DATE/TIME TEST BEGAN: 06/26/2016 9:15 p.m.

DATE/TIME TEST COMPLETED: 07/05/2016 3:45 p.m.

TEST CONDITIONS

Ceriodaphnia dubia neonates were exposed to diluted effluent as specified by EPA 1002.0. At the end of the test period Survival and Reproduction were measured and compared statistically against a control to determine if Chronic Toxicity was present in the samples.

Animal Age at Test Start	<8 hours.
Number of Organisms/Dilution Volume/Replicates	1 organism/15 ml/10 replicates.
Food	Fed daily 0.1 ml YTC and Algae.
Aeration	None required.
Dissolved Oxygen	Measured daily old/new.
Water Replacement	Renewed daily.
Temperature	25 ± 1 degree C.
Photo Period	16 hours light 8 hours dark.
pH	Measured initially and at 24 hours for each sample.
Dilution Water	Reconstituted lab water approx 100 mg/L hardness.
Receiving Water	None Received
Sample Concentrations	Control, 6.25, 12.5, 25, 50, 100%

SUMMARY

Results: X Pass Fail

There was NO significant effect on reproduction. (Results of Steel's Many-One Rank Test)

NOEC (Reproduction) = 100

IC25 required by NPDES permit =

LOEC (Reproduction) = >100

IC25 estimated from test data = >100%

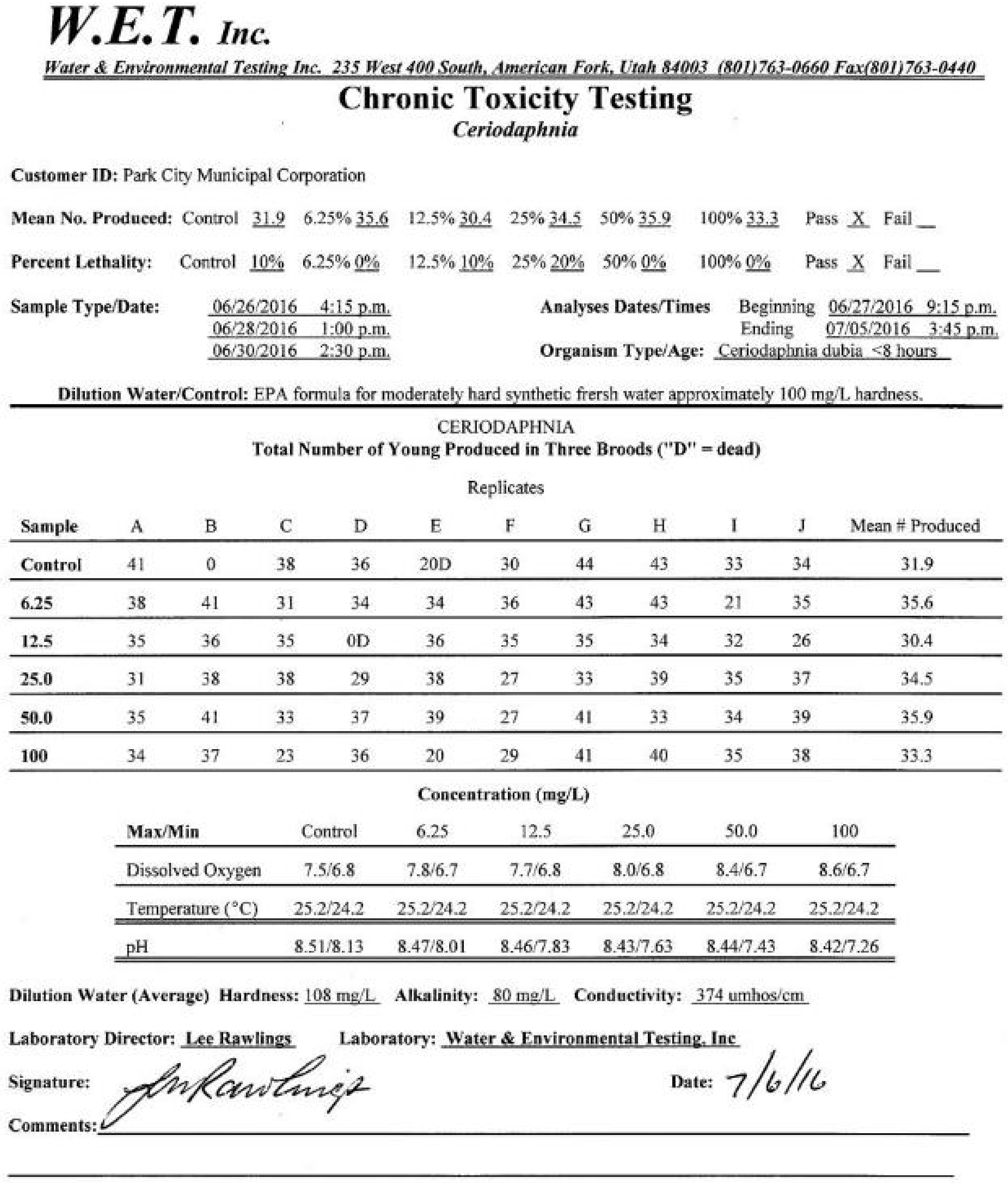
There was NO significant effect on survival. (Fisher's Exact Test)

NOEC (Survival) = 100

LOEC (Survival) = >100

Enclosed are data sheets and statistical reports.

Sincerely,
Lee Rawlings
Lab Director
Enclosure



W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Toxicity Testing

Ceriodaphnia

Customer ID: Park City Municipal Corporation

Mean No. Produced: Control 31.9 6.25% 35.6 12.5% 30.4 25% 34.5 50% 35.9 100% 33.3 Pass X Fail __

Percent Lethality: Control 10% 6.25% 0% 12.5% 10% 25% 20% 50% 0% 100% 0% Pass X Fail __

Sample Type/Date:
06/26/2016 4:15 p.m.
06/28/2016 1:00 p.m.
06/30/2016 2:30 p.m.

Analyses Dates/Times Beginning 06/27/2016 9:15 p.m.
Ending 07/05/2016 3:45 p.m.

Organism Type/Age: Ceriodaphnia dubia <8 hours

Dilution Water/Control: EPA formula for moderately hard synthetic frersh water approximately 100 mg/L hardness.

CERIODAPHNIA

Total Number of Young Produced in Three Broods ("D" = dead)

Replicates

Sample	A	B	C	D	E	F	G	H	I	J	Mean # Produced
Control	41	0	38	36	20D	30	44	43	33	34	31.9
6.25	38	41	31	34	34	36	43	43	21	35	35.6
12.5	35	36	35	0D	36	35	35	34	32	26	30.4
25.0	31	38	38	29	38	27	33	39	35	37	34.5
50.0	35	41	33	37	39	27	41	33	34	39	35.9
100	34	37	23	36	20	29	41	40	35	38	33.3

Concentration (mg/L)

Max/Min	Control	6.25	12.5	25.0	50.0	100
Dissolved Oxygen	7.5/6.8	7.8/6.7	7.7/6.8	8.0/6.8	8.4/6.7	8.6/6.7
Temperature (°C)	25.2/24.2	25.2/24.2	25.2/24.2	25.2/24.2	25.2/24.2	25.2/24.2
pH	8.51/8.13	8.47/8.01	8.46/7.83	8.43/7.63	8.44/7.43	8.42/7.26

Dilution Water (Average) Hardness: 108 mg/L **Alkalinity:** 80 mg/L **Conductivity:** 374 umhos/cm

Laboratory Director: Lee Rawlings **Laboratory:** Water & Environmental Testing, Inc

Signature: Rawlings **Date:** 7/6/16

Comments:

Page 3 of 11

W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Whole Effluent Toxicity Chemical Result Report

July 6, 2016

CUSTOMER NAME:

Park City Municipal Corporation
Attn: Iwona Goodley
1884 3 Kings Drive
Park City, Utah 84060

SAMPLE DESCRIPTION:

Chemistries to go with Chronic Biomonitoring sampling began 06/26/2016

Analysis	Chronic Ceriodaphnia		
	Repl. 1	Repl. 2	Repl. 3
Log #	9842	9845	9847
Total Hardness, Recon (EPA 130.2), mg/L	108	108	108
Total Hardness, Effluent (EPA 130.2), mg/L	368	380	408
Ammonia, Effluent (EPA 350.2/350.3), mg/L	<0.05	<0.05	<0.05
Initial Chlorine Residual (EPA 330.5), mg/L	0.16	0.10	0.30
Final Chlorine Residual (EPA 330.5), mg/L	<0.05	<0.05	<0.05
Conductivity, Effluent (EPA 120.1), umhos/cm	745	767	776
Alkalinity, Effluent (EPA 310.1), mg/L $CaCO^3$	114	118	116
Recon Initial pH (EPA 150.1)	8.27	8.32	8.51
After 24 hours pH (EPA 150.1)	8.18	8.47	8.49
100% Initial pH (EPA 150.1)	7.26	7.35	7.51
100% After 24 hours pH (EPA 150	8.33	8.40	8.36

Le Rawlings

Reviewed: Lee Rawlings, Lab Director
Water & Environmental Testing, Inc.

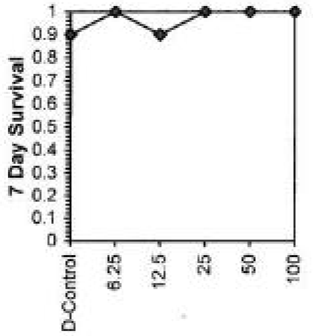
Ceriodaphnia Survival and Reproduction Test-7 Day Survival

Start Date:	6/27/2016 21:15	Test ID:	PCMC6-16	Sample ID:	Park City MC 6-16 chronic cero
End Date:	7/5/2016 15:45	Lab ID:	WET inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6	7	8	9	10
D-Control	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6.25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical
D-Control	0.9000	1.0000	1	9	10	10		
6.25	1.0000	1.1111	0	10	10	10	0.5000	0.0500
12.5	0.9000	1.0000	1	9	10	10	0.7632	0.0500
25	1.0000	1.1111	0	10	10	10	0.5000	0.0500
50	1.0000	1.1111	0	10	10	10	0.5000	0.0500
100	1.0000	1.1111	0	10	10	10	0.5000	0.0500

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test Treatments vs D-Control	100	>100		1



Page 1 ToxCalc v5.0.32 Reviewed by: LR

Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	6/27/2016 21:15	Test ID:	PCMC6-16	Sample ID:	Park City MC 6-16 chronic cero
End Date:	7/5/2016 15:45	Lab ID:	WET inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6	7	8	9	10
D-Control	41.000	0.000	38.000	36.000	20.000	30.000	44.000	43.000	33.000	34.000
6.25	38.000	41.000	31.000	34.000	34.000	36.000	43.000	43.000	21.000	35.000
12.5	35.000	36.000	35.000	0.000	36.000	35.000	35.000	34.000	32.000	26.000
25	31.000	38.000	38.000	29.000	38.000	27.000	33.000	39.000	35.000	37.000
50	35.000	41.000	33.000	37.000	39.000	27.000	41.000	33.000	34.000	39.000
100	34.000	37.000	23.000	36.000	20.000	29.000	41.000	40.000	35.000	38.000

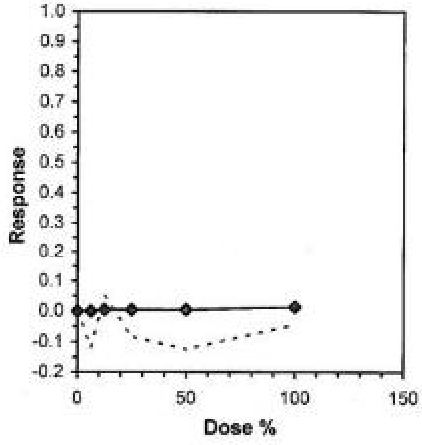
			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
D-Control	31.900	1.0000	31.900	0.000	44.000	41.468	10			33.750	1.0000
6.25	35.600	1.1160	35.600	21.000	43.000	18.358	10	110.50	75.00	33.750	1.0000
12.5	30.400	0.9530	30.400	0.000	36.000	36.472	10	96.00	75.00	33.600	0.9956
25	34.500	1.0815	34.500	27.000	39.000	12.392	10	103.00	75.00	33.600	0.9956
50	35.900	1.1254	35.900	27.000	41.000	12.209	10	108.50	75.00	33.600	0.9956
100	33.300	1.0439	33.300	20.000	41.000	21.284	10	102.50	75.00	33.300	0.9867

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Kolmogorov D Test indicates non-normal distribution (p <= 0.05)	1.23245	0.895	-2.0914	5.95672
Bartlett's Test indicates unequal variances (p = 2.80E-03)	18.1214	15.0863		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test Treatments vs D-Control	100	>100		1

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			

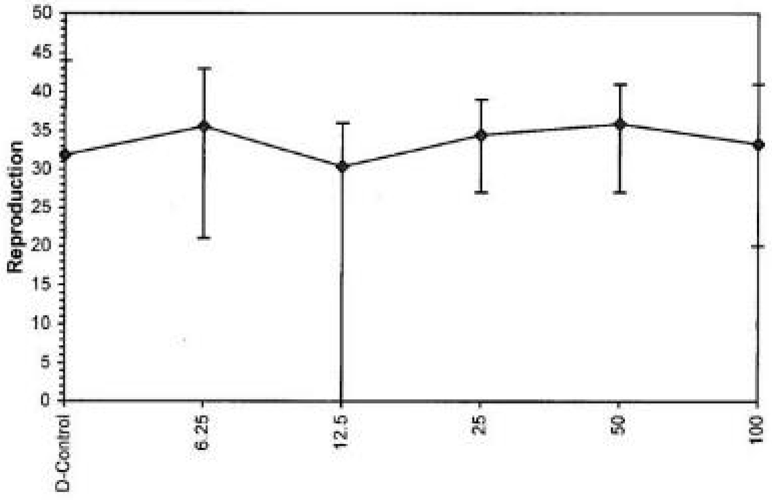


Page 1 ToxCalc v5.0.32 Reviewed by: LR

Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	6/27/2016 21:15	Test ID:	PCMC6-16	Sample ID:	Park City MC 6-16 chronic cero
End Date:	7/5/2016 15:45	Lab ID:	WET inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



ToxCalc v5.0.32 Reviewed by: LR

Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	6/27/2016 21:15	Test ID:	PCMC6-16	Sample ID:	Park City MC 6-16 chronic cero
End Date:	7/5/2016 15:45	Lab ID:	WET inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

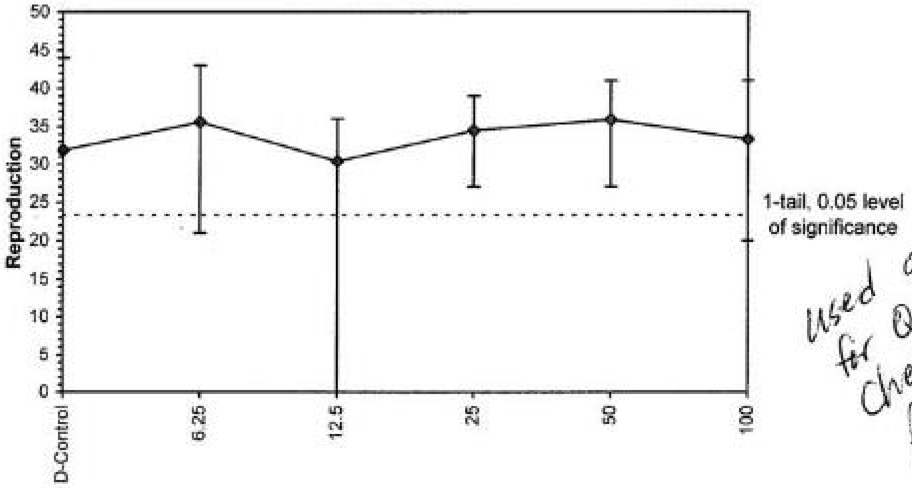
Conc-%	1	2	3	4	5	6	7	8	9	10
D-Control	41.000	0.000	38.000	36.000	20.000	30.000	44.000	43.000	33.000	34.000
6.25	38.000	41.000	31.000	34.000	34.000	36.000	43.000	43.000	21.000	35.000
12.5	35.000	36.000	35.000	0.000	36.000	35.000	35.000	34.000	32.000	26.000
25	31.000	38.000	38.000	29.000	38.000	27.000	33.000	39.000	35.000	37.000
50	35.000	41.000	33.000	37.000	39.000	27.000	41.000	33.000	34.000	39.000
100	34.000	37.000	23.000	36.000	20.000	29.000	41.000	40.000	35.000	38.000

			Transform: Untransformed						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
D-Control	31.900	1.0000	31.900	0.000	44.000	41.468	10			
6.25	35.600	1.1160	35.600	21.000	43.000	18.358	10	-0.979	2.287	8.641
12.5	30.400	0.9530	30.400	0.000	36.000	36.472	10	0.397	2.287	8.641
25	34.500	1.0815	34.500	27.000	39.000	12.392	10	-0.688	2.287	8.641
50	35.900	1.1254	35.900	27.000	41.000	12.209	10	-1.059	2.287	8.641
100	33.300	1.0439	33.300	20.000	41.000	21.284	10	-0.370	2.287	8.641

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Kolmogorov D Test indicates non-normal distribution (p <= 0.05)	1.23245	0.895	-2.0914	5.95672
Bartlett's Test indicates unequal variances (p = 2.80E-03)	18.1214	15.0863		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test Treatments vs D-Control	100	>100		1	8.64061	0.27087	46.64	71.3926	0.66025	5, 54

Dose-Response Plot

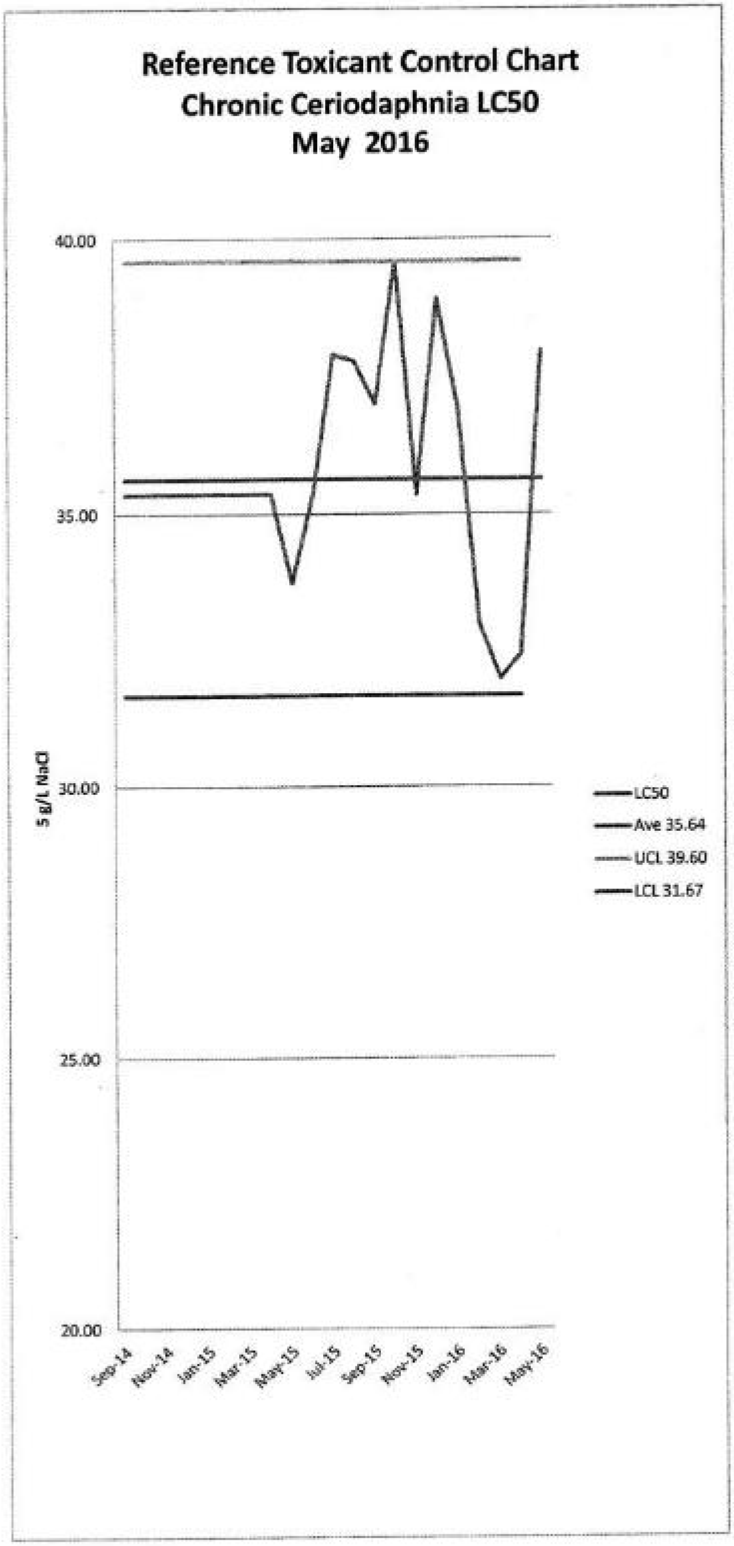


used only for QC Check Pass LR 7/5/16

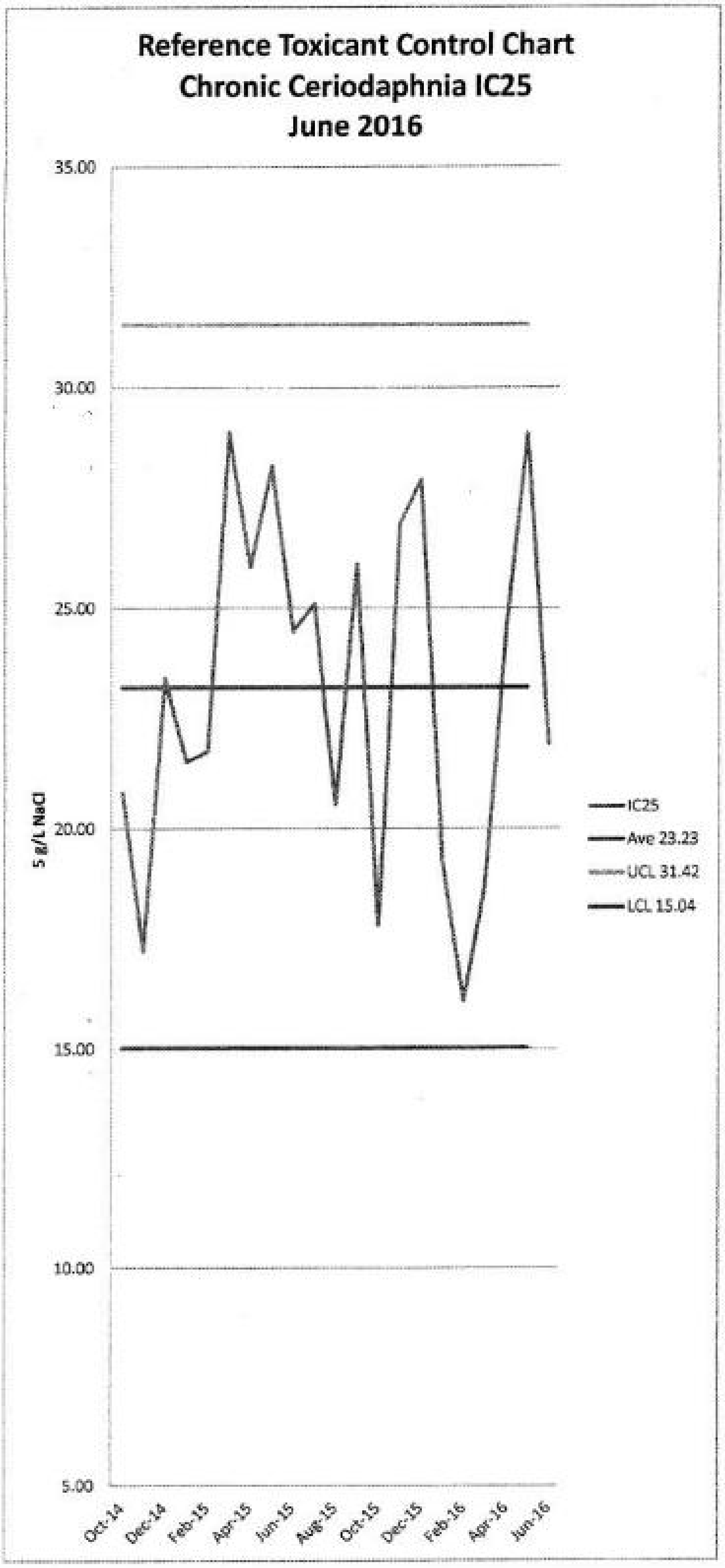
Page 1

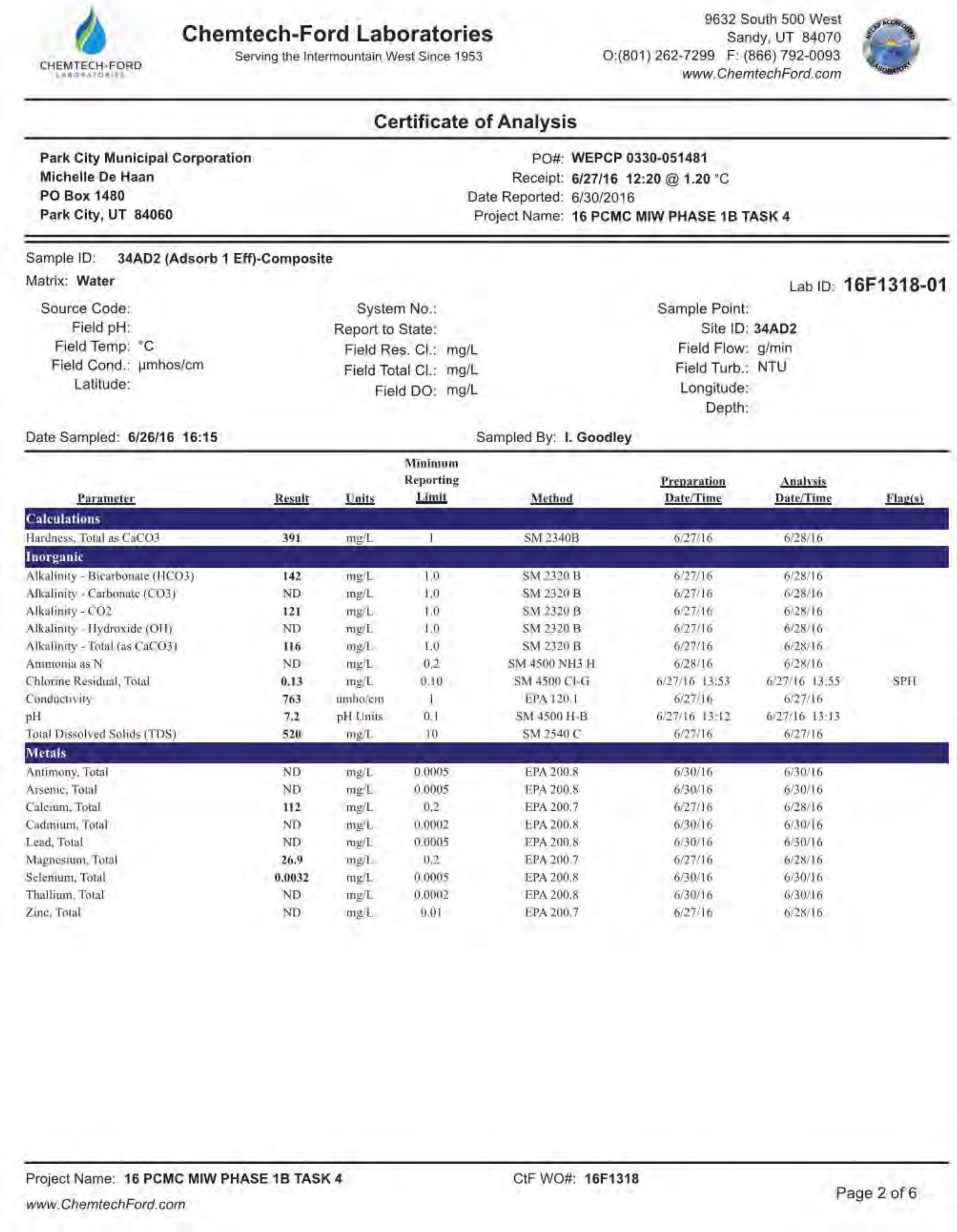
ToxCalc v5.0.32

Reviewed by: LR



Reference Toxicant Control Chart
Chronic Ceriodaphnia LC50
May 2016


Reference Toxicant Control Chart
Chronic Ceriodaphnia IC25
June 2016
35.00
30.00
25.00
20.00
15.00
10.00
5.00
5 g/L NaCl
Oct-14
Dec-14
Feb-15
Apr-15
Jun-15
Aug-15
Oct-15
Dec-15
Feb-16
Apr-16
Jun-16
IC25
Ave 23.23
UCL 31.42
LCL 15.04



Chemtech-Ford Laboratories
Serving the Intermountain West Since 1953

9632 South 500 West
Sandy, UT 84070
O:(801) 262-7299 F: (866) 792-0093
www.ChemtechFord.com

Certificate of Analysis

Park City Municipal Corporation
Michelle De Haan
PO Box 1480
Park City, UT 84060

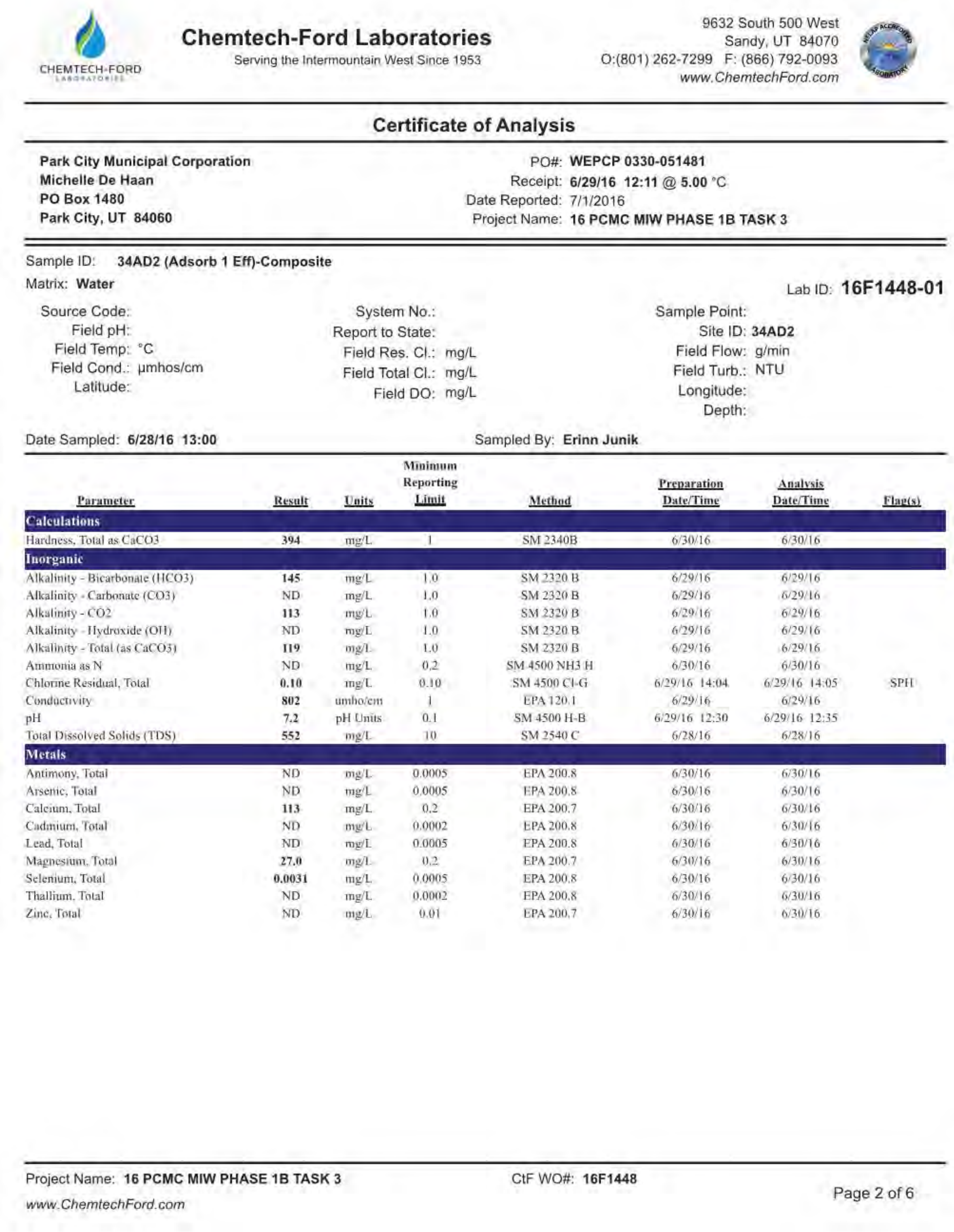
PO#: **WEPCP 0330-051481**
Receipt: **6/27/16 12:20 @ 1.20 °C**
Date Reported: 6/30/2016
Project Name: **16 PCMC MIW PHASE 1B TASK 4**

Sample ID: **34AD2 (Adsorb 1 Eff)-Composite**
Matrix: **Water**
Lab ID: **16F1318-01**

Source Code:
Field pH:
Field Temp: °C
Field Cond.: µmhos/cm
Latitude:
System No.:
Report to State:
Field Res. Cl.: mg/L
Field Total Cl.: mg/L
Field DO: mg/L
Sample Point:
Site ID: **34AD2**
Field Flow: g/min
Field Turb.: NTU
Longitude:
Depth:

Date Sampled: **6/26/16 16:15**
Sampled By: **I. Goodley**

Parameter	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Calculations							
Hardness, Total as CaCO3	**391**	mg/L	1	SM 2340B	6/27/16	6/28/16	
Inorganic							
Alkalinity - Bicarbonate (HCO3)	**142**	mg/L	1.0	SM 2320 B	6/27/16	6/28/16	
Alkalinity - Carbonate (CO3)	ND	mg/L	1.0	SM 2320 B	6/27/16	6/28/16	
Alkalinity - CO2	**121**	mg/L	1.0	SM 2320 B	6/27/16	6/28/16	
Alkalinity - Hydroxide (OH)	ND	mg/L	1.0	SM 2320 B	6/27/16	6/28/16	
Alkalinity - Total (as CaCO3)	**116**	mg/L	1.0	SM 2320 B	6/27/16	6/28/16	
Ammonia as N	ND	mg/L	0.2	SM 4500 NH3 H	6/28/16	6/28/16	
Chlorine Residual, Total	**0.13**	mg/L	0.10	SM 4500 Cl-G	6/27/16 13:53	6/27/16 13:55	SPH
Conductivity	**763**	umho/cm	1	EPA 120.1	6/27/16	6/27/16	
pH	**7.2**	pH Units	0.1	SM 4500 H-B	6/27/16 13:12	6/27/16 13:13	
Total Dissolved Solids (TDS)	**520**	mg/L	10	SM 2540 C	6/27/16	6/27/16	
Metals							
Antimony, Total	ND	mg/L	0.0005	EPA 200.8	6/30/16	6/30/16	
Arsenic, Total	ND	mg/L	0.0005	EPA 200.8	6/30/16	6/30/16	
Calcium, Total	**112**	mg/L	0.2	EPA 200.7	6/27/16	6/28/16	
Cadmium, Total	ND	mg/L	0.0002	EPA 200.8	6/30/16	6/30/16	
Lead, Total	ND	mg/L	0.0005	EPA 200.8	6/30/16	6/30/16	
Magnesium, Total	**26.9**	mg/L	0.2	EPA 200.7	6/27/16	6/28/16	
Selenium, Total	**0.0032**	mg/L	0.0005	EPA 200.8	6/30/16	6/30/16	
Thallium, Total	ND	mg/L	0.0002	EPA 200.8	6/30/16	6/30/16	
Zinc, Total	ND	mg/L	0.01	EPA 200.7	6/27/16	6/28/16	



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Certificate of Analysis

Park City Municipal Corporation
Michelle De Haan
PO Box 1480
Park City, UT 84060

PO#: **WEPCP 0330-051481**
Receipt: **6/29/16 12:11 @ 5.00** °C
Date Reported: 7/1/2016
Project Name: **16 PCMC MIW PHASE 1B TASK 3**

Sample ID: **34AD2 (Adsorb 1 Eff)-Composite**
Matrix: **Water**
Lab ID: **16F1448-01**

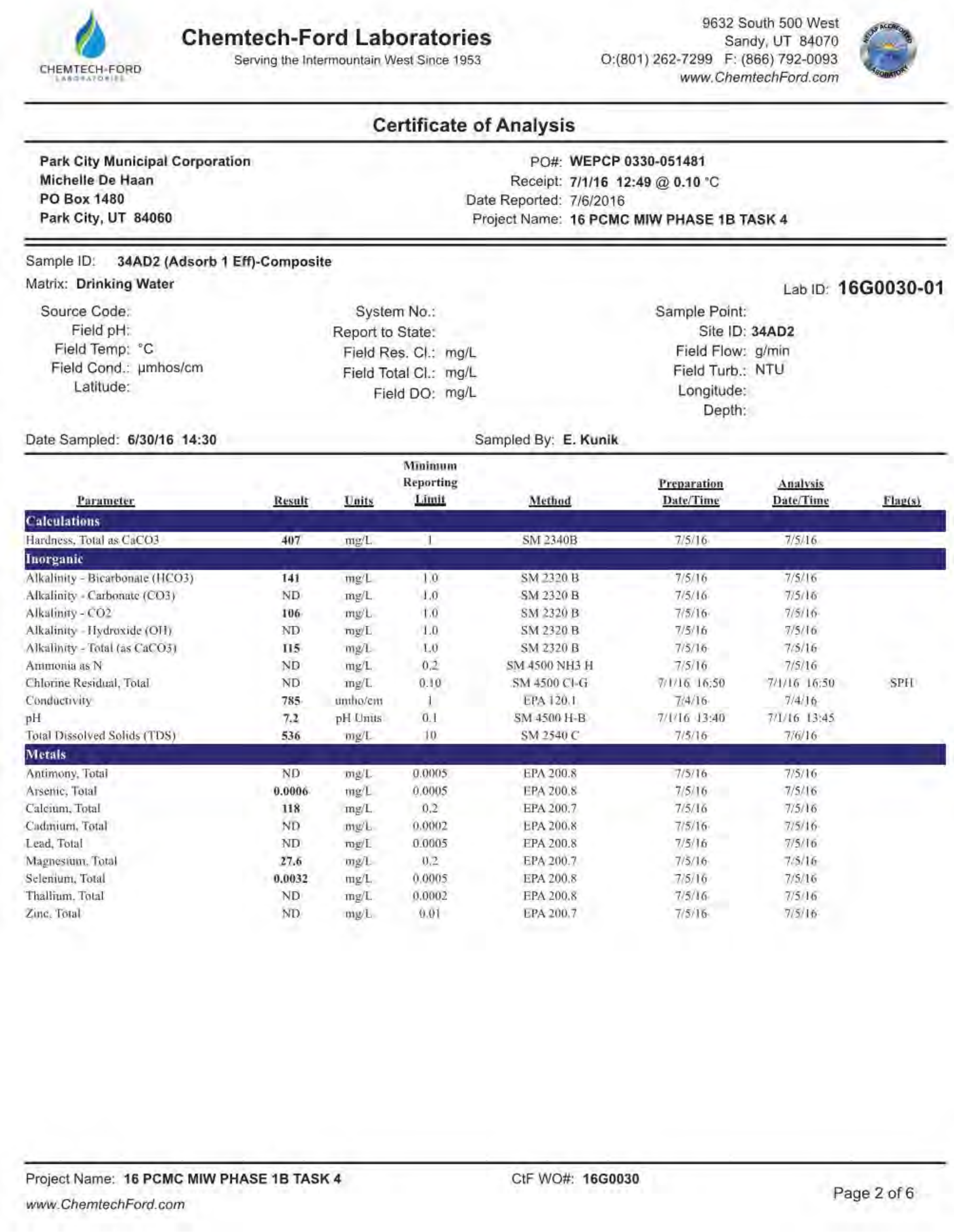
Source Code:
Field pH:
Field Temp: °C
Field Cond.: µmhos/cm
Latitude:

System No.:
Report to State:
Field Res. Cl.: mg/L
Field Total Cl.: mg/L
Field DO: mg/L

Sample Point:
Site ID: **34AD2**
Field Flow: g/min
Field Turb.: NTU
Longitude:
Depth:

Date Sampled: **6/28/16 13:00**
Sampled By: **Erinn Junik**

Parameter	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Calculations							
Hardness, Total as CaCO3	**394**	mg/L	1	SM 2340B	6/30/16	6/30/16	
Inorganic							
Alkalinity - Bicarbonate (HCO3)	**145**	mg/L	1.0	SM 2320 B	6/29/16	6/29/16	
Alkalinity - Carbonate (CO3)	ND	mg/L	1.0	SM 2320 B	6/29/16	6/29/16	
Alkalinity - CO2	**113**	mg/L	1.0	SM 2320 B	6/29/16	6/29/16	
Alkalinity - Hydroxide (OH)	ND	mg/L	1.0	SM 2320 B	6/29/16	6/29/16	
Alkalinity - Total (as CaCO3)	**119**	mg/L	1.0	SM 2320 B	6/29/16	6/29/16	
Ammonia as N	ND	mg/L	0.2	SM 4500 NH3 H	6/30/16	6/30/16	
Chlorine Residual, Total	**0.10**	mg/L	0.10	SM 4500 Cl-G	6/29/16 14:04	6/29/16 14:05	SPH
Conductivity	**802**	umho/cm	1	EPA 120.1	6/29/16	6/29/16	
pH	**7.2**	pH Units	0.1	SM 4500 H-B	6/29/16 12:30	6/29/16 12:35	
Total Dissolved Solids (TDS)	**552**	mg/L	10	SM 2540 C	6/28/16	6/28/16	
Metals							
Antimony, Total	ND	mg/L	0.0005	EPA 200.8	6/30/16	6/30/16	
Arsenic, Total	ND	mg/L	0.0005	EPA 200.8	6/30/16	6/30/16	
Calcium, Total	**113**	mg/L	0.2	EPA 200.7	6/30/16	6/30/16	
Cadmium, Total	ND	mg/L	0.0002	EPA 200.8	6/30/16	6/30/16	
Lead, Total	ND	mg/L	0.0005	EPA 200.8	6/30/16	6/30/16	
Magnesium, Total	**27.0**	mg/L	0.2	EPA 200.7	6/30/16	6/30/16	
Selenium, Total	**0.0031**	mg/L	0.0005	EPA 200.8	6/30/16	6/30/16	
Thallium, Total	ND	mg/L	0.0002	EPA 200.8	6/30/16	6/30/16	
Zinc, Total	ND	mg/L	0.01	EPA 200.7	6/30/16	6/30/16	



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Certificate of Analysis

Park City Municipal Corporation
Michelle De Haan
PO Box 1480
Park City, UT 84060

PO#: **WEPCP 0330-051481**
Receipt: **7/1/16 12:49 @ 0.10** °C
Date Reported: 7/6/2016
Project Name: **16 PCMC MIW PHASE 1B TASK 4**

Sample ID: **34AD2 (Adsorb 1 Eff)-Composite**
Matrix: **Drinking Water**
Lab ID: **16G0030-01**

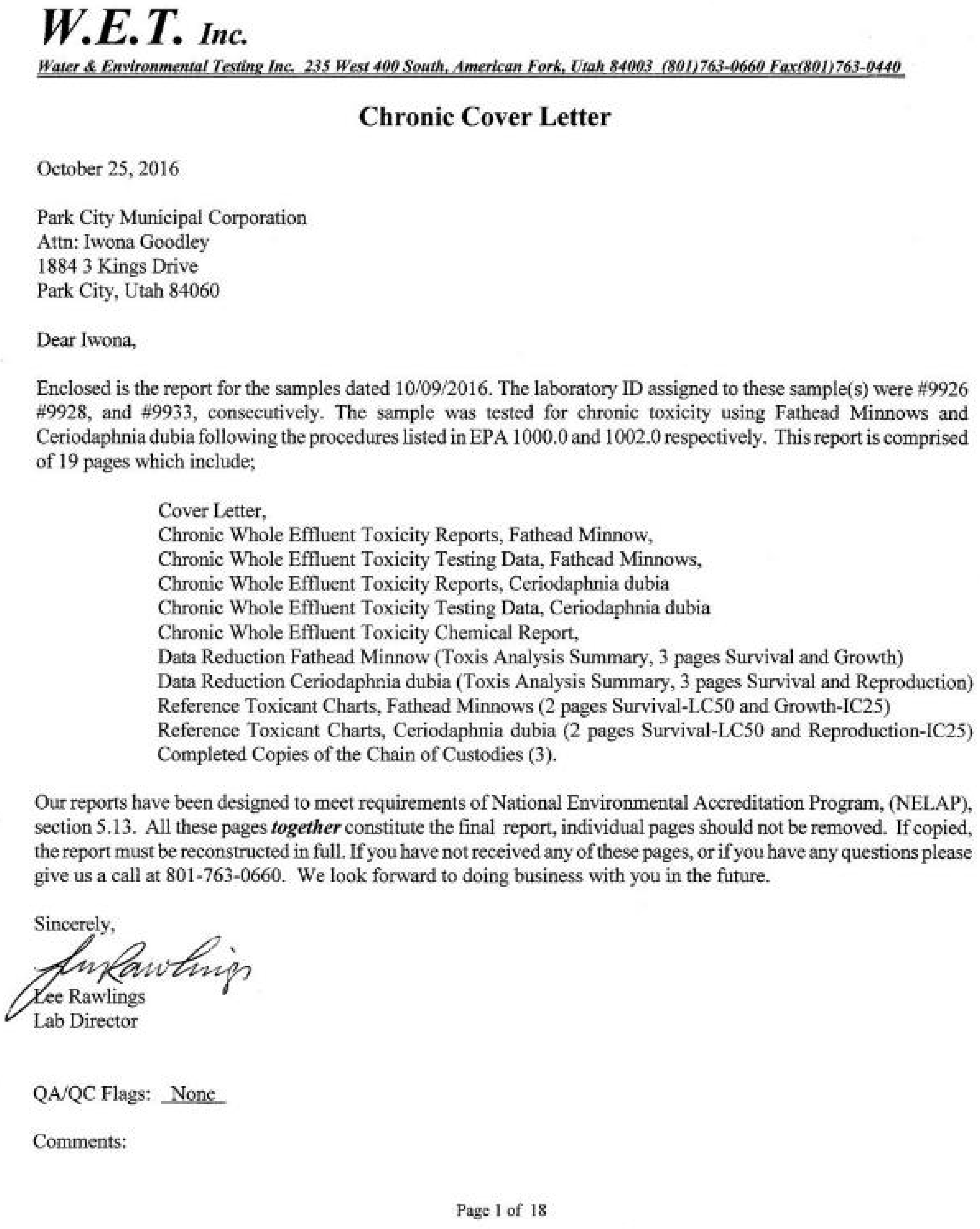
Source Code:	System No.:	Sample Point:
Field pH:	Report to State:	Site ID: **34AD2**
Field Temp: °C	Field Res. Cl.: mg/L	Field Flow: g/min
Field Cond.: µmhos/cm	Field Total Cl.: mg/L	Field Turb.: NTU
Latitude:	Field DO: mg/L	Longitude:
		Depth:

Date Sampled: **6/30/16 14:30**
Sampled By: **E. Kunik**

Parameter	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Calculations							
Hardness, Total as CaCO3	**407**	mg/L	1	SM 2340B	7/5/16	7/5/16	
Inorganic							
Alkalinity - Bicarbonate (HCO3)	**141**	mg/L	1.0	SM 2320 B	7/5/16	7/5/16	
Alkalinity - Carbonate (CO3)	ND	mg/L	1.0	SM 2320 B	7/5/16	7/5/16	
Alkalinity - CO2	**106**	mg/L	1.0	SM 2320 B	7/5/16	7/5/16	
Alkalinity - Hydroxide (OH)	ND	mg/L	1.0	SM 2320 B	7/5/16	7/5/16	
Alkalinity - Total (as CaCO3)	**115**	mg/L	1.0	SM 2320 B	7/5/16	7/5/16	
Ammonia as N	ND	mg/L	0.2	SM 4500 NH3 H	7/5/16	7/5/16	
Chlorine Residual, Total	ND	mg/L	0.10	SM 4500 Cl-G	7/1/16 16:50	7/1/16 16:50	SPH
Conductivity	**785**	umho/cm	1	EPA 120.1	7/4/16	7/4/16	
pH	**7.2**	pH Units	0.1	SM 4500 H-B	7/1/16 13:40	7/1/16 13:45	
Total Dissolved Solids (TDS)	**536**	mg/L	10	SM 2540 C	7/5/16	7/6/16	
Metals							
Antimony, Total	ND	mg/L	0.0005	EPA 200.8	7/5/16	7/5/16	
Arsenic, Total	**0.0006**	mg/L	0.0005	EPA 200.8	7/5/16	7/5/16	
Calcium, Total	**118**	mg/L	0.2	EPA 200.7	7/5/16	7/5/16	
Cadmium, Total	ND	mg/L	0.0002	EPA 200.8	7/5/16	7/5/16	
Lead, Total	ND	mg/L	0.0005	EPA 200.8	7/5/16	7/5/16	
Magnesium, Total	**27.6**	mg/L	0.2	EPA 200.7	7/5/16	7/5/16	
Selenium, Total	**0.0032**	mg/L	0.0005	EPA 200.8	7/5/16	7/5/16	
Thallium, Total	ND	mg/L	0.0002	EPA 200.8	7/5/16	7/5/16	
Zinc, Total	ND	mg/L	0.01	EPA 200.7	7/5/16	7/5/16	

Project Name: **16 PCMC MIW PHASE 1B TASK 4**   CtF WO#: **16G0030**
www.ChemtechFord.com   Page 2 of 6

Attachment D – Low Flow WET Test Results



W.E.T. Inc.
Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Cover Letter

October 25, 2016

Park City Municipal Corporation
Attn: Iwona Goodley
1884 3 Kings Drive
Park City, Utah 84060

Dear Iwona,

Enclosed is the report for the samples dated 10/09/2016. The laboratory ID assigned to these sample(s) were #9926 #9928, and #9933, consecutively. The sample was tested for chronic toxicity using Fathead Minnows and Ceriodaphnia dubia following the procedures listed in EPA 1000.0 and 1002.0 respectively. This report is comprised of 19 pages which include;

Cover Letter,
Chronic Whole Effluent Toxicity Reports, Fathead Minnow,
Chronic Whole Effluent Toxicity Testing Data, Fathead Minnows,
Chronic Whole Effluent Toxicity Reports, Ceriodaphnia dubia
Chronic Whole Effluent Toxicity Testing Data, Ceriodaphnia dubia
Chronic Whole Effluent Toxicity Chemical Report,
Data Reduction Fathead Minnow (Toxis Analysis Summary, 3 pages Survival and Growth)
Data Reduction Ceriodaphnia dubia (Toxis Analysis Summary, 3 pages Survival and Reproduction)
Reference Toxicant Charts, Fathead Minnows (2 pages Survival-LC50 and Growth-IC25)
Reference Toxicant Charts, Ceriodaphnia dubia (2 pages Survival-LC50 and Reproduction-IC25)
Completed Copies of the Chain of Custodies (3).

Our reports have been designed to meet requirements of National Environmental Accreditation Program, (NELAP), section 5.13. All these pages ***together*** constitute the final report, individual pages should not be removed. If copied, the report must be reconstructed in full. If you have not received any of these pages, or if you have any questions please give us a call at 801-763-0660. We look forward to doing business with you in the future.

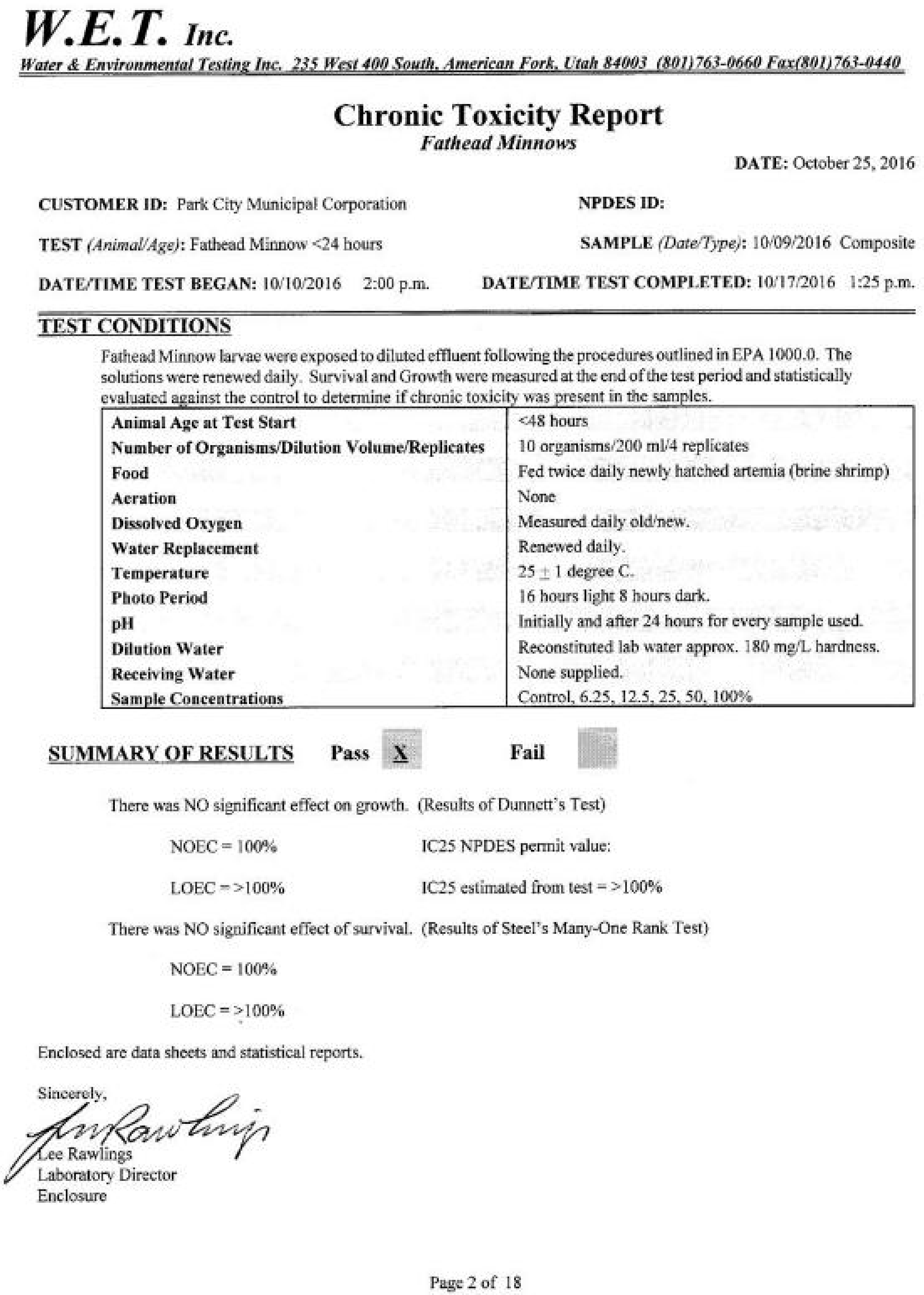
Sincerely,

Lee Rawlings
Lab Director

QA/QC Flags: None

Comments:

Page 1 of 18



W.E.T. Inc.
Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Toxicity Report

Fathead Minnows

DATE: October 25, 2016

CUSTOMER ID: Park City Municipal Corporation

NPDES ID:

TEST *(Animal/Age)*: Fathead Minnow <24 hours

SAMPLE *(Date/Type)*: 10/09/2016 Composite

DATE/TIME TEST BEGAN: 10/10/2016 2:00 p.m.

DATE/TIME TEST COMPLETED: 10/17/2016 1:25 p.m.

TEST CONDITIONS

Fathead Minnow larvae were exposed to diluted effluent following the procedures outlined in EPA 1000.0. The solutions were renewed daily. Survival and Growth were measured at the end of the test period and statistically evaluated against the control to determine if chronic toxicity was present in the samples.

Animal Age at Test Start	<48 hours
Number of Organisms/Dilution Volume/Replicates	10 organisms/200 ml/4 replicates
Food	Fed twice daily newly hatched artemia (brine shrimp)
Aeration	None
Dissolved Oxygen	Measured daily old/new.
Water Replacement	Renewed daily.
Temperature	25 ± 1 degree C.
Photo Period	16 hours light 8 hours dark.
pH	Initially and after 24 hours for every sample used.
Dilution Water	Reconstituted lab water approx. 180 mg/L hardness.
Receiving Water	None supplied.
Sample Concentrations	Control, 6.25, 12.5, 25, 50, 100%

SUMMARY OF RESULTS

Pass ☒ **Fail** ☐

There was NO significant effect on growth. (Results of Dunnett's Test)

NOEC = 100%

IC25 NPDES permit value:

LOEC = >100%

IC25 estimated from test = >100%

There was NO significant effect of survival. (Results of Steel's Many-One Rank Test)

NOEC = 100%

LOEC = >100%

Enclosed are data sheets and statistical reports.

Sincerely,

Lee Rawlings
Laboratory Director
Enclosure

Page 2 of 18

W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Toxicity Testing

Fathead Minnow

Customer ID: Park City Municipal Corporation

Final Mean Weight mg/fish: Control 0.52 6.25% 0.57 12.5% 0.52 25% 0.58 50.0% 0.63 100% 0.62 Pass X Fail __

Percent Lethality: Control 10% 6.25% 5% 12.5% 20% 25% 2.5% 50.0% 0% 100% 2.5% Pass X Fail __

IC25 value required by NPDES permit: __ %

IC25 estimated from the test: >100%

Sample Type/Date:
10/09/2016 3:00 p.m.
10/11/2016 3:15 p.m.
10/13/2016 3:00 p.m.

Analyses Dates/Times
Beginning 10/10/2016 2:00 p.m.
Ending 10/17/2016 1:25 p.m.

Initial Organism Age: <24 hours

Dilution Water/Control: EPA formulation for Hard Synthetic Fresh Water approximately 180 mg/L hardness.

FATHEAD MINNOWS
Replicates

	Number of Organisms/Percent Survival				**Mean Weight after 7 days (mg/fish)**				
Sample	A	B	C	D	A	B	C	D	Mean Weight
Control	8/80%	9/90%	9/90%	10/100%	0.41	0.55	0.50	0.61	0.52
6.25	8/80%	10/100%	10/100%	10/100%	0.41	0.66	0.62	0.58	0.57
12.5	7/70%	8/80%	7/70%	10/100%	0.49	0.51	0.49	0.60	0.52
25.0	10/100%	10/100%	9/90%	10/100%	0.61	0.60	0.53	0.56	0.58
50.0	10/100%	10/100%	10/100%	10/100%	0.58	0.66	0.66	0.62	0.63
100	9/90%	10/100%	10/100%	10/100%	0.59	0.61	0.63	0.65	0.62

Concentration (%)

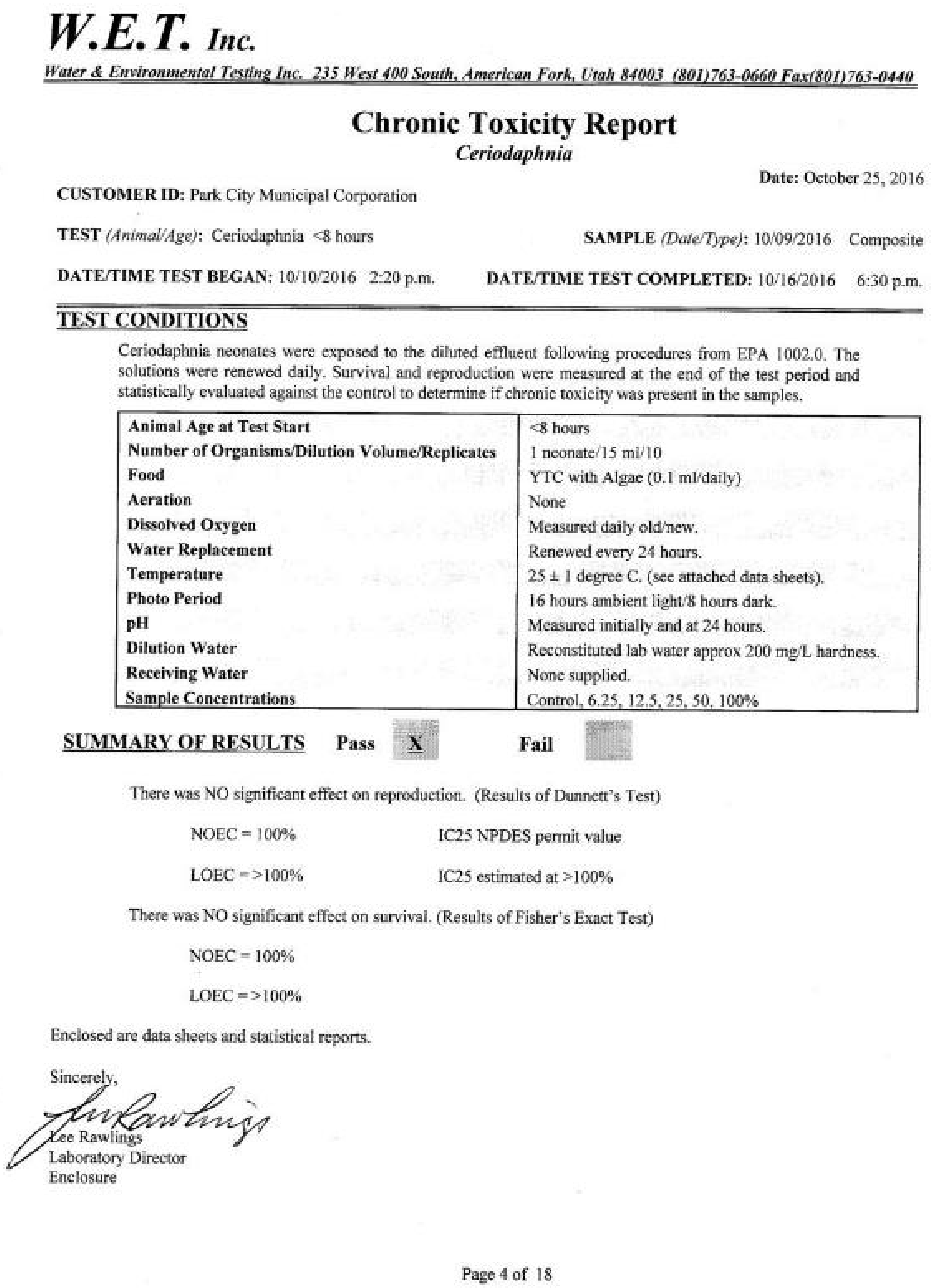
Max/Min	Control	6.25	12.5	25.0	50.0	100
Dissolved Oxygen	7.7/5.3	7.8/4.9	7.8/4.4	7.8/4.0	8.0/5.8	8.3/4.6
Temperature (°C)	25.0/23.8	25.0/23.8	25.0/23.8	25.0/23.8	25.0/23.8	25.0/23.8
Ph	8.56/8.10	8.33/7.95	8.20/7.87	8.05/7.71	7.99/7.36	7.84/7.00

Dilution Water (Average) Hardness: 176 mg/L **Alkalinity:** 128 mg/L **Conductivity:** 589 umhos/cm

Laboratory Director: Lee Rawlings **Laboratory:** Water & Environmental Testing, Inc.

Signature: Lee Rawlings **Date:** 10/30/16

Comments:



W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Toxicity Report

Ceriodaphnia

Date: October 25, 2016

CUSTOMER ID: Park City Municipal Corporation

TEST *(Animal/Age)*: Ceriodaphnia <8 hours

SAMPLE *(Date/Type)*: 10/09/2016 Composite

DATE/TIME TEST BEGAN: 10/10/2016 2:20 p.m.

DATE/TIME TEST COMPLETED: 10/16/2016 6:30 p.m.

TEST CONDITIONS

Ceriodaphnia neonates were exposed to the diluted effluent following procedures from EPA 1002.0. The solutions were renewed daily. Survival and reproduction were measured at the end of the test period and statistically evaluated against the control to determine if chronic toxicity was present in the samples.

Animal Age at Test Start	<8 hours
Number of Organisms/Dilution Volume/Replicates	1 neonate/15 ml/10
Food	YTC with Algae (0.1 ml/daily)
Aeration	None
Dissolved Oxygen	Measured daily old/new.
Water Replacement	Renewed every 24 hours.
Temperature	25 ± 1 degree C. (see attached data sheets).
Photo Period	16 hours ambient light/8 hours dark.
pH	Measured initially and at 24 hours.
Dilution Water	Reconstituted lab water approx 200 mg/L hardness.
Receiving Water	None supplied.
Sample Concentrations	Control, 6.25, 12.5, 25, 50, 100%

SUMMARY OF RESULTS

Pass X **Fail**

There was NO significant effect on reproduction. (Results of Dunnett's Test)

NOEC = 100%   IC25 NPDES permit value

LOEC = >100%   IC25 estimated at >100%

There was NO significant effect on survival. (Results of Fisher's Exact Test)

NOEC = 100%

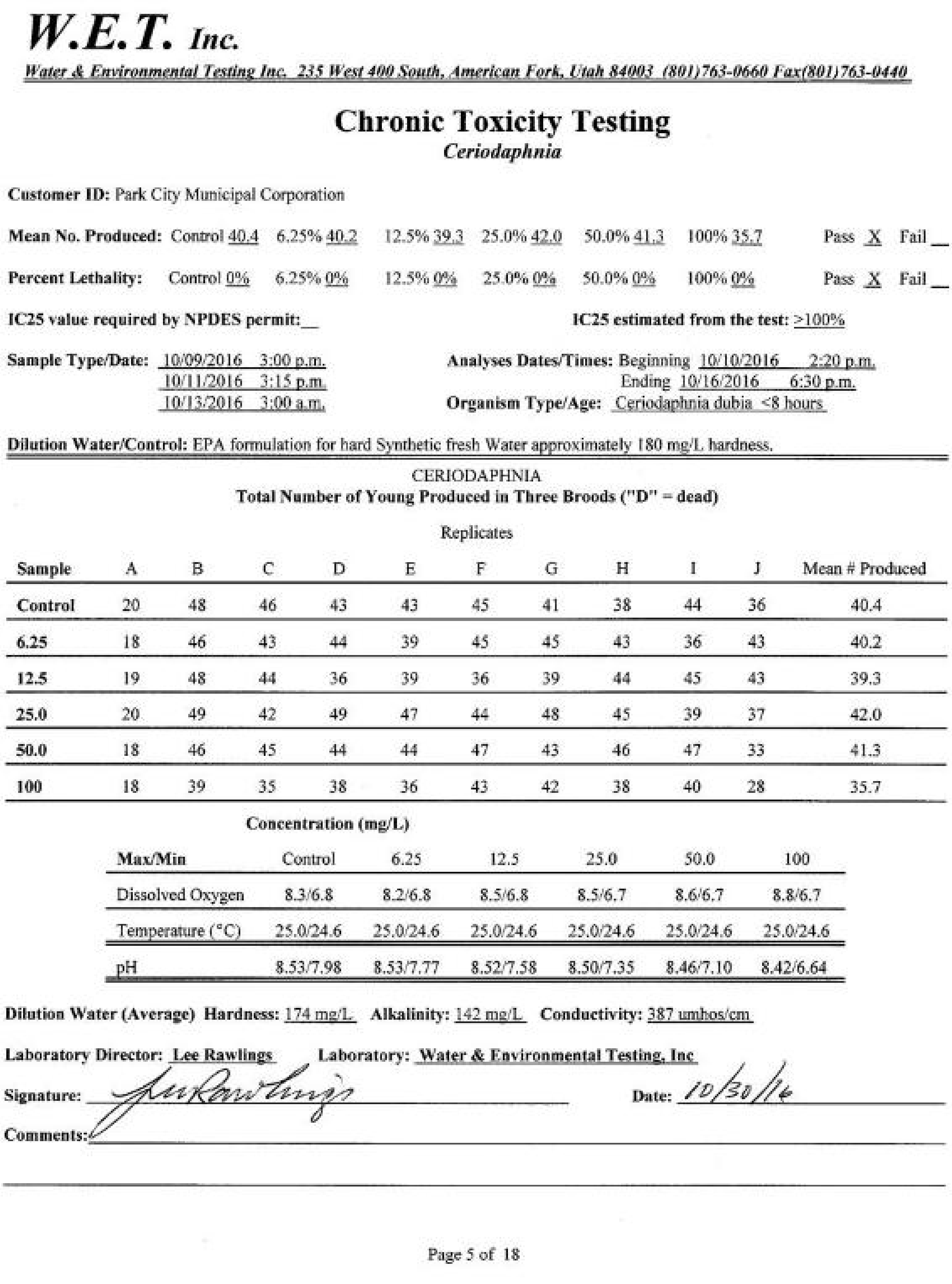
LOEC = >100%

Enclosed are data sheets and statistical reports.

Sincerely,

Lee Rawlings
Laboratory Director
Enclosure

Page 4 of 18



W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Toxicity Testing

Ceriodaphnia

Customer ID: Park City Municipal Corporation

Mean No. Produced: Control 40.4 6.25% 40.2 12.5% 39.3 25.0% 42.0 50.0% 41.3 100% 35.7 Pass X Fail __

Percent Lethality: Control 0% 6.25% 0% 12.5% 0% 25.0% 0% 50.0% 0% 100% 0% Pass X Fail __

IC25 value required by NPDES permit: __

IC25 estimated from the test: >100%

Sample Type/Date: 10/09/2016 3:00 p.m.
10/11/2016 3:15 p.m.
10/13/2016 3:00 a.m.

Analyses Dates/Times: Beginning 10/10/2016 2:20 p.m.
Ending 10/16/2016 6:30 p.m.

Organism Type/Age: Ceriodaphnia dubia <8 hours

Dilution Water/Control: EPA formulation for hard Synthetic fresh Water approximately 180 mg/L hardness.

CERIODAPHNIA

Total Number of Young Produced in Three Broods ("D" = dead)

Replicates

Sample	A	B	C	D	E	F	G	H	I	J	Mean # Produced
Control	20	48	46	43	43	45	41	38	44	36	40.4
6.25	18	46	43	44	39	45	45	43	36	43	40.2
12.5	19	48	44	36	39	36	39	44	45	43	39.3
25.0	20	49	42	49	47	44	48	45	39	37	42.0
50.0	18	46	45	44	44	47	43	46	47	33	41.3
100	18	39	35	38	36	43	42	38	40	28	35.7

Concentration (mg/L)

Max/Min	Control	6.25	12.5	25.0	50.0	100
Dissolved Oxygen	8.3/6.8	8.2/6.8	8.5/6.8	8.5/6.7	8.6/6.7	8.8/6.7
Temperature (°C)	25.0/24.6	25.0/24.6	25.0/24.6	25.0/24.6	25.0/24.6	25.0/24.6
pH	8.53/7.98	8.53/7.77	8.52/7.58	8.50/7.35	8.46/7.10	8.42/6.64

Dilution Water (Average) Hardness: 174 mg/L **Alkalinity:** 142 mg/L **Conductivity:** 387 umhos/cm

Laboratory Director: Lee Rawlings **Laboratory:** Water & Environmental Testing, Inc

Signature: Lee Rawlings **Date:** 10/30/16

Comments:

W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 300 South, American Fork Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Whole Effluent Toxicity Chemical Result Report

October 25, 2016

CUSTOMER NAME:
Park City Municipal Corporation
Attn: Iwona Goodley
1884 3 Kings Drive
Park City, Utah 84060

SAMPLE DESCRIPTION:

Chemistries to go with Chronic Biomonitoring testing sampled on 10/09/2016.

Analysis	Chronic Daphnia			Chronic Minnow		
	Repl. 1	Repl. 2	Repl. 3	Repl. 1	Repl. 2	Repl. 3
Log #	9926	9928	9933	9926	9928	9933
Total Hardness, Recon (EPA 130.2), mg/L	176	176	176	176	176	176
Total Hardness, Effluent (EPA 130.2), mg/L	452	440	425	452	440	424
Ammonia, Effluent (EPA 350.2/350.3), mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Initial Chlorine Residual (EPA 330.5), mg/L	0.25	0.10	0.12	0.25	0.10	0.12
Final Chlorine Residual (EPA 330.5), mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Conductivity, Effluent (EPA 120.1), umhos/cm	868	850	858	868	850	858
Alkalinity, Effluent (EPA 310.1), mg/L $CaCO^3$	74	84	90	74	84	90
Recon Initial pH (EPA 150.1)	8.44	7.98	8.08	8.41	8.23	8.45
After 24 hours pH (EPA 150.1)	8.52	8.52	8.53	8.18	8.13	8.23
100% Initial pH (EPA 150.1)	6.96	6.64	7.02	7.00	7.02	7.07
100% After 24 hours pH (EPA 150.1)	8.27	8.31	8.42	7.84	7.70	7.72

Reviewed: Lee Rawlings, Lab Director
Water & Environmental Testing, Inc.

Page 6 of 18

Larval Fish Growth and Survival Test-7 Day Survival

Start Date:	10/10/2016 14:00	Test ID:	PC10-16cf	Sample ID:	Park City 10-16 chronic fathead
End Date:	10/17/2016 13:25	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	PP-Pimephales promelas
Comments:					

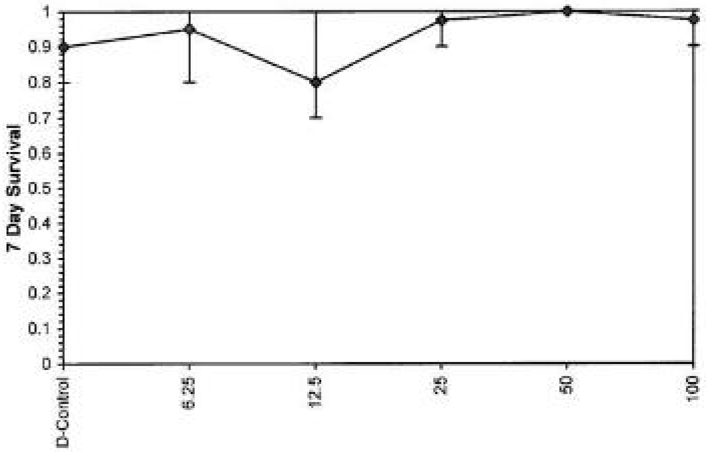
Conc-%	1	2	3	4
D-Control	0.8000	0.9000	0.9000	1.0000
6.25	0.8000	1.0000	1.0000	1.0000
12.5	0.7000	0.8000	0.7000	1.0000
25	1.0000	1.0000	0.9000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	0.9000	1.0000	1.0000	1.0000

			Transform: Arcsin Square Root					Rank	1-Tailed
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical
D-Control	0.9000	1.0000	1.2543	1.1071	1.4120	9.935	4		
6.25	0.9500	1.0556	1.3358	1.1071	1.4120	11.411	4	21.00	10.00
12.5	0.8000	0.8889	1.1254	0.9912	1.4120	17.662	4	14.00	10.00
25	0.9750	1.0833	1.3713	1.2490	1.4120	5.942	4	22.50	10.00
50	1.0000	1.1111	1.4120	1.4120	1.4120	0.000	4	24.00	10.00
100	0.9750	1.0833	1.3713	1.2490	1.4120	5.942	4	22.50	10.00

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.92595	0.916	0.20259	1.2316
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs D-Control				

Dose-Response Plot



Page 1 ToxCalc v5.0.32 Reviewed by: LR

Larval Fish Growth and Survival Test-7 Day Growth

Start Date:	10/10/2016 14:00	Test ID:	PC10-16cf	Sample ID:	Park City 10-16 chronic fathead
End Date:	10/17/2016 13:25	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	PP-Pimephales promelas
Comments:					

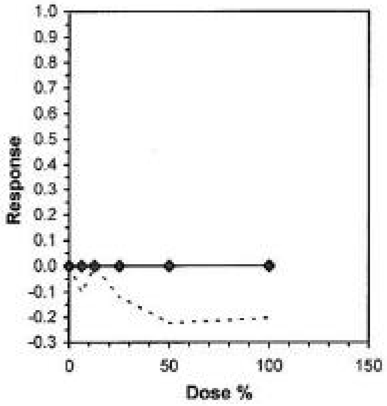
Conc-%	1	2	3	4
D-Control	0.4060	0.5490	0.4990	0.6070
6.25	0.4060	0.6640	0.6160	0.5770
12.5	0.4810	0.5060	0.4850	0.6000
25	0.6080	0.5980	0.5330	0.5610
50	0.5840	0.6560	0.6620	0.6190
100	0.5890	0.6080	0.6320	0.6500

			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	0.5153	1.0000	0.5153	0.4060	0.6070	16.528	4				0.5707	1.0000
6.25	0.5658	1.0980	0.5658	0.4060	0.6640	19.847	4	-1.081	2.410	0.1126	0.5707	1.0000
12.5	0.5180	1.0053	0.5180	0.4810	0.6000	10.764	4	-0.059	2.410	0.1126	0.5707	1.0000
25	0.5750	1.1160	0.5750	0.5330	0.6080	6.006	4	-1.279	2.410	0.1126	0.5707	1.0000
50	0.6303	1.2232	0.6303	0.5840	0.6620	5.748	4	-2.462	2.410	0.1126	0.5707	1.0000
100	0.6197	1.2028	0.6197	0.5890	0.6500	4.318	4	-2.237	2.410	0.1126	0.5707	1.0000

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.94056		0.916		-0.7401	1.53054
Bartlett's Test indicates equal variances (p = 0.15)					8.17362		15.0863			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.11259	0.21851	0.00948	0.00437	0.10307	5, 18
Treatments vs D-Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



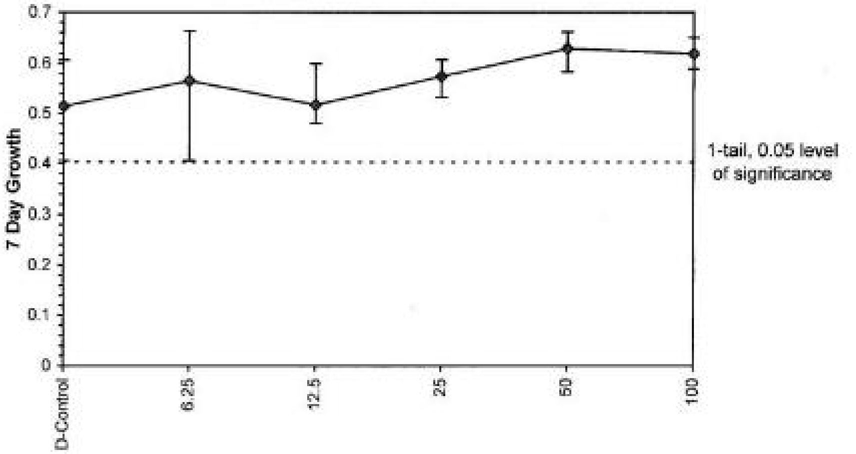
ToxCalc v5.0.32

Reviewed by: LR

Larval Fish Growth and Survival Test-7 Day Growth

Start Date:	10/10/2016 14:00	Test ID:	PC10-16cf	Sample ID:	Park City 10-16 chronic fathead
End Date:	10/17/2016 13:25	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	PP-Pimephales promelas
Comments:					

Dose-Response Plot



Reviewed by:

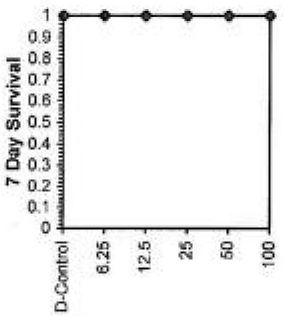
Ceriodaphnia Survival and Reproduction Test-7 Day Survival

Start Date:	10/10/2016 14:20	Test ID:	PC10-16cc	Sample ID:	Park City 10-16 chronic cero
End Date:	10/16/2016 18:30	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6	7	8	9	10
D-Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6.25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical
D-Control	1.0000	1.0000	0	10	10	10		
6.25	1.0000	1.0000	0	10	10	10	1.0000	0.0500
12.5	1.0000	1.0000	0	10	10	10	1.0000	0.0500
25	1.0000	1.0000	0	10	10	10	1.0000	0.0500
50	1.0000	1.0000	0	10	10	10	1.0000	0.0500
100	1.0000	1.0000	0	10	10	10	1.0000	0.0500

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test Treatments vs D-Control	100	>100		1



Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/10/2016 14:20	Test ID:	PC10-16cc	Sample ID:	Park City 10-16 chronic cero
End Date:	10/16/2016 18:30	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6	7	8	9	10
D-Control	20.000	48.000	46.000	43.000	43.000	45.000	41.000	38.000	44.000	36.000
6.25	18.000	46.000	43.000	44.000	39.000	45.000	45.000	43.000	36.000	43.000
12.5	19.000	48.000	44.000	36.000	39.000	36.000	39.000	44.000	45.000	43.000
25	20.000	49.000	42.000	49.000	47.000	44.000	48.000	45.000	39.000	37.000
50	18.000	46.000	45.000	44.000	44.000	47.000	43.000	46.000	47.000	33.000
100	18.000	39.000	35.000	38.000	36.000	43.000	42.000	38.000	40.000	28.000

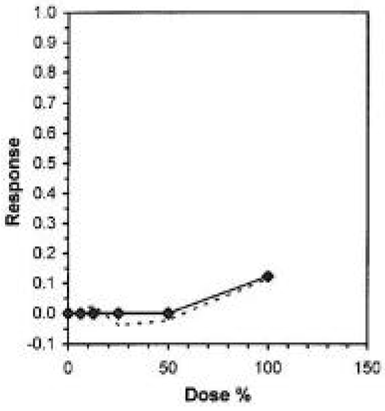
			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
D-Control	40.400	1.0000	40.400	20.000	48.000	19.843	10			40.640	1.0000
6.25	40.200	0.9950	40.200	18.000	46.000	20.806	10	104.50	75.00	40.640	1.0000
12.5	39.300	0.9728	39.300	19.000	48.000	20.778	10	99.00	75.00	40.640	1.0000
25	42.000	1.0396	42.000	20.000	49.000	20.848	10	117.00	75.00	40.640	1.0000
50	41.300	1.0223	41.300	18.000	47.000	22.134	10	116.50	75.00	40.640	1.0000
100	35.700	0.8837	35.700	18.000	43.000	21.005	10	78.50	75.00	35.700	0.8784

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Kolmogorov D Test indicates non-normal distribution (p <= 0.05)	1.70795	0.895	-1.8334	2.6447
Bartlett's Test indicates equal variances (p = 0.99)	0.41272	15.0863		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs D-Control				

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL	Skew
IC05	70.567			
IC10	91.134			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



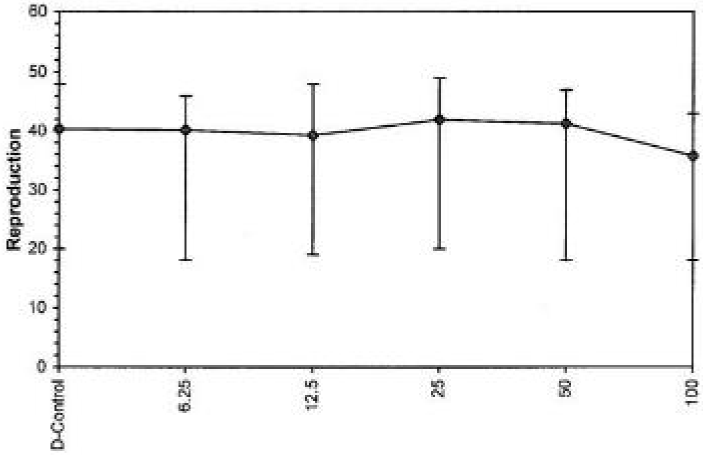
ToxCalc v5.0.32

Reviewed by: 4R

Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/10/2016 14:20	Test ID:	PC10-16cc	Sample ID:	Park City 10-16 chronic cero
End Date:	10/16/2016 18:30	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Page 2 ToxCalc v5.0.32 Reviewed by:

Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/10/2016 14:20	Test ID:	PC10-16cc	Sample ID:	Park City 10-16 chronic cero
End Date:	10/16/2016 18:30	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

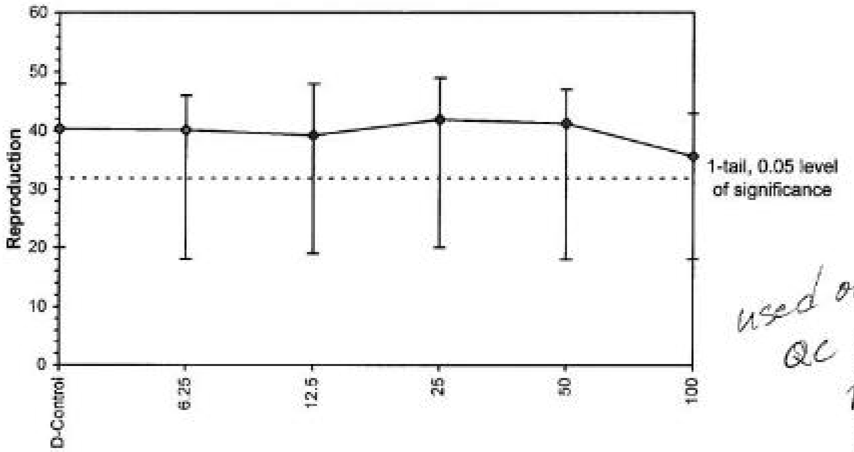
Conc-%	1	2	3	4	5	6	7	8	9	10
D-Control	20.000	48.000	46.000	43.000	43.000	45.000	41.000	38.000	44.000	36.000
6.25	18.000	46.000	43.000	44.000	39.000	45.000	45.000	43.000	36.000	43.000
12.5	19.000	48.000	44.000	36.000	39.000	36.000	39.000	44.000	45.000	43.000
25	20.000	49.000	42.000	49.000	47.000	44.000	48.000	45.000	39.000	37.000
50	18.000	46.000	45.000	44.000	44.000	47.000	43.000	46.000	47.000	33.000
100	18.000	39.000	35.000	38.000	36.000	43.000	42.000	38.000	40.000	28.000

			Transform: Untransformed						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
D-Control	40.400	1.0000	40.400	20.000	48.000	19.843	10			
6.25	40.200	0.9950	40.200	18.000	46.000	20.806	10	0.054	2.287	8.529
12.5	39.300	0.9728	39.300	19.000	48.000	20.778	10	0.295	2.287	8.529
25	42.000	1.0396	42.000	20.000	49.000	20.848	10	-0.429	2.287	8.529
50	41.300	1.0223	41.300	18.000	47.000	22.134	10	-0.241	2.287	8.529
100	35.700	0.8837	35.700	18.000	43.000	21.005	10	1.260	2.287	8.529

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Kolmogorov D Test indicates non-normal distribution (p <= 0.05)	1.70795	0.895	-1.8334	2.6447
Bartlett's Test indicates equal variances (p = 0.99)	0.41272	15.0863		

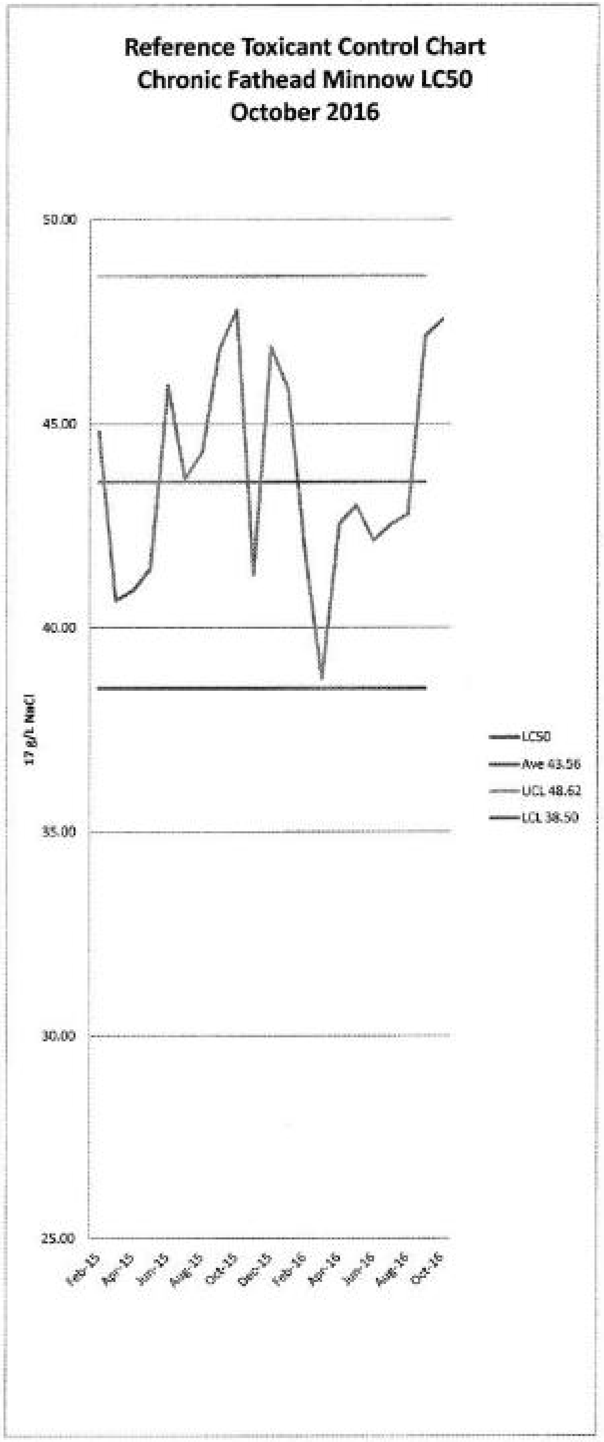
Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test Treatments vs D-Control	100	>100		1	8.52906	0.21112	49.3367	69.5611	0.61907	5, 54

Dose-Response Plot

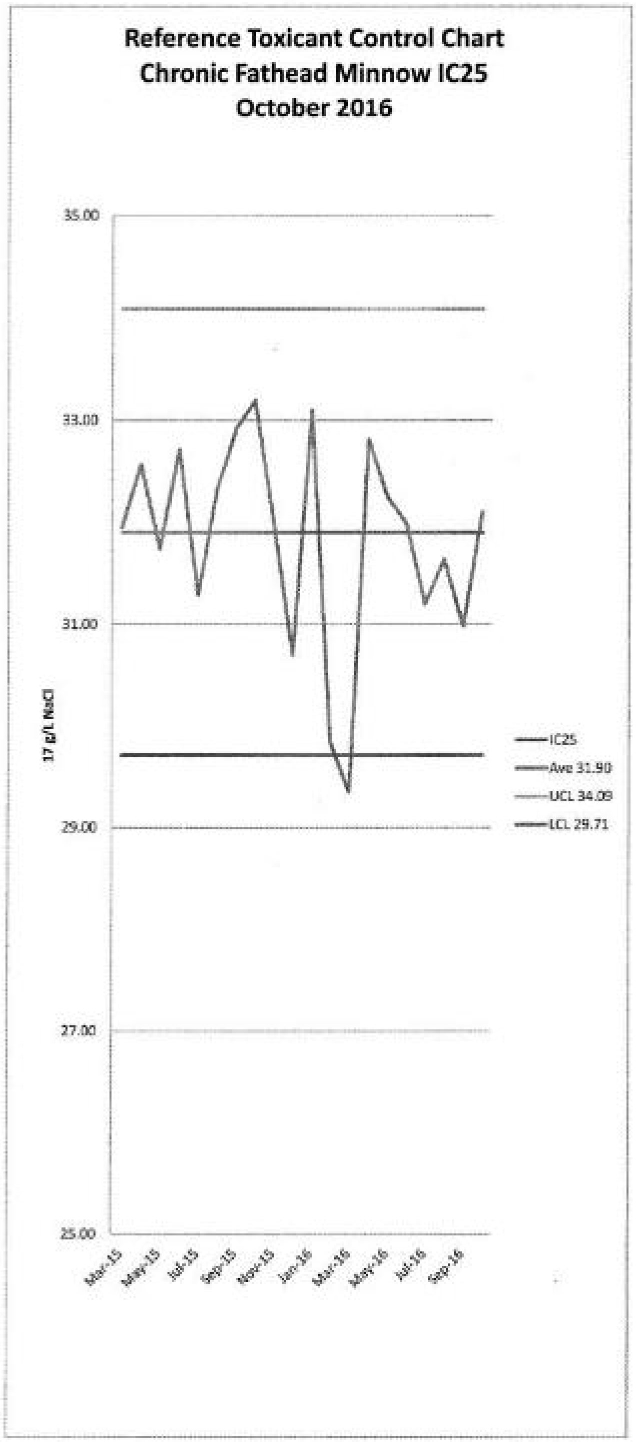


used only for
QC check
Pass
VR
10/19/16

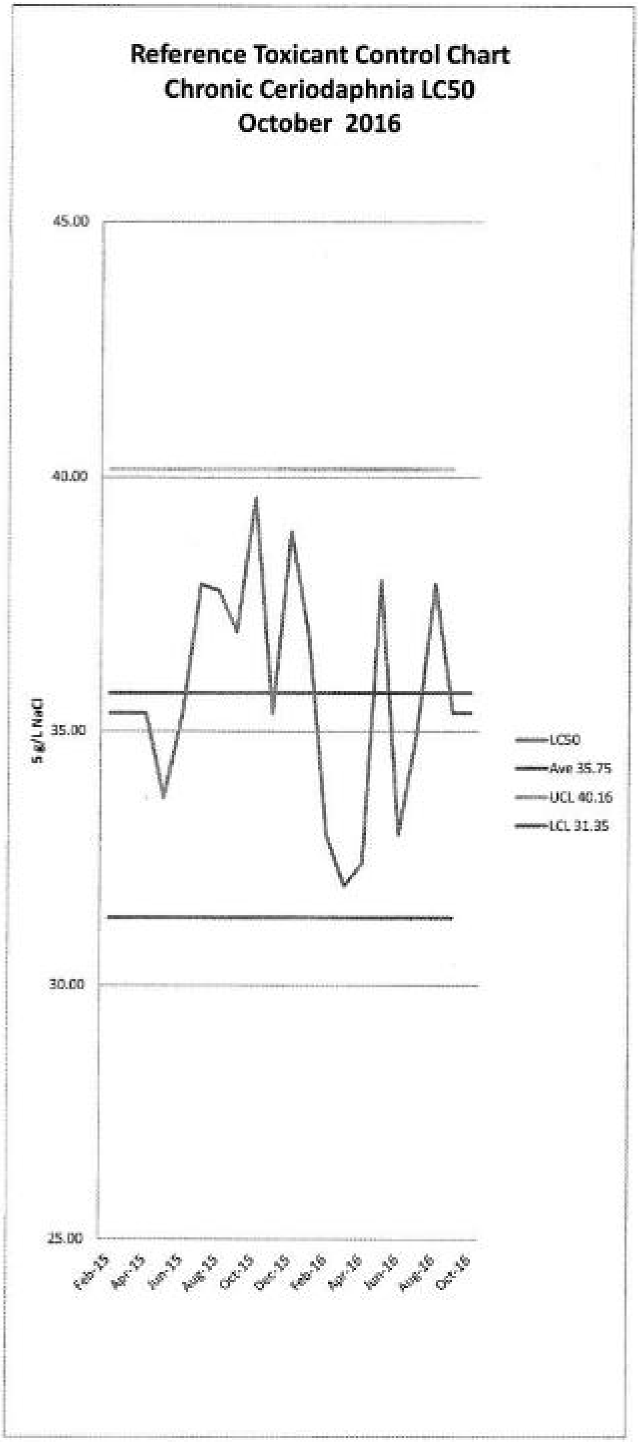
Page 1 ToxCalc v5.0.32 Reviewed by: VR

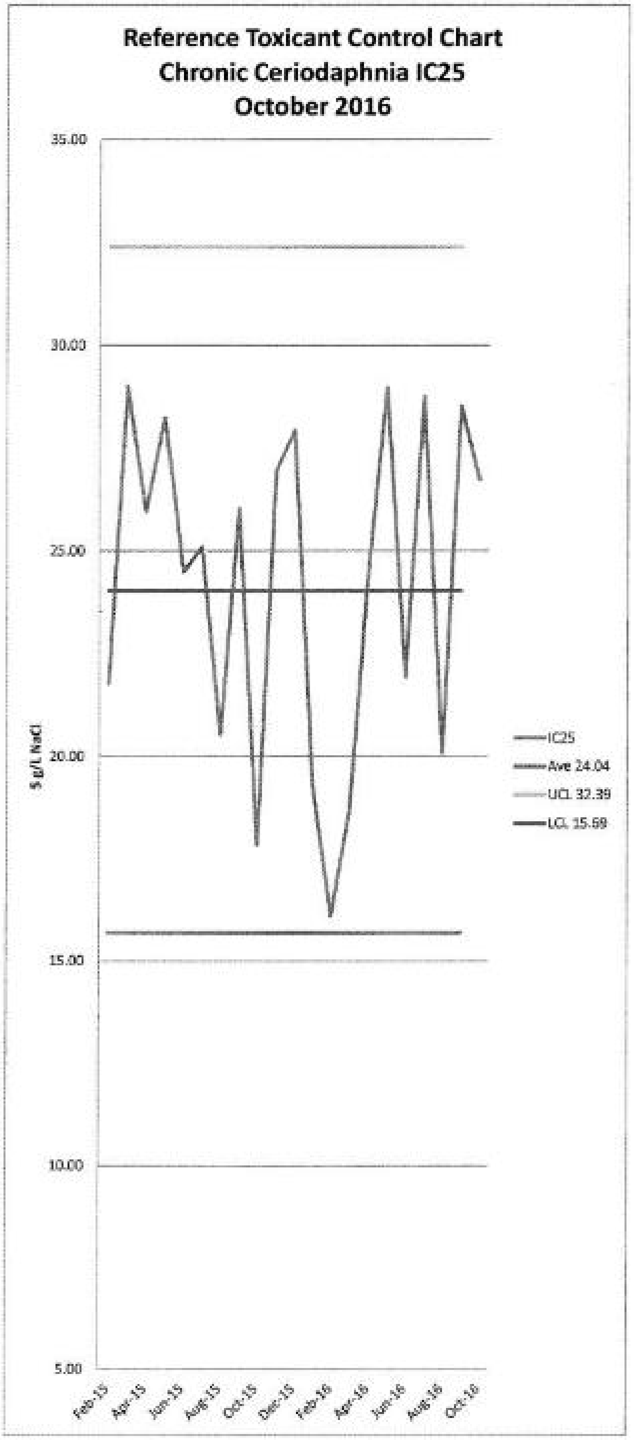


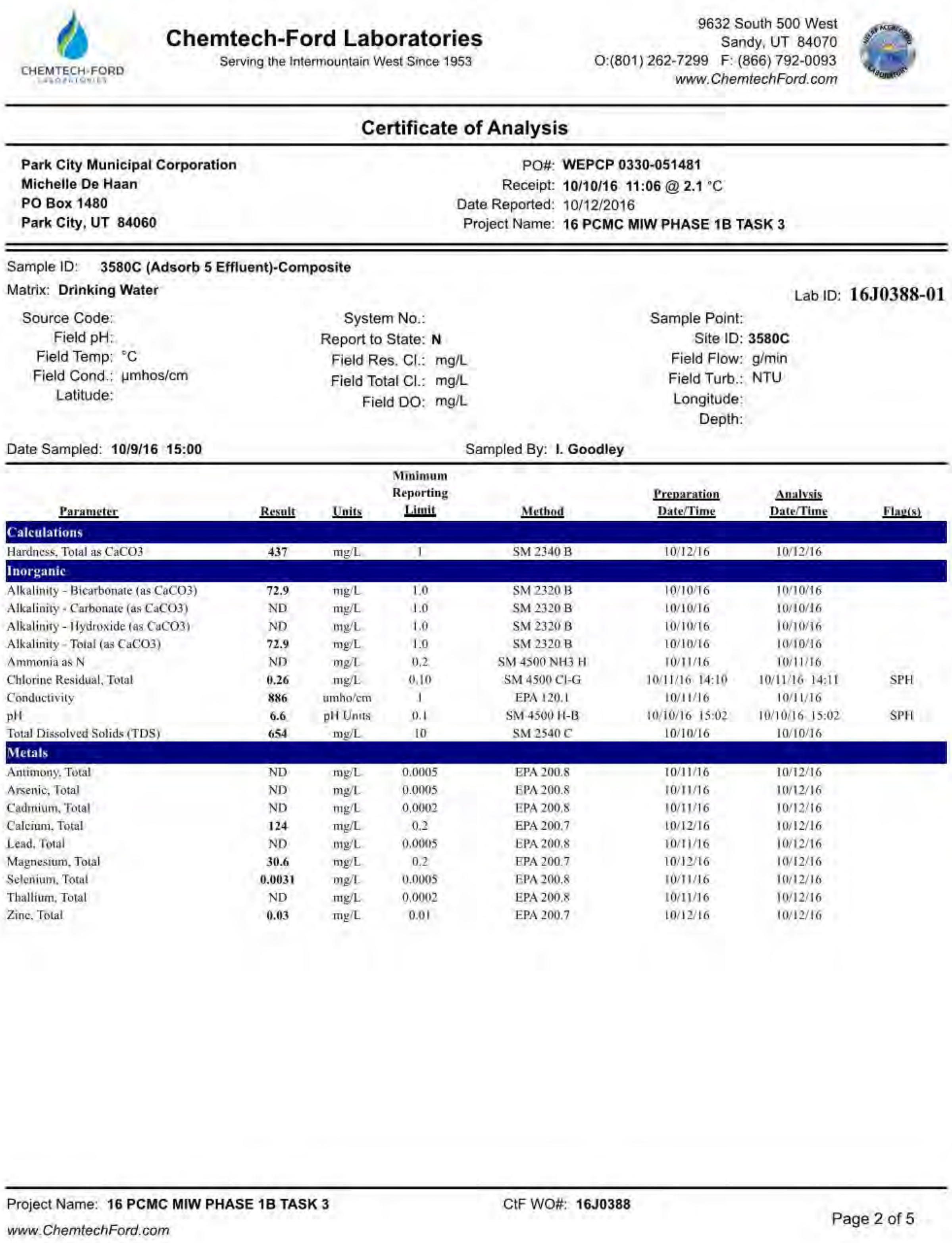
Reference Toxicant Control Chart
Chronic Fathead Minnow LC50
October 2016



Reference Toxicant Control Chart
Chronic Fathead Minnow IC25
October 2016


Reference Toxicant Control Chart
Chronic Ceriodaphnia LC50
October 2016
45.00
40.00
35.00
30.00
25.00
5 g/L NaCl
Feb-15
Apr-15
Jun-15
Aug-15
Oct-15
Dec-15
Feb-16
Apr-16
Jun-16
Aug-16
Oct-16
LC50
Ave 35.75
UCL 40.16
LCL 31.35


Reference Toxicant Control Chart
Chronic Ceriodaphnia IC25
October 2016



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Certificate of Analysis

Park City Municipal Corporation
Michelle De Haan
PO Box 1480
Park City, UT 84060

PO#: **WEPCP 0330-051481**
Receipt: **10/10/16 11:06 @ 2.1** °C
Date Reported: 10/12/2016
Project Name: **16 PCMC MIW PHASE 1B TASK 3**

Sample ID: **3580C (Adsorb 5 Effluent)-Composite**
Matrix: **Drinking Water**
Lab ID: **16J0388-01**

Source Code:
Field pH:
Field Temp: °C
Field Cond.: µmhos/cm
Latitude:

System No.:
Report to State: **N**
Field Res. Cl.: mg/L
Field Total Cl.: mg/L
Field DO: mg/L

Sample Point:
Site ID: **3580C**
Field Flow: g/min
Field Turb.: NTU
Longitude:
Depth:

Date Sampled: **10/9/16 15:00**
Sampled By: **I. Goodley**

Parameter	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Calculations							
Hardness, Total as CaCO3	**437**	mg/L	1	SM 2340 B	10/12/16	10/12/16	
Inorganic							
Alkalinity - Bicarbonate (as CaCO3)	**72.9**	mg/L	1.0	SM 2320 B	10/10/16	10/10/16	
Alkalinity - Carbonate (as CaCO3)	ND	mg/L	1.0	SM 2320 B	10/10/16	10/10/16	
Alkalinity - Hydroxide (as CaCO3)	ND	mg/L	1.0	SM 2320 B	10/10/16	10/10/16	
Alkalinity - Total (as CaCO3)	**72.9**	mg/L	1.0	SM 2320 B	10/10/16	10/10/16	
Ammonia as N	ND	mg/L	0.2	SM 4500 NH3 H	10/11/16	10/11/16	
Chlorine Residual, Total	**0.26**	mg/L	0.10	SM 4500 Cl-G	10/11/16 14:10	10/11/16 14:11	SPH
Conductivity	**886**	umho/cm	1	EPA 120.1	10/11/16	10/11/16	
pH	**6.6**	pH Units	0.1	SM 4500 H-B	10/10/16 15:02	10/10/16 15:02	SPH
Total Dissolved Solids (TDS)	**654**	mg/L	10	SM 2540 C	10/10/16	10/10/16	
Metals							
Antimony, Total	ND	mg/L	0.0005	EPA 200.8	10/11/16	10/12/16	
Arsenic, Total	ND	mg/L	0.0005	EPA 200.8	10/11/16	10/12/16	
Cadmium, Total	ND	mg/L	0.0002	EPA 200.8	10/11/16	10/12/16	
Calcium, Total	**124**	mg/L	0.2	EPA 200.7	10/12/16	10/12/16	
Lead, Total	ND	mg/L	0.0005	EPA 200.8	10/11/16	10/12/16	
Magnesium, Total	**30.6**	mg/L	0.2	EPA 200.7	10/12/16	10/12/16	
Selenium, Total	**0.0031**	mg/L	0.0005	EPA 200.8	10/11/16	10/12/16	
Thallium, Total	ND	mg/L	0.0002	EPA 200.8	10/11/16	10/12/16	
Zinc, Total	**0.03**	mg/L	0.01	EPA 200.7	10/12/16	10/12/16	

Project Name: **16 PCMC MIW PHASE 1B TASK 3**
CtF WO#: **16J0388**
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Page 2 of 5

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PO Box 1480
Park City, UT 84060

PO#: **WEPCP 0330-051481**
Receipt: **10/12/16 9:37 @ 0.3** °C
Date Reported: 10/18/2016
Project Name: **16 PCMC MIW PHASE 1B TASK 3**

Sample ID: **3580C (Adsorb 5 Eff)-Composite**
Matrix: **Water**
Lab ID: **16J0497-01**

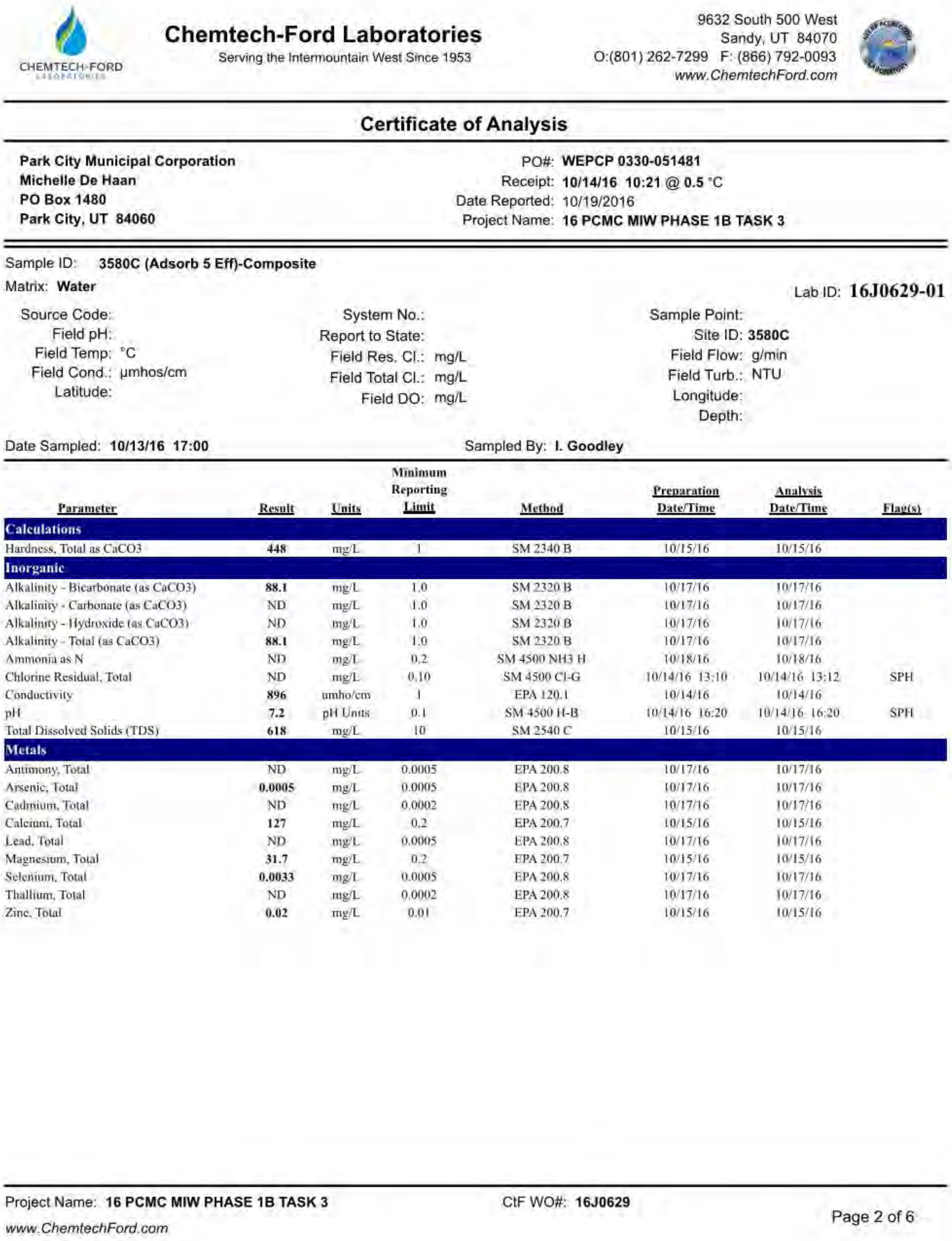
Source Code:
Field pH:
Field Temp: °C
Field Cond.: µmhos/cm
Latitude:

System No.:
Report to State:
Field Res. Cl.: mg/L
Field Total Cl.: mg/L
Field DO: mg/L

Sample Point:
Site ID: **3580C**
Field Flow: g/min
Field Turb.: NTU
Longitude:
Depth:

Date Sampled: **10/11/16 15:15**
Sampled By: **I. Goodley**

Parameter	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Calculations							
Hardness, Total as CaCO3	**426**	mg/L	1	SM 2340 B	10/13/16	10/13/16	
Inorganic							
Alkalinity - Bicarbonate (as CaCO3)	**81.8**	mg/L	1.0	SM 2320 B	10/13/16	10/14/16	
Alkalinity - Carbonate (as CaCO3)	ND	mg/L	1.0	SM 2320 B	10/13/16	10/14/16	
Alkalinity - Hydroxide (as CaCO3)	ND	mg/L	1.0	SM 2320 B	10/13/16	10/14/16	
Alkalinity - Total (as CaCO3)	**81.8**	mg/L	1.0	SM 2320 B	10/13/16	10/14/16	
Ammonia as N	ND	mg/L	0.2	SM 4500 NH3 H	10/13/16	10/13/16	
Chlorine Residual, Total	ND	mg/L	0.10	SM 4500 Cl-G	10/13/16 10:36	10/13/16 10:38	SPH
Conductivity	**865**	umho/cm	1	EPA 120.1	10/14/16	10/14/16	
pH	**6.6**	pH Units	0.1	SM 4500 H-B	10/12/16 17:00	10/12/16 17:00	SPH
Total Dissolved Solids (TDS)	**622**	mg/L	10	SM 2540 C	10/12/16	10/12/16	
Metals							
Antimony, Total	ND	mg/L	0.0005	EPA 200.8	10/14/16	10/14/16	
Arsenic, Total	ND	mg/L	0.0005	EPA 200.8	10/14/16	10/14/16	
Cadmium, Total	ND	mg/L	0.0002	EPA 200.8	10/14/16	10/14/16	
Calcium, Total	**121**	mg/L	0.2	EPA 200.7	10/13/16	10/13/16	
Lead, Total	ND	mg/L	0.0005	EPA 200.8	10/14/16	10/14/16	
Magnesium, Total	**29.7**	mg/L	0.2	EPA 200.7	10/13/16	10/13/16	
Selenium, Total	**0.0030**	mg/L	0.0005	EPA 200.8	10/14/16	10/14/16	
Thallium, Total	ND	mg/L	0.0002	EPA 200.8	10/14/16	10/14/16	
Zinc, Total	**0.01**	mg/L	0.01	EPA 200.7	10/13/16	10/13/16	



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Certificate of Analysis

Park City Municipal Corporation
Michelle De Haan
PO Box 1480
Park City, UT 84060

PO#: **WEPCP 0330-051481**
Receipt: **10/14/16 10:21 @ 0.5** °C
Date Reported: 10/19/2016
Project Name: **16 PCMC MIW PHASE 1B TASK 3**

Sample ID: **3580C (Adsorb 5 Eff)-Composite**
Matrix: **Water**
Lab ID: **16J0629-01**

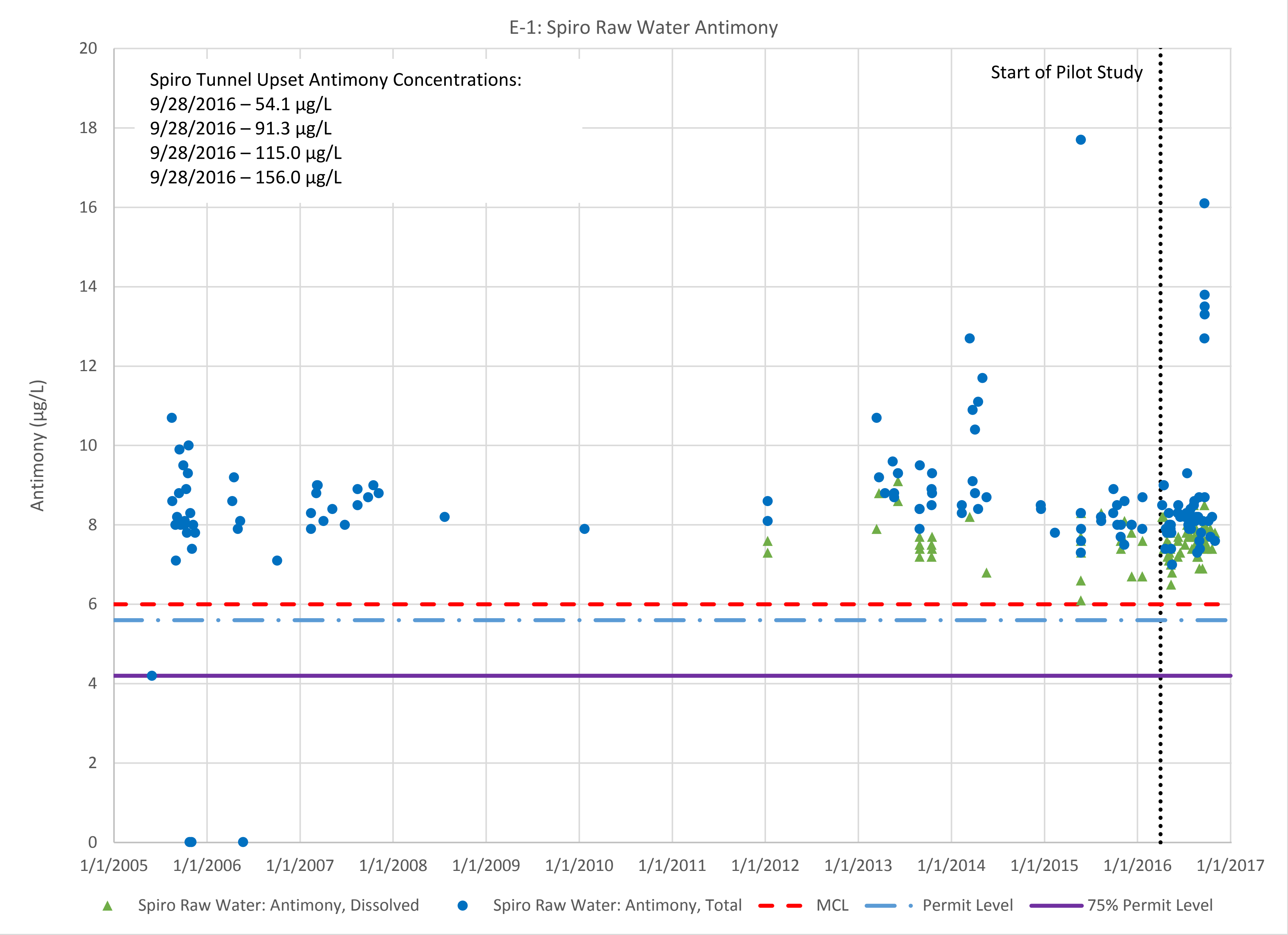
Source Code:	System No.:	Sample Point:
Field pH:	Report to State:	Site ID: **3580C**
Field Temp: °C	Field Res. Cl.: mg/L	Field Flow: g/min
Field Cond.: µmhos/cm	Field Total Cl.: mg/L	Field Turb.: NTU
Latitude:	Field DO: mg/L	Longitude:
		Depth:

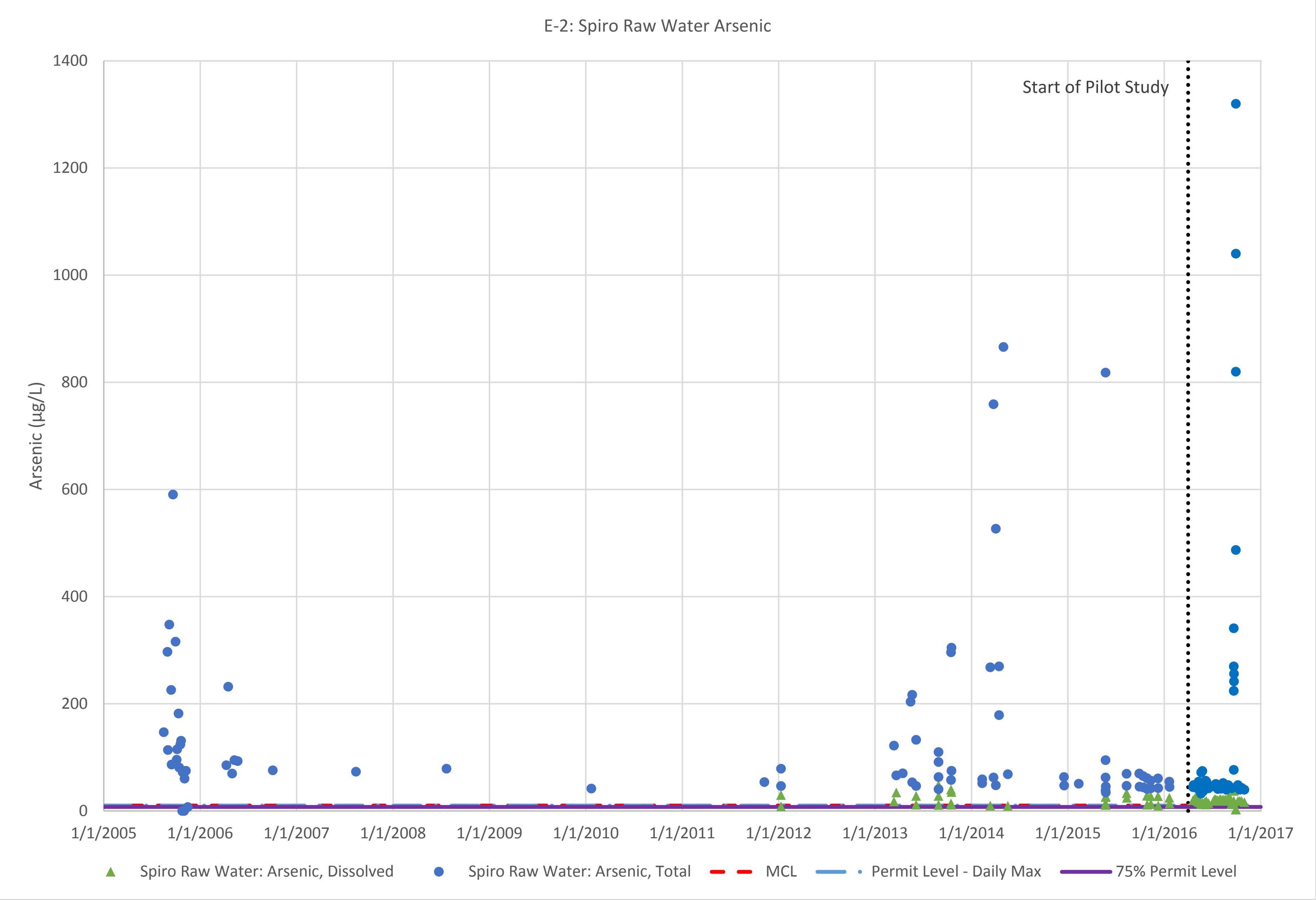
Date Sampled: **10/13/16 17:00**
Sampled By: **I. Goodley**

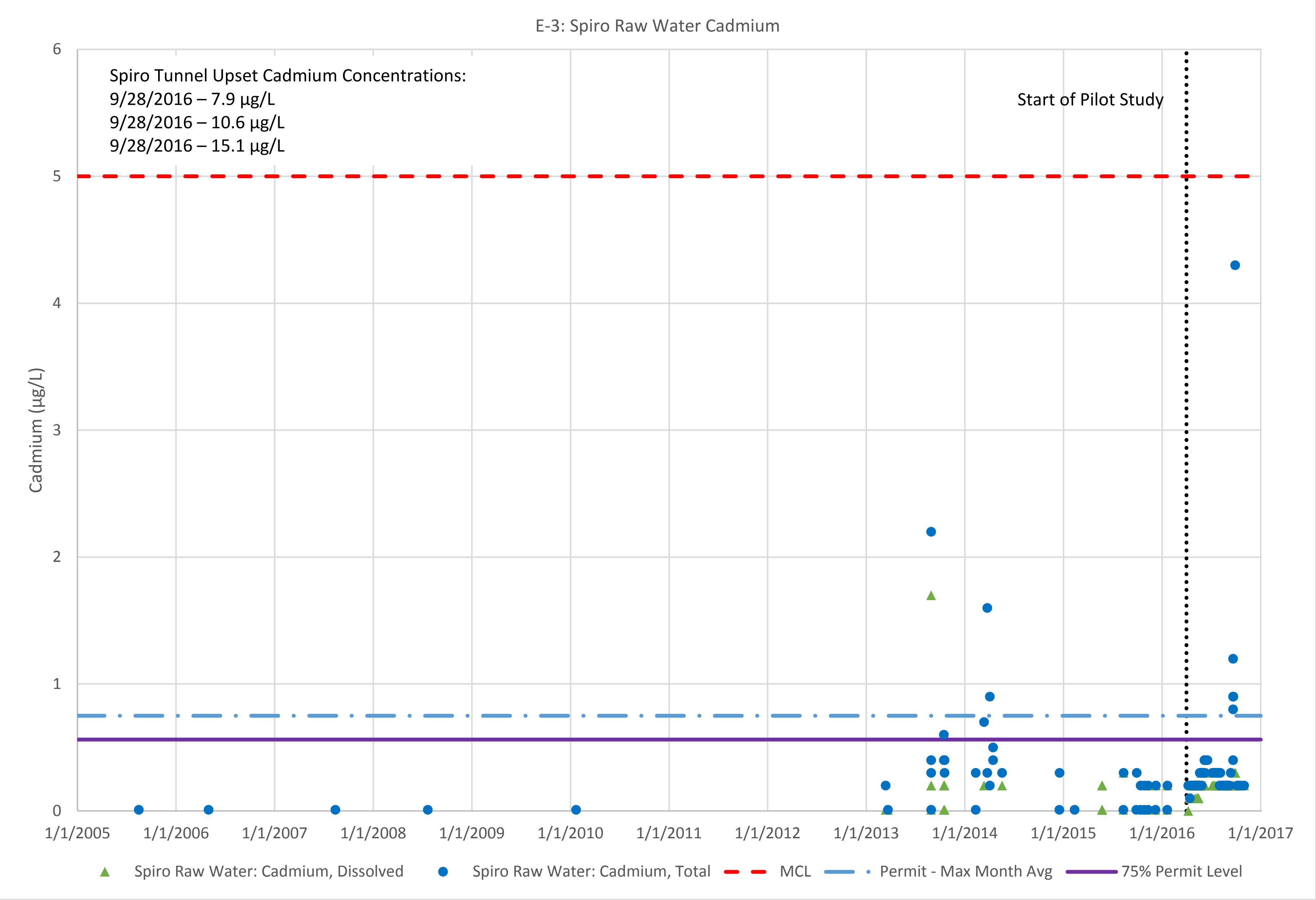
Parameter	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Calculations							
Hardness, Total as CaCO3	**448**	mg/L	1	SM 2340 B	10/15/16	10/15/16	
Inorganic							
Alkalinity - Bicarbonate (as CaCO3)	**88.1**	mg/L	1.0	SM 2320 B	10/17/16	10/17/16	
Alkalinity - Carbonate (as CaCO3)	ND	mg/L	1.0	SM 2320 B	10/17/16	10/17/16	
Alkalinity - Hydroxide (as CaCO3)	ND	mg/L	1.0	SM 2320 B	10/17/16	10/17/16	
Alkalinity - Total (as CaCO3)	**88.1**	mg/L	1.0	SM 2320 B	10/17/16	10/17/16	
Ammonia as N	ND	mg/L	0.2	SM 4500 NH3 H	10/18/16	10/18/16	
Chlorine Residual, Total	ND	mg/L	0.10	SM 4500 Cl-G	10/14/16 13:10	10/14/16 13:12	SPH
Conductivity	**896**	umho/cm	1	EPA 120.1	10/14/16	10/14/16	
pH	**7.2**	pH Units	0.1	SM 4500 H-B	10/14/16 16:20	10/14/16 16:20	SPH
Total Dissolved Solids (TDS)	**618**	mg/L	10	SM 2540 C	10/15/16	10/15/16	
Metals							
Antimony, Total	ND	mg/L	0.0005	EPA 200.8	10/17/16	10/17/16	
Arsenic, Total	**0.0005**	mg/L	0.0005	EPA 200.8	10/17/16	10/17/16	
Cadmium, Total	ND	mg/L	0.0002	EPA 200.8	10/17/16	10/17/16	
Calcium, Total	**127**	mg/L	0.2	EPA 200.7	10/15/16	10/15/16	
Lead, Total	ND	mg/L	0.0005	EPA 200.8	10/17/16	10/17/16	
Magnesium, Total	**31.7**	mg/L	0.2	EPA 200.7	10/15/16	10/15/16	
Selenium, Total	**0.0033**	mg/L	0.0005	EPA 200.8	10/17/16	10/17/16	
Thallium, Total	ND	mg/L	0.0002	EPA 200.8	10/17/16	10/17/16	
Zinc, Total	**0.02**	mg/L	0.01	EPA 200.7	10/15/16	10/15/16	

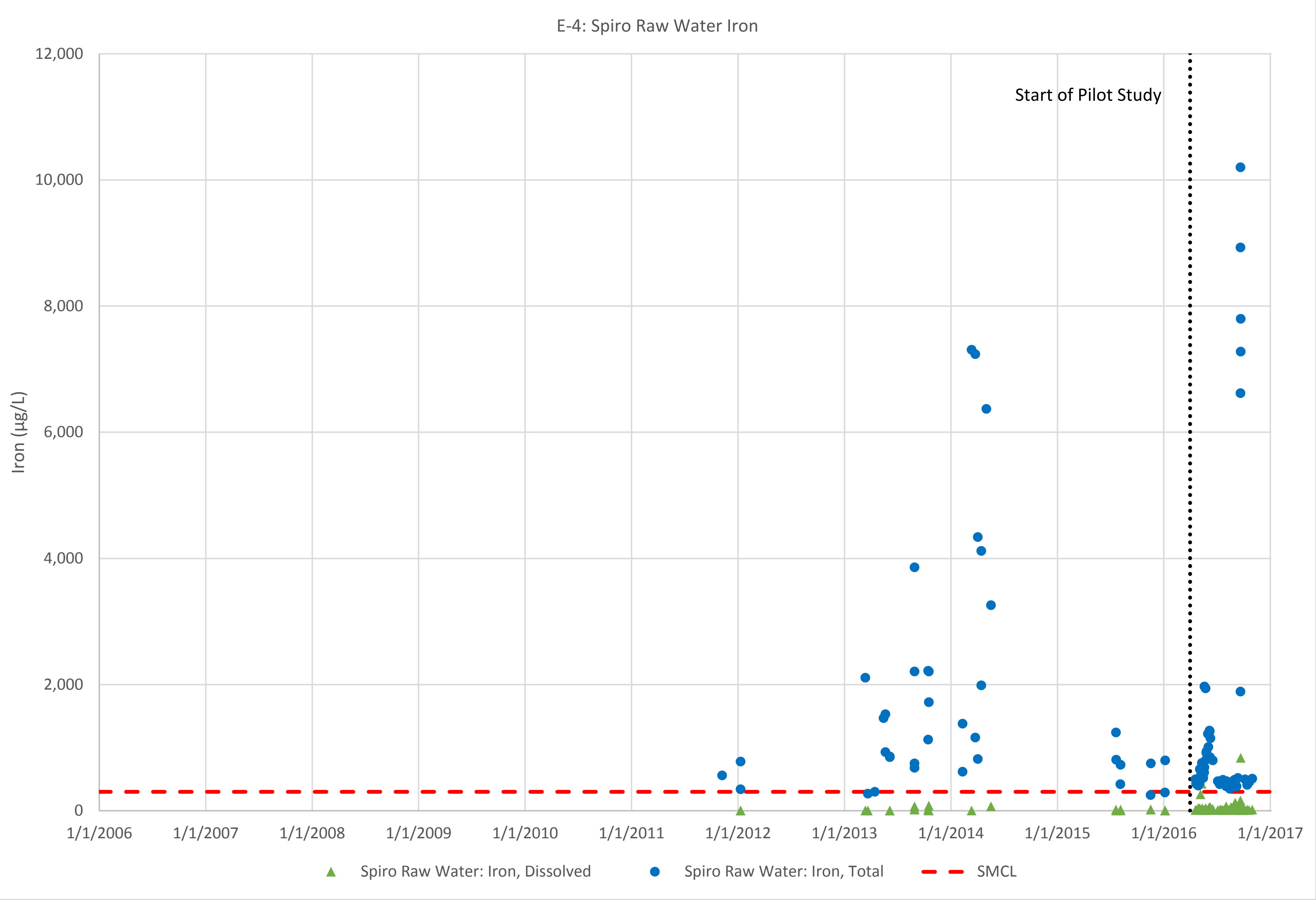
Appendix E

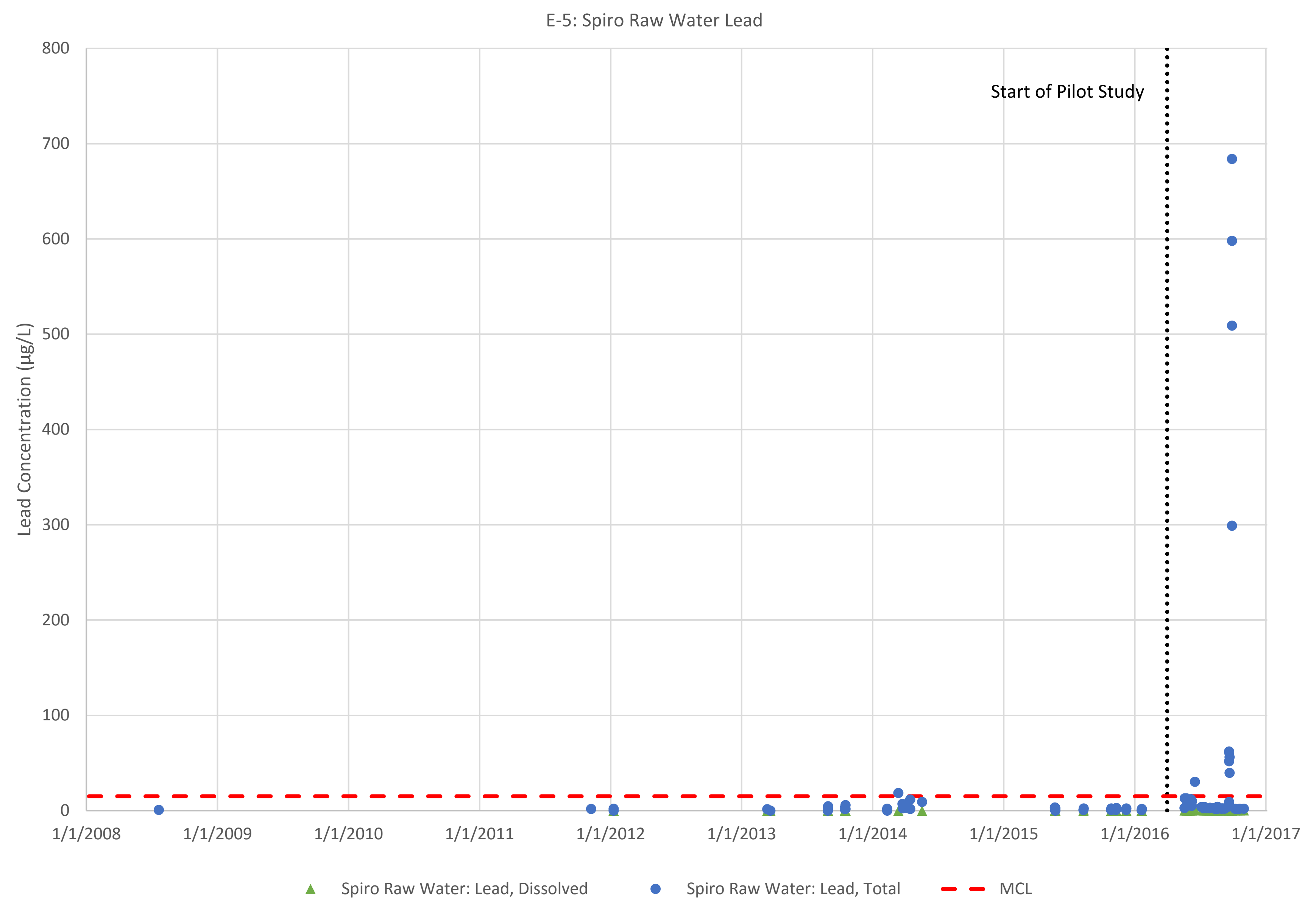
Raw Water Quality Time Series Graphs

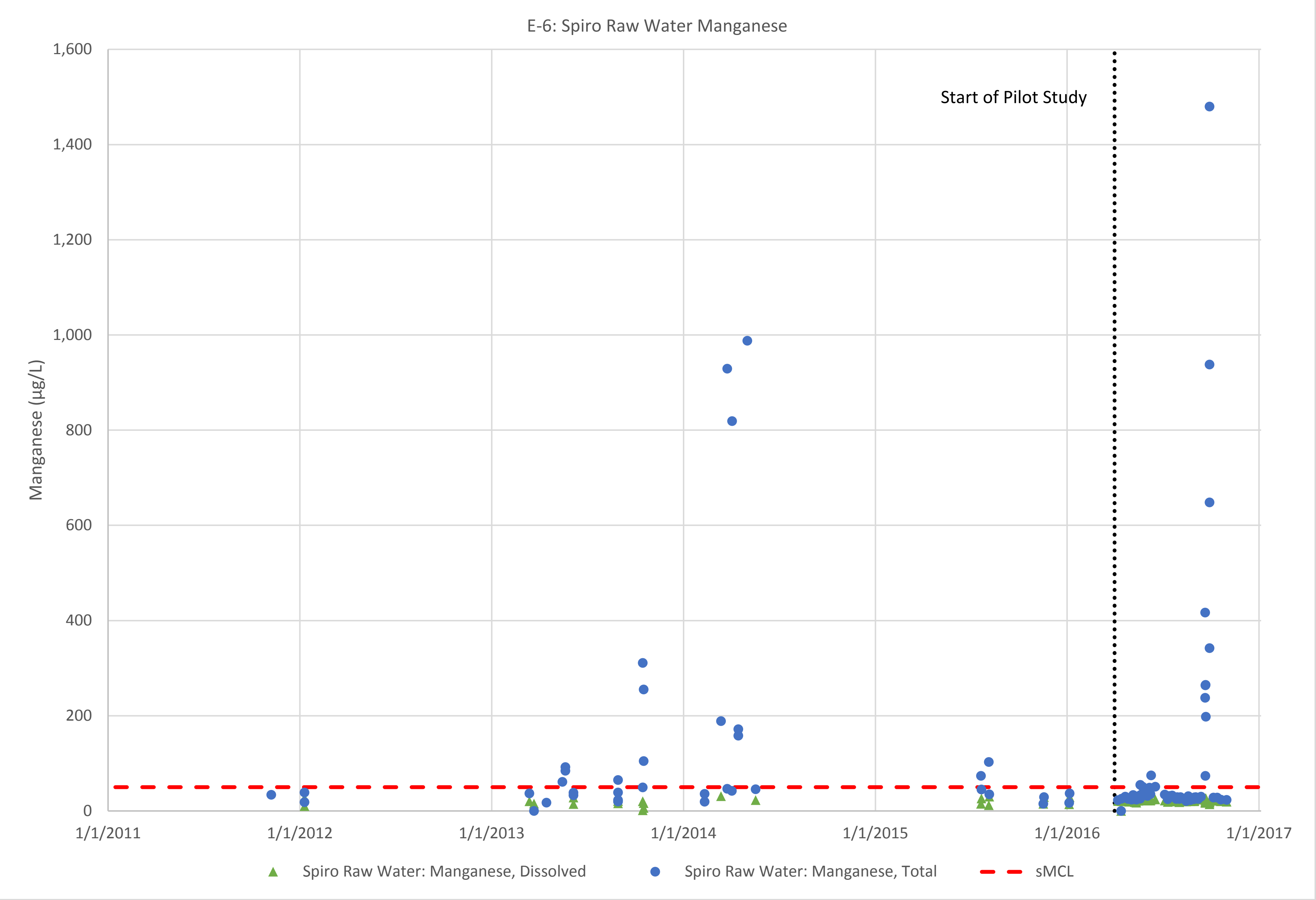

E-1: Spiro Raw Water Antimony
Spiro Tunnel Upset Antimony Concentrations:
9/28/2016 – 54.1 µg/L
9/28/2016 – 91.3 µg/L
9/28/2016 – 115.0 µg/L
9/28/2016 – 156.0 µg/L
Start of Pilot Study
Antimony (µg/L)
20
18
16
14
12
10
8
6
4
2
0
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Spiro Raw Water: Antimony, Dissolved
Spiro Raw Water: Antimony, Total
MCL
Permit Level
75% Permit Level

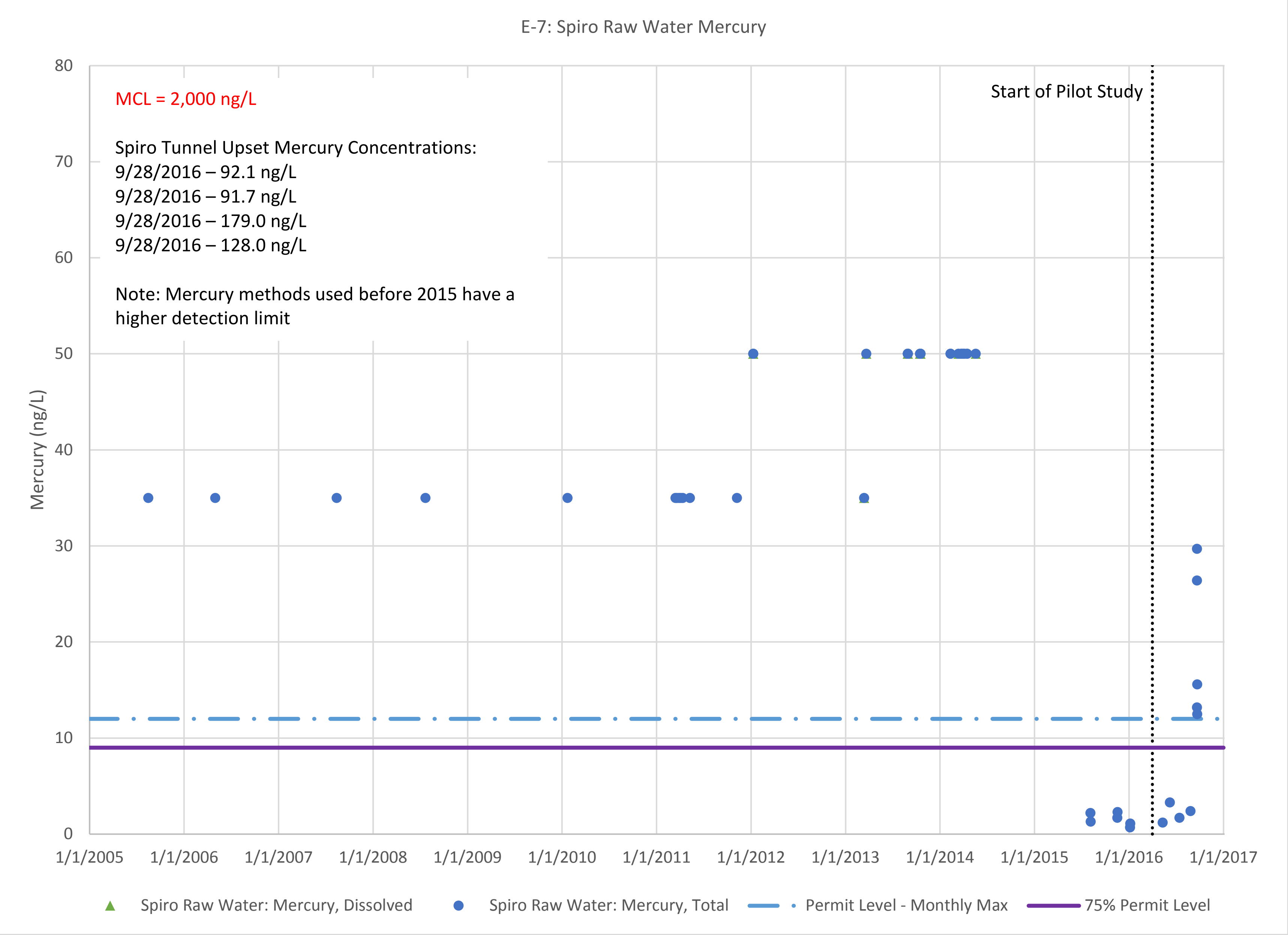

E-2: Spiro Raw Water Arsenic
Arsenic (µg/L)
1400
1200
1000
800
600
400
200
0
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Start of Pilot Study
▲ Spiro Raw Water: Arsenic, Dissolved
● Spiro Raw Water: Arsenic, Total
MCL
Permit Level - Daily Max
75% Permit Level

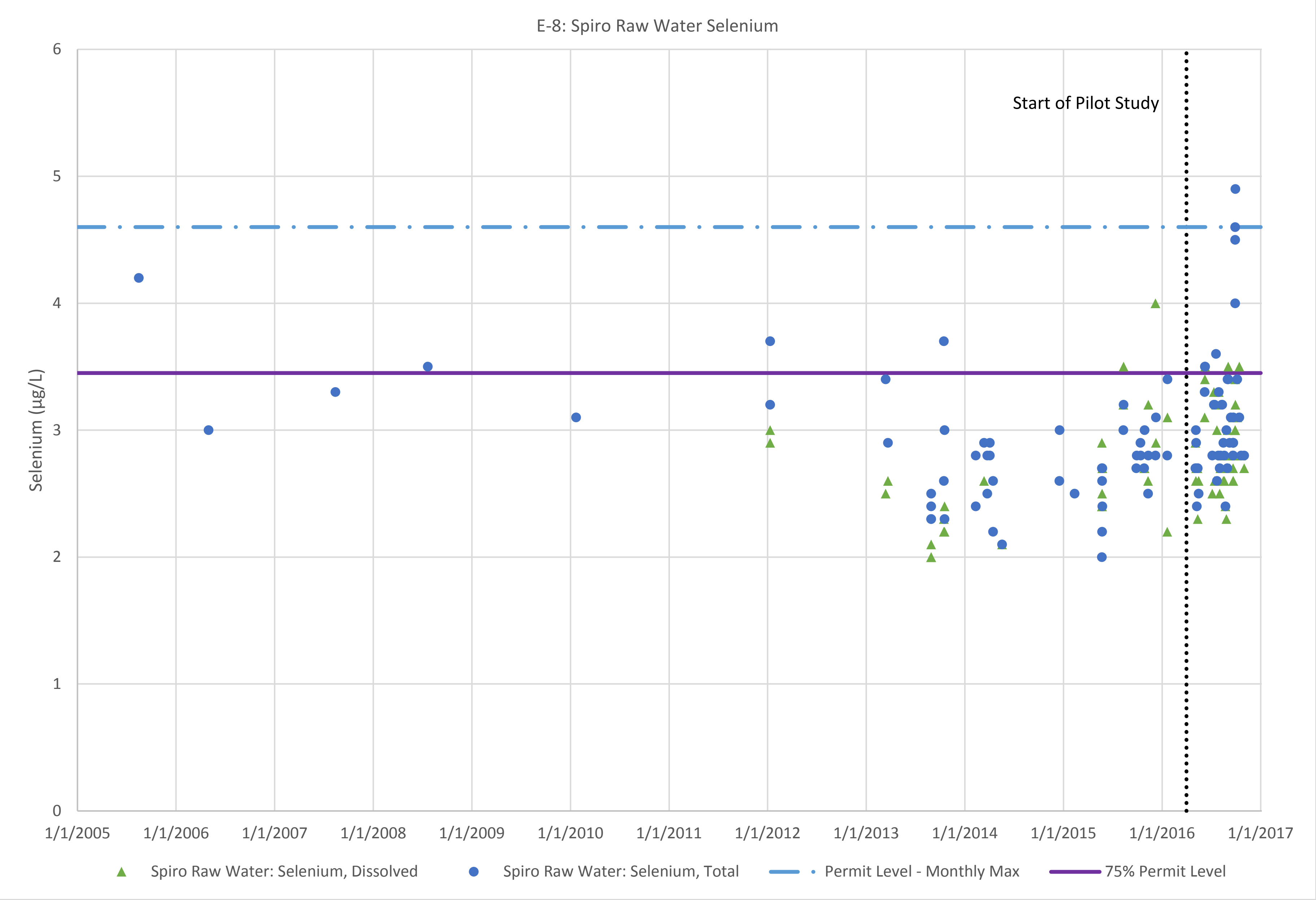

E-3: Spiro Raw Water Cadmium
Cadmium (µg/L)
0
1
2
3
4
5
6
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Spiro Tunnel Upset Cadmium Concentrations:
9/28/2016 – 7.9 µg/L
9/28/2016 – 10.6 µg/L
9/28/2016 – 15.1 µg/L
Start of Pilot Study
▲ Spiro Raw Water: Cadmium, Dissolved
● Spiro Raw Water: Cadmium, Total
MCL
Permit - Max Month Avg
75% Permit Level

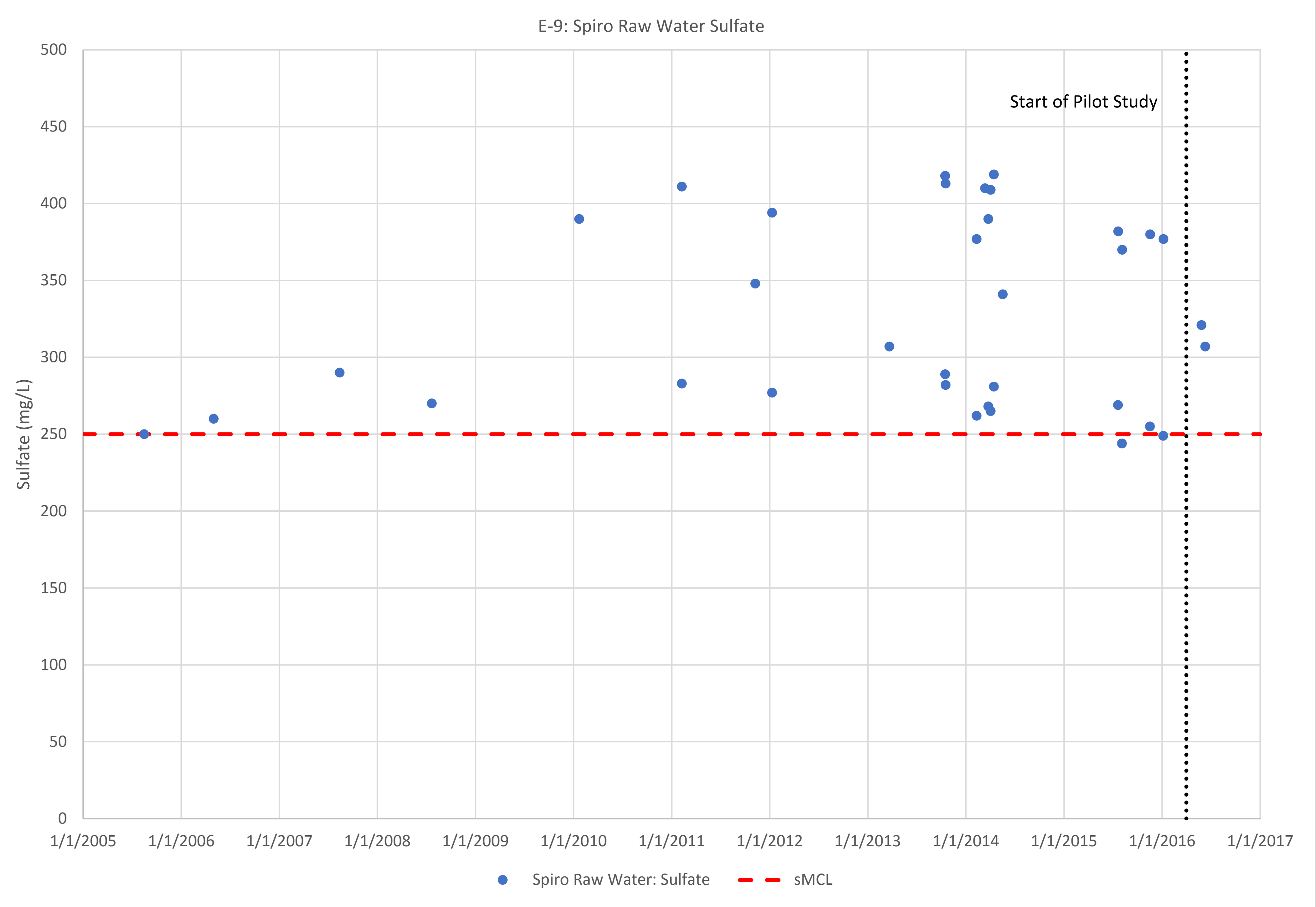

E-4: Spiro Raw Water Iron
Iron (µg/L)
12,000
10,000
8,000
6,000
4,000
2,000
0
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Start of Pilot Study
Spiro Raw Water: Iron, Dissolved
Spiro Raw Water: Iron, Total
SMCL

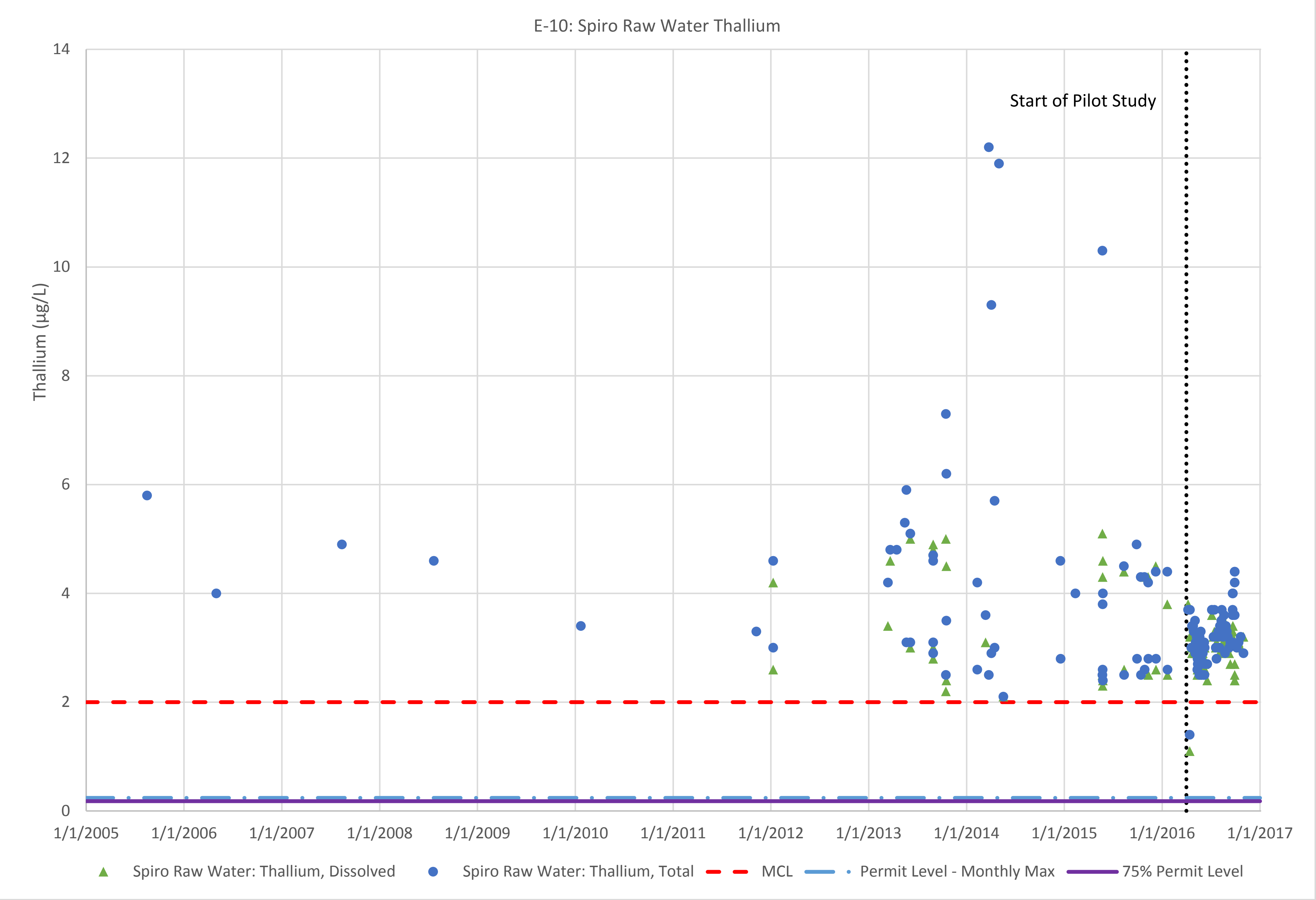

E-5: Spiro Raw Water Lead
Lead Concentration (µg/L)
800
700
600
500
400
300
200
100
0
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Start of Pilot Study
▲ Spiro Raw Water: Lead, Dissolved
● Spiro Raw Water: Lead, Total
MCL

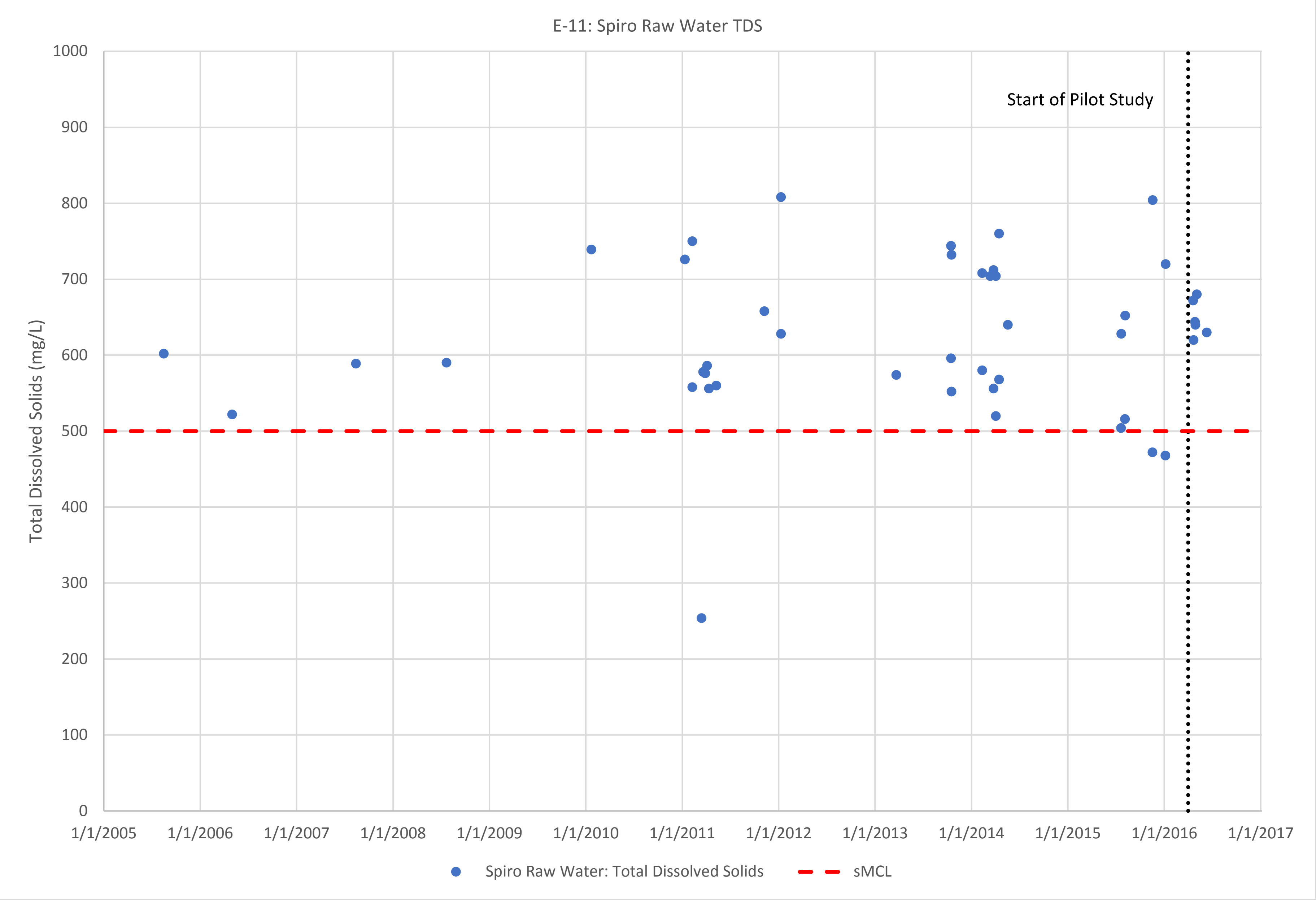

E-6: Spiro Raw Water Manganese
Manganese (µg/L)
1,600
1,400
1,200
1,000
800
600
400
200
0
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Start of Pilot Study
Spiro Raw Water: Manganese, Dissolved
Spiro Raw Water: Manganese, Total
sMCL

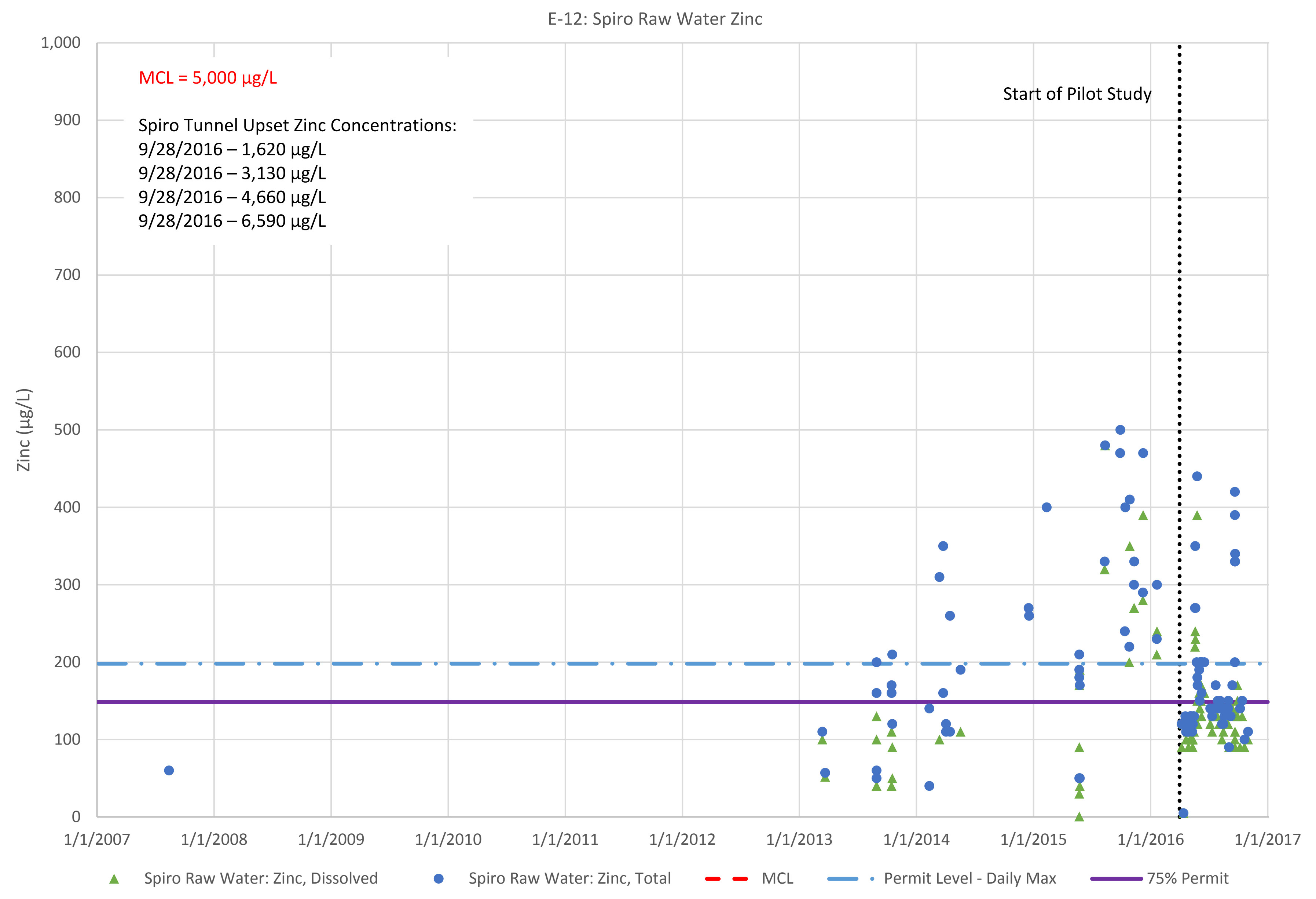

E-7: Spiro Raw Water Mercury
MCL = 2,000 ng/L
Spiro Tunnel Upset Mercury Concentrations:
9/28/2016 – 92.1 ng/L
9/28/2016 – 91.7 ng/L
9/28/2016 – 179.0 ng/L
9/28/2016 – 128.0 ng/L
Note: Mercury methods used before 2015 have a higher detection limit
Start of Pilot Study
Mercury (ng/L)
80
70
60
50
40
30
20
10
0
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Spiro Raw Water: Mercury, Dissolved
Spiro Raw Water: Mercury, Total
Permit Level - Monthly Max
75% Permit Level

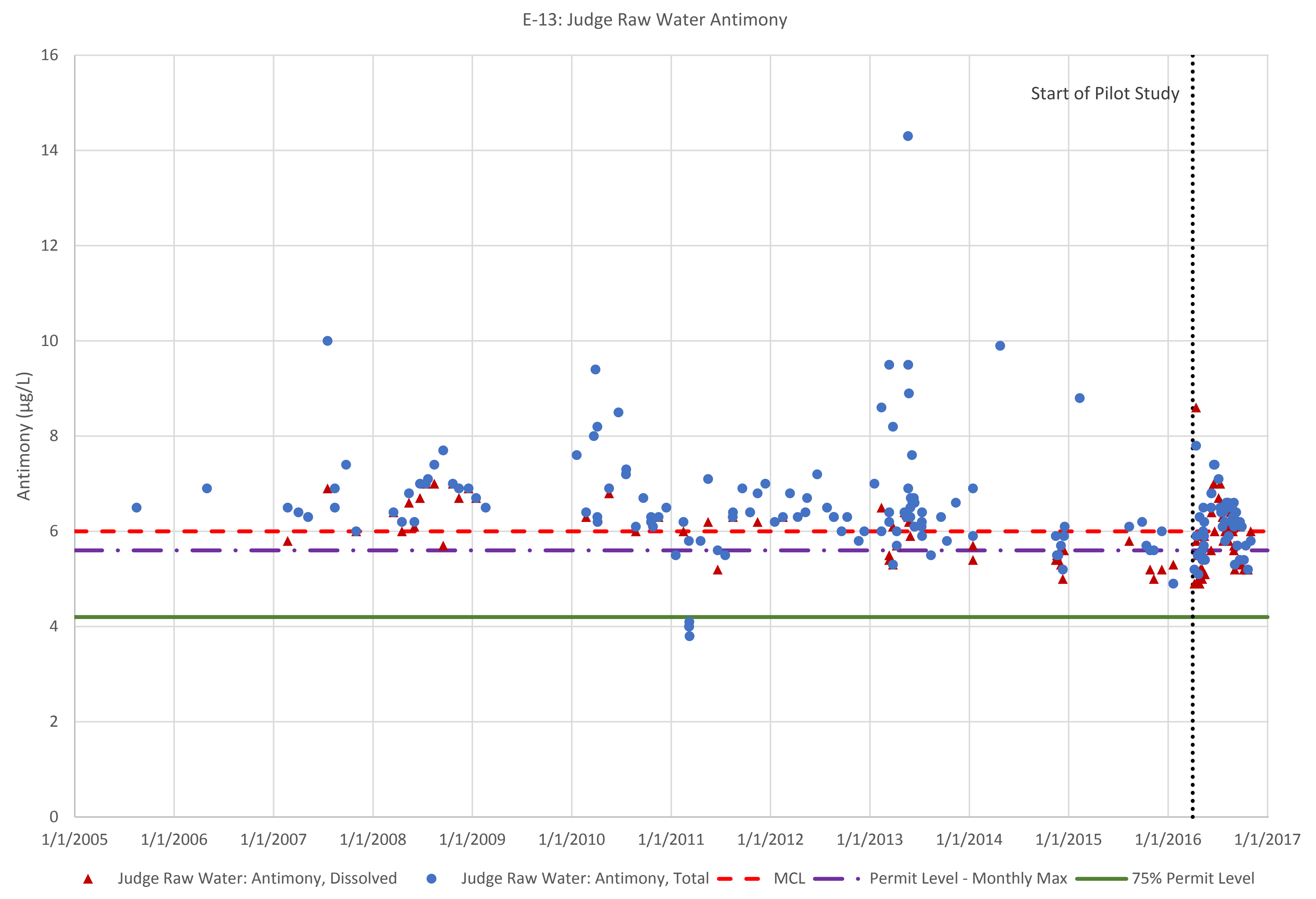

E-8: Spiro Raw Water Selenium
Start of Pilot Study
Selenium (µg/L)
0
1
2
3
4
5
6
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Spiro Raw Water: Selenium, Dissolved
Spiro Raw Water: Selenium, Total
Permit Level - Monthly Max
75% Permit Level

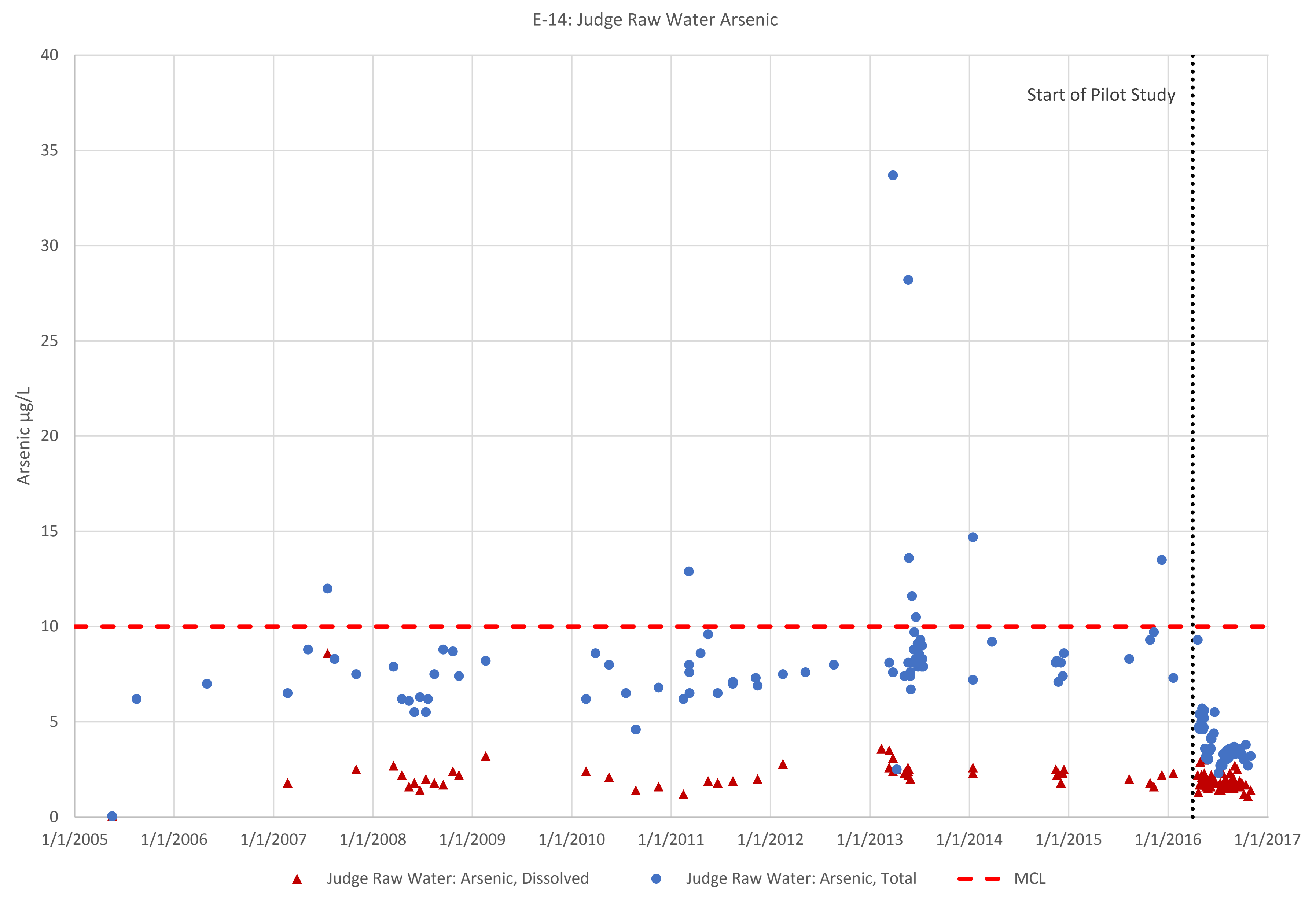

E-9: Spiro Raw Water Sulfate
Start of Pilot Study
Sulfate (mg/L)
500
450
400
350
300
250
200
150
100
50
0
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
● Spiro Raw Water: Sulfate
sMCL

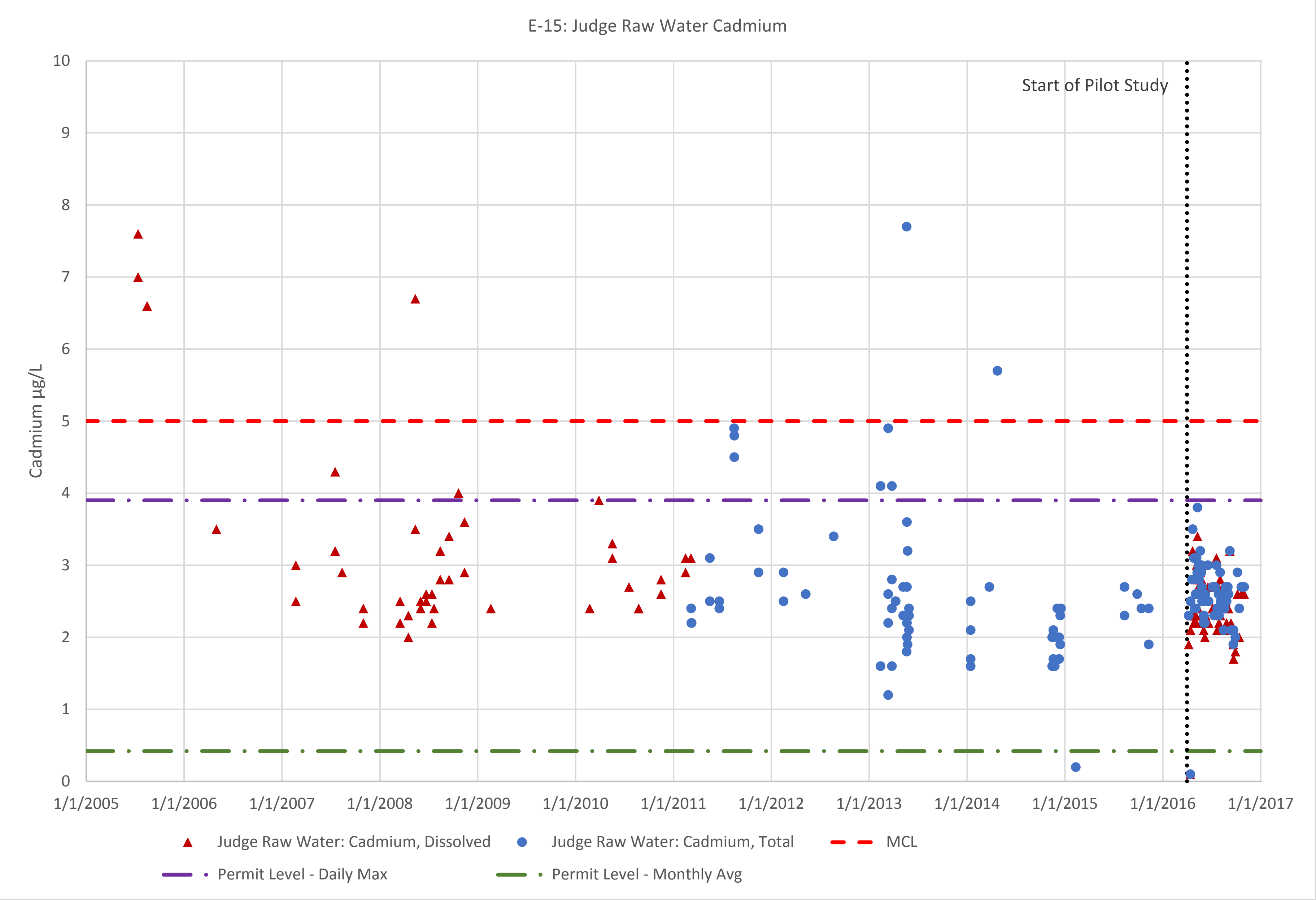

E-10: Spiro Raw Water Thallium
Thallium (µg/L)
0
2
4
6
8
10
12
14
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Start of Pilot Study
Spiro Raw Water: Thallium, Dissolved
Spiro Raw Water: Thallium, Total
MCL
Permit Level - Monthly Max
75% Permit Level

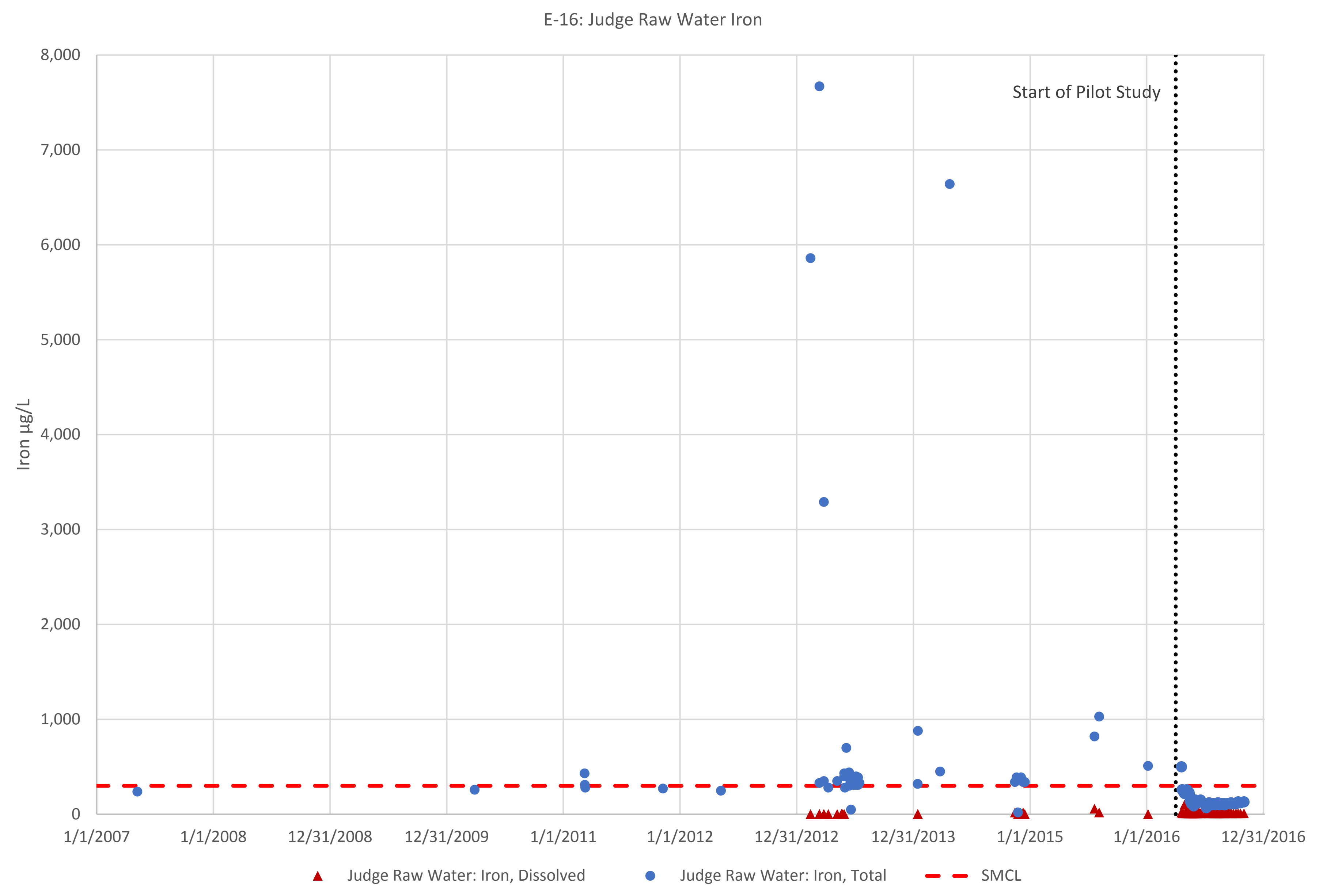

E-11: Spiro Raw Water TDS
Total Dissolved Solids (mg/L)
1000
900
800
700
600
500
400
300
200
100
0
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Start of Pilot Study
● Spiro Raw Water: Total Dissolved Solids
sMCL

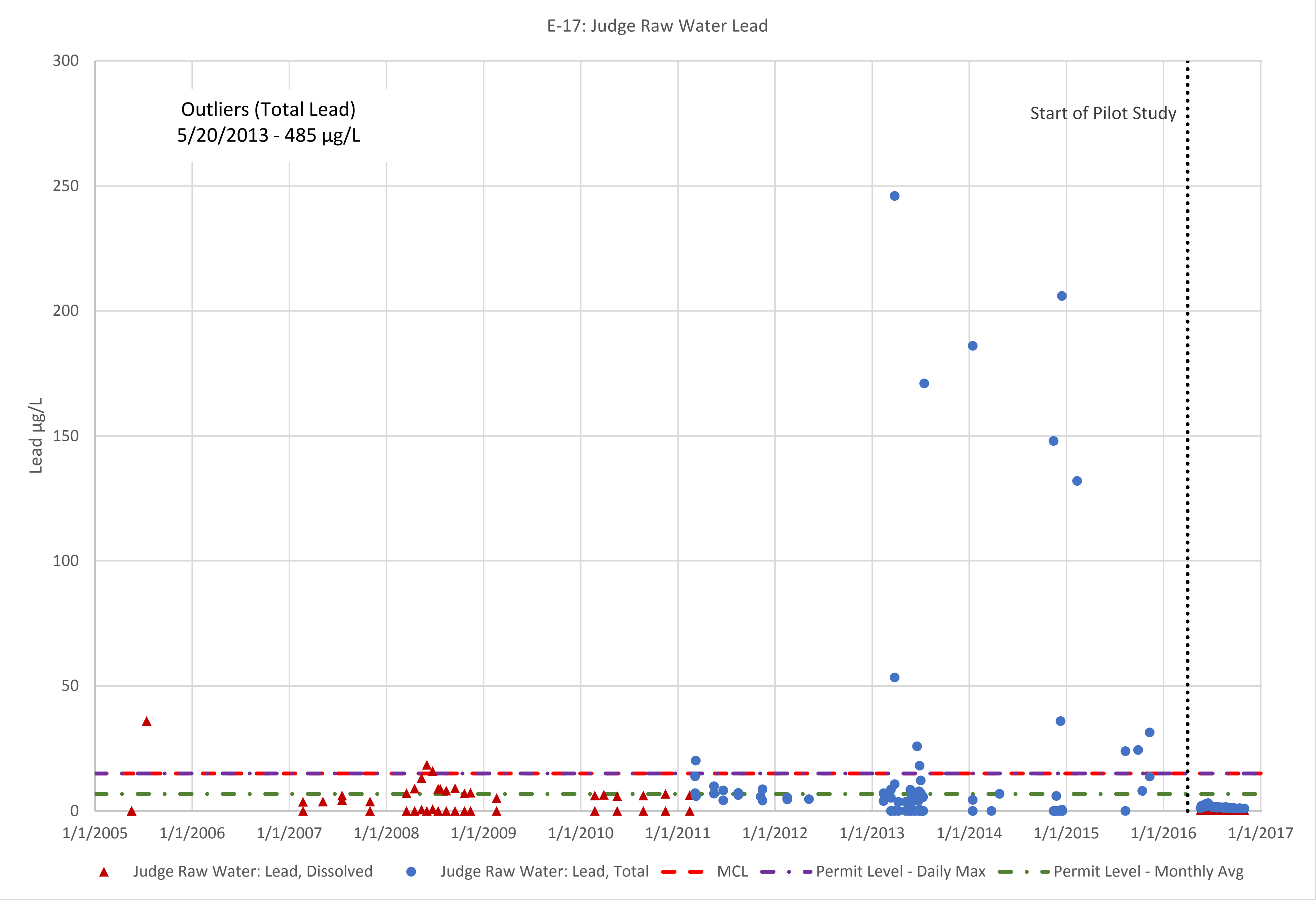

E-12: Spiro Raw Water Zinc
MCL = 5,000 µg/L
Spiro Tunnel Upset Zinc Concentrations:
9/28/2016 – 1,620 µg/L
9/28/2016 – 3,130 µg/L
9/28/2016 – 4,660 µg/L
9/28/2016 – 6,590 µg/L
Start of Pilot Study
Zinc (µg/L)
1,000
900
800
700
600
500
400
300
200
100
0
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Spiro Raw Water: Zinc, Dissolved
Spiro Raw Water: Zinc, Total
MCL
Permit Level - Daily Max
75% Permit

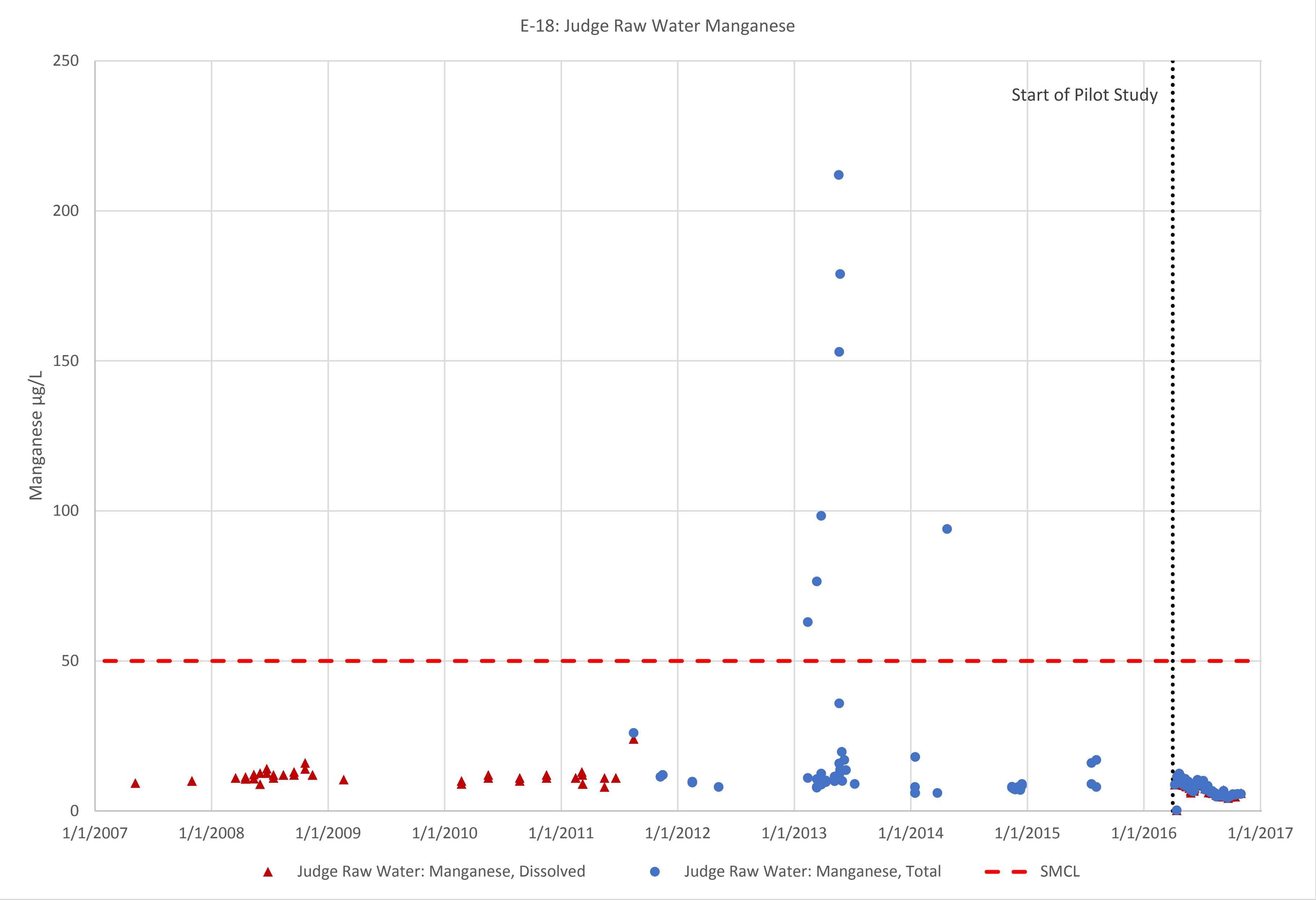

E-13: Judge Raw Water Antimony
Antimony (µg/L)
16
14
12
10
8
6
4
2
0
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Start of Pilot Study
Judge Raw Water: Antimony, Dissolved
Judge Raw Water: Antimony, Total
MCL
Permit Level - Monthly Max
75% Permit Level

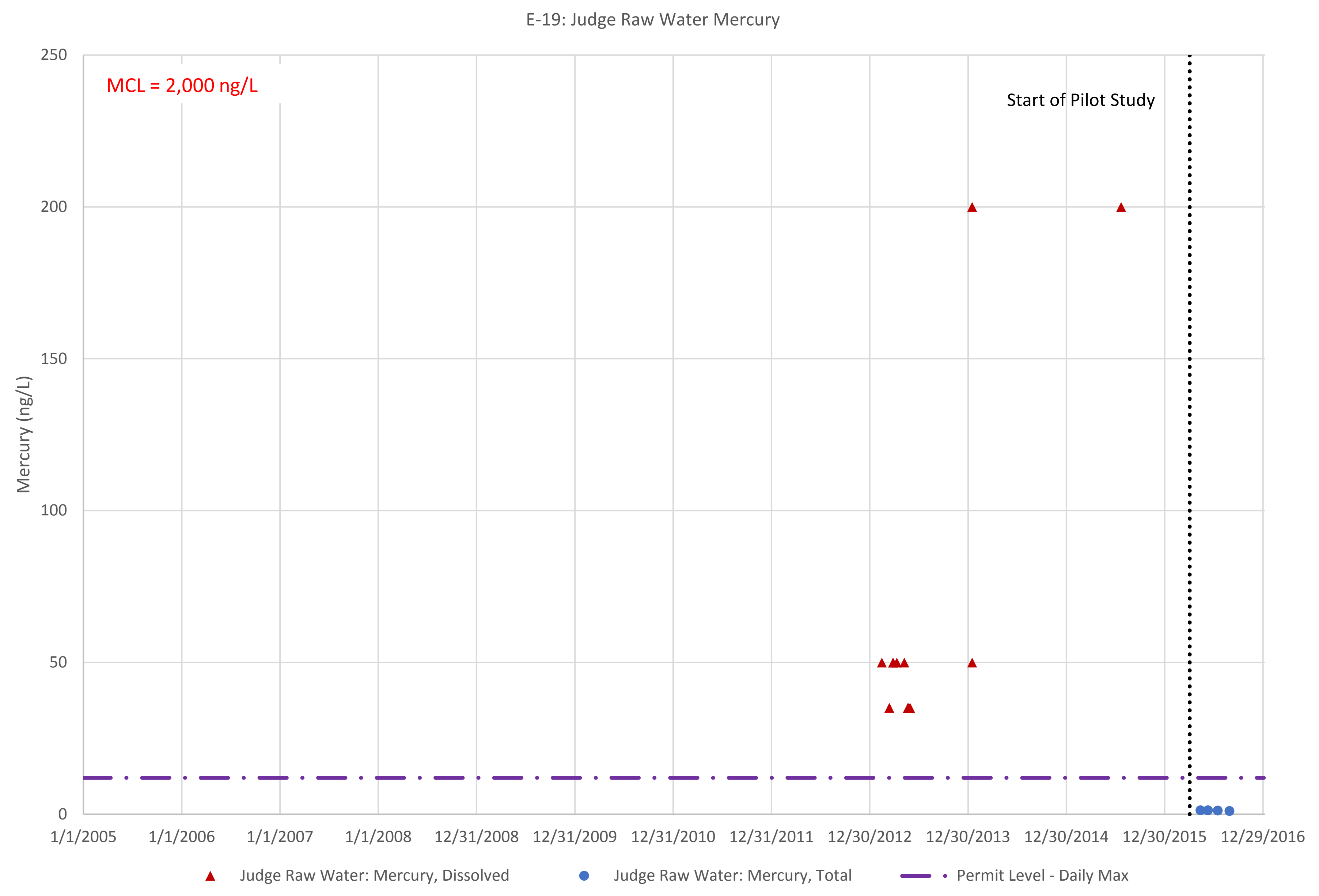

E-14: Judge Raw Water Arsenic
Start of Pilot Study
Arsenic µg/L
40
35
30
25
20
15
10
5
0
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
▲ Judge Raw Water: Arsenic, Dissolved
● Judge Raw Water: Arsenic, Total
MCL

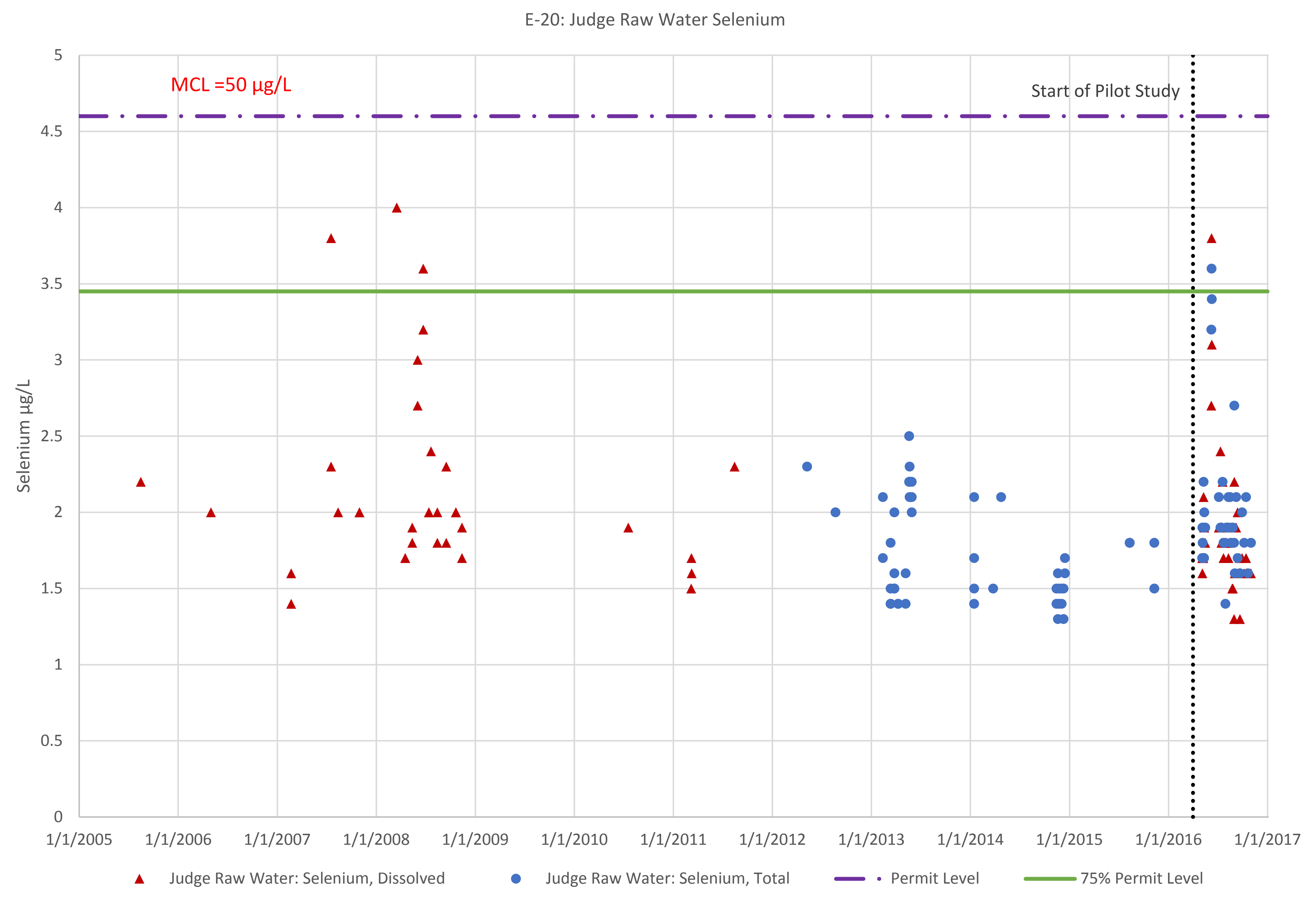

E-15: Judge Raw Water Cadmium
Start of Pilot Study
Cadmium µg/L
10
9
8
7
6
5
4
3
2
1
0
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Judge Raw Water: Cadmium, Dissolved
Judge Raw Water: Cadmium, Total
MCL
Permit Level - Daily Max
Permit Level - Monthly Avg

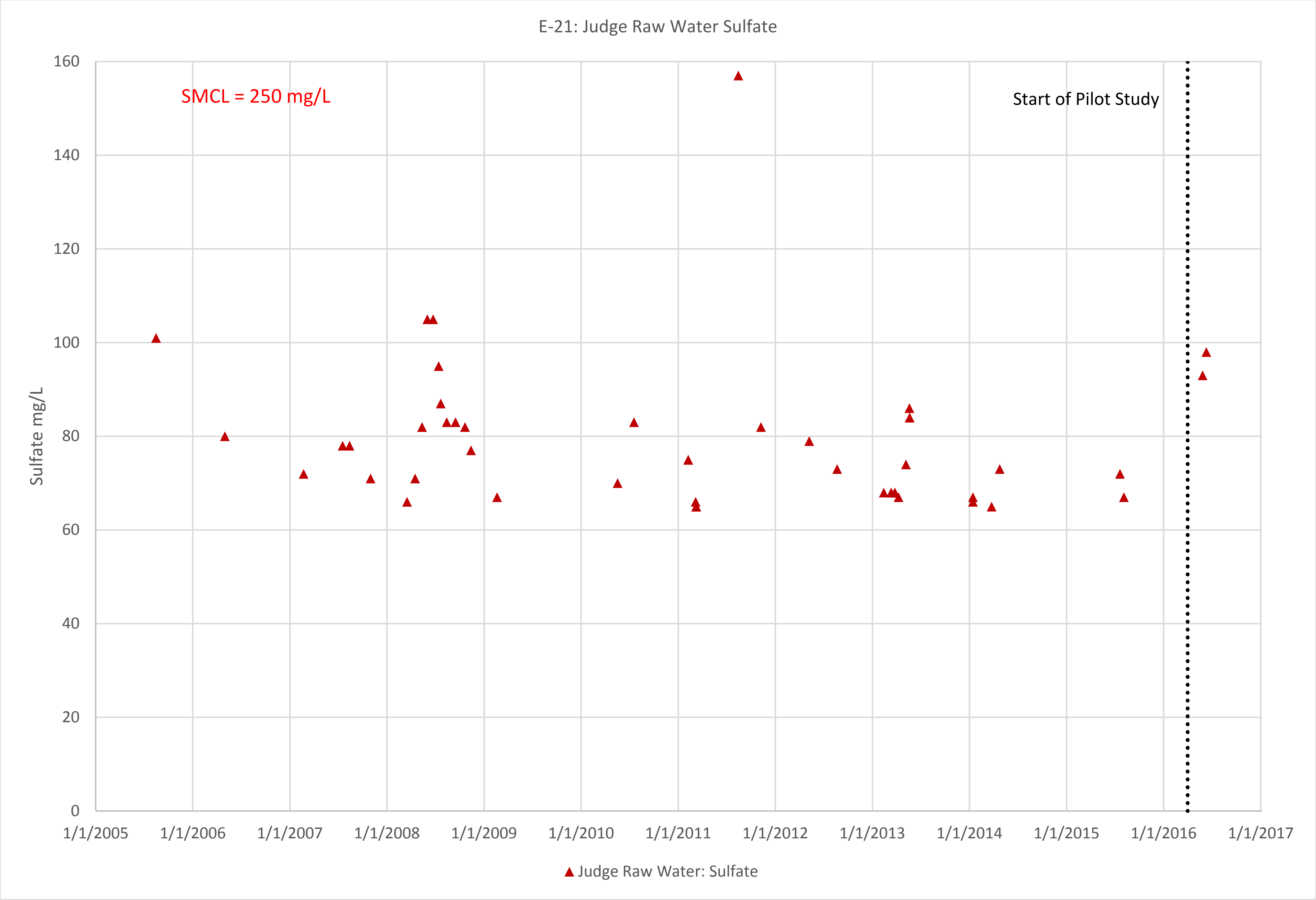

E-16: Judge Raw Water Iron
Start of Pilot Study
Iron µg/L
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1/1/2007
1/1/2008
12/31/2008
12/31/2009
1/1/2011
1/1/2012
12/31/2012
12/31/2013
1/1/2015
1/1/2016
12/31/2016
▲ Judge Raw Water: Iron, Dissolved
● Judge Raw Water: Iron, Total
SMCL

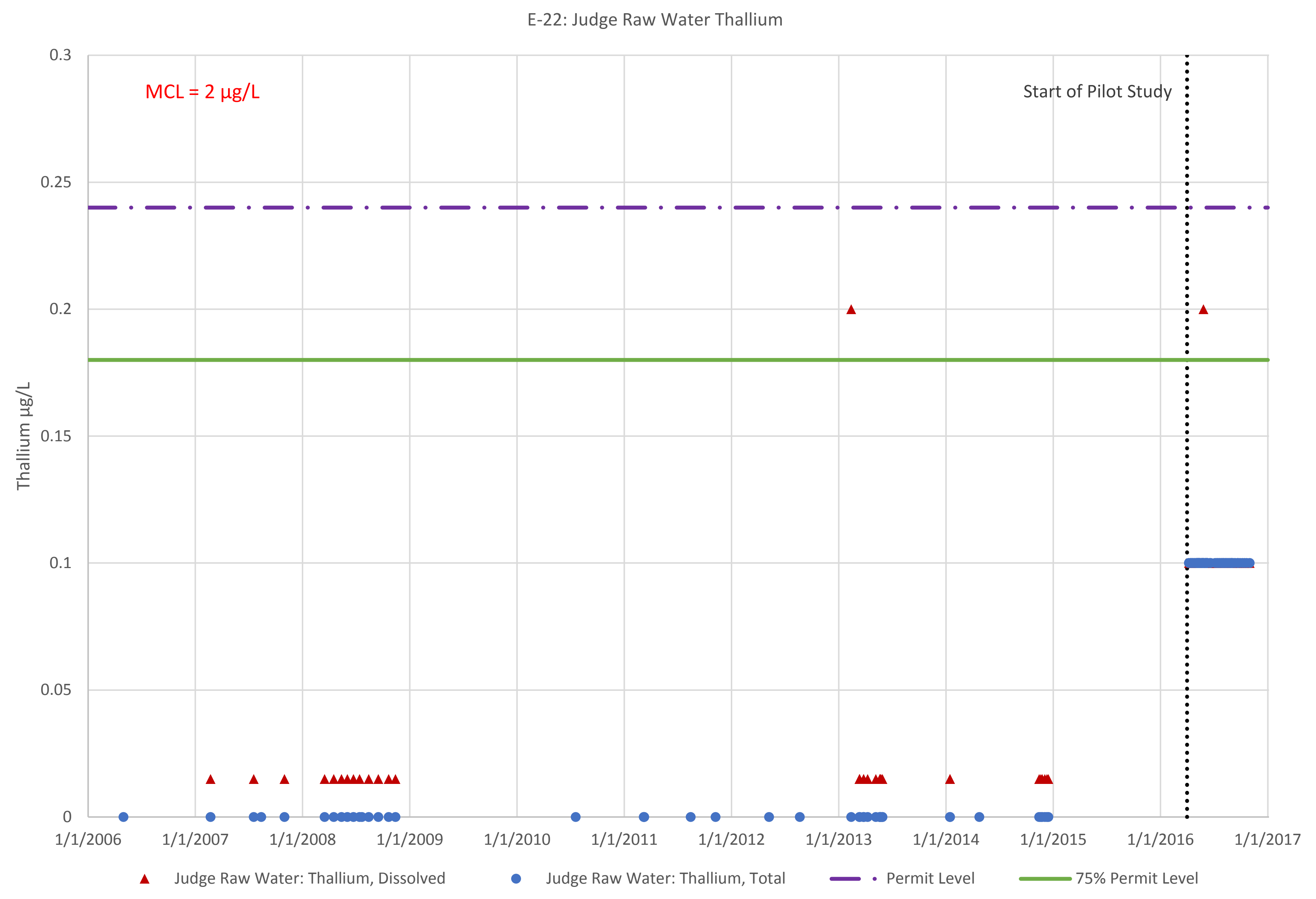

E-17: Judge Raw Water Lead
Outliers (Total Lead)
5/20/2013 - 485 µg/L
Start of Pilot Study
Lead µg/L
300
250
200
150
100
50
0
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Judge Raw Water: Lead, Dissolved
Judge Raw Water: Lead, Total
MCL
Permit Level - Daily Max
Permit Level - Monthly Avg

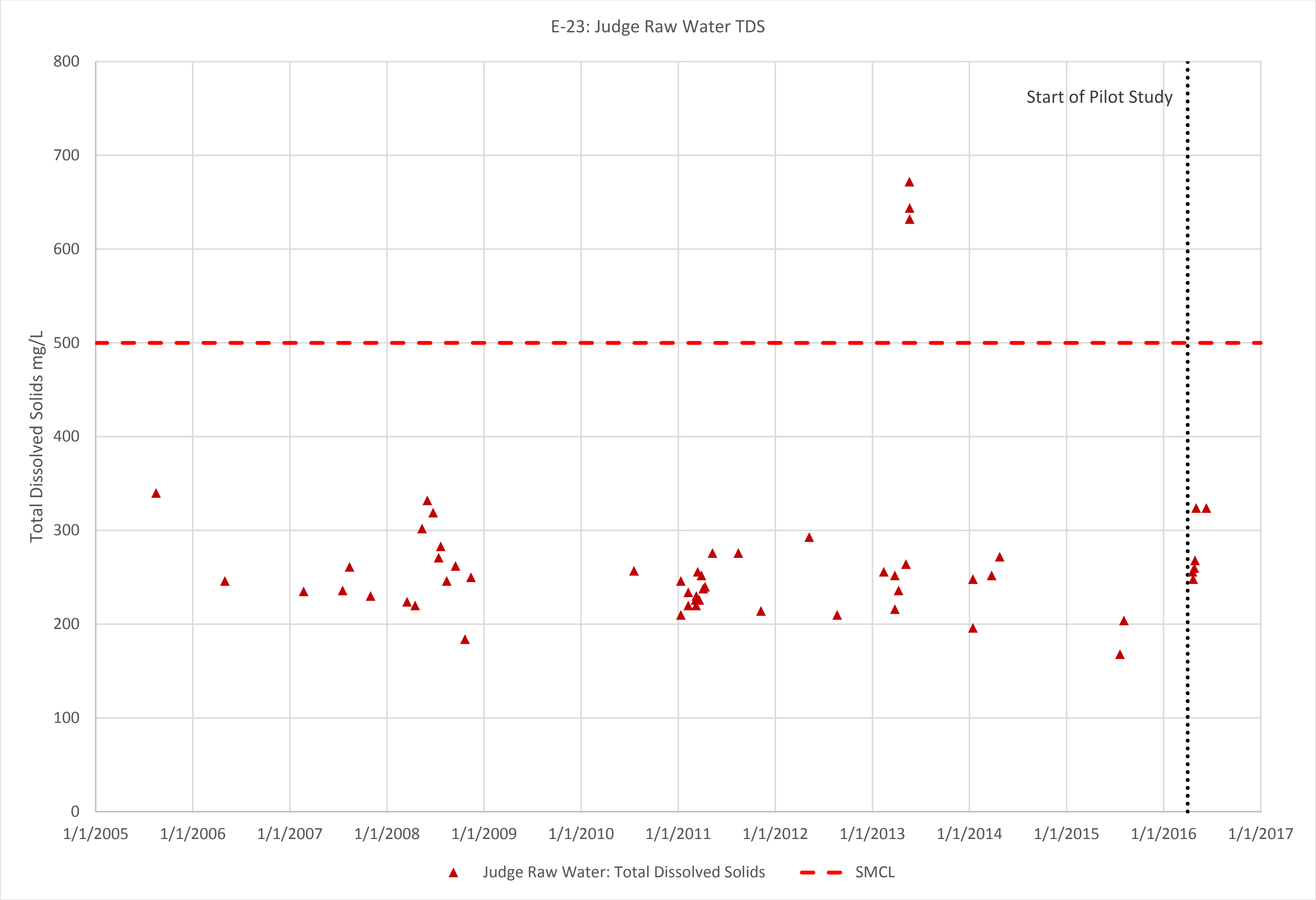

E-18: Judge Raw Water Manganese
Manganese µg/L
250
200
150
100
50
0
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Start of Pilot Study
Judge Raw Water: Manganese, Dissolved
Judge Raw Water: Manganese, Total
SMCL


E-19: Judge Raw Water Mercury
MCL = 2,000 ng/L
Start of Pilot Study
Mercury (ng/L)
250
200
150
100
50
0
1/1/2005
1/1/2006
1/1/2007
1/1/2008
12/31/2008
12/31/2009
12/31/2010
12/31/2011
12/30/2012
12/30/2013
12/30/2014
12/30/2015
12/29/2016
▲ Judge Raw Water: Mercury, Dissolved
● Judge Raw Water: Mercury, Total
Permit Level - Daily Max


E-20: Judge Raw Water Selenium
MCL =50 µg/L
Start of Pilot Study
Selenium µg/L
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Judge Raw Water: Selenium, Dissolved
Judge Raw Water: Selenium, Total
Permit Level
75% Permit Level


E-21: Judge Raw Water Sulfate
SMCL = 250 mg/L
Start of Pilot Study
Sulfate mg/L
0
20
40
60
80
100
120
140
160
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
▲ Judge Raw Water: Sulfate


E-22: Judge Raw Water Thallium
MCL = 2 µg/L
Start of Pilot Study
Thallium µg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Judge Raw Water: Thallium, Dissolved
Judge Raw Water: Thallium, Total
Permit Level
75% Permit Level


E-23: Judge Raw Water TDS
Total Dissolved Solids mg/L
800
700
600
500
400
300
200
100
0
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Start of Pilot Study
▲ Judge Raw Water: Total Dissolved Solids
SMCL

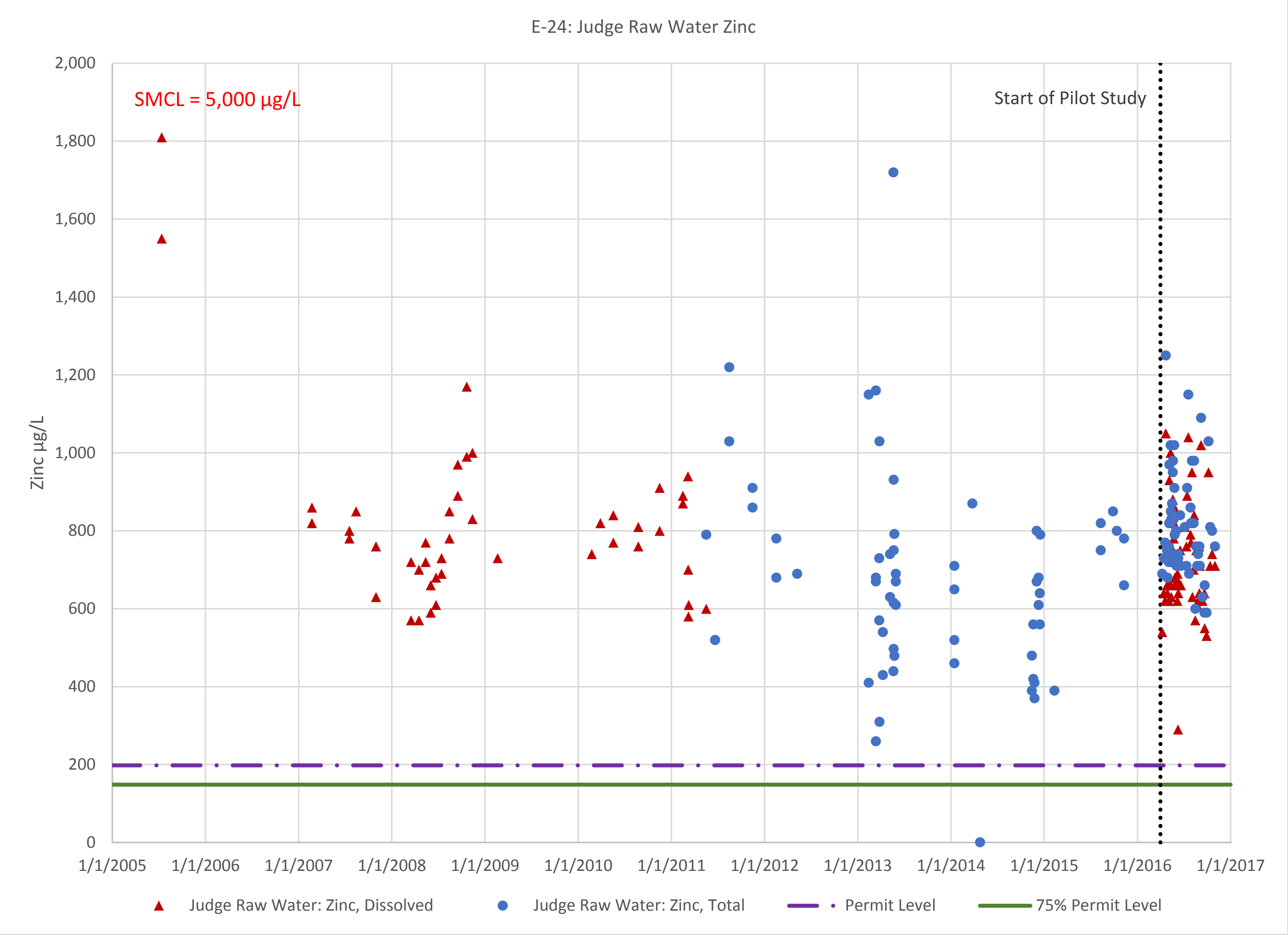

E-24: Judge Raw Water Zinc
SMCL = 5,000 µg/L
Start of Pilot Study
Zinc µg/L
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Judge Raw Water: Zinc, Dissolved
Judge Raw Water: Zinc, Total
Permit Level
75% Permit Level

Figure E-25: Raw Water Alkalinity

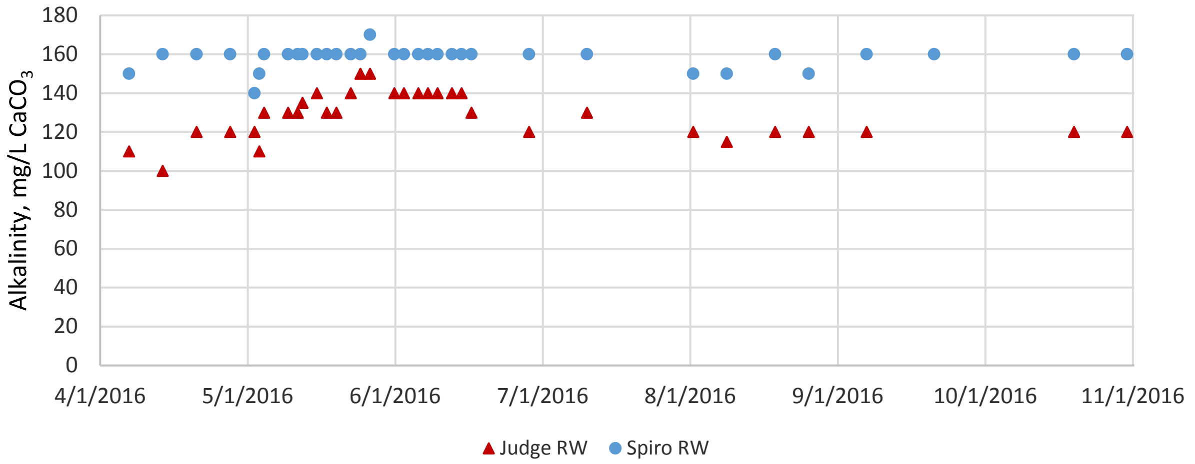


Figure E-26: Raw Water Hardness

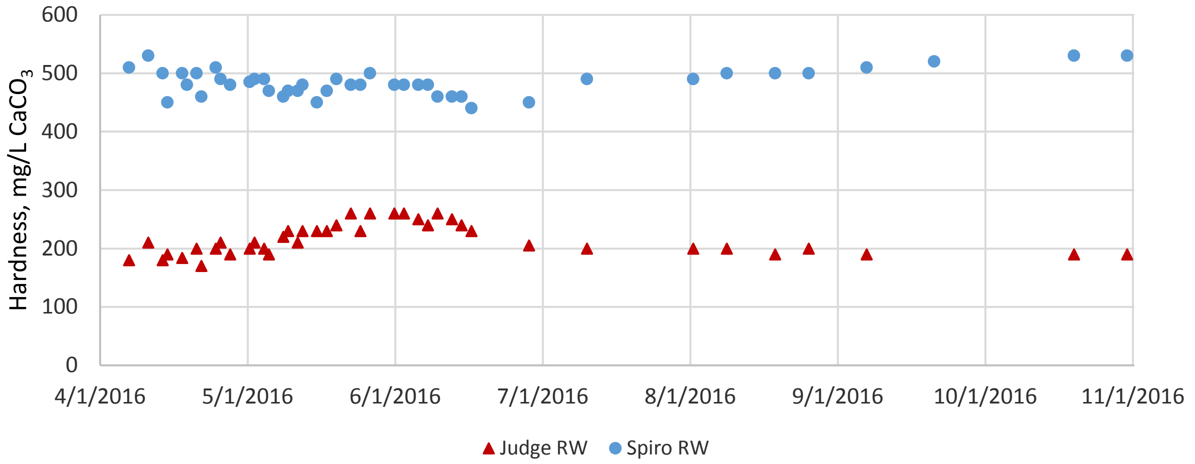
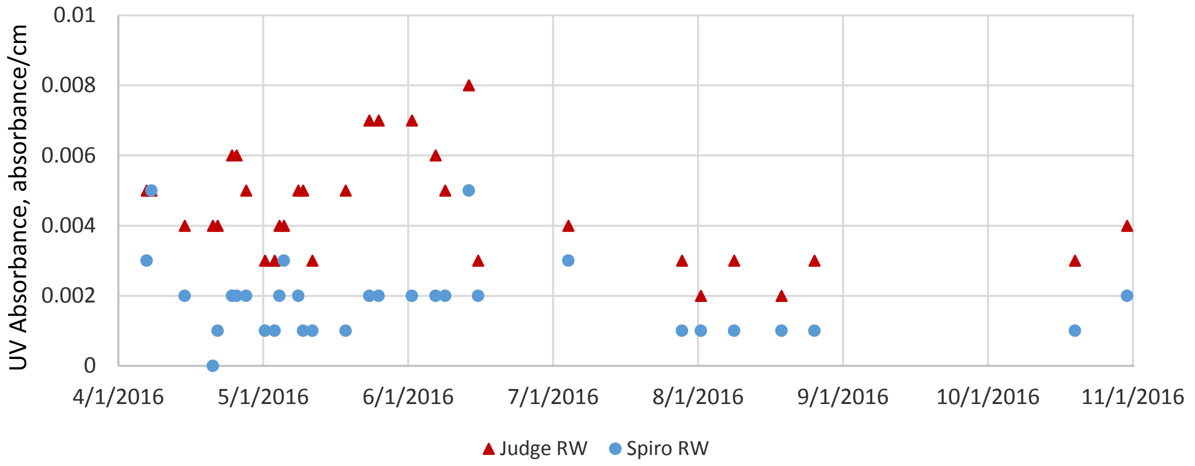


Figure E-27: Raw Water UV Absorbance[a]



[a] UV absorbance tests were conducted using sample water filtered through a 0.45-micron paper filter.

Figure E-28: Raw Water Conductivity

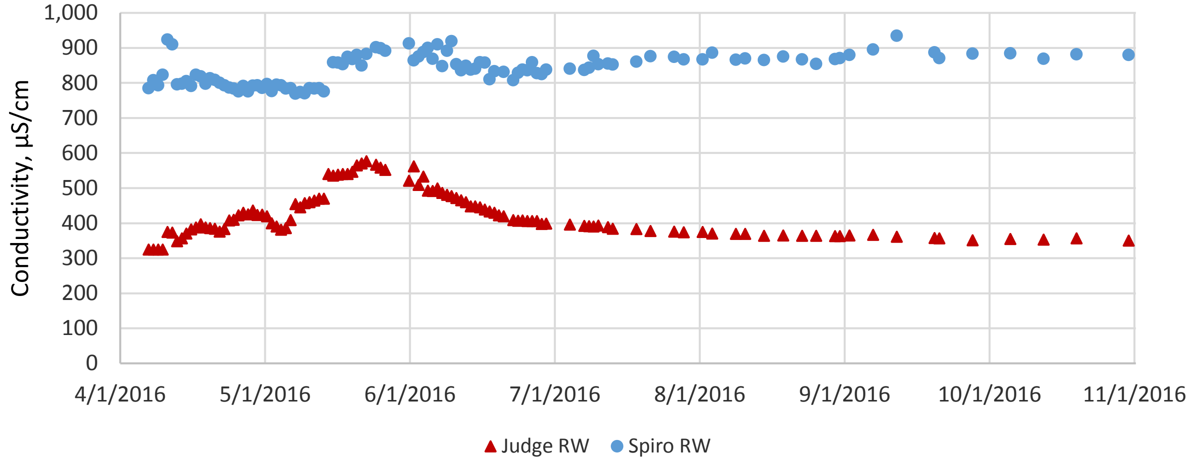
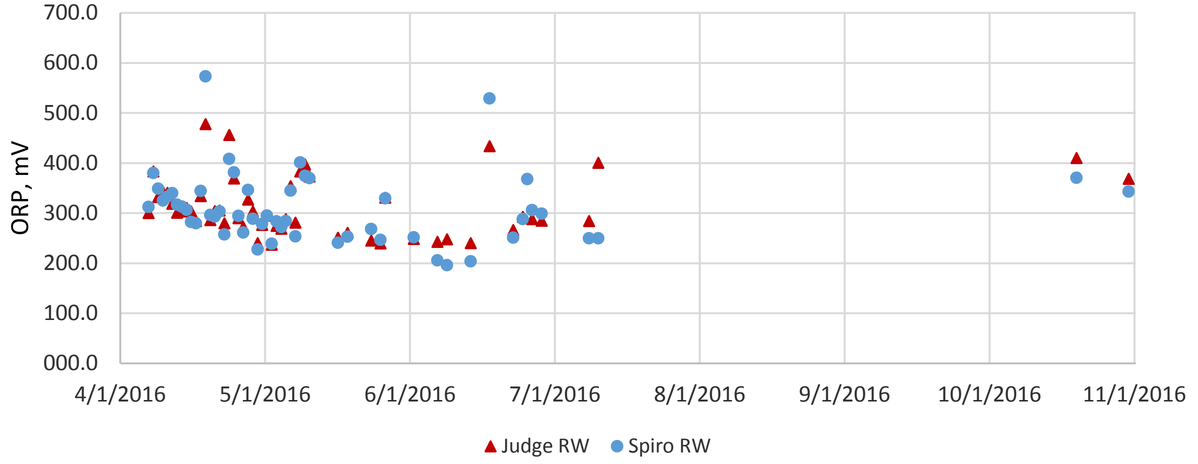


Figure E-29: Raw Water Oxidation Reduction Potential



Appendix F
Optimized 42-inch Pyrolusite Filter Run Profiles

Figure F-1: PY01 Filter Profile

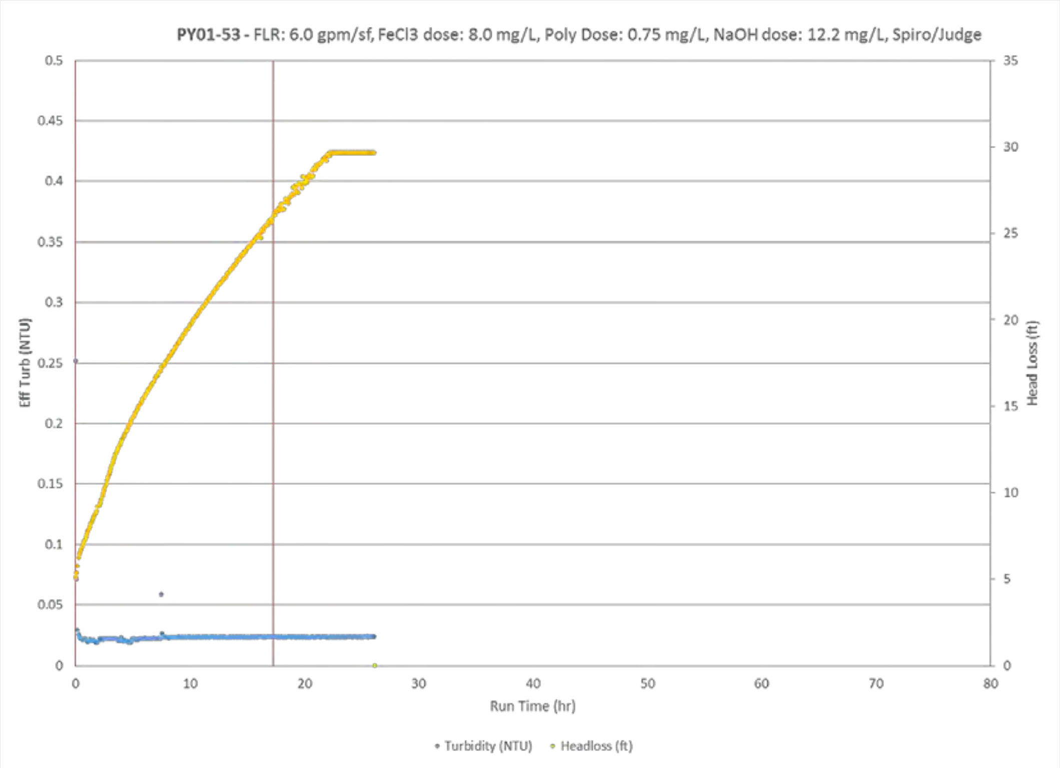


Figure F-2: PY01 Filter Profile

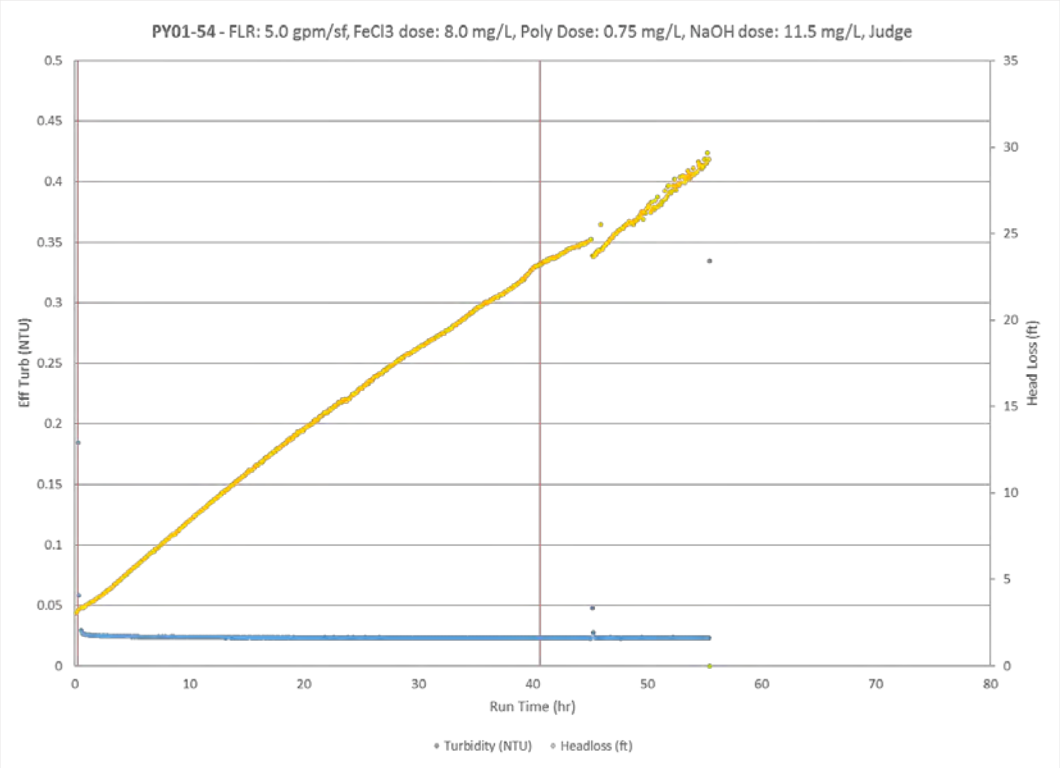


Figure F-3: PY01 Filter Profile

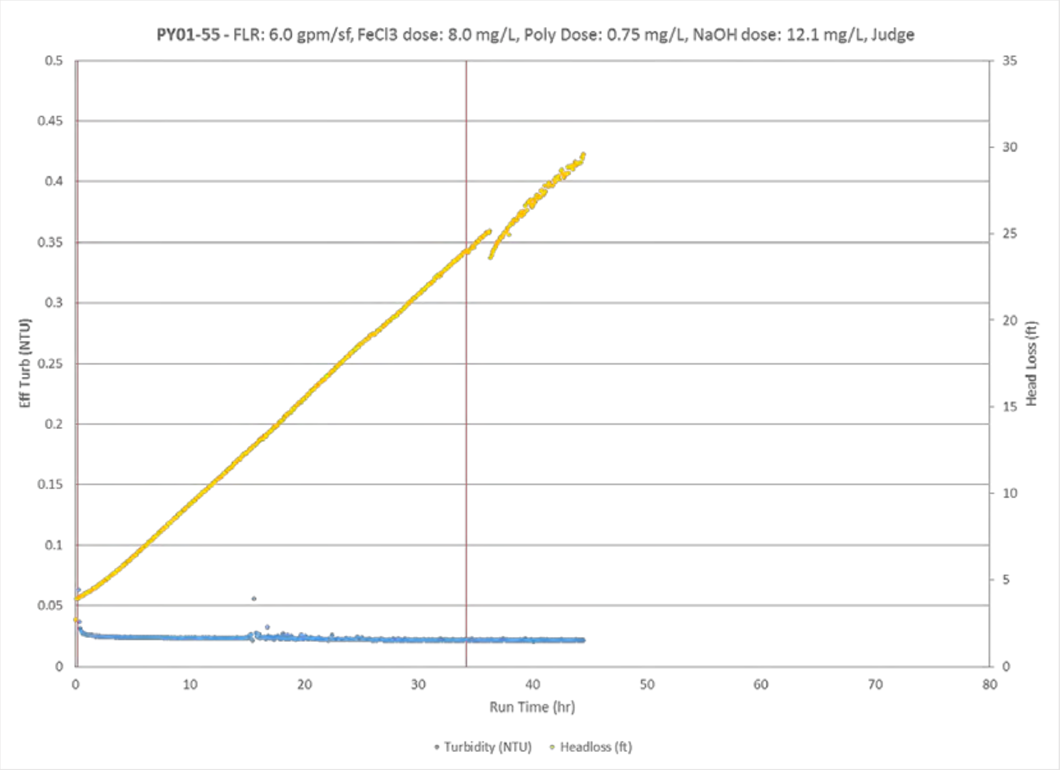


Figure F-4: PY01 Filter Profile

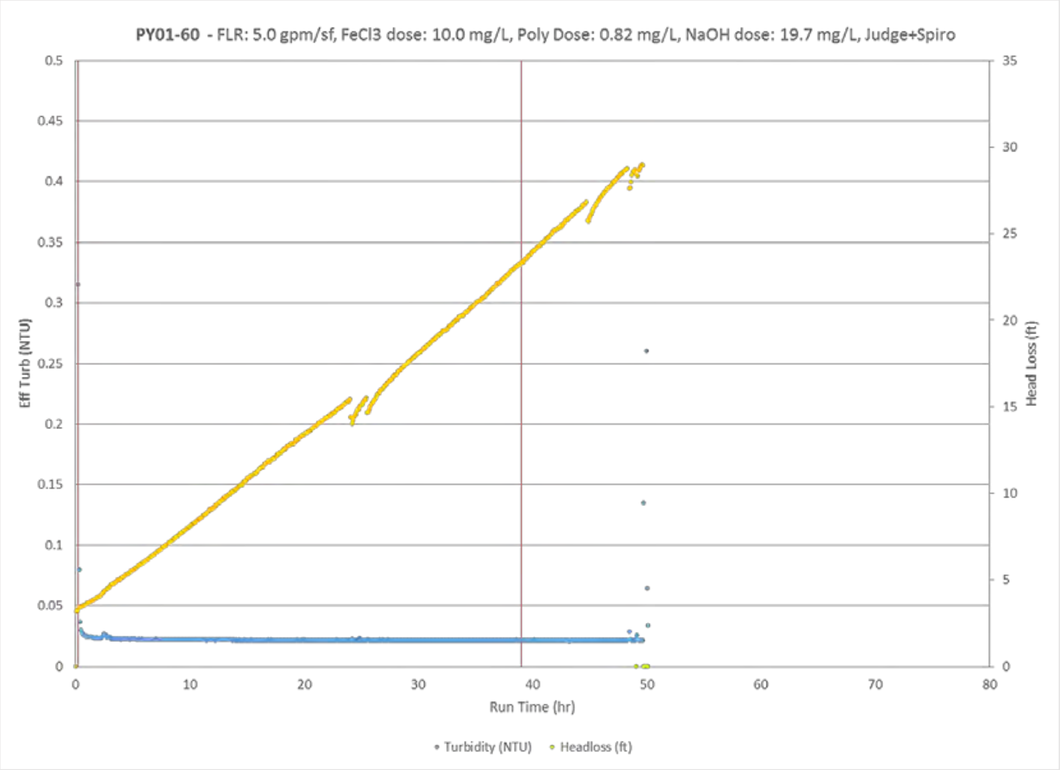


Figure F-5: PY01 Filter Profile

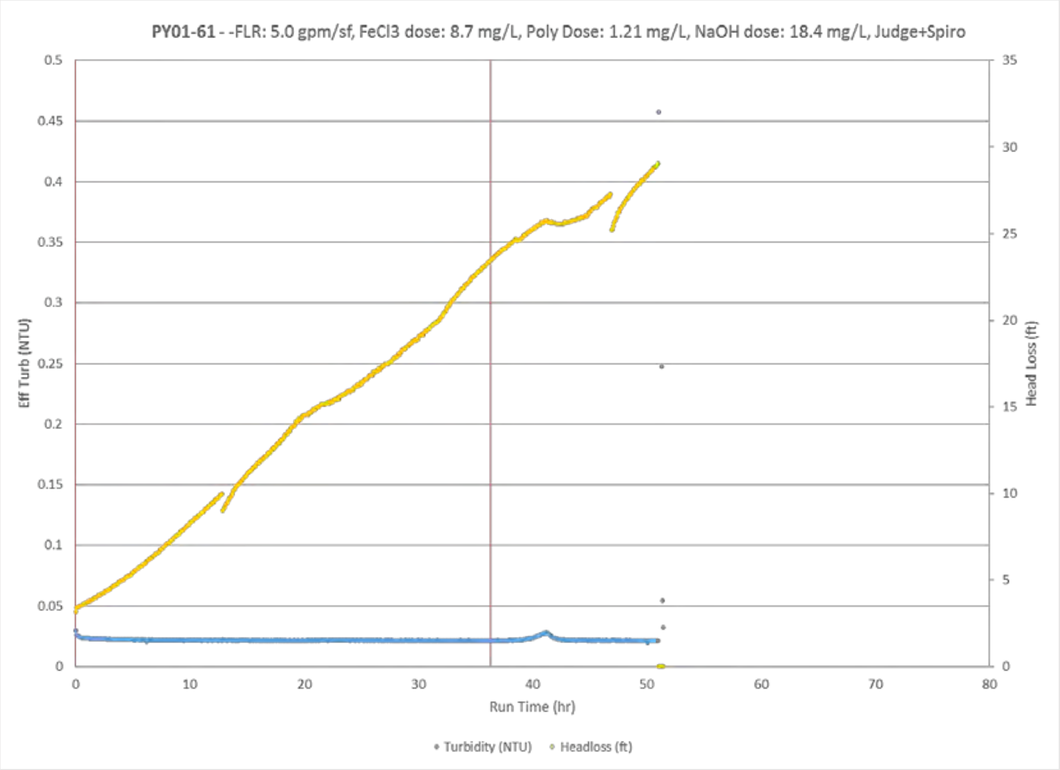


Figure F-6: PY01 Filter Profile

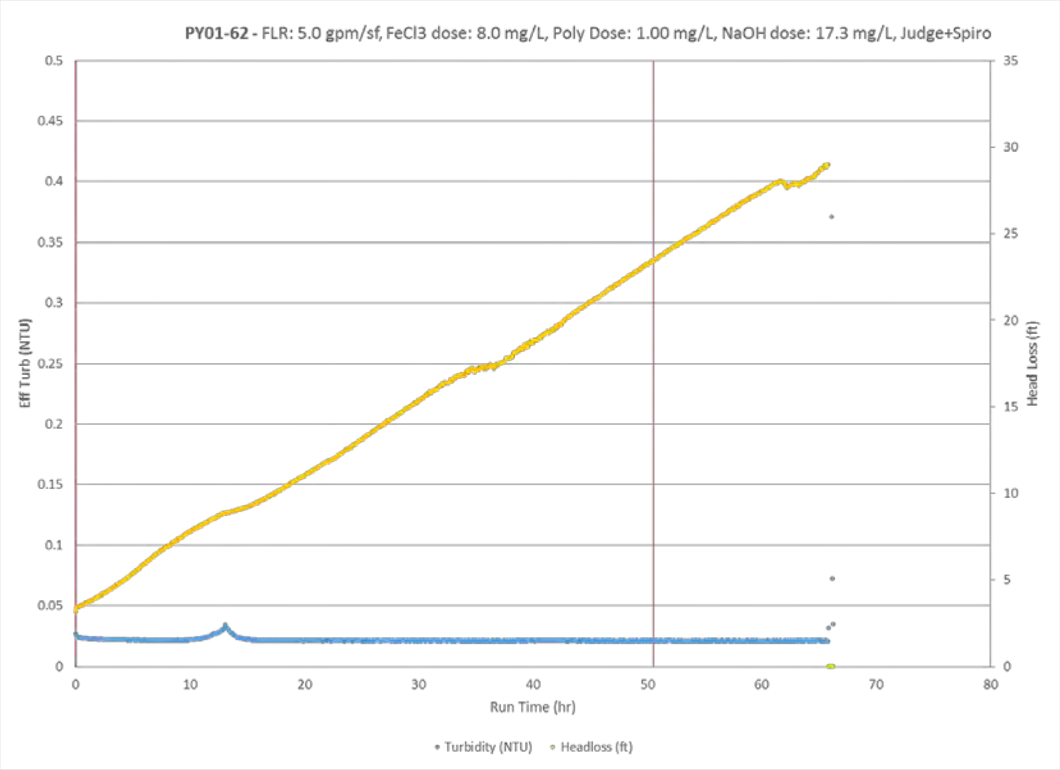


Figure F-7: PY01 Filter Profile

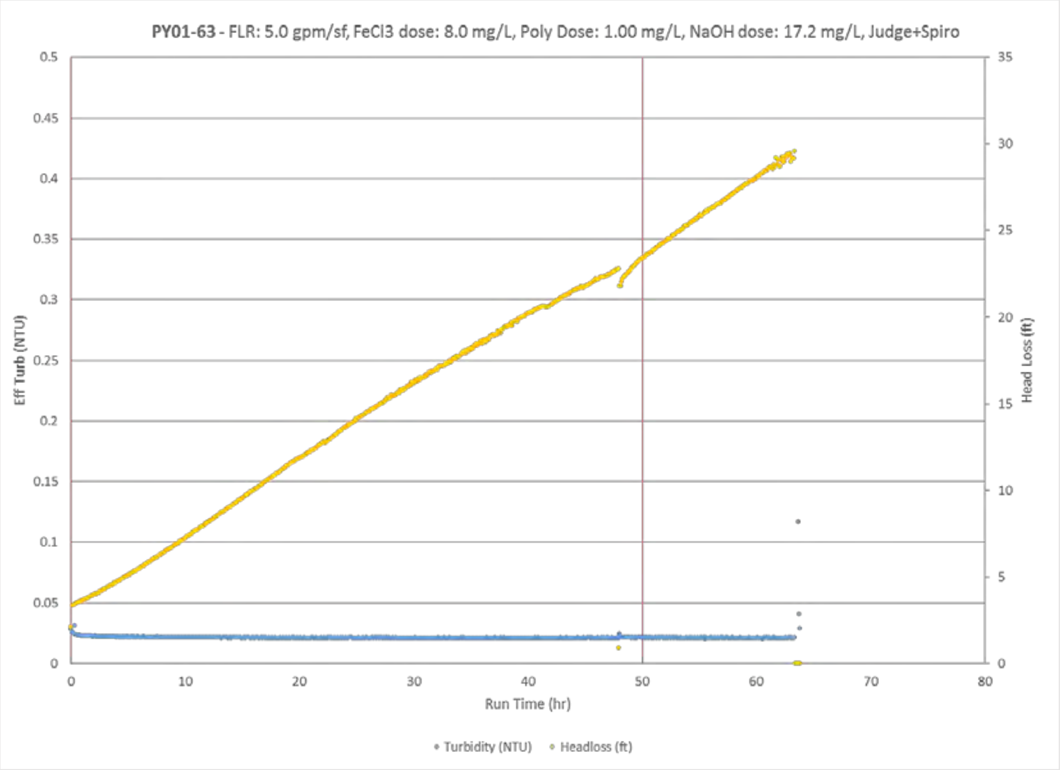


Figure F-8: PY01 Filter Profile

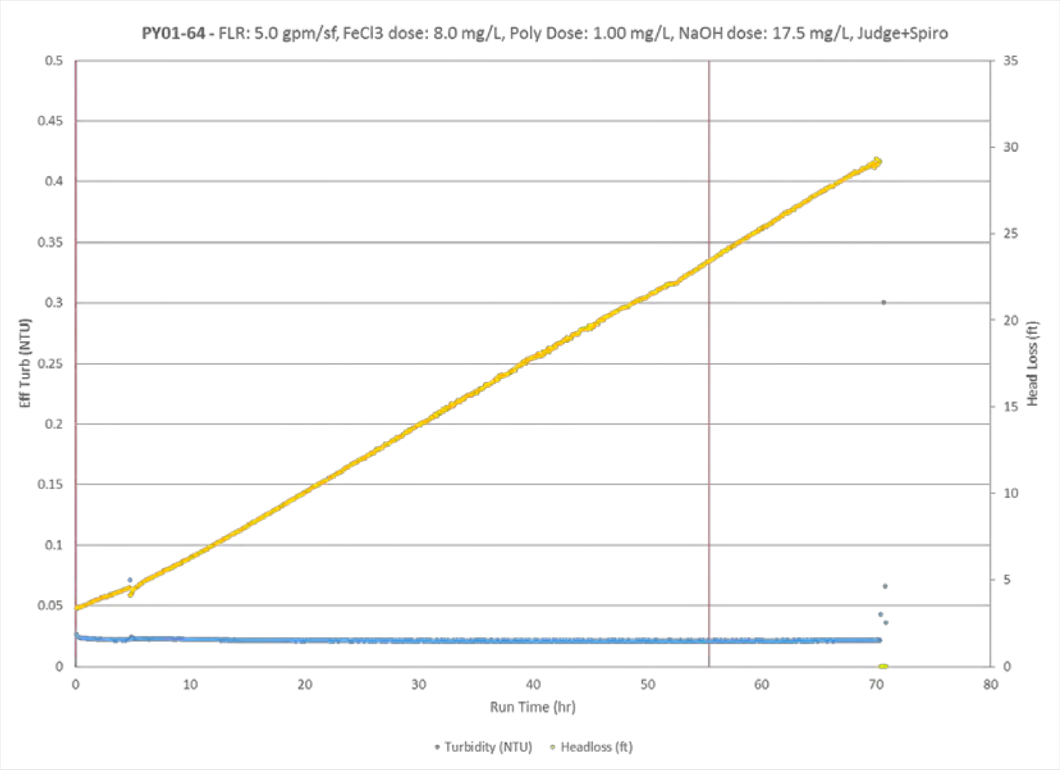


Figure F-9: PY01 Filter Profile

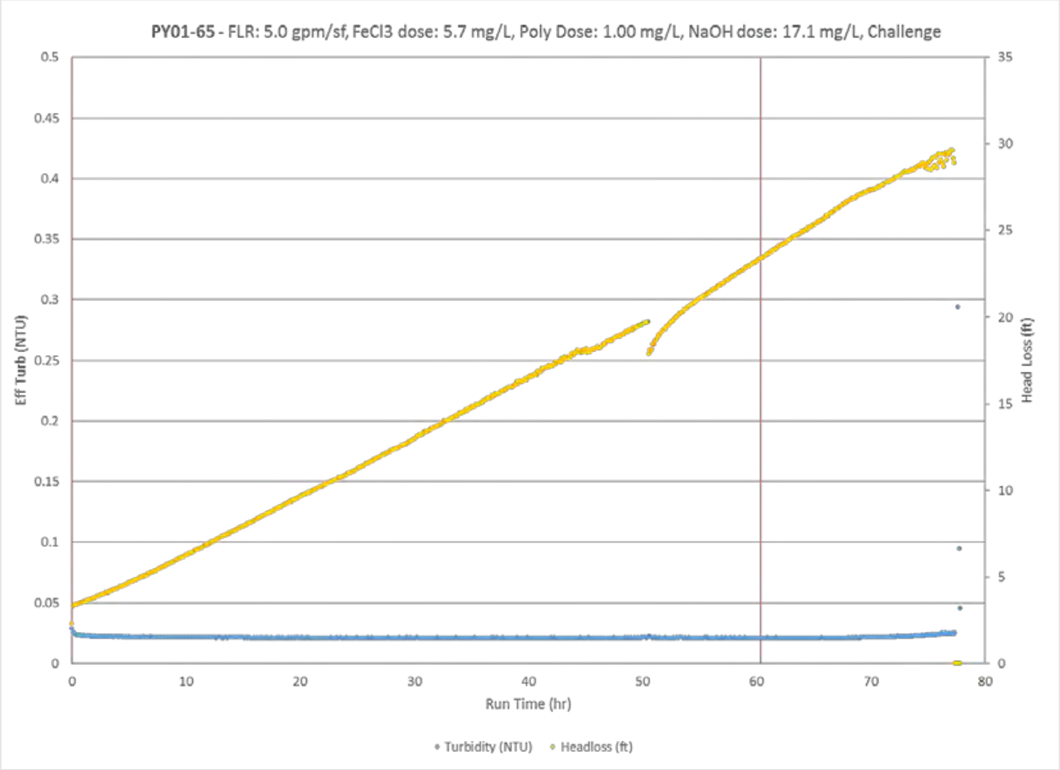


Figure F-10: PY01 Filter Profile

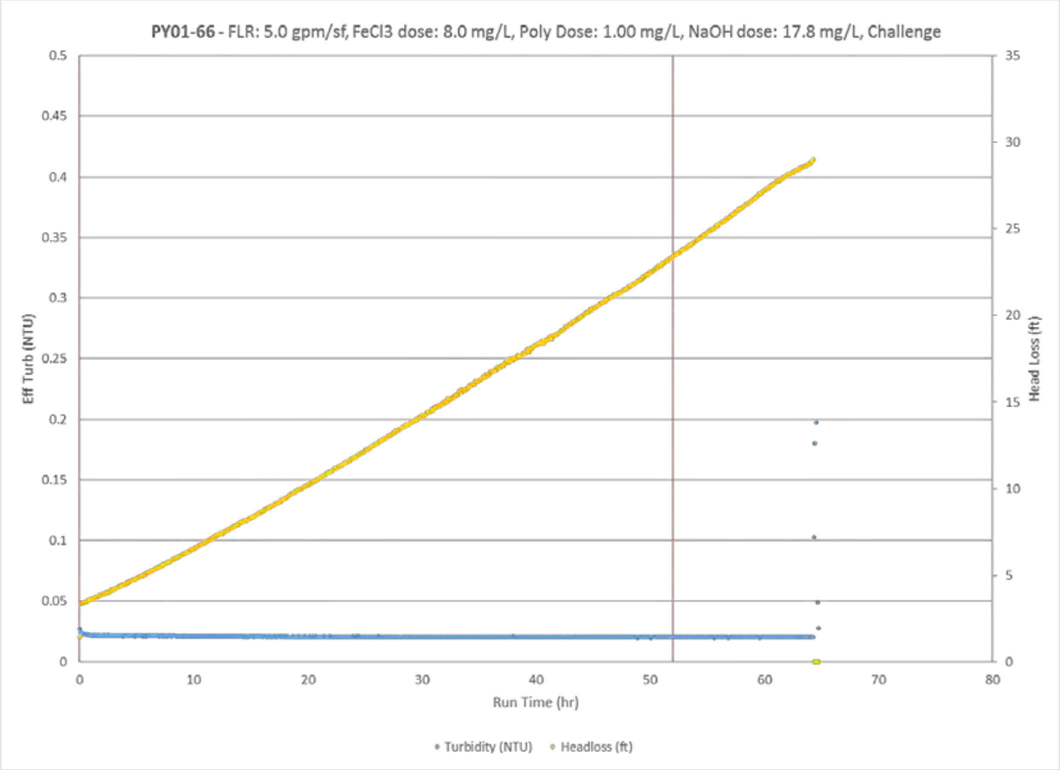


Figure F-11: PY01 Filter Profile

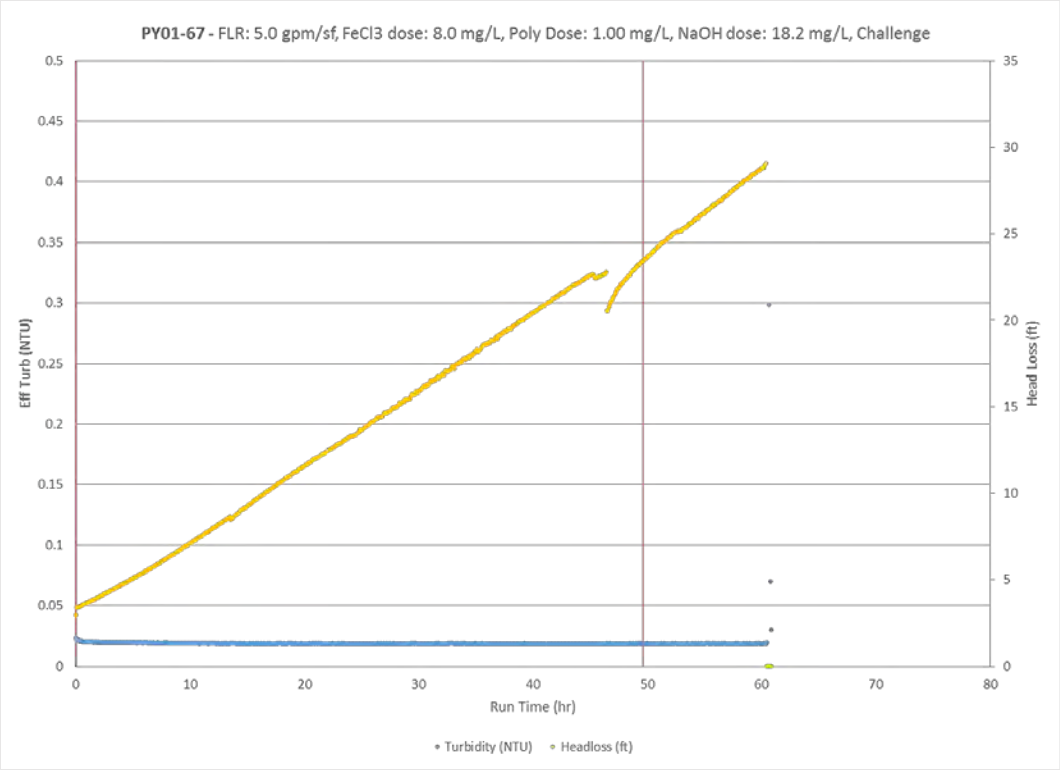


Figure F-12: PY01 Filter Profile

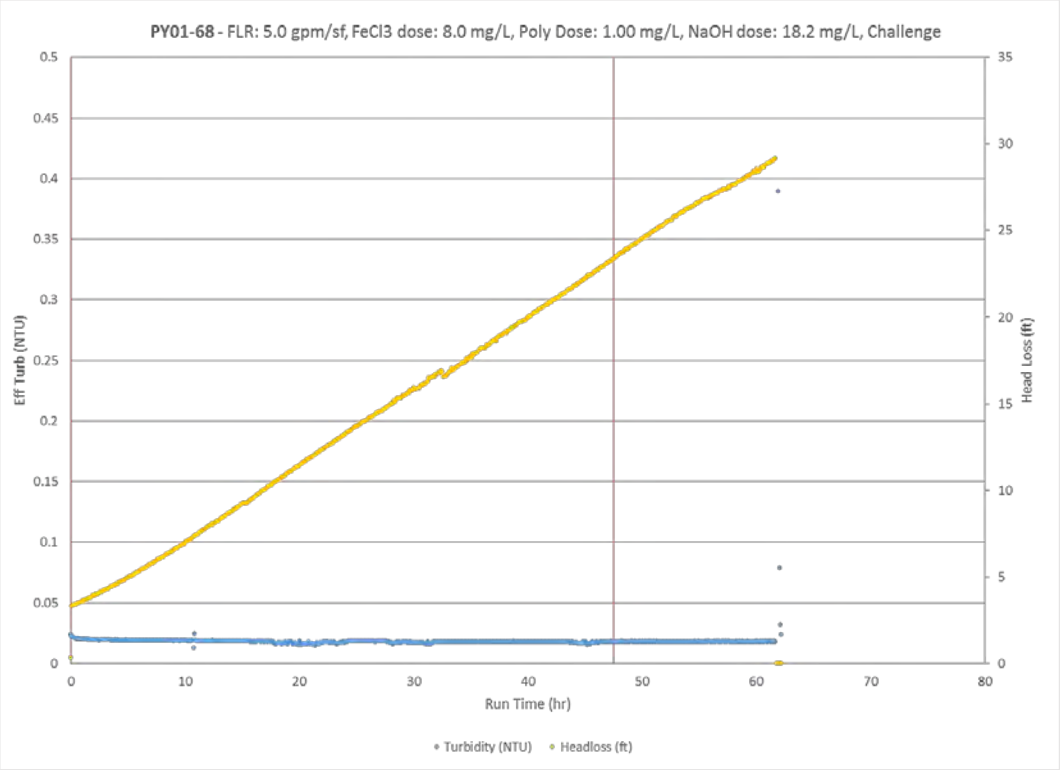


Figure F-13: PY01 Filter Profile

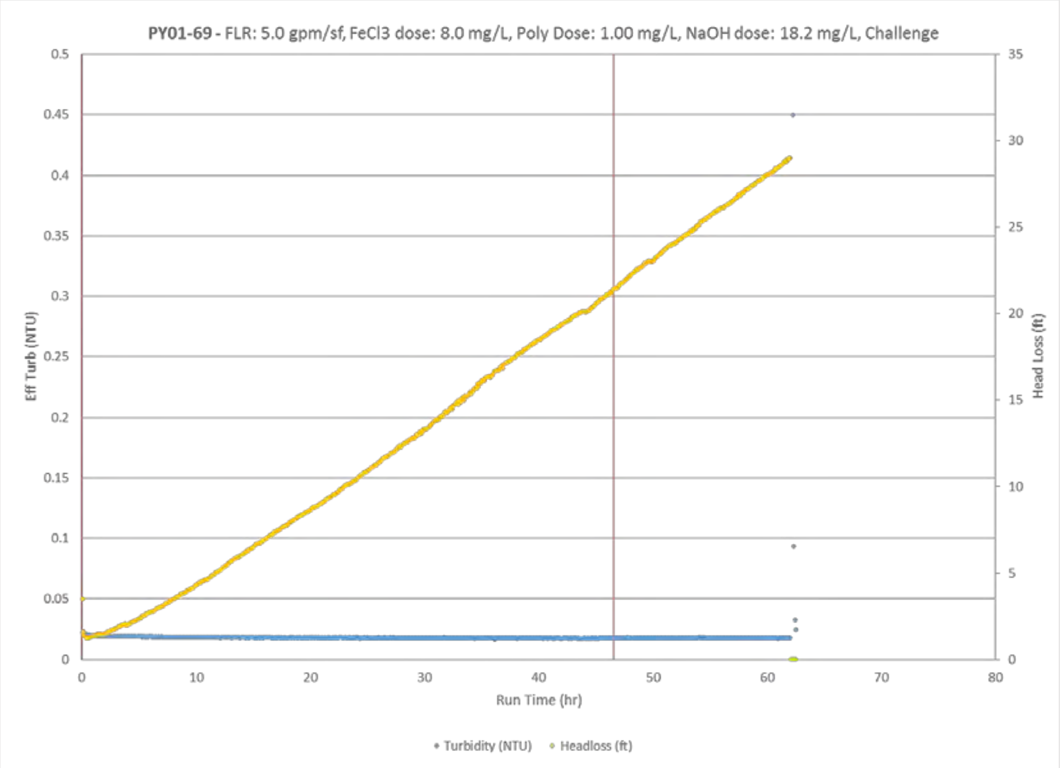


Figure F-14: PY01 Filter Profile

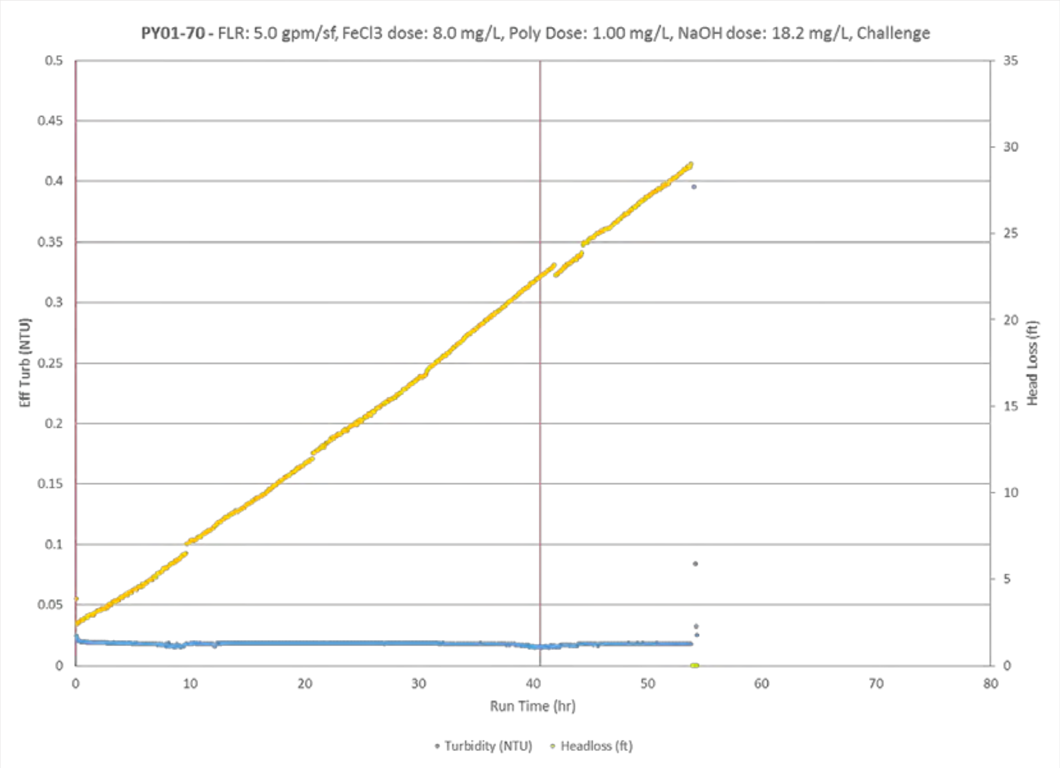


Figure F-15: PY01 Filter Profile

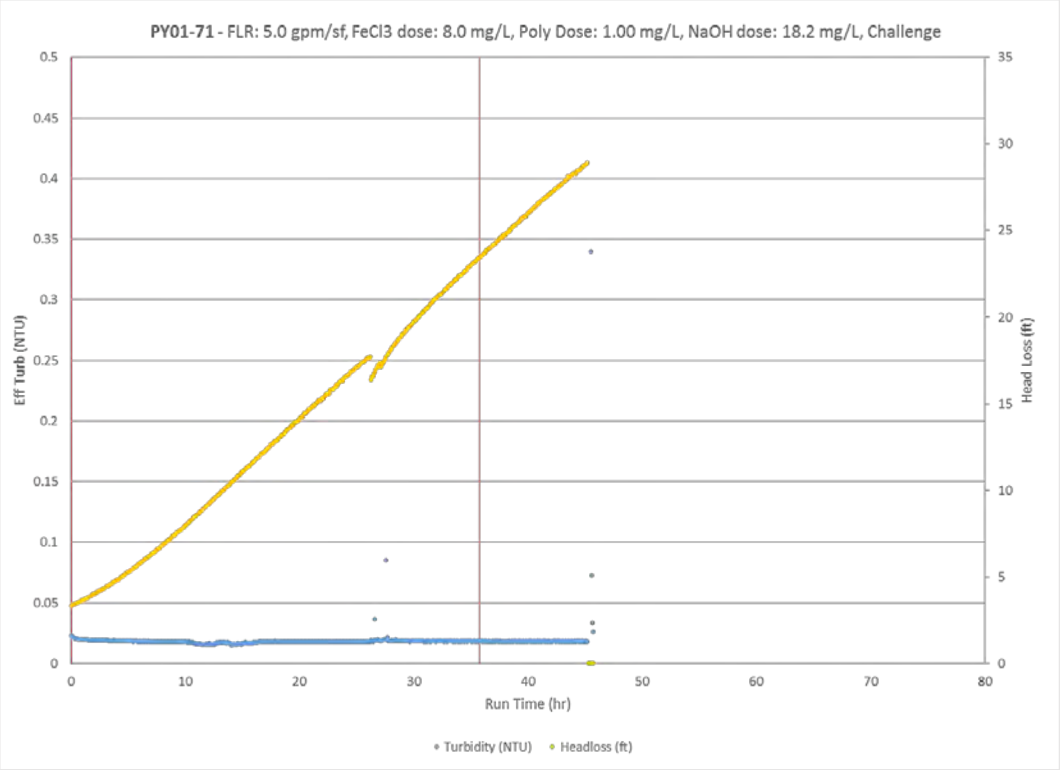


Figure F-16: PY01 Filter Profile

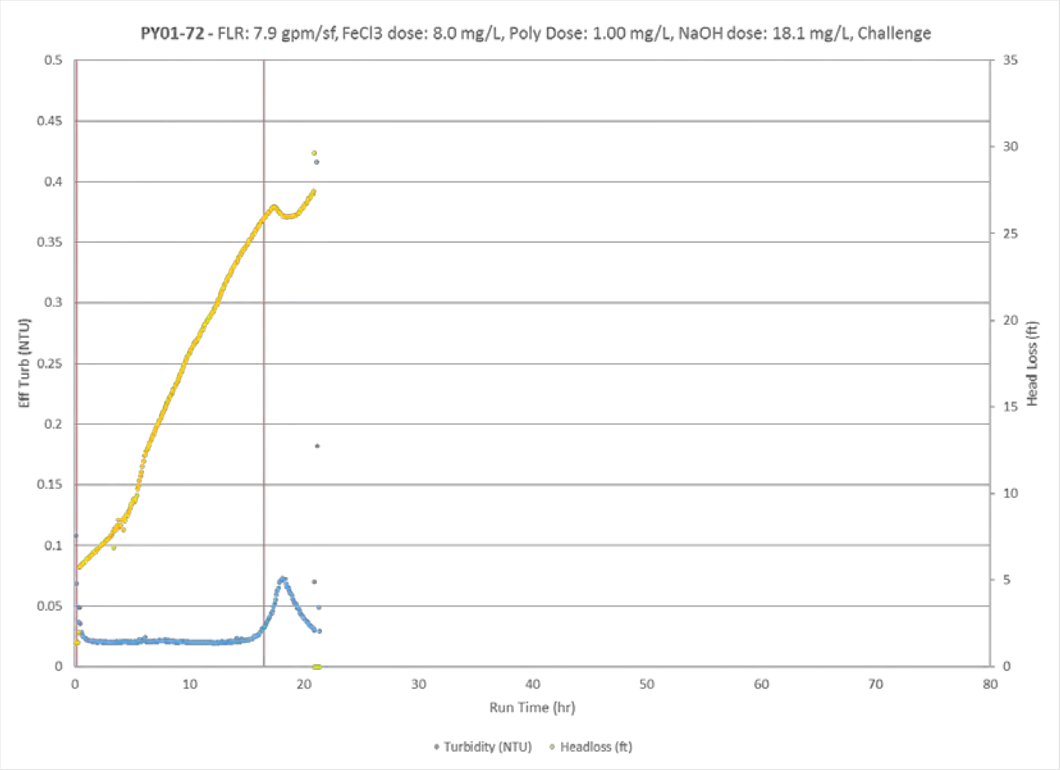


Figure F-17: PY01 Filter Profile

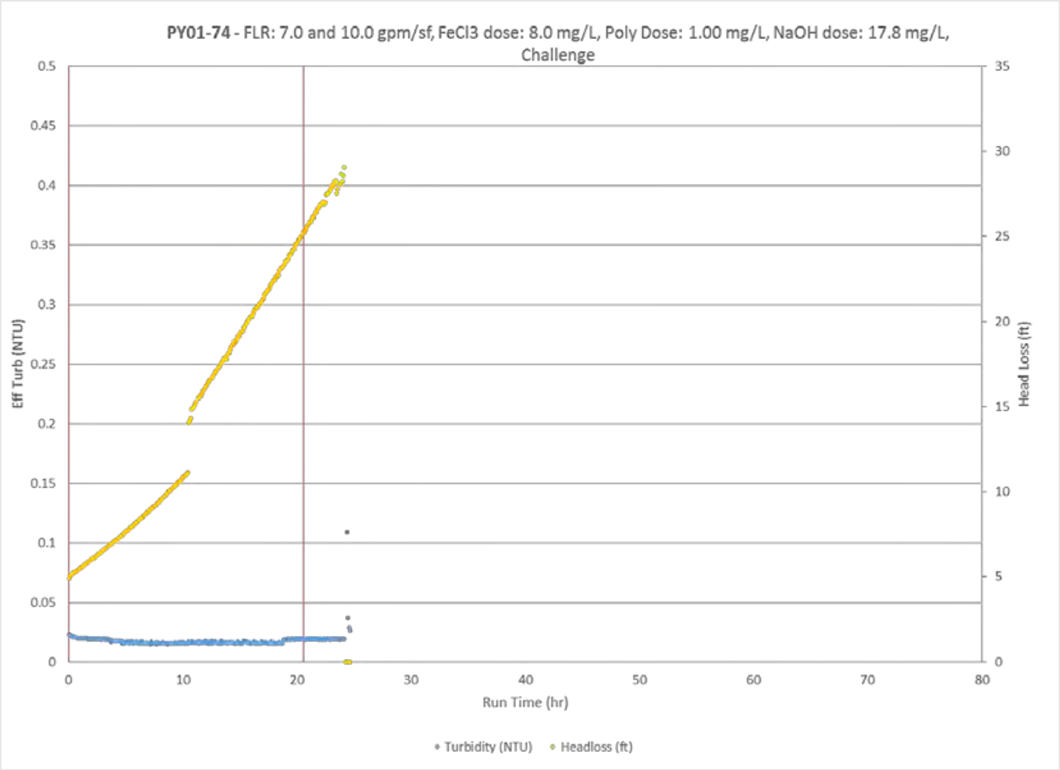


Figure F-18: PY01 Filter Profile

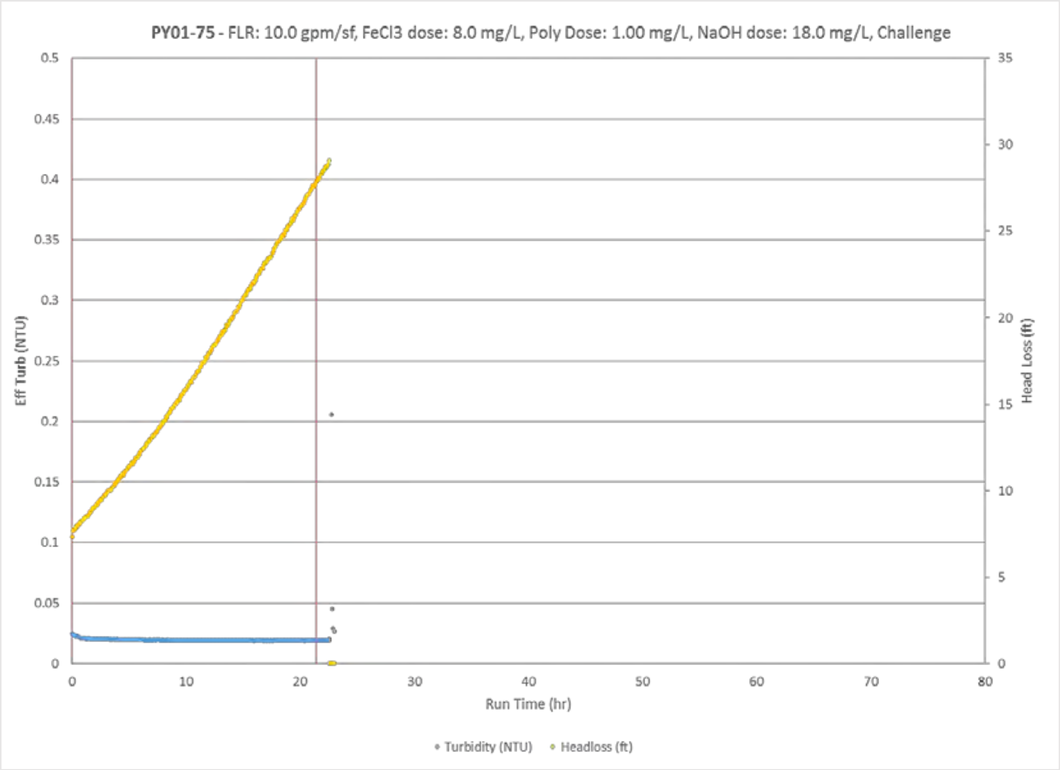


Figure F-19: PY01 Filter Profile

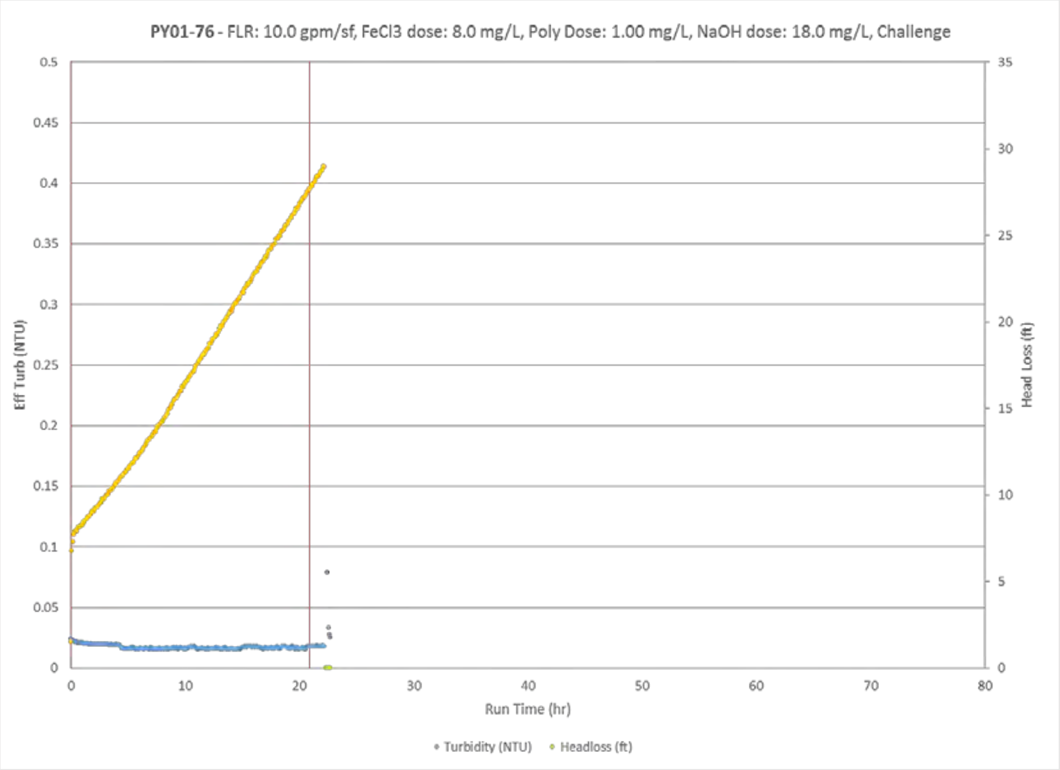


Figure F-20: PY01 Filter Profile

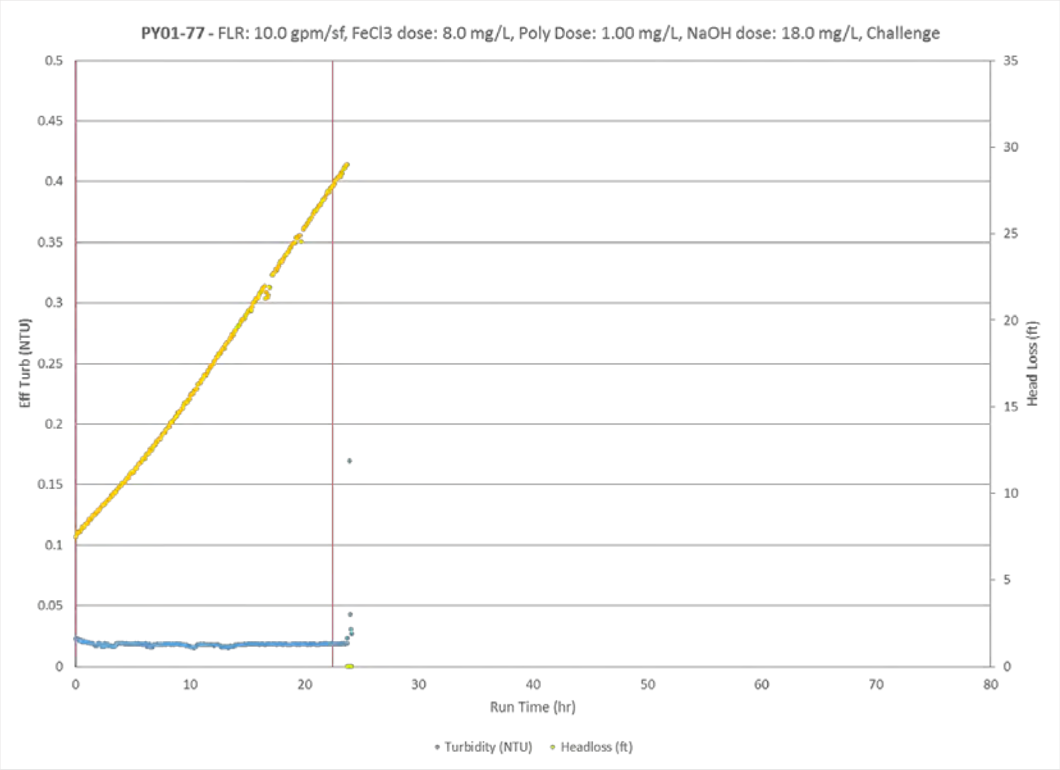


Figure F-21: PY01 Filter Profile

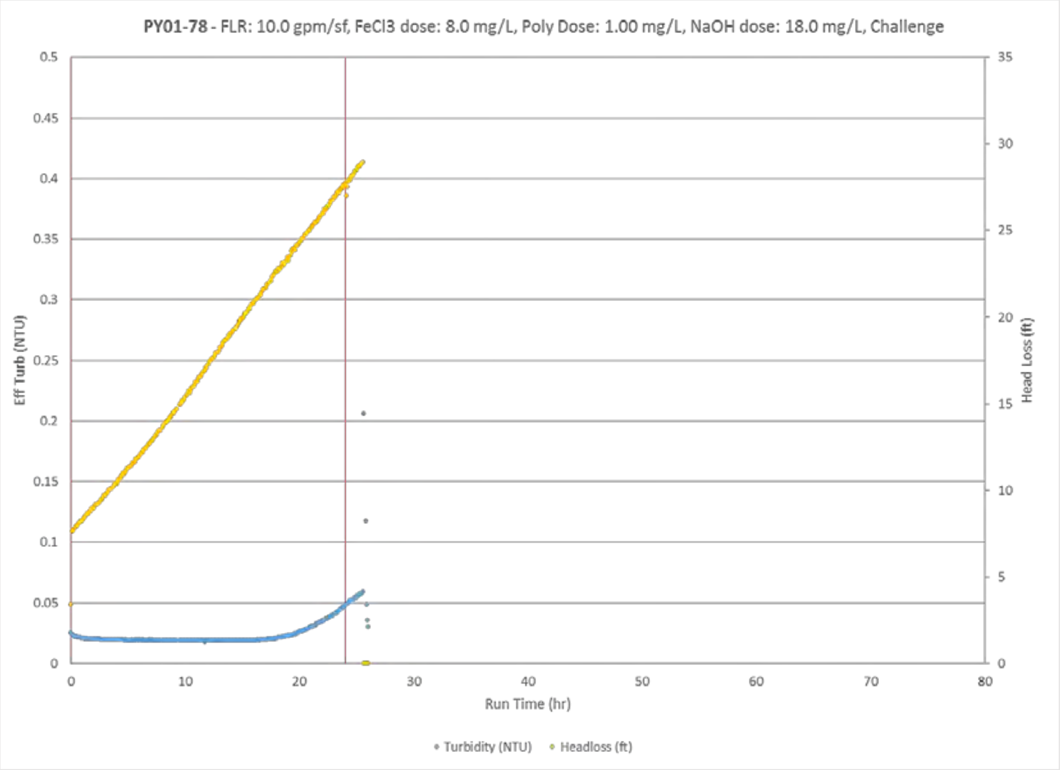


Figure F-22: PY01 Filter Profile

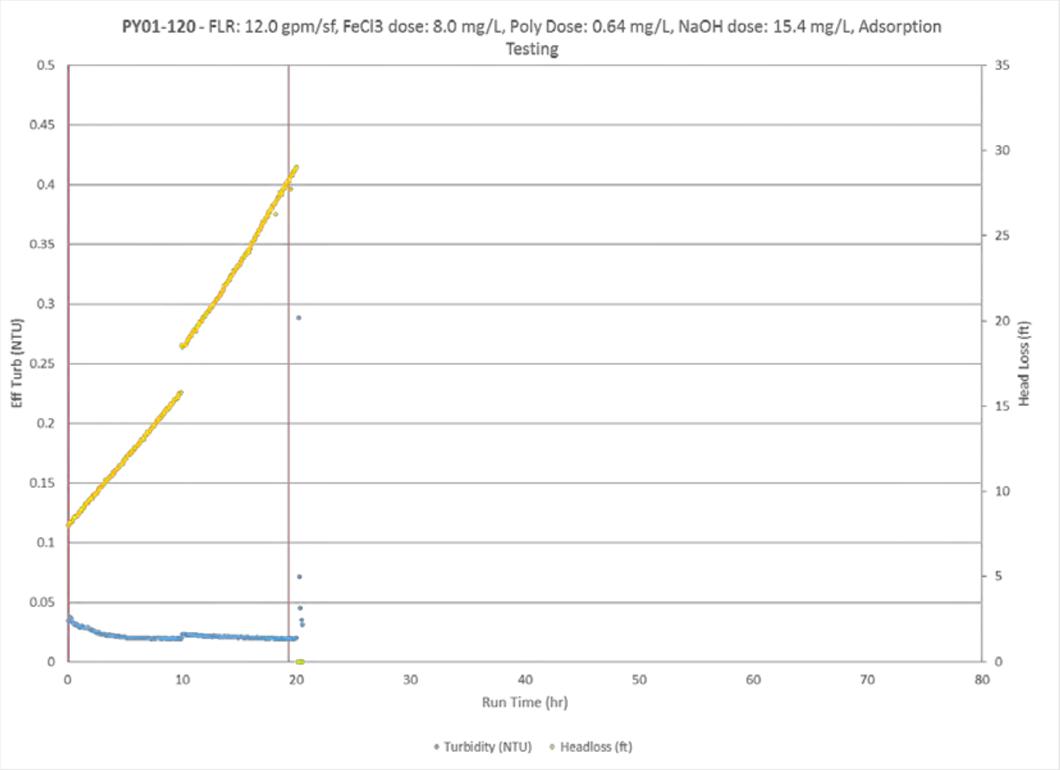


Figure F-23: PY01 Filter Profile

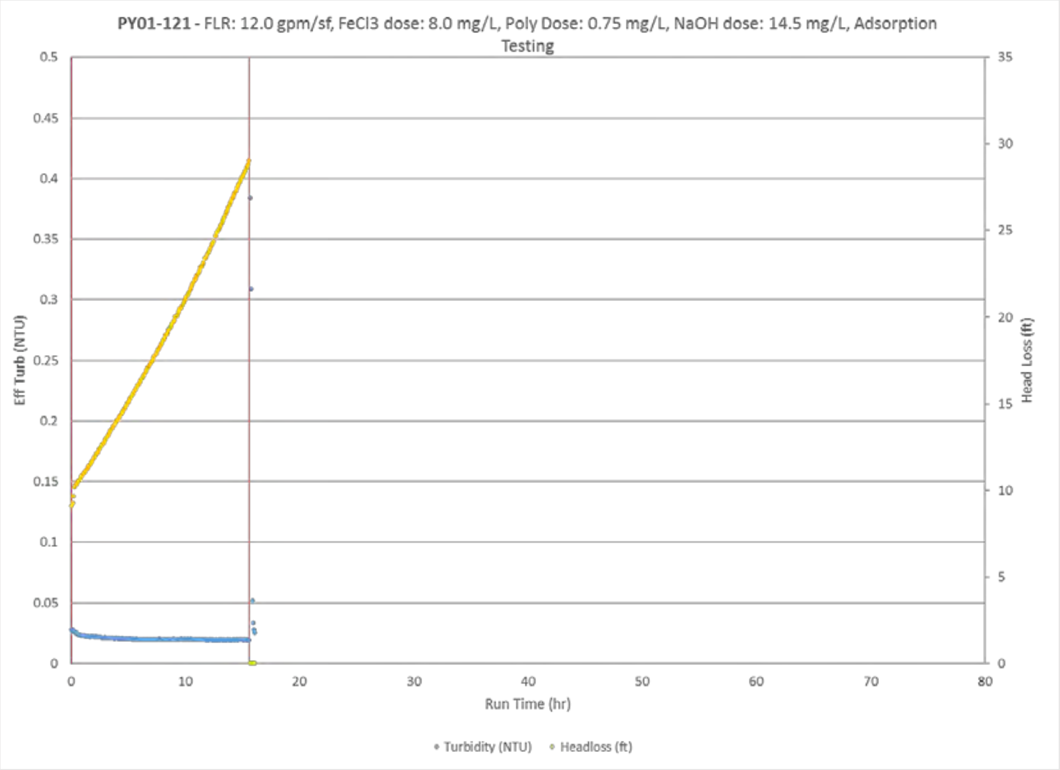


Figure F-24: PY01 Filter Profile

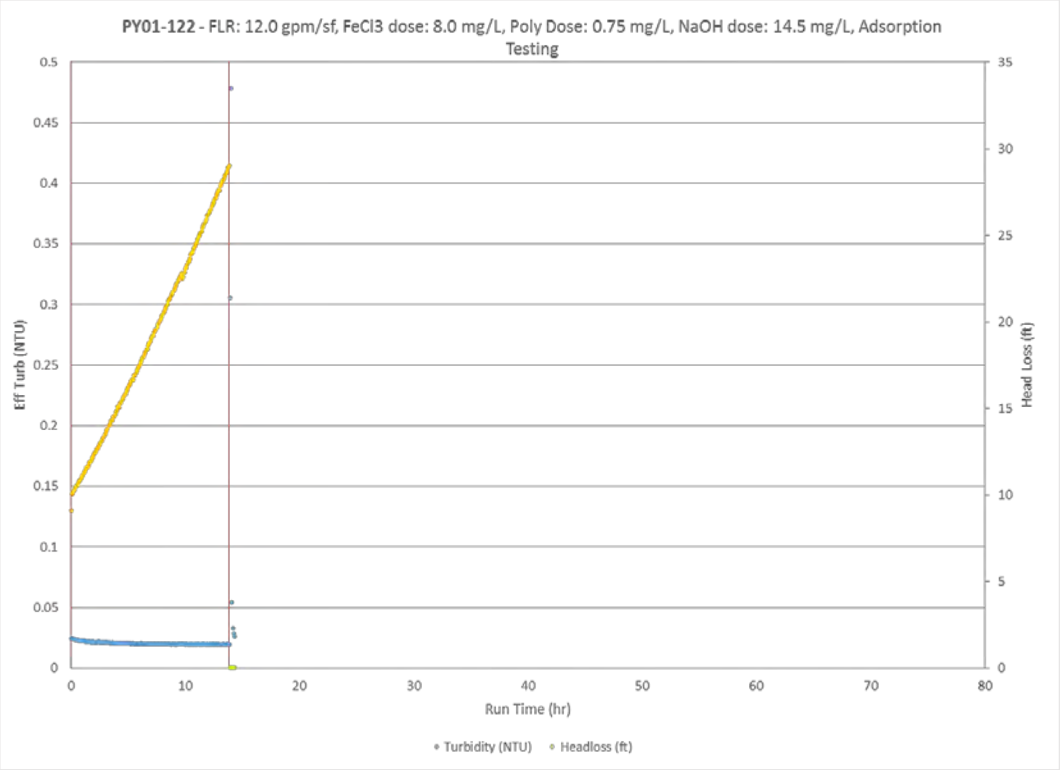


Figure F-25: PY01 Filter Profile

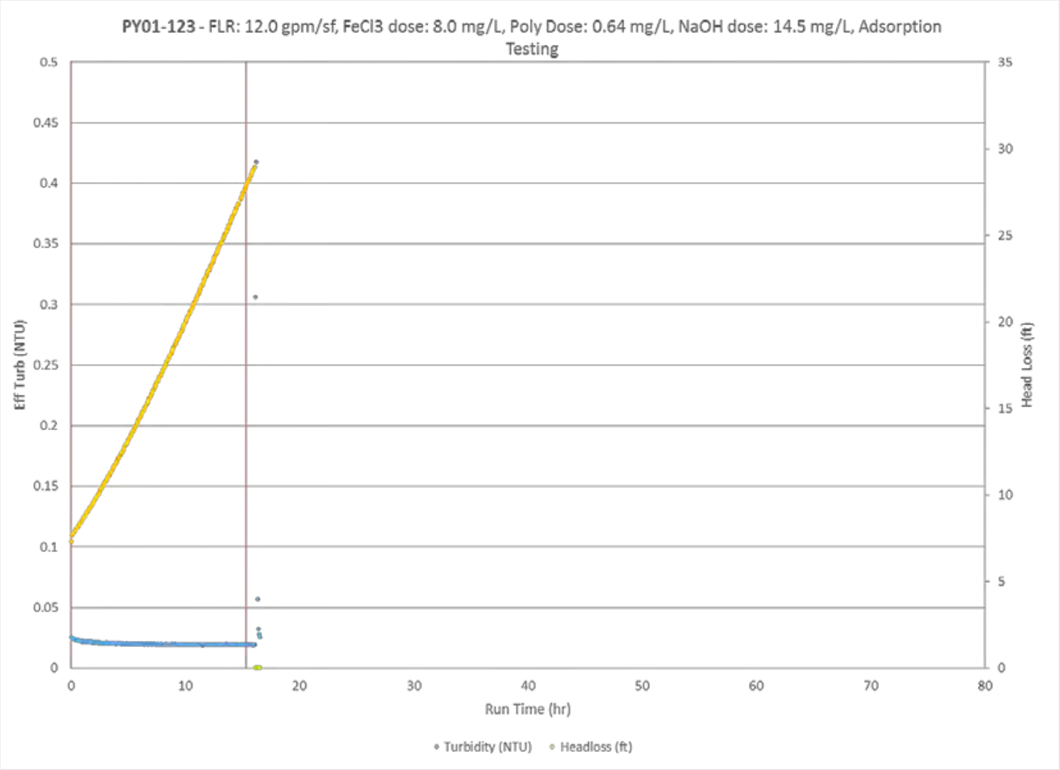


Figure F-26: PY01 Filter Profile

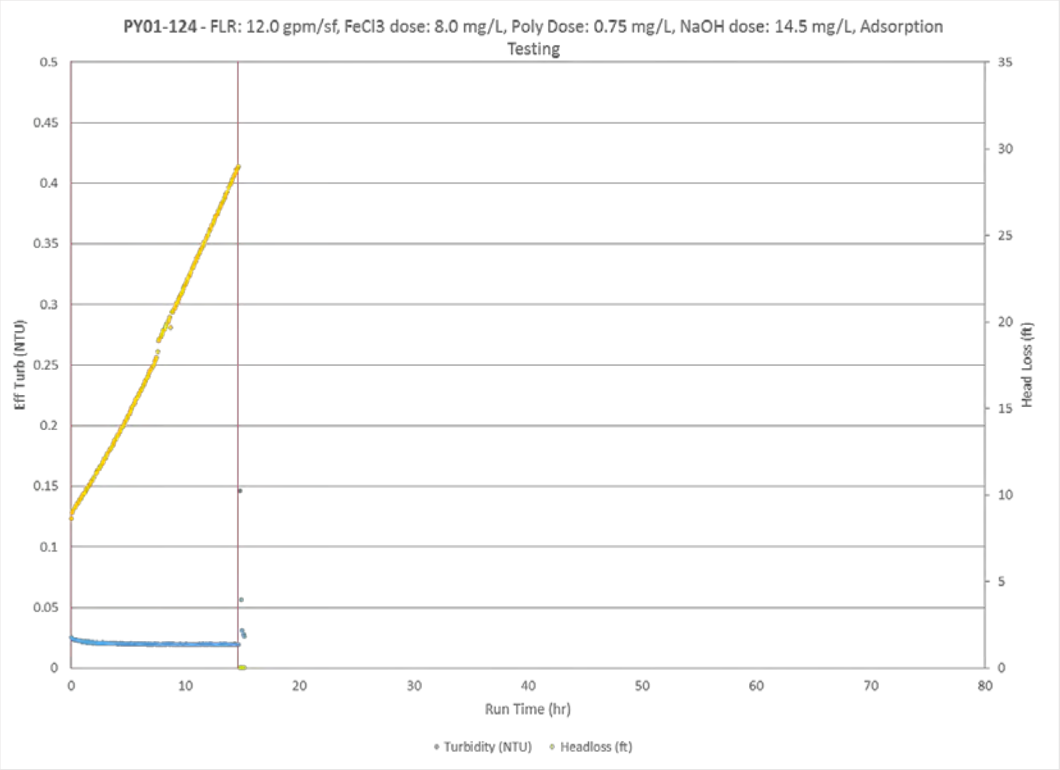


Figure F-27: PY01 Filter Profile

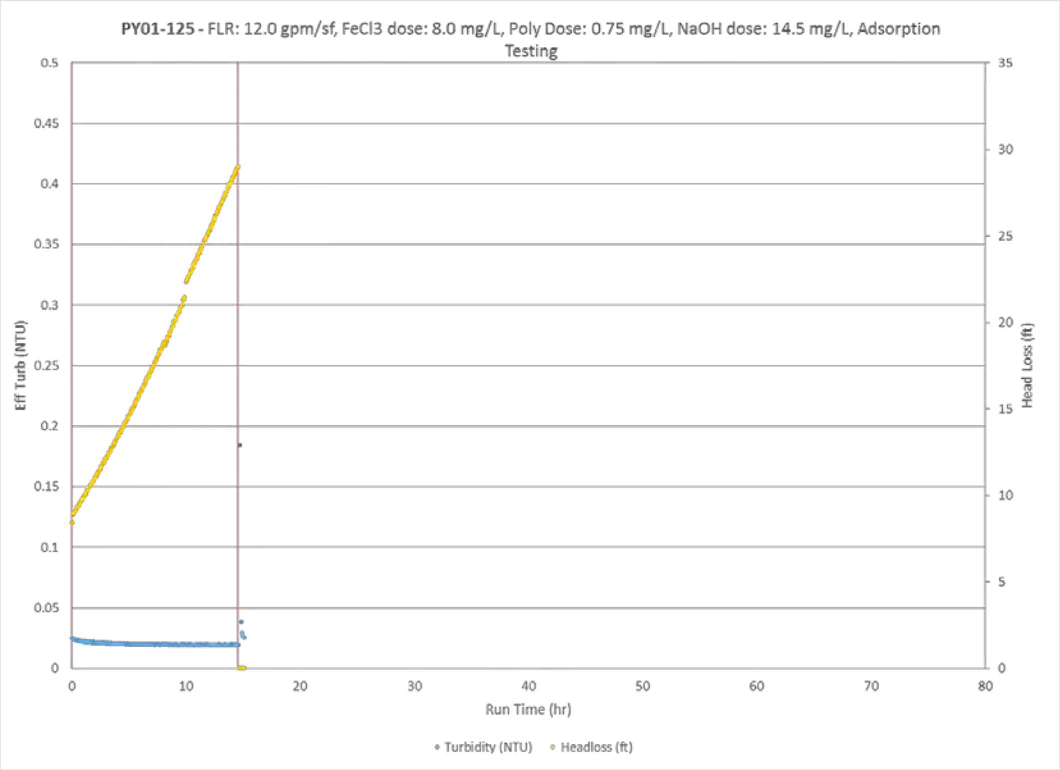


Figure F-28: PY01 Filter Profile

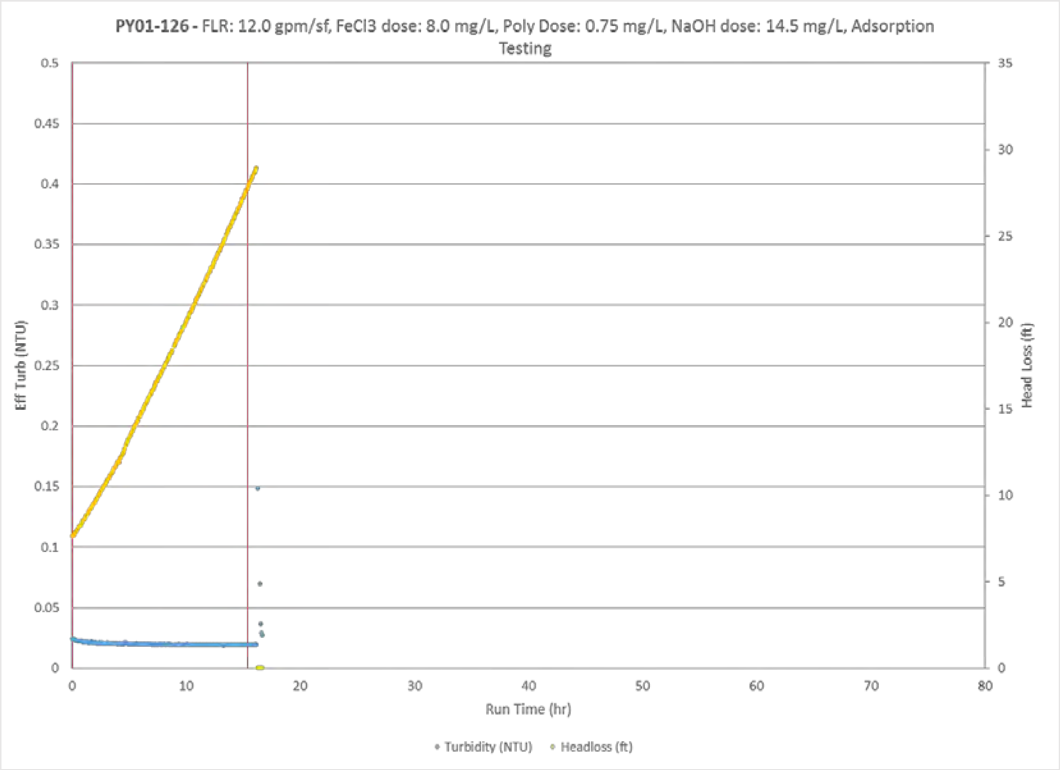


Figure F-29: PY01 Filter Profile

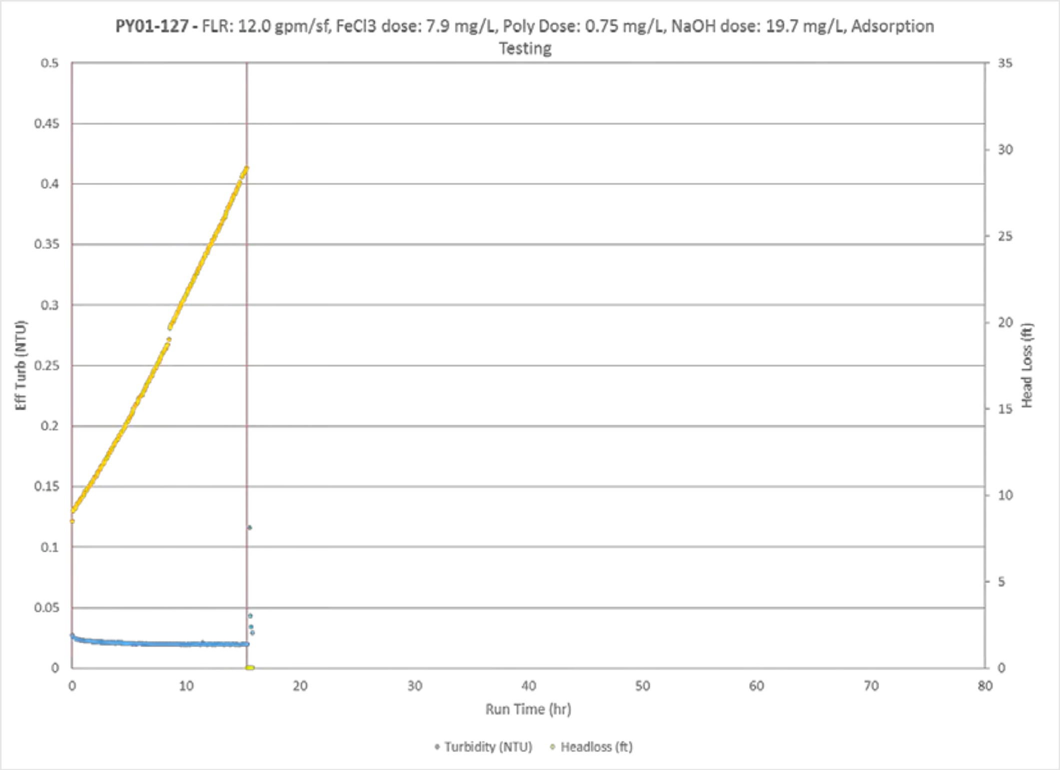


Figure F-30: PY01 Filter Profile

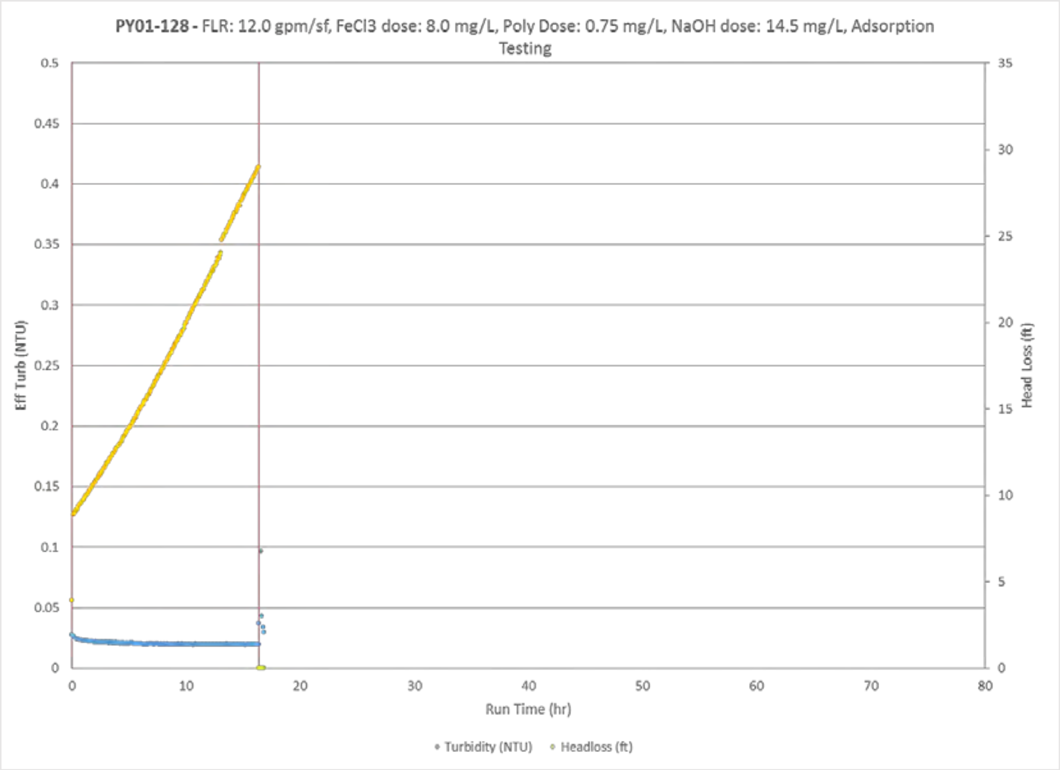


Figure F-31: PY01 Filter Profile

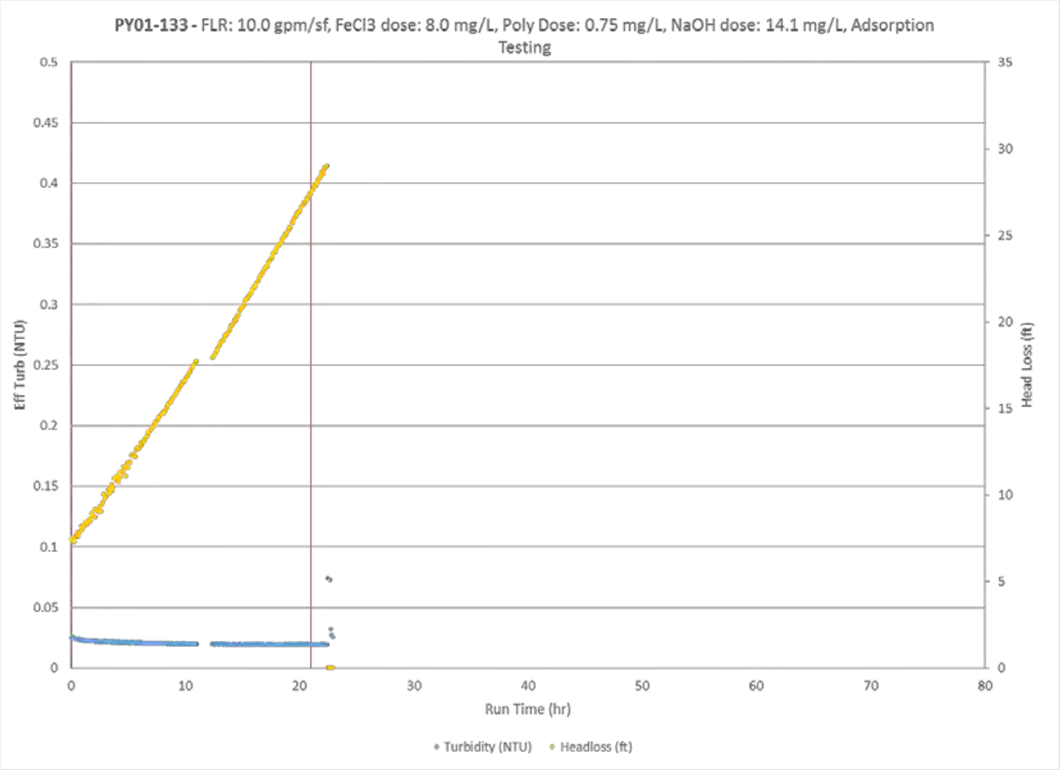


Figure F-32: PY01 Filter Profile

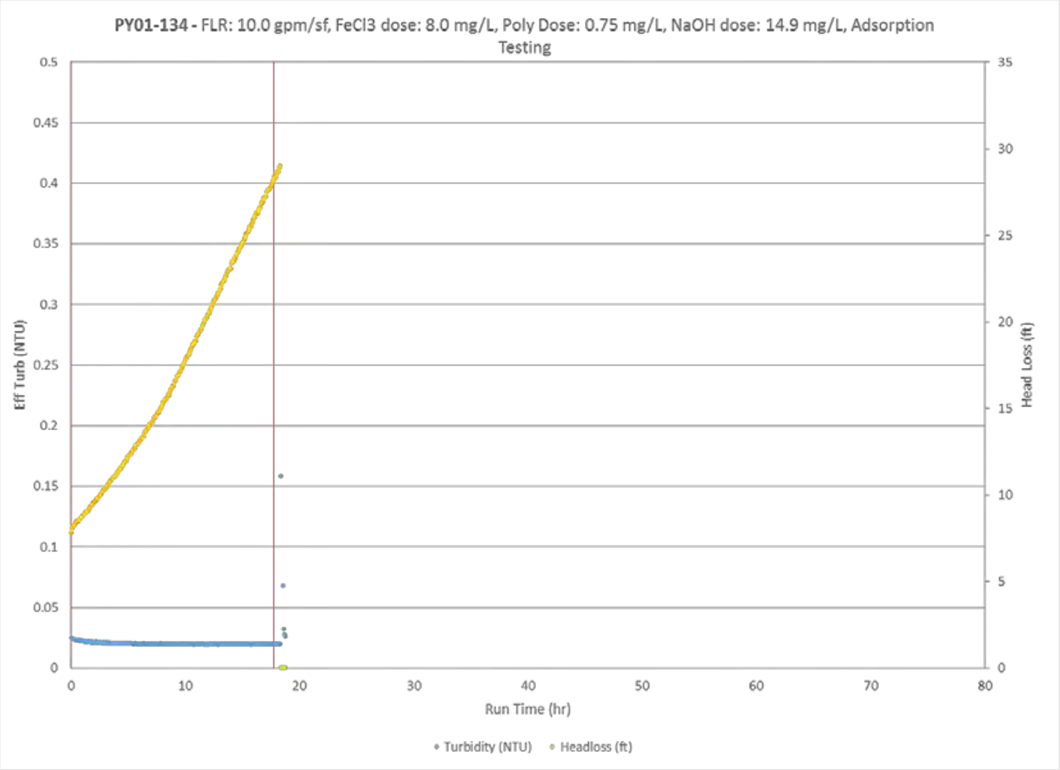


Figure F-33: PY01 Filter Profile

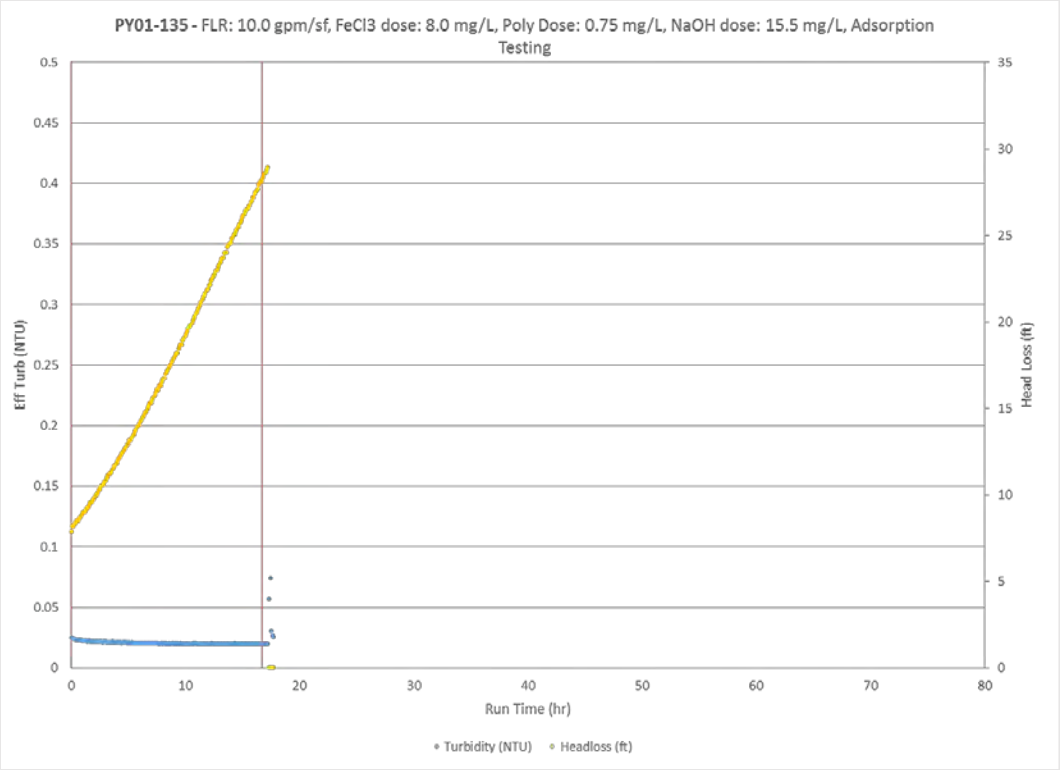


Figure F-34: PY01 Filter Profile

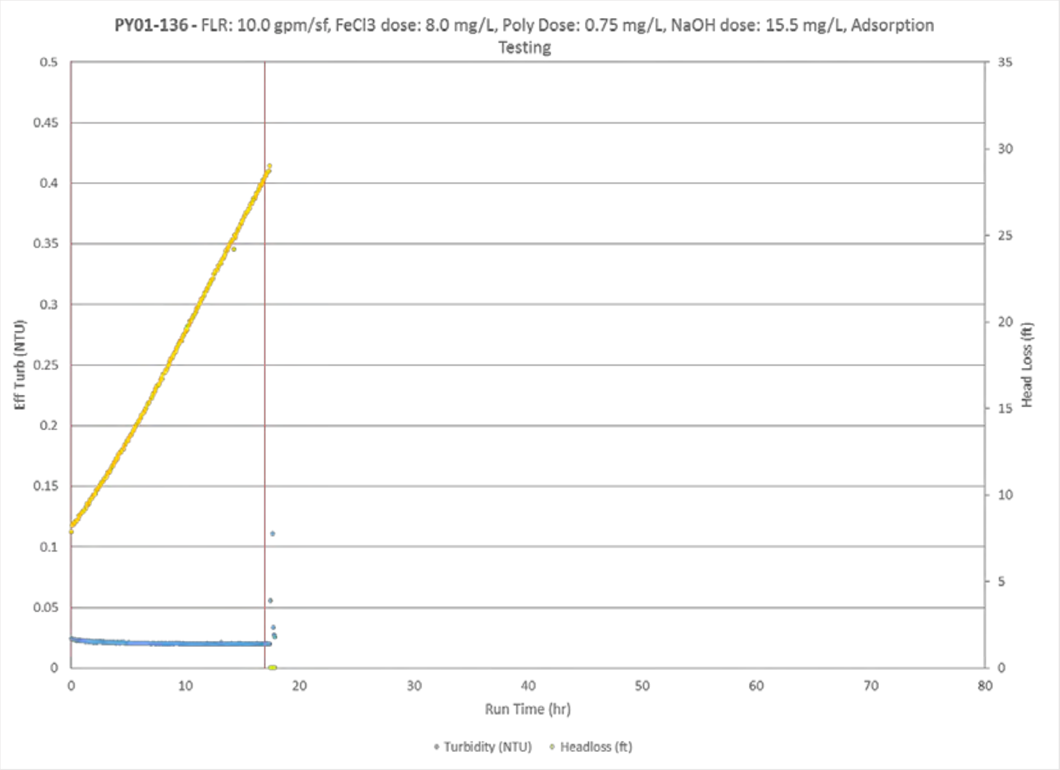


Figure F-35: PY01 Filter Profile

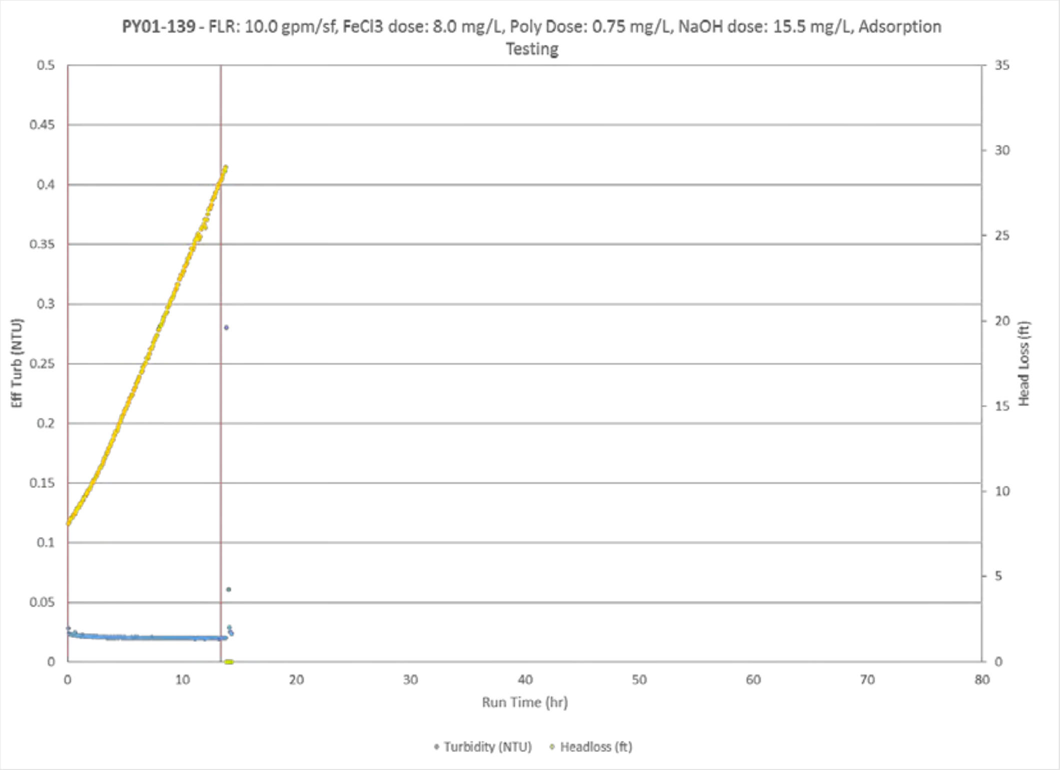


Figure F-36: PY01 Filter Profile

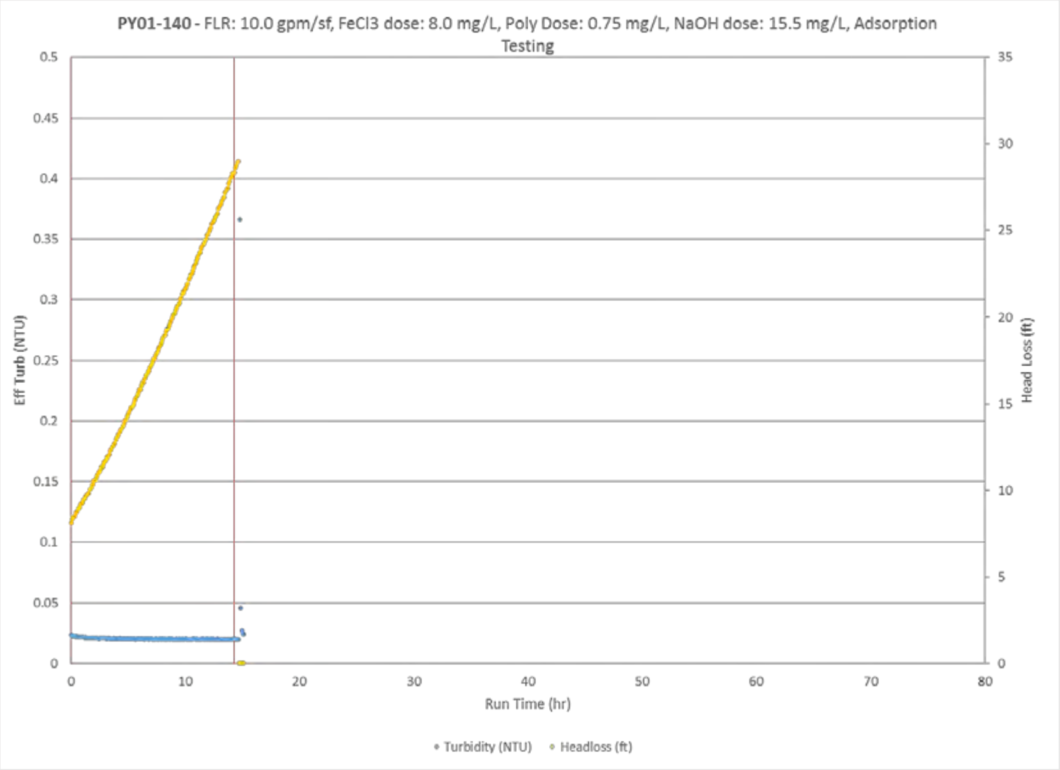


Figure F-37: PY01 Filter Profile

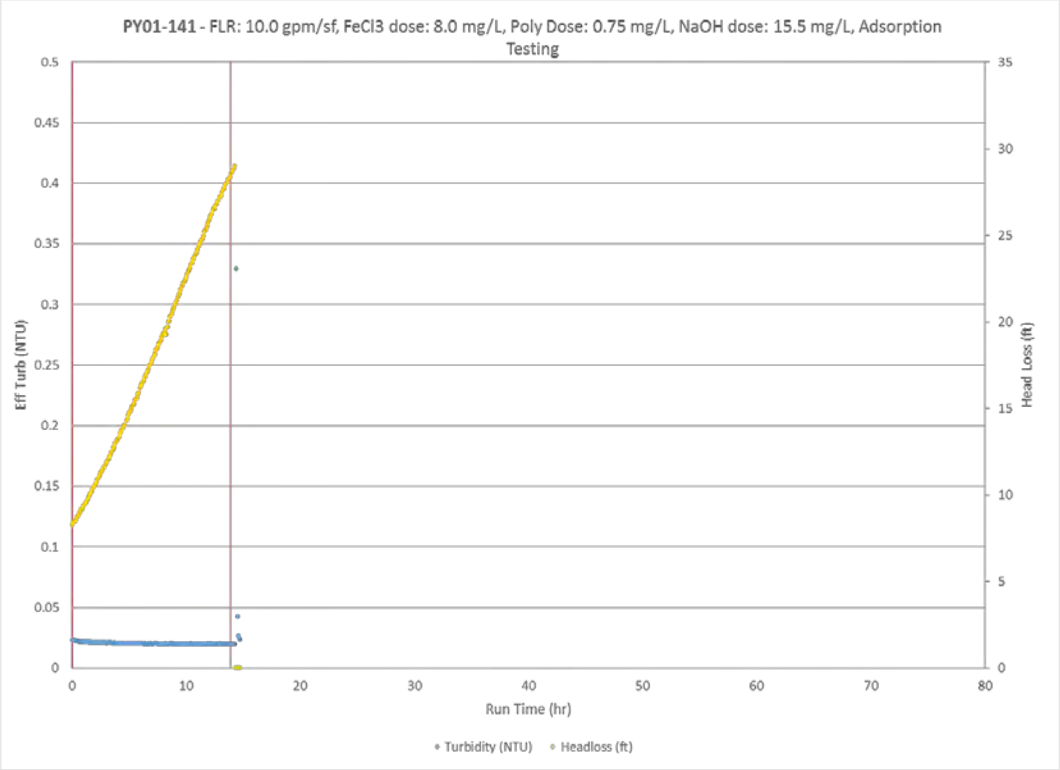


Figure F-38: PY01 Filter Profile

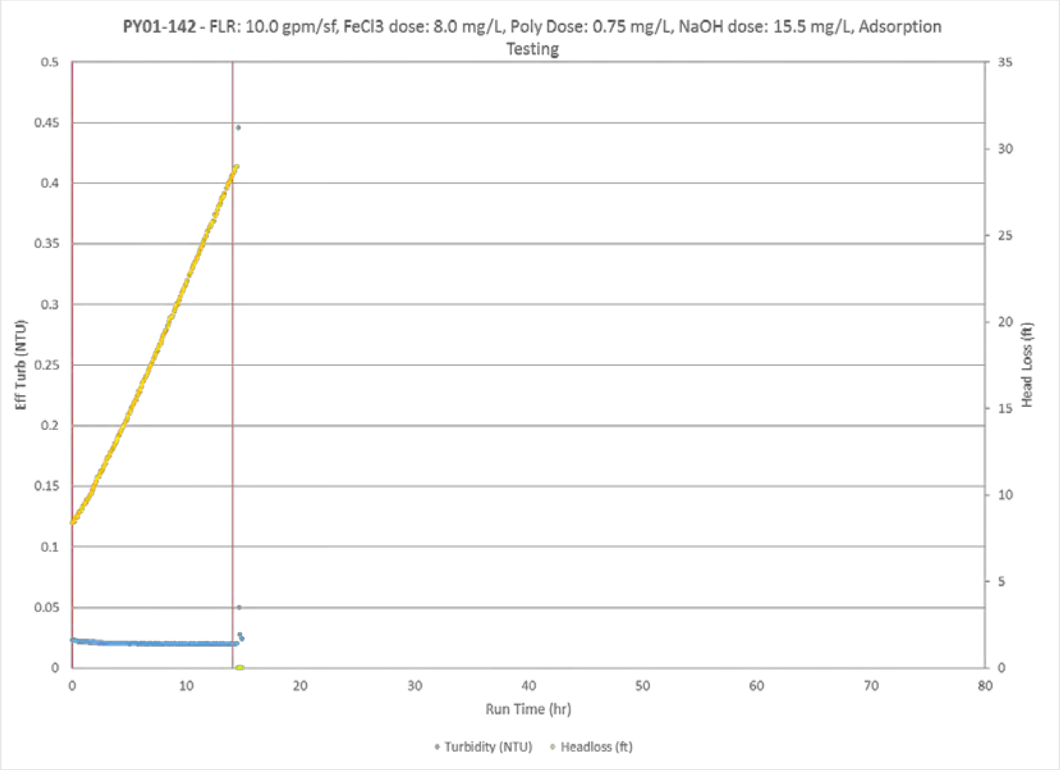


Figure F-39: PY01 Filter Profile

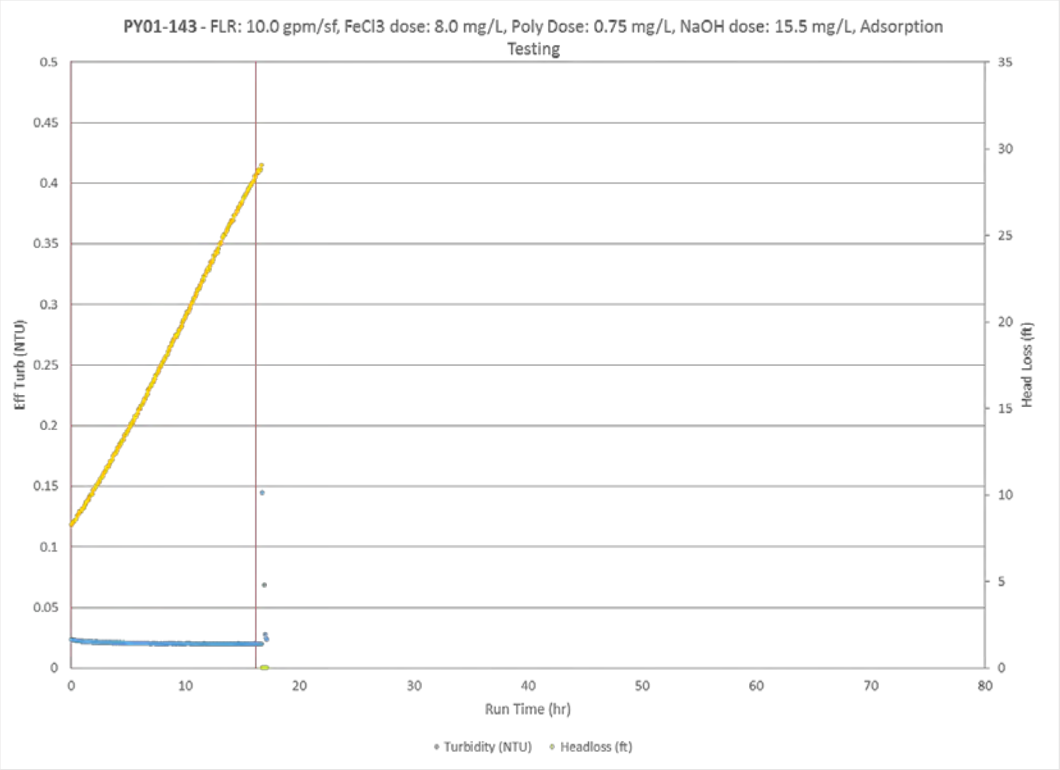


Figure F-40: PY01 Filter Profile

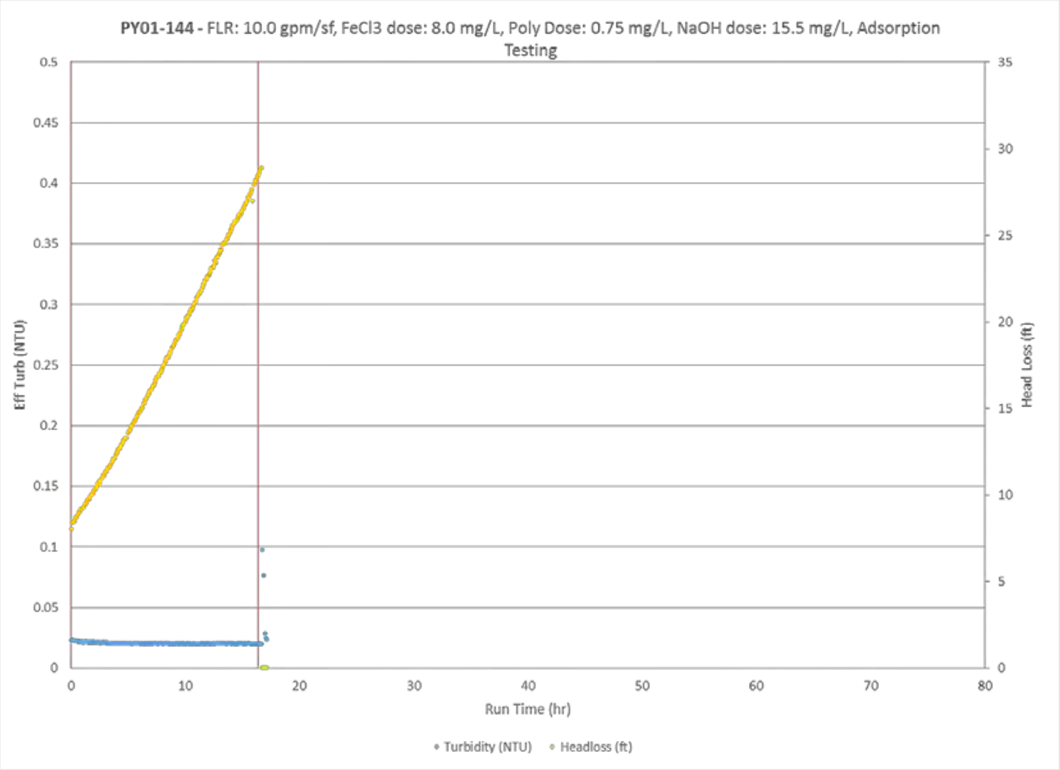


Figure F-41: PY01 Filter Profile

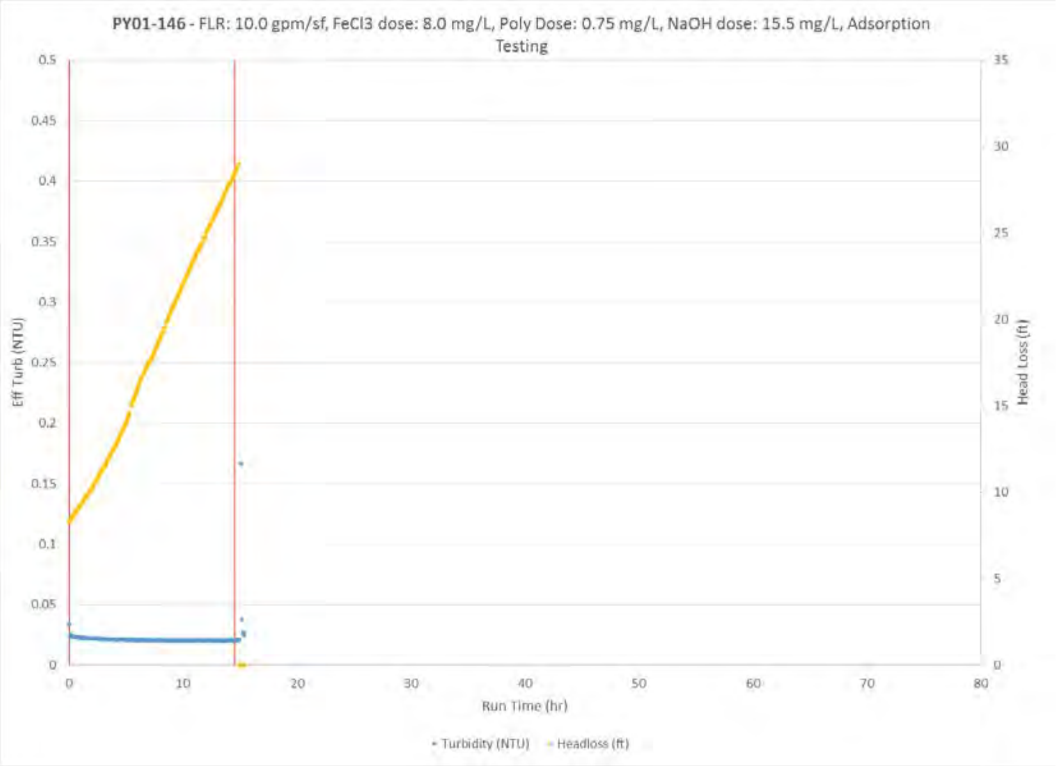


Figure F-42: PY01 Filter Profile

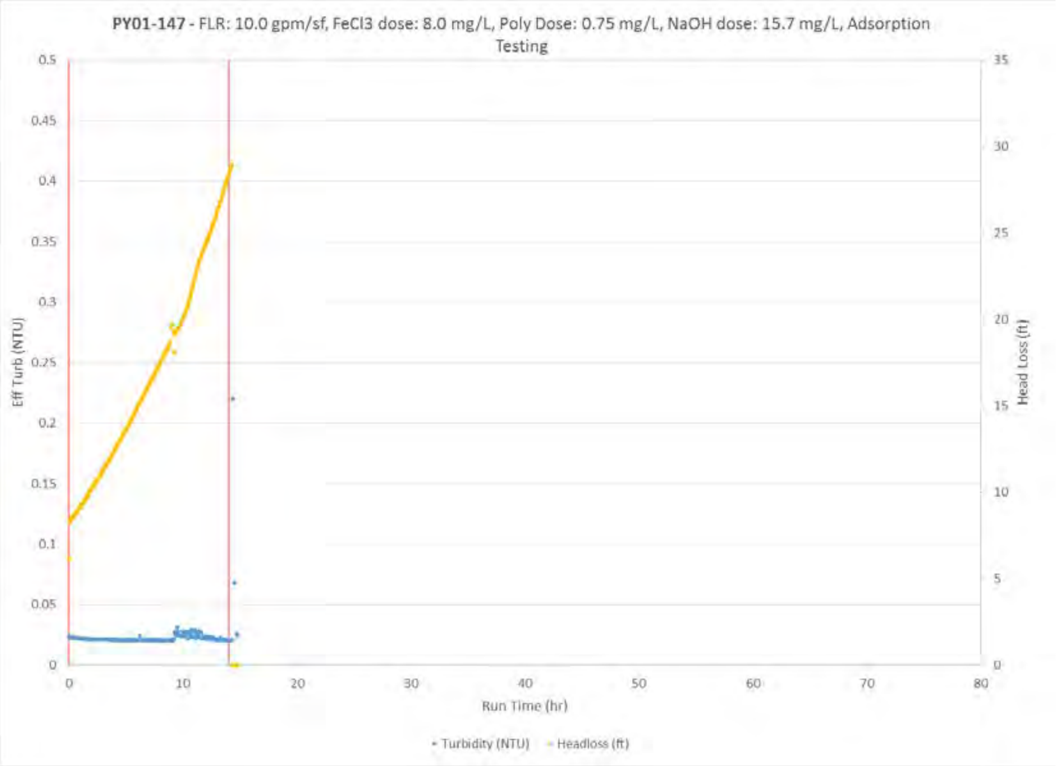


Figure F-43: PY01 Filter Profile

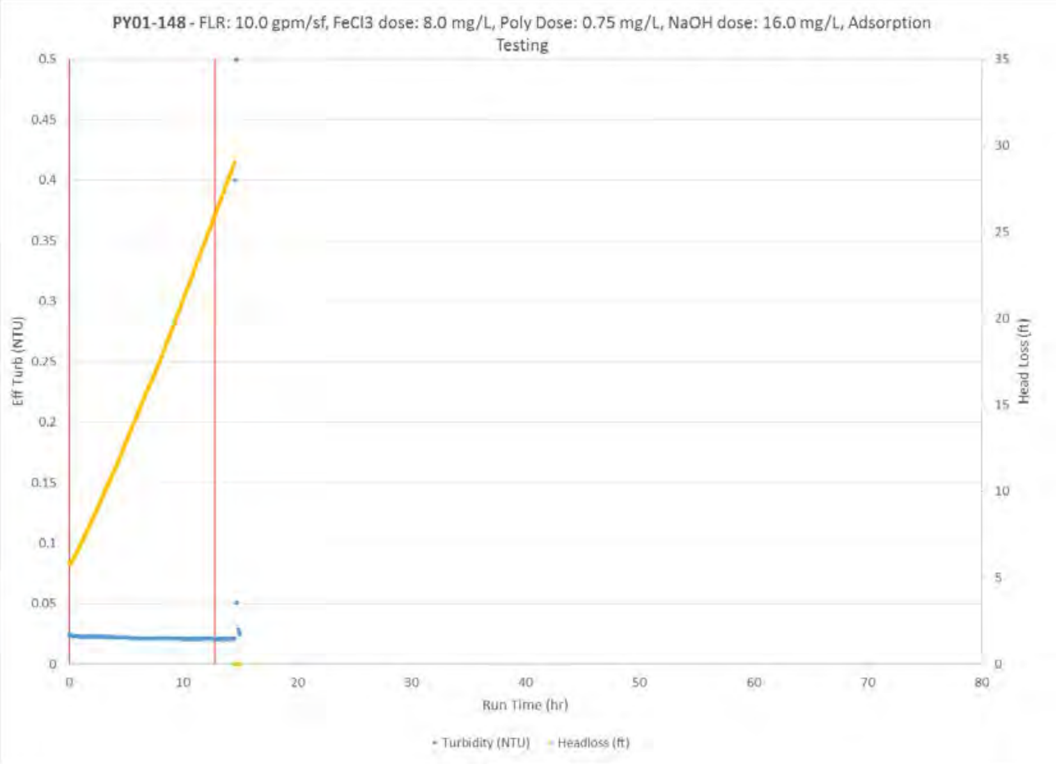


Figure F-44: PY01 Filter Profile

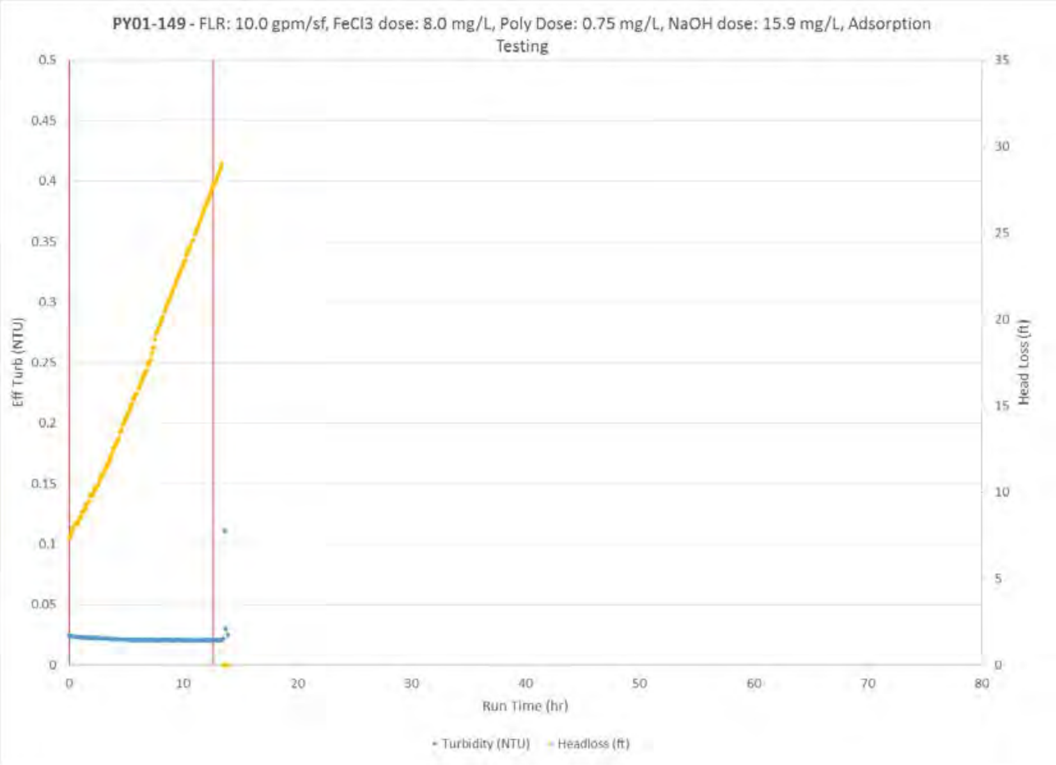


Figure F-45: PY01 Filter Profile

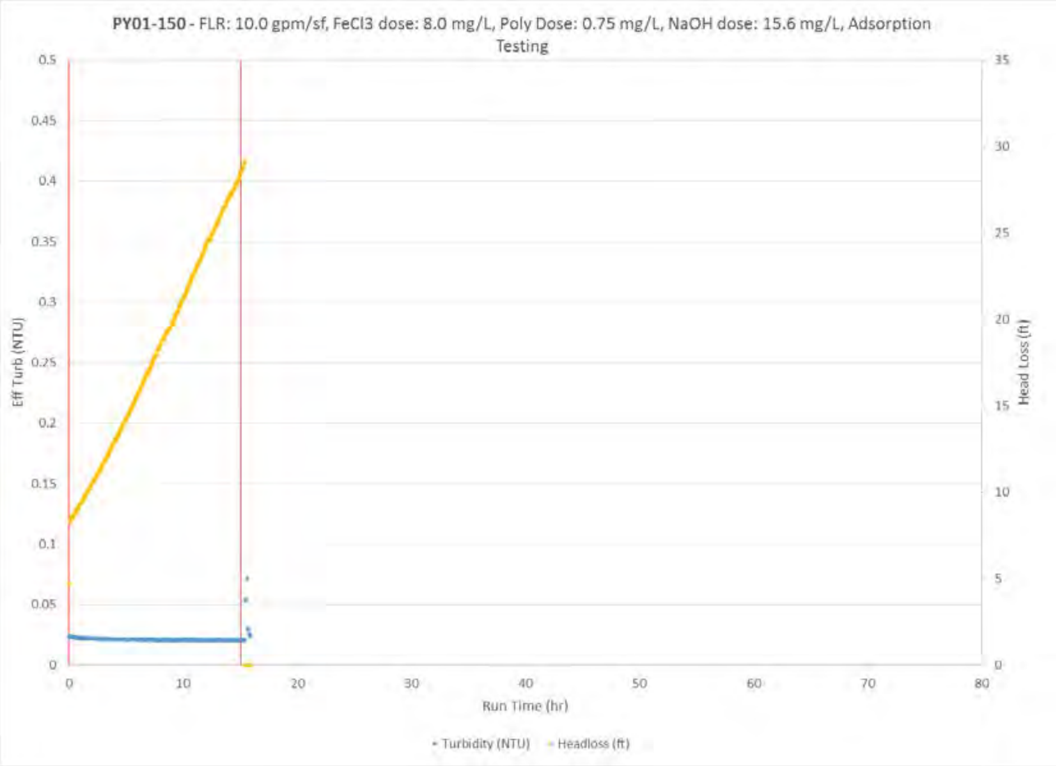


Figure F-46: PY01 Filter Profile

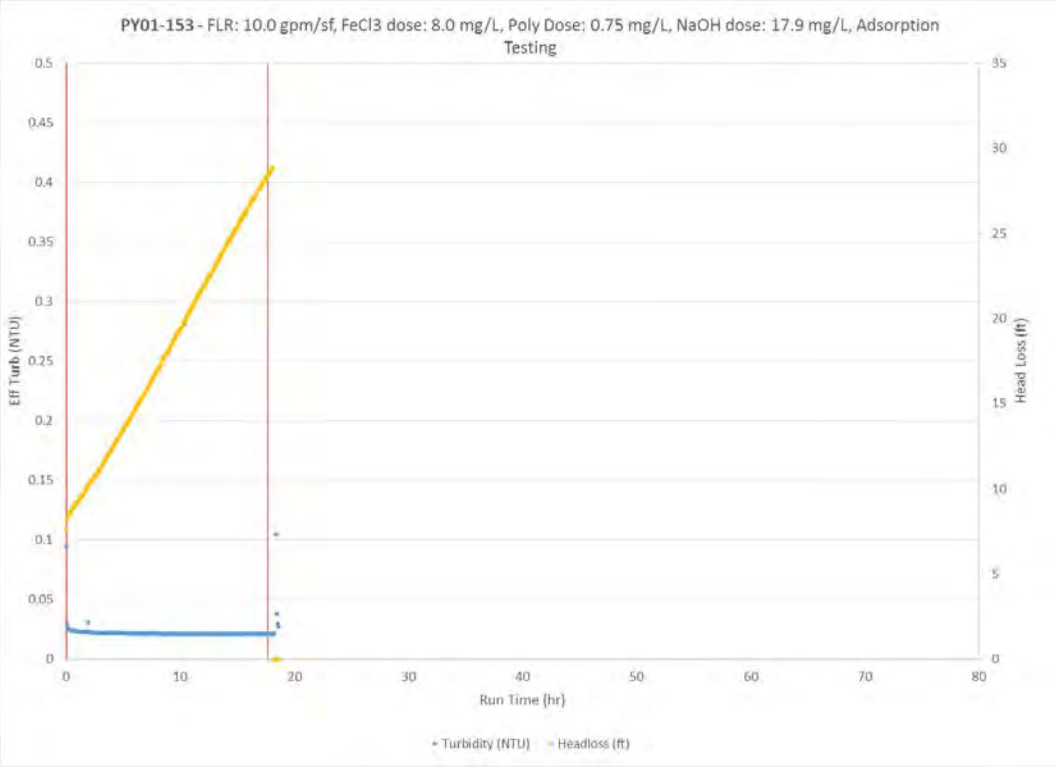


Figure F-47: PY01 Filter Profile

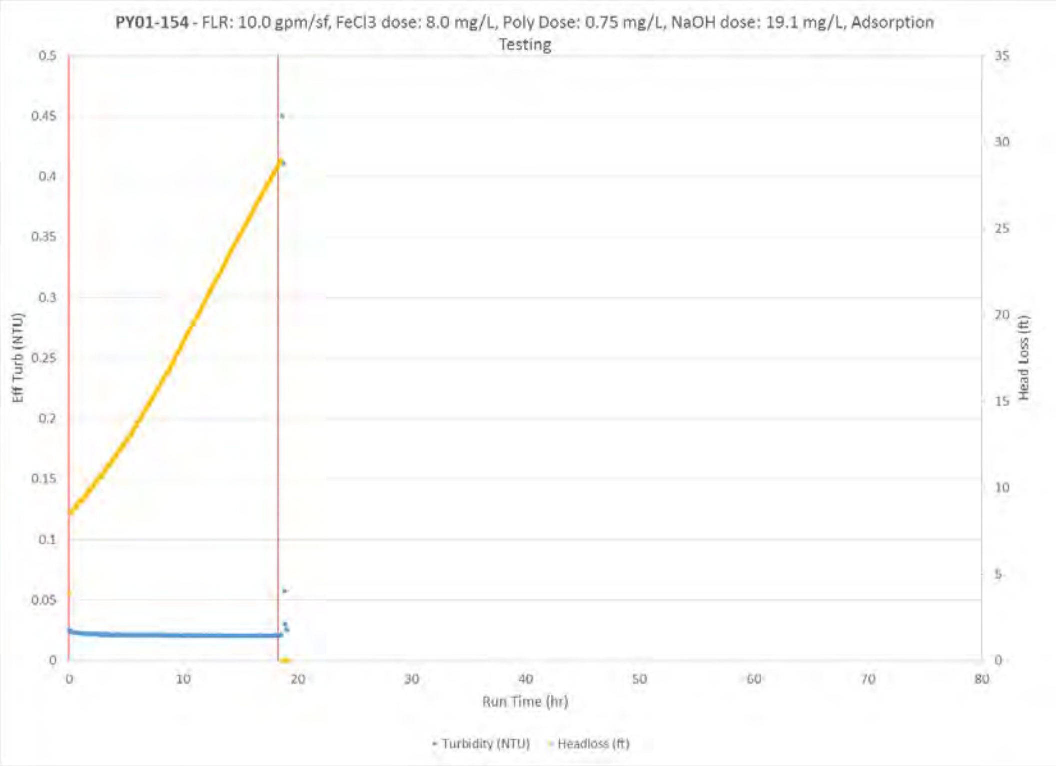


Figure F-48: PY01 Filter Profile

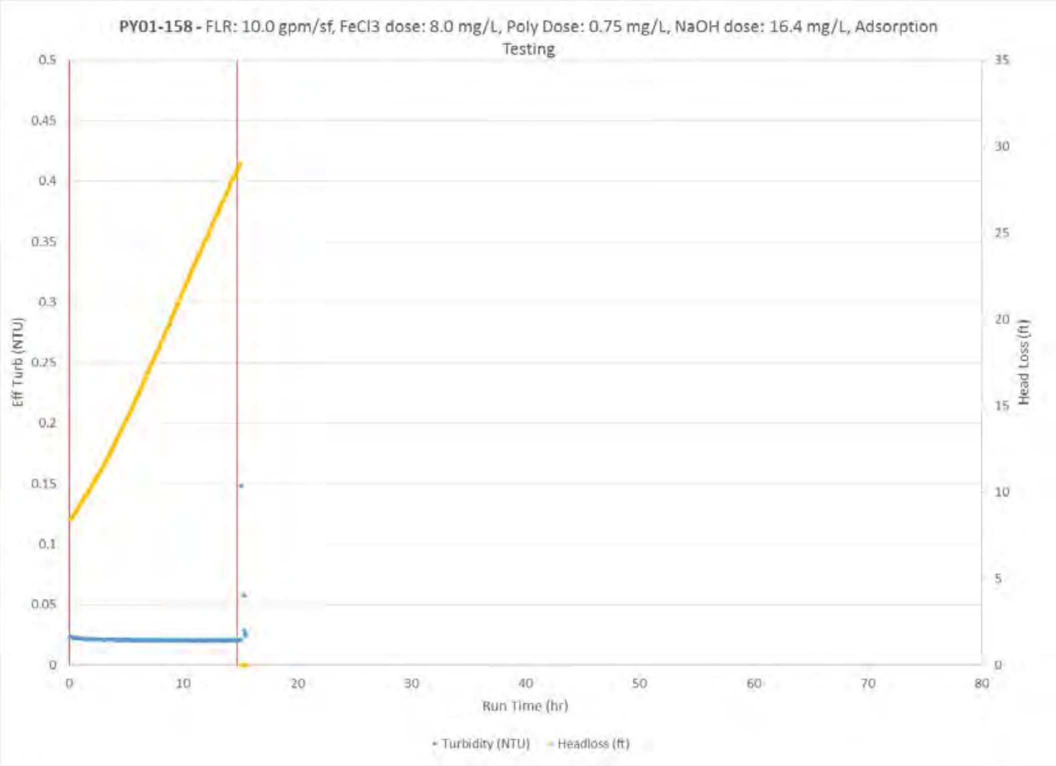


Figure F-49: PY01 Filter Profile

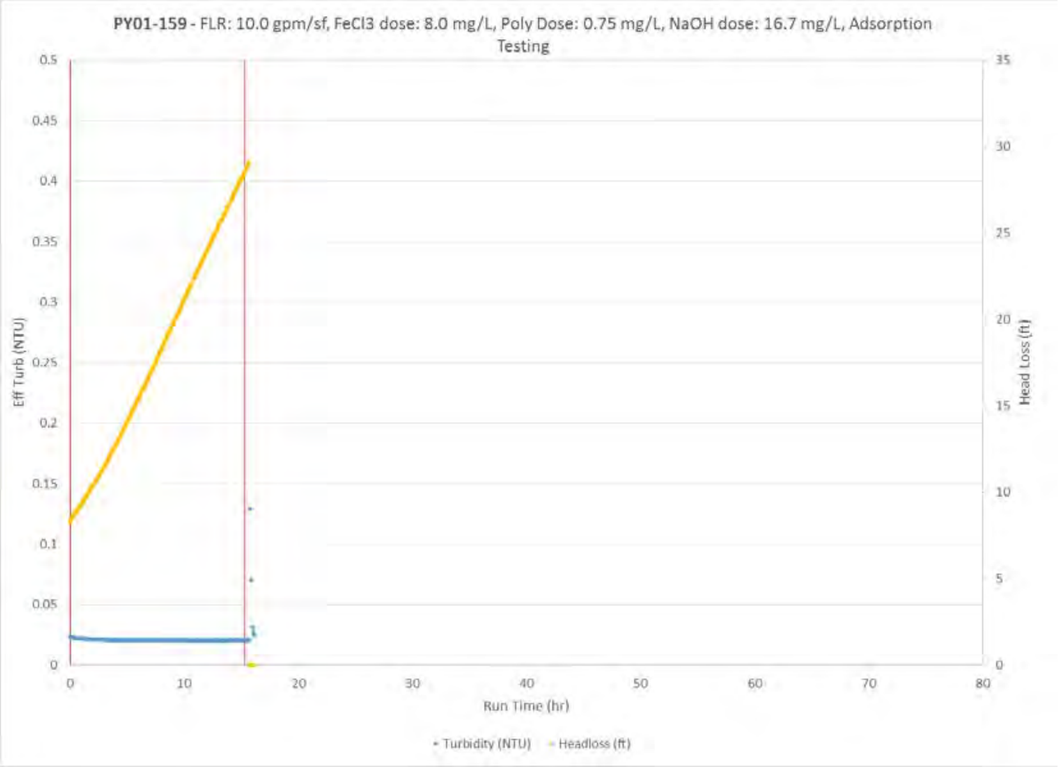


Figure F-50: PY01 Filter Profile

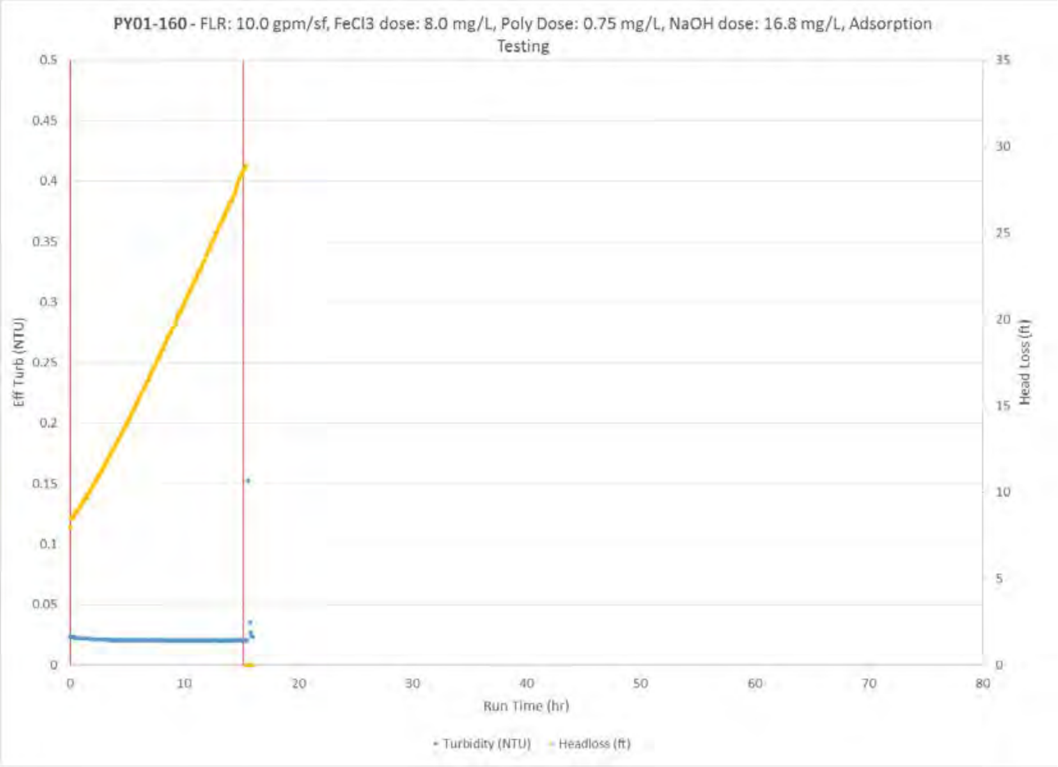


Figure F-51: PY01 Filter Profile

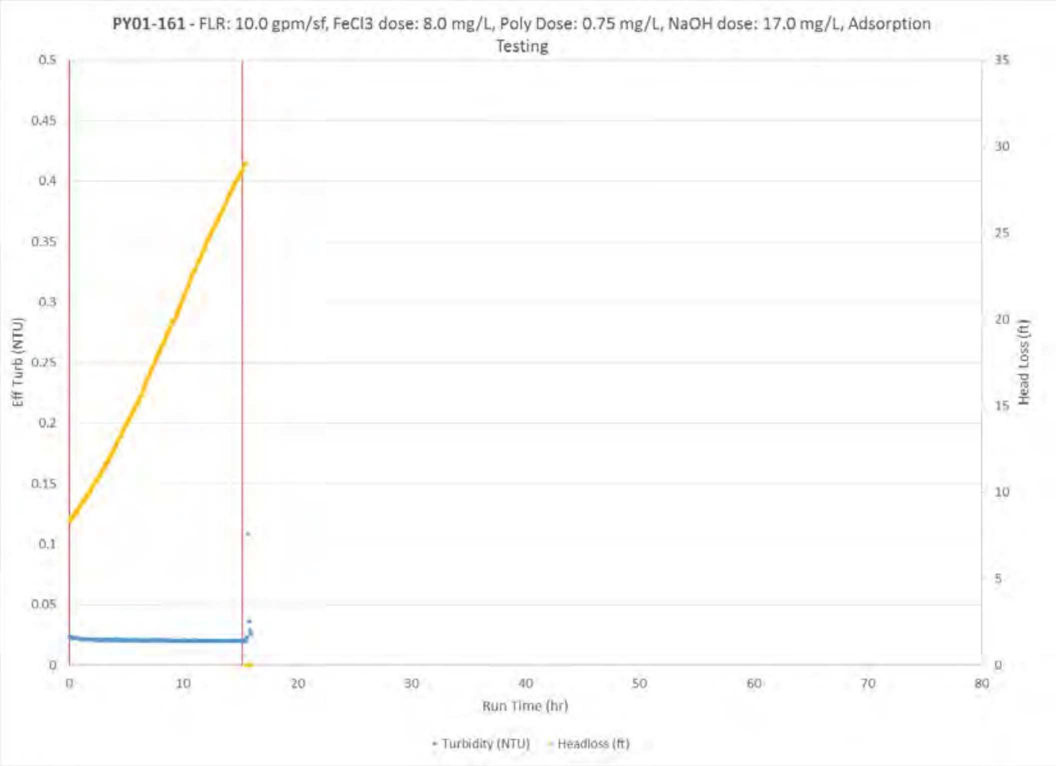


Figure F-52: PY01 Filter Profile

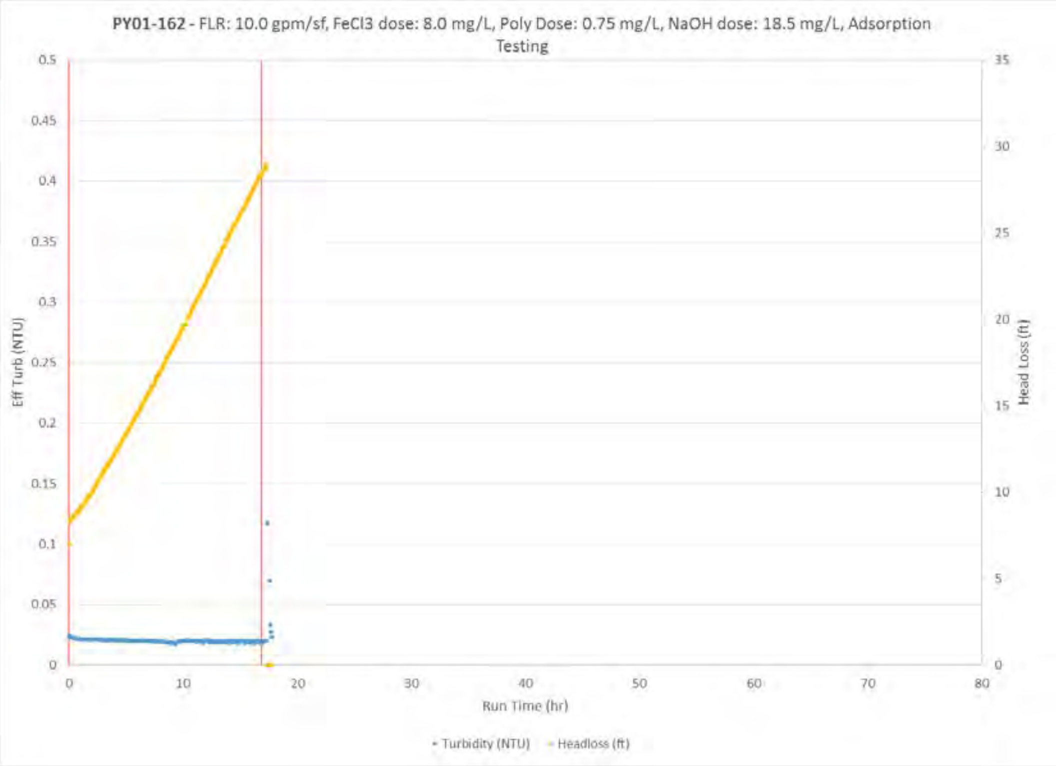


Figure F-53: PY01 Filter Profile

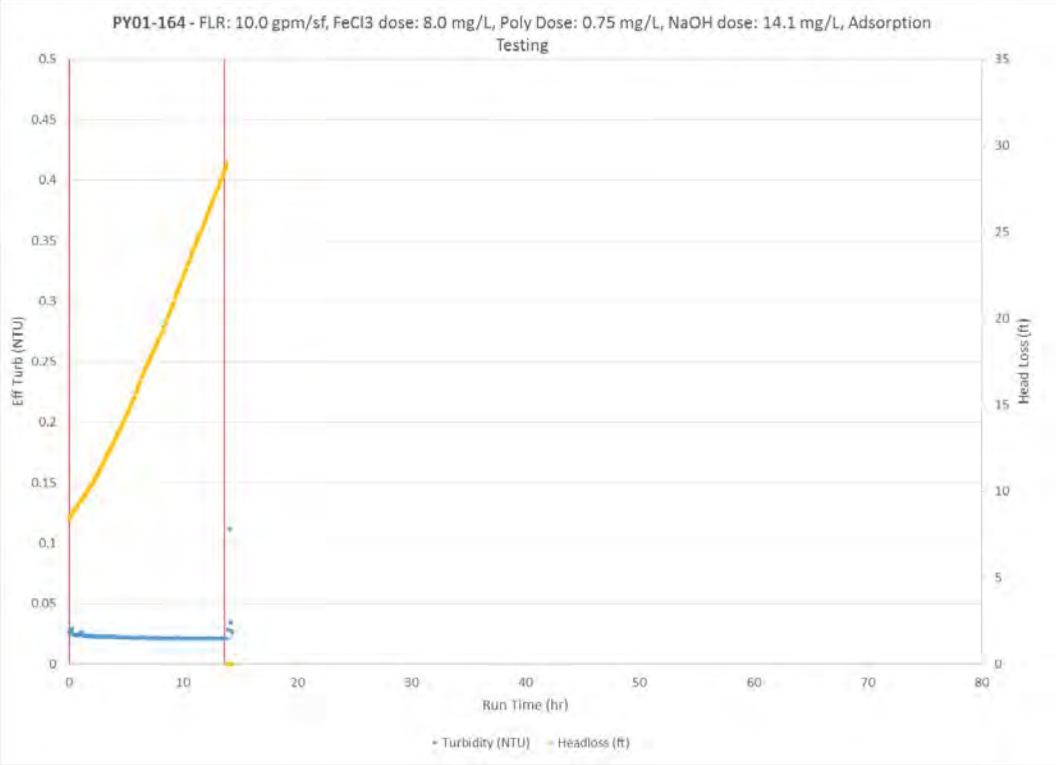


Figure F-54: PY01 Filter Profile

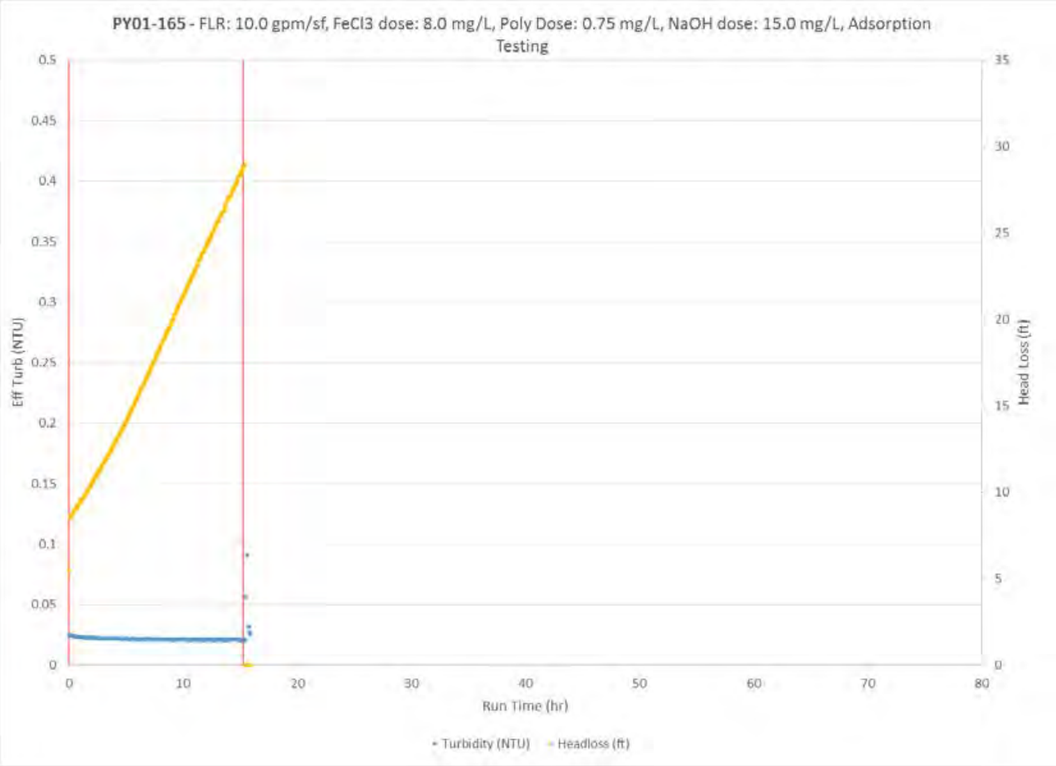


Figure F-55: PY01 Filter Profile

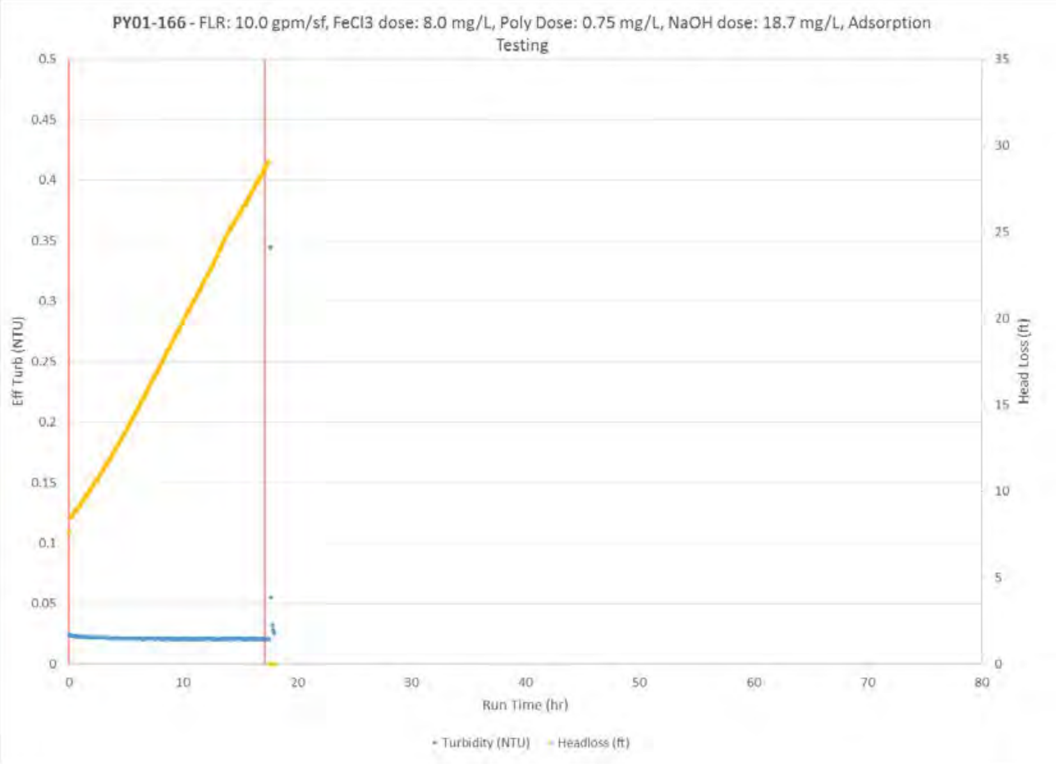


Figure F-56: PY01 Filter Profile

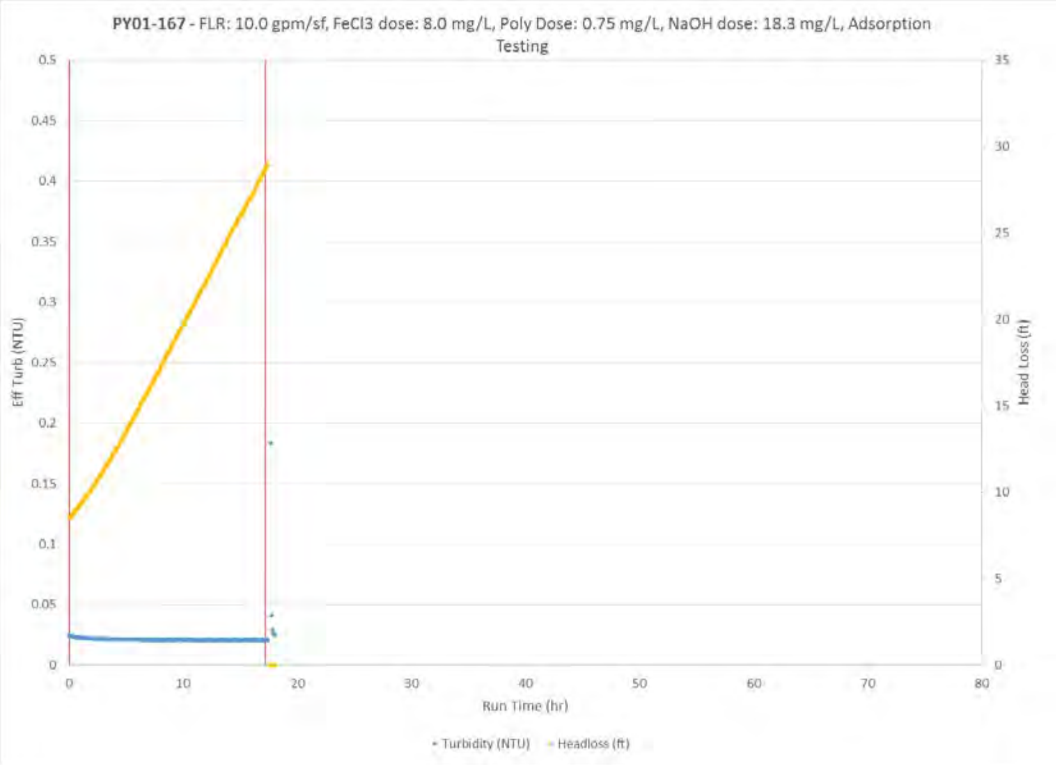


Figure F-57: PY01 Filter Profile

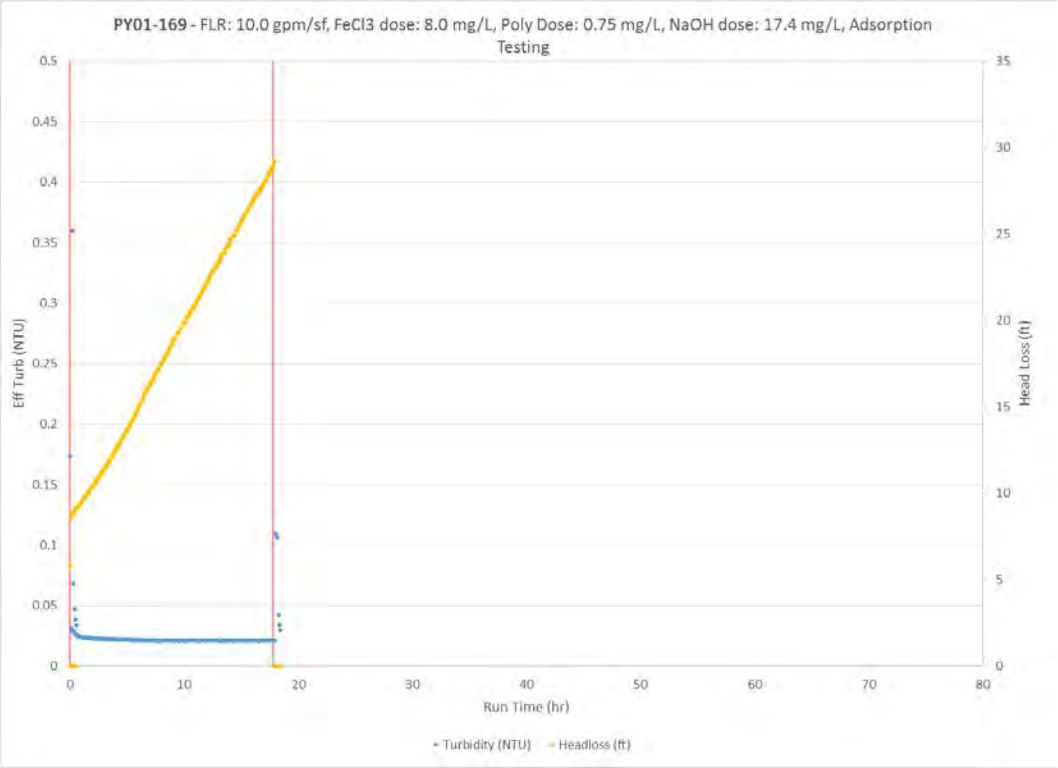


Figure F-58: PY01 Filter Profile

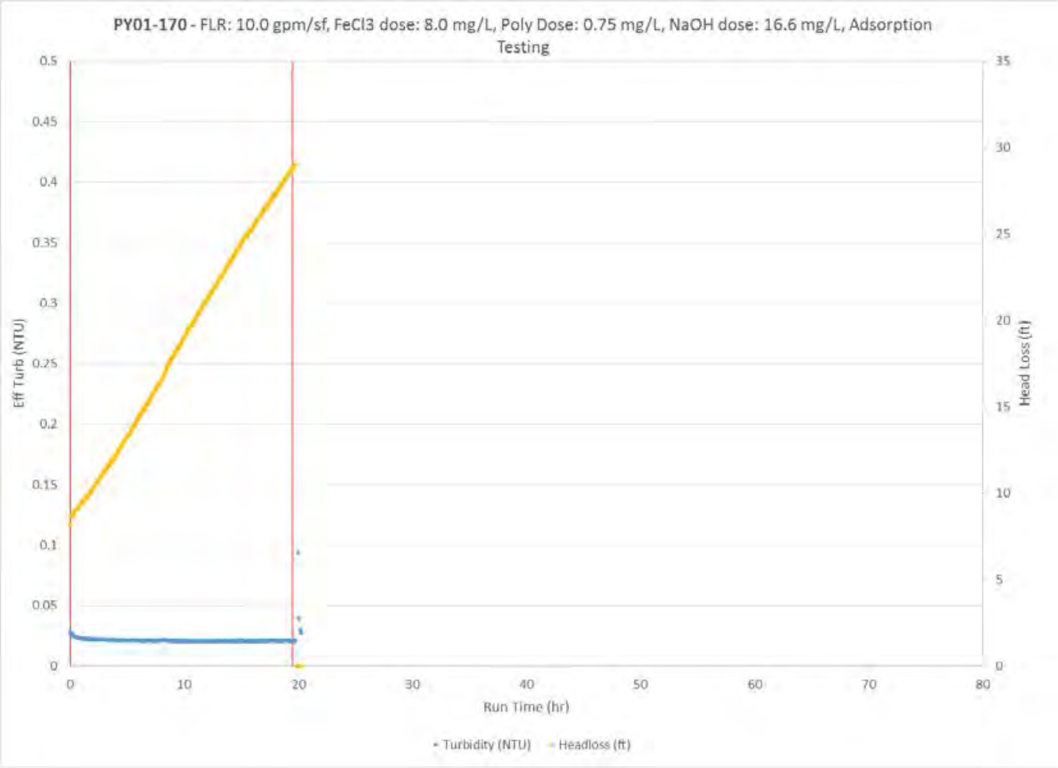


Figure F-59: PY01 Filter Profile

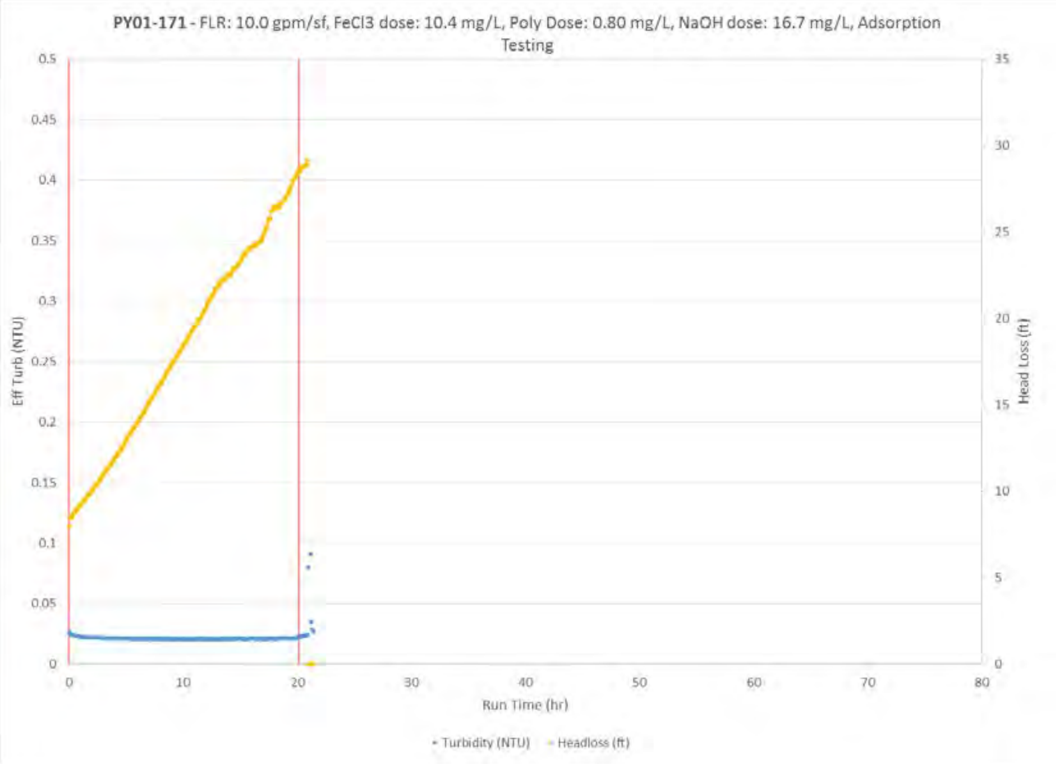


Figure F-60: PY01 Filter Profile

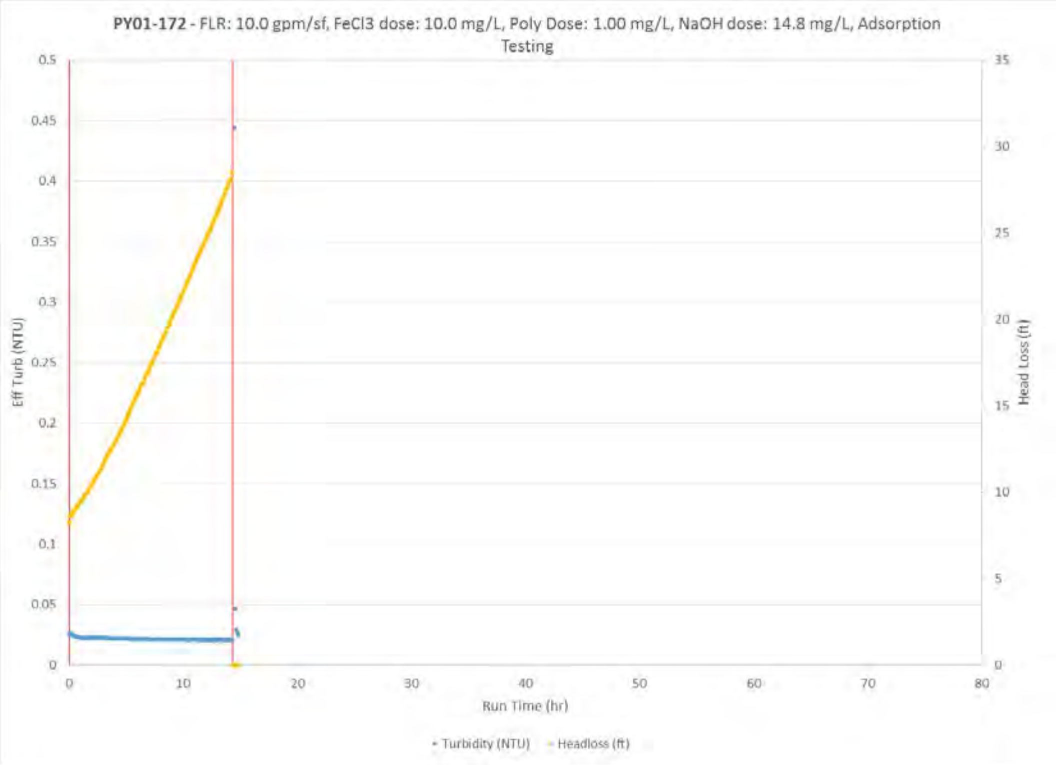


Figure F-61: PY01 Filter Profile

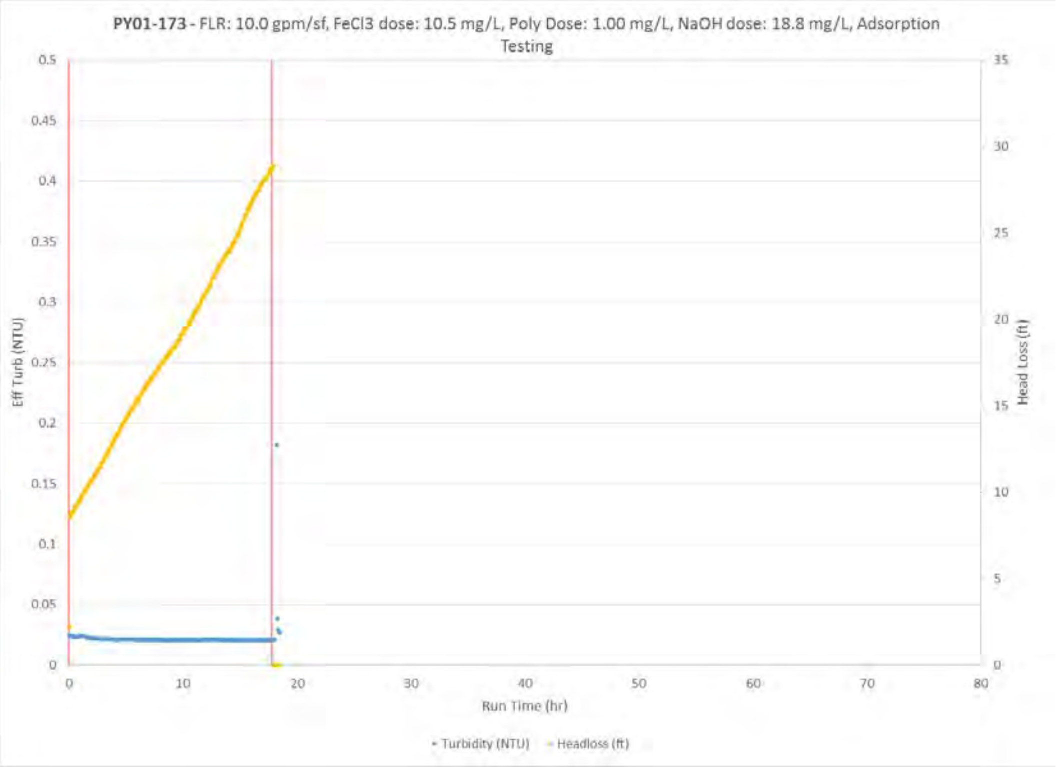


Figure F-62: PY01 Filter Profile

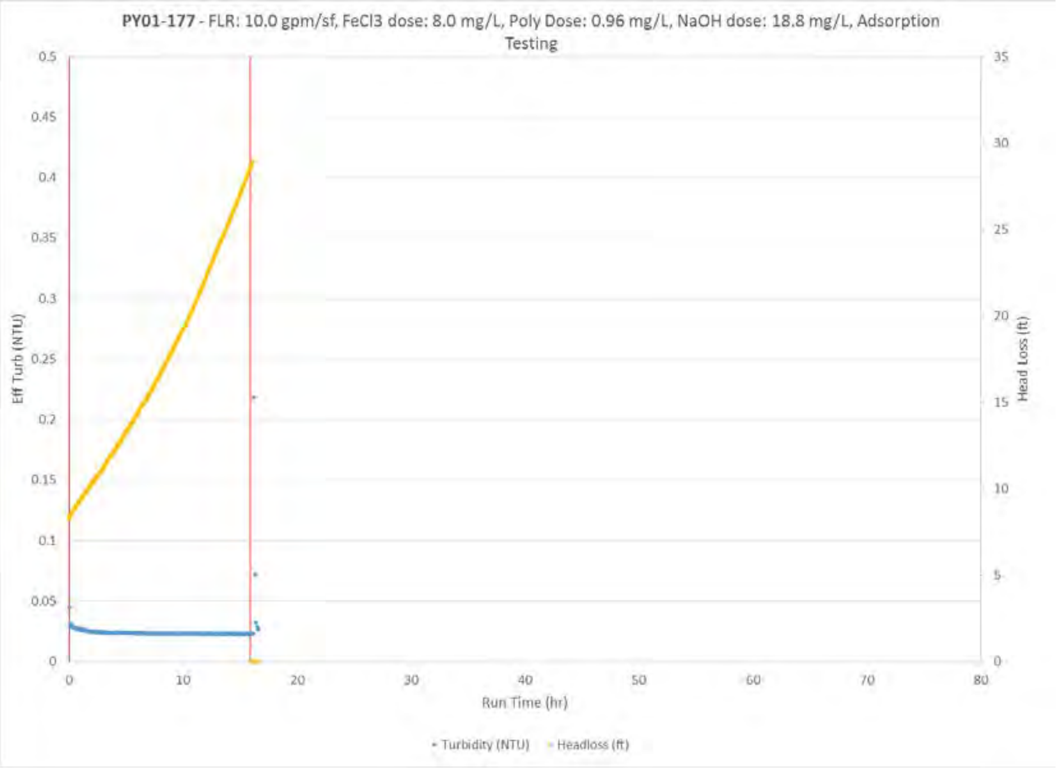


Figure F-63: PY01 Filter Profile

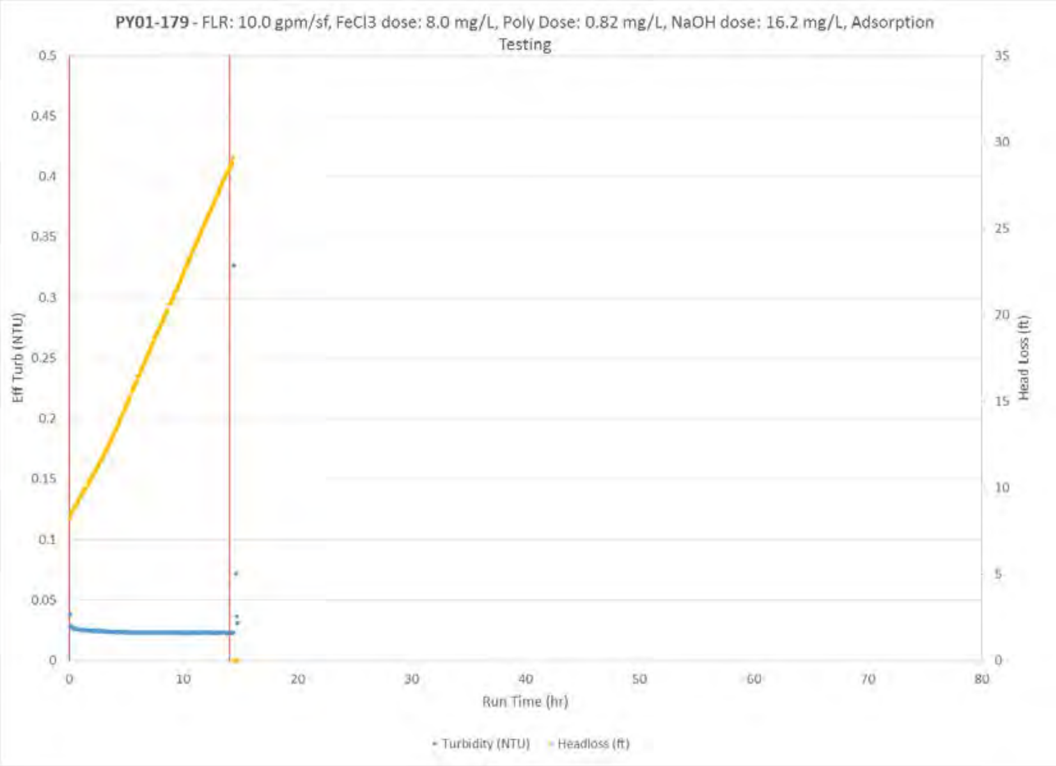


Figure F-64: PY01 Filter Profile

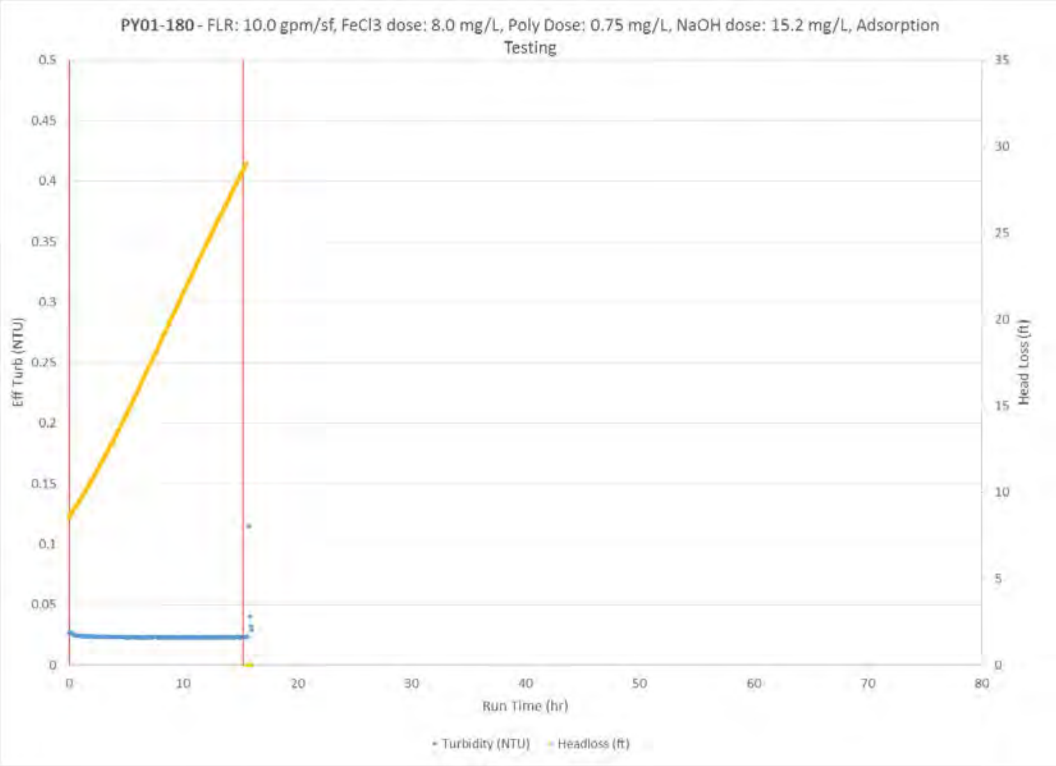


Figure F-65: PY01 Filter Profile

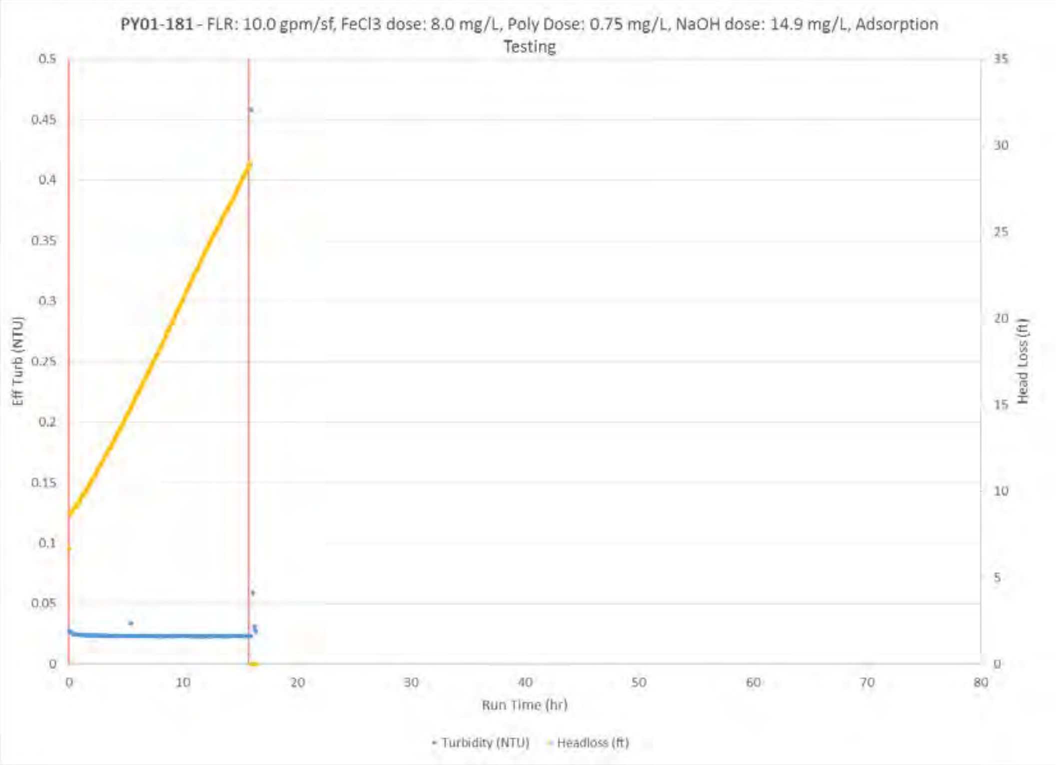


Figure F-66: PY01 Filter Profile

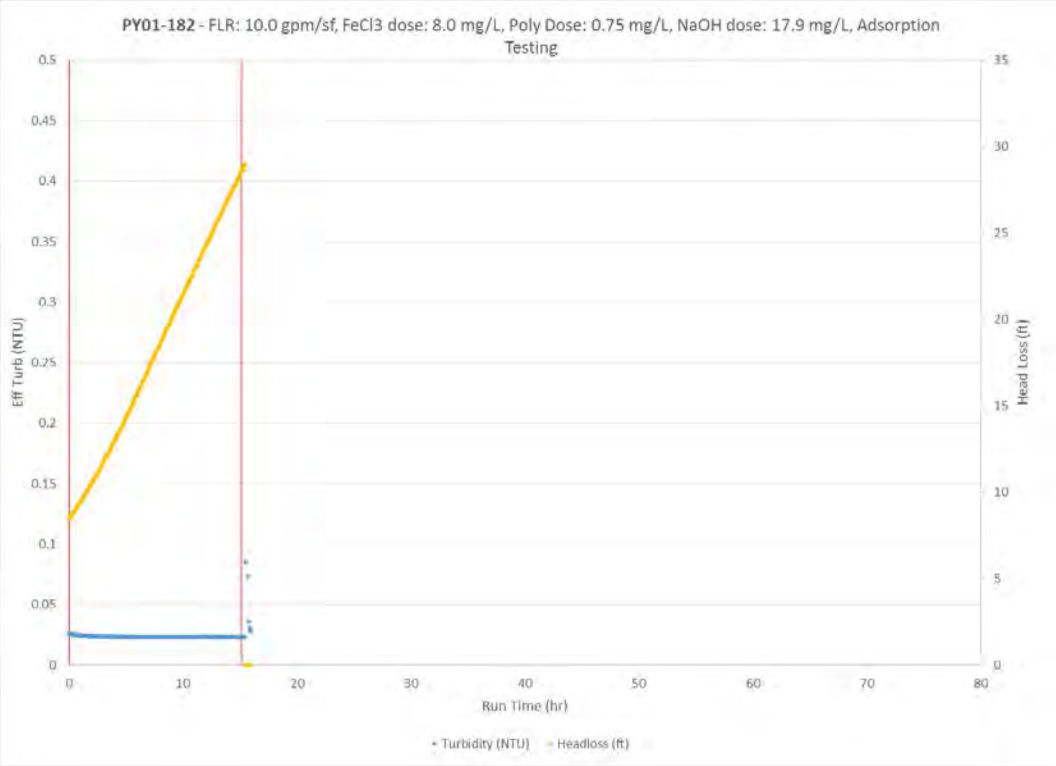


Figure F-67: PY01 Filter Profile

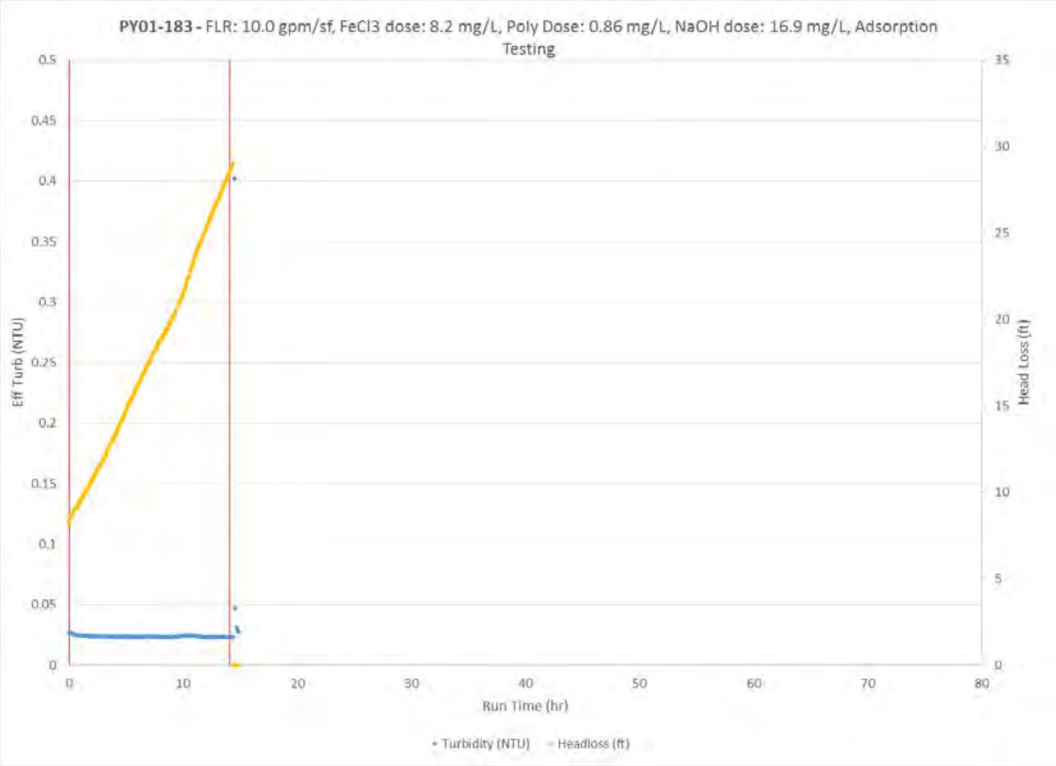


Figure F-68: PY01 Filter Profile

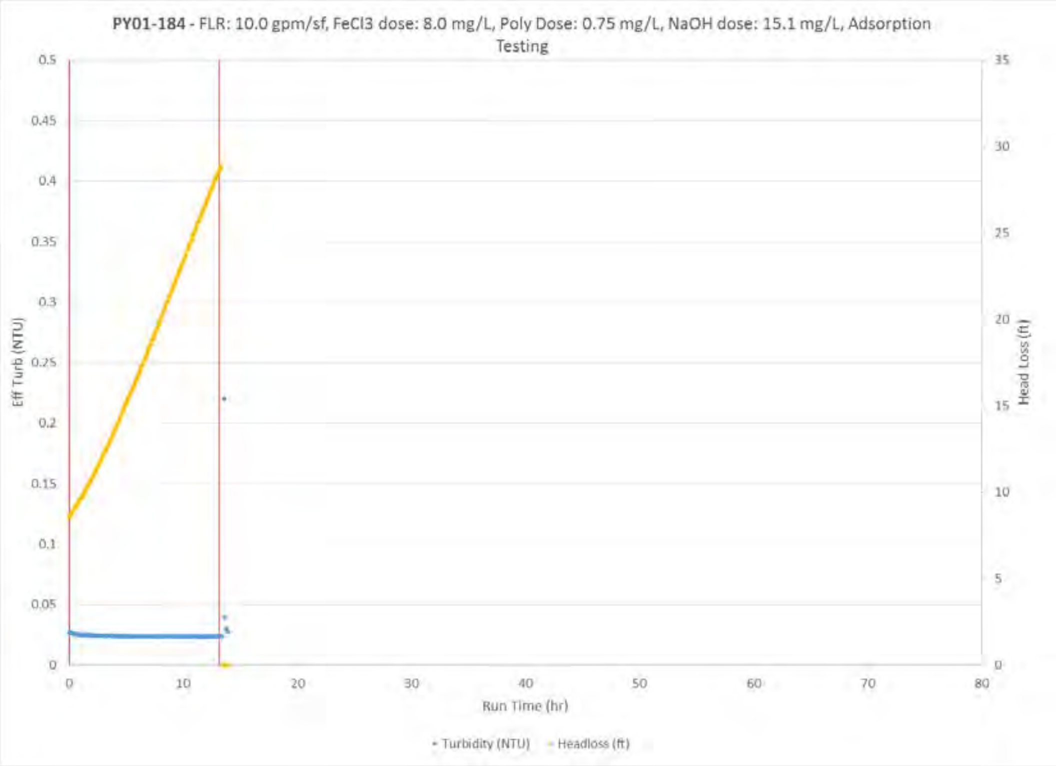


Figure F-69: PY01 Filter Profile

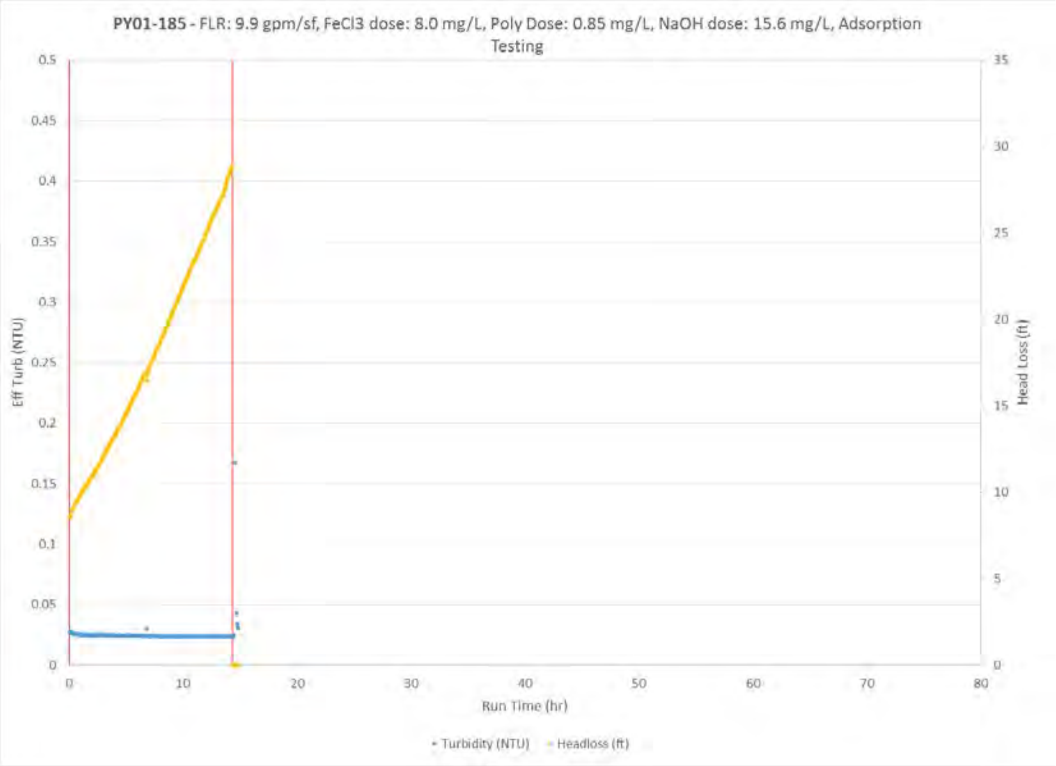


Figure F-70: PY01 Filter Profile

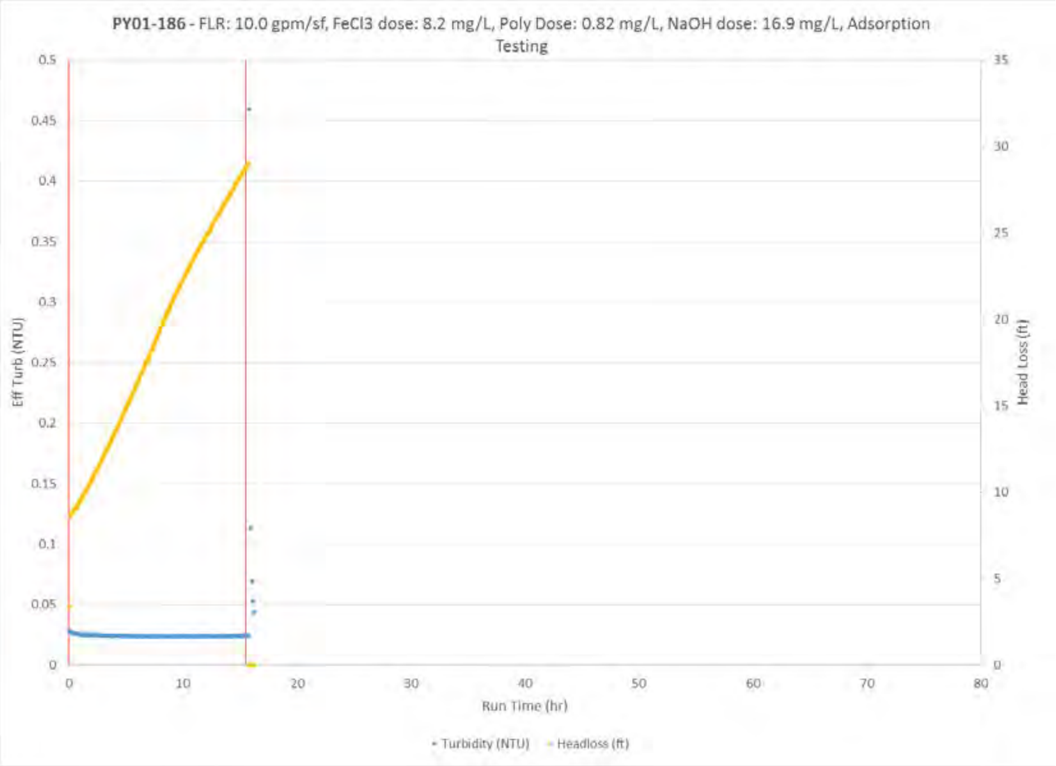


Figure F-71: PY01 Filter Profile

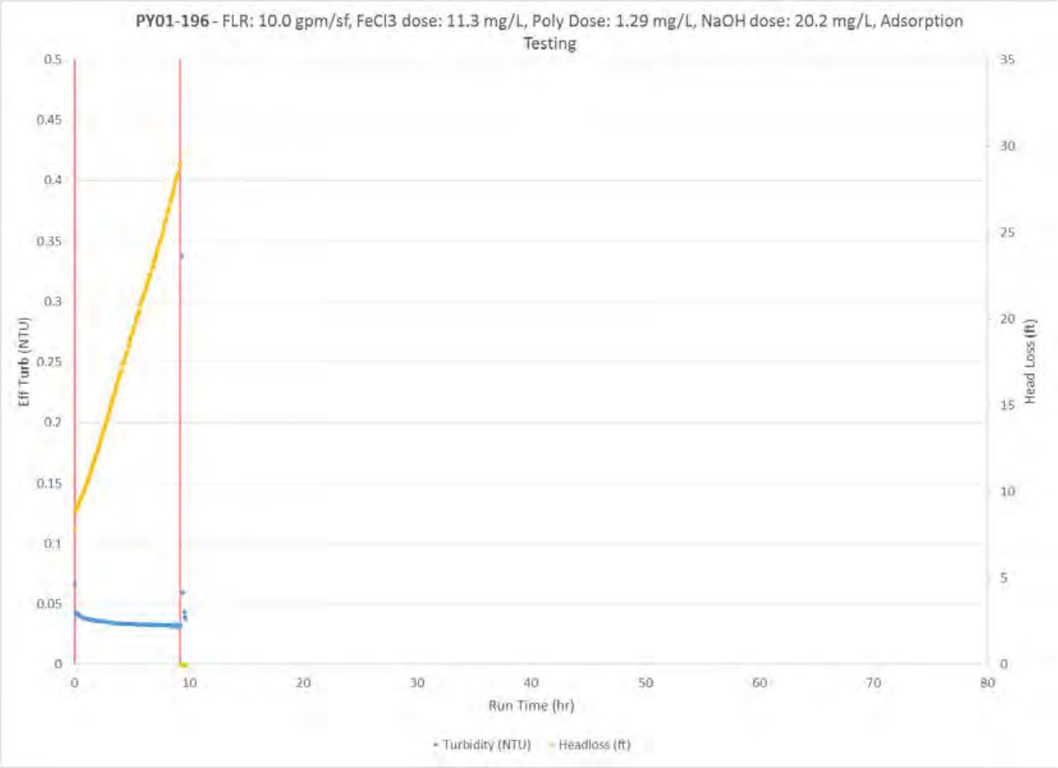


Figure F-72: PY01 Filter Profile

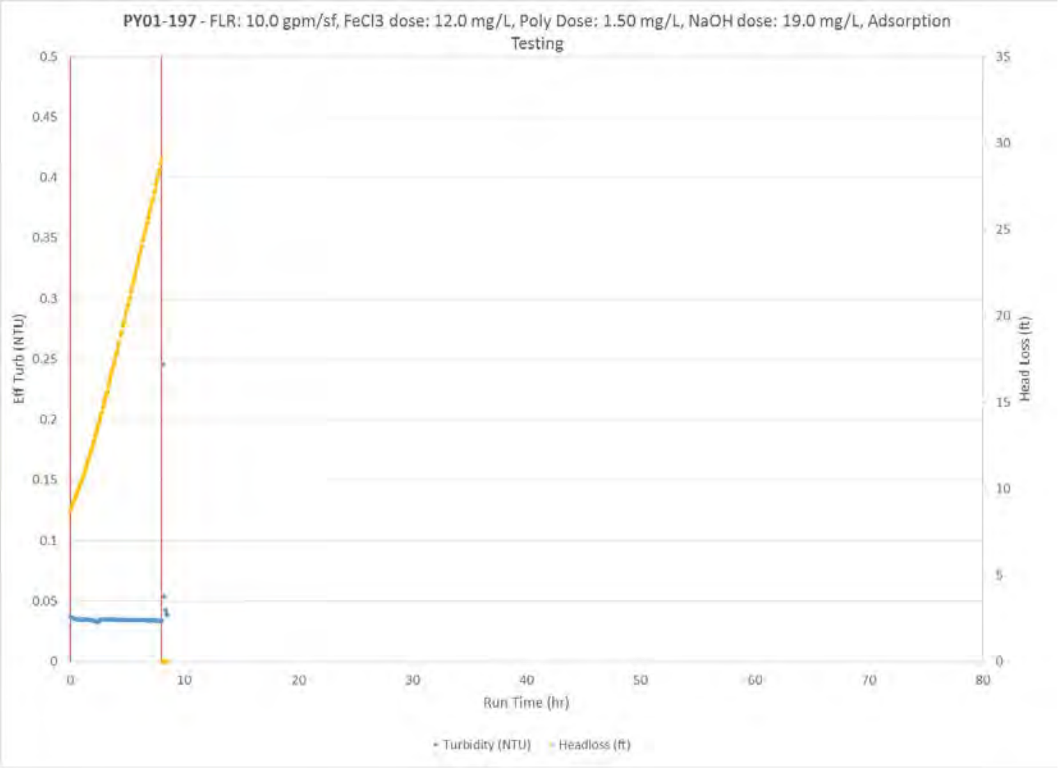


Figure F-73: PY01 Filter Profile

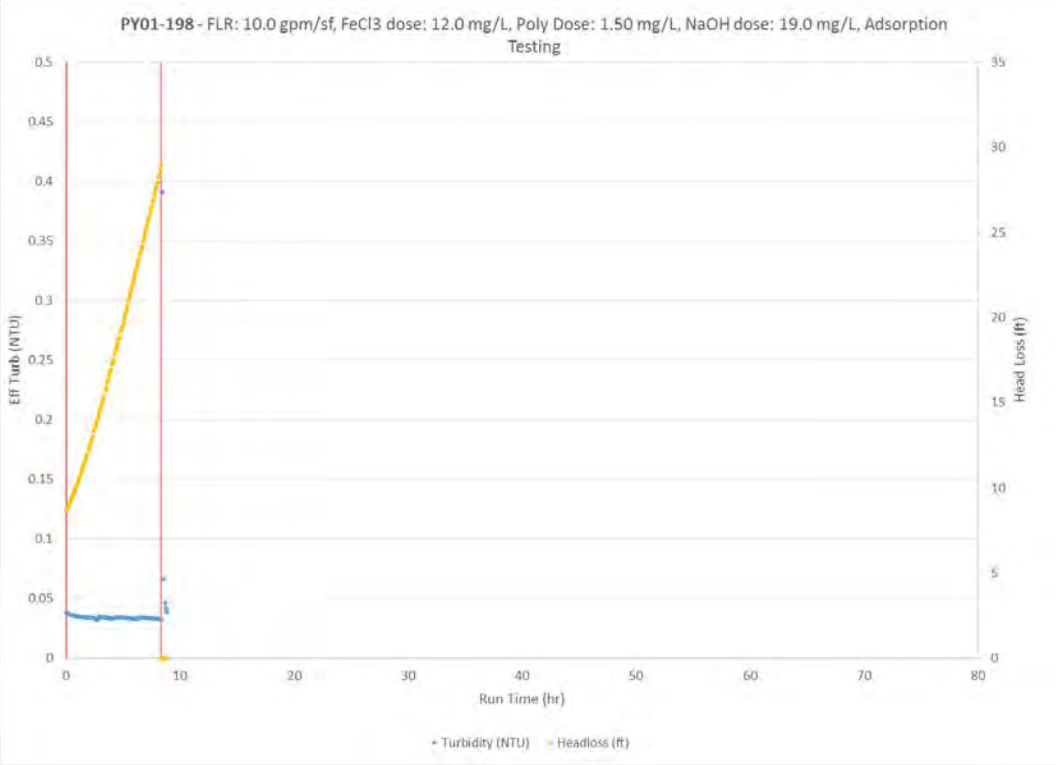


Figure F-74: PY01 Filter Profile

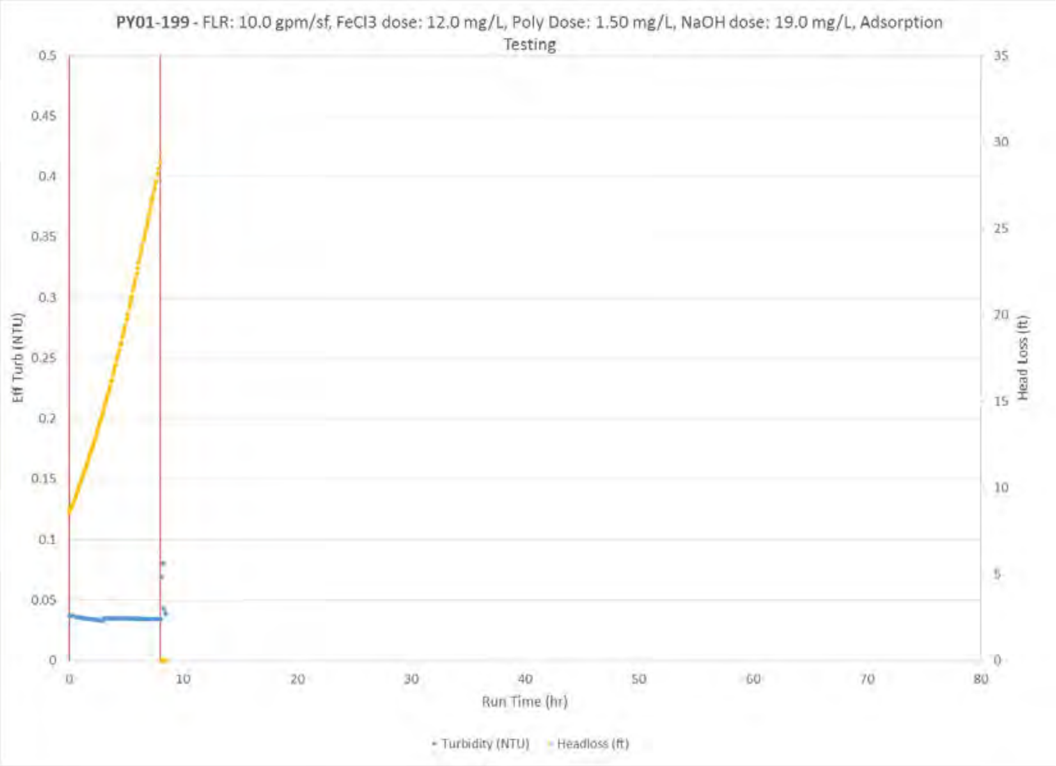


Figure F-75: PY01 Filter Profile

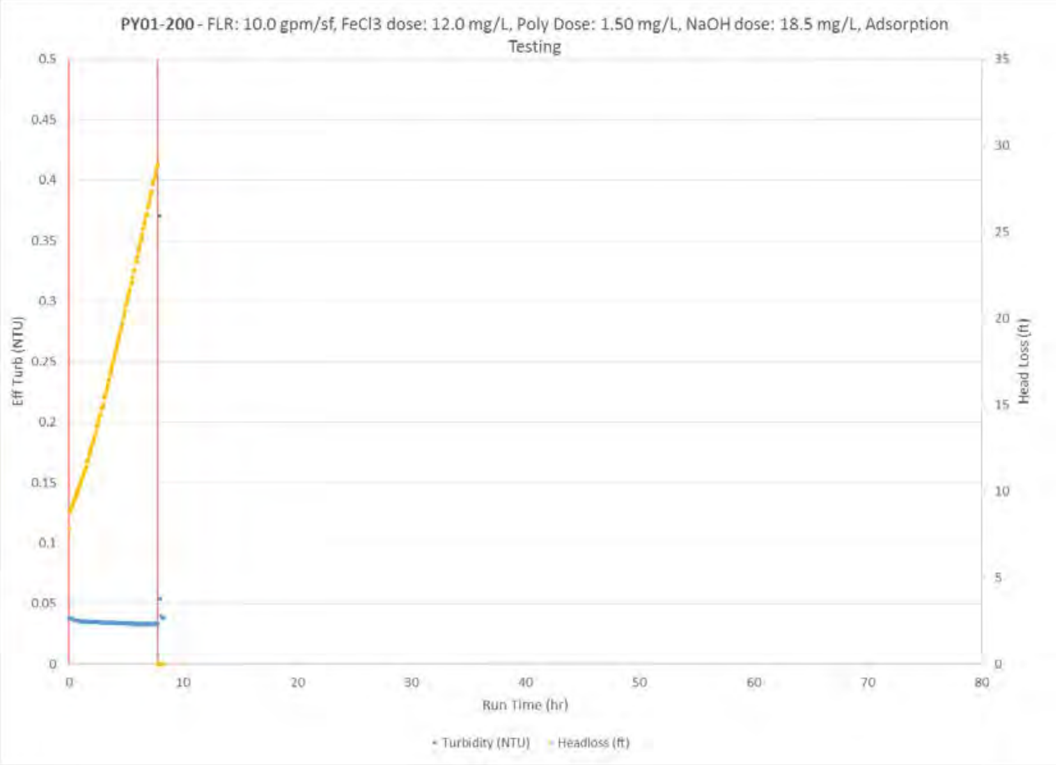


Figure F-76: PY01 Filter Profile

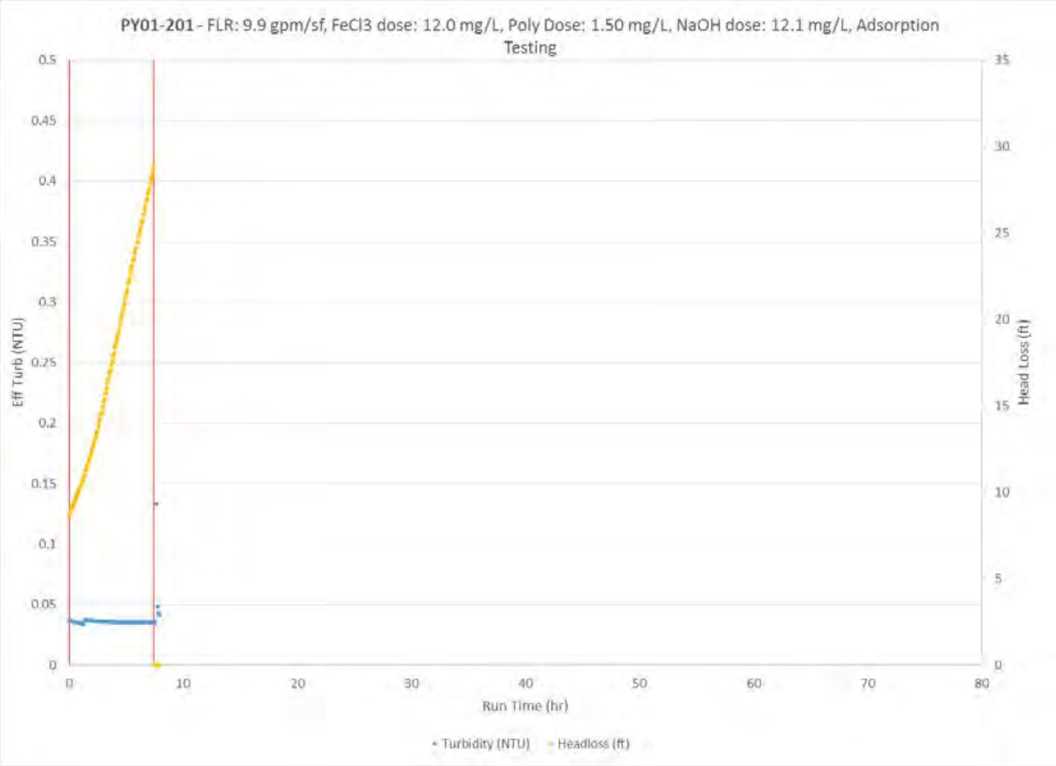


Figure F-77: PY01 Filter Profile

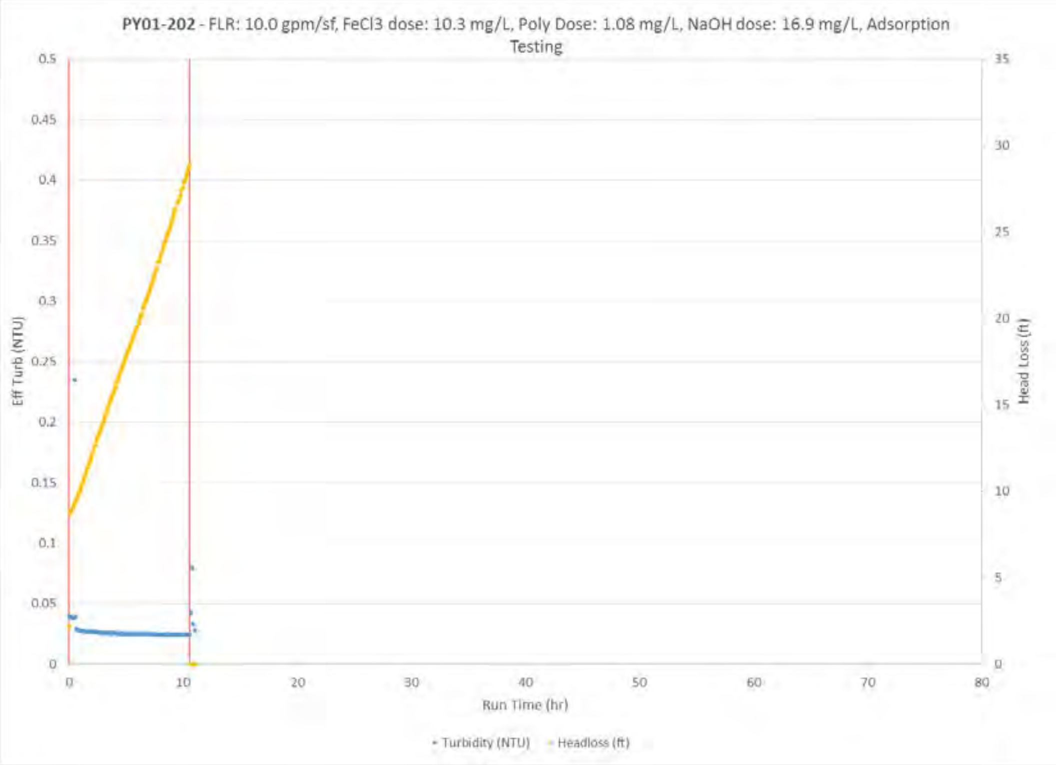


Figure F-78: PY01 Filter Profile

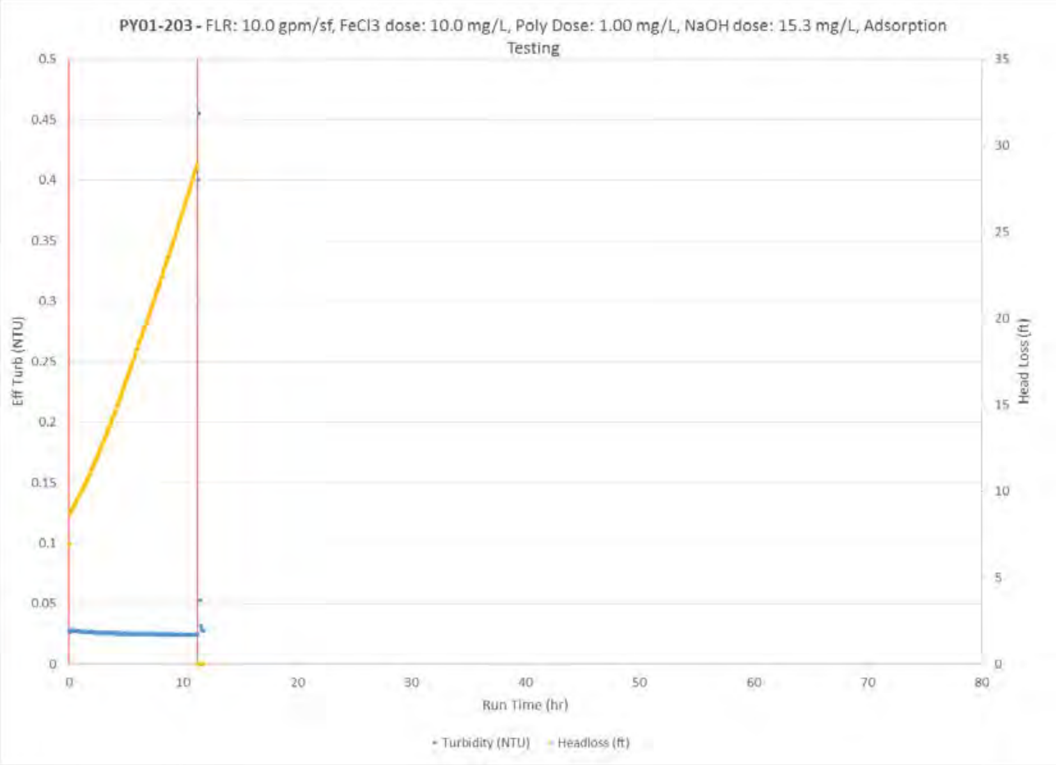


Figure F-79: PY01 Filter Profile

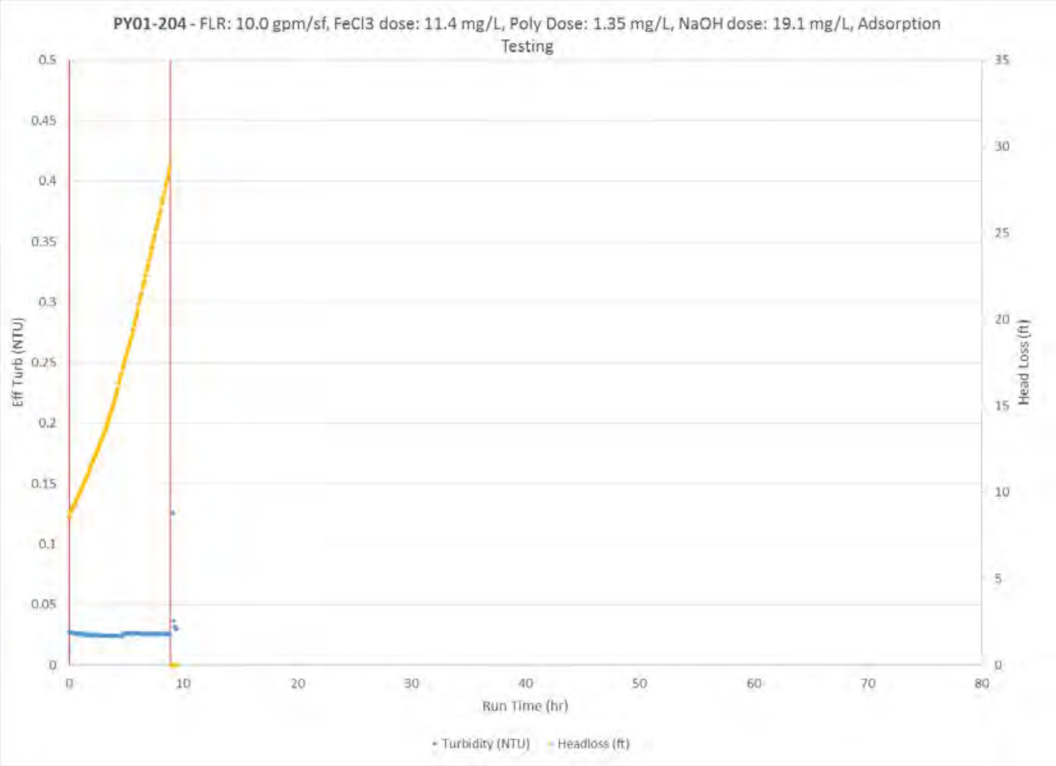


Figure F-80: PY01 Filter Profile

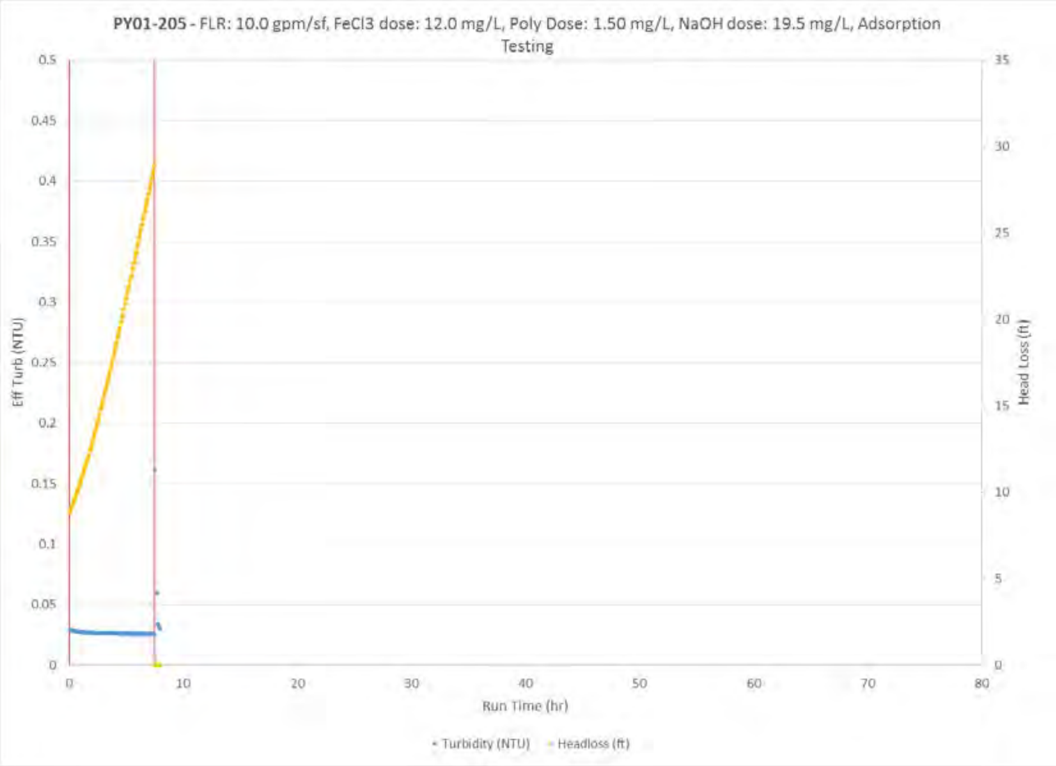


Figure F-81: PY01 Filter Profile

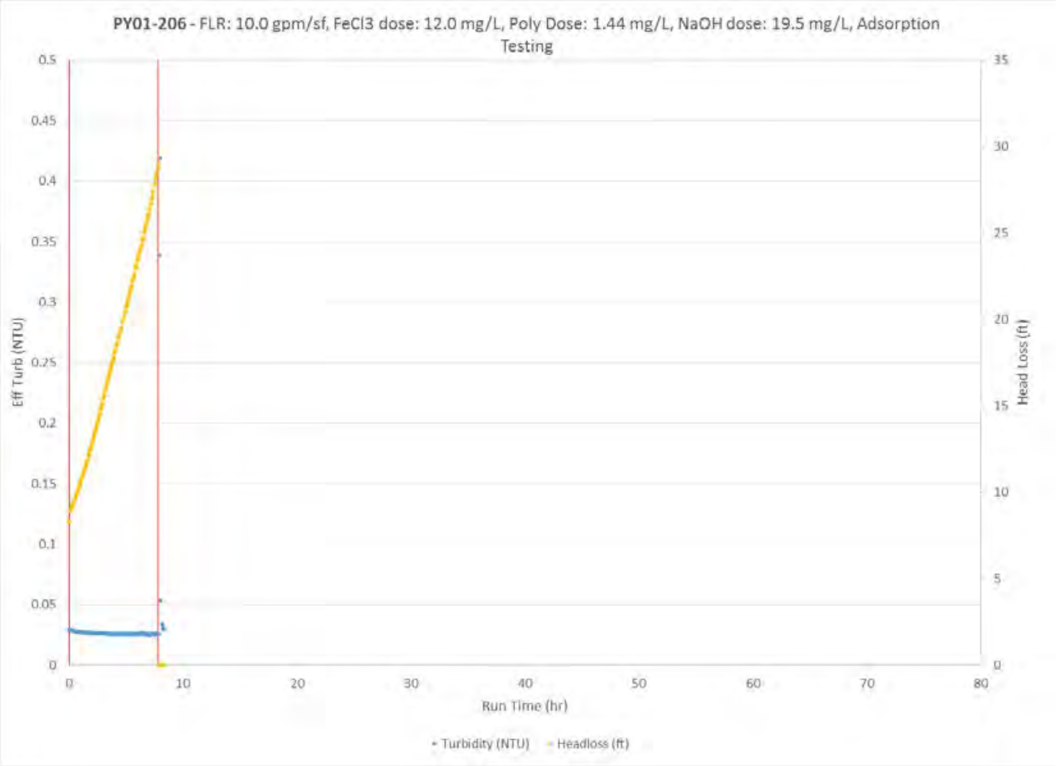


Figure F-82: PY01 Filter Profile

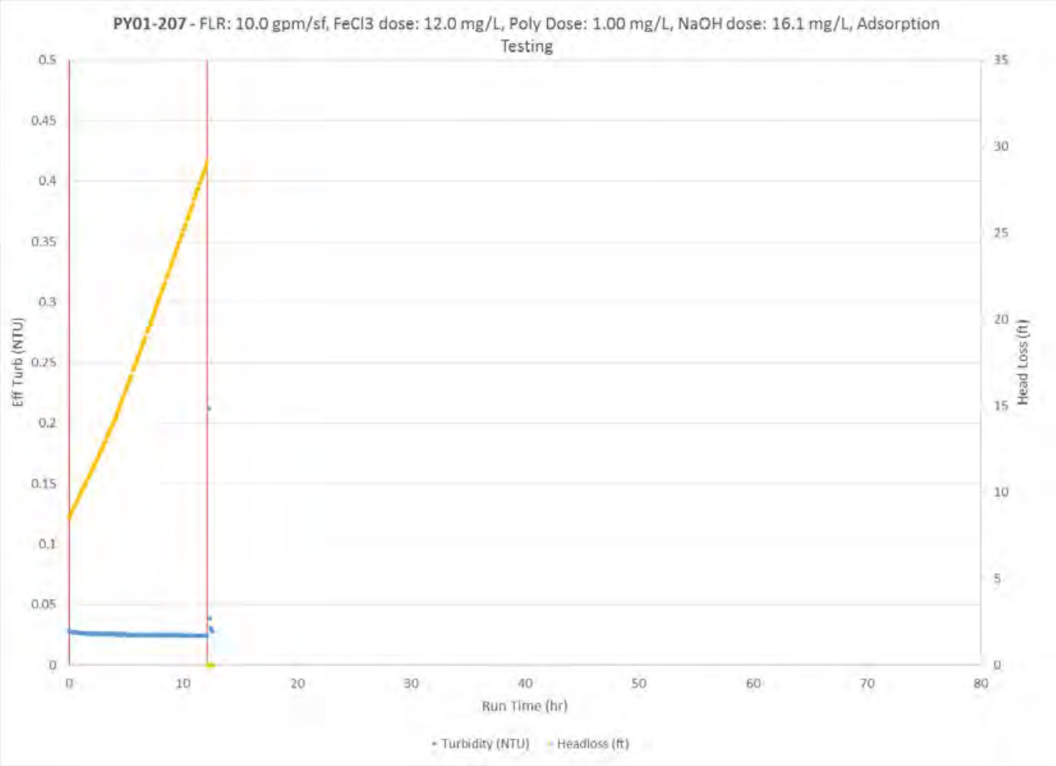


Figure F-83: PY01 Filter Profile

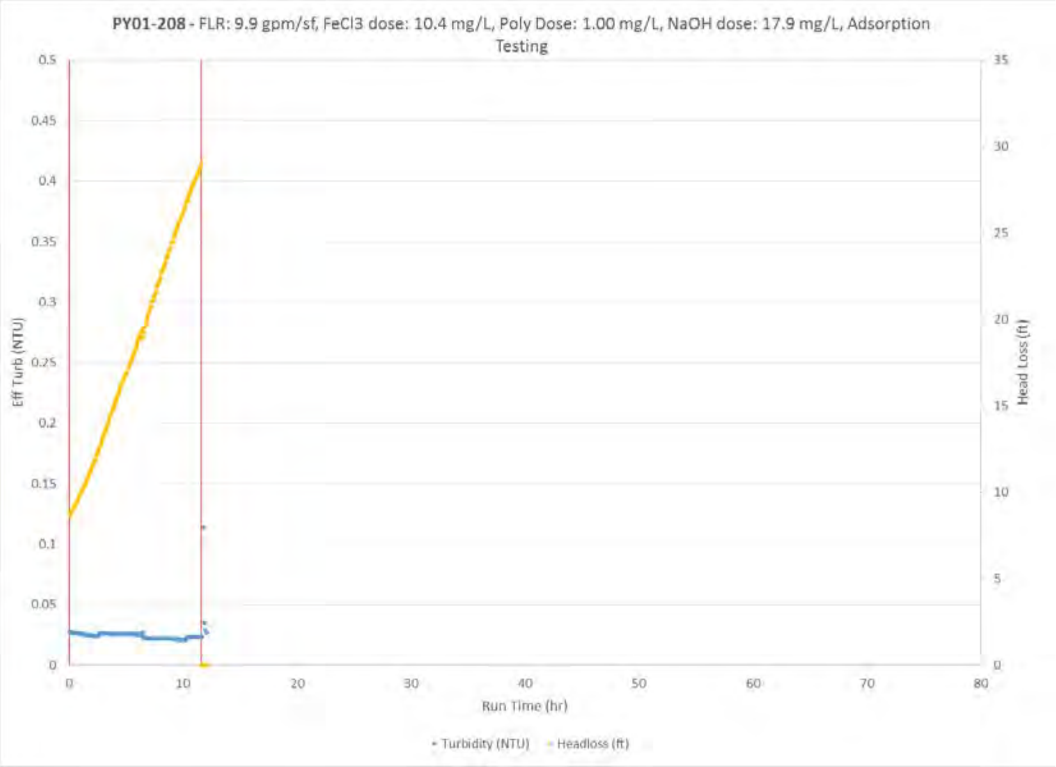


Figure F-84: PY01 Filter Profile

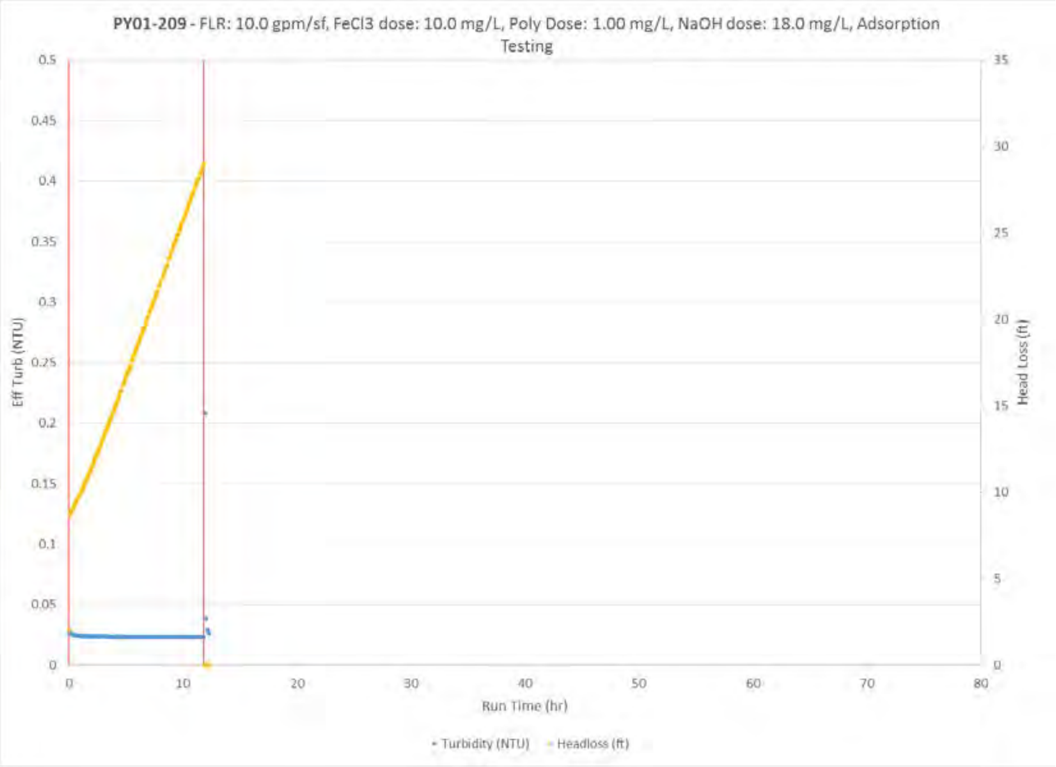


Figure F-85: PY01 Filter Profile

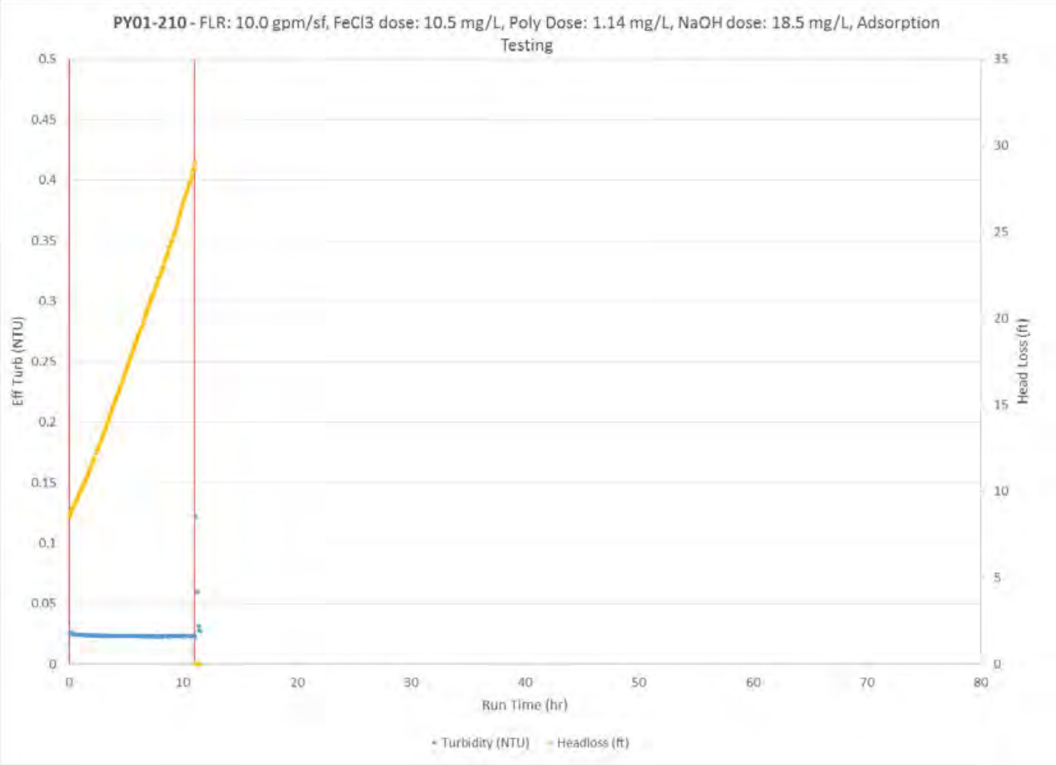


Figure F-86: PY01 Filter Profile

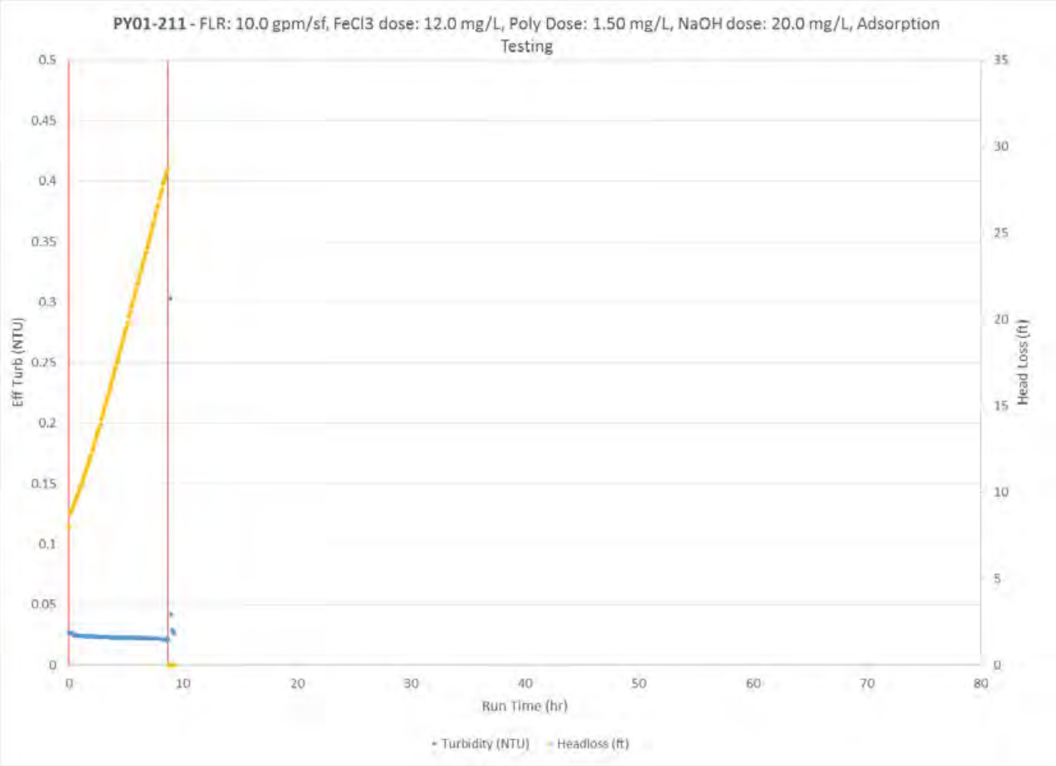


Figure F-87: PY01 Filter Profile

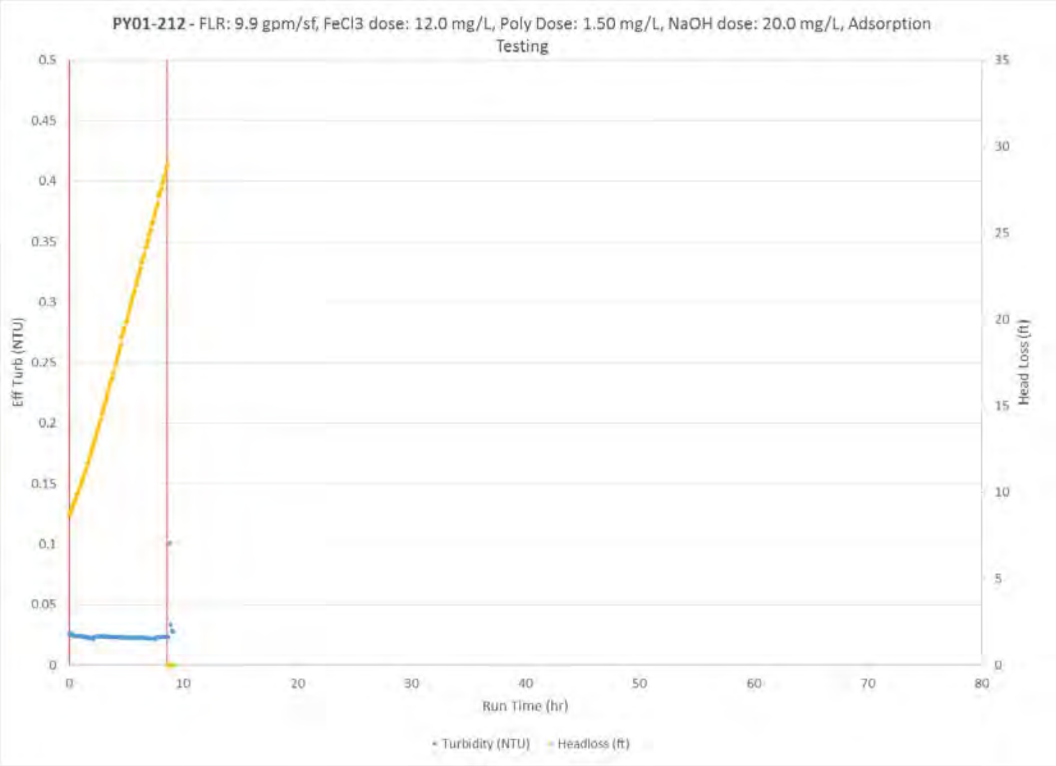


Figure F-88: PY01 Filter Profile

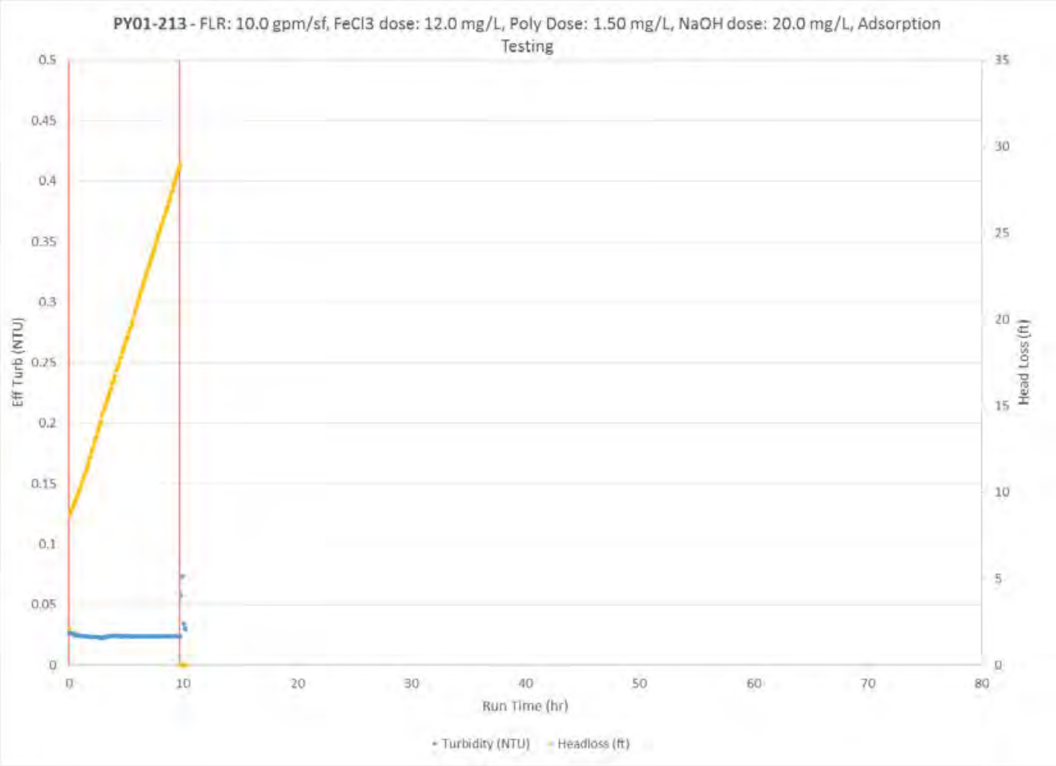


Figure F-89: PY01 Filter Profile

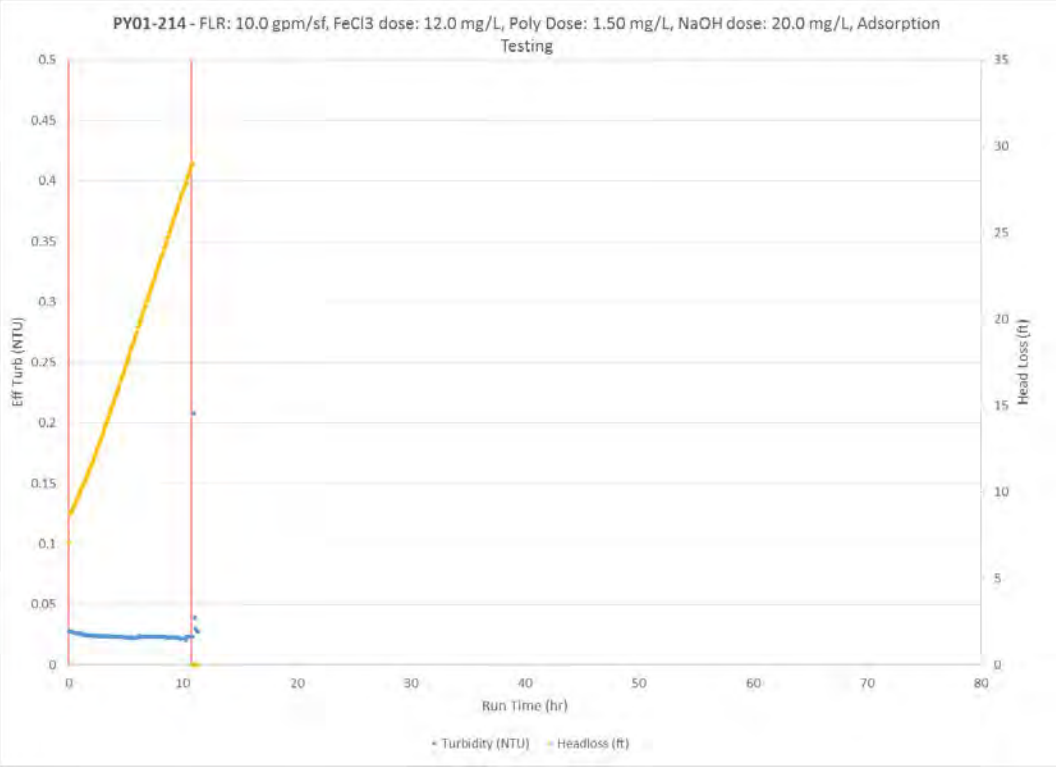


Figure F-90: PY01 Filter Profile

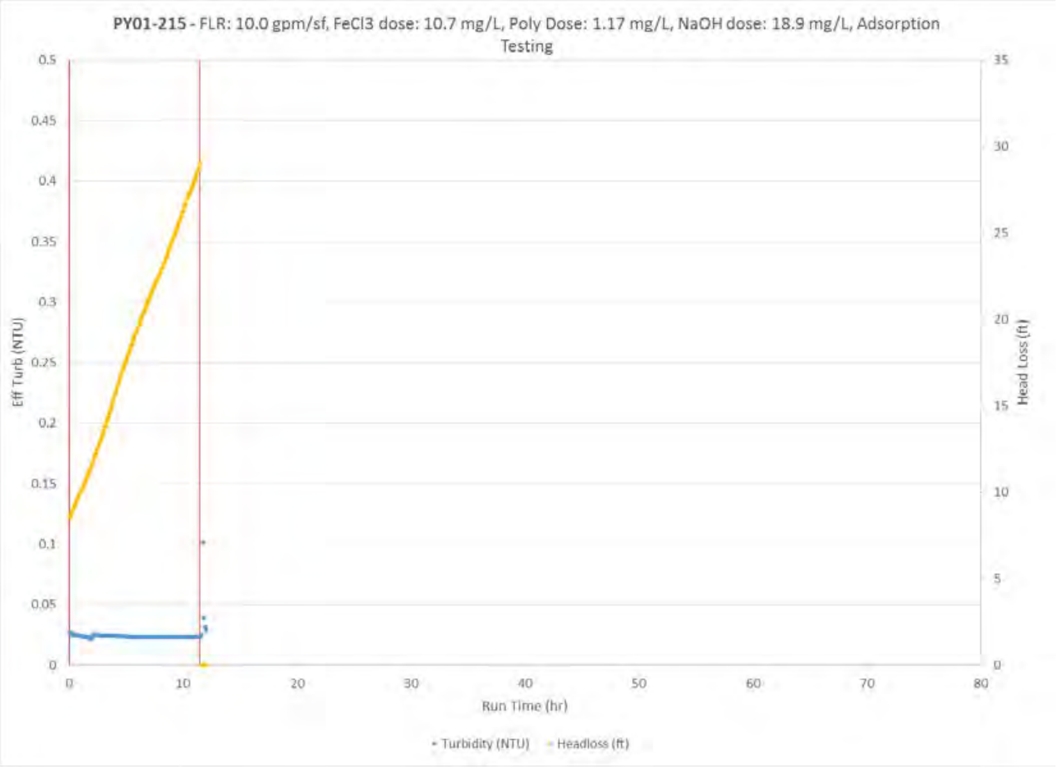


Figure F-91: PY01 Filter Profile

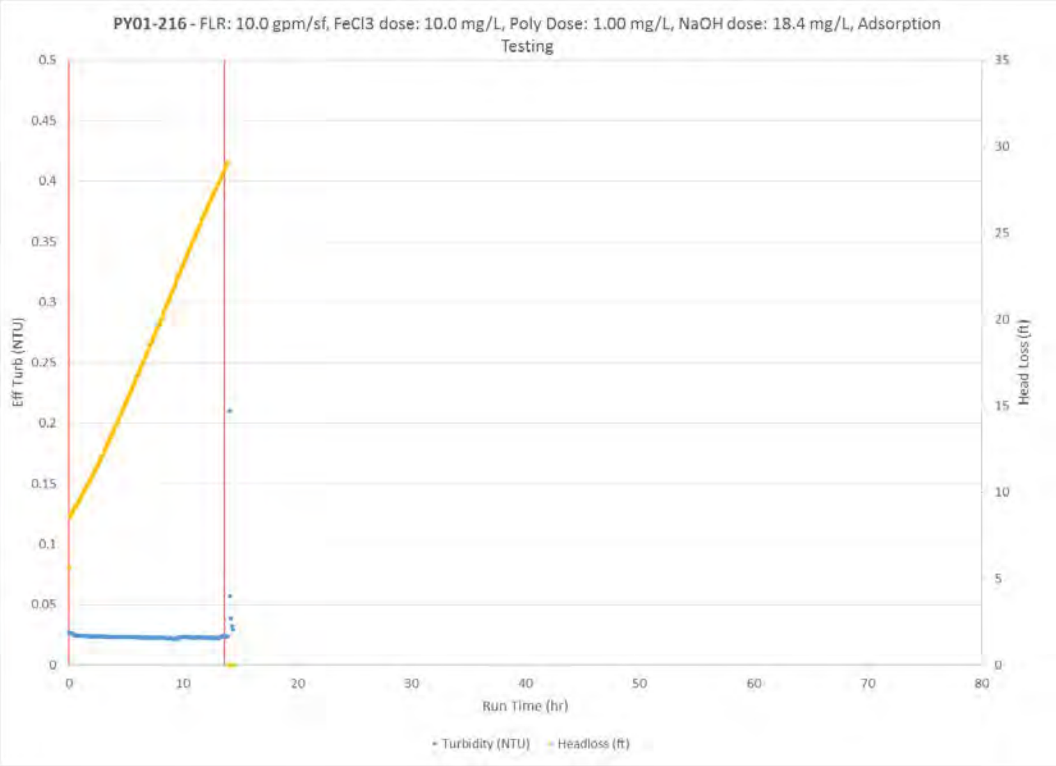


Figure F-92: PY01 Filter Profile

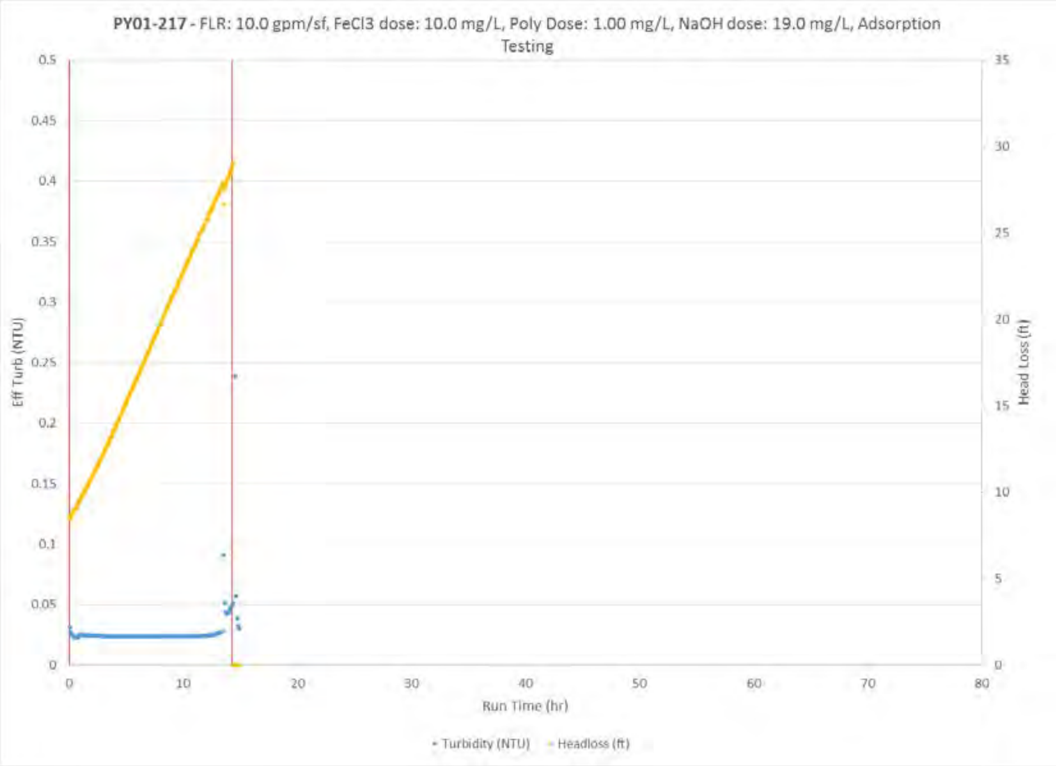


Figure F-93: PY01 Filter Profile

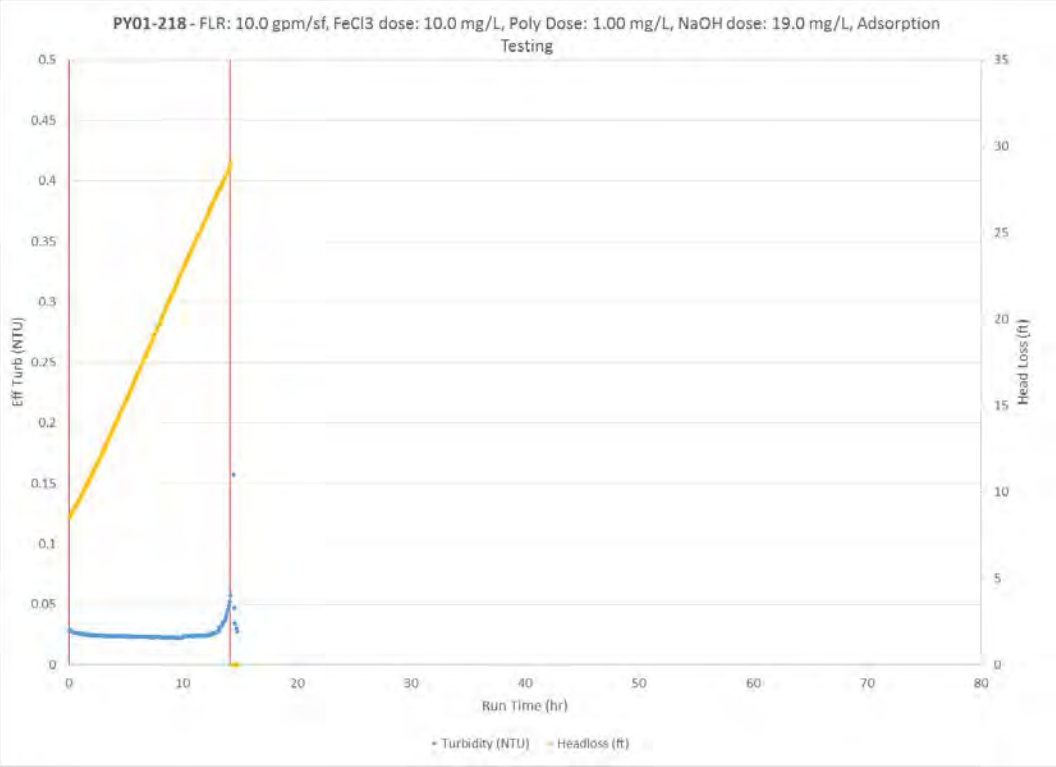


Figure F-94: PY01 Filter Profile

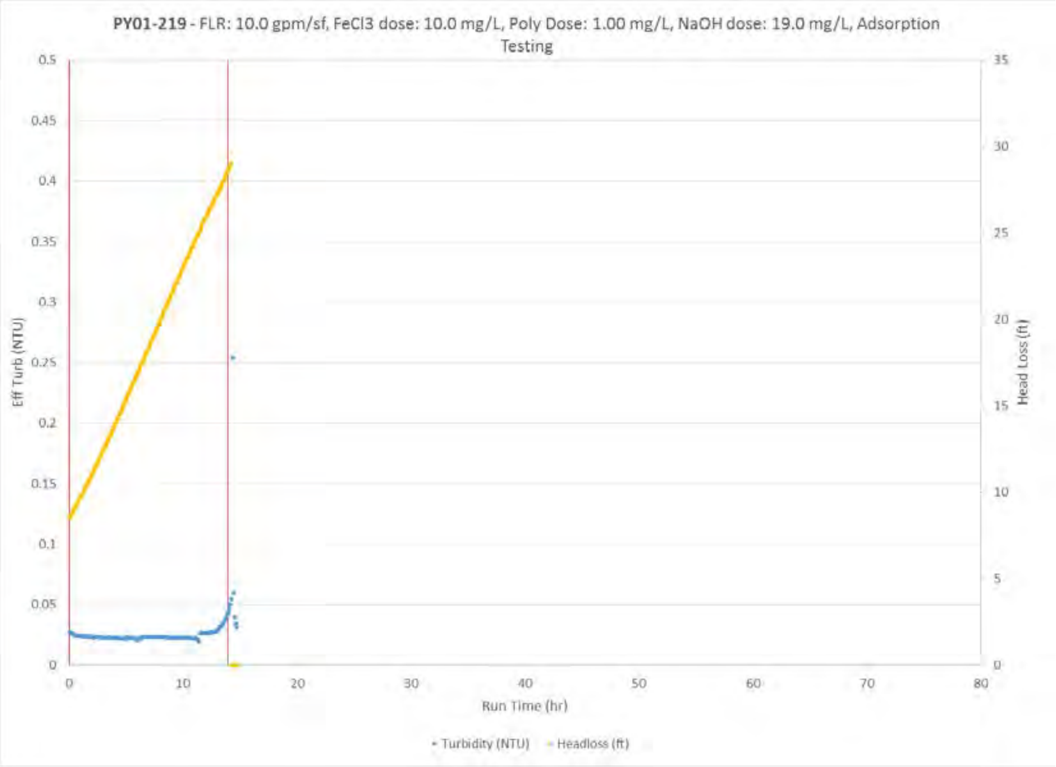


Figure F-95: PY01 Filter Profile

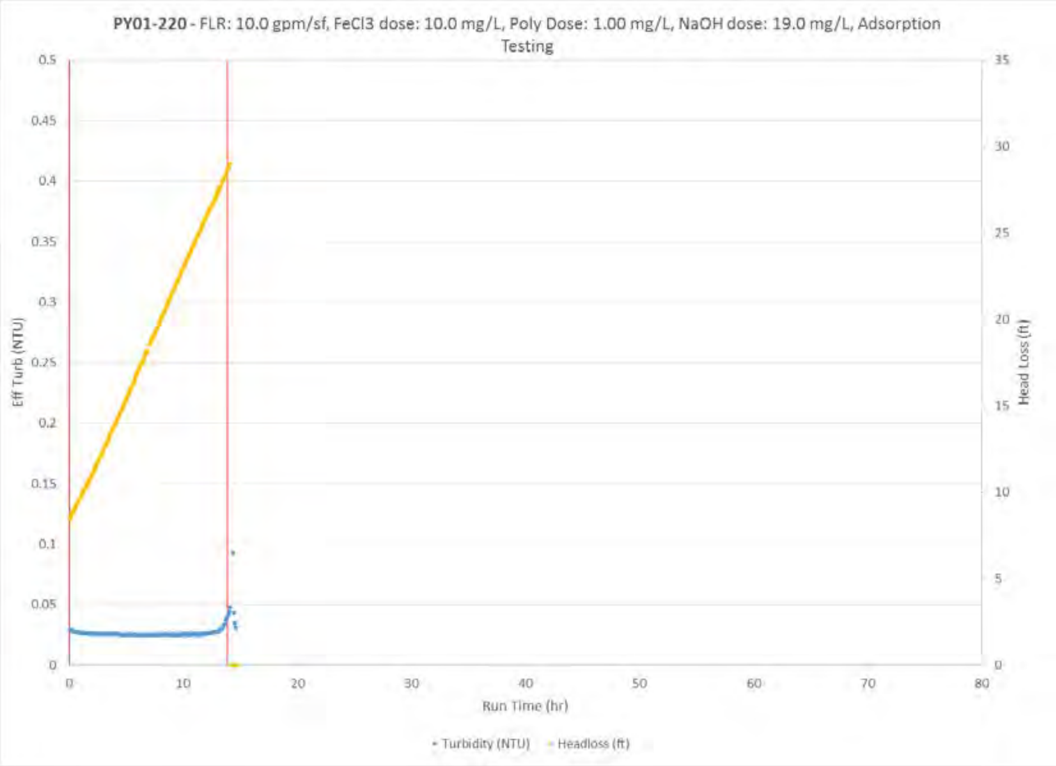


Figure F-96: PY01 Filter Profile

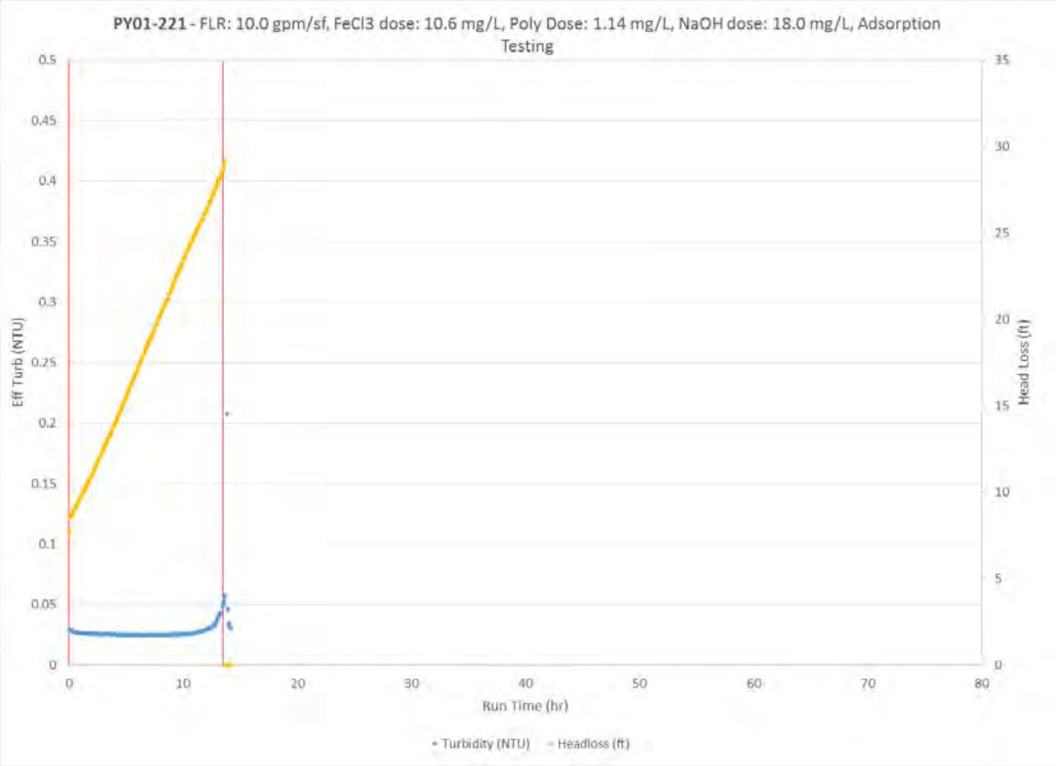


Figure F-97: PY01 Filter Profile

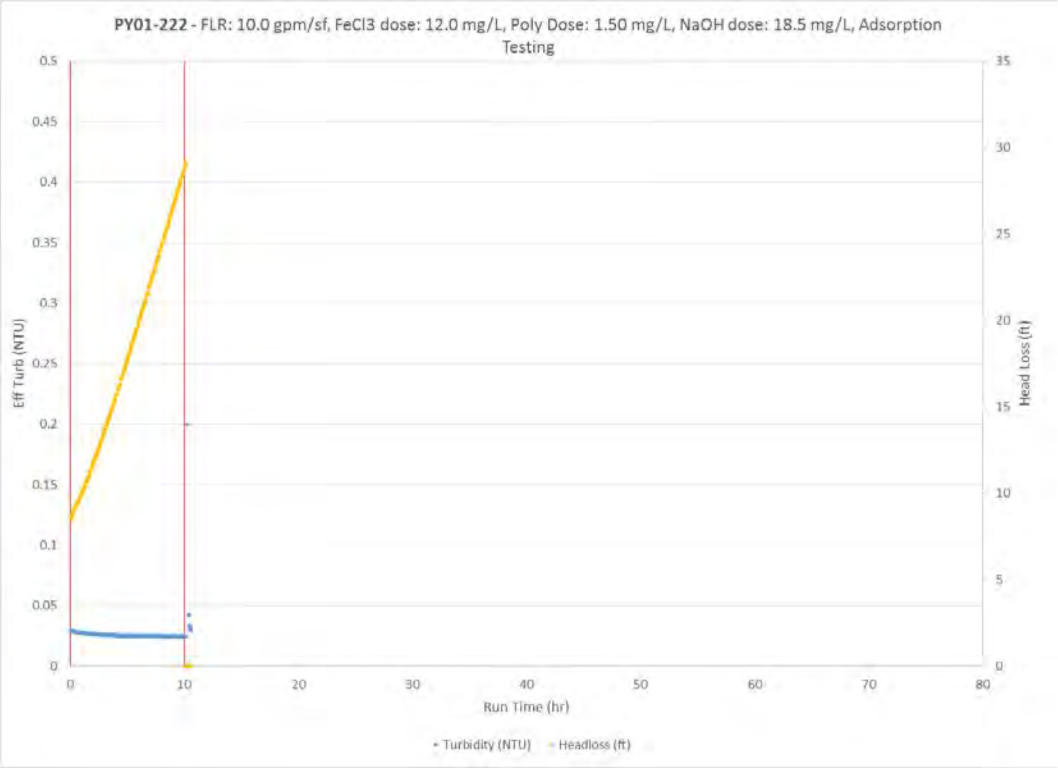


Figure F-98: PY01 Filter Profile

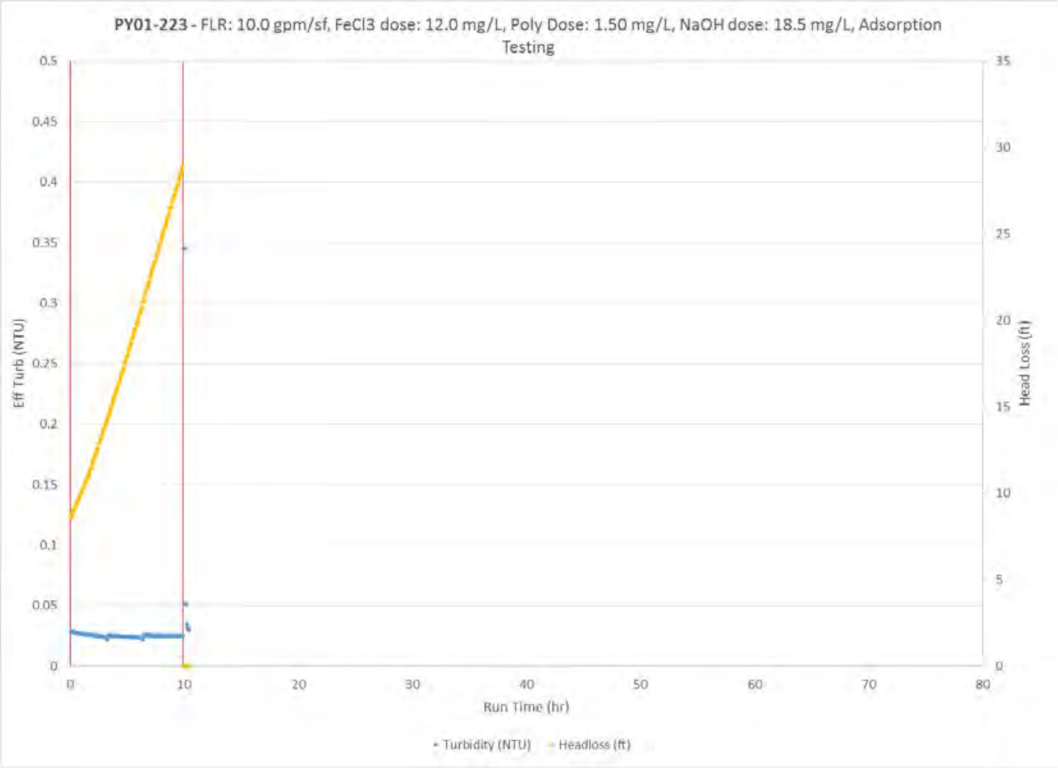


Figure F-99: PY01 Filter Profile

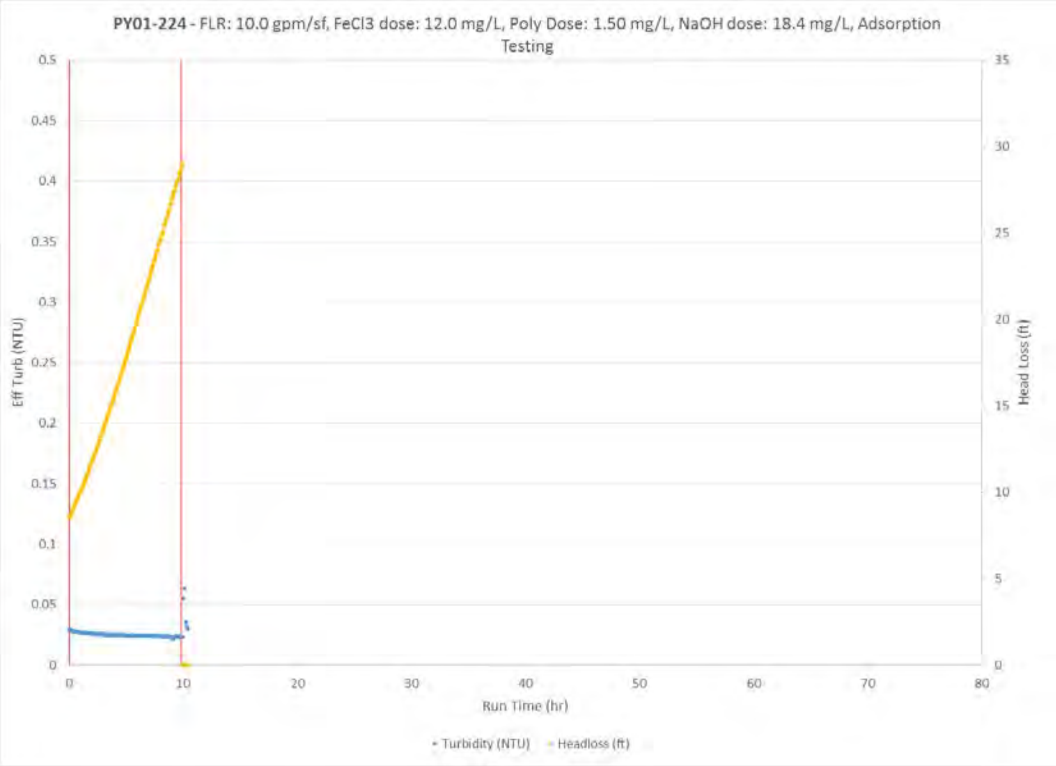


Figure F-100: PY01 Filter Profile

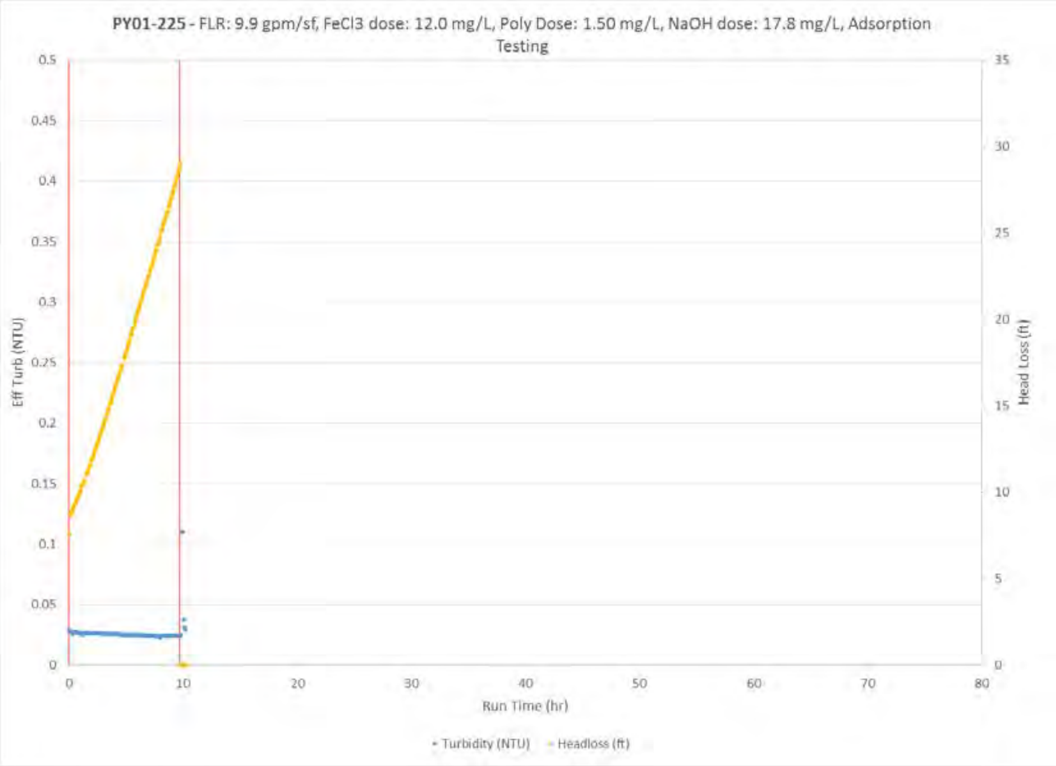


Figure F-101: PY01 Filter Profile

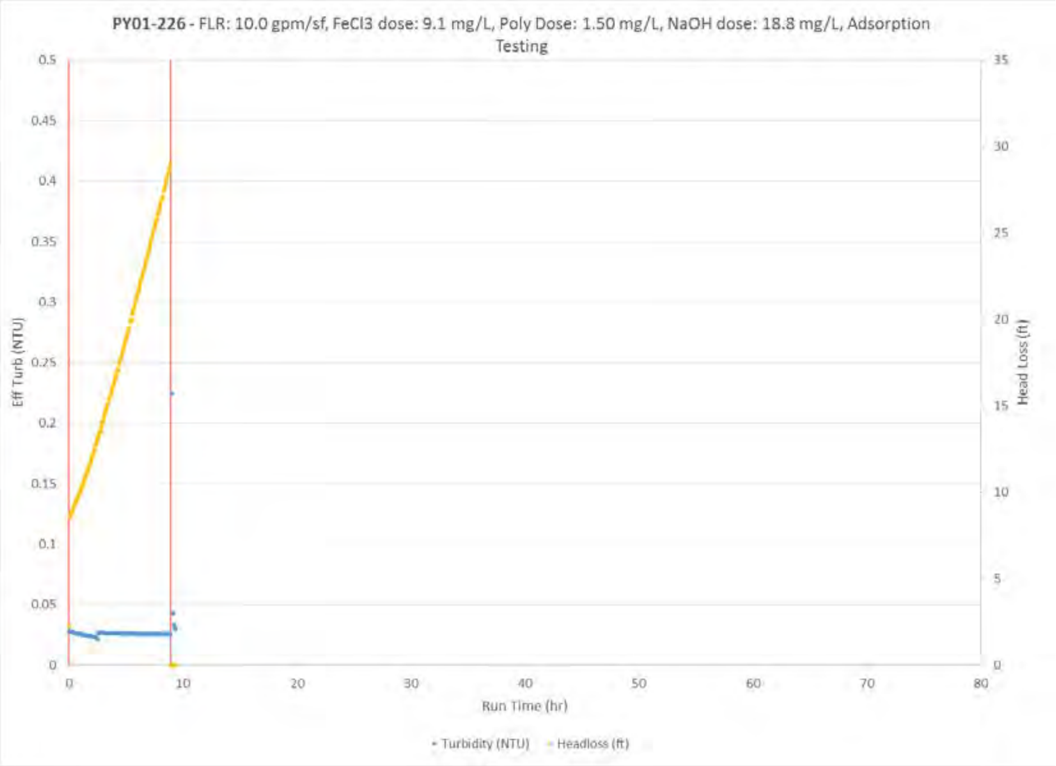


Figure F-102: PY01 Filter Profile

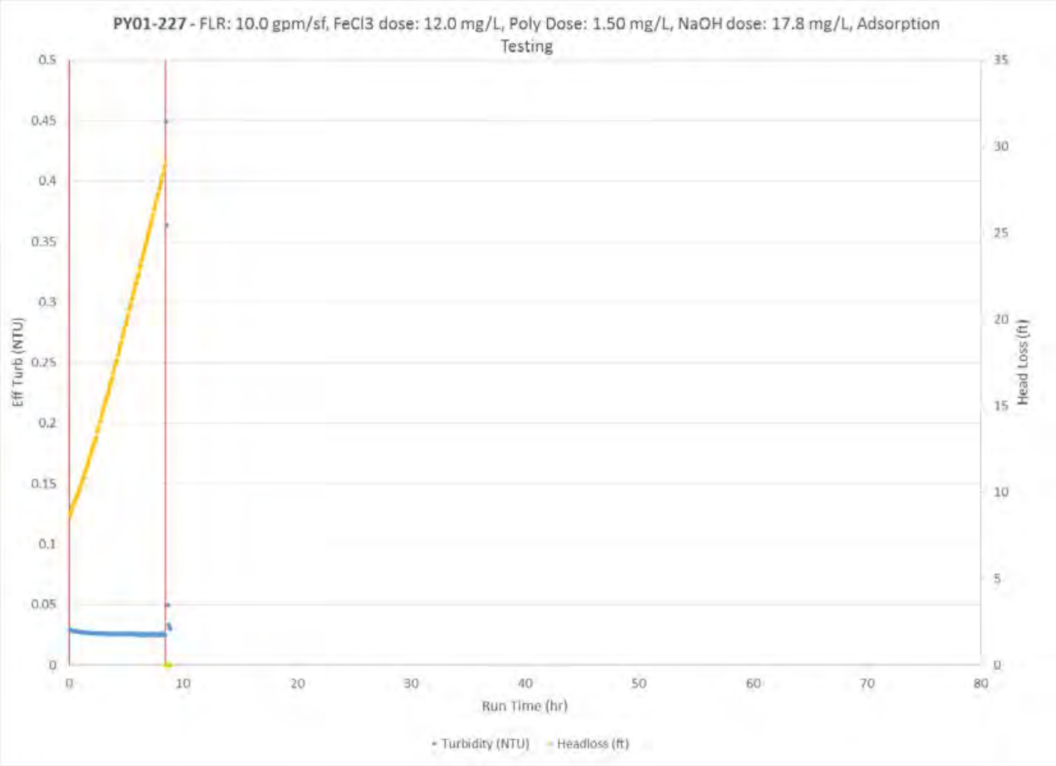


Figure F-103: PY01 Filter Profile

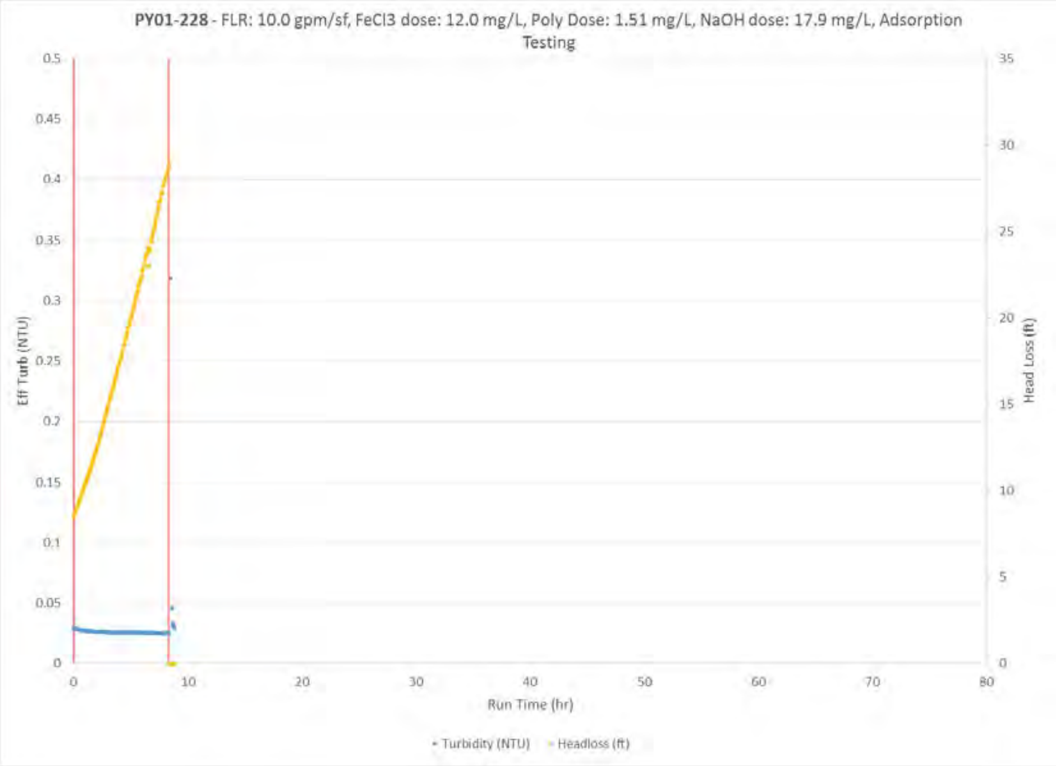


Figure F-104: PY01 Filter Profile

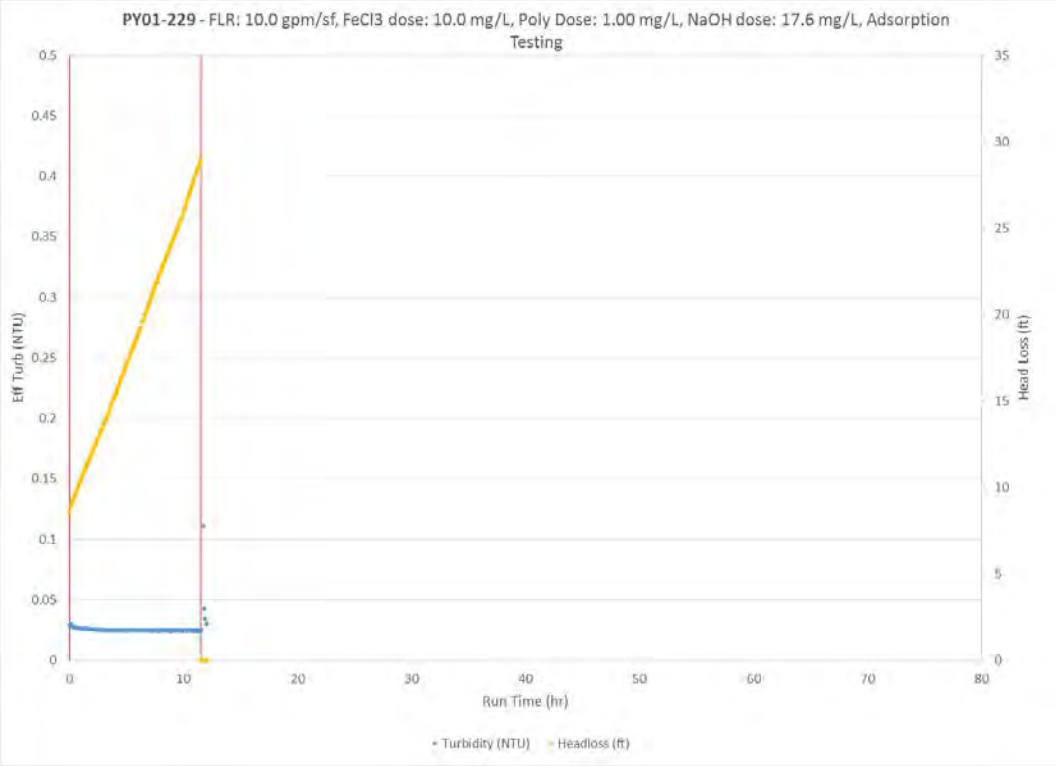


Figure F-105: PY01 Filter Profile

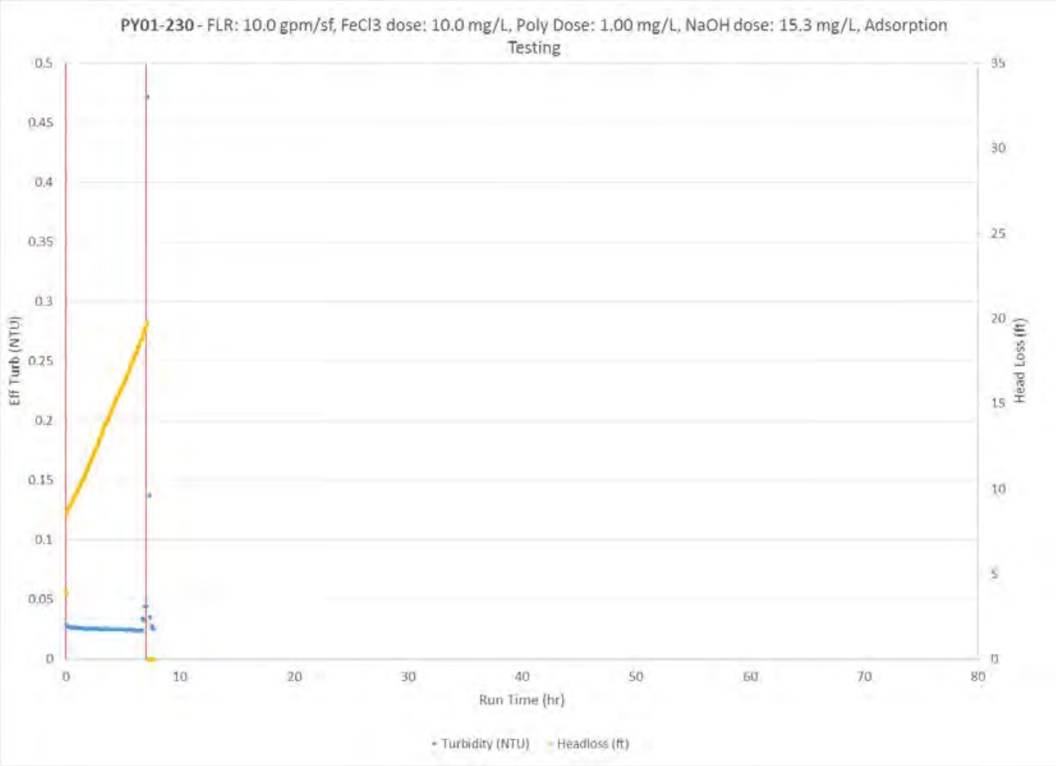


Figure F-106: PY01 Filter Profile

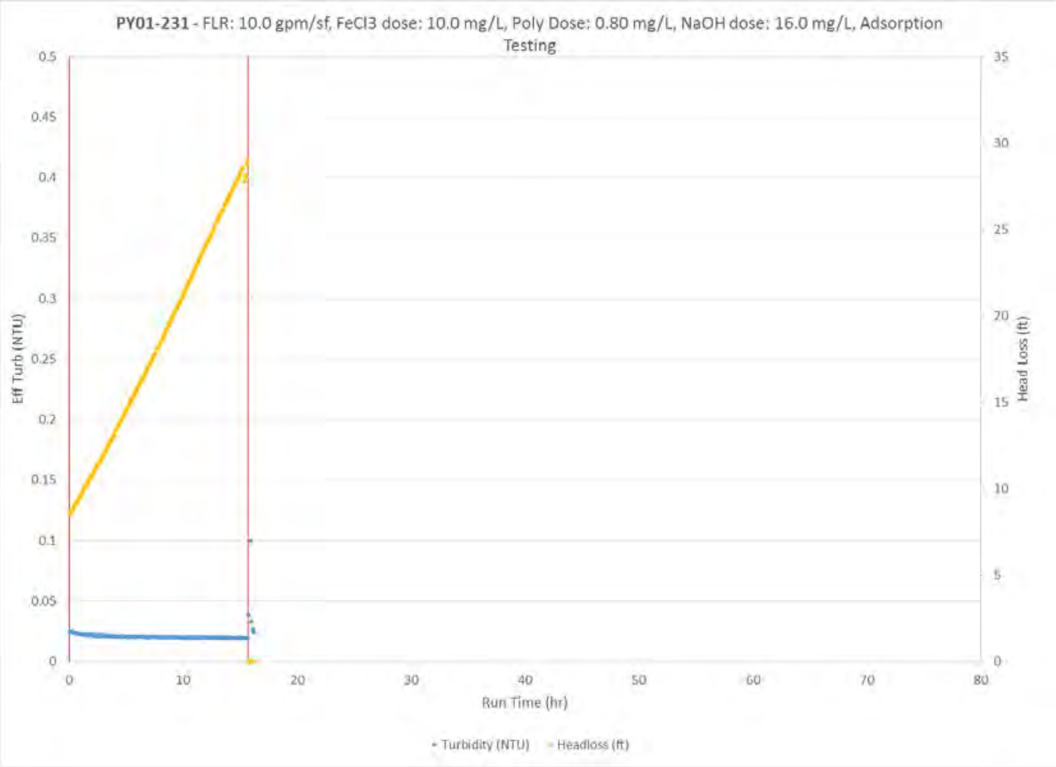


Figure F-107: PY01 Filter Profile

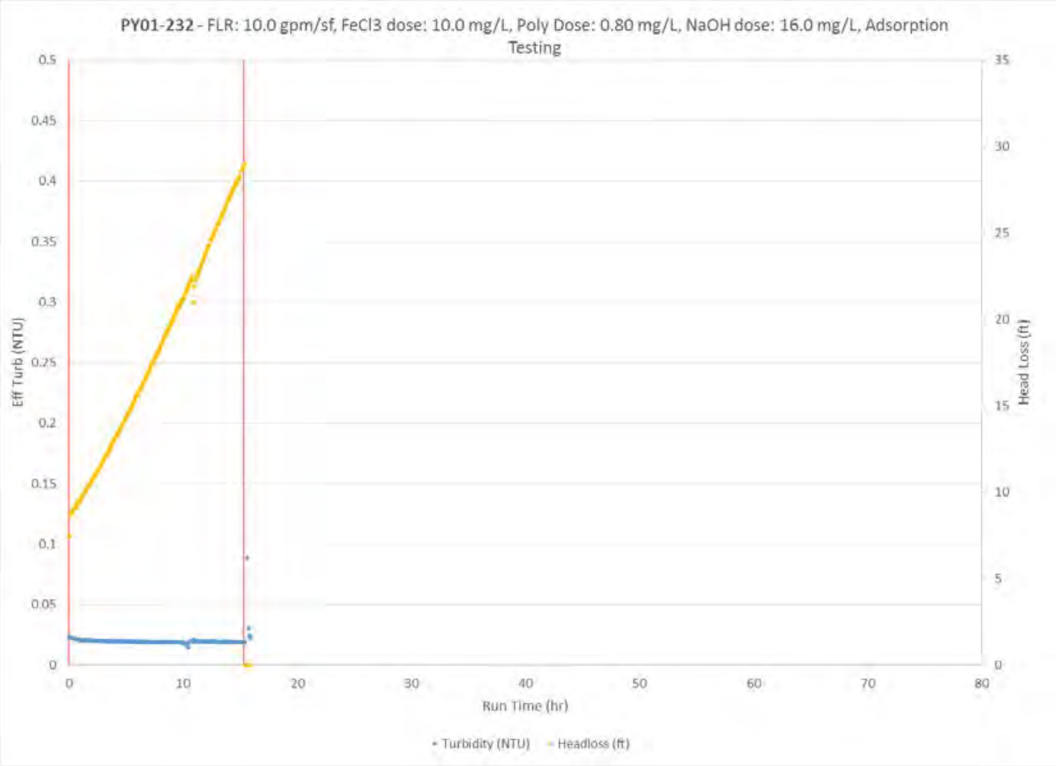


Figure F-108: PY01 Filter Profile

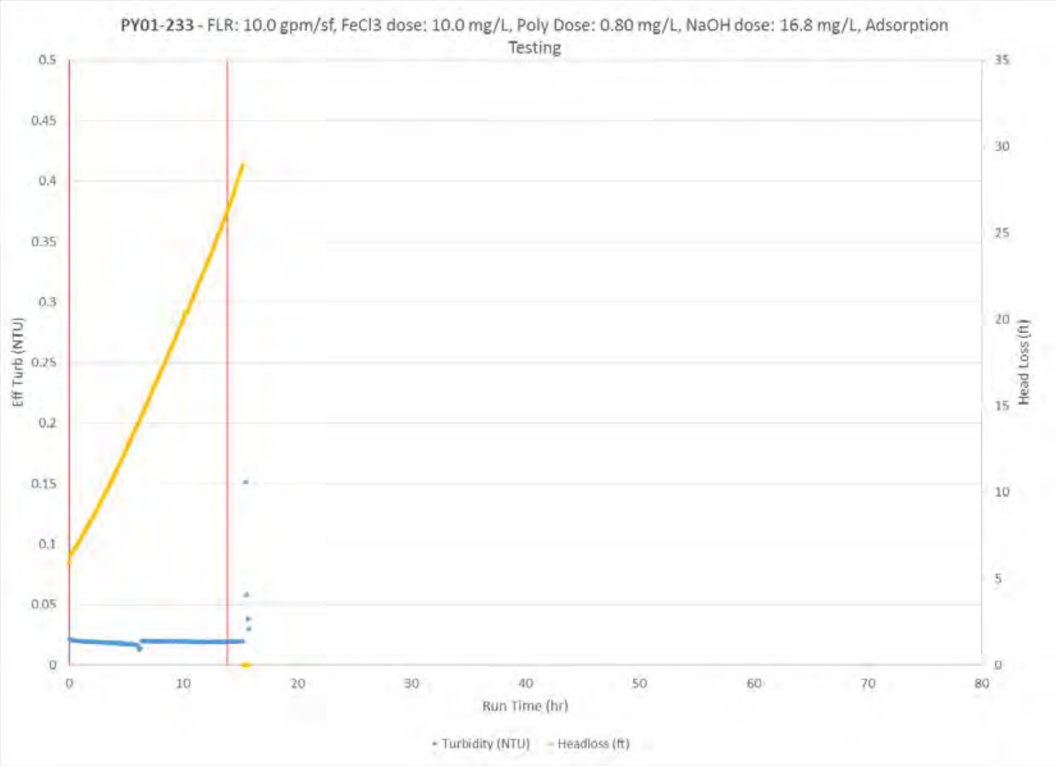


Figure F-109: PY01 Filter Profile

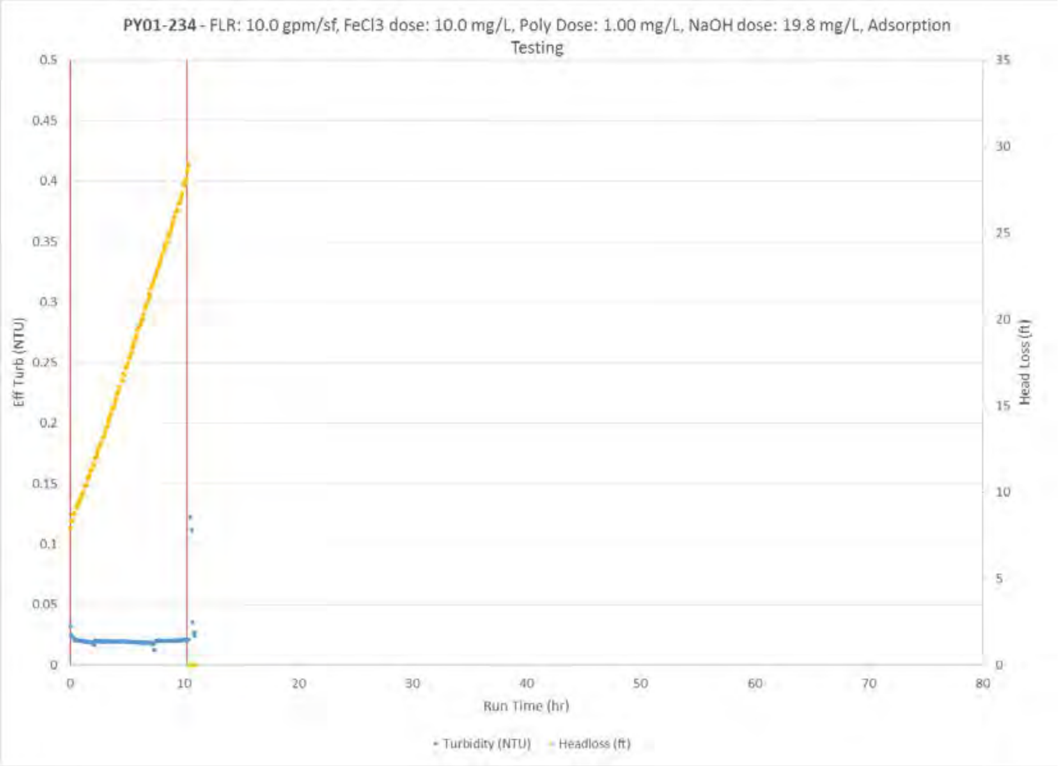


Figure F-110: PY01 Filter Profile

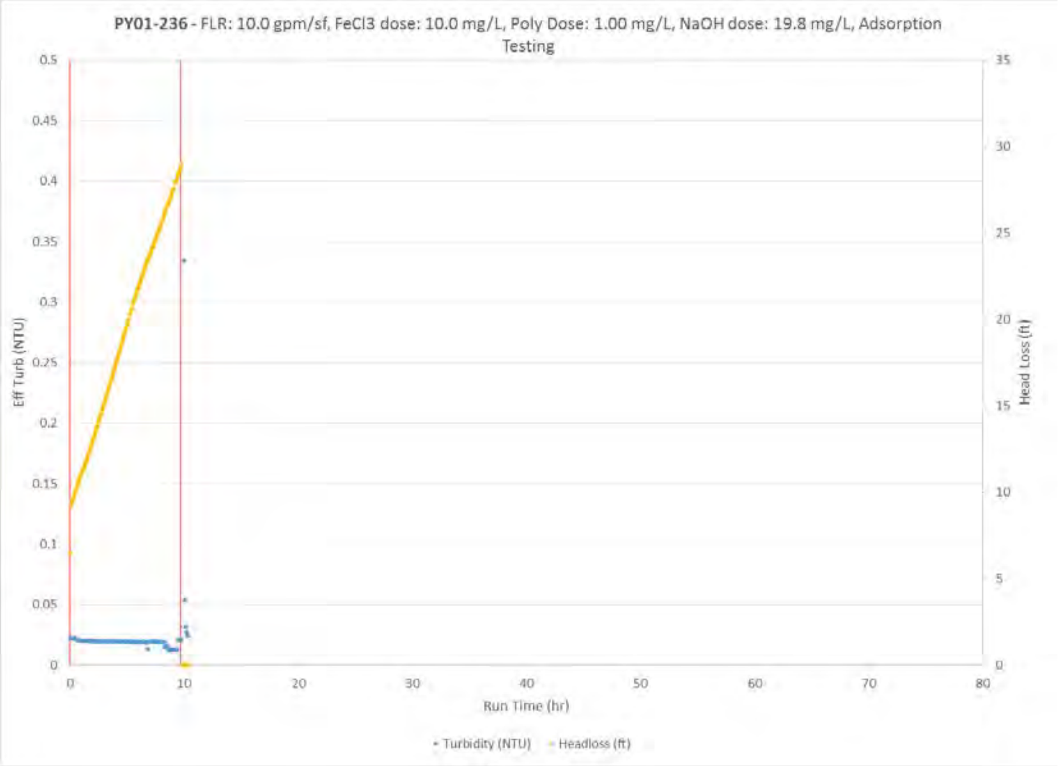


Figure F-111: PY01 Filter Profile

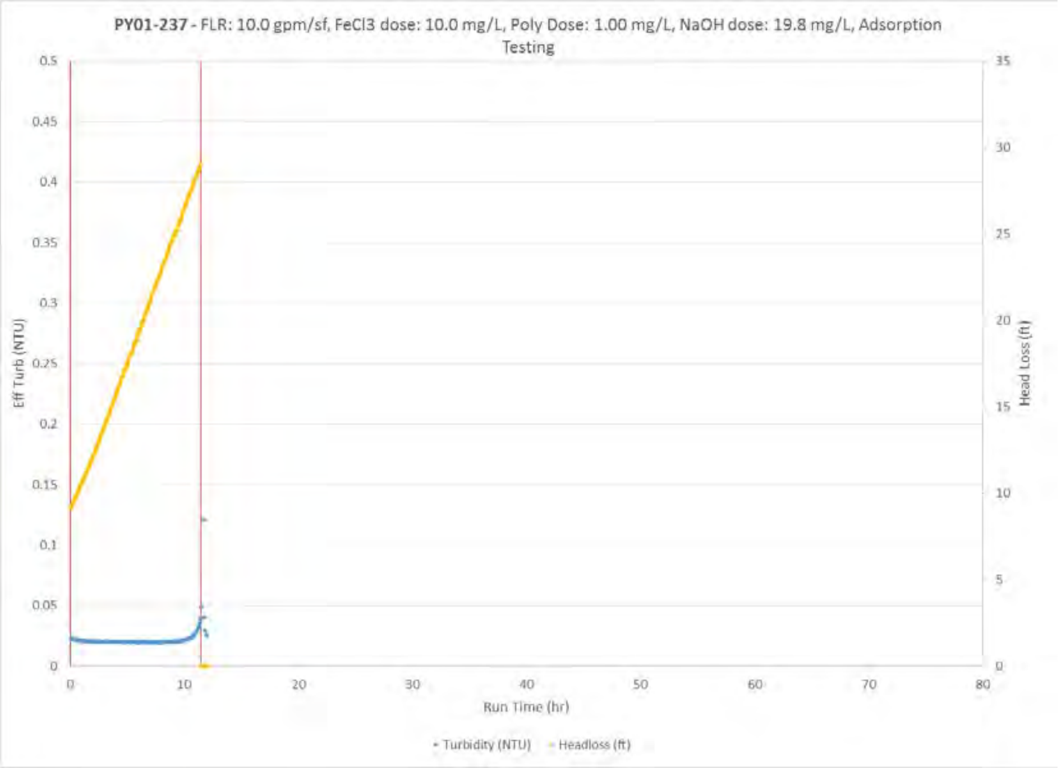


Figure F-112: PY01 Filter Profile

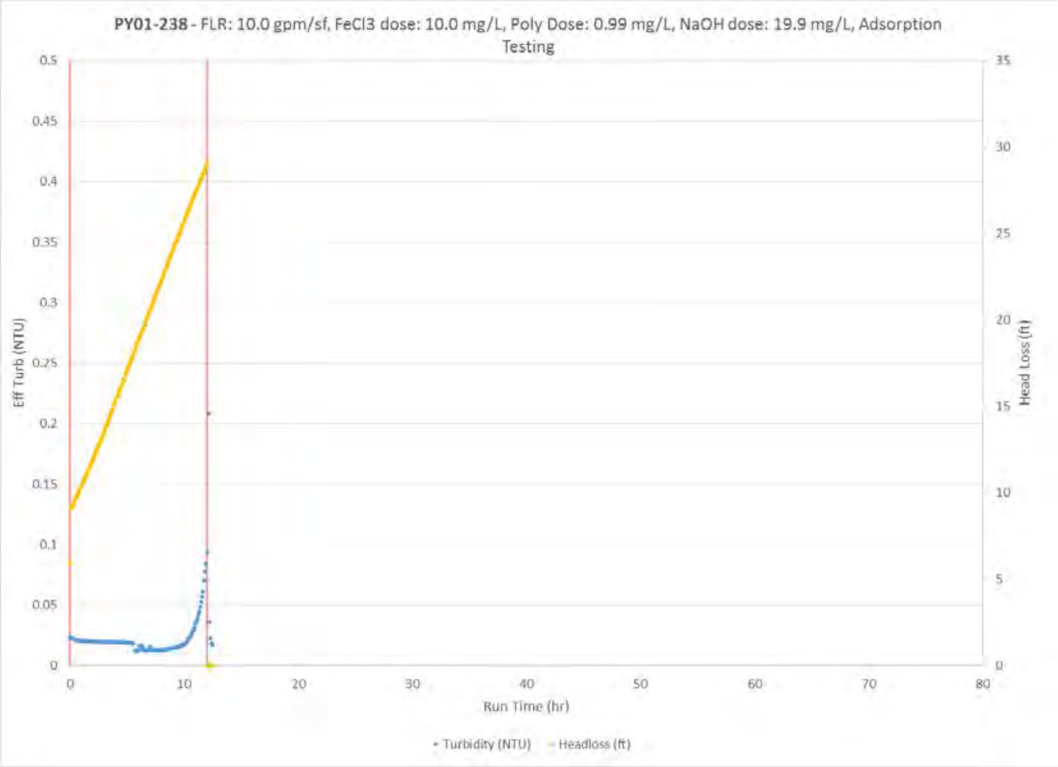


Figure F-113: PY01 Filter Profile

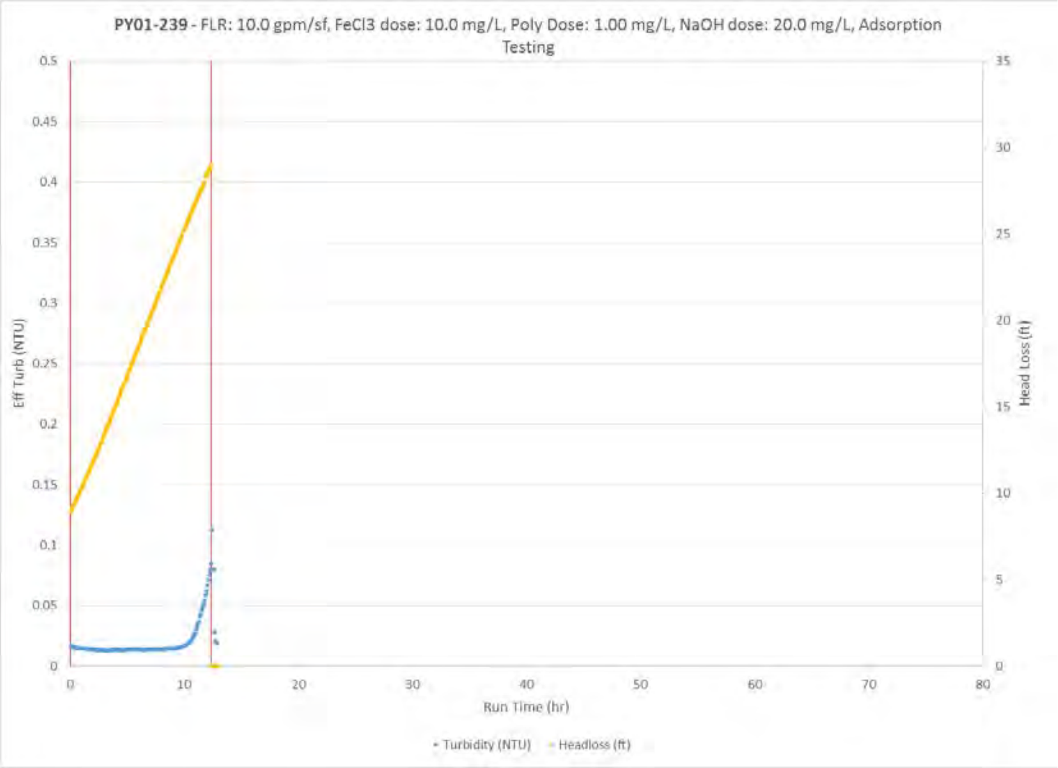


Figure F-114: PY01 Filter Profile

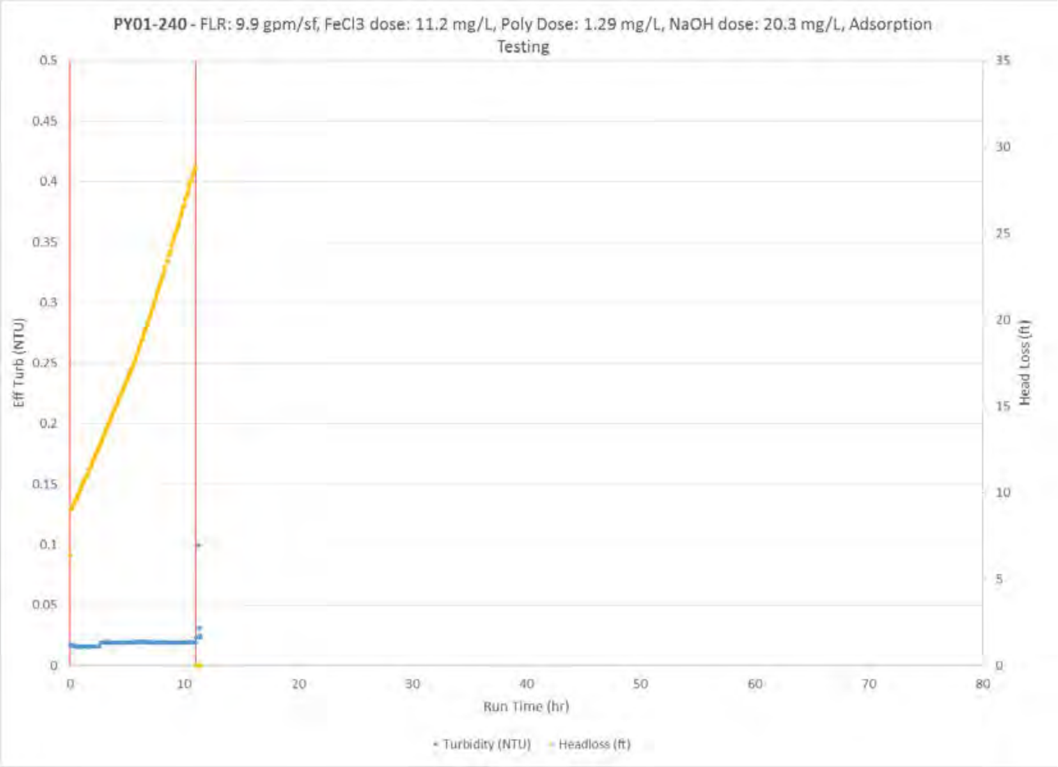


Figure F-115: PY01 Filter Profile

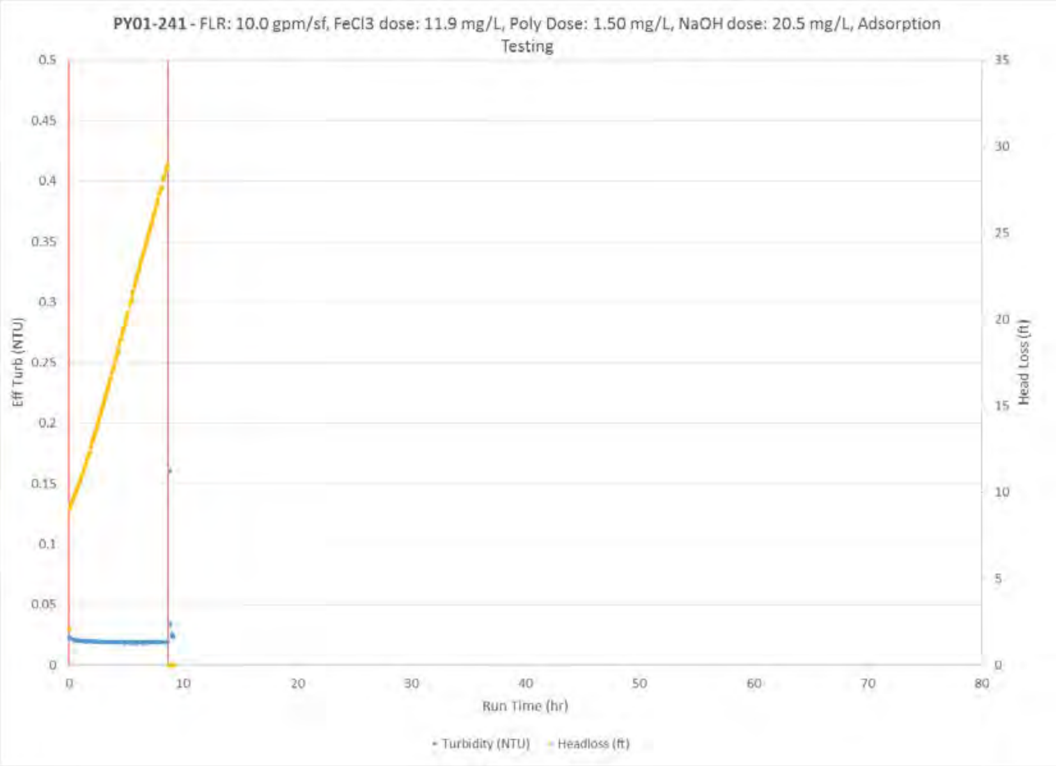


Figure F-116: PY01 Filter Profile

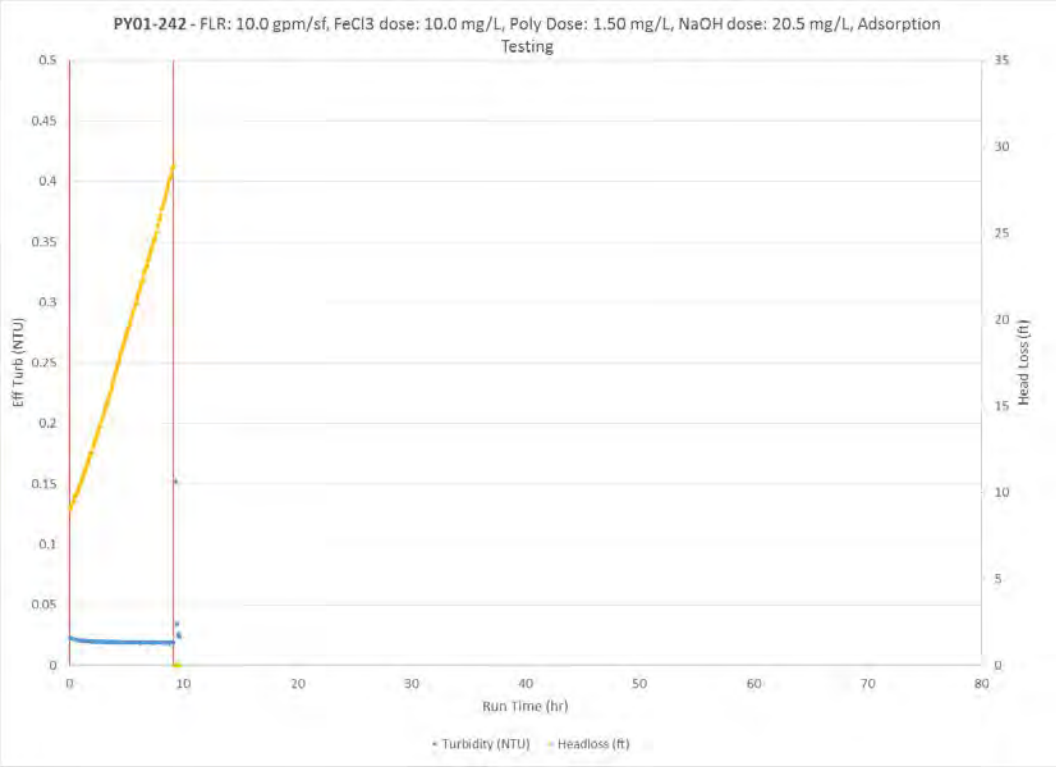


Figure F-117: PY01 Filter Profile

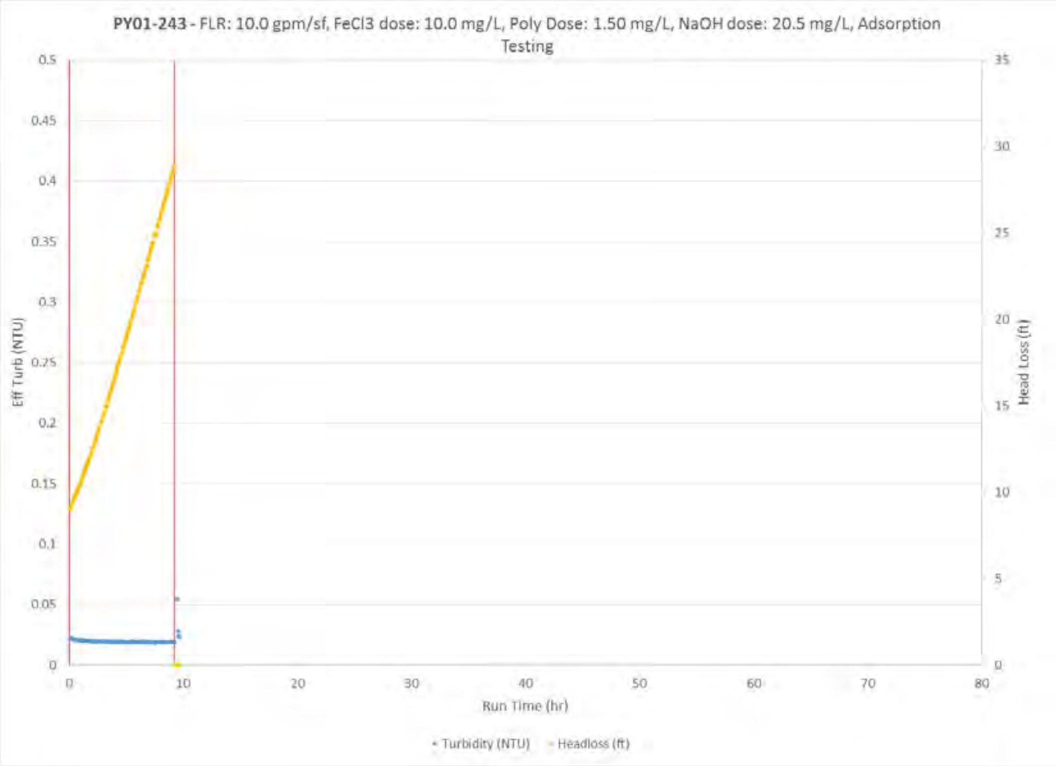


Figure F-118: PY01 Filter Profile

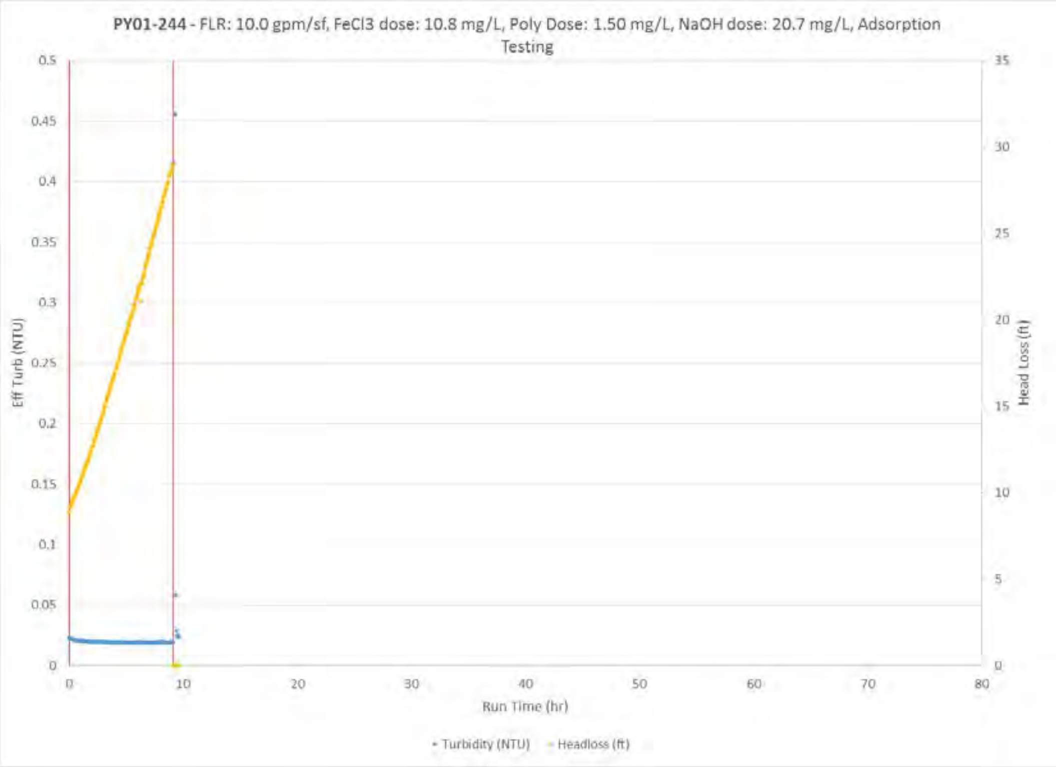


Figure F-119: PY01 Filter Profile

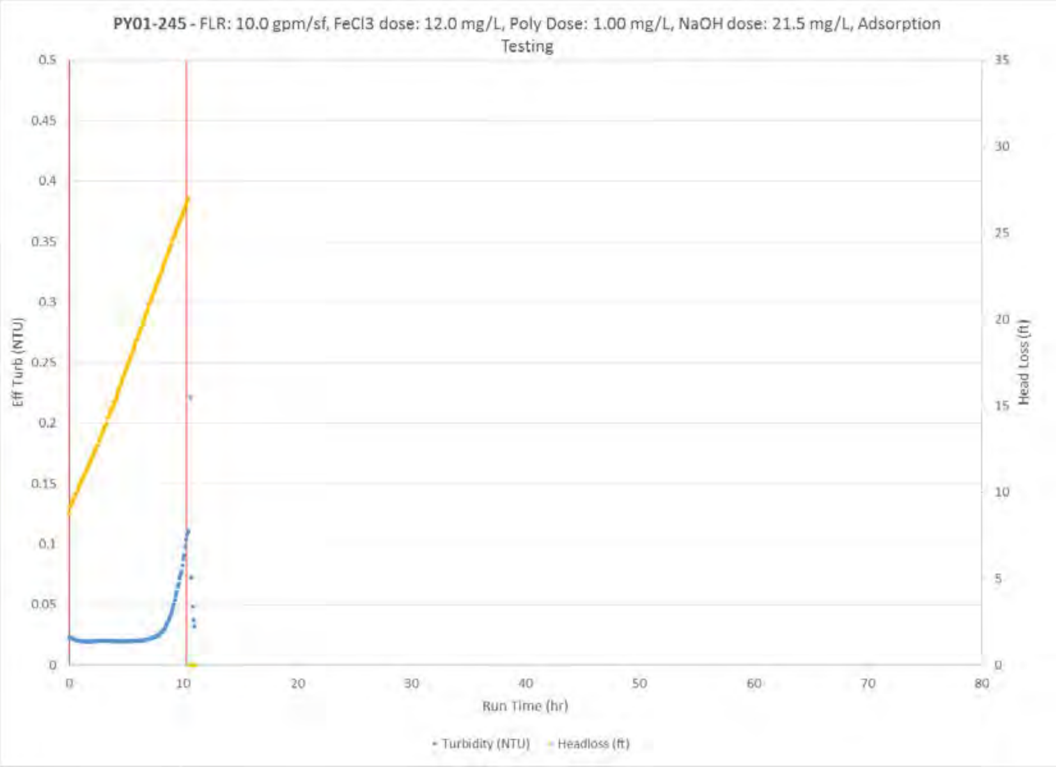


Figure F-120: PY01 Filter Profile

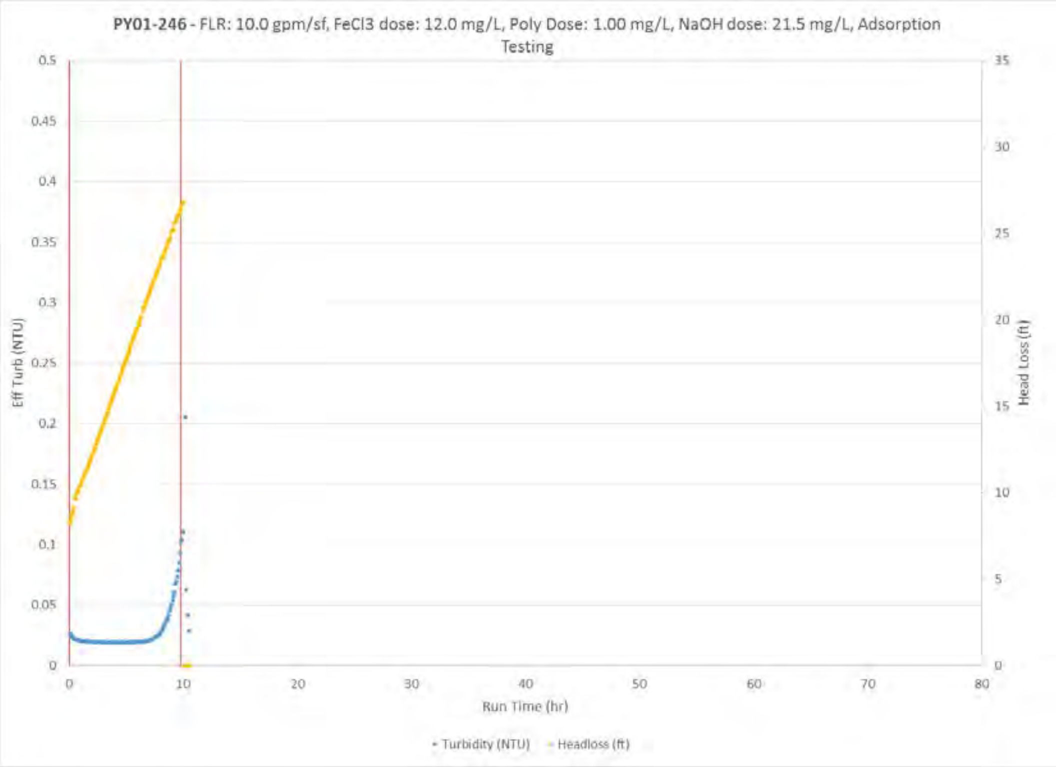


Figure F-121: PY01 Filter Profile

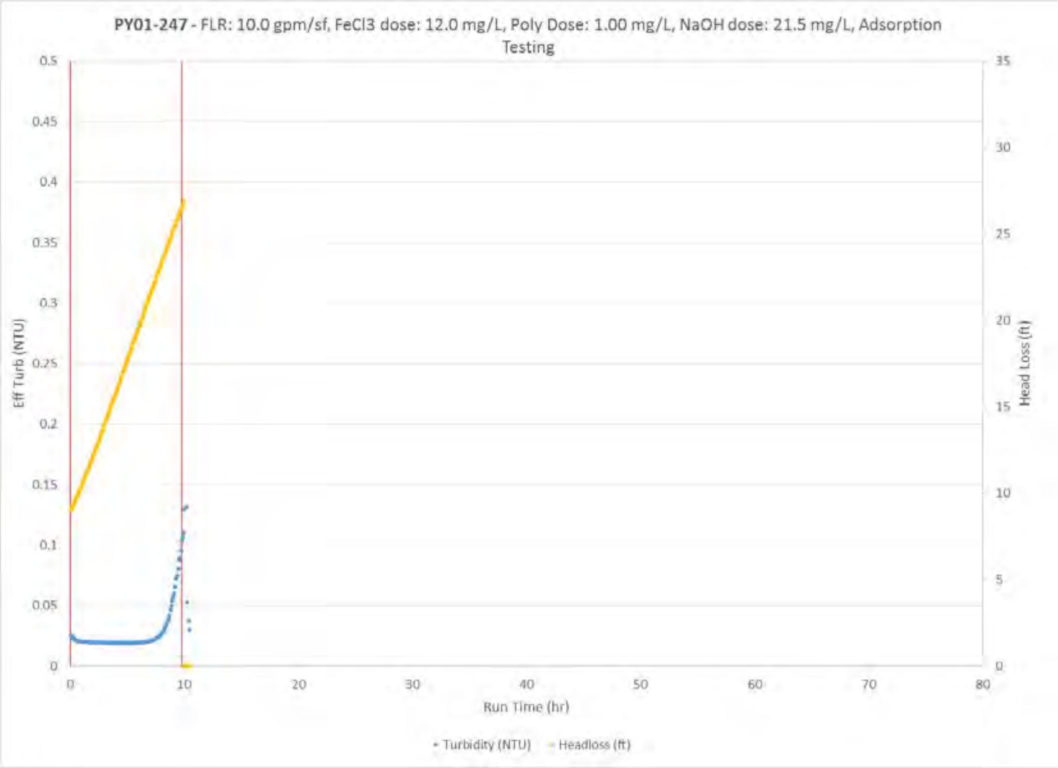


Figure F-122: PY01 Filter Profile

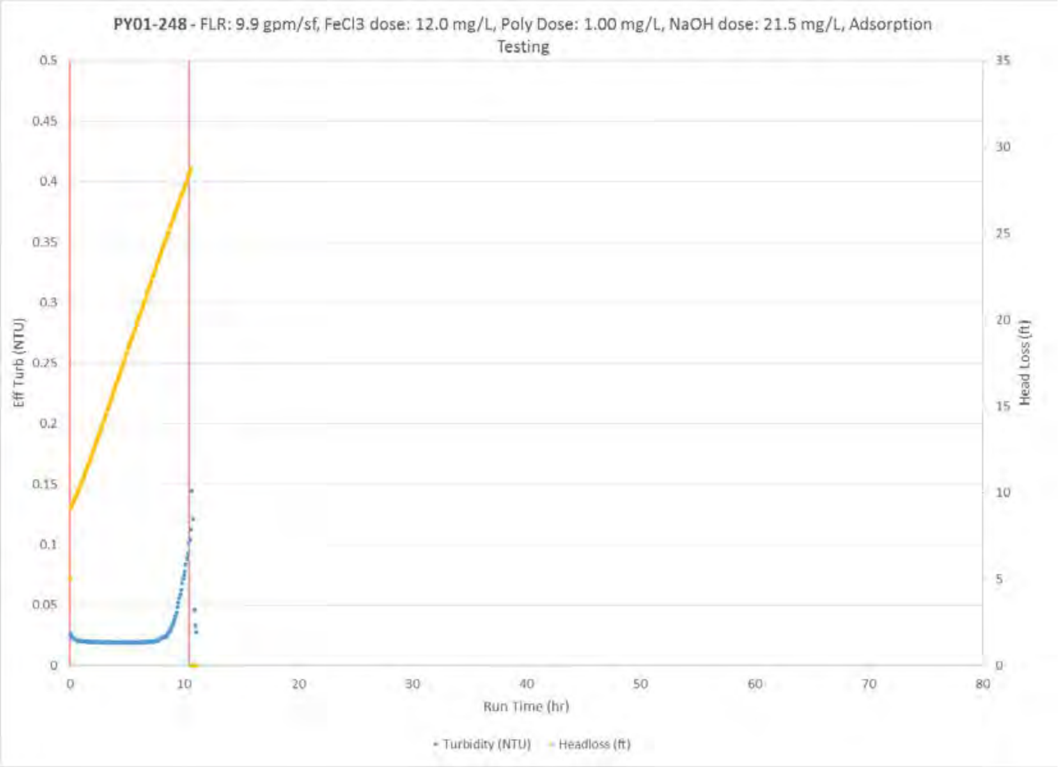


Figure F-123: PY01 Filter Profile

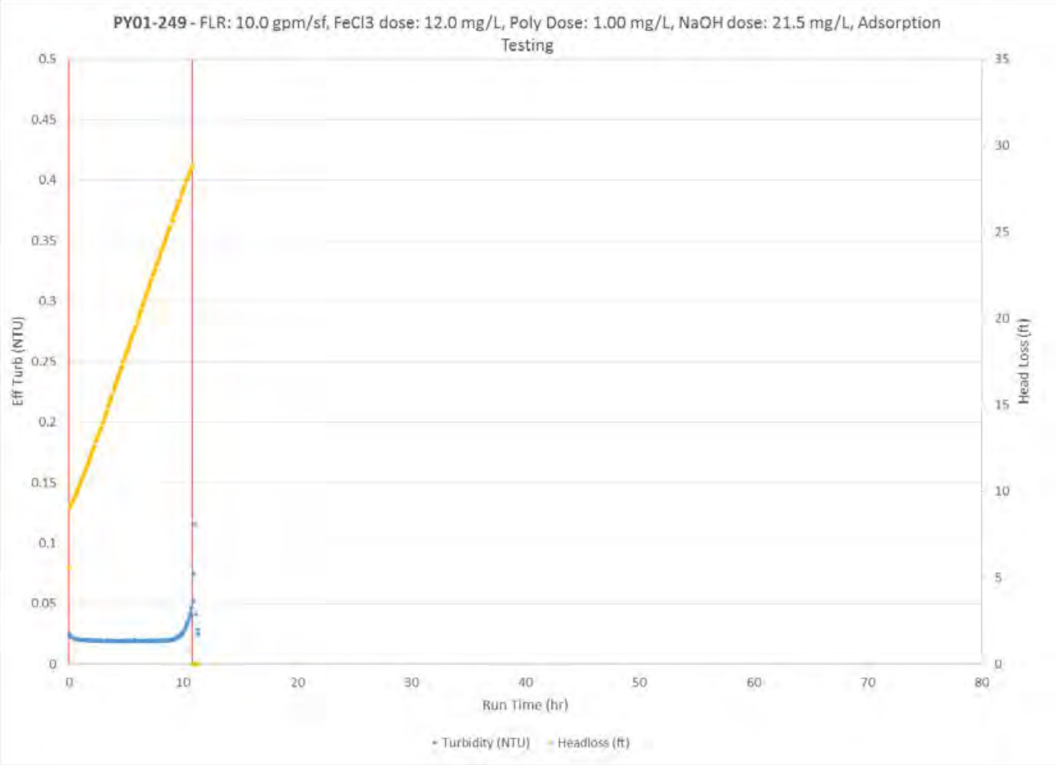


Figure F-124: PY01 Filter Profile

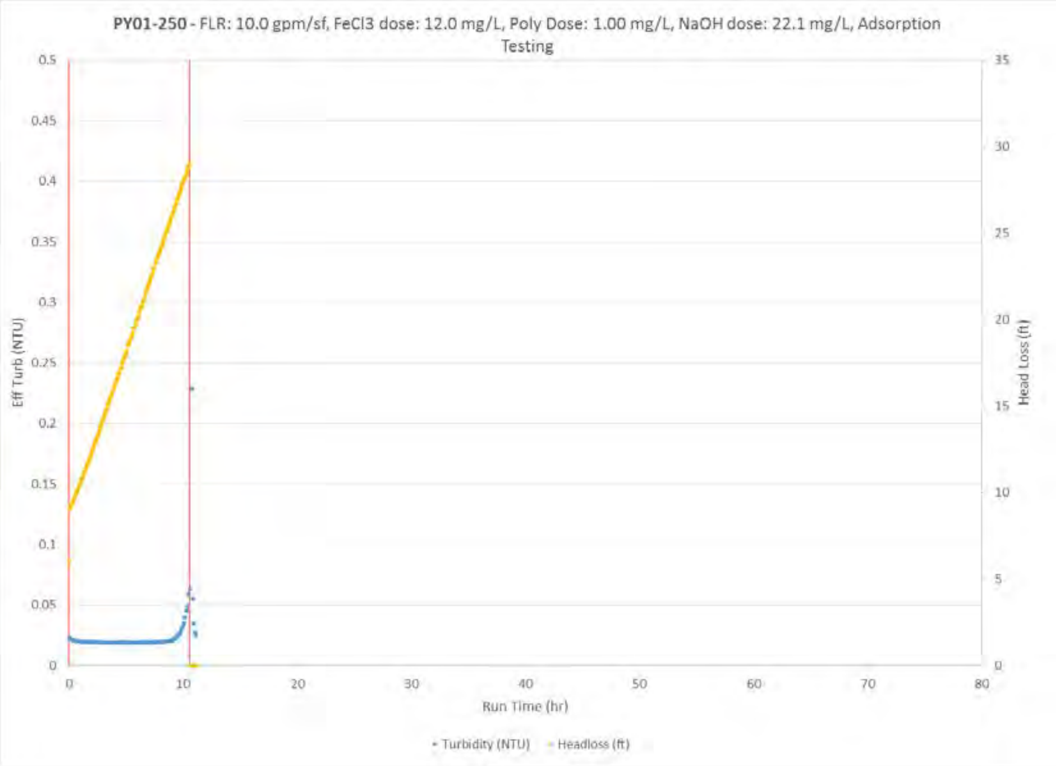


Figure F-125: PY02 Filter Profile

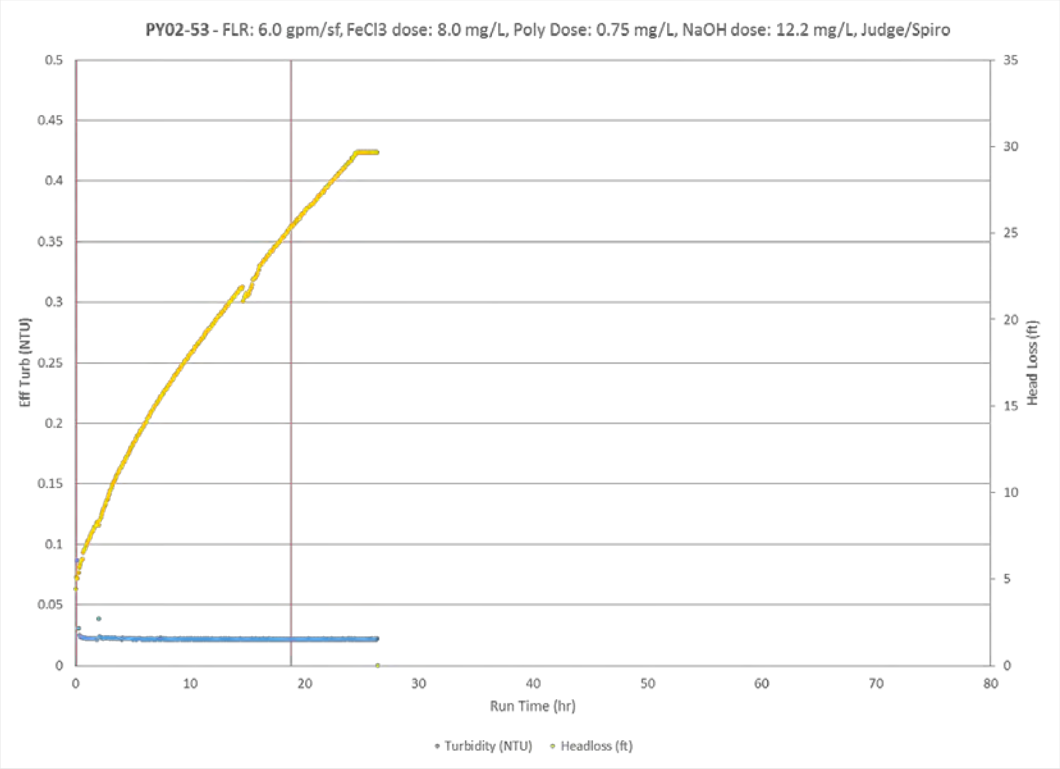


Figure F-126: PY02 Filter Profile

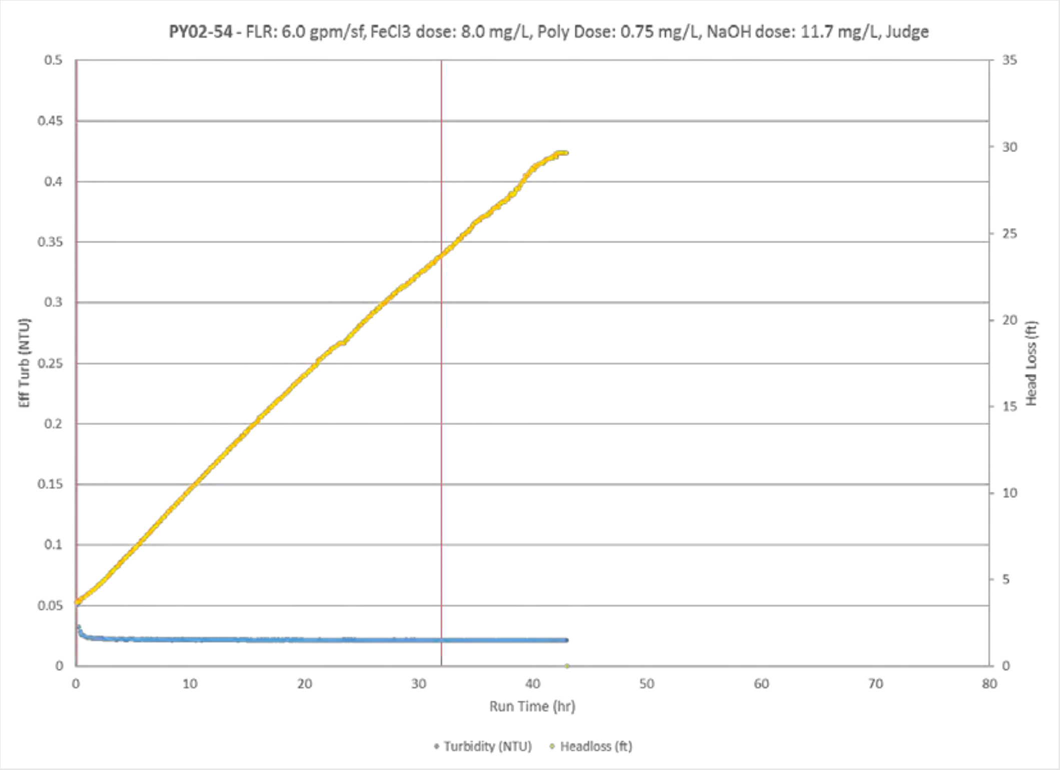


Figure F-127: PY02 Filter Profile

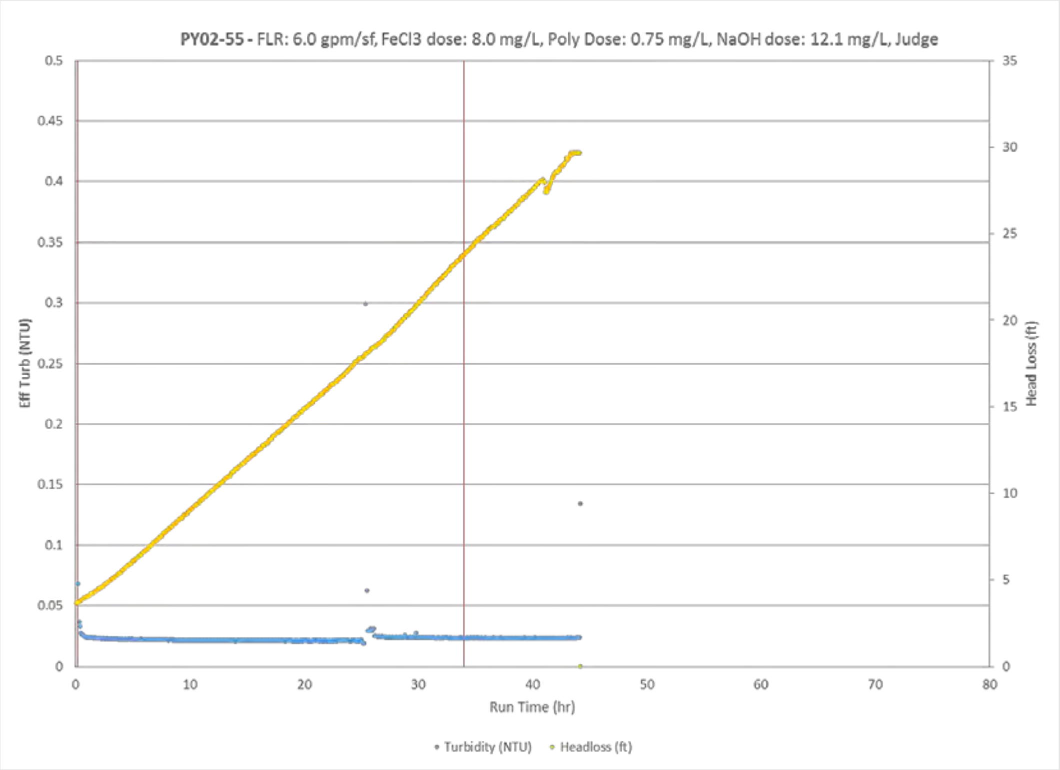


Figure F-128: PY02 Filter Profile

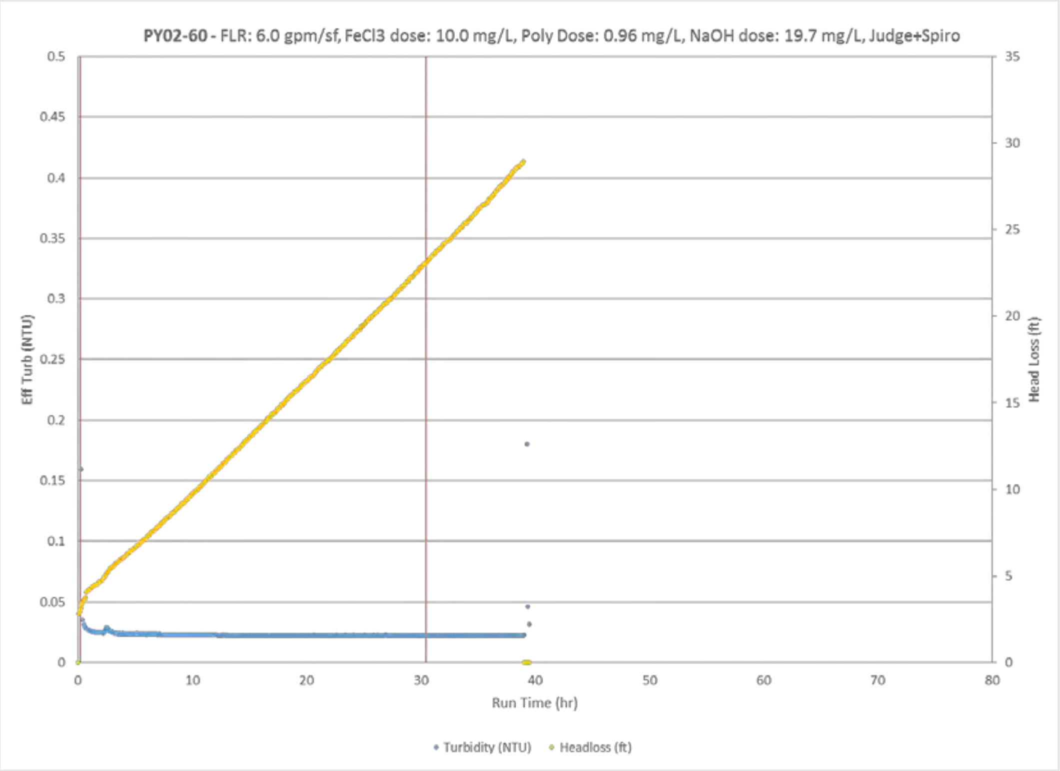


Figure F-129: PY02 Filter Profile

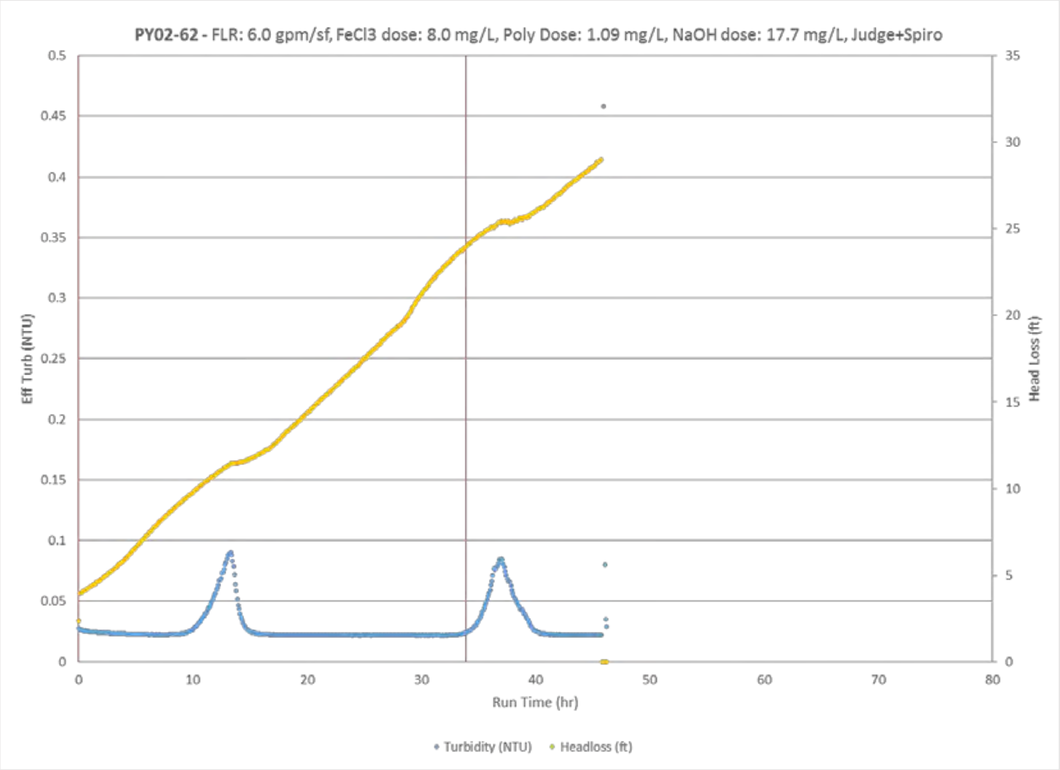


Figure F-130: PY02 Filter Profile

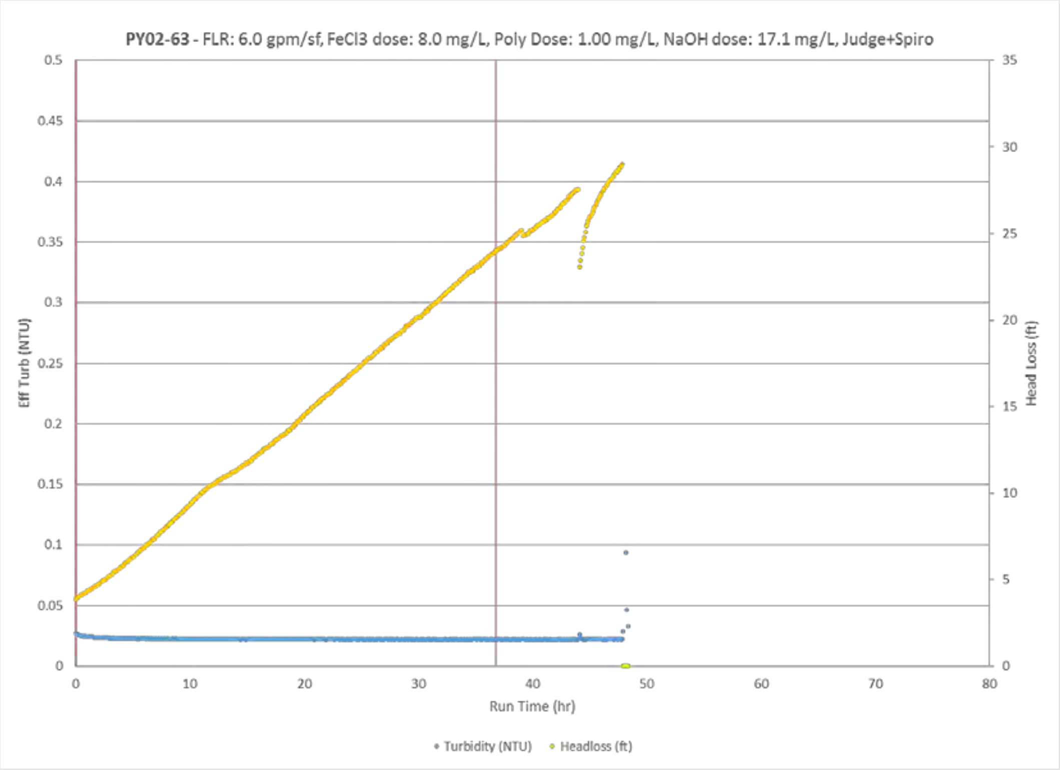


Figure F-131: PY02 Filter Profile

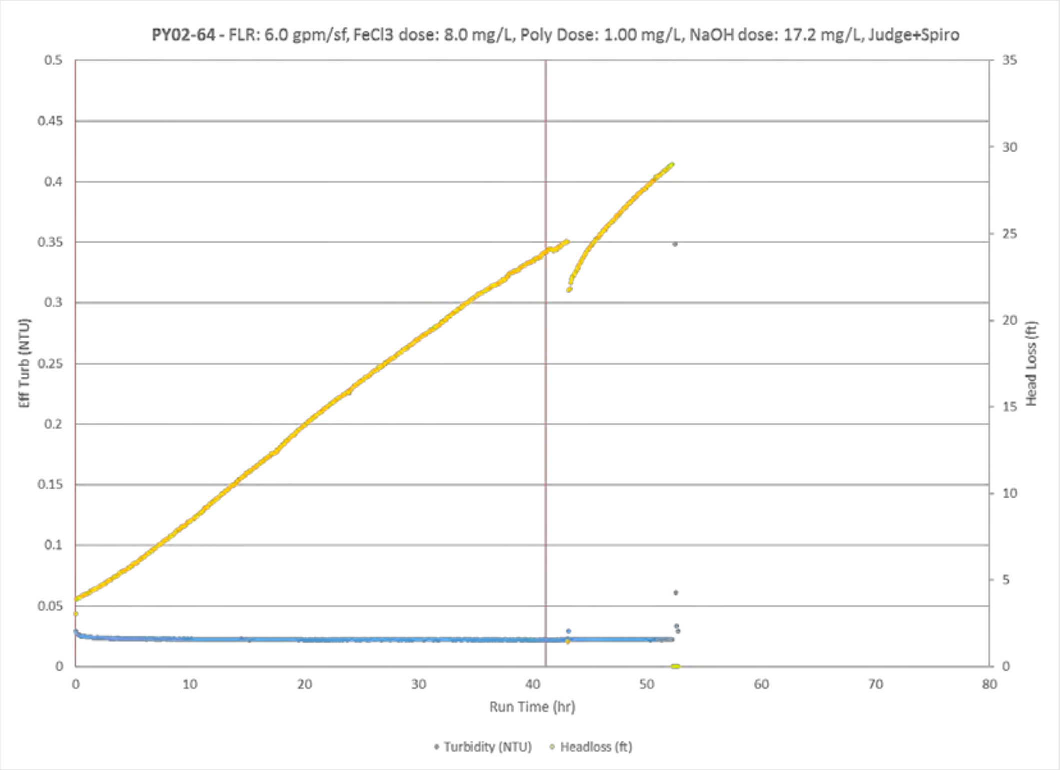


Figure F-132: PY02 Filter Profile

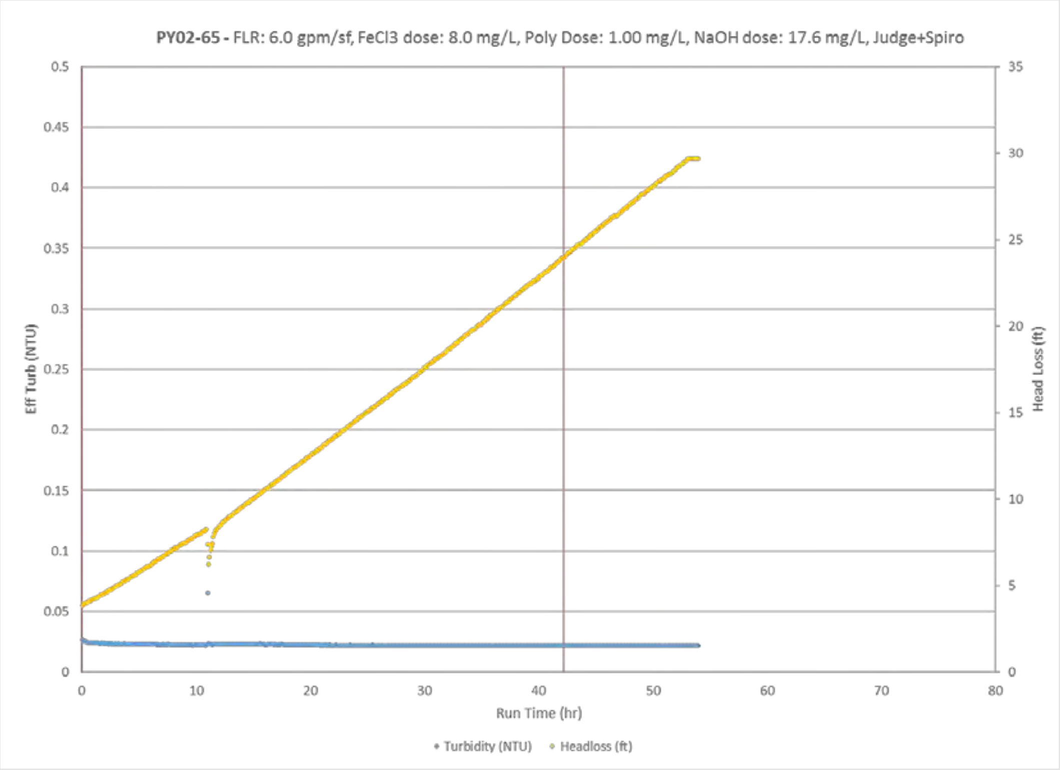


Figure F-133: PY02 Filter Profile

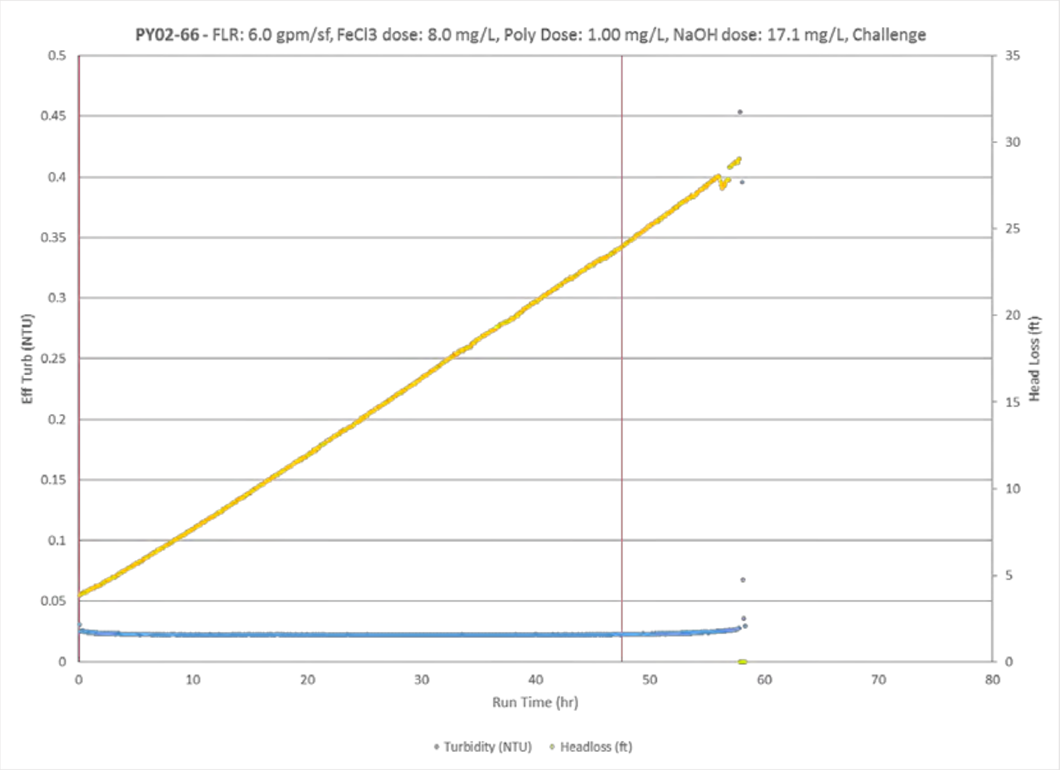


Figure F-134: PY02 Filter Profile

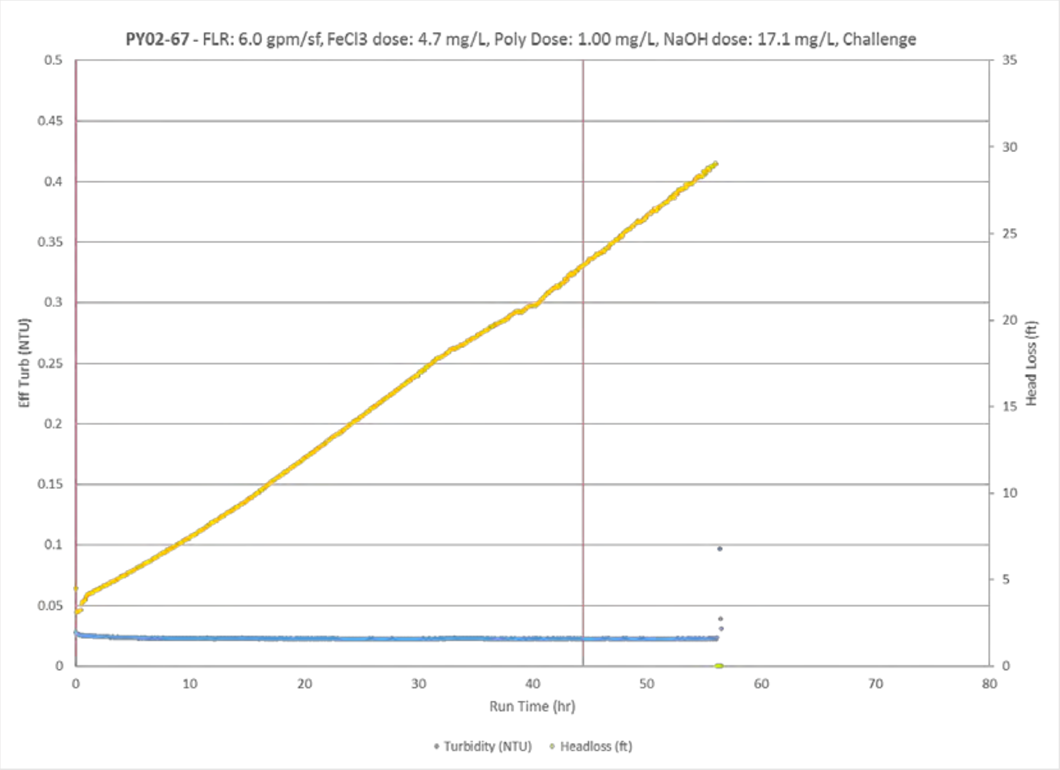


Figure F-135: PY02 Filter Profile

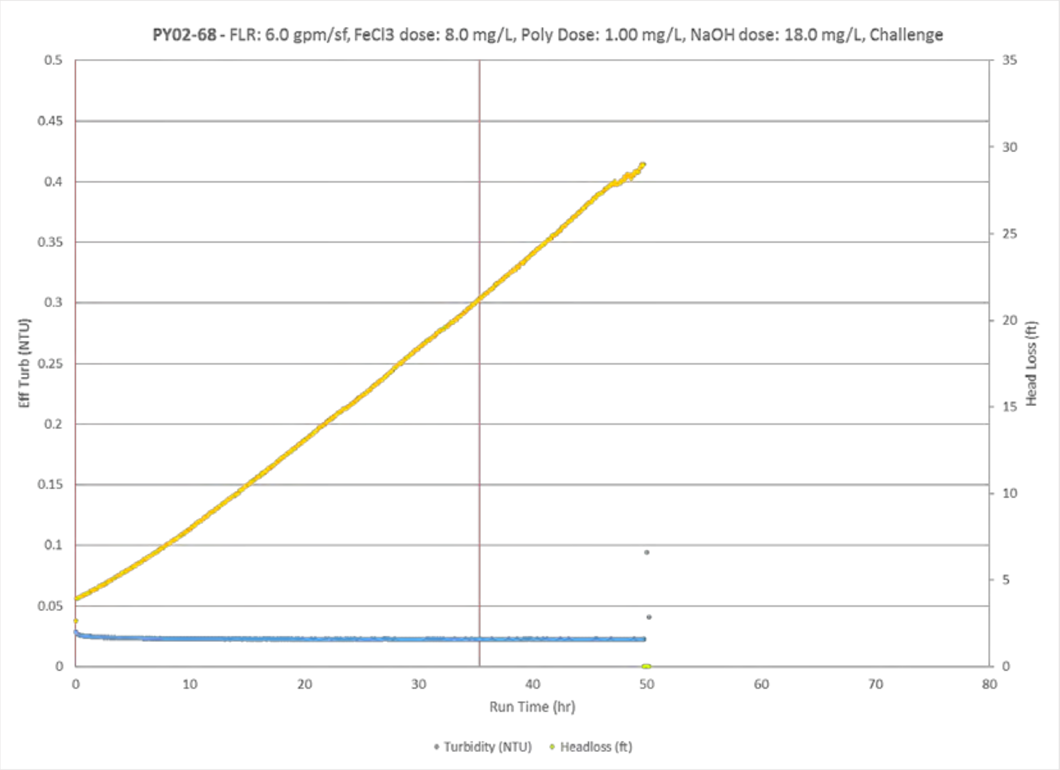


Figure F-136: PY02 Filter Profile

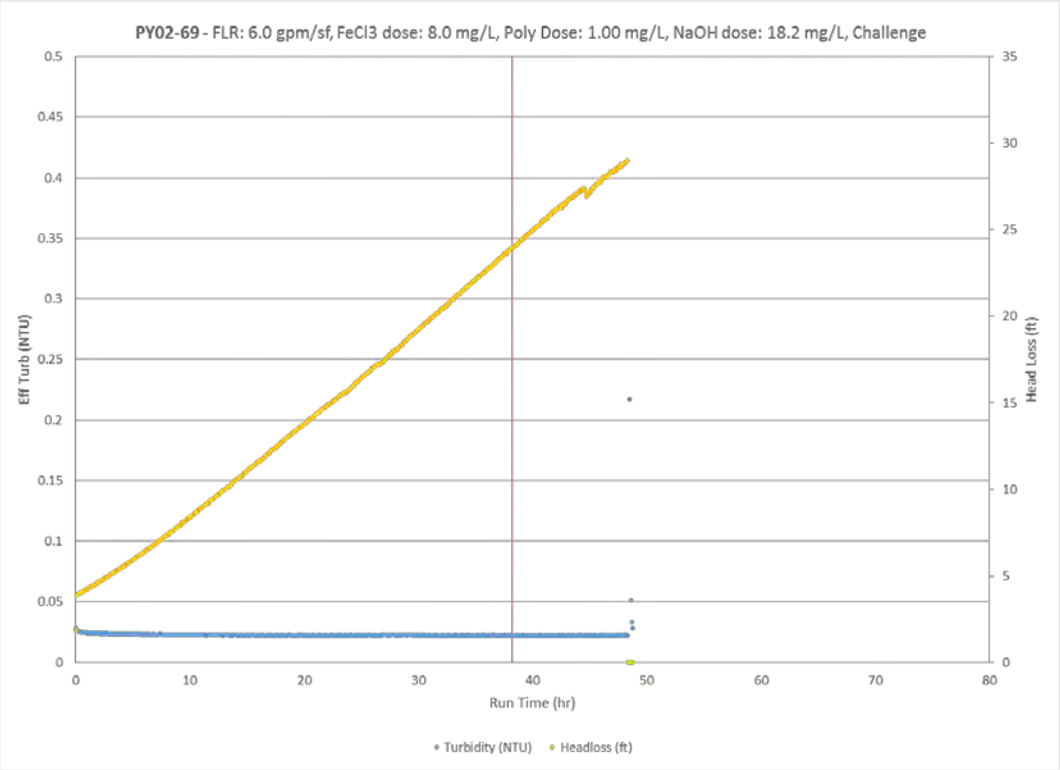


Figure F-137: PY02 Filter Profile

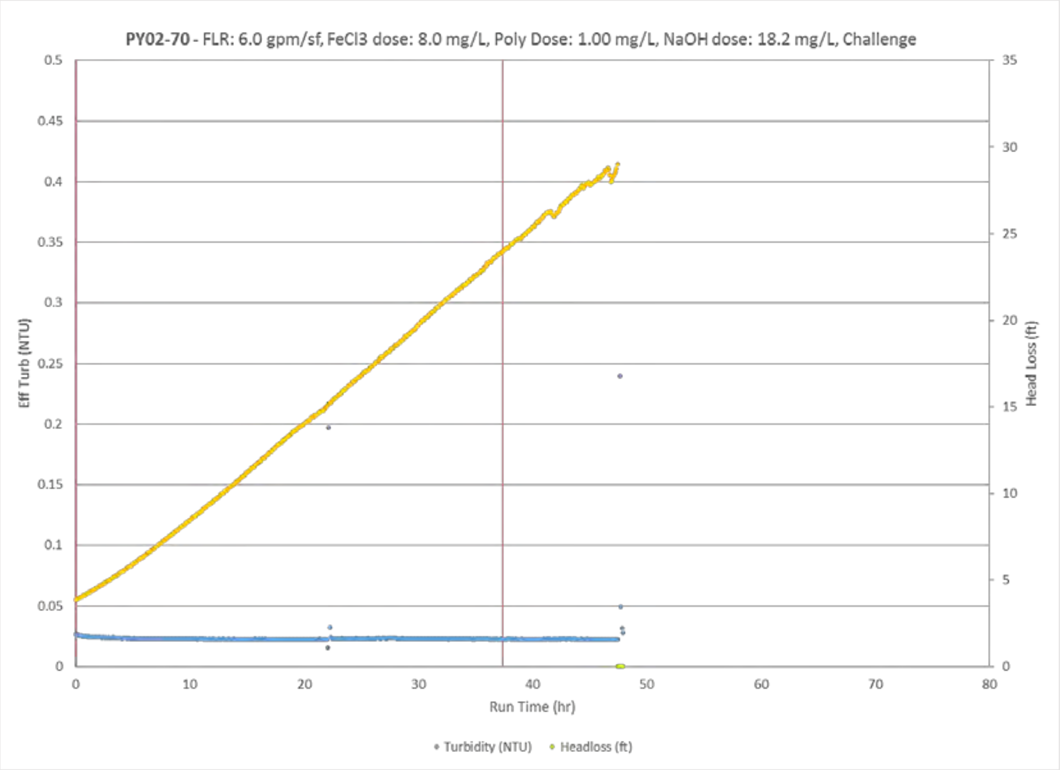


Figure F-138: PY02 Filter Profile

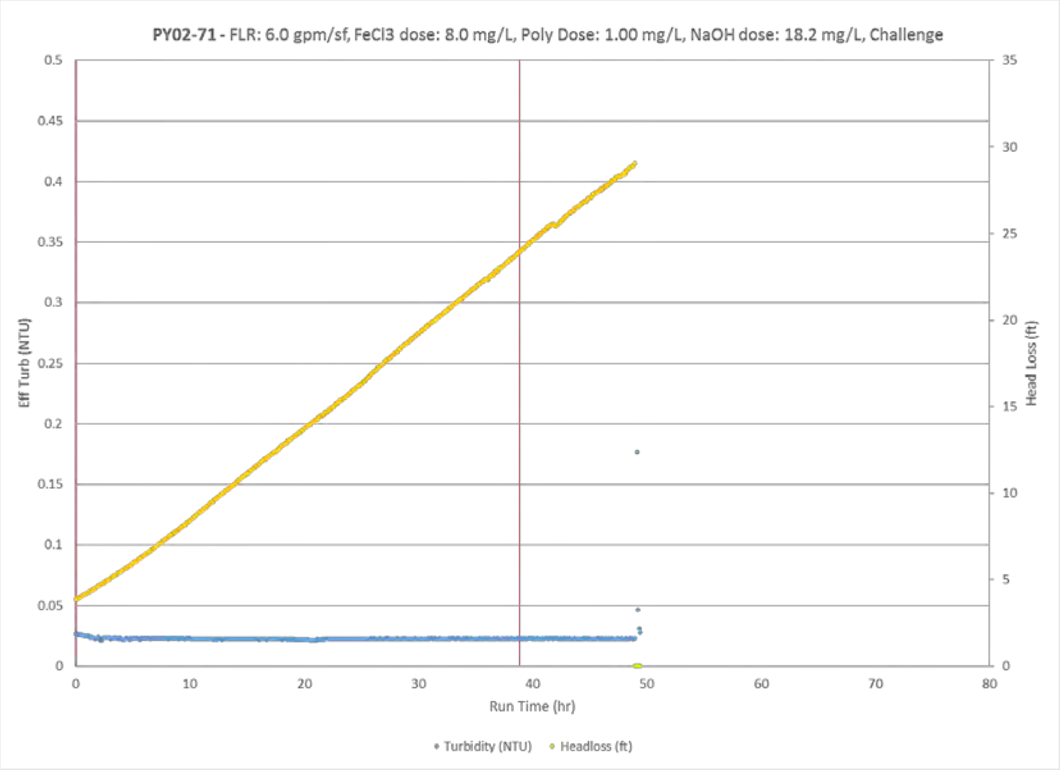


Figure F-139: PY02 Filter Profile

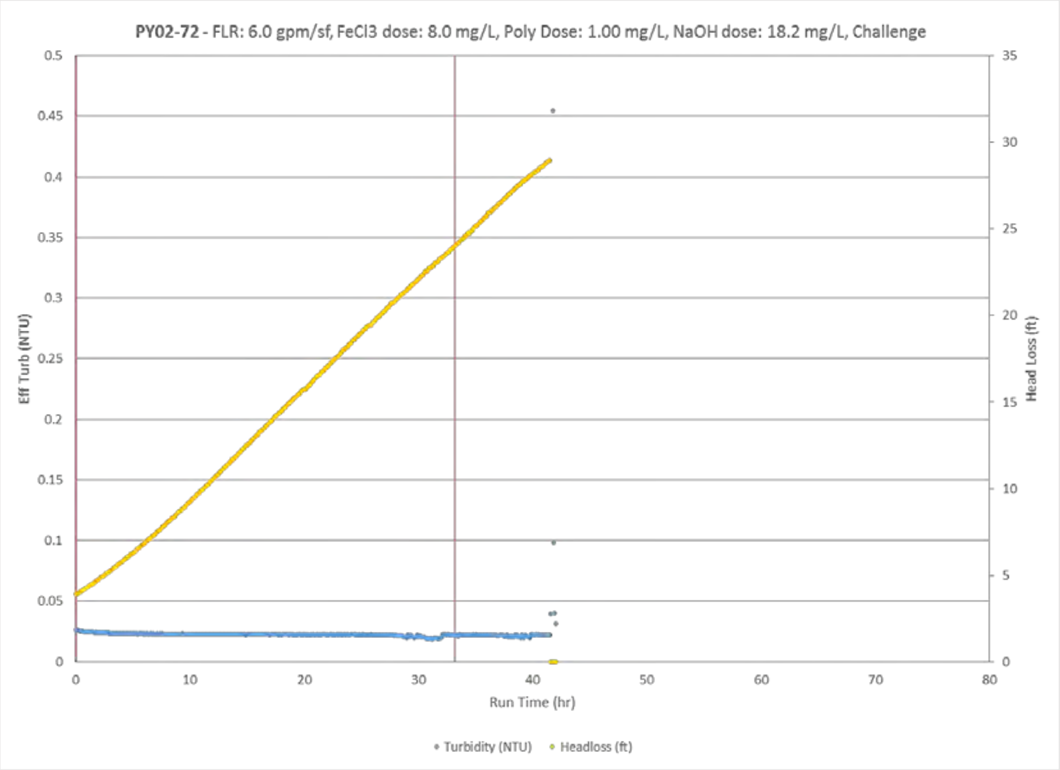


Figure F-140: PY02 Filter Profile

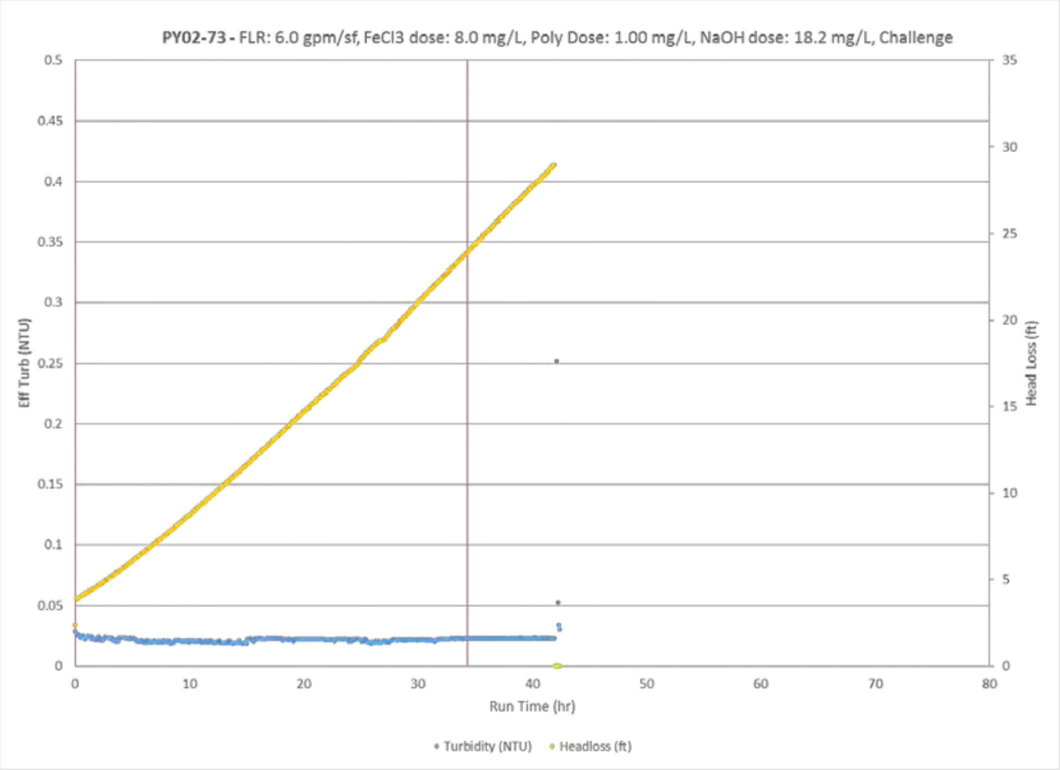


Figure F-141: PY02 Filter Profile

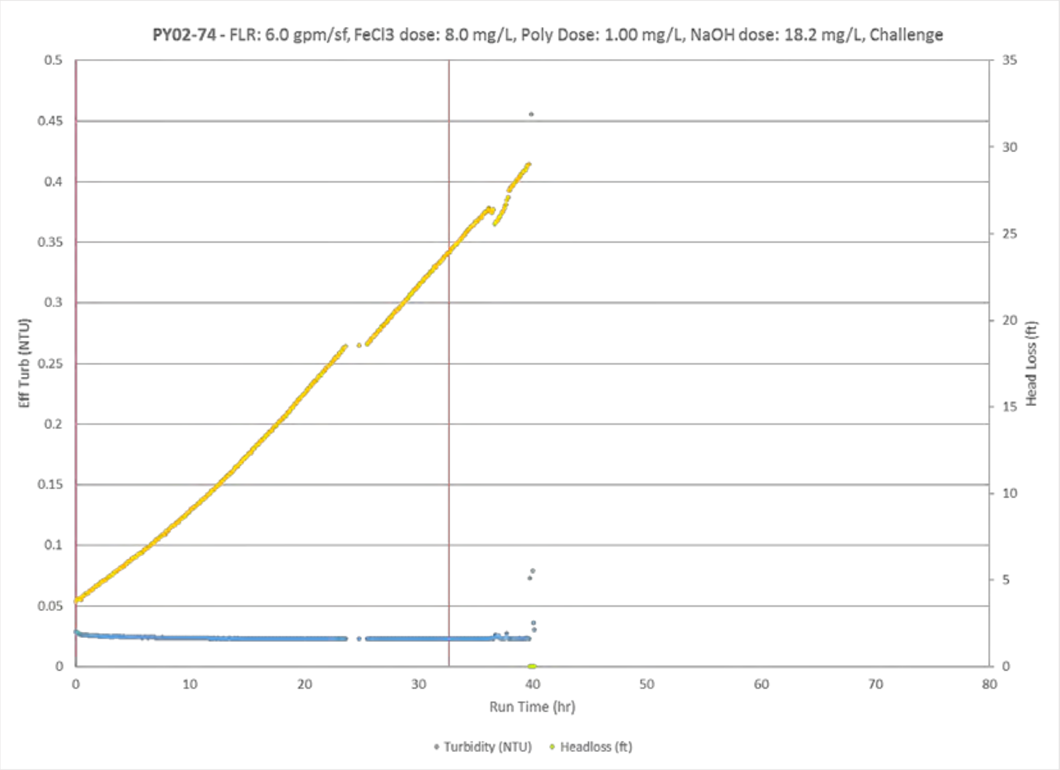


Figure F-142: PY02 Filter Profile

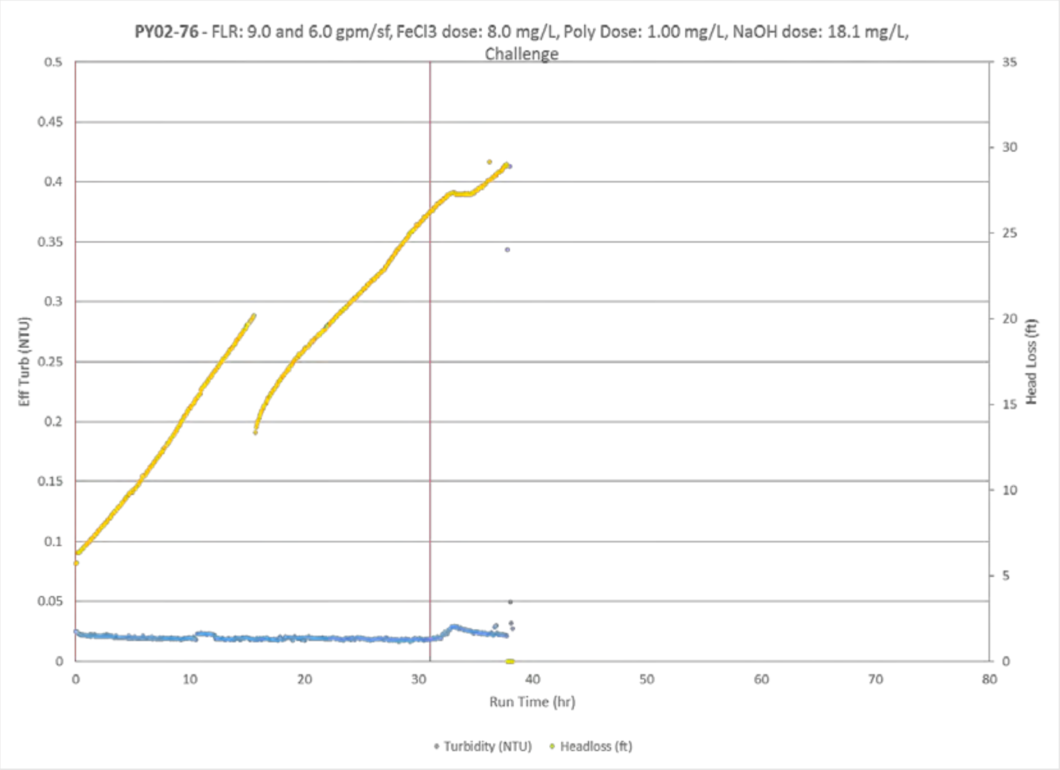


Figure F-143: PY02 Filter Profile

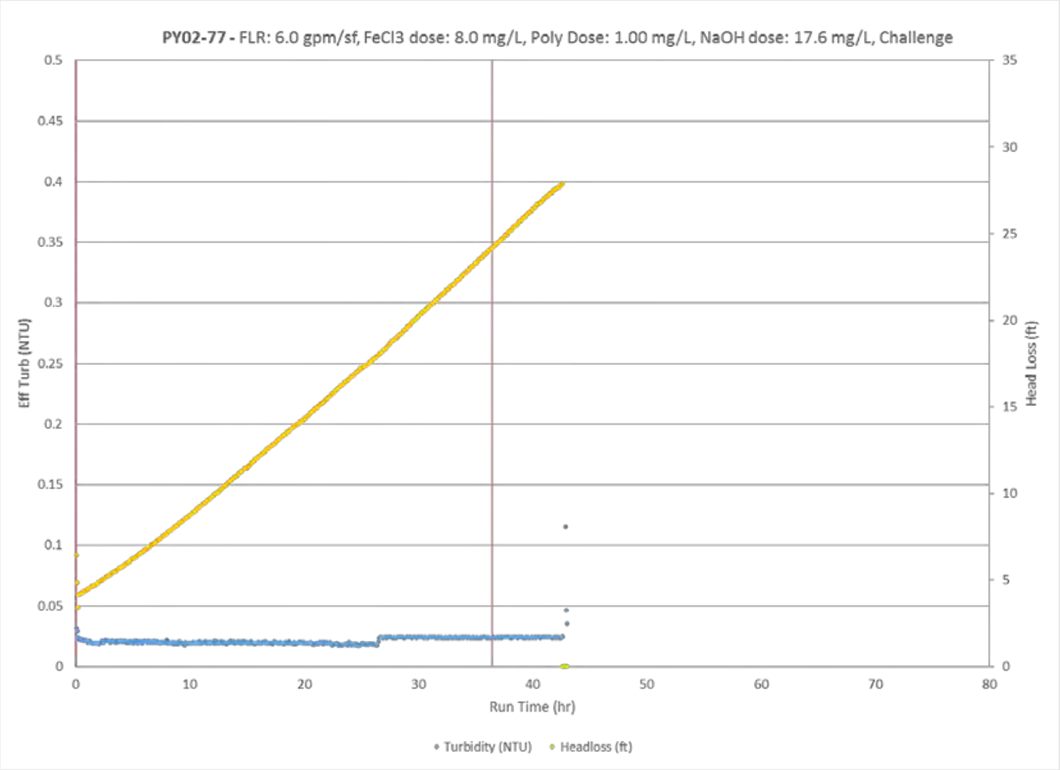


Figure F-144: PY02 Filter Profile

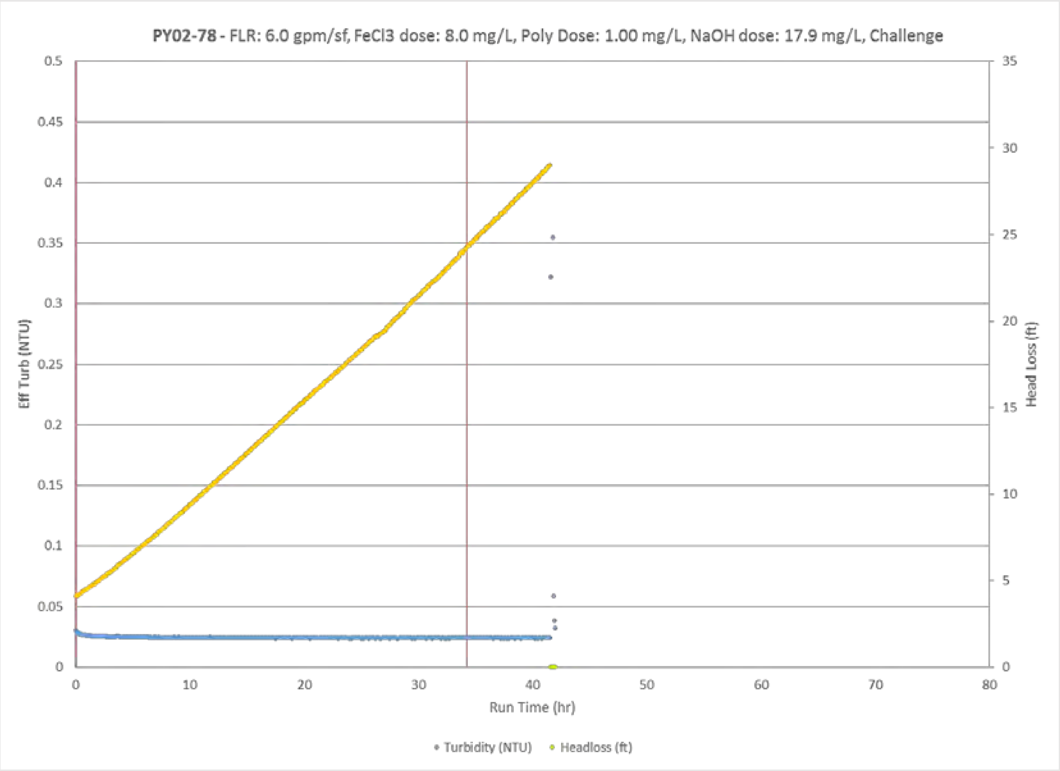


Figure F-145: PY02 Filter Profile

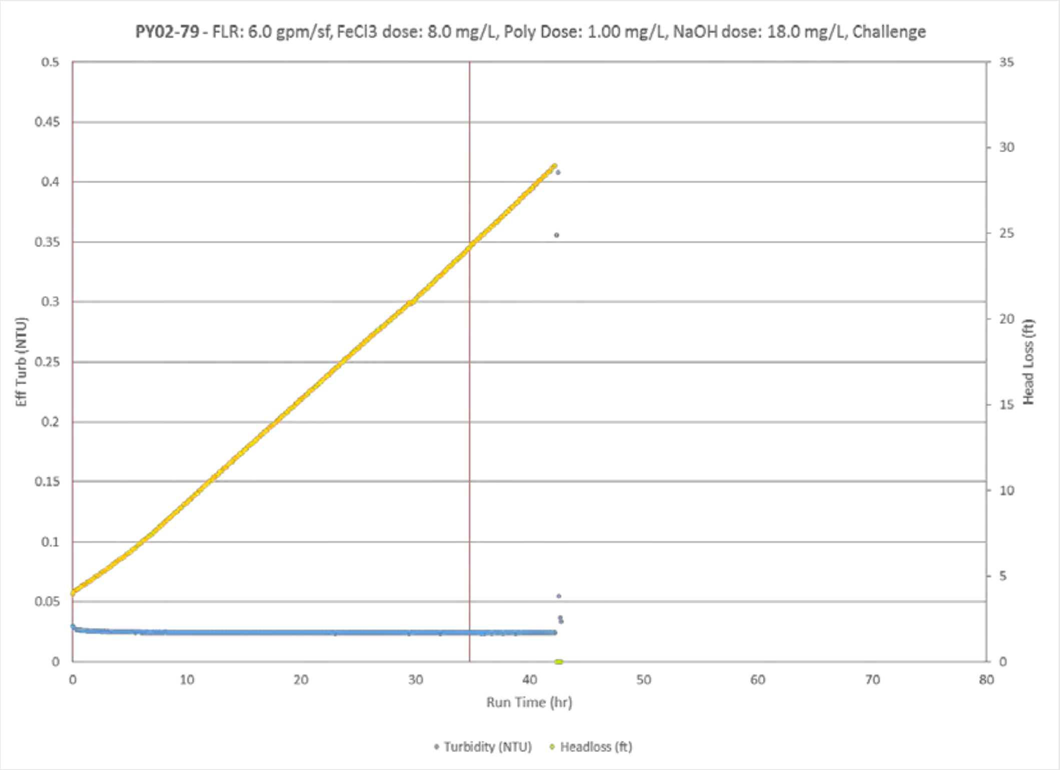


Figure F-146: PY02 Filter Profile

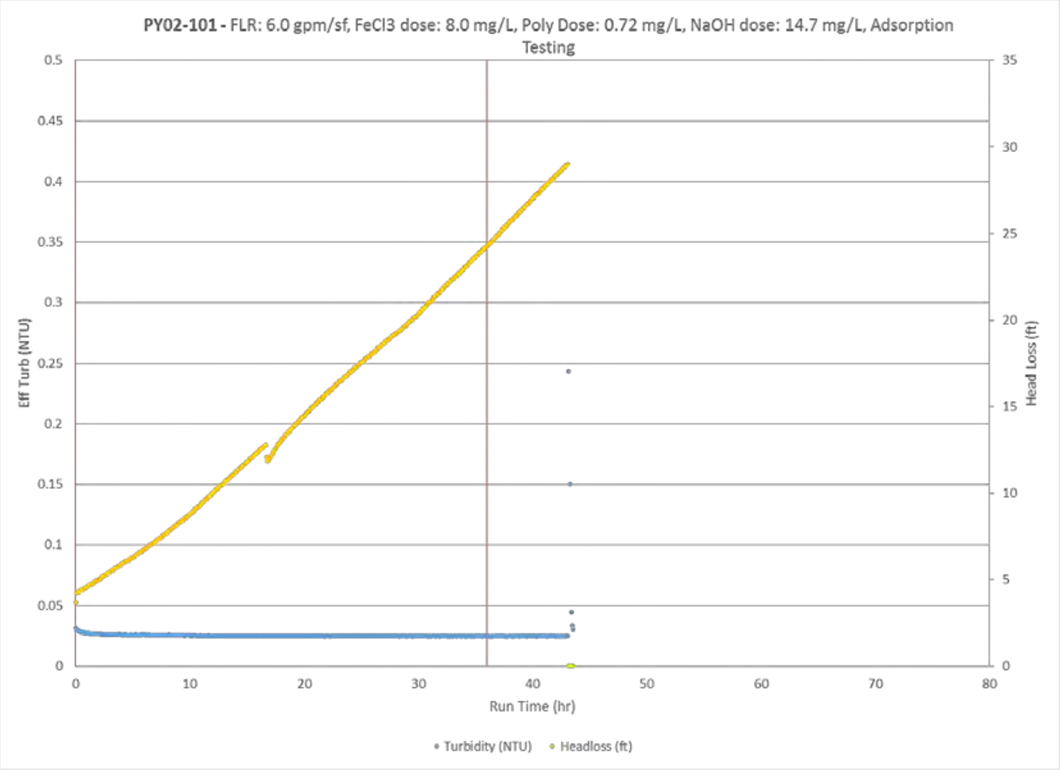


Figure F-147: PY02 Filter Profile

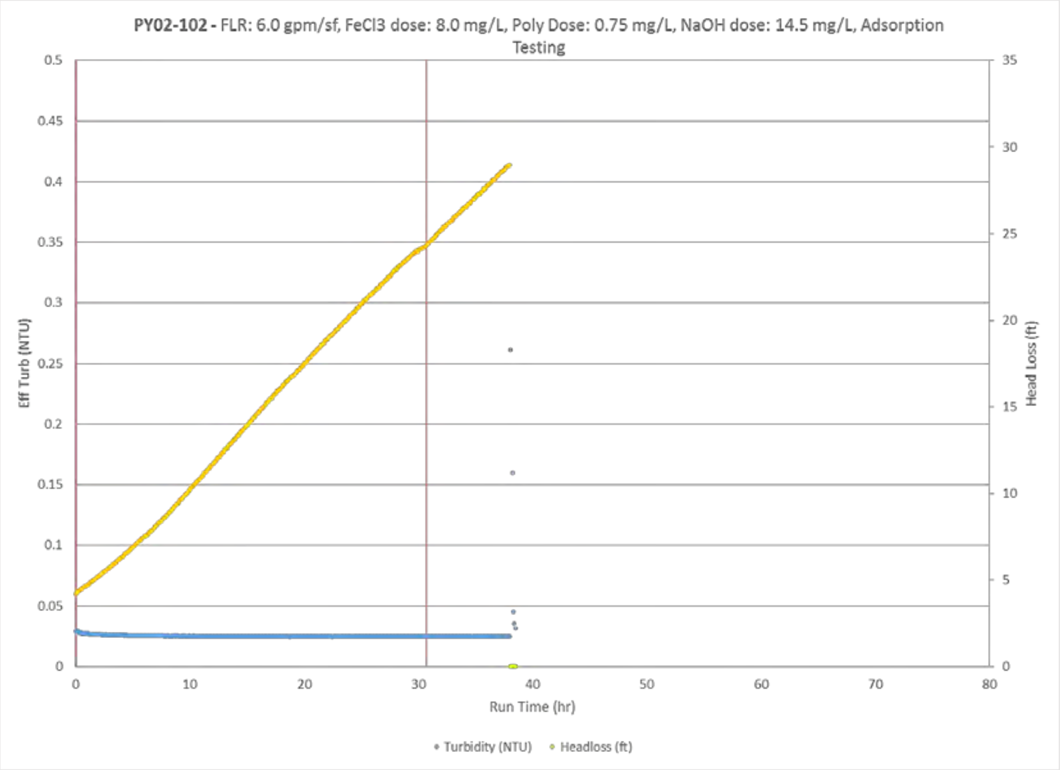


Figure F-148: PY02 Filter Profile

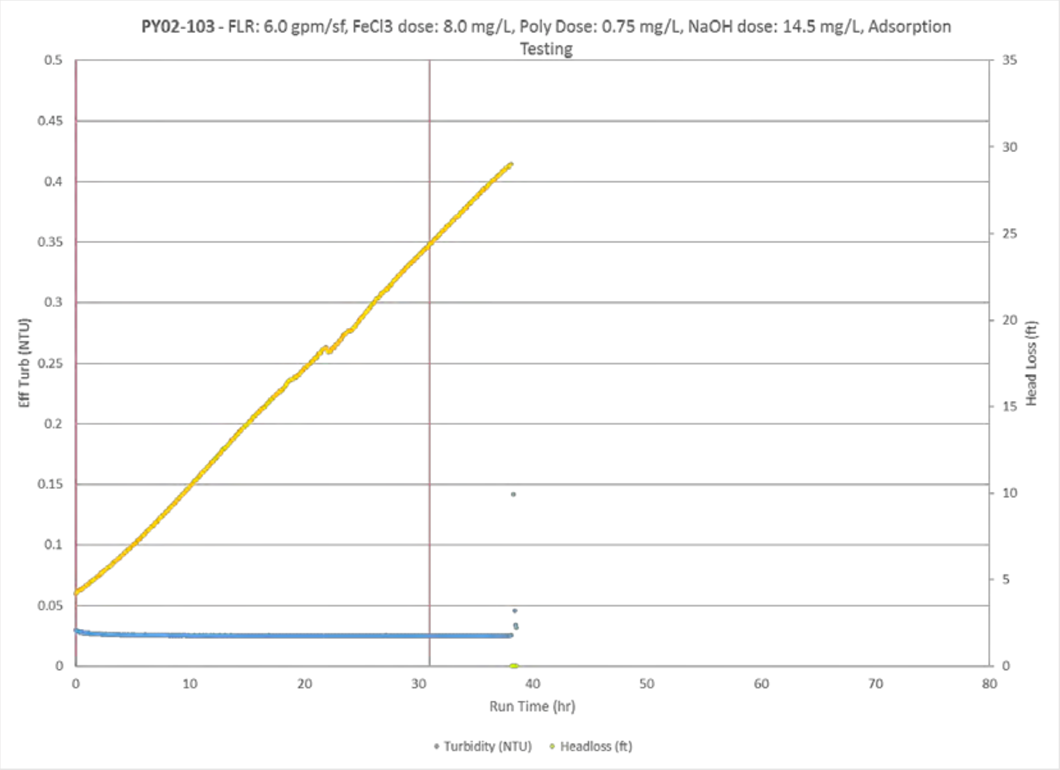


Figure F-149: PY02 Filter Profile

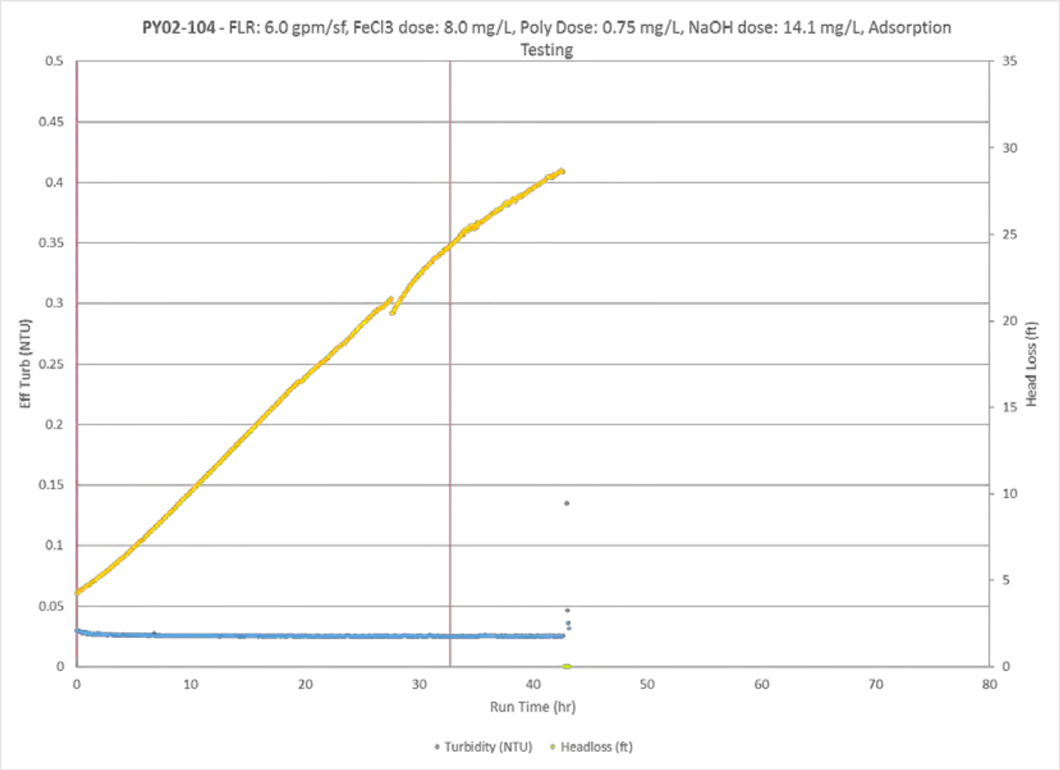


Figure F-150: PY02 Filter Profile

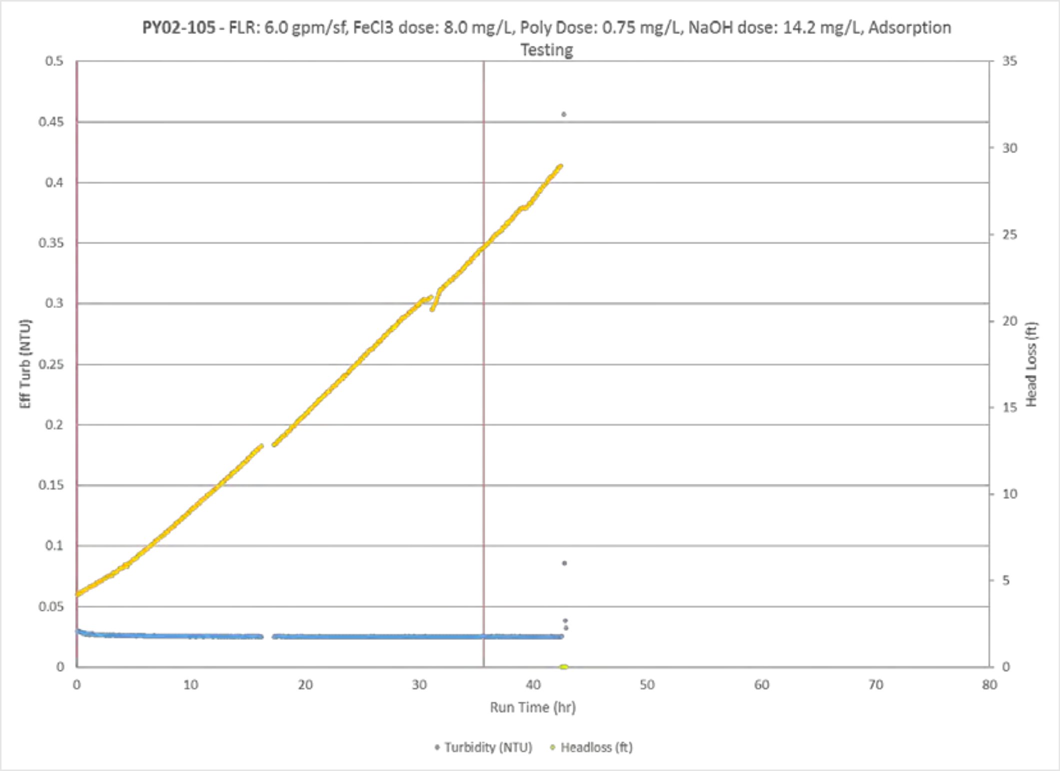


Figure F-151: PY02 Filter Profile

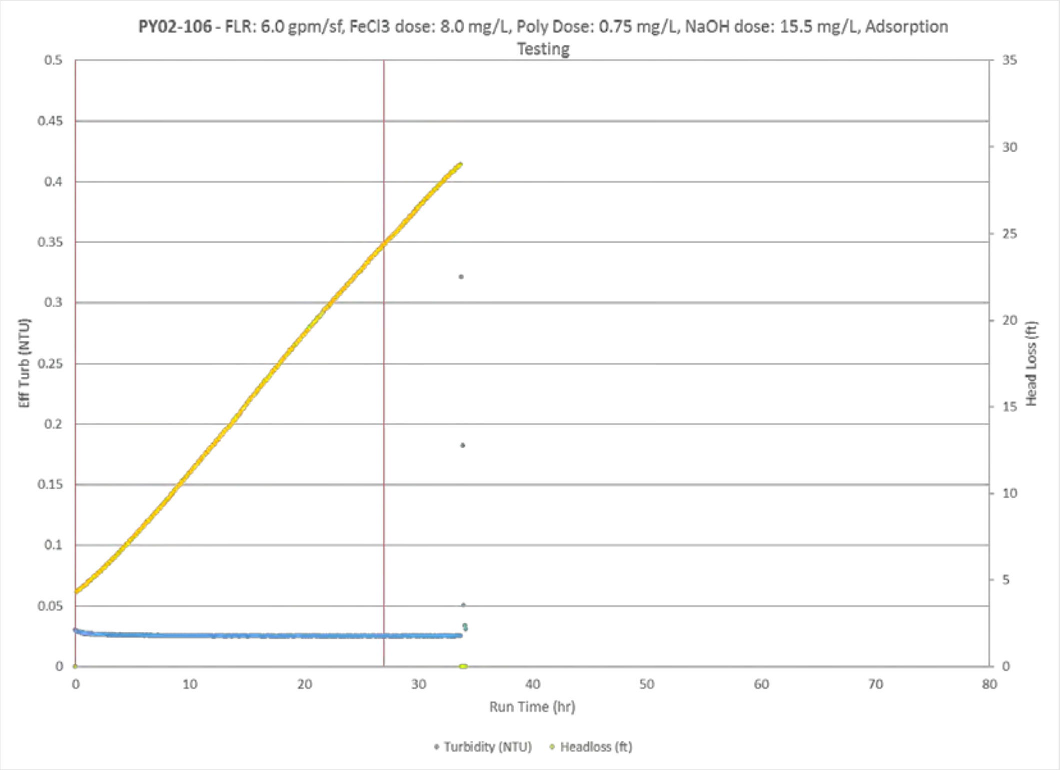


Figure F-152: PY02 Filter Profile

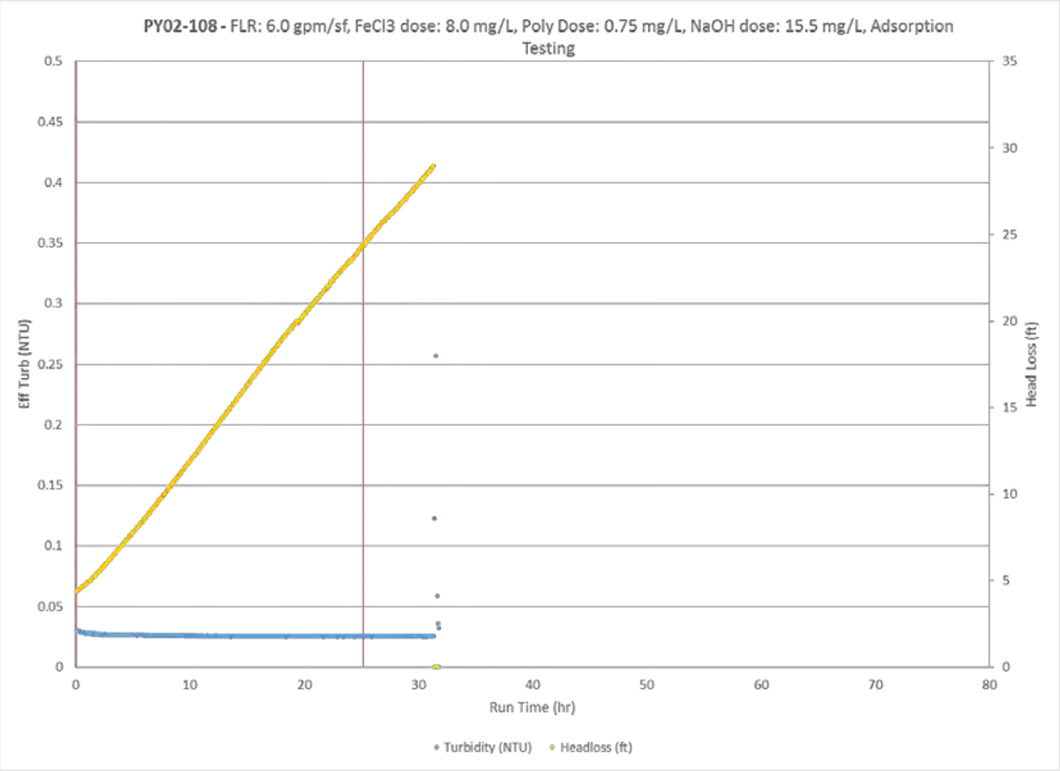


Figure F-153: PY02 Filter Profile

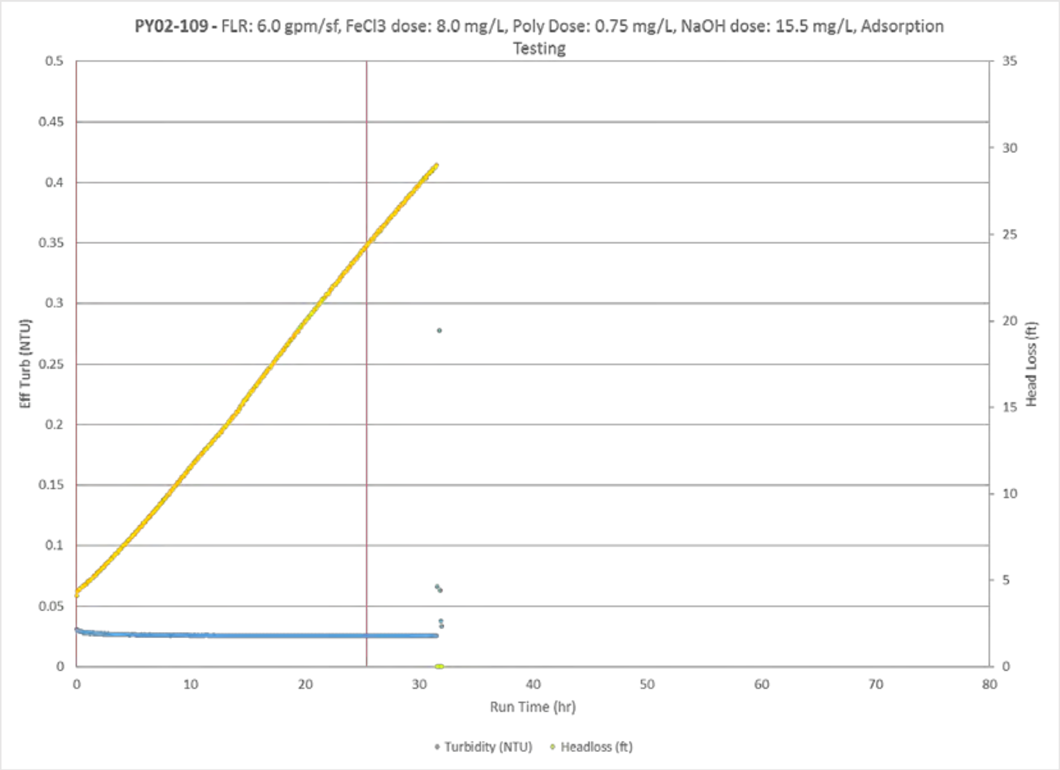


Figure F-154: PY02 Filter Profile

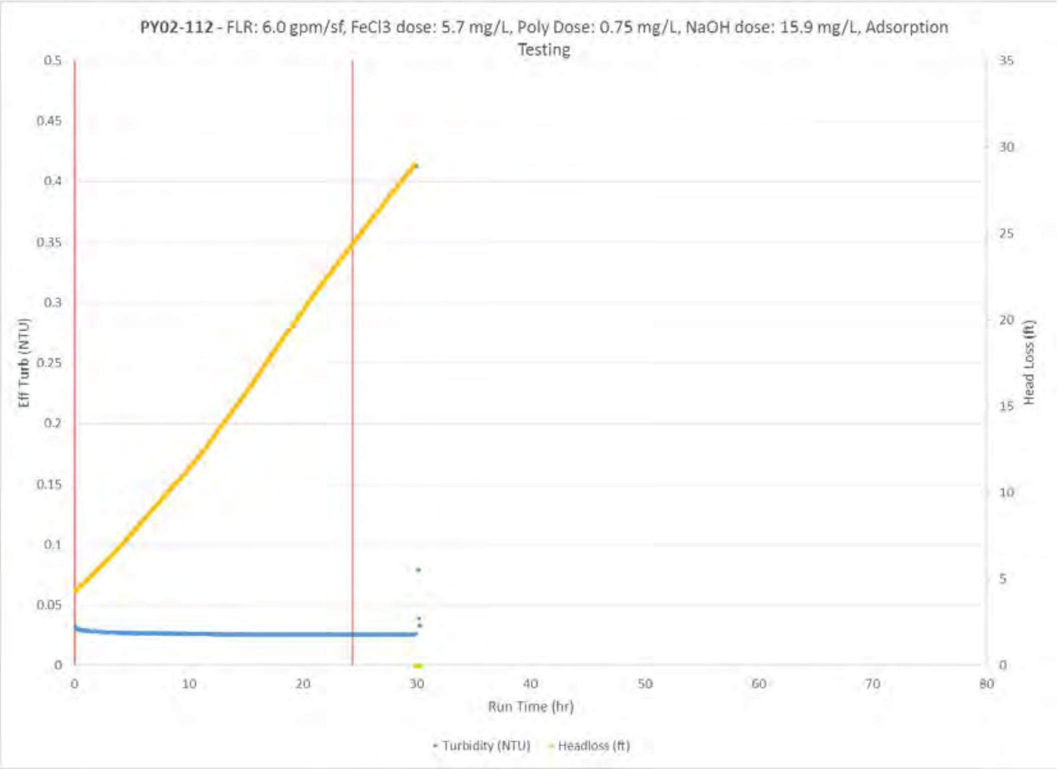


Figure F-155: PY02 Filter Profile

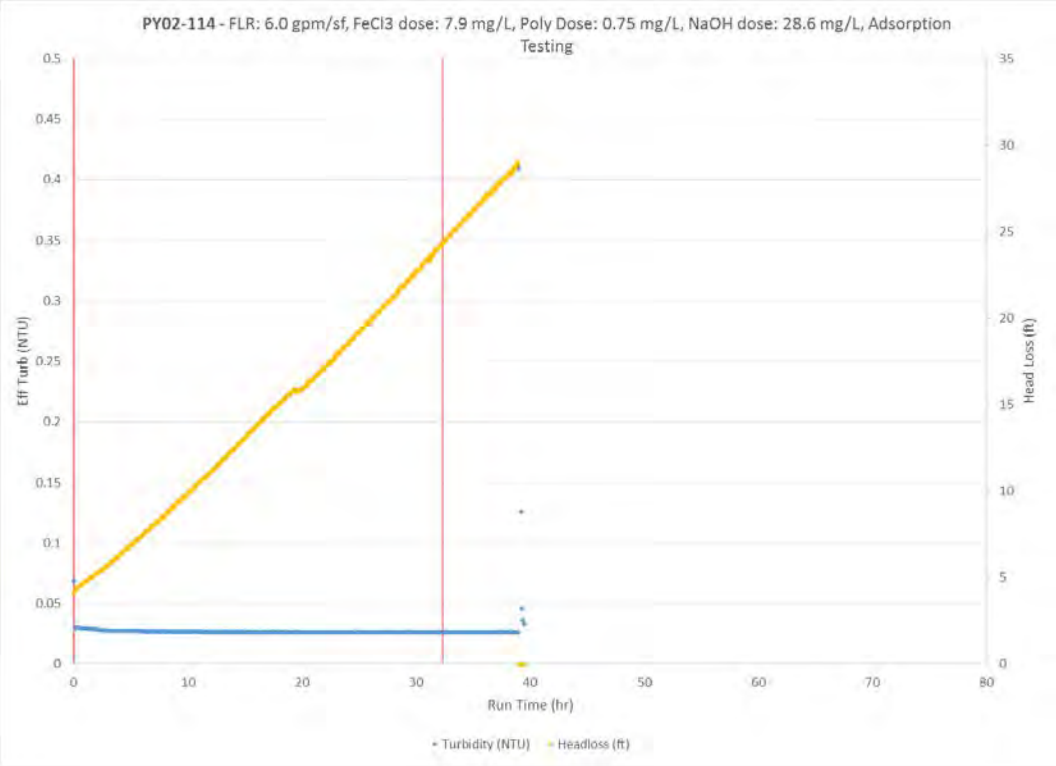


Figure F-156: PY02 Filter Profile

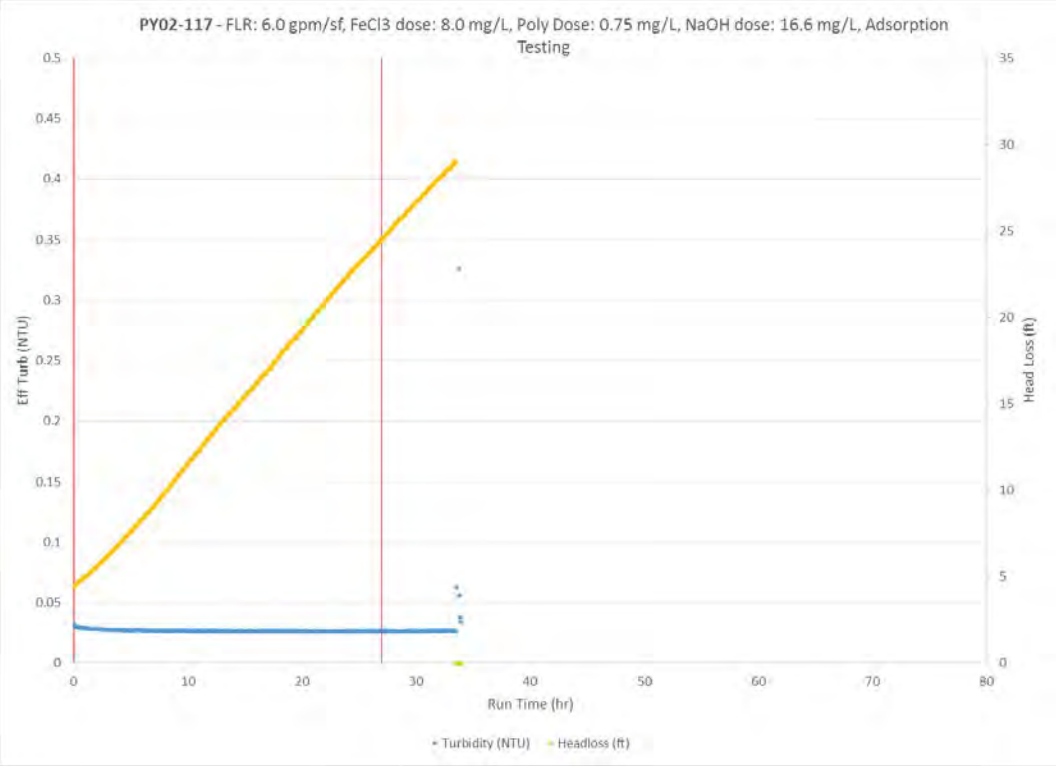


Figure F-157: PY02 Filter Profile

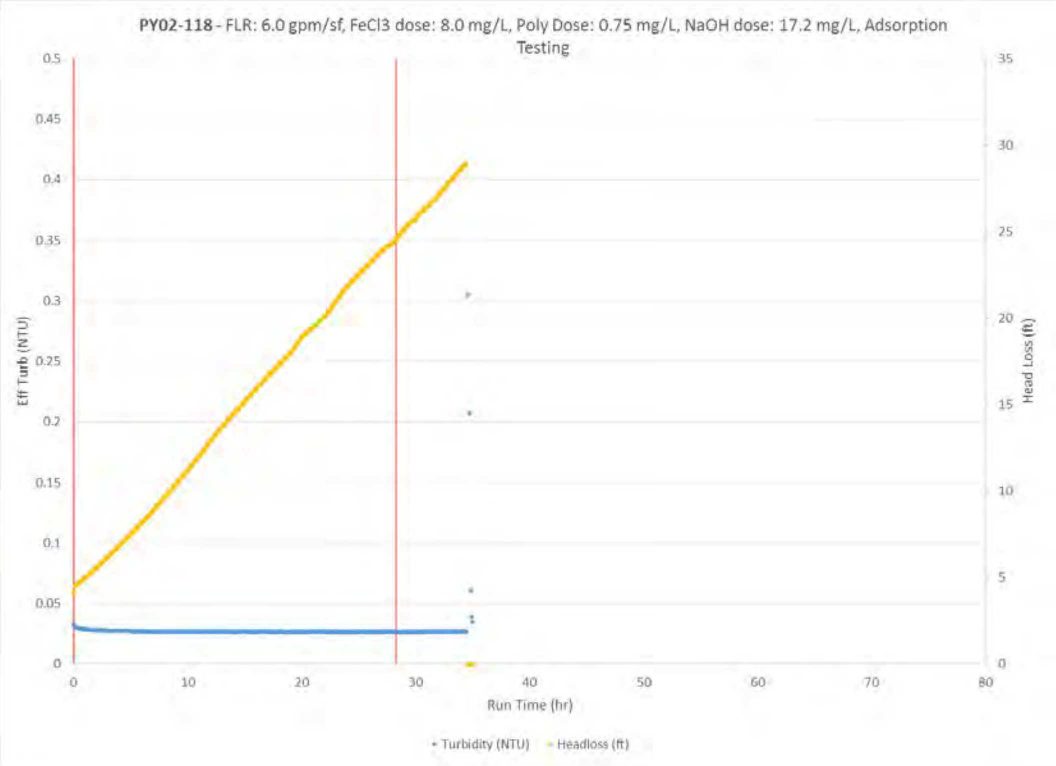


Figure F-158: PY02 Filter Profile

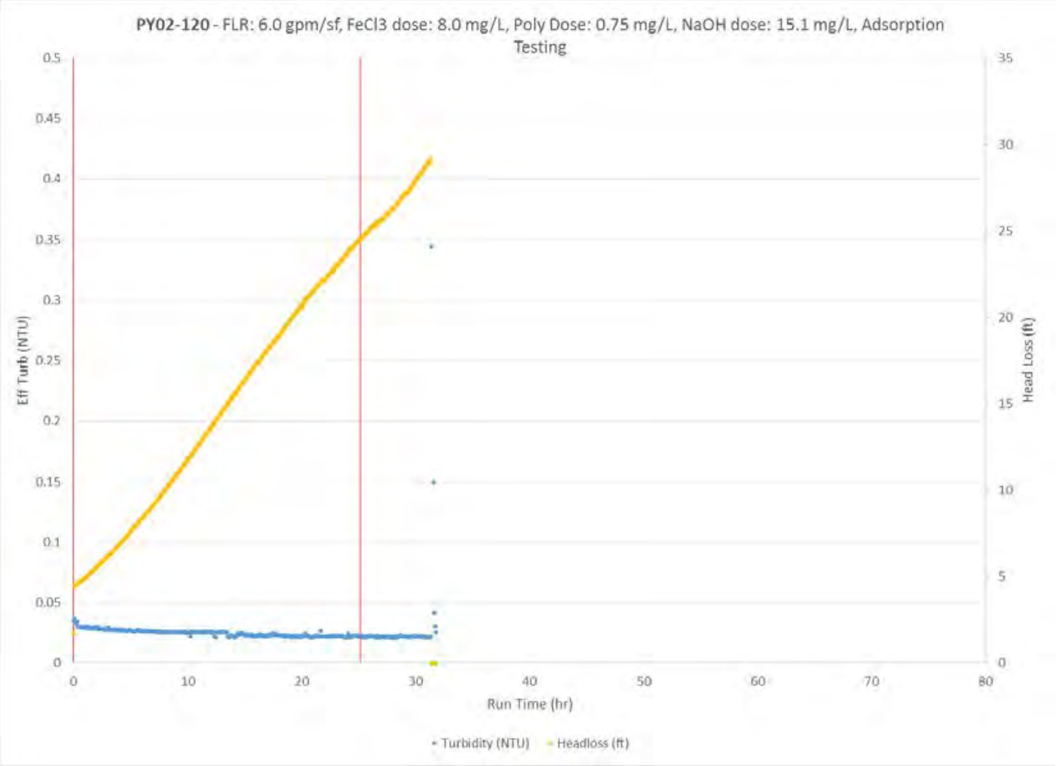


Figure F-159: PY02 Filter Profile

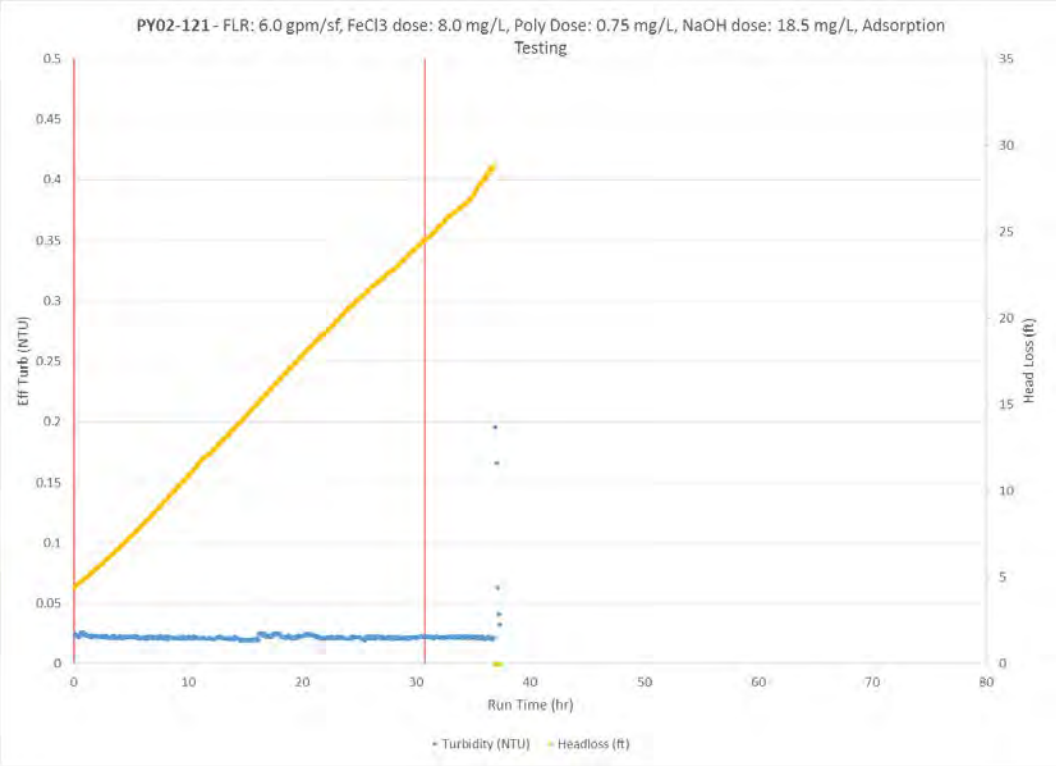


Figure F-160: PY02 Filter Profile

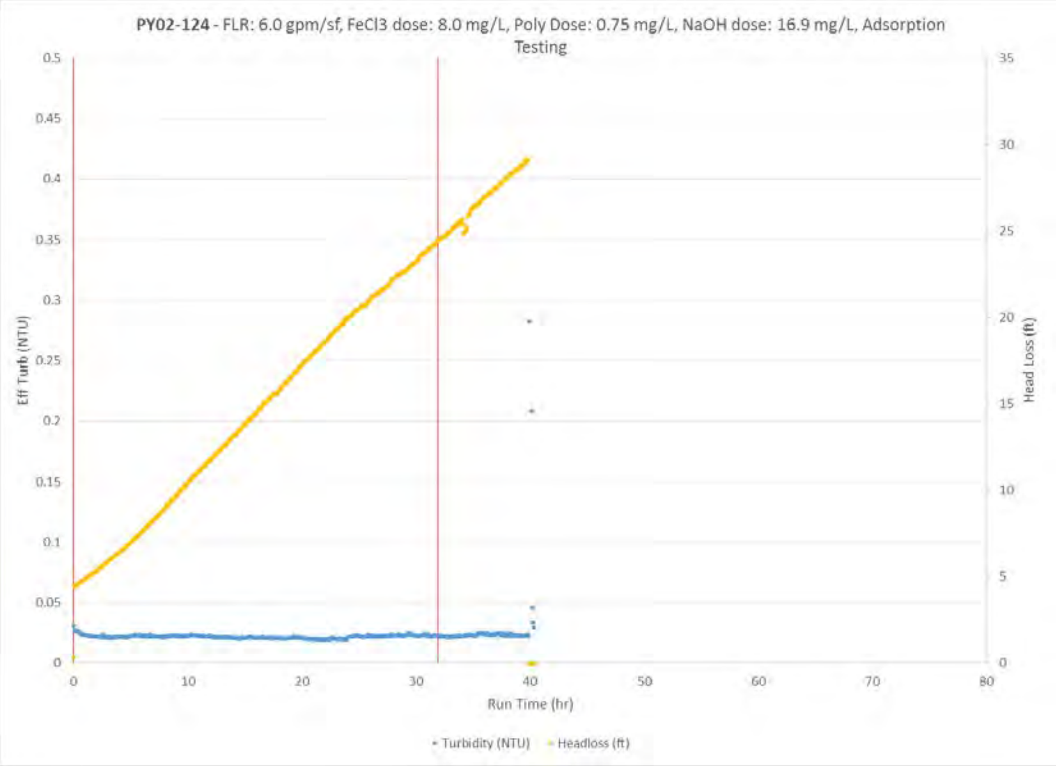


Figure F-161: PY02 Filter Profile

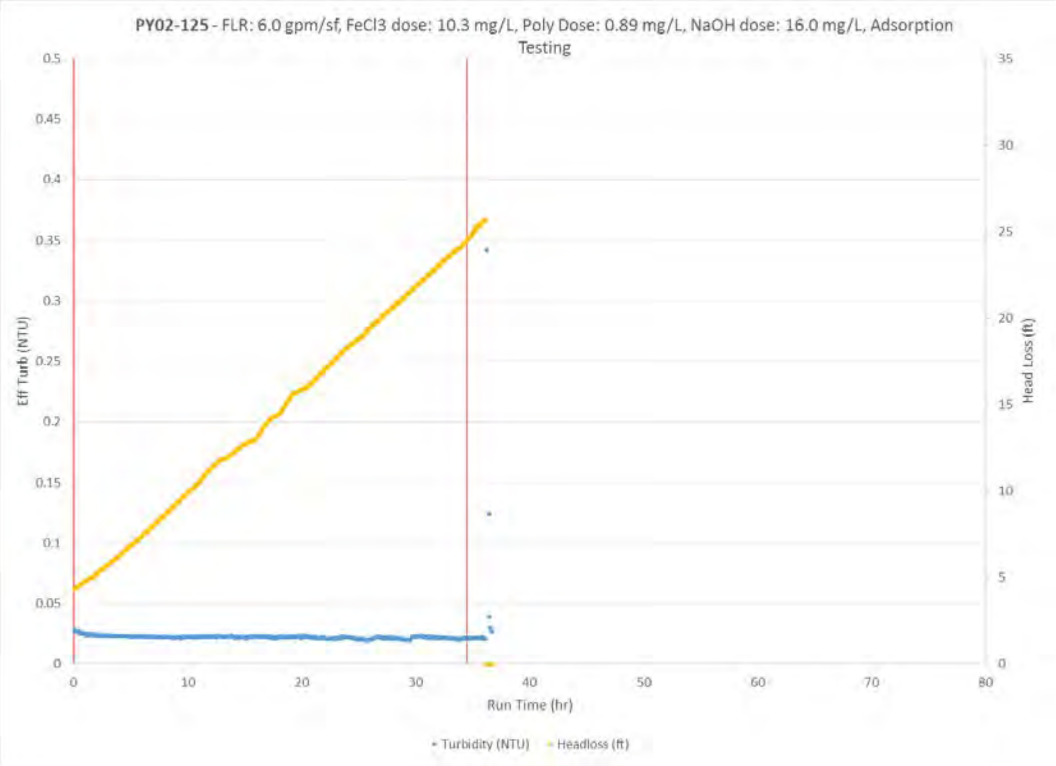


Figure F-162: PY02 Filter Profile

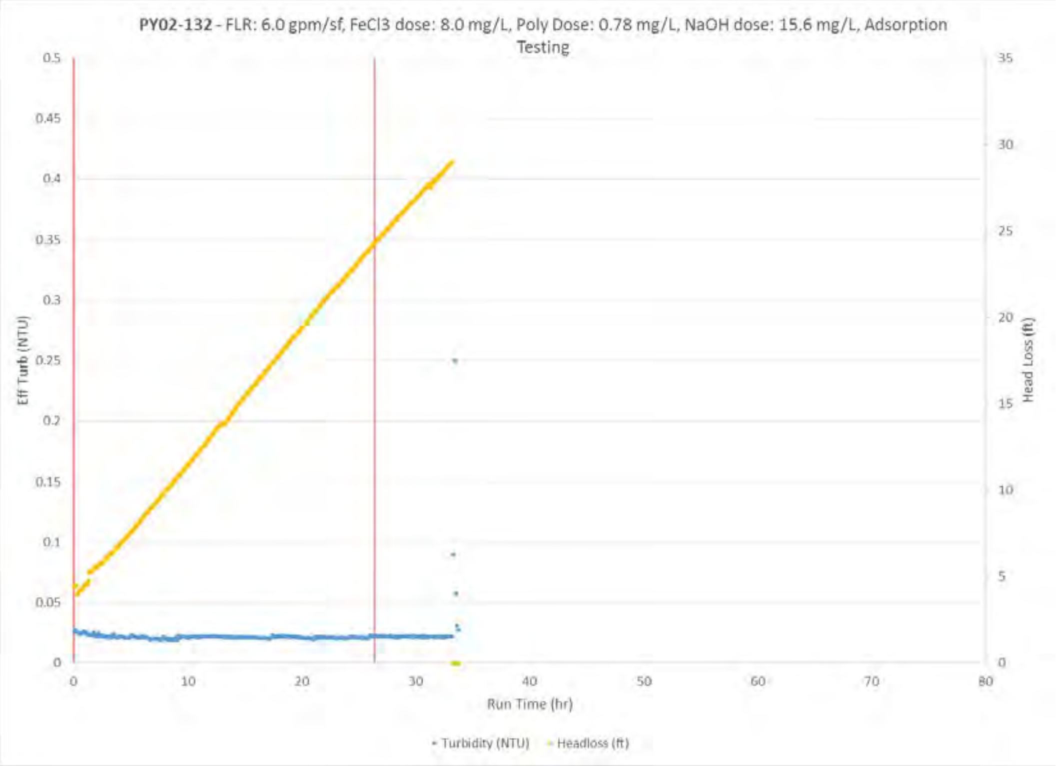


Figure F-163: PY02 Filter Profile

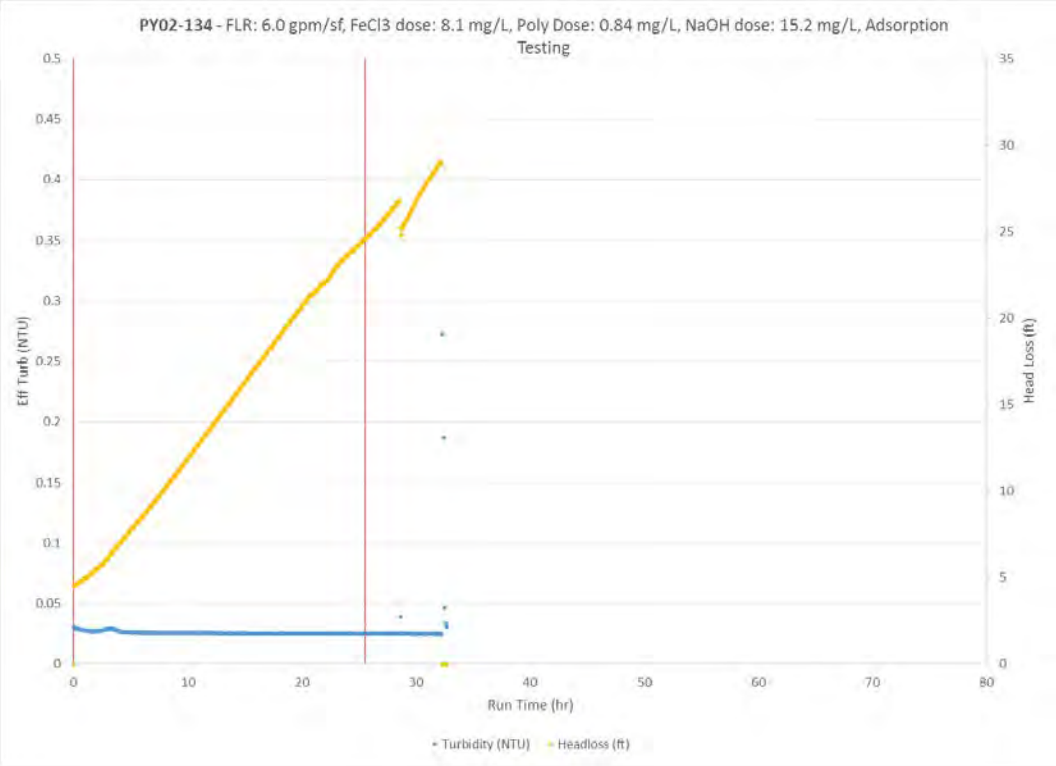


Figure F-164: PY02 Filter Profile

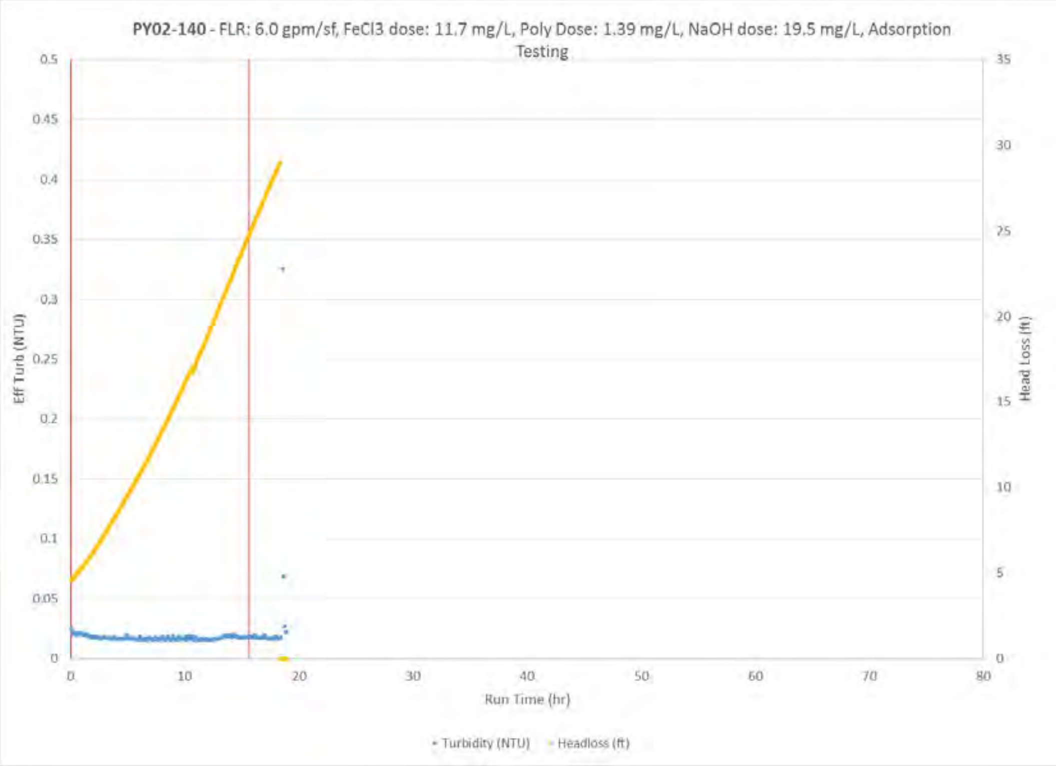


Figure F-165: PY02 Filter Profile

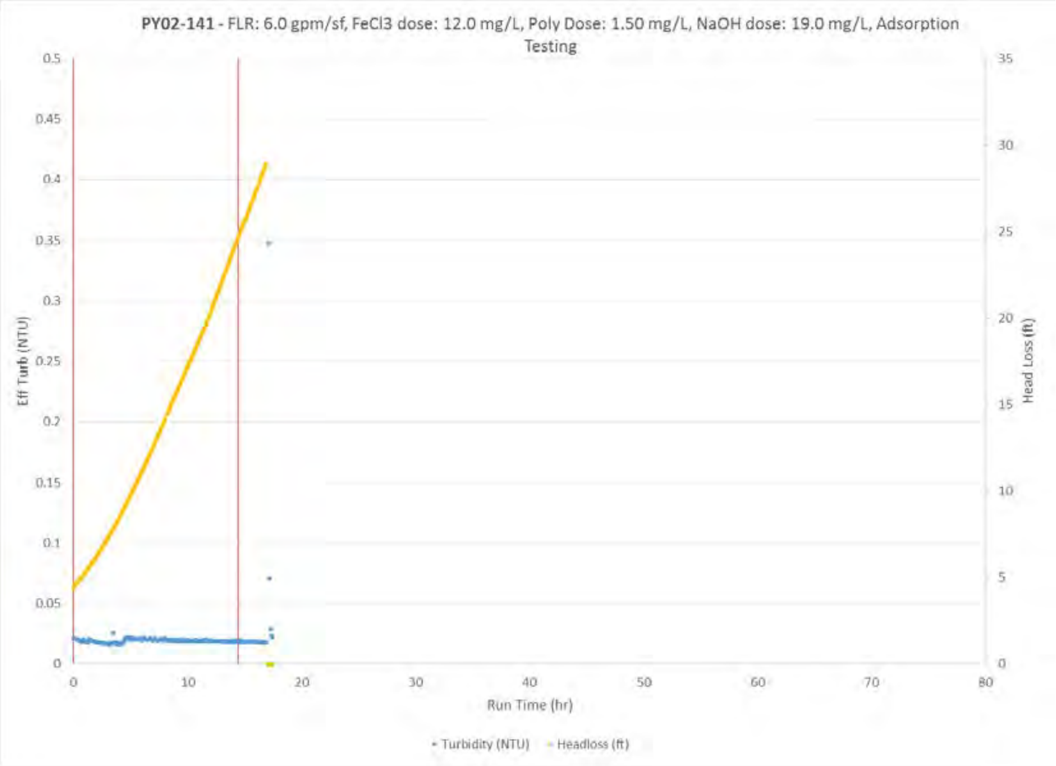


Figure F-166: PY02 Filter Profile

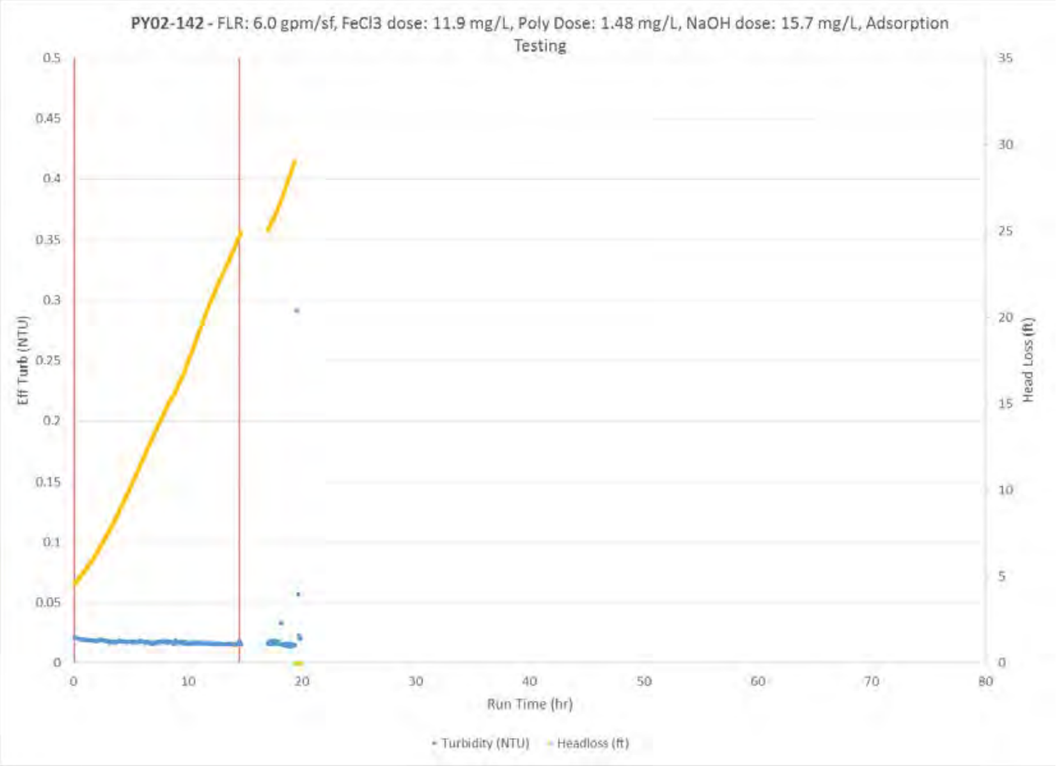


Figure F-167: PY02 Filter Profile

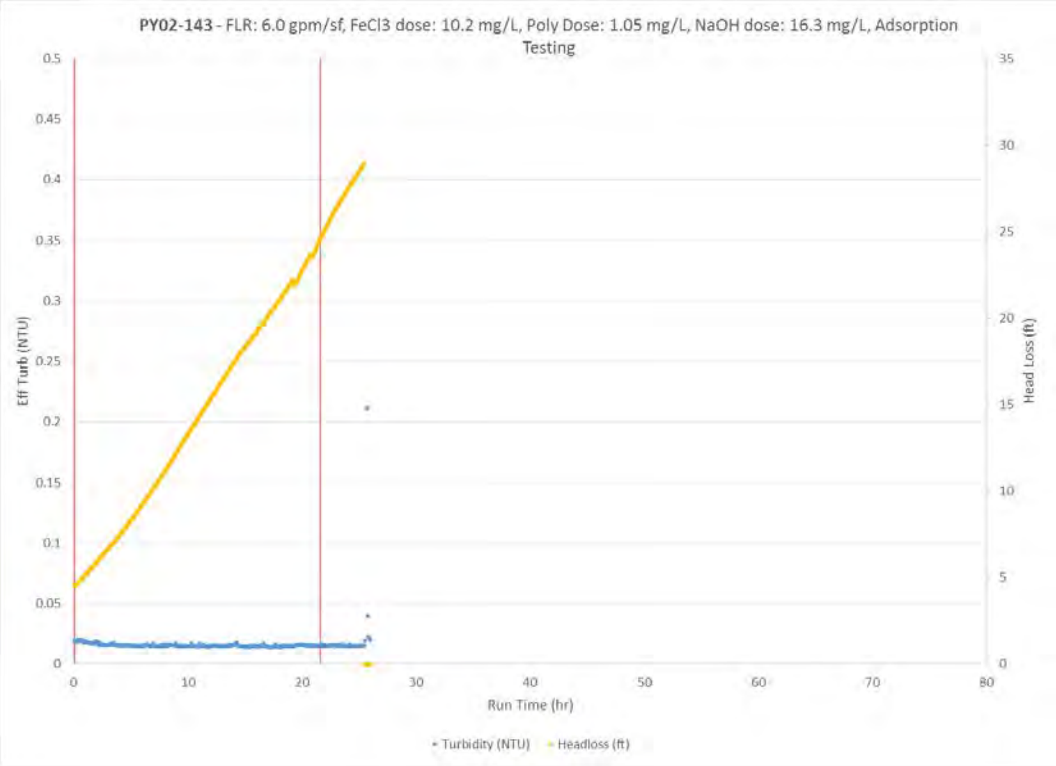


Figure F-168: PY02 Filter Profile

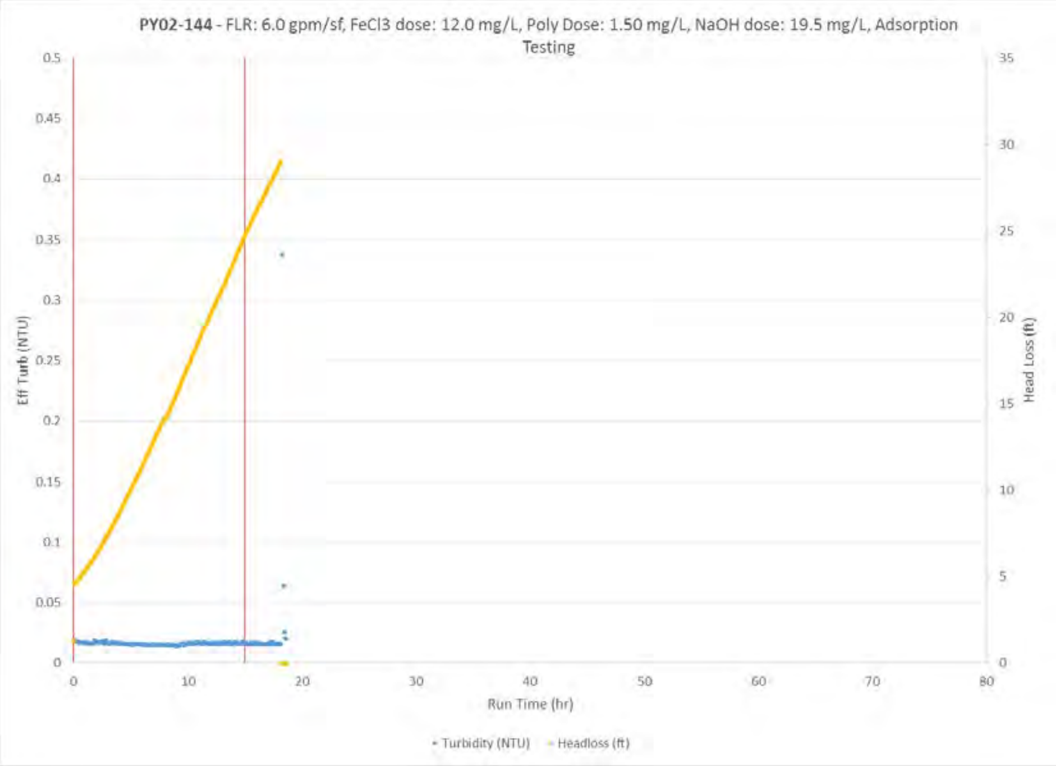


Figure F-169: PY02 Filter Profile

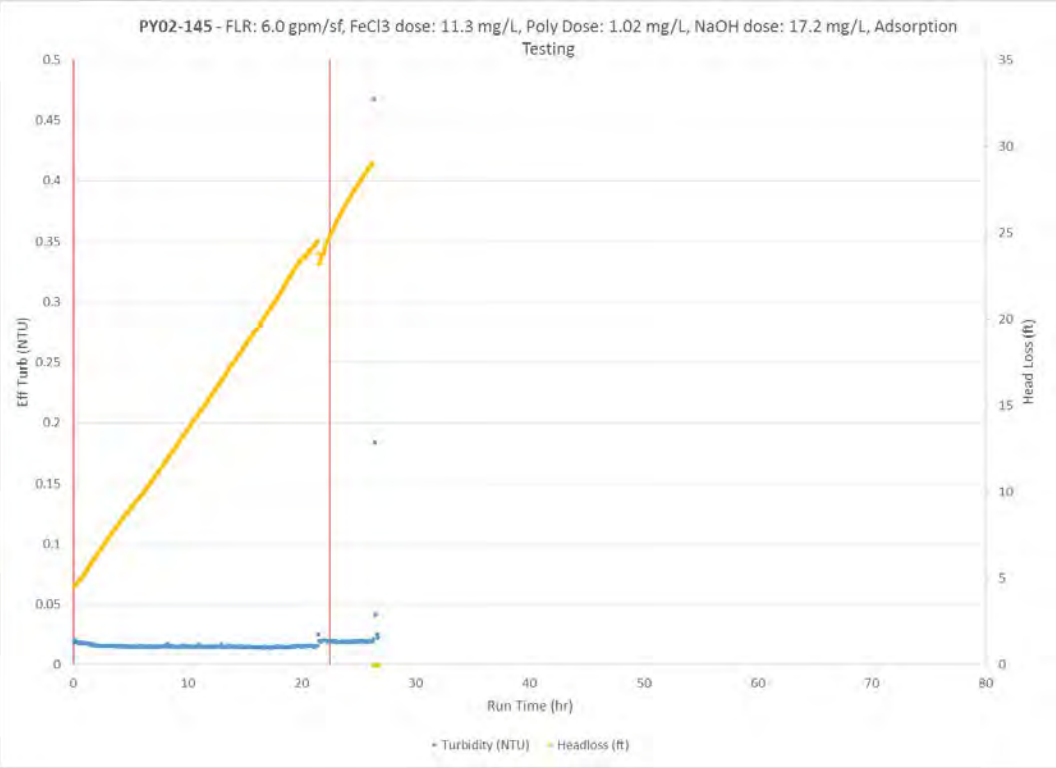


Figure F-170: PY02 Filter Profile

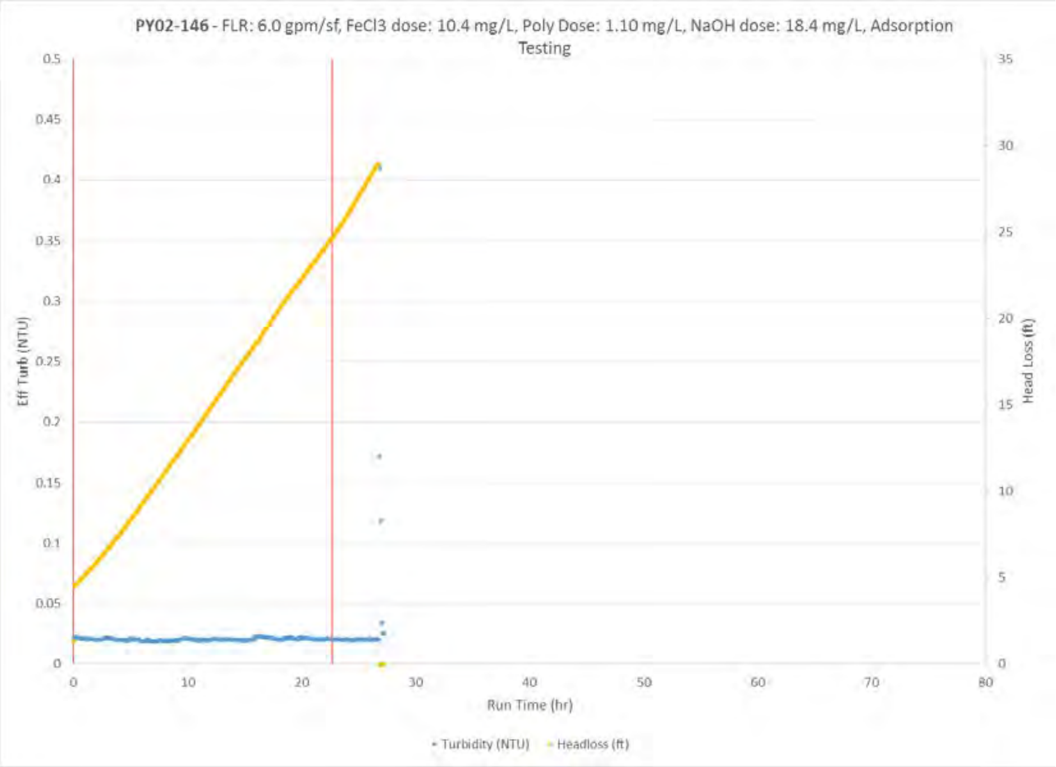


Figure F-171: PY02 Filter Profile

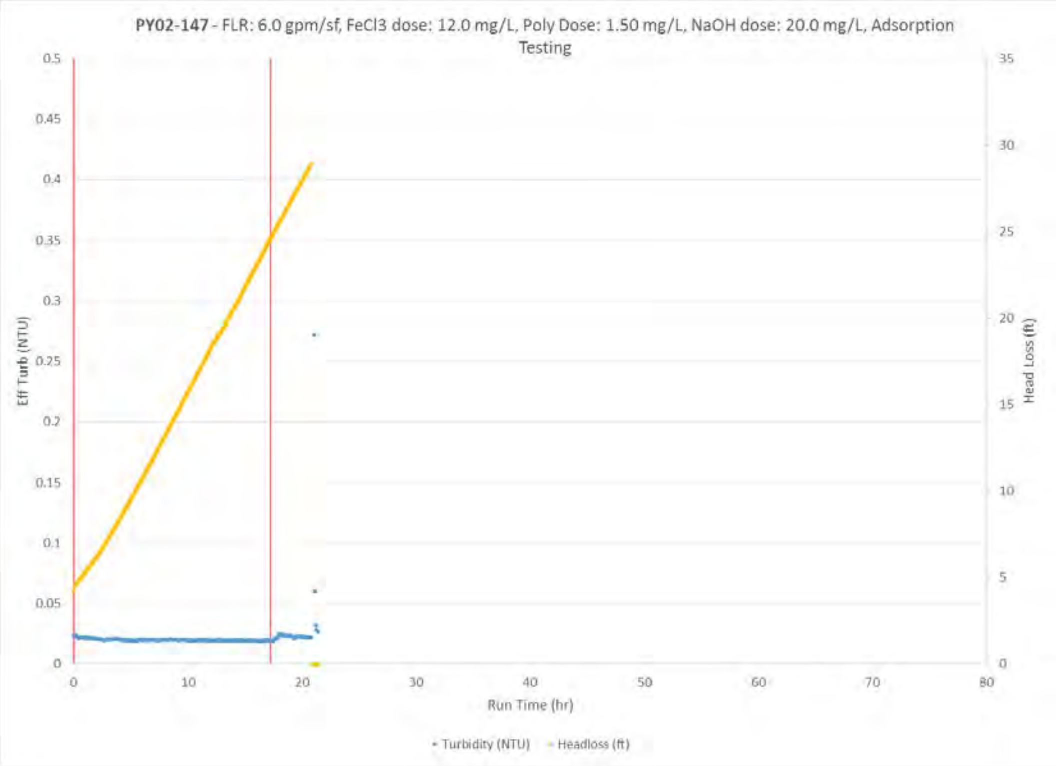


Figure F-172: PY02 Filter Profile

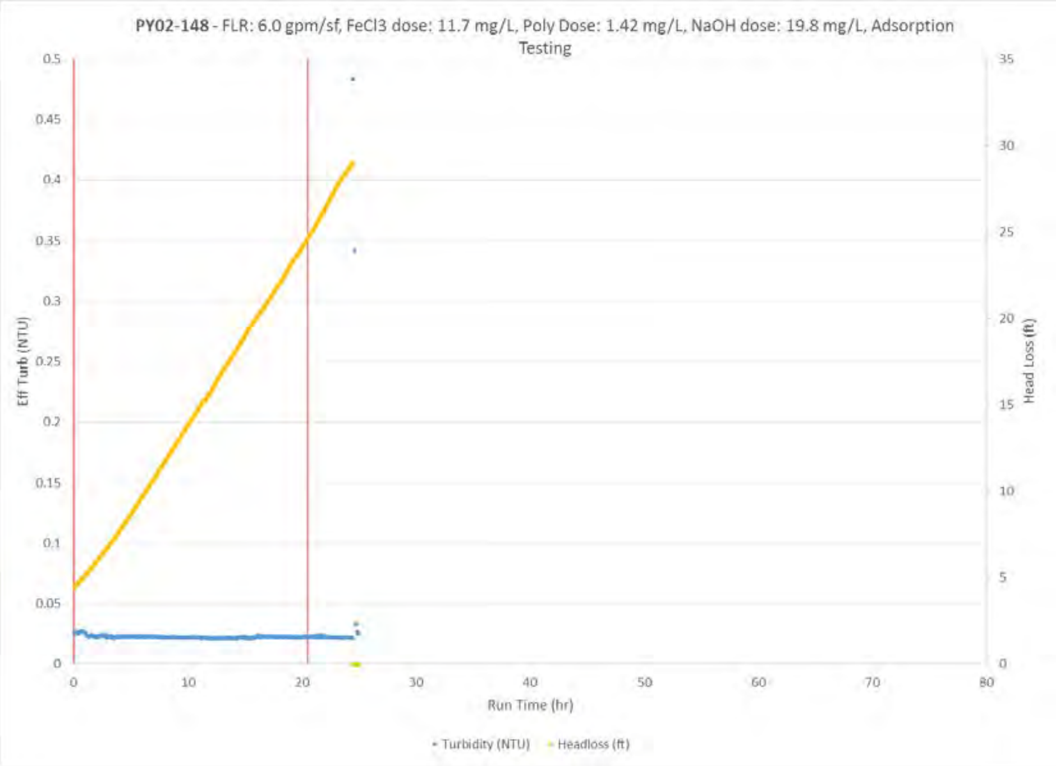


Figure F-173: PY02 Filter Profile

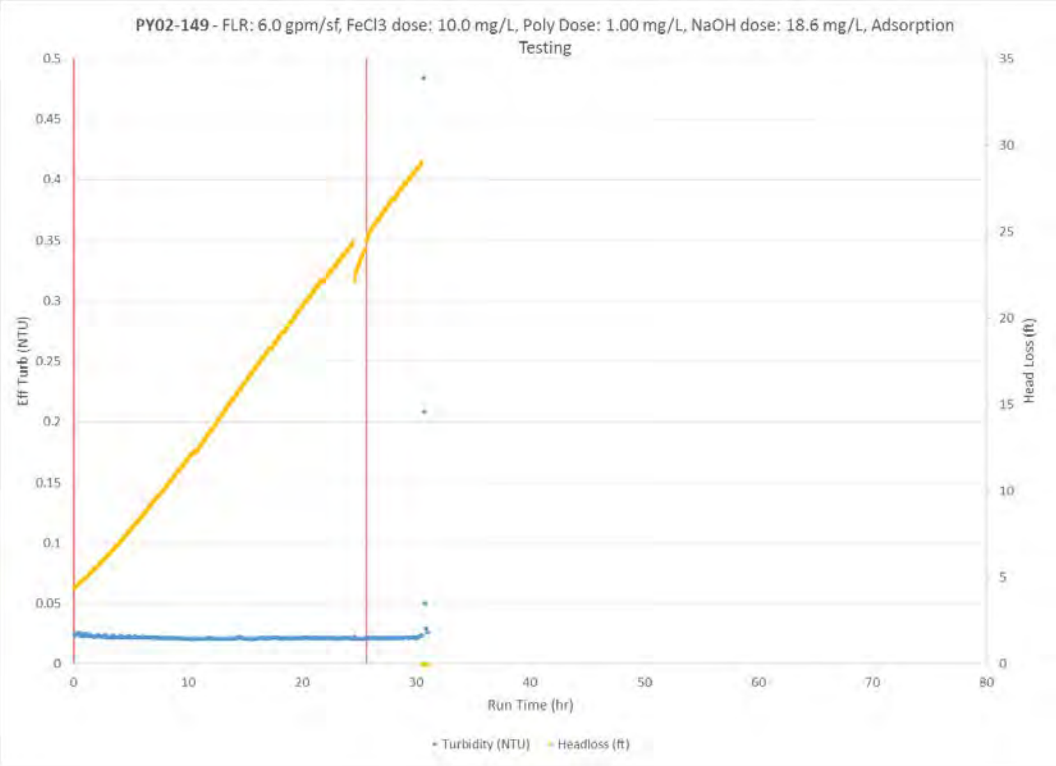


Figure F-174: PY02 Filter Profile

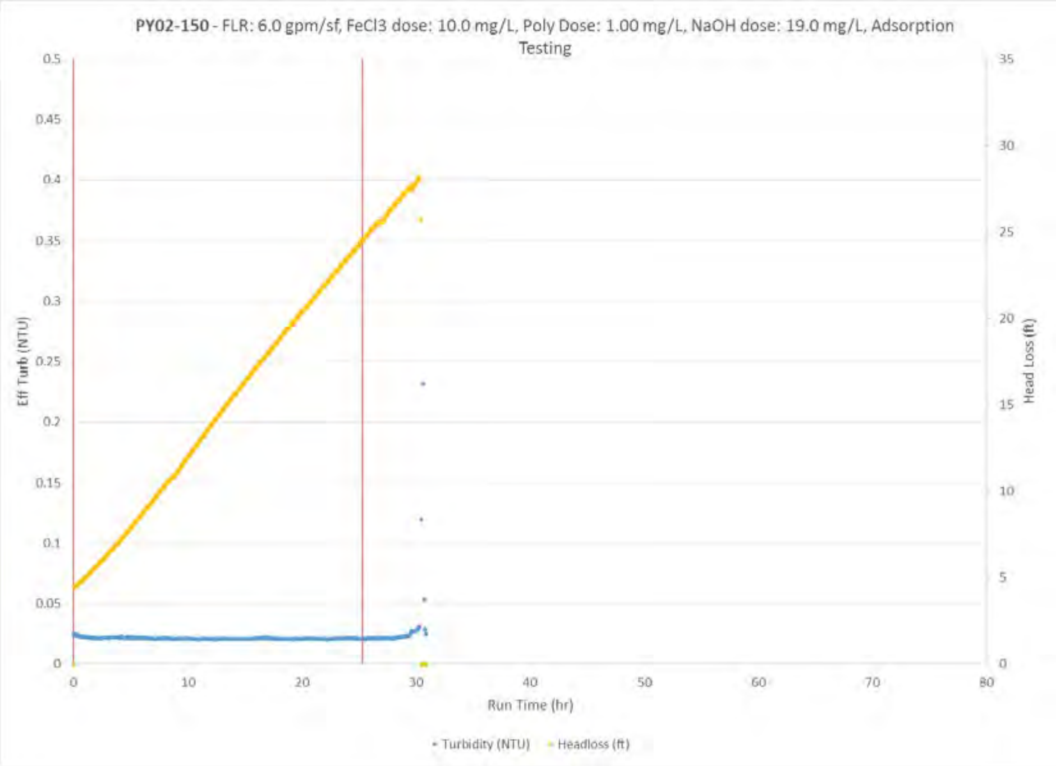


Figure F-175: PY02 Filter Profile

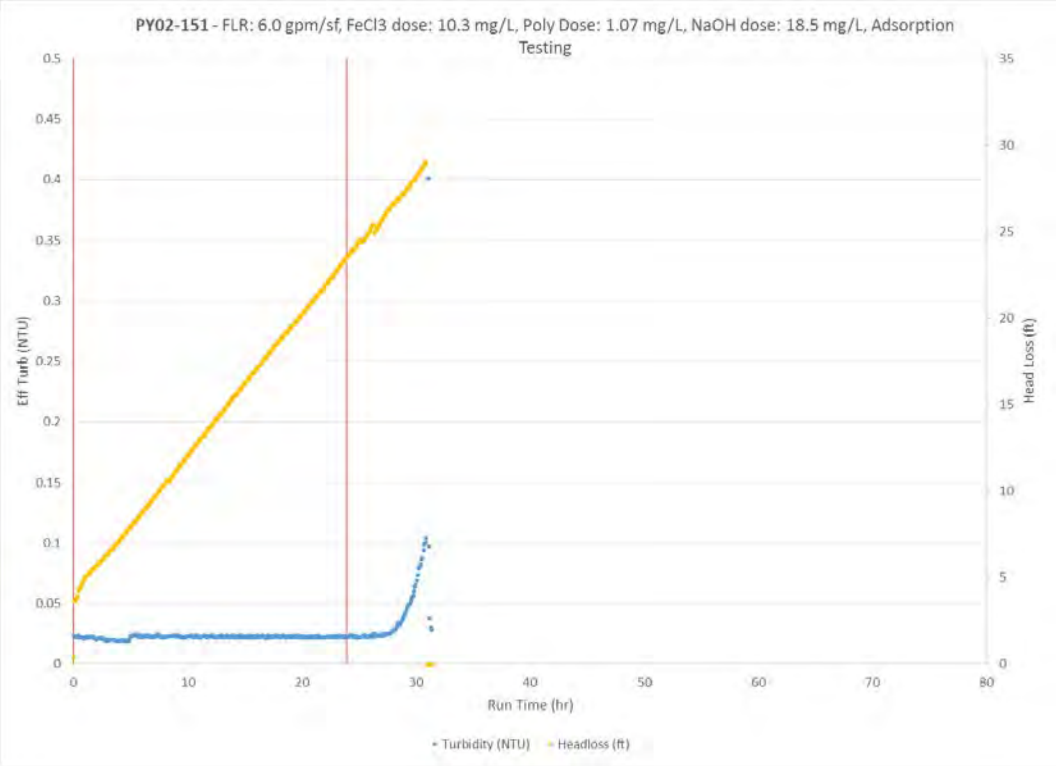


Figure F-176: PY02 Filter Profile

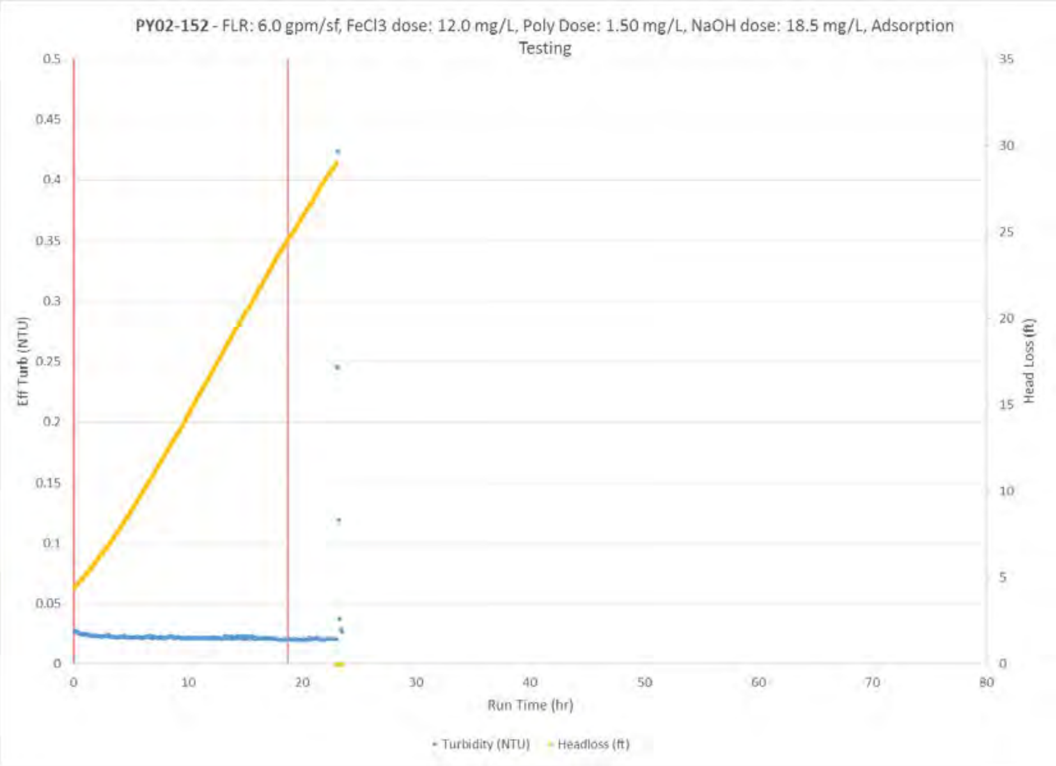


Figure F-177: PY02 Filter Profile

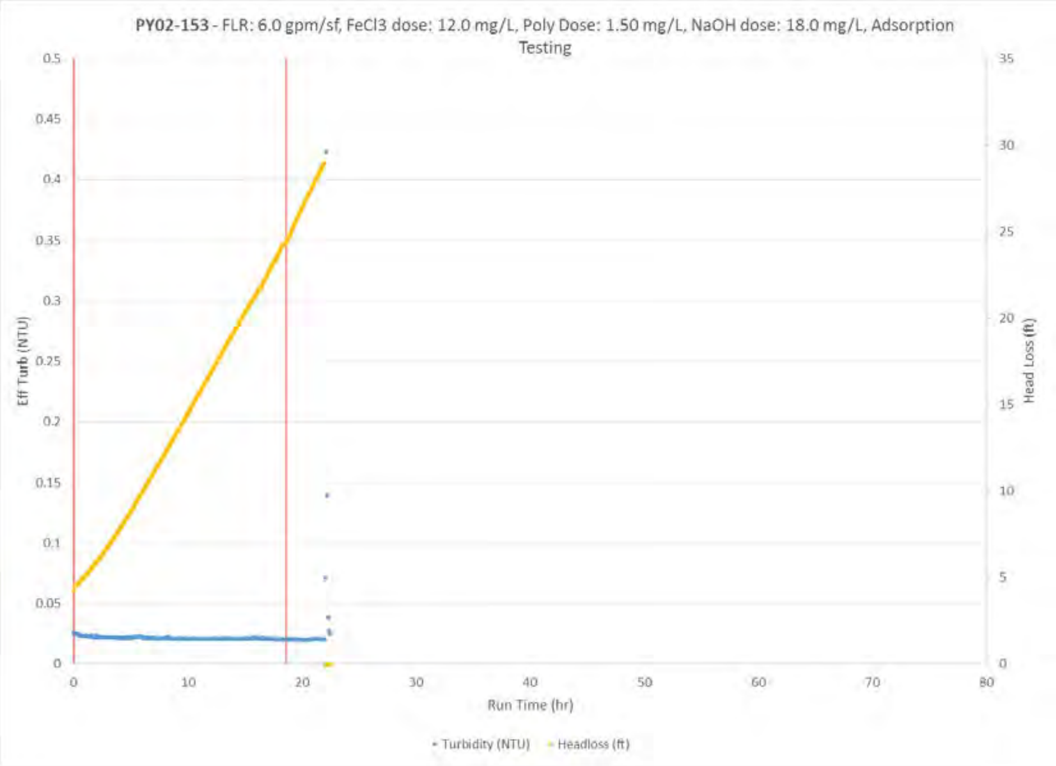


Figure F-178: PY02 Filter Profile

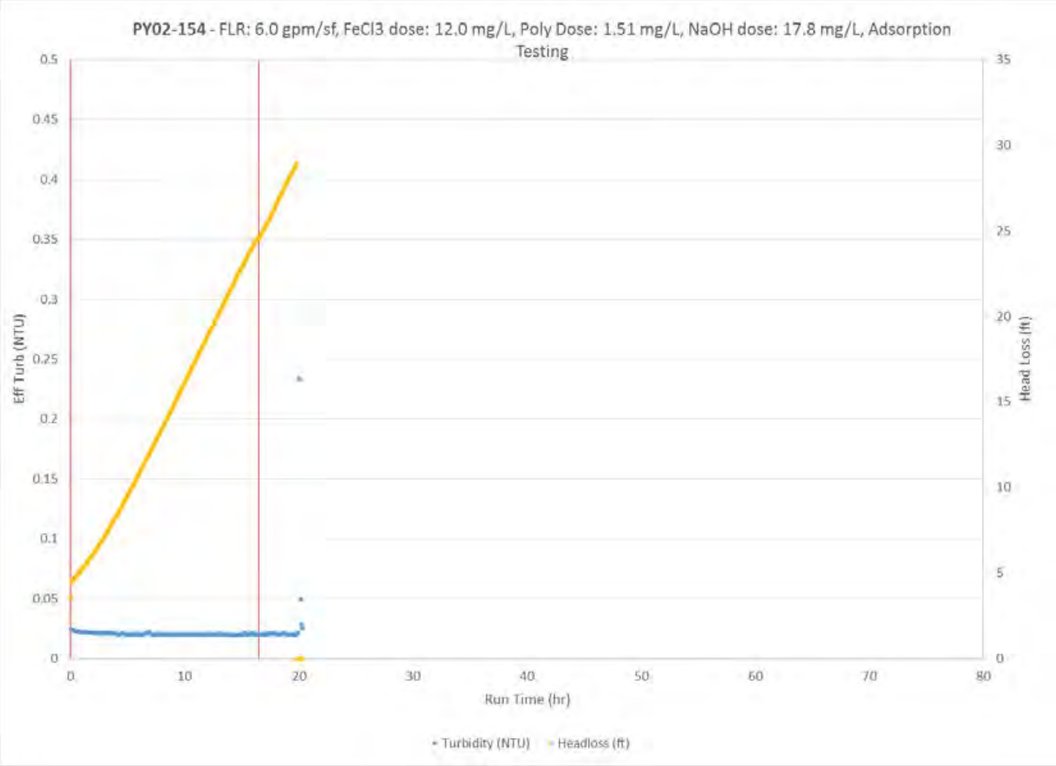


Figure F-179: PY02 Filter Profile

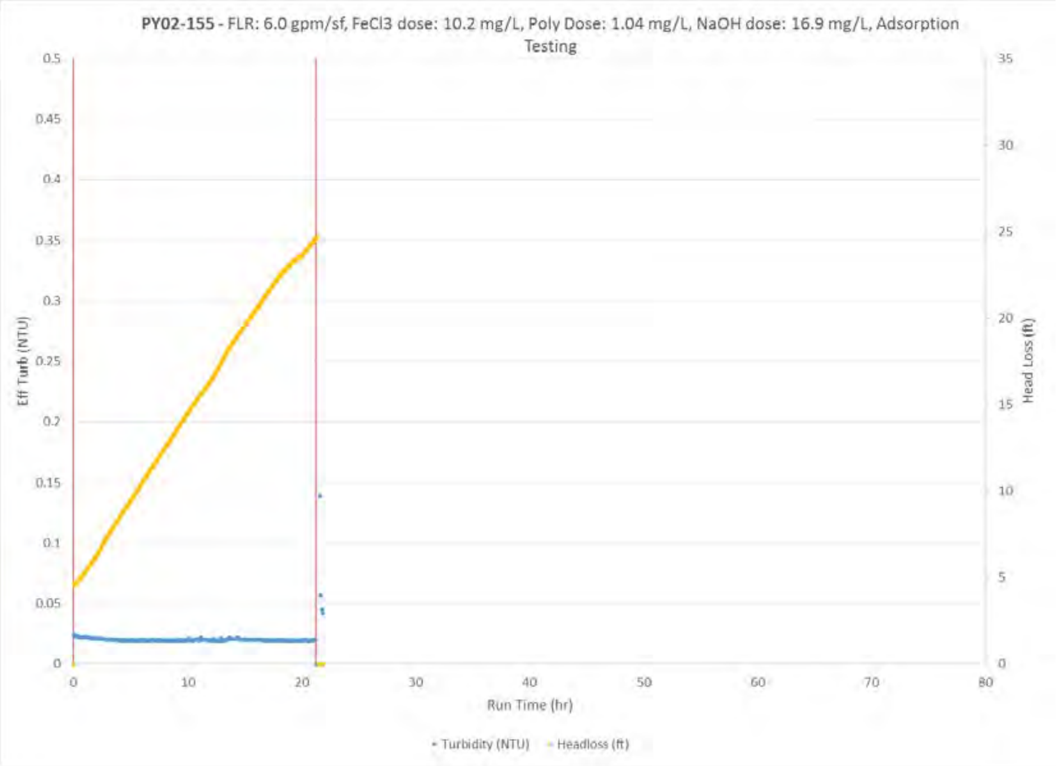


Figure F-180: PY02 Filter Profile

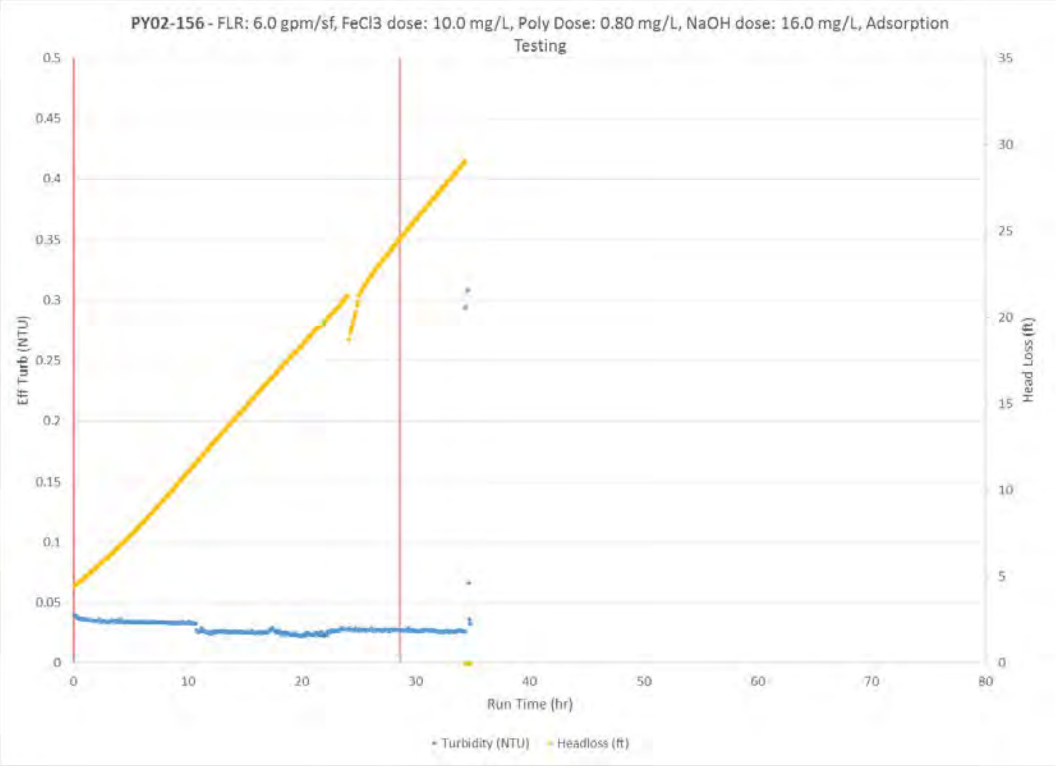


Figure F-181: PY02 Filter Profile

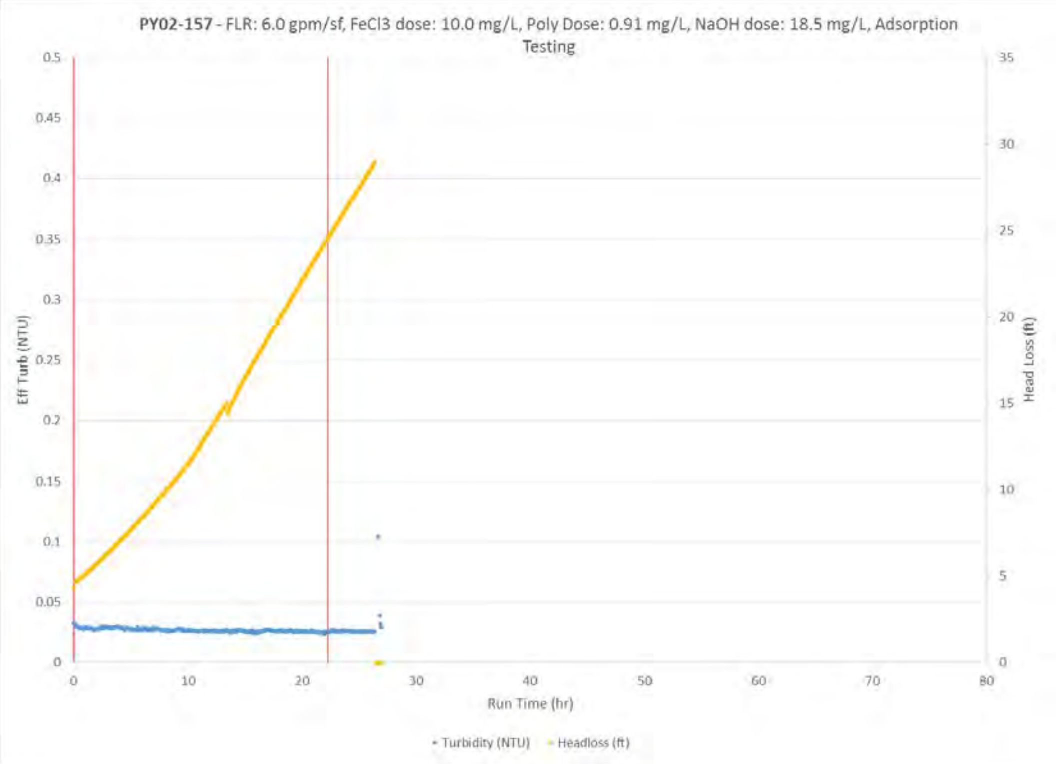


Figure F-182: PY02 Filter Profile

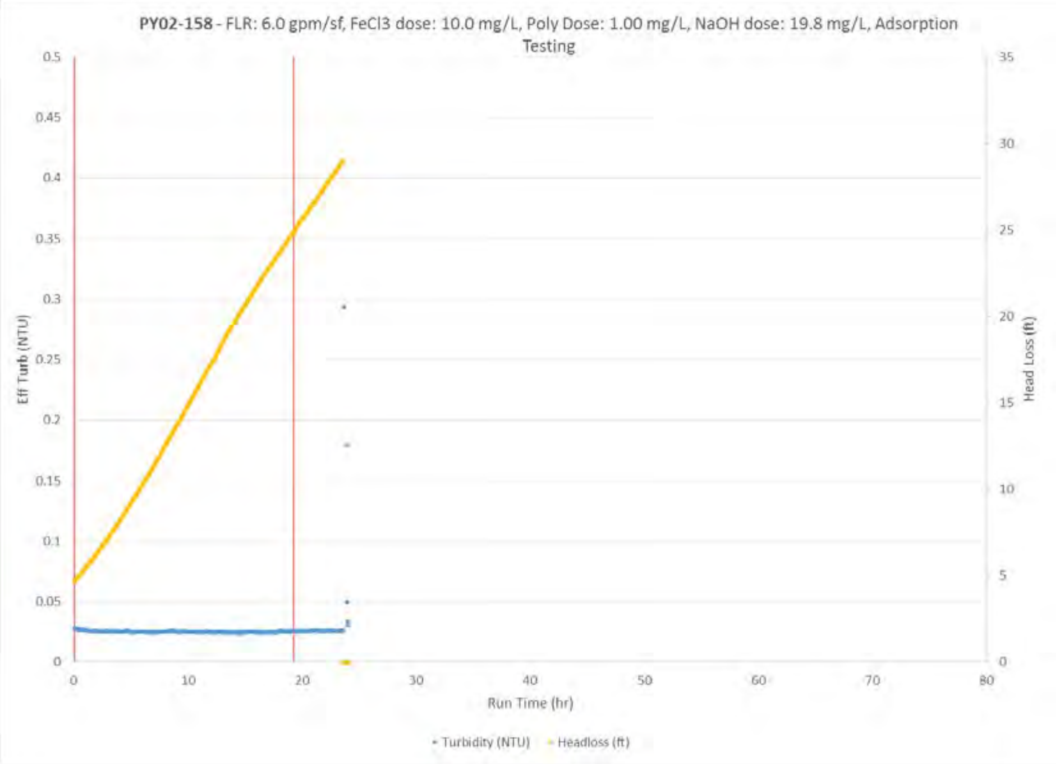


Figure F-183: PY02 Filter Profile

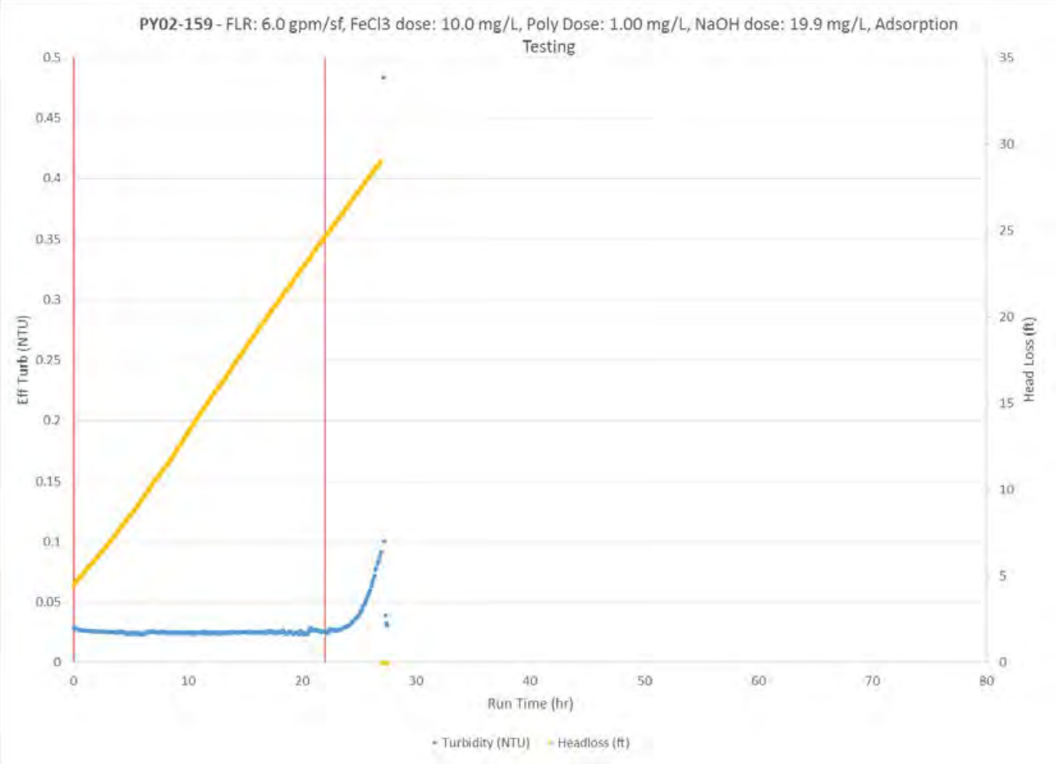


Figure F-184: PY02 Filter Profile

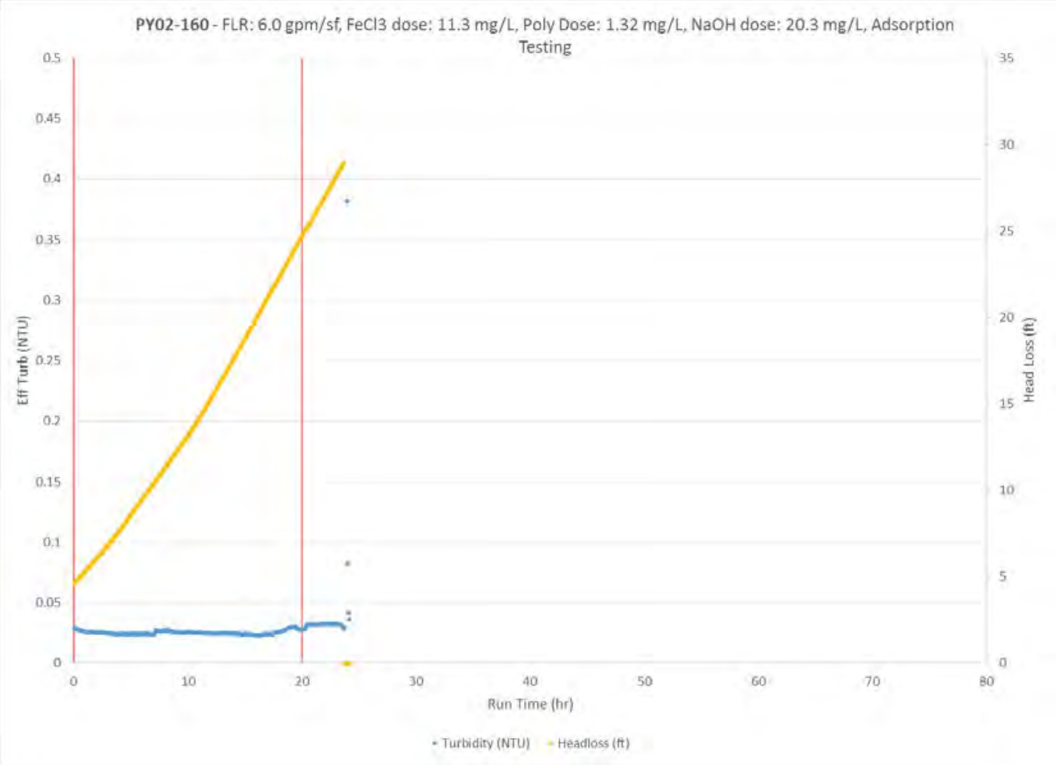


Figure F-185: PY02 Filter Profile

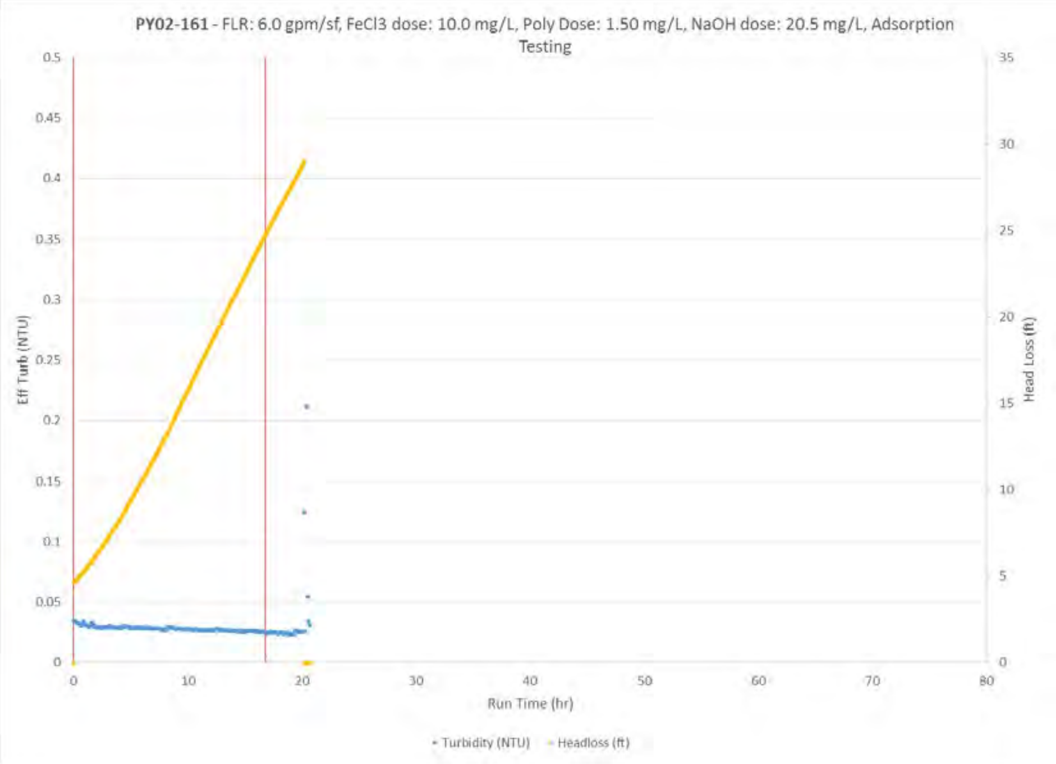


Figure F-186: PY02 Filter Profile

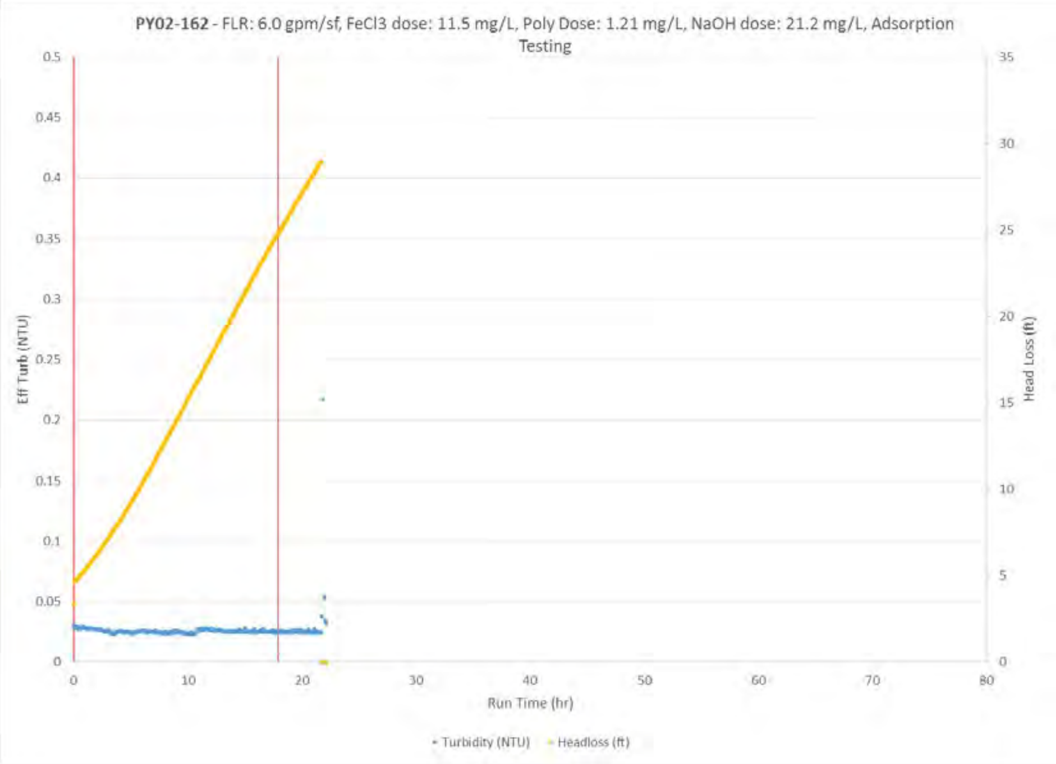


Figure F-187: PY02 Filter Profile

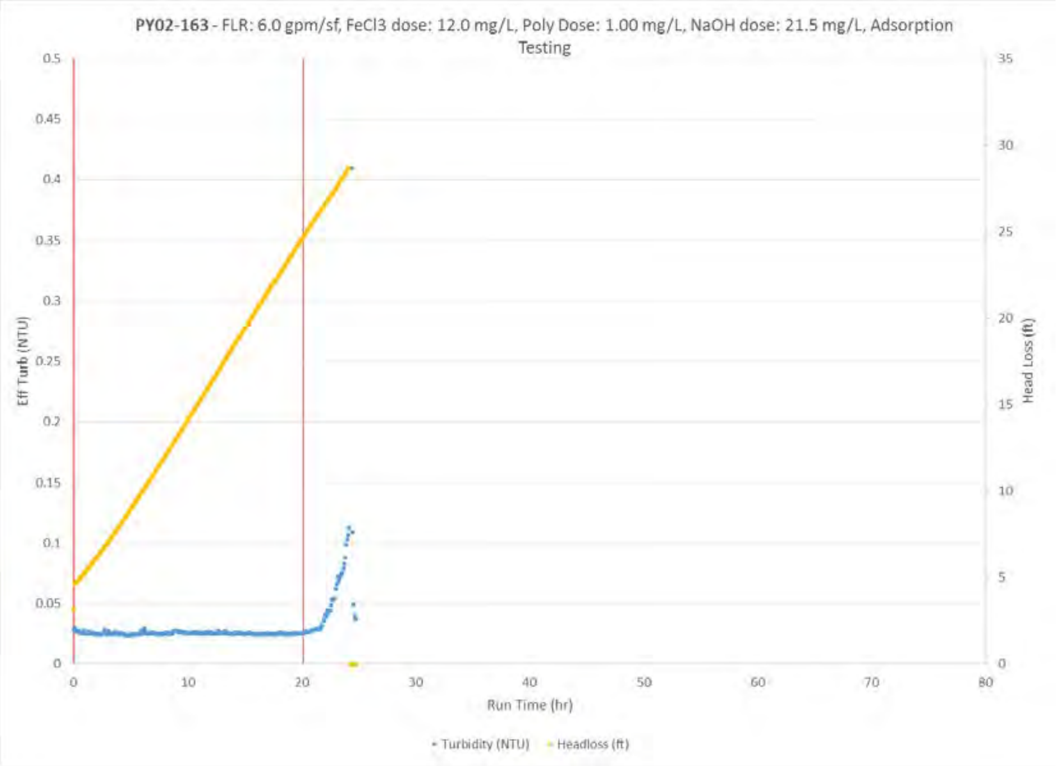


Figure F-188: PY02 Filter Profile

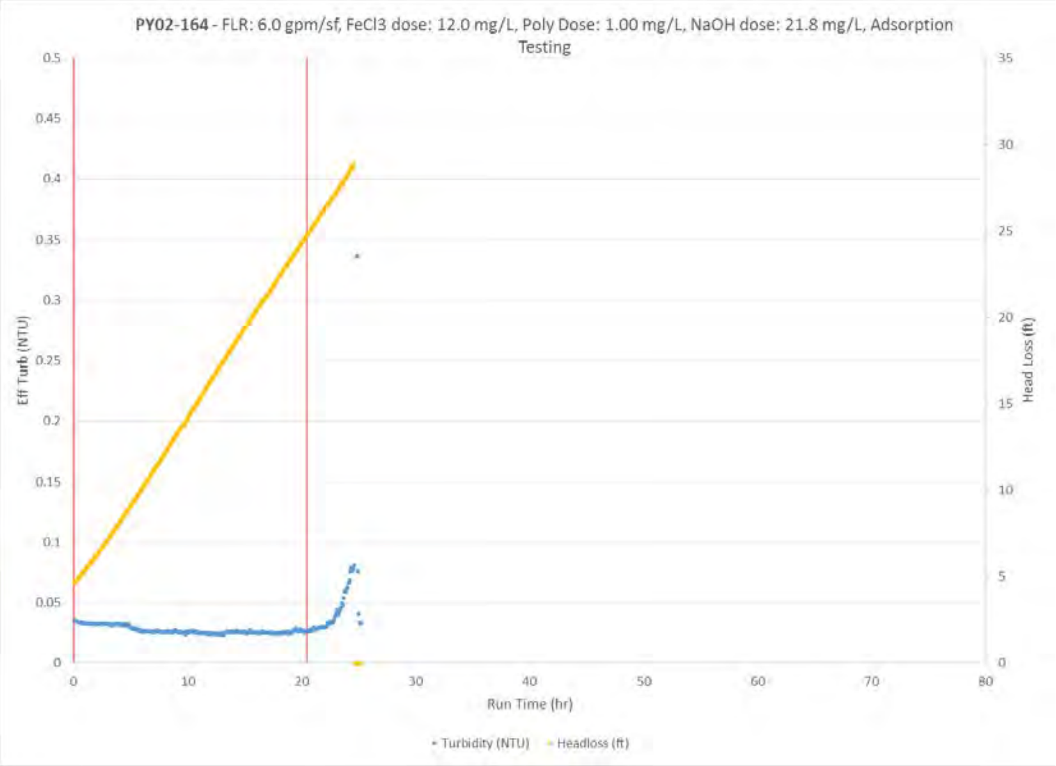


Figure F-189: PY07 Filter Profile

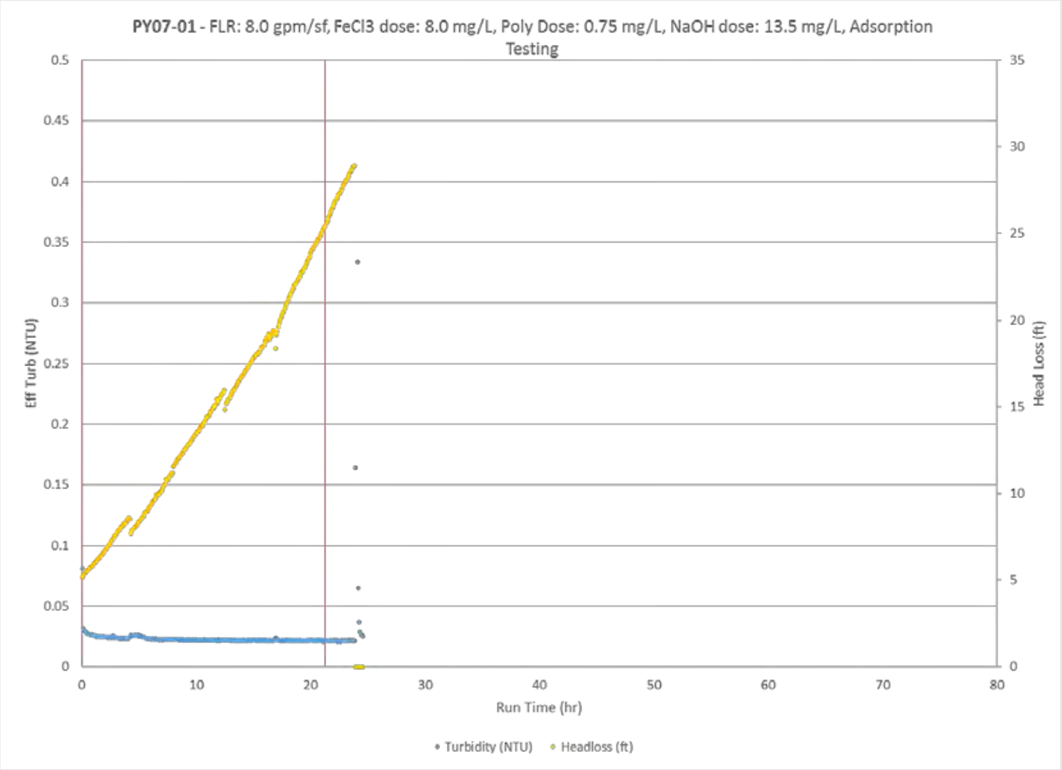


Figure F-190: PY07 Filter Profile

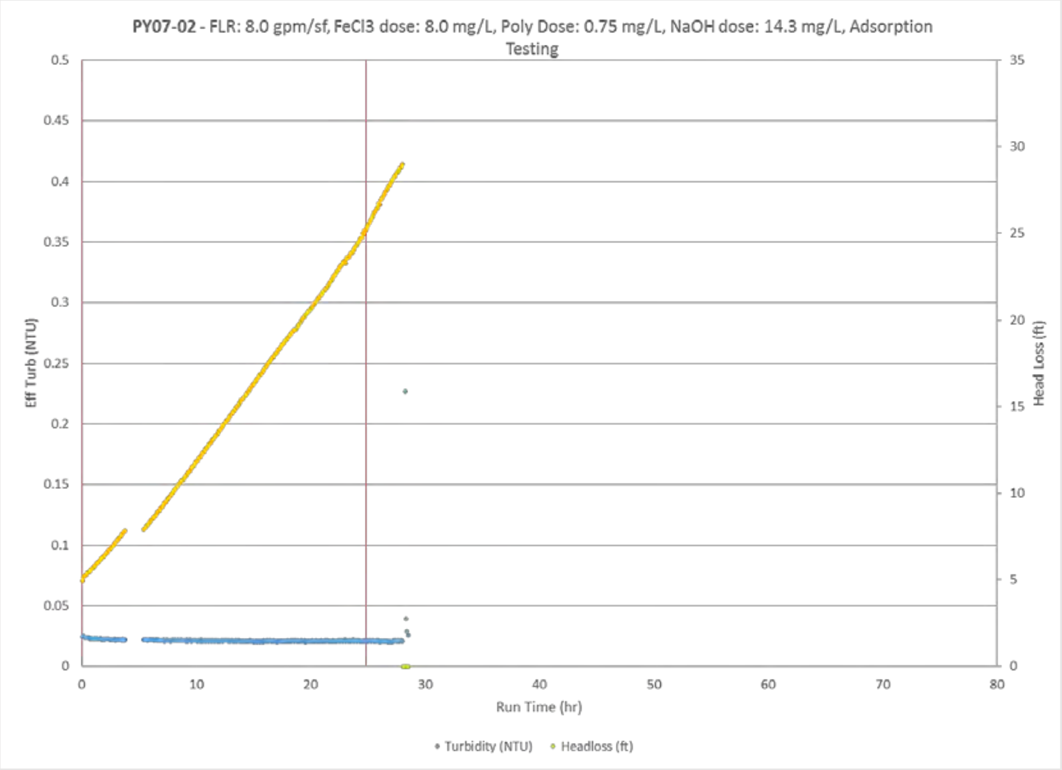


Figure F-191: PY07 Filter Profile

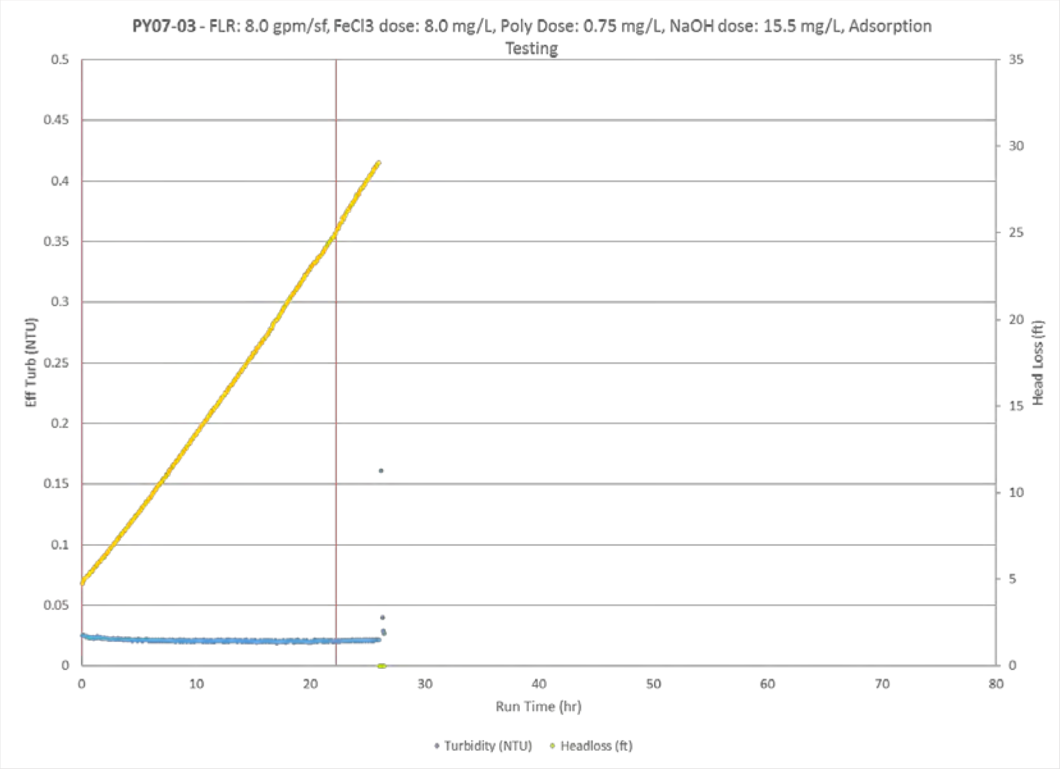


Figure F-192: PY07 Filter Profile

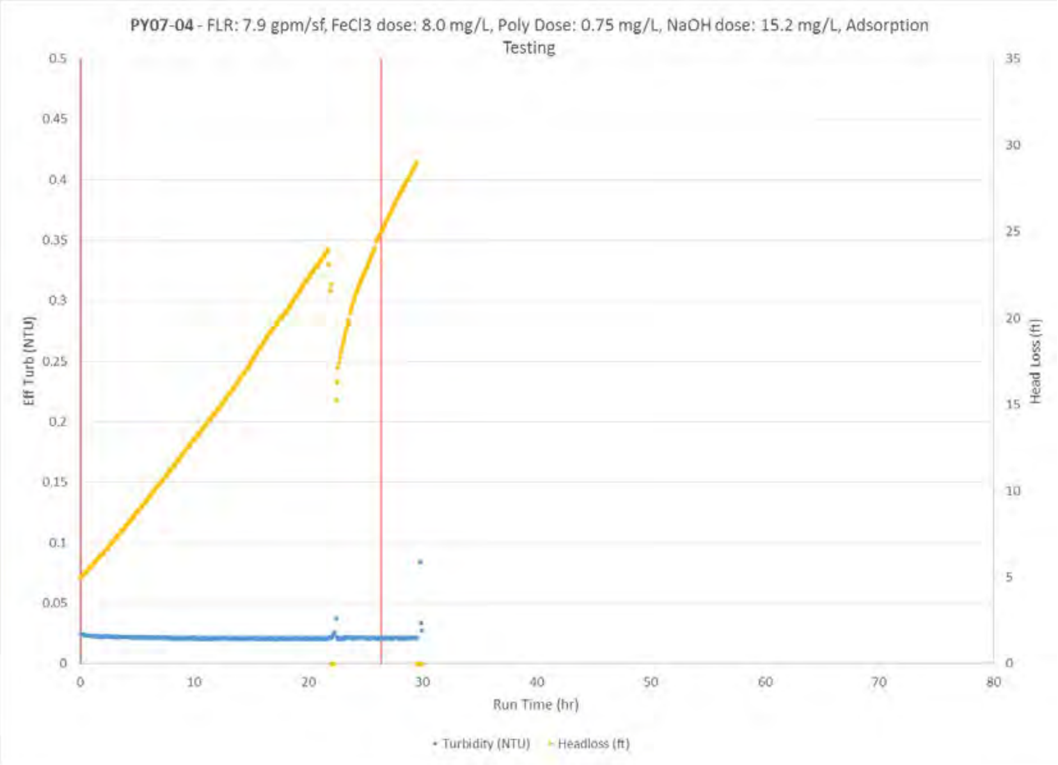


Figure F-193: PY07 Filter Profile

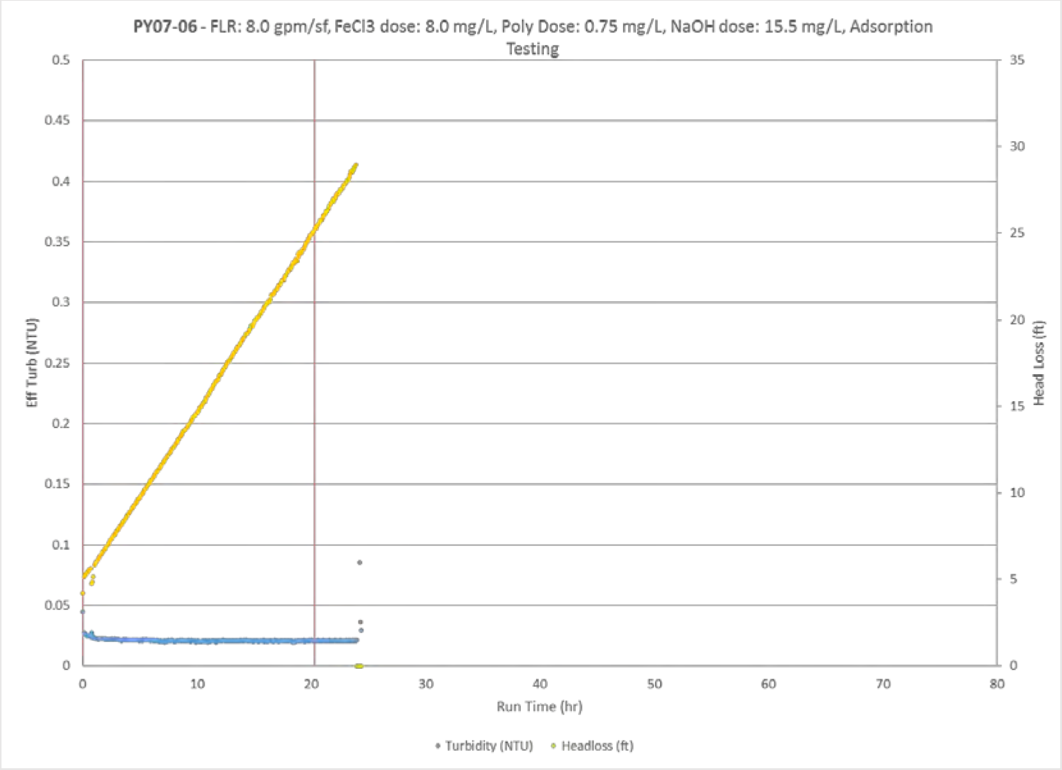


Figure F-194: PY07 Filter Profile

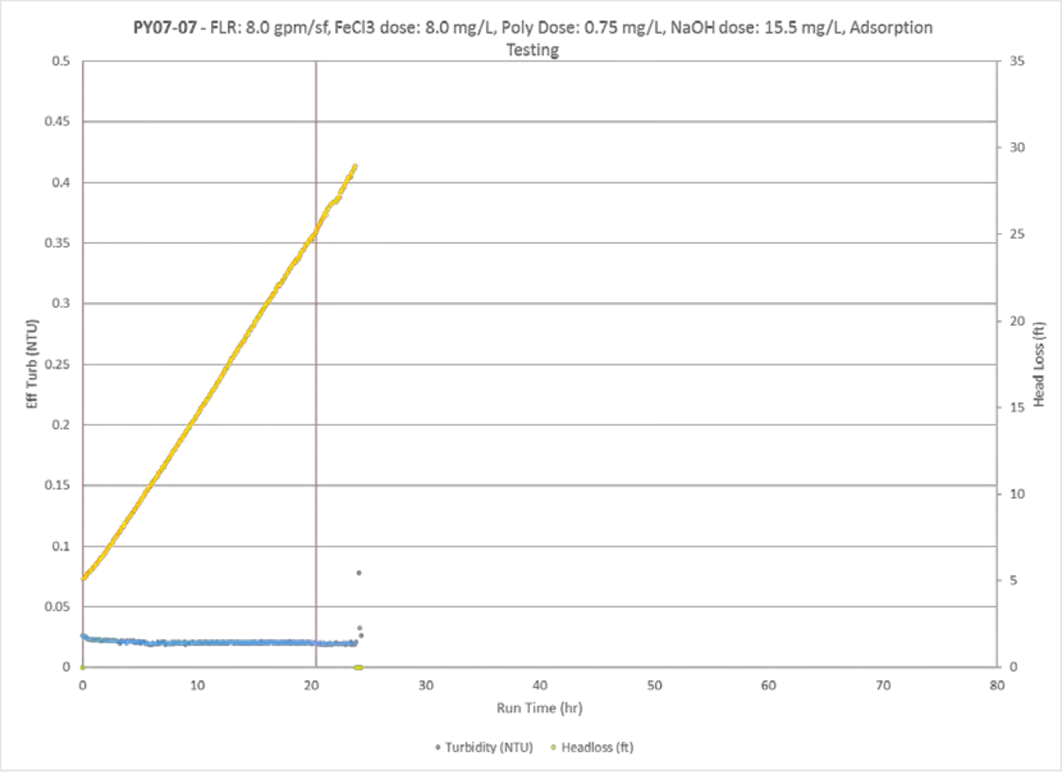


Figure F-195: PY07 Filter Profile

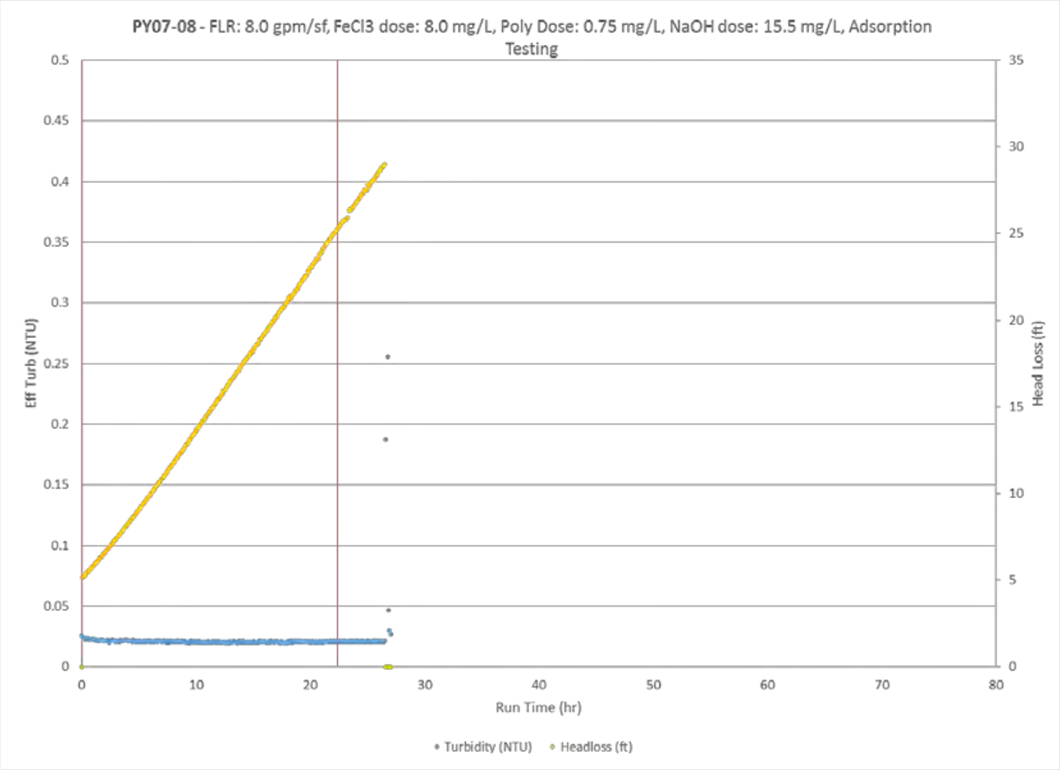


Figure F-196: PY07 Filter Profile

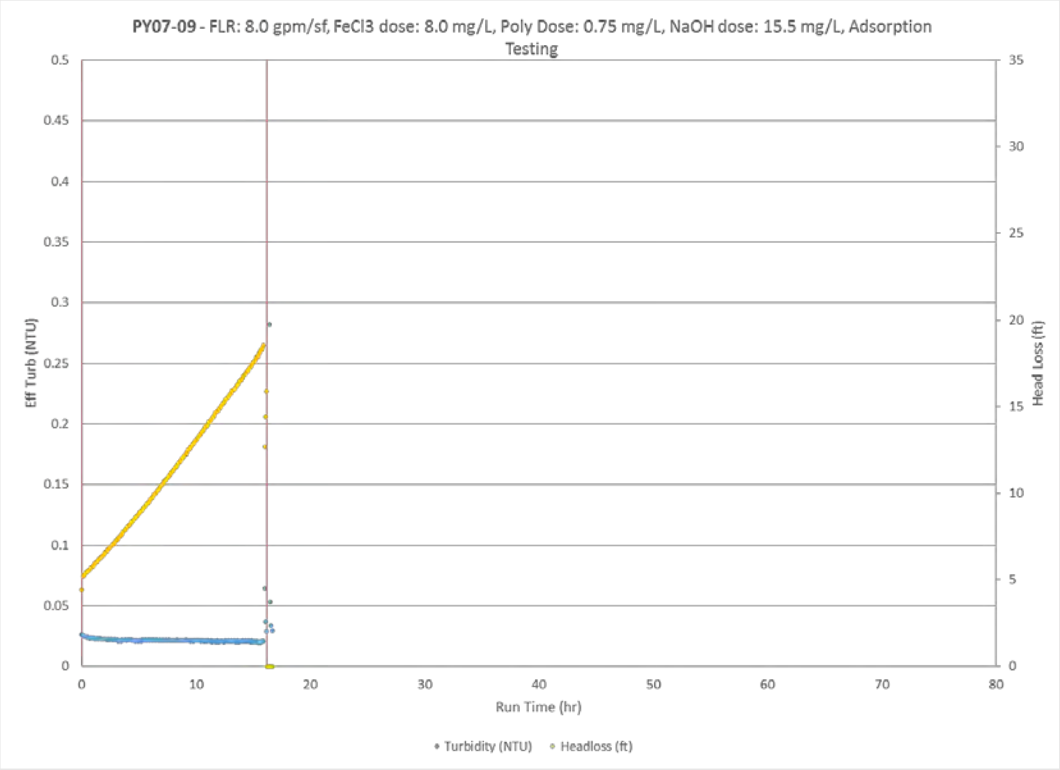


Figure F-197: PY07 Filter Profile

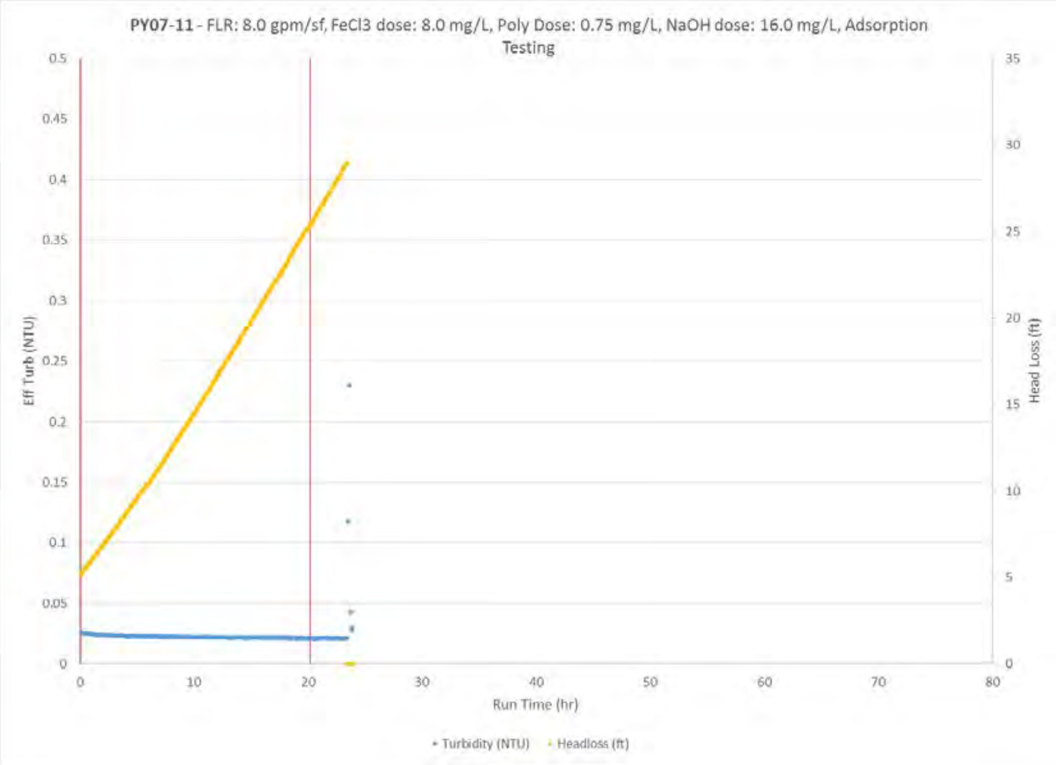


Figure F-198: PY07 Filter Profile

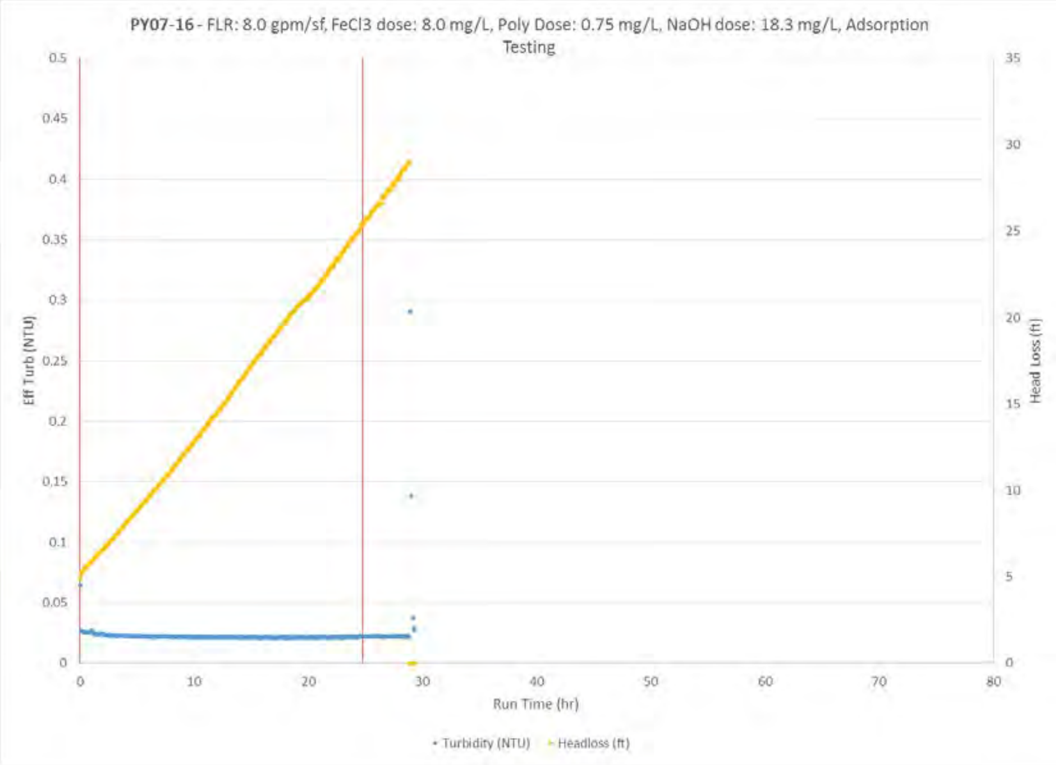


Figure F-199: PY07 Filter Profile

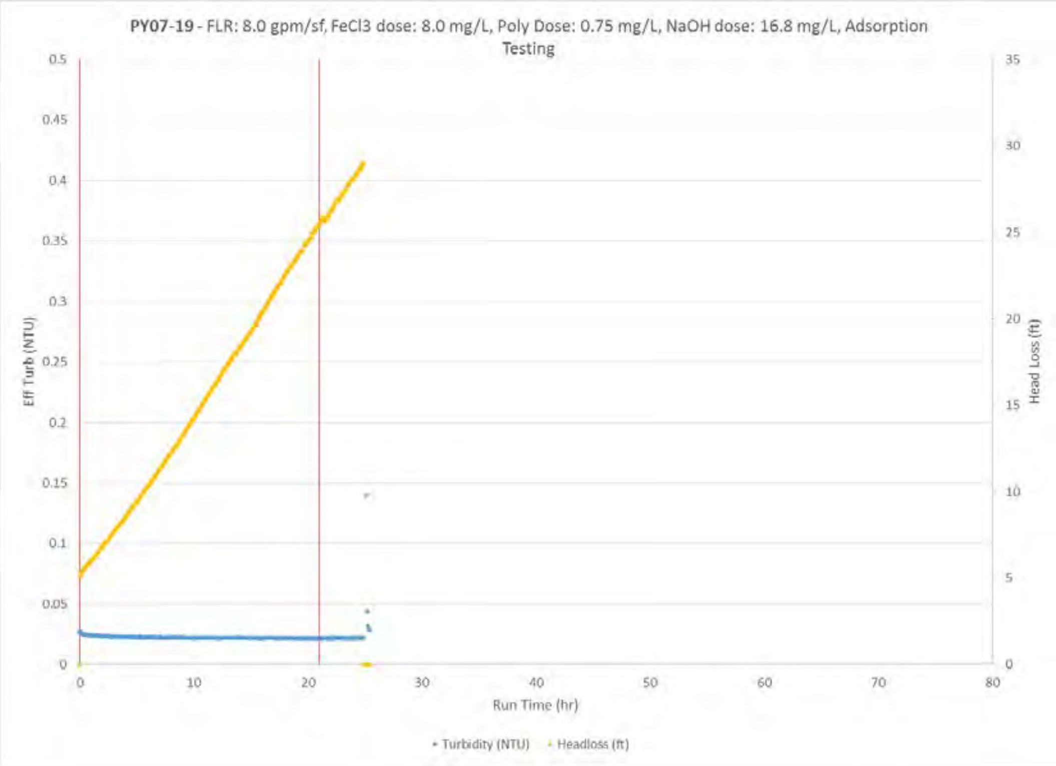


Figure F-200: PY07 Filter Profile

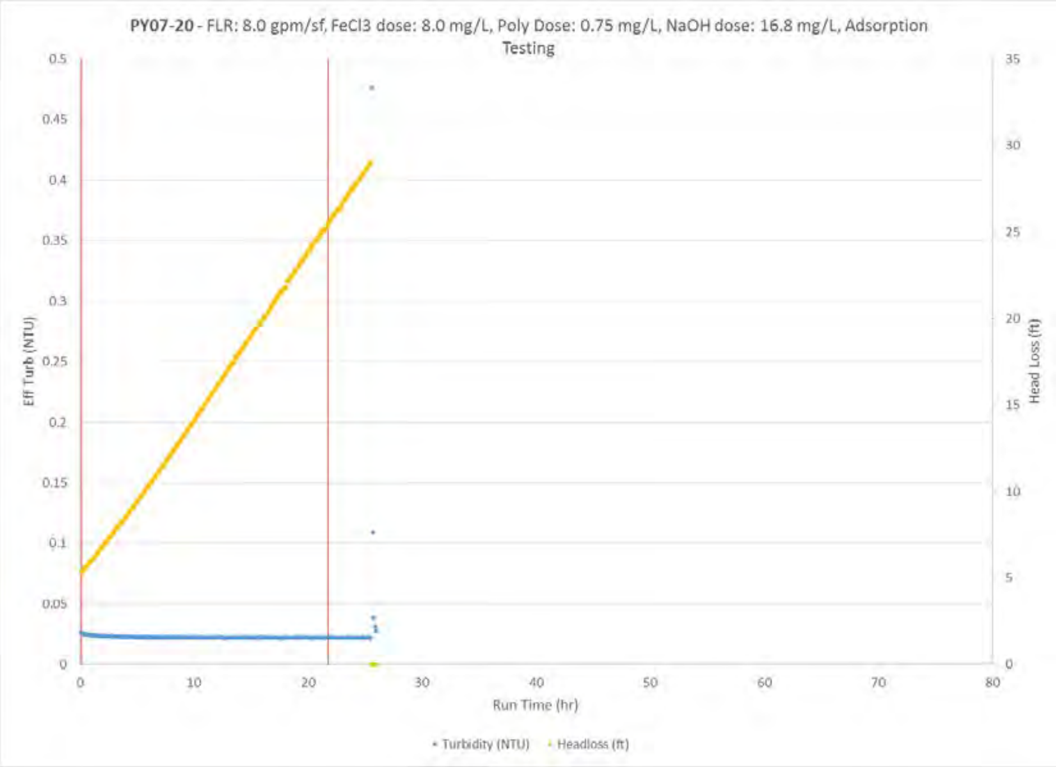


Figure F-201: PY07 Filter Profile

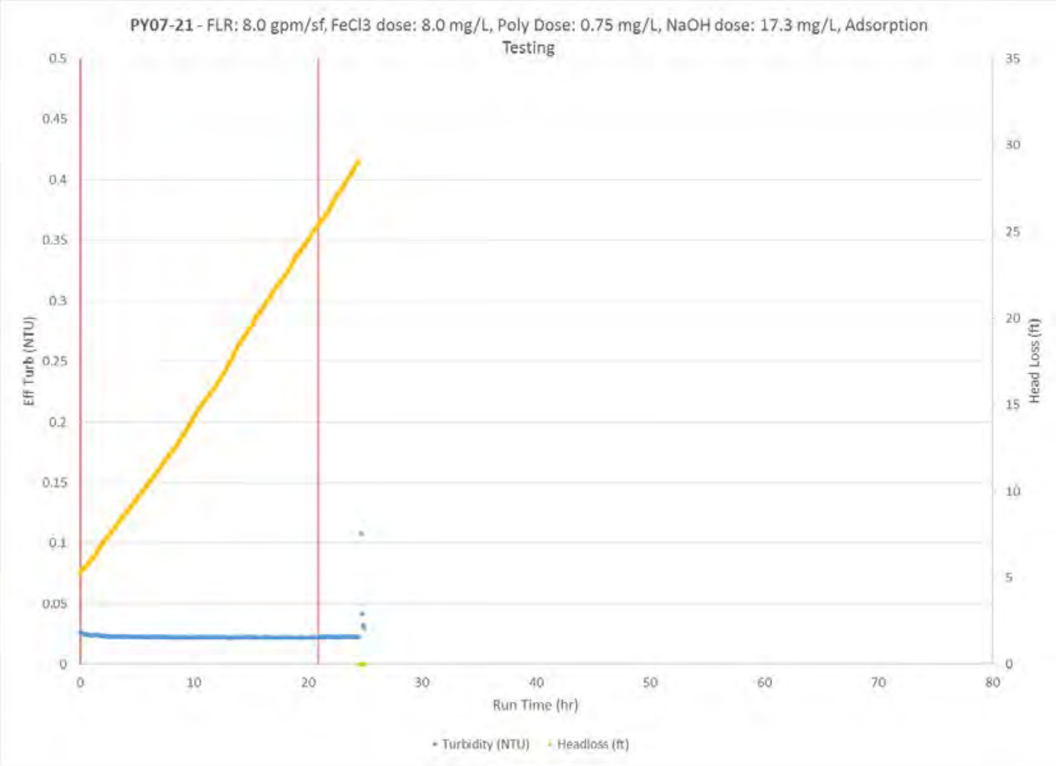


Figure F-202: PY07 Filter Profile

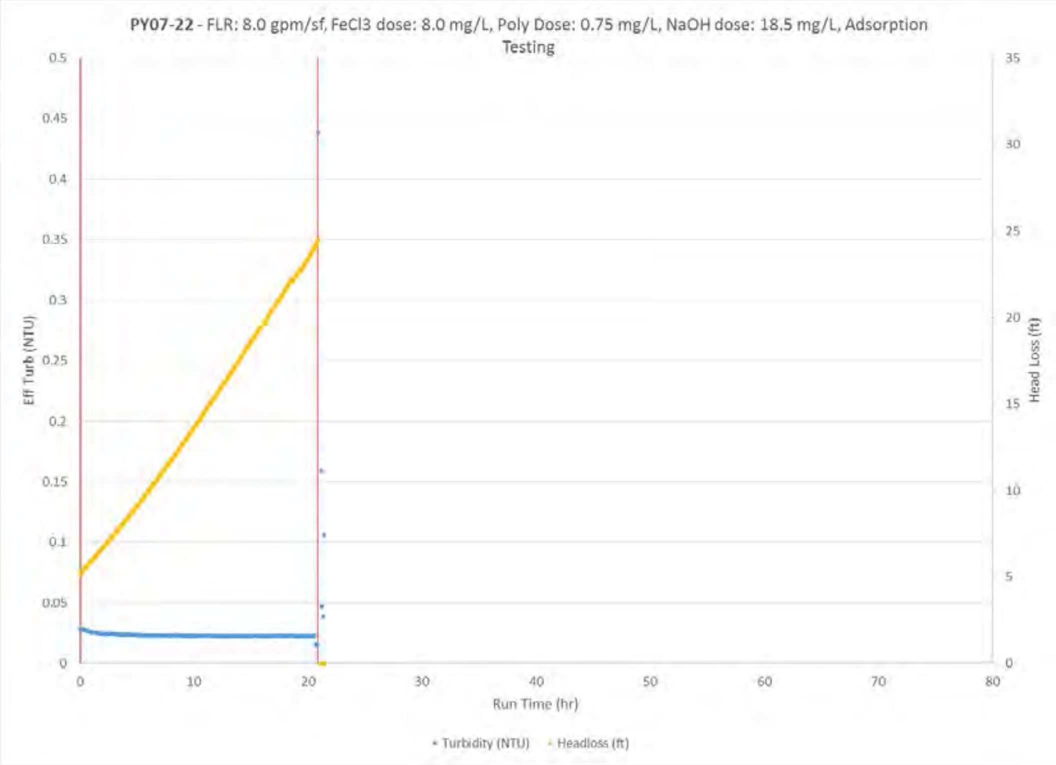
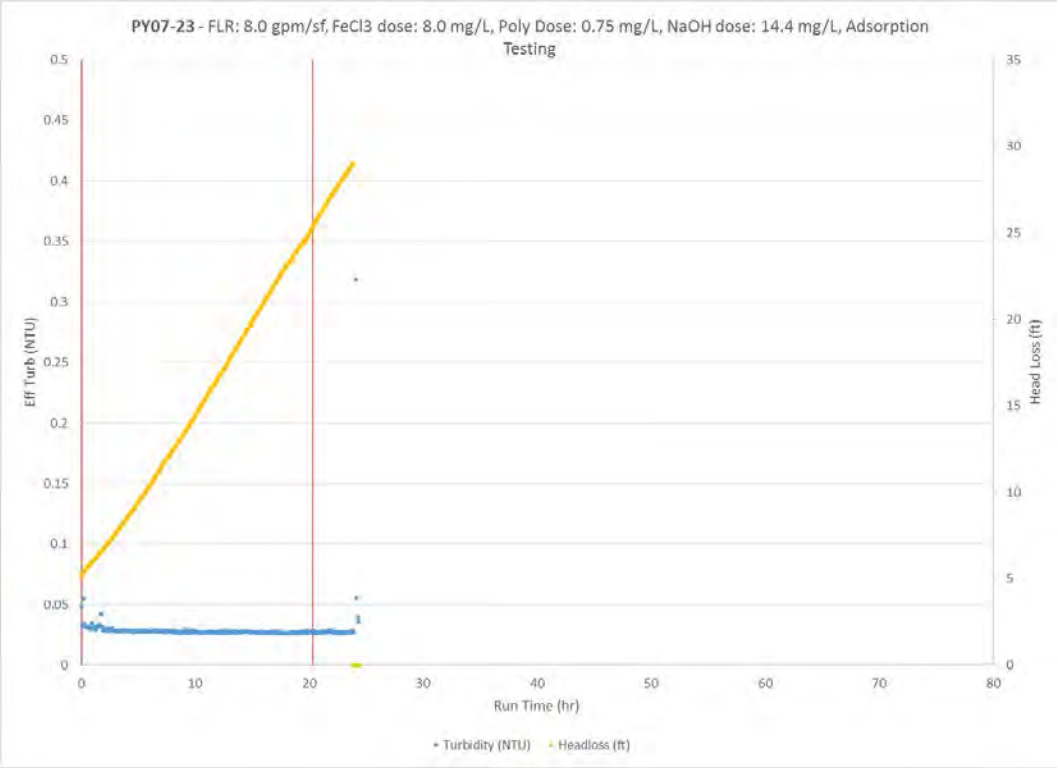


Figure F-203: PY07 Filter Profile



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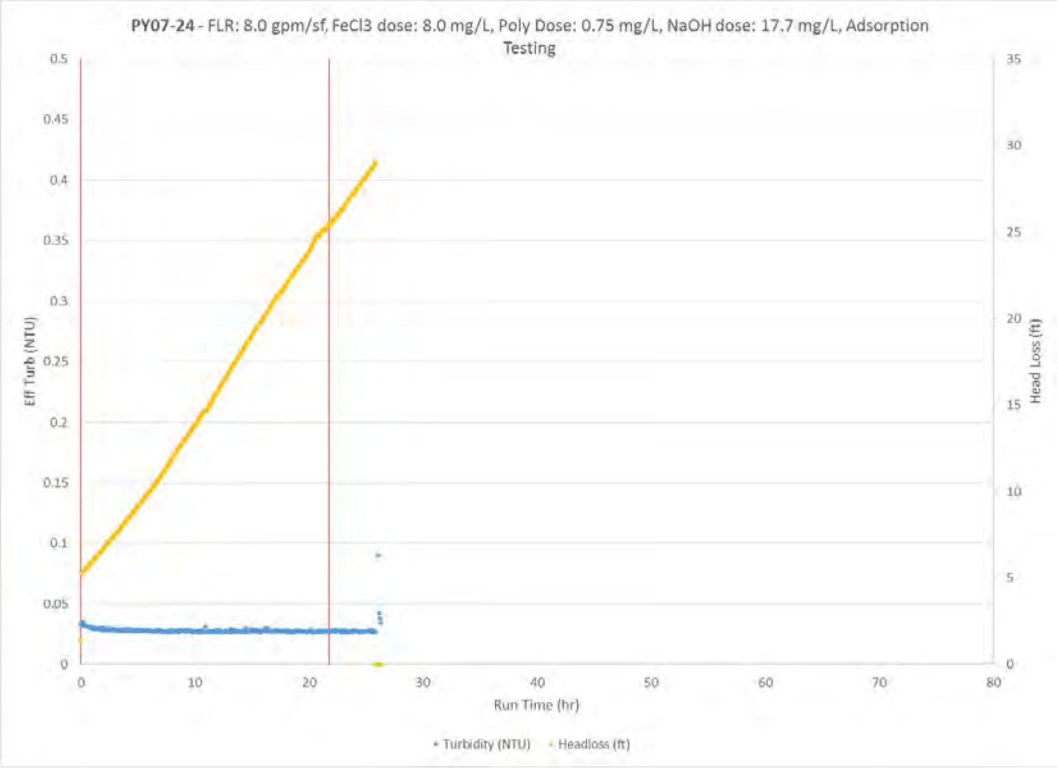

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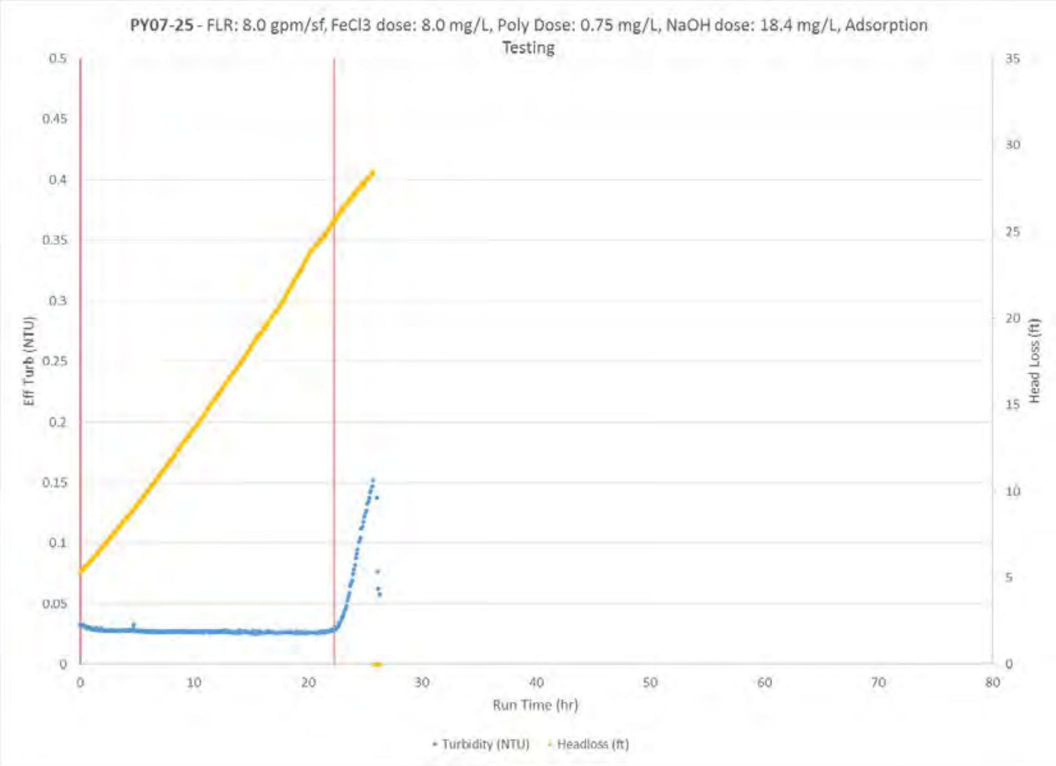

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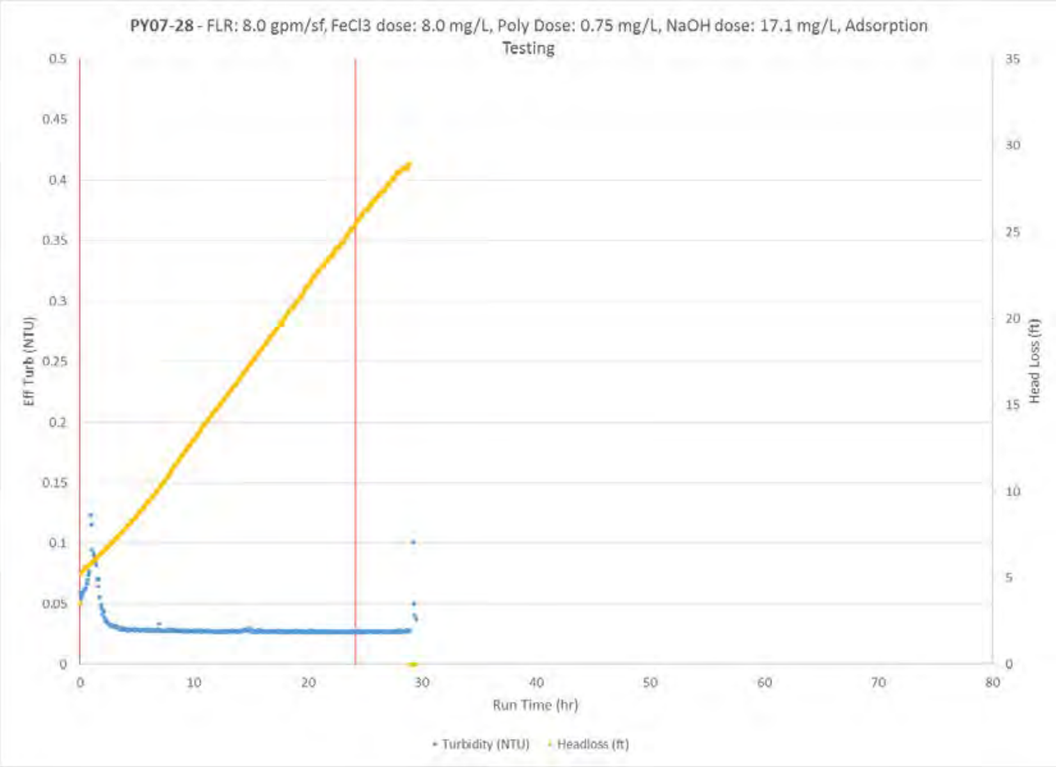

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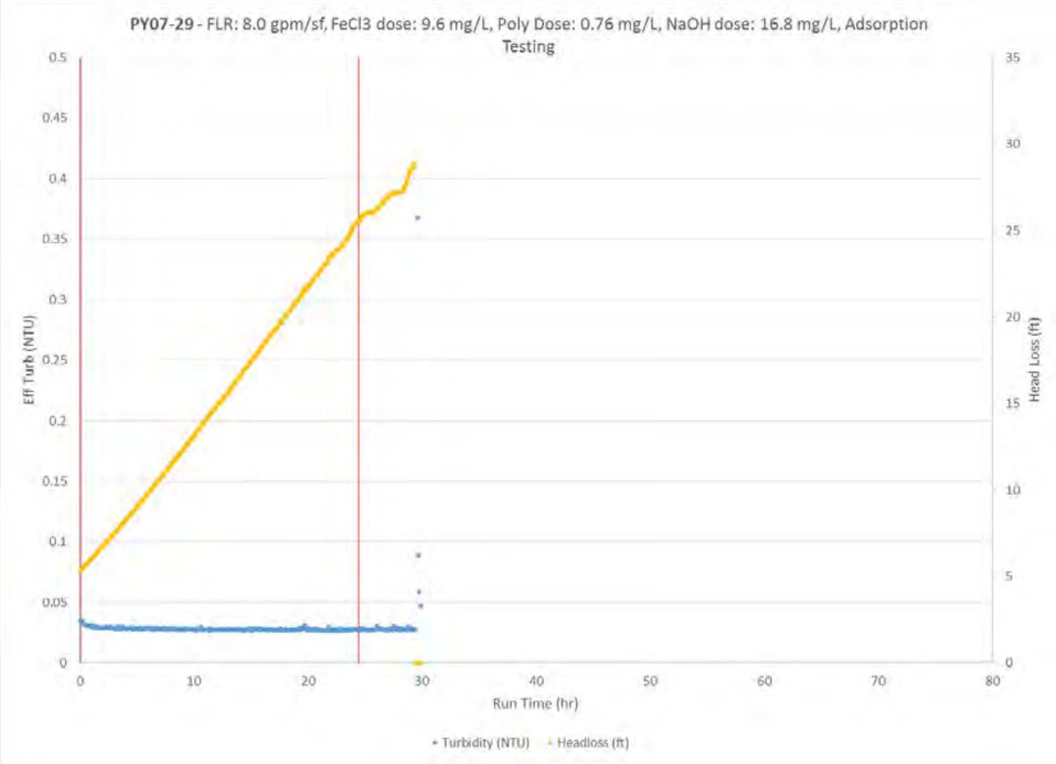

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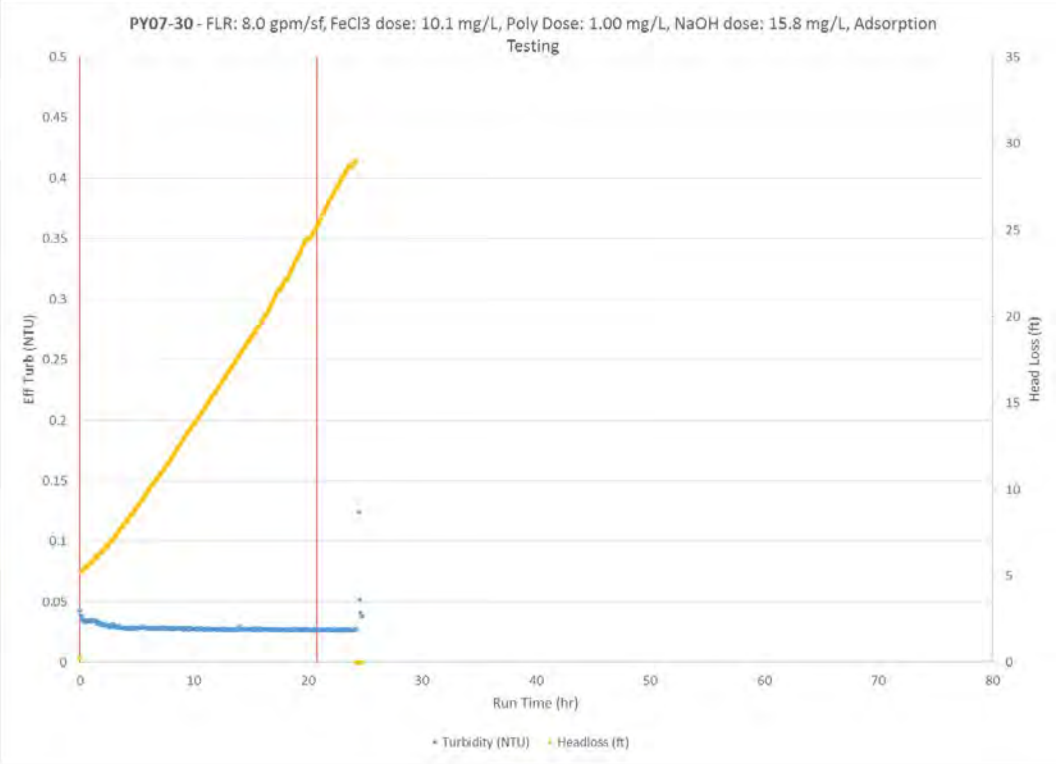

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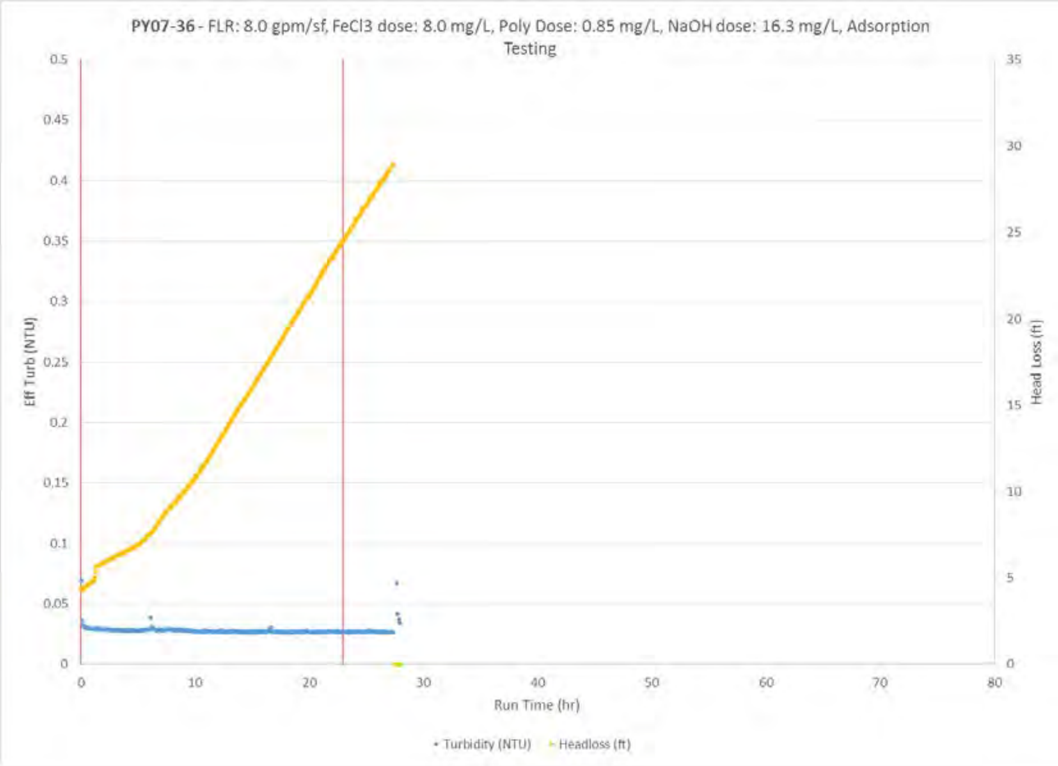

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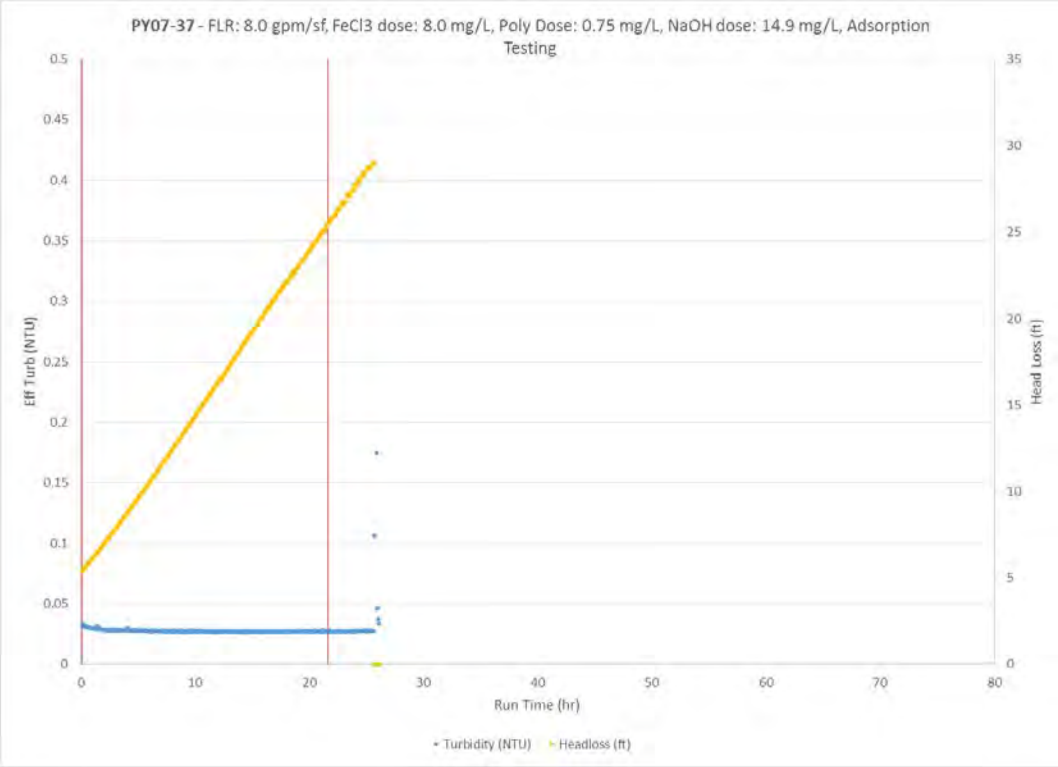

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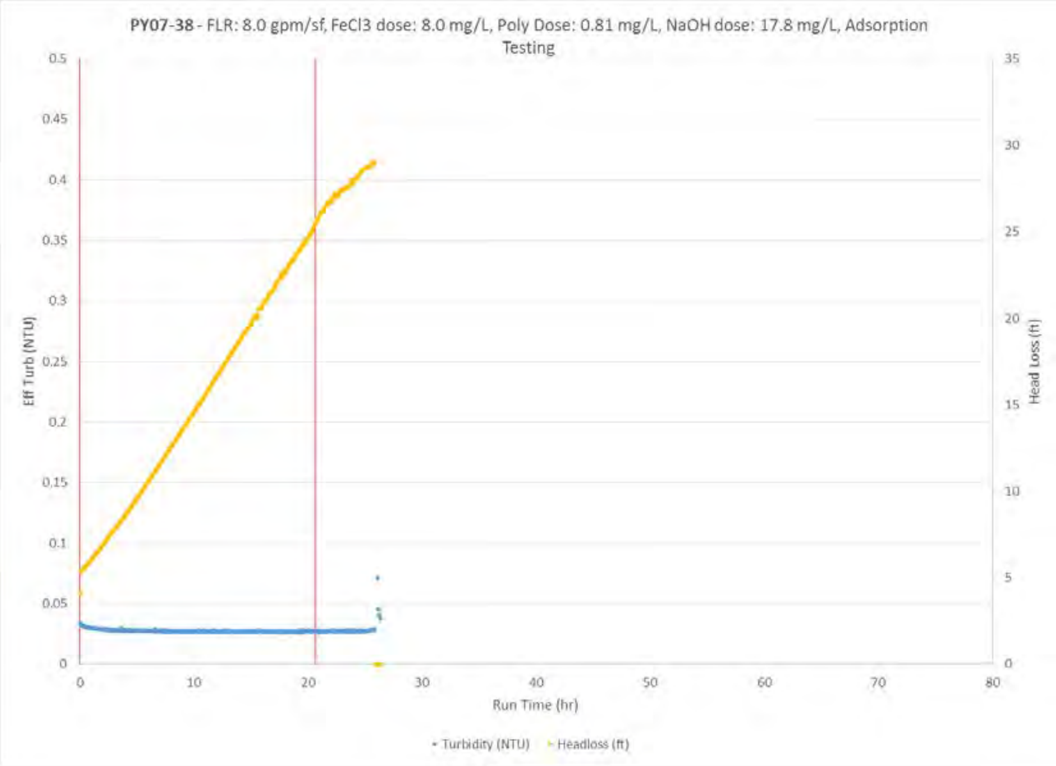

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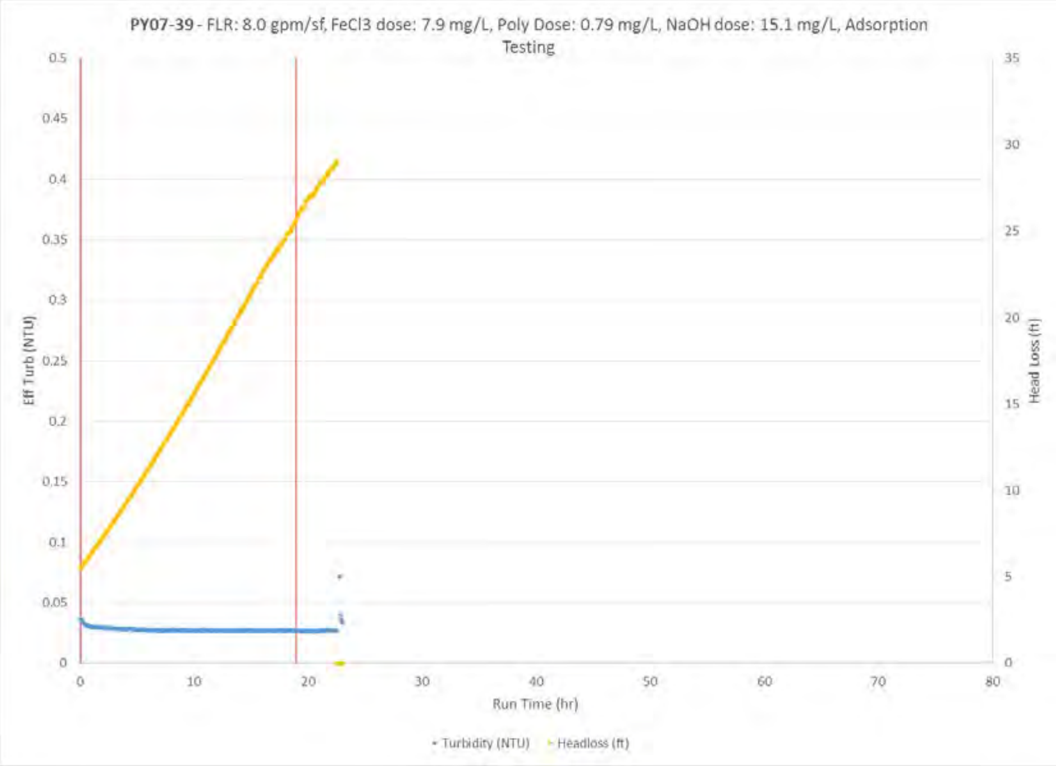

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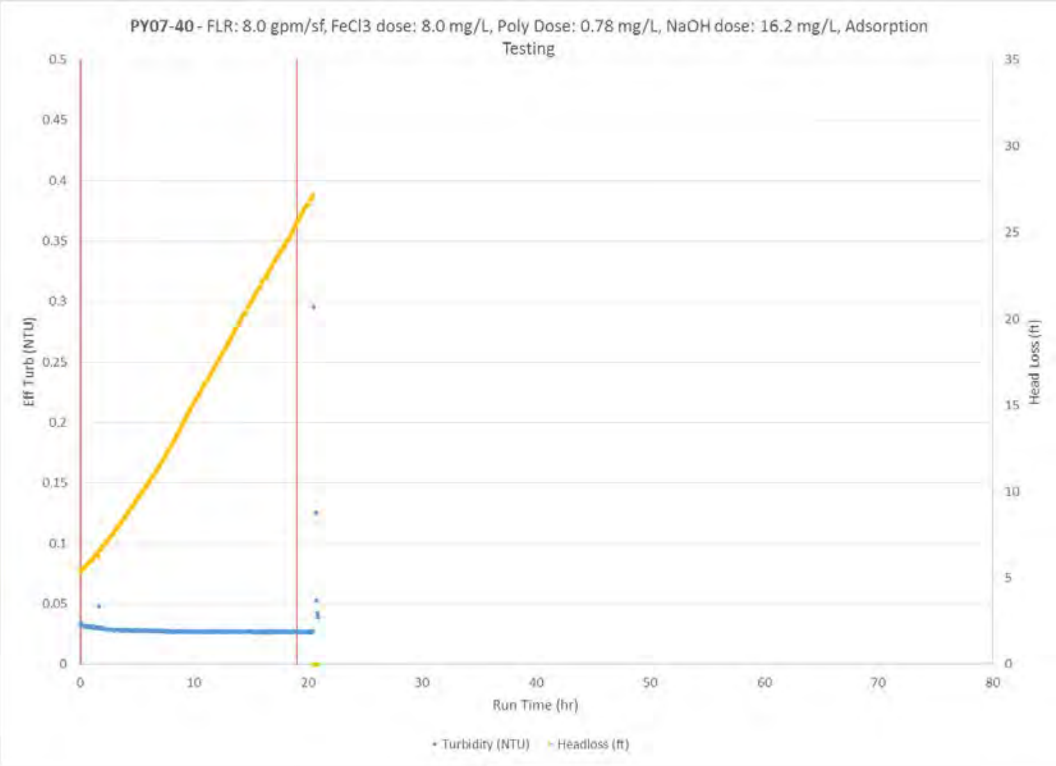

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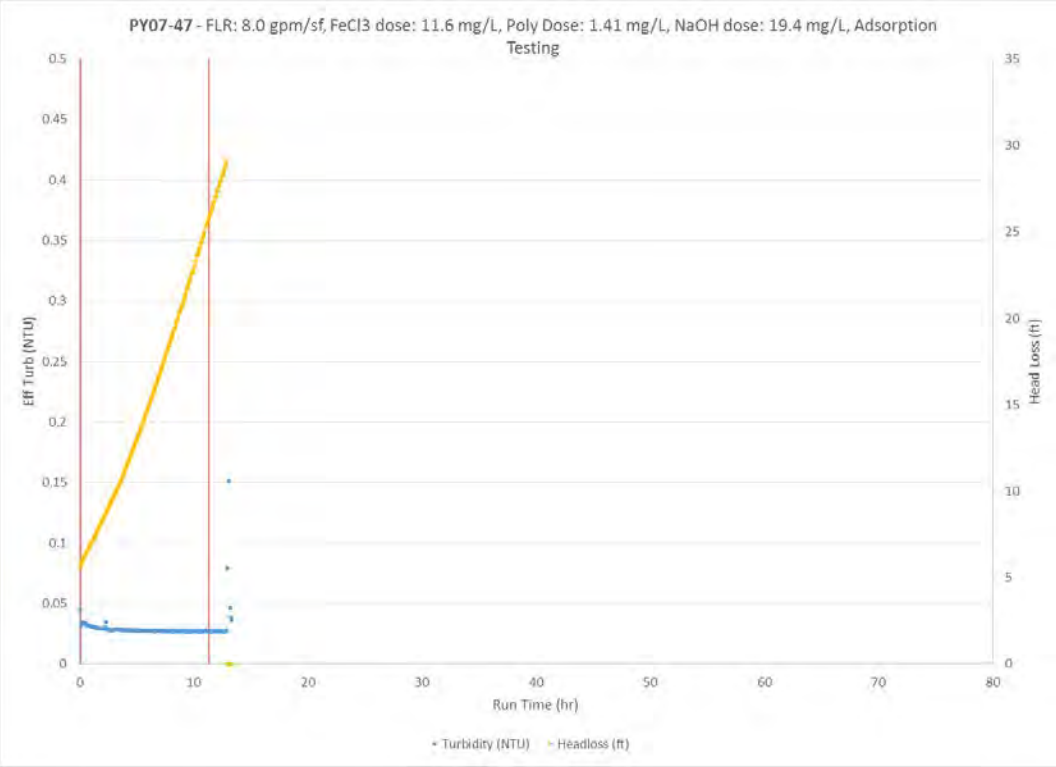

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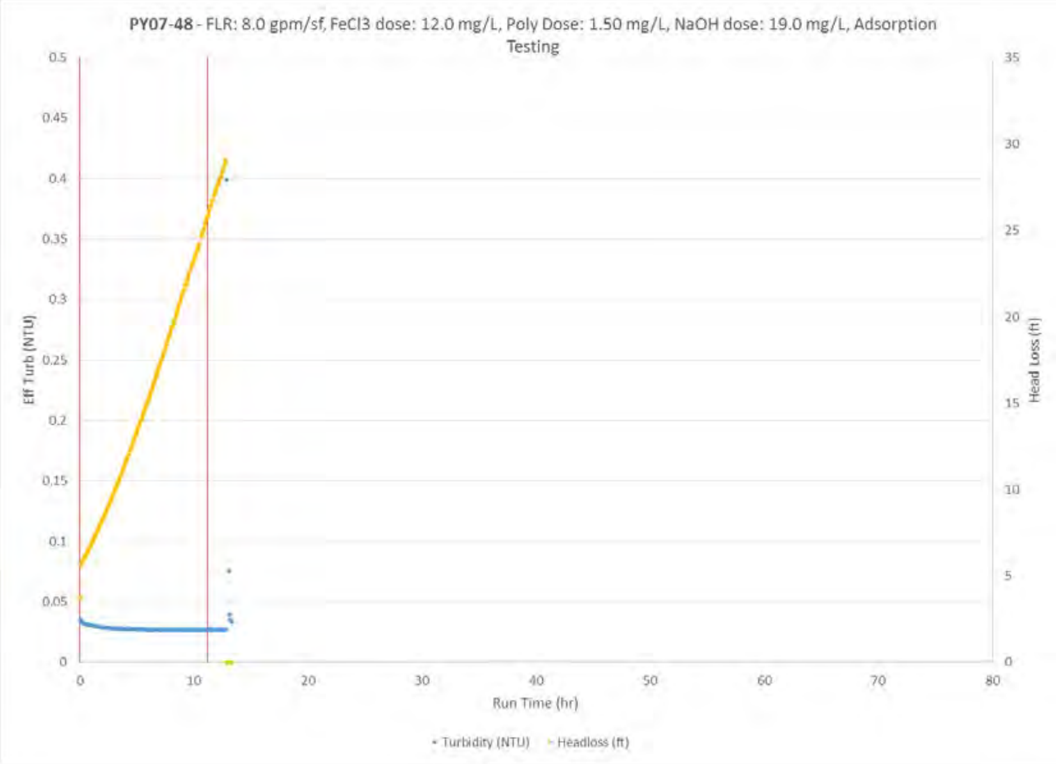

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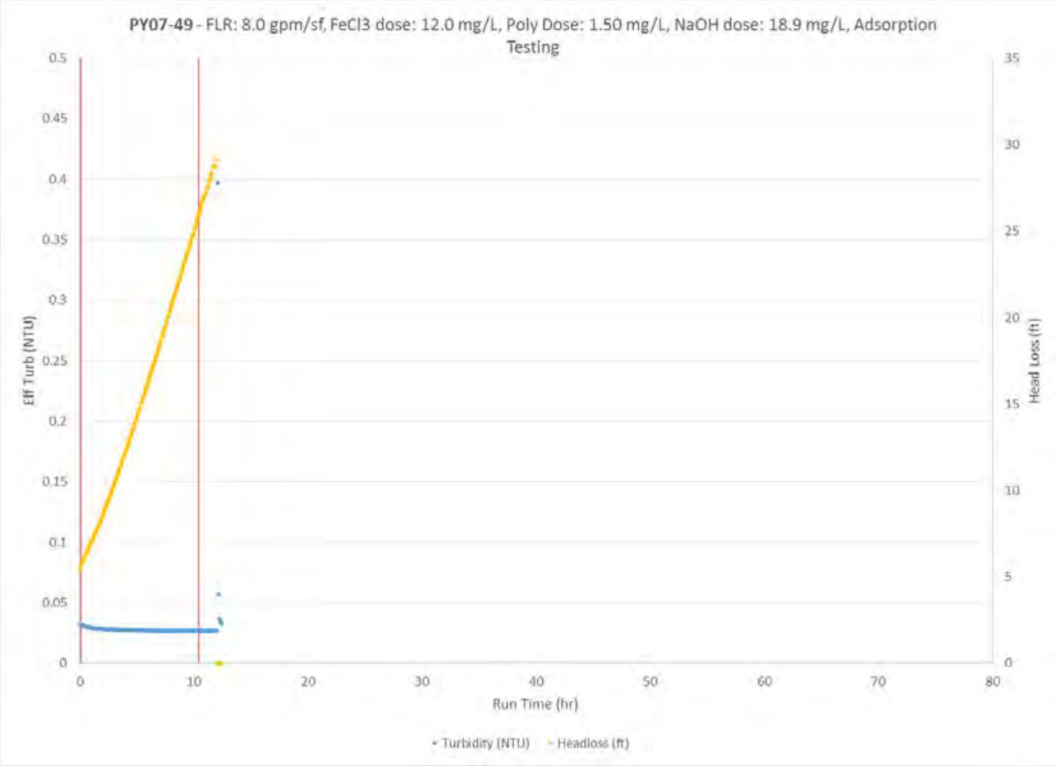

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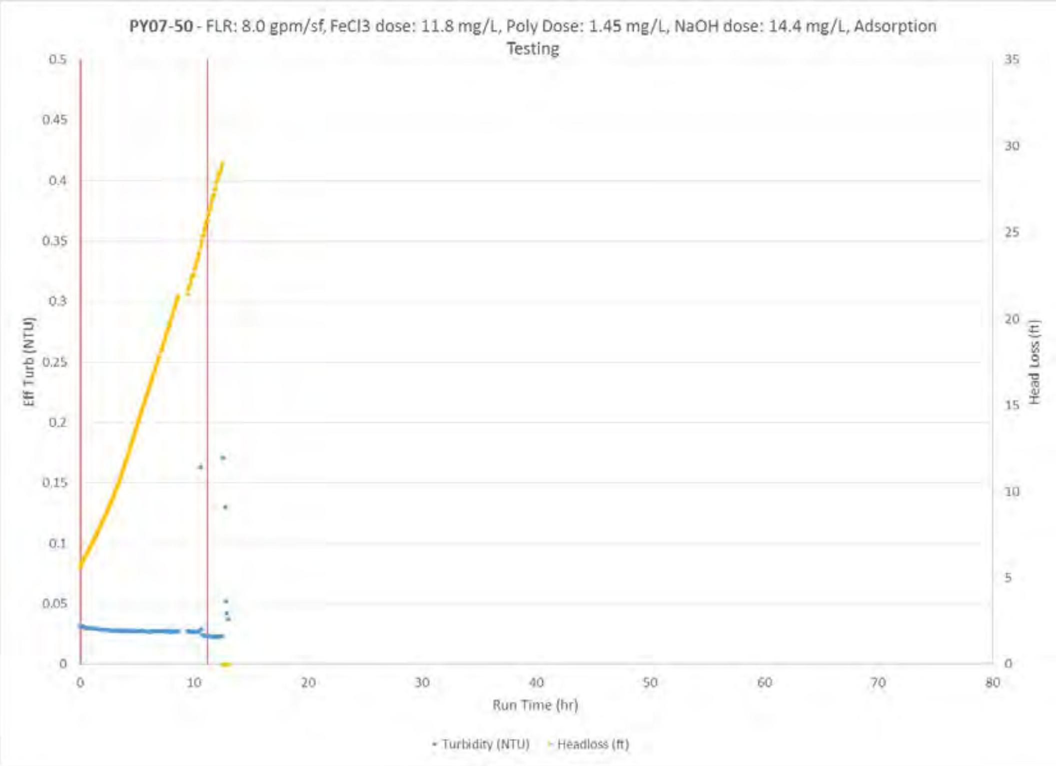

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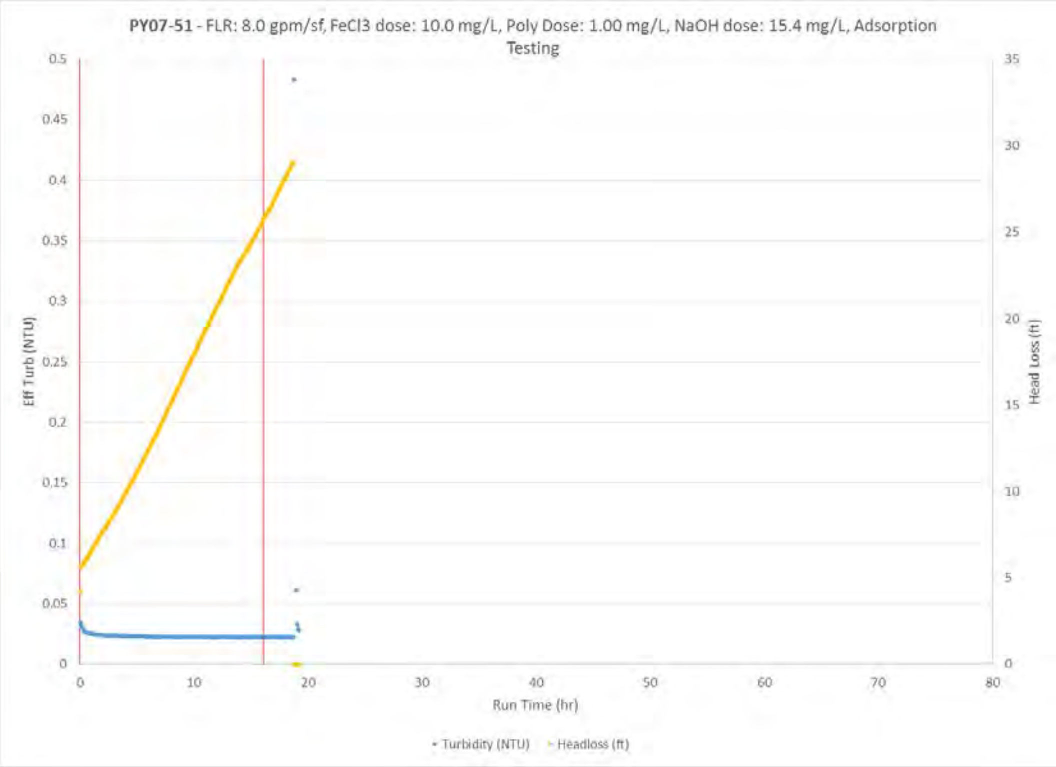

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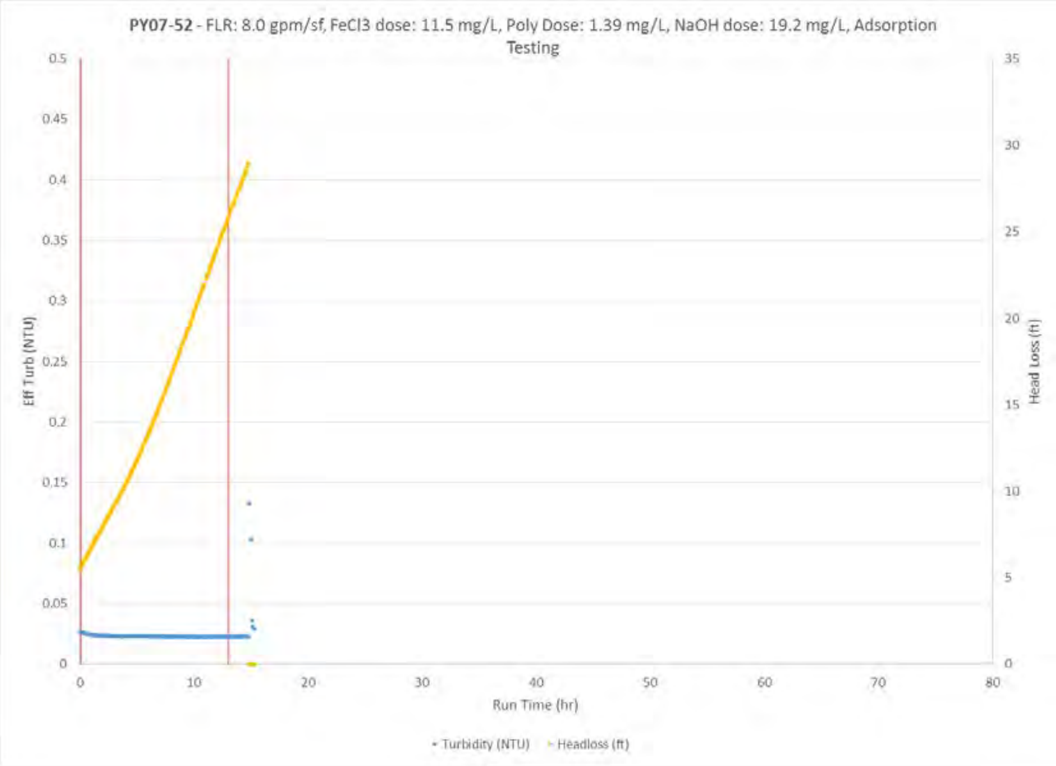

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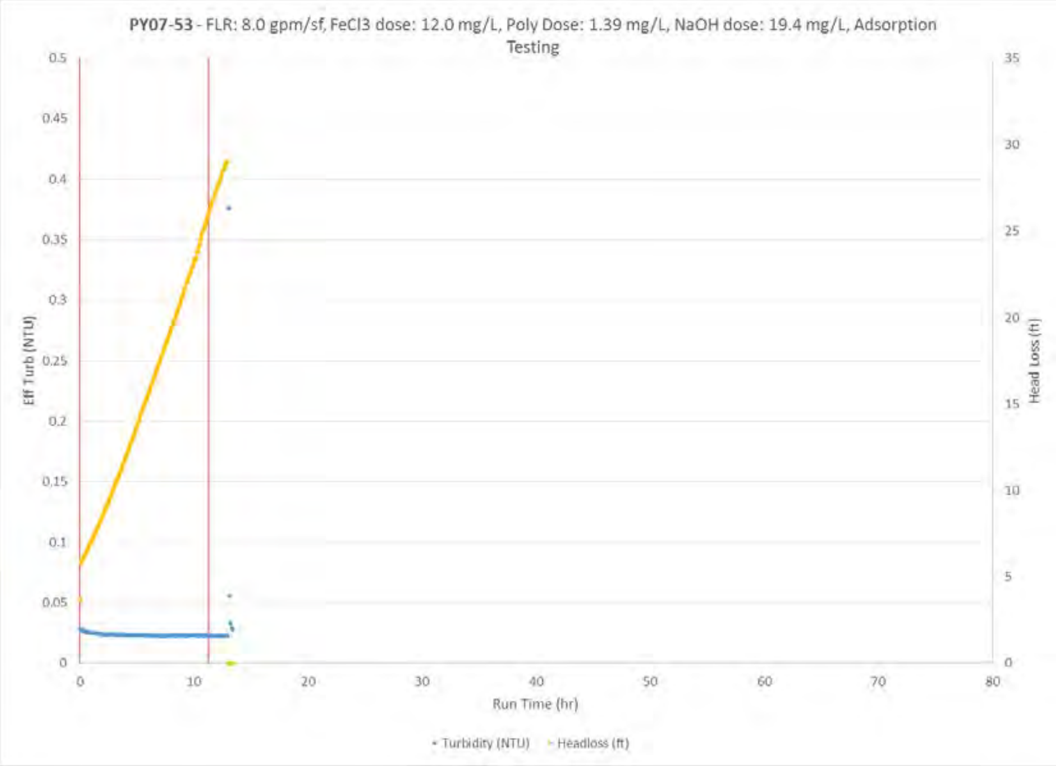

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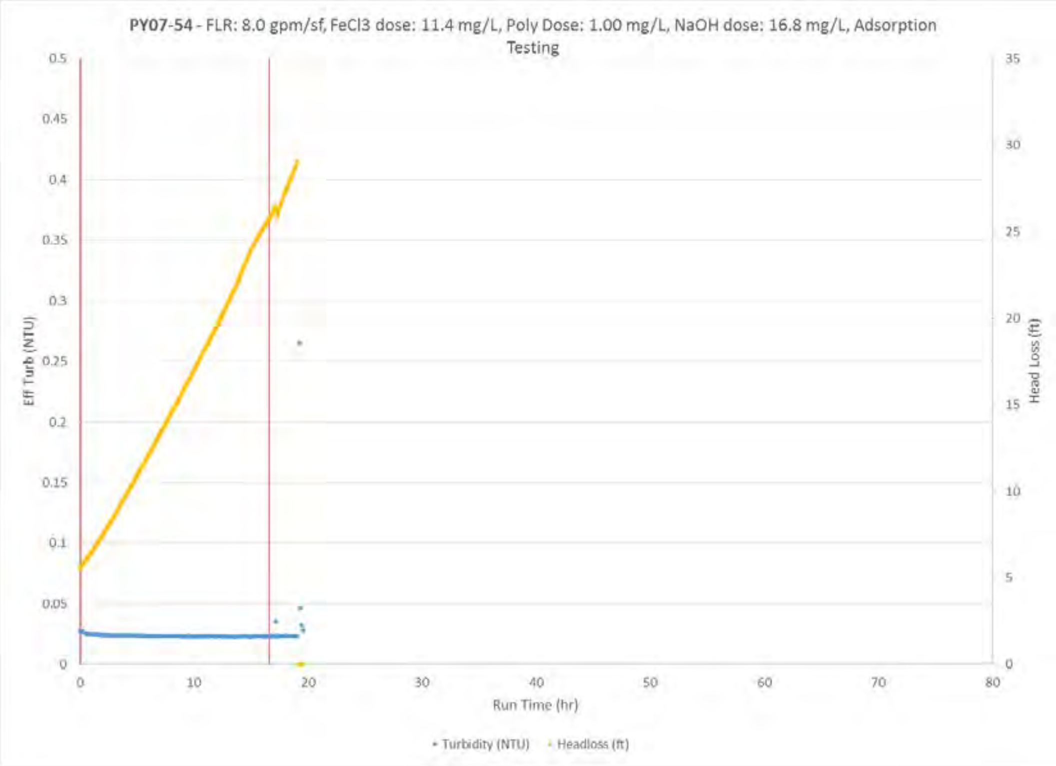

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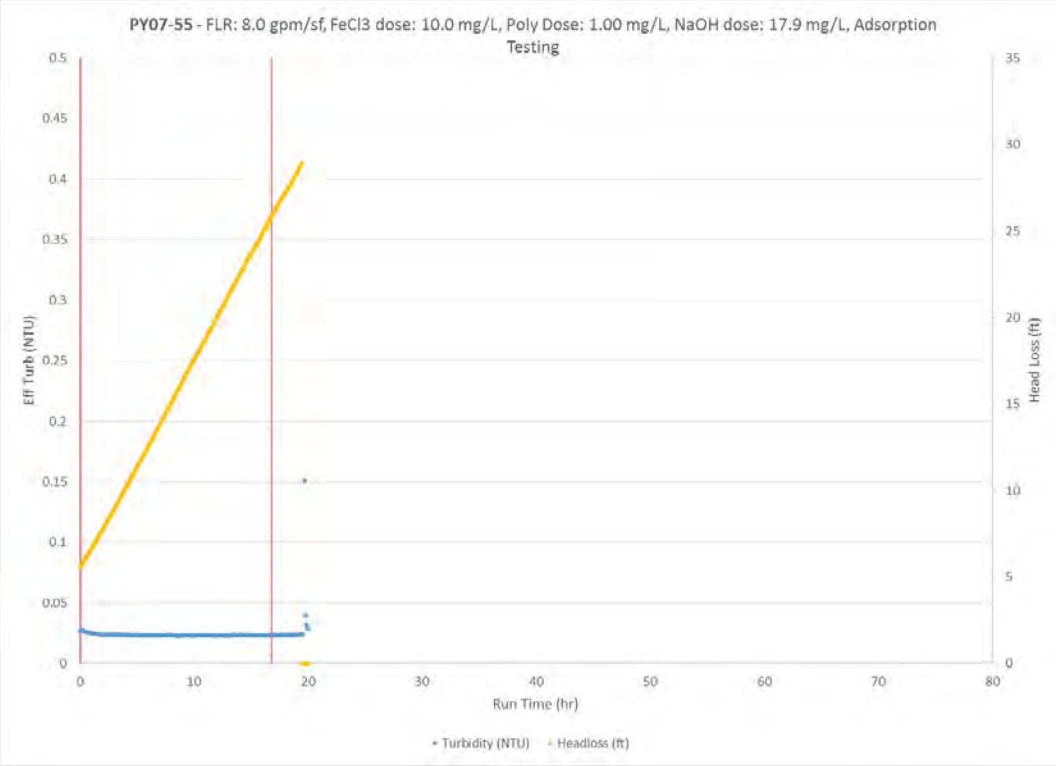

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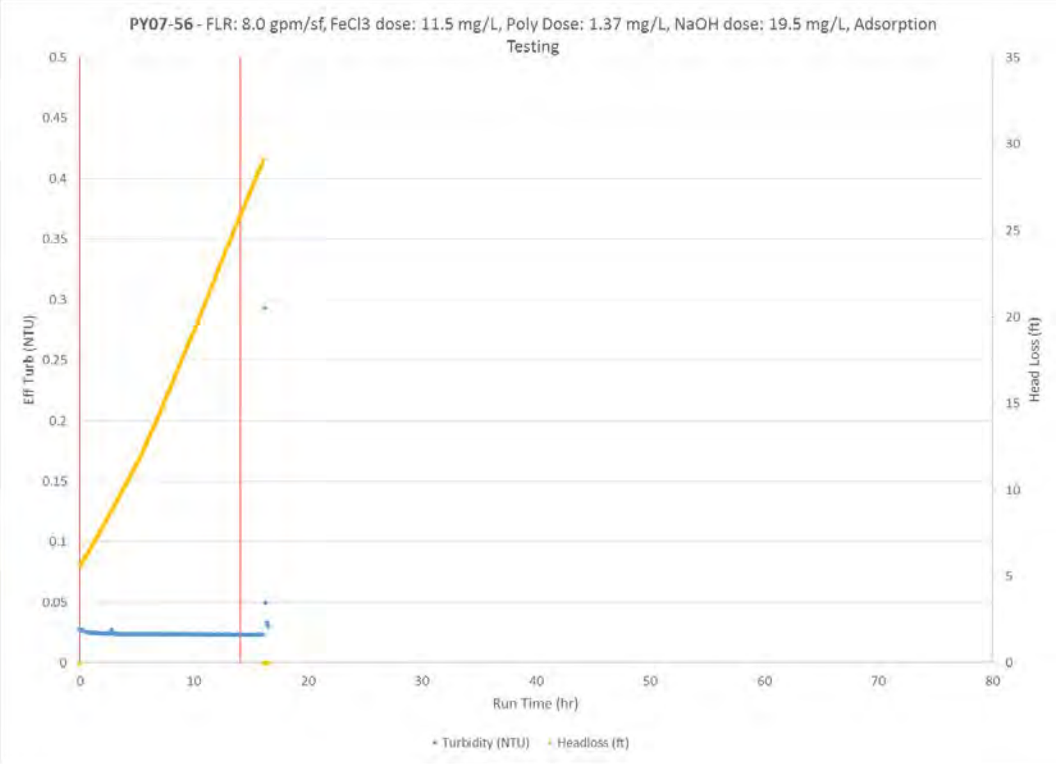

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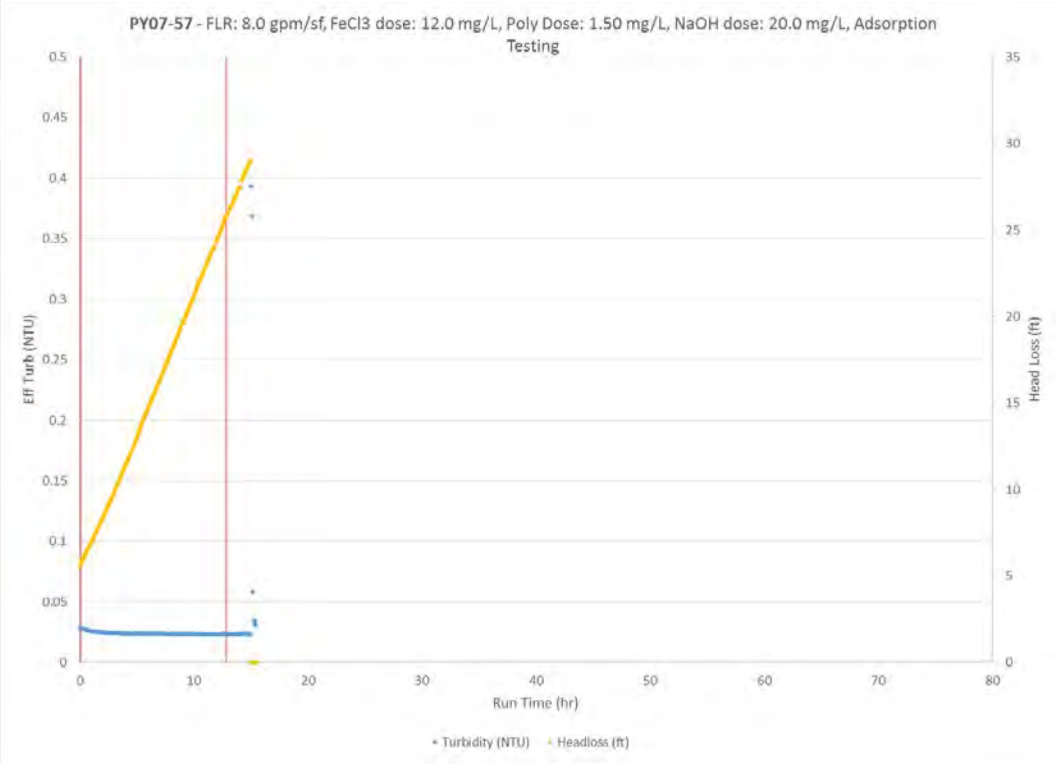

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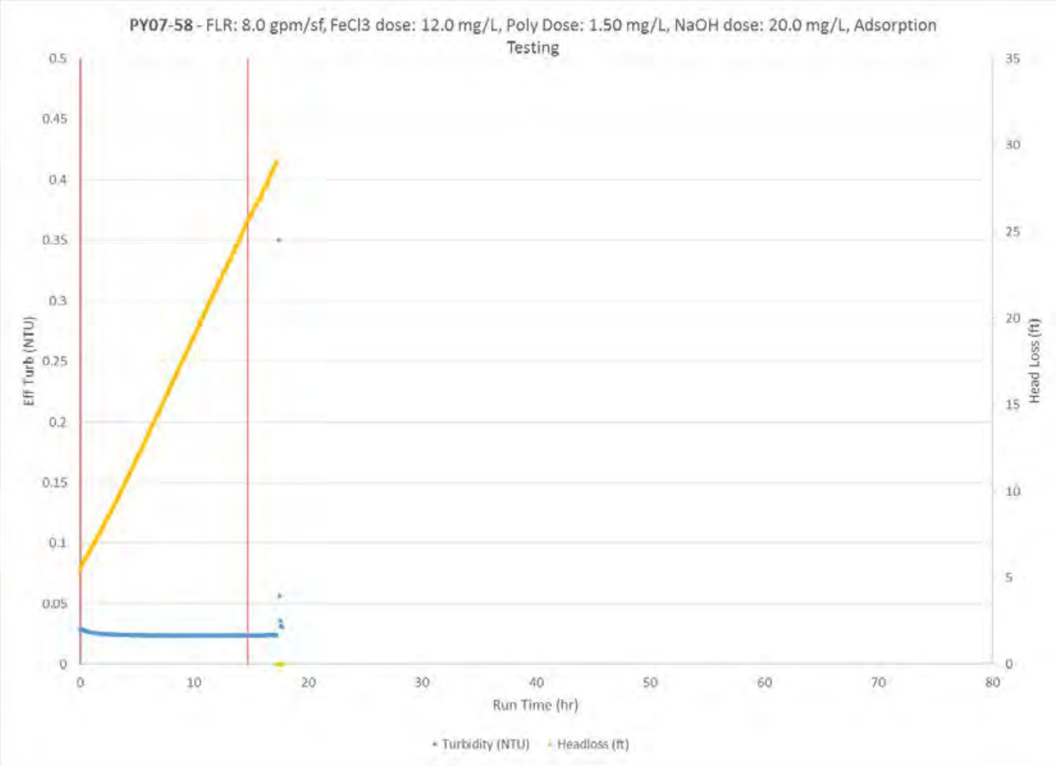

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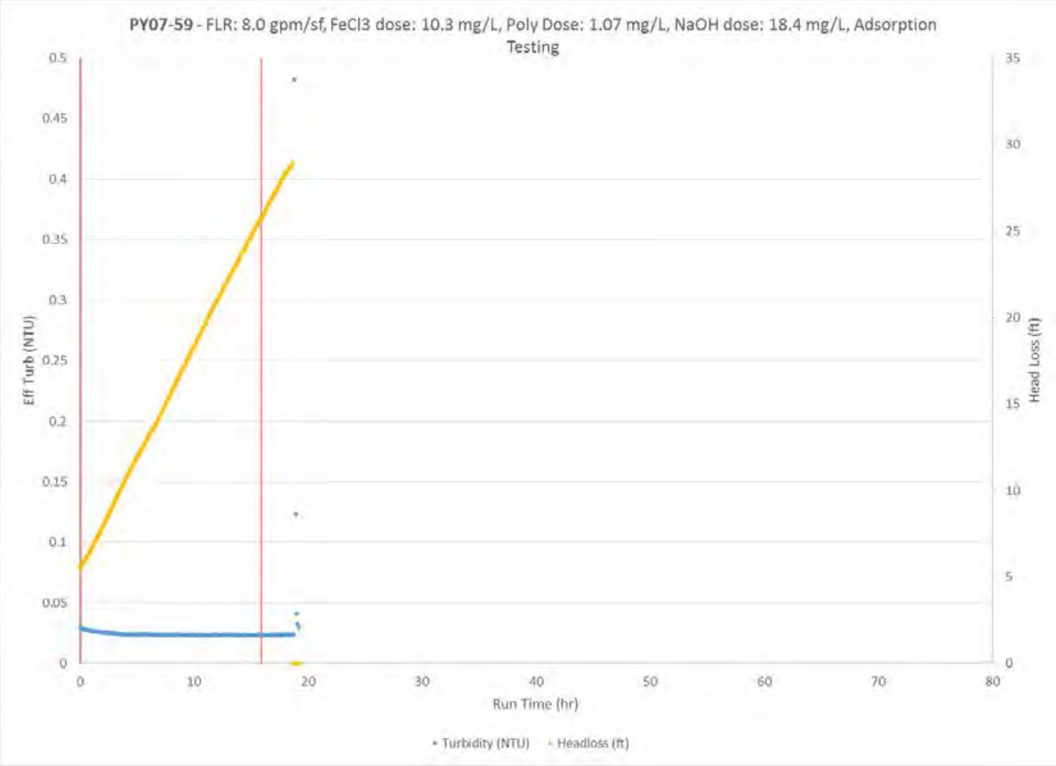

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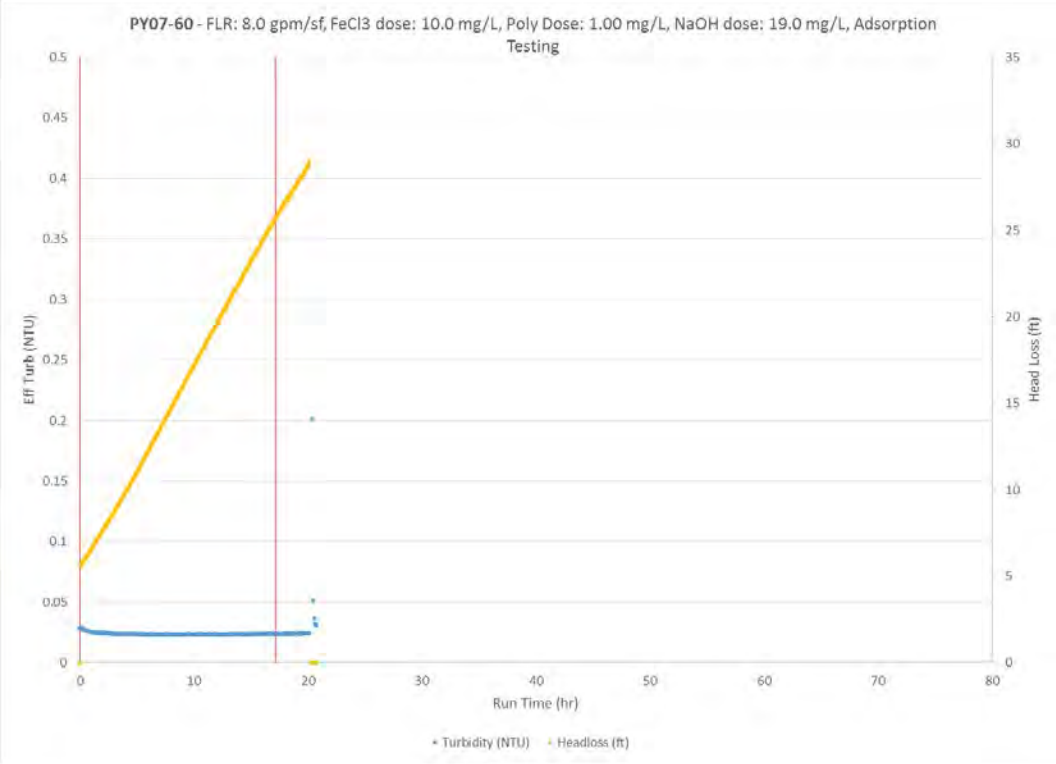

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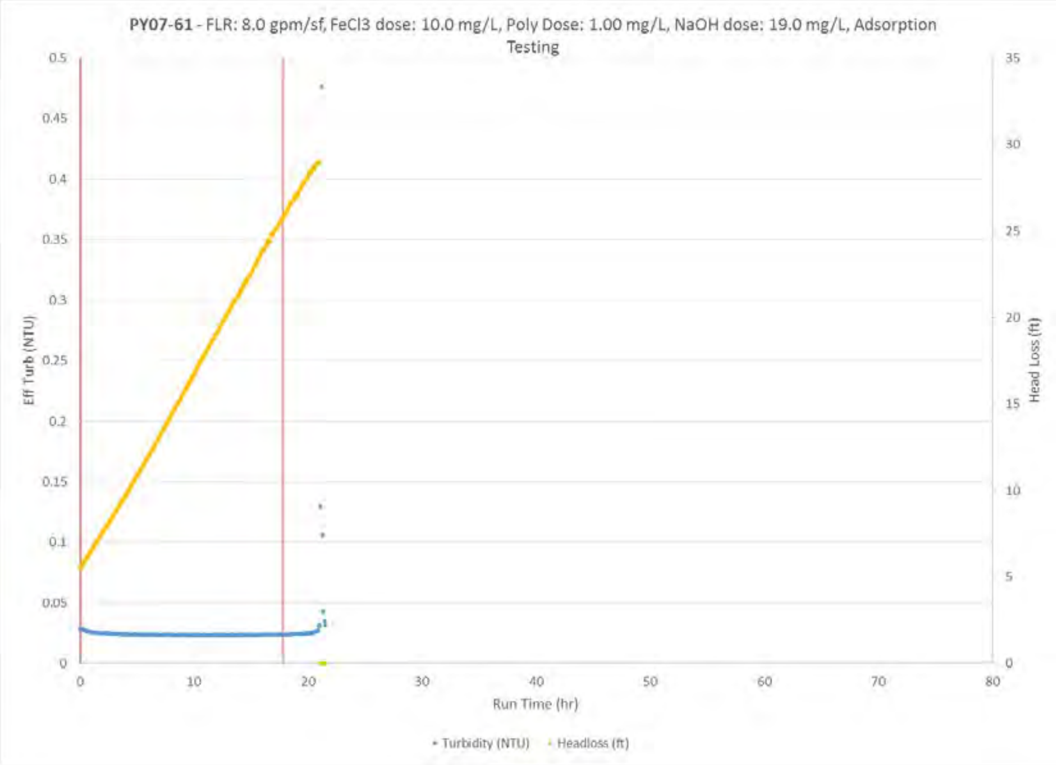

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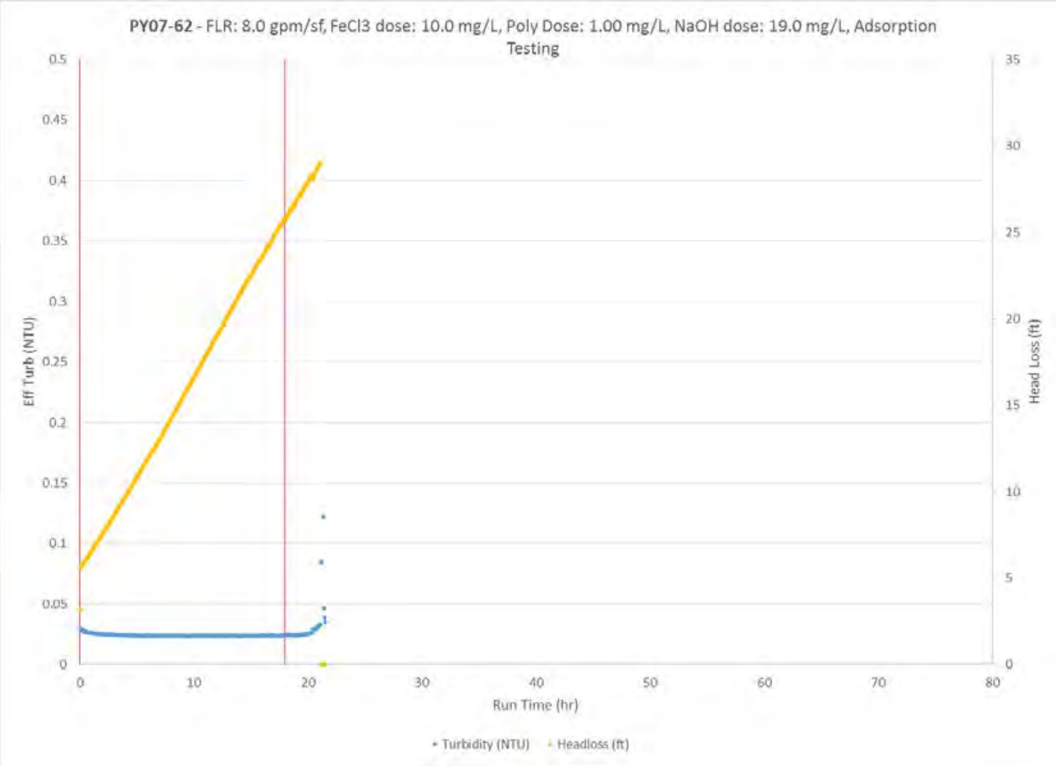

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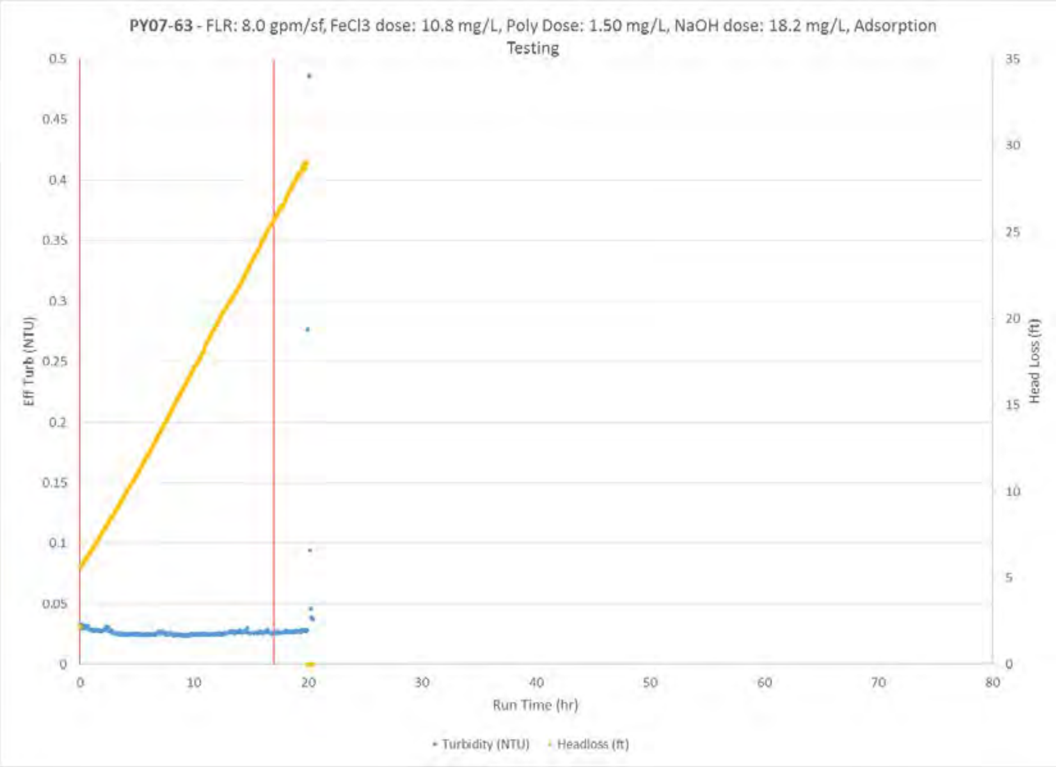

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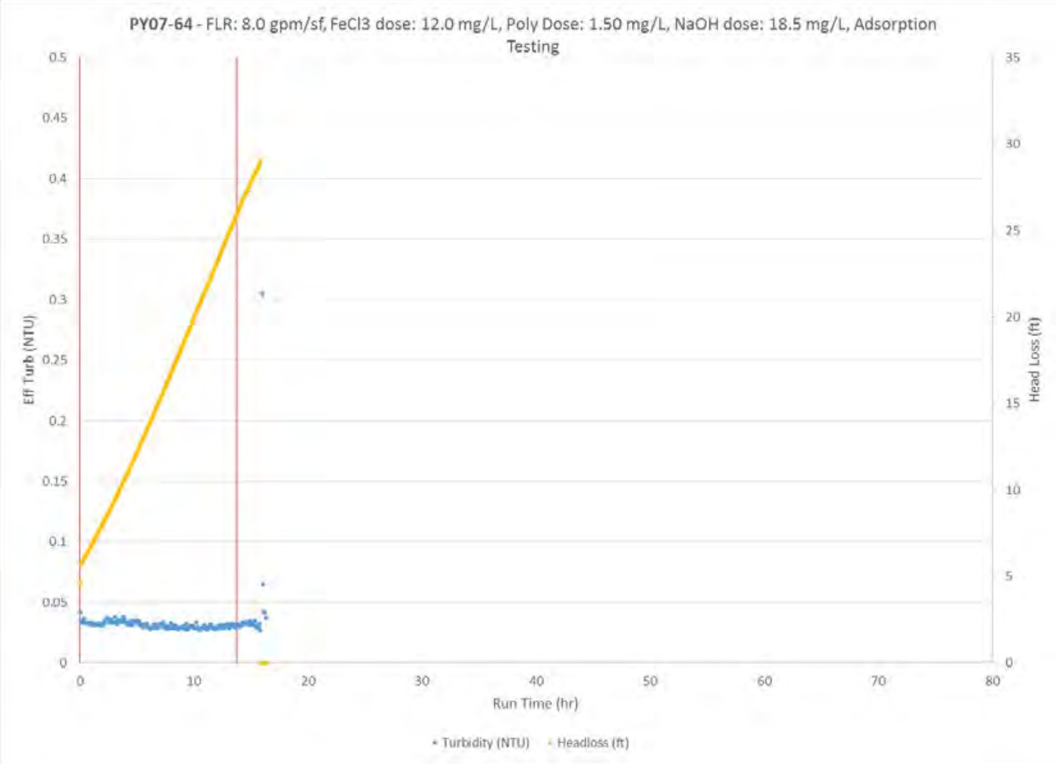

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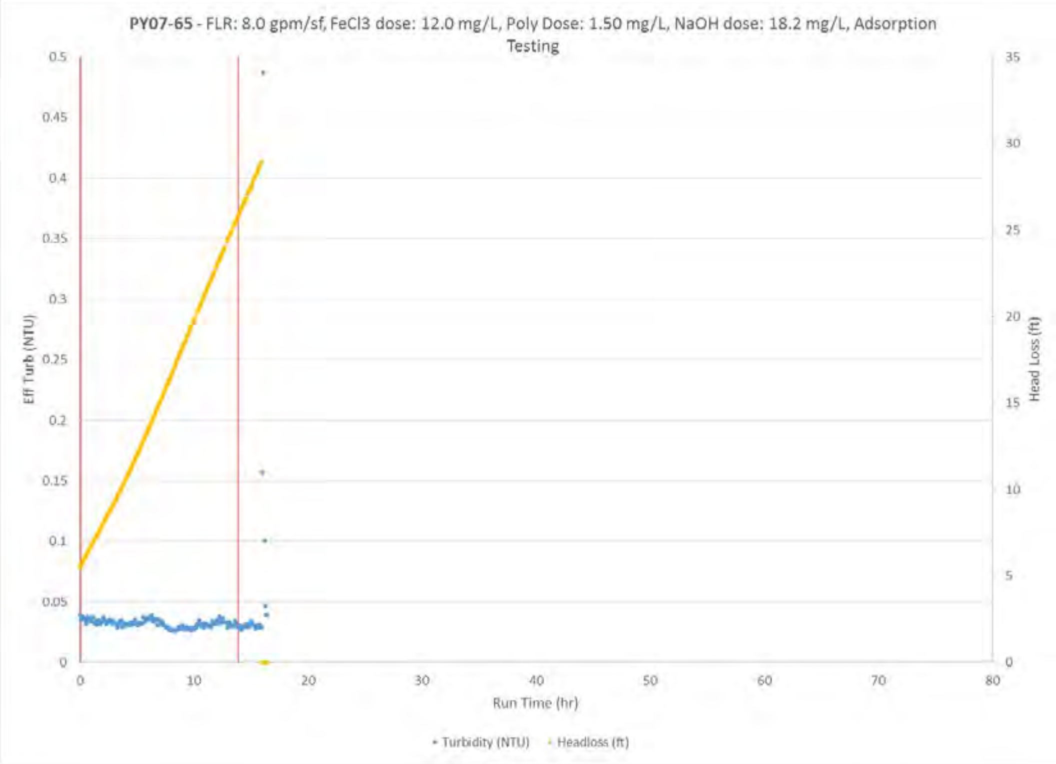

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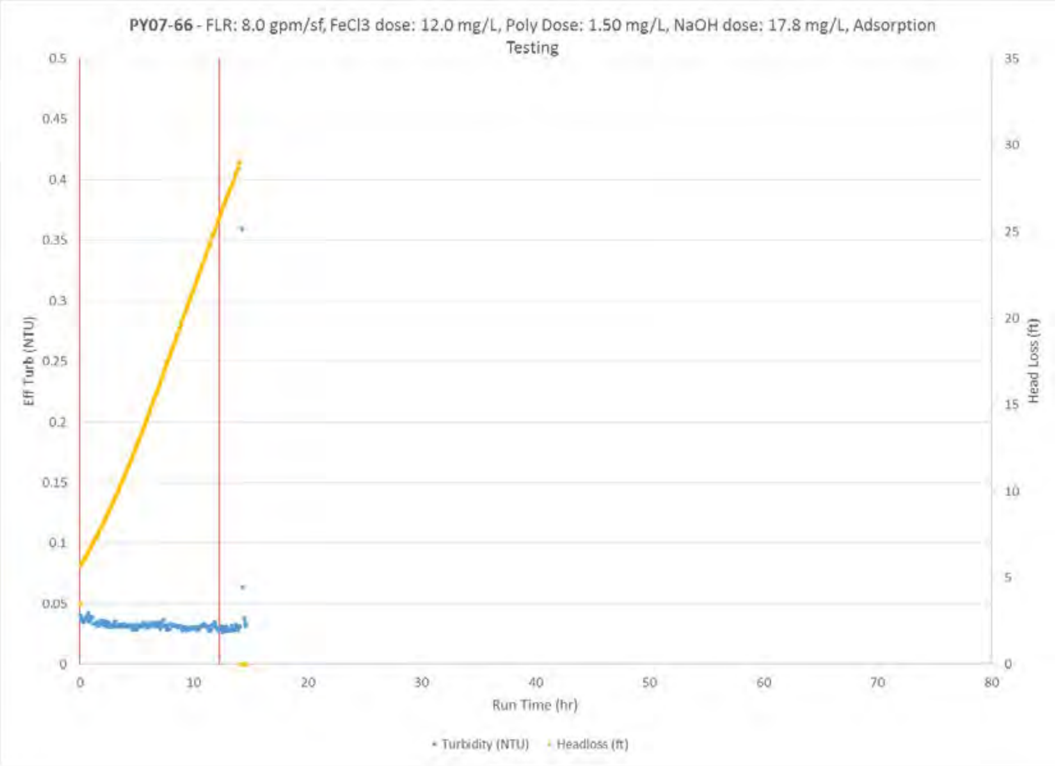

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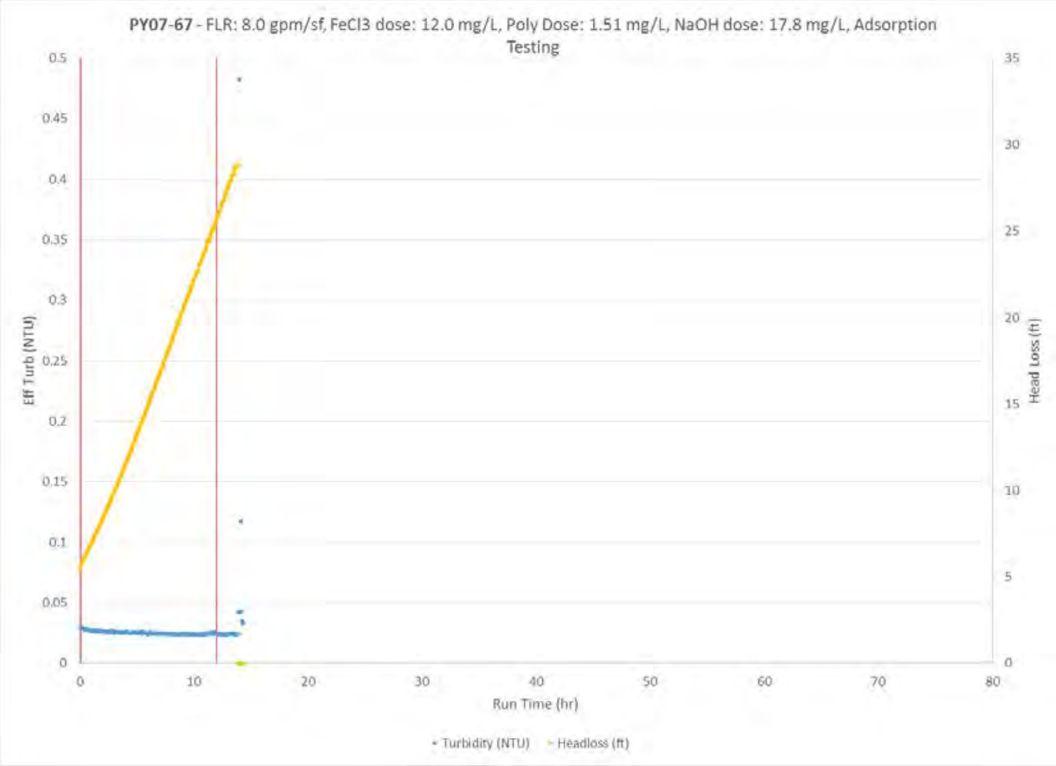

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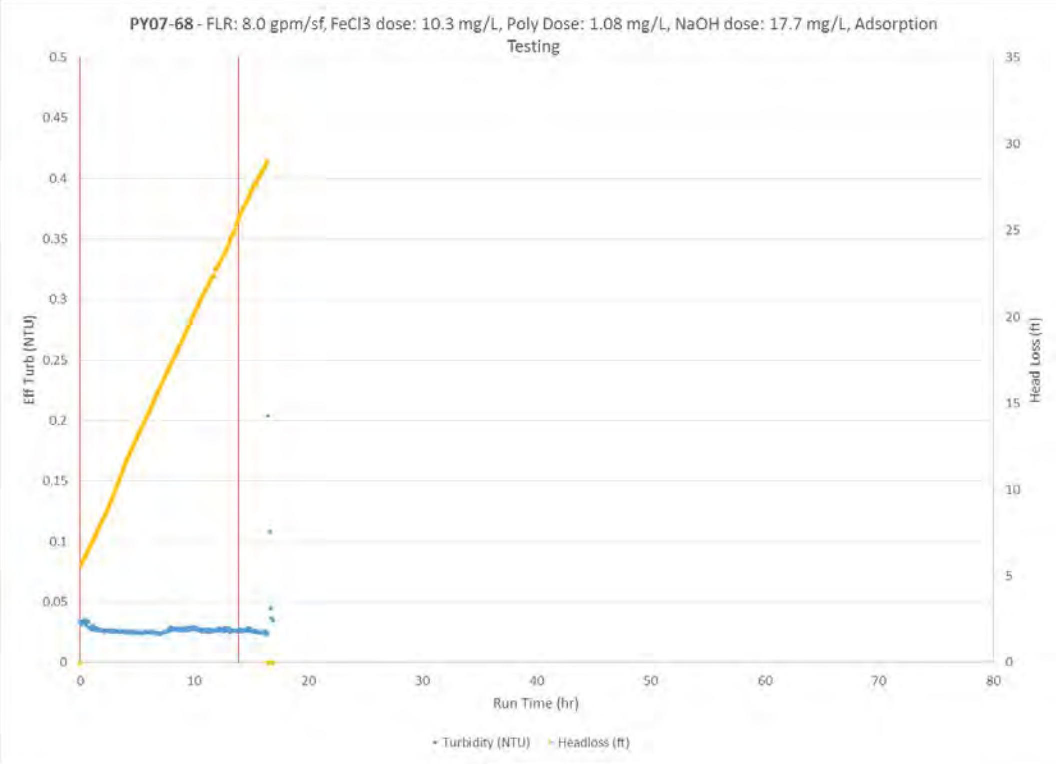

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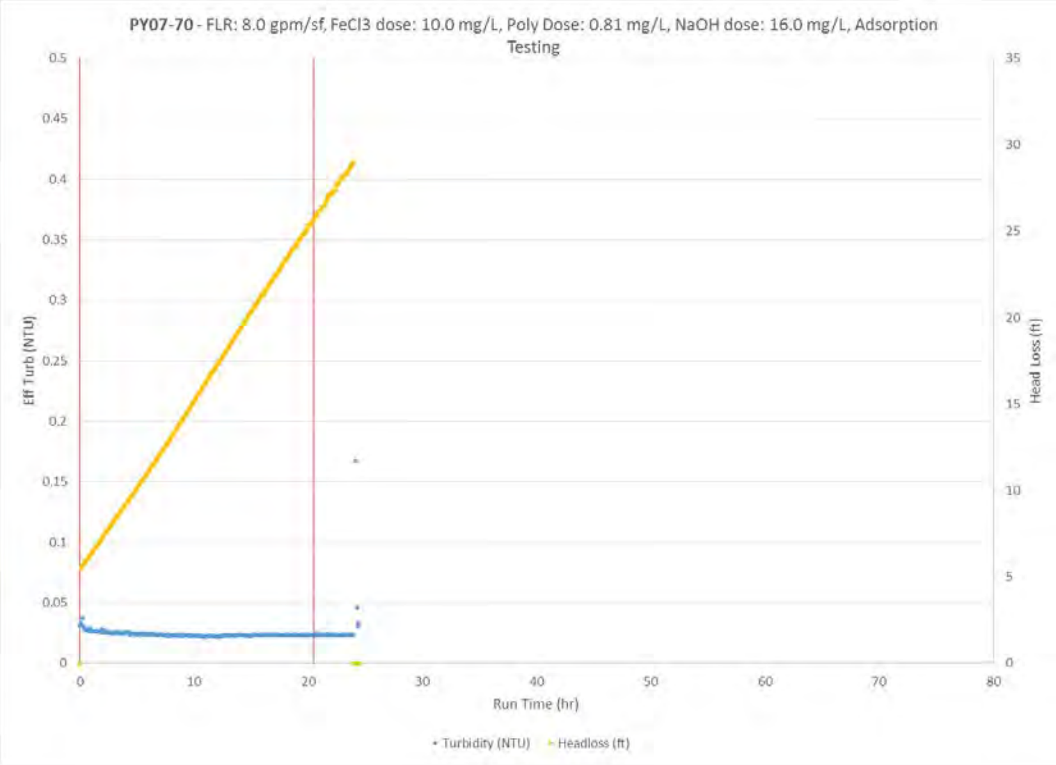

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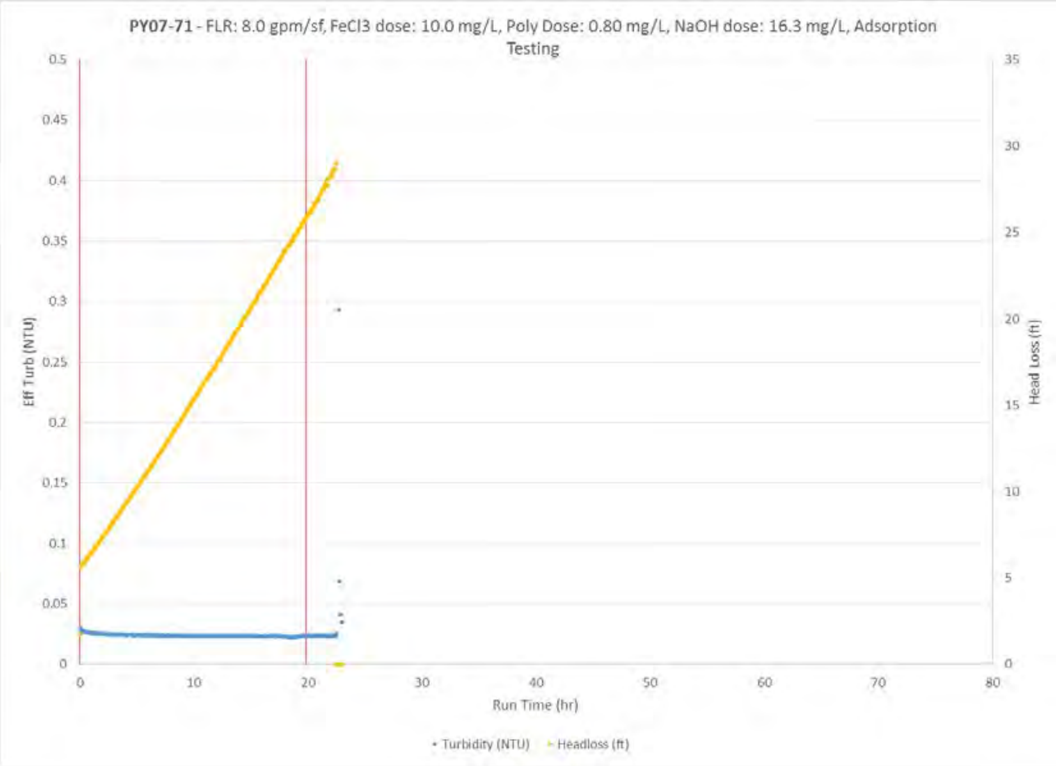

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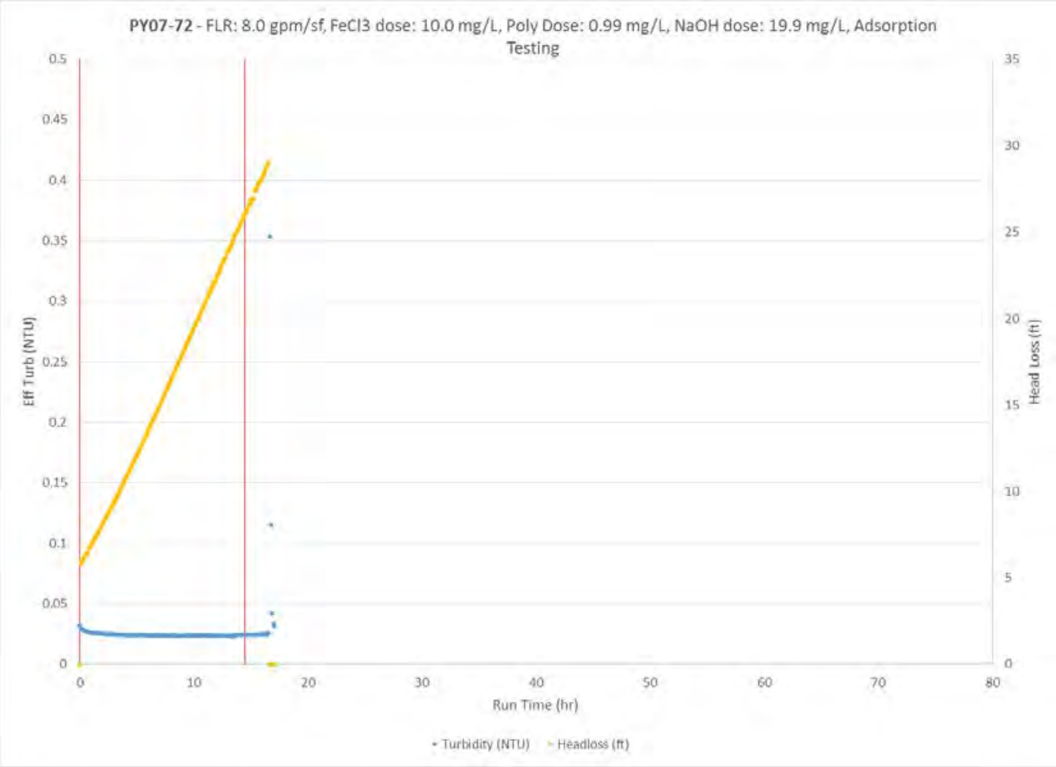

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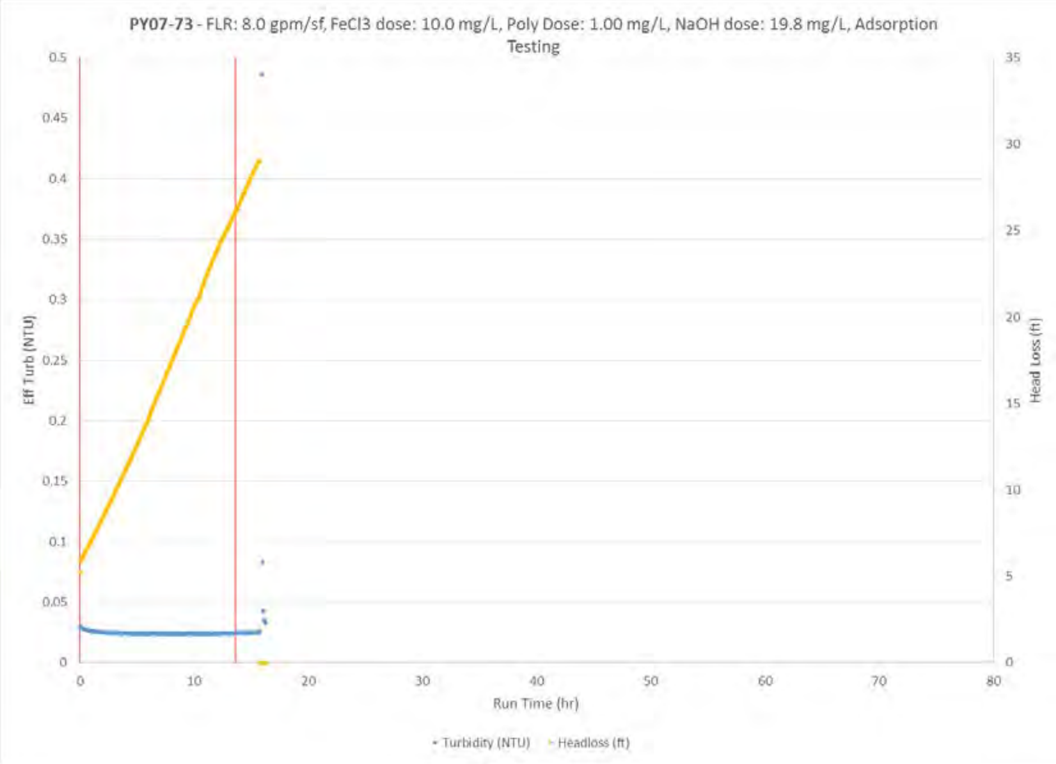

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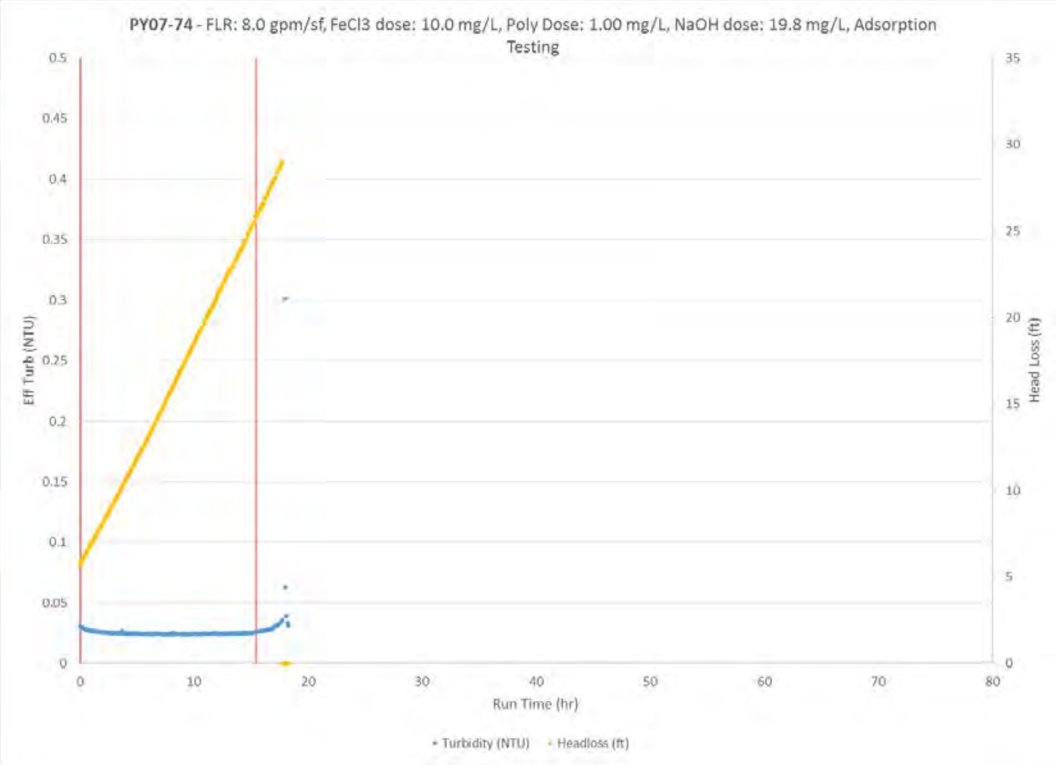

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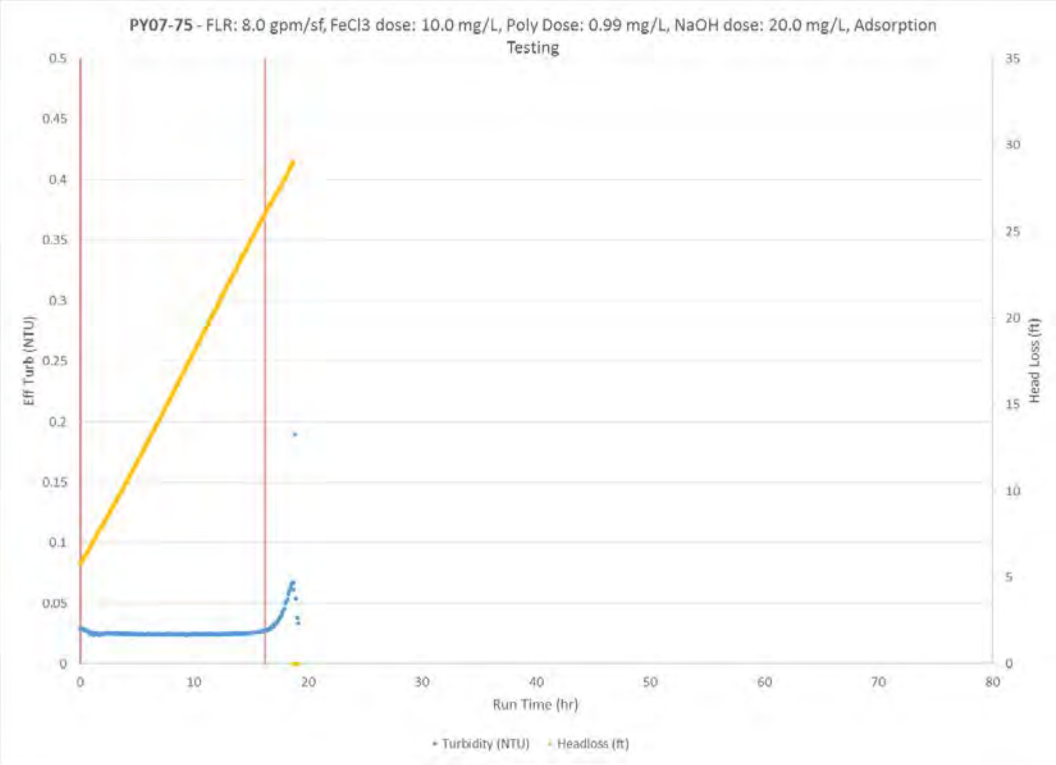

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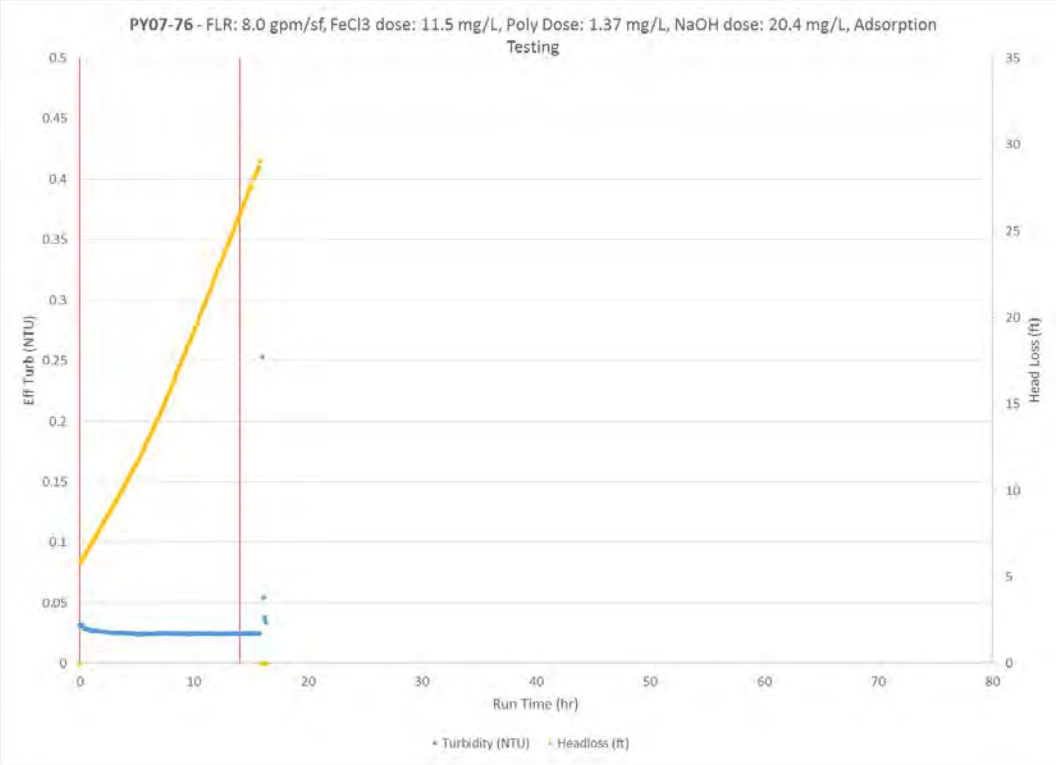

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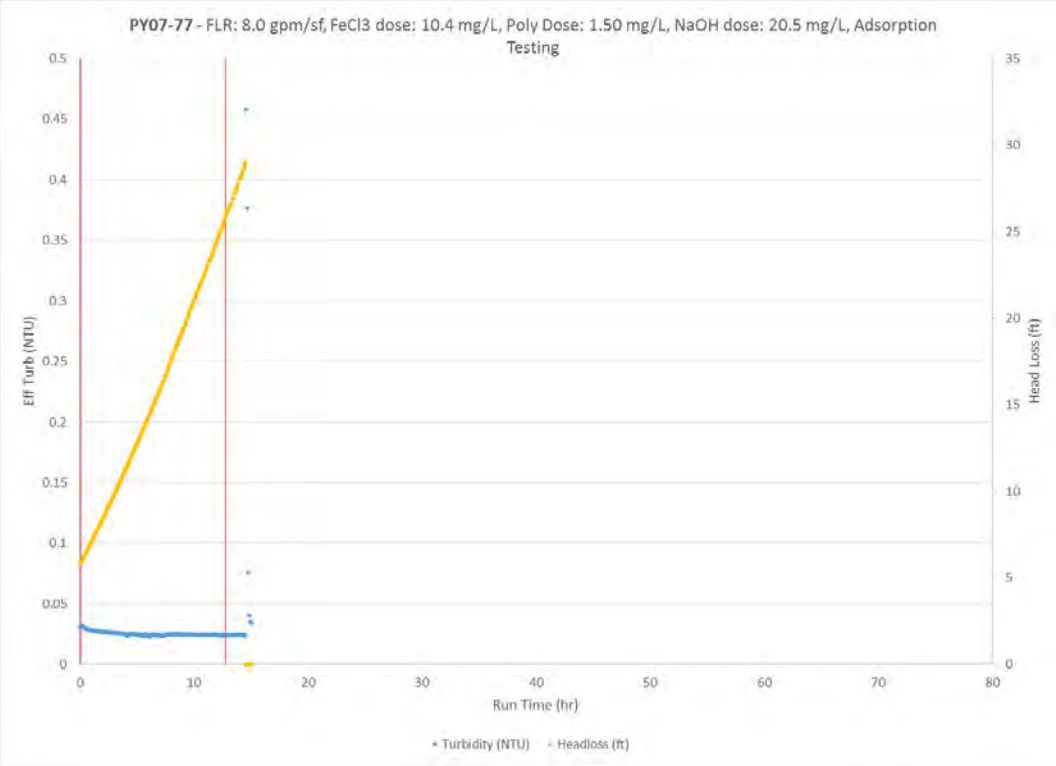

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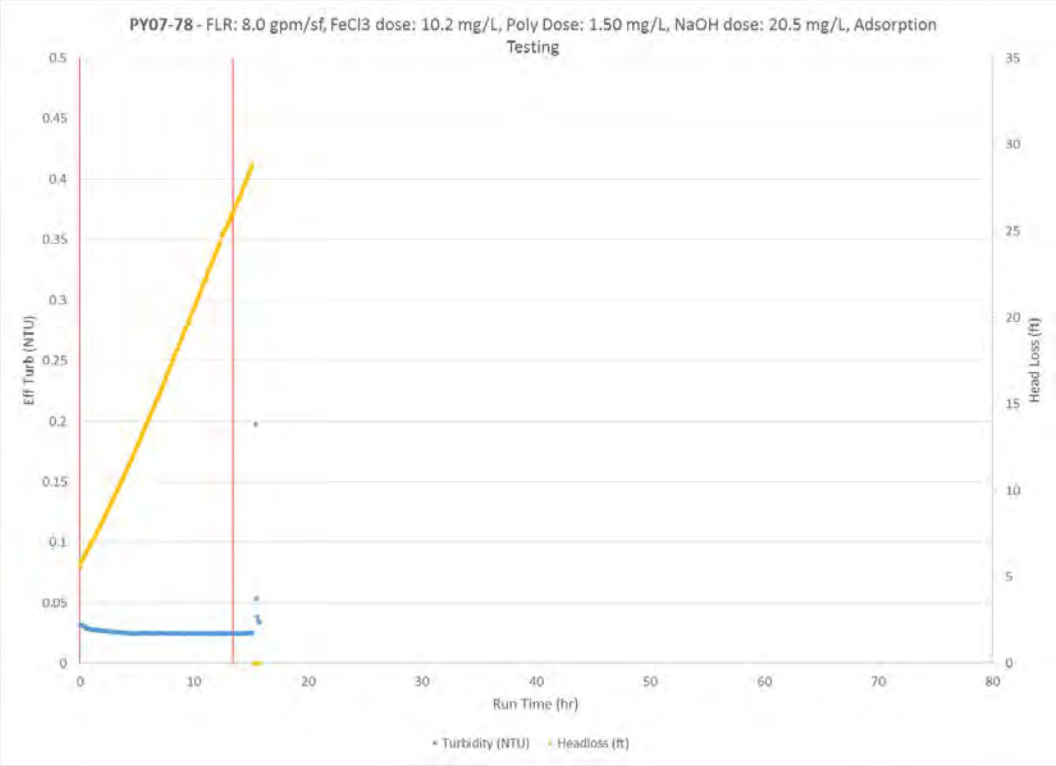

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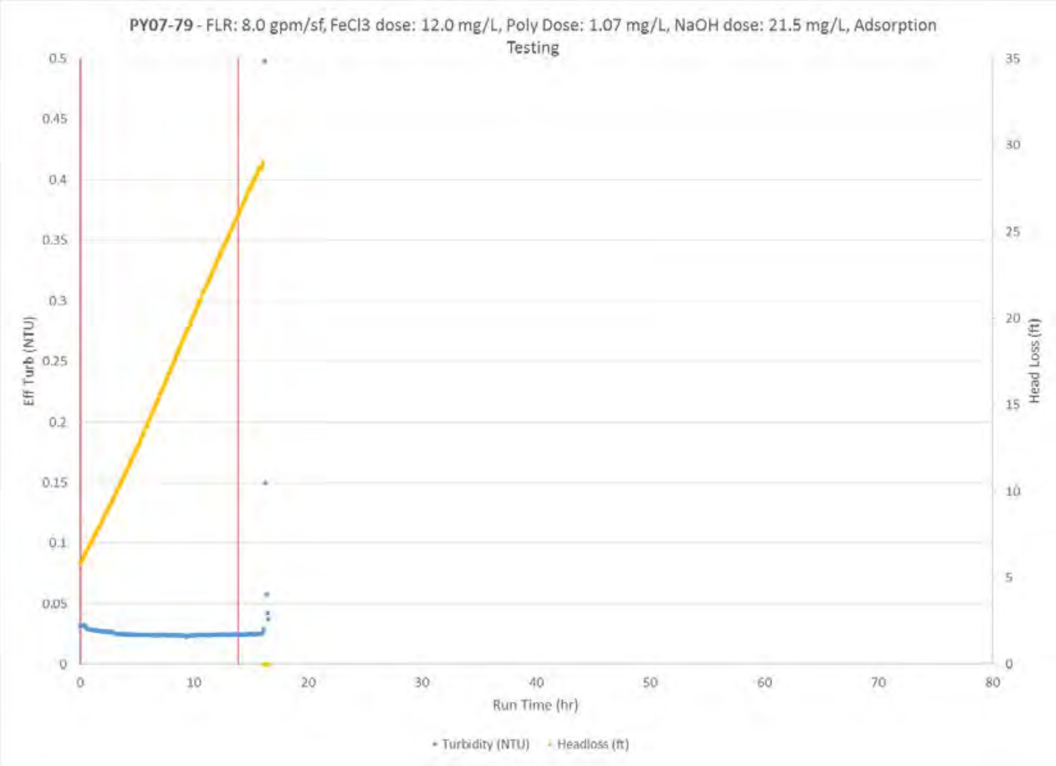

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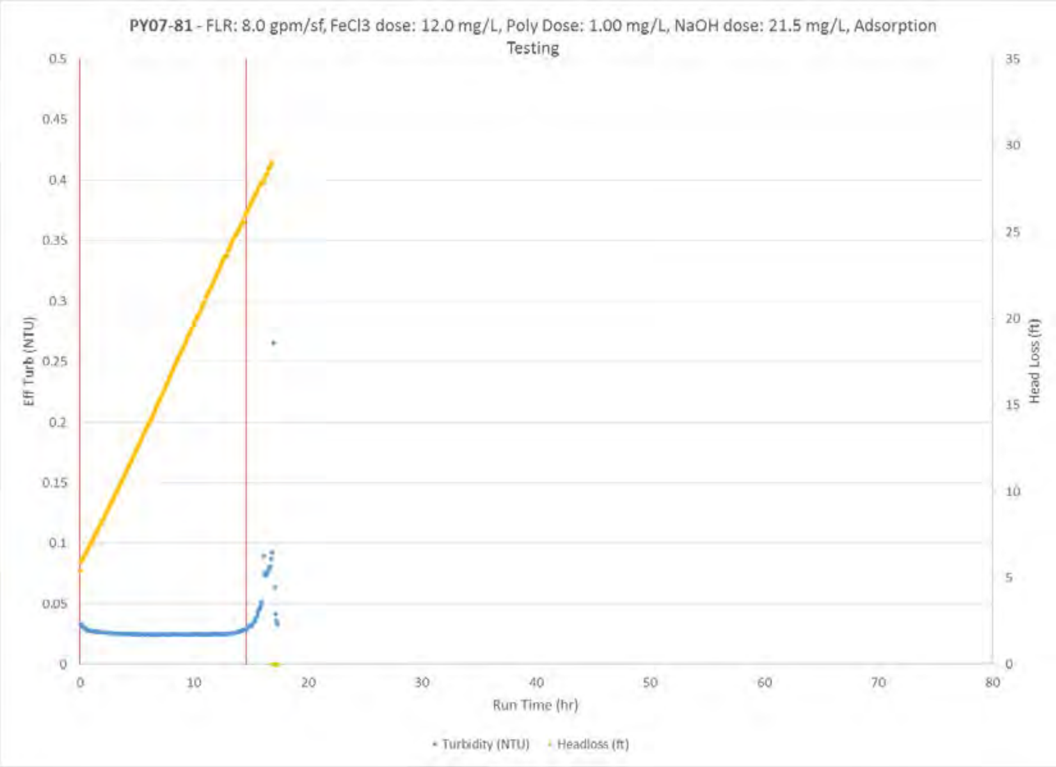

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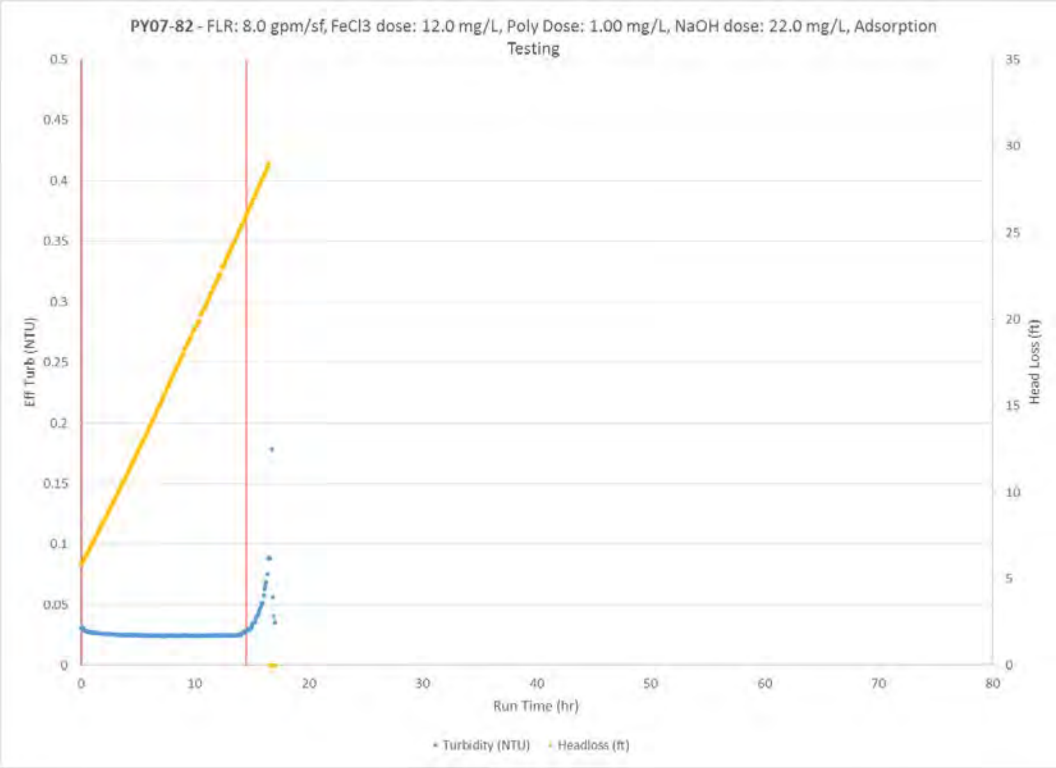


Appendix G
Pilot Testing Protocol

Judge and Spiro Tunnels Mining-Influenced Water Treatment Evaluation: Pilot Testing Protocol

PREPARED FOR:	Park City Municipal Corporation
PREPARED BY:	CH2M
DATE:	March 31, 2016
CONTACT INFORMATION:	Paul Swaim, PE - 720-286-5280 Brock Emerson, PE - 385-474-8518

Executive Summary

This document is the Pilot Testing Protocol for Park City Municipal Corporation (PCMC) Mining-Influenced Water Pilot Study. This pilot study will support the design of the full-scale mining-influenced water (MIW) treatment plant. This document includes an overview of water quality goals, definition of pilot testing objectives and key questions to be answered from pilot testing, a description of the pilot plant equipment, the detailed pilot testing experimental plan, a preliminary pilot testing schedule, a summary of water quality testing to be conducted, and initial discussion of staffing and data analysis/reporting.

Background Information

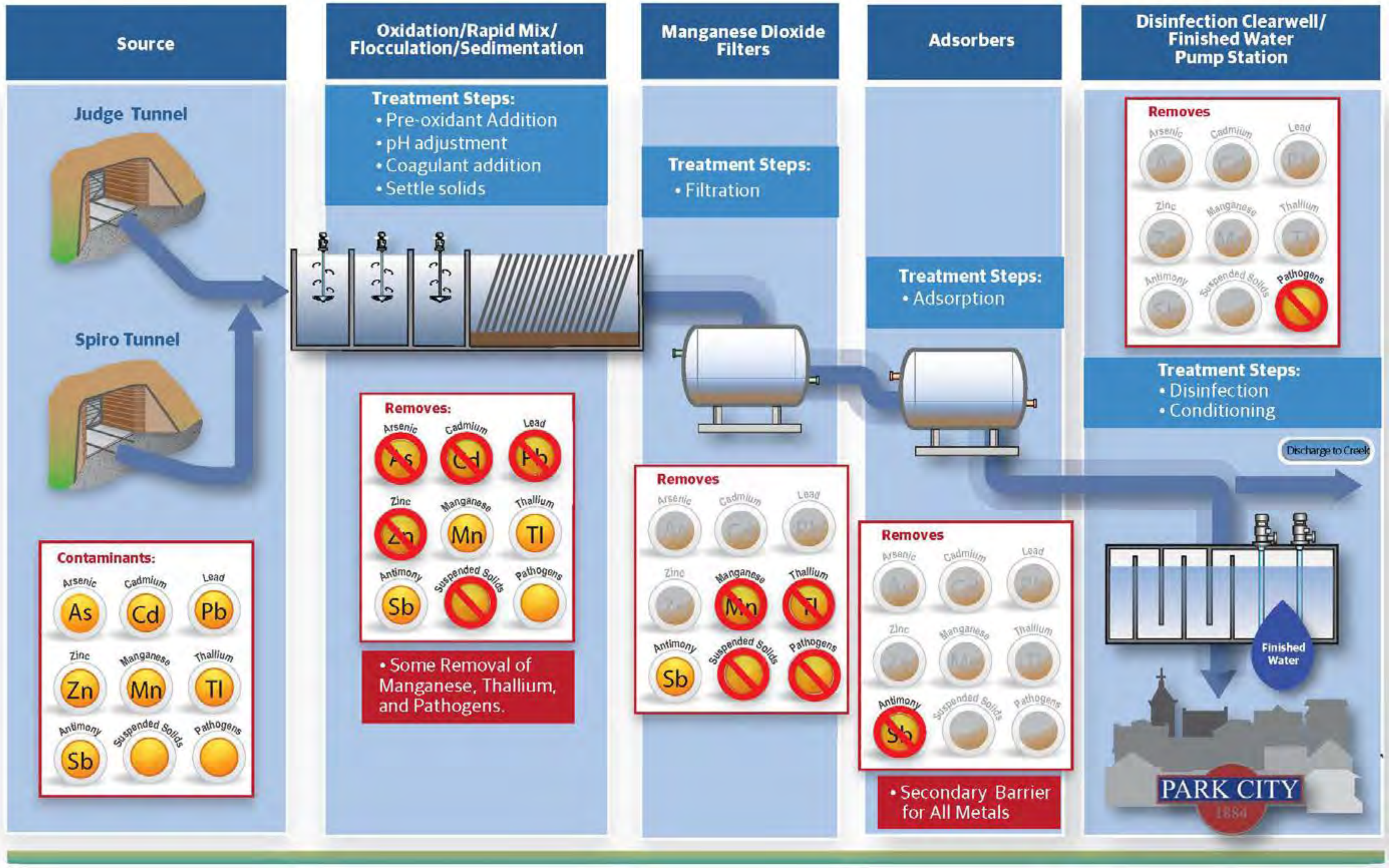
PCMC has been issued Utah Pollutant Discharge Elimination System (UPDES) permits for the discharge of waters from Judge and Spiro Tunnels. PCMC entered into a Stipulated Compliance Order (SCO), concurrent with the issuance of the permits, which established schedules and certain terms and conditions for bringing the tunnel water discharges into compliance with the UPDES permits. The mine tunnel waters are currently used by PCMC (and other entities) for municipal drinking water, irrigation, and snowmaking. The Judge and Spiro Tunnels Mining-Influenced Water (MIW) Treatment Evaluation developed plans for meeting drinking water requirements and the SCO requirements for the tunnel waters. Pilot testing represents a key step in finalizing the selection of the preferred treatment process for Judge Tunnel water, Spiro Tunnel water, and combined tunnel water flows.

Purpose of Pilot Testing

Pilot testing will be conducted for the purpose of demonstrating proof of performance (i.e., validating full treatment train effectiveness and updating desktop cost estimates) for treatment of Judge and Spiro Tunnel water for drinking water and/or stream discharge. Pilot testing will focus only on the best options from the evaluation of alternatives and benefit-cost analysis completed previously. Pilot operational parameters will be set based on the chemical doses that provided effective treatment results during previous bench-scale testing. Pilot testing will provide verification of design parameters and set the stage for conceptual, preliminary, and final design of the MIW treatment facilities.

Specifically, pilot testing will build on the previous project decisions, and the treatment process will consist of pre-oxidation, flocculation, sedimentation, filtration, and adsorption. A schematic view of the treatment process is shown in Figure ES-1, including contaminant removal from each major treatment step.

Figure ES-1: Mining-Influenced Water Treatment Schematic



Source

Judge Tunnel

Spiro Tunnel

Contaminants:

Oxidation/Rapid Mix/ Flocculation/Sedimentation

Treatment Steps:
- Pre-oxidant Addition
- pH adjustment
- Coagulant addition
- Settle solids

Removes:

- Some Removal of Manganese, Thallium, and Pathogens.

Manganese Dioxide Filters

Treatment Steps:
- Filtration

Removes

Adsorbers

Treatment Steps:
- Adsorption

Removes

- Secondary Barrier for All Metals

Disinfection Clearwell/ Finished Water Pump Station

Removes

Treatment Steps:
- Disinfection
- Conditioning

Finished Water Quality Goals and Targets

Pilot testing will provide performance data on removal of each of the metals of concern, as identified in Table ES-1. The metals shown in Table ES-1 are those that have been measured at concentrations at least 50 percent of the drinking water maximum contaminant level (MCL) or that are specifically limited as part of the UPDES discharge limits for the two mine tunnel waters.

Table ES-1: Metals of Concern for PCMC's Mining-Influenced Waters

Judge Tunnel	**Spiro Tunnel**
Antimony *(MCL and stream discharge)*	Antimony *(MCL and stream discharge)*
Arsenic *(MCL)*	Arsenic *(MCL and stream discharge)*
Cadmium *(MCL and stream discharge)*	Cadmium *(MCL and stream discharge)*
Lead *(MCL and stream discharge)*	Lead *(MCL)*
Mercury *(MCL and stream discharge)**	Mercury *(MCL and stream discharge)**
	Selenium *(MCL and stream discharge)**
	Thallium *(MCL and stream discharge)*
Zinc *(stream discharge)*	Zinc *(stream discharge)*

* indicates all concentrations measured are less than the relevant limits, so removal through treatment is not required.

In addition to the constituents shown in Table ES-1, treatment will target the removal of iron and manganese to levels well below the secondary MCLs. In both tunnel waters, there are also stream discharge limits for total suspended solids, pH, and dissolved oxygen, and pilot data will confirm that the treated water also meets these requirements. Pilot testing will provide performance data for the removal of turbidity and other parameters of interest for treatment performance and regulatory requirements. Finally, pilot testing will provide representative water quality for use in whole effluent toxicity (WET) testing.

Key Questions to Be Addressed By Pilot Testing

The key questions to be addressed during pilot testing are as follows:

- Does the optimum treatment approach from the previous decision evaluation and bench-scale testing perform as expected, meeting PCMC water quality goals, including drinking water MCLs and stream discharge limits for Judge Tunnel water, Spiro Tunnel water, and combined tunnel water?
- Does the same treatment approach perform acceptably under varying seasonal water quality? How does the treatment process perform during periods of miner activity in the tunnel? How does the process respond to or recover from an upset?
- Does pilot testing identify any limitations of the treatment approach that must be addressed in full-scale facility design and/or operations? Are there key findings from pilot study operations that help to familiarize operators with the treatment approach?
- To what extent is each metal of interest removed through each treatment step? Does this information support blending and bypass treatment alternatives that could be used to reduce the capital and O&M cost of the full scale treatment facility?

- Does the optimum treatment approach pass the required WET tests and allow regulatory approval of WET testing results?
- Does adsorption media performance and media capacity match projections and allow selecting a preferred type of media?
- From the solids and discharge streams, how do the residuals settle and dewater? Do residuals pass the toxicity characteristic leaching potential (TCLP) test? What are the estimated solids quantities by water source and blend ratio?
- What chemical doses are required to stabilize finished water for the distribution system?
- What are the updated and/or refined design criteria for full-scale (i.e., flocculation time, filter loading rates, empty bed contact time for adsorption, chemical doses)? Does the data generated during pilot testing demonstrate these design criteria to DDW and/or DWQ?
- What are the chemical and energy costs for the full-scale facility? How much truck traffic will be associated with chemicals, solids, and media replacement during full-scale plant operation?
- What are the updated and/or refined construction and O&M costs for full-scale?

Summary of Pilot Testing Tasks

The pilot testing experimental plan consists of task-by-task descriptions for the five defined pilot testing tasks. The pilot testing tasks are as follows:

- Task 1 – Bench-Scale Testing *(already completed)*
- Task 2 – Pilot Plant Commissioning
- Task 3 – Treatment for Metals Removal
- Task 4 – Challenge Testing and WET Test #1
- Task 5 – Adsorption Testing to Assess Exhaustion and WET Test #2

The pilot study tasks are summarized in Table ES-2.

Testing Details

Testing will be conducted using Spiro Tunnel water alone, Judge Tunnel water alone, and combined Judge/Spiro Tunnel water. For testing with combined water, a 2:1 blend of Spiro-to-Judge water will be tested. This blend is representative of the flowrates anticipated at the future full-scale facility. It is anticipated that both tunnel waters will be treated utilizing the same treatment process. In each case, testing will address treatment for both drinking water and for stream discharge.

Pilot testing will be conducted at a pilot plant set up at the Spiro Water Treatment Plant (WTP). PCMC envisions decommissioning the existing Spiro WTP and building a new MIW treatment facility, possibly at this same site. Blending of flows, such as with Thiriot Springs flows, will not be used as a “treatment” method for compliance. The purpose of pilot testing is to determine the capability of the treatment train to remove the metals of concern for discharge to any stream under consideration (i.e., McLeod Creek, Empire Creek, Silver Creek, and the Weber River).

Pilot testing will begin in April 2016 and continue for several months. Depending on the test results, testing will continue into September and possibly longer (into November). Flowrates through the pilot plant will be approximately 5 to 10 gallons per minute. Information on the flows and loadings to the sanitary sewer associated with pilot testing are described later in this document, with calculations summarized in Attachment B.

Table ES-2: Task by Task Pilot Testing Summary

Testing Phase	Description	Objective	Anticipated Duration and Source Water	Key Tasks
Task 1	Bench Testing	Fill outstanding data gaps Determine the most effective chemical doses	Completed Judge and Spiro source waters	*<u>Decision Point</u>: Established starting point chemical doses for subsequent testing (pre-chlorination, coagulation, and pH adjustment)*
Task 2	Pilot Plant Commissioning	Get the pilot plant running for testing, and establish treatment operating conditions that work effectively for turbidity removal, metals removal, and unit process performance for subsequent testing. Evaluate thallium (and manganese) removal by dual media filtration versus removal by filtration with pyrolusite.	2 Weeks Setup; 5 Weeks Initial Operation Spiro water only (Setup: March 22 through April 1. Initial operation: April 4 through May 8)	Calibrate pilot plant and laboratory equipment Disinfect pilot plant equipment, including filter media, in accordance with AWWA standard. Confirm pilot plant operation as specified and intended Establish operating procedures Perform initial pilot operation and filter runs to work the "kinks" out Establish baseline for treatment performance for turbidity and metals removal Evaluate acclimation of anthracite/sand media and pyrolusite media for manganese and thallium removal. Testing with Spiro water (which contains thallium) alone is necessary for this task. *<u>Decision Point</u>: Establish treatment operating conditions that work effectively for turbidity removal, metals removal, and unit process performance with Spiro water for subsequent testing*
Task 3	Metals Removal	Confirm the optimum pH and chemical doses for metals removal (and distribution system water quality).	5 Weeks Spiro water for 1 week; Judge water for 2 weeks; Blend for 2 weeks (2:1 ratio of Spiro to Judge water) (May 9 through June 12)	Run consecutive tests with Spiro water to evaluate performance and identify best coagulant dose and pH for metals removal based on metals grab sampling. Repeat with Judge water, and then with blend water (2:1 ratio of Spiro to Judge water). Evaluate performance of granular media filters using two filters with anthracite/sand media and two filters with pyrolusite media. Evaluate a range of filter loading rates (e.g., 5 to 10 gpm/sf) that will achieve PCMC's previously stated goals. Conduct initial supplemental tests on clarifier and filter backwash solids. *<u>Decision Point</u>: Determine optimum treatment conditions for turbidity removal, metals removal, and unit process performance for subsequent testing including possible pH adjustment.*
Task 4	Challenge Testing and WET Test #1	Treat blended water for WET Test #1 during a spring period of potentially higher flow. Evaluate the robustness of each treatment train during periods of miner activity, adverse water quality, and other challenging conditions.	4 weeks Blend of Judge and Spiro Tunnel Water (2:1 ratio of Spiro to Judge water) 4 weeks (June 13 through July 10)	Operate four adsorber columns. Sample at media midpoints and effluent, assess performance, and select EBCT for subsequent testing. Run full pilot plant at optimized treatment conditions to provide representative water quality under spring high flow condition for WET Test #1. Conduct challenge testing with miner activity in tunnels to simulate adverse water quality. Also simulate rapid flow changes and other challenging conditions. *<u>Decision Point</u>: Make adjustments to the previously-determined optimum treatment conditions for turbidity removal, metals removal, and unit process performance if needed based on the results of the first whole effluent toxicity test and challenge testing.*
Task 5	Adsorber Life to Assess Exhaustion and WET Test #2	Run upstream steady state conditions and evaluate adsorber media to predict exhaustion for antimony removal. Treat blended water for WET Test #2 during a fall period of normal flow.	10 - 20 Weeks Blend of Judge and Spiro Tunnel Water (2:1 ratio of Spiro to Judge water) Up to 20 weeks (July 11 through November 25, pending possible earlier stop)	Run 4 adsorption columns for extended periods of time to assess bed volumes to bed exhaustion on a blend of treated Spiro and Judge water. Run full pilot plant at optimized treatment conditions to provide representative water quality under fall normal flow condition for WET Test #2. Conduct additional supplemental tests on clarifier and filter backwash solids. *<u>Decision Point</u>: Determine best adsorbent based on metals removal, need to pH adjust, media life, and lifecycle cost*

TECHNICAL MEMORANDUM

Judge and Spiro Tunnels Mining-Influenced Water Treatment Evaluation: Pilot Testing Protocol

PREPARED FOR:	Park City Municipal Corporation
PREPARED BY:	CH2M
DATE:	March 31, 2016
PROJECT NUMBER:	659671.A1.03.31.02

Introduction and Purpose

Park City Municipal Corporation (PCMC) has recently been issued Utah Pollutant Discharge Elimination System (UPDES) permits for the discharge of waters from Judge and Spiro Tunnels. PCMC entered into a Stipulated Compliance Order (SCO), concurrent with the issuance of the permits, which established schedules and certain terms and conditions for bringing the tunnel water discharges into compliance with the UPDES permits. The mine tunnel waters are currently used by PCMC (and other entities) for municipal drinking water, irrigation, and snowmaking. This project, the Judge and Spiro Tunnels Mining-Influenced Water (MIW) Treatment Evaluation, consists of engineering services to assist PCMC in developing plans for meeting drinking water treatment requirements, the SCO requirements, and long-term goals for the tunnel waters. As defined by PCMC, the expected outcome of this phase of the project is identification of the preferred treatment process alternative for Judge Tunnel water, Spiro Tunnel water, and combined tunnel water flows.

As Phase IB of the project, pilot testing will be conducted for the purpose of demonstrating proof of performance (i.e., validating full treatment train effectiveness and updating desktop cost estimates) for treatment of Judge and Spiro Tunnel water for drinking water and/or stream discharge. Pilot testing will focus only on the best options from the benefit-cost analysis completed in Phase IA. Pilot testing represents the follow-on step after bench-scale testing, which was completed by Water Quality Technology Solutions (WQTS) for PCMC in fall 2015 as Phase IB-i. From the bench-scale test results, operational parameters will be set based on the chemical doses that provided the best treatment results. Pilot testing will provide verification of design parameters (e.g., filter loading rate) and set the stage for later design of treatment facilities for Judge and/or Spiro Tunnel water.

Specifically, pilot testing will build on the decisions made during Phase IA of the project regarding treatment, so the treatment process will consist of pre-oxidation, flocculation, sedimentation, filtration, and adsorption. Testing will be conducted using Spiro Tunnel water alone, Judge Tunnel water alone, and combined Judge/Spiro Tunnel water. It is anticipated that both tunnel waters will be treated utilizing the same treatment process. In each case, testing will address treatment for both drinking water requirements and for stream discharge, including experiments to inform the design of residuals handling systems. For drinking water treatment, testing will include ensuring water quality will be stable when entering the PCMC distribution system.

Pilot testing will be conducted at a pilot plant set up at the Spiro Water Treatment Plant. The pilot plant will include pH adjustment and oxidation (Skid 3), followed by coagulation/flocculation/sedimentation (Skid 1), granular media filtration (Skid 2), and post-filter adsorption (Skid 3). Flow through the pilot plant will be approximately 5 to 10 gallons per minute.

Finished Water Quality Goals and Targets

Pilot testing will provide performance data on removal of each of the metals of concern, as shown in Table 1 below. The metals shown in Table 1 are those that have been measured at concentrations at least 50 percent of the drinking water maximum contaminant level (MCL) or secondary MCL in any single sample in the PCMC MIW water quality database. Pilot testing will also provide performance data for the removal of turbidity and other parameters of interest for treatment performance and regulatory requirements. Pilot testing will fill the remaining data gaps, including providing representative water quality for use in whole effluent toxicity (WET) testing and enabling prediction of adsorptive media life until exhaustion. Thus, the primary objective of pilot testing will be to provide the information needed to finalize decision evaluations and confirm the preferred alternative for conceptual design (Phase IC and Phase II).

Table 1: Metals of Concern for Drinking Water in Mining-Influenced Waters

Judge Tunnel	**Spiro Tunnel**
Primary Drinking Water Standards	
Antimony	Antimony
Arsenic	Arsenic
Cadmium	
Lead	Lead
	Thallium
Secondary Drinking Water Standard	
Aluminum	
Iron	Iron
Manganese	Manganese
Sulfate	Sulfate
Total Dissolved Solids	Total Dissolved Solids

Of the constituents shown in Table 1, treatment will not target the removal of sulfate or total dissolved solids based on the decision evaluation completed in Phase I of the project. Aluminum is listed for Judge Tunnel water, but all dissolved aluminum values have been more than an order of magnitude less than the secondary MCL. It is anticipated that particulate aluminum will be filtered and removed, and additional treatment addressing aluminum removal is not planned.

In addition to the relevant drinking water limits, in Judge Tunnel water, there are stream discharge limits for mercury and zinc. Mercury has not been detected above 50 percent of the stream discharge limit, whereas zinc will require removal from Judge Tunnel water to meet the stream discharge limit. In Spiro Tunnel water, cadmium and zinc must be removed to meet stream discharge limits. In Spiro Tunnel water, selenium is also regulated for stream discharge, but all measured values have been less than the discharge limit.

In both waters, there are also stream discharge limits for total suspended solids, pH, and dissolved oxygen.

Testing Goals and Objectives

This pilot study will be conducted to obtain sufficient data on the pilot treatment processes to establish design criteria for a full-scale treatment plant that will meet PCMC goals for water quality, operate efficiently, and provide the ability to meet regulatory and water quality changes.

Specifically, the pilot study of Judge and Spiro Tunnel waters will be conducted to address the following objectives:

- Verify the optimum treatment approach and observe the performance of that treatment approach under varying seasonal water quality. This reduces risk of the full scale treatment facility not being able to meet treatment objectives as water qualities and flows change. In other words, pilot testing will allow a better understanding of the limitations of the treatment approach.
- Address key data gaps to refine and confirm construction and operations and maintenance (O&M) costs. Continuous pilot operations will allow the ability to build on bench-scale testing results and hone in on operational windows (e.g., pH and coagulant range), and performance goals. This, in turn, will allow more realistic projections of chemical and energy costs of the future full scale facility.
- Provide profile of metals removal though each process step, allowing the ability to determine blending and bypass treatment alternatives that could be used to reduce the capital and O&M cost of the full scale treatment facility.
- Provide treated water for WET testing and achieve regulatory approval of WET testing results.
- Gain operational experience and familiarize operators with the treatment approach. Allow a better ability to estimate future staffing needs for full scale operations.
- Generate solids and discharge streams so that residuals treatment alternatives can be adequately sized and estimated in O&M costs.
- Generate finished drinking water so that stabilization chemistry can be adequately designed and estimated in O&M costs
- Refine design criteria for full scale (i.e., flocculation time, filter loading rates, empty bed contact time for adsorption, chemical doses). As needed, demonstrate criteria for future Utah Division of Drinking Water (DDW) and Division of Water Quality (DWQ) approval of for the water treatment facility based on permit limits and discussions between PCMC, DDW, and DWQ.
- Perform challenge testing, including testing during periods of miner activity in the tunnel, to understand the robustness of the treatment process with regard to risk of stream discharge compliance issues.

From these key questions, the objective of pilot plant operation and data collection will be to generate the requisite data to develop design criteria and estimate costs for the full-scale treatment facilities. With this approach, pilot testing will be conducted with this end result in mind.

Key Questions

To address these objectives, pilot testing will focus on answering the following key questions:

- Does the optimum treatment approach from the previous decision evaluation and bench-scale testing perform as expected, meeting PCMC water quality goals, including drinking water MCLs and stream discharge limits for Judge Tunnel water, Spiro Tunnel water, and combined tunnel water?
- Does the same treatment approach perform acceptably under varying seasonal water quality? How does the treatment process perform during periods of miner activity in the tunnel? How does the process respond to or recover from an upset?
- Does pilot testing identify any limitations of the treatment approach that must be addressed in full-scale facility design and/or operations? Are there key findings from pilot study operations that help to familiarize operators with the treatment approach?
- To what extent is each metal of interest removed through each treatment step (e.g., clarification, filtration, and adsorption)? Does this information support blending and bypass treatment alternatives that could be used to reduce the capital and O&M cost of the full scale treatment facility?
- Does the optimum treatment approach pass the required WET tests and allow regulatory approval of WET testing results?
- Does adsorption media performance and media capacity match projections and allow selecting a preferred type of media?
- From the solids and discharge streams, how do the residuals settle and dewater? Do residuals pass the toxicity characteristic leaching potential (TCLP) test? What are the estimated solids quantities by water source and blend ratio?
- What chemical doses are required to stabilize finished water for the distribution system?
- What are the updated and/or refined design criteria for full-scale (i.e., flocculation time, filter loading rates, empty bed contact time for adsorption, chemical doses)? Does the data generated during pilot testing demonstrate these design criteria to DDW and/or DWQ?
- What are the chemical and energy costs for the full-scale facility? How much truck traffic will be associated with chemicals, solids, and media replacement during full-scale plant operation?
- What are the updated and/or refined construction and O&M costs for full-scale?

Water Quality and Operational Goals for Pilot Testing

The tests conducted during the pilot study will be evaluated with respect to water quality and operational parameters. For this project, criteria have been established to quantitatively assess treatment performance and to determine whether or not the desired levels of performance have been achieved. These treatment goals will serve as guidelines for conducting the pilot experiments and for making decisions, but they should not be considered absolute. The treatment goals have been conservatively set based on current and anticipated water quality requirements and engineering judgment.

Water Quality Goals

Early in Phase IA of the project, PCMC set water quality goals that may be more stringent than existing DWQ permit levels and DDW regulations as they relate to these source waters. DWQ permits are renewed every 5-years and stream discharge limits could potentially become more stringent in the future based on the receiving water body. Similarly, EPA/DDW requirements may also change over time. PCMC has decided to establish drinking water quality goals that match what would be necessary for compliance with specific elements of the EPA's Surface Water Treatment Rule. It is important that the design conditions are robust enough to achieve the potential for more stringent standards and regulations in the future, as such changes could result in costly changes to treatment facilities (as PCMC experienced with the Park Meadows well). The pilot plant process being evaluated is expected to meet many of these criteria without significant modification.

Goals are shown for Judge Tunnel water in Table 2 and for Spiro Tunnel water in Table 3. In all cases, the treatment goal is less than or equal to 75 percent of the MCL, sMCL, or stream discharge limit. The goal for settled water turbidity goals is less than or equal to 2.0 NTU, with values lower than 1.0 NTU desired if possible. The goal for filtered water turbidity is less than or equal to 0.10 NTU.

Table 2: Raw Water Quality and Treatment Requirements for Parameters of Concern in Judge Tunnel Water[c]

Analytes	**50th Percentile (mg/L)**	**Max (mg/L)**	**MCL or sMCL (mg/L)**	**Stream Discharge Max Monthly Average (mg/L)**
Antimony	0.0064 (0.0062)	0.0143 (0.0070)	0.006	0.0056
Cadmium	0.0032 (0.0023)	0.0077 (0.0070)	0.005	0.00042
Lead[a]	0.007 (0.000)	0.485 (0.005)	0.015	0.0068
Mercury[b]	N/A	2.9E-7 (N/A)	0.002	1.20E-05
Zinc	0.76 (0.61)	1.81 (1.55)	5	0.198
Arsenic	0.0080 (0.0022)	0.1120 (0.0086)	0.01	N/A
Selenium	0.0020 (0.0018)	0.0040 (0.0040)	0.05	N/A
Thallium[a]	1.5E-5 (1.5E-5)	0.0002 (0.0002)	0.002	N/A
Iron[a]	0.34 (0.00)	7.67 (0.02)	0.3	N/A
Manganese	0.011 (0.011)	0.098 (0.024)	0.05	N/A
Aluminum[a]	0.005 (0.005)	0.200 (0.005)	0.2	N/A

[a] For purposes of calculations, ND was estimated as 50% of minimum detection limit.

[b] For mercury, maximum measured total concentration is 2.9 ng/L; dissolved Hg never measured above MRL.

[c] Parenthetical values represent dissolved concentration for the same analyte

Table 3: Raw Water Quality and Treatment Requirements for Parameters of Concern in Spiro Tunnel Water[c]

Analytes	50th Percentile (mg/L)	Max (mg/L)	MCL or sMCL (mg/L)	Stream Discharge Max Monthly Average (mg/L)
Antimony	0.0086 (0.0076)	0.0127 (0.0091)	0.006	0.0056
Cadmium	0.0004 (0.0002)	0.0022 (0.0017)	0.005	0.00075
Lead[a]	0.0020 (0.000)	0.186 (0.000)	0.015	N/A
Mercury[a,b]	N/A	N/A	0.002	N/A
Zinc	0.16 (0.10)	0.40 (0.13)	5	0.388
Arsenic	0.0915 (0.0161)	0.5091 (0.0483)	0.01	0.010 (as daily max)
Selenium	0.0028 (0.0023)	0.0042 (0.0030)	0.05	0.0046
Thallium[a]	0.0042 (0.0032)	0.0122 (0.0050)	0.002	0.00024
Iron[a]	1.43 (0.01)	6.84 (0.72)	0.3	N/A
Manganese	0.046 (0.020)	0.988 (0.031)	0.05	N/A
Aluminum[a]	0.033 (0.005)	0.060 (0.005)	0.2	N/A

[a] For purposes of calculations, ND was estimated as 50% of minimum detection limit.

[b] All values for mercury were recorded as ND.

[c] Parenthetical values represent dissolved concentration for the same analyte

Operational Goals

The pilot testing effort will include a focus on evaluating filter performance throughout filter runs. A filter run is defined as beginning as soon as flow is returned to the filter after a backwash, and the filter run will end with termination due to time, turbidity breakthrough, or terminal headloss. The time that elapses from the start of the run to the time that the filtered water turbidity reaches 0.10 NTU will be used to determine the unit filter maturation volume (UFMV) or filter ripening volume.

All filters will be expected to maintain a filtered water turbidity of less than 0.10 NTU during the filter run once ripening (maturation) has occurred. The value of 0.10 NTU was selected because it represents a conservative filtered water turbidity goal, and 0.1 NTU is the DDW Alliance turbidity goal for filtered water. This goal exceeds the most stringent requirements in the USEPA’s Long-Term 2 Enhanced Surface Water Treatment Rule, which grants an additional 0.5-log *Cryptosporidium* removal credit for filtration plants that keep turbidity below 0.15 NTU at least 95 percent of the time (for individual filters and for combined filter effluent). Thus, the filtered water turbidity goal will be more stringent than any value in USEPA regulations and match the local Alliance goal (of which PCMC is a member). It is anticipated that the filtered water turbidity will typically be less than 0.10 NTU.

To characterize filter performance, the unit filter run volume (UFRV) for the filter run is calculated as the product of the filtration rate (in gpm/sf) and the filter run time (in minutes). A UFRV of 5,000 gal/sf is typically considered a minimum value for acceptable filter performance. For this pilot study, it is anticipated that UFRVs will substantially exceed 5,000 gal/sf, and that UFRVs greater than 10,000 gal/sf will be achieved routinely. To calculate UFRV, time zero for the filter run time determination will be the time at which the maturation or ripening period concludes and filtered water turbidity is less than 0.10 NTU.

If the filtered water turbidity rises from an acceptable level to 0.10 NTU for more than 5 minutes, the filter run will be considered to have ended based on turbidity breakthrough, and the UFRV will be calculated based on the filter loading rate and filter run time before turbidity breakthrough occurs. If turbidity breakthrough does not occur, the filter run will be considered to end when the filter reaches an accumulated headloss of 10 feet, not including initial headloss due to clean media and underdrain losses.

In some instances, it may be demonstrated for given test conditions through prior filter runs that turbidity breakthrough is not expected. In these cases, filter runs may be terminated prior to reaching terminal headloss, and the rate of headloss accumulation will be extrapolated for calculation of UFRV. For filter runs that are terminated due to time or terminal headloss, UFRVs will be calculated based on the slope of the headloss curve and calculated for 20 feet of accumulated headloss. In these instances, the actual UFRV (before termination of the filter run) and estimated URFV (based on extrapolation) will both be recorded.

The filter operational goals for the pilot study are presented in Table 4.

Table 4: Pilot Study Filter Operational Goals

Parameter	Unit	Goal
Unit Filter Run Volume (UFRV)	gal/sf	≥ 5,000
Turbidity Maturation and Breakthrough Level	NTU	0.10
Terminal Headloss (not including clean media and underdrain losses)	feet	20.0
Filter Run Time	hours	≥ 24
Filter Maturation Volume	gal/sf	≤ 150[a]

Note: [a] indicates goal will be refined based on initial pilot plant operations.

The pilot testing will not provide useful information for determining filter backwash requirements for the full-scale WTP due to the pilot equipment size. The goal of pilot filter backwashing (and air scour use) will be to clean the media sufficiently after each filter run. Design experience will serve as the basis for determining full-scale filter backwash requirements.

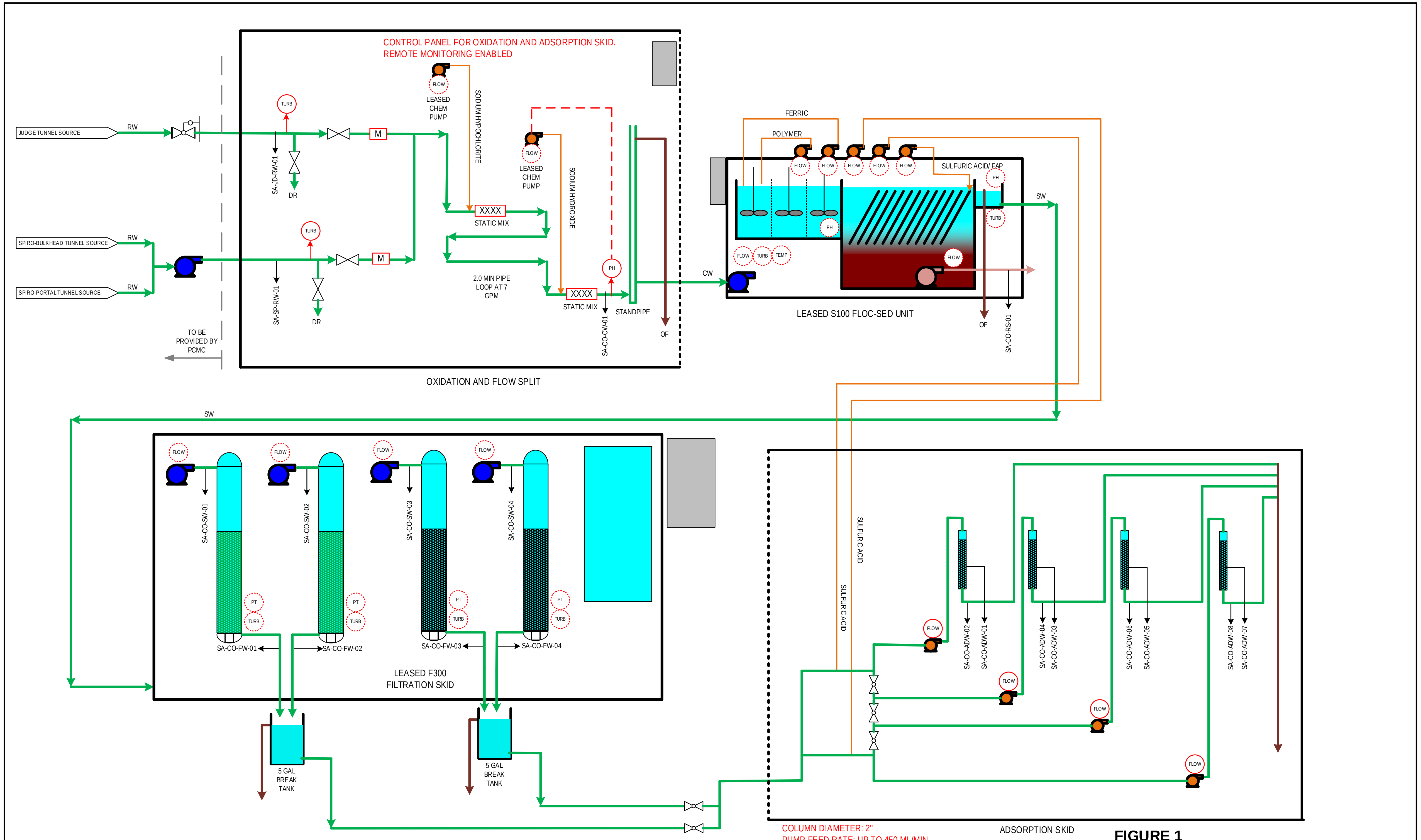
Pilot Plant Process Flow Diagram

Treatment at the pilot plant will consist of pre-oxidation and pH adjustment in a pipeline contactor; conventional filtration treatment (i.e., rapid mixing, flocculation, and sedimentation); granular media filtration; and post-filter adsorption. Disinfection will not be provided as part of the pilot plant, as the treated water will not be distributed as potable water, and pilot testing of the disinfection process does not provide essential information. A simplified process flow schematic for the pilot plant is included as Figure 1.

The MIW Pilot Plant will be located at the Spiro WTP. As shown in Figure 1, the pilot equipment will have four main components installed on three equipment skids, as follows:

- Oxidation and Flow Split Skid (shared skid with Adsorption skid)
- Sedimentation Skid - S100
- Filtration Skid - F300
- Adsorption Skid (shared skid with Oxidation and Flow Split skid)

These three skids will be provided by Intuitech.



COLUMN DIAMETER: 2"
PUMP FEED RATE: UP TO 450 ML/MIN
MAX MEDIA DEPTH: 36"
ABILITY TO AIR-SCOUR WITH PORTABLE COMPRESSOR
ABILITY TO BACKWASH WITH GARDEN HOSE CONNECTION

FIGURE 1

JUDGE AND SPIRO M-I-W TREATMENT DEMONSTRATION PILOT PFD

PARK CITY MUNICIPAL CORPORATION
PARK CITY, UTAH

659671.A1.03.31

Pilot Testing Experimental Plan

This section summarizes the Experimental Plan for the pilot testing tasks identified for the pilot study. This Experimental Plan is intended to be a flexible document that allows for modification based on testing results as they are developed and reviewed by the project team. Five specific testing tasks have been identified as follows:

- Task 1 – Bench-Scale Testing *(already completed)*
- Task 2 – Pilot Plant Commissioning
- Task 3 – Treatment for Metals Removal
- Task 4 – Challenge Testing and WET Testing
- Task 5 – Adsorption Testing to Assess Exhaustion

The Experimental Plan and testing schedule have been developed to facilitate Task 4 testing in the late spring/early summer when tunnel flowrates have typically been elevated.

The five tasks identified for pilot testing are described in the following sections. For each task, this piloting protocol outlines the Experimental Plan for testing. Throughout the project, additional tests will be conducted at bench-scale using water samples from the pilot plant to generate additional key data for the full-scale treatment plant. These additional experiments are described as sub-sections under the primary tasks as appropriate in the following sections.

Decision points have been defined at the end of each testing task. These decision points will dictate the operating conditions to be used for subsequent tasks. The decision point for each testing task is identified in the following task descriptions.

A summary of the pilot testing tasks was shown in Table ES-2.

Task 1 – Bench-Scale Testing

Duration*: Already completed*

Source Water*: Spiro Tunnel Water and Judge Tunnel water*

Objective*: Establish initial treatment conditions for pilot testing*

Pilot testing represents the follow-on step after bench-scale testing, which was completed by WQTS for PCMC in 2015 as Phase IB-i. The information summarized herein is based on test results described in the following WQTS TMs:

- Experimental Test Plan (October 12, 2015)
- Interim Results of Test 2 – Ferric Chloride Coagulation at Multiple pH Conditions (November 14, 2015)
- Interim Results of Test 3 – Lime Softening at different pH levels, with Ferric Chloride Addition, flocculation, sedimentation, and filtration (November 19, 2015)
- Interim Results of Test 4 – Adsorption Testing (December 13, 2015)

Pre-Treatment Conditions

From the Test 2 bench-scale test results, the overall best treatment performance was achieved with the following treatment conditions:

- Pre-oxidation with a chlorine dose of 2.0 mg/L
- Coagulation with a ferric chloride coagulant dose of 5.0 mg/L (as $FeCl_3$)
- Base (sodium hydroxide) addition for post-coagulation pH of 9.0

The post-coagulation pH of 9.0 provided the best removal (following sedimentation and paper filtration) of cadmium, copper, zinc, and manganese, while also providing effective removal of arsenic and iron. At pH 9.0, the same treatment conditions provided only marginal removal (less than 30 to 50 percent) of antimony and thallium. From WQTS TM, softening at pH of 9.5 to 11.0 did not provide additional metals removal compared to that achieved with ferric chloride coagulation at pH 9.0

A ferric chloride dose of 5.0 mg/L performed as well, or nearly as well, as higher doses for removal of arsenic, cadmium, copper, iron, manganese, and zinc. Among the metals tested, an increased ferric chloride dose (up to 40 mg/L) slightly improved removal of antimony and thallium. The minimal benefit resulting from this higher ferric chloride dose will not be tested at pilot-scale due to only slightly better metals removal and significant solids generation at full-scale. The ferric chloride dose of 5 mg/L will be the dose used during pilot testing initially, and assuming confirmation of performance for metals removal, throughout testing.

Filter Media and Adsorptive Media

From WQTS' TM summarizing Test 4, the results further established the filter media and adsorptive media to be used in pilot testing. Thallium was most effectively removed with pyrolusite filter media ("greensand"). WQTS' TM describes the theory that, because the existing Spiro WTP has a history of removing thallium with pre-chlorination and granular filter media (using a proprietary media, PM100), the use of anthracite/sand filter media with pre-chlorination may achieve similar results. Based on these test results, the pilot plant will be equipped with the following filter media:

- 2 filters with pyrolusite filter monomedia

- 2 filters with anthracite/sand filter dual media

In all cases, continuous pre-chlorination will be essential for adsorption of manganese dioxide onto the media for removal of manganese and thallium.

From the adsorptive media tests, the granular titanium oxide media, Metsorb, provided the best antimony removal. WQTS TM recommended also considering granular iron-oxide media (e.g., granular ferric hydroxide, GFH^{TM} or Bayoxide^{TM}), since this type of media has been shown to provide antimony removal at pH reduced to approximately 6.5 in WQTS' testing for another utility.

With the configuration of each adsorption column, column midpoint sampling will be possible to assess the performance of different empty bed contact times (EBCTs). From discussions with the media vendors, the treatment benefits of increasing EBCT are not expected to be as significant as the benefits with GAC media for organics removal. From these test results, the pilot plant will be equipped with the following adsorptive media:

- 1 column with Metsorb granular titanium oxide media at a pH value that provides the desired pH for water entering the distribution system
- 1 column with Metsorb granular titanium oxide media at a reduced pH, as defined by the manufacturer as the optimum pH for media performance and incorporating life-cycle cost evaluations
- 1 column with GFH™ iron oxide media at a pH value that provides the desired pH for water entering the distribution system
- 1 column with GFH™ iron oxide media at a reduced pH, as defined by the manufacturer as the optimum pH for media performance and incorporating life-cycle cost evaluations

Additional discussion of adsorption media options, including the rationale for these specific media for testing, is provided later in this document.

Because of the need for removal of thallium with manganese dioxide adsorption at the filters and previous filtration pilot testing by PCMC and WQTS, Metsorb media will not be tested as filter media during the pilot testing. It is assumed that concurrent filtration, manganese dioxide surface adsorption of manganese and thallium, and antimony (and other metals) adsorption by the Metsorb media would not be possible. Thus, Metsorb will only be considered as a post-filter adsorption media, consistent with the manufacturer's recommendation.

Additional Bench-Scale Tests

Based on the necessary limitation to the scope of the previous bench-scale testing, and because of the opportunities afforded by running a pilot plant, there are additional tests that will be performed at bench-scale during the pilot testing to most effectively generate key information. For example, bench-scale tests will be used for the following purposes:

- Jar testing to assess the treatment benefits of polymer addition as part of coagulation
- Residuals tests to assess solids dewaterability and to measure metals concentrations in settled solids
- Finished water stabilization tests to determine chemical doses to achieve finished water quality goals

These tests are described under the tasks for which each type of test will be most appropriate in the following sections.

Task 2 – Pilot Plant Commissioning

Duration*: 7 weeks (2 weeks setup: March 22 through April 1; 5 weeks initial operation: April 4 through May 8)*

Source Water*: Spiro Tunnel Water (only)*

Objective*: Get the pilot plant running for testing, and establish treatment operating conditions that work effectively for turbidity removal, metals removal, and unit process performance for subsequent testing. Evaluate thallium (and manganese) removal by dual media filtration versus removal by filtration with pyrolusite.*

Equipment Installation and Pilot Plant Setup

At the Spiro Water Treatment Plant (WTP) site, PCMC will furnish the leased flocculation/ sedimentation skid, leased filter columns skid, and purchase the combination raw water/post-adsorption skid for testing. PCMC plans to have completed the field work necessary for utility connection/tie-in, including electrical, and completed source water connections for Judge Tunnel water and Spiro Tunnel Water, as well as sewer discharge to enable installation of a fully functional pilot plant. This work is scheduled to be completed prior to start date for mobilization of the pilot plant operations team on-site. All testing for Task 2 will be conducted using Spiro Tunnel water only because only Spiro water contains thallium and this approach will allow monitoring of filter performance for thallium removal.

Beginning on March 22, once all of the equipment items for pilot testing arrive on site, the equipment should be removed from crates (with the crates preserved for future return transportation of the equipment skids) and installed in the Spiro WTP. Upon arrangement of the skids, the operations team will make final piping connections to and from each skid. PCMC will provide all electrical connections to the piloting equipment. The equipment should be checked for any broken components.

Once these steps are completed and the pilot plant is installed in place and plumbed for flow, it will be necessary to run raw water through the pilot plant and to calibrate the instruments and equipment. Key calibration steps include the following:

- Confirm raw water supply at sufficient flow and pressure
- Calibrate on-line turbidimeters using formazin standards
- Develop calibration curves for chemical metering pumps using graduated cylinders and stopwatches
- Calibrate on-line pH analyzers
- Perform bucket tests as possible to verify flowmeter operation and measurements
- Identify and label sampling points
- Confirm operation of filter backwash system and air scour system
- Confirm functional operation, including accuracy of data values and data tracking at the pilot plant PLCs. Select alarms for email notifications.
- Verify operation of all pilot plant components, running the system for a minimum 24-hour time period to complete trouble-shooting.
- Load all filter media, including thorough backwashing to remove fines, and sample media for laboratory sieve analysis.

The pilot plant installation and setup task is expected to require two weeks of on-site work, with completion by April 1.

Confirm Operations, Calibrate Equipment, and Establish Operating Procedures

Prior to commencing pilot testing, chemical deliveries should be completed so all pilot plant treatment chemicals are on-hand for use. In addition, chemicals and consumables needed for on-site laboratory analyses should be ordered and on hand. The pilot operations team will develop and document protocols for pilot plant laboratory procedures, instrument calibrations, chemical batching (if necessary) and chemical feeds, solids wasting from the clarifier, filter backwashing, and other steps for regular pilot plant operation. During this time period, CH2M's engineering/laboratory specialist will visit the site for one week to set up the pilot laboratory, calibrate instruments, establish laboratory and instrument protocols, and review lab procedures with pilot operations staff. Batching protocols for chemicals will be established to ensure replacing any chemical solution reservoirs using diluted coagulant or polymer at least every 48 to 72 hours.

The pilot operations team will also establish procedures for data collection, download/transfer, database entries, and filter performance tracking. CH2M will arrange for an automation specialist to visit the site to establish and document data transfer and tracking protocols.

Additional startup activities will be completed during the time period, including the following:

- Set flocculation mixer speeds and solids wasting rate from clarifier
- Install column extensions and load filter media to the desired depth in the four filter columns, including initial backwashing to establish correct media depths. Collect a sample of each media type for sieve analysis.
- Chlorinate the system (not including the adsorption skids and adsorption media, since the adsorption media will not be installed yet). Follow AWWA C651-14 Standard for potable water.

From experience, filter backwash procedures, using air scour as well, will be established to result in clean media, rather than to try to gather specific information for full-scale design. One critical step in pilot filter operations is to develop a consistent procedure for use of a rubber mallet at each filter column to settle media at the start of the filter run to ensure consistent clean bed headloss and headloss accumulation performance. It is recommended that, at the time of media installation, the media depth upon natural media settling be marked, and then the rubber mallet be used to compact the media to the minimum depth. From experience, for pilot operations, the media should be lightly compacted following each backwash to a point approximately one third of the depth beyond natural settling. This depth of media should be marked for each column with tape for use in achieving consistent depth and operation after each backwash. If media loss is apparent over time, additional media may need to be added. When backwashing occurs in auto mode overnight or other times when the pilot plant is unattended, the media will be tapped to achieve the marked depth once a pilot operator is next on site.

The task to confirm operations, calibrate equipment, and establish operating procedures is expected to be completed at the end of the third week of on-site work (i.e., completed by April 8).

Initial Operating Period

Beginning on April 11, a four-week initial pilot plant operating period will commence. Throughout this time period, the goal will be for the pilot plant to operate around the clock, including weekends, with the pilot operations team tracking and recording data, collecting samples, and following operating protocols. Initially, operations will confirm process and filter operation, and the operators will work out any "kinks" that may occur, particularly during overnight operation.

This start-up operating period will first be used to identify effective treatment conditions for turbidity and metals removal for subsequent testing. Following hypochlorite addition for pre-oxidation, the initial pH will be raised to 9.0 through clarification and filtration, and no acid will be fed at the clarifier overflow weir to reduce the pH back down to approximately 7.5 to 8.0 (or alternative value that provides a near zero calcium carbonate precipitation potential). A ferric chloride dose of 5 mg/L will be applied, but this dose may be increased if necessary to seed the clarifier with significant floc deposition. Polymer will not be used at this time.

Figure ES-1 shows the contaminants removed through each treatment step. As shown, pre-oxidation/rapid mix/flocculation/sedimentation will be a key barrier for removing arsenic, cadmium, lead, zinc, and suspended solids, while also providing some removal of manganese, thallium, and pathogens. Granular media filtration, using manganese dioxide filters or anthracite/sand filters, will remove arsenic, manganese, thallium, suspended solids, and pathogens. Post-filter adsorption will remove antimony and serve as a secondary barrier for other metals.

Floc/sed conditions will be set to provide approximately 30 minutes of flocculation time and a reasonable plate loading rate (e.g., 0.2 to 0.3 gpm/sf). For flocculation, conditions will consist of tapered flocculation. The mixing energy (i.e., G values) will decrease from stage to stage through the three stages of flocculation. For the plate settler, a solids wasting rate and valve opening frequency will be set as a starting point and adjusted based on floc buildup at the plates. Over time, it may be necessary to “knock” solids down from the top of the plates and/or “poke” solids into the waste opening for acceptable turbidity performance on a continuous basis. Thus, clarifier operations should be monitored and procedures developed and modified based on operating experience.

The pilot study is not intended to provide a detailed evaluation of plate settling loading rates to determine design criteria. Instead, the objective of pilot testing is to operate the clarifier to provide effective and representative treatment. Significant experience is available with plate settling to allow effective design without attempting to refine design parameters at pilot-scale. At flowrates of 5 to 10 gpm, plate settling results are not scalable from pilot to full scale. Thus, the goal of pilot clarifier operation will be to produce acceptable settled water quality. Once settled water turbidity is less than 2.0 NTU and stable, begin collecting samples (including metals) per the sampling plan in Table 5.

In addition, as soon as settled water turbidity is less than 2.0 NTU and stable, begin filter operation. At that time, filter runs will be conducted, and allowed to run to completion. The two parallel filter columns with identical filter media configurations will be run at 5 and 6 gpm/sf for all filter runs. Filter aid polymer will not be used at this time. Adsorption testing will not yet be conducted during Task 2. For each filter run, operate until the filters ripen and filtered water (FW) turbidity stabilizes, and then allow the filter run to continue overnight and until termination due to turbidity breakthrough or headloss accumulation. It should be noted that, on some pilot filter tests, it has taken several repeat filter runs until filters begin to achieve performance targets. Thus, it may be necessary to backwash and start filter runs several times before the project goals are achieved. Potable water will be used to fill the backwash supply reservoir to enable backwashing with clean water during this phase. Pretreatment optimization, such as chemical dose or flocculation energy adjustment, may also be required for acceptable filter performance.

For all four filters, filter media acclimation time will be closely monitored as a function of bed volumes during the first few weeks of operation. Samples from each filter effluent (and the settled water) will be collected as per Table 5 and analyzed for manganese and thallium to determine the acclimation time for each media type before effective thallium removal is achieved.

If filter runs are regularly terminating due to turbidity breakthrough and filter run time is less than 24 hours, filter aid polymer (FAP) dosing will be tried at this time. For this task, it will be necessary to obtain two recommended NSF-approved FAP products from vendors, including at least one non-ionic FAP product. Start with a low FAP dose (e.g., 0.05 mg/L) and determine if FAP dosing improves filter performance as indicated by a longer time to turbidity breakthrough. In general, when working effectively, FAP will provide a longer period of stable FW turbidity but with more rapid headloss accumulation. Optimize the FAP type (if necessary) and FAP dose through a series of filter runs at a single filter loading rate such as 5 or 6 gpm/sf. Continue adjusting the FAP dose in small increments until terminal headloss occurs while FW turbidity is still low and stable. If it appears that filter aid polymer is necessary and improves performance, then filter aid polymer addition will become a regular part of the optimized treatment train for subsequent operation.

Following these filter runs, the time will be ideal for any adjustments to the initial filter media configuration. If filtered water turbidity is not as low as desired, smaller effective size filter media could be installed. If headloss accumulation rates are too rapid and turbidity is acceptable, larger effective size filter media could be installed. Changes in filter media will re-set the clock regarding acclimation of media for thallium removal, so changes should be made only if truly necessary.

These tests are intended to establish a baseline for treatment process performance for turbidity and metals removal. Throughout this time frame, the thallium removal of the pyrolusite filter and the dual media filter will be evaluated. Results will be compared for the two filter media configurations in terms of performance for manganese and thallium removal.

Throughout the initial operating period for Task 2, the pilot operators will download and transfer data to databases of water quality and operational performance data. During testing in the initial operating period of Task 2, a weekly summary briefing will be prepared by the pilot operators each week to briefly summarize the testing activities from the previous week. These weekly summaries will be used by the full team to guide the direction of pilot testing. The summary briefing will be distributed no later than close of business on Tuesday of each week. Weekly conference calls will be held to discuss the direction of testing. Water quality changes, source waters tested, key tasks completed, early indications of key results, and a look-ahead plan for the coming week will be included in the discussion

Jar Testing to Assess Polymer Addition

During Task 2, jar tests will be performed using a six-jar test apparatus relocated from the Quinns Junction WTP laboratory area. Prior to jar testing, a basic jar test protocol will be developed. For all jar tests, for each jar, supernatant will be analyzed for settled water turbidity, ultraviolet absorbance at 254 nanometers (UVA), pH, and other parameters if indicated. Jar tests will be performed either on raw water samples or pre-oxidized and/or pH adjusted samples. The same parameters (turbidity, UVA, pH) will be analyzed in the "raw" water used for jar testing.

During Task 2, jar testing will be conducted to evaluate the use of a coagulant aid polymer in the clarification process. Two of the major polymer representatives will be asked to provide polymers that are expected to work well in the tunnel source waters.

For the jar testing, a systematic test approach is recommended in which one jar test (six jars) is tested with a single ferric chloride dose of 5 mg/L. For these tests, pre-oxidized/pH adjusted Spiro water (or blended water) can be used as the source water. One jar will be dosed with ferric chloride and no polymer. With the other five jars, the candidate coagulant aid polymer will be tested at up to five polymer doses. The jar test should then be repeated with an additional coagulant aid polymer.

From the results, compare the water quality and floc formation with ferric chloride alone versus the best performing polymer type and dose. If necessary, perform follow-up tests. If the jar test results show similar settled water turbidity and UVA with and without polymer, then no coagulant aid polymer will be used in subsequent tests. If floc formation and settled water turbidity and UVA are improved with polymer addition, then polymer addition will be tested in the pilot plant. Optimization should be performed at pilot-scale to confirm the polymer type and dose, and then once settled water turbidity (and filter performance) meet the study goals, metals removal should be confirmed.

It should be noted that polymer addition is frequently employed to achieve good settled water quality at reduced coagulant dose. If the settled water quality is consistently less than 2.0 NTU without polymer addition, then there may be no compelling reason to use polymer at this facility.

Additional jar testing is recommended to augment pilot testing as necessary to make adjustments for changes in raw water quality. The same jar test should be repeated with Judge water. If the pilot plant operation results in difficulty meeting water quality and operational performance goals at any time during testing, jar testing will allow rapid assessment of changes in chemical doses.

Task 2 Conclusions

The results will be documented at the end of the Task 2 testing period. As noted previously, the intent is to establish a baseline for treatment performance for turbidity and metals removal. At the end of Task 2, the pilot operators will develop brief, concise documentation of the recommended treatment conditions and baseline performance with the underlying goal of detailing key information for design decisions and key findings from pilot activities.

***Task 2 Decision Point*: Establish treatment operating conditions that work effectively for turbidity removal, metals removal, and unit process performance with Spiro water for subsequent testing.**

Task 3 – Treatment for Metals Removal

Duration: *5 weeks (May 9 through June 12)*

Source Water: *Spiro Tunnel Water, Judge Tunnel water, and blended water, as indicated*

Objective: *Confirm the optimum pH and chemical doses for metals removal (and distribution system water quality).*

Throughout Task 3, using the protocols developed in Task 2, the pilot operators will download and transfer data to databases of water quality and operational performance data. During testing for Task 3, a weekly summary briefing will be prepared by the pilot operators each week to briefly summarize the testing activities from the previous week. These weekly summaries will be used by the full team to guide the direction of pilot testing. The summary briefing will be distributed no later than close of business on Tuesday of each week. Weekly conference calls will be held to discuss the direction of testing. Water quality changes, source waters tested, key tasks completed, early indications of key results, and a look-ahead plan for the coming week will be included in the discussion.

Conduct Steady-State Operations

For the first week of Task 3, consecutive tests will be run using Spiro water to evaluate performance and confirm pre-oxidation conditions and the best coagulant dose and pH for metals removal based on metals grab sampling. Consistent with Task 2, treatment conditions must also provide settled water turbidity less than 2.0 NTU. As was the case in Task 2, it is assumed that the pre-oxidant dose will be sufficiently high to carry through the filters.

For the testing with Spiro water alone, testing will generate data to evaluate the performance of granular media filters at different filter loading rates using two filters with anthracite/sand media and two filters with pyrolusite media. During this week, testing will evaluate higher filter loading rates (e.g., 8 to 10 gpm/sf). The typical filter performance parameters (FW turbidity, UFRV, maturation volume, headloss accumulation, and reason for filter run termination) will be monitored throughout this phase and compared to results at lower filter loading rates from Task 2.

Additionally, at the end of this time frame, the thallium removal of the pyrolusite filter and the dual media filter will be evaluated. At this time, there will have been six weeks of operations to compare the two filter media configurations in terms of performance for manganese and thallium removal.

For the next two weeks, repeat the above tests with Judge water alone. It should be noted that some adjustments to chemical doses and optimum treatment conditions to maintain settled water turbidity less than 2.0 NTU may be required. In the first filter runs with Judge water, refer to the FAP testing described under Task 2 and repeat this testing if necessary.

Once upstream treatment conditions and FAP conditions have been confirmed, operate each filter column at filter loading rates of 5, 6, 8, and possibly 10 gpm/sf and complete entire filter runs. If possible, two filter runs will be completed at each filter loading rate. At each filter loading rate, record clean bed headloss and underdrain headloss. By operating the two parallel filter columns at the same rate, duplicate filter run results will be obtained for each filter loading rate. For each filter run, collect samples from each filter during a period of stable operation for metals and other analyses per Table 5.

In the final two weeks of Task 3, use a blend of Spiro and Judge water for testing. It is recommended that the blend ratio be approximately 2:1 Spiro-to-Judge water because Spiro water flows at higher rates than Judge water. By this time, the previous testing should have identified the optimum treatment conditions for each water by itself, and the optimum treatment conditions for the source water blend will be approximated from these results. Filter runs will be conducted at the highest rate that worked effectively for both source waters and met PCMC goals. Consecutive filter runs will be conducted for the remainder of the Task 3 test period.

Before starting Task 4, it will be necessary to install the adsorptive media in the four columns. Installing the adsorptive media will be similar to installing the filter media, and each column should be thoroughly backwashed in preparation for operation, along with any other preparatory steps such as chlorination. Media will be loaded based on supplier recommendations. Adsorptive media should be installed during Task 3, and during the tests with the blended source water in the last two weeks of Task 3, flow will be introduced to each post-filter adsorption column. After four hours, each column will be sampled for turbidity, pH, and UVA. Once results confirm acceptable water quality, a sample from each column's effluent will be collected for metals analyses. These results will be turned around as rapidly as possible and then used to confirm the full pilot treatment train is ready for the first whole effluent toxicity test in Task 4. The adsorber columns will be operated from this point forward.

Conduct Supplemental Tests

During Task 3, two types of supplemental tests will be performed: solids dewaterability testing and finished water stabilization testing. Each test is described in the following sections.

Perform Initial Solids Dewaterability Testing

The volume of solids produced, and the corresponding settleability and dewaterability of the solids, represent important considerations for the treatment process. During Task 3 of the pilot study, the pilot operators will perform initial basic experiments to gather data on solids production and solids characteristics for the conventional treatment train. It is recommended that clarifier waste solids be collected once during Task 3 for each water alone. Subsequent solids testing will be conducted from the combined sources in Task 5 for additional solids testing. The information gathered from this task will be used to estimate solids quantities by water source.

To conduct these solids tests, 5-gallon buckets of solids will be collected from the clarifier waste stream. For these tests, physical observations regarding solids settling will be recorded over time (30 minutes and 1, 2, 4, 24, and 72 hours), and photographs will be taken. Periodic manual decants will be conducted to assist in estimating dewaterability. Following decanting, thickened solids will be evaluated to assess the metals concentration in the solids.

Finished Water Stabilization Testing

During the testing with each individual tunnel water, samples of filter effluent from each type of adsorber column (e.g., granular titanium oxide media; iron-oxide media) will be collected for finished water stabilization testing. For these tests, acid or base will be added at bench-scale as appropriate to determine chemical doses necessary for PCMC's target finished water chemistry. At this time, chemical doses will be added to achieve pH and alkalinity that correspond to near-zero calcium carbonate precipitation potential. These bench-scale tests will be conducted twice with each water during Task 3.

Disinfection By-Product Simulated Distribution System and Chlorine Demand/Decay Testing

Once effective treatment is provided for the blended source waters in the fifth week of Task 3, a disinfection by-product (DBP) simulated distribution system test (SDS) may be completed. A chlorine demand and decay test will also be completed. For this test, samples of water will be chlorinated with chlorine doses of 2 to 4 mg/L, adjusted to the finished water pH, alkalinity, and CCPP goals, and held for contact times of 4, 24, 72, and 120 hours. At the end of the contact time, each sample will be analyzed for final chlorine residual. The DBP test will be conducted only if TOC increases to levels of 1.0 mg/L or higher at any time in either of the two raw water sources. If so, the DBP test will be conducted along with the chlorine demand/decay tests, and samples will be sent to an off-site laboratory for analyses for trihalomethanes and haloacetic acids (suite of nine).

Task 3 Conclusions

As noted previously, the intent of Task 3 is to confirm the optimum pH and chemical doses for metals removal (and distribution system water quality) for each source water and for the combined source water. Task 3 will provide the key information on the metals removal capability of the treatment train for both drinking water MCLs and stream discharge limits.

<u>Task 3 Decision Point</u>**: Determine optimum treatment conditions for turbidity removal, metals removal, and unit process performance for subsequent testing including possible pH adjustment.**

Task 4 – Challenge Testing and WET Test #1

<u>Duration</u>: *4 weeks (June 13 through July 10)*

<u>Source Water</u>: *Blend of Judge and Spiro Tunnel Water (2:1 ratio of Spiro to Judge water)*

<u>Objective</u>: *Treat blended water for whole effluent toxicity (WET) Test #1 during a spring period of potentially higher flow. Evaluate the robustness of each treatment train during periods of miner activity, adverse water quality, and other challenging conditions.*

Throughout Task 4, using the protocols developed in Task 2, the pilot operators will download and transfer data to databases of water quality and operational performance data. During testing for Task 4, a weekly summary briefing will be prepared by the pilot operators each week to briefly summarize the testing activities from the previous week. These weekly summaries will be used by the full team to guide the direction of pilot testing. The summary briefing will be distributed no later than close of business on Tuesday of each week. Weekly conference calls will be held to discuss the direction of testing. Water quality changes, source waters tested, key tasks completed, early indications of key results, and a look-ahead plan for the coming week will be included in the discussion.

Whole Effluent Toxicity Test #1

Throughout Task 4, the full pilot plant will be operated at optimized treatment conditions to provide representative water quality. With the adsorption media installed during Task 3, and after the metals results are available to confirm treated water quality, whole effluent toxicity (WET) Test #1 will be conducted. During the pilot study, two WET tests are required per the SCO agreements, with tests to be conducted during a fall periods of normal flow (Task 5) and during a spring period of potentially elevated flow. Given the anticipated timing of Task 3, it is assumed that the WET test during a period of elevated flow conditions will be conducted first.

One week prior to WET Test #1, CH2M will prepare and distribute a brief protocol for the WET test. This protocol will detail test logistics, sample volumes, and testing approaches. The WET test will be conducted using the Metsorb column unless the team agrees to use a different column based on cost analyses completed by CH2M or based on the results from the tests at the end of Task 3. For this test, the Metsorb column will be operated for at least 24 hours before sampling for the WET test. The WET test will be conducted with blended Spiro and Judge water at a presumed blend of 2:1 Spiro-to-Judge. Although raw water testing is not noted in the SCO documents, if it is required, raw water testing will be included in the test protocol.

For planning purposes, it is assumed that the elevated flow WET test will be conducted during the first week of Task 4. Following the initial WET test, testing will shift to conducting pilot plant operations through the challenge testing period for the remainder of the four-week time period.

The results of the first WET test will be available prior to conducting the second WET test during Task 5. If the test is not passed, adjustments to the treatment conditions may be required. Upon receiving the results of the first WET test, the team will convene via a conference call to discuss the results and possible adjustments if required.

Conduct Pilot Plant Operations through Challenge Testing Period

For these tests, challenge testing will be conducted with miner activity in the tunnels to simulate adverse water quality, if possible. If it is possible to schedule miner activity, the source water will consist of only the tunnel water that will be affected. For these tests, all four adsorber columns will be operated continuously. Sampling frequencies may be altered to obtain the best possible data on treatment performance during these times. Additionally, jar tests and/or rapid treatment adjustments may be necessary to achieve treatment goals.

Testing for this task will also include challenge testing to assess the robustness and resiliency of the full treatment process. These tests will consist of simulating rapid flow changes and other challenging conditions. For these tests, a blend of 2:1 Spiro-to-Judge water will be used. Sampling will be conducted at the midpoint of each column and in each column’s effluent.

For these tests, full-scale WTP operator input should be solicited to identify events that are likely to occur at full-scale and jeopardize stable plant performance. The identified events should be mimicked at pilot-scale to the extent possible. Prior to this time, PCMC staff and operators will be consulted to identify the most representative challenge tests for the pilot plant. In the testing schedule, two weeks have been reserved for testing at the pilot plant to simulate potential events, such as the following:

- Sudden changes in filter loading rate (e.g., ramp up from 5 to 8 gpm/sf during a filter run, ramp back down to 5 gpm/sf)
- Take one chemical system off-line for a period of time (e.g., 15 to 30 minutes without polymer)
- Sudden changes in floc/sed flowrate
- Other emergency operating scenarios identified by WTP operators

The future full-scale treatment facility is likely to be operated with changing production rates, so changes in filter loading rates during the course of filter runs will be likely. It is recommended that several different tests be performed during the two weeks to evaluate the impacts of changes in filter loading rates, and to allow the resiliency of treatment performance at different loading rates to be assessed.

Task 4 Conclusions

As noted previously, the objectives of Task 4 are to treat water for whole effluent toxicity tests with each water, at a period of normal flow and a period of higher flow from each tunnel, and to evaluate the robustness of each treatment train during periods of miner activity, adverse water quality, and other challenging conditions. Adjustments to the treatment conditions will be made throughout Task 4 as required.

<u>Task 4 Decision Point</u>: Make adjustments to the previously-determined optimum treatment conditions for turbidity removal, metals removal, and unit process performance if needed based on the results of the first whole effluent toxicity test and challenge testing.

Task 5 – Adsorber Life to Assess Exhaustion and WET Test #2

<u>Duration</u>*: Up to 20 weeks (July 11 through November 25, pending possible earlier stop)*

<u>Source Water</u>*: Blend of Judge and Spiro Tunnel Water (2:1 ratio of Spiro to Judge water)*

<u>Objective</u>*: Run upstream steady state conditions and evaluate adsorber media to predict exhaustion for antimony removal. Treat blended water for WET Test #2 during a fall period of normal flow.*

Throughout Task 5, using the protocols developed in Task 2, the pilot operators will download and transfer data to databases of water quality and operational performance data. During testing for Task 5, a bi-weekly summary briefing will be prepared by the pilot operators to briefly summarize the testing activities from the previous week. These bi-weekly summaries will be used by the full team to guide the direction of pilot testing. The summary briefing will be distributed no later than close of business on Wednesday of every other week. Weekly (or bi-weekly) conference calls will also be held to discuss the direction of testing. Water quality changes, key tasks completed, early indications of key results, and a look-ahead plan for the coming week will be included in the discussion.

Adsorber Life to Assess Exhaustion

Task 5 of pilot testing will be the longest duration testing phase, and the objective will be to generate data on adsorber media life to exhaustion through extended post-filter contact with the adsorptive media columns. To do this, it will be necessary to maintain upstream steady state treatment conditions. The overall goal of Task 5 will be to determine the best adsorber(s) based on metals removal, potential pH adjustment needs, media life, and lifecycle cost.

All testing will be conducted with the previously-optimized conditions (pre-oxidation, pH adjustment steps, coagulant chemicals and doses, FAP addition (if needed), filter loading rate, filter media configuration). Task 5 testing will utilize a blend of Judge and Spiro water, with an approximate blend of 2:1 Spiro-to-Judge water at all times. Throughout Task 5, additional data collection, sampling, and process performance tracking will be completed. Although the focus of Task 5 is on adsorber media life, Task 5 testing affords an extended opportunity to gather additional data on chemical dosing, process performance, metals removal, and filter performance. Thus, data collection and sampling will continue following the same approaches and protocols from previous testing tasks.

A specific filter media configuration and filter loading rate will be selected as the filtered water to be used in Task 5. During Task 5, one or two of the filter columns can be used in additional tests, with the filtered water piped out separately from the columns providing water for adsorber testing. For example, testing could be conducted to assess acclimation time for thallium removal at a different filter loading rate or with a mix of media, such as pyrolusite and Metsorb (if the properties of the two media products match up for filtering and backwashing).

Additional treatment chemicals could also be tested in Task 5, such as using carbon dioxide (possibly in combination with air stripping) for pH reduction in place of sulfuric acid. Prior to Task 5, the steering committee will weigh in on potential additional chemicals for testing based on life-cycle cost evaluations of the identified alternatives.

For Task 5, adsorber media will have been installed during Task 3. In Task 4, the adsorptive media will be used as part of the WET testing, and tracking of bed volumes will have commenced. During Task 5, each adsorptive media column will be sampled according to the schedule shown in Table 5, incorporating modifications made as the pilot testing progresses, with samples collected at each column’s midpoint and in each column’s effluent.

For the columns being tested at reduced pH, pH will be adjusted using acid to achieve the desired pH target in the adsorber column influent. Preliminarily, based on WQTS’ recommendation and manufacturer input, the target pH will be 6.5. Because the treated water will require base addition to achieve the target pH, alkalinity, and calcium carbonate precipitation potential (CCPP), O&M cost will be reduced if the pH target for adsorption can be increased without sacrificing adsorber performance. The other two columns will be tested at the desired pH for finished water quality entering the distribution system, and results will be compared as part of a lifecycle cost comparison to ultimately determine the optimum pH for adsorber operation.

Data entry and tracking for the adsorption columns will focus on generating graphs of metals removal over the number of bed volumes treated for each media type and each EBCT. Due to the extensive time required to run each column until target metals concentrations increase to the stream discharge limits and/or drinking water MCLs, the data generated will be assessed to validate that metals removal vs. bed volume relationships are approximately linear. If linear relationships are demonstrated (or another predictable shape of curve is demonstrated), the time to conclude Task 5 can be determined. As a worst-case, it has been assumed that Task 5 will continue for a maximum of 20 weeks.

It is not anticipated that the adsorptive media columns will require backwashing during Task 5. However, based on operator observations, the columns may be backwashed if it appears necessary due to headloss accumulation, media appearance, or the measured media depth (media compaction). At the end of Task 5, the media will be backwashed and sampled to allow an assessment of backwash waste water quality.

Once the test is concluded, each media column will be subjected to no flow for at least 72 hours, and then with flow resumed, samples of the initial effluent will be collected to assess if metals leaching from the media is occurring.

Whole Effluent Toxicity Test #2

During Task 5, the second WET test will be conducted during a fall period of normal flow. WET Test #2 will follow the same brief protocol from WET Test #1. WET Test #2 will again be conducted with blended Spiro and Judge water at a presumed blend of 2:1 Spiro-to-Judge. Although raw water testing is not noted in the SCO documents, if it is required, raw water testing will be included in the test protocol.

Perform Additional Solids Dewaterability Testing

During Task 5, additional solids dewaterability testing will be conducted to build on the results from Task 3 of the pilot study. For this task, the pilot operators will perform additional basic experiments to gather data on solids production and solids characteristics for the conventional treatment train. It is recommended that clarifier waste solids be collected on at least three occasions during Task 5 testing with the blended water.

To conduct these solids tests, 5-gallon buckets of solids will be collected from the clarifier waste stream. For these tests, physical observations regarding solids settling will be recorded over time (30 minutes and 1, 2, 4, 24, and 72 hours), and photographs will be taken. Periodic manual decants will be conducted to assist in estimating dewaterability. Following decanting, thickened solids will be evaluated to assess the metals concentration in the solids and to confirm disposal to a municipal landfill. Tests may be conducted with the residuals to verify that the solids pass the toxicity characteristic leaching potential (TCLP) test. Settled solids samples may also be sent to a manufacturer of mechanical dewatering equipment (e.g., Andritz) for testing from one of the tests as well.

Finished Water Stabilization Testing

During this task, samples of effluent from each type of adsorber column (e.g., granular titanium oxide media; iron-oxide media) will be collected for finished water stabilization testing. For these tests, acid or base will be added at bench-scale as appropriate to determine chemical doses necessary for PCMC's target finished water chemistry. At this time, chemical doses will be added to achieve pH and alkalinity that correspond to near-zero calcium carbonate precipitation potential. These bench-scale tests will be repeated at least times during Task 5.

Disinfection By-Product Simulated Distribution System and Chlorine Demand/Decay Testing

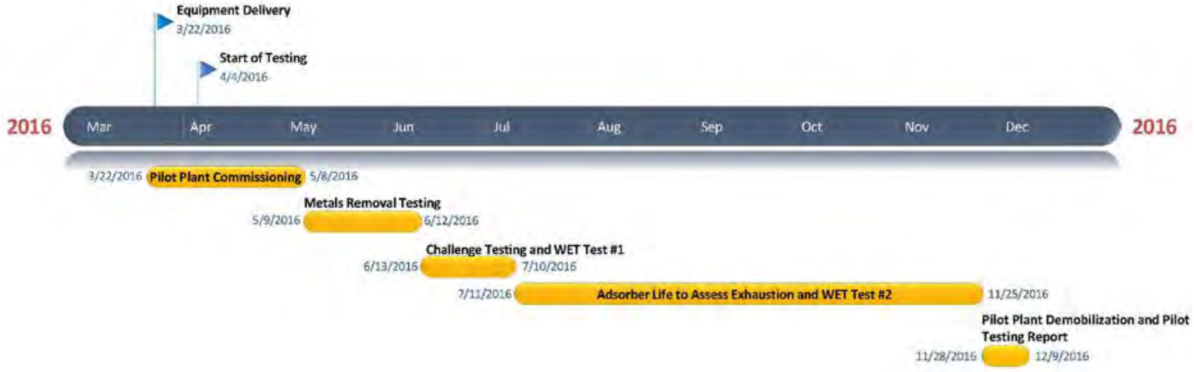
During Task 5, chlorine demand/decay tests will be conducted on at least two occasions. In addition, SDS DBP tests should also be completed if an SDS DBP test was previously conducted during Task 3. Refer to Task 3 for an overview of these tests.

<u>Decision Point</u>: Determine best adsorber(s) based on metals removal, potential pH adjustment needs, media life, and lifecycle cost.

Preliminary Pilot Testing Schedule

A preliminary schedule for pilot testing has been developed, as presented in Figure 2. From experience on other pilot studies, it is likely that the actual results achieved and other unexpected events will result in adjustments to the testing schedule. The purpose of this preliminary schedule is to present the general path forward for testing, and to ensure that the overall scope of testing is consistent with the time allotted.

Figure 2: Preliminary Pilot Testing Schedule



Testing Duration. The detailed, task-by-task plan for pilot testing was shown in Table ES-2. As shown, the pilot study includes 2 weeks of setup and installation, followed by 5 weeks of initial operations, beginning April 4, to calibrate equipment, establish treatment conditions, and get the "kinks" out (Task 2). This will be followed by 5 weeks of steady-state testing with frequent sampling to demonstrate metals removal performance and finished water quality (Task 3). Following Task 3, Task 4 will include whole effluent toxicity testing conducted twice (normal flow and high flow conditions) with each water, and then challenge testing. These testing tasks will be operationally intensive.

Following Task 4, pilot testing will shift to an extended period of testing under consistent treatment conditions to enable prediction of adsorbent life. The duration of adsorbent testing is expected to range from a minimum of 10 weeks to a longer period of time, depending on adsorbent performance. If adsorbent life extends toward the upper end of expectations, there will be a point of diminishing returns for continuing to test.

Water Quality Testing

Table 5 indicates the preliminary sampling schedule for the last four weeks of Task 2. The information shown in Table 5 includes the responsible party for each parameter, as well as the expected sampling frequency during the planned pilot testing. The testing shown in Table 5 has also been tabulated with quantities of each analysis and additional information as shown in Table A-1 in Attachment A.

As the pilot study transitions to Task 3: Metals Testing, Task 4: Challenge Testing and WET Test #1, and Task 5: Adsorber Life to Assess Exhaustion and WET Test #2, the sampling schedule will be discussed and evaluated with the team, and modifications will be made to balance the usefulness of the data and the cost and operational burden of sampling and analysis.

Sampling for each phase will designed to support the objectives of each phase:

- Task 2: Collect baseline raw water metals and water quality. Evaluate thallium and manganese removal with pyrolusite versus anthracite/sand dual media filters.
- Task 3: Demonstrate metals removal for permitted metals in Spiro, Judge, and blended water. Focus on raw, settled, and filtered water from pyrolusite and anthracite/sand filter columns. Sampling for laboratory analysis is expected to occur approximately 3 days each week.
- Task 4: Run the full pilot train (including adsorption) treatment. Obtain data for raw, settled, filtered, and post adsorption for regulated metals in the Spiro, Judge, and blended water. Sampling for laboratory analysis is expected to occur approximately 3 days each week.
- Task 5: Testing to assess the life of adsorption media. Sampling for laboratory analysis is expected to occur approximately once each week.

Several parameters will be evaluated as part of this pilot testing effort. A summary of the various metals to be measured is included in Table 6. Where appropriate, the field testing method is identified. The anticipated analytical methods are highlighted as recommended, with alternate methods also designated.

Table 5: Monitoring and Sampling Matrix for Routine Pilot Plant Operations (Task 2, First Four Weeks of Operation)

Parameter	**Raw Water**	**Oxidized Water**	**Settled Water**	**Filtered Water**	**Post Filt/ Adsorption**	**Monitoring Method**
Flowrate	Judge and Spiro Continuous	Continuous	Continuous	Continuous (each filter)	Off Line	SCADA
Chemical Doses	-	Continuous	Continuous	-	Off Line	SCADA + Pilot Operator
Headloss	-	-	-	Continuous (each filter)	Off Line	SCADA
Turbidity	Continuous + 2/day for both Judge and Spiro	-	Continuous + 2/day	Continuous + 1/day (each filter)	Off Line	SCADA + Pilot Operator
Water Temperature	-	-	Continuous +1/day	-	Off Line	SCADA + Pilot Operator
pH	1/day for both Judge and Spiro	Continuous + 1/day	Continuous + 1/day	-	Off Line	SCADA + Pilot Operator
ORP (see note a)	1/day for both Judge and Spiro	Continuous + 1/day	Continuous + 1/day	-	Off Line	SCADA + Pilot Operator
Alkalinity (see note a)	2/week both Judge and Spiro	-	1/day	-	Off Line	Pilot Operator
Hardness (see note a)	1/day both for Judge and Spiro	-	-	-	Off Line	Pilot Operator
UV Absorbance	1/week both Judge and Spiro	-	1/week	1/week (each filter)	Off Line	Pilot Operator
TOC/DOC (see note a)	1/week both Judge and Spiro	-	1/week	1/week (each filter)	Off Line	PCMC's Outside Laboratory
Chlorine Residual	-	2/day	2/day	1/day (each filter)	Off Line	Pilot Operator
MBAS	1/pilot both Judge and Spiro	-	-	-	Off Line	PCMC's Outside Laboratory
Gross Alpha	1/pilot both Judge and Spiro	-	-	-	Off Line	PCMC's Outside Laboratory
Gross Beta	1/pilot both Judge and Spiro	-	-	-	Off Line	PCMC's Outside Laboratory
Aluminum (Al) Total and Dissolved	1/week both Judge and Spiro (Grab) 1/month both Judge and Spiro (Lab)	-	1/week (Grab) 1/month (Lab)	1/week (Grab) each filter 1/month (Lab) each filter	Off Line	Pilot Operator and PCMC's Outside Laboratory
Antimony (Sb) Total and Dissolved	3/week both Judge and Spiro	-	3/week	1/filter run (each filter)	Off Line	PCMC's Outside Laboratory
Arsenic (As) Total and Dissolved	3/week both Judge and Spiro	-	3/week	1/filter run (each filter)	Off Line	PCMC's Outside Laboratory
Cadmium (Cd) Total and Dissolved	4/week both Judge and Spiro (Grab) 2/week both Judge and Spiro (Lab)	-	4/week (Grab- Total only) 2/week (Lab)	4/ week (Grab- Total only) 2/week (Lab)	Off Line	Pilot Operator and PCMC's Outside Laboratory
Iron (Fe) Total and Dissolved	4/week both Judge and Spiro (Grab) 2/week both Judge and Spiro (Lab)	-	4/week (Grab- Total Only) 2/week (Lab)	4/ week (Grab Total Only) 2/week (Lab)	Off Line	Pilot Operator and PCMC's Outside Laboratory
Lead (Pb) Total and Dissolved	4/week both Judge and Spiro (Grab) 2/week both Judge and Spiro (Lab)	-	4/week (Grab- Total only) 2/week (Lab)	4/ week (Grab- Total only) 2/week (Lab)	Off Line	Pilot Operator and PCMC's Outside Laboratory
Manganese (Mn) Total and Dissolved	4/week both Judge and Spiro (Grab) 2/week both Judge and Spiro (Lab)	-	4/week (Grab- Total only) 2/week (Lab)	4/ week (Grab- Total only) 2/week (Lab)	Off Line	Pilot Operator and PCMC's Outside Laboratory
Mercury(Hg) (note a) Total and Dissolved	1/week both Judge and Spiro	-	1/week	1/week (each filter)	Off Line	PCMC's Outside Laboratory
Selenium (Se) Total and Dissolved	1/week both Judge and Spiro	-	1/week	1/week (each filter)	Off Line	PCMC's Outside Laboratory
Thallium (Tl) (note a) Total and Dissolved	3/week both Judge and Spiro	1/week	3/week	1/filter run (each filter)	Off Line	PCMC's Outside Laboratory
Zinc (Zn) Total and Dissolved	1/day both Judge and Spiro (Grab) 2/week both Judge and Spiro (Lab)	-	1/day (Grab) 2/week (Lab)	1/day (Grab) 2/week (Lab)	Off Line	Pilot Operator and PCMC's Outside Laboratory

Note a: Sample frequency will be reduced if frequency results are highly consistent

Table 6: Summary of Analytical Methods

Parameter	Regulatory Limit		Field Method/ Range	Field Method Equipment	Lab Method/Reporting and Detection Limits
Aluminum (Al)	200 µg/L	**Recommended**	**HACH 8012 (Aluminum): 8 – 800 µg/L**	**HACH DR Spectrophotometer, AluVer 3 Aluminum Reagent 1 Powder Pillow, Ascorbic Acid Powder Pillow, Bleaching 3 Reagent Powder Pillow, Mixing cylinder**	**EPA 200.7 (ICP):** **MRL 100 µg/L** **MDL 17.6 µg/L**
		Alternate	HACH 8326 (Eriochrome Cyanine R): 6 – 250 µg/L	HACH DR Spectrophotometer, ECR Reagent Powder Pillows, Hexamethylenetetramine Buffer Reagent Powder Pillows, ECR Masking Reagent Solution, Mixing Cylinder	EPA 200.8 (ICP-MS): MRL 10 µg/L MDL 3.17 µg/L
Antimony (Sb)	5.6 µg/L	Alternate	None	None	EPA 200.7 (ICP): MRL 100 µg/L MDL 17.6 µg/L
		Recommended			**EPA 200.8 (ICP-MS):** **MRL 0.50 µg/L** **MDL 0.031 µg/L**
Arsenic (As)	10 µg/L	Alternate	None	None	EPA 200.7 (ICP): MRL 25 µg/L MDL 6.32 µg/L
		Recommended			**EPA 200.8 (ICP-MS):** **MRL 0.50 µg/L** **MDL 0.030 µg/L**
Cadmium (Cd)	0.42 µg/L	**Recommended**	**HACH 8017 (Dithizone): 0.7 – 80 µg/L**	**HACH DR Spectrophotometer, Cadmium Reagent Set: Buffer Powder Pillows, Chloroform, DithiVer Metals Reagent Powder Pillows, Potassium Cyanide, Sodium Hydroxide solution**	EPA 200.7 (ICP): MRL 5.00 µg/L MDL 0.24 µg/L
		Alternate	HACH 10217 (Cadion): 20 – 300 µg/L	HACH DR Spectrophotometer, Cadmium TNT852 Reagent Set	**EPA 200.8 (ICP-MS):** **MRL 0.50 µg/L** **MDL 0.030 µg/L**
Iron (Fe)	SMCL	**Recommended**	**HACH 8112 (TPTZ): 12 – 1,800 µg/L**	**HACH DR Spectrophotometer, TPTZ Iron Reagent Powder Pillow**	**EPA 200.7 (ICP):** **MRL 100 µg/L** **MDL 8.00 µg/L**
		Alternate	HACH 8365 (FerroMo): 10 – 1,800 µg/L	HACH DR Spectrophotometer, FerroMo Reagent 1 Powder Pillow, FerroMo Reagent 2 Powder Pillow	
		Alternate	HACH 8008 (FerroVer): 20 – 3,000 µg/L	HACH DR Spectrophotometer, FerroVer Reagent Powder Pillow	
Lead (Pb)	6.8 µg/L	Alternate	HACH 10216 (PAR): 100 – 2,000 µg/L	HACH DR Spectrophotometer, Lead TNTplus Reagent Set	EPA 200.7 (ICP): MRL 5.00 µg/L MDL 1.46 µg/L
		Recommended	**HACH 8033 (Dithizone): 3 – 300 µg/L**	**HACH DR Spectrophotometer, Citrate Buffer Powder Pillows, Chloroform, DithiVer Metals Reagent Powder Pillows, Potassium Cyanide, Sodium Hydroxide Standard Solution, Separatory Funnel**	**EPA 200.8 (ICP-MS):** **MRL 0.50 µg/L** **MDL 0.041 µg/L**

Manganese (Mn)	SMCL	**Recommended**	**HACH 8149 (PAN): 6 – 700 µg/L**	**HACH DR Spectrophotometer, Manganese Reagent Set: Alkaline Cyanide Reagent, Ascorbic Acid Powder Pillow, PAN Indicator Solution**	EPA 200.7 (ICP): MRL 10.0 µg/L MDL 0.73 µg/L **EPA 200.8 (ICP-MS):** **MRL 0.50 µg/L** **MDL 0.025 µg/L**
Mercury (Hg)	0.012 µg/L	**Recommended**	None	None	**E1631:** **MRL 1.0 ng/L (0.001 µg/L)** **MDL 0.2 ng/L (0.0002 µg/L)**
Selenium (Se)	4.6 µg/L	Alternate	None	None	EPA 200.7 (ICP): MRL 30.0 µg/L MDL 10.5 µg/L
		Recommended			**EPA 200.8 (ICP-MS):** **MRL 0.50 µg/L** **MDL 0.069 µg/L**
Thallium (Tl)	0.24 µg/L	Alternate	None	None	EPA 200.7 (ICP): MRL 20.0 µg/L MDL 3.39 µg/L
		Recommended			**EPA 200.8 (ICP-MS):** **MRL 0.20 µg/L** **MDL 0.013 µg/L**
Zinc (Zn)	198 µg/L	**Recommended**	**HACH 8009 (Zincon): 10 – 3,000 µg/L**	**HACH DR Spectrophotometer, Zinc Reagent Set: Cyclohexanone, ZincoVer® 5 Reagent Powder Pillow**	**EPA 200.7 (ICP):** **MRL 20.0 µg/L** **MDL 1.78 µg/L**
		Alternate			EPA 200.8 (ICP-MS): MRL 10.0 µg/L MDL 2.50 µg/L

Notes

MRL = Method Reporting Limit
MDL = Method Detection Limit
Lab Method MRLs and MDLs are laboratory dependent, values in the table are for CH2M ASL

Pilot Plant Equipment

Flowrates of approximately 10 gallons per minute (gpm) will be conveyed to the pilot plant influent connection from both the Judge and Spiro Tunnels. Raw water connections will be provided for both sources with the ability to measure and set the desired flow into the pilot. The Judge flow is assumed to be available at sufficient pressure (>20 pounds per square inch) and quantity (10 gpm) such that pumping to the pilot plant is not necessary. Flow from the Spiro Bulkhead and Portal are combined in the raw water wet well at the Spiro WTP. Spiro flow will be a blend of the two sources and historic water quality data has indicated that both sources have similar water quality. Spiro flow to the pilot will be pumped from the wet well to provide water at sufficient pressure (>20 pounds per square inch) and quantity (10 gpm). A duty and standby sump pump will be provided.

Flow control to the pilot plant will be accomplished using manual flow control valves with continuous flowrate monitoring at the Oxidation and Flow Split Skid. The valve configuration will be such that operators can open a Raw-Water-To-Waste valve to keep velocities higher in the raw water pipeline. Flow to the process will be controlled through a manual throttling valve and magnetic flow meter. The flow rate from each water source will be continuously recorded through the SCADA system. The downstream flow will be limited by the S100 Unit.

Judge and Spiro water will be combined at the Oxidation and Flow Split Skid, allowing for the treating of 100% Spiro water, 100% Judge water, or any desired blend of the two waters. Additionally, sodium hypochlorite (pre-oxidation) and sodium hydroxide (pH adjustment) will be added on this skid. The target flow rate for this skid will be 7.0 gpm. There will be a standpipe with an overflow that feeds the S100 skid integral to the skid. Flow in excess of the 6.2 gpm S100 design flow, will be wasted to the drain.

Minimal flows from the pilot plant will be discharged to the sanitary sewer for disposal. Calculations of sewer flows and loadings are summarized in Attachment B of this document in Table B-1.

Chemical Feed Systems

Sodium hypochlorite will be added at the Oxidation and Flow Split Skid. The chlorine chemical skid will be located adjacent to this skid. As shown in Table 7, the chemical pump rate available is 0.02 gpd to 47.5 gpd. At a process flowrate of 7 gpm, and assuming a 12.5% hypochlorite solution, dose ranges of 0.2 mg/L to values much higher than will ever be needed (i.e., 711 mg/L) will be possible at the pilot. The initial target dose will be 2 mg/L. This dose will provide oxidation to improve metals removal (e.g., change the valence state of arsenic so it absorbs to ferric particles and is removed).

This dose will be adjusted by the pilot plant operators as needed based on daily samples of chlorine residual in the oxidized water, settled water, and filtered water. The intent is that a measured free chlorine residual of 0.5 mg/L (+/- 0.2 mg/L) will typically be present in the filter effluent.

Table 7: Sodium Hypochlorite Dosing

Sodium Hypochlorite (NaOCl)			Oxidation Flow Rate (gpm)	7 gpm
	Percent Active Chemical (%)	12.5	Active Dose (mg/L)	2 mg/L
	Specific Gravity	1.2	Active Needed (lbs/day)	0.17
			Product Needed (gal/day)	0.13
			Product Needed (gal/week)	0.94
	Chem Storage	7 gal	Chem Refill Frequency	52 d
	Min Pump Flow	0.02 gpd	Min Active dose possible	0.2 mg/L
	Max Pump Flow	47.5 gpd	Max Active dose possible	711 mg/L

Sodium Hydroxide will also be added at the Oxidation and Flow Split Skid, using a separate chemical system adjacent to the skid. As shown in Table 8, the chemical pump rate available is 0.02 gpd to 47.5 gpd. At a process flowrate of 7 gpm, and assuming a 50% sodium hydroxide solution, dose ranges of 1.2 mg/L to values much higher than will ever be needed (i.e., 3,647 mg/L) will be possible at the pilot. The initial target dose will be 2 mg/L based on WQTS bench testing results. The sodium hydroxide dose will be automatically modulated to hit a target pH based on a pH probe located after the static mixer on the Oxidation and Flow Split skid, as shown in the pilot plant process flow diagram (Figure 1). The initial pH will setpoint be 9.0, but it may be modified during pilot testing.

Table 8: Sodium Hydroxide Dosing

Sodium Hydroxide (NaOH)			Oxidation Flow Rate (gpm)	7 gpm
	Percent Active Chemical (%)	50	Active Dose (mg/L)	23 mg/L
	Specific Gravity	1.54	Active Needed (lbs/day)	1.92
			Product Needed (gal/day)	0.30
			Product Needed (gal/week)	2.10
	Chem Storage	7 gal	Chem Refill Frequency	23 d
	Min Pump Flow	0.02 gpd	Min Active dose possible	1.2 mg/L
	Max Pump Flow	47.5 gpd	Max Active dose possible	3647 mg/L

Following chlorination and oxidation, the flow will continue to the S100 skid. S100 includes rapid mix/flocculation/sedimentation, with 3-stage flocculation, flocculation time from 30 to 45 minutes (depending on flowrate), and variable speed flocculation mixers. Following flocculation, an inclined lamella plate settling basin is outfitted with a variable number of lamella plates. The S100 unit has the following design parameters:

- The maximum flow for the S100 unit is 6.2 gpm.
- Rapid Mix Volume: 5 gallons (at 6.2 gpm, 1.3 minutes rapid mix time)
- Floc Basin 1, 2, and 3 Volume: 60 gallons per stage (at 6.2 gpm, 9.7 minutes per stage)
- Sedimentation Basin Volume: 130 gallons (at 6.2 gpm, 21.0 minutes)
- Sedimentation Basin Settling Area: 40.5 sf (at 6.2 gpm there is an effective surface loading rate of 0.15 gpm/sf assuming all 25 plates are used)

The rapid mix will be set at 500 sec^{-1}. The mixers for three stages of flocculation will be set as follows: Stage 1 at 60 sec^{-1}, Stage 2 at 40 sec^{-1}, Stage 3 at 20 sec^{-1}.

The number of lamella plates can be adjusted by removing plates to achieve the desired plate loading rate. Twelve of the available 25 plates will be removed. With 13 of the available 25 plates being used, the setting area will be 21.1 square feet and the effective surface loading rate will be 0.29 gpm/sf.

Five liquid chemical storage containers are located on the skid (S100). Each of these chemical addition systems have pump with capacity from 0.10 gpd to 25.0 gpd. These chemical systems will be used as follows:

- Chemical System 1: Ferric Chloride Addition on S100
- Chemical System 2: Coagulant Aid Polymer on S100
- Chemical System 3: Sulfuric Acid Addition at S100 (post settling)/ Filter Aid Polymer
- Chemical System 4: Sulfuric Acid Addition pre-adsorption
- Chemical System 5: Sulfuric Acid Addition pre-adsorption

Each chemical feed system is automatically controlled to maintain the operator-entered dose setpoint. The sedimentation basin includes a solids removal system that can adjust the frequency and quantity of solids disposal. Solids will discharge to the sanitary sewer connection at the Spiro WTP. The sedimentation basin includes an overflow weir to maintain constant level and continuous effluent flow.

Ferric Chloride will be used as the coagulant. At pilot start up, a dose of 20 mg/L (as $FeCl_3$) will be used to condition and seed the sedimentation basin. After approximately three days, the coagulant dose will be reduced to 5 mg/L. Dilute ferric solutions will be made every other day using DI water if feasible, or potable water if DI water is not available in sufficient quantities. Initially, a 4% solution will need to be made on-site in order to use the chemical feed pumps provided on S100. See Table 9 for ferric chloride dosing information. Ferric levels will be managed such that storage time is limited to 48 hours and max pump flow is 25 gpd.

Table 9: Ferric Chloride Dosing

Ferric Chloride (FeCl3)			Oxidation Flow Rate (gpm)	6.2 gpm
	Percent Active Chemical (%)	4	Active Dose (mg/L)	5 mg/L
	Specific Gravity	1.01	Active Needed (lbs/day)	0.37
			Product Needed (gal/day)	1.10
			Product Needed (gal/week)	7.70
	Chem Storage	7 gal	Chem Refill Frequency	6.4 d
	Min Pump Flow	0.10 gpd	Min Active dose possible	0.5 mg/L
	Max Pump Flow	25.0 gpd	Max Active dose possible	113.7 mg/L

A coagulant aid polymer will be selected through jar testing, and used if necessary and/or beneficial, as described in Task 2.

Sulfuric Acid will be used to lower the pH. There are two points where acid can be added, either post sedimentation or prior to the adsorption columns. To allow for the greatest flexibility in dose range, two concentrations of sulfuric acid will be used. Tables 10 and 11 show sulfuric acid dosing information.

Table 10: Sulfuric Acid Dosing – Post-Sedimentation/Pre-Filtration

Sulfuric Acid (H2SO4)			Oxidation Flow Rate (gpm)	6.2 gpm
	Percent Active Chemical (%)	25	Active Dose (mg/L)	15.5 mg/L
	Specific Gravity	1.18	Active Needed (lbs/day)	1.15
			Product Needed (gal/day)	0.47
			Product Needed (gal/week)	3.27
	Chem Storage	7 gal	Chem Refill Frequency	15 d
	Min Pump Flow	0.10 gpd	Min Active dose possible	3.3 mg/L
	Max Pump Flow	25.0 gpd	Max Active dose possible	830 mg/L

Table 11: Sulfuric Acid Dosing – Post-Filtration/Pre-Adsorption

Sulfuric Acid (H2SO4)			Oxidation Flow Rate (gpm)	0.6 gpm
	Percent Active Chemical (%)	1	Active Dose (mg/L)	15.5 mg/L
	Specific Gravity	1.007	Active Needed (lbs/day)	0.111
			Product Needed (gal/day)	1.32
			Product Needed (gal/week)	9.26
	Chem Storage	7 gal	Chem Refill Frequency	5.3 d
	Min Pump Flow	0.10 gpd	Min Active dose possible	1.2 mg/L
	Max Pump Flow	25.0 gpd	Max Active dose possible	293 mg/L

Alternatively, the Sulfuric Acid- Post Sedimentation/ Pre-Filtration pump can also be used for a Filter Aid Polymer. This polymer will be selected during Task 2.

Pilot Treatment Systems

Following clarification treatment and the overflow weir, 6.2 gpm of settled water will be routed to F300, the filter skid. The filter skid influent piping will include individual variable speed filter feed pumps for each of four filter columns that are automatically controlled to maintain an operator-entered filter loading rate. Each filter column is 6-inches in diameter and can accommodate approximately 6 feet of filter media depth and a filter loading rate up to 10.2 gpm per square foot (gpm/sf).

The pilot filter skid also includes an automated filter backwash system including air scour, and backwashing can be initiated manually or automatically based on headloss, turbidity, run-time, or run volume. Backwash rate and air scour rate regimes can be entered by the operator and automatically controlled via a PID controller.

Treated water, overflows, analyzer discharge flows, and waste flows from the pilot plant processes will be collected and routed to the existing Spiro plant drain system.

Potable water for use at the pilot plant will be obtained through a hose connection from a hose bib in the main process area. The potable water will be used in process washdown, washing labware, and pilot filter backwashing (when needed at startup).

There are four filter columns on the F300 skid. Both manganese dioxide ore (pyrolusite) and anthracite/sand dual media filters will be tested. Columns 1 and 2 will be filled with 42-inches of AS741, manganese dioxide ore, manufactured by American Minerals. This product is NSF certified and a commercially available product. Preliminary information indicates an effective size of 0.43 mm and a uniformity coefficient of 1.56 for the installed pyrolusite.

Columns 3 and 4 will be anthracite/sand dual media filters. A profile of 60-inches of 1.25-1.35 mm e.s. anthracite (UC <1.4) over 12-inches of 0.55-0.65 mm e.s. sand (UC <1.4) will be installed. The media has been provided by Xylem-Leopold. This product is NSF certified and a commercially available product.

All media will be soaked in a strong hypochlorite solution (e.g., at least 50 mg/L of chlorine) for at least 12 hours before starting operation of the pilot filters.

Additionally, a dose of 25 mg/L chlorine will be run through the pilot plant prior to start up. Flow will then be stopped for 24 hours to allow for disinfection of the unit. When flow resumes, chlorine will be sampled to verify a free chlorine residual of greater than 10 mg/L is present. The pilot plant then will be flushed for 24 hours using raw water.

Starting in Task 3, four adsorption media columns will be tested. All columns will be 2-inches in diameter and will be fed with a dedicated peristaltic pump capable of delivering up to 0.12 gpm. All four adsorption columns will be capable of being fed with a single filter column. The maximum flowrate for a single filter column is 2.1 gpm.

There will be two independent pH adjustment points on the adsorption skid. With these points, two pH set points can be used concurrently on the skid. Three adsorption media will be used during the pilot. The media depth, flow rate, and design empty bed contact time (EBCT) is presented in Table 12.

Table 12: Adsorption Columns and Media Design

Parameter	Column 1	Column 2	Column 3	Column 4
Media Name	Metsorb TiO2 Media	Metsorb TiO2 Media	GFH Media	GFH Media
Manufacture	Graver Technologies	Graver Technologies	Evoqua Water Technologies	Evoqua Water Technologies
Column Diameter	2”	2”	2”	2”
Media Depth	36”	36”	36”	36”
Column Flow Rate	0.0612 gpm	0.0612 gpm	0.0612 gpm	0.0612 gpm
EBCT at Bottom of Column	8 min	8 min	8 min	8 min
EBCT at Midpoint of Column	4 min	4 min	4 min	4 min
Budgetary Cost per cu ft.	\$180- \$235	\$180- \$235	\$182	\$182
Target pH	Distribution pH	6.5 pH	Distribution pH	6.5 pH

Additional granular titanium oxide media products were considered for testing, but initial cost quotes from the media vendors indicated the cost to be nearly twice as high as the Metsorb product. Therefore, testing a more expensive media was ruled out as not providing useful information for the future full-scale facility. Instead, identifying the impact of pH was identified as providing more valuable information for the future full-scale facility.

Process Analyzers, Auto Operation, and Data Recording

Judge and Spiro raw water turbidity will be measured continuously by process analyzers, with data logging of each turbidity. Immediately preceding the static mixers on the Oxidation and Flow Split skid (Figure 1), the water will be oxidized and pH adjusted, and thereafter the pH will be analyzed and logged. On the sedimentation skid, inlet pH, temperature, and turbidity will be recorded as well as settled water pH and turbidity. At the filter skid, continuous analyzers will include filter effluent turbidimeters for each filter. In addition, filter flowrate, headloss, backwash flowrate, and air scour flowrate will be measured and logged, with on-line measurements of filter column level and backwash tank level. For the adsorption skid, pH and column flowrates will be recorded.

Each signal will be transmitted to the pilot skid's local control panels (one at each skid) with programmable logic controllers (PLCs) for data tracking. Remote monitoring and control is possible using a standard web browser. Email alarm notification can be provided for selected parameters and set points.

Laboratory Equipment and Supplies

A basic process laboratory will be set up adjacent to the pilot skids for use by the pilot operators to support pilot testing activities. The laboratory will be outfitted with a new bench-top spectrophotometer. In addition, a bench-top turbidimeter will be obtained for the pilot plant process lab, along with sample vials and primary and secondary standards for calibration. A laboratory-quality thermometer, pH meter and accompanying pH standard solutions, and an alkalinity titration stand will also be obtained for pilot testing.

For alkalinity titrations, Standard Method 2320 is recommended, with 0.02 N hydrochloric acid using a burette stand and stir plate. Bromocresol Green Methyl Red indicator is also needed with this method, along with an alkalinity standard.

The pilot plant laboratory will be outfitted with basic laboratory equipment. Available items will be brought to the pilot plant from the Quinns Junction WTP (QJWTP) if appropriate. Personal Protection Equipment (PPE), such as protective eyewear and gloves, as identified in the Health and Safety Plan will be provided. In the previous draft version of this document, a detailed list was provided of recommended laboratory equipment to be purchased for the initial month of the pilot study. This equipment has now been procured.

Prior to the start of pilot testing, the following chemicals will be obtained:

- Ferric chloride coagulant
- Coagulant aid polymer samples
- Sodium hydroxide
- Sulfuric acid (two strengths)
- Sodium hypochlorite
- Filter aid polymer samples

In all cases, chemicals currently used by PCMC at the Spiro WTP (or QJWTP) will be used for pilot testing if possible. For ease of use, PCMC operators will transfer smaller batches of chemical (e.g., 5-gallons) to the pilot plant area as needed or on a regular schedule. Vessels for transferring chemicals will be worked out on site. For any chemicals that cannot be obtained from PCMC supplies, separate delivery from a supplier will be arranged prior to the start of pilot testing. The specific gravity, solution strength, percent active chemical, and/or bulk density will be recorded for each chemical used.

Staffing

Staffing/Operations. For regular pilot plant operations, after initial operations early in Task 2, the treatment processes will operate around the clock throughout the testing period. Testing around the clock will ensure filter runs proceed to termination and the adsorptive media are loaded consistently (in Task 5), thereby maximizing the value and expediency of testing. Pilot operators will be present on site during a defined work day (e.g., 8 to 10 hours per day) to make sure the treatment processes run continuously.

As described herein, for the first 14 weeks of testing (Tasks 2 through 4), a dedicated operations team committed to keeping the pilot plant in service and producing finished water around the clock will be required. The success of this phase of testing will be reliant on pilot operators immediately addressing issues.

The pilot study described herein will require around the clock treatment process operation, with filter runs continuing overnight and over weekends. On specific holiday weekends or in other special circumstances, the pilot plant may be shut down for short-term periods of time. Staffing will be during the normal workday, with occasional longer hours during special circumstances. It is anticipated that at least one pilot operator will be present seven days per week, full-time during the normal work week and for at least a couple of hours on weekends. For Tasks 2 through 4, staffing with approximately 2.0 full time equivalent (FTE) operations staff is planned, with additional assistance from PCMC's licensed operators. The two dedicated pilot plant operators will consist of one operator from PCMC and one operator from CH2M. During pilot chartering, a regular weekly schedule will be developed for the operations staff.

For Task 5, pilot plant operations are expected to be comparatively easier due to consistent treatment conditions and reduced sampling. It will still be imperative to keep the pilot plant running and producing water at all times, including weekends. For this task, which will occur over several months, it is anticipated that PCMC's single full-time operator will operate the pilot plant, with support from PCMC operations staff.

Throughout pilot testing, there will be a Steering Team, a Logistics Team, a Project Engineer, and an Operations Team, as follows:

- Steering Team (McClain, De Haan, Najm, Swaim, Davis): Participate in regularly scheduled weekly one-hour conference calls with Logistics Team during Tasks 2 through 4. Regularly review and discuss results and focus on ensuring testing goals are being met and identifying needs to course-correct if necessary.
- Logistics Team (Emerson, Busch): Maintain daily communication with Operations Team. Liaison with Steering Team. Coordinate pilot installation and commissioning as well as operational logistics during the pilot study. Provide direction and clarification on executing Steering Team's plan to Operations Team as needed.
- Pilot Study Manager (Emerson). Leads the pilot study and coordination among the teams, and is also trained and able to operate the pilot plant. Makes sure databases are continuously updated for access and data review by the Steering Team and the Operations Team. Raises issues for input from the larger team as needed. Oversees the daily operation of the pilot plant, including the continuous stocking of needed testing equipment, chemicals, sample bottles, and other consumables.
- Operations Team (Pilot Plant Operators: Goodley and Kunik): With support from the Logistics Team, execute the Steering Team's plan. Work towards continuous operations. Perform all sampling, maintenance, and on-site analytical work to gather the needed data.

The operations staff at the Spiro WTP, under the direction of Chad Busch, will also be asked to periodically check in on the pilot plant to make sure nothing out of the ordinary is taking place.

Rules of the Road

Based on experience, there are a few "rules of the road" for pilot operations that should be considered. These "rules of the road" include the following:

- Keep a daily log book and record observations in the book. Observations should include changes in water quality, operational difficulties and oddities encountered, trouble-shooting, and anything else the pilot operator feels is worth noting (e.g., a change in chemical suppliers, major weather events).
- Change only one variable at a time. If more than one variable is adjusted concurrently, it will not be possible to determine the impact of the change.
- Allow at least three bed volumes or retention times after making an operational change before evaluating the impact.
- Filter backwashing will expand the media bed, and once backwash is completed, the media will settle. The pilot team will establish a consistent approach to media compaction, using a rubber mallet, to be implemented as soon as possible after each backwash. One approach that has correlated well to side-by-side full-scale filter performance is as follows:
    - Measure the media depth with no compaction
    - Using the rubber mallet, lightly tap the side of the filter column repeatedly until no more media settling/compaction occurs, then measure the media depth.
    - Determine the difference in the two measured depths
    - Develop a protocol, such as three light taps with the mallet, that provides compaction of the media to approximately 33 percent of this difference. Additionally, the top of the filter media after 33 percent compaction will be physically marked on the outside of the filter column with tape to establish the target media depth after each backwash.
- There is no such thing as a dumb observation or dumb question. The best pilot studies are generated by pilot operators who are inquisitive and who feel empowered to ask questions and make suggestions based on their intuition.

Reporting

Staying "on top" of pilot testing results as they are generated is essential to a successful pilot study. Pilot studies produce significant amounts of data, and getting behind on the data analysis will lead to missing key results and expending extra time trying to catch up. Based on previous experience on water treatment pilot studies, the pilot team will institute a number of recurring steps for tabulating data, completing data analysis, reporting out to share observations and results, documenting troubleshooting efforts, drawing conclusions on results to date, and suggesting course corrections as they may be needed. Key elements of establishing recurring steps to adhere to this recommendation are as follows:

- Daily data updates and operators log book
- Weekly reporting
- Data collection and file management

Each of these elements is described in the following sections.

Daily Data Updates and Operators' Log Book

The recommendation to set up and maintain an operators' log book was presented in the prior section of this document. Prior to the start of the study, an excel workbook will be set up to enter data daily. The data entry will include raw water quality, settled water quality, and filtered water quality, chemical types and doses, key operating criteria (e.g., flocculation time, filter loading rate), filter run numbers and results (UFRV, reason for termination), and headloss information (initial, final, and accumulation rate). Filter runs will be numbered sequentially throughout the study so they can be tracked. The data file will be updated daily and backed up to either an external drive or server location.

Weekly Briefings

The pilot team will prepare a weekly briefing and send it out to the broader team no later than close of business Tuesday of the following week. The weekly briefing will typically include the following elements:

- Raw water quality summary table
- Description of treatment during the week (e.g., chemicals used and doses, flocculation time, filter loading rates)
- Summary table of flocculation/sedimentation conditions and settled water quality (turbidity, UVA)
- Filter performance summary including observations and results
- Summary of problems encountered and current status
- Schedule of testing for the upcoming week

With this weekly briefing, information sharing will be maximized, and the potential for surprises will be reduced. Also, regular data crunching and analysis will be required so no potentially important observations are missed.

Data Collection and File Management

In addition to the grab sample data, data from the online analyzers will also be tracked and analyzed. CH2M will work with the pilot equipment supplier to decide on the best approach to grabbing, tracking, and analyzing the on-line data set.

Data from outside laboratory analyses will be entered into the data file immediately upon receiving the results.

For the filters, an initial task will be the approach establishing the protocols for reviewing filter data, and headloss and turbidity performance over the course of the filter run in particular. Downloading the data into individual excel files for each filter or for each run, and then scrutinizing the data to understand the patterns of headloss accumulation and turbidity will be essential to understanding filter performance.

Attachment A

Table A-1: Laboratory Sampling Plan for Task 2

						Raw Water (Spiro)		Raw Water (Judge)		Oxidized Water		Settled Water		Filtered Water	
Task 2: Pilot Plant Commissioning (4 weeks|4/11-5/8)	MRL	MDL	T/D	Wks	Totals	Sa/Wk	#Sa	Sa/Wk	#Sa	Sa/Wk	#Sa	Sa/Wk	#Sa	Sa/Wk	#Sa
Aluminum (Al) | LAB | EPA 200.7 (ICP)	100 µg/L	17.6 µg/L	T/D	4	32	1	8	1	8	0	0	1	8	1	8
Antimony (Sb) | LAB | EPA 200.8 (ICP-MS)	0.50 µg/L	0.031 µg/L	T/D	4	104	3	24	3	24	0	0	3	24	4	32
Arsenic| LAB | EPA 200.8 (ICP-MS)	0.50 µg/L	0.030 µg/L	T/D	4	104	3	24	3	24	0	0	3	24	4	32
Cadmium (Cd)| LAB | EPA 200.8 (ICP-MS)	0.50 µg/L	0.030 µg/L	T/D	4	80	2	16	2	16	0	0	2	16	4	32
Iron (Fe)| LAB | EPA 200.7 (ICP)	100 µg/L	8.0 µg/L	T/D	4	80	2	16	2	16	0	0	2	16	4	32
Lead| LAB | EPA 200.8 (ICP-MS)	0.50 µg/L	0.041 µg/L	T/D	4	80	2	16	2	16	0	0	2	16	4	32
Manganese (Mn)| LAB | EPA 200.8 (ICP-MS)	0.50 µg/L	0.025 µg/L	T/D	4	80	2	16	2	16	0	0	2	16	4	32
Mercury| LAB | EPA 200.8 (ICP-MS)	0.001 µg/L	0.0002 µg/L	T/D	4	56	1	8	1	8	0	0	1	8	4	32
Selenium | LAB | EPA 200.8 (ICP-MS)	0.50 µg/L	0.069 µg/L	T/D	4	56	1	8	1	8	0	0	1	8	4	32
Thallium (Tl)| LAB | EPA 200.8 (ICP-MS)	0.20 µg/L	0.013 µg/L	T/D	4	104	3	24	3	24	0	0	3	24	4	32
Zinc (Zn)| LAB | EPA 200.7 (ICP)	20 µg/L	1.780 µg/L	T/D	4	80	2	16	2	16	0	0	2	16	4	32
TOC/DOC | LAB | SM 5310 C	0.50 mg/L	0.20 mg/L		4	80	2	16	2	16	0	0	2	16	4	32
MBAS | LAB | SM 5540 C	0.08 mg/L	0.03 mg/L		-	1	1	1								
Gross Alpha | LAB | EPA 900.0	-1	-		-	1	1	1								
Gross Beta | LAB | EPA 900.0	-1	-		-	1	1	1								

Notes:

- *All analyses of Sb, Cd, Mn, Tl, and Zn to be 48-72 hr turnaround time*
- *All samples to be 1-week turnaround time unless otherwise noted*
- *In addition to samples shown, above, Sb, Cd, Mn, Tl, and Zn to be sampled April 7 in each of two raw waters, settled water, and 2 filters for T/D (quantity 10 of each analysis, 5 T, 5 D, with 24-hr turnaround time)*
- *Above schedule is tentative; to be confirmed with two-week lookahead schedules during actual pilot testing.*