Breathing New Life into Existing Assets

Full-Scale Performance Results for Cloth Media Filters to Meet 0.1 mg/L TP

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Overview

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  - Liquid Process Flow Diagram
  - Filter Retrofits
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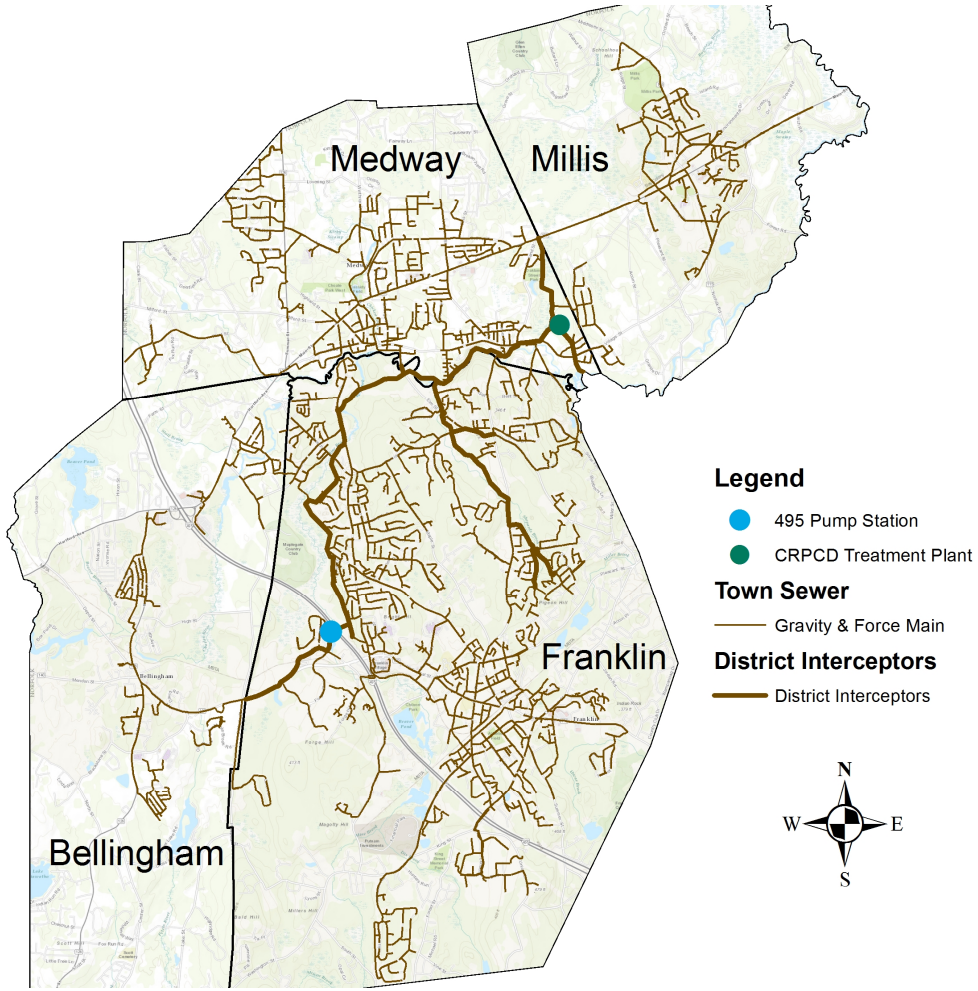
  - Test Set-Up
  - Test Results

Background

Charles River Pollution Control District (CRPCD)

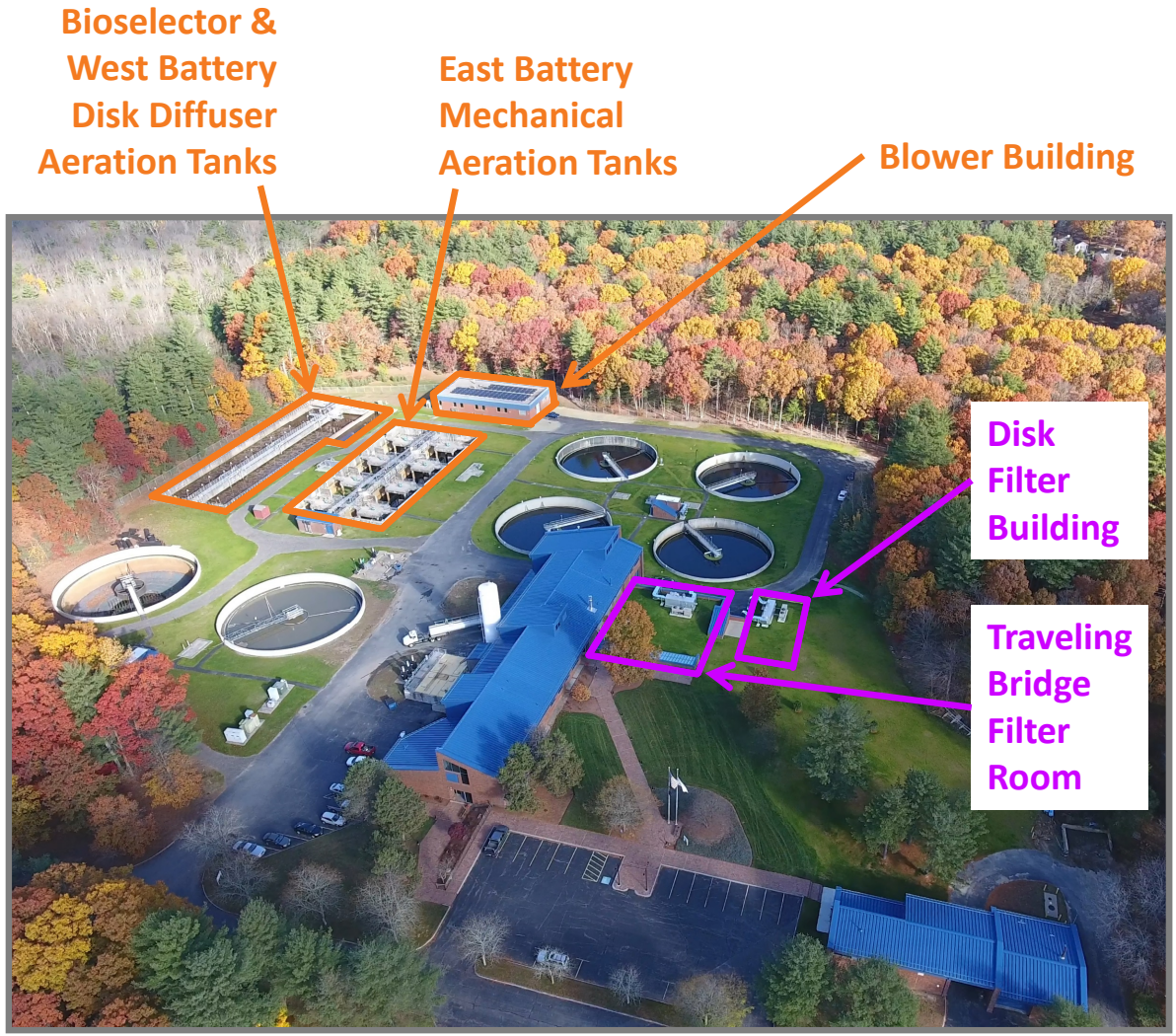


- Serves over 40,000 people in Franklin, Medway, Millis, Bellingham
- 13 miles of interceptor and 1 pumping station
- WWTF discharges to upper reach of Charles River in Medway

WWTF Overview

- Design ADF:
  5.7 MGD
- Current ADF:
  4.5 MGD

- Built in 1978-1980
- Upgraded 1998-2000
- Upgraded again 2011-2016, including facilities highlighted



NPDES Effluent Permit History for Phosphorus and Metals

Parameter	2002 Permit	2014 Permit
Notes	Issued in 2000; Modified in 2002	TMDL Finalized in 2011 Draft Issued in 2012; Final in 2014
Apr-Oct Total P	0.2 mg/L monthly average	**0.1 mg/L monthly average**
Nov-Mar Total P	Report 1x/month	**0.3 mg/L monthly average**
Total Aluminum	Report 1x/month	Eliminated from permit
Total Copper	10 µg/L monthly average	13 µg/L monthly average

WWTF Improvements – Phase C

Phosphorus Removal Study and Design

- **AquaDisk pilot study (May 2011):**
  1. 5 micron cloth can meet 0.1 mg/L
  2. Dedicated rapid mix/flocculation tankage not required

  → **Retrofit of existing filters was most cost-effective tertiary treatment alternative**

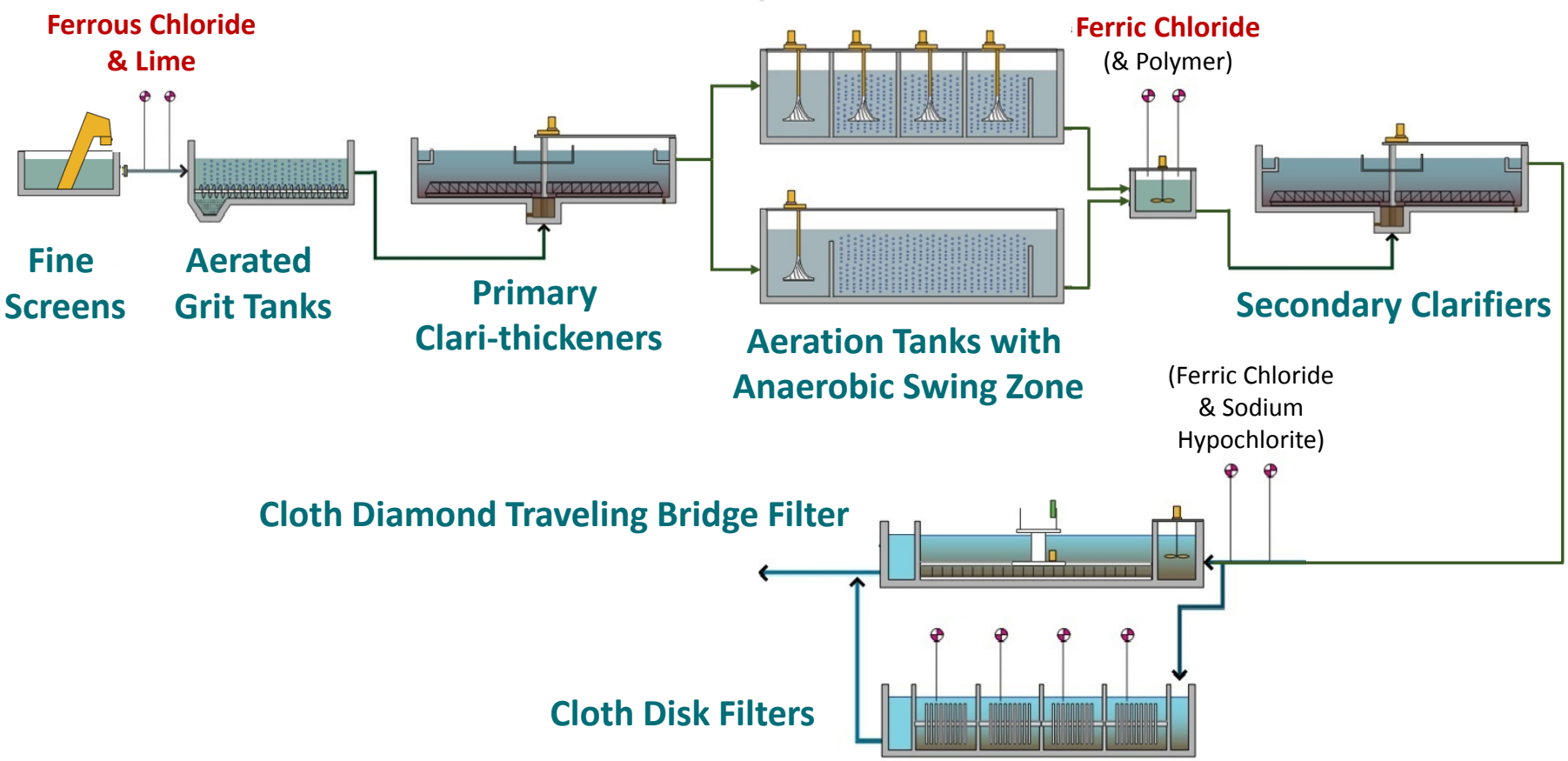
- **Facilities planning, BioWin modeling, and final design (2012-2013):**
  1. Chemical savings of A/O process, particularly in winter
  2. Able to operate in A/O year-round for at least 10 years

  → **Retrofit aeration tanks into A/O process with anaerobic/aerobic swing zones**

A/O Process Design:

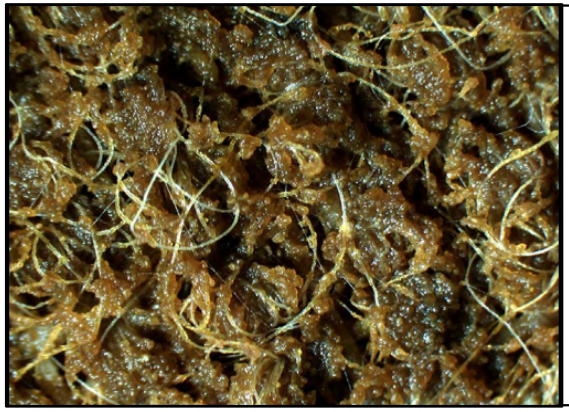
- Bioselector = anaerobic
- First stage each tank = anaerobic swing zone
- Total anaerobic = 31-36% of total volume

Liquid Treatment Process Flow Diagram



Filter System Retrofits: Key Design Features

- **Filters equipped with 5 micron polyester pile cloth (chlorine-resistant)**
  - 1 AquaDiamond filter conversion
  - 4 AquaDisk filters rehabilitated
- **Cleaning/housekeeping features:**
  - Algae sweeps added to secondary clarifiers
  - Density current baffles in secondary clarifiers
  - Sodium hypochlorite for cleaning organic foulants, including algae
  - Sodium hydrosulfite batch cleaning of Fe^{3+} solids
  - Dehumidification for filter buildings
- **New instruments**
  - Vacuum alarm on AquaDiamond filter
  - Ultralow range phosphate analyzer in secondary effluent
  - Turbidimeter in tertiary effluent

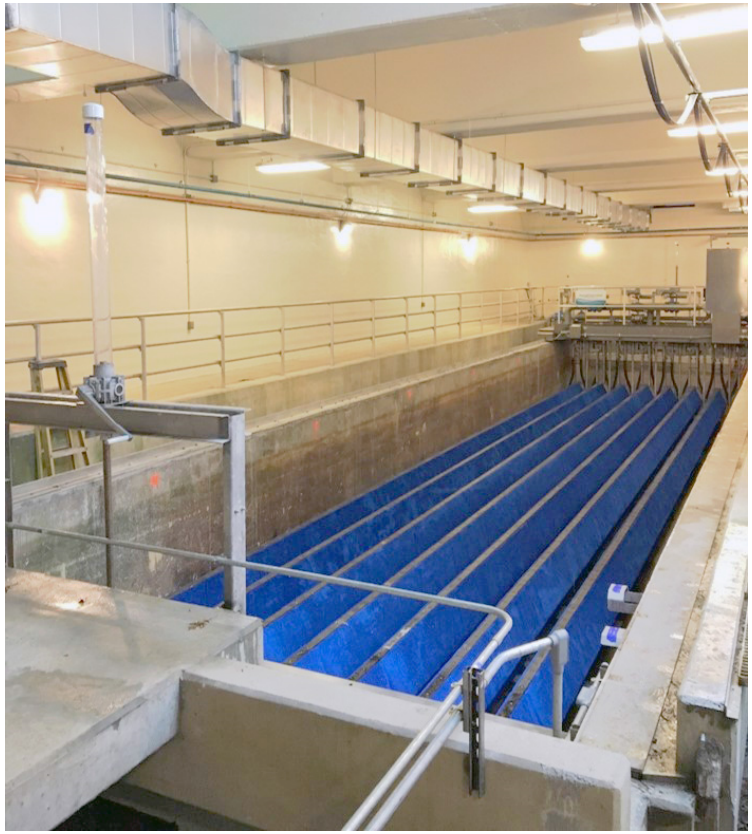


Source: Aqua-Aerobic Systems Bench-Scale Evaluation of Used AquaDisk Filter Media for CRPCD (May 2011)

Filter System Retrofits: AquaDiamond Filter

- 1 of 2 traveling bridge sand filters converted to AquaDiamond cloth filter

- Design data:
  - 60 ft long laterals
  - 1,920 sf filtration area
  - 3.25 gpm/sf = 9 mgd rated average
  - 6.5 gpm/sf = 18 mgd rated peak



Filter System Retrofits: AquaDisk Filters

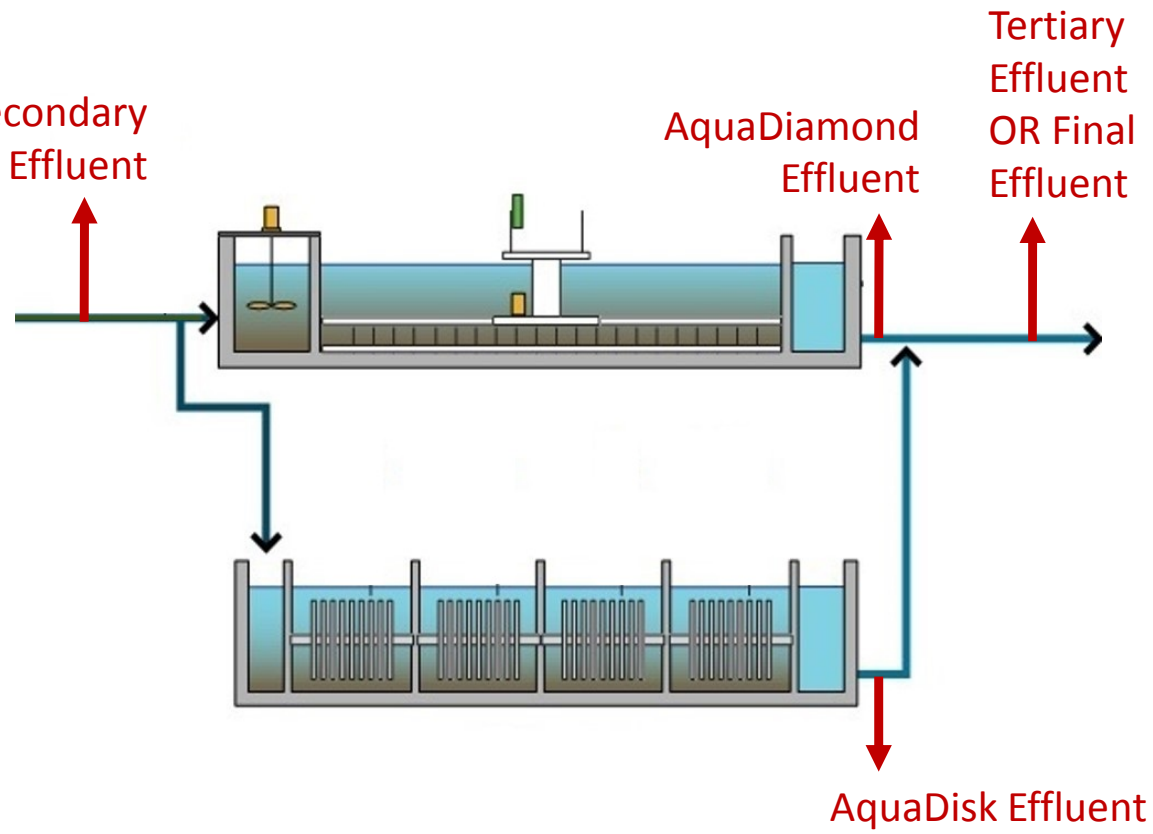
- 4 disk filters
- Design data, each filter:
  - 12 disks
  - 646 sf filtration area
  - 3.25 gpm/sf = 3 mgd rated average
  - 6.5 gpm/sf = 6 mgd rated peak
- Each filter was inspected and mechanical components repaired by manufacturer
- New submersible pressure transducers

Filter System Performance Testing

Performance Guarantee and Performance Testing

- **Performance guarantee to meet 0.1 mg/L TP contingent on District providing secondary effluent of certain quality:**
  - < 0.30 mg/L TP
  - < 0.03 mg/L sNRP
  - Low PO_4-P (generally < 0.06 mg/L)
- **Manufacturer guaranteed:**
  - Average effluent < 0.10 mg/L TP
  - Suitable performance with peak hydraulic loading rates
  - Backwash rate < 5% of forward flow
- **Objectives of 30-day filter performance test:**
  1. Verify each filter type individually and operating together can meet the effluent quality guaranteed
  2. Provide manufacturer time on-site operating system before turning system over to District

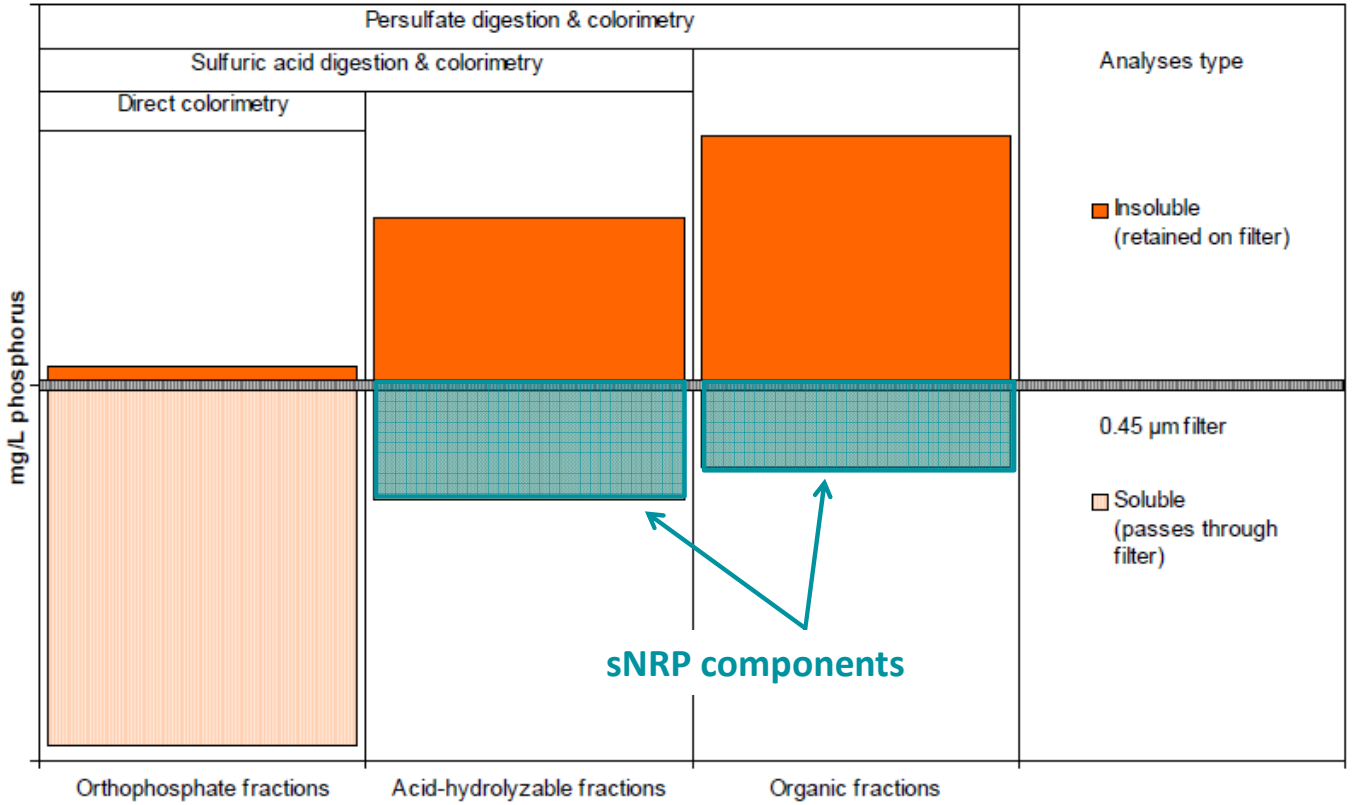
Performance Test Sample Locations and Analytes



Analytes Sampled:

- **TSS**
- **Total P**
- **Dissolved P**
- **PO_4-P**

Soluble Non-Reactive Phosphorus (sNRP)



For the CRPCD Filter Performance test:

Final Effluent sNRP = (Filtered TP) – (Filtered PO_4-P)

*** Note: fractions shown are typical for Raw Wastewater**

Performance Test Scenarios

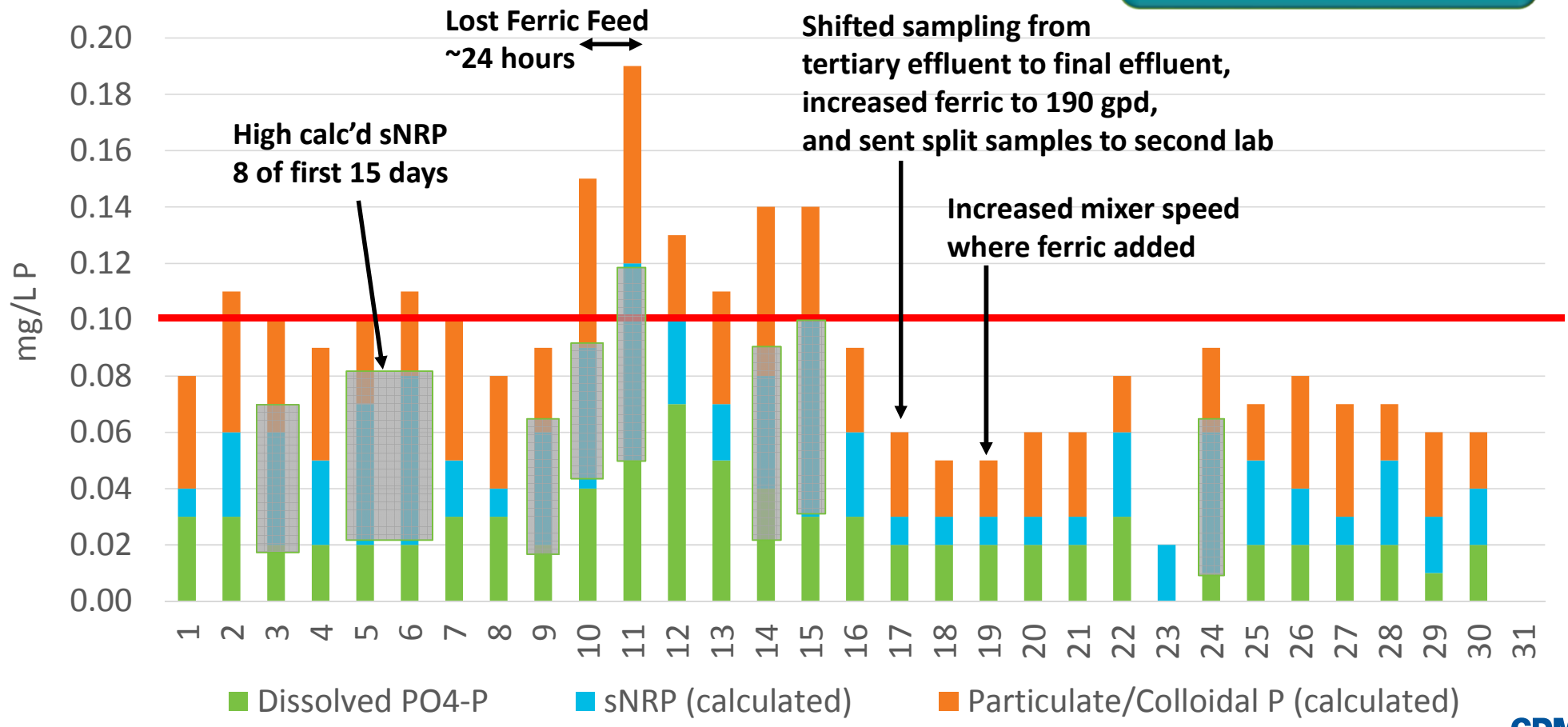
Five of eight diamond laterals at influent end of tank

Duration	Test Condition	GPM/SF
Days 1-7	AquaDiamond (no blankoff) + 1 AquaDisk	1.4 – 2.1
Days 8-10	AquaDisk (2 in service)	2.4 – 3.6
Days 11-13	AquaDiamond (with blankoff) + 1 AquaDisk	3.0 – 4.3
Days 14-16	AquaDiamond only (with blankoff)	4.2 – 5.4
Days 17-29	AquaDiamond (with blankoff) + 1 AquaDisk	2.1 – 4.3
Day 30	AquaDisk only (1-2 in service)	5.0 – 6.2

Note: Hydraulic stress test loading rates shown in pink

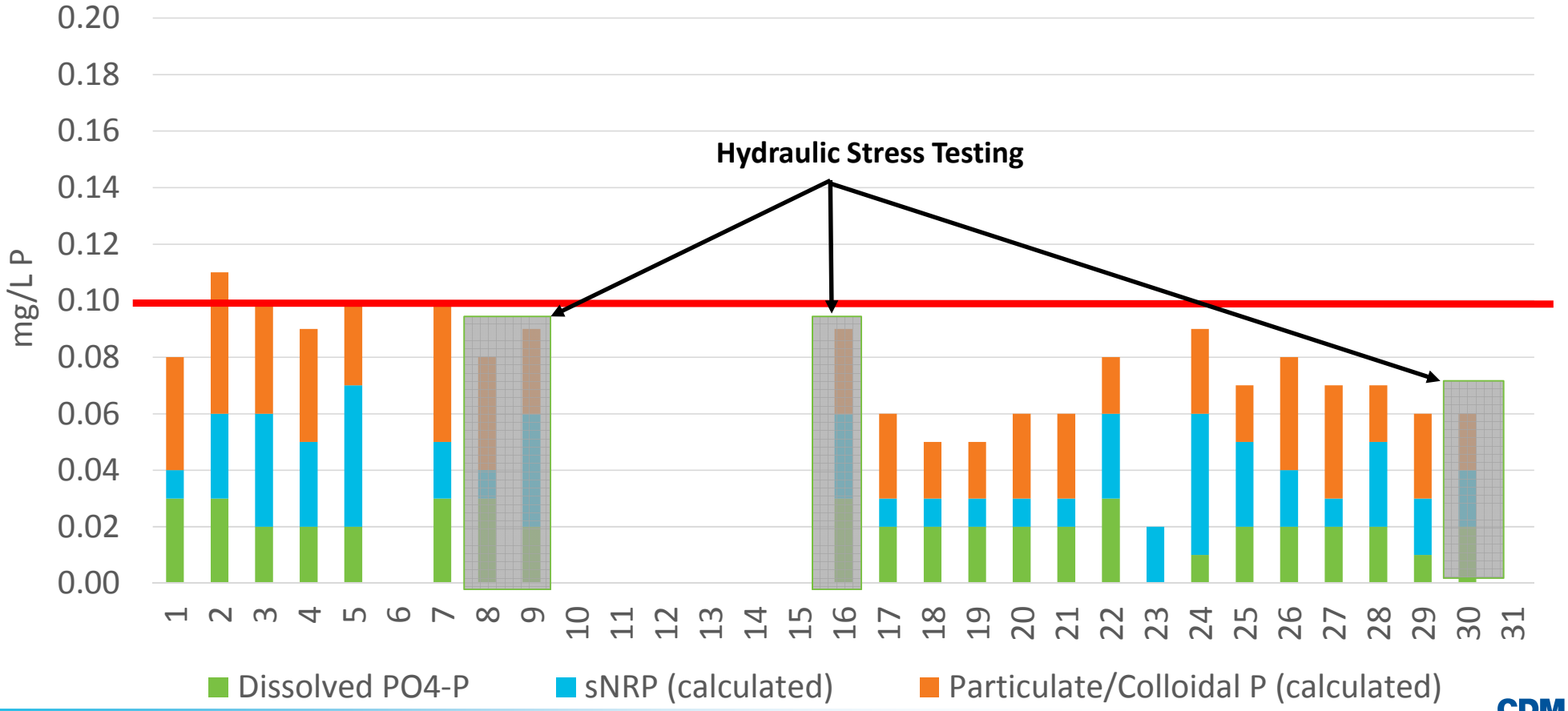
Effluent Phosphorus Results: All Data

30-day average TP = 0.085 – 0.090 mg/L



Effluent Phosphorus Results: Graded Results Only

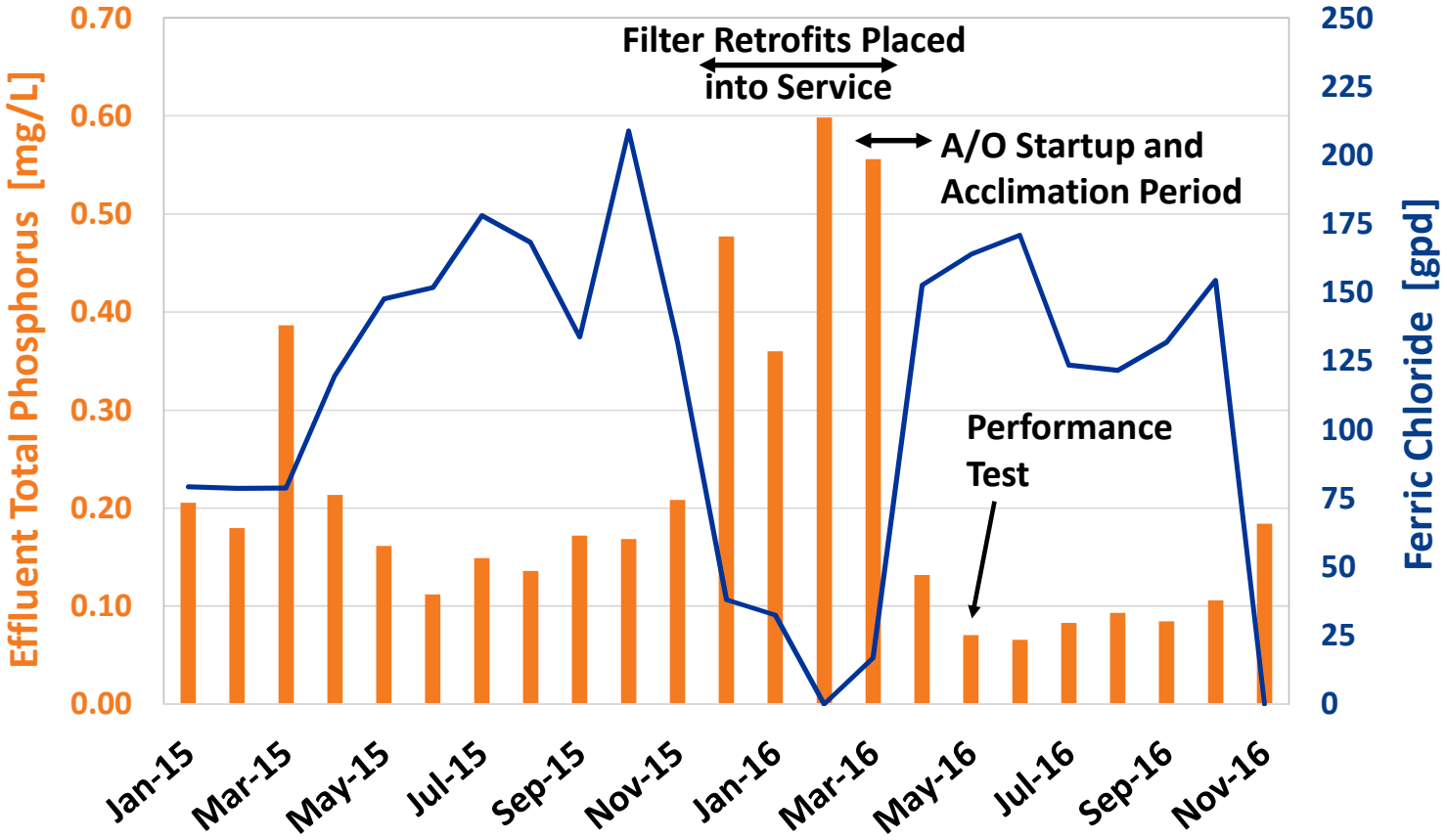
30-day average TP = 0.067 – 0.075 mg/L



Backwash as % of Forward Flow

Filter System	Average During Days 1-7 (Typical Hydraulic Loading)	Maximum During 30-Day Test
AquaDiamond	0.4%	1.5% (with blankoff plates)
AquaDisk	0.2%	0.4%

Final Effluent Before vs. After Phase C Improvements: Monthly Average Performance



Final Effluent TSS :

- Historical average = 4-6 mg/L
- 2016 average = 1.4 mg/L

Conclusions

1. **CRPCD achieving 0.10 mg/L monthly average TP limit using cloth filters equipped with 5 micron cloth**
   - Without dedicated rapid mix/flocculation
   - With proper cleaning to maintain hydraulic throughput
   - Backwashing frequency has not increased substantially
   - Maximized available assets by using existing tankage and no intermediate pumping
   - Performance is robust and handles moderate process disruptions, including elevated hydraulic loading, occasional sNRP of 0.03-0.05 mg/L, and brief loss of ferric chloride

2. **A/O upgrade has provided chemical savings in spite of more stringent TP limits:**
   - Apr-Oct: Ferric usage to meet 0.1 mg/L is similar to prior years when required to meet 0.2 mg/L
   - Nov-Mar: Ferric usage may not be required to meet 0.3 mg/L, whereas in prior years without ferric effluent exceeded 0.3 mg/L

Acknowledgements

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