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Treatment Train for Removing PFAS from High Concentration Stormwater

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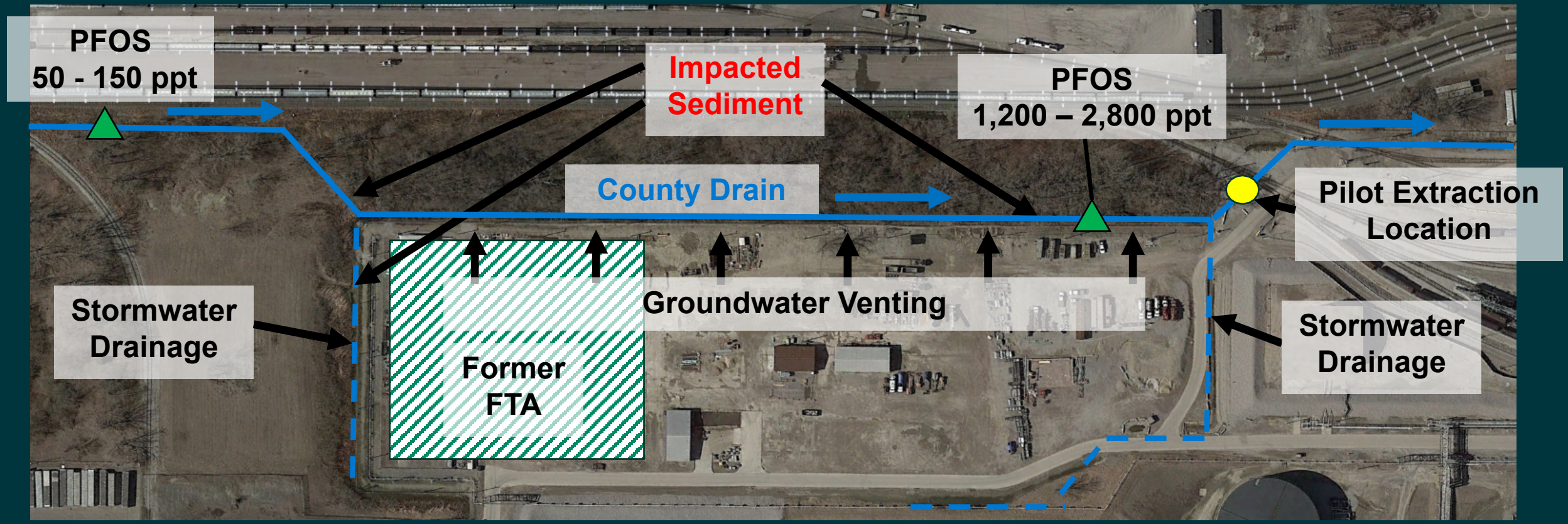
Presentation Outline

- Site Background
- Pilot System Design
- ~1 Year of Performance Data
- Challenges
- System Optimization
- Path Forward
- Key Takeaways

Site Background



Pilot Design Basis Summary

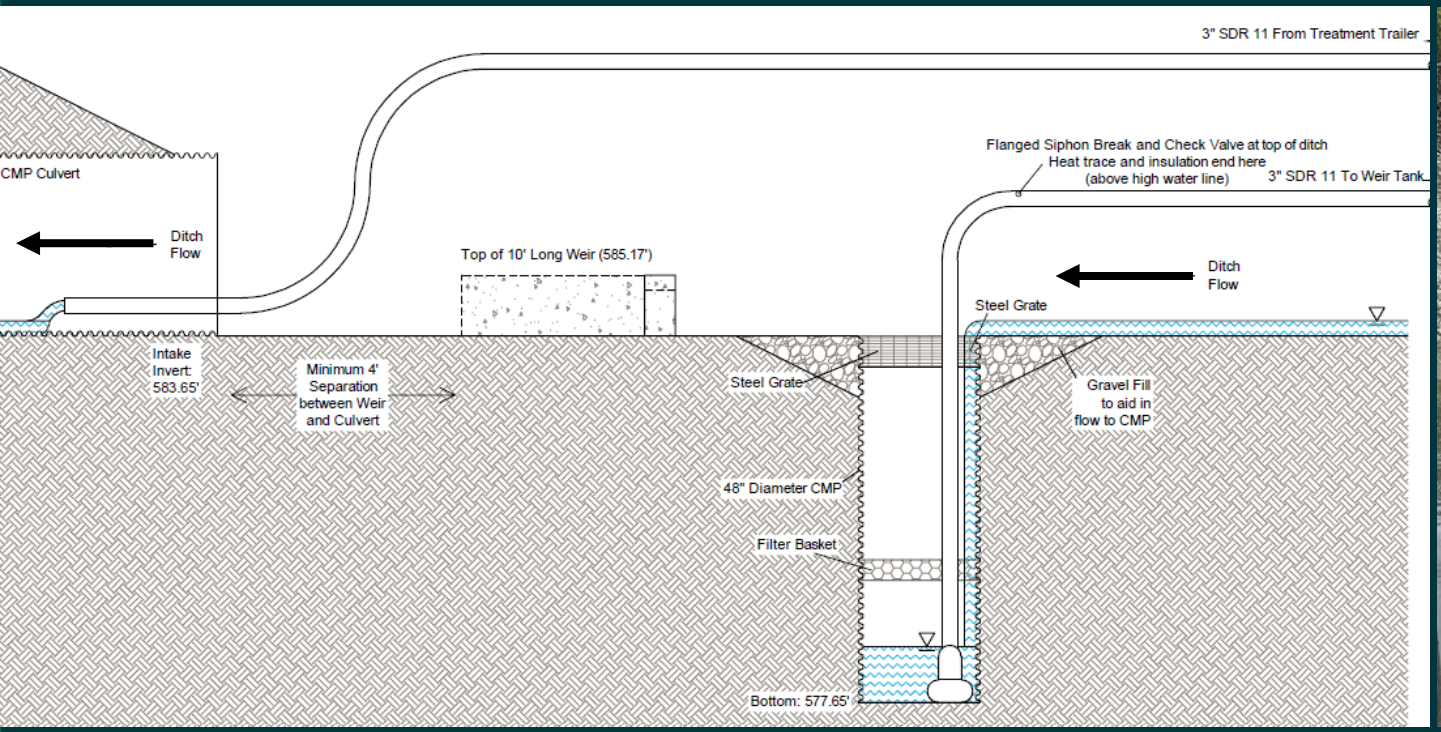
- Pilot flowrate of 100 gpm based on measurements of baseflow (5-83 gpm) over 8 months
- IX selected as PFAS treatment due to system footprint limitations and client desire for proven technology
- Robust sediment removal in pre-treatment system (TSS can have significant impact on IX resin)
- DRO, Metals, and TOC were present and can also affect resin. Concentrations varied based on rainfall conditions.
  - Include pre-treatment for TSS and some metals treatment
  - Operate pilot and evaluate the need for additional pre-treatment
- Pre-Treatment includes:
  - 18,000-gallon Weir tank
  - Sand filters
  - Bag filters
- PFAS Treatment: IX Resin (Purolite PFA694)
  - Three IX vessels in series
- Regulatory discharge limit of 65 ppt for PFOS

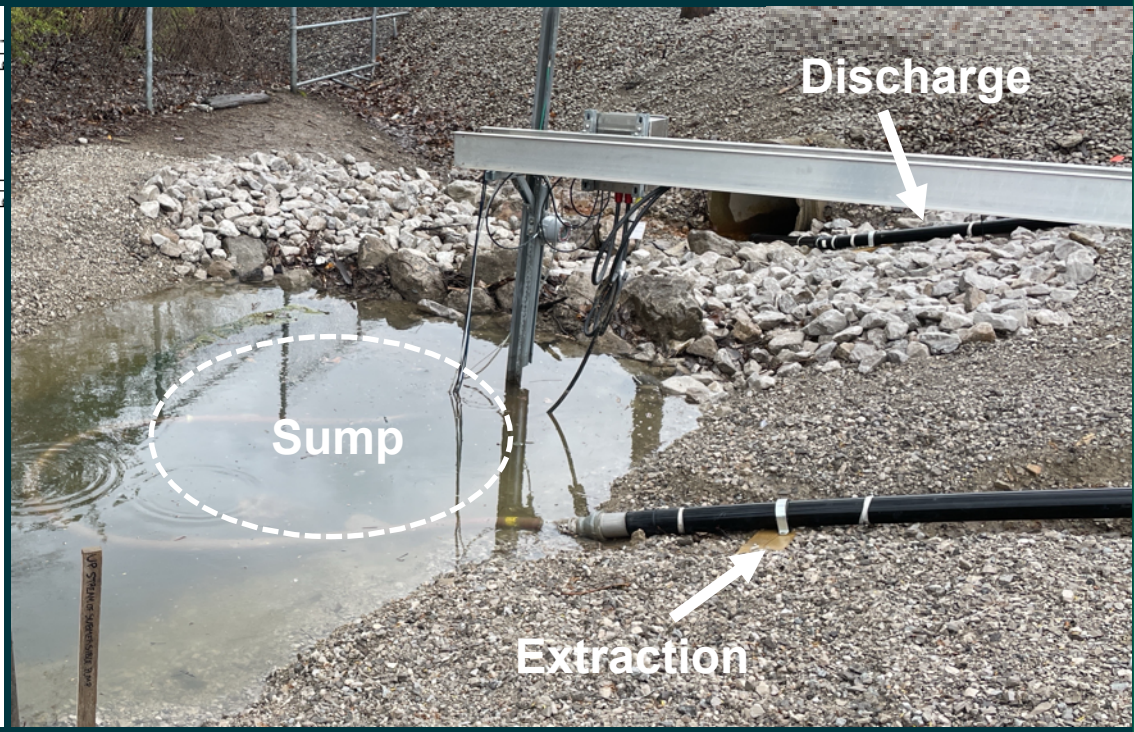

Weir Tank


Sand Filters

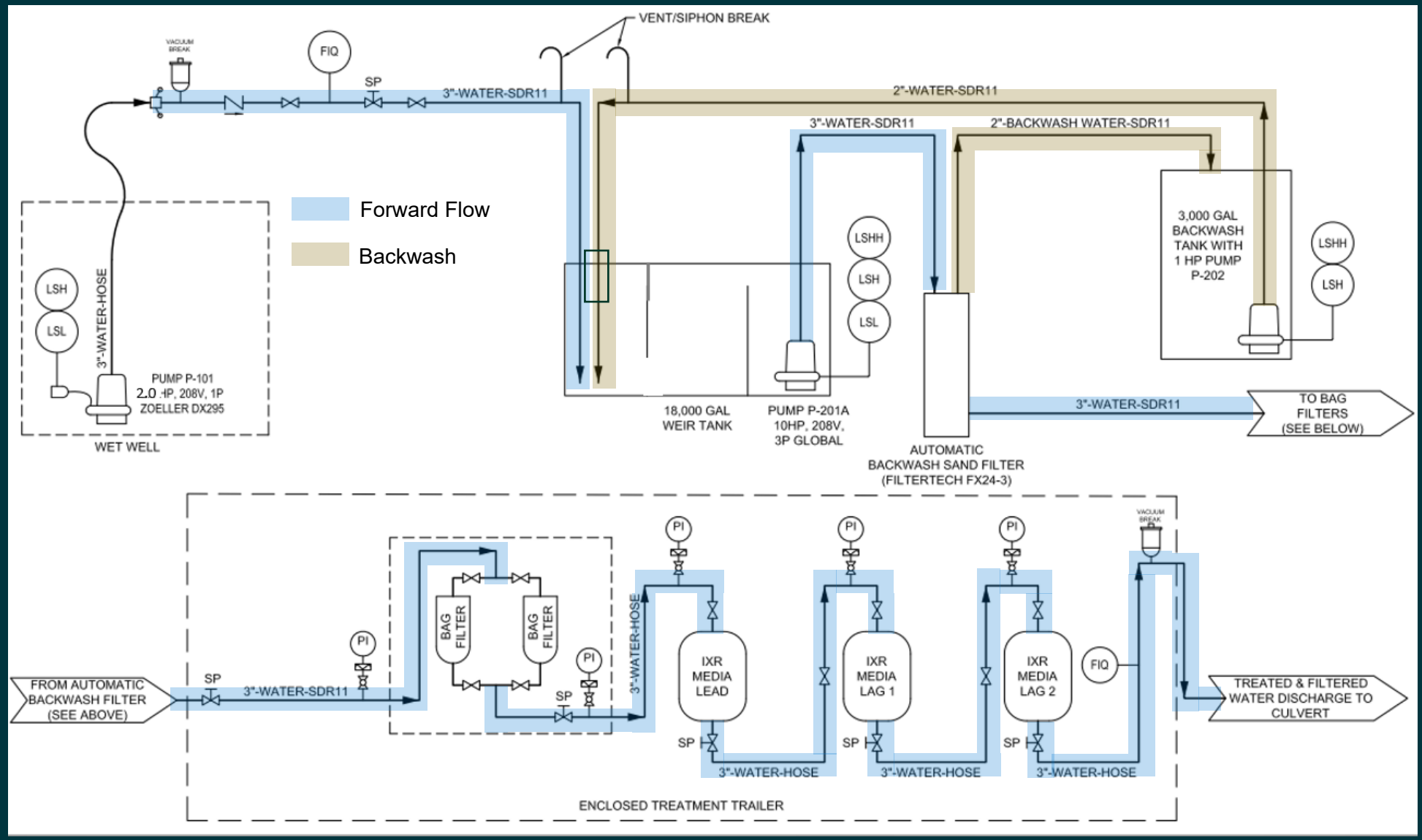

Bag Filters

Stormwater Extraction to Pilot Treatment System





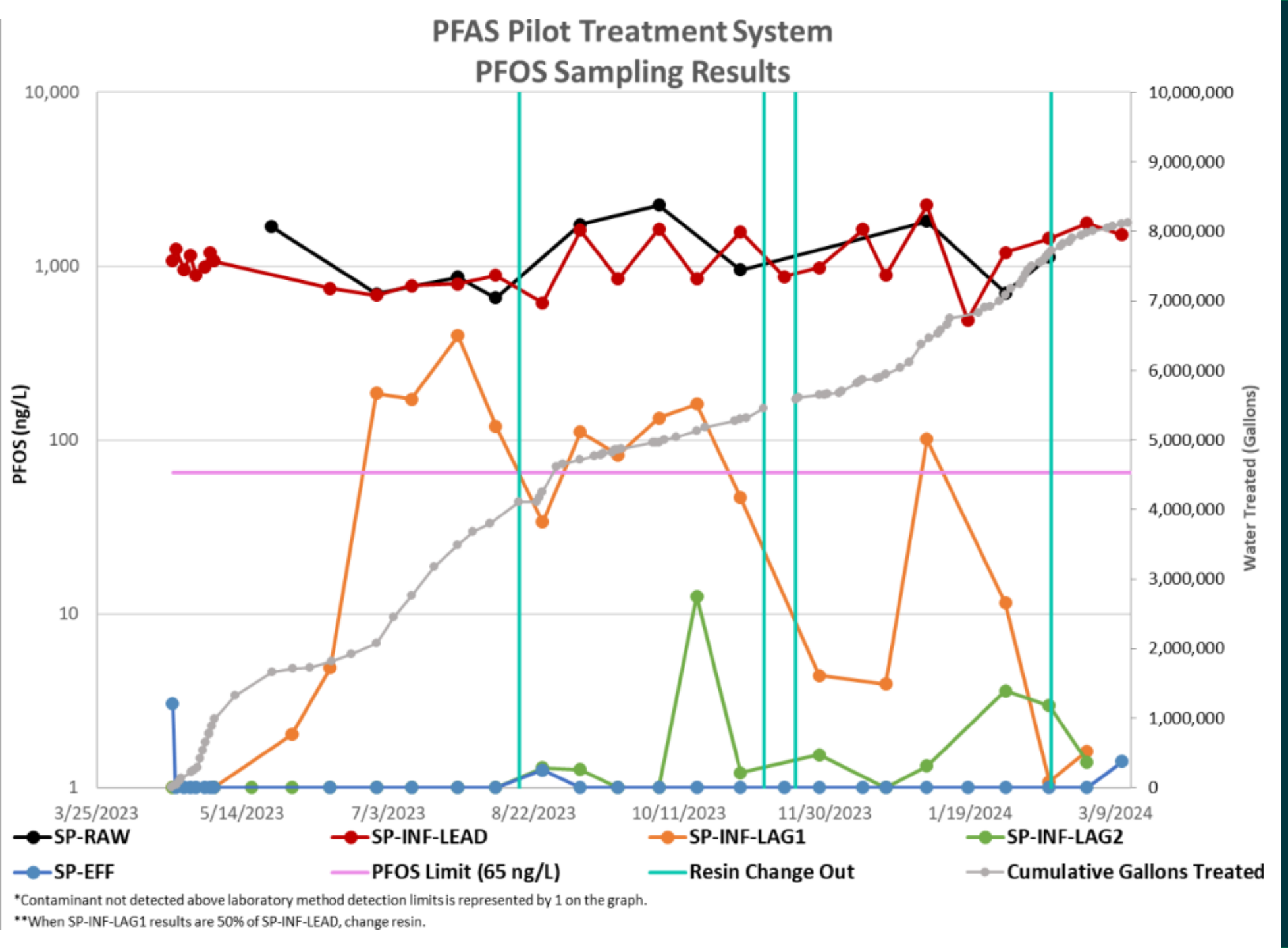
Pilot System Process Flow Diagram



Pre-Treatment Evaluation Phase Prior to Processing through Resin

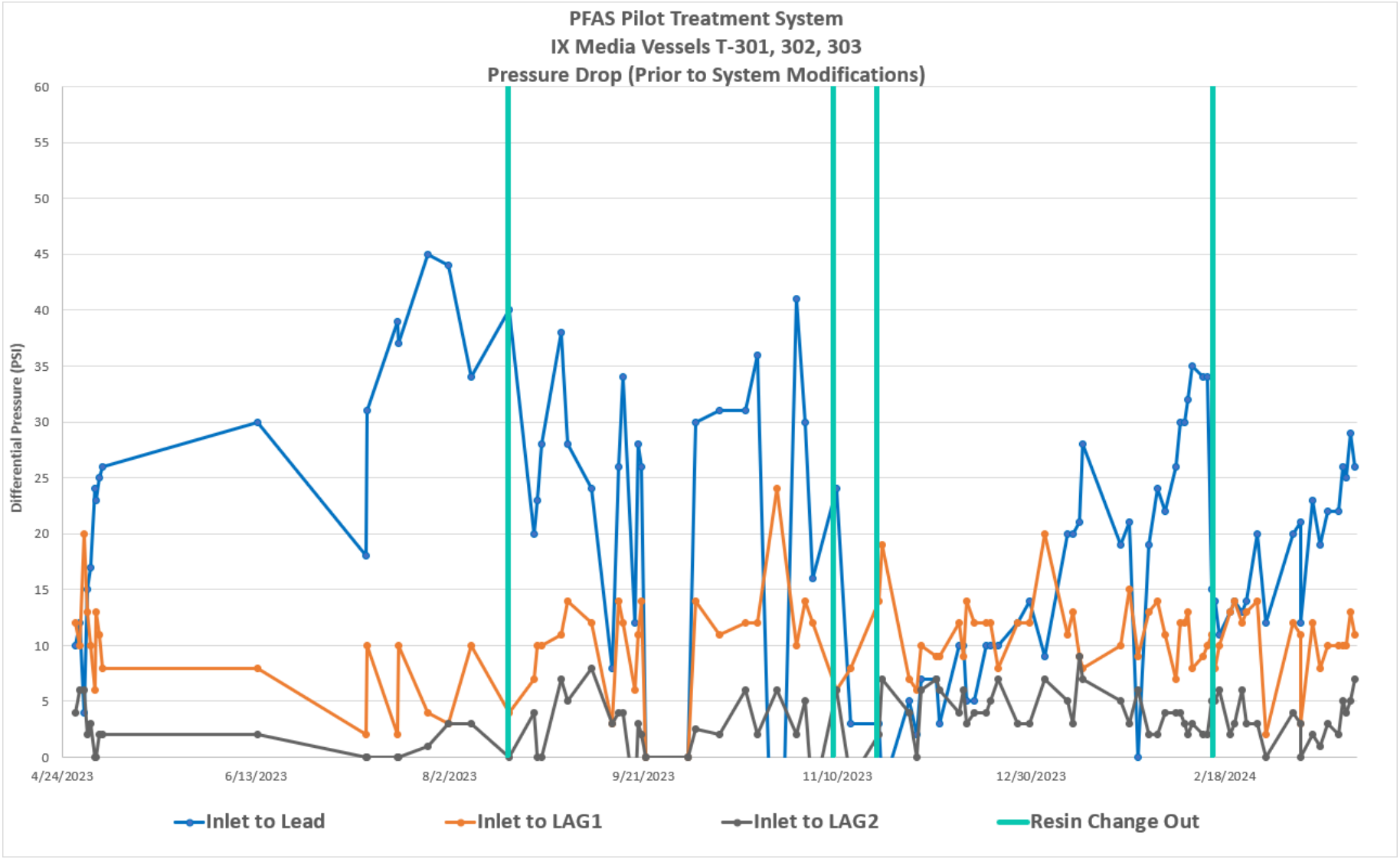
- Initially processed water only through pre-treatment system
- TSS and Iron removal appeared effective
- Inconsistent results for Mn and TOC
- Following discussions with Purolite, decided to start processing pre-treated water through resin for pilot-scale evaluation
- Decision made to optimize pilot as necessary based on performance data

		Desired	Raw Ditch	Influent to Lead Resin		
Analyte	Units	Purolite	Water	4/3/2023	4/10/2023	
Diesel Range Organics						
DRO	ug/L	NA (ND?)	103 - 564	345	498	?
Metals						
Arsenic	ug/L		1.13 - 2.62	<0.07	1.09J	
Calcium	ug/L		45,000 - 57,700	46,000	128,000	
Chromium	ug/L		0.989 - 7.32	<0.332	>0.334	
Copper	ug/L		1.96 - 9.74	2.65	1.46	
Iron	ug/L	<500	698 - 2,670	162	146	✓
Lead	ug/L		0.601 - 12.9	1.34	0.836	
Magnesium	ug/L		6,740 - 13,100	13,400	41,800	
Manganese	ug/L	<20	81 - 635	5.73	209	?
General Chemistry						
Total Suspended Solids (TSS)	mg/L	ND	3 - 35	1.4	<1.0	✓
Total Alkalinity as CaCO3	mg/L		46 - 143	99.6	317	
Total Hardness	mg/L		127 - 219	143	541	
Total Organic Carbon	mg/L	<2	1.32 - 10.2	2.94	8.21	?
Anions						
Bromide	mg/L		<1.25	-	-	
Nitrate	mg/L	<5	<0.250	-	-	
Nitrite	mg/L		<0.250	-	-	
Sulfate	mg/L	<200	72.6	-	-	
Chloride	mg/L		63.6	-	-	



- Initial resin changeout based on >65 ppt in Effluent of LEAD
- Modified changeout criteria:
  - Effluent of LEAD >50% of influent
  - >65 ppt in effluent of LAG 1
- PFOS concentrations in effluent of LAG 1 and system effluent remained low and did not drive resin changeouts

Pressure Drop Across IX Resin Vessels Drives Changeouts

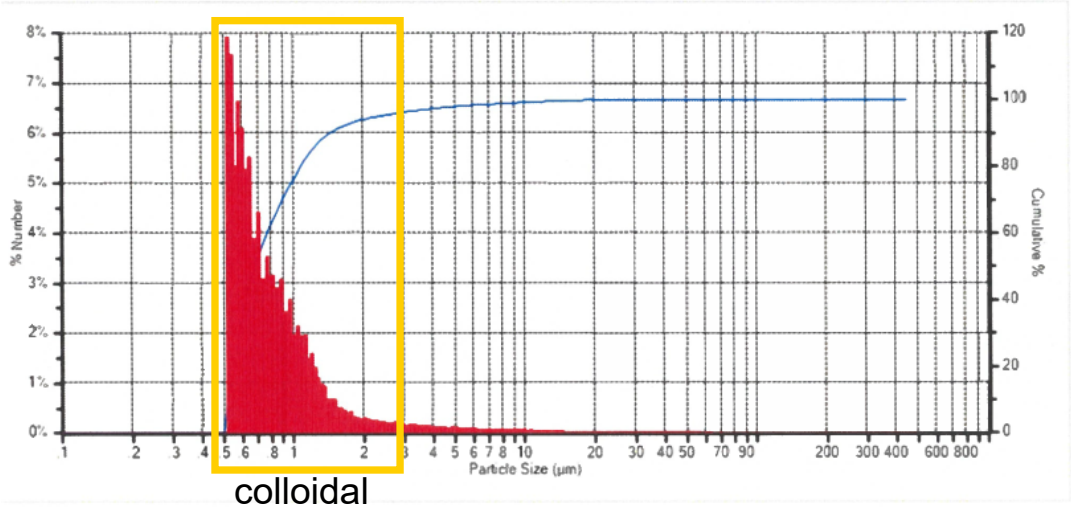


- Significant DP increases across lead resin vessel
- Major contributor to system shutdowns due to high pressure
- Resin changeouts every 3-4 months due to high DP
- Two changeouts in Nov 2023 significantly reduced DP, but then rapid increase

Root Cause Analysis for High DP

1. High concentration of colloidal particles making it through pre-treatment
   - Visual observation
   - Particle size analysis
   - Resin sample analysis (dirt loading)
2. Iron and Manganese fouling
   - Total/dissolved metals in water
   - Visual observation
   - Iron and Manganese content on resin samples
   - Elemental analysis on resin particulate (Energy Dispersive X-Ray Spectroscopy)
3. Organic fouling
   - DRO and TOC concentrations in water
   - Organic loading on resin samples

Particle Size Distribution in IX Resin Influent



Pre-Treatment Optimization Options

Particulate	Metals	Organics
Improve particulate removal from backwash water		GAC
Optimize sand filter		Organoclay
Add Filteraid (coagulant/flocculant) + Separator		
Ultrafiltration	Oxidant addition	

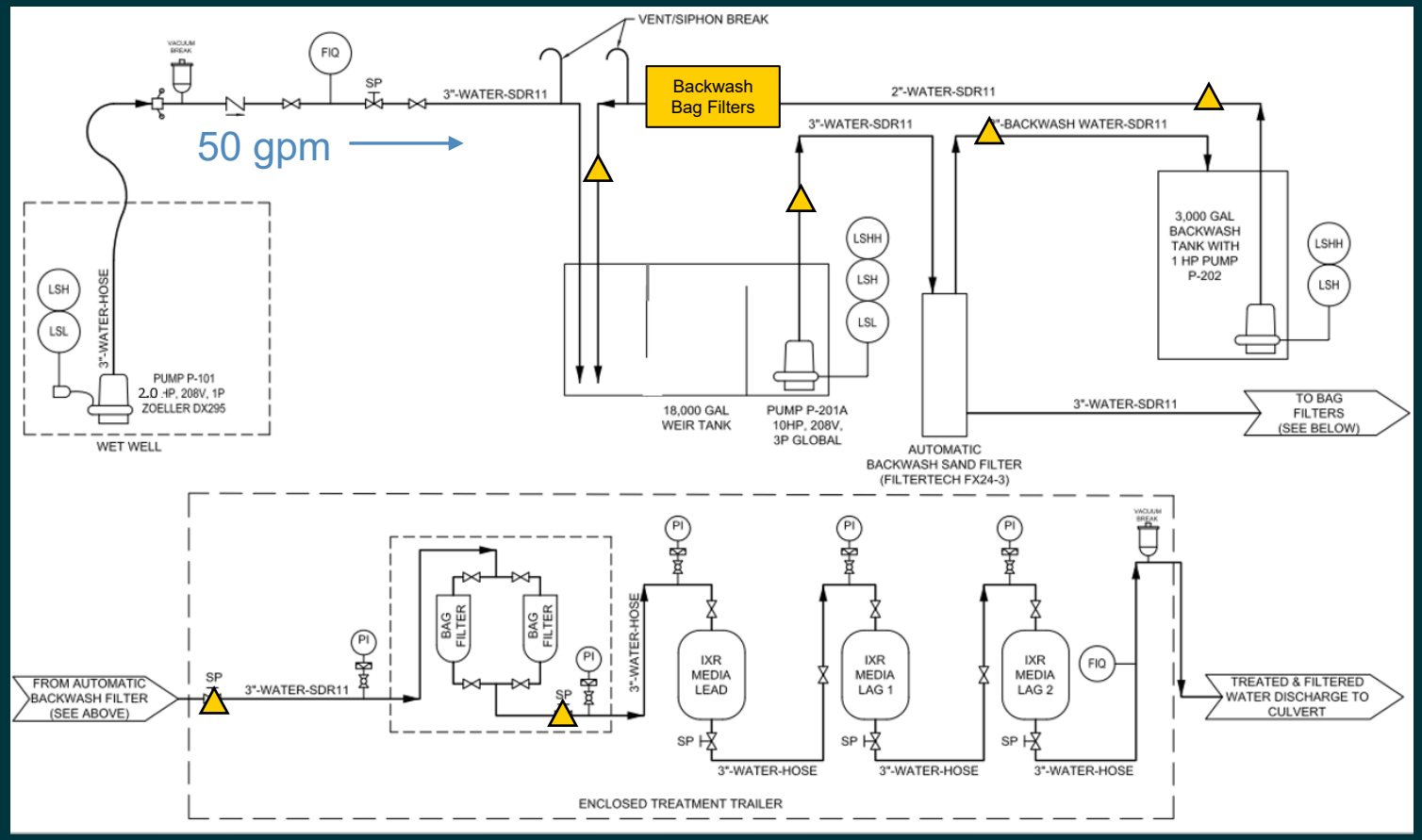
Processes Screened Based on:

- Ease of implementation
- Required O&M
- Cost

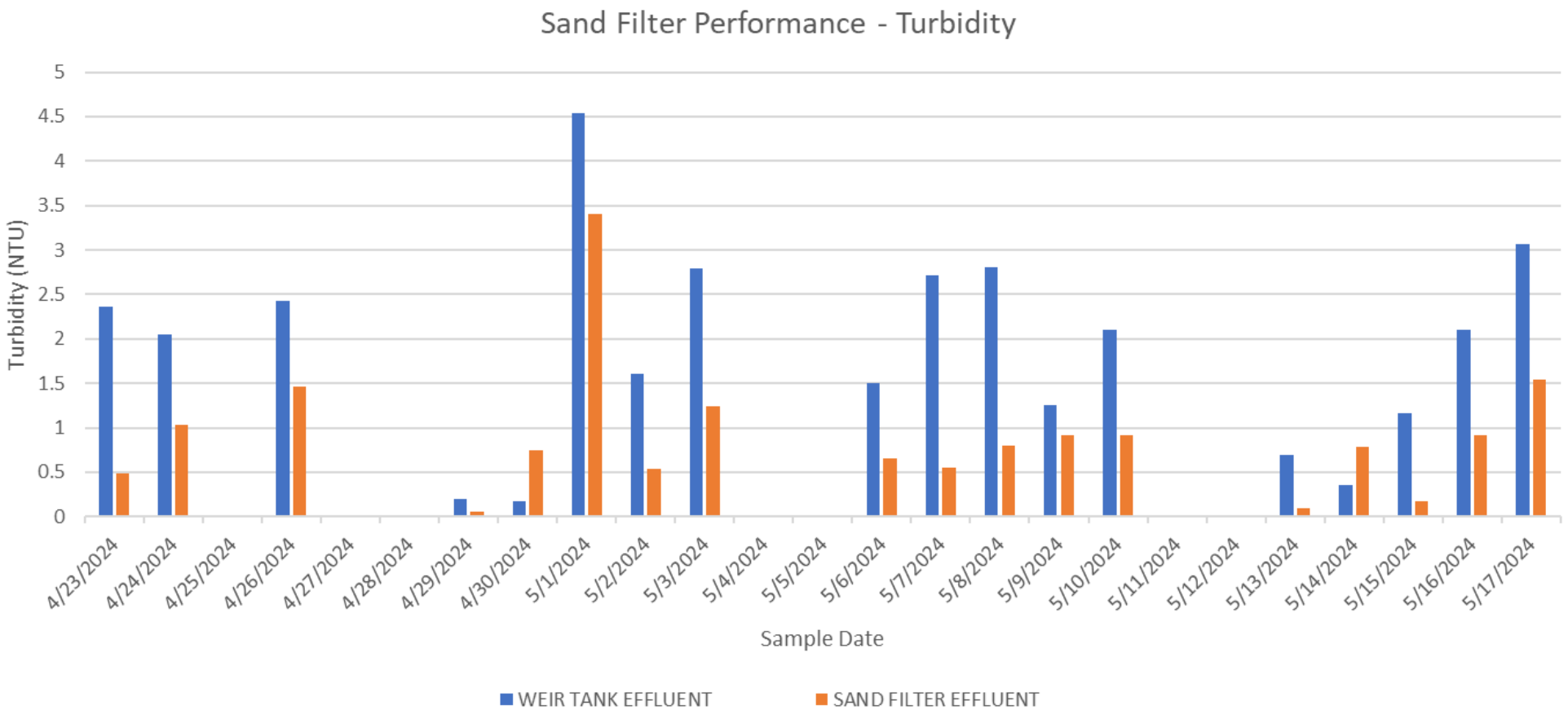
Initial Pre-Treatment Optimization Approach

1. Improve particulate removal from backwash water
   - Replaced particulate sock with 0.5 um bag filters
   - Reduces colloidal particles returning to the weir tank

2. Sand Filter Optimization
   - Reduce hydraulic loading to see if performance improves
     - Simulates larger sand filter/reduced hydraulic loading
     - “Low-Flow Trial”
   - Measure particle size distribution, TSS, and metals (total/dissolved) to evaluate improvement
   - Optimize sand filter backwash operation

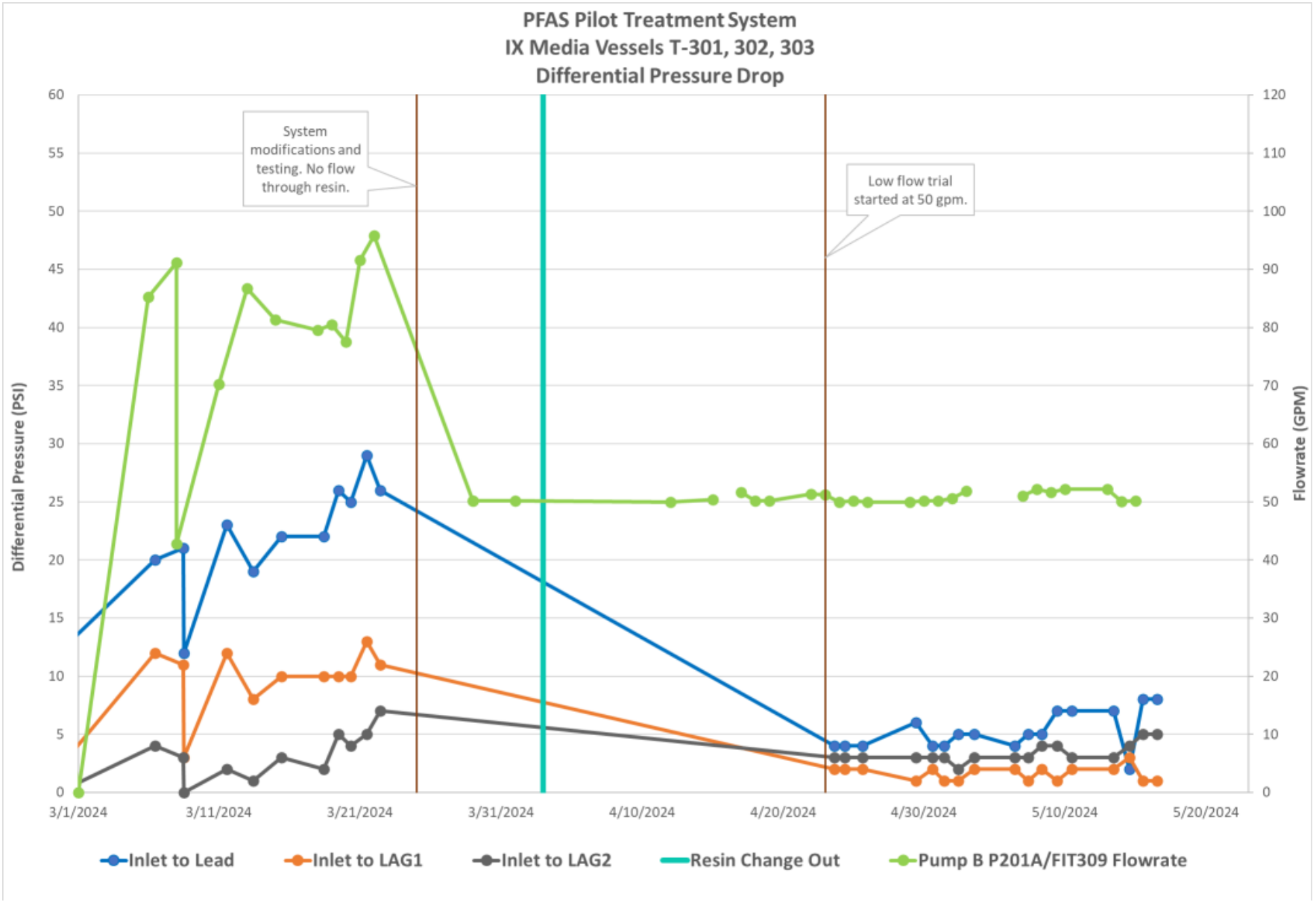


Results of Initial Pre-Treatment Optimization – Sand Filter



- Turbidity readings indicate sand filter removing particulate
- With two exceptions, turbidity < 1.5 NTU at sand filter effluent (previously 5-10 NTU during 100 gpm operation)
- Awaiting particle size and metals data to confirm/better understand sand filter performance

Prelim Results of Initial Pre-Treatment Optimization – Resin DP



- Differential pressure across resin vessels has significantly reduced
- DPs across lead resin vessel used to be as high as 30 psi and drive resin changeouts
- DP across lead resin vessel currently 4-8 psi during system optimization
- Results are very similar when you normalize DP to flowrate
- Awaiting resin analysis (dirt loading, metals, organic loading) to confirm resin health

Path Forward for Continued Pilot Optimization

- Await data and continue to evaluate low-flow trial results
  - Determine whether to invest in a larger sand filter
- Return pilot operation to 100 gpm, collect data, and evaluate performance
  - Evaluate need for additional pre-treatment optimization
    - Adding GAC to treatment train
      - Remove organics
      - Further protect resin
  - Improve cost effectiveness of forward flow bag filter filtration
- Continue collecting performance data to support design of the full-scale stormwater treatment system

Key Takeaways

- Stormwater is a **different animal** than groundwater or industrial effluent treatment
- **Pre-treatment optimization** can be more **challenging** than PFAS removal
- **Long term piloting** is recommended for successful full-scale treatment
  - Water quality can vary seasonally and with different storm events
  - Pre-treatment may need to be optimized over time
- **Understanding seasonal flowrates** for baseflow and different storm events is critical
- PFAS stormwater treatment is challenging, but can be done!

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THANK YOU!

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