Combating Costly Nitrogen Credits and Kilowatt Hours in Connecticut: The Story of Greenwich's Full-Scale ABAC Pilot

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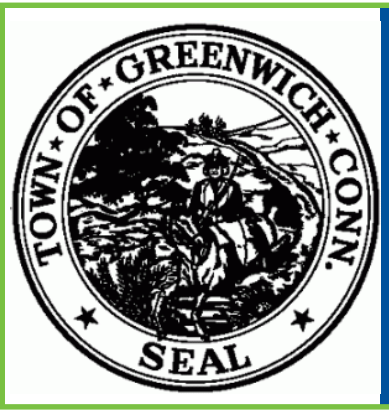

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Grass Island Wastewater Treatment Plant (GIWWTP)

- Greenwich, CT
- Design flow: 12.5 MGD
- Nitrogen removal
  - 5 aeration basins
  - MLE configuration
    - No supplemental carbon

Grass Island Wastewater Treatment Plant (GIWWTP)

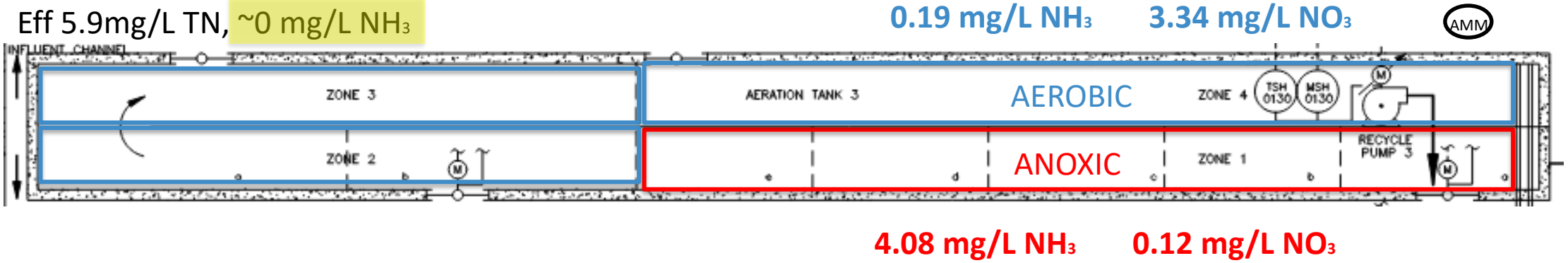
- Existing aeration system
  - Fine bubble diffusers in aerobic zones
  - Coarse-bubble mixing in anoxic zones
  - Three 250 Hp single-stage gearbox-drive centrifugal blowers (4500-10,000scfm)
  - Automatic aeration control based on DO, using analyzers in basin 3 and pressure-based blower control
- Energy Audit (2020 JK Muir)
  - Blowers may be oversized
  - Can't turn down enough during low flow periods
  - Energy Savings from smaller blower

Historical Biological Nitrogen Removal Performance

Pre-pilot (March 2022)

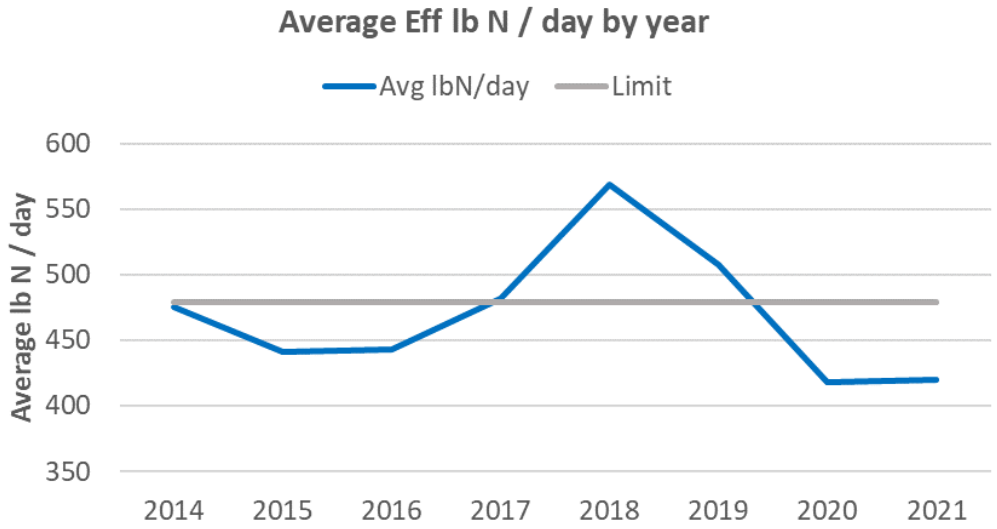
Inf 24.9mg/L TN, 18.2mg/L NH_3

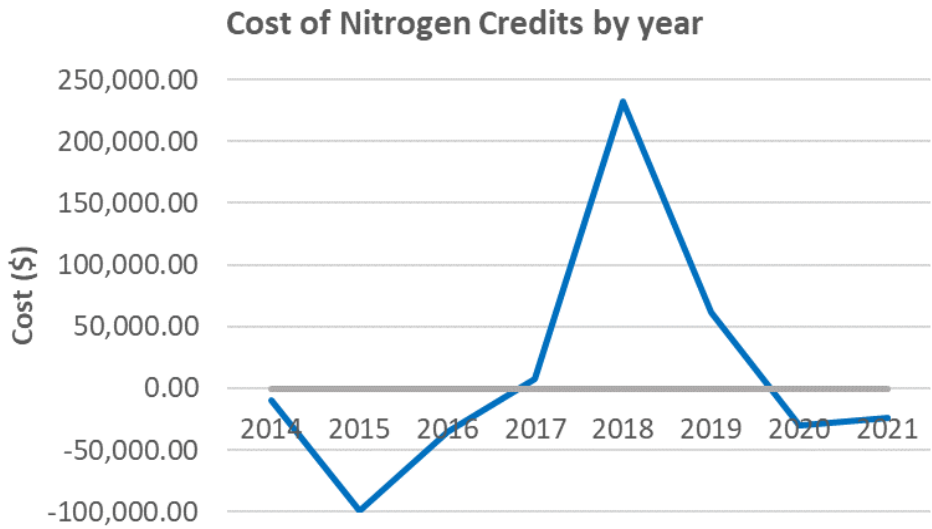
Eff 5.9mg/L TN, ~0 mg/L NH_3

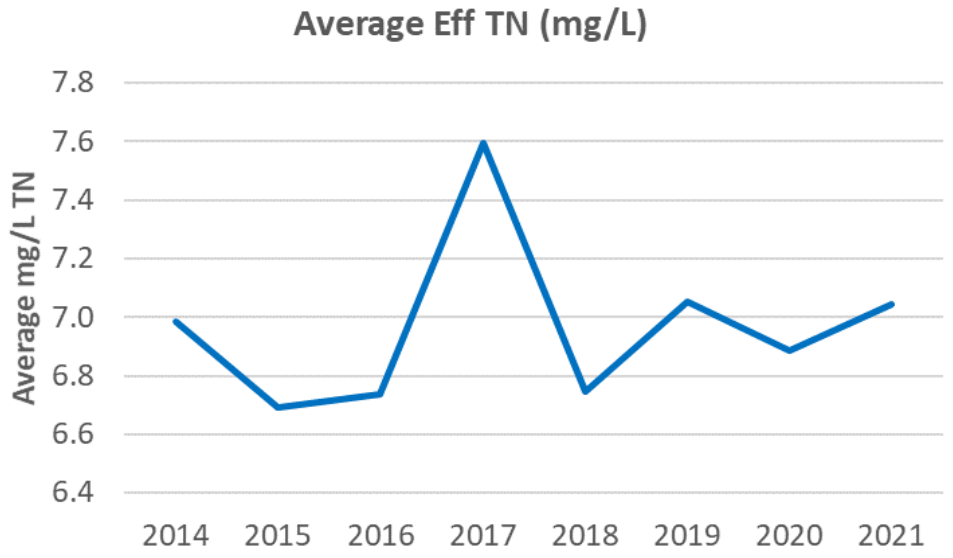


- Consistent ~0 mg/L NH_3 in effluent
  - We may be nitrifying more ammonia than we can get rid of via denitrification
    - Wasting Energy

Historical Biological Nitrogen Removal Performance







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GIWWTP Goals

1. Energy Savings
2. Fine-Tune Nitrogen Removal

Ammonia Based Aeration Control (ABAC)

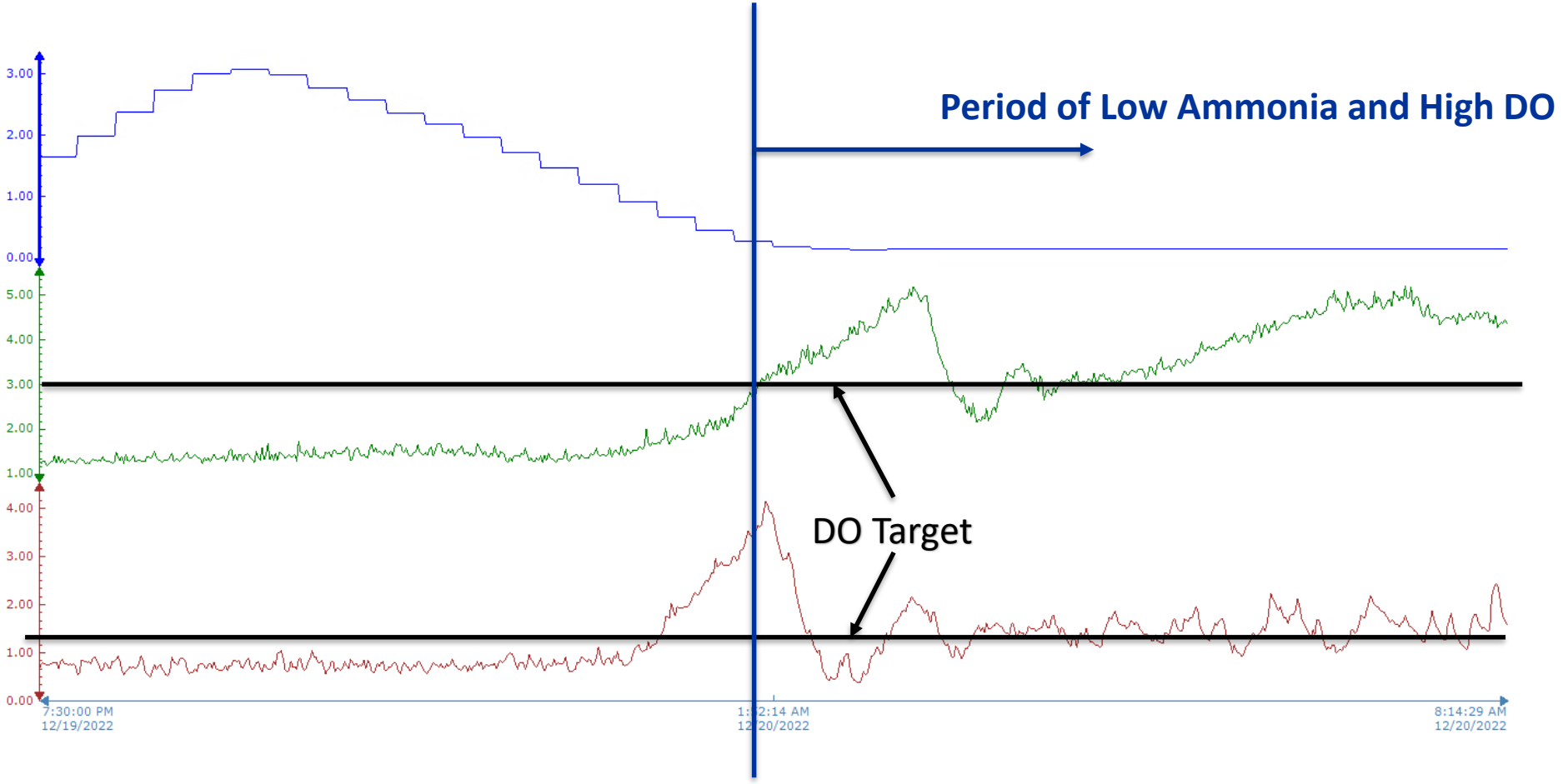
- Aeration system controlled to target an ammonia setpoint
  - Set point at which all nitrate created is denitrified
  - No energy wasted generating DO to nitrify all ammonia
- ABAC recognizes that under typical conditions the full process capacity is not needed
  - BNR process design typically set for maximum conditions
  - ABAC should reduce routine DO set point
    - Energy Savings
  - Proposed using a smaller blower for pilot
    - Additional Energy Savings

Potential for ABAC at Greenwich

Ammonia

Zone 2B DO

Zone 3 DO



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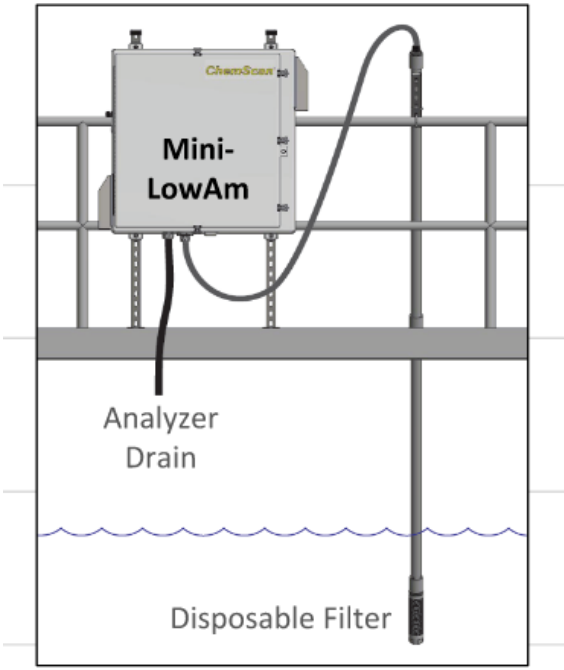
ABAC at GIWWTP – Improvements Required

- Replace valve actuators on droplegs for aeration tank 3 (used for DO control)
- Install demo blower
- Install ammonia analyzer on aeration tank 3
- Incorporate programming to run in ABAC mode



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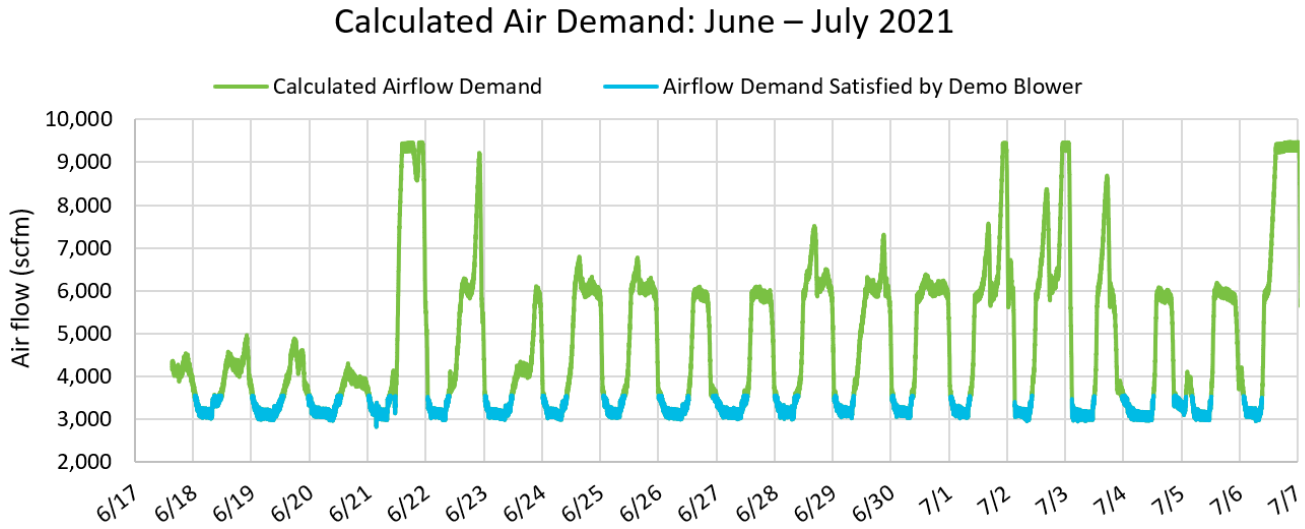
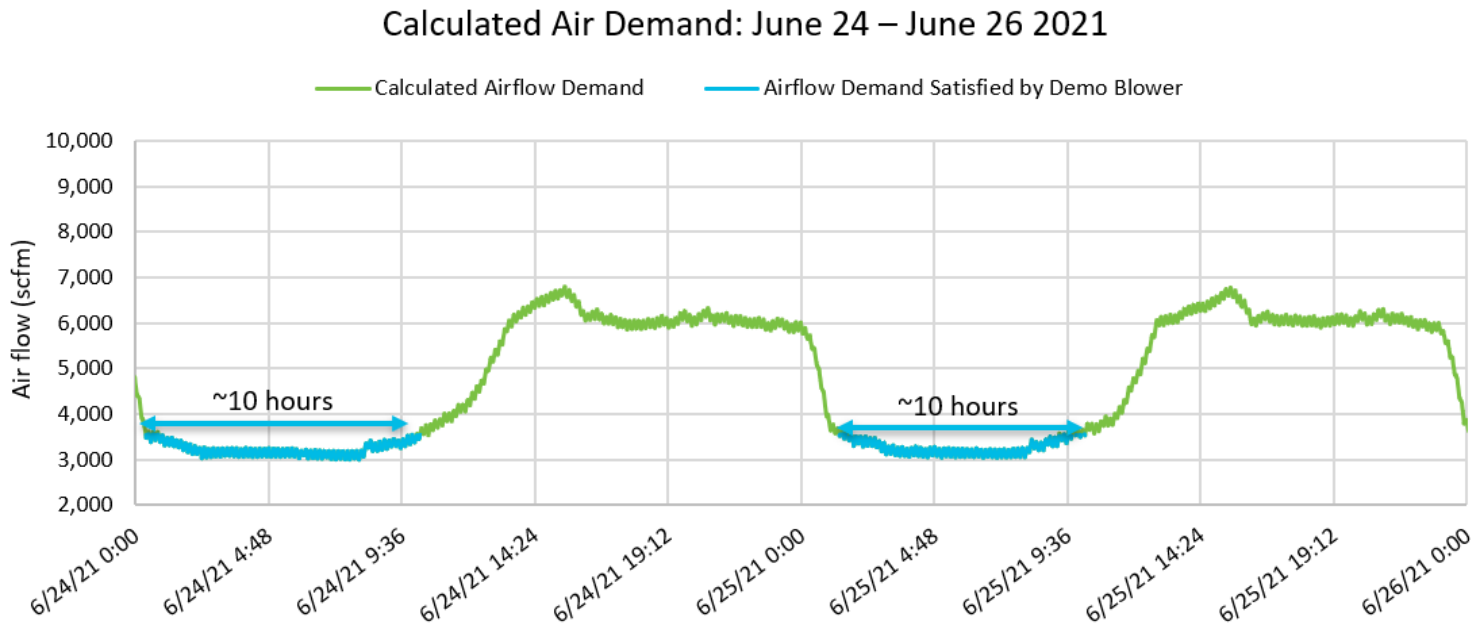
Projected Airflow Demand

- Calculated Air Demand – Sum of all aeration tank air flows





Existing Aeration Control

- 5 Tanks each with 4 zones
- Zone 1 is split into 5 subzones which uses air for mixing (cycling on and off)
- Tank 3 and 5 have 4 DO sensors which are used for DO control
  - Zone 2 DO setpoint 3.00 ppm
  - Zone 3 DO Setpoint 1.45 ppm

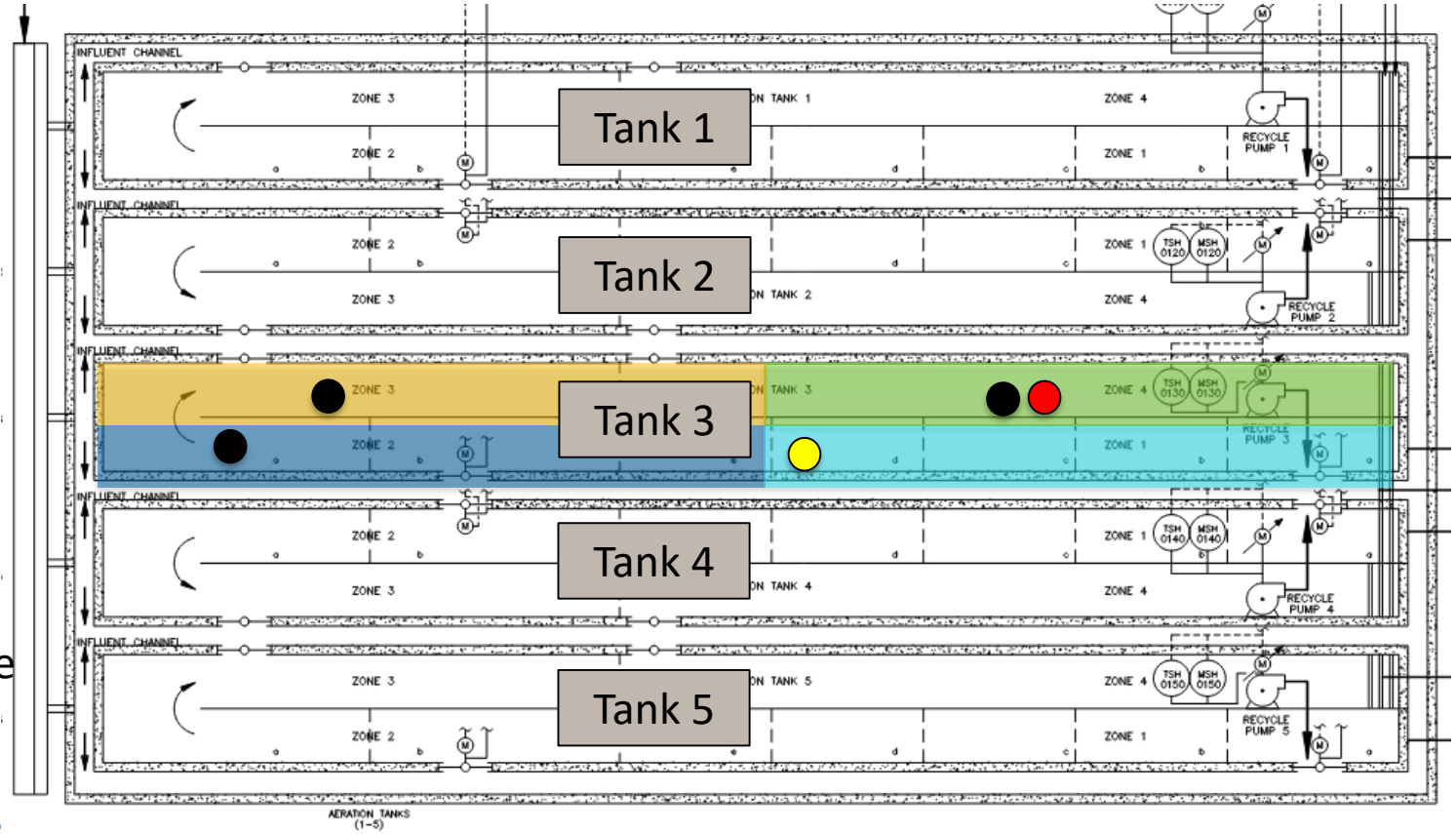
Zone 1 Anoxic

Zone 2 Aerobic

Zone 3 Aerobic

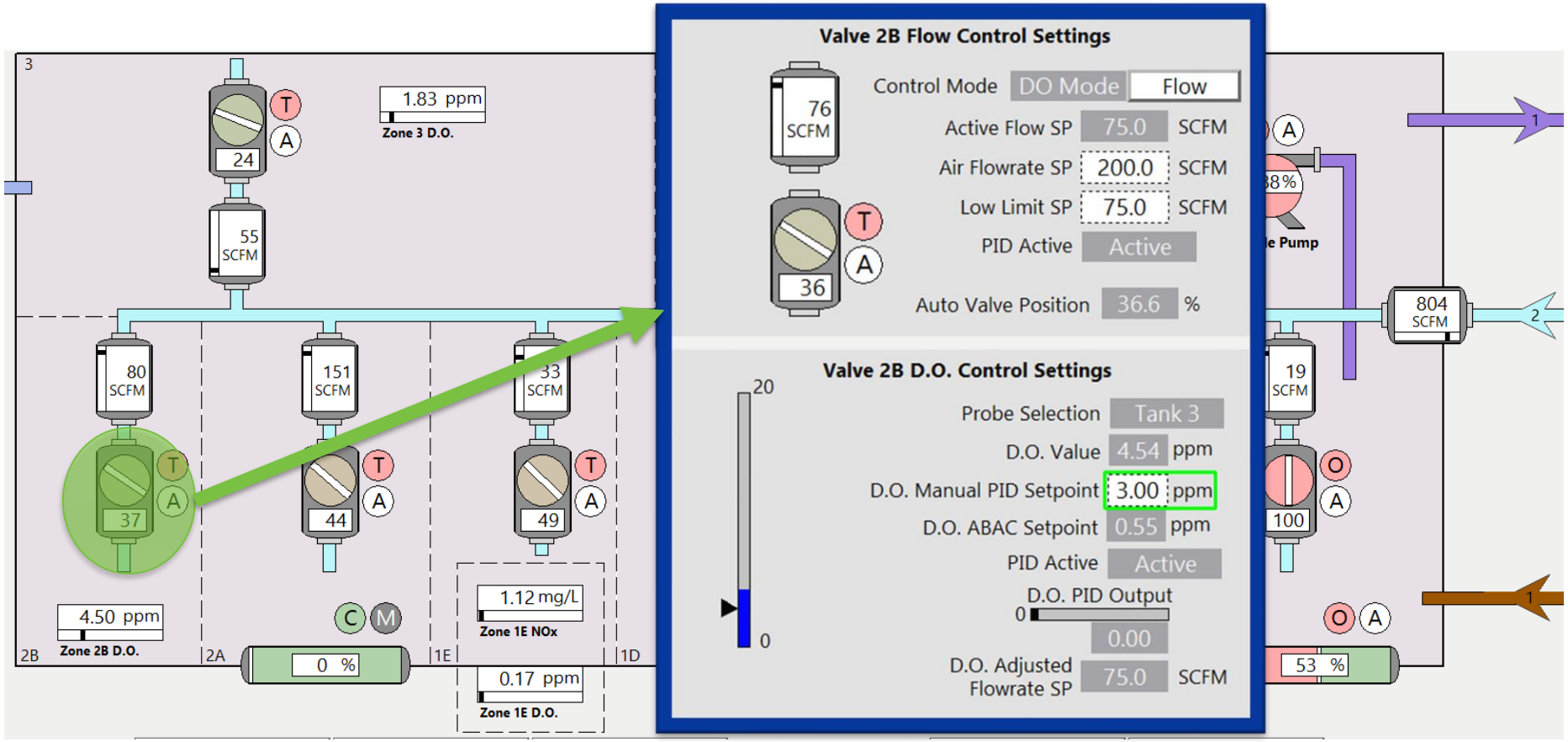
Zone 4 Aerobic

- Control DO Probe
- Feedback DO/Nitrate Probe
- Ammonia Probe



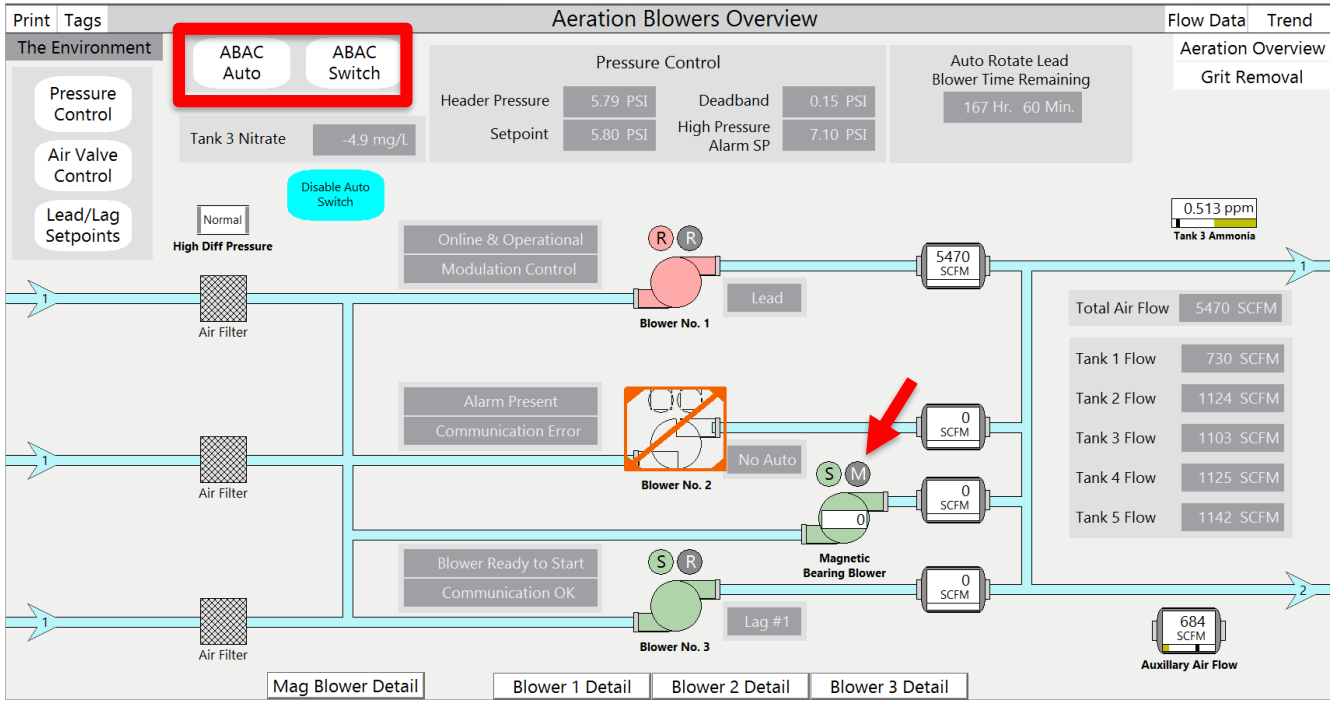
Existing Aeration Control, Cont.

- Each drop has a flowmeter and modulating valve with PID flow control
- Zones 2B, 3, and 4 have DO control on top of flow control



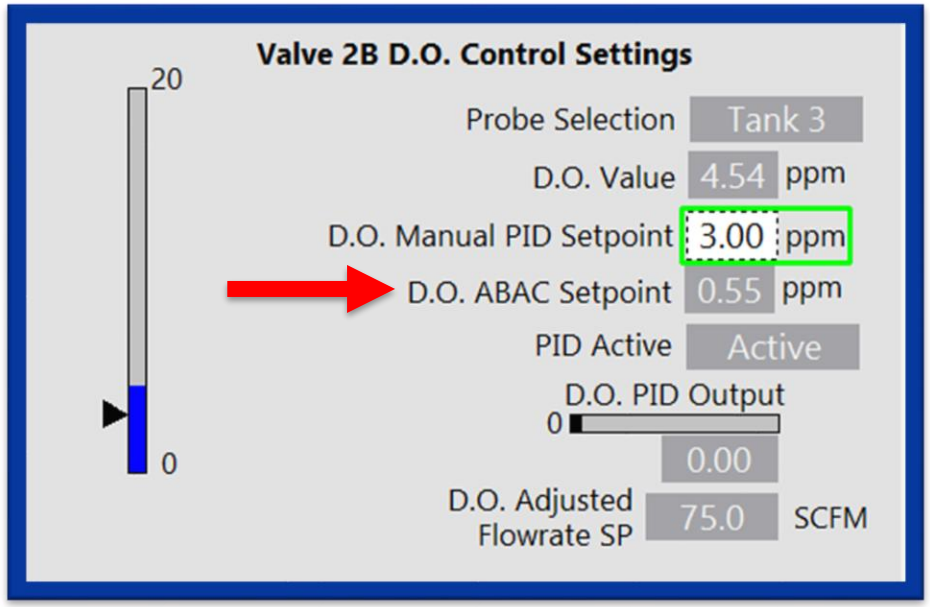
Demo Blower Programming and Functionality

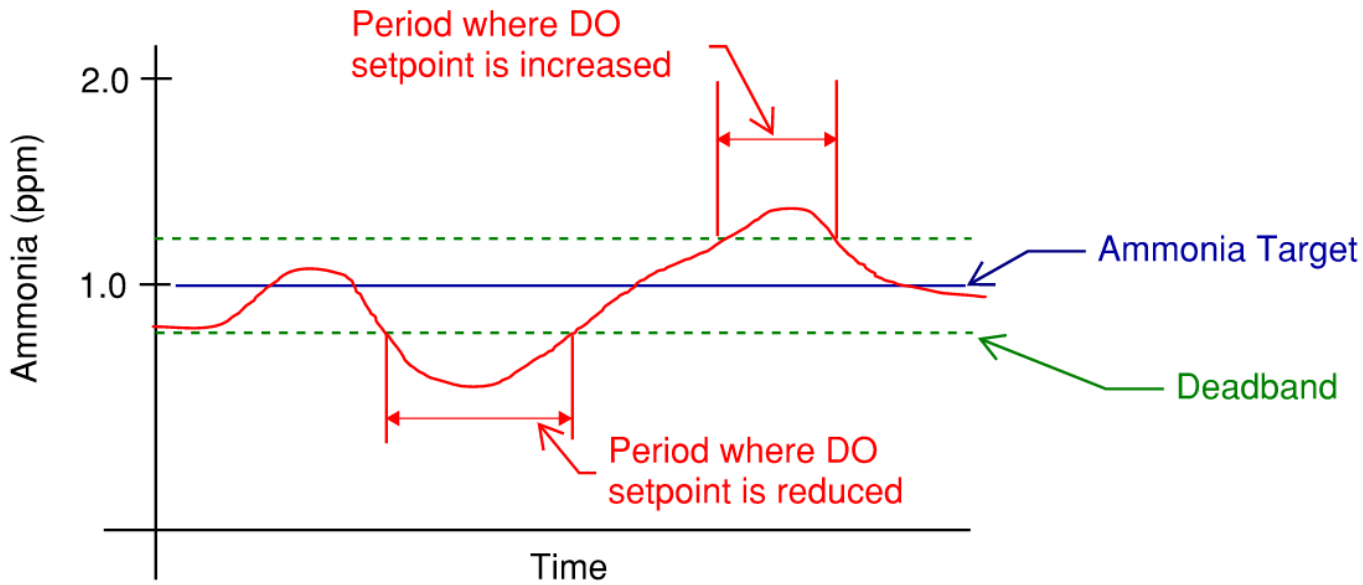
- Demo blower to be used when ABAC control is enabled.
- Flow based control instead of pressure-based control
- Interlocks when header pressure is too high or when existing blower system being used
- Flow will be calculated by summing the existing flow control setpoints
- Pressure safety logic included to cut back on demand or open designated valves to relieve pressure before hitting shutdown (interlock) pressure



ABAC Programming and Functionality

- ABAC “sits on top” of DO control and adjusts the DO setpoint
- DO setpoint increased or decreased based on Ammonia Feedback
- ABAC is active until either Ammonia increased above setpoint or DO cannot be maintained
- Step function using a “wait and see” methodology to determine if more adjustments are necessary





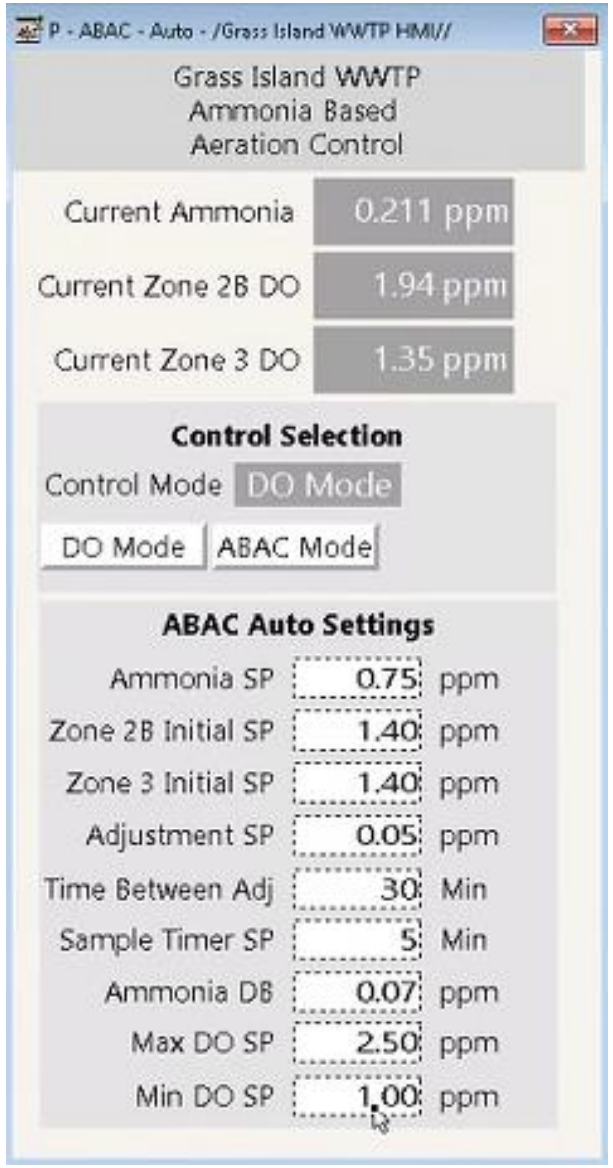
Control Mode Switching

Entering into ABAC Control

- Manually initiated ABAC
- Auto Switchover based on Flow Demand within range of demo blower
- Auto Switchover on Ammonia Decline (added during pilot)

Exiting ABAC Control

- Blower capacity exceeded
- DO too low
- Ammonia too high



Auto ABAC to DO Switchover

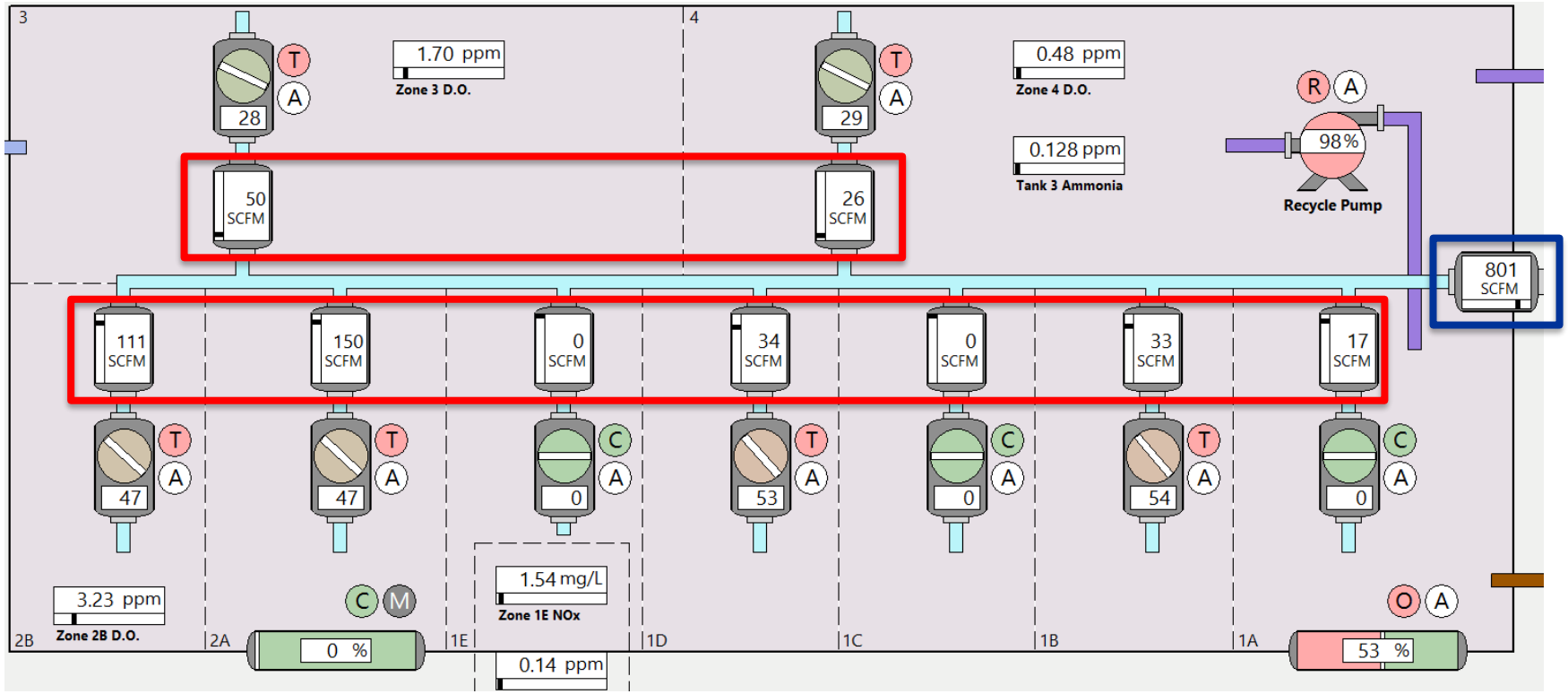
Blower Capacity	3600	SCFM
Time Delay	30	Min
DO Deadband	0.50	ppm
Time Delay	60	Min
Ammonia DB	0.10	ppm
Time Delay	60	Min

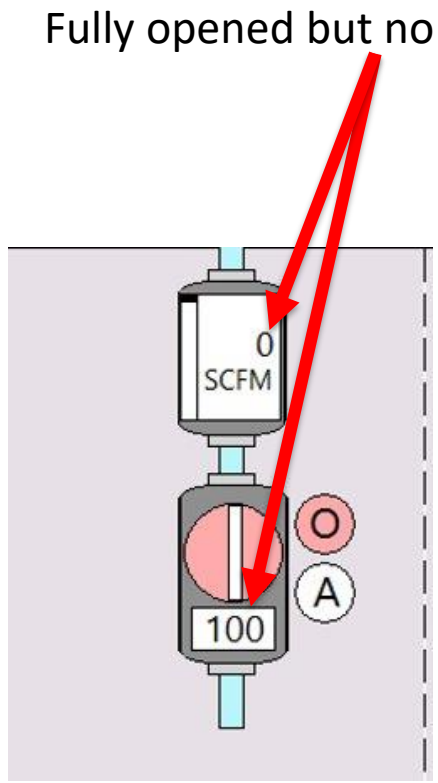
Auto DO to ABAC Switchover

Enabled?	☐	
Min DO Time	60	Min
Time Delay	10	Min

Control Challenges

- Drop leg flowmeters do not add up to the main tank flowmeter
- Valves not responding to control

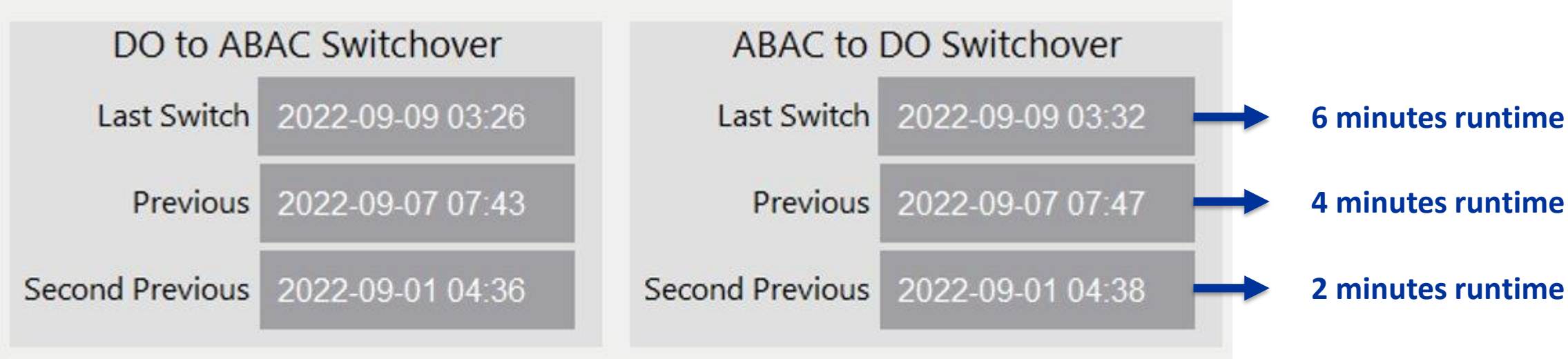




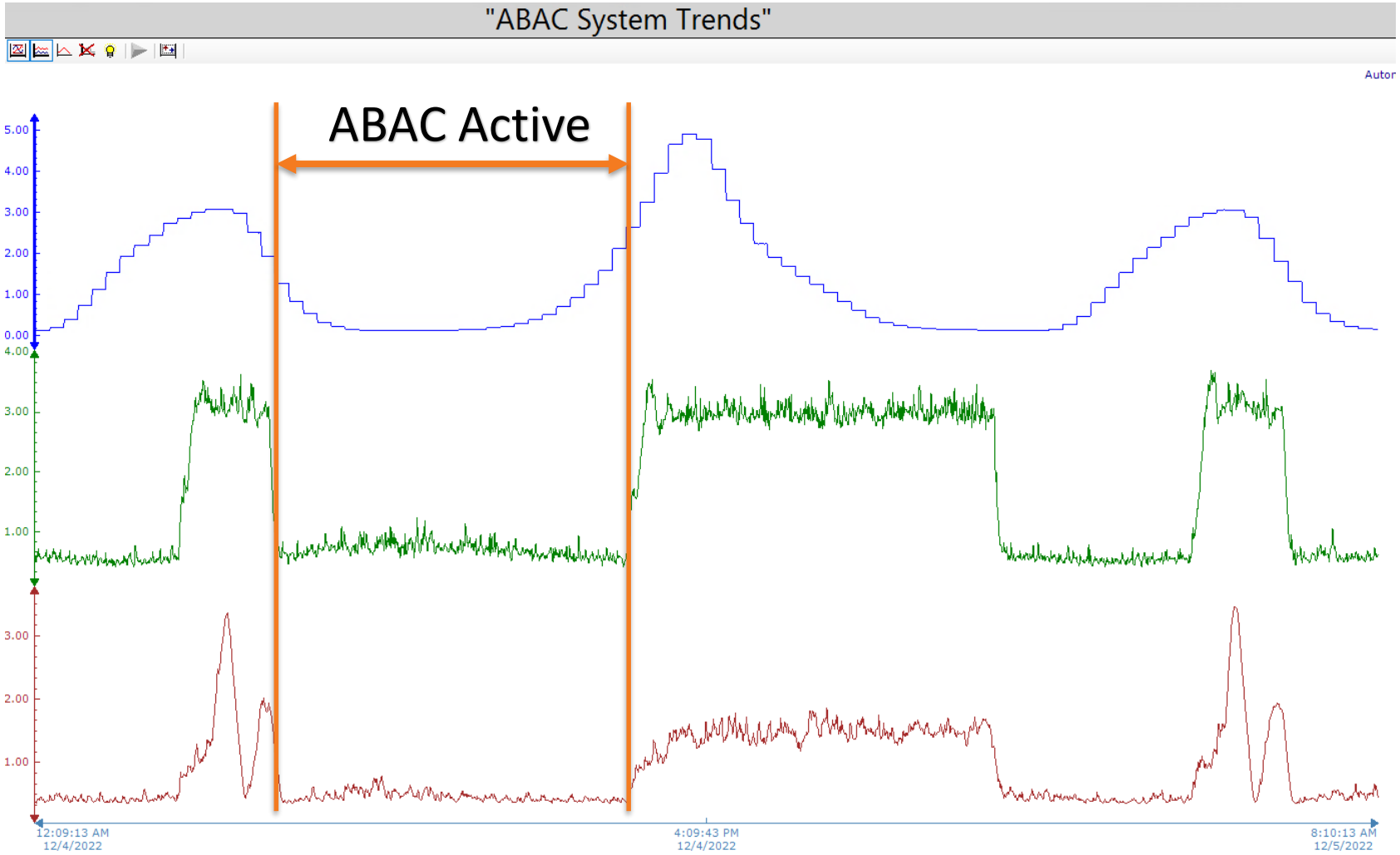
Dropleg Flowmeter Total (Red) = 421 SCFM
Tank Flowmeter (Blue) = 801 SCFM

Control Challenges (cont.)

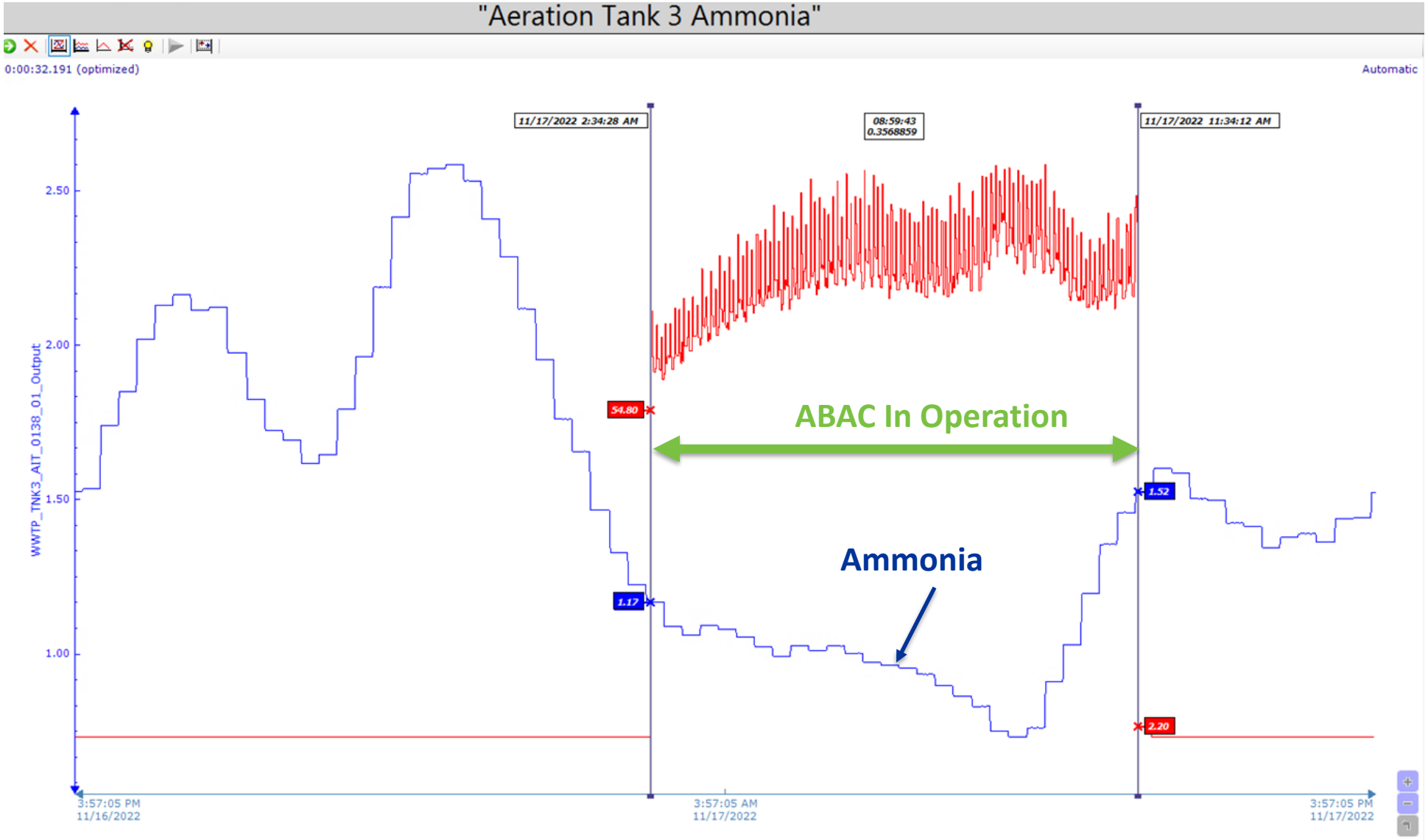
- Blower malfunctioning (shuts down immediately after start or after only a few minutes)



Results of Piloting: Example Data

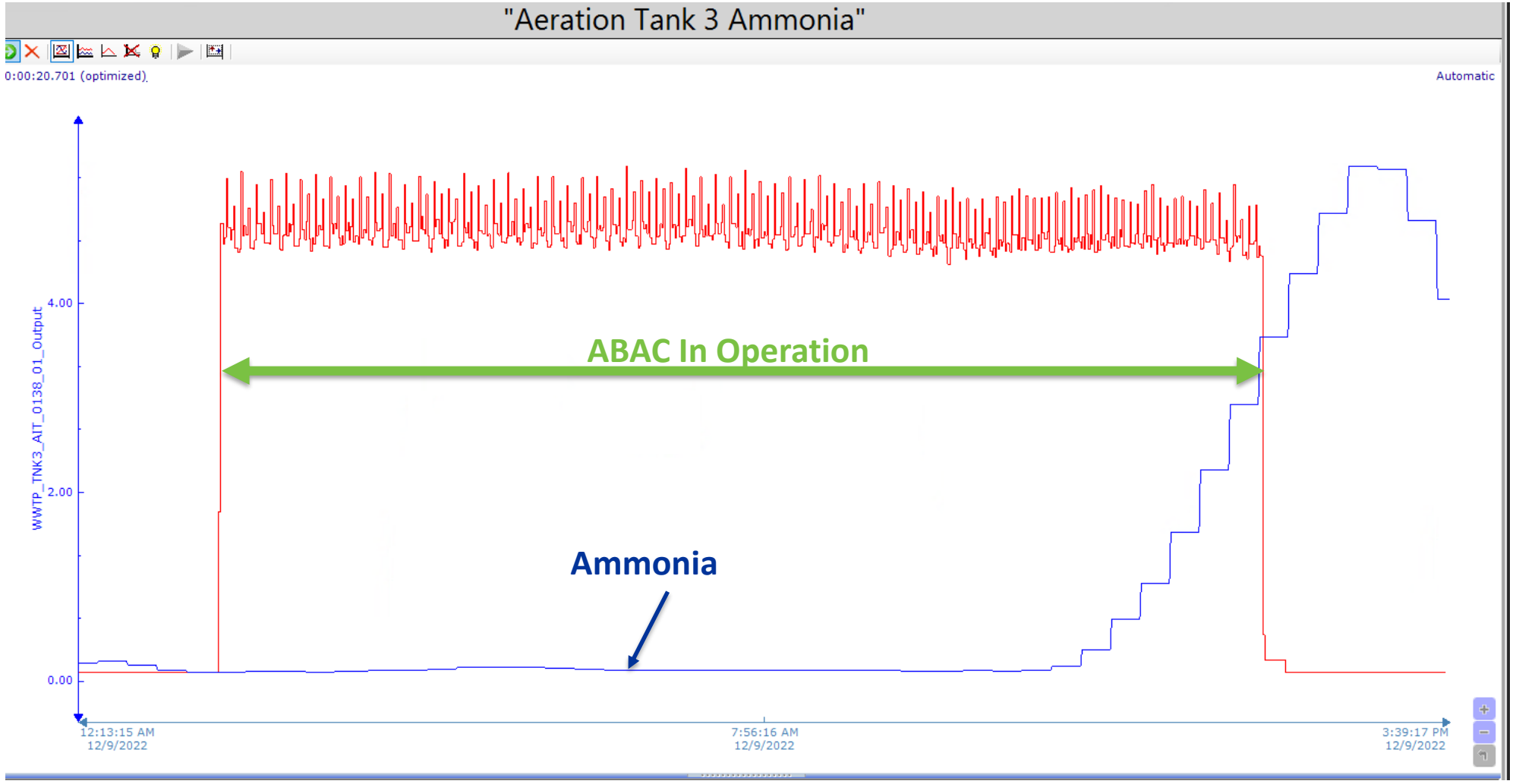


Results of Piloting: Trend Data



Results of Piloting: Lessons Learned

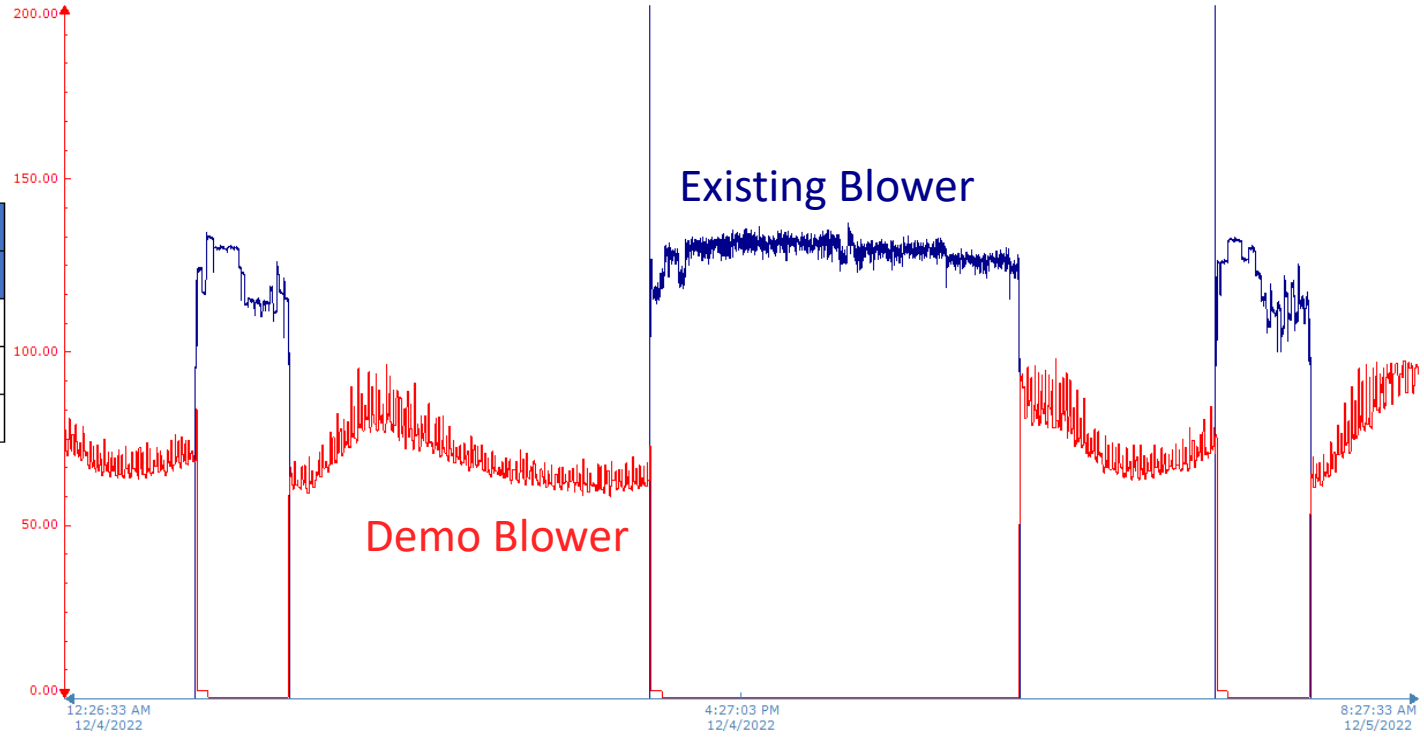
Even at minimum air flow, the plant was ammonia still very low (~0.2 ppm)



Results: Demo Blower Uses Less Energy

- SCADA Historian collected all energy data on a minute basis for analysis
- Collected power data (kW) from new blower
- Collected Amps data from existing blowers. Used voltage and power factor to convert to kW.

	(kW)		
	Old Blower 1	Old Blower 3	ABAC
Min	78.0	80.4	50.3
Max	135.9	143.5	97.1
Avg	115.4	116.4	72.7



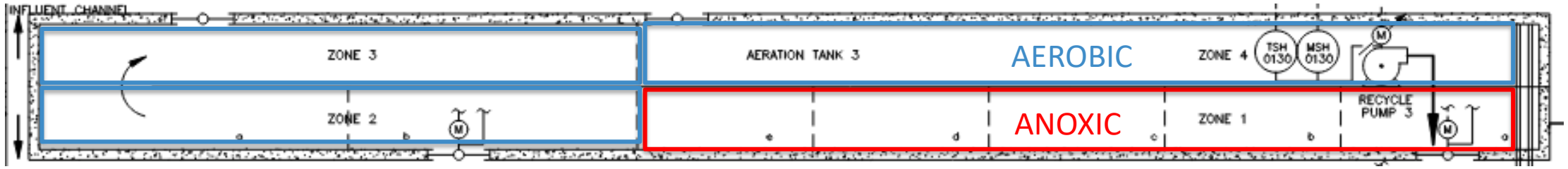
Results: Carryover Ammonia increased Eff TN

Pre-pilot (March 2022)

Inf 24.9mg/L TN, 18.2mg/L NH_3

Eff 5.9mg/L TN, ~0 mg/L NH_3

0.19 mg/L NH_3 **3.34 mg/L NO_3**



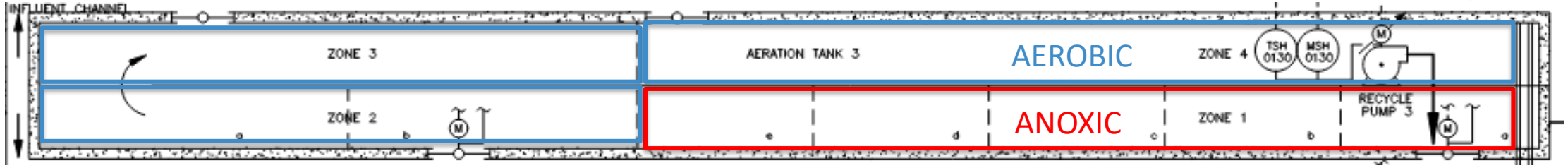
4.08 mg/L NH_3 **0.12 mg/L NO_3**

Pilot (November 2022)

Inf 27.1 mg/L TN, 19.8 mg/L NH_3

Eff 7.81 mg/L TN, 1.69 mg/L NH_3

0.55 mg/L NH_3 **7.40 mg/L NO_3**



9.90 mg/L NH_3 **0.16 mg/L NO_3**

Conclusions

- Existing blowers at GIWWTP may not actually be that oversized
  - Significant increases in effluent ammonia (and therefore effluent TN) despite short run times
- Smaller blower was able to support process during low flow/loadings
  - May see energy savings from a permanent installation of an appropriately sized blower
- The trial of smaller blower and ABAC had competing interests in terms of functionality
  - Had to optimize set points to maximize run time instead of focus on BNR
  - May have been better to assess ABAC on existing 250hp blowers
- Need to better understand how ammonia levels respond to low DO conditions at GIWWTP

Future Work

- Considering ABAC pilot on existing 250hp blowers

Thank you!
Questions?

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Water Partnership with CDM Smith

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