Low DO…How low can we go? Low-energy nutrient removal

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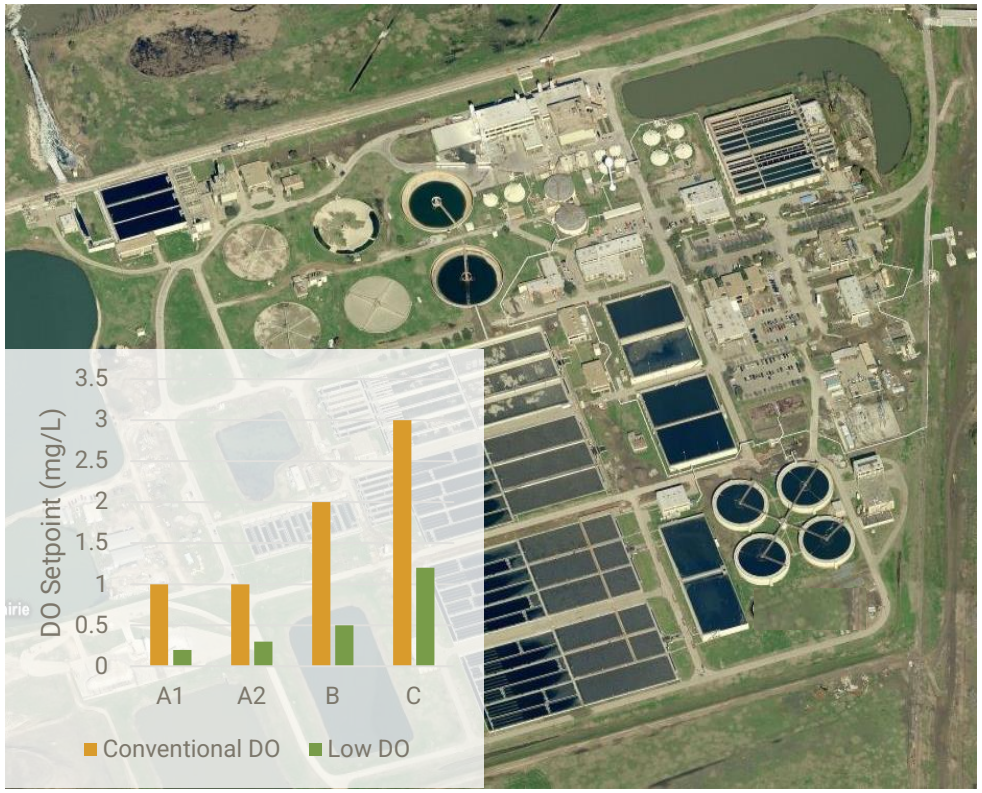
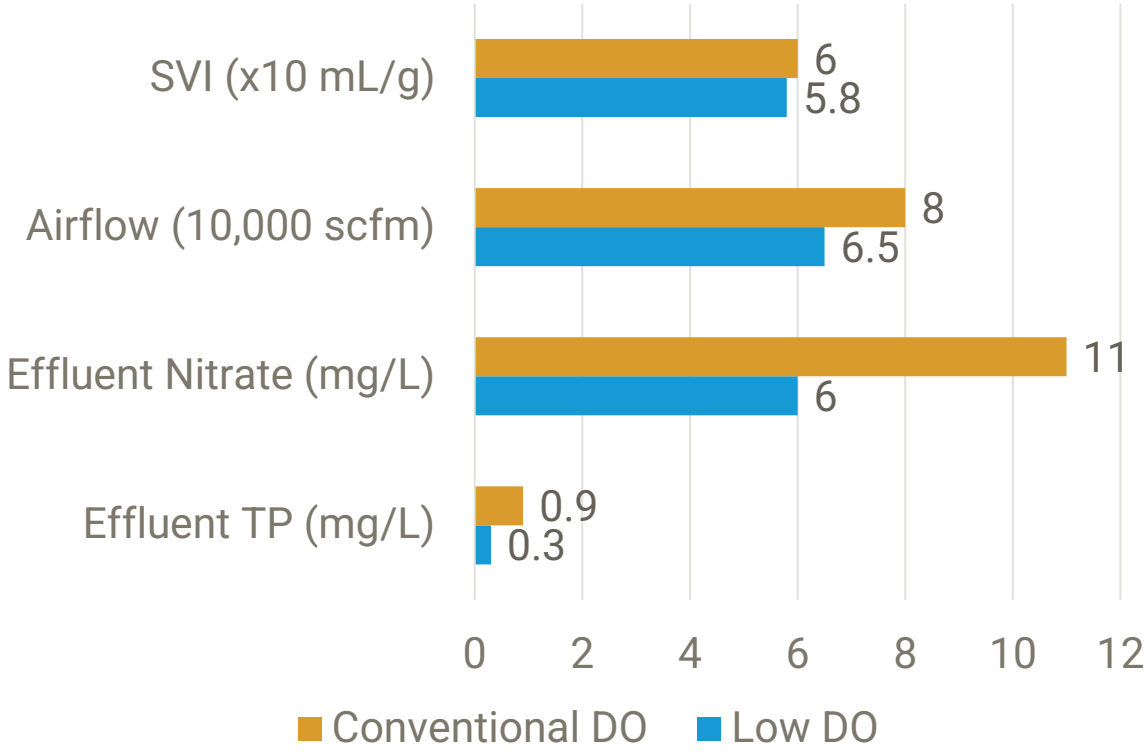
Low DO operation has been shown to benefit aeration, denitrification, and maintain settling rates



TRA CRWS Treatment Plant



Key Questions

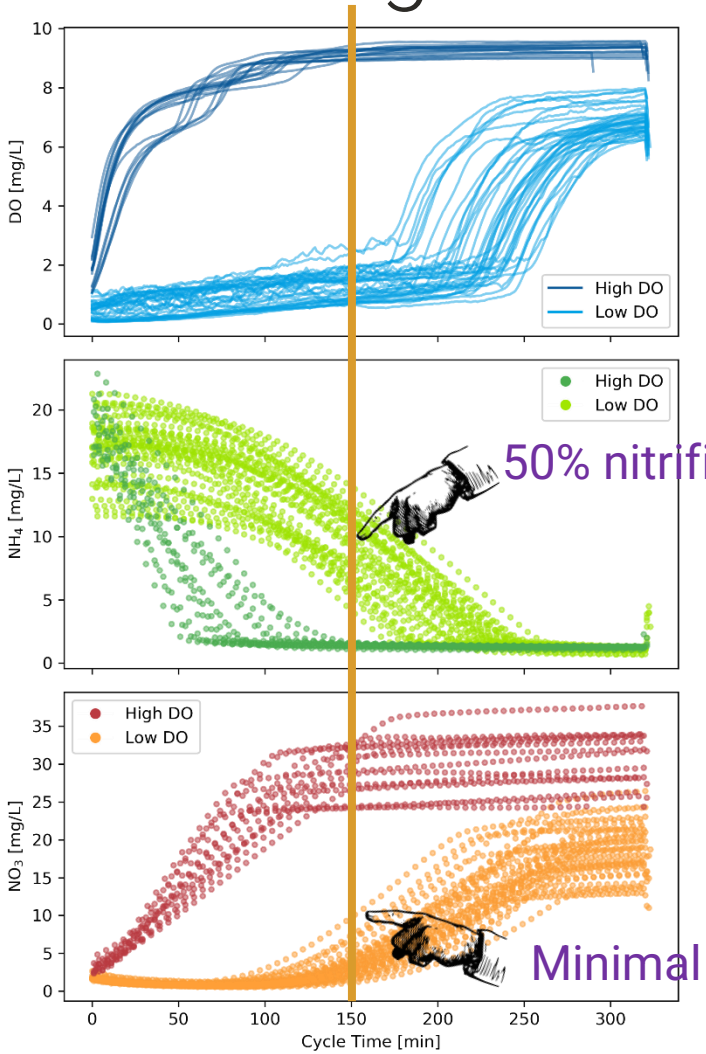
How has low DO impacted capacity and nitrification rate?

Can nitrification upsets be monitored?

For a low DO community, are we decreasing nitrification capacity?

How do we understand nitrification capacity?

Nitrification rate testing throughout the day, every day, generates a large amount of data



50% nitrification achieved

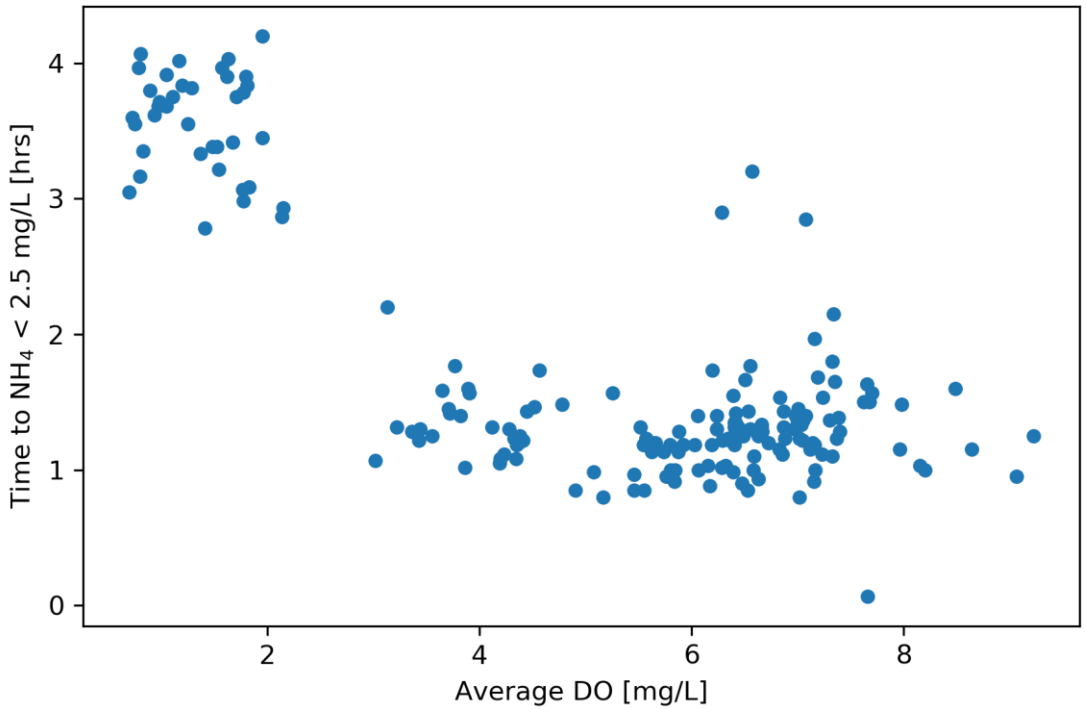
Minimal nitrate formation

Aeration manually controlled for DO targets

Understand nitrification rate

Understand SND impacts of DO

Ability to estimate nitrification rates at different COD concentrations for a low DO adapted ecology

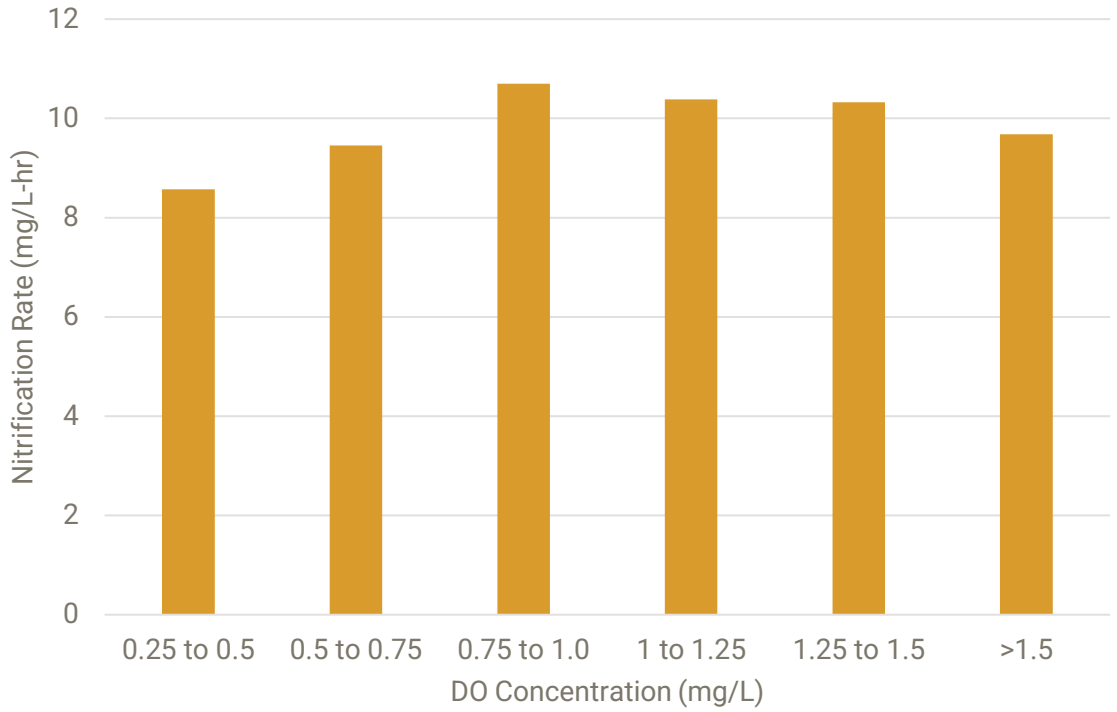


Low DO *DOES* change the specific nitrification rate

Low *DOES NOT* change the nitrification capacity

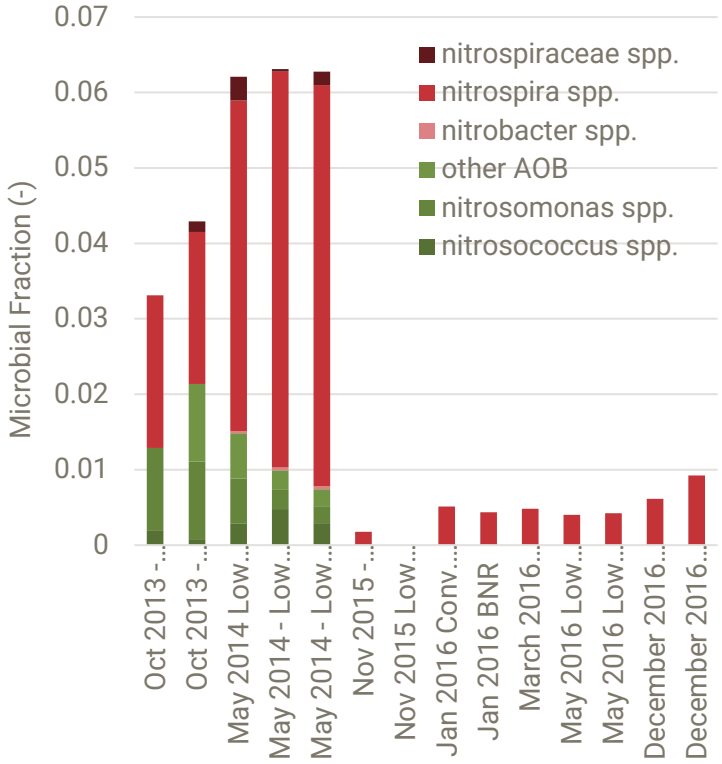
Aeration control becomes a critical component for low DO systems

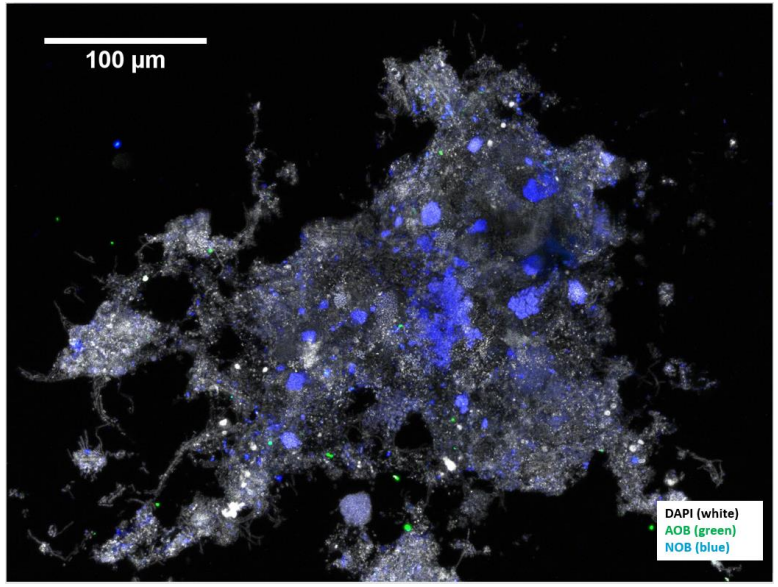
Compiling large data can indicate how much of an impact DO has on nitrification rate

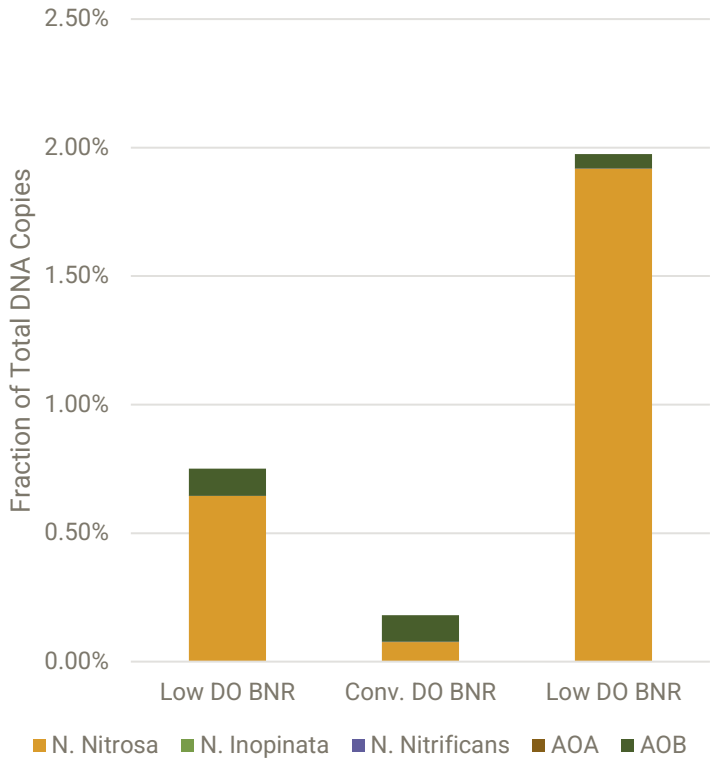


Should this response be expected immediately after changing DO?

A different nitrifying community does occur at low DO conditions







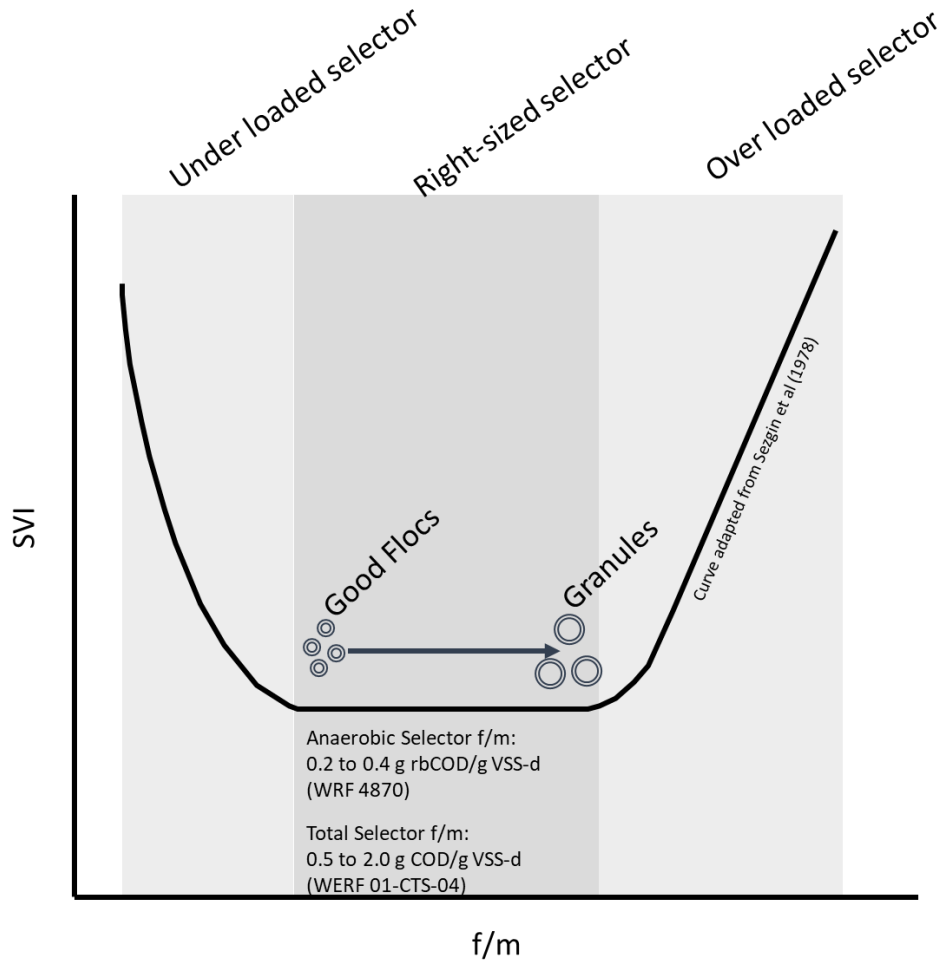
Long term next generation sequencing: progression towards non-conventional nitrifiers (Microbe Detectives)

Fluorescence in situ hybridization: Minimal conventional AOB, NOB cluster on the inner floc/granule (indicator of k-strategist) (Wells Lab, Northwestern University)

Quantitative PCR: Confirmation of dominance of Nitrospira nitrosa, a confirmed comammox (CMX) organism (Noguera Lab, University of Wisconsin)

Can low DO co-exist with good settling?

What drives metabolic pressures for settleability?



Part 1: Selector Zone Sizing

- Under loaded selector: small floc, potential for filaments, irregular shape
- Over loaded selector: dispersed floc, filaments prevalent, “stringy” shape
- Right-sized selector: dense aggregates, ranging from good flocs to granules

What drives metabolic pressure for settleability?

Part 2: Microthrix competition

- f/m is a driver in anaerobic and anoxic volume
  - Staged selectors are critical
- COD type plays a large role
  - *M. parcivella* favored by long-chain VFA

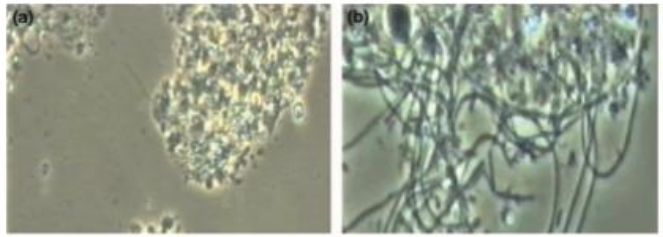


Fig. 1. (a) Phase contrast of activated sludge samples with low – zero *Microthrix parvicella* content. (b) Phase contrast of activated sludge samples with high *Microthrix parvicella* content (1000× phase contrast).

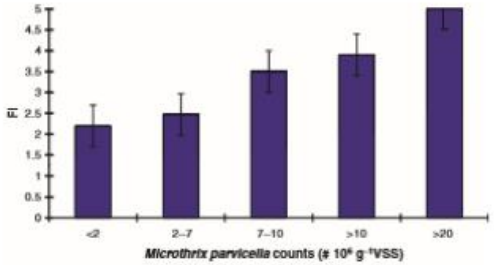


Fig. 2. Correlation between *Microthrix parvicella* counts and filament index.

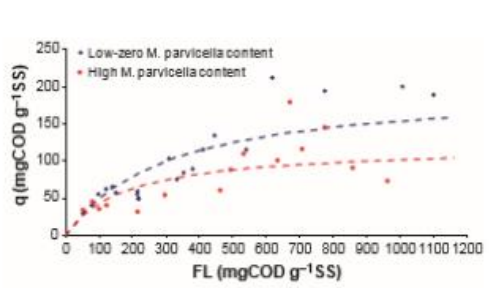


Fig. 3. Effect of *Microthrix parvicella* content and FL on biomass biosorption capacity under aerobic conditions.

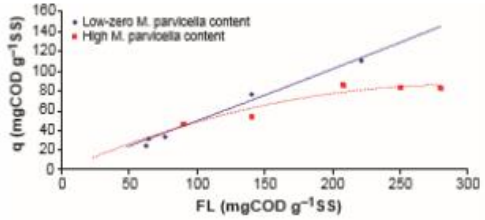


Fig. 4. Effect of *Microthrix parvicella* content and FL on biomass biosorption capacity under anoxic conditions.

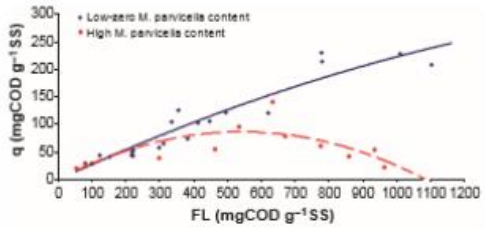
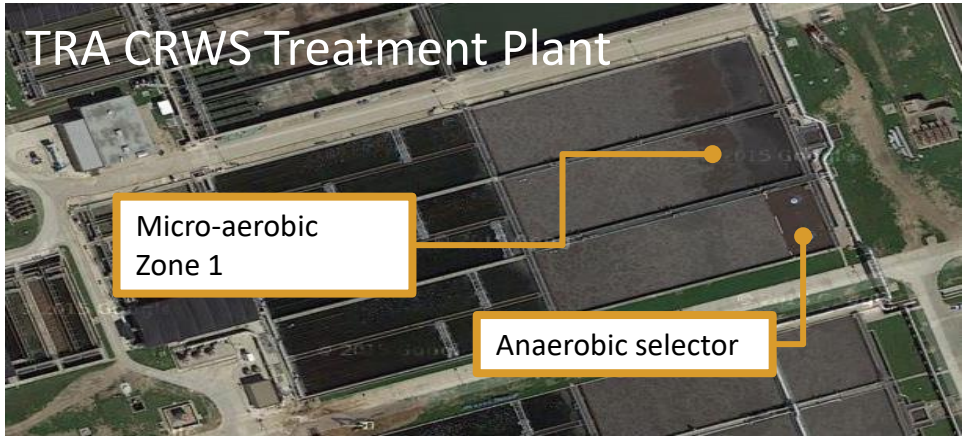


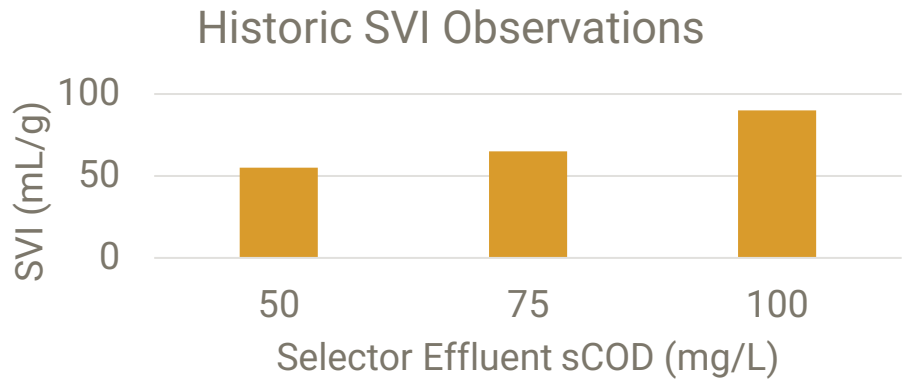
Fig. 5. Effect of *Microthrix parvicella* content and FL on biomass biosorption capacity under anaerobic conditions.

100–150 mgCOD g^{-1}SS (depending on biomass *M. parvicella* content), biosorption is almost linearly proportional

Noutsopoulos et al (2012) FEMS Microbiol Ecol

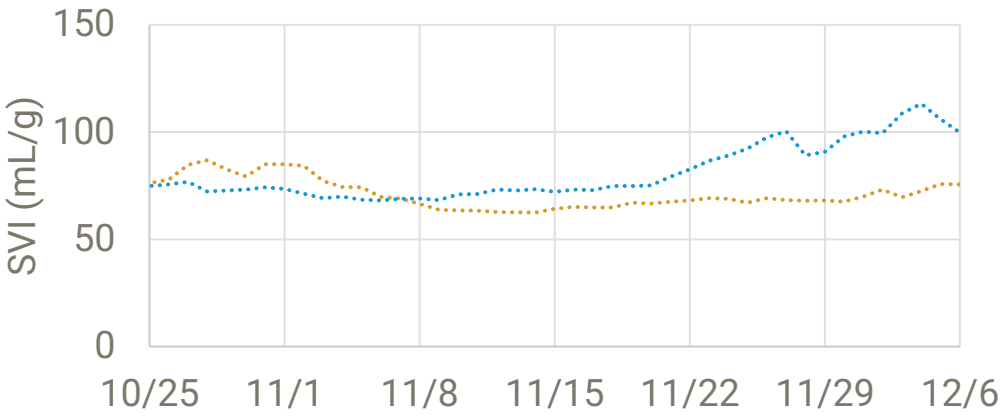
What drives metabolic pressure for settleability?





Part 3: rbCOD bleedthrough

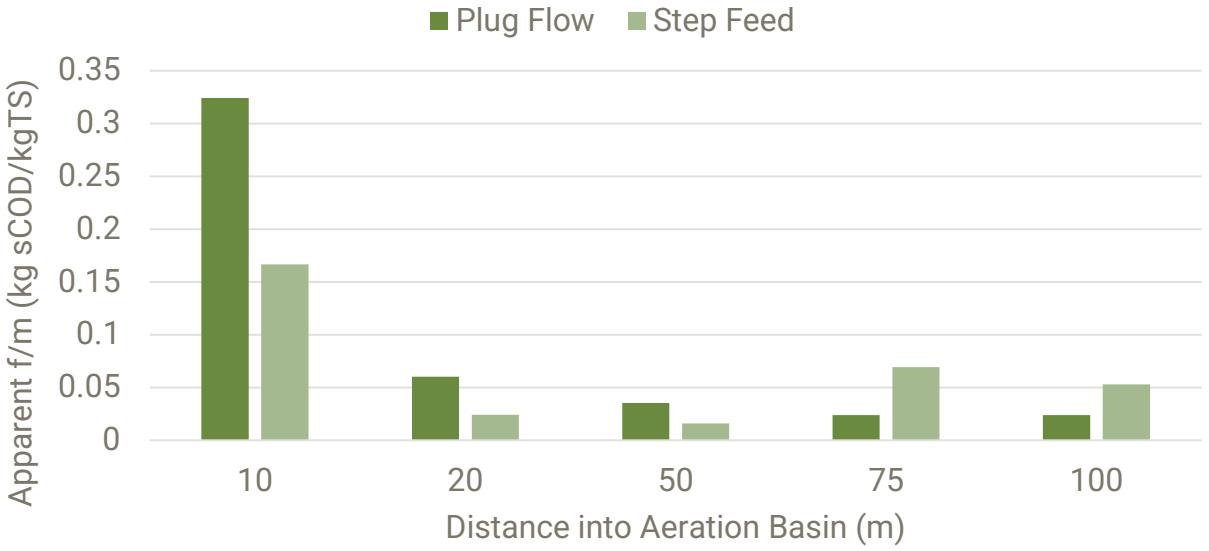
Anaerobic selector plus micro-aerobic zone 1 (0.2 mg/L DO) used to achieve TN and TP removal and well as chloramine disinfection. Historic operation has shown that effluent sCOD from the selector zone leads to settling impacts. Zone 1 growth pressures can control these settling impacts.

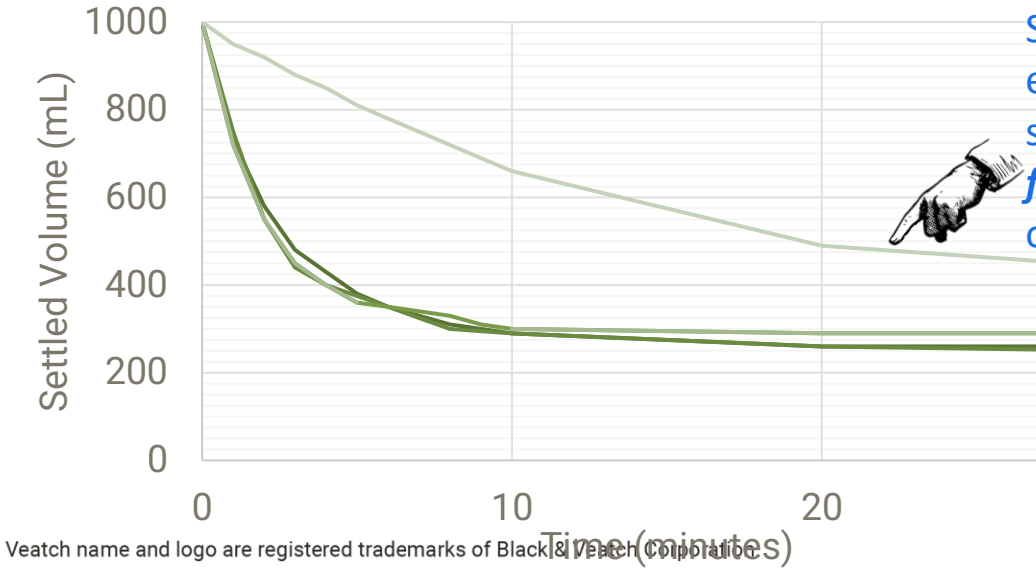


What drives metabolic pressure for settleability?

Part 4: Feast and Famine conditions

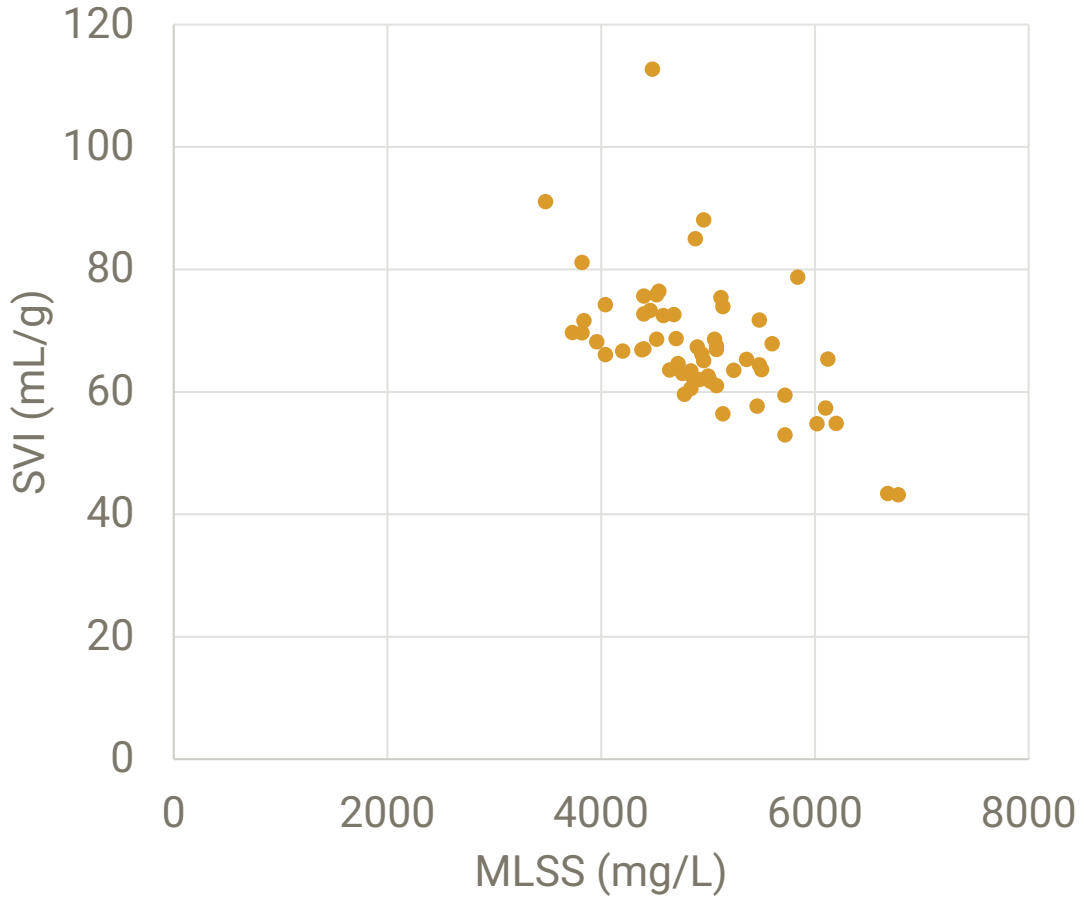
Experimentation with feast and famine conditions using step feed highlighted the need for growth gradients

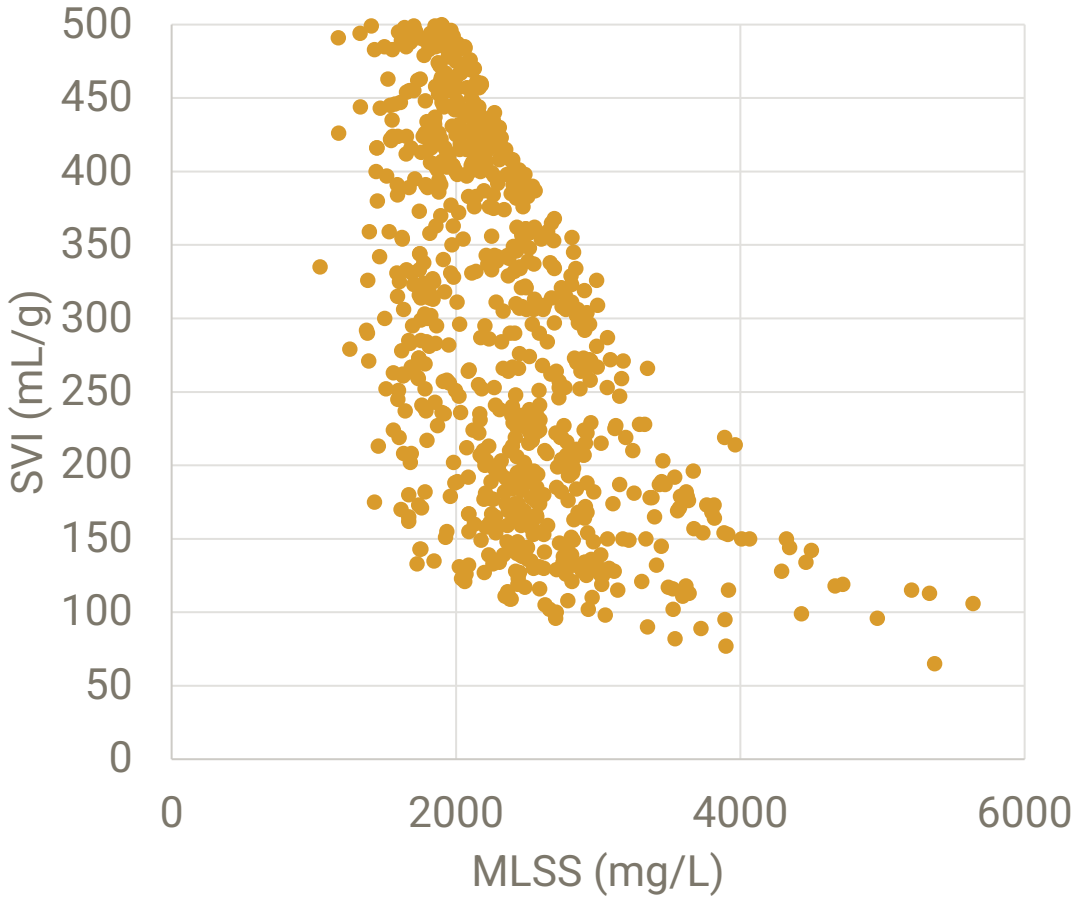




Step feed basin exhibited reduced settleability after ***four weeks*** of operation

Take home: F/M and selector condition is the most important aspect of settleability





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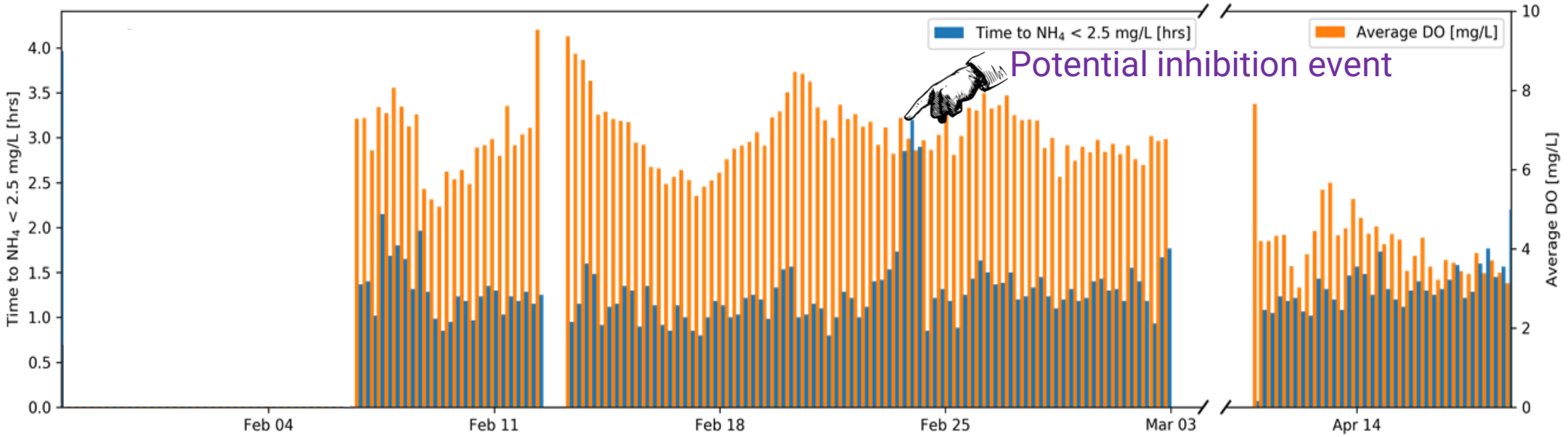
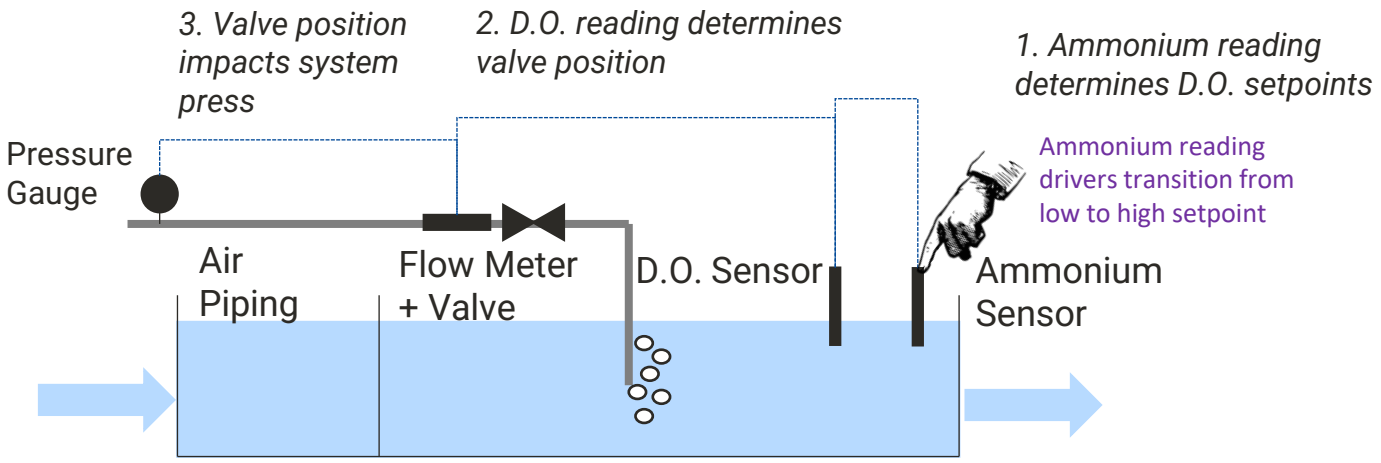
What is the value of all this data?

Benefit 1: identification of potential inhibition events



Benefit 2: DO control optimization

Ammonium Based Aeration Control (ABAC)



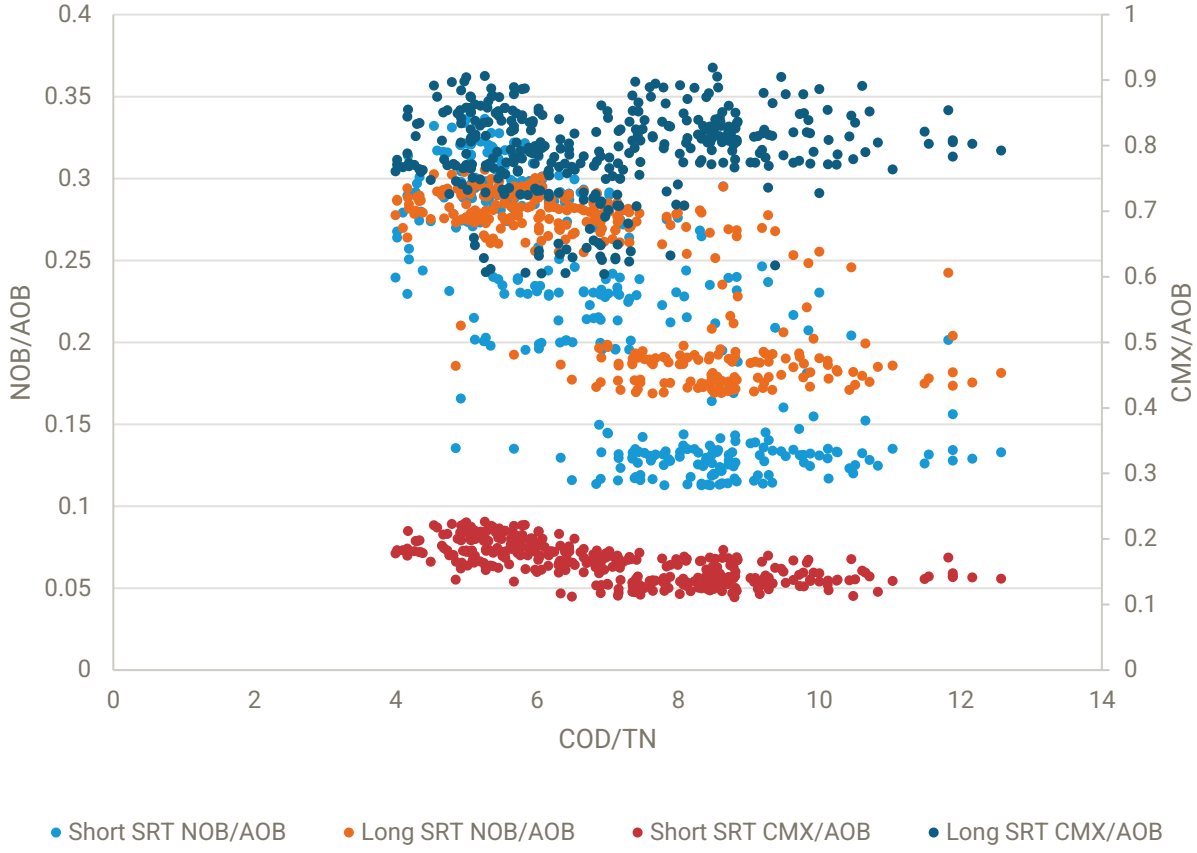
No value in going higher than 1.5 mg/L

Example Setpoints

Zone	Low DO, mg/L	High DO, mg/L
A1	0.3	0.3
A2	0.5	0.5
B	0.9	1.5
C	1.2	1.5
Target NH_4		1.0

Is nitrification CAPACITY impacted by low DO operation?

- Capacity is maintained at low DO
- A different population is produced
- Incorporating unique nitrifiers like CMX into the model space is a key for future planning and design



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Thank You!

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