An Attempt to Sustainably Stabilize EBPR Performance at Meriden, CT with Side-Stream EBPR

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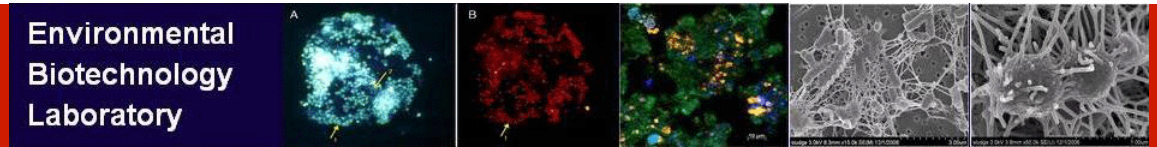

Acknowledgements

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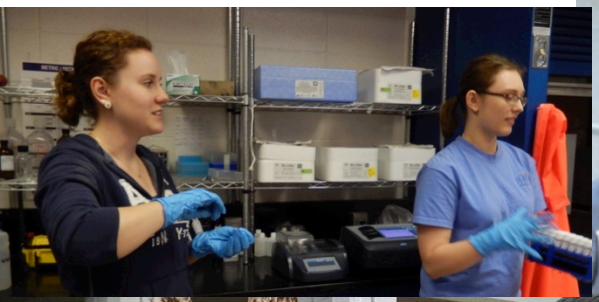
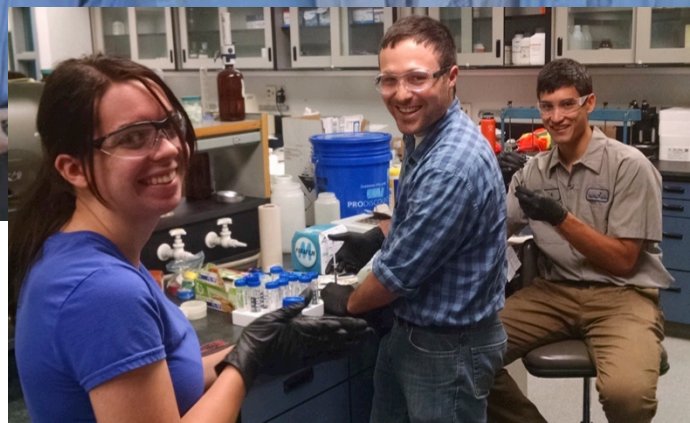
- Clean Water Services – Durham Facility
- Undergraduate research assistants

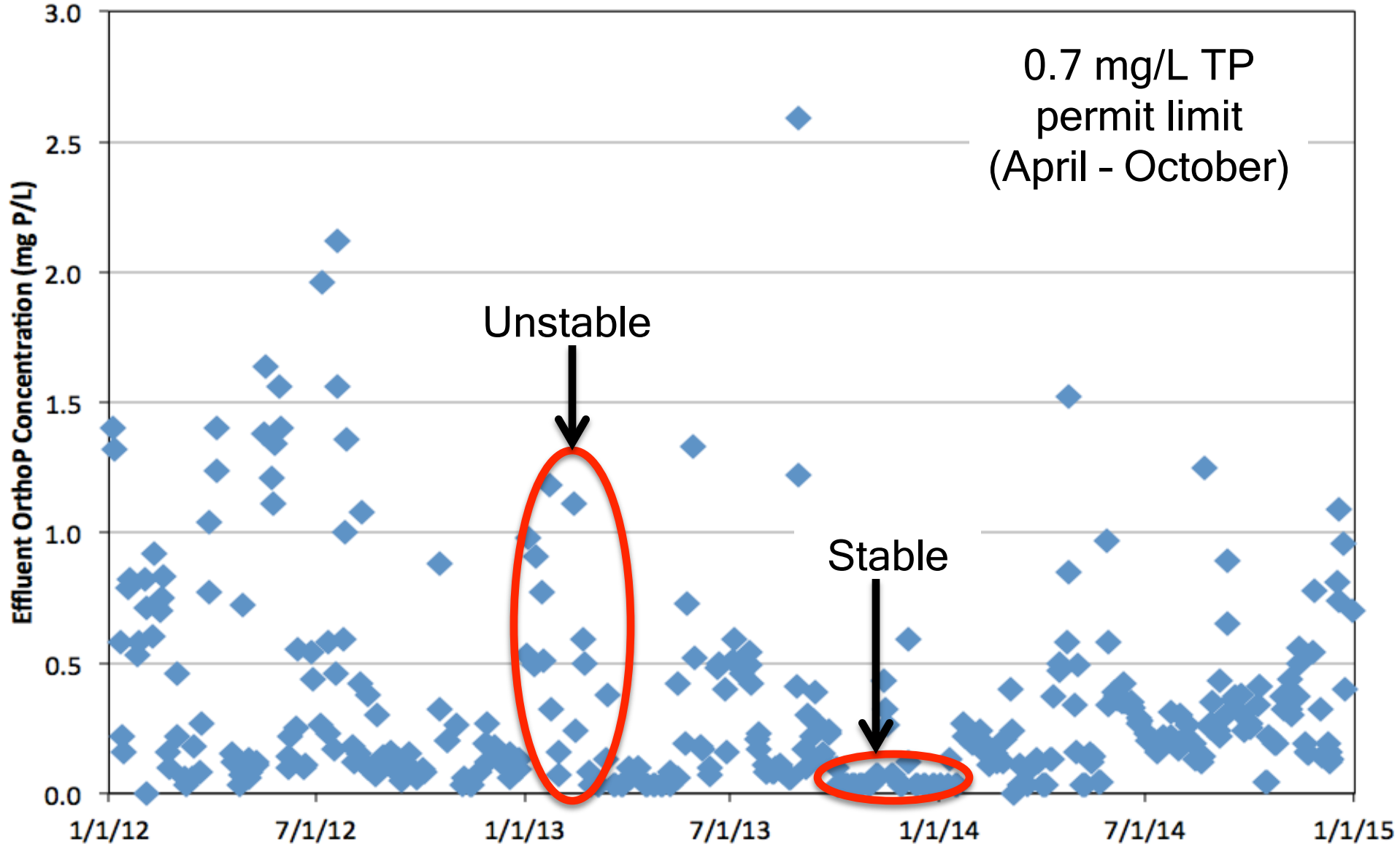




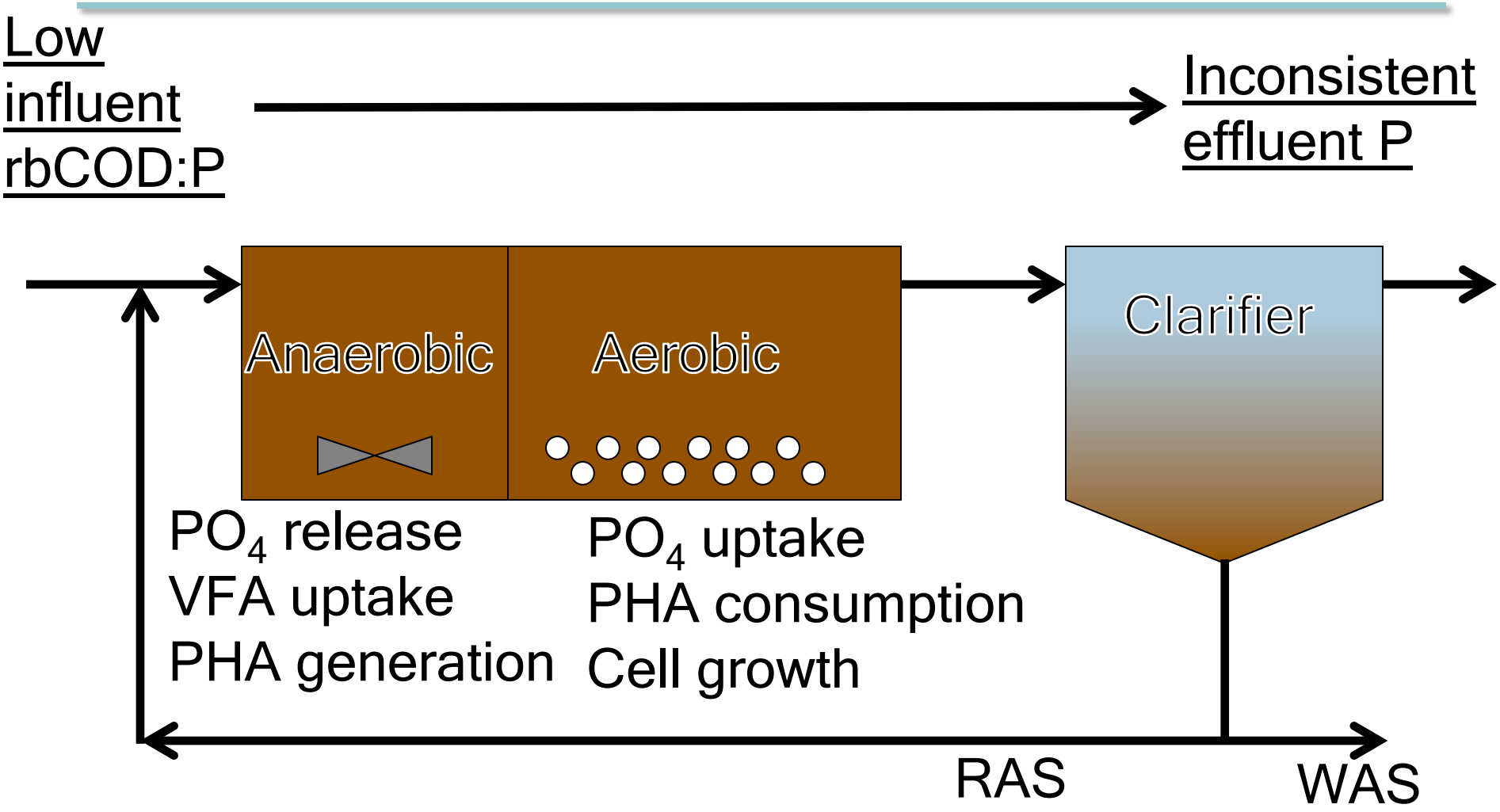
Motivation for Improving EBPR

- EBPR operation is notoriously “unstable”
  - Sometimes due to lack of carbon
- Meriden staff are frustrated because this is the only part of plant they can’t control
  - And permit limits keep getting lower

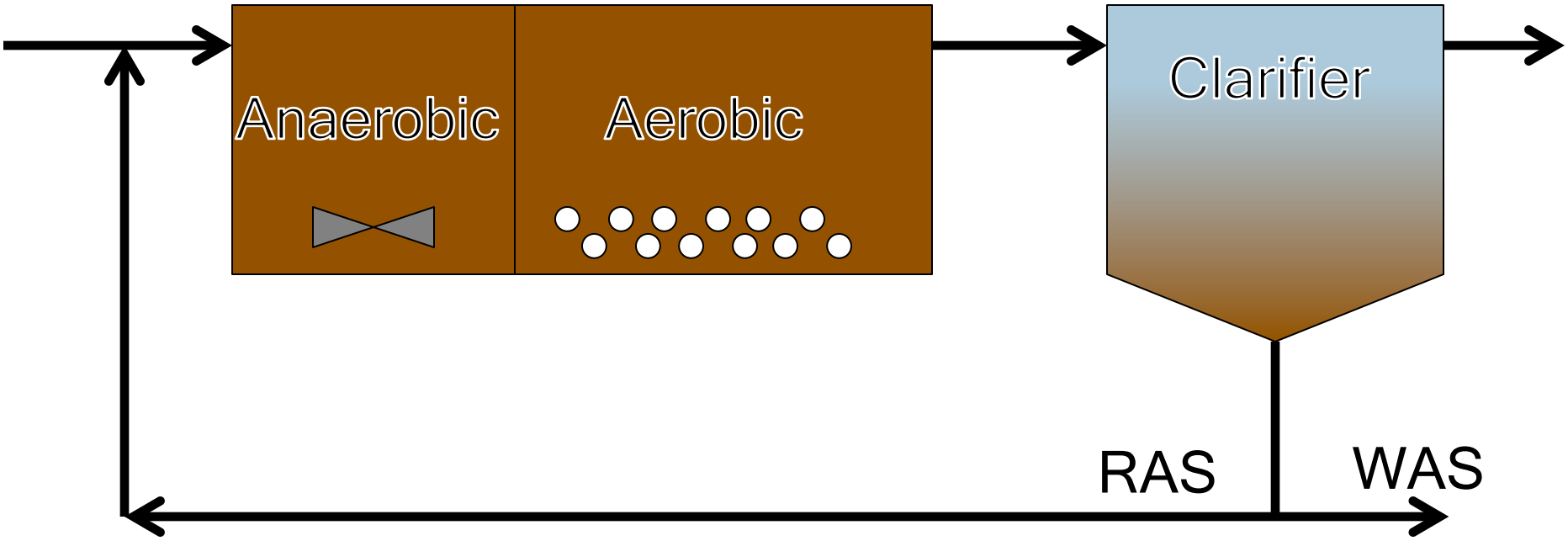
Highly Variable Effluent OrthoP in Meriden



Typical EBPR Process Configuration



S^{2}EBPR Process Configuration – Side-Stream RAS



Hypothesized Ways S^2EBPR Improves Stability

- Is there VFA production in side-stream?
- Is there active VFA uptake in side-stream reactor*?
- Is there a shift in microbiological population?
  - To more efficient polyphosphate accumulating organisms (PAOs)?
  - With fewer glycogen accumulating organisms (GAOs)?

* - Bi et al, 2013 and Lopez et al, 2006

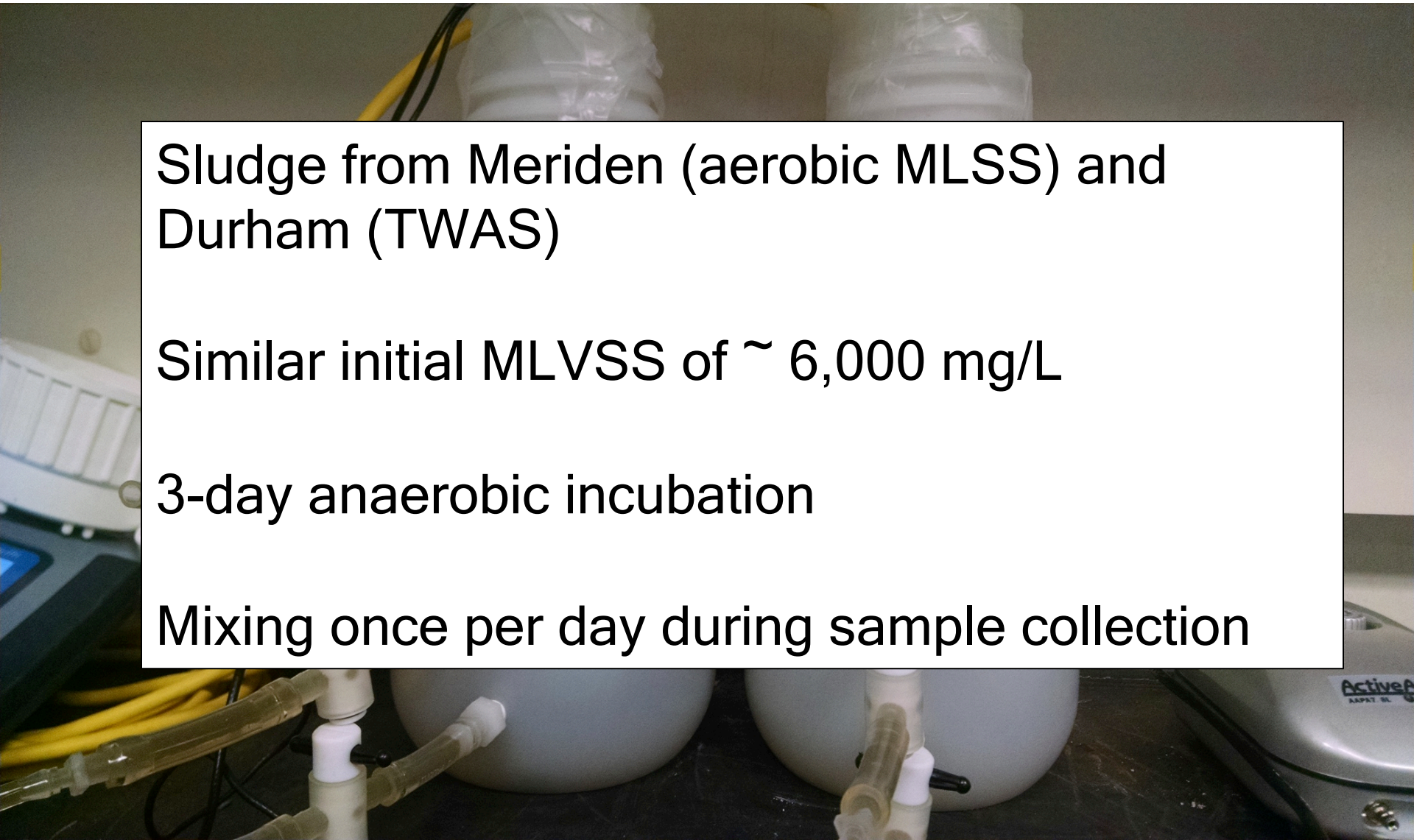
What We Currently Know About S^{2}EBPR

- In operation at full-scale facilities
  - 50+ in Europe (mostly Denmark)
  - ~6 in North America
- No consensus on operation
  - Several different flow schemes
- Standard models (e.g., BioWin, GPS-X) don't fit observed data
- Fundamental understanding is lacking

Testing to Understand S^{2}EBPR

- Simulated S^{2}EBPR Batch Testing
  - Meriden, CT
  - Durham (Clean Water Services, Tigard, OR)
  - Westside Regional (West Kelowna, BC)
  - Cedar Creek (Olathe, KS)
- S^{2}EBPR Pilot Testing
  - Meriden, CT

Simulated S^2EBPR Batch Testing Reactors



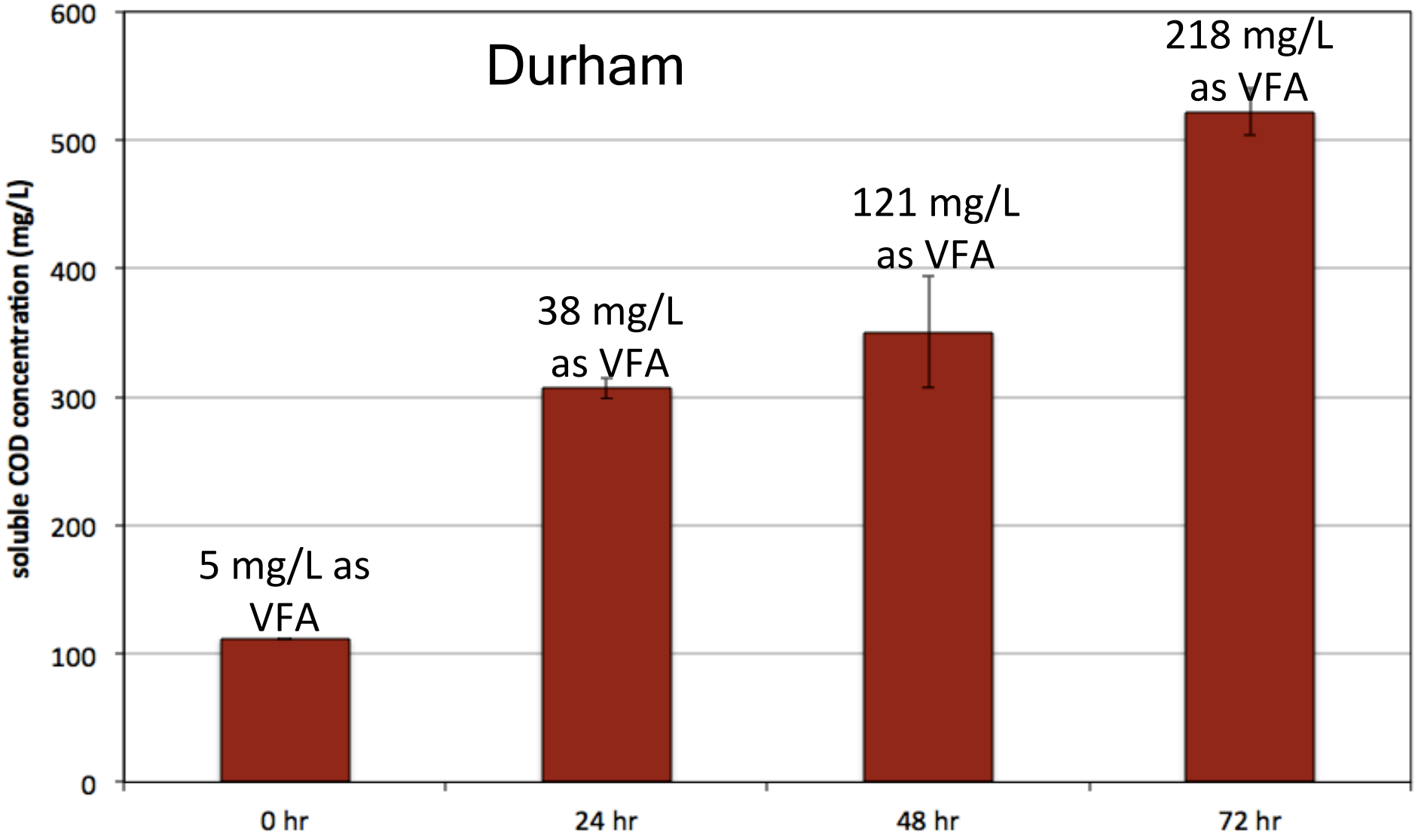
Sludge from Meriden (aerobic MLSS) and Durham (TWAS)

Similar initial MLVSS of ~ 6,000 mg/L

3-day anaerobic incubation

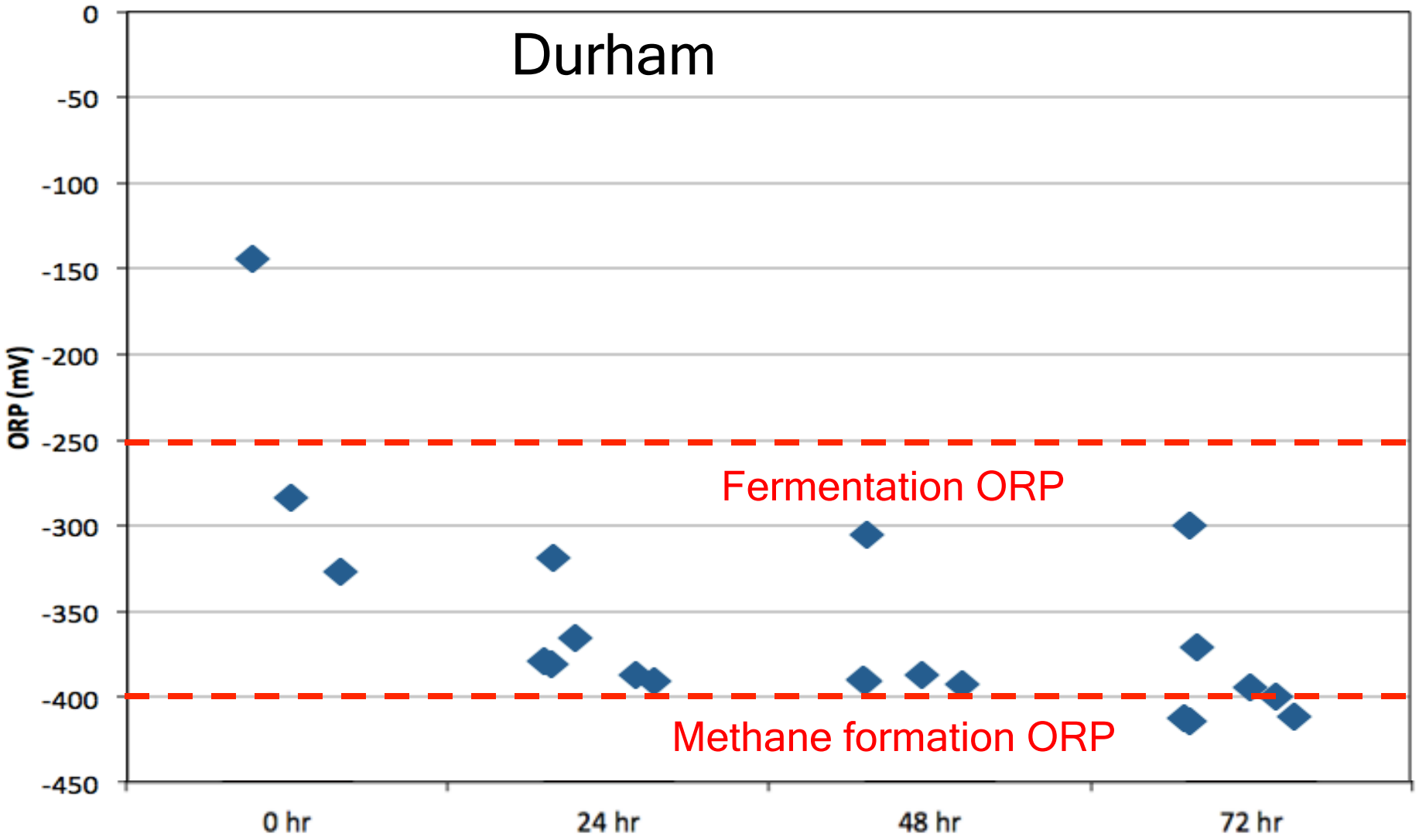
Mixing once per day during sample collection

VFA Production in Simulated S^{2}EBPR Batch Test



- Residual VFA quadrupled and sCOD tripled after just one day

Low ORP in Simulated S^{2}EBPR Batch Tests

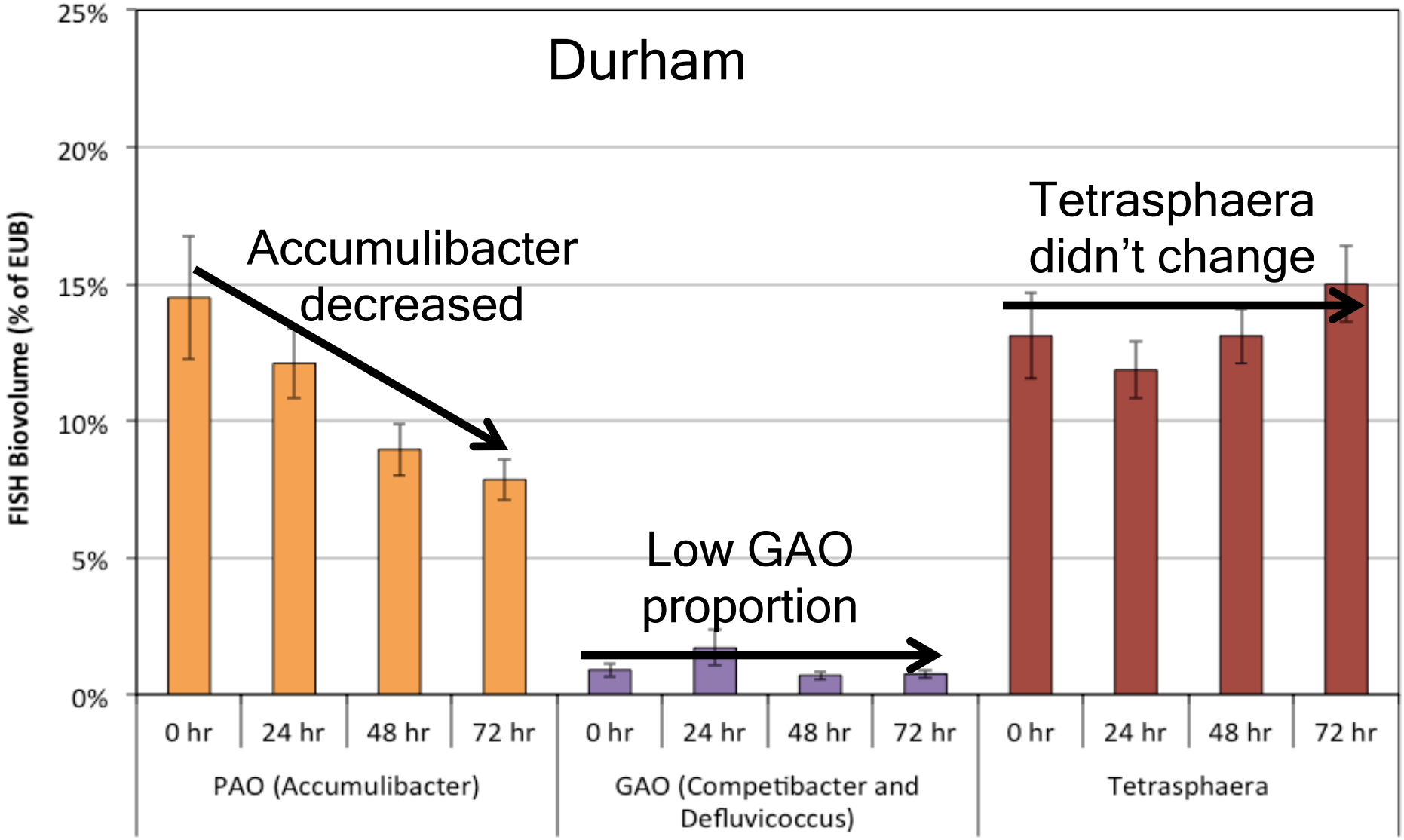


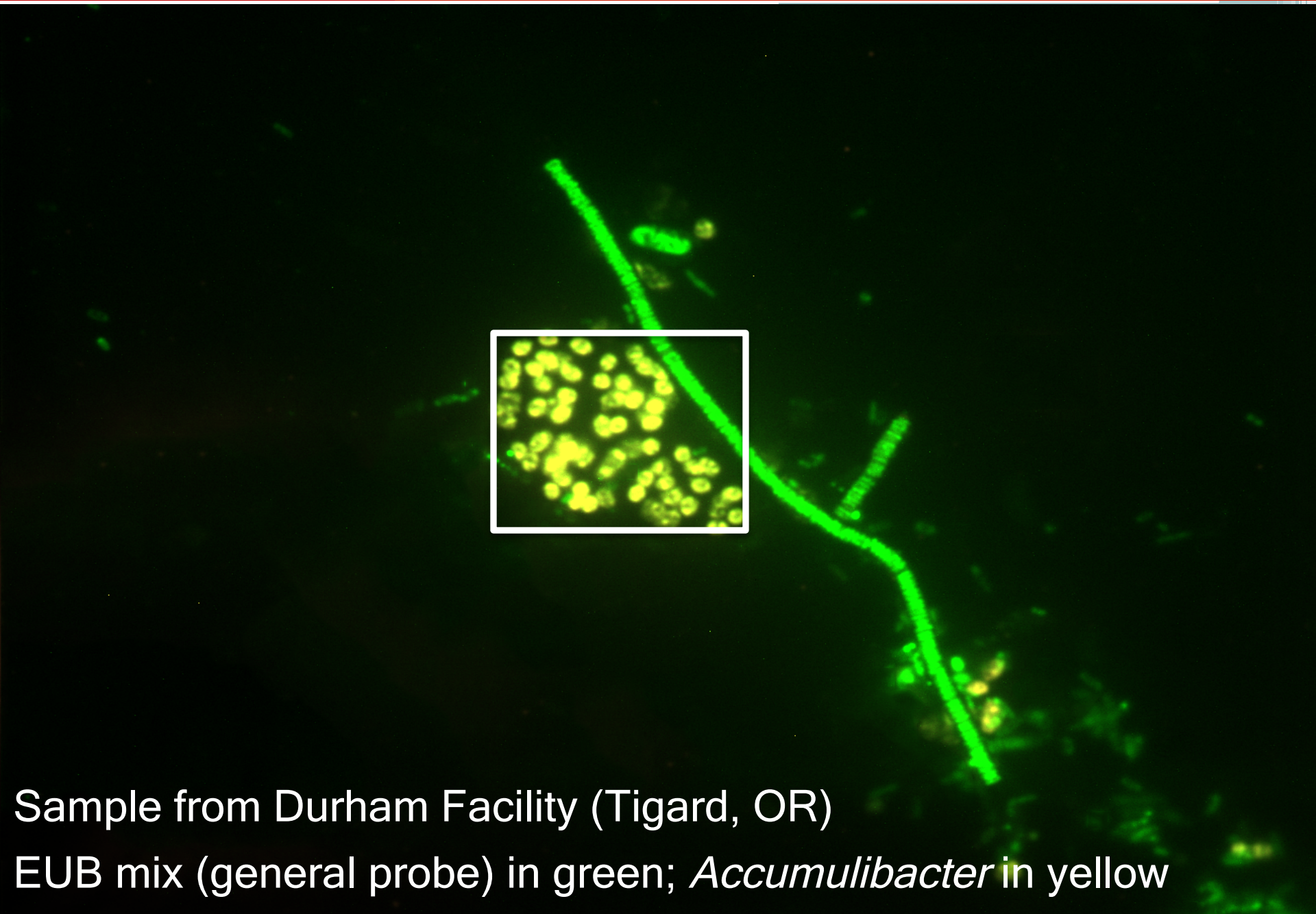
- Low ORP allows for fermentation and VFA production

Key Organisms in EBPR Processes

- *Accumulibacter*
  - Commonly known PAOs
  - Important for effective EBPR
- *Tetrasphaera*
  - Lesser known PAOs
  - Widely present in WRRFs (15%+ of population)
  - Some are also fermenters
- *Competibacter*
  - Commonly known GAOs
  - Competes with PAOs for VFA

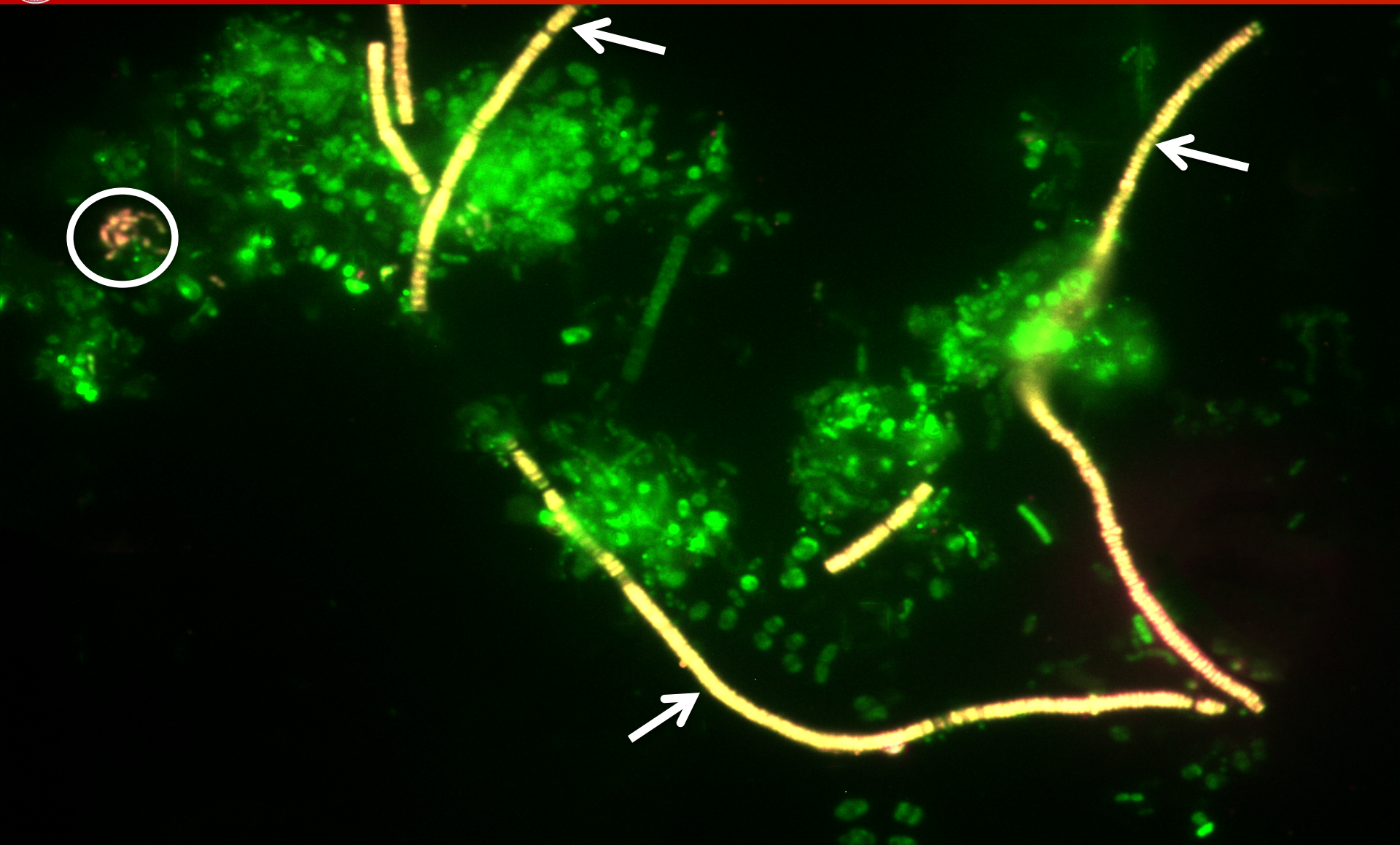
Microbiological Population Shifts in S²EBPR Batch Test





Sample from Durham Facility (Tigard, OR)

EUB mix (general probe) in green; *Accumulibacter* in yellow



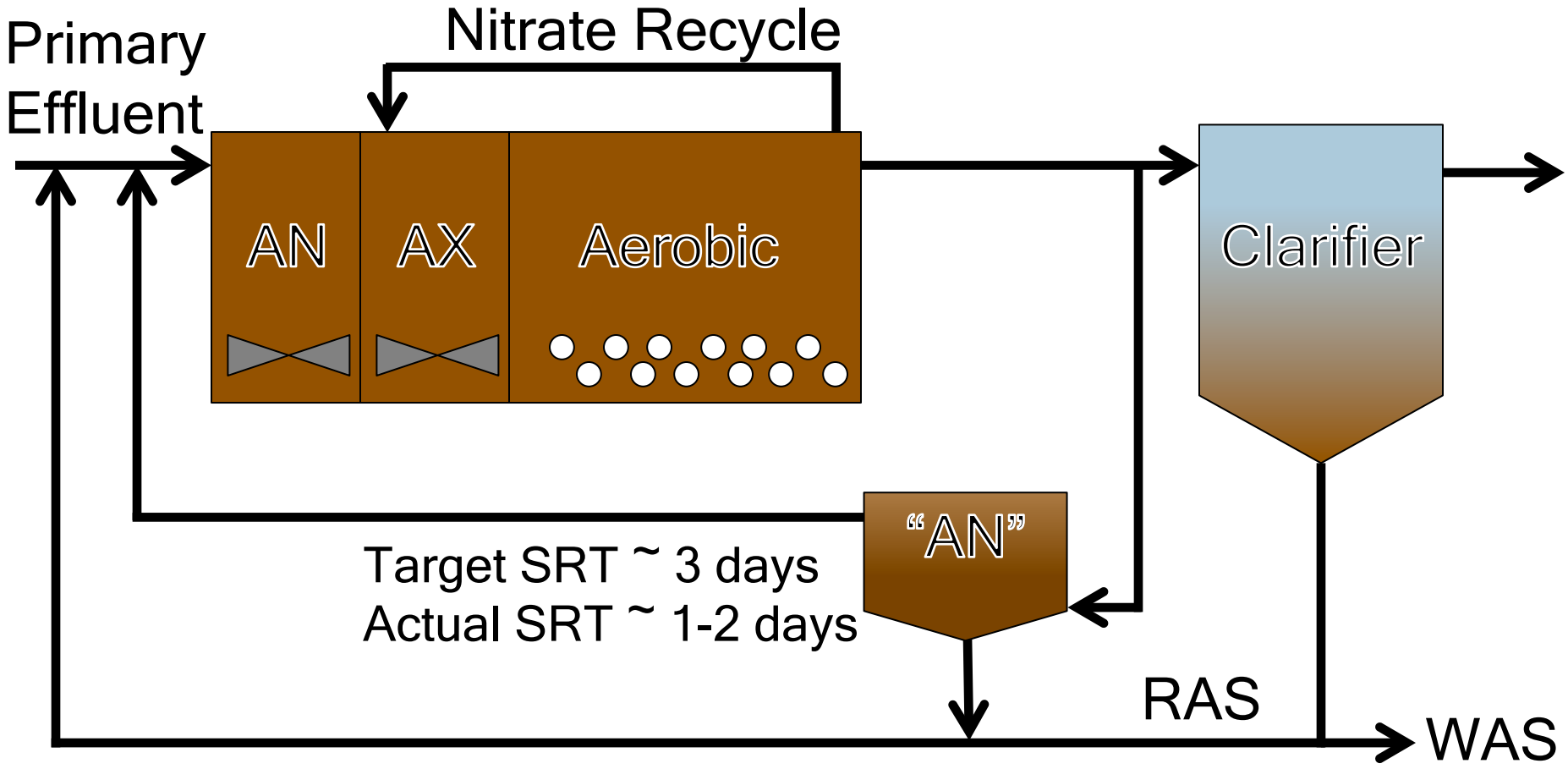
Sample from Durham Facility (Tigard, OR)

EUB mix (general probe) in green; *Tetrasphaera* in red & orange

Meriden S^2EBPR Pilot – Goals

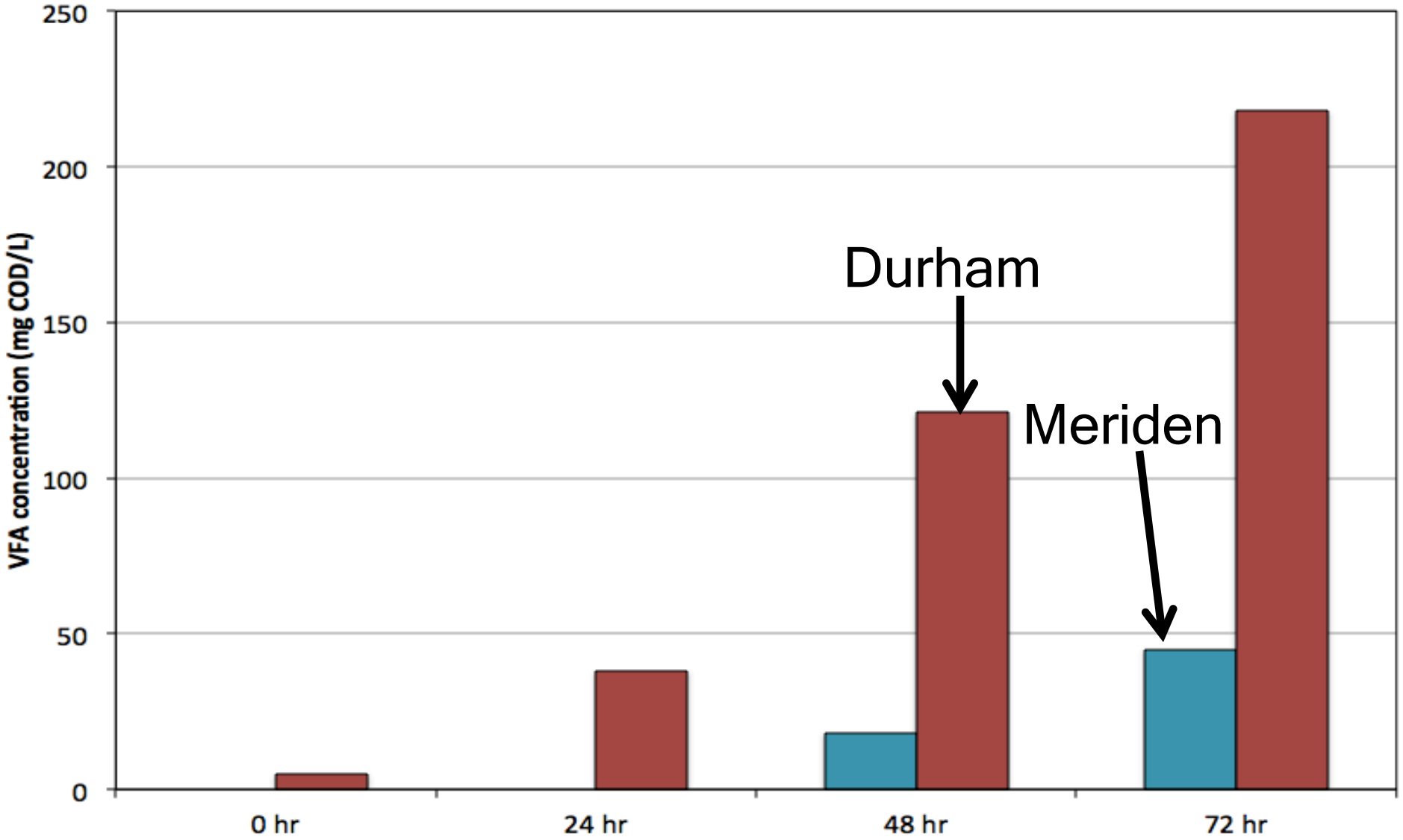
- Effectively implement S^2EBPR
  - Stabilize EBPR operation
  - Reduce ferric chloride use
- Improve understanding of process
- Minimize effort for plant staff

Meriden S²EBPR Pilot –Overview (Mar-Aug 2015)



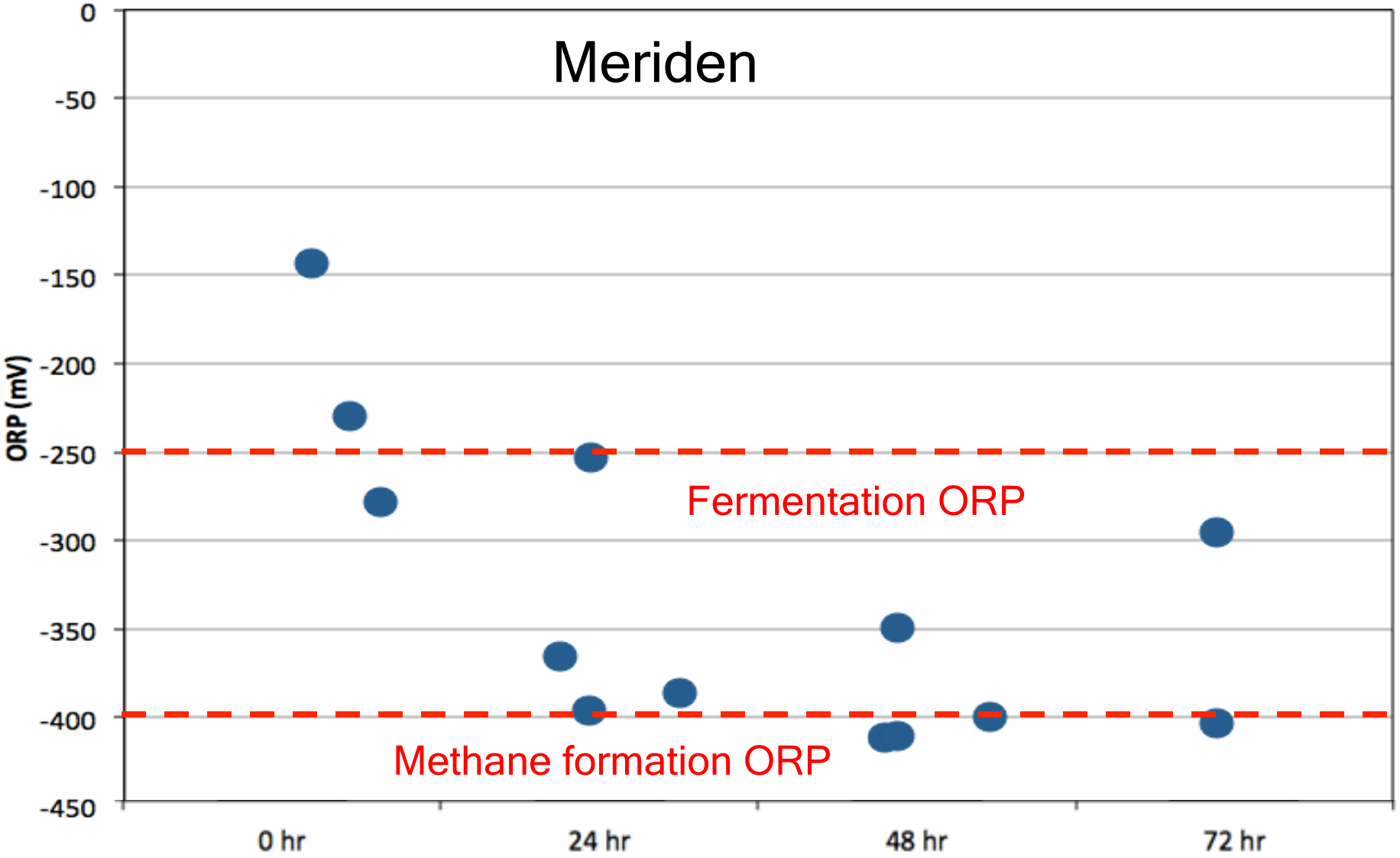
- Aerobic MLSS was feed to side-stream reactor (unused clarifier)

Delayed VFA Production in Meriden S^{2}EBPR Batch Test



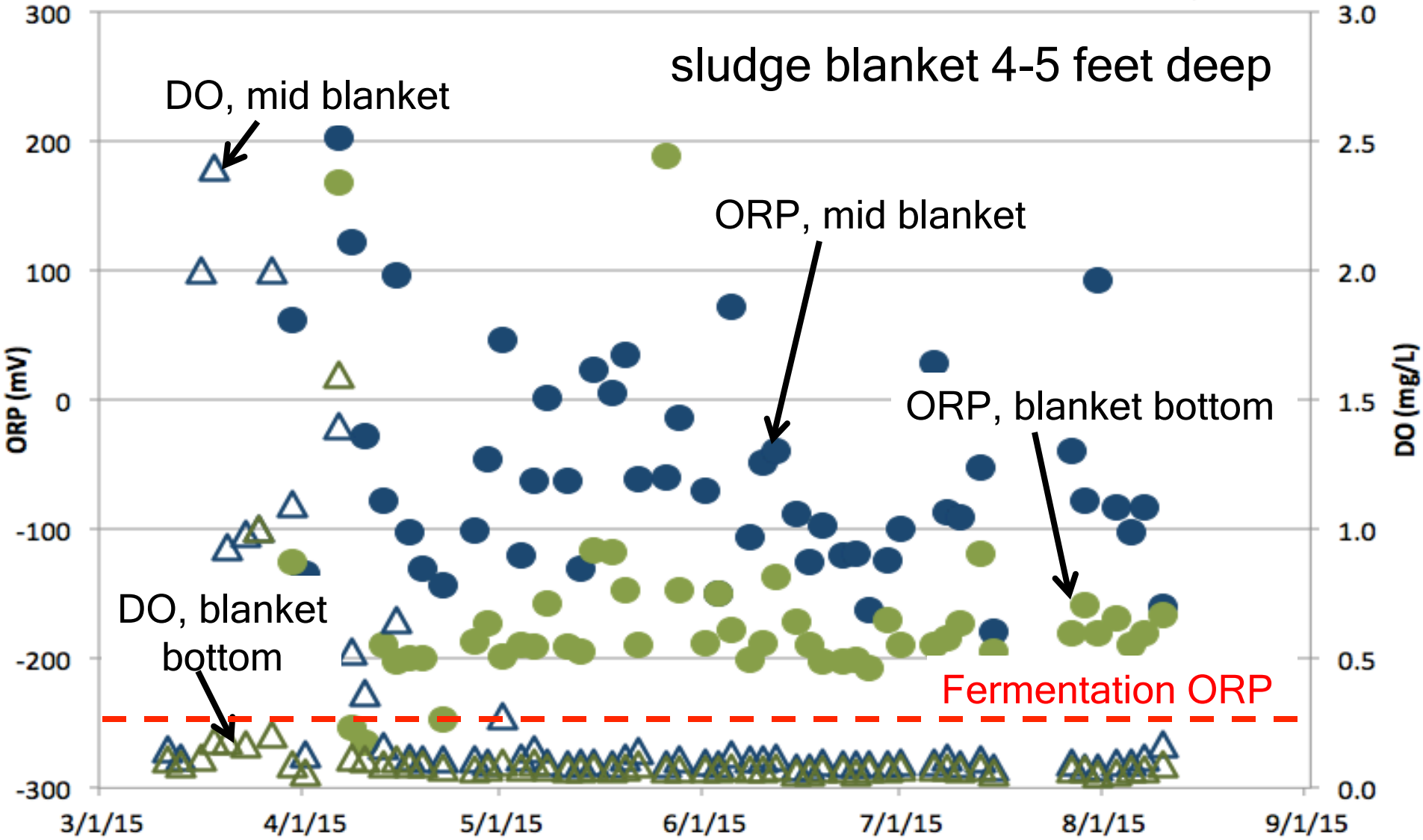
- 1-2 day HRT not long enough for VFA generation with aerobic MLSS

Low ORP in Simulated S^{2}EBPR Batch Tests



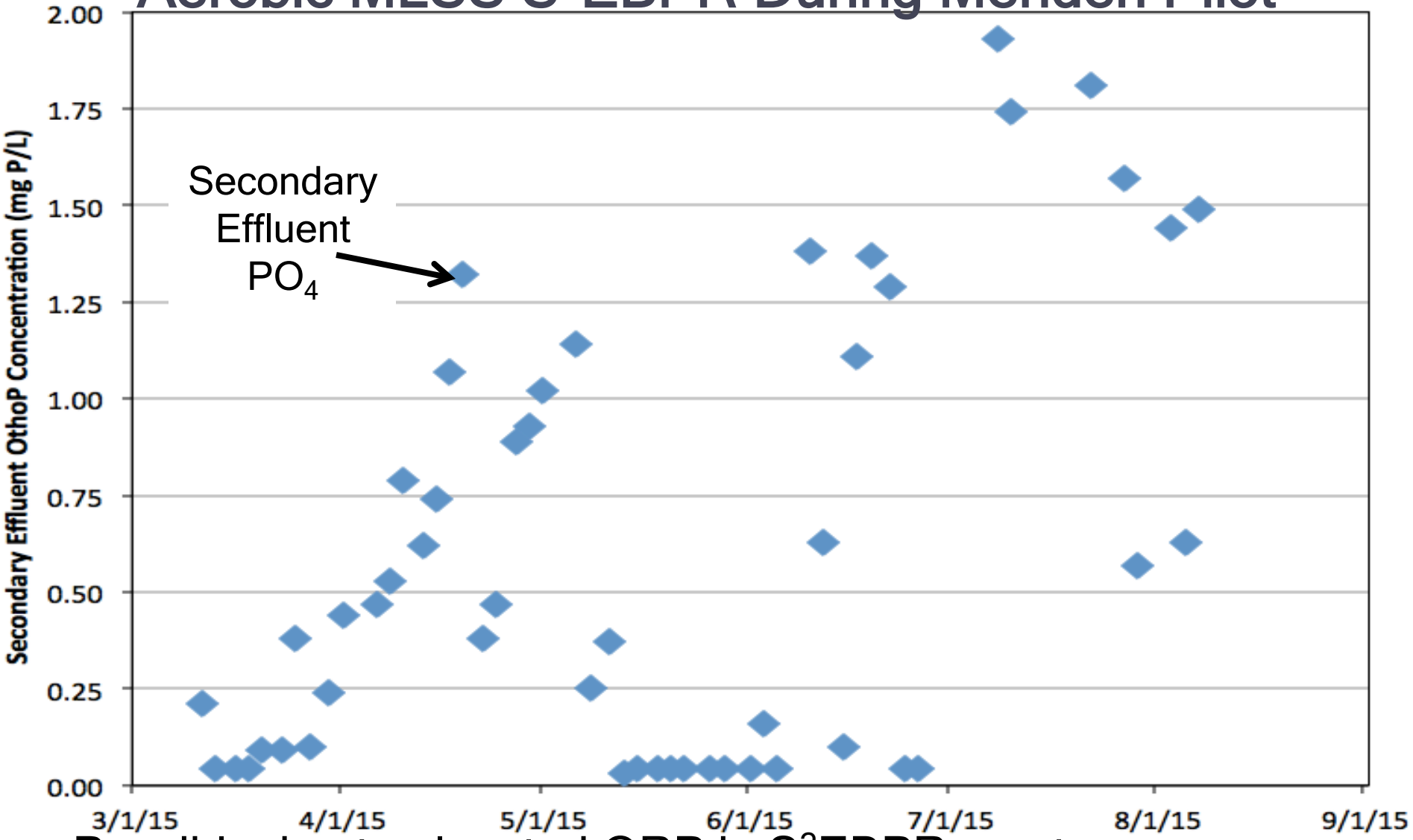
- ORP not low long enough for residual VFA generation in first 2 days

In S²EBPR Pilot Reactor: Low DO, too High ORP



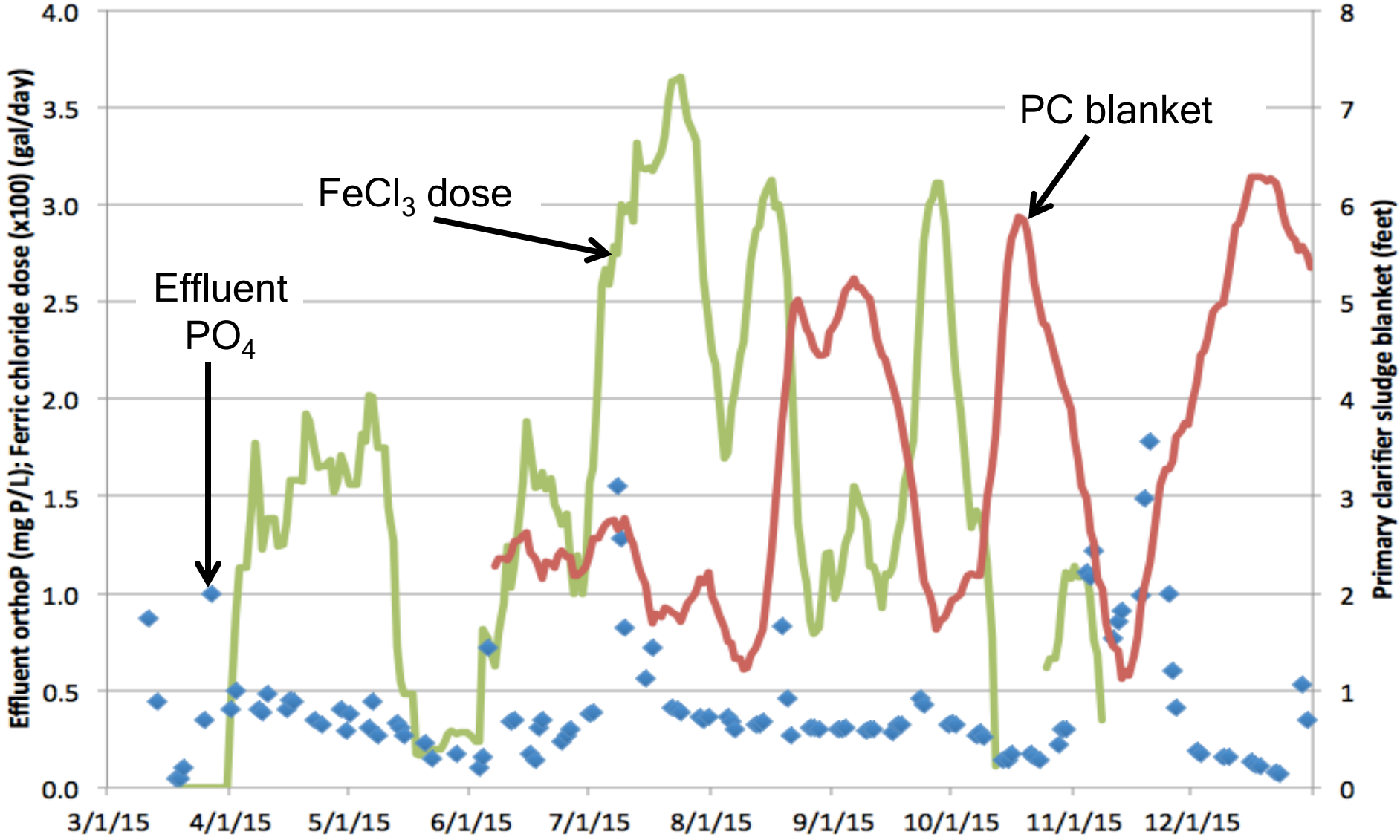
- While DO in sludge blanket was low; ORP was too high for fermentation

Minimal Improvements to EBPR Stability w/ Aerobic MLSS S^{2}EBPR During Meriden Pilot



- Possibly due to elevated ORP in S^{2}EBPR reactor

Meriden's Fix: Increase PC Blanket Level for VFA



- Increase carbon to anaerobic zone by primary sludge fermentation!

Notes from the Operators

- Be committed for significant additional sampling, analyses, and labor
- Communicate constantly with engineers and researchers
- Be willing to experiment
  - Use your expertise!

Takeaway Messages

- VFA production occurred in simulated S^2EBPR batch reactors
  - But low ORP and adequate HRT required
- Aerobic MLSS is a poor feedstock for S^2EBPR reactor
  - Getting ORP low enough is problematic
  - RAS, WAS, or anaerobic MLSS preferred
- Highly trained and engaged treatment plant staff is critical

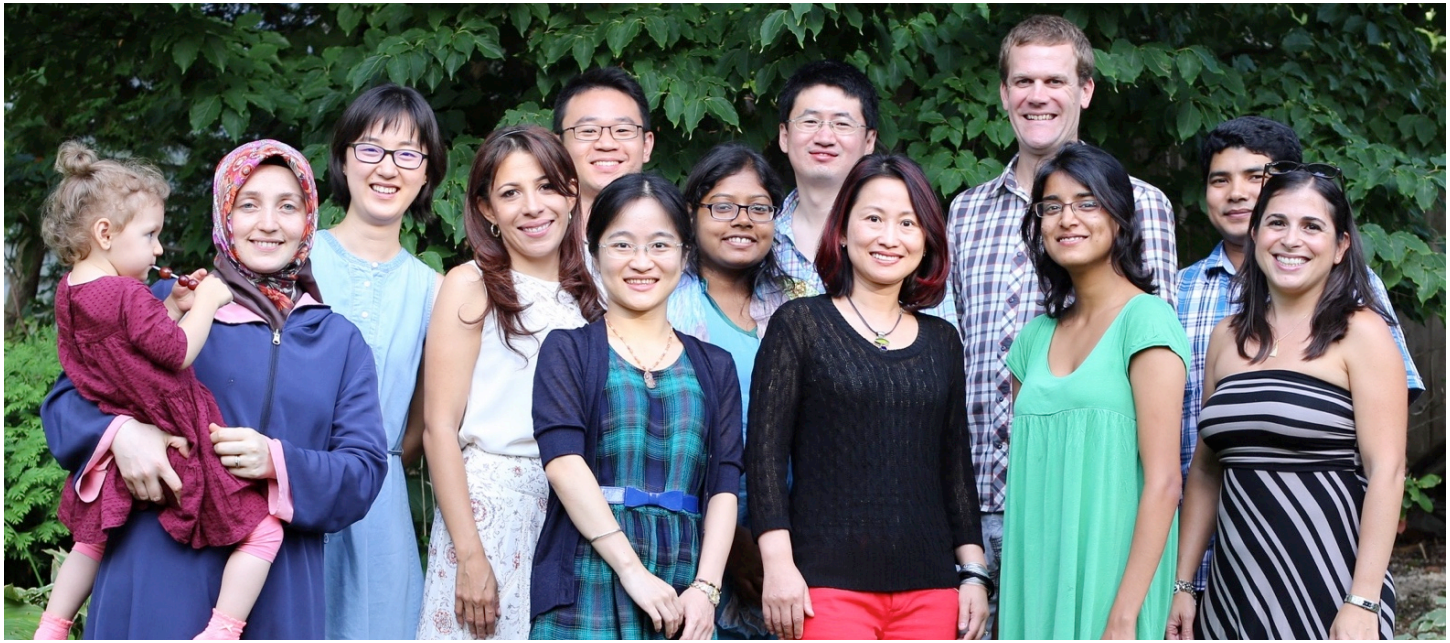
Meriden S^{2}EBPR Pilot – Next Steps

- Pilot test #2, March 2016
- Alternative operation with RAS or TWAS instead of aerobic MLSS
  - Reduce ORP in reactor
  - Increase VFA production

References

- Lopez, C.; Pons, M.N.; Morgenroth, E. (2006). Endogenous processes during long-term starvation in activated sludge performing enhanced biological phosphorus removal. *Water Research*, **40**, 1519-1530.
- Bi, D.; Gou, X.; Chen, D. (2013). Phosphorus release mechanisms during digestion of EBRP sludge under anaerobic, anoxic and aerobic conditions. *Water Science & Technology*, **67**(9), 1953-1959.

Discussion & Questions



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