Removing the Primary Barrier to Successful Mainstream Deammonification

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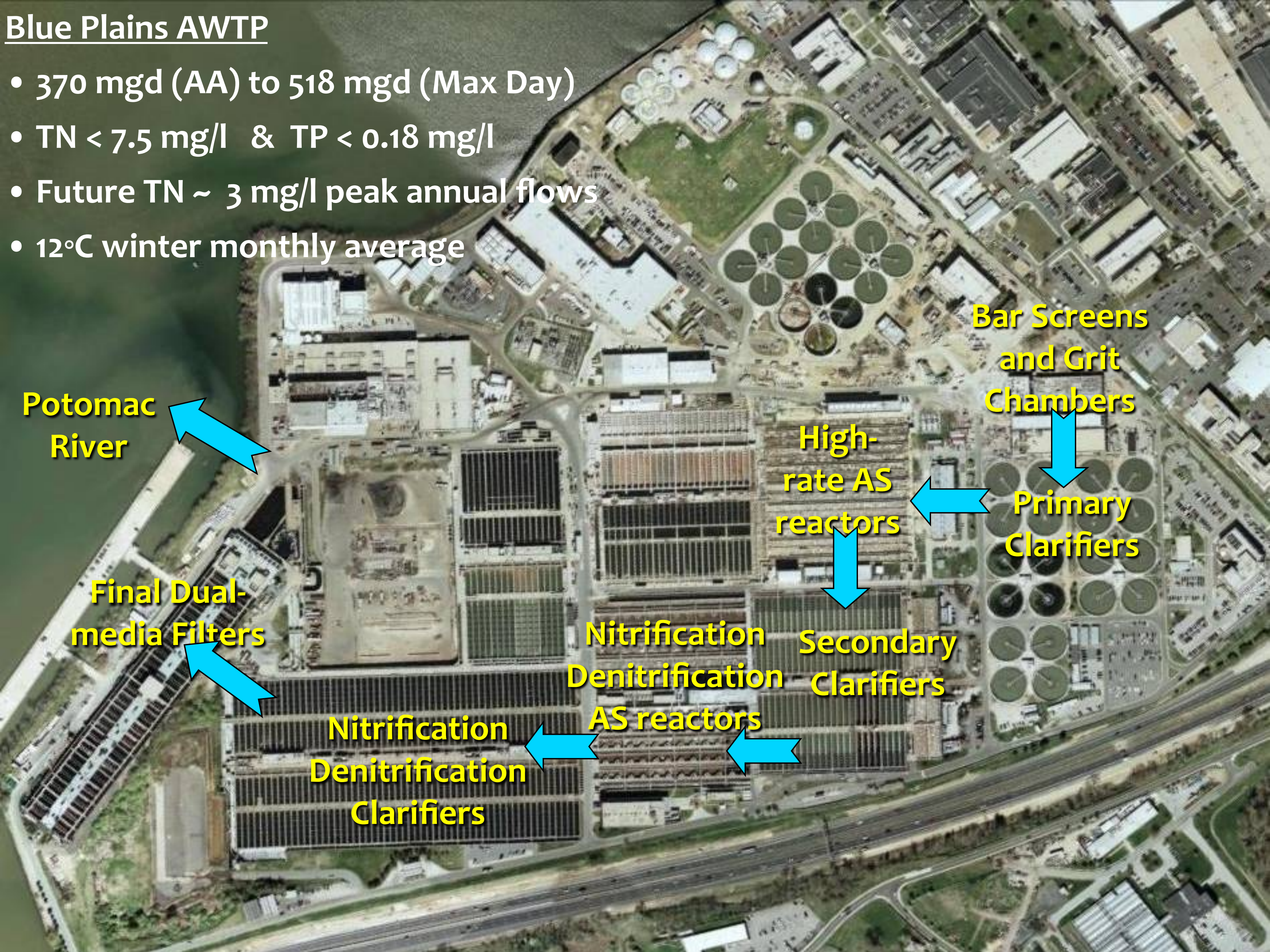
dc water is life

Outline

- Background
  - Blue Plains AWTP [Today and Tomorrow]
    - Nitrogen Shortcut [Benefits/Challenges]
  - Anammox separation approaches
- Screen/Sieve Application
  - Mechanisms & Research Findings

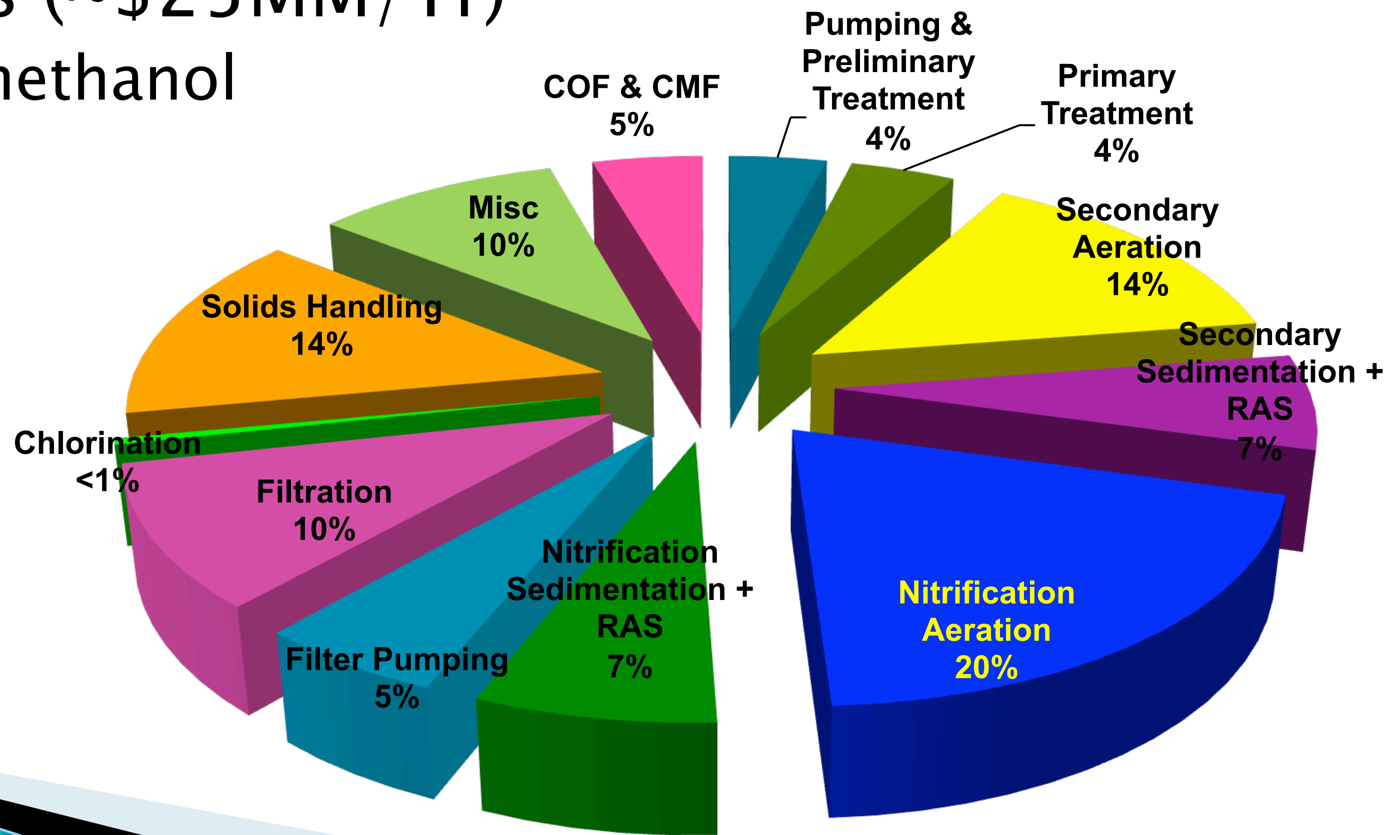
Blue Plains AWTP

- 370 mgd (AA) to 518 mgd (Max Day)
- TN < 7.5 mg/l & TP < 0.18 mg/l
- Future TN ~ 3 mg/l peak annual flows
- 12∘C winter monthly average



Annual Operation Cost

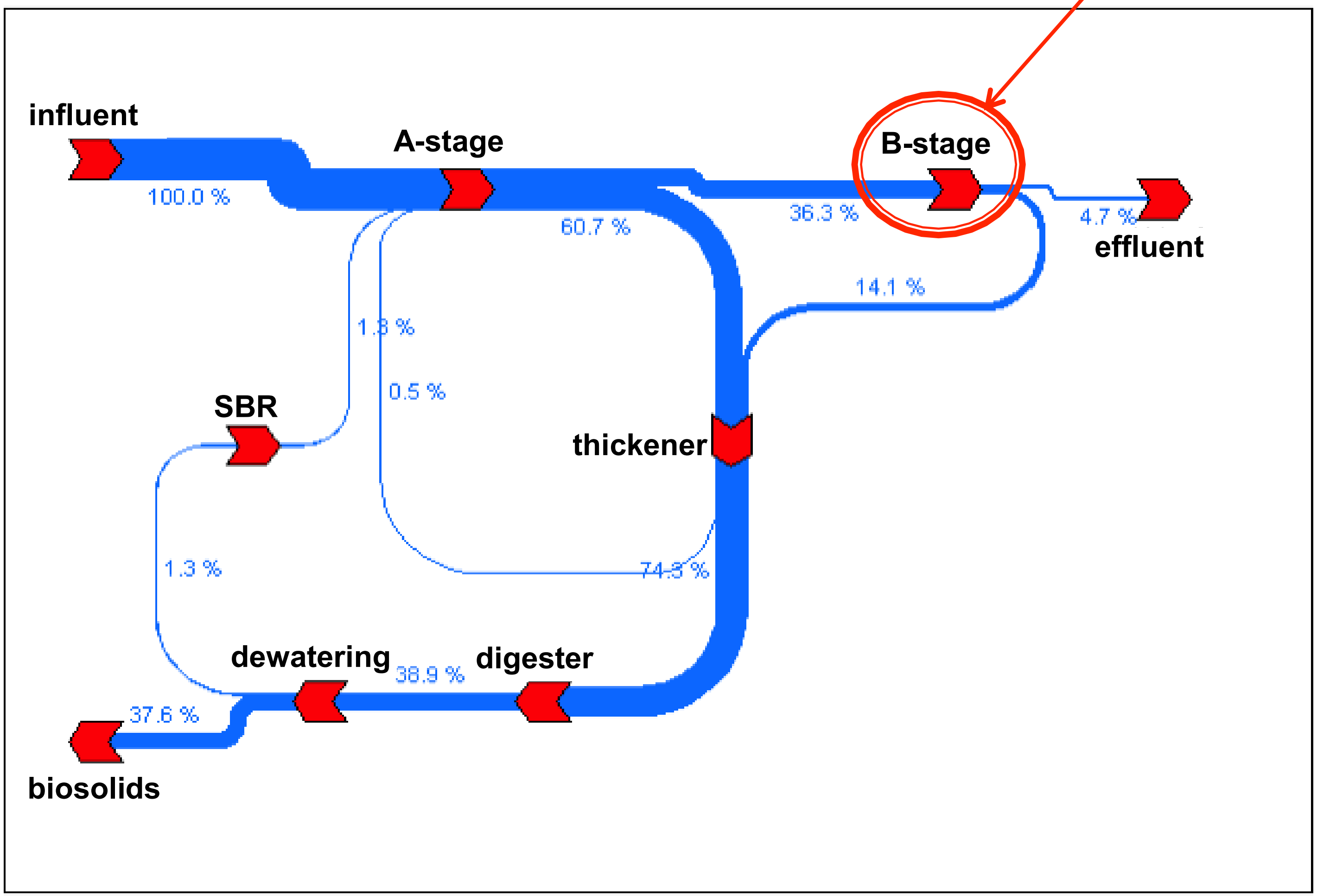
- Aeration (~$25MM/Yr)
  - 34% for aeration
- Chemicals (~$25MM/Yr)
  - 36% for methanol



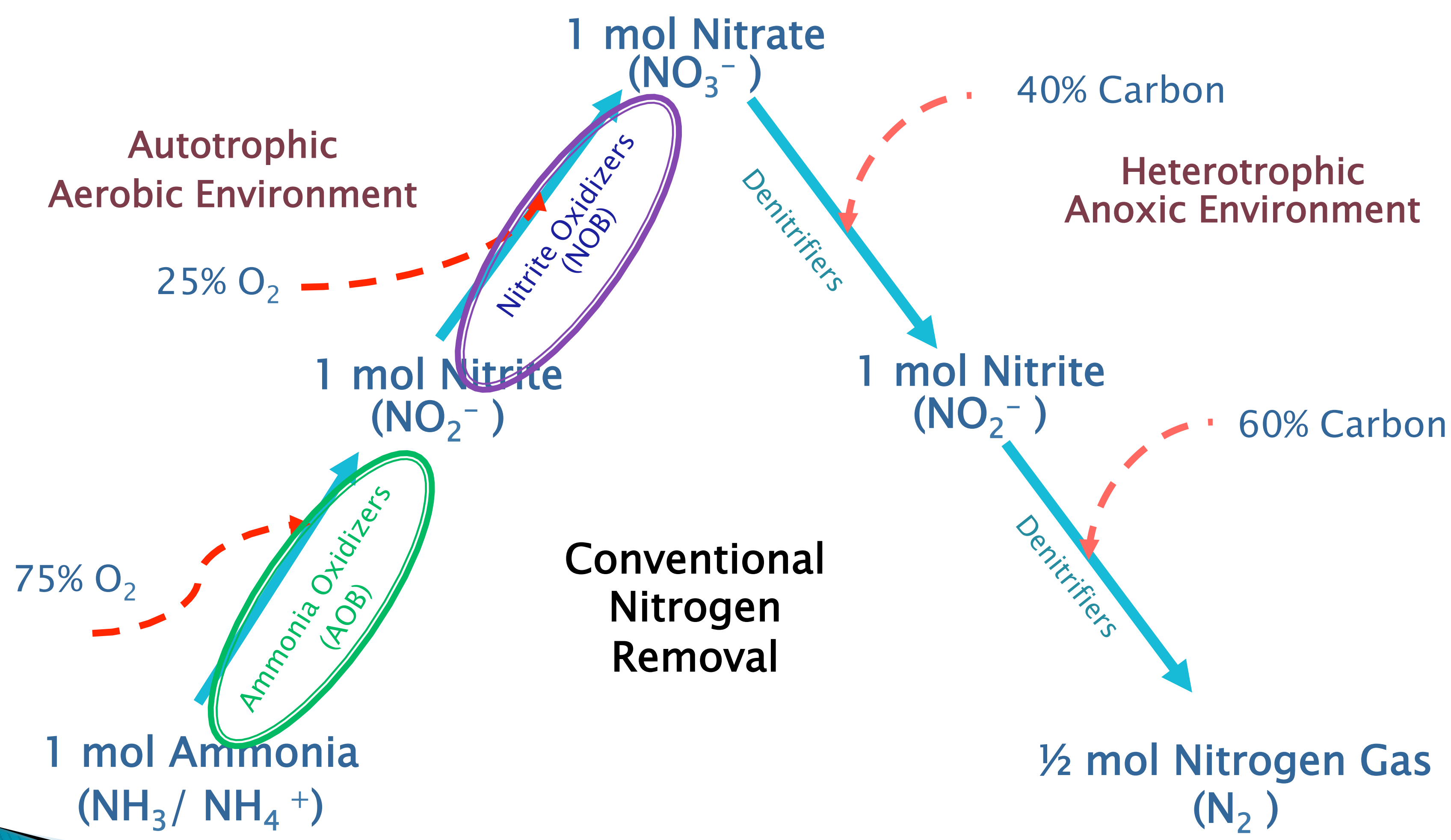
Blue Plains Facilities Upgrade

Blue Plains Tomorrow

- **A-Stage** – (55-75% COD removal)
- **B-Stage** – Deammonification *(Research Focus)*

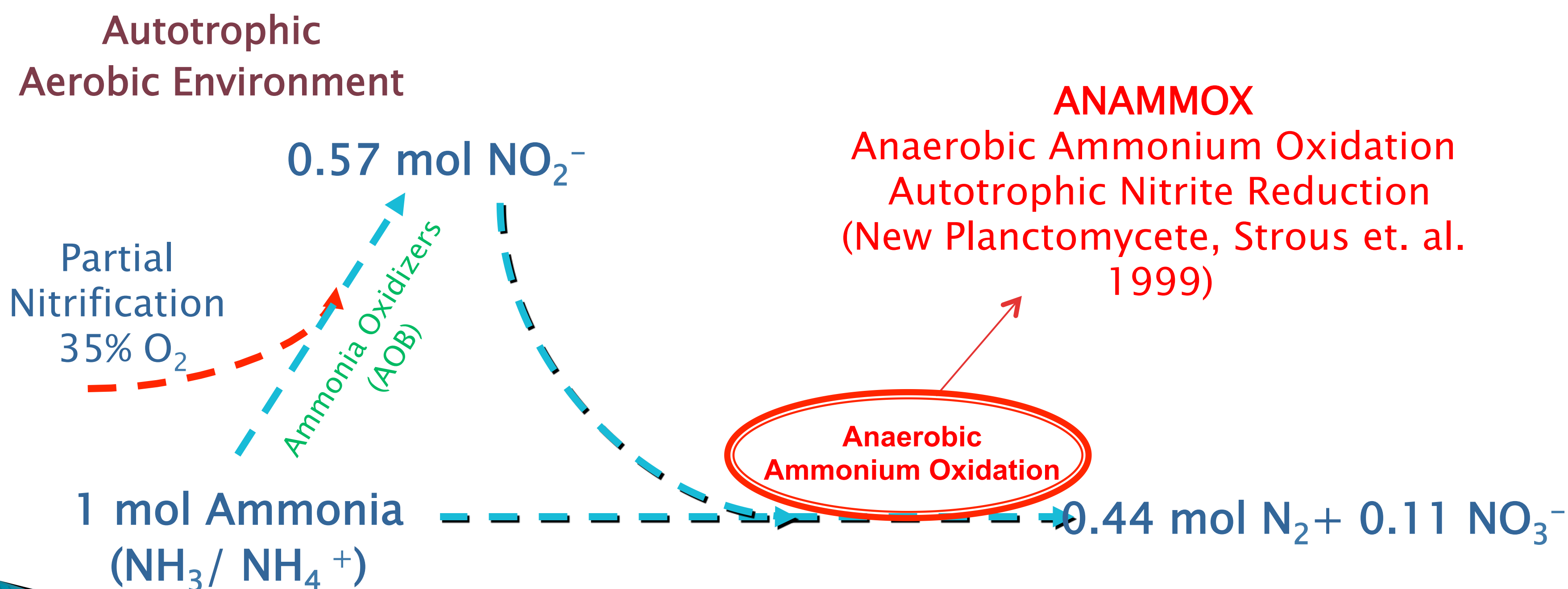


Conventional Nitrogen Removal



Partial Nitritation/Anammox – Deammonification

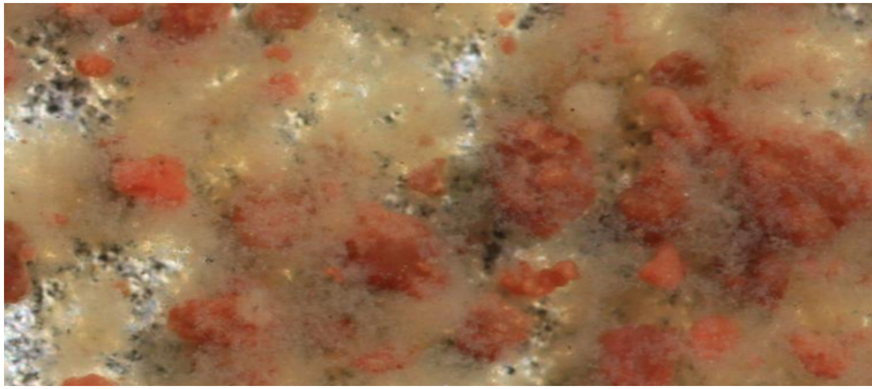
- > 65% reduction in Oxygen
- Eliminate demand for supplemental carbon



Primary Challenge – Selection and Retention of Anammox

1. Slow growing organisms
   - Anammox doubling time → 1-2 weeks

     [Versus]
   - AOB doubling time → 1 day
   - NOB doubling time → 1.5 day



2. Optimize retention of AOB

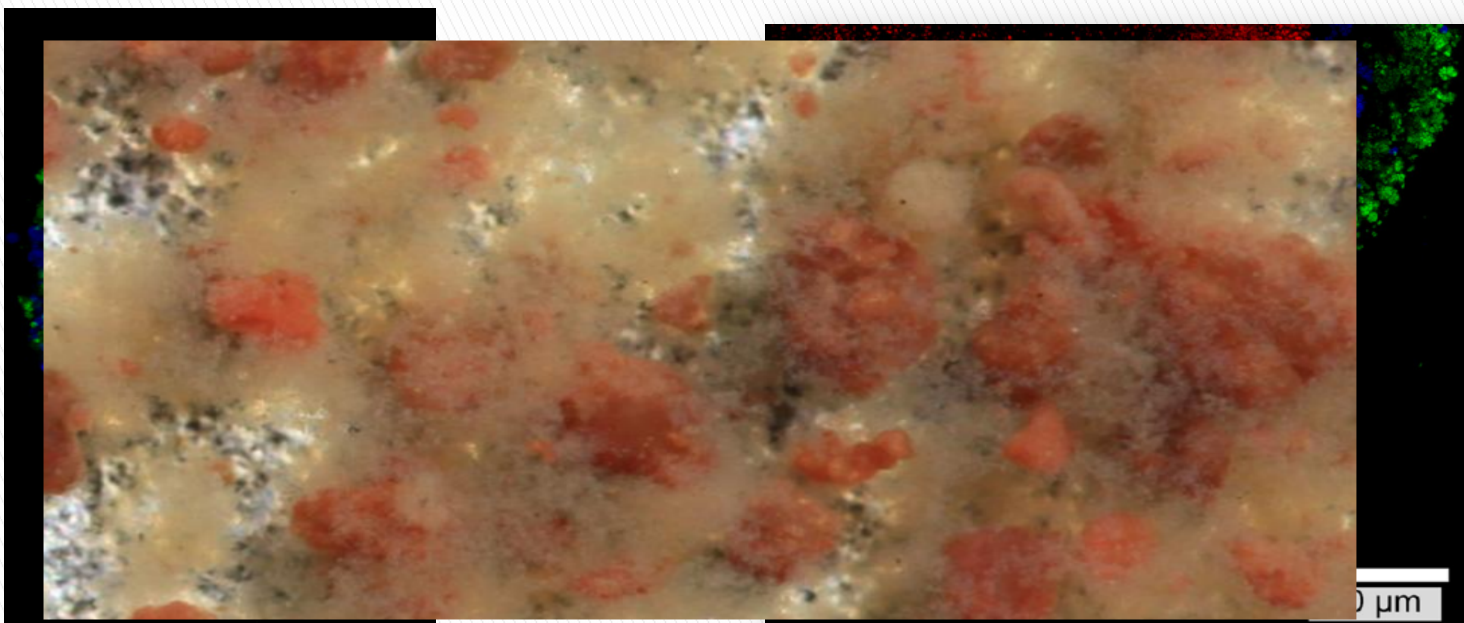
3. Out-select NOB

Retention Techniques

- Selection for heavy granules (airlift reactors)
- Selection for well settling granules (SBR)
- Selection for dense granules (cyclones)
- Attached growth [Ex. MBBR]

Screen Concept

Flocs [compressible]	Granules [non-compressible]
Fluffy, Brown Particles	Dense, Redish Particles
10-150 um	> 200 um
Majority NOB and AOB	Majority Anammox



Screens Selection Mechanisms & Research Objectives

Selection Based on:

Size

- Determine long term effect of sieve size used for screening to separate organism SRT
- Effect of frequency of sieve usage on particle distribution

Compressibility

- Floc Out-selection & anammox retention efficiency

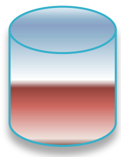
Shear Resistance

- Effect on anammox nitrogen removal using a mechanical method for NOB Removal

Overall:

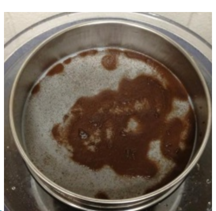
Best method for deammonification operation (Anammox retention/NOB removal)

Selection Based on Size

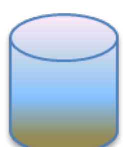


Mixed liquor

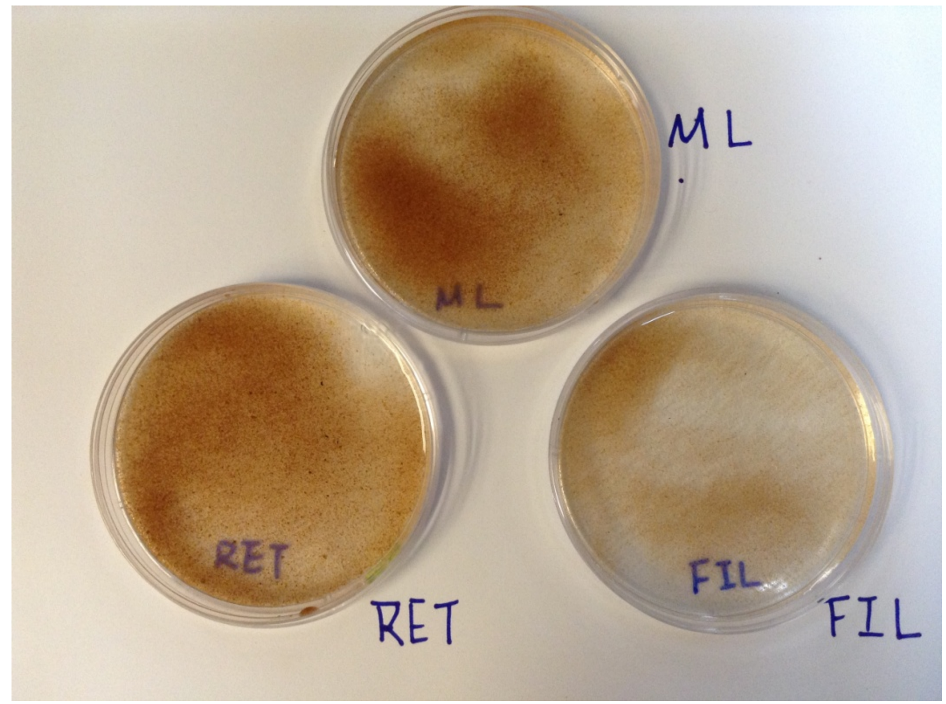
screen



Particles > mesh size

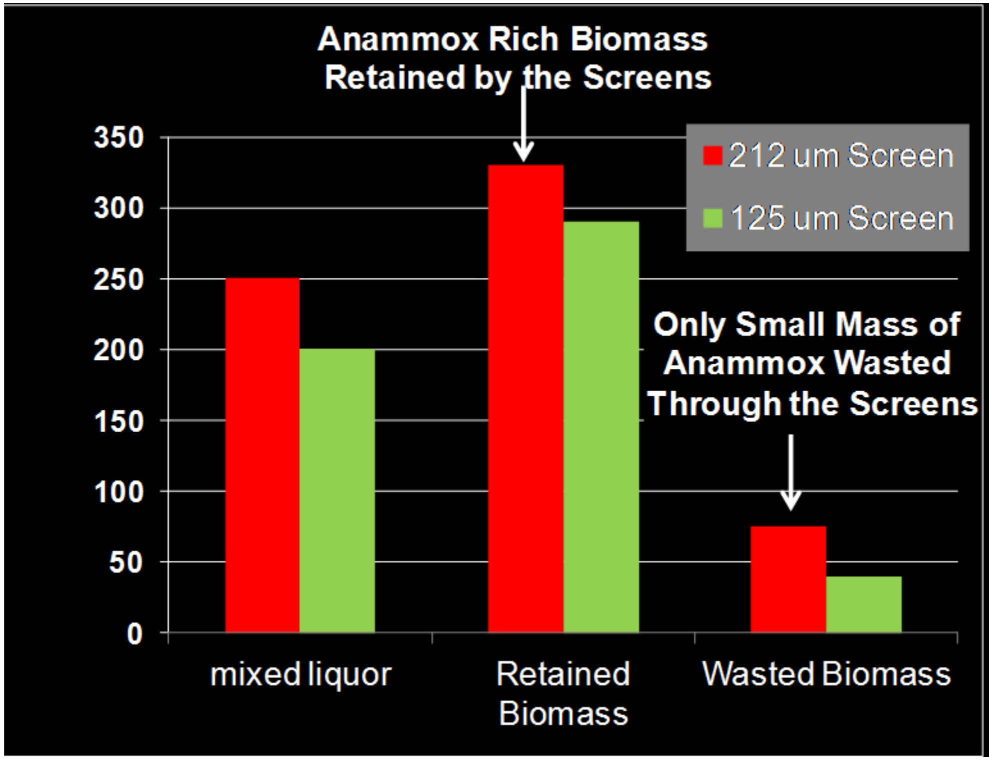


Particles < mesh size

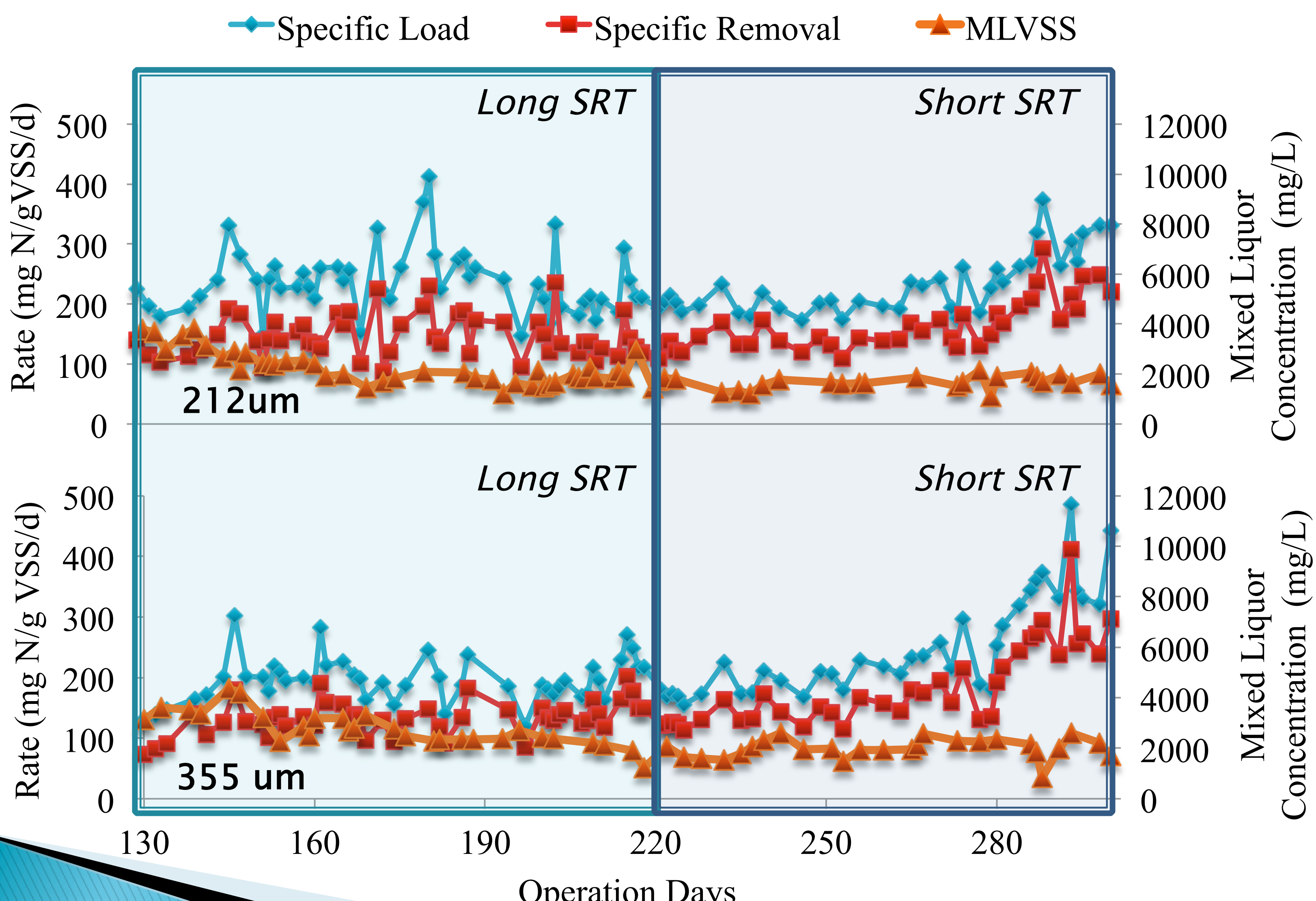


Anammox Retention – Size selection

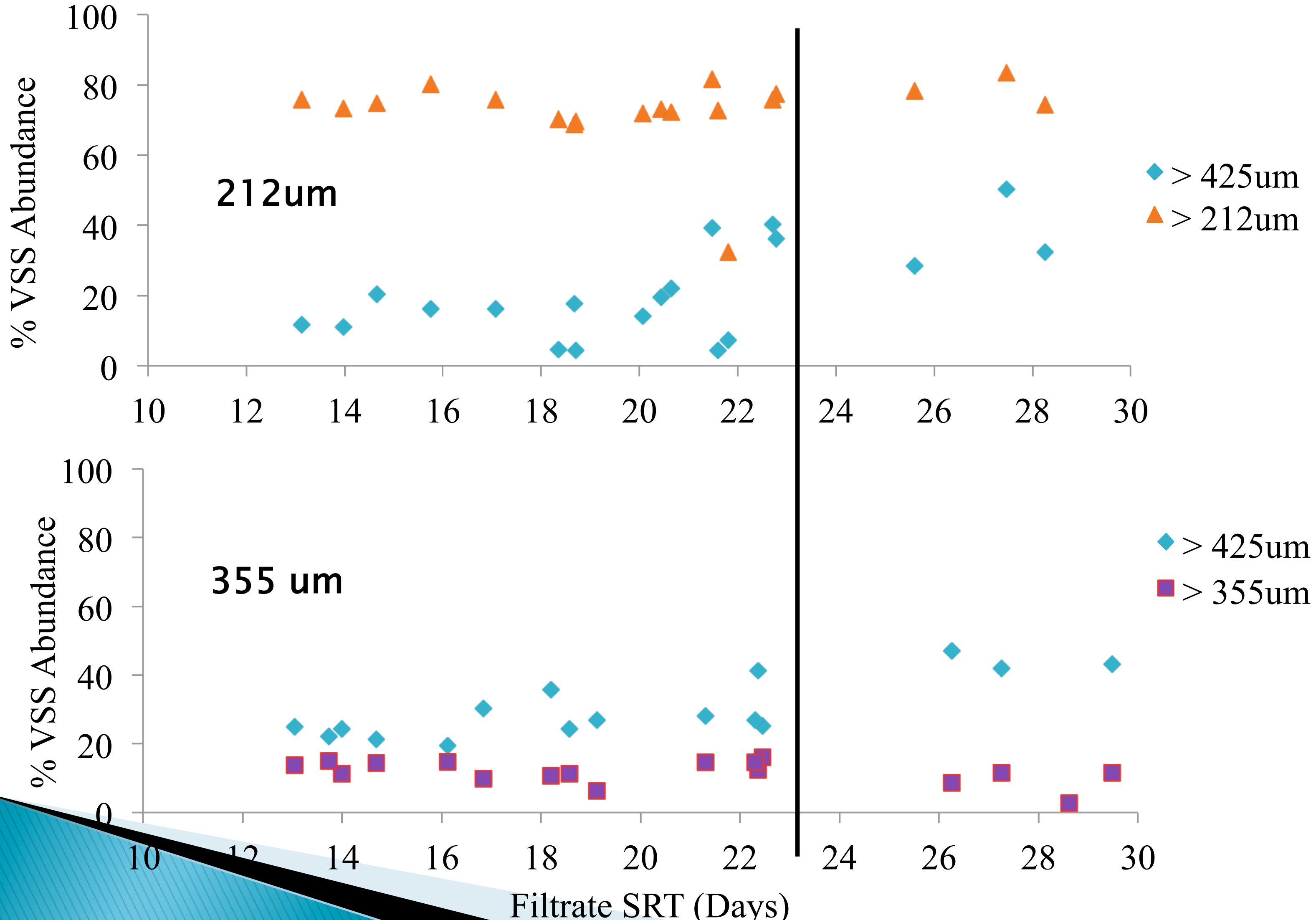
- Effective anammox retention
  - Average – 85%
- Size selection – selects for activity
  - Smaller particles have higher activity



Effect of Size on Reactor Rates

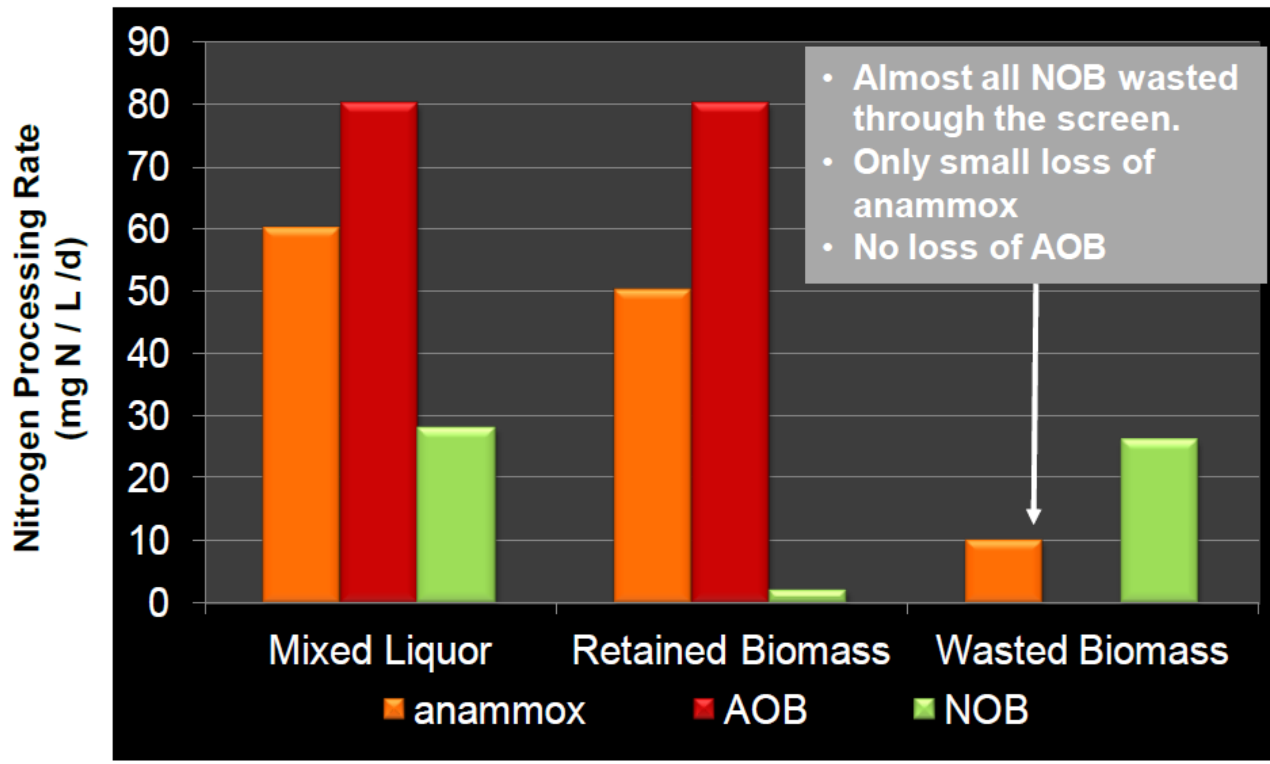


Effect of Frequency on Particle Distribution

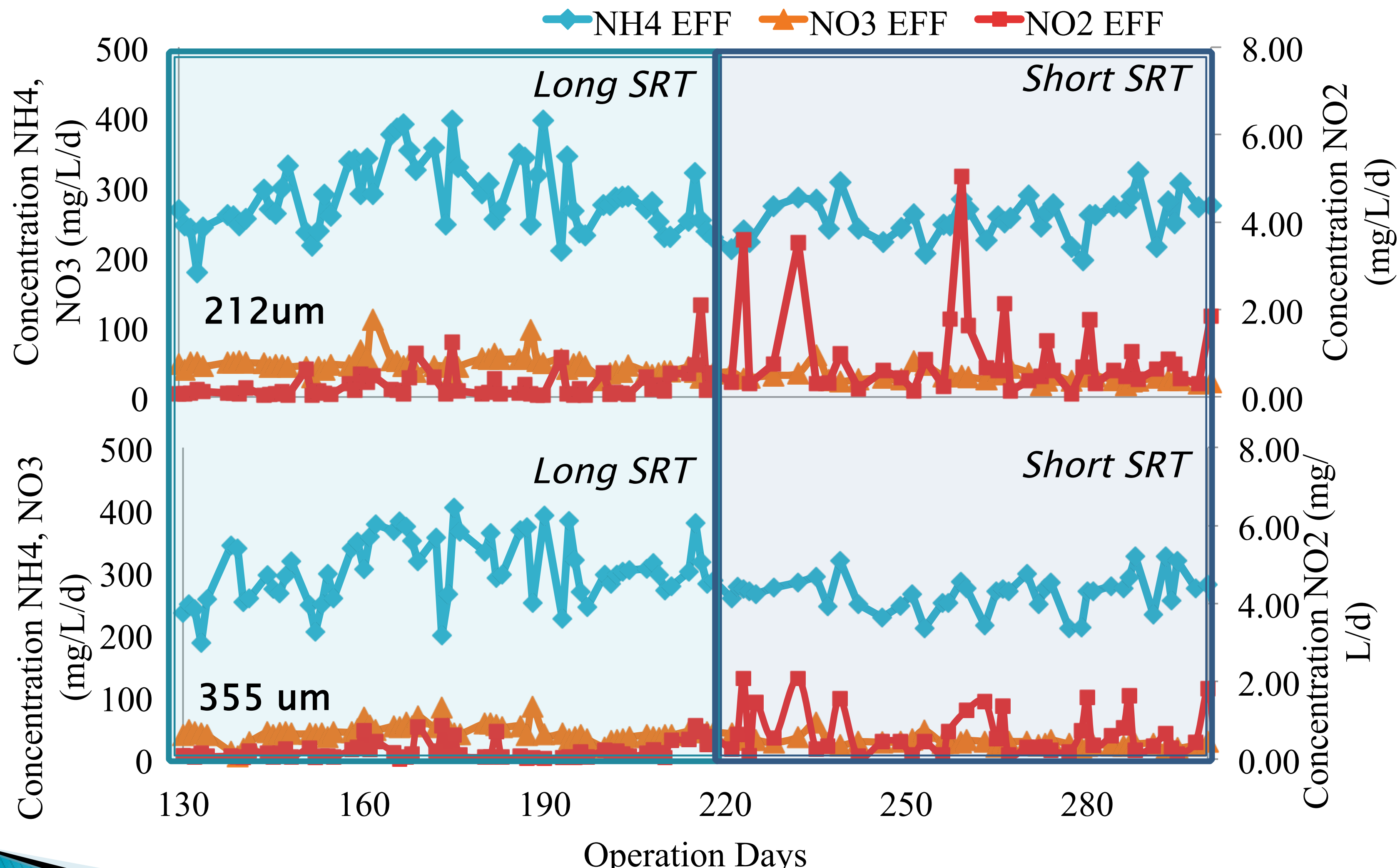


Selective wasting of NOB – Size selection

- Effective NOB out-selection
- Size selection
  - NOB activity found in smaller size particles

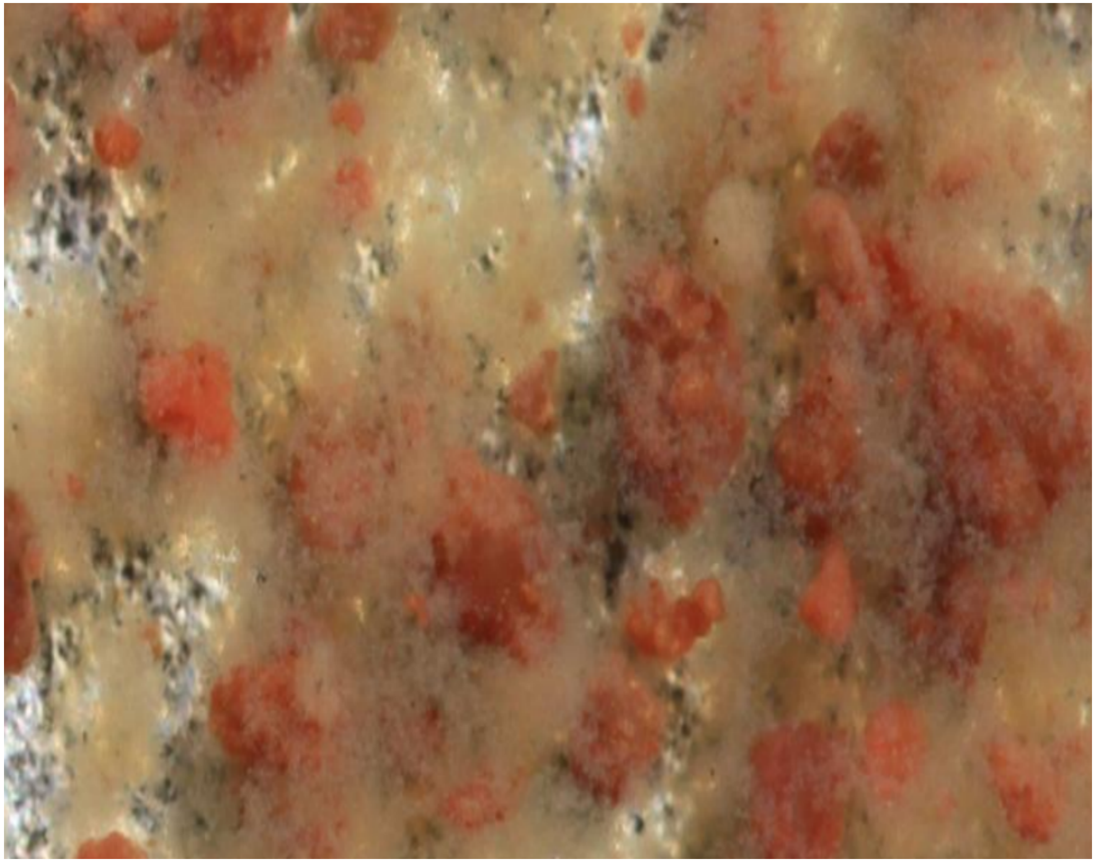


Effect of Size on Effluent Quality

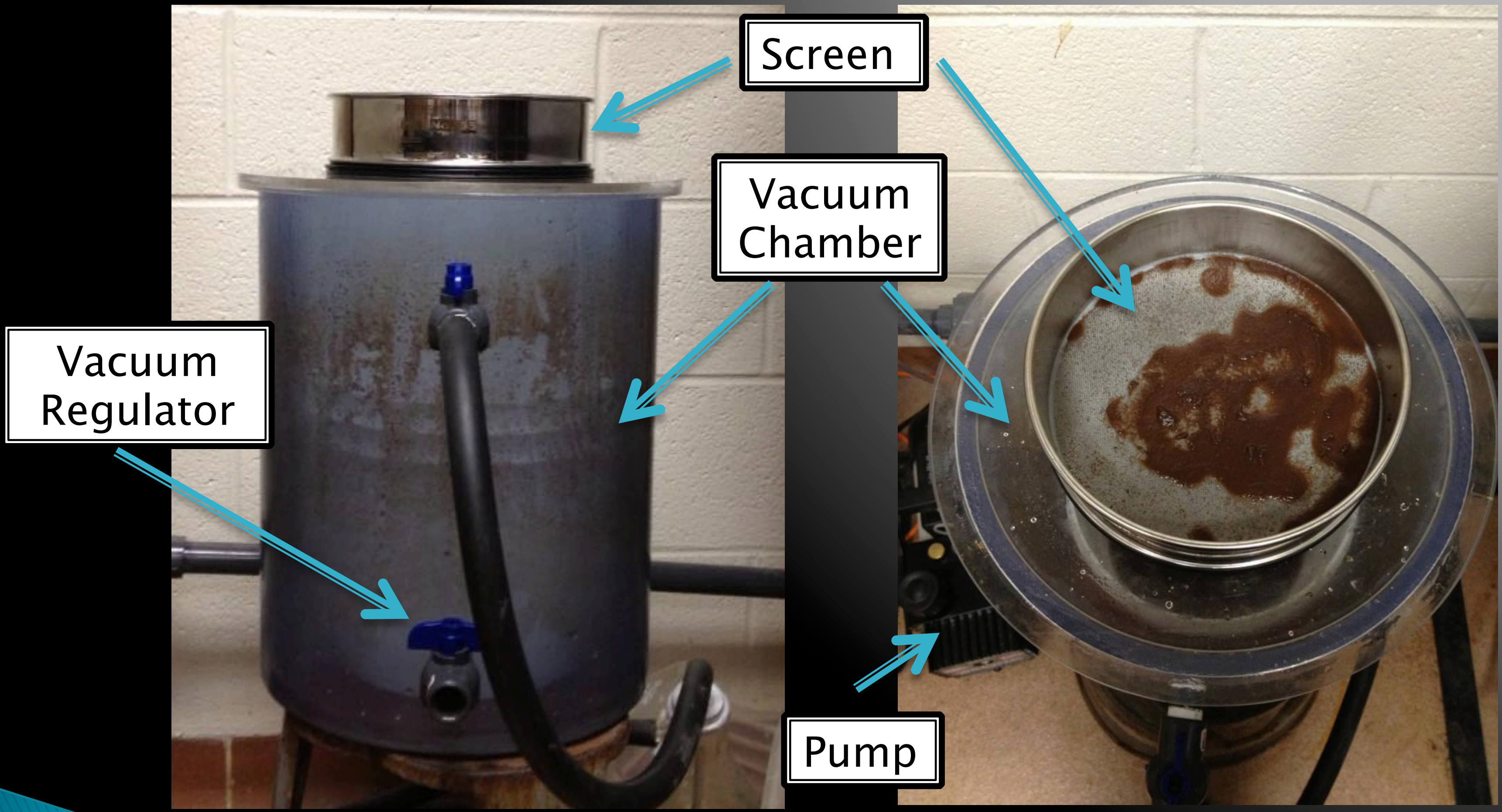


Selection Based on Compressibility

- Method for washout
- Smaller particles are compressible flocs
- Larger granules are rigid
- Prevent accumulation of nitrite and nitratation



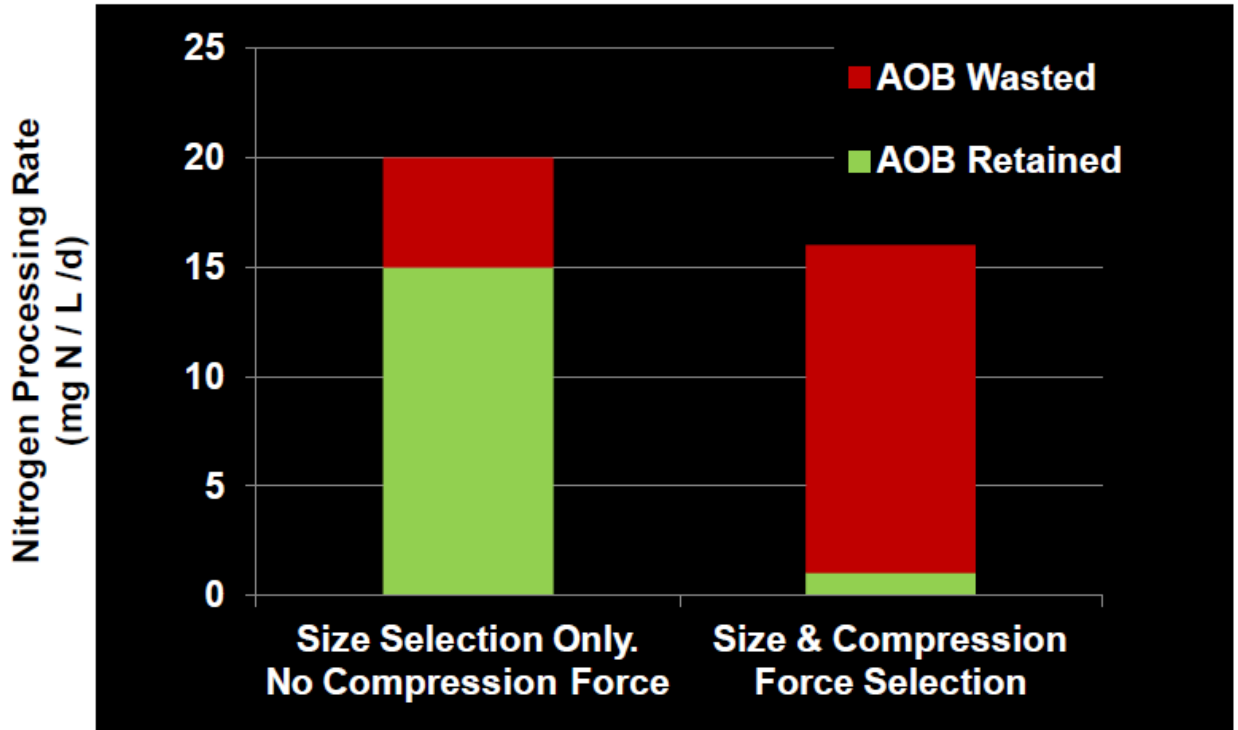
Experimental Design



Side View

Top View

Selective Retention of AOB – Size/Compressibility



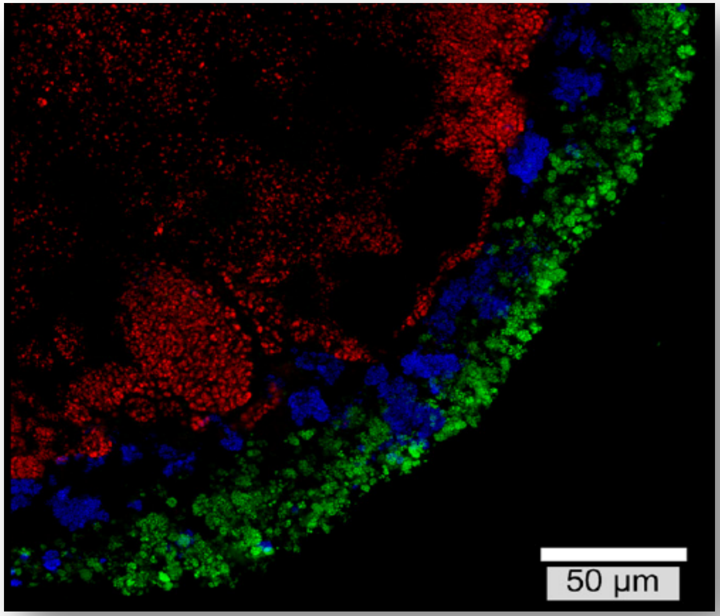
The mass of AOB retained or wasted from the system can be controlled by altering the compression force that is applied across the screen

Selection Based on Shear Resistance

- Application of shear stress to remove NOB from granules

- Effects of shear on anammox

  - Nitrogen Removal Performance
  - Settleability (Retention)
  - Particle Distribution



FISH Image
AOB Anammox NOB

Experimental Design

- Shear rate (G) provides the stress applied

$$G = \sqrt{\frac{2\pi NT}{\mu V}}$$

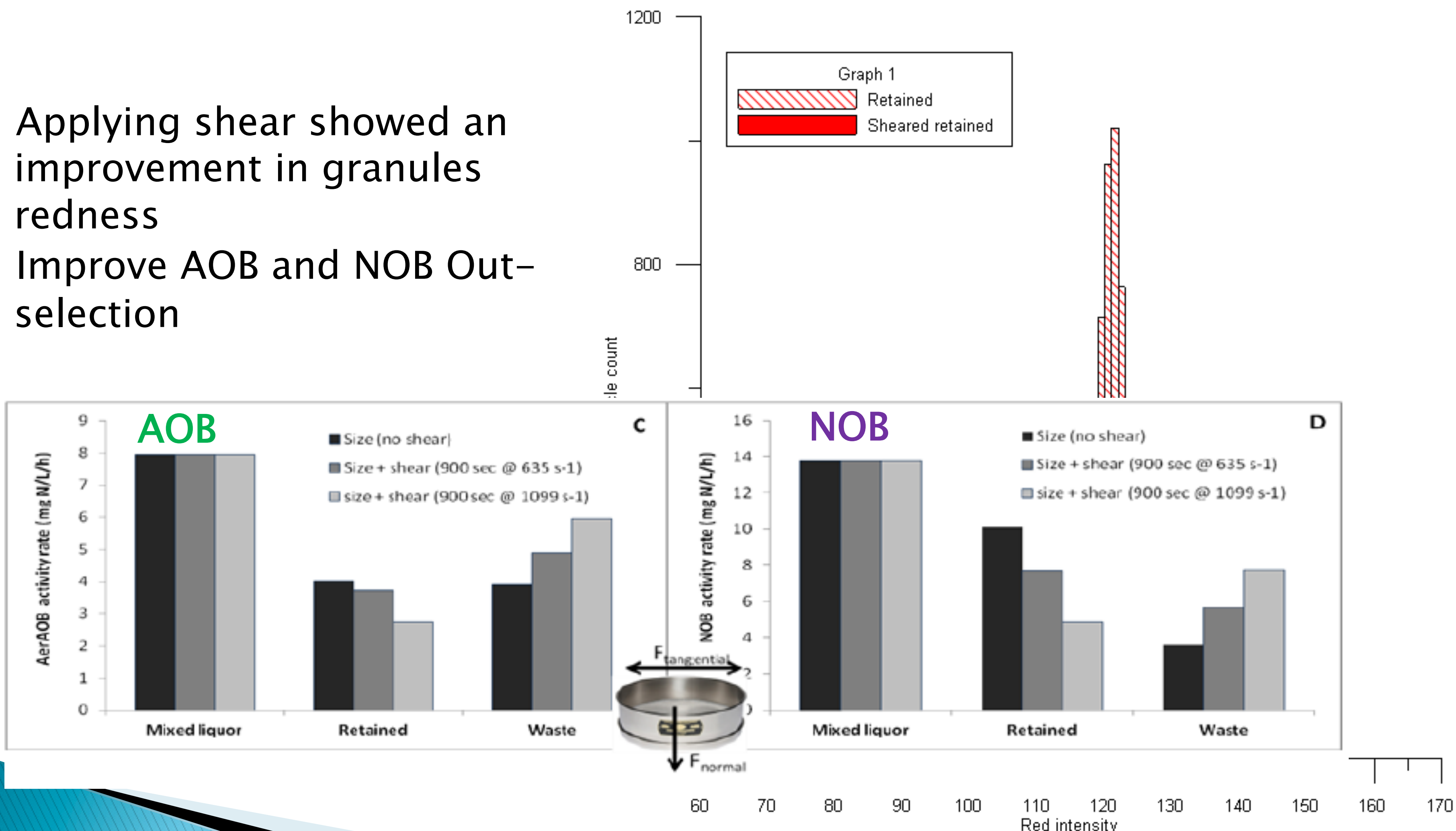
N = Impeller speed (revolutions per second)
T = Torque on the impeller (N-m)
μ = Sludge viscosity (Pa-s)
V = Sample volume (m^3)

- Shear calculated from 500, 800, 1000, 1200 and 1500 RPM

- Sludge concentration of TSS 2000 mg/L

Experimental Design

- Applying shear showed an improvement in granules redness
- Improve AOB and NOB Out-selection



Conclustions

- Effective Retention of the Right Amount & Size of Anammox Organisms Using Size Selection
- Effective Wasting of the NOB Using Size Selection
- Controlled Retention of the AOB using both Size and Compressibility Selection for Optimized Performance
- Improve System Functionality Using Size, Compressibility and Shear Selection.