Full Plant Deammonification for Energy Neutral Wastewater Treatment

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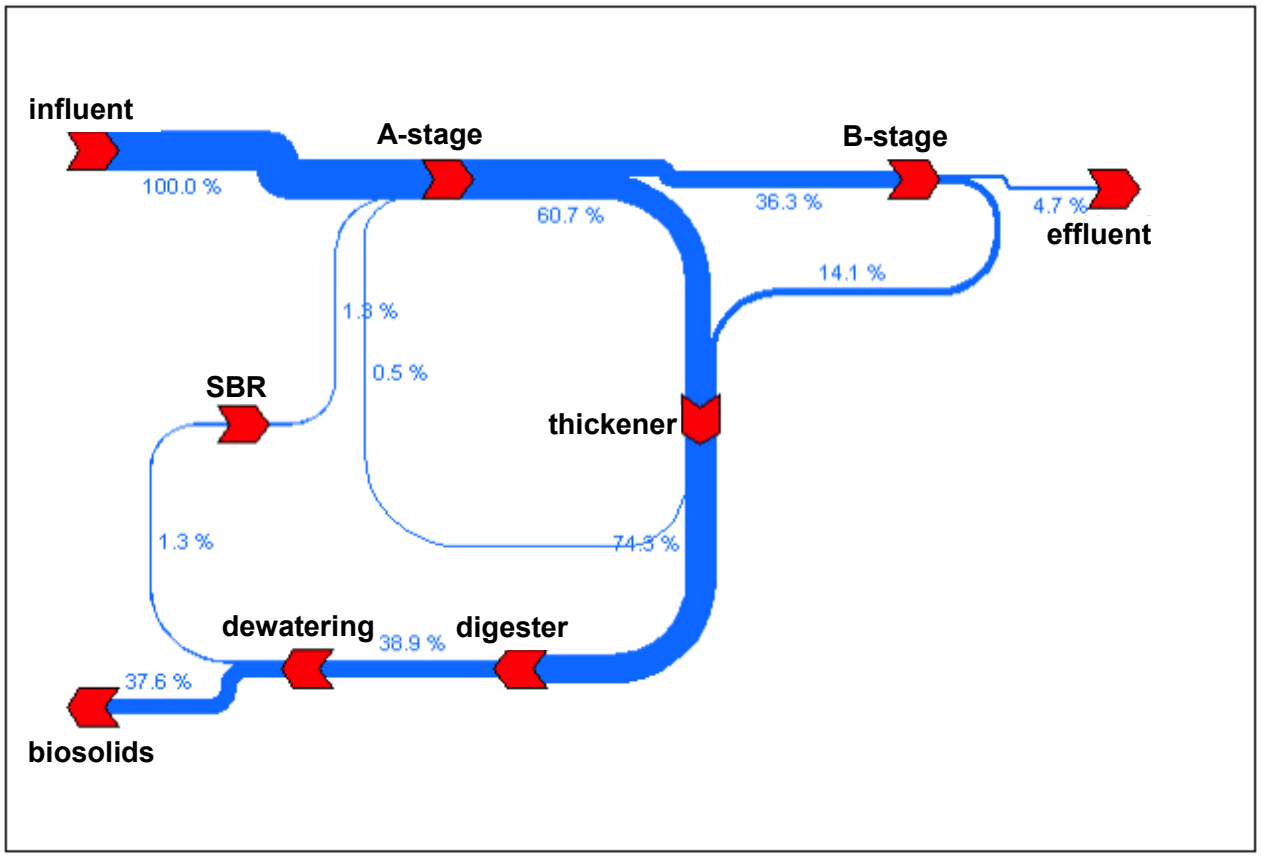
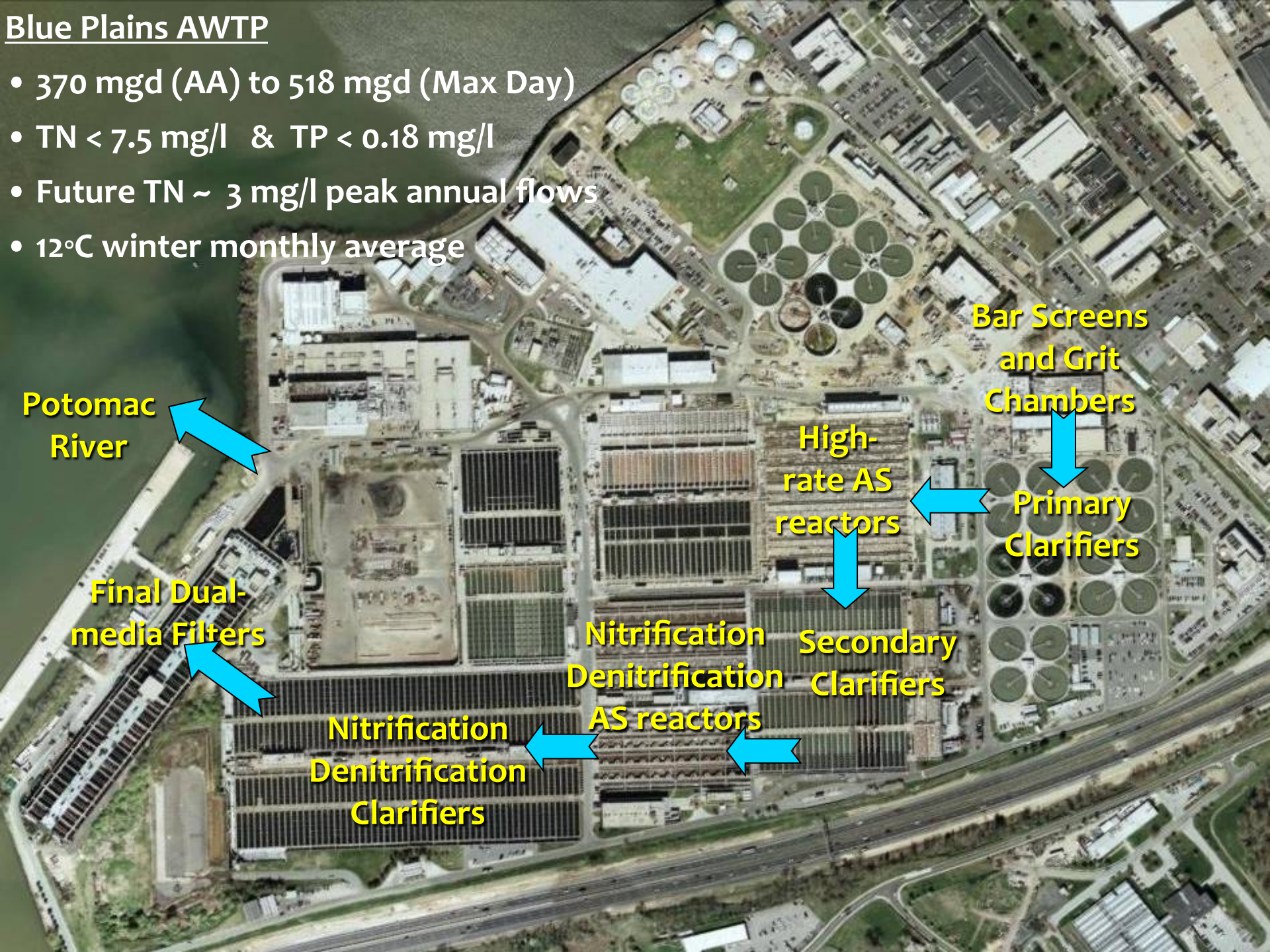
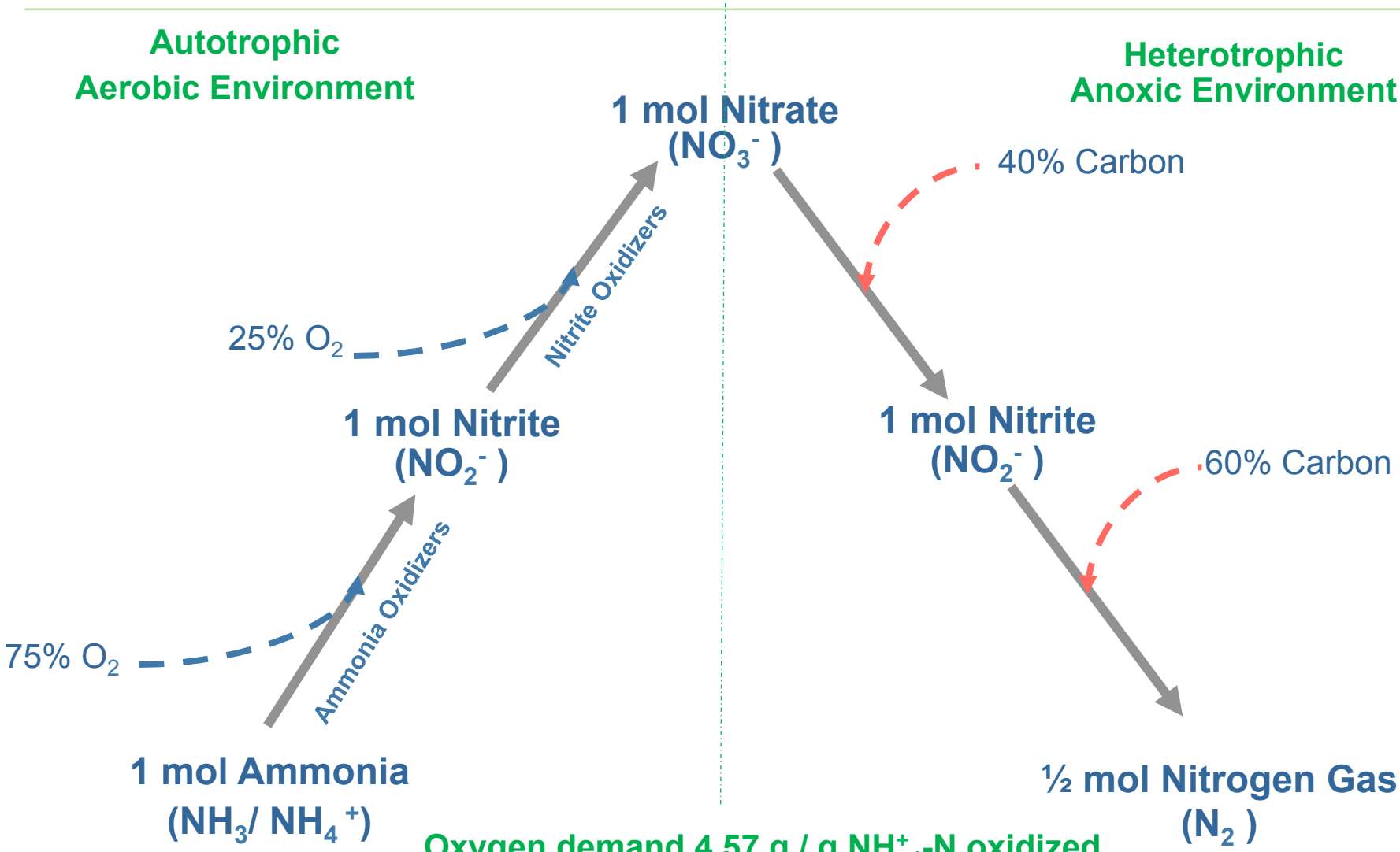
- High Rate, CEPT or A-Stage:
  - 55-75% COD removal
- B-stage: 10 - 15 days SRT
  - Deammonification



Carbon Removal


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
Bar Screens and Grit Chambers
Primary Clarifiers
High-rate AS reactors
Secondary Clarifiers
Nitrification Denitrification AS reactors
Nitrification Denitrification Clarifiers
Final Dual-media Filters
Potomac River

Fundamentals of Nitrification - Denitrification



Oxygen demand 4.57 g / g NH^+_4-N oxidized
Carbon demand 4.77 g COD / g NO^-_3-N reduced

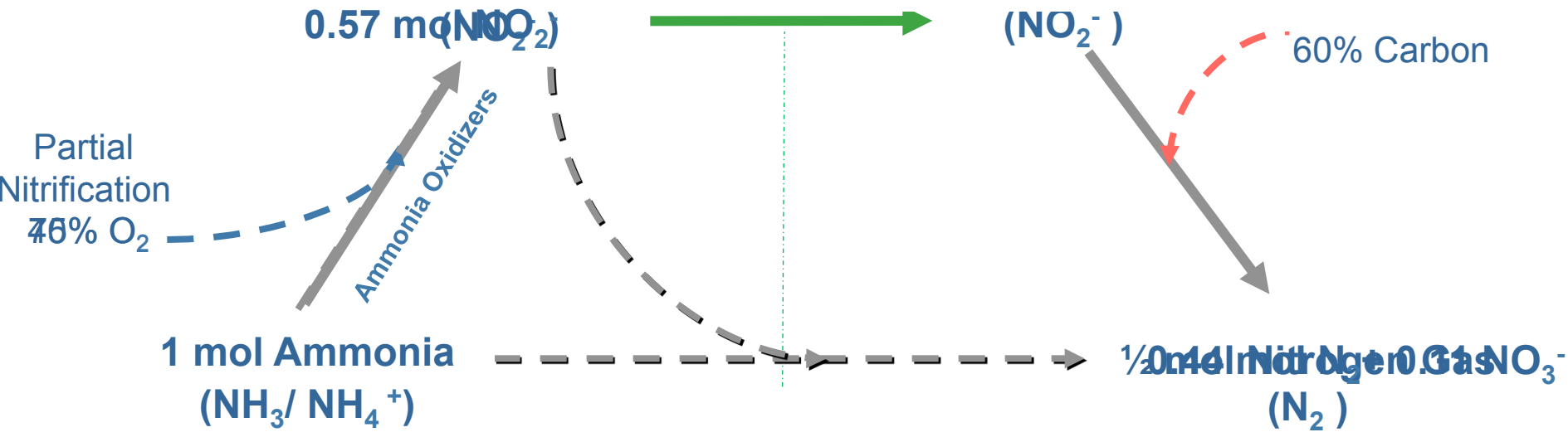
Fundamentals of Deammonification

Autotrophic
Aerobic Environment

ANAMMOX
Autotrophic
Anoxic Environment

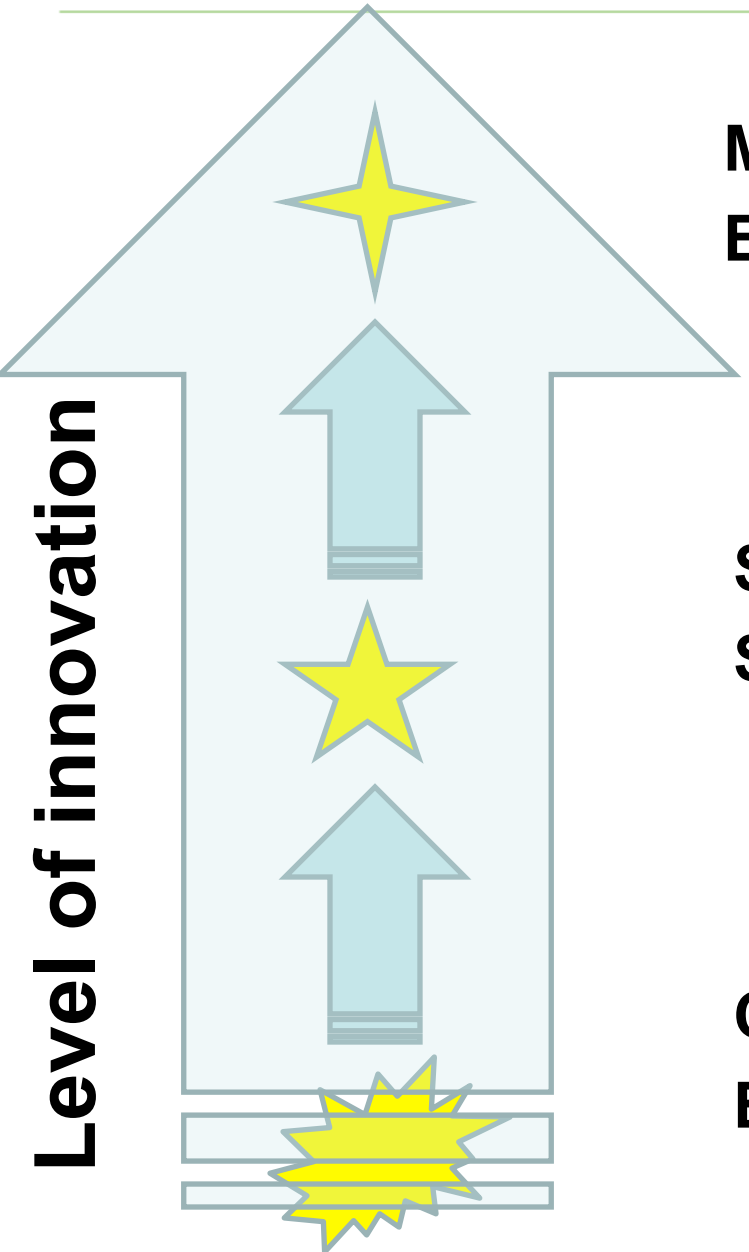
Anaerobic Ammonium Oxidation
Autotrophic Nitrite Reduction
(New Planctomycete, Strous et. al. 1999)

$$NH_4^+ + 1.32\ NO_2^- + 0.066\ HCO_3^- + 0.13\ H^+ \rightarrow 0.26\ NO_3^- + 1.02 N_2 + 0.066\ CH_2O_{0.5}N_{0.15} + 2.03\ H_2O$$



Oxygen demand 1.9 g / g NH^+_4-N oxidized

How mature is deammonification technology?



Main-stream Deammonification

Emerging technology

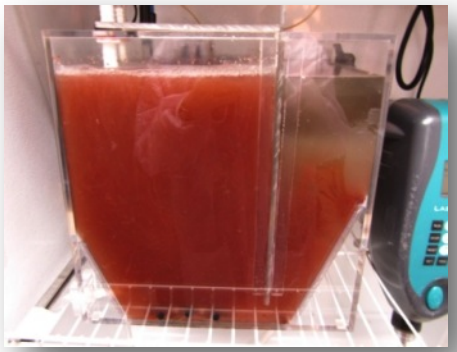
Side-stream Deammonification

State of the Art

Conventional N-removal technologies

Established

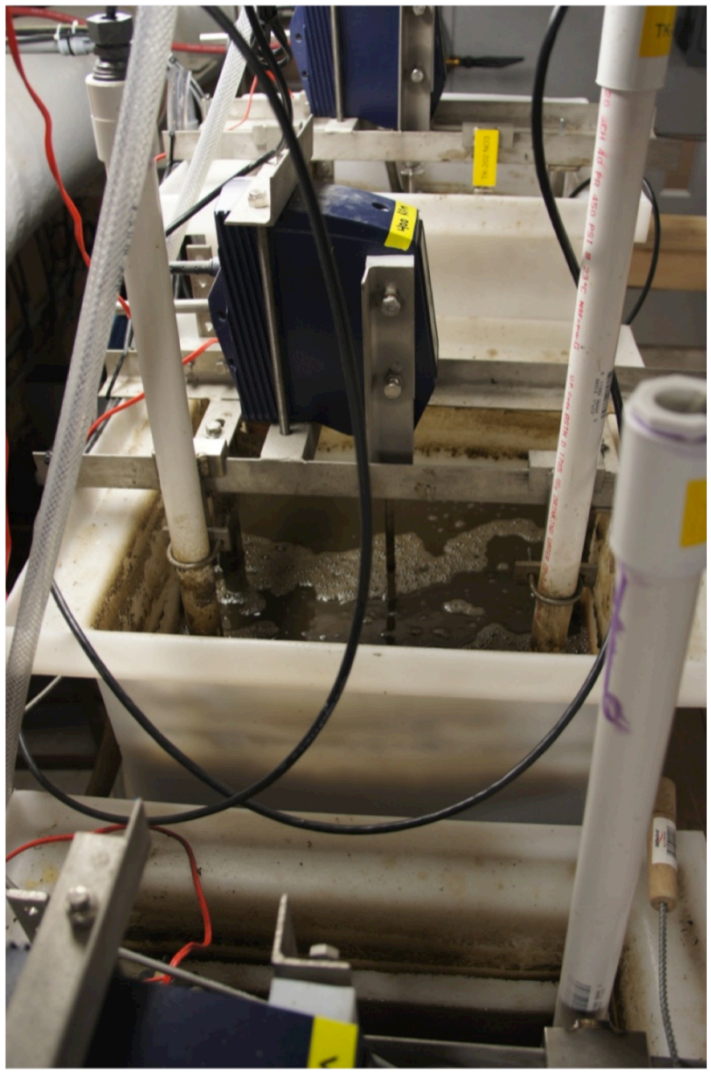
WERF-Mainstream Deammonification 3 different sites and scales



Objective of bench-scale pilot at DC Water

- **Investigate fundamental process kinetics** and control mechanisms identified for NOB out-selection, AOB and anammox enrichment, development and calibration of process model.

WERF-Mainstream Deammonification 3 different sites and scales



Objective of pilot-scale tests at HRSD, Virginia

- **Focus on NOB out-selection and control optimization** to support design work at considered plant.
- **Biofilm Post-Anoxic Anammox**

WERF-Mainstream Deammonification 3 different sites and scales

Objective of full-scale pilot at WWTP Strass

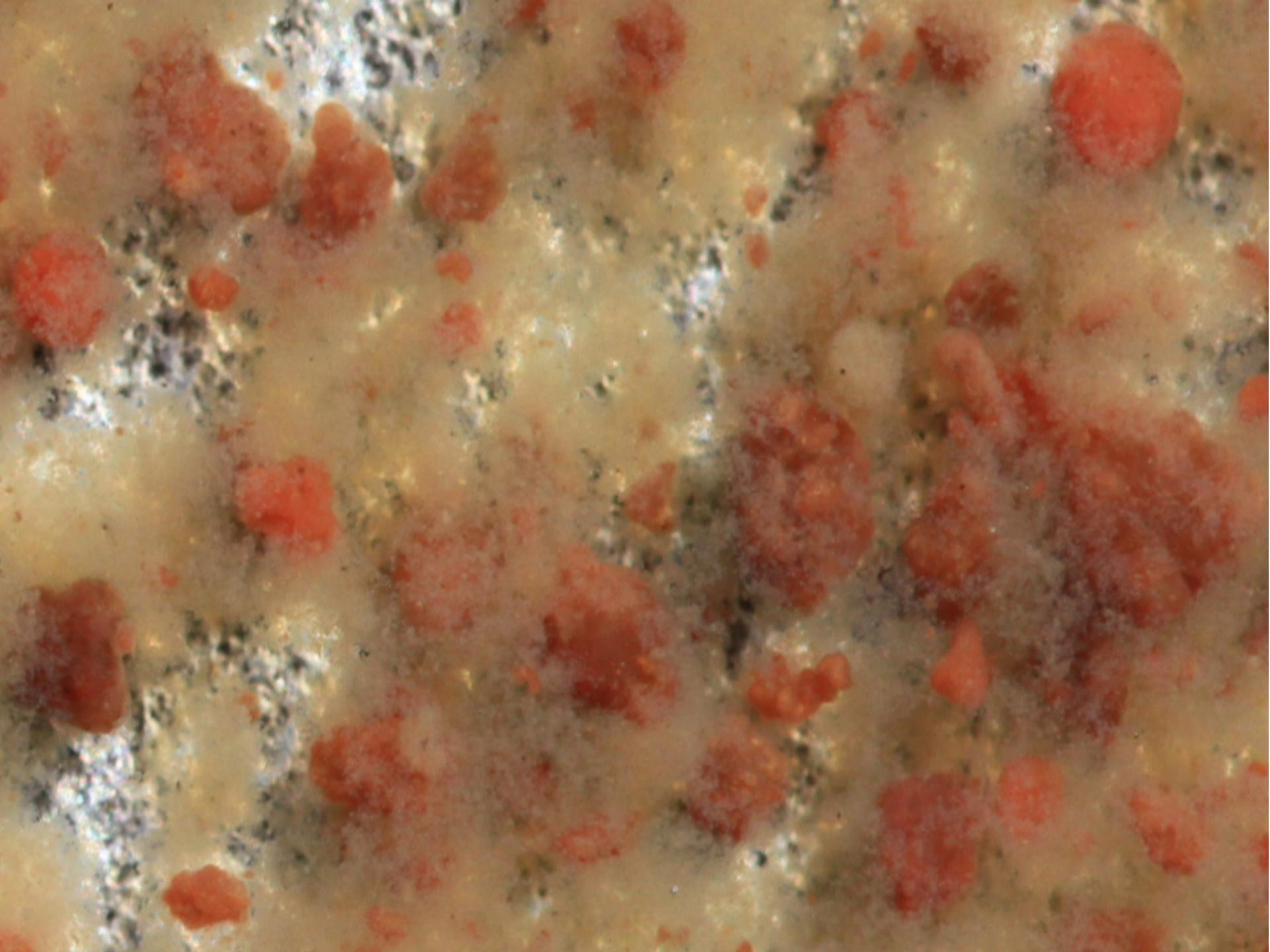
- **Demonstration** projects at Strass WWTP and Glarnerland WWTP is to demonstrate the feasibility of the deammonification concept, applicable control strategies.

Our Recipe

- Anammox
  - Anammox Bioaugmentation
  - Anammox Retention
- AOB
  - AOB Bioaugmentation
- NOB Out-Selection
  - Aggressive Aerobic SRT Management
  - Ammonia Residual
  - High DO
  - Intermittent Aeration
  - Rapid Transitions to Anoxia
- Effluent Polishing

Our Recipe

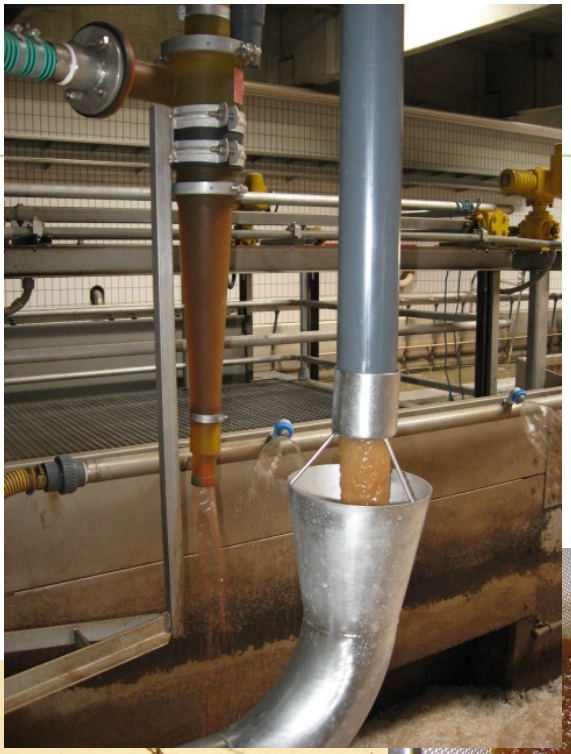
- Anammox
  - Anammox Bioaugmentation
  - Anammox Retention (long SRT maintained in granules or biofims)
- AOB
  - AOB Bioaugmentation

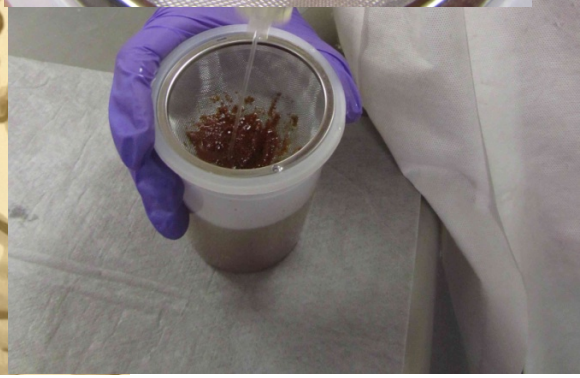


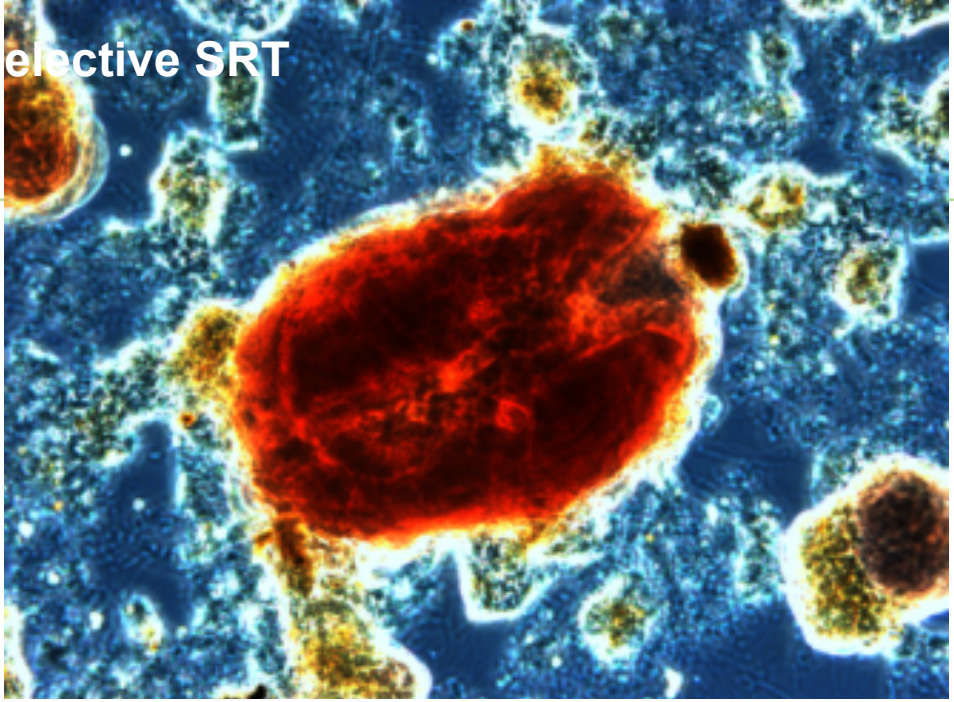
Cyclone, Sieve or Biofilm Media?

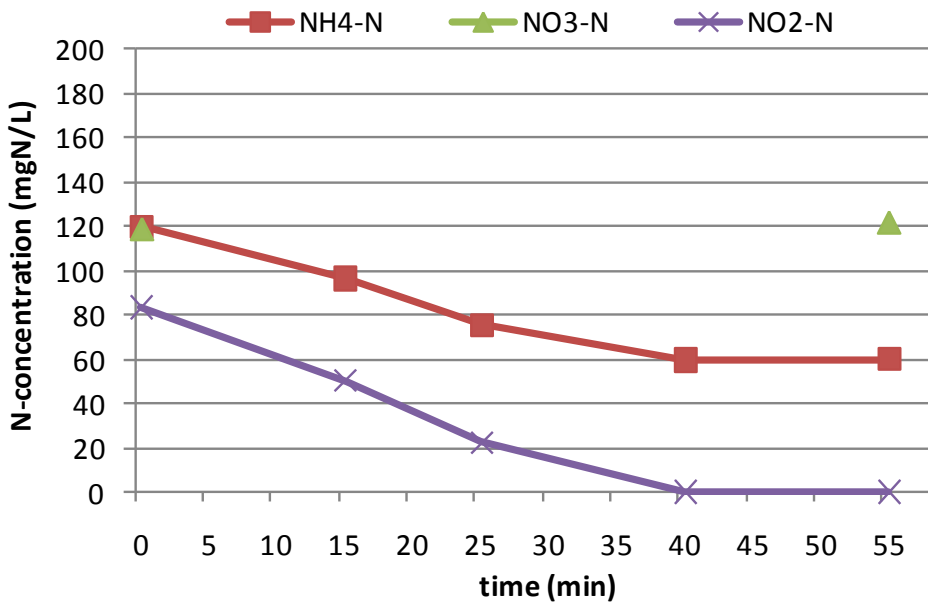
Three anammox retention procedures

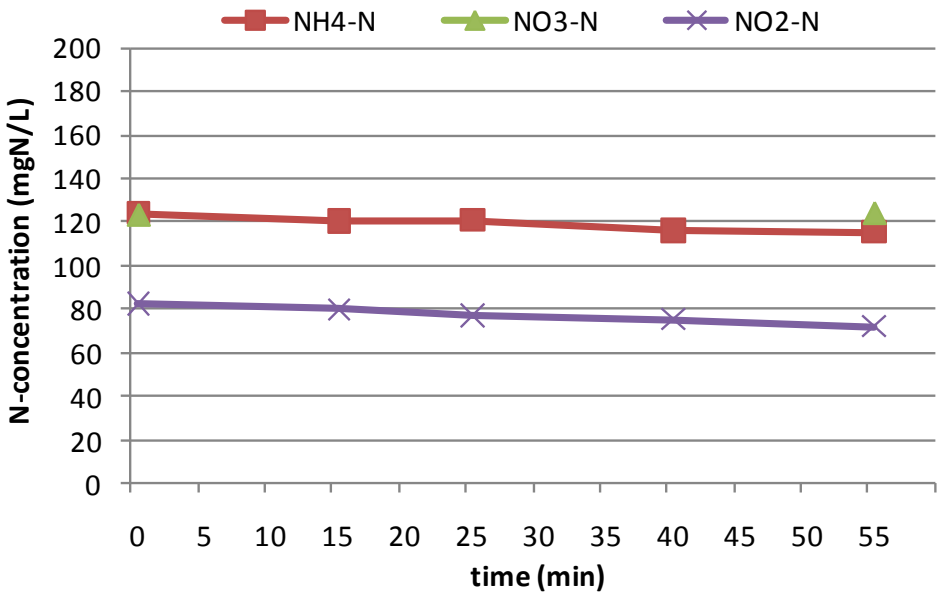
1) Cyclones- Strass
2) Sieves- Blue Plains
3) Biofilm Media- HRSD











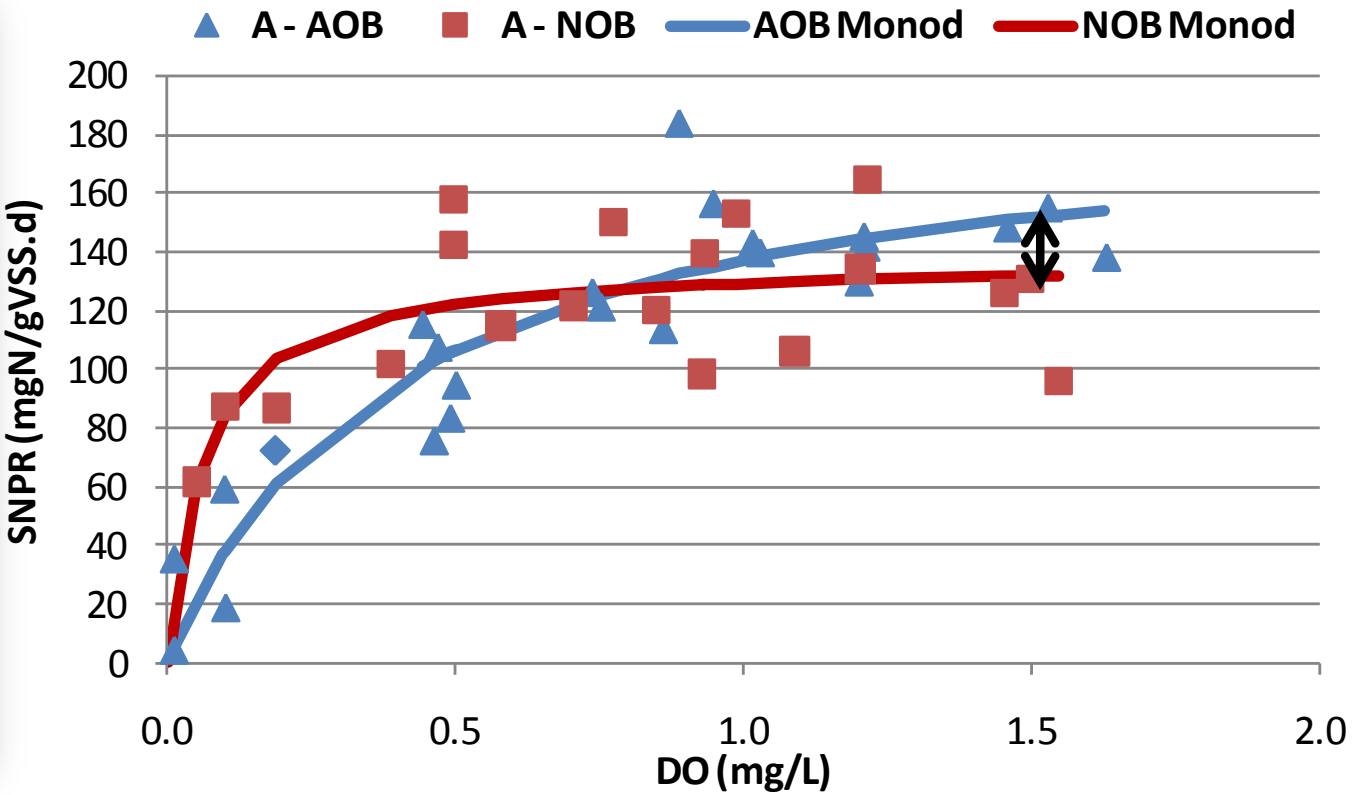
cyclone under-flow (recycled)

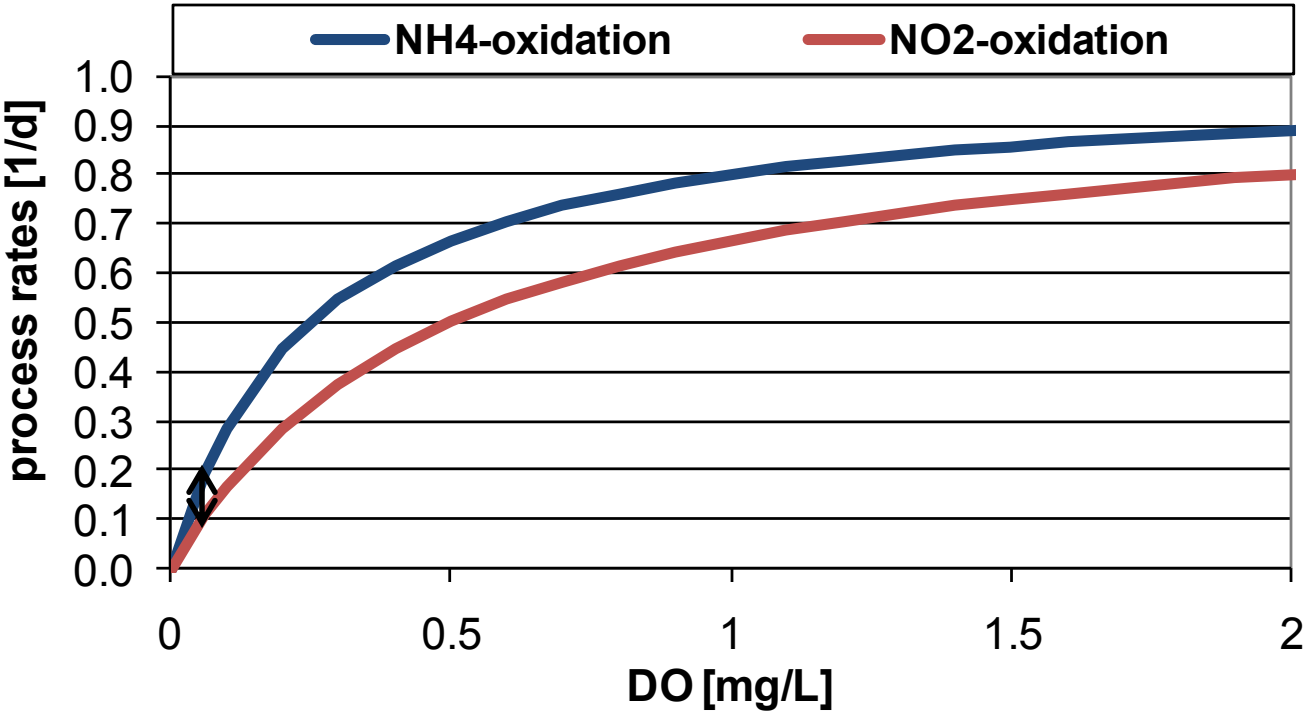
and overflow (wasted)

Our Recipe

- NOB Out-Selection
  - Aggressive Aerobic SRT Management
  - Ammonia Residual
  - High DO
  - Intermittent Aeration
  - Rapid Transitions to Anoxia
- Effluent Polishing

Oxygen Affinity



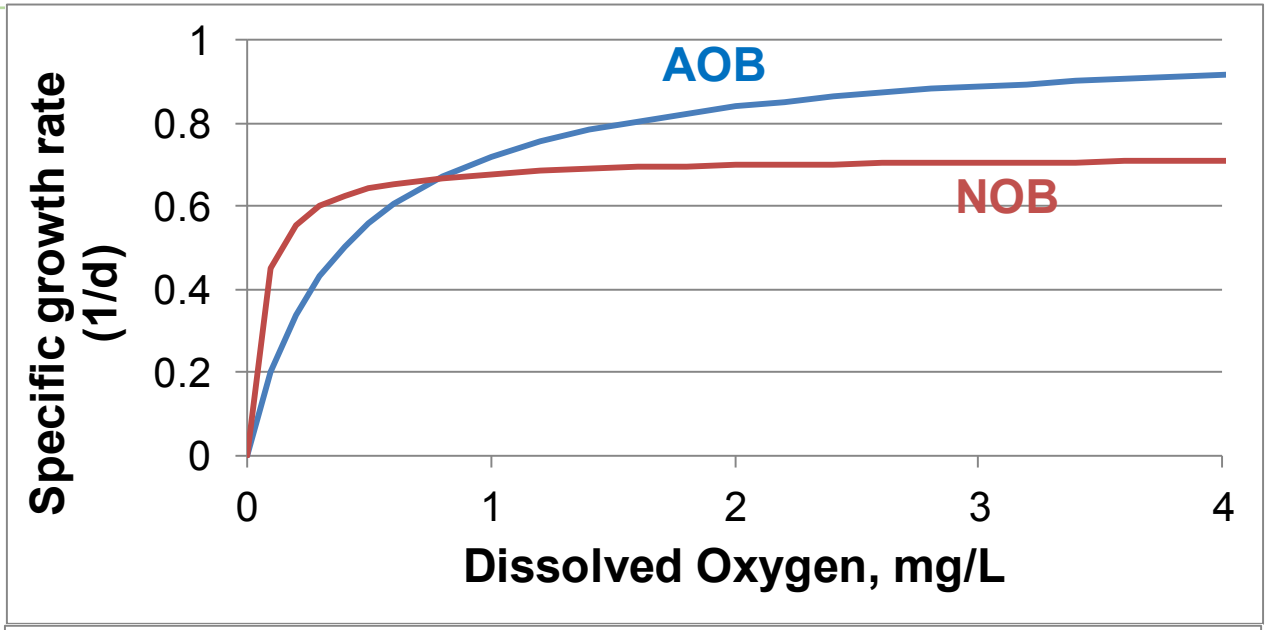


	AOB-growth	NOB-growth
	Monod	Monod
μ_{max} [1/d]	0.9	0.7
Arrhenius	1.07	1.06
k_O [mg DO/L]	0.25	0.50

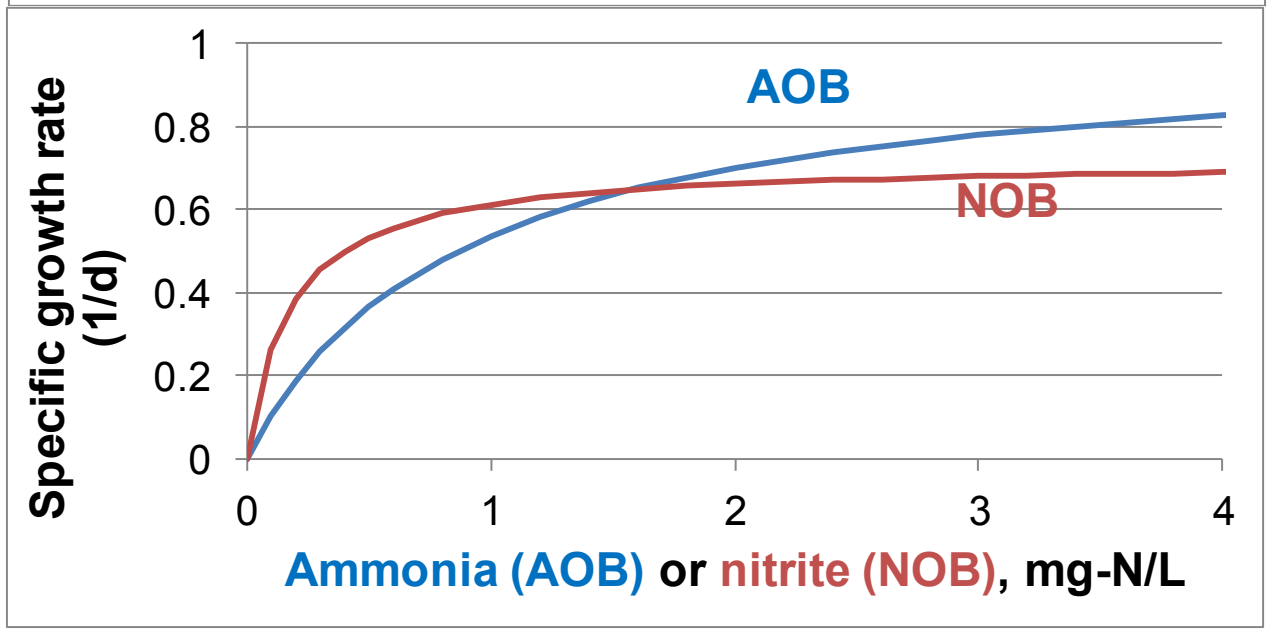
Frequently used parameter set for maximum AOB- and NOB-growth rates and oxygen affinity (K_O)

Oxygen and Nitrogen Affinities

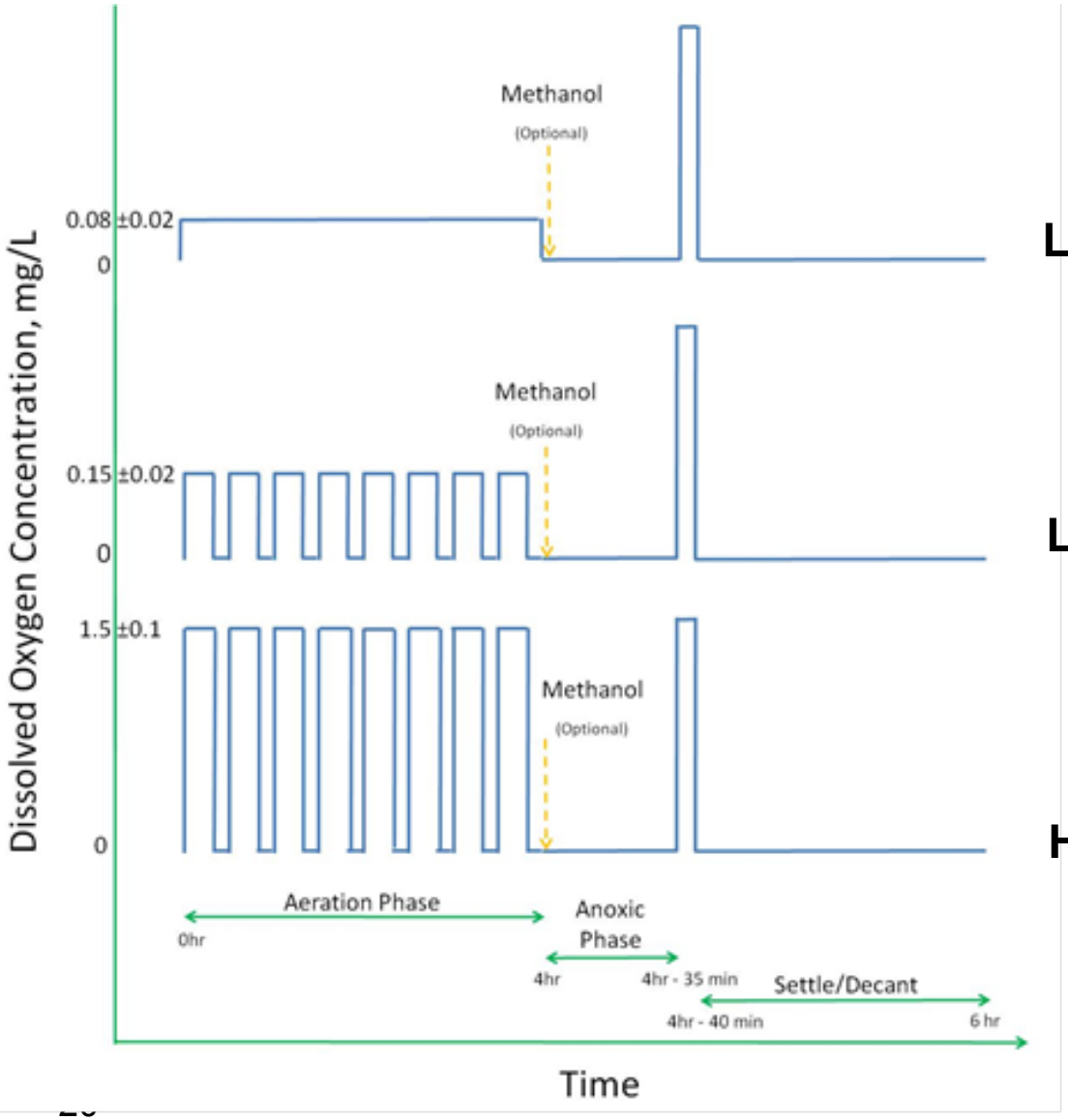
From:
Current WERF Study



Extracted From:
Chandran and Smets (2005)
Water Research, **39,** 4969



DC Water Trials

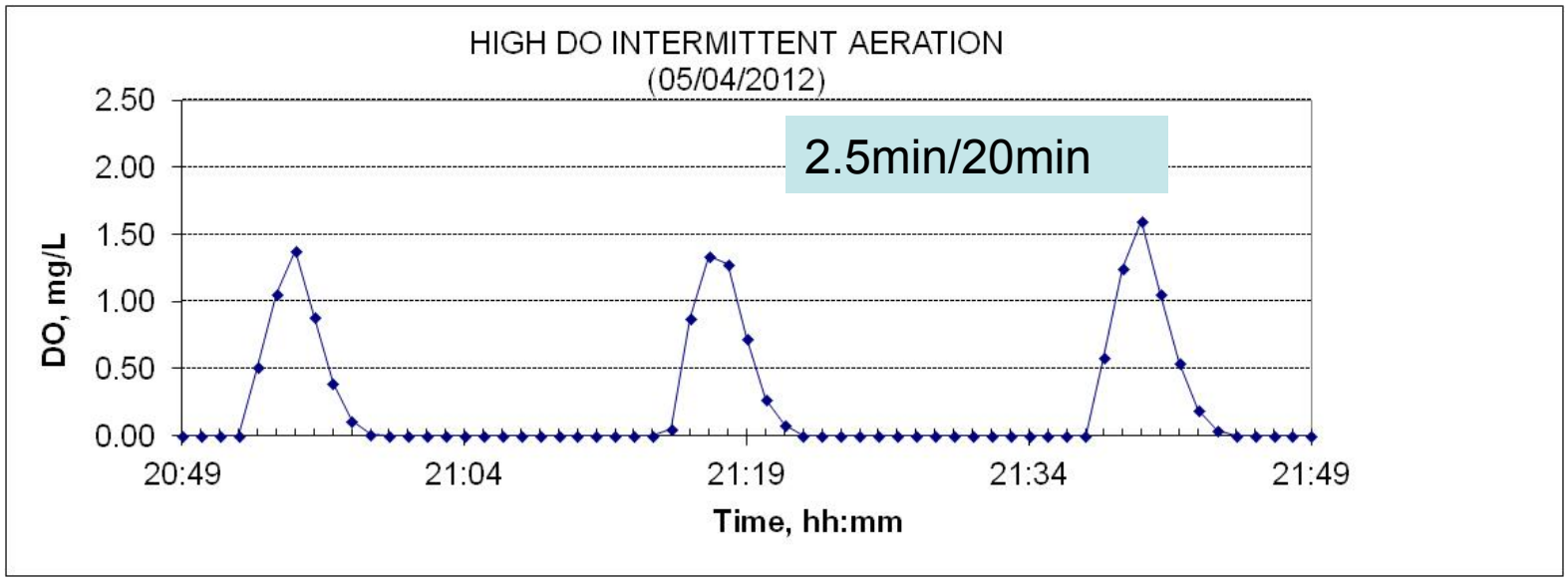


Low/Constant DO

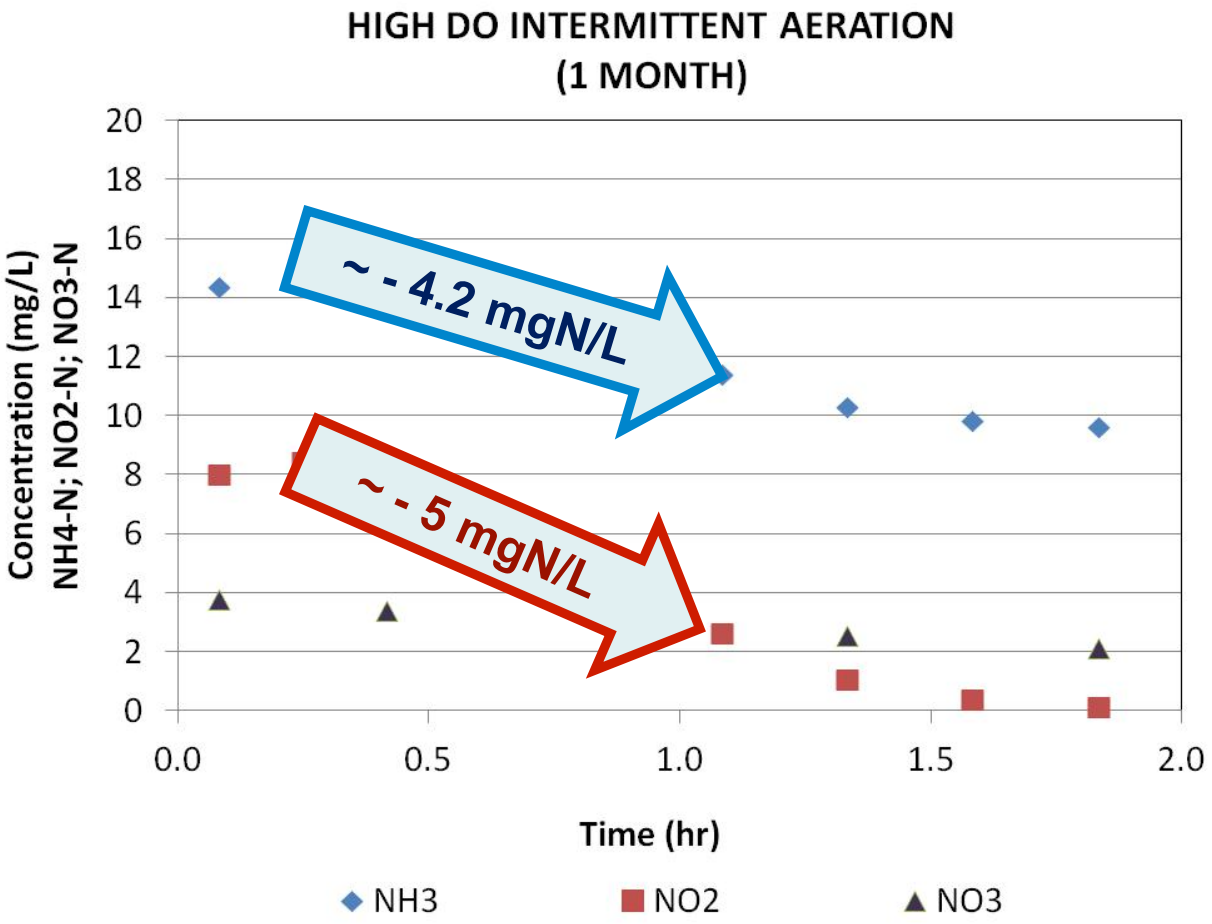
Low/Intermittent aeration

High/Intermittent aeration

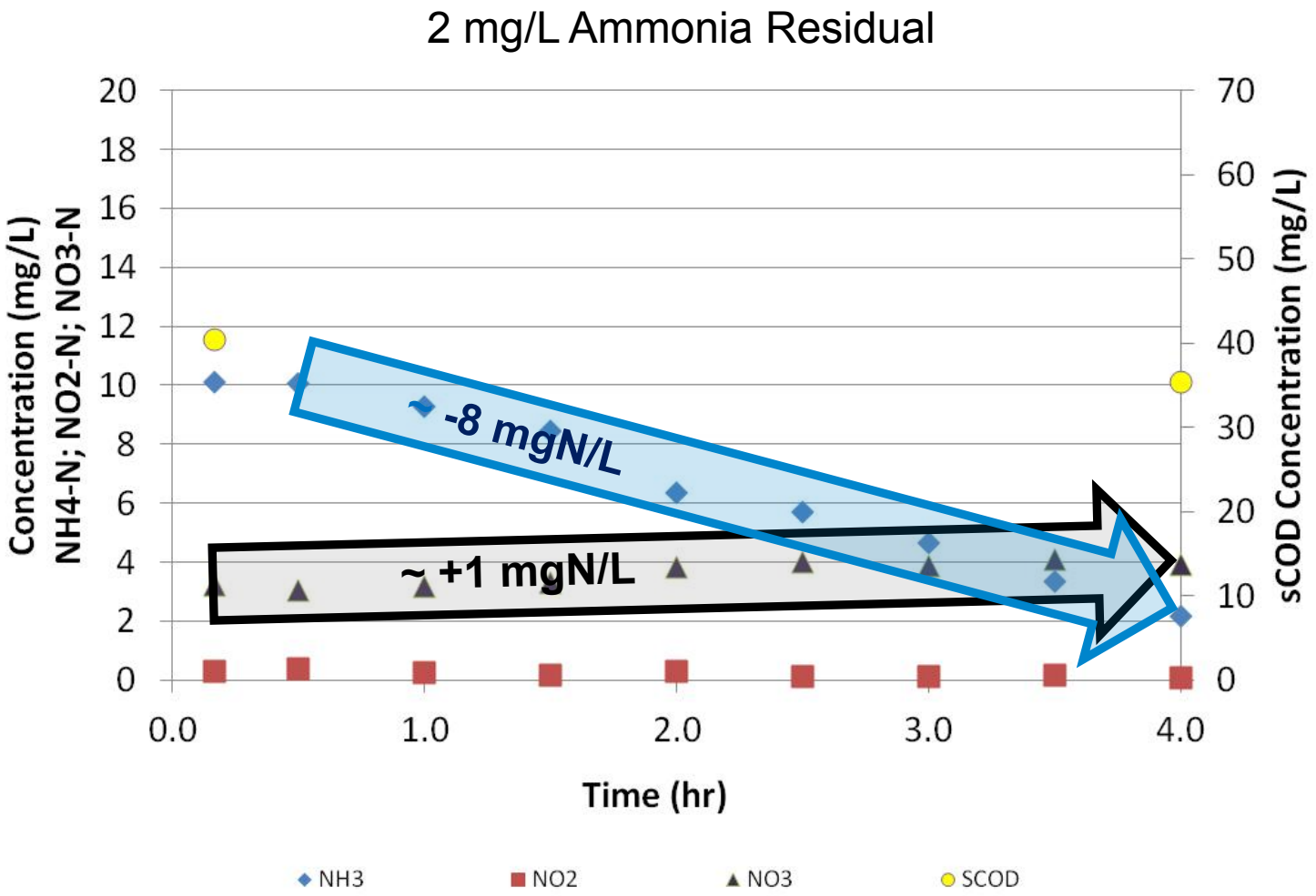
Dissolved Oxygen Slope and Profiles



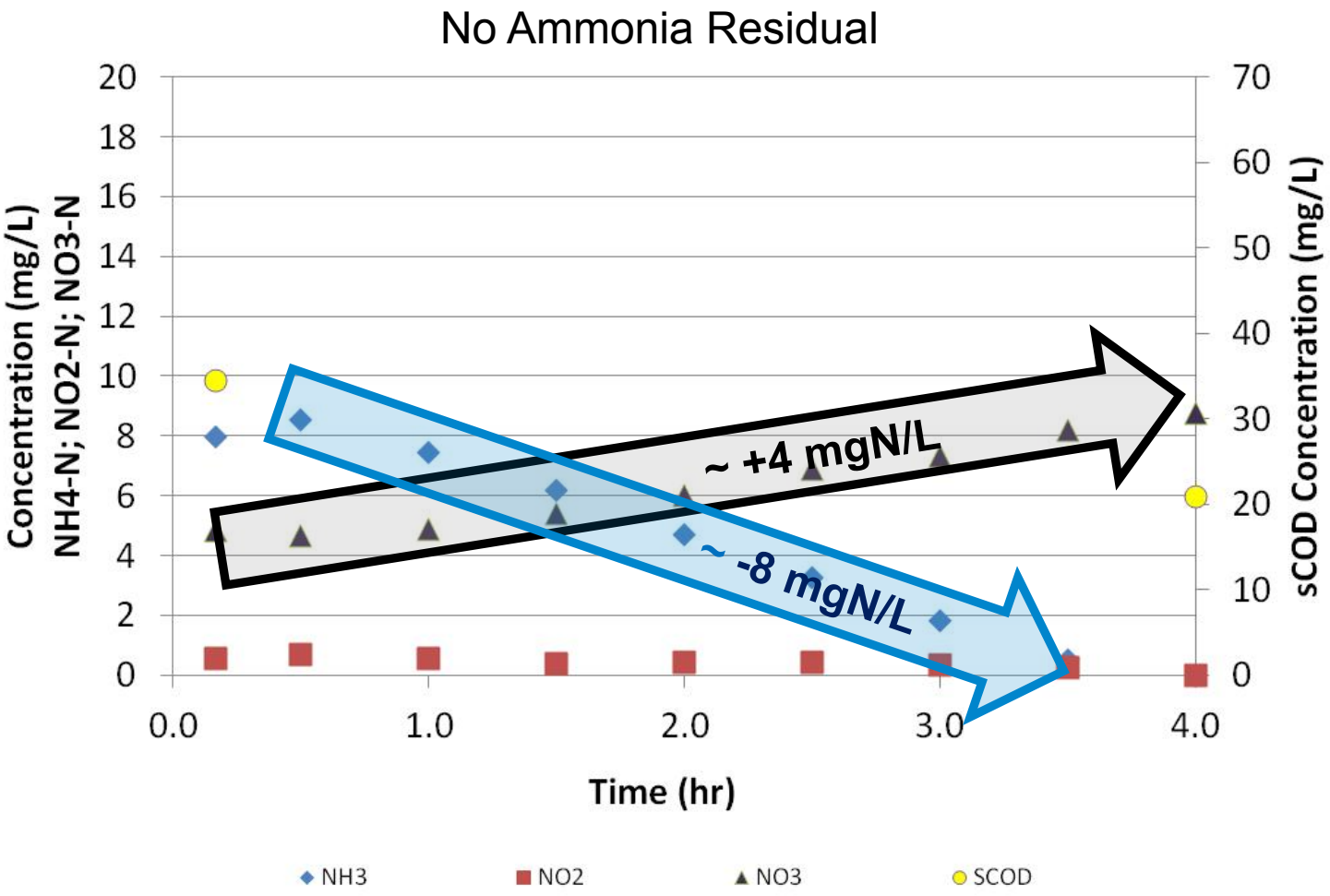
HIGH DO
Intermittent Air – "Anammox Activity"



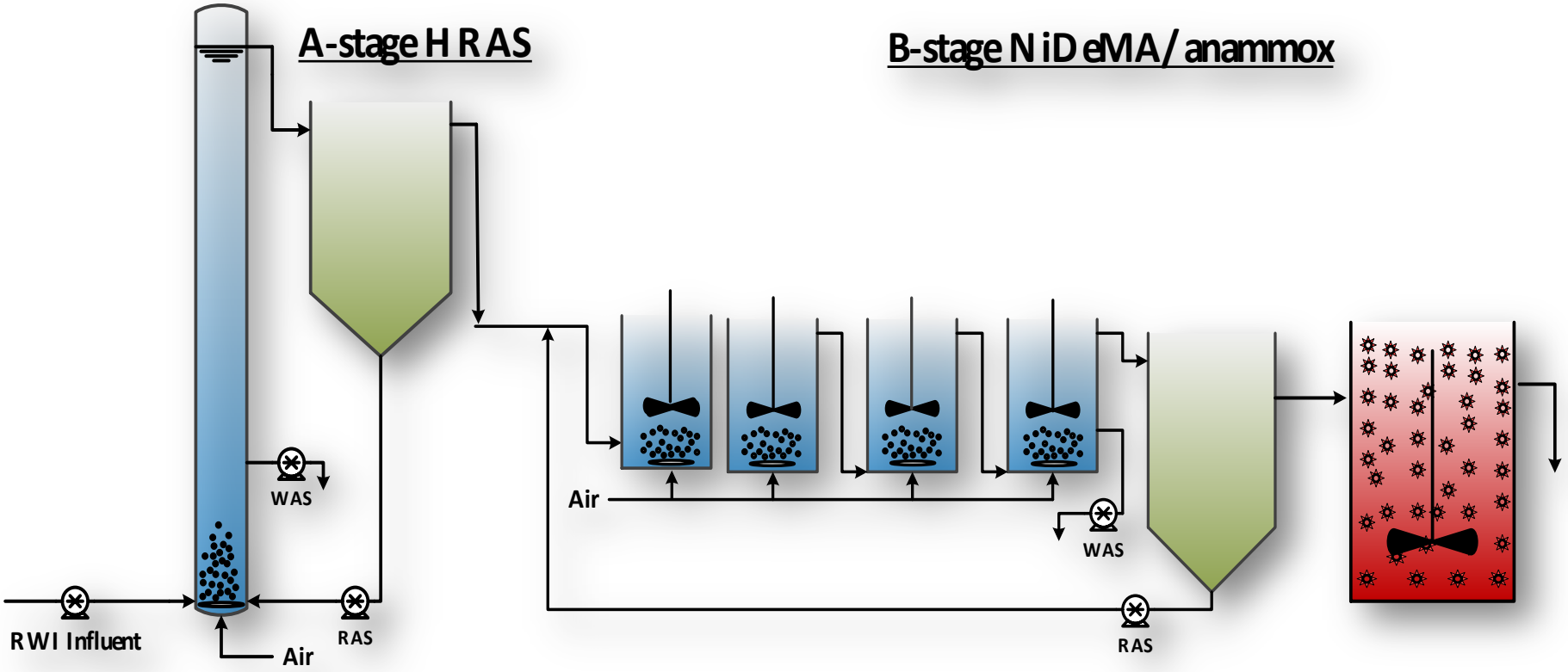
HIGH DO
Intermittent Air – "N Profiles"



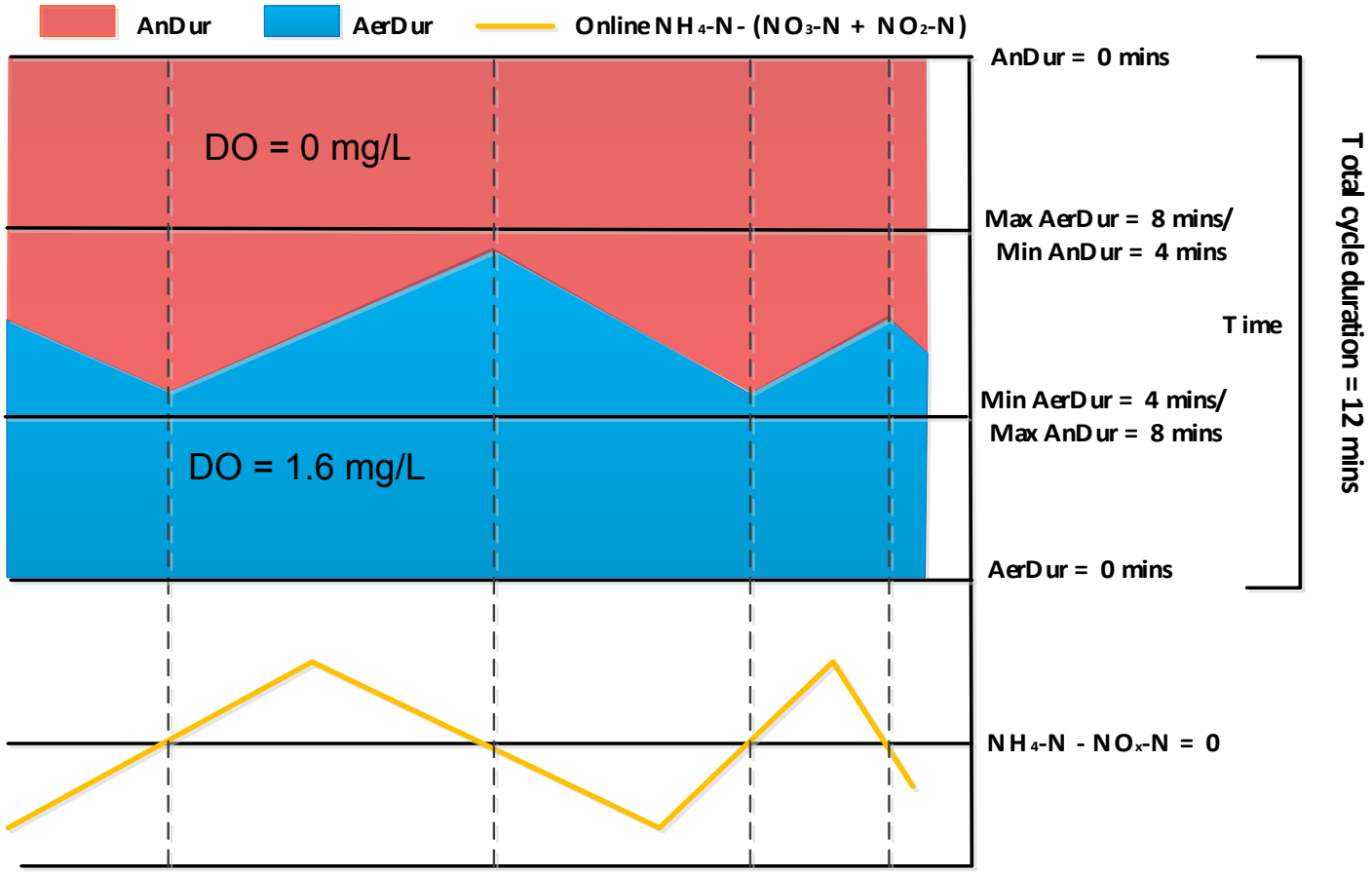
HIGH DO
Intermittent Air – "N Profiles"



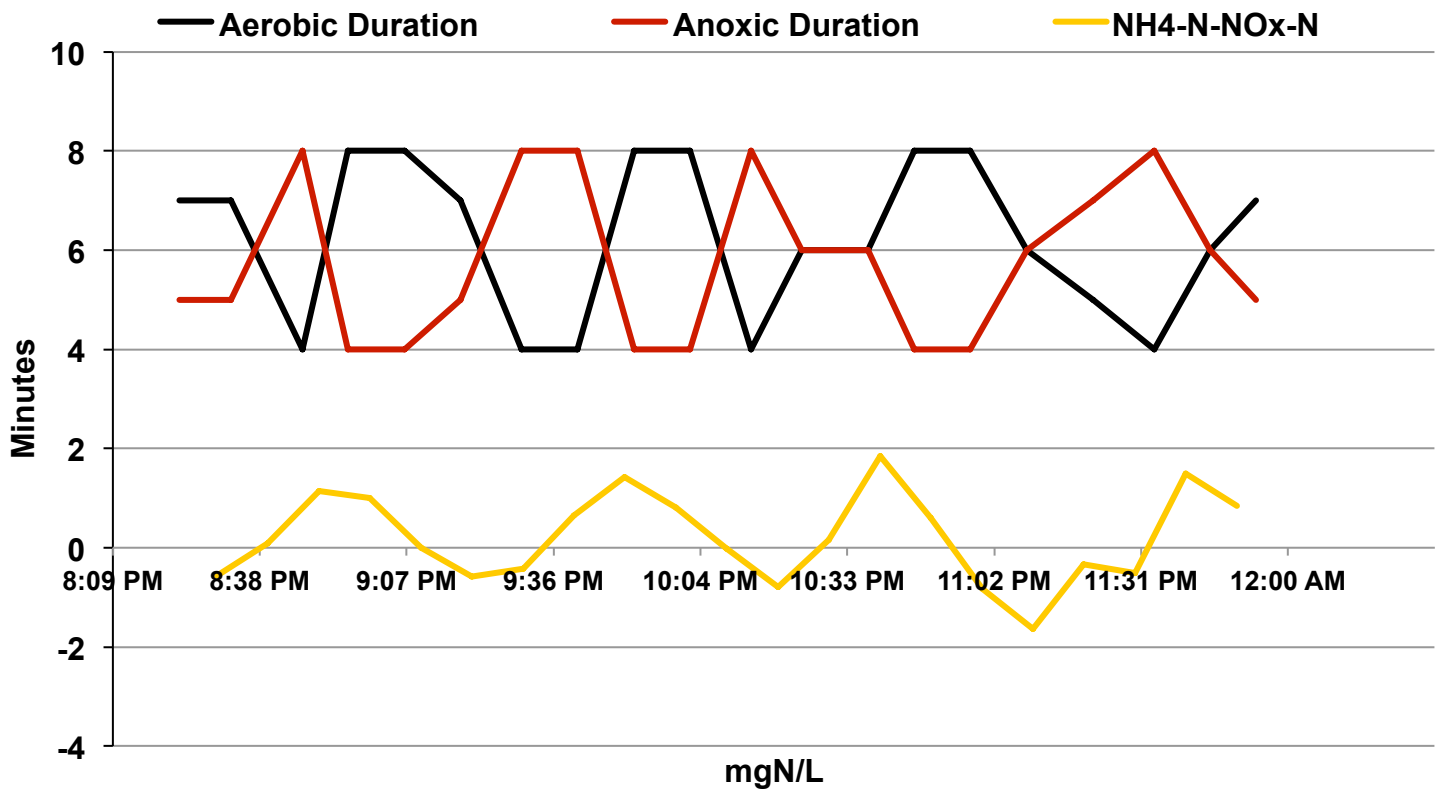
HRSD Process Schematic



Ammonia vs NOx (AVN) Controller



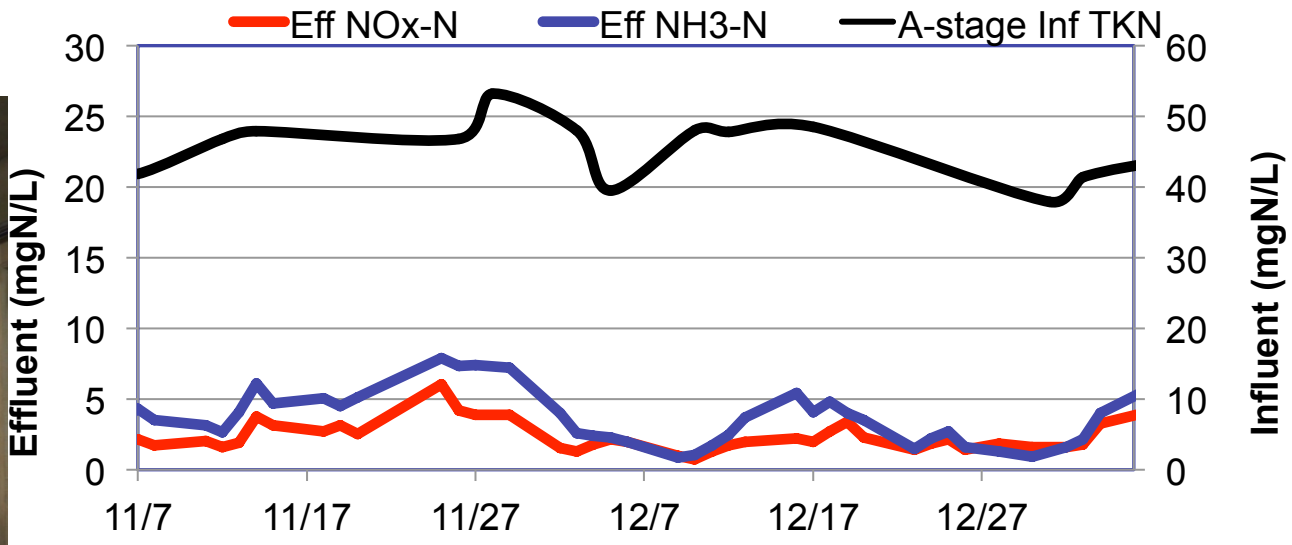
AVN control

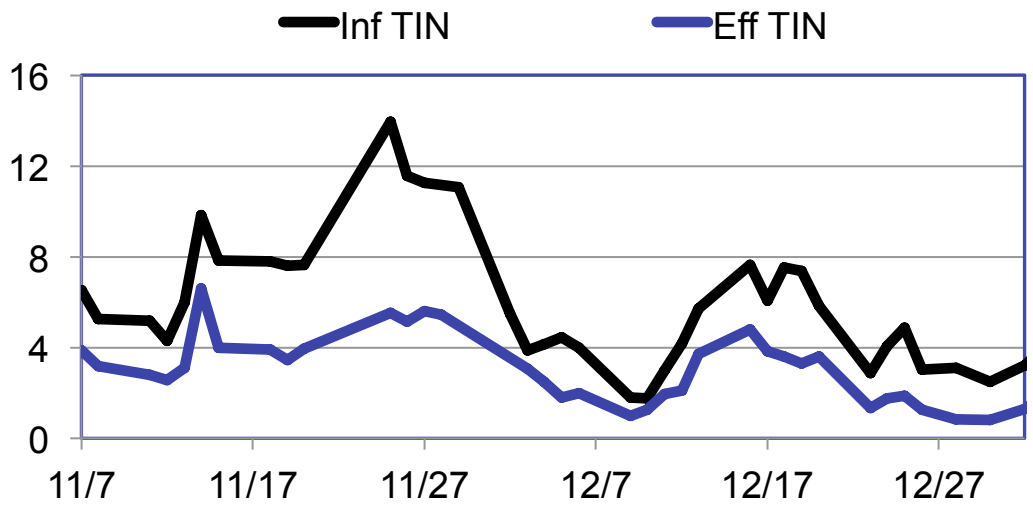

Aerobic Duration
Anoxic Duration
NH4-N-NOx-N
10
8
6
4
2
0
-2
-4
Minutes
8:09 PM
8:38 PM
9:07 PM
9:36 PM
10:04 PM
10:33 PM
11:02 PM
11:31 PM
12:00 AM
mgN/L

Process Performance

Nitritation/ Denitritation

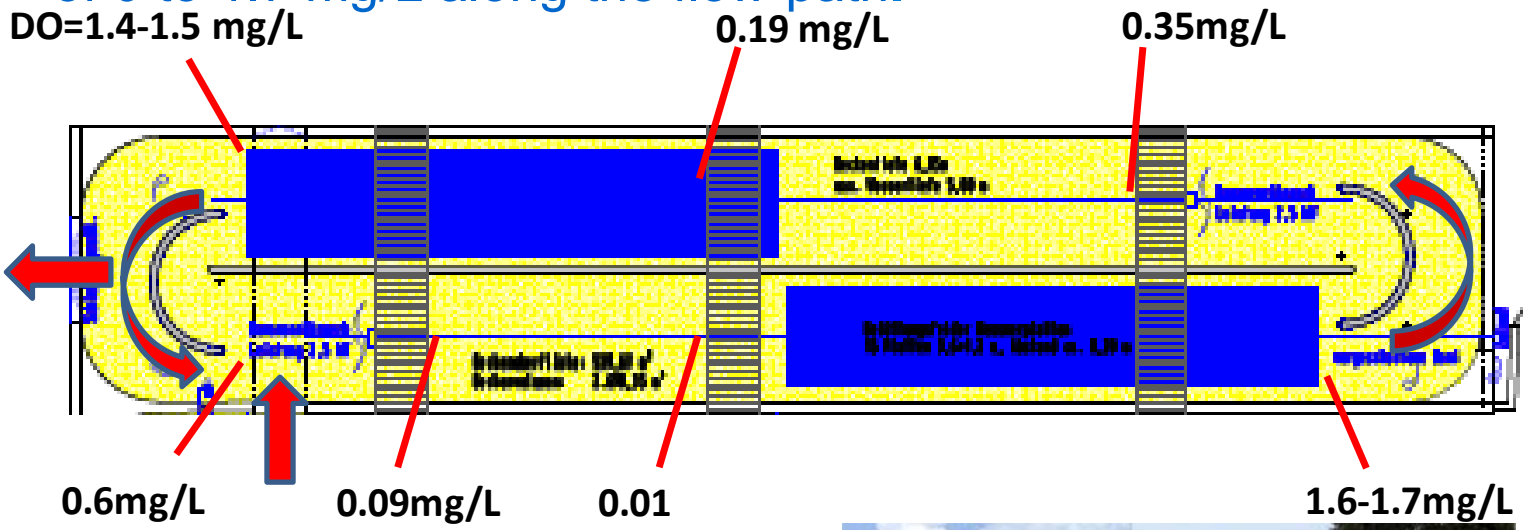
Post- Anoxic Anammox MBBR



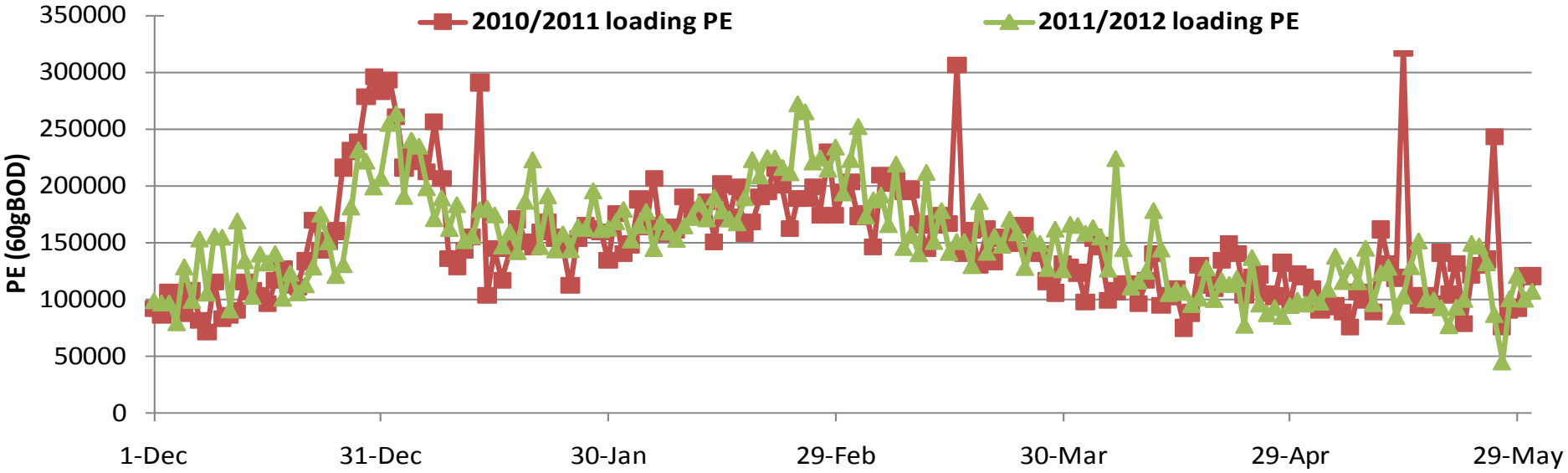


Strass Demonstration

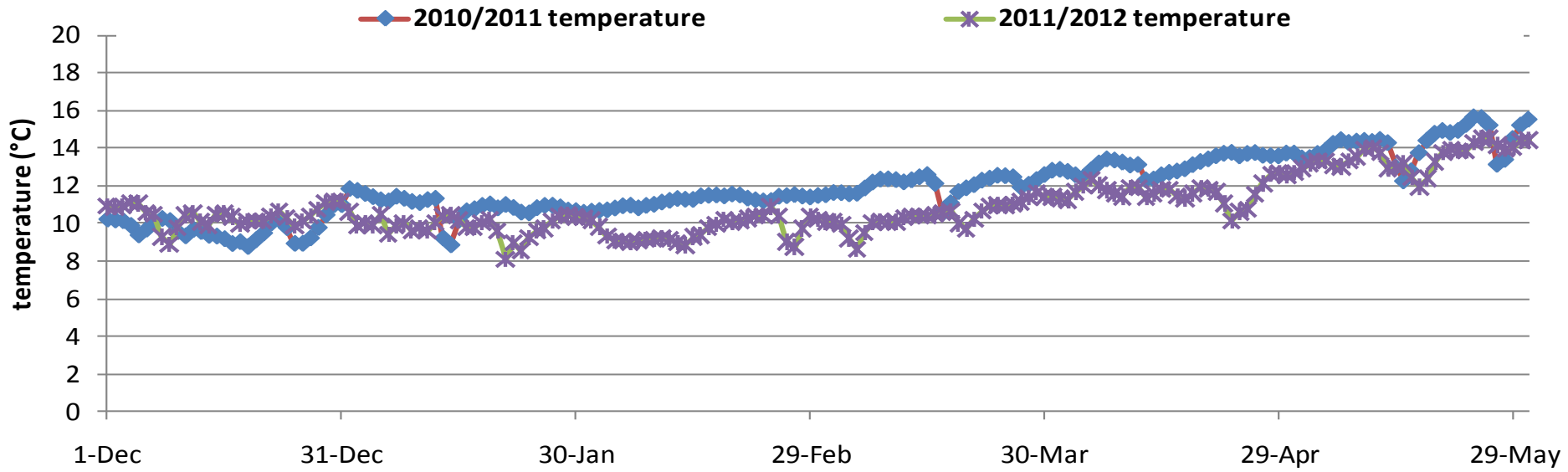
- Carousel type aeration tank at Strass WWTP providing a DO-range of 0 to 1.7 mg/L along the flow-path.



Cyclones installed at the B-stage in Strass, Cyclone A (left), Cyclone B since early September 2011 (right).



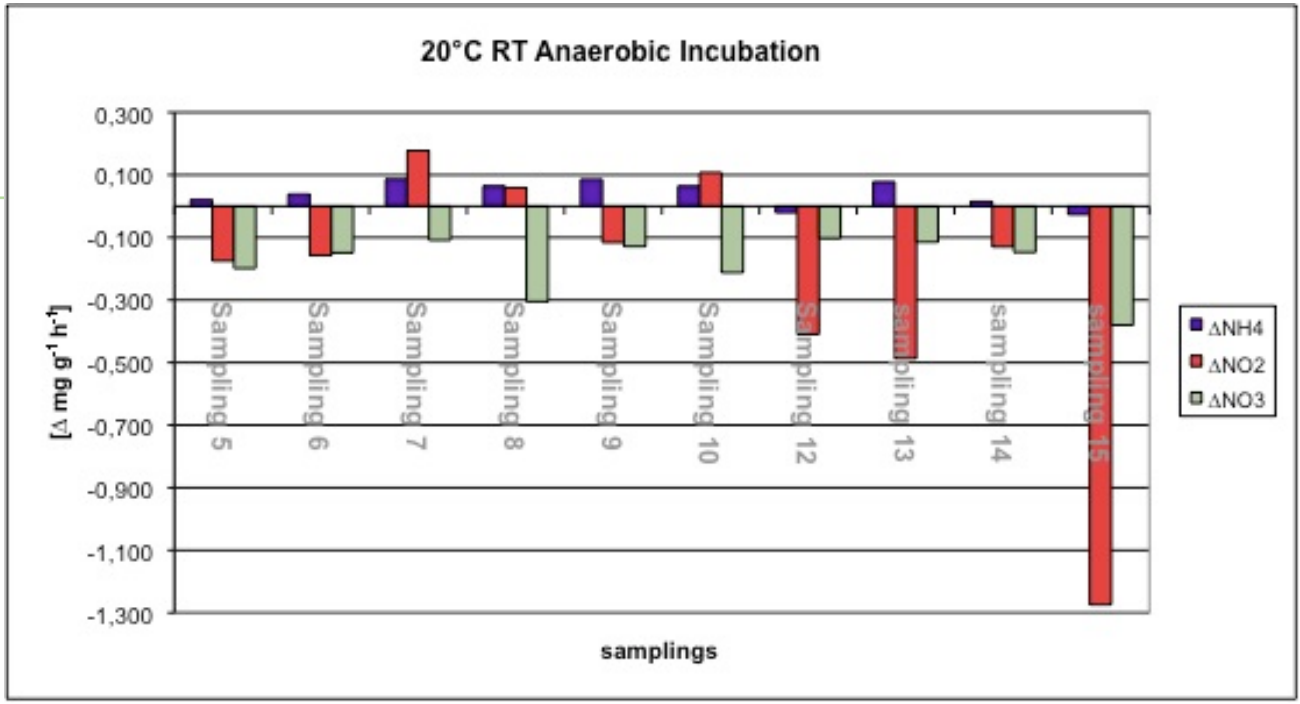
plant loading profiles (PE) before and after project start



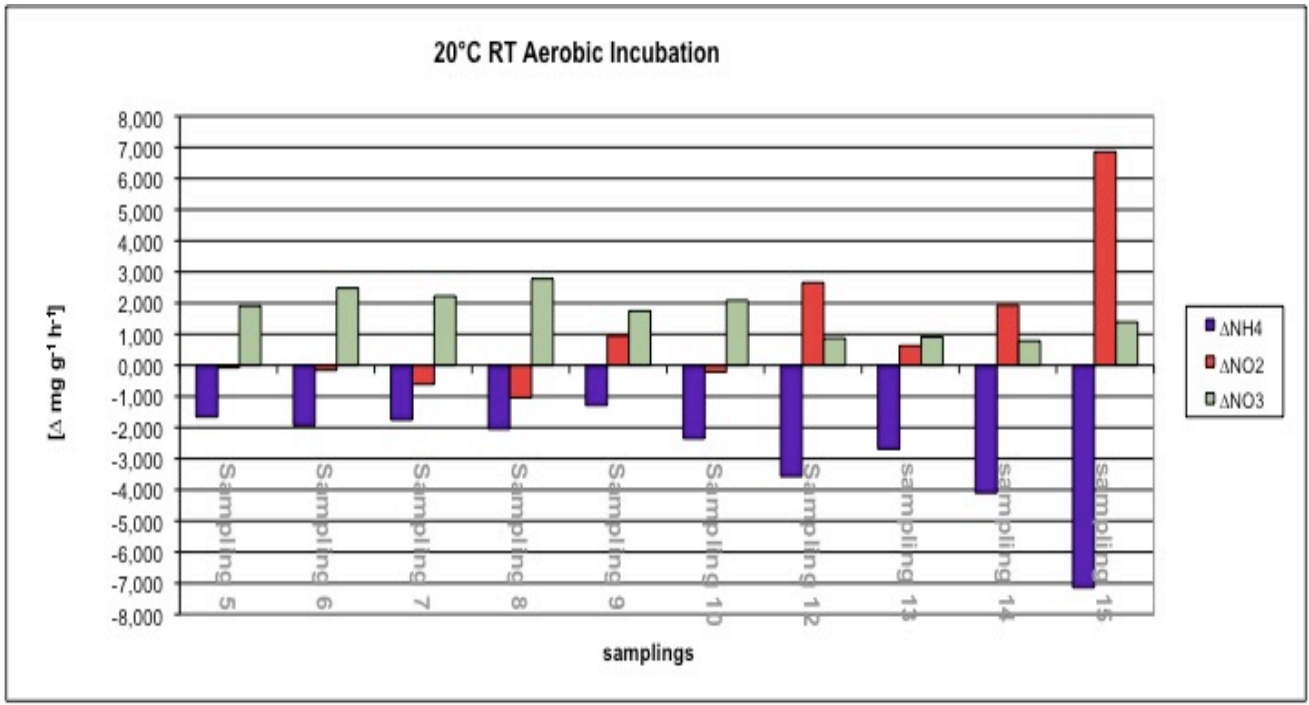
comparison of temperature profiles (°C)

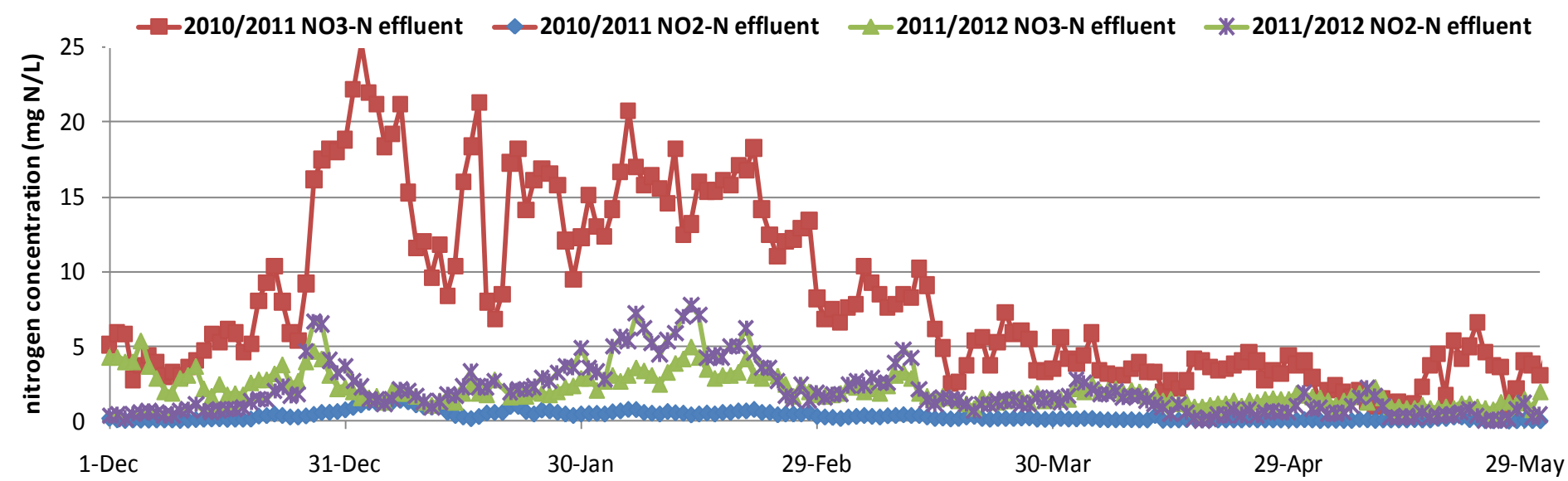
DCWATER.COM

The last samples show ammonia removal during anaerobic activity test (anammox activity)

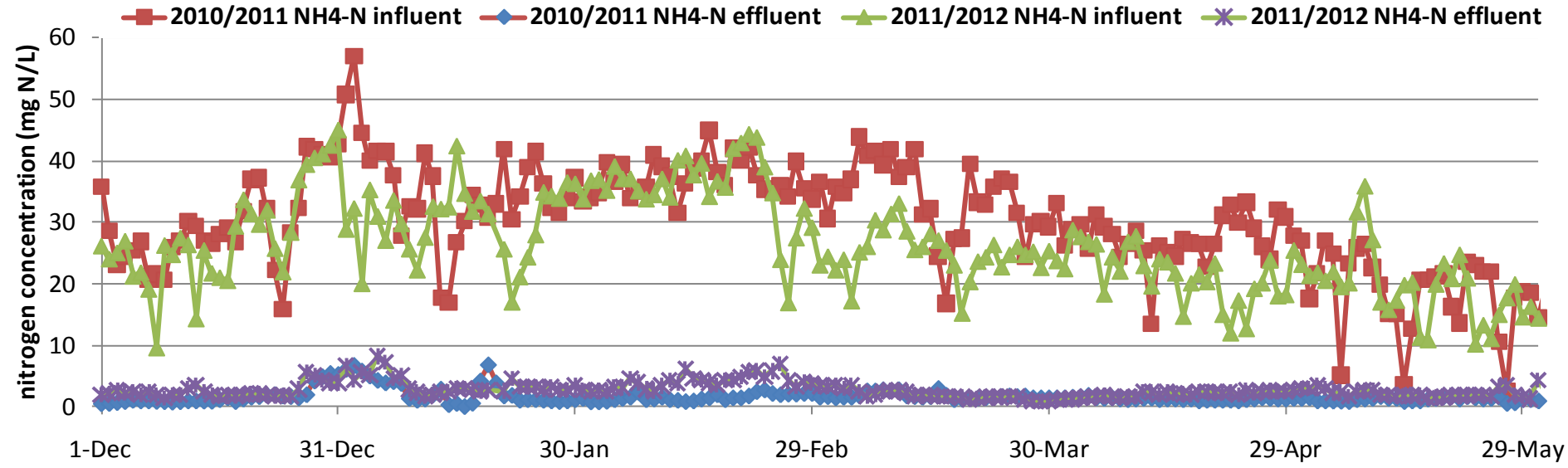


Only 25% of NOx produced from ammonia oxidation is converted to nitrate during aerobic activity test of the last sample





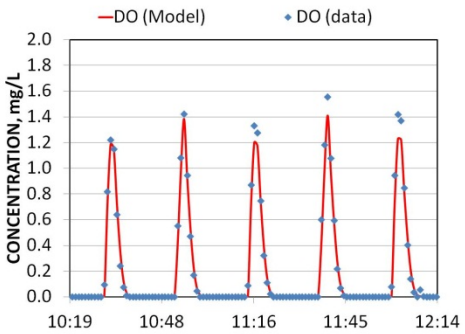
Comparison of this year's and last year's operational data of the full-scale pilot Strass indicating advanced NOB-repression (typically high nitrate level at Christmas peak-load; similar temperature conditions of ca. 10°C , load conditions and ammonia effluent concentrations of ca. 2-5 mgN/L for both years)



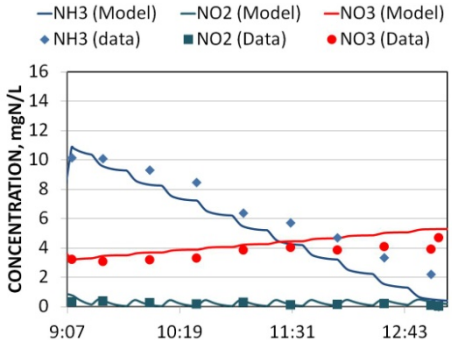
MODEL PARAMETER CALIBRATION
Simulation Results

High/Intermittent aeration

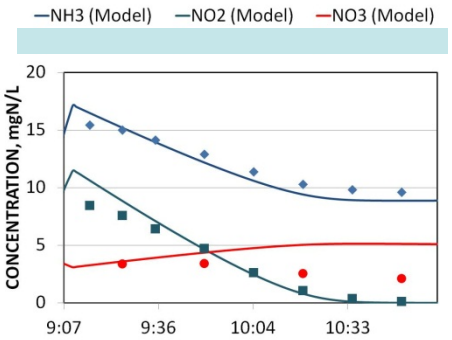
DO Profiles



N Profiles



AMX Activity



	AOB-growth	NOB-growth
	Monod	Monod
$\mu_{max} * X_a / Y_a$	193	137
k_O [mg DO/L]	0.40	0.06

Specific nitrogen process rates for AOB and NOB yielded from constant DO-tests

The People

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