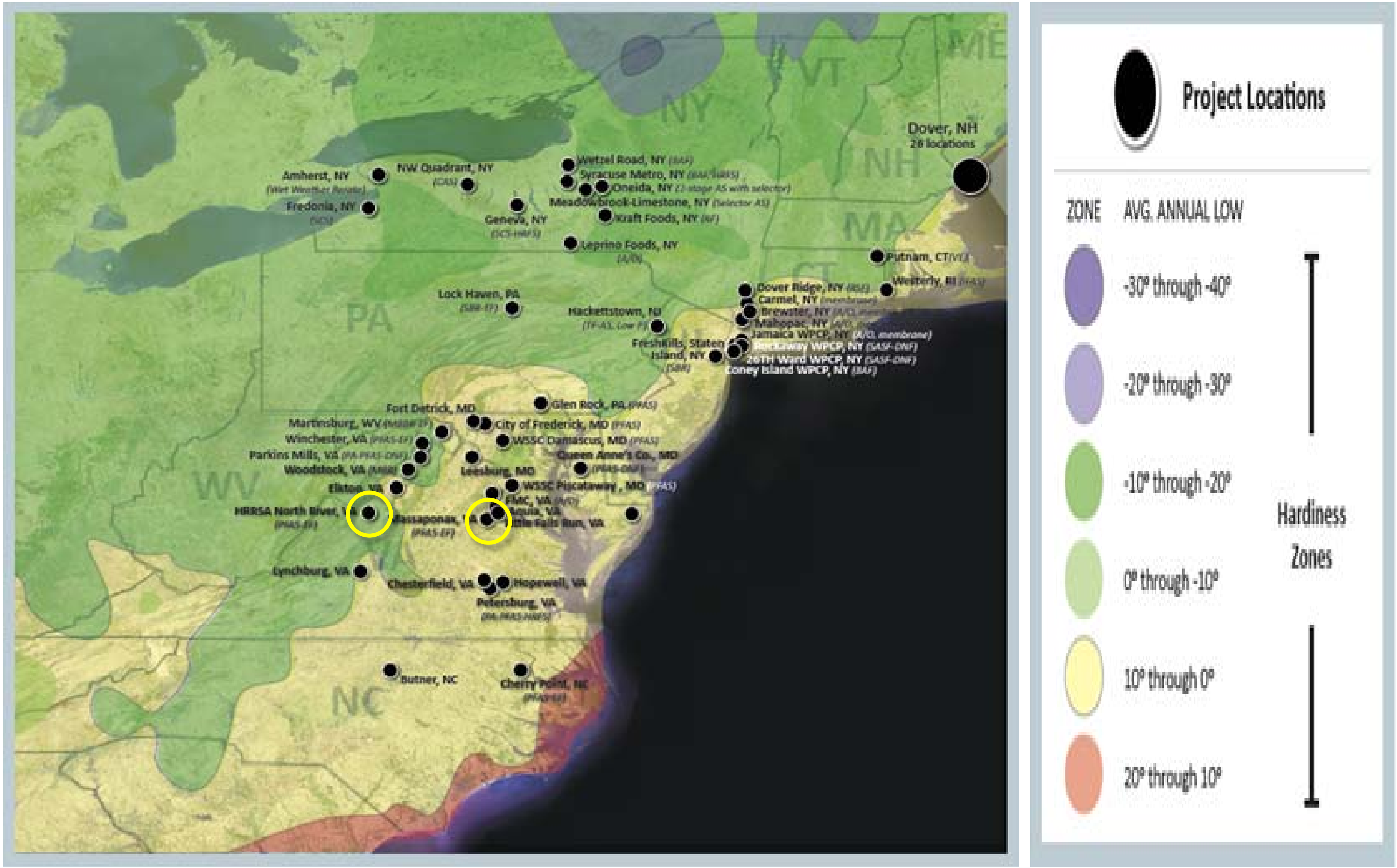
Carbon and Oxygen Engineering to Achieve Affordable Nutrient Removal

Mark R. Greene, PhD, Senior Technical Director

June 23, 2011

Climatic Zones



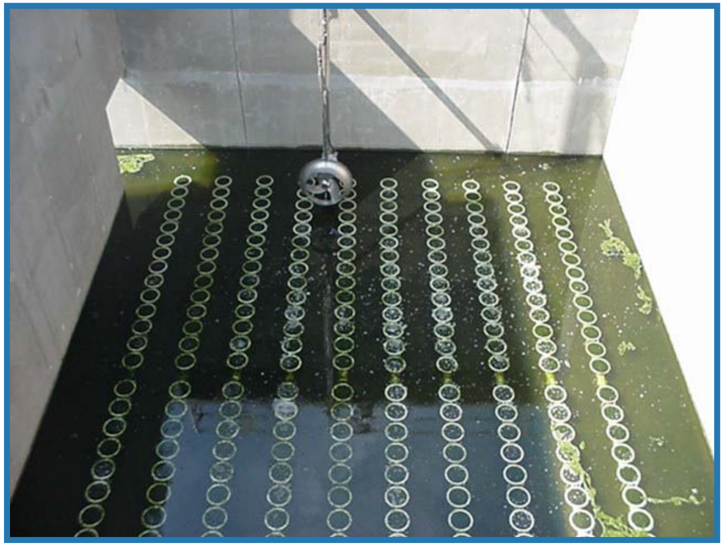
Massaponax, VA

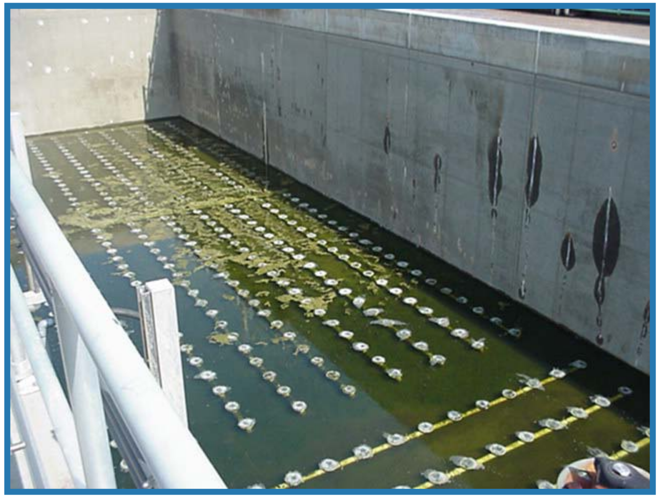
- 8 MGD BNR
- 12-day SRT
- 12-hr HRT
- 11^{o}C
- TN 8 mg/L
- TP 1.5 mg/L

BNR Flow Sheet

Post-Start Up Conditions – BNR Performance

- 5-6 MGD
- 2-Train Operation
- Swing Tanks ANOXIC
- TN (5.6 - 6.6 mg/L)





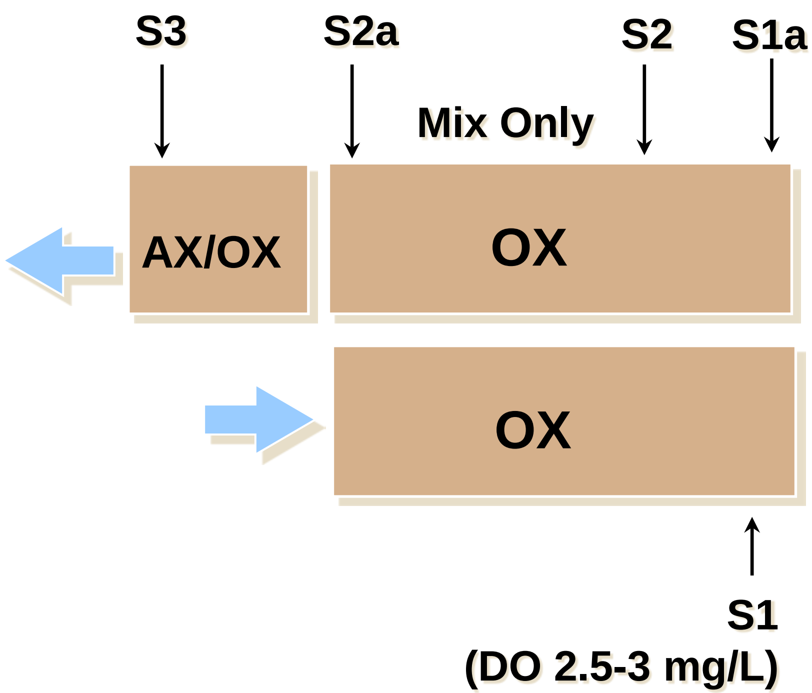
Optimization Program for ENR Upgrade

- DO Control
  - Secondary ANOXIC Demonstration
  - SN-DEN

- BNR Process Operations

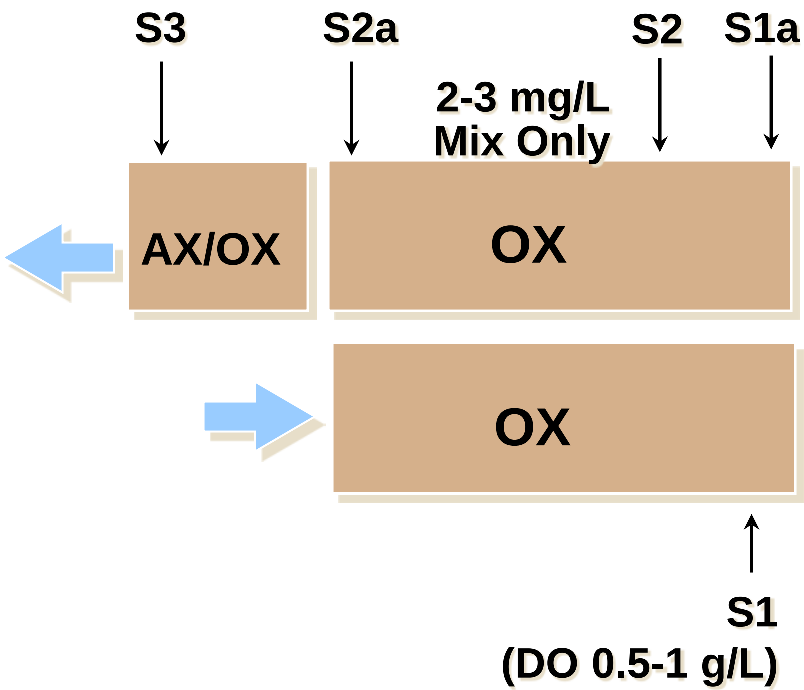
Conventional BNR	Thru November 2004
Secondary ANOXIC (Reference)	Thru March 2005
Side by side comparison	April - June 2005
SN-DEN	June - November 2005

Secondary Denite (JAN - FEB 2005)



- Nitrification almost complete by S1
- DO 2.5 to 3.0 mg/L
- Ammonia "bleed through" S2 - S3
- OX operation of AX/OX

SN-DEN DO Control



- Manual control (bi-weekly)
- SN-DEN through - S2
- Nitrate (1-1.5 mg/L)
- Ammonia Polishing S2-S3
- AX operation of AX/OX

Reactor Effluent TN (mg/L)

	REFERENCE	SN—DEN
November	3.9	
December	5.8*	
January	4.8	
February	4.3	
March	4.6	3.2
April	4.3	3.0
May	4.0	2.5
June	3.9	3.0

*IR Out of Service

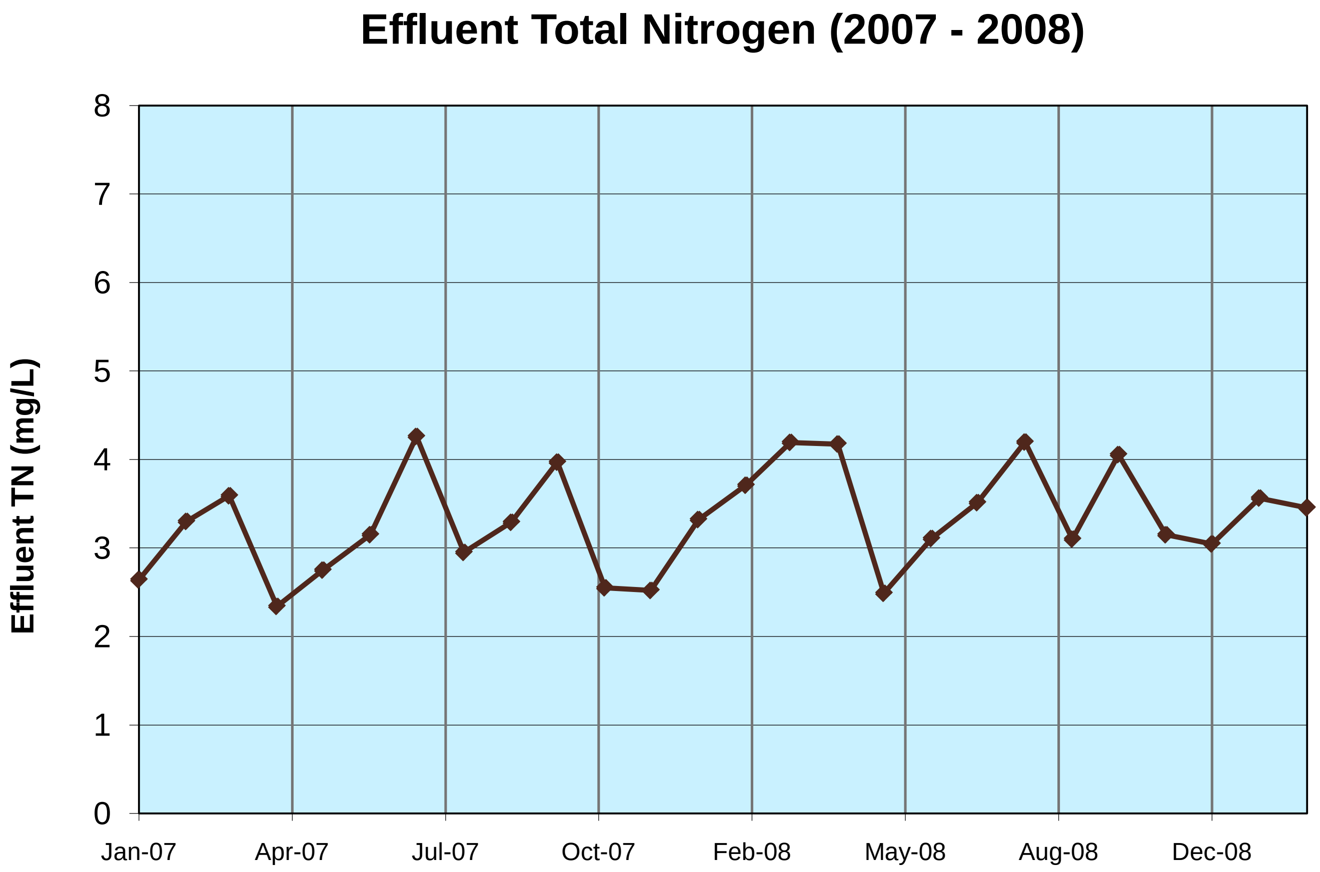
N-Removal Comparison (March)

	NO_3 — N		NH_4 — N	
	REF	SNDEN	REF	SNDEN
S1	0.9	0.8	3.6	3.4
S1A	2.1	1.4	0.5	1.7
S2	3.7	1.3	0.4	1.5
S2A	2.9	1.3	0.4	1.0
S3	2.7	1.1	0.5	0.7

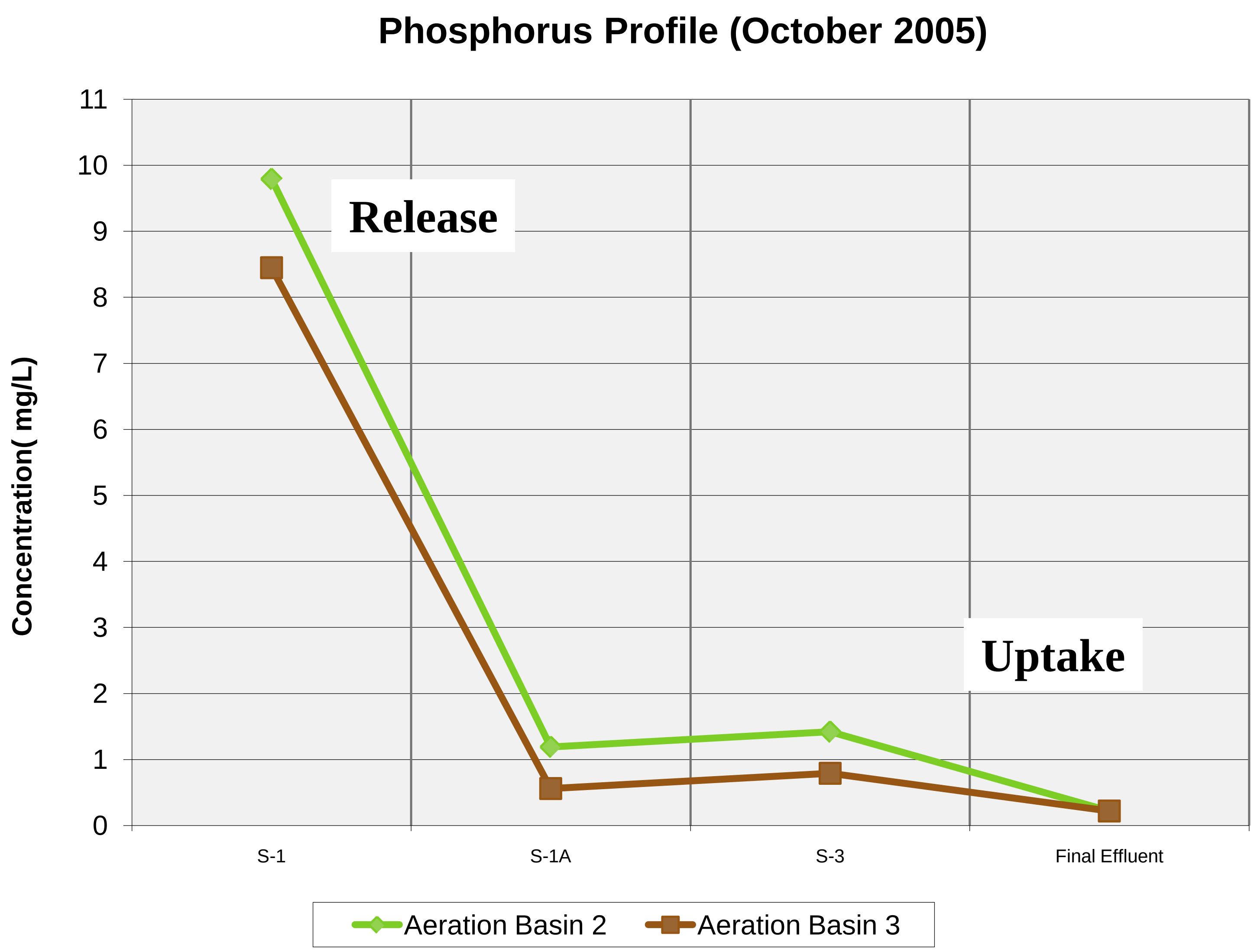
N-Removal Comparison (April - June)

	NO_3 — N		NH_4 — N	
	REF	SNDEN	REF	SNDEN
S1	0.3	0.4	4.1	3.8
S1A	2.8	0.8	0.2	0.4
S2	2.8	0.8	0.1	0.1
S2A	2.0	0.6	0.1	0.1
S3	2.0	0.8	0.8	3.4

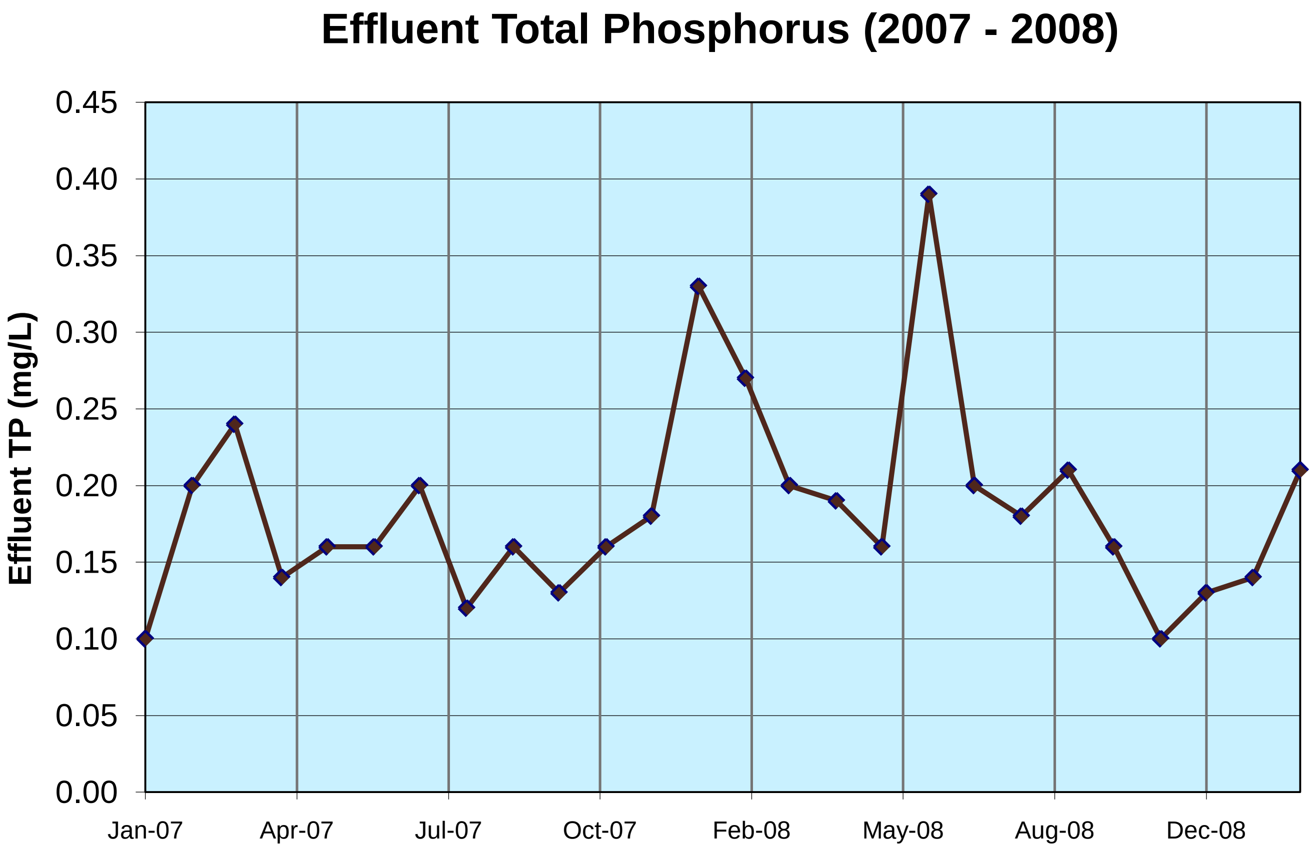
Post Start-Up Evaluation



Post Start-Up Evaluation



Post Start-Up Evaluation

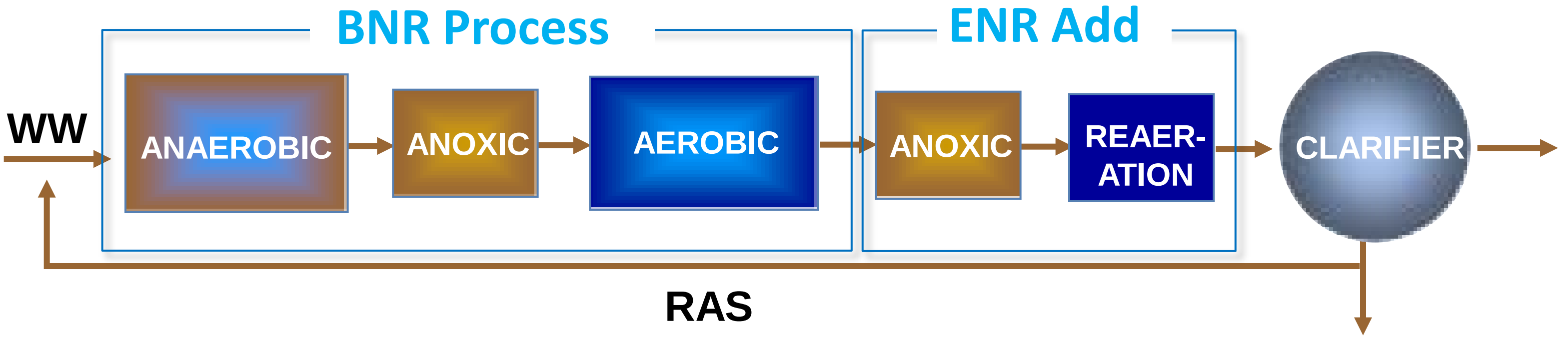


Massaponax, VA

- ENR upgrade using existing tanks
- TN < 4 mg/L
- TP 0.4 mg/L
- SN-DEN may be adequate
- Plant operations is critical
- DO monitoring and control

HRRSA North River WWTF - ENR

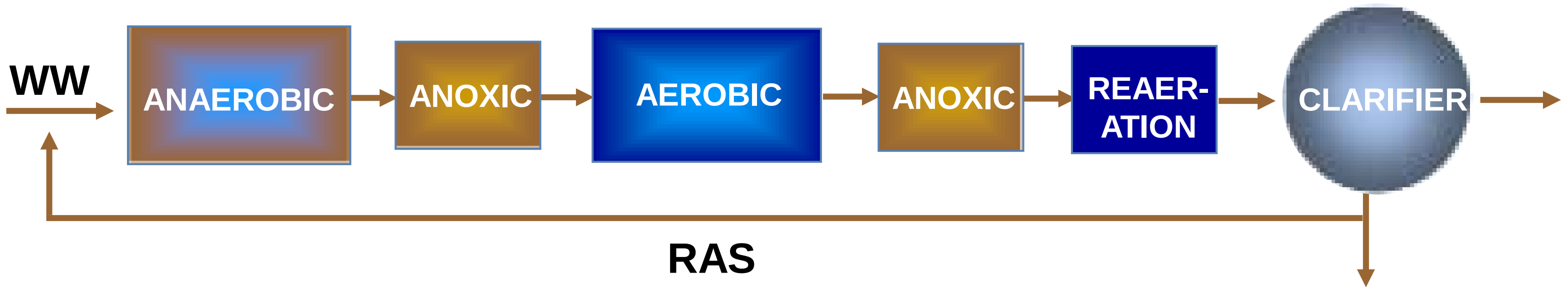
- 16 MGD BNR → 22 MGD ENR
- Short SRT, high F:M
- VFA Static Fermenter
- Primary Sludge Activation
- Pilot facility – Carbon source
- DO Flux issues



BNR to ENR Upgrade

- 16 MGD-rated North River WWTF
  - BNR effluent design basis: 8 mg/L TN and 1.5 mg/L TP
- Expansion and upgrade to 22 MGD ENR
  - ENR effluent design basis: 3 mg/L TN and 0.3 mg/L TP
- BNR – More reactors is " Better"
  - Driven by nitrification
  - Restricted by sludge loading on final clarifiers
- ENR – Less reactors is " Better"
  - Driven by excess DO

Biological Process Overview



- Determine minimum MCRT for each Zone
- Calculate MLSS inventory and Reactor volume
- Select max month design criteria for Clarifiers
  - Solids loading rate, RAS capacity, area

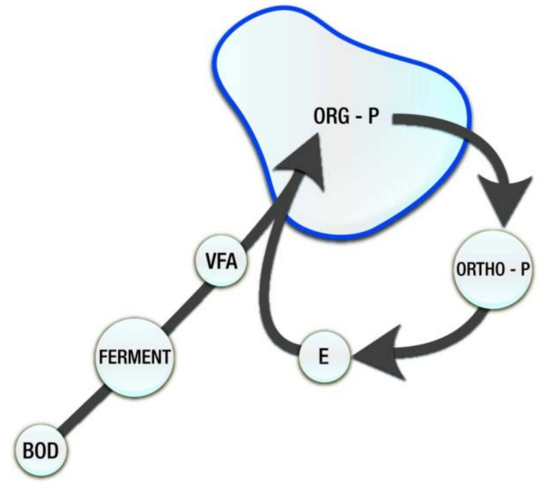
Full-scale Optimization Demonstration

- Reconfigure BNR reactors to plug-flow configuration
- Performed during warm and cold weather conditions
- Minimum sludge retention time to achieve suitable nitrification was determined
  - Lead to significant reduction in bioreactor volume
- Importance of DO flux on primary and secondary denitrification was measured

Demonstration Results

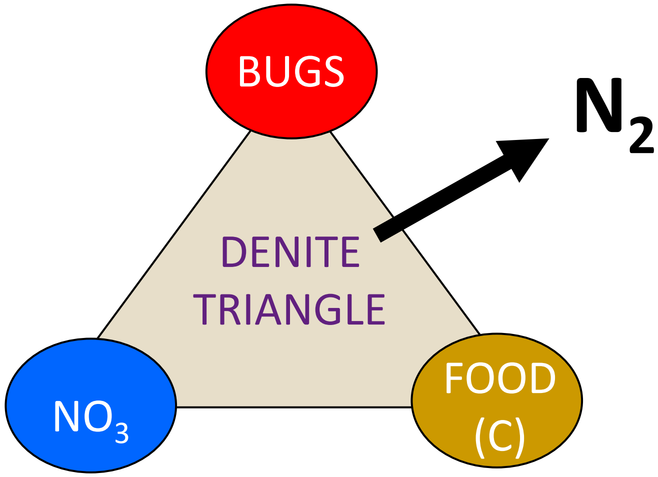
Anaerobic Zone (Phosphorus Removal)

- Existing design provides 0.7 days MCRT at max month conditions
- Consistent with O'Brien & Gere's experience
- Design basis = 0.7 days MCRT (1.1 hr HRT)



Primary Anoxic Zone (Denitrification)

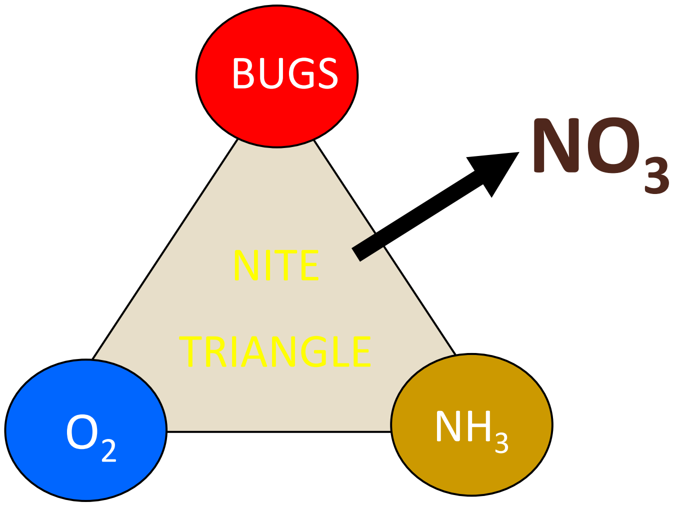
- 2.2 days MCRT are required for complete nitrate removal
- Design basis = 3.0 days MCRT based on experience



Demonstration Results

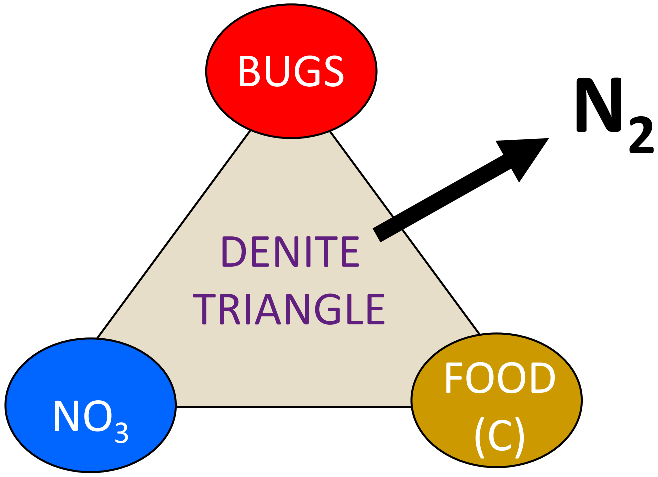
Oxic Zone (BOD Removal & Nitrification)

- Winter 2005: nitrification was maintained with 8.7 days aerated MCRT
- Winter 2004: nitrification was lost with 7.9 days aerated MCRT
- Design basis = 9.0 days MCRT

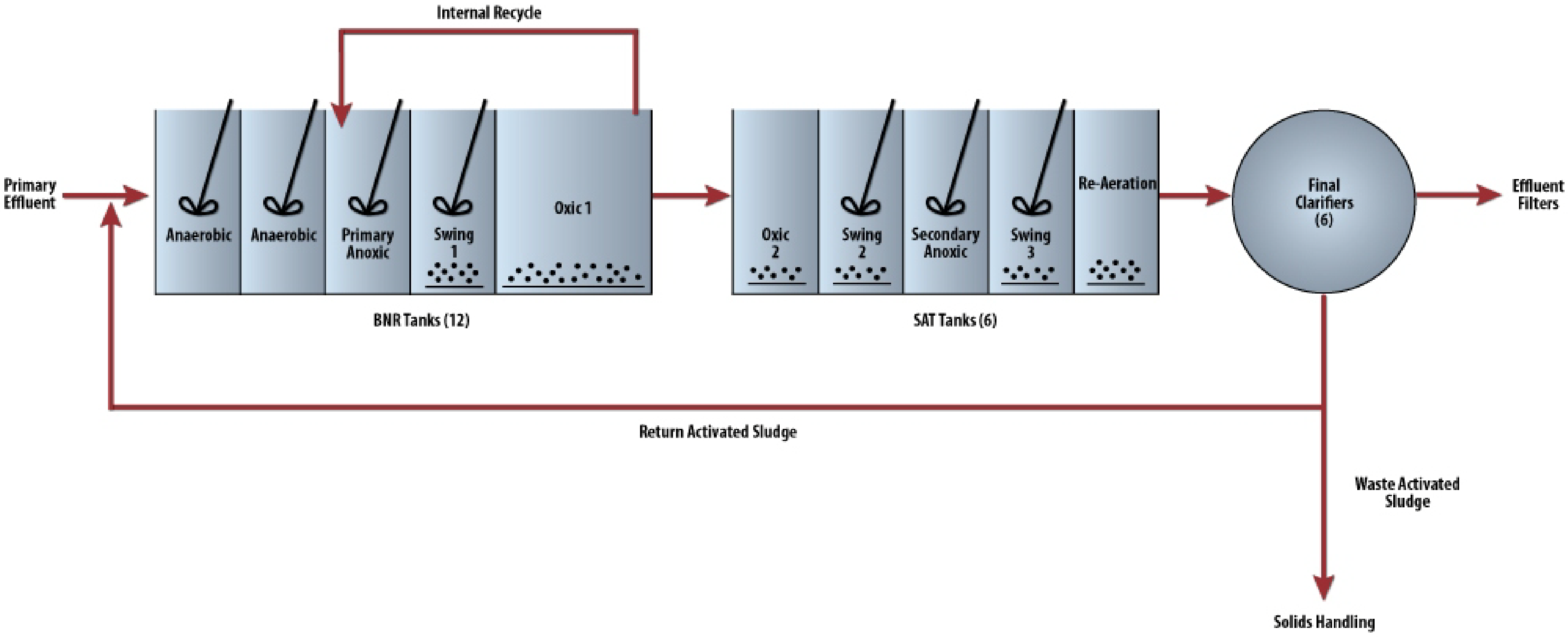


Secondary Anoxic Zone (Denitrification)

- Bench-scale test: 1.6 days MCRT (complete denitrification in summer)
- Design basis = 2.4 days MCRT (cold weather conditions)



ENR Biological Process



Bench-scale Testing

- Evaluate secondary denitrification
  - With or without an external carbon source
  - Warm and cold weather conditions
    - Summer, without C: 1.2 hrs
    - Winter, without C: 2.3 hrs (design basis)
    - Winter, with C: 0.8 hrs (contingency basis)

- Four viable sources of supplemental carbon
  - Methanol
  - Acetic Acid
  - Food processing wastes
  - Proprietary chemical blends (Micro Cg)

Supplemental Carbon Feed System

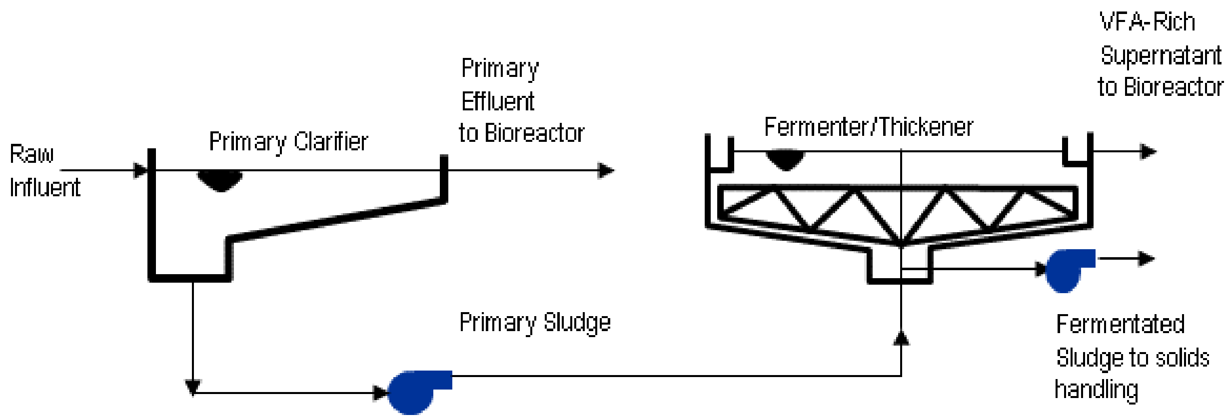
- Ultimate Long Term Solution:
  - 20% Acetic is the fall-back chemical
    - Consistent properties, not proprietary, readily available
  - Micro-C glycerin
    - Less costly option, if compatible with the effluent filters

- Not Recommended:
  - 56% acetic acid
    - Possible corrosion issues, poor health hazard rating
  - Waste glycerin
    - Stratification during storage
  - Sugar water
    - Potential for clogged feed piping, filter media, and stratification / settling in the storage tanks

Fermenter

- Design Parameters modified from BNR PER
  - 20% reduction in sludge
  - 5-day SRT
- Design Conditions
  - 22 MGD plant flow
  - 220 mg/L TSS primary influent
  - 60% removal in primary clarifiers
  - Sludge in fermenter is 5.8% TS
- 200,000 gallons required for sludge storage
- Existing Fermenter is 45' diameter, 12' deep
  - Total Volume = 143,000 gal
  - 75% available for sludge storage = 107,000 gal
- Two Fermenters are required

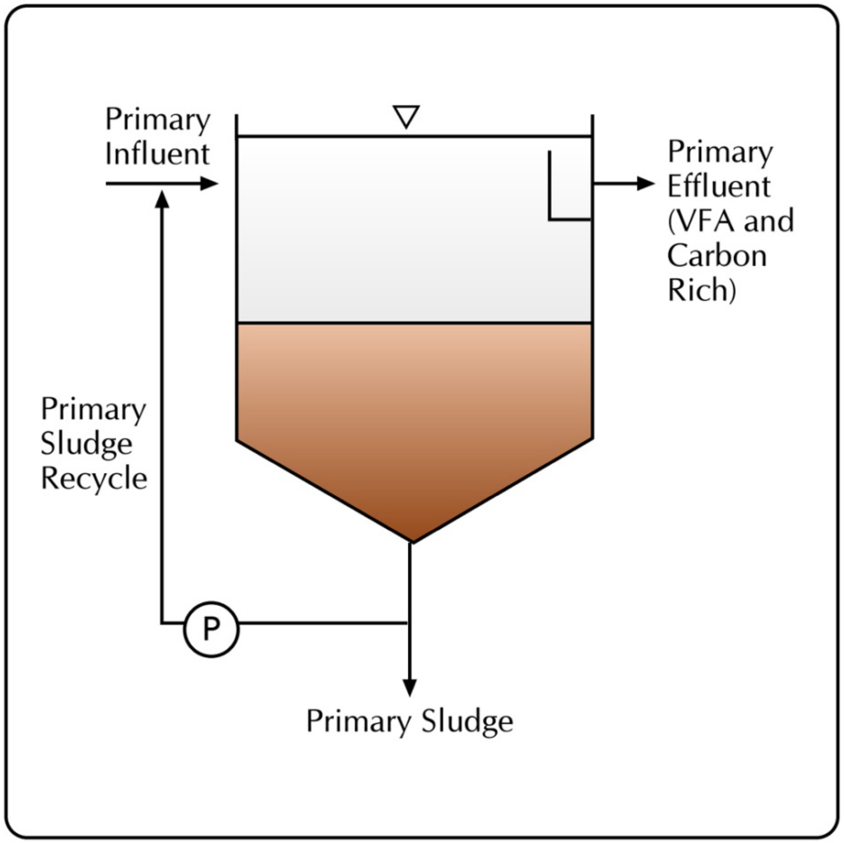
Primary Sludge Static Fermenter (Thickeners)



- Use gravity thickener for fermentation, supernatant (VFA) sent to BNR
- A high-torque sludge scraper mechanism required, high thickener sludge concentration ~4 - 8%
- Advantage
  - Independent operations and controls of the primary clarifier and fermenter/thickener
- Disadvantage
  - Balancing sludge wastage and monitoring sludge blanket is very hard

VFA / Carbon Source

Primary Activation



Primary Activation produces valuable carbon, enhancing nutrient removal.

NewGemini-Mac-QP-HRRSA/afd/WW.prp/Harrisonburg-Rockingham Regional Sewer Authority/2-05/HRRSAPrimActivation.fh9

An Approach to Nutrient Removal

- Optimize use of existing infrastructure to reduce cost
- Reduce operating cost impact, i.e. EBioP
- Provide flexibility for plant operations
  - Dual zones (mixing and aeration)
- Key is site specific testing program
  - Pilot or full-scale

Carbon Management
DO Management

QUESTIONS?

Mark Greene (315) 956-6271 Mark.Greene@obg.com

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www.obg.com

THANK YOU

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