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Achieving Extremely Low Effluent TN and TP Concentration at Very Low SRTs Using IFAS Technology

WEFTEC 2014, New Orleans

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Technical Sessions

Purposes

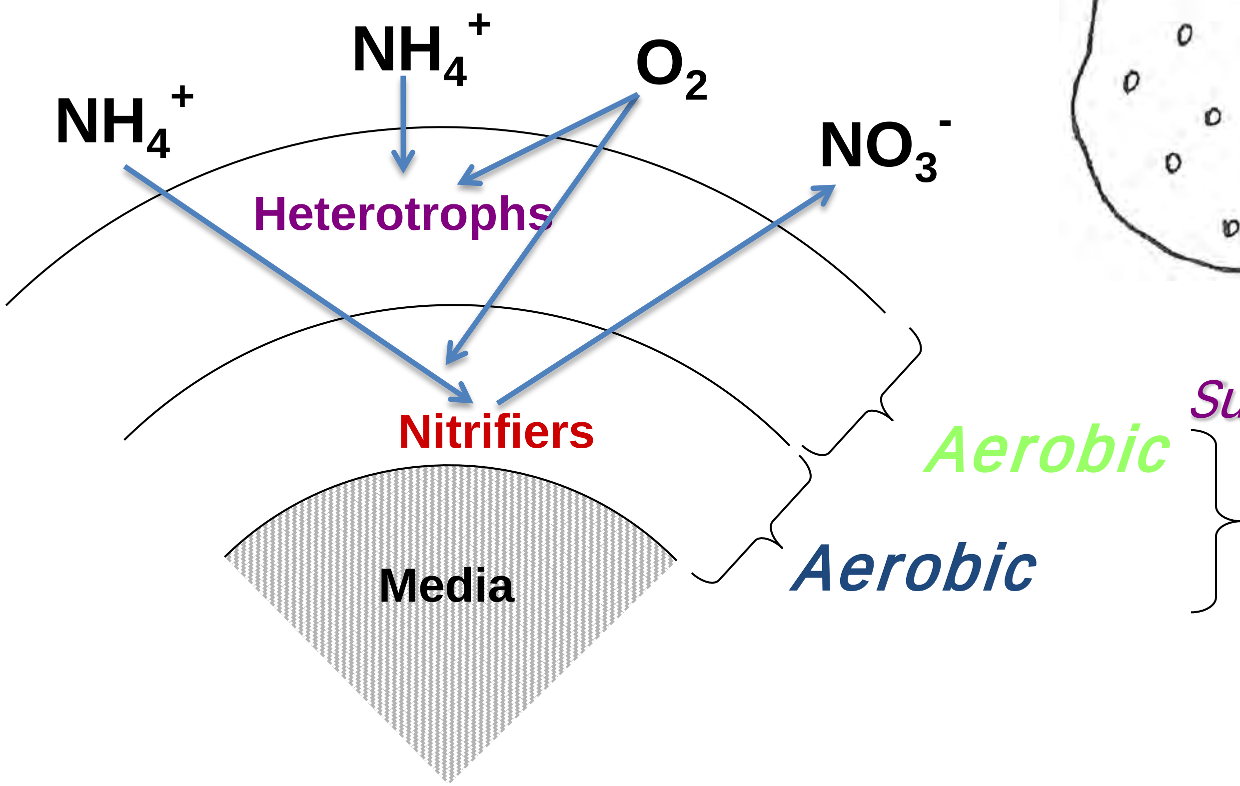
- Investigate the ability of IFAS processes with extremely short SRTs to remove total nitrogen
- Investigate ability of development of PAOs in the sludge blanket in the secondary clarifiers
- Summarize the evolving understanding of the Bio-P removal mechanism in the sludge blanket

Design and Operation of an IFAS

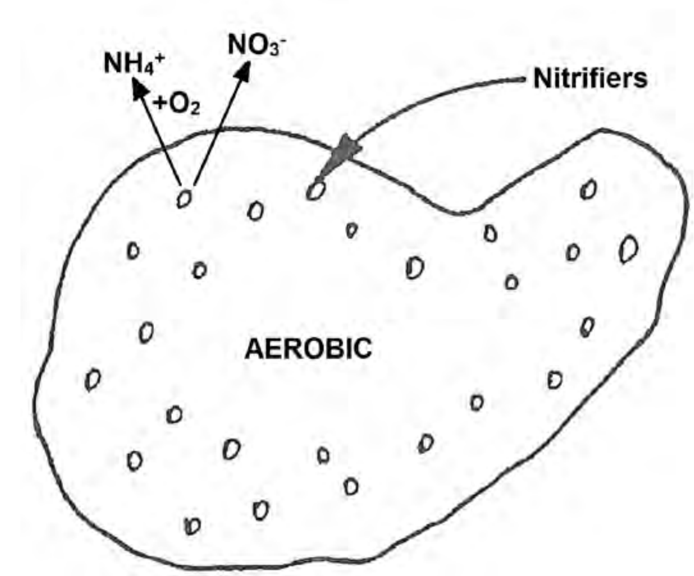
IFAS design is easy !

1. Very similar to Conventional Activated Sludge System
2. However, nitrification exists in both suspended and attached biomass
   - High load (low SRT) – nitrification in biofilm dominates
   - Low load (high SRT) – nitrification in suspension plays a greater role
   - Higher nitrification rates at a given SRT in CAS – seeding effect from attached biomass
   - Higher DO Setpoint (3-4 mg/L)

Nitrification in IFAS

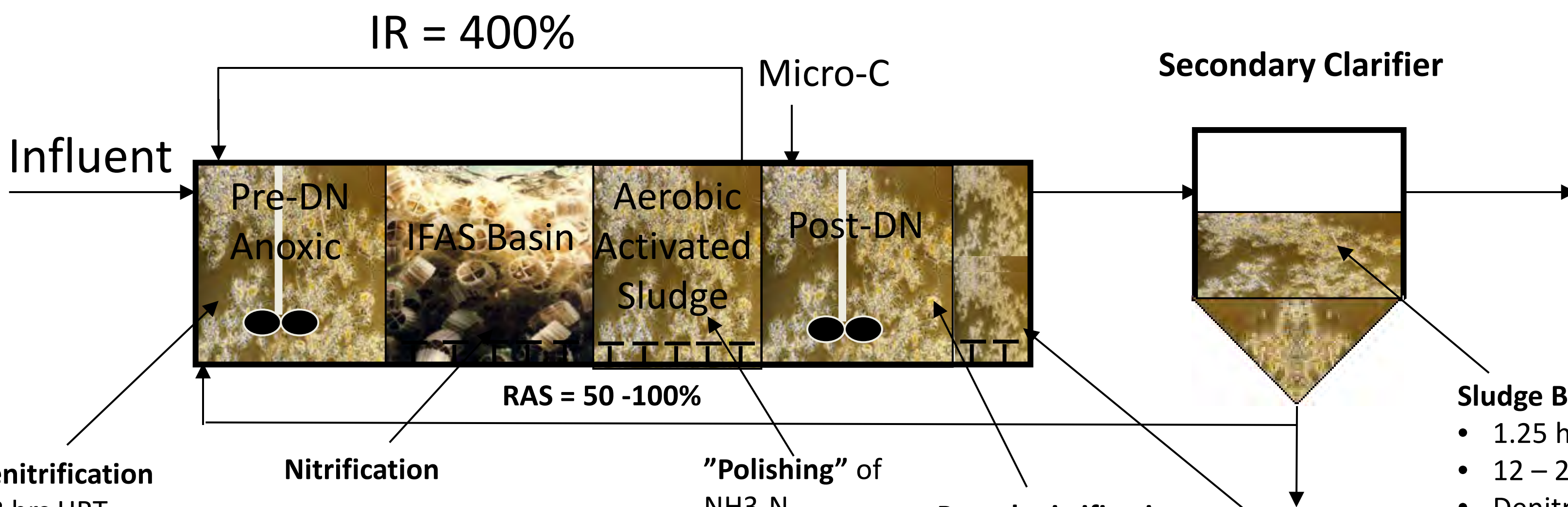


Nitrification on carrier



Nitrification on Suspended Biomass

IFAS Process Configuration



Pre-denitrification
- 1.8 hrs HRT
- 1.30 days SRT
- Uses internal biodegradable soluble carbon

Nitrification
- 1.8 hrs HRT
- 1.30 days SRT
- BOD-depletion and partial nitrification by suspended biomass
- High-rate nitrification by attached biomass

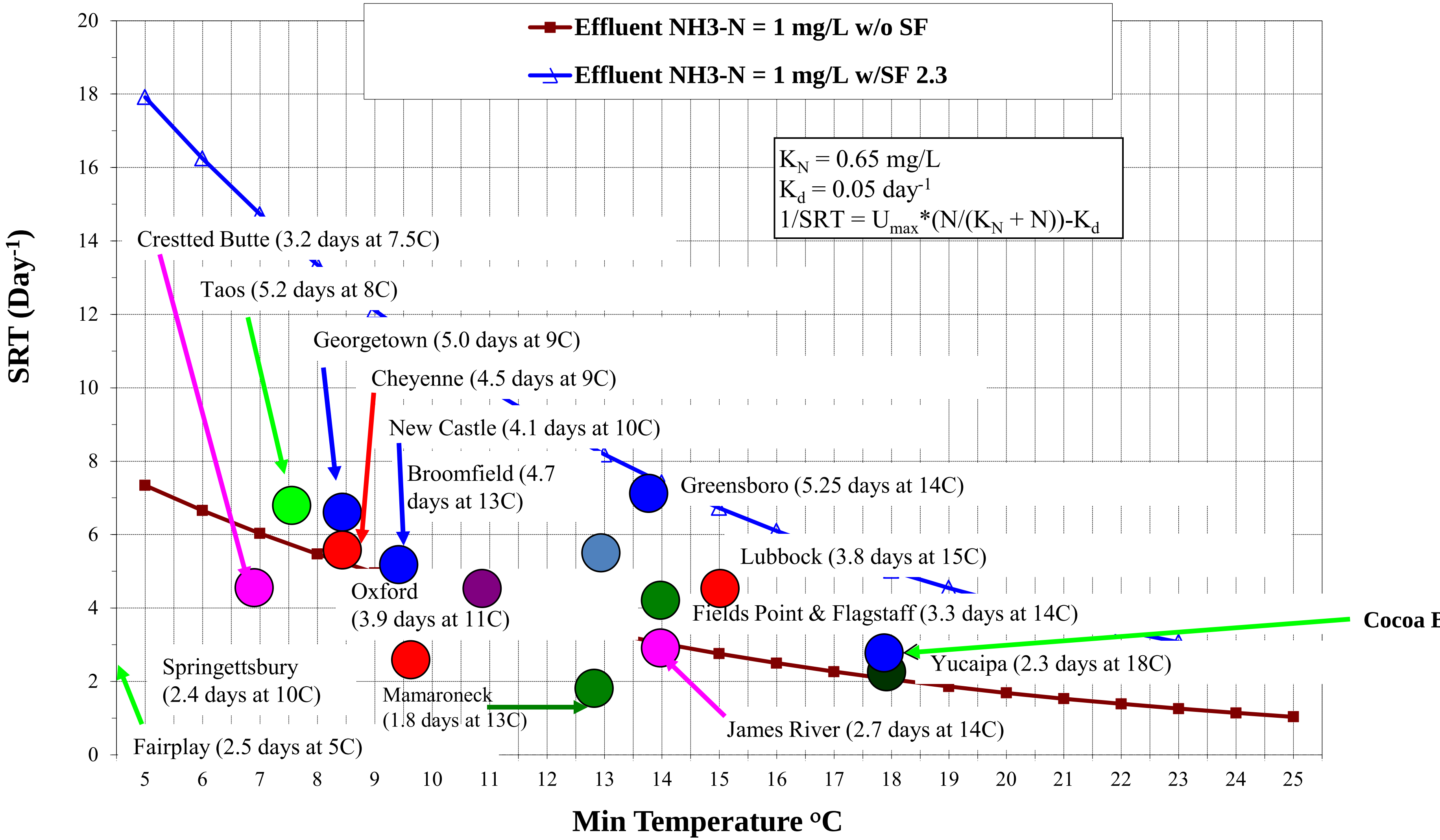
"Polishing" of NH3-N
- 1.8 hrs HRT
- 1.30 hrs SRT
- Ammonia polishing

Post-denitrification
- 0.92 hrs HRT
- 0.6 day SRT
- Uses external carbon

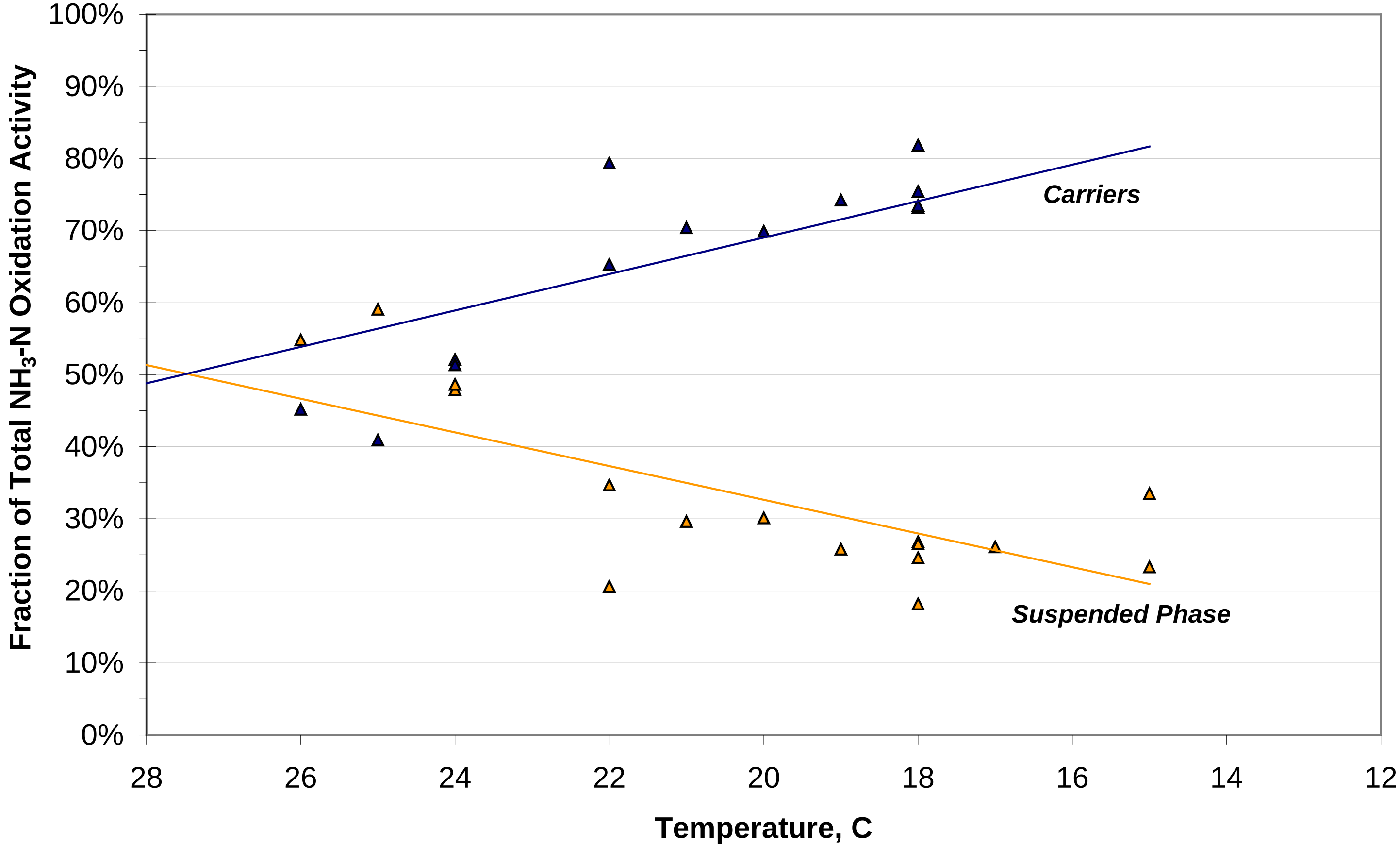
Post-aerobic
Removal of excess carbon
Oxygenation of effluent

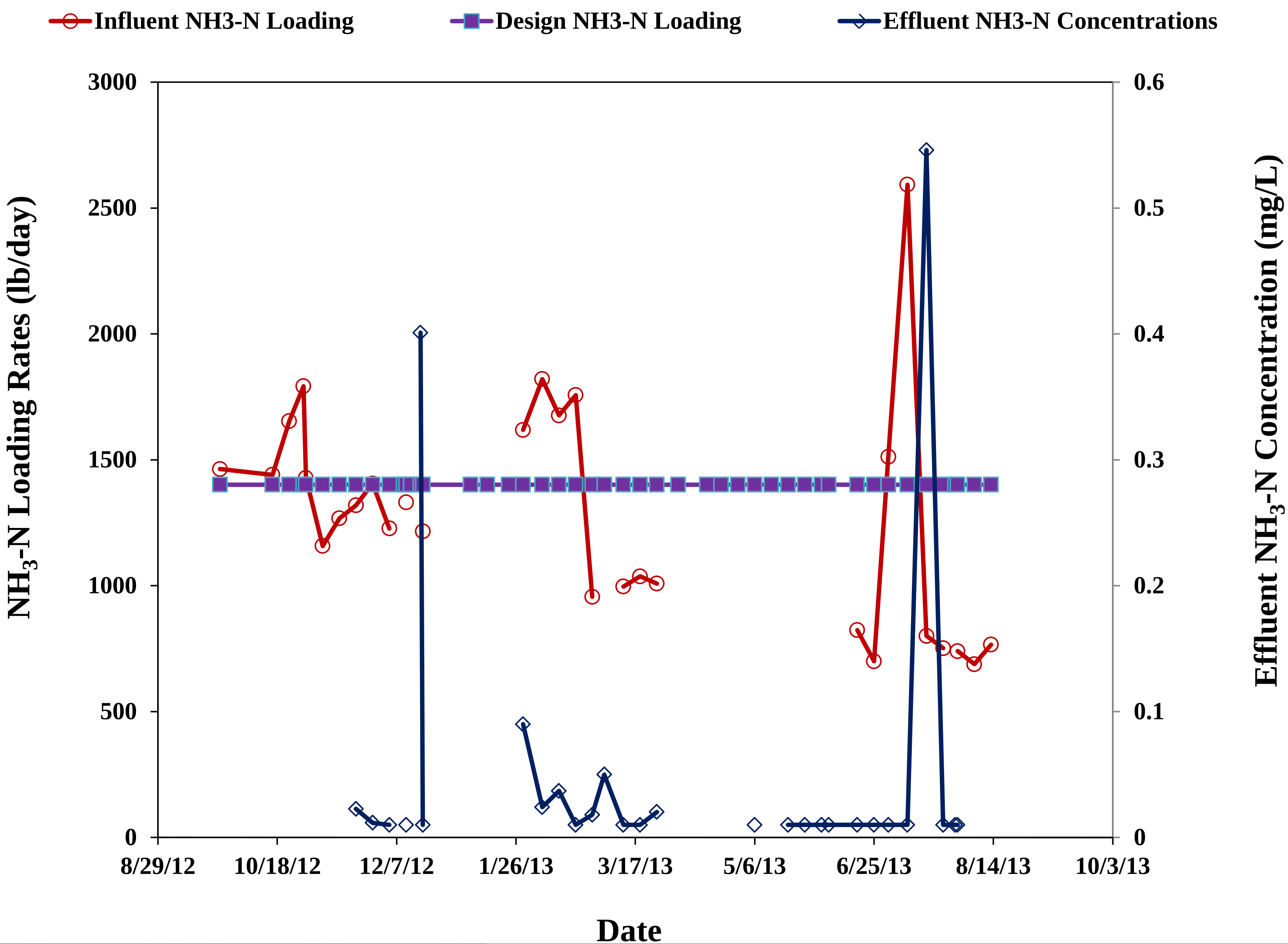
Sludge Blanket
- 1.25 hrs HRT
- 12 – 24 hrs SRT
- Denitrification
- P Release

SRT For Nitrification

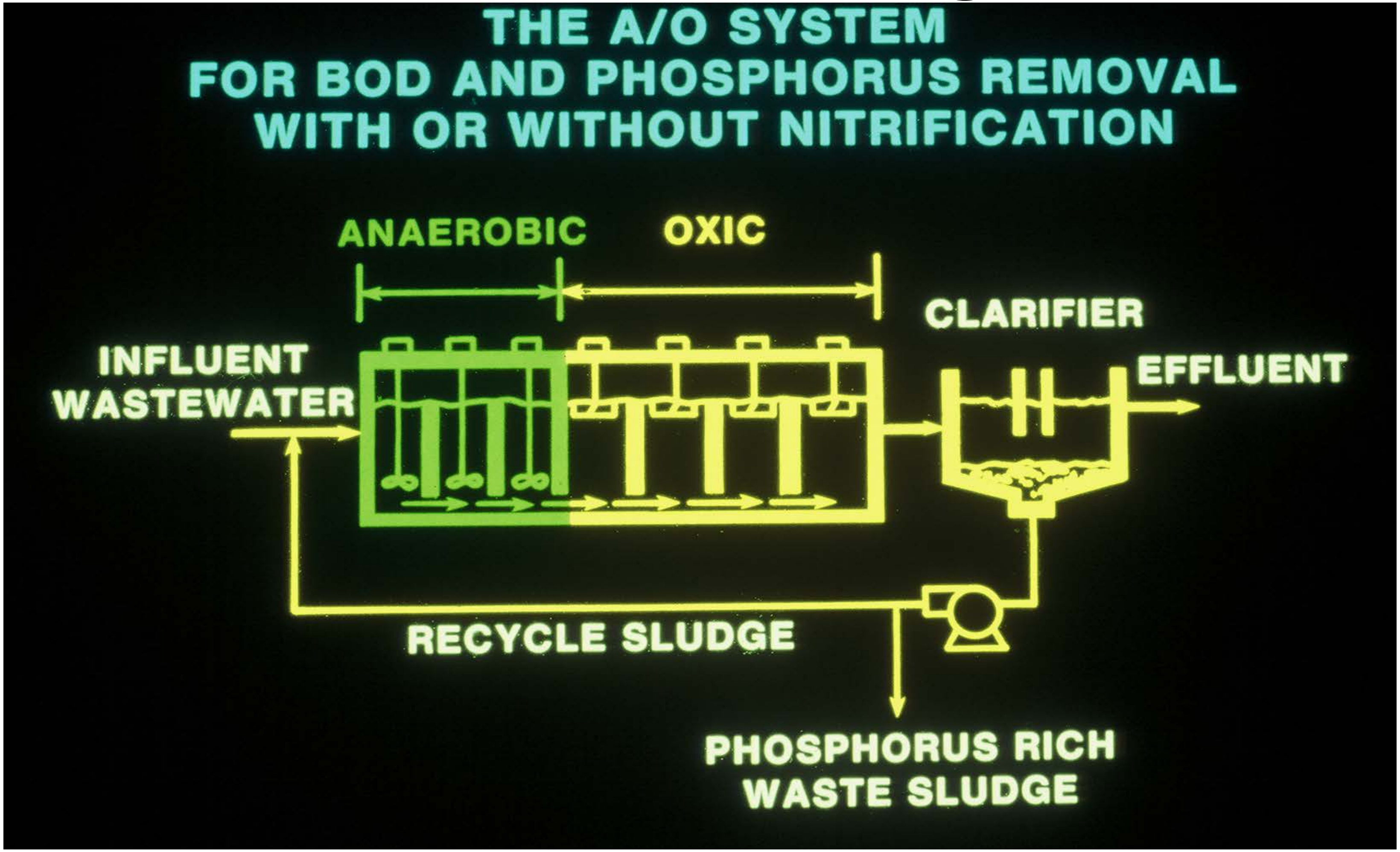


Seasonal Shift in Ammonia Oxidation Activity

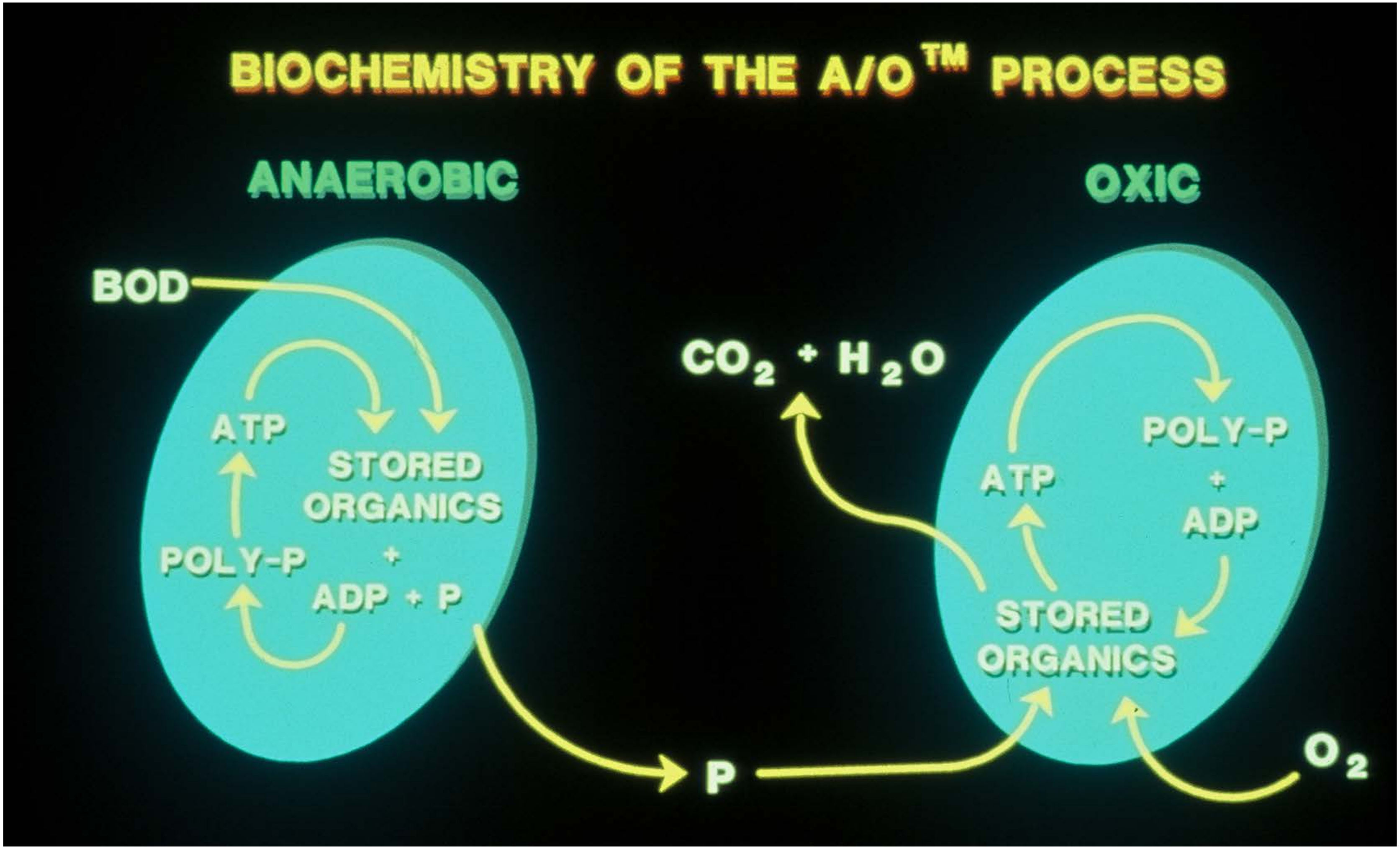


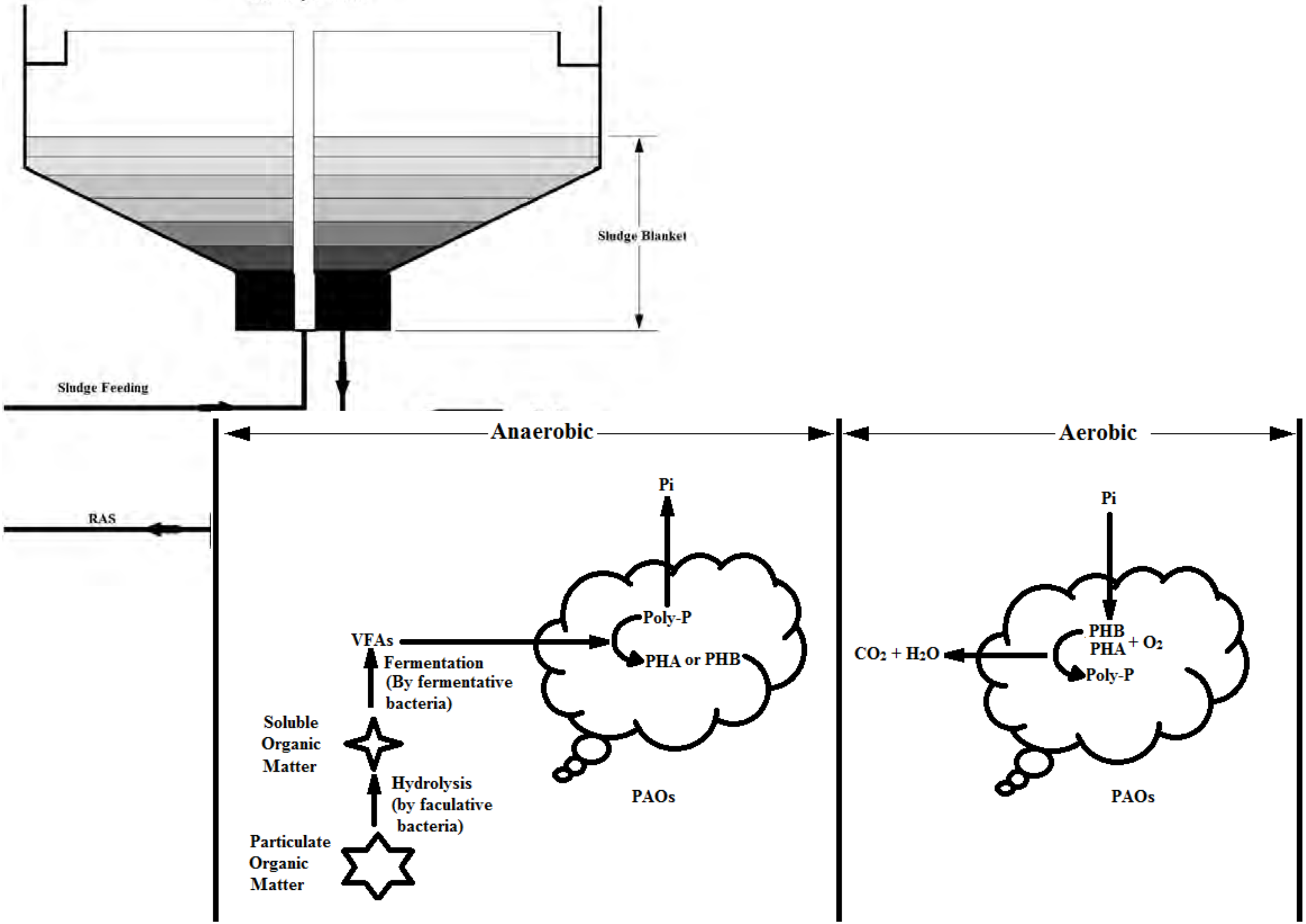

Influent NH3-N Loading
Design NH3-N Loading
Effluent NH3-N Concentrations
NH_3-N Loading Rates (lb/day)
Effluent NH_3-N Concentration (mg/L)
3000
2500
2000
1500
1000
500
0
0.6
0.5
0.4
0.3
0.2
0.1
0
8/29/12
10/18/12
12/7/12
1/26/13
3/17/13
5/6/13
6/25/13
8/14/13
10/3/13
Date

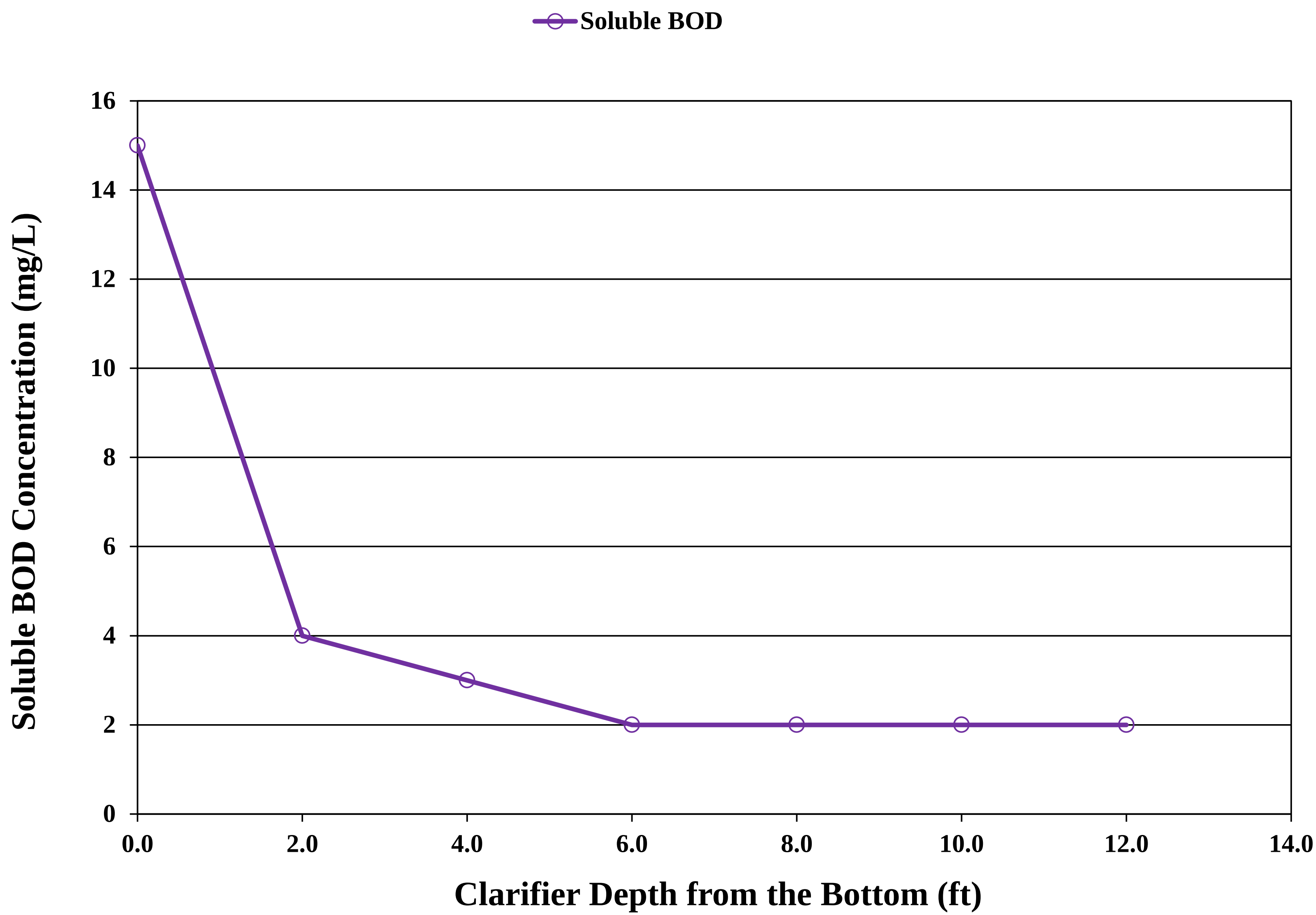
The Classic EBPR Configuration



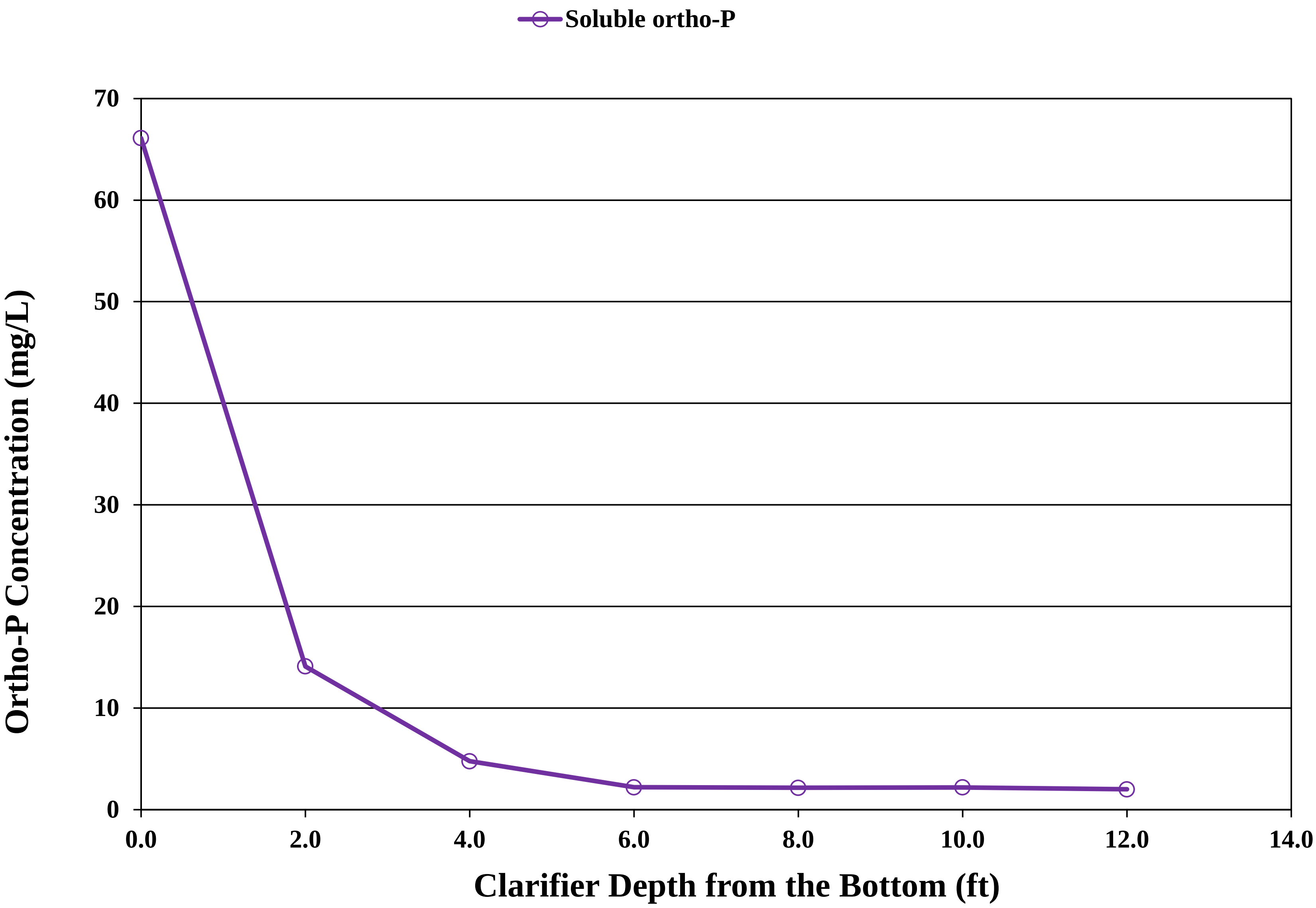
Bio-P Removal Mechanism



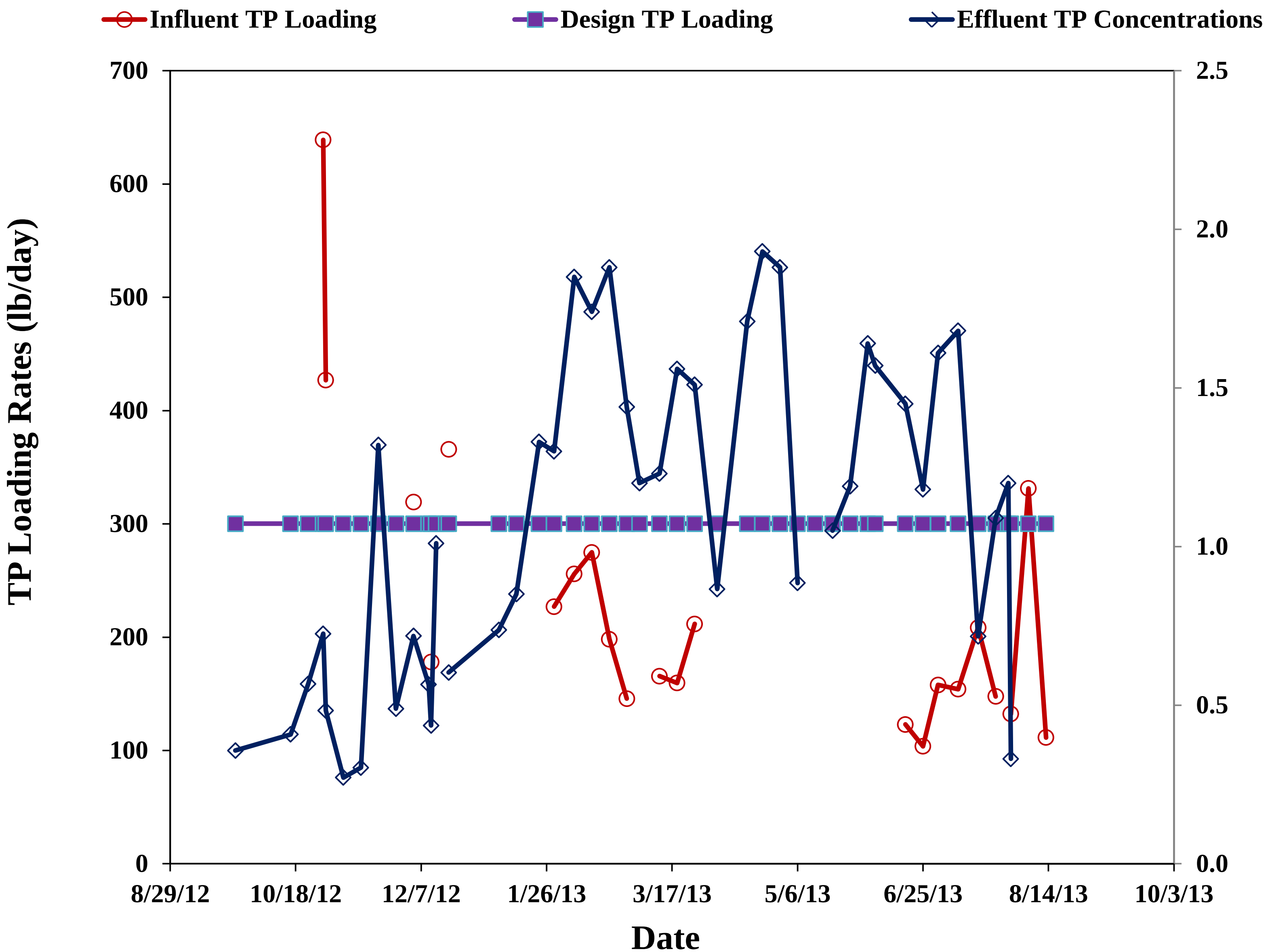

Sludge Blanket
Sludge Feeding
RAS
Anaerobic
Aerobic
Pi
Poly-P
VFAs
PHA or PHB
Fermentation
(By fermentative
bacteria)
Soluble
Organic
Matter
Hydrolysis
(by faculative
bacteria)
Particulate
Organic
Matter
PAOs
Pi
PHB
PHA
+ O_2
$CO_2 + H_2O$
Poly-P
PAOs



Soluble BOD
Soluble BOD Concentration (mg/L)
0
2
4
6
8
10
12
14
16
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
Clarifier Depth from the Bottom (ft)



Soluble ortho-P
Ortho-P Concentration (mg/L)
0
10
20
30
40
50
60
70
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
Clarifier Depth from the Bottom (ft)


Influent TP Loading
Design TP Loading
Effluent TP Concentrations
700
600
500
400
300
200
100
0
2.5
2.0
1.5
1.0
0.5
0.0
TP Loading Rates (lb/day)
Effluent TP Concentration (mg/L)
8/29/12
10/18/12
12/7/12
1/26/13
3/17/13
5/6/13
6/25/13
8/14/13
10/3/13
Date

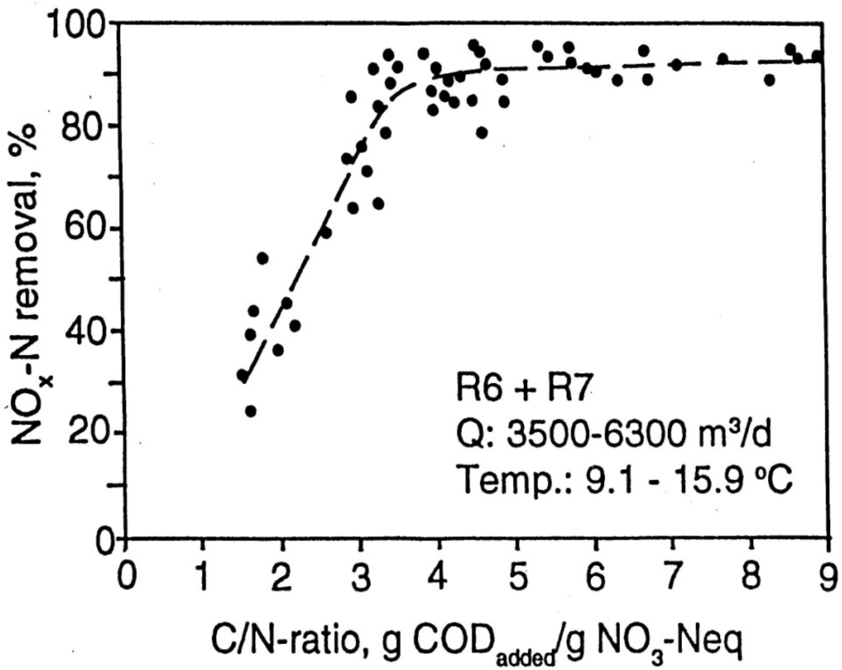
Post-Denitrification

$$r_{DN} = k * [S_{COD}/(S_{COD}+K_{S,COD})] * [S_{NO3}/(S_{NO3}+K_{S,NO3})]$$

What this equation tells us?

•Availability of carbon source is normally the limiting factor (K_S = 2,5 -5 mg SBCOD/l) when C/N ratio is less 3 mg COD/mg

• If very low effluent NO_3-N (< 1-3 mg/l) is required, NO_3-N is the limiting factor and determining the DN-rate (K_S = 0,5-2,0 mg NO_3/l)

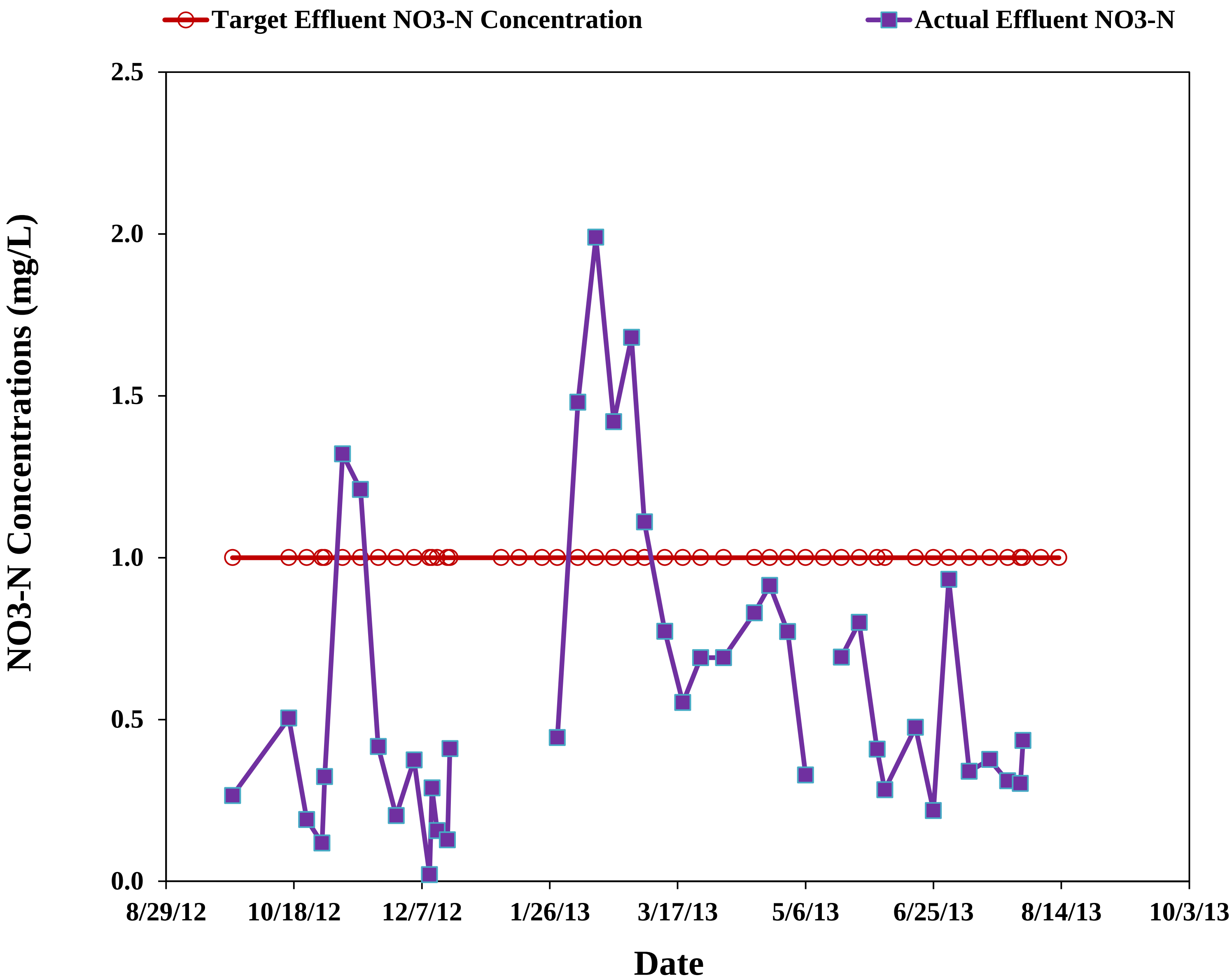


Sources of rbCOD

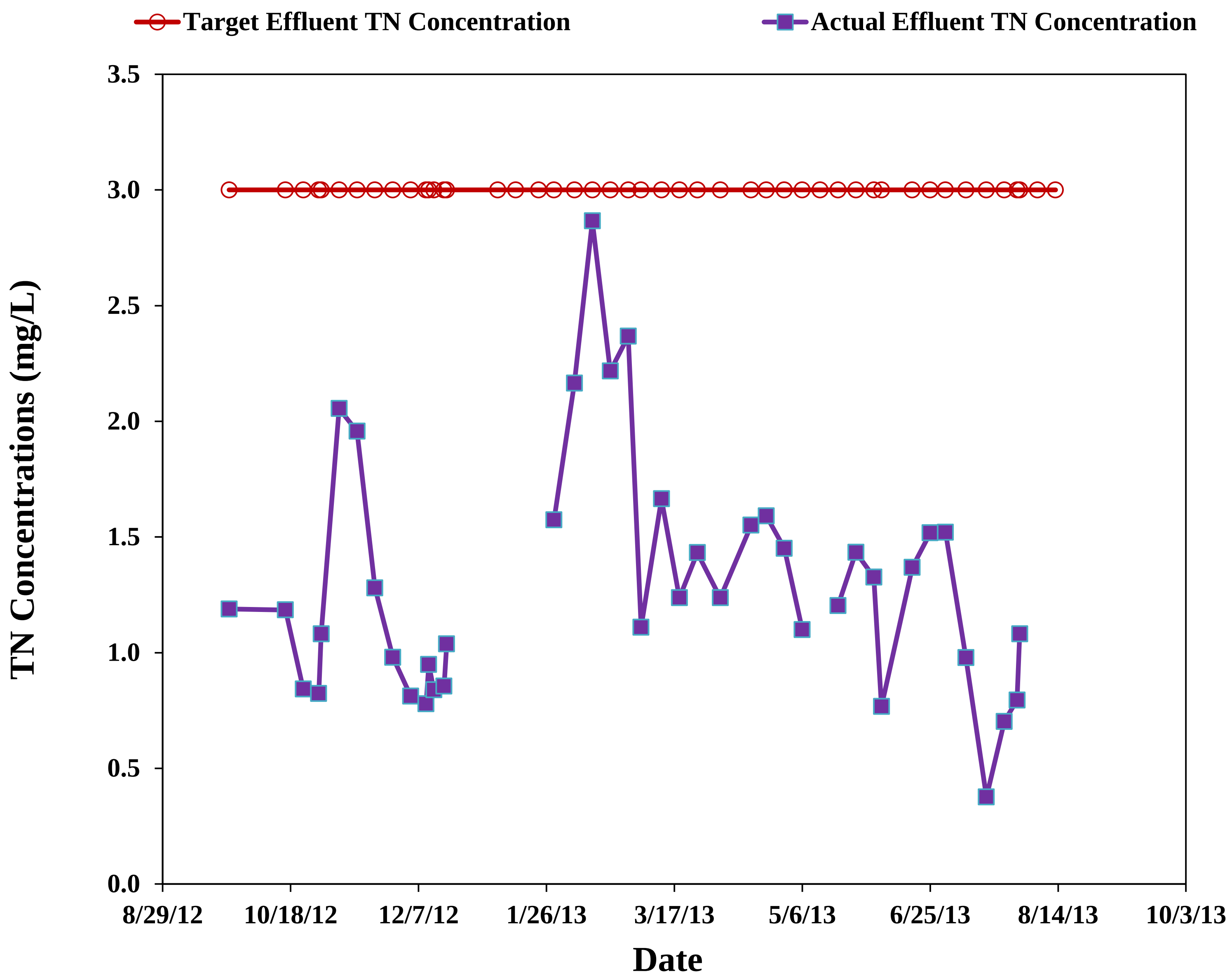
1. $COD_{SO,\ Decay} = (1-f_D) \times b_H \times X_H \times HRT$

2. $$COD_{SO,Hydrolysis} = K_H \times \eta_{fe} \times \frac{K_{NO3}}{K_{NO3}+S_{NO3}} \times \frac{X_S/X_H}{K_X + X_S/X_H} \times X_H \times V$$

$$DN\ Potential = \frac{COD_{SO,Hydryolysis}}{2.86/(1-Y_{ANX})} + \frac{COD_{SO,Decay}}{2.86}$$



Target Effluent NO3-N Concentration
Actual Effluent NO3-N
NO3-N Concentrations (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
8/29/12
10/18/12
12/7/12
1/26/13
3/17/13
5/6/13
6/25/13
8/14/13
10/3/13
Date


Target Effluent TN Concentration
Actual Effluent TN Concentration
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
TN Concentrations (mg/L)
8/29/12
10/18/12
12/7/12
1/26/13
3/17/13
5/6/13
6/25/13
8/14/13
10/3/13
Date

Take-home Message

1. The IFAS processes have established themselves as a well-proven, robust and compact processes for nutrient removal)(now altogether > 600 plants in > 50 countries – 60 installations in the USA).
2. The IFAS is an excellent technology for upgrading existing CAS systems within the existing tankage for either maintaining nitrification at higher flow rates/loads or upgrading a CAS plant to meet new nitrification or total nitrogen removal requirements.
3. The IFAS technology could achieve extremely low NH3-N and NO3-N concentrations in secondary effluent. Total inorganic nitrogen (TIN) concentrations as low as 0.5 mg/L are achievable utilizing IFAS technology.
4. The experience with the operation of Cocoa Beach WRF IFAS plant shows the following: (1) the sludge blanket control strategy in the secondary clarifiers is able to achieve TN and TP less than 1 mg/L and 3 mg/L in effluent in most cases if the sludge blanket is carefully controlled; (2) this process is not as sensitive to TBOD5/TP ratio in plant influent wastewater as the other EBPR processes; (3) this process does not impact the total process SRT selection.

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Acknowledgement

- All Plant Staff
- Britt Williams
- Mike Baker