Efficient Nutrient Removal under Low Dissolved Oxygen Operations

NEWEA 2017 Annual Conference

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NEWEA
WORKING FOR WATER QUALITY

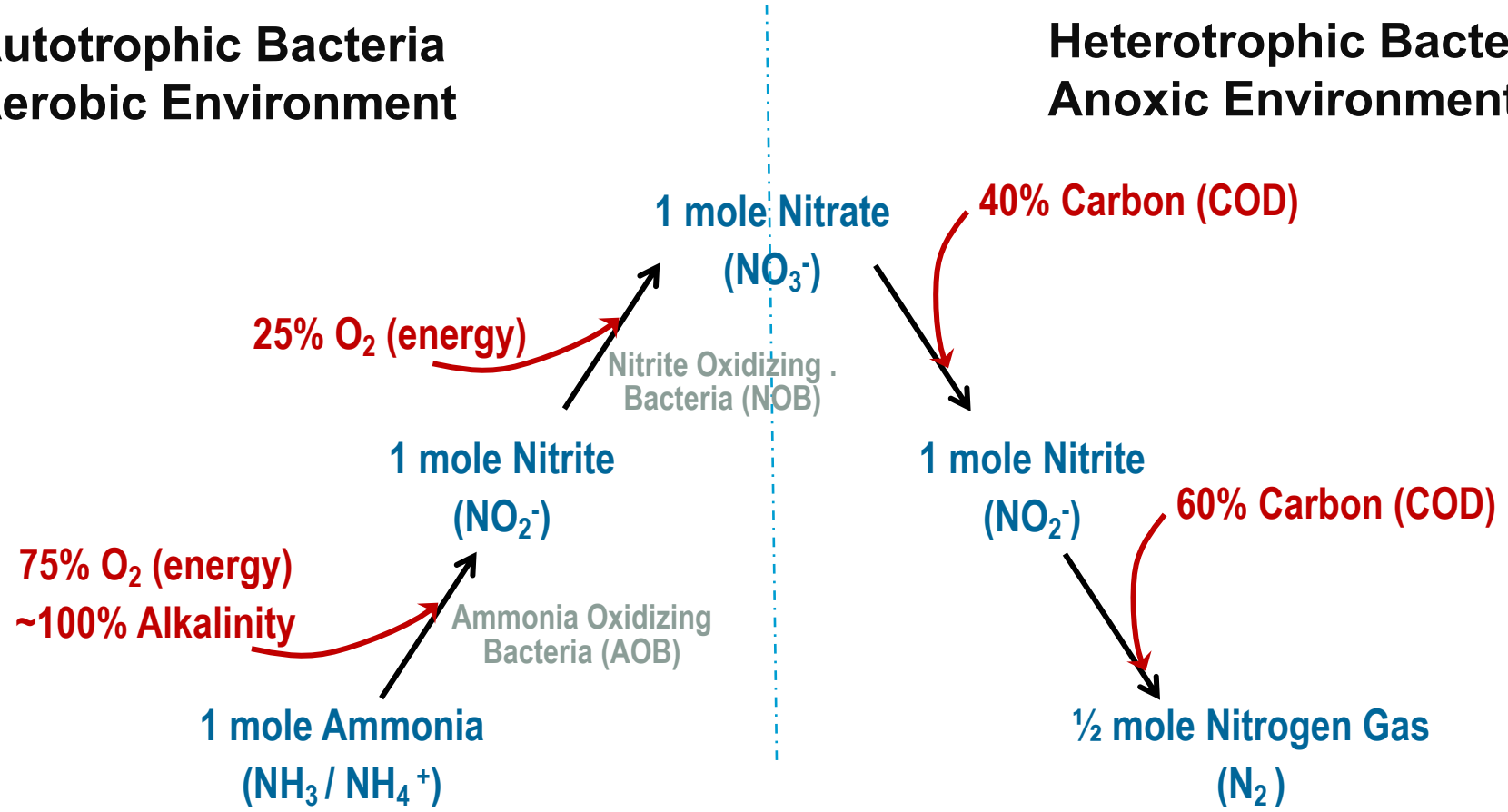
Agenda

St Petersburg Southwest WRF

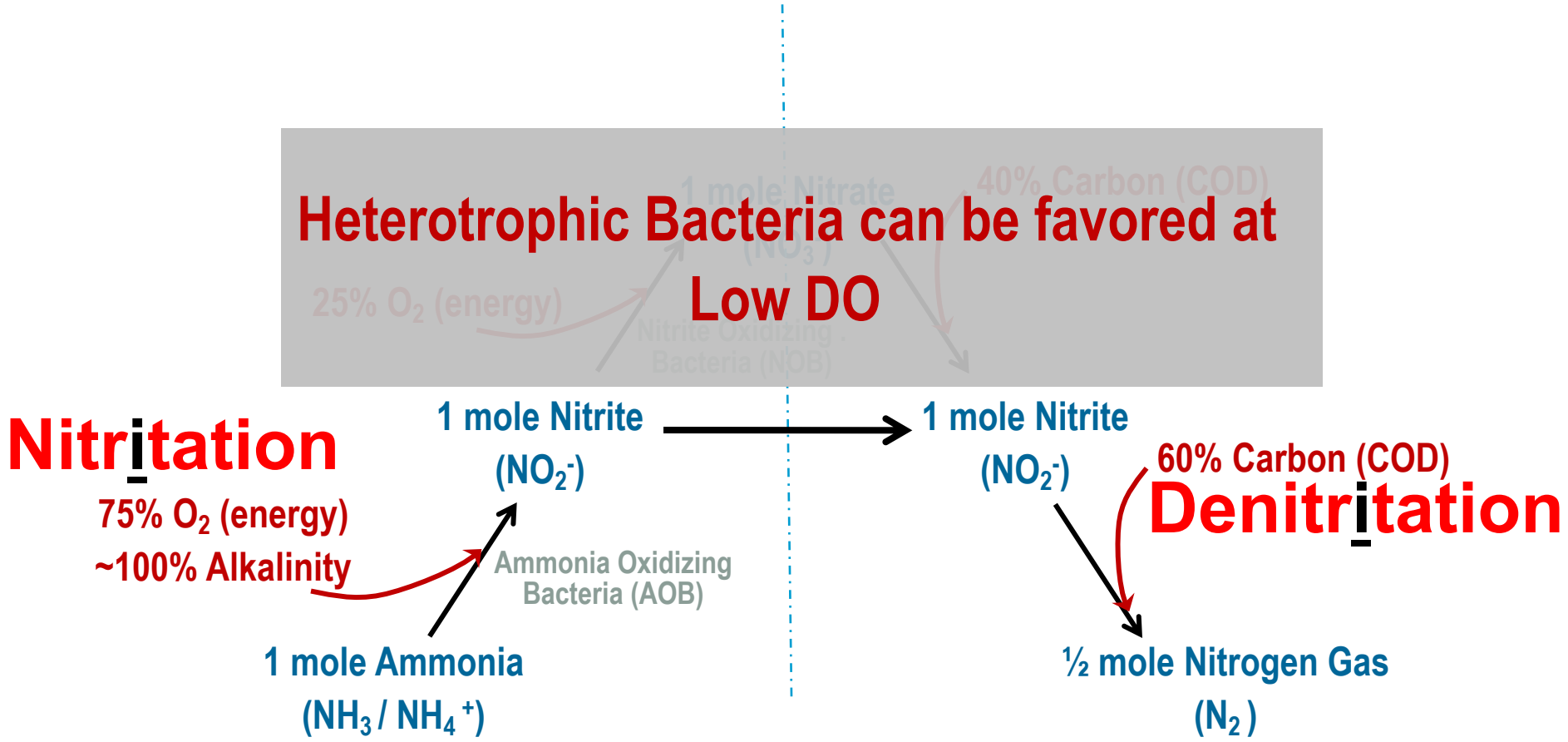
Madison Nine Springs WRF

Rochester NH

Conventional Nitrification-Denitrification



Nitritation-Denitritation = "Nitrite-Shunt"



Benefits

- 25% reduction in oxygen demand (energy)
- 40% reduction in carbon (e^- donor) demand
- 40% reduction in biomass production

City of St. Petersburg Southwest WRF

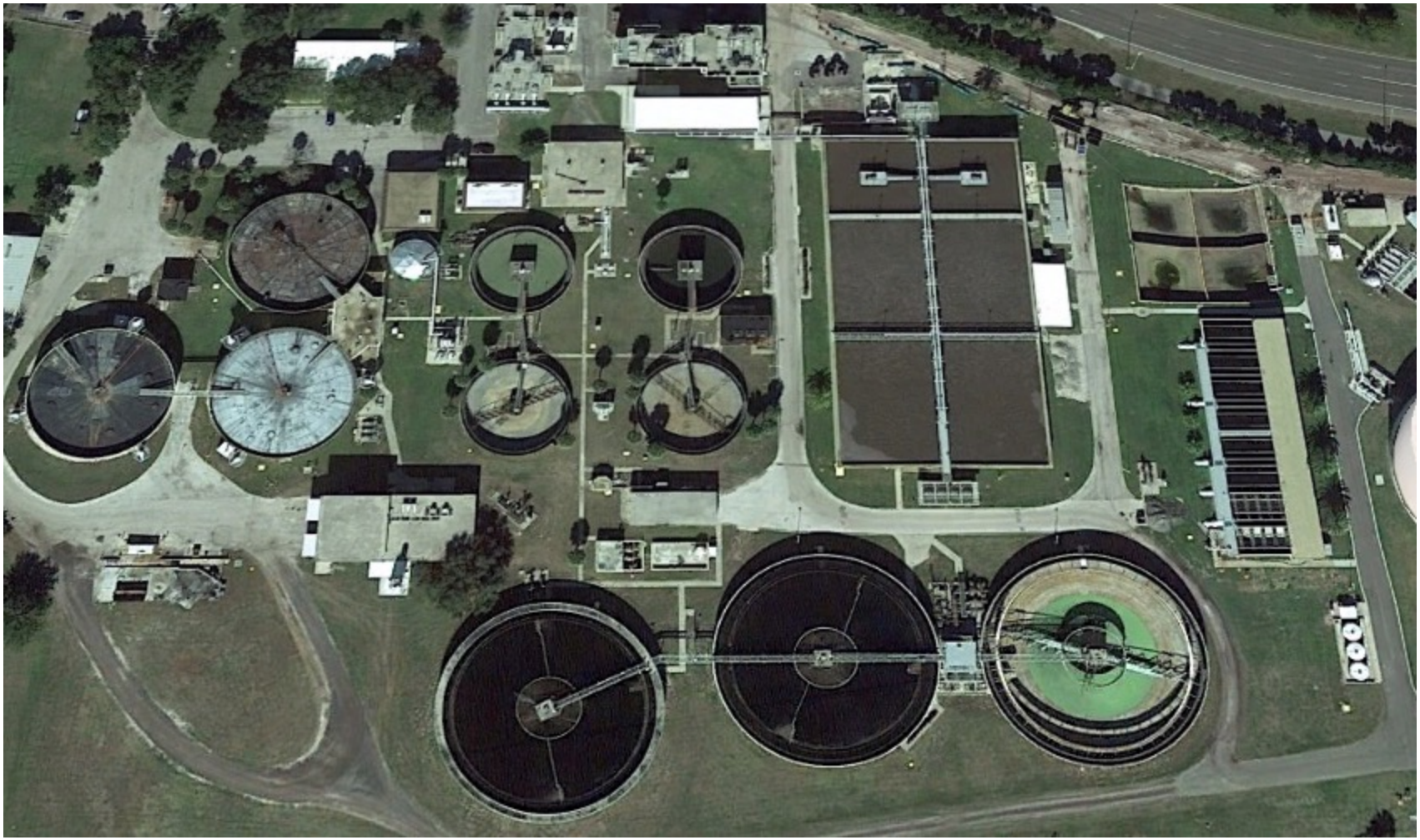
Mainstream Nitrite Shunt

Brown AND Caldwell

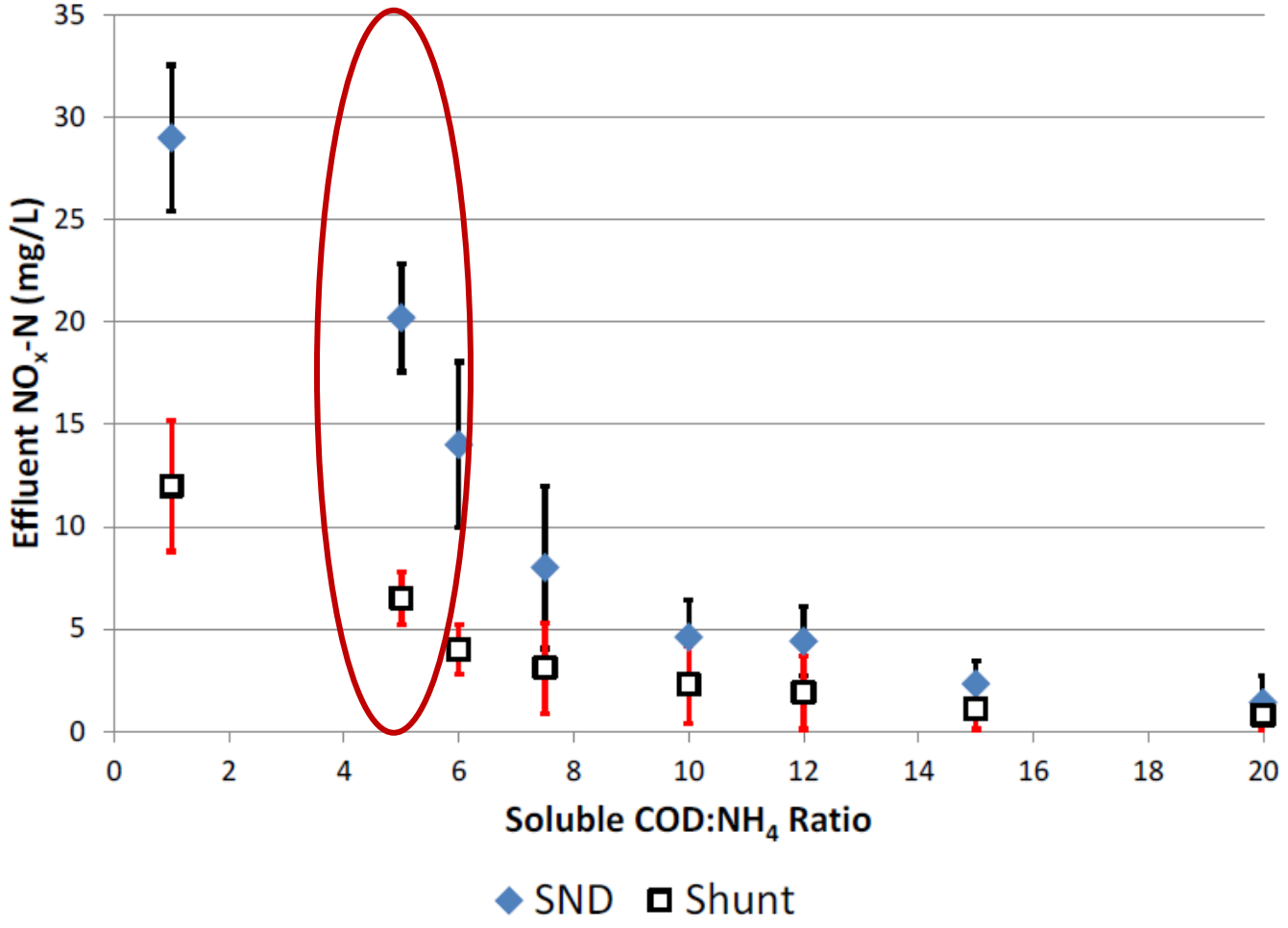
City of St. Petersburg Southwest WRF

- Current Average Flow = 9.5 MGD
- Influent TKN ≈ 42 mgN/L
- TP ≈ 4 mgP/L
- Temp. = 20 to 30 C
- SRT = 4 to 5 days
- Effluent nutrient targets
  - Total N = 10 mg/L
  - Total P = 1.0 mg/L

City of St. Petersburg Southwest WRF



Carbon Requirements for Mainstream Biological Nitrogen Removal Processes

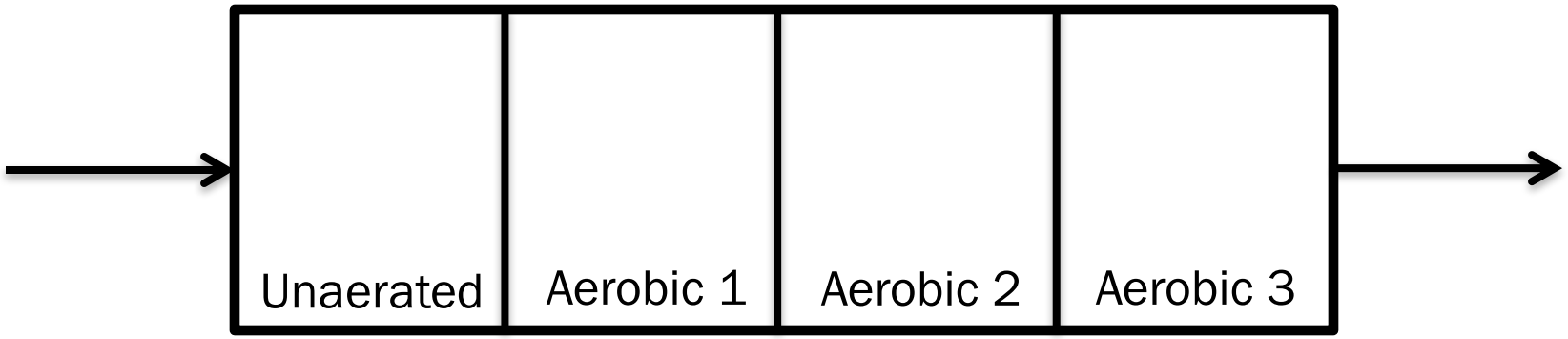


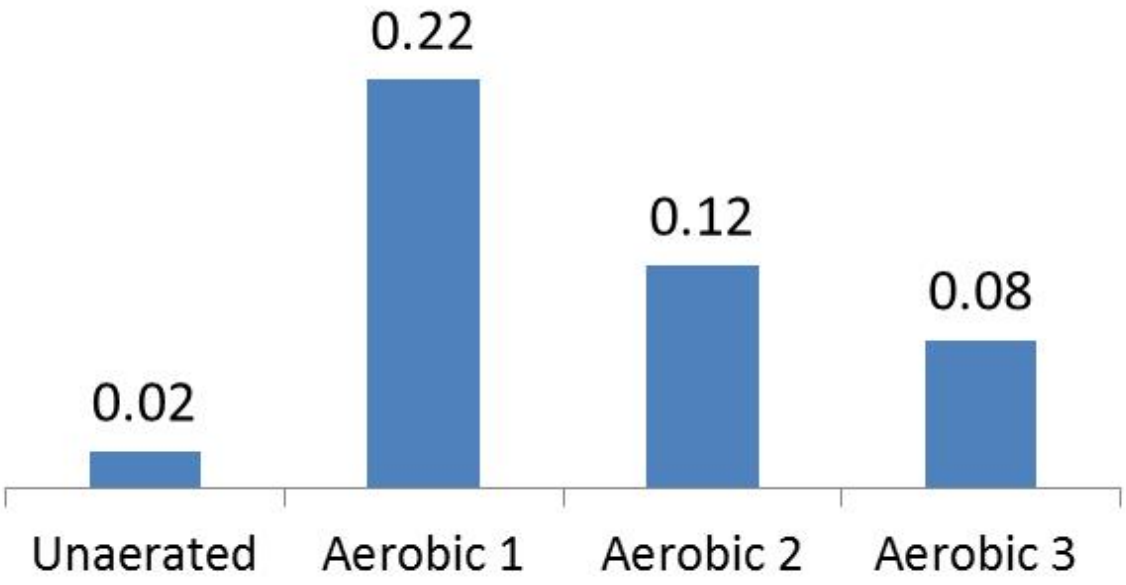
Brown and Caldwell Internal Data

Nitrite Shunt Control Strategy (DO, SRT, NH4, NO3)

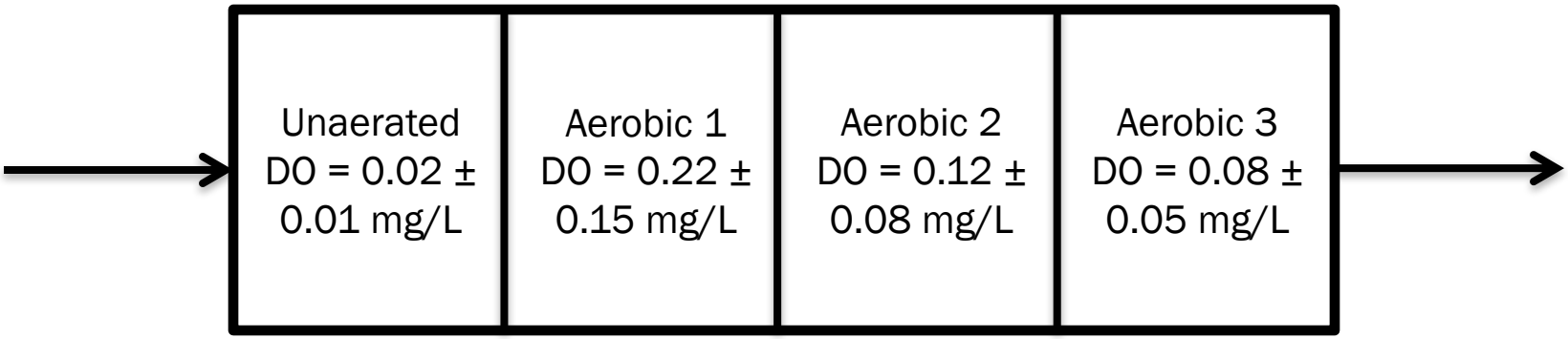
Control Parameter	Condition	Action
NH_4^+	< 1 mgN/L	Reduce SRT Maintain DO = 0.1 mg/L
	> 3 mgN/L	Increase SRT Increase DO ≈ 0.3 mg/L
NO_3^-	> 1 mgN/L	Reduce DO to 0.1 mg/L
	< 1 mgN/L	No action

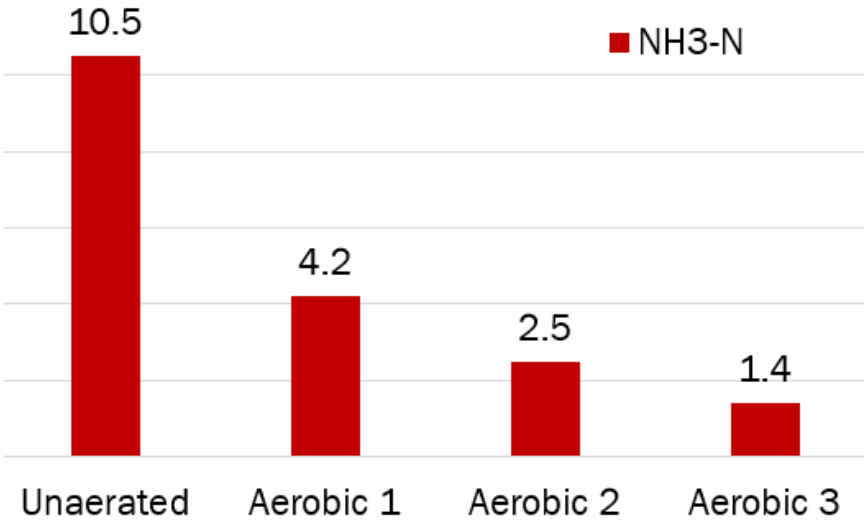
Dissolved Oxygen Profile

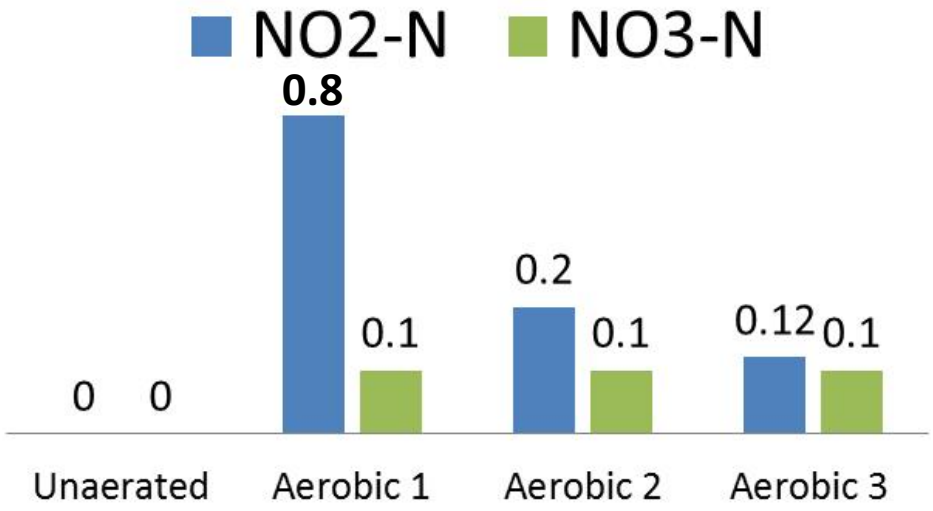




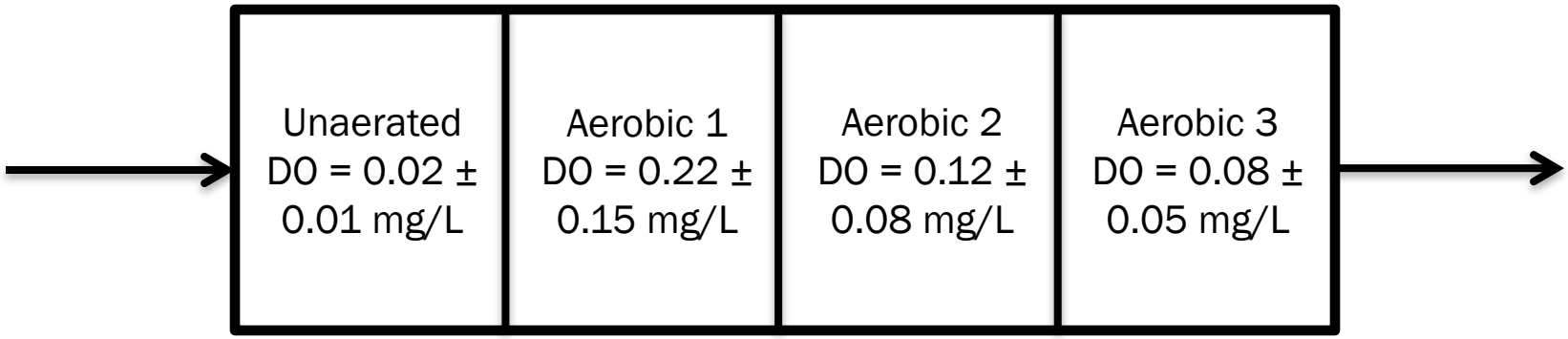
Inorganic Nitrogen Profile

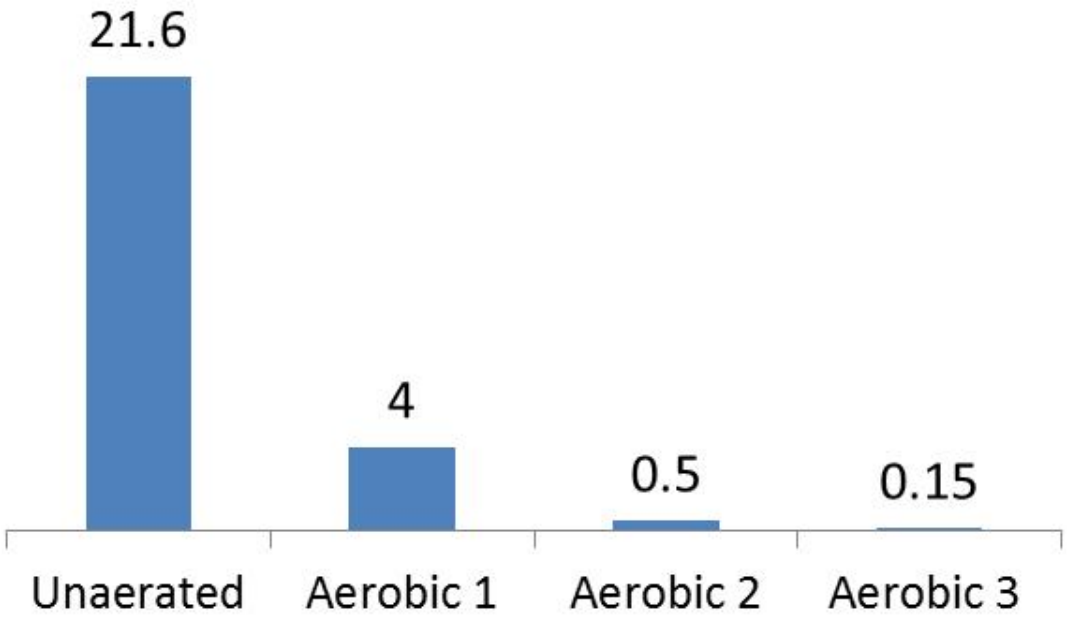




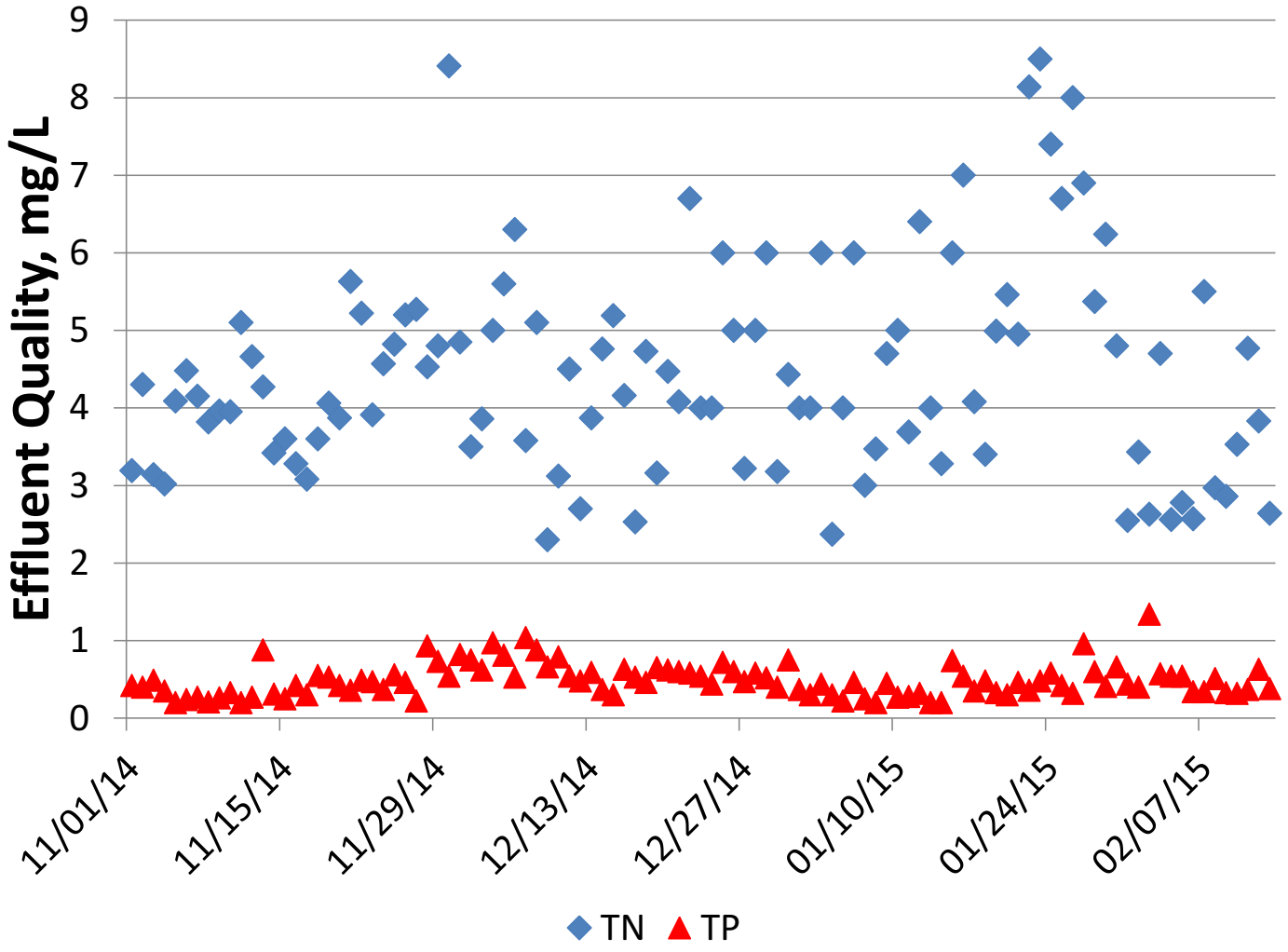


Soluble PO_4-P Profile

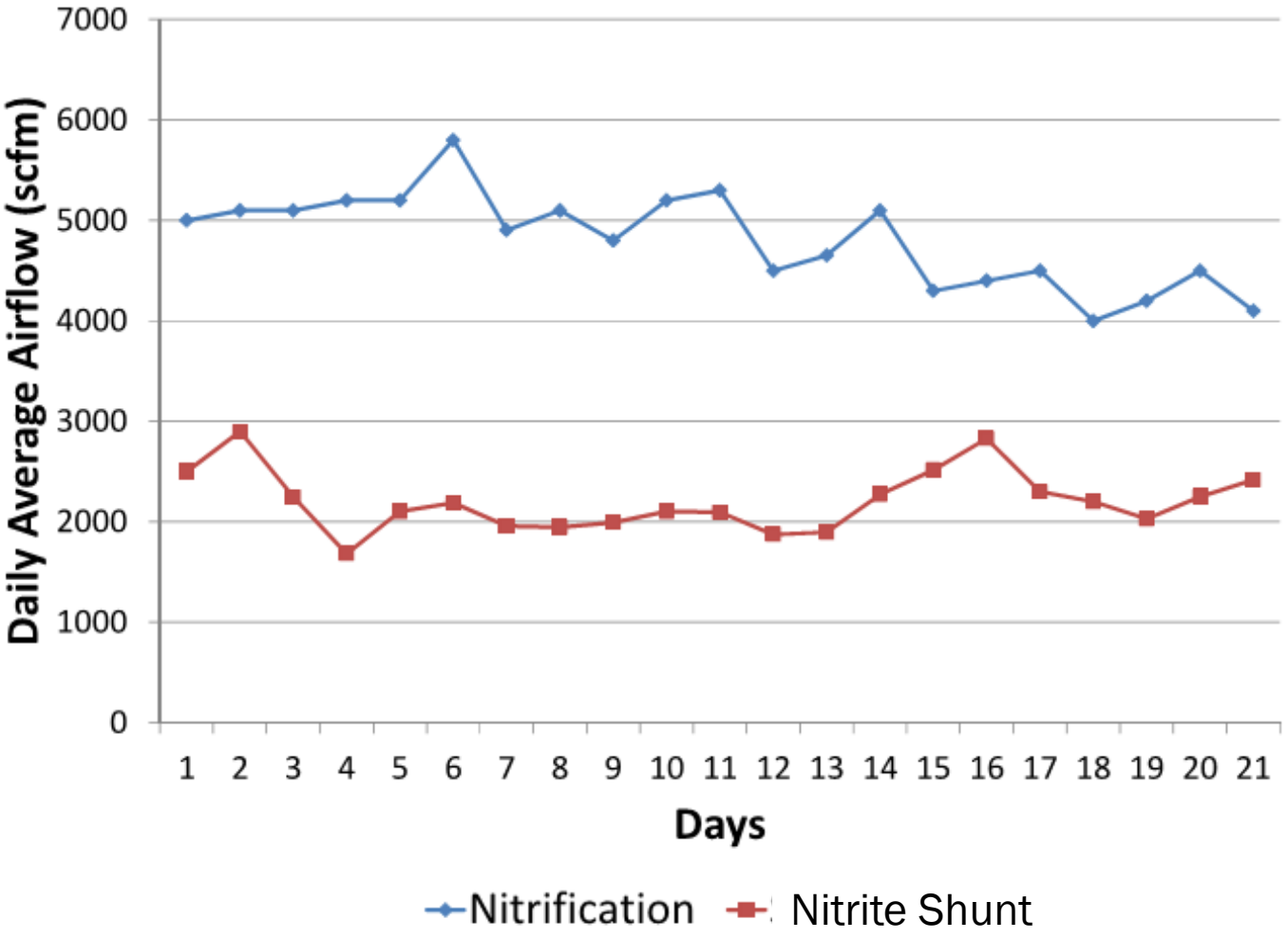




Final Effluent TN and TP



Aeration Comparison



Final Thoughts

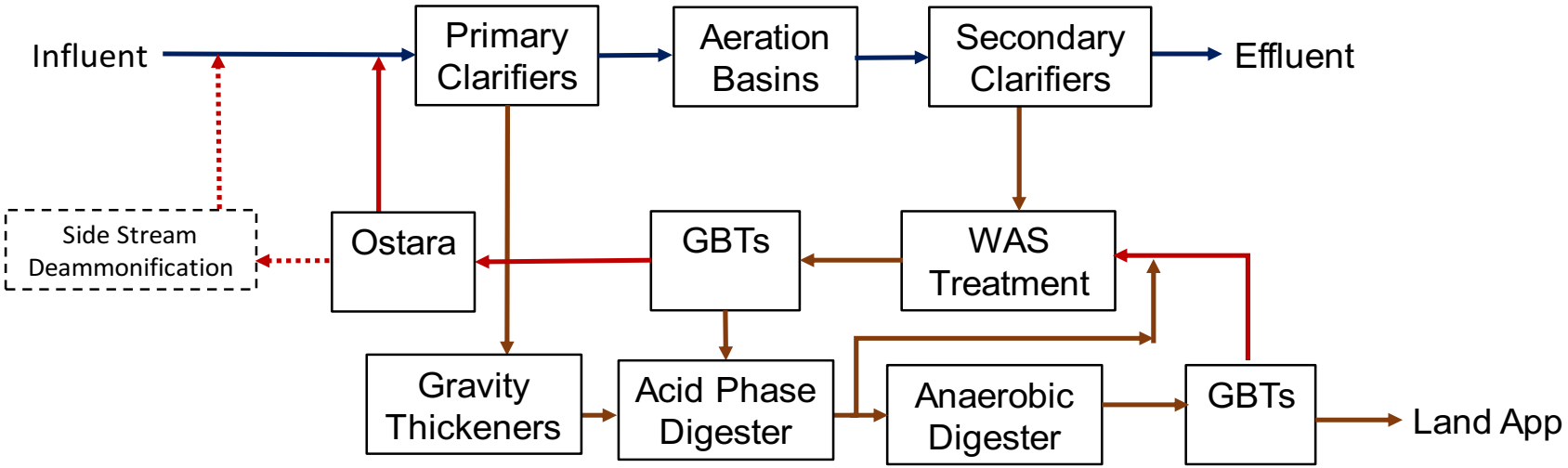
- Good N and P removal performance achieved at low DO operation
- Testing showed significant NOB suppression
- Very simple A/O process (RAS only; no IMLR)
- Simple control strategy
- 50% reduction in airflow

Madison Nine Springs WRF

Conventional vs Mainstream Nitrite Shunt

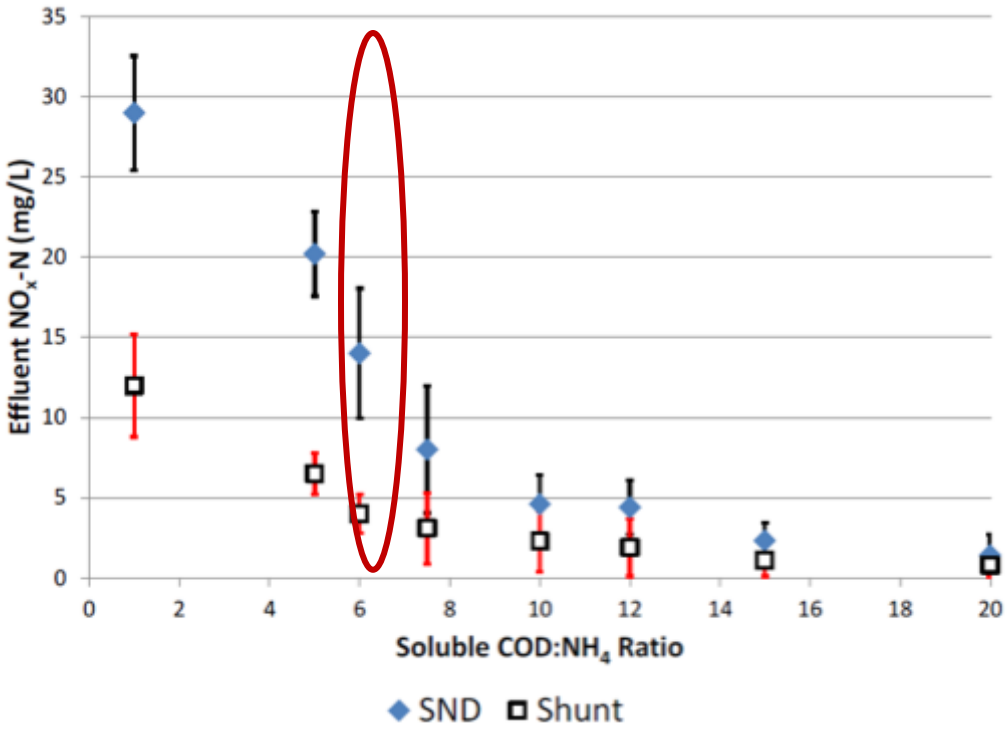
Brown AND Caldwell

Conventional vs Nitrite Shunt

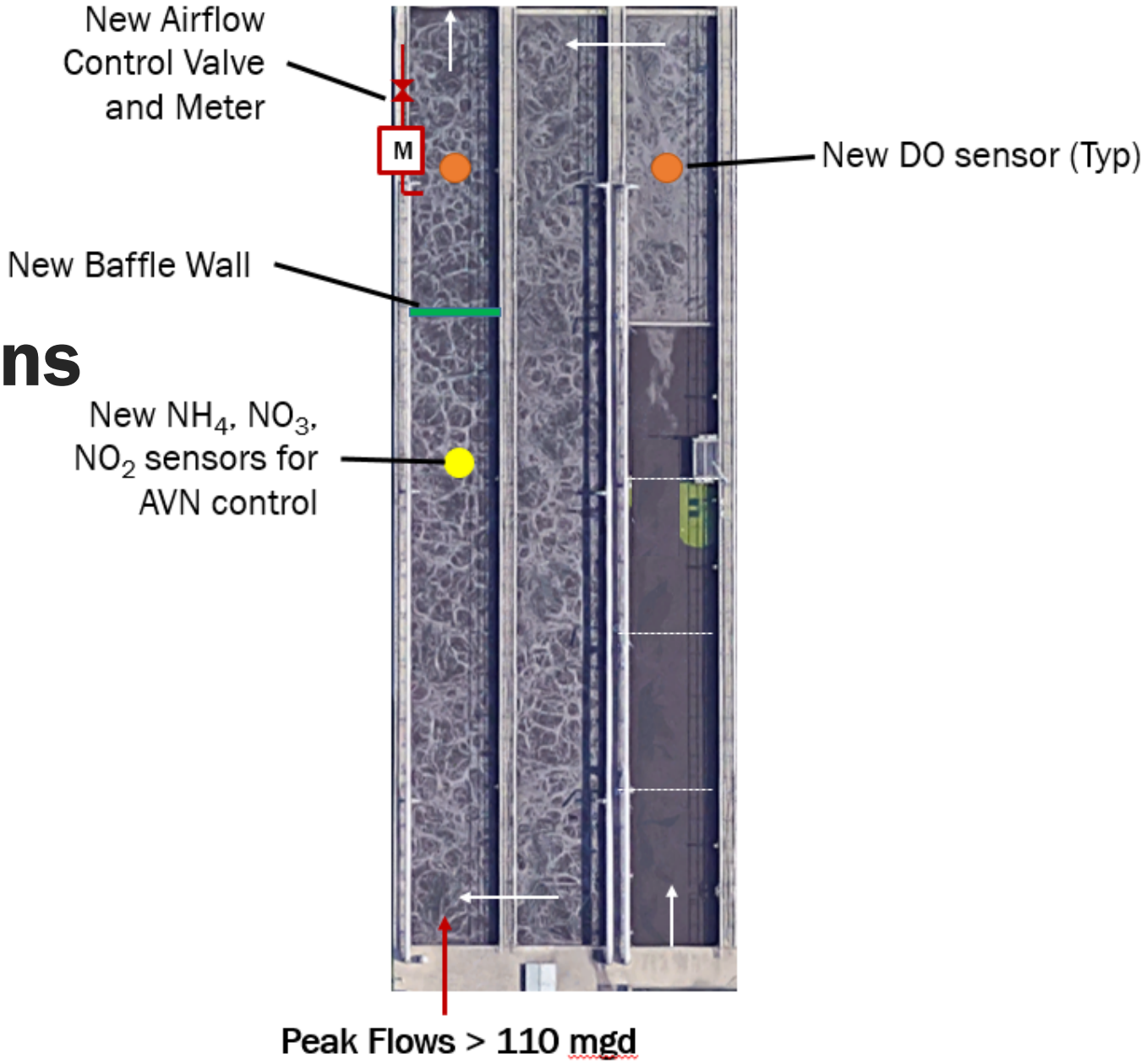


Madison Nine Springs WRF

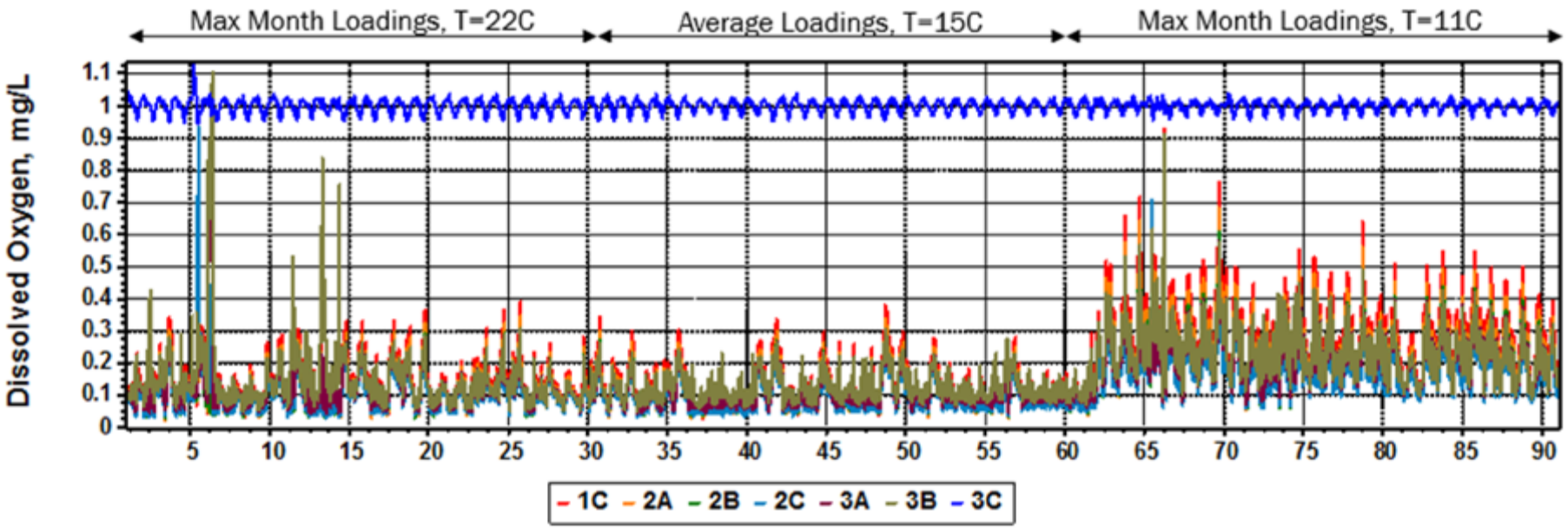
- Design Flow = 60 MGD
- Influent TKN ≈ 45 mgN/L
- TP ≈ 6 mgP/L
- SRT = 10 days
- Temp. = 11 to 20 C
- Target Effluent
  - Total N = 10 mg/L
  - Total P = 0.4 mg/L
  - Full nitrification



Nitrite Shunt Aeration Basin Modifications



Dissolved Oxygen Profile



BNR Alternative Life Cycle Analysis

Item	Alternative Cost, $ Million			
	UCT	UCT with Sidestream Deammonification	Mainstream Nitrite Shunt	CEPT with Nitrite Shunt
Capital Costs	**$22**	**$27**	**$30**	**$31**
Additional Annual Operating Costs				
Blower energy	$0.83	$0.76	$0.50	$0.50
Non-blower energy	$0.10	$0.12	($0.01)	($0.01)
Chemicals	$1.8	$1.5	$0.10	$0.62
O&M Labor	$0.04	$0.10	$0.10	$0.11
Biosolids/energy/ struvite recovery	$0.04	$0.04	($0.15)	$0.05
Total O&M	**$2.8**	**$ 2.5**	**$0.6**	**$1.3**
Present Worth	**$74**	**$74**	**$40**	**$55**

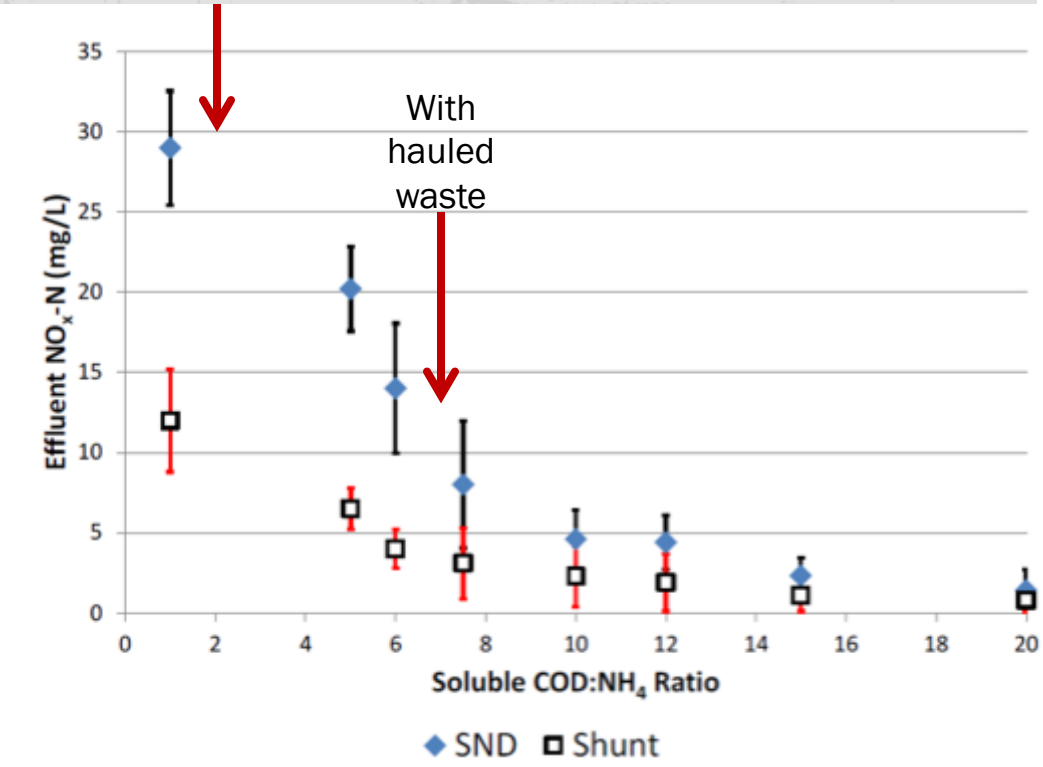
City of Rochester WWTF

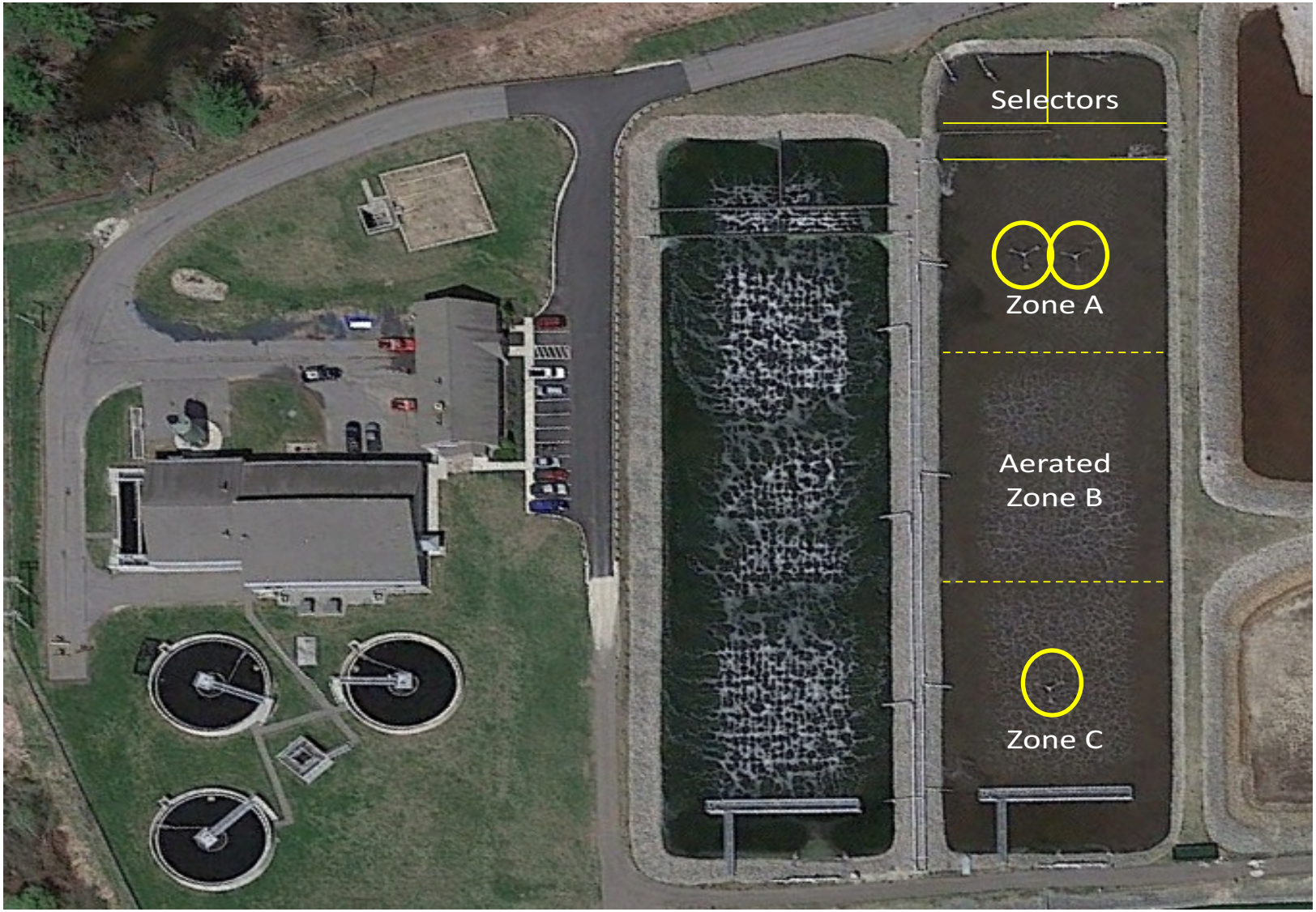
Low DO Operations

Brown AND Caldwell

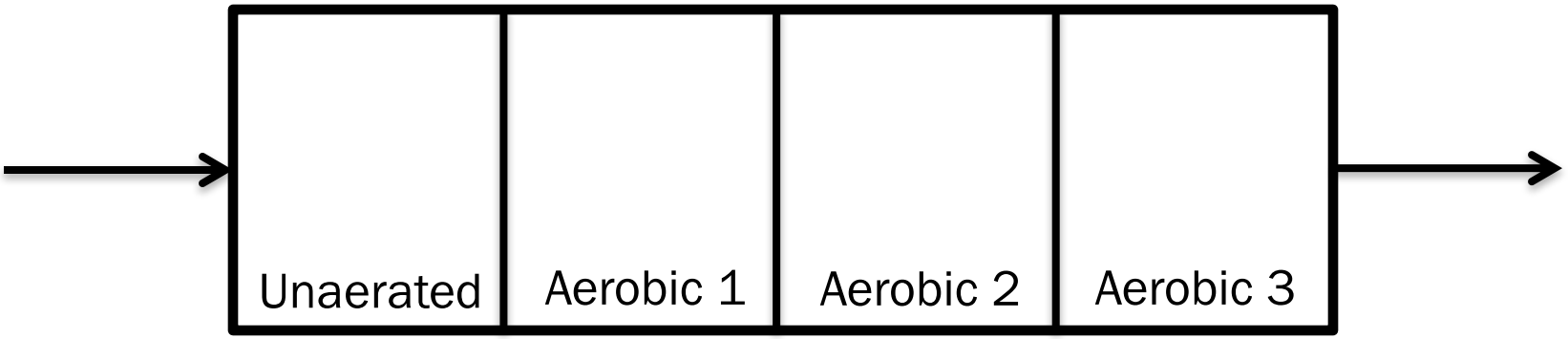
City of Rochester WWTF

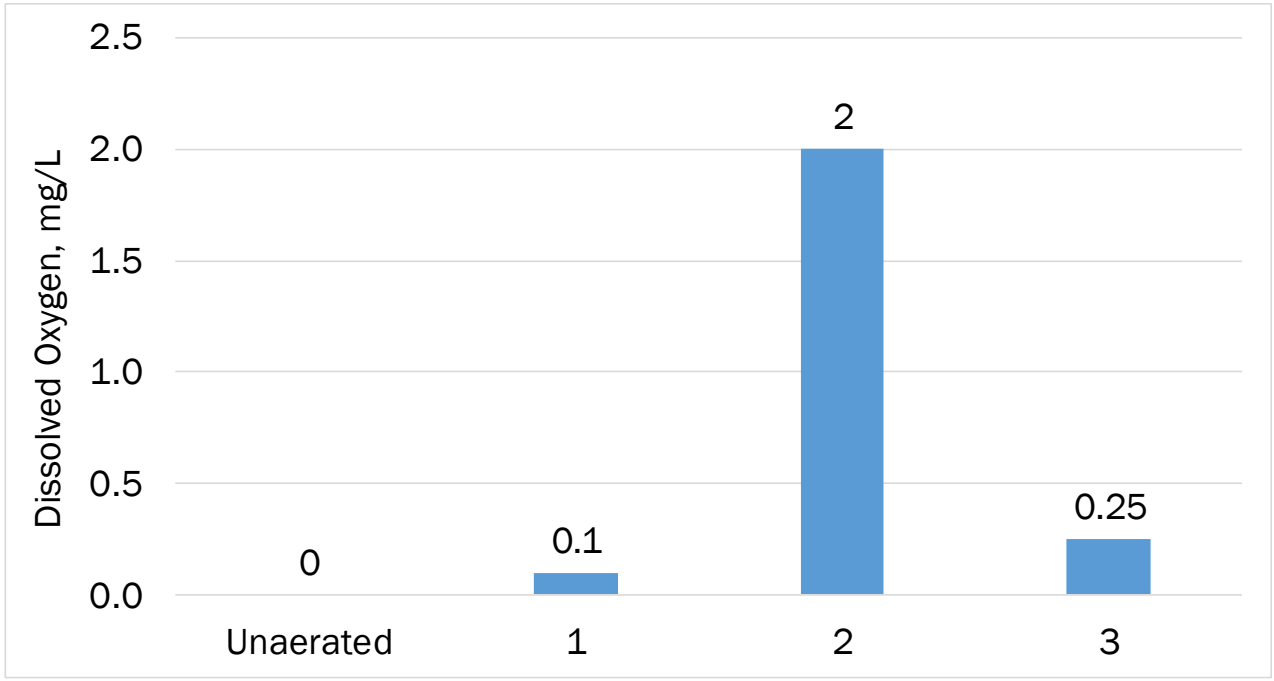
- Current Average Flow = 2.9 MGD
- Influent TKN ≈ 30 mgN/L
- TP ≈ 4 mgP/L
- SRT = 30 days
- Temp. = 6 to 20 C
- Target Effluent
  - Total N = 8 mg/L



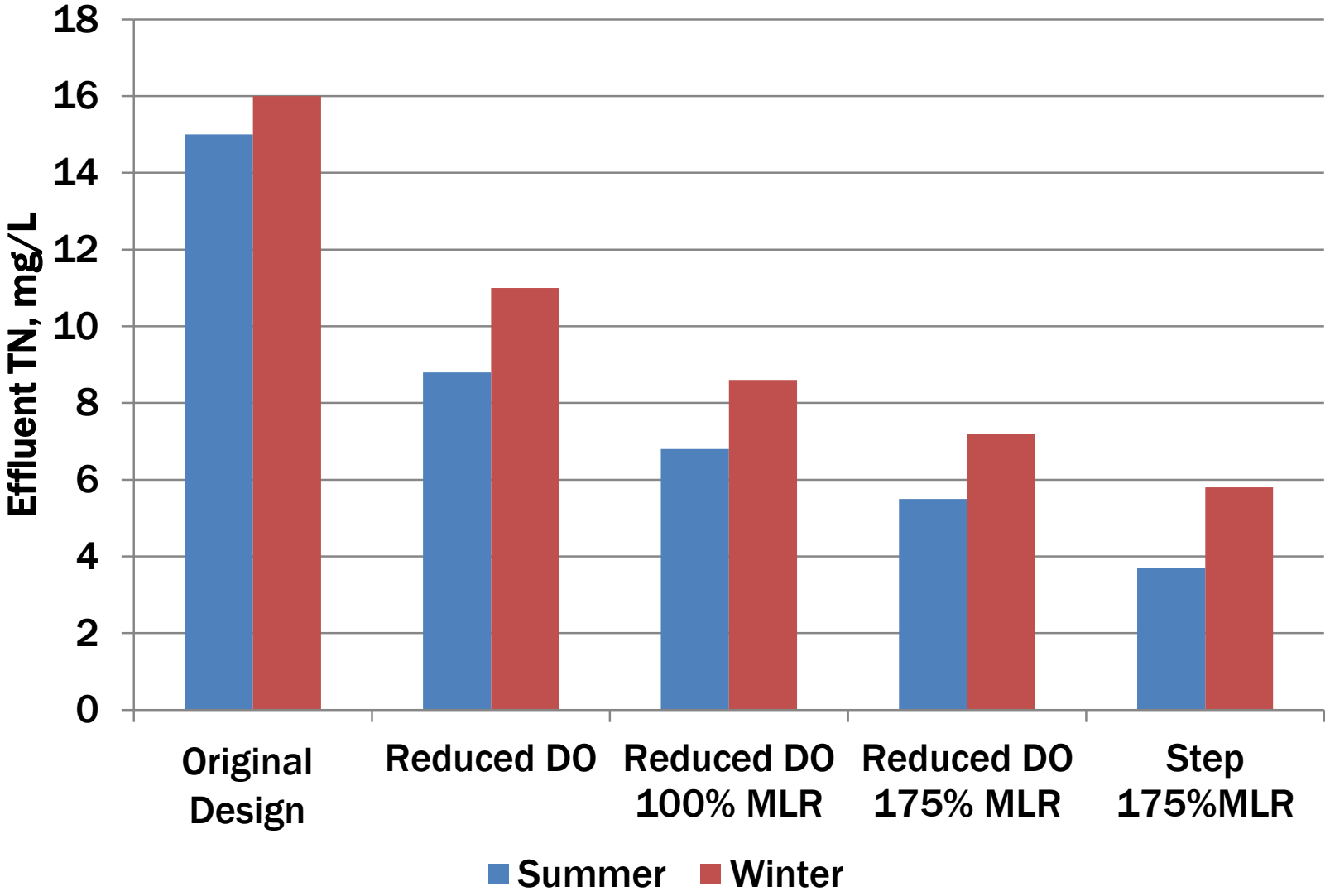

Selectors
Zone A
Aerated
Zone B
Zone C

Dissolved Oxygen Profile





Effluent TN


18
16
14
12
10
8
6
4
2
0
Effluent TN, mg/L
Original Design
Reduced DO
Reduced DO 100% MLR
Reduced DO 175% MLR
Step 175%MLR
Summer
Winter

Rochester Big Picture

- Effluent TN < 10 mgN/L
- Effluent TP< 1.0 mg/L
- Annual power costs reduced by ≈ 50%
- Alkalinity addition(soda ash) reduced by ≈ 50%
- Sludge quality (SVI) not impacted by low DO

Questions & Discussion

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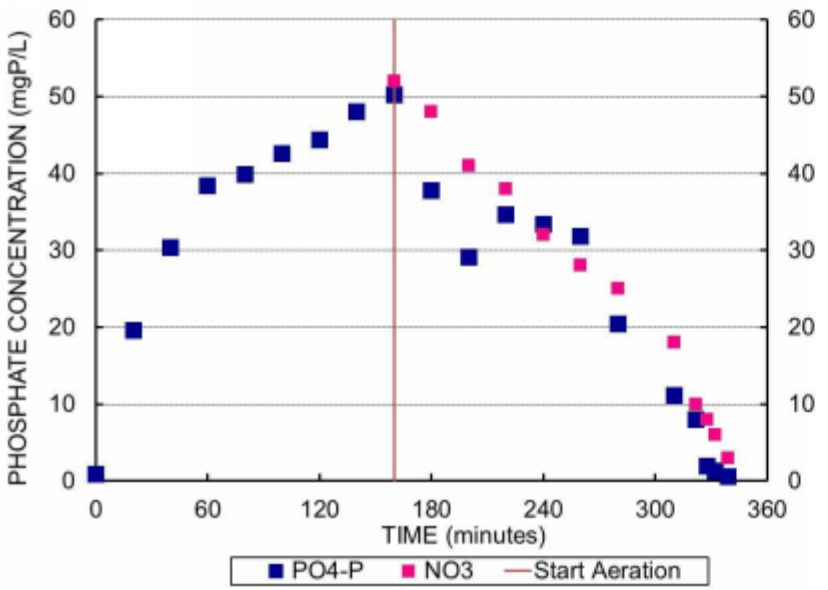
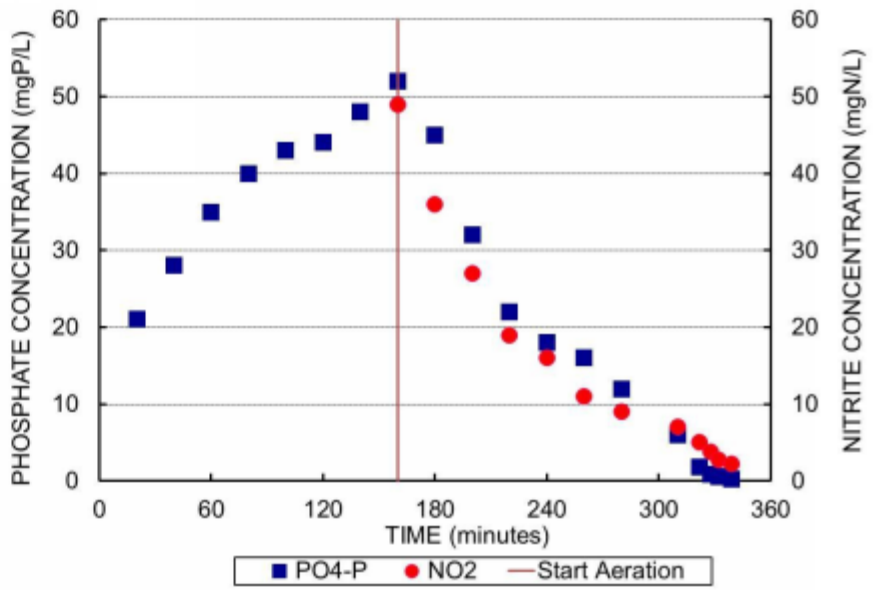
Brown AND Caldwell

Phosphorus Release and Uptake Tests





PRU #	DO (mg/L)	Max P-Uptake Rate (mgP/gVSS/hr)	Max P-Release Rate (Ac) (mgP/gVSS/hr)
NO_2	0 then 0.3	4.01	13.21
NO_3	0 then 0.3	3.30	16.89