


Retrofitting an Aeration Basin with Anoxic Zone to Reduce Operations Cost and Improve Performance

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Case Study – Mount Vernon WWTP

- Project Background
- Retrofit Ideas
- Model
- Implementation
- Reality Check
- Design & Construction
- Conclusion

Background

- The City of Mount Vernon is located approximately half way between Everett and Bellingham in Washington State.
- Largest community in Skagit County.
- Draper Valley Farm is the largest industrial customer (15-20% of loading).

Mount Vernon
Wastewater Treatment Plant - Before Upgrade

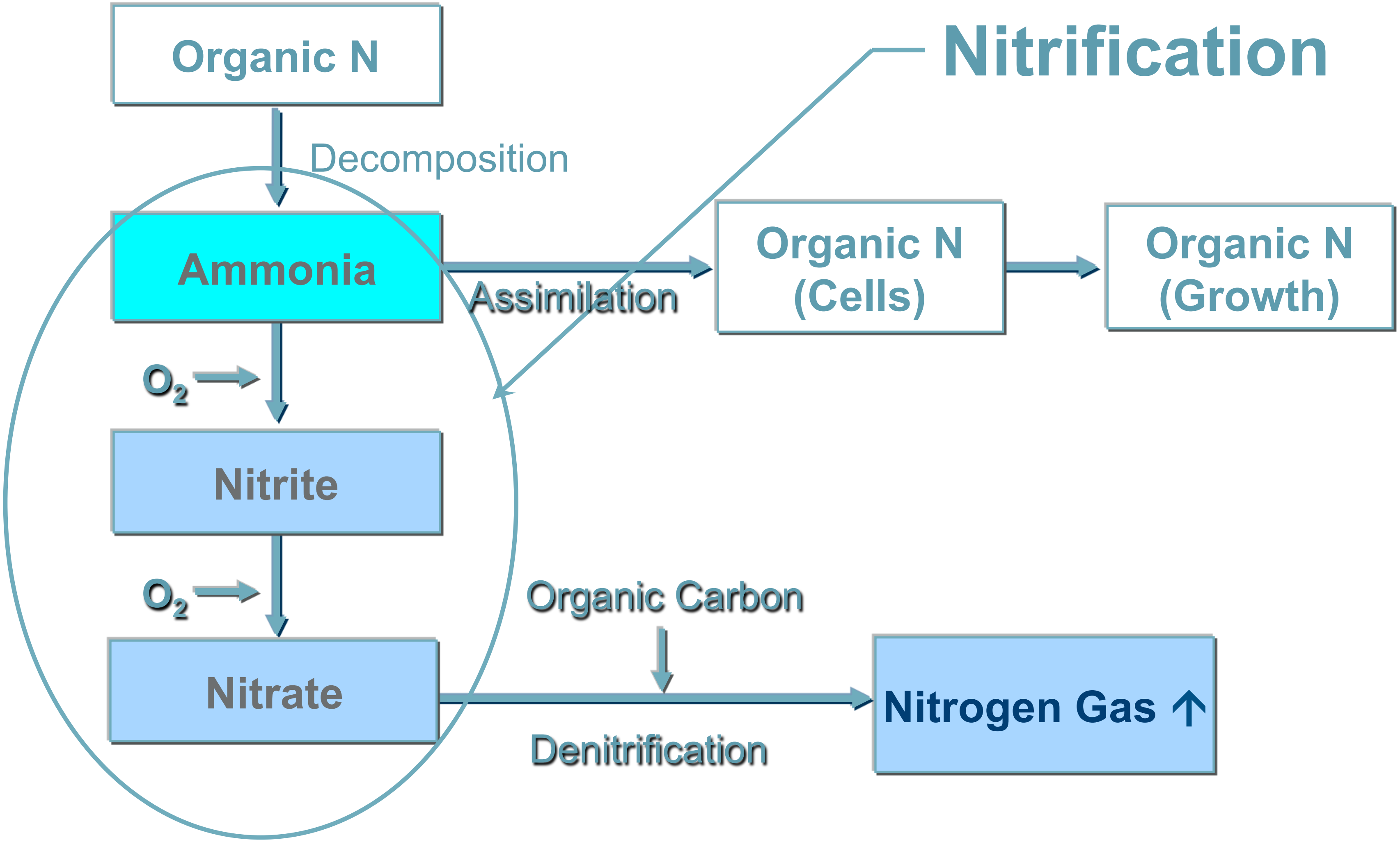
Wastewater Treatment Plant

- Provides secondary treatment utilizing the activated sludge process. This process is more flexible than others (trickling filters for example) in adapting to changes, such as nutrient removal.
- Originally designed for TSS and BOD removal only
- Began partial nitrifying in 2001

Why Nitrify?

- Required by new permit
- Difficult to avoid in summer
- Develop data for plant upgrade design
- Operator interest

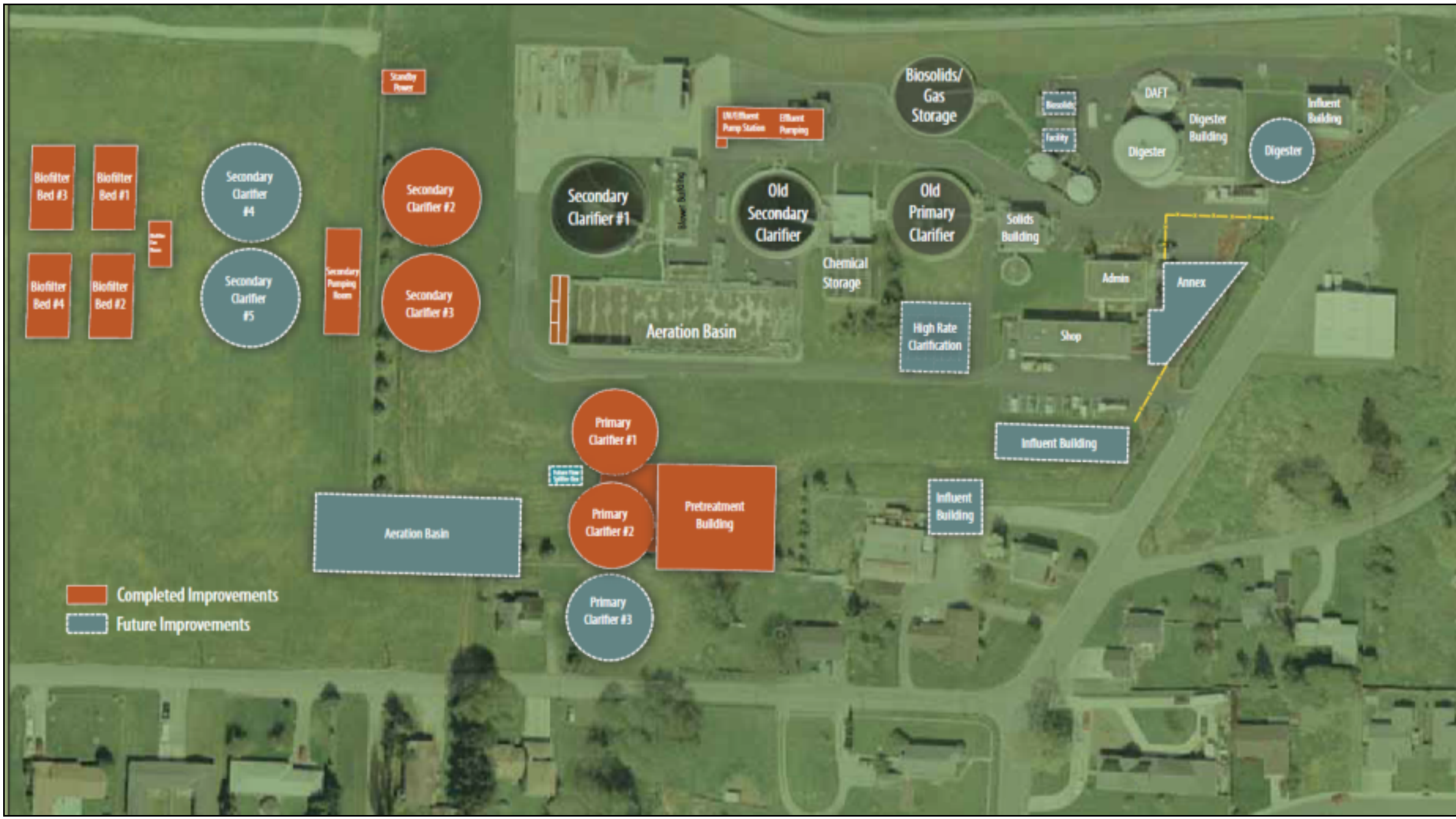
Nitrogen Transformations



Wastewater Treatment Plant Capacity

- Average day design flow of 5.6 MGD
- Peak design flow of 12.0 MGD

Future Expansions
Increase Plant Capacity from 10.8 MGD to 16.4 MGD



Aeration Basin Influent

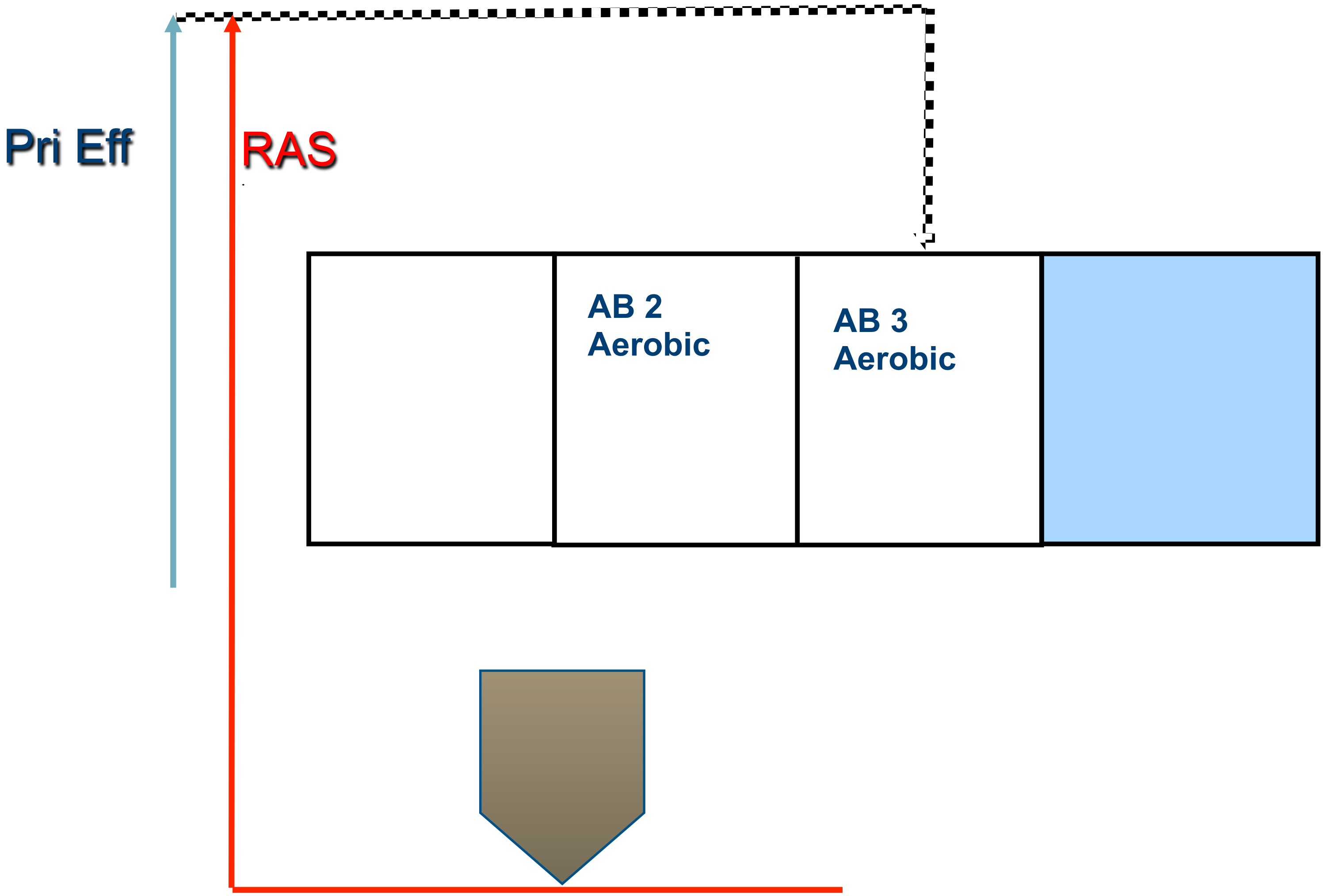
Parameter	Unit	Summer
Flow	MGD	2.63
COD	mg/L	265
BOD	mg/L	122
TSS	mg/L	75
TKN	mg/L	45
NH_3	mg/L	30-45
Temperature	^0C	20

NPDES Permit Effluent Average Monthly Limits

- Must try to remove Ammonia from July 1st through October 31st.
- 30 mg/L of BOD_5
- 30 mg/L of TSS
- 200 Fecal Coliform

Activated Sludge Process

Original Design



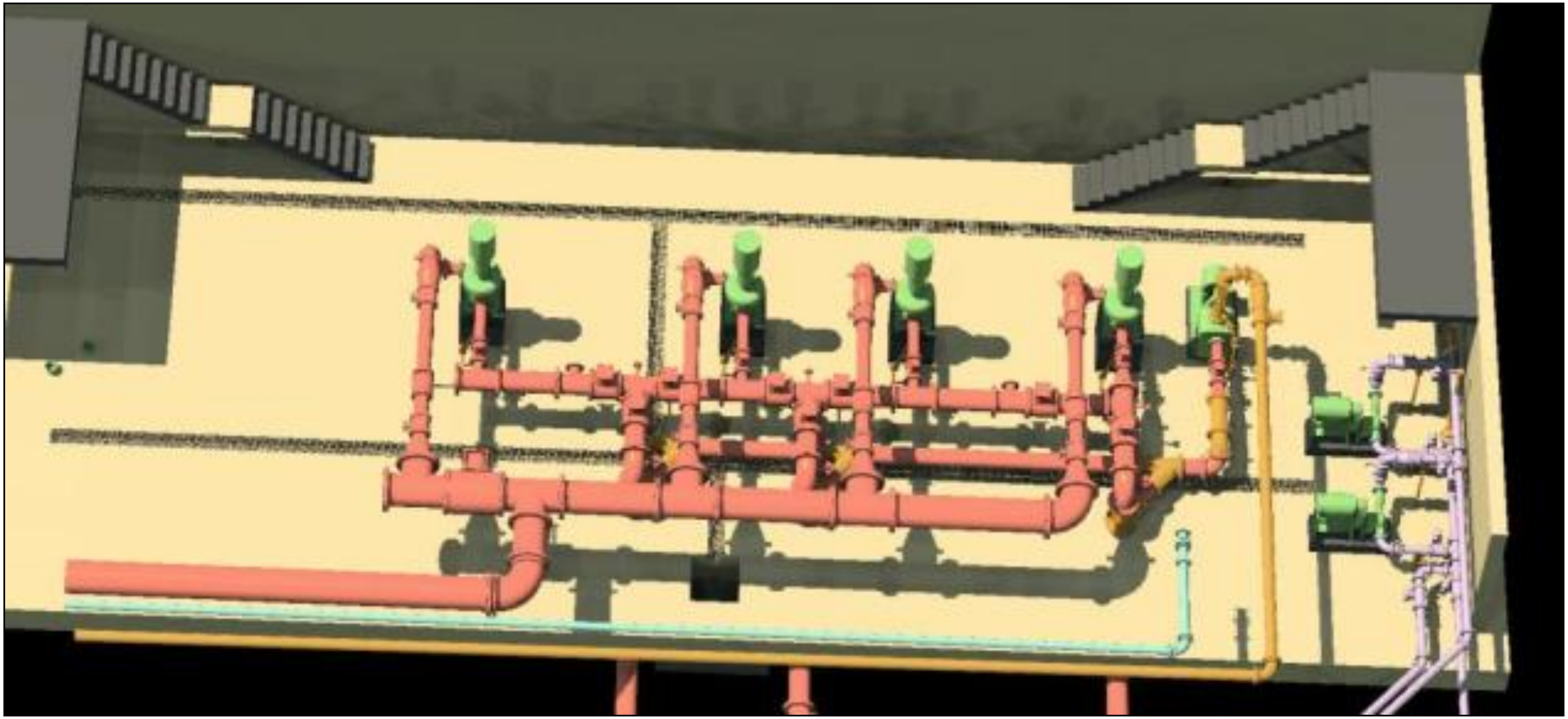
Previous Summer Nitrification Problems

- Floating sludge in clarifiers
- Trying to nitrify to just meet permit limits resulted in nitrite lock
- Nitrite lock - disinfection problems
- Insufficient alkalinity results in low effluent pH

Denitrification in Wrong Place

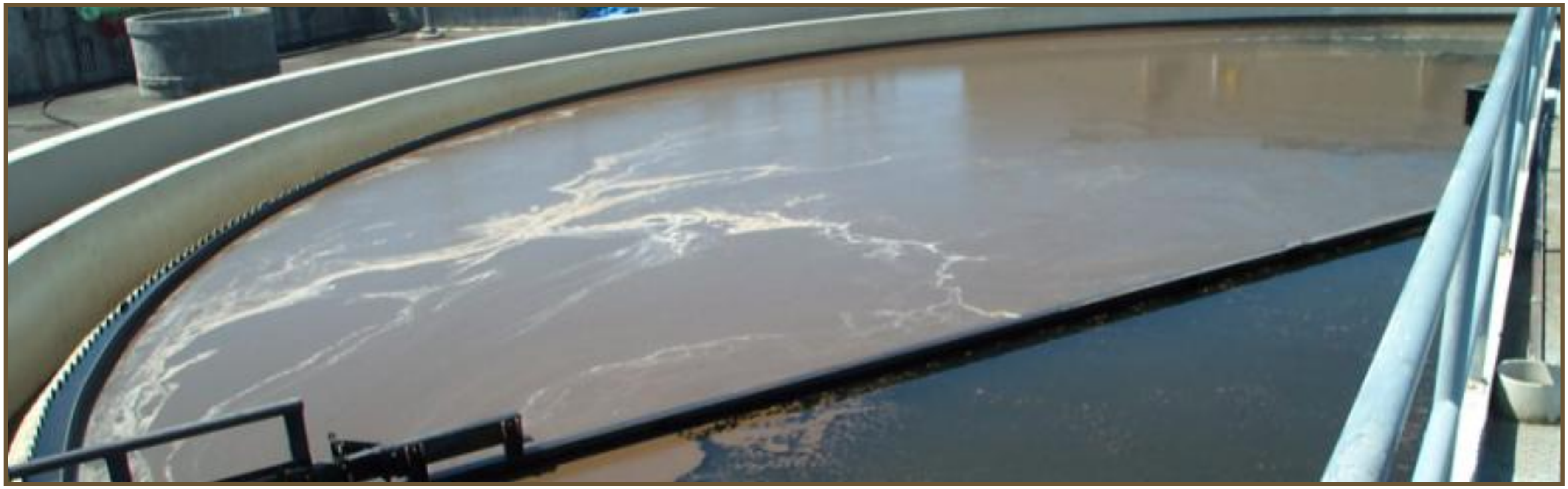
Attempt to Minimize Floating Sludge

- Increase RAS to the maximum to minimize clarifier sludge detention time was not effective

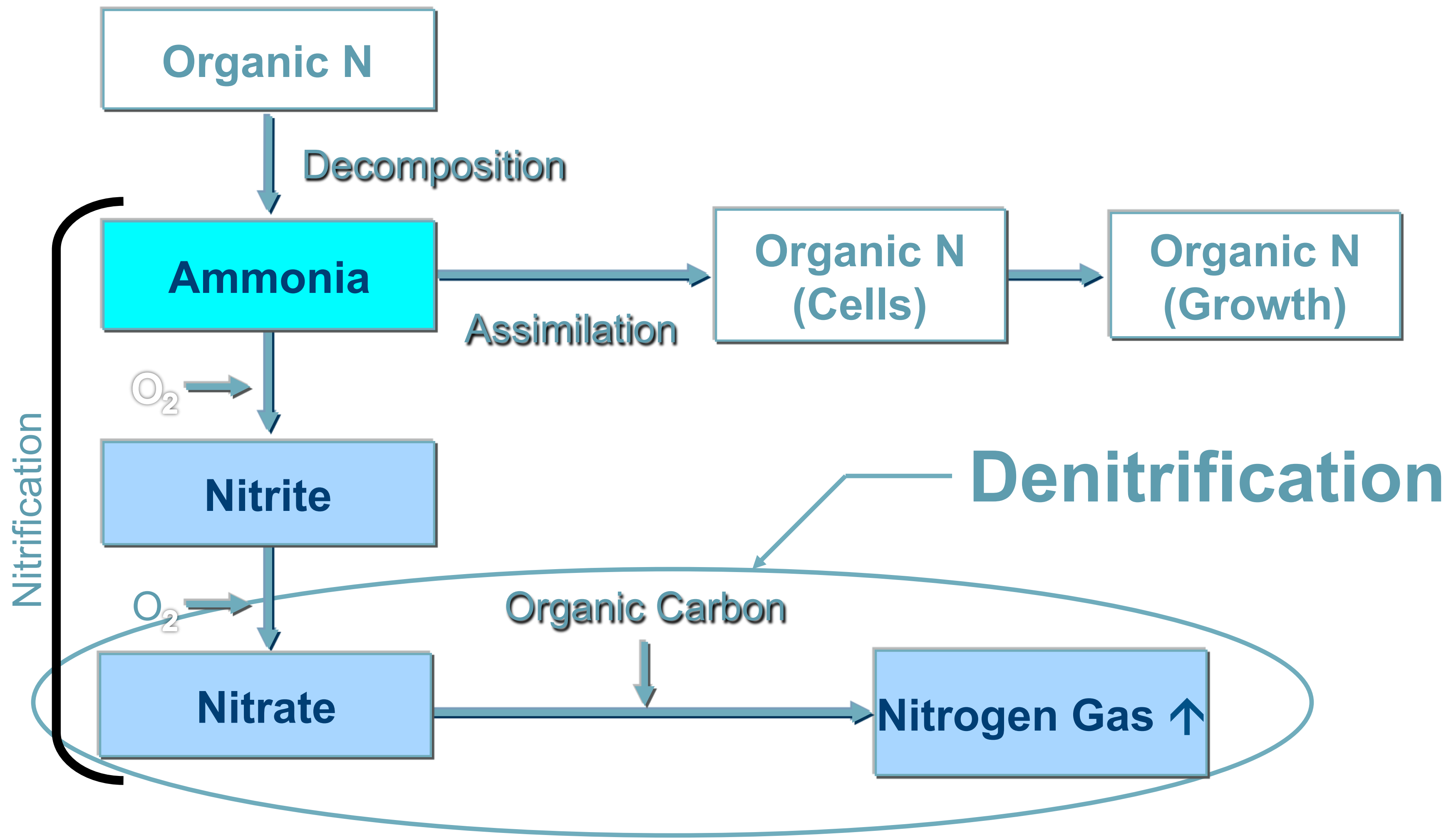


Why Did Sludge Float

- Nitrification converts ammonia to nitrate
- Without oxygen in the secondary clarifiers, nitrates will denitrify producing nitrogen gas
- Gas bubbles float the sludge blanket



Nitrogen Transformations



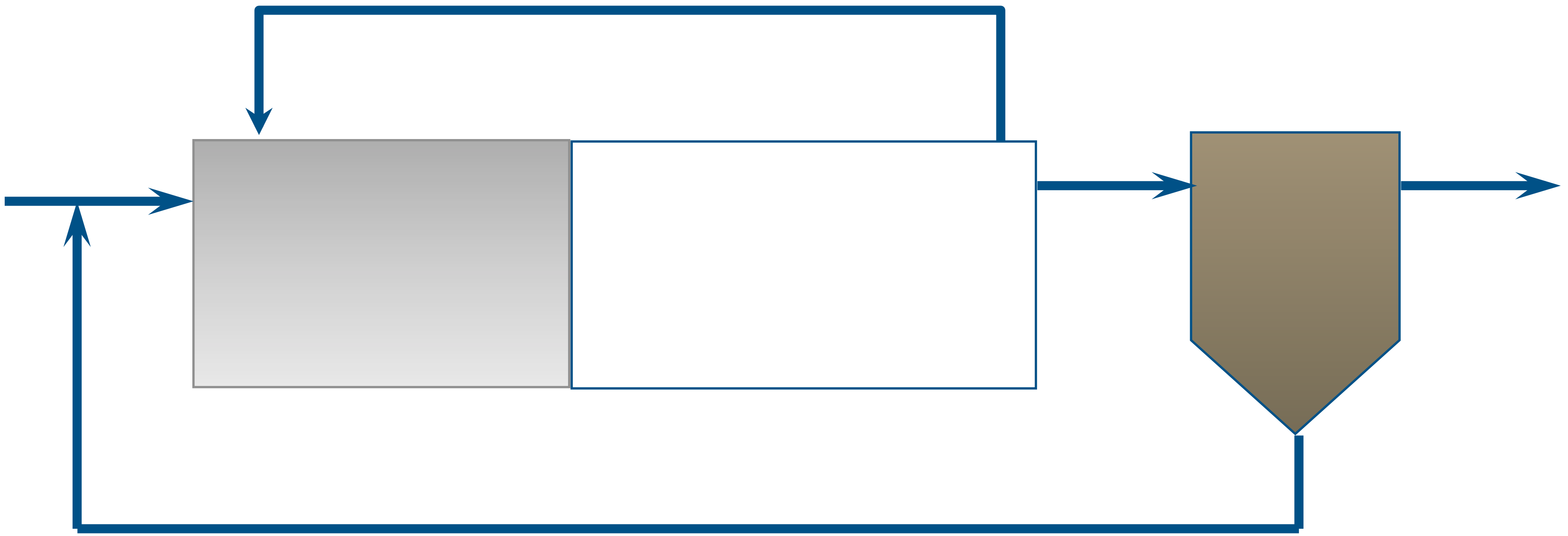
Solving the Problem

- What can be done to prevent floating sludge?
  - Prevent denitrification in secondary clarifier
  - Denitrify somewhere else before nitrate enters clarifier

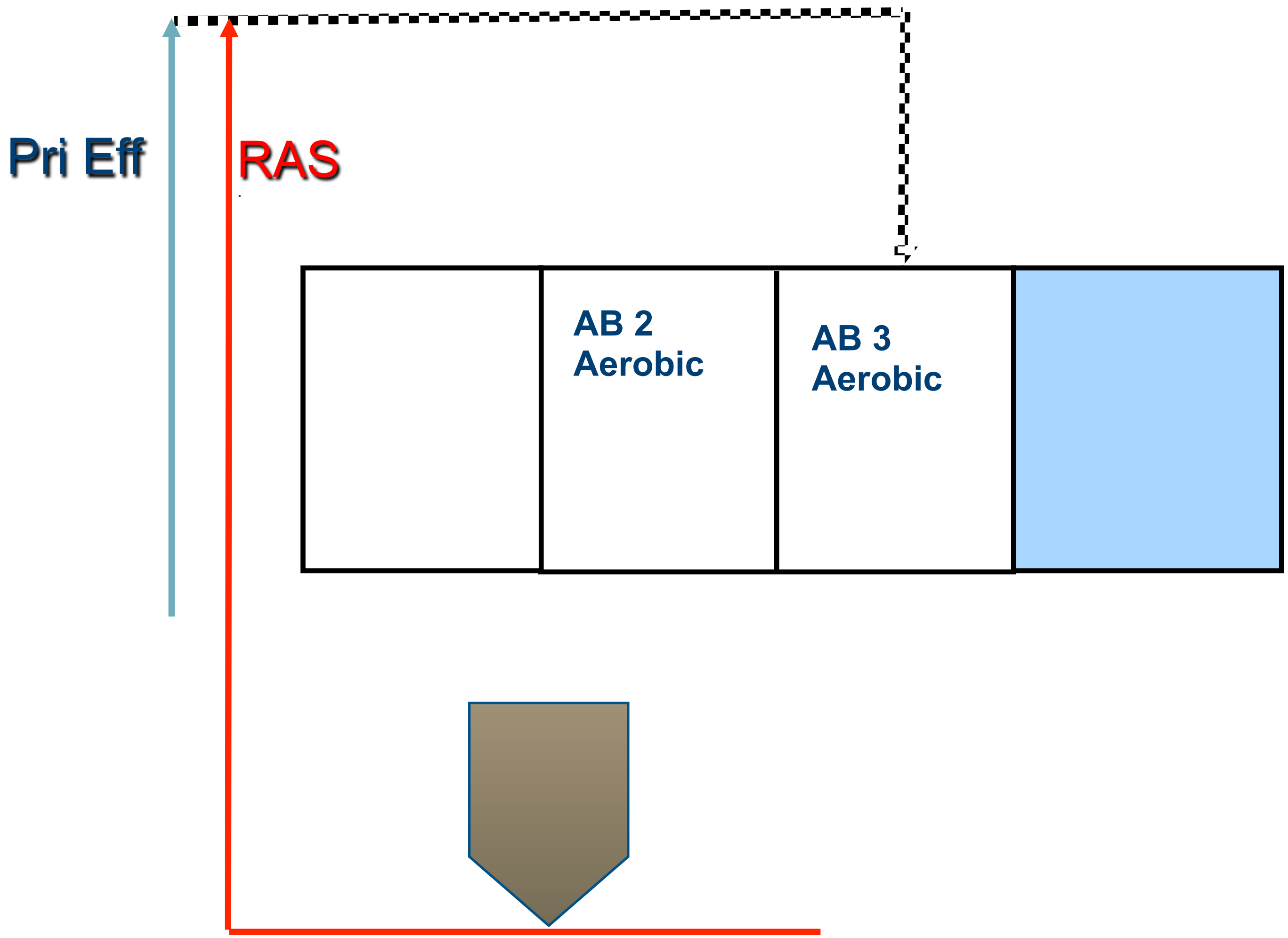
Solving the Problem

- How to remove the nitrate?
  - Create an anoxic zone in the activated sludge basins, pump nitrate rich MLSS to the anoxic zone, provide a carbon source and the biomass will do the rest.

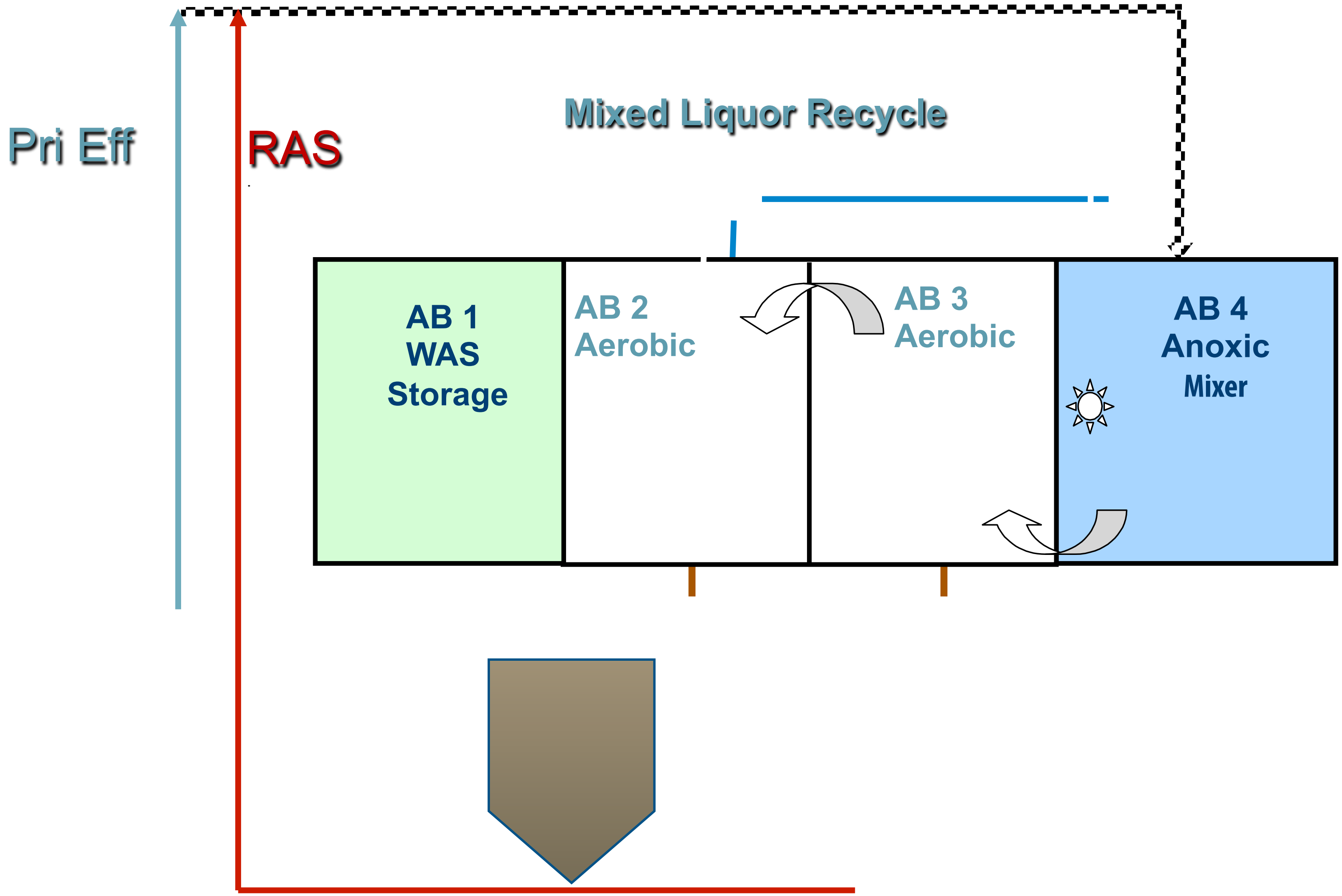
Modified Ludzack Ettinger (MLE) System



Original Design

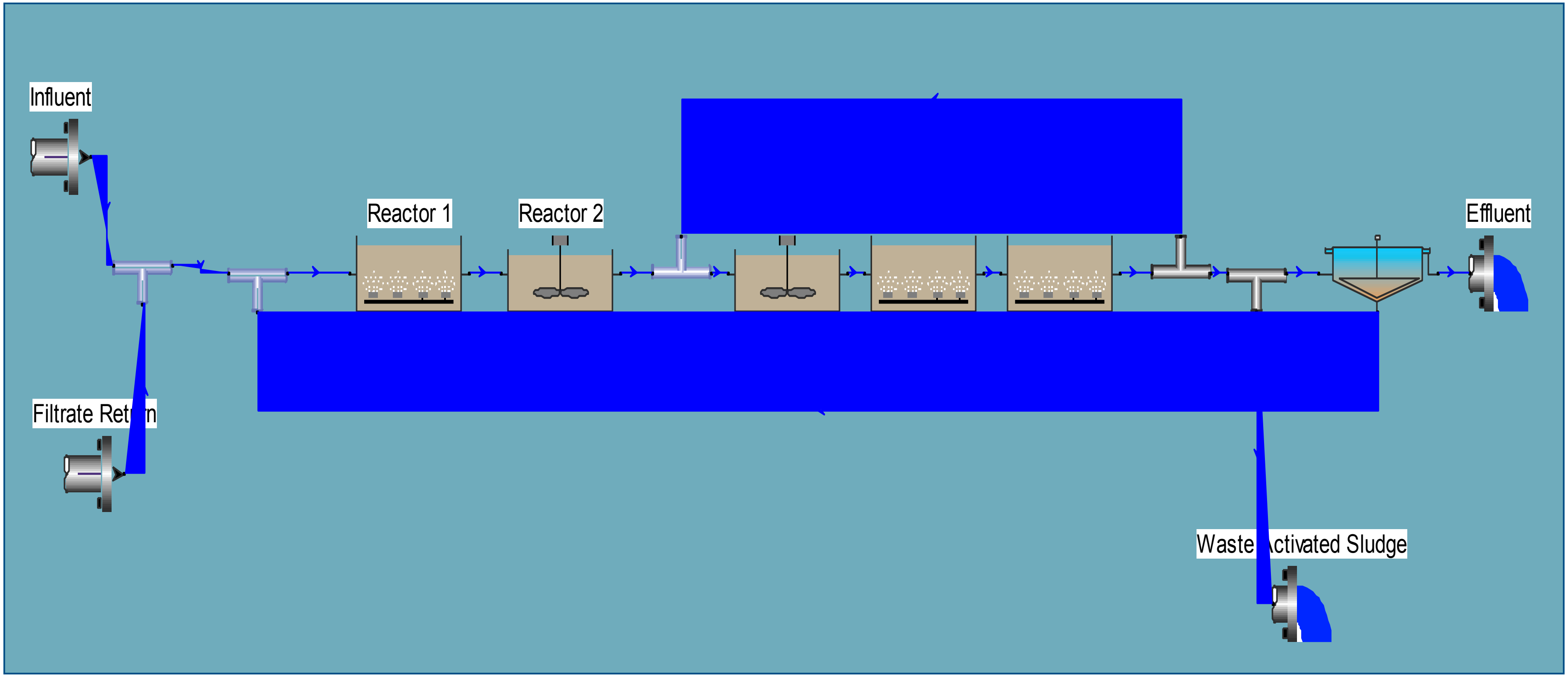


Anoxic Basin Retrofit



Will the Idea Work?

- Before modifications are made, run computer model to determine feasibility – BioWin Model



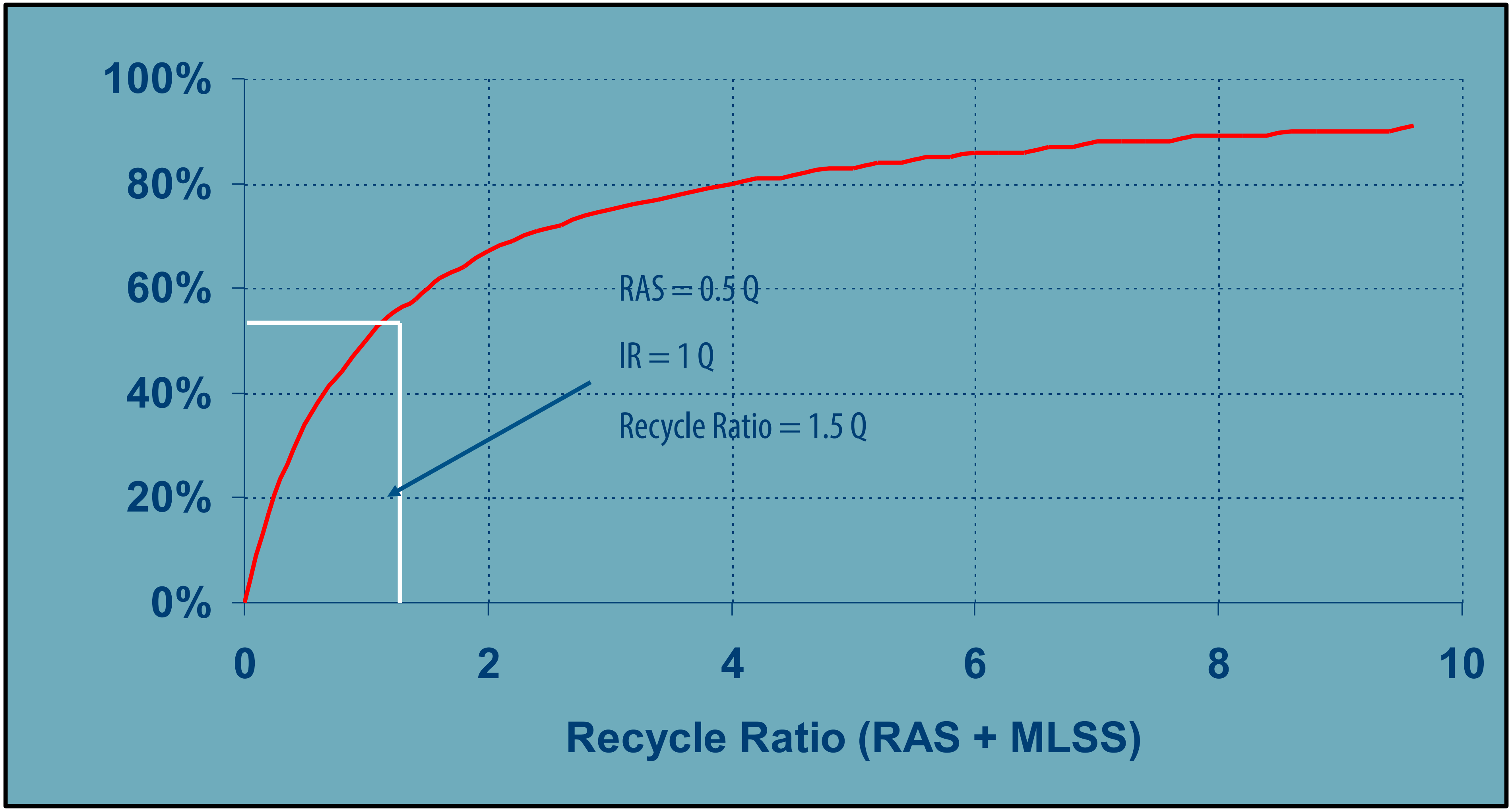
Base Conditions

- 100% Mixed Liquor Recycle (MLR) rate and 50% RAS rate
- Initial reactor D.O. at 2 mg/L (to simulate aeration by screw pumps)
- Sufficient aeration capacity to meet oxygen demand in aerobic reactors

Base Run Output

- Complete nitrification (98% ammonia removal)
- 50% nitrate removal was slightly lower than textbook denitrification performance
- High effluent nitrate (17 mg/l) due to high influent ammonia (36 mg/l)

Denitrification vs. Recycle



Additional Model Observations

- 200% MLR rate resulted in same effluent nitrate concentration
- Modeling a higher influent BOD resulted in much lower effluent nitrate
- Results indicate actual BOD/TKN ratio is too low to achieve theoretical denitrification removal at higher MLR rates

Modeling Conclusions

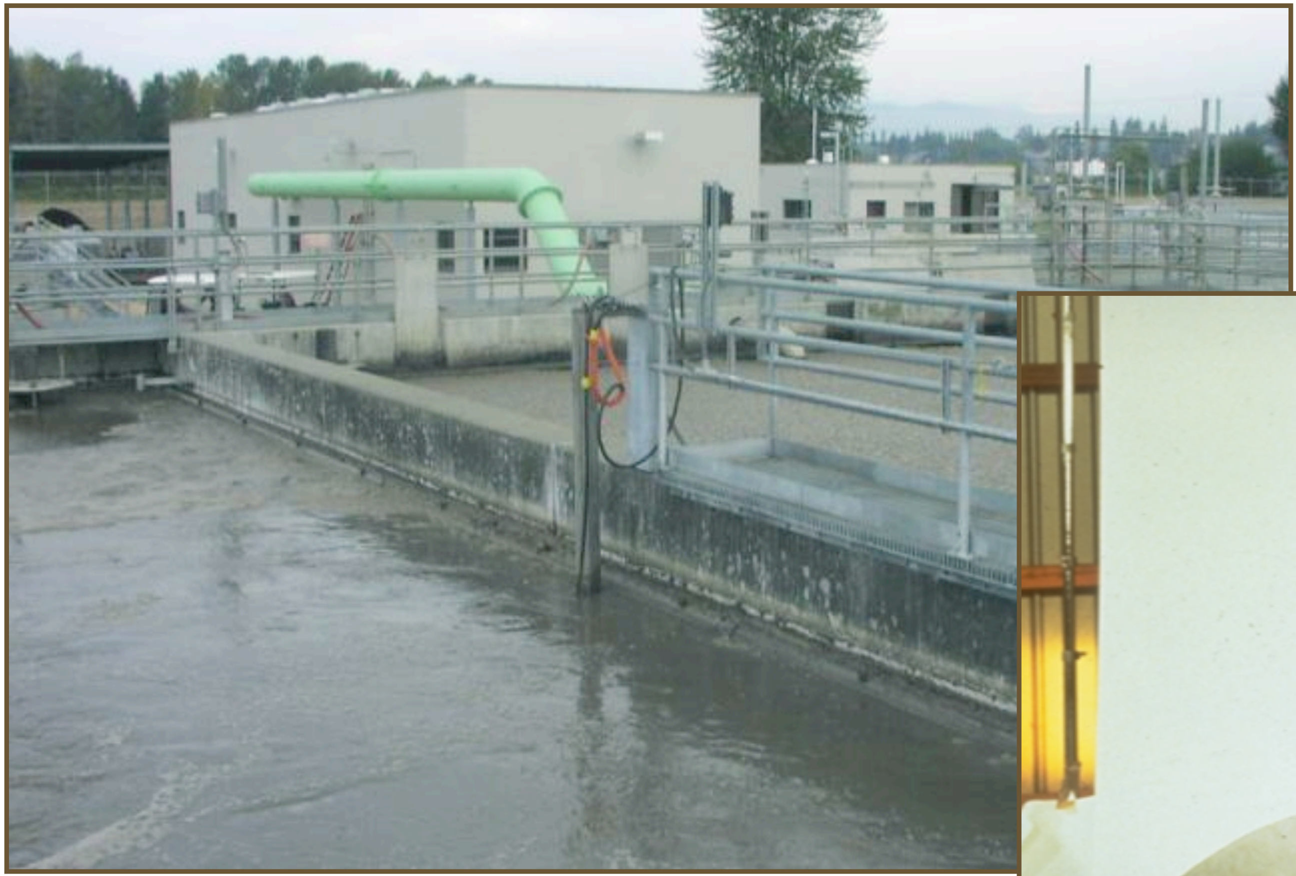
- MLE mode will:
  - Recover alkalinity consumed in nitrification
  - Reduce oxygen demand
  - Result in effluent nitrate 50% lower than operating without denitrification
- Lower effluent nitrate will result in less potential for floating sludge in clarifier
- High influent ammonia relative to influent BOD results in lower denitrification rate
- Thus – proceed with implementation!

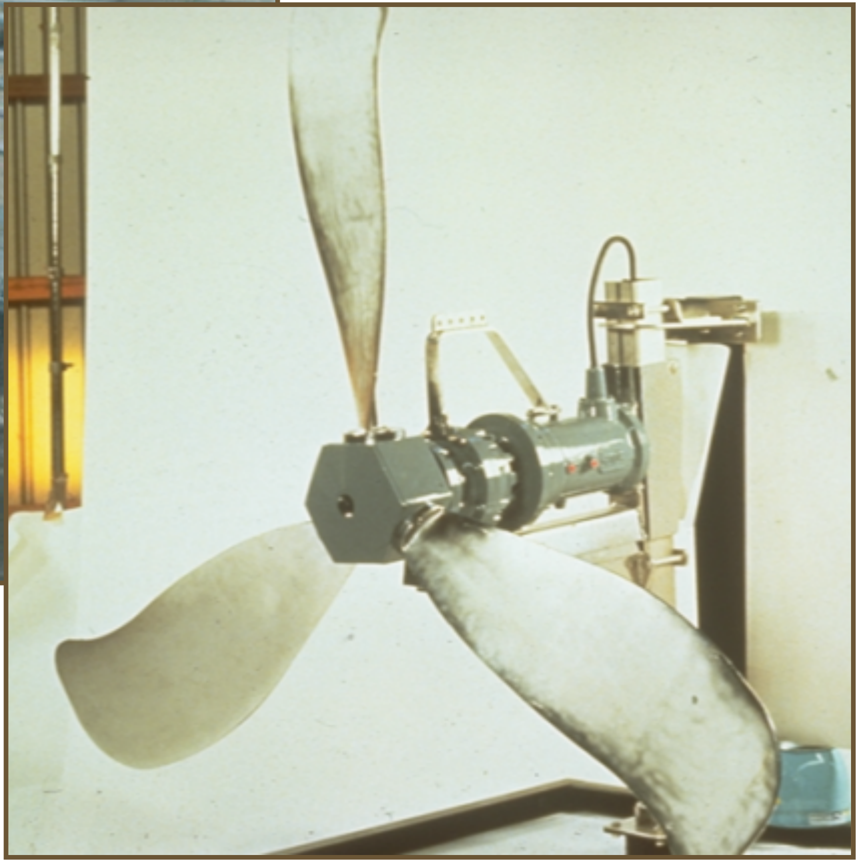
Economic Retrofit

- Use spare vertical turbine pump
- Use existing basins
- Purchase Flygt submersible mixer
- Equipment/piping installed by plant staff
- Modifications completed in June 2003

MLR Pump

Anoxic Basin Mixer

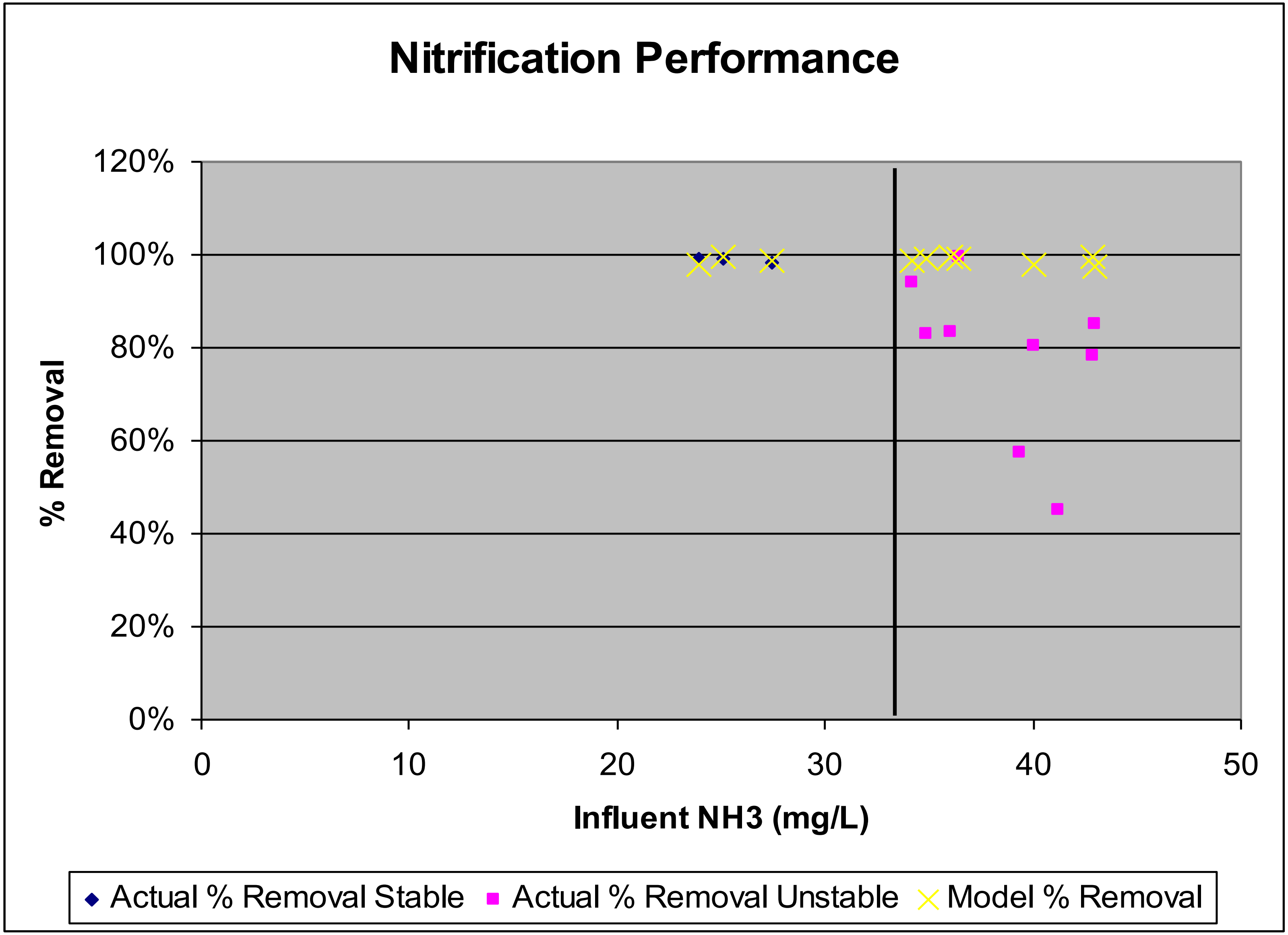


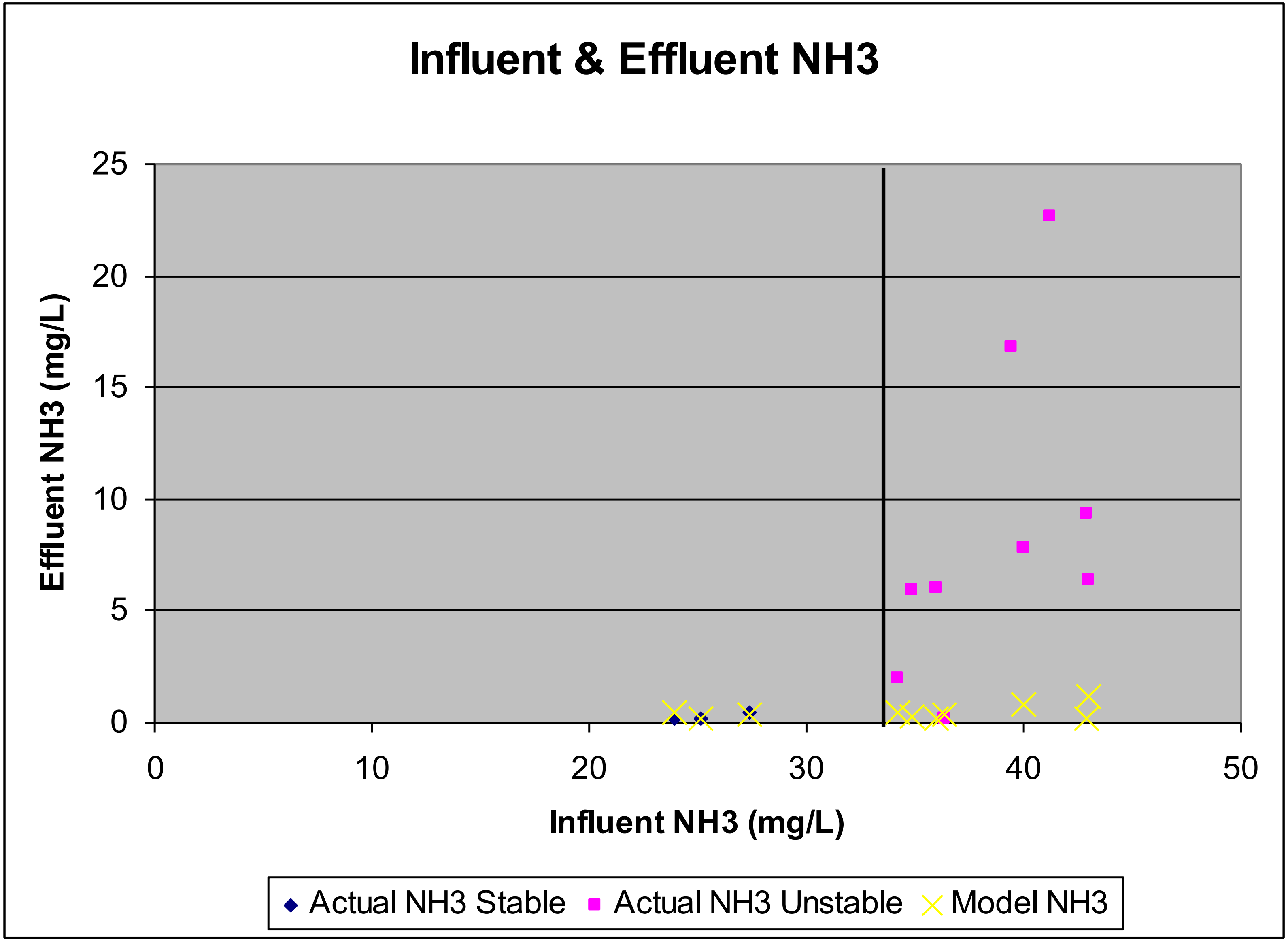


Reality Check

- Additional sampling and analysis conducted
- Actual influent parameters used in additional model runs
- Compare real life performance to model prediction

Nitrification Performance





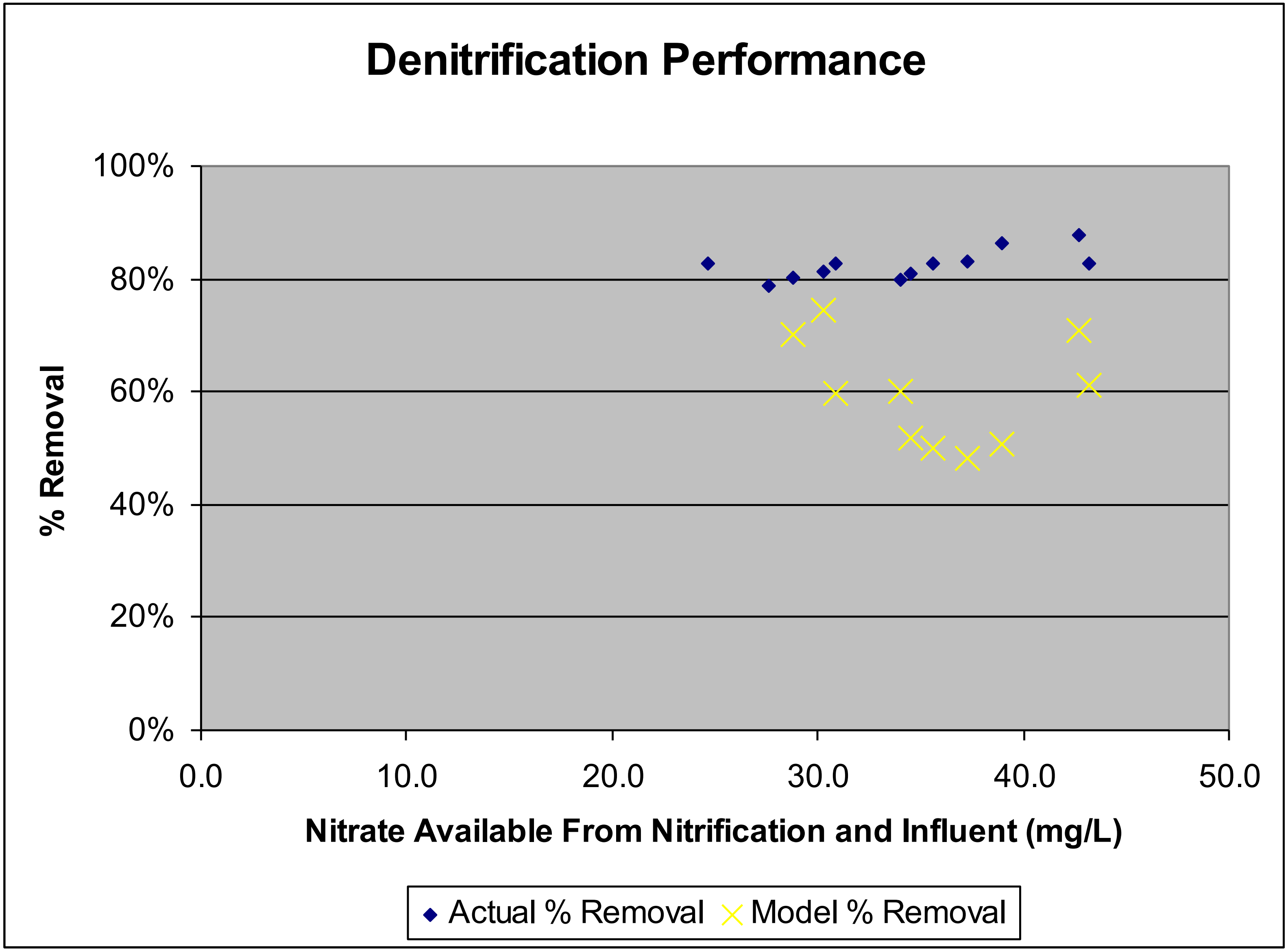
Influent & Effluent NH3
Effluent NH3 (mg/L)
25
20
15
10
5
0
0
10
20
30
40
50
Influent NH3 (mg/L)
Actual NH3 Stable
Actual NH3 Unstable
Model NH3

Comparison of Nitrification

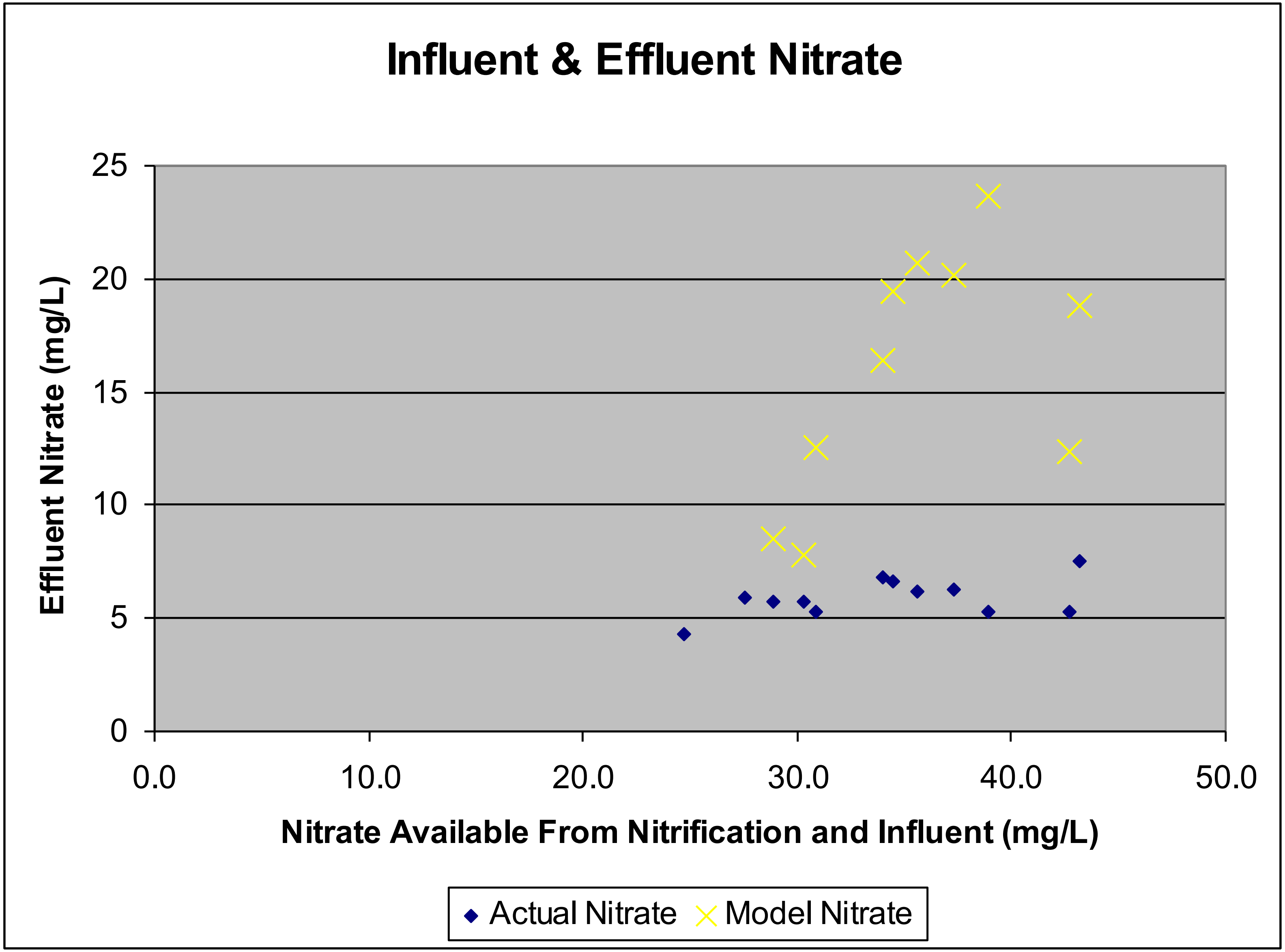
- Real life data indicates unstable nitrification at influent ammonia level higher than approximately 34 mg/L
- Computer model predicts complete nitrification for the same range of influent ammonia concentrations

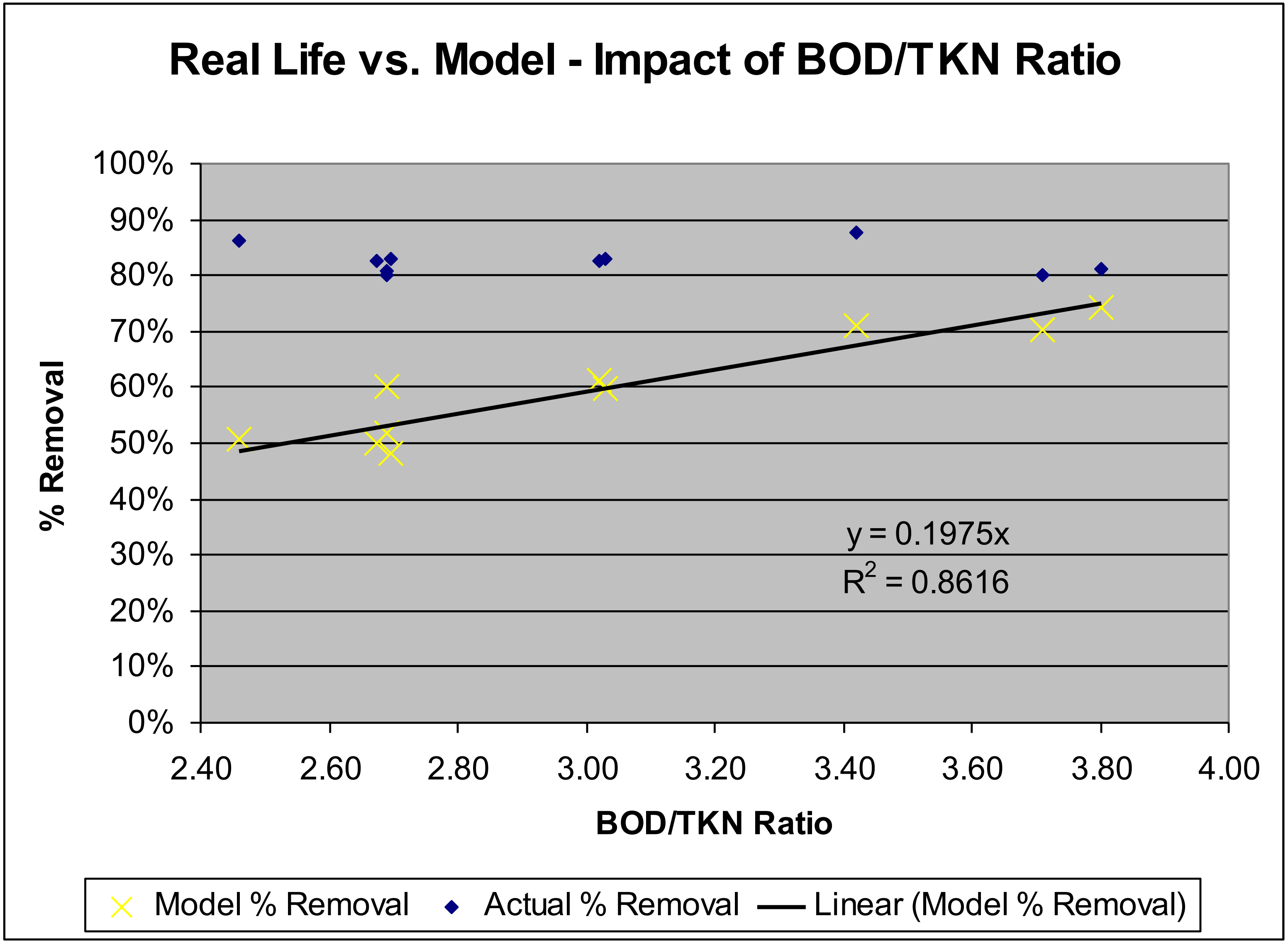
Potential Reason

- Plant staff reported occasional difficulty maintaining sufficient D.O. (2 mg/L) in first aeration basin. Model assumes sufficient aeration at all times
- Implication – further work required to assess aeration capacity and fine tune controls



Denitrification Performance
100%
80%
60%
40%
20%
0%
% Removal
0.0
10.0
20.0
30.0
40.0
50.0
Nitrate Available From Nitrification and Influent (mg/L)
Actual % Removal
Model % Removal


Influent & Effluent Nitrate
Effluent Nitrate (mg/L)
25
20
15
10
5
0
0.0
10.0
20.0
30.0
40.0
50.0
Nitrate Available From Nitrification and Influent (mg/L)
Actual Nitrate
Model Nitrate


Real Life vs. Model - Impact of BOD/TKN Ratio
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Removal
y = 0.1975x
R2 = 0.8616
2.40
2.60
2.80
3.00
3.20
3.40
3.60
3.80
4.00
BOD/TKN Ratio
Model % Removal
Actual % Removal
Linear (Model % Removal)

Comparison of Denitrification

- Real life data indicates 80% nitrate removal for BOD/TKN ratio from 2.5 to 3.8.
- Actual nitrate removal meets theoretical maximum value even though BOD/TKN ratio is too low (< 4.0).
- Hypothesis – model kinetic parameters based on domestic wastewater. Industrial contribution (23% of plant flow) may change dynamics.

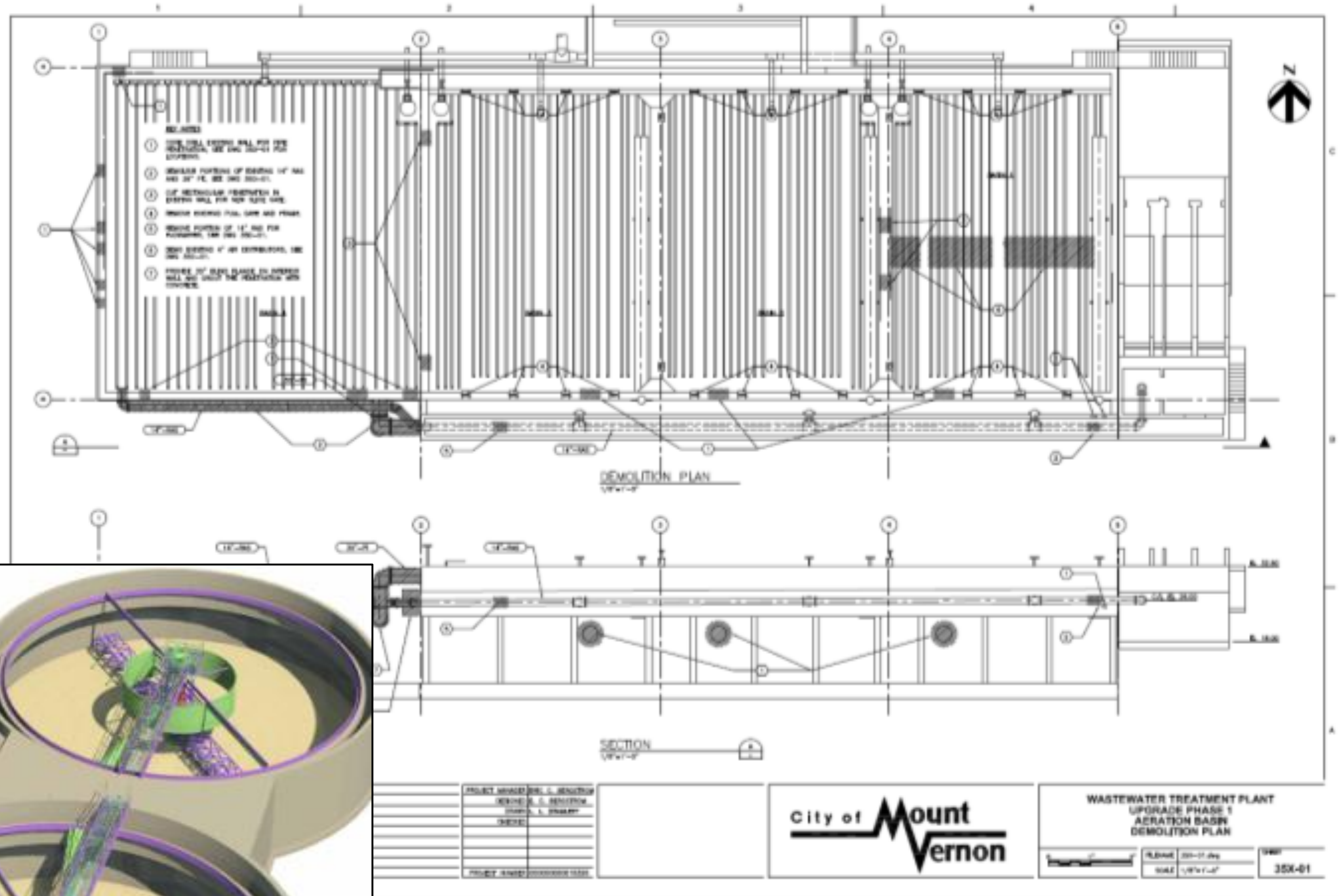
Trial Outcome

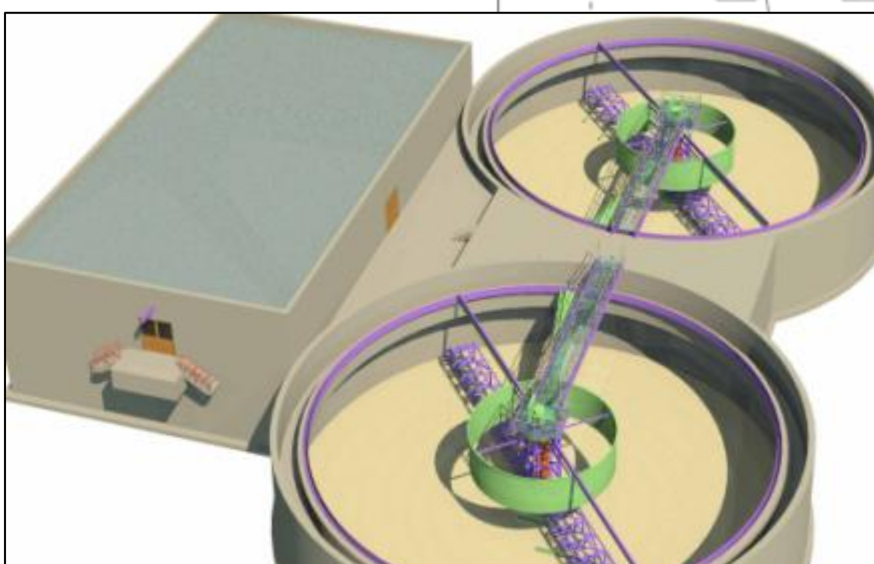
- Plant meets effluent permit limits and nitrogen loading was reduced to improve water quality
- Clarifier floating sludge problem solved
- Good data for plant upgrade generated (additional data needed to fully calibrate model)
- Plant staff enjoyed modifying process

Other Insights

- Side stream treatment of the dewatering filtrate may be required to reduce ammonia loading on the aeration basins.
- Basic nitrogen removal, to 8 to 10 mg/L, doesn't necessarily need to involve massive investment in capital facilities.

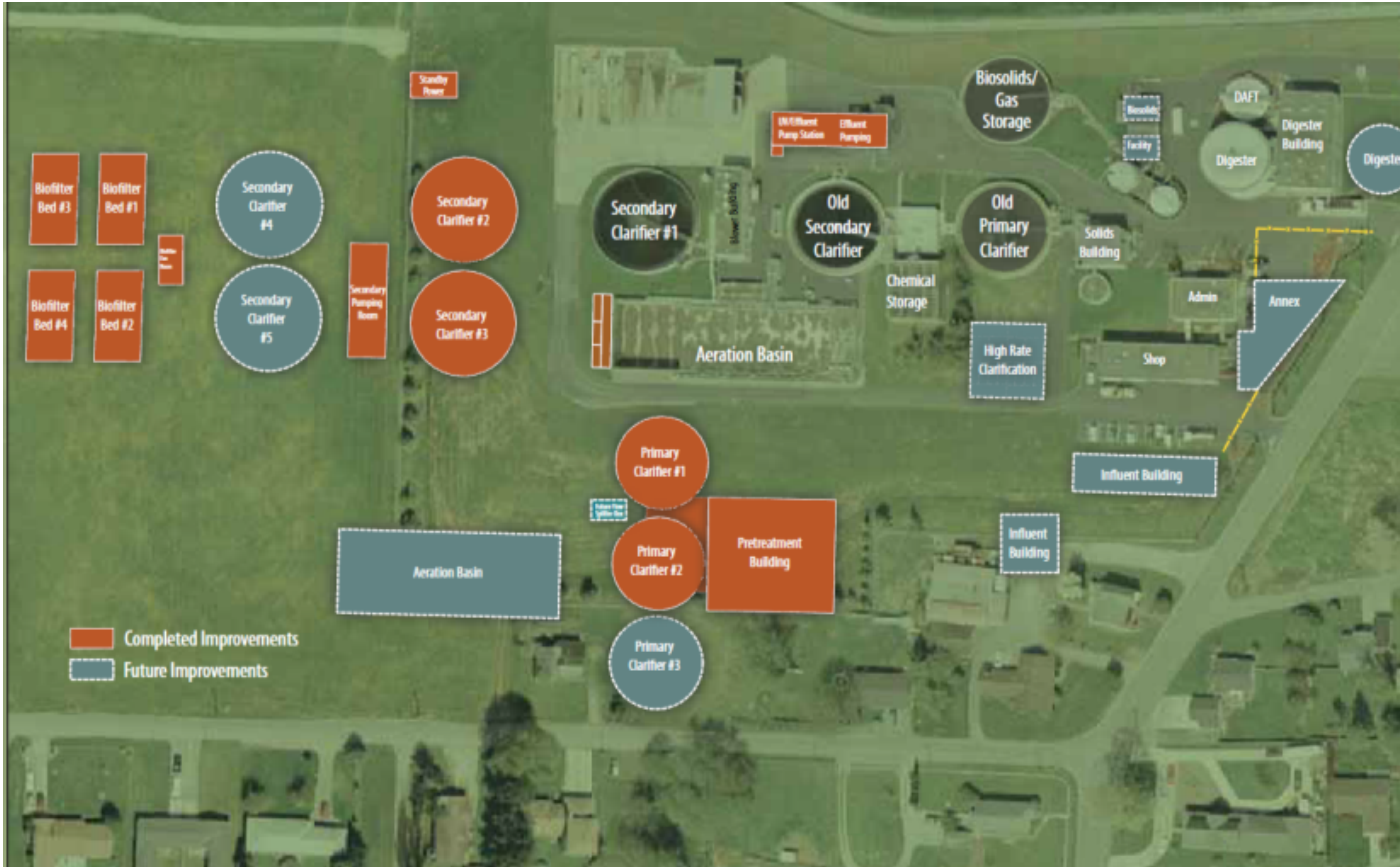
Design & Construction Services



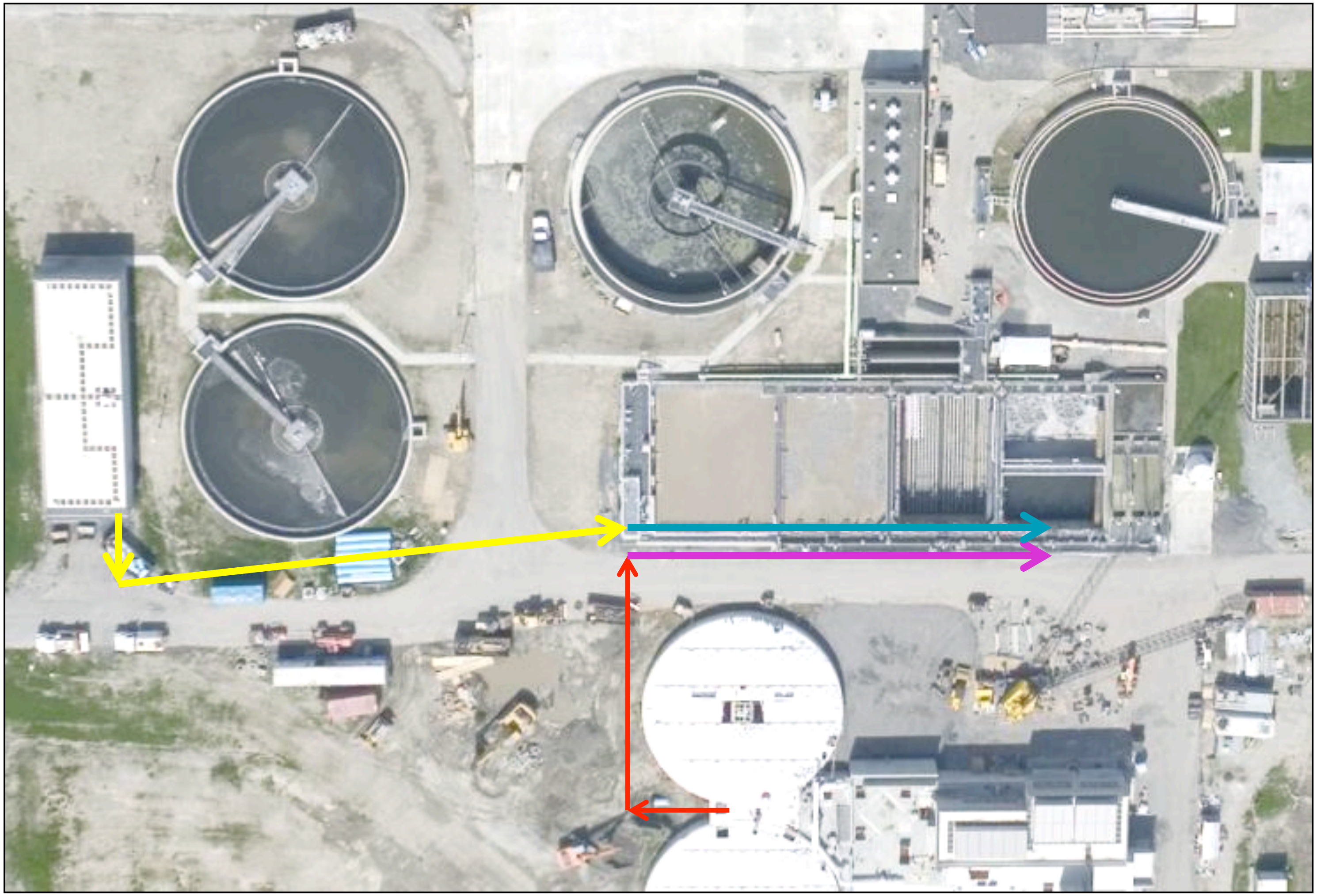


Future Expansions

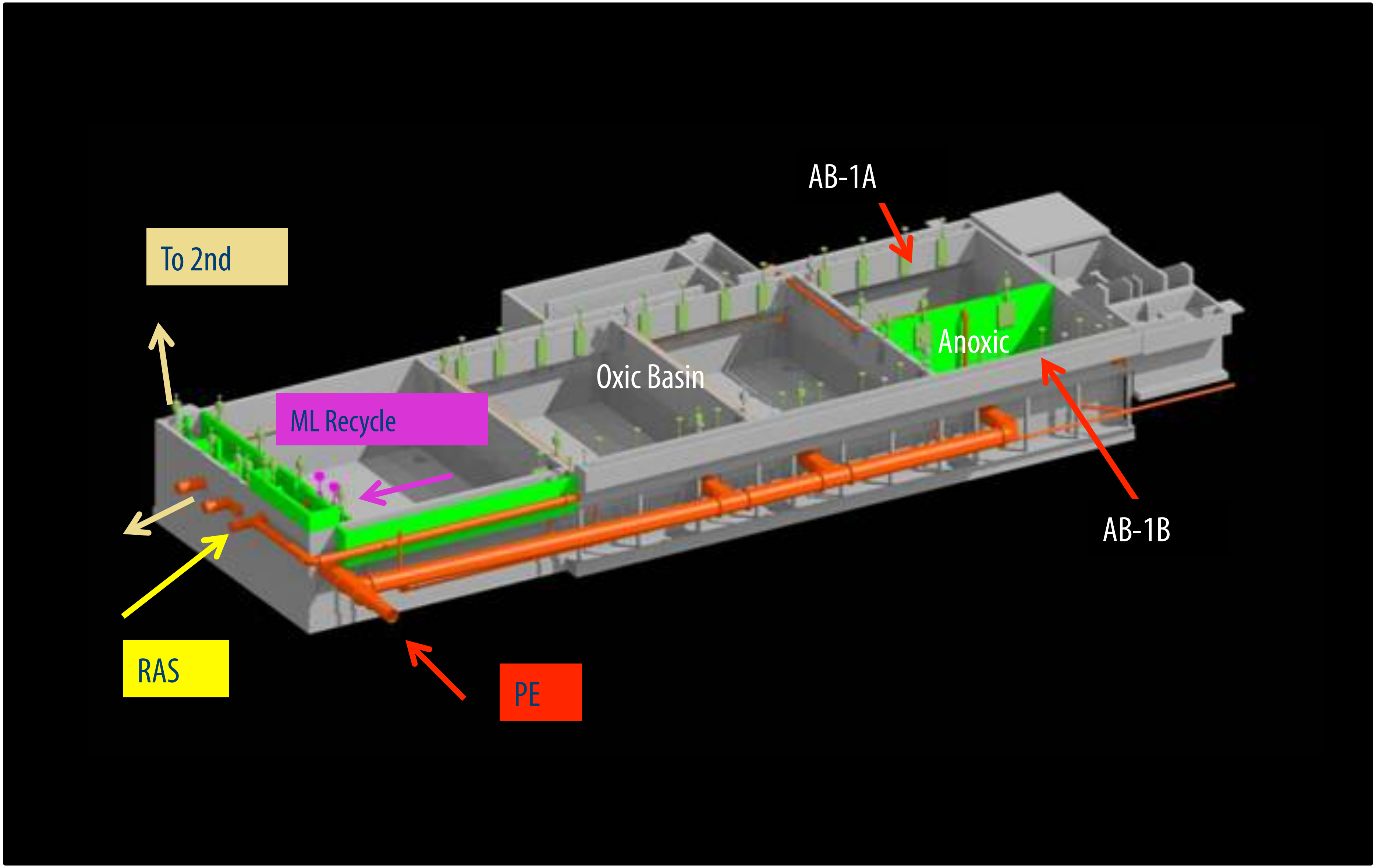
Increase Plant Capacity from 10.8 MGD to 16.4 MGD



NDN Flow Pattern



New Process for Old Basins



Design Criteria

Constituent	Units	Annual Average	Max Month Wet Weather	Max Hour Wet Weather
Flow (BOD mode)	mgd	9.0	15.0	22.0
Flow (nitrification mode)	mgd	4.6	7.6	22.0
BOD (BOD mode)	lb/day	13,600	17,300	N/A
	mg/l	181	138	N/A
BOD (nitrification mode)	lb/day	7,000	8,500	N/A
	mg/l	182	134	N/A
Ammonia (nitrification mode)	lb/day	800	1,000	N/A
	mg/l	20.8	15.8	N/A

How's it working

Month 2012	Average Flow MGD	Average TSS (mg/l)	Average BOD (mg/l)	Average NH_3-N / NO_3 (mg/l)
BOD Mode				
Feb	5.1	7	5	20.0
March	5.3	6	5	23.9
April	4.5	15	9	30.3
May	4.4	4	9	20.0
Nitrification Mode				
July	3. 8	7	16	4.6/6.7
August	2.8	6	13	0.8/0.8
September	2.6	7	12	1.8/2.5
October	2.5	9	12	2.2/9.6

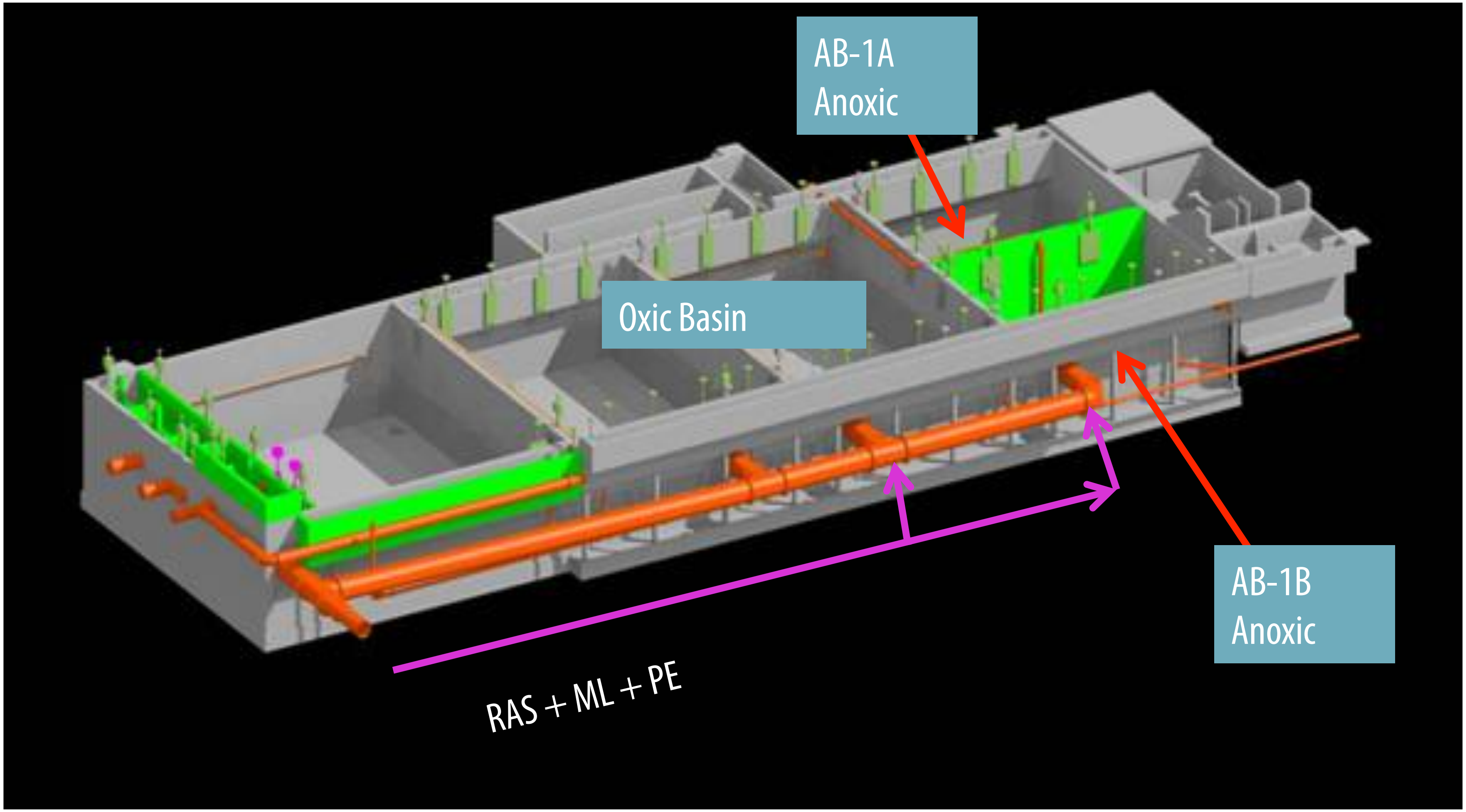
Process Control Activities

- NH_3/NO_3 monitoring in each basin
- Adjustments to D.O., wasting rate, or caustic rate.
- Tight pH control with pH probe.
- Dewatering controls
- RAS and MLR rate controls
- Seasonal BNR/BOD mode

How's it working

- Other Observations
  - Side stream treatment not used in AB-1A
  - Additional mixer placed in AB-1A to increase size of anoxic zone
    - Resulted in a decrease of nitrate and thus of denitrification in the secondary clarifier
    - SVI dropped from 300 to 180 in 30 day and then to 80 after an additional 30 days
    - Filament growth was reduced to almost nothing

How's it working



How's it working

- By using our skills, the HDR/Mount Vernon team was successful in helping Mount Vernon develop and implement low-cost process modifications that improved plant operation, and achieved a secondary benefit of improved water quality.

Acknowledgements

- Gary Duranceau – WWTP Superintendent
- Andrew Denham– Process Control/Lab
- Ray Pickens – Electrical Modification
- Ron Eastman – Mechanical Modification
- Dr. JB Neethling – BioWin Modeler
- Bob Bower – Operations Specialist

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