



Membrane Bioreactor Phosphorus Removal Demonstration Study

Steve Berggruen, P.E. – Regional Manager
Milwaukee, Wisconsin
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Background

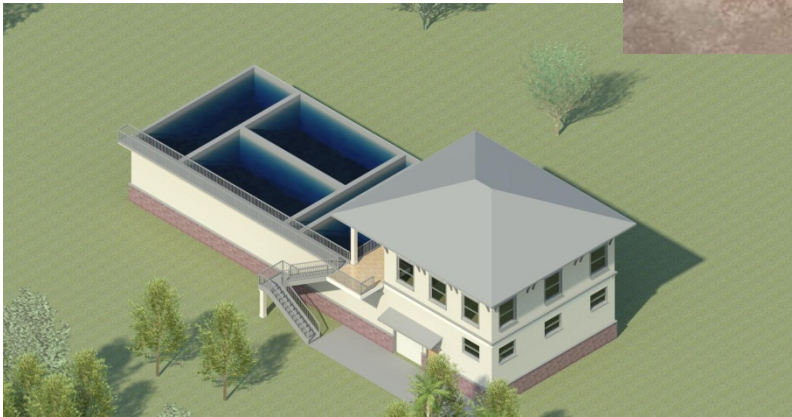
- Testing conducted at the Ridgewood Estates WWTP – Milford, Michigan
- Test Period: Nine months (October – June)
- Testing Program: Physical/Chemical Phosphorus Removal through a Membrane Bioreactor (MBR) System. Reduction of nitrogen compounds and Bio-P (attempted)

Pilot Plant Objectives

- Show capability of MBR system to reduced effluent TP to < 0.03 mg/l
- Demonstrate ability of system to removed conventional pollutants including nitrogen species
- Demonstrate long-term system operation with little or no maintenance
- Produce design information regarding sustainable flux at varying MLSS concentrations and waste temperatures

Membrane Bioreactor (MBR)

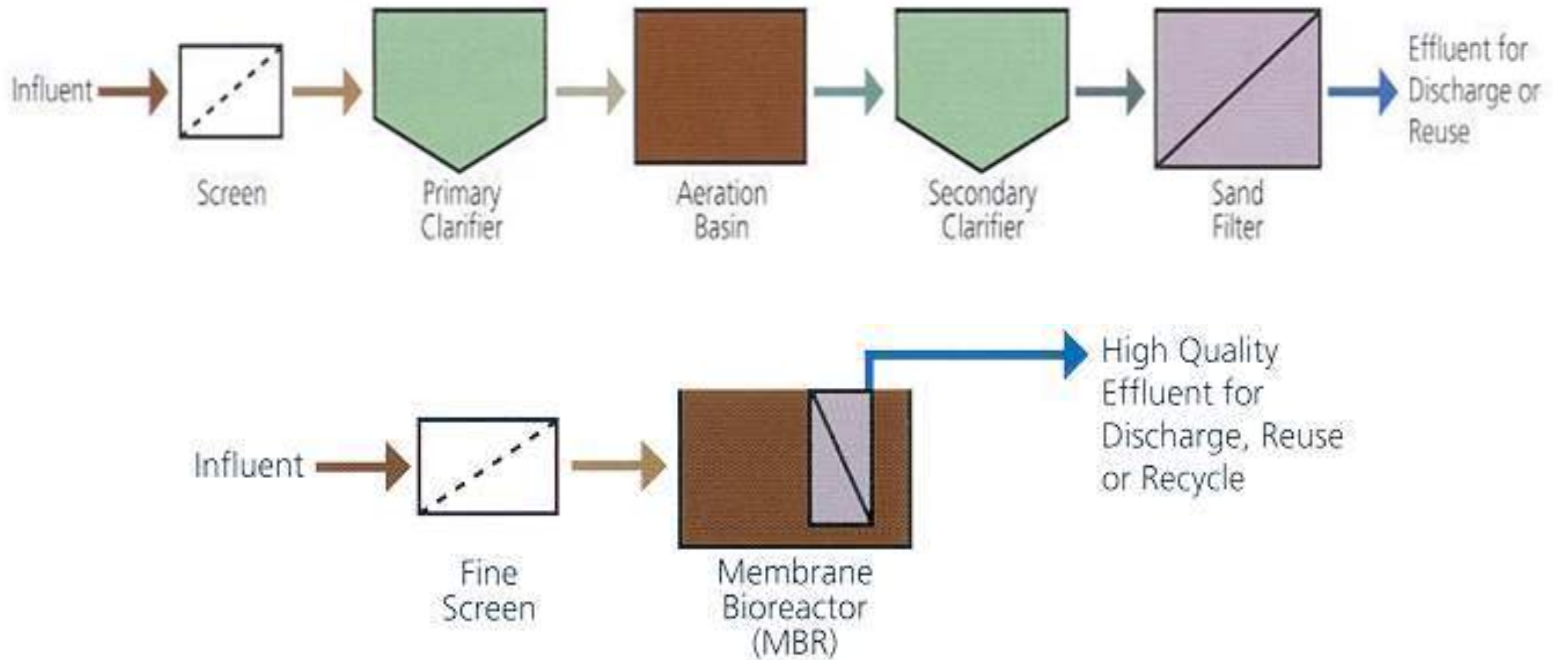
- High Quality Effluent
- Small Footprint
- Simple to Operate



Membrane Bioreactors

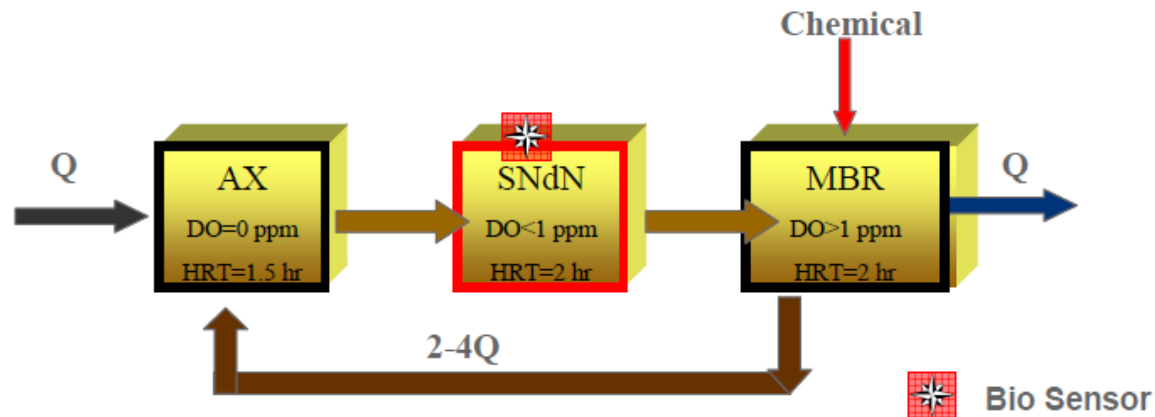
Modification of the traditional activated sludge process

Combine aeration, clarification and filtration into a single step (reduced footprint)

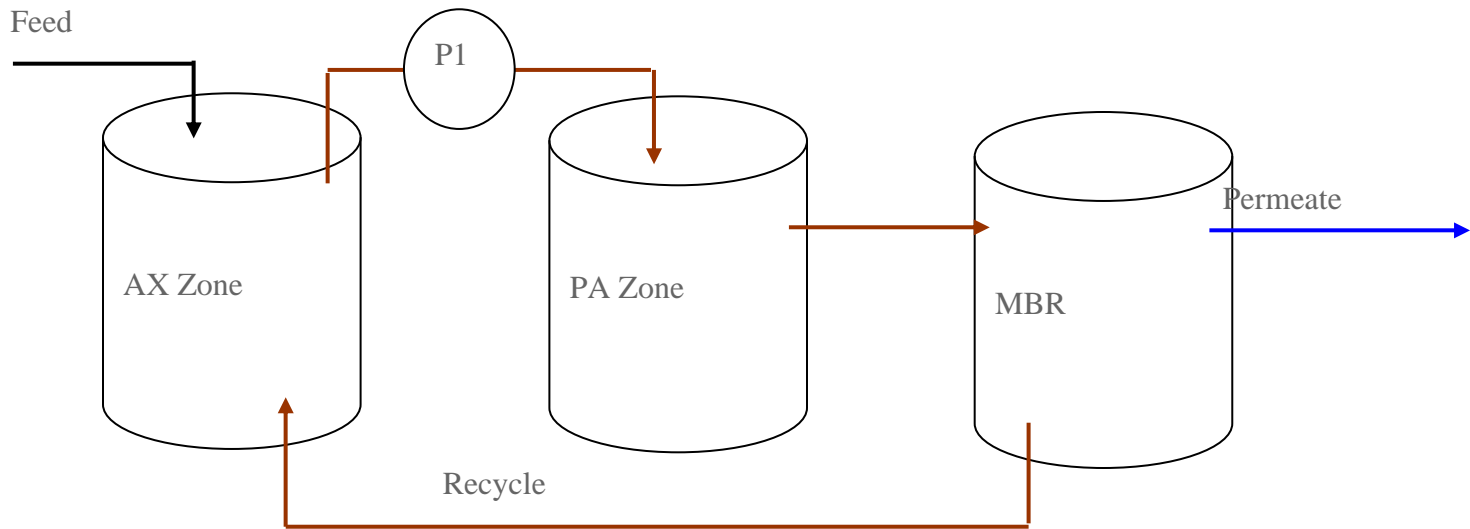


Process and System Overview

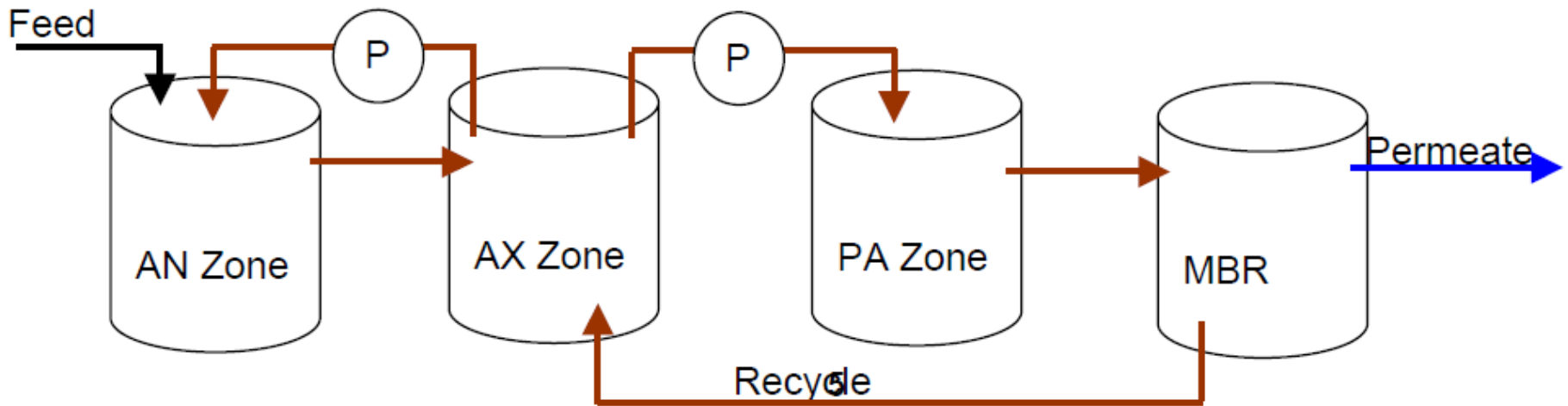
- Automatic 3-mm fine screen
- Anoxic (AX) Basin
- Pre-Aeration (PA) Basin
- Membrane Bioreactor (MBR) Basin



Pilot Study Process Configuration



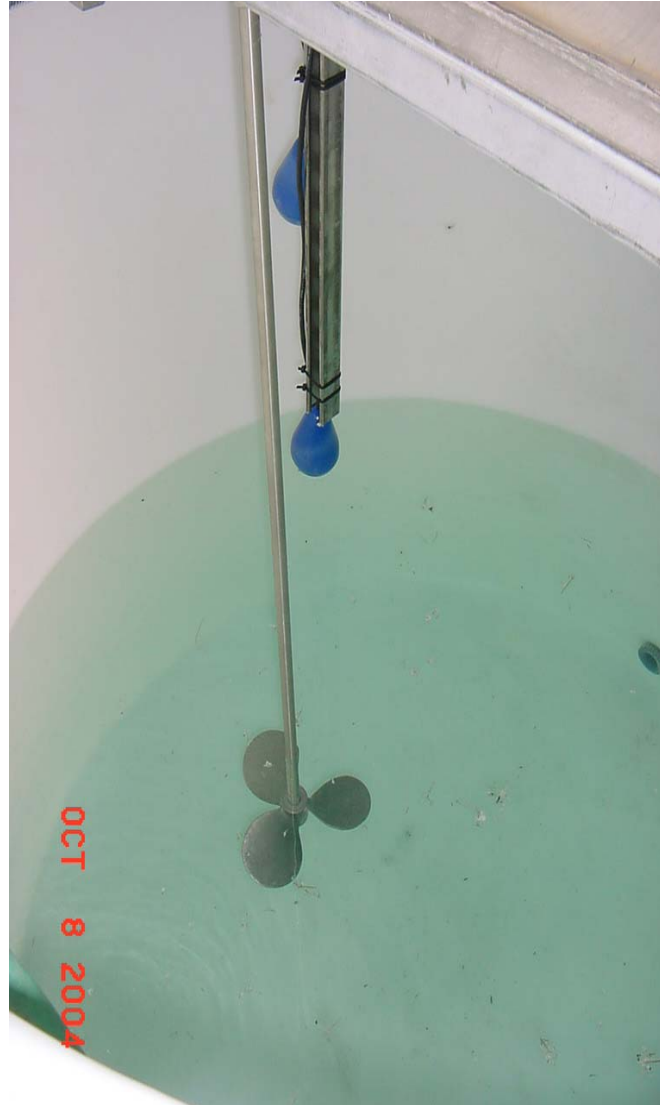
Pilot Study Process Configuration (Alternate – Phase 2)



MBR System



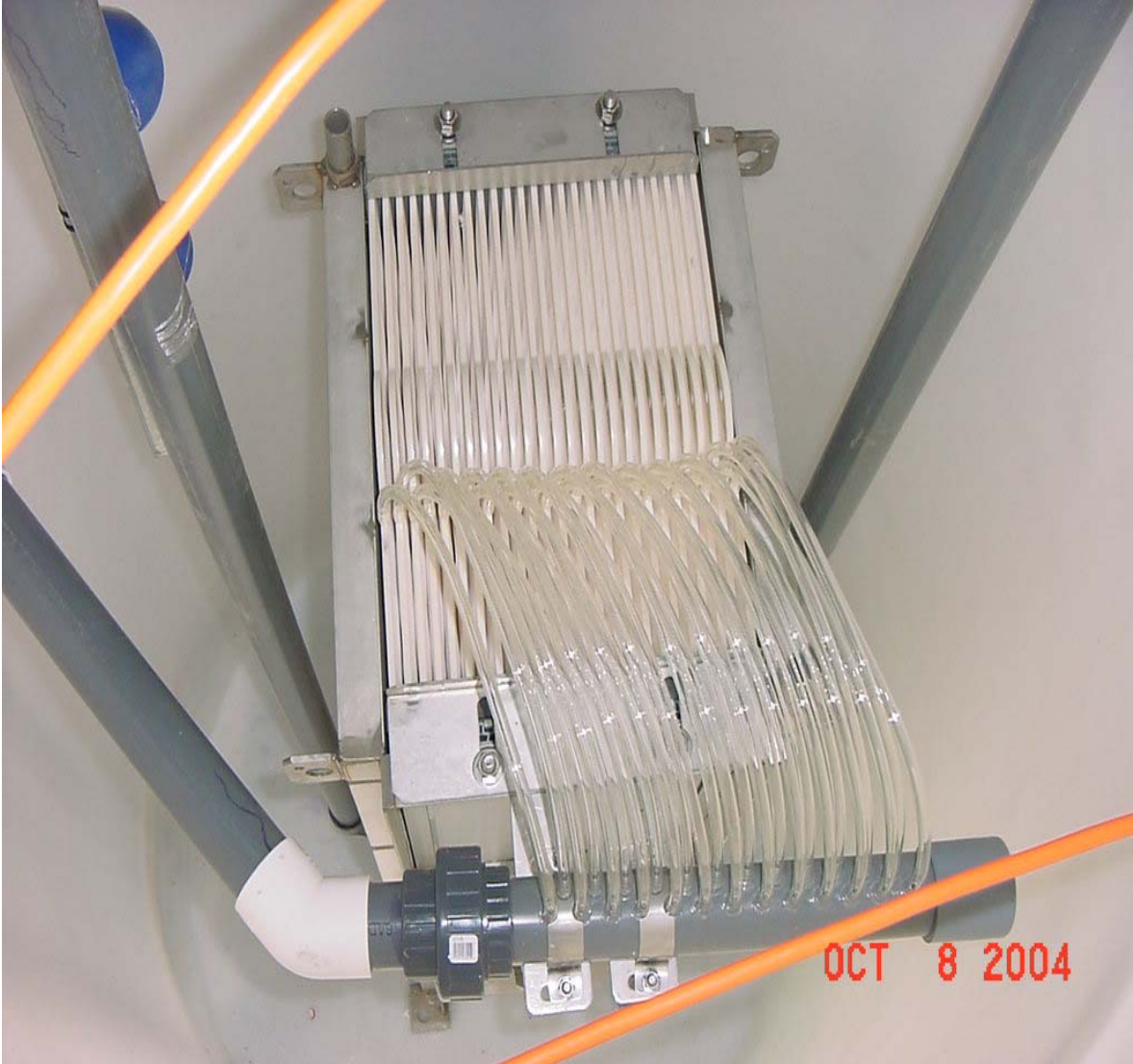
Anoxic (AX) Basin



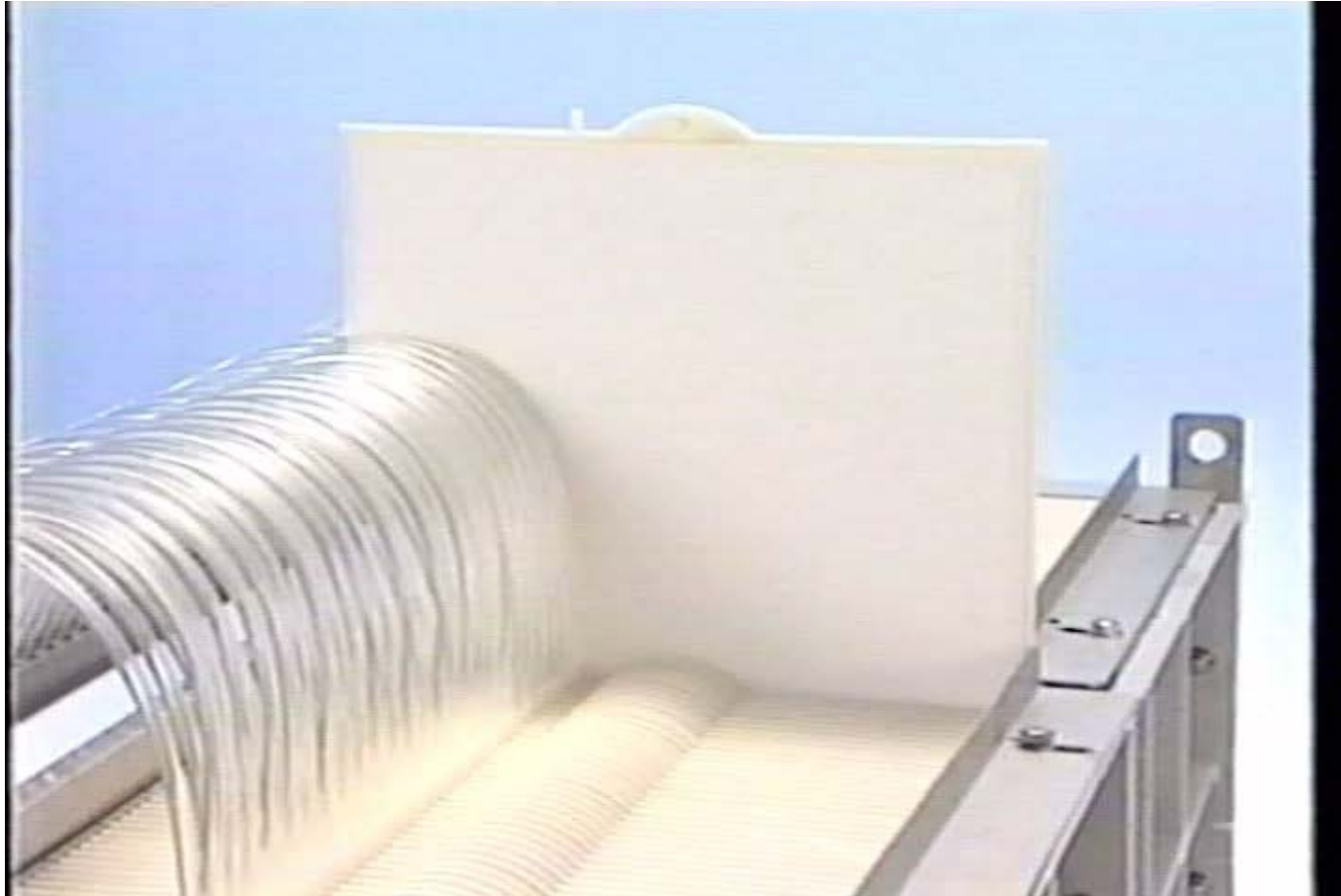
Pre-Aeration Basin



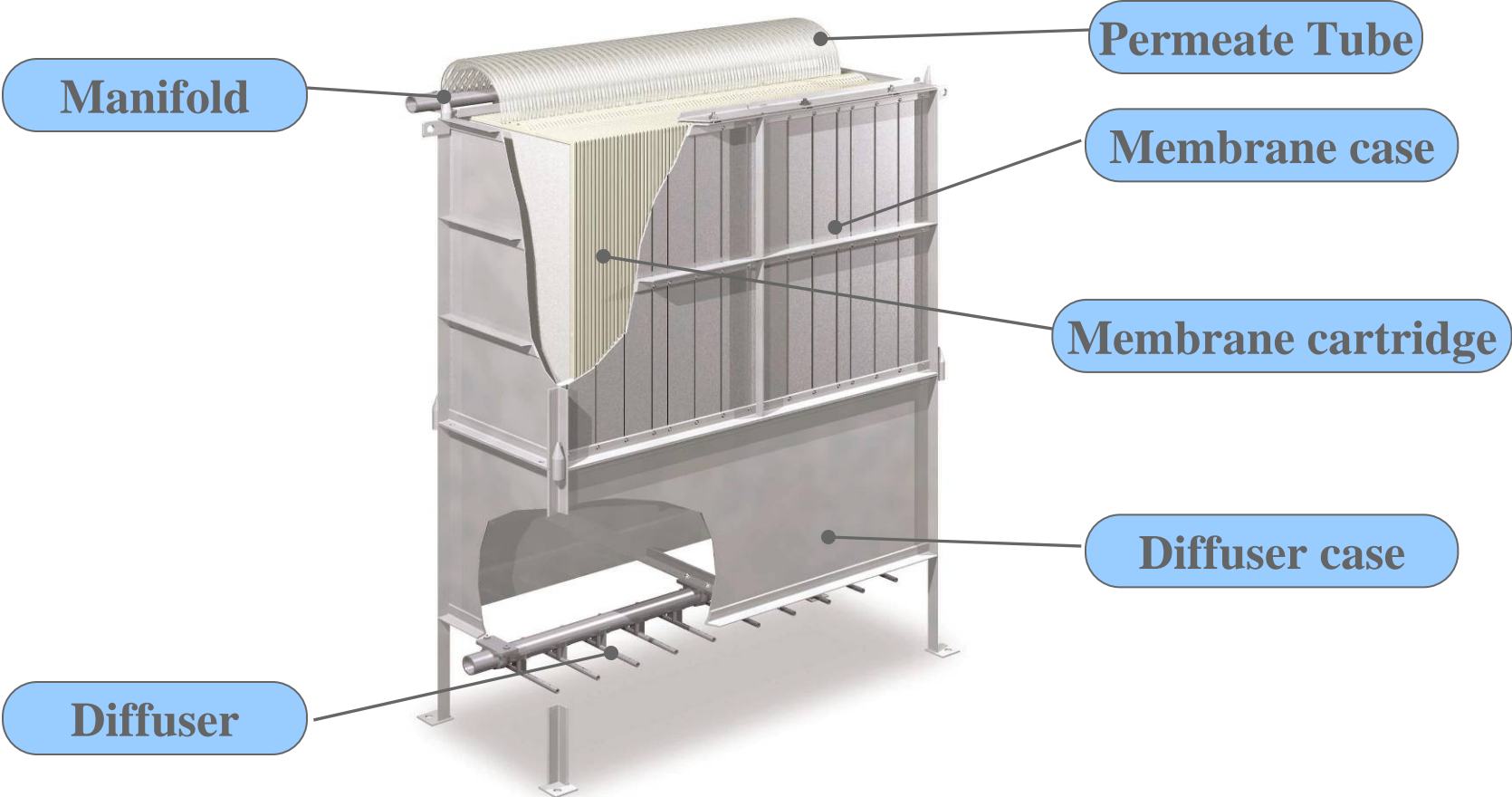
MBR with Submerged Membrane Unit



Flat-Plate Membrane Structure



The Submerged Membrane Unit (SMU)



CIP Cartridge Distribution



- Cleaning takes approximately 2-4 hour / MBR basin, using a dilute solution of 0.5% Sodium Hypochlorite or Citric Acid
- In-situ cleaning of membranes without draining MLSS
- Chlorine dosage less than that typically used for filamentous microorganism control
- No tank liners required

Wastewater Characteristics

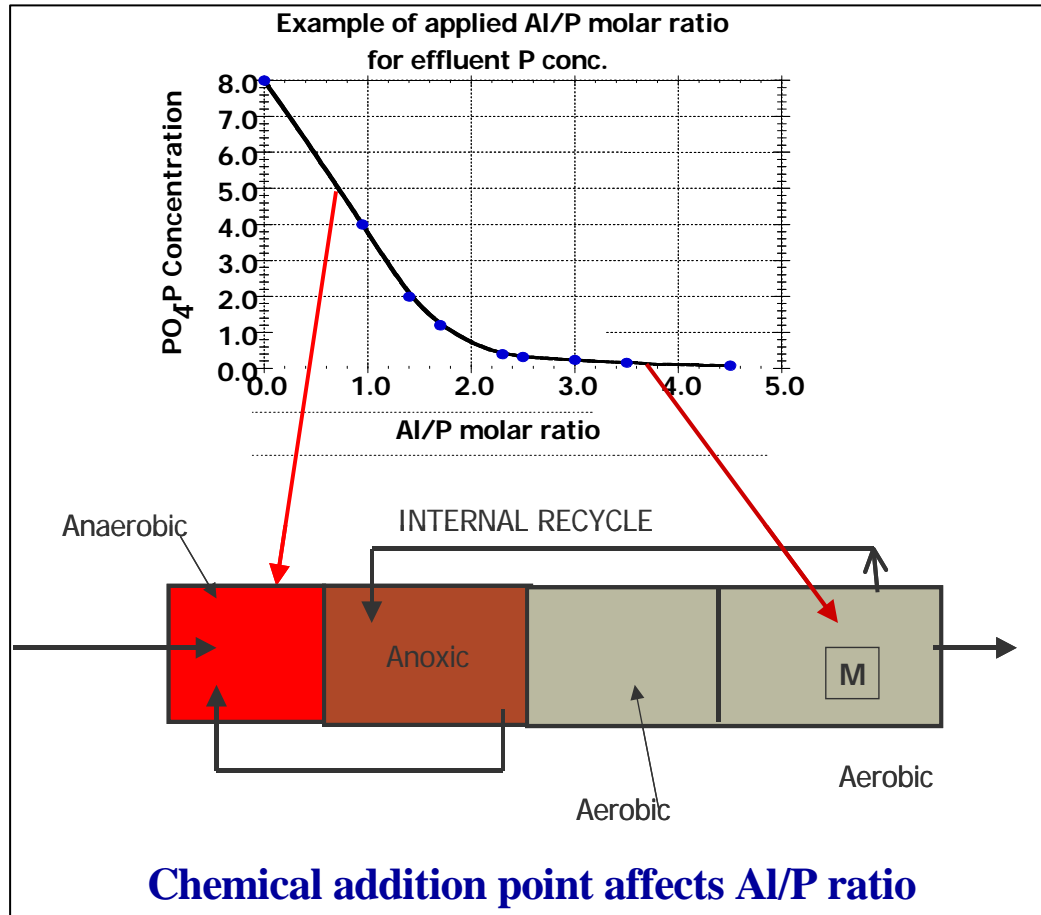
Parameter	Average	Minimum	Maximum	Unit
CBOD5	392.6	180.0	1095.0	mg/l
NH3	26.1	15.5	52.8	mg/l
T-P	5.6	3.2	8.2	mg/l
TSS	626.5	147.5	1970.0	mg/l

Note: Flow to pilot plant set at 1.5 gpm (2,160 gpd)

Testing Program - Phosphorus

- Data collected over a four month period
- Two alum dosing rates tested (1 gpd / 2 gpd)
- Effluent TP rise at 1 gpd alum
- Average effluent TP < 0.03 mg/l
- 43 effluent samples
- TP less than detectable in 28% of samples
- No SA conducted on optimal dose or point

Impact of Chemical Addition Location on Phosphorus Removal



(Stensel, 2003)

Pilot Operating Conditions & Results

- MLSS
- Temperature
- Effluent BOD
- Effluent Nitrogen
- Effluent Phosphorus



Operational Overview

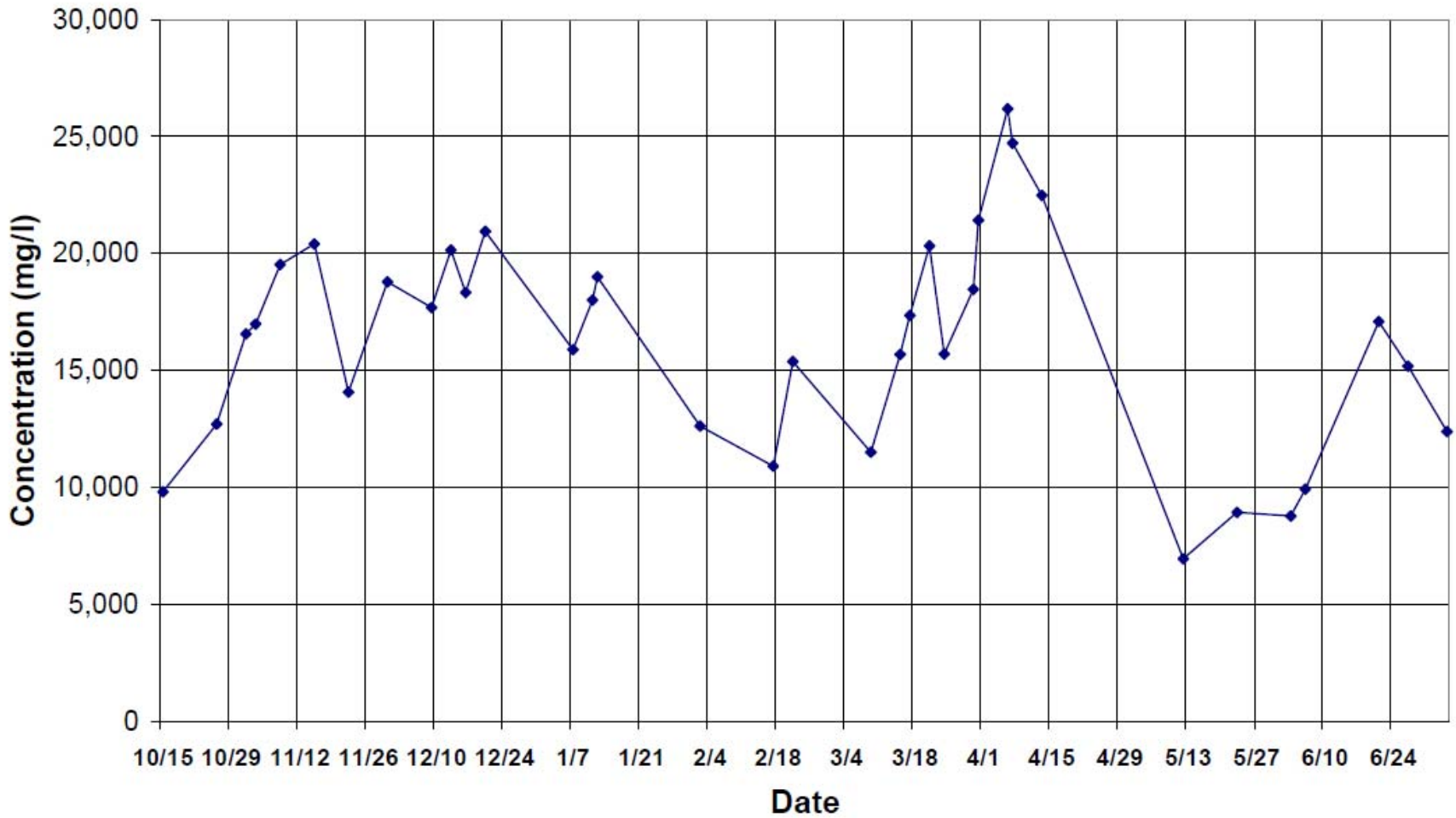
- MLSS: 6,940 – 26,180 mg/l
- Temperature: 6.2 – 15.8 degrees C
- HRT: 21 hours
- SRT: 57 days
- F:M 0.03 1/day or less

Effluent Overview

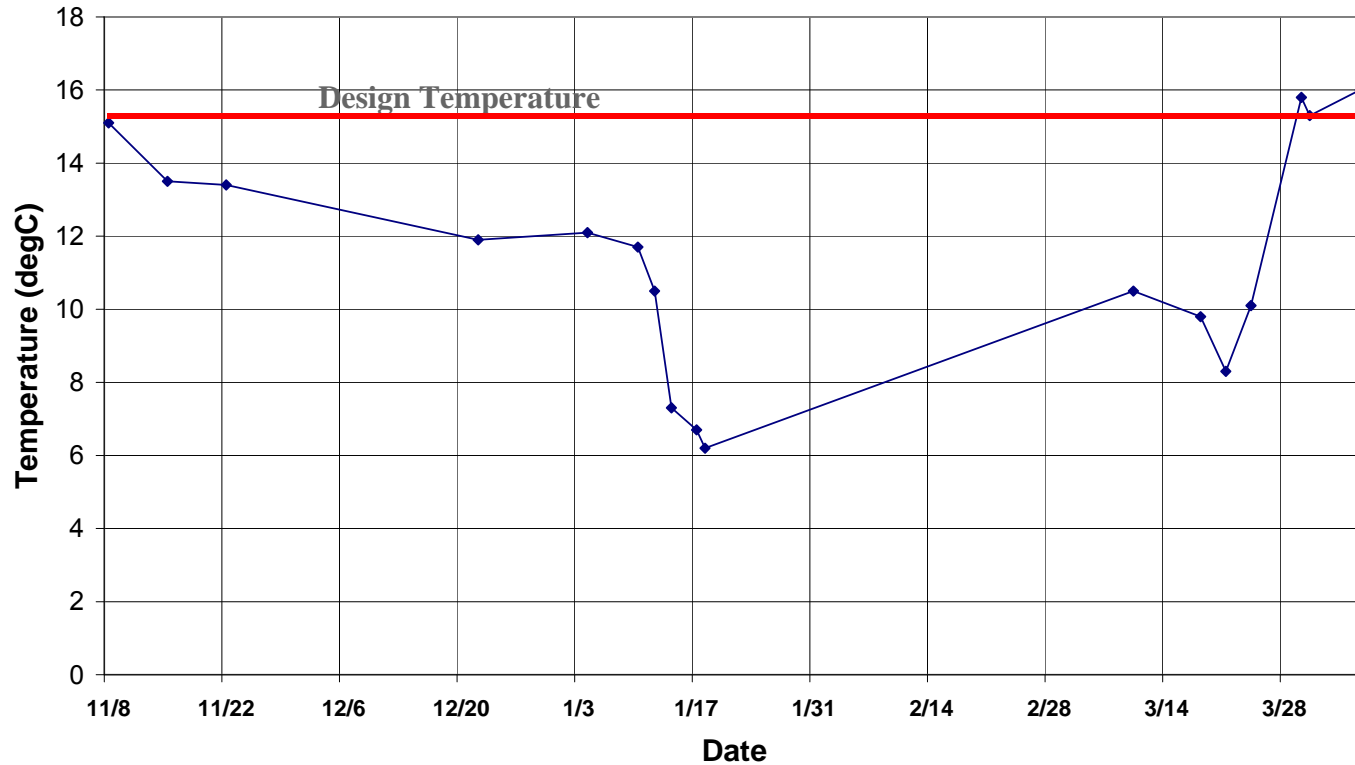
- Effluent TSS: 2.5 mg/l (ave)
- Effluent BOD: 16.8 mg/l (Phase 1), 5.4 mg/l (Phase 2)*
- Effluent N: 11.4 mg/l NH₃-N (Phase 1), 0.3 mg/l NH₃-N (Phase 2)*
13.6 mg/l TIN (Phase 1), 2.6 mg/l TIN (Phase 2)*
- Effluent P: 0.05 mg/l (all data points)
0.03 mg/l (at optimal dosage)

*Phase 2 included increased blower speed for full nitrification and increased recycle of nitrates back to AX

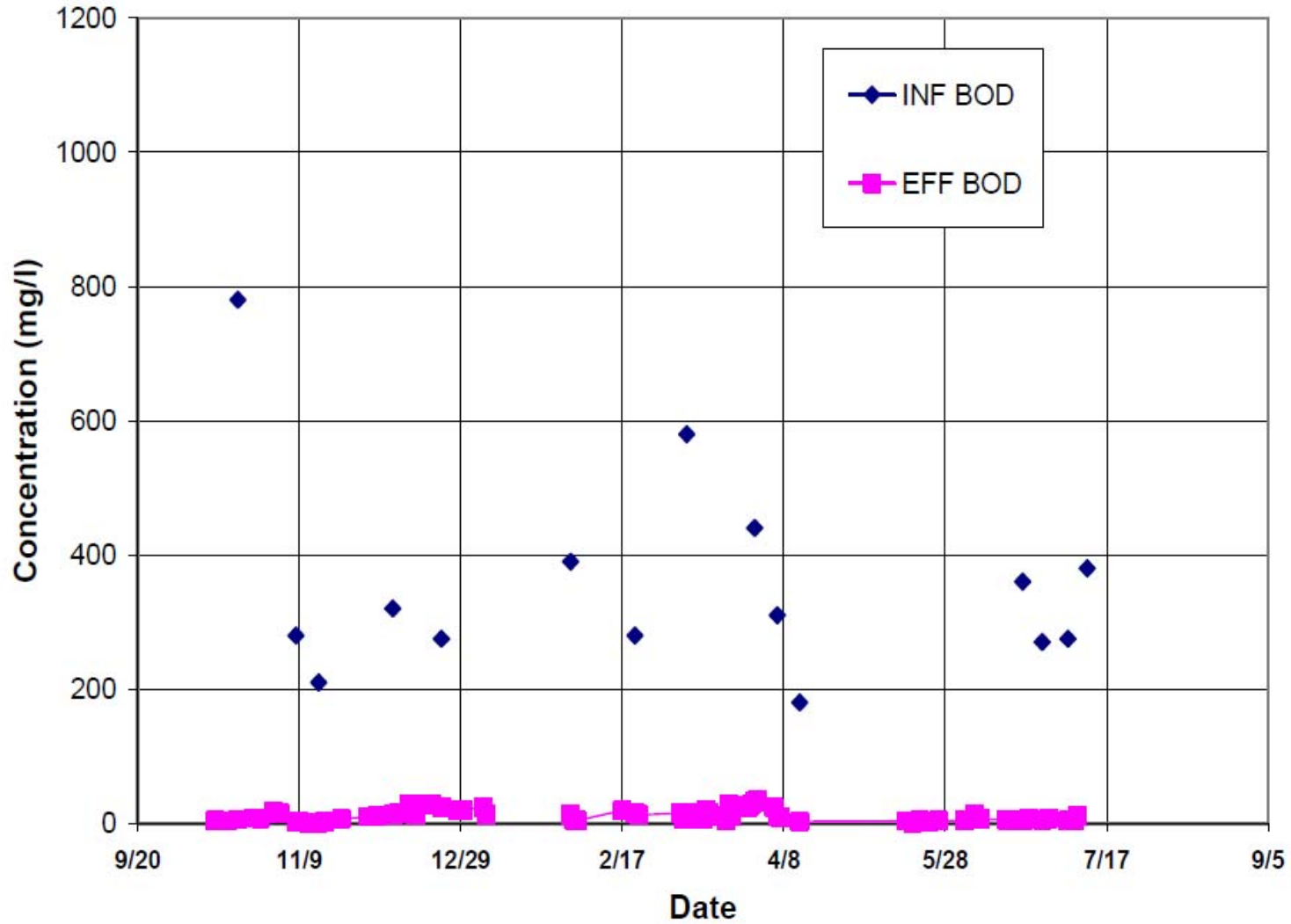
MBR MLSS Concentration Profile



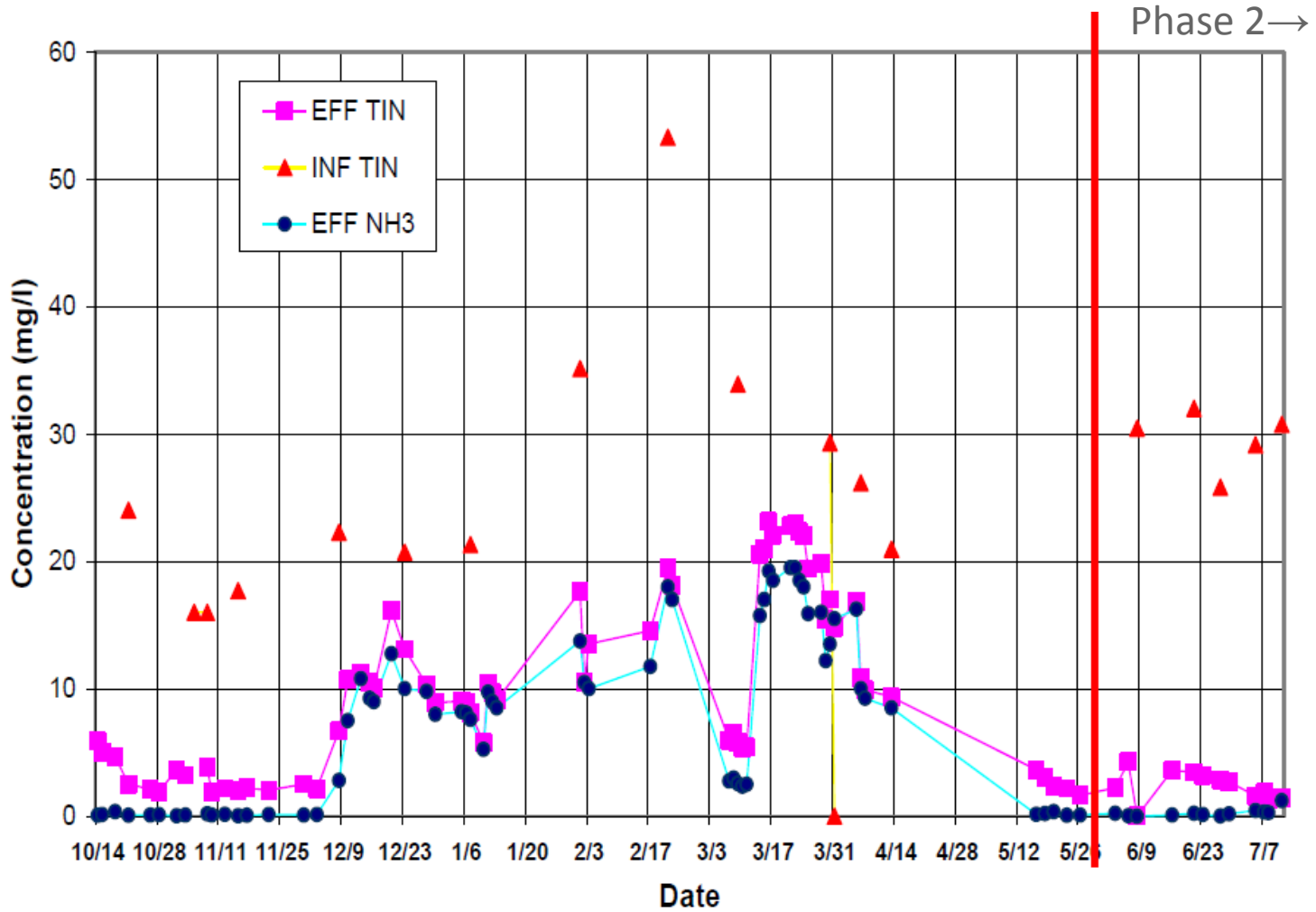
Recorded Water (Sludge) Temperatures



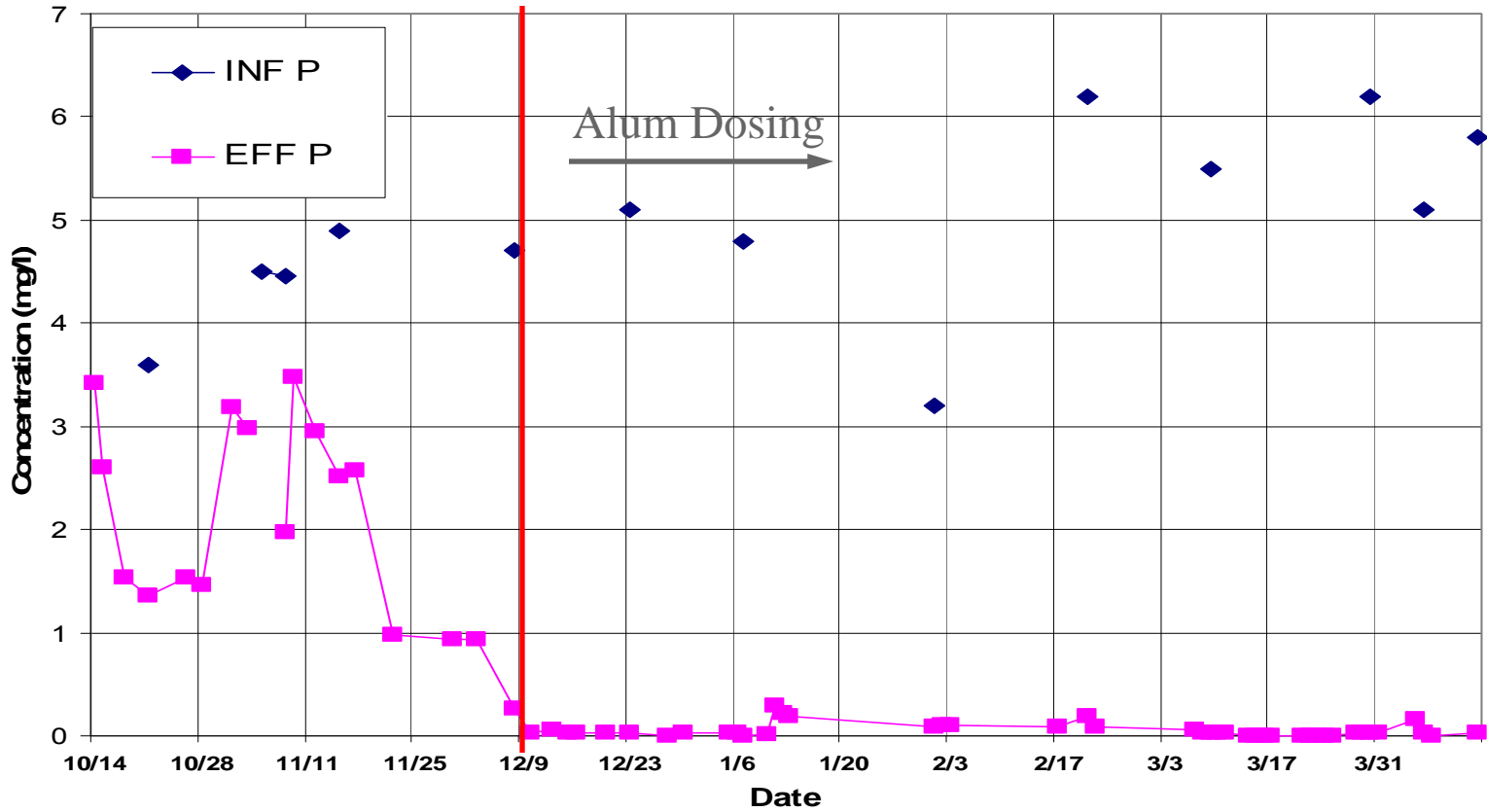
Permeate BOD Profile



Permeate Nitrogen Profile



Phosphorus Trending



Membrane Performance

- Sustained Flux: 10 gfd
- Excellent results despite variable MLSS and low T
- Transmembrane Pressure (TMP):
 - 0.4 – 0.6 psi (ave)
 - 1.6. – 1.8 psi (peak)
- Permeability: 42 gfd/psi (ave) during both phases
- Membrane Maintenance:
 - No irreversible or permanent fouling detected
 - Only one clean-in-place (CIP) procedure in 9 months
 - 3-hour cleaning period using 0.5% bleach solution

Conclusions

- Show capability of MBR system to reduced effluent TP to < 0.03 mg/l. **YES**
- Demonstrate ability of system to removed conventional pollutants including nitrogen species. **YES (somewhat)**
- Demonstrate long-term system operation with little or no maintenance **YES**
- Produce design information regarding sustainable flux at varying MLSS concentrations and waste temperatures **YES**

Thank You

