Poo-Gloos – An Eco-Friendly Solution for Wastewater Lagoons

Kraig Johnson, Ph.D., P.E.

Wastewater Compliance Systems, Inc.


WARNING
Due to the frequency of human-bear encounters, the B.C. Fish and Wildlife Branch is advising hikers hunters, fishermen and any persons that use the out of doors in a recreational or work related function to take extra precautions while in the field.
We advise the outdoorsman to wear little noisy bells on clothing so as to give advance warning to any bears that might be close by so you don't take them by surprise.
We also advise anyone using the out-of-doors to carry "Pepper Spray" with him in case of an encounter with a bear.
Outdoorsmen should also be on the watch for fresh bear activity, and be able to tell the difference between black bear feces and grizzly bear feces. Black bear feces is smaller and contains lots of berries and squirrel fur. Grizzly bear shit has bells in it and smells like pepper.
FORT STEELE
CAMPGROUND


JON M HUNTSMAN CENTER

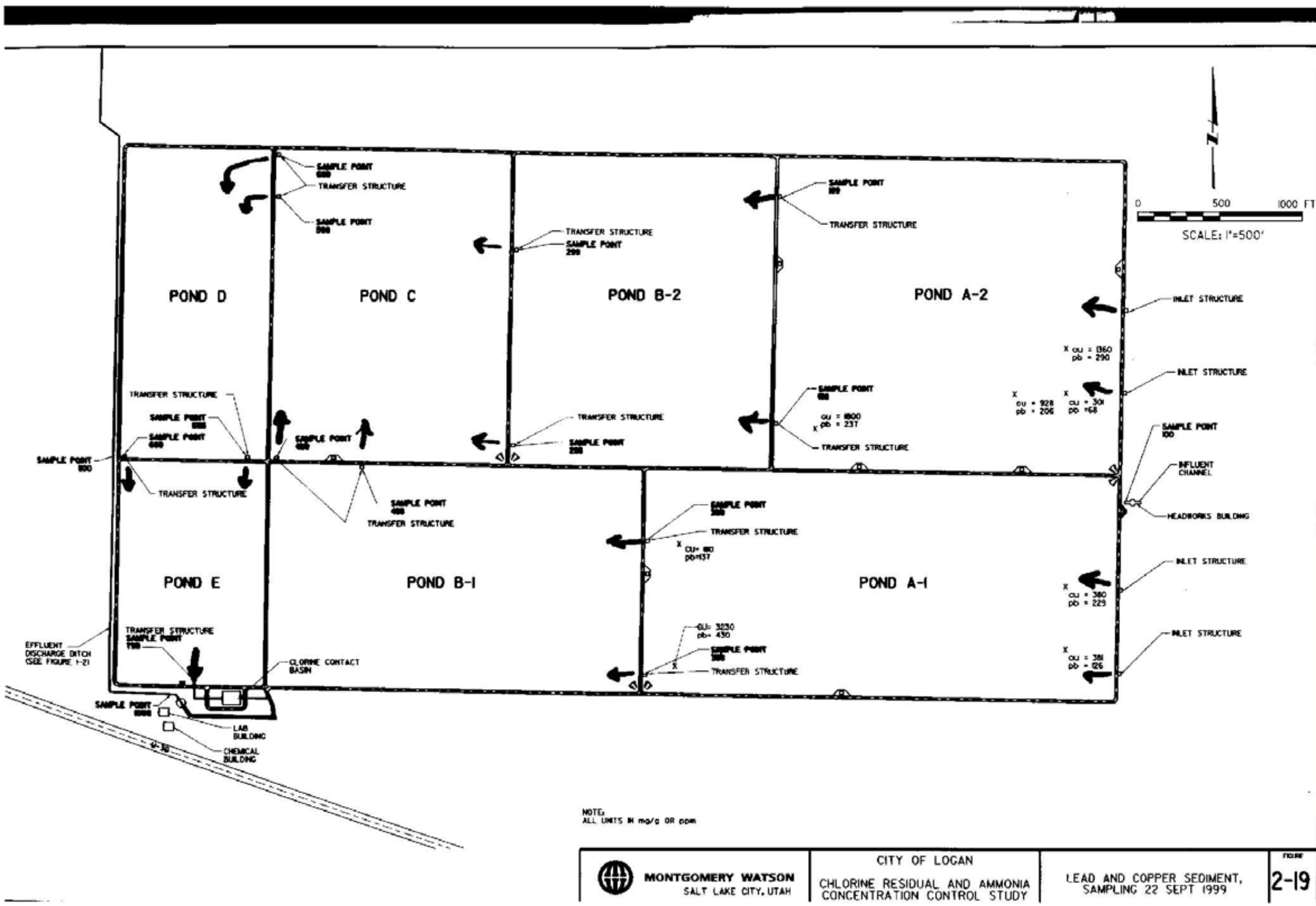

POND D
POND C
POND B-2
POND A-2
POND E
POND B-1
POND A-1
SAMPLE POINT
TRANSFER STRUCTURE
SAMPLE POINT 100
INLET STRUCTURE
INFLUENT CHANNEL
HEADWORKS BUILDING
cu = 1360 pb = 290
cu = 928 pb = 206
cu = 301 pb = 68
cu = 1800 pb = 237
CU= 3230 pb= 430
EFFLUENT DISCHARGE DITCH (SEE FIGURE 1-2)
CLORINE CONTACT BASIN
LAB BUILDING
CHEMICAL BUILDING
0 500 1000 FT
SCALE: 1"=500'
NOTE: ALL UNITS IN mg/g OR ppm
MONTGOMERY WATSON
SALT LAKE CITY, UTAH
CITY OF LOGAN
CHLORINE RESIDUAL AND AMMONIA CONCENTRATION CONTROL STUDY
LEAD AND COPPER SEDIMENT, SAMPLING 22 SEPT 1999
FIGURE
2-19

Figure 3-1
BOD Levels through Cells (Annual Averages)

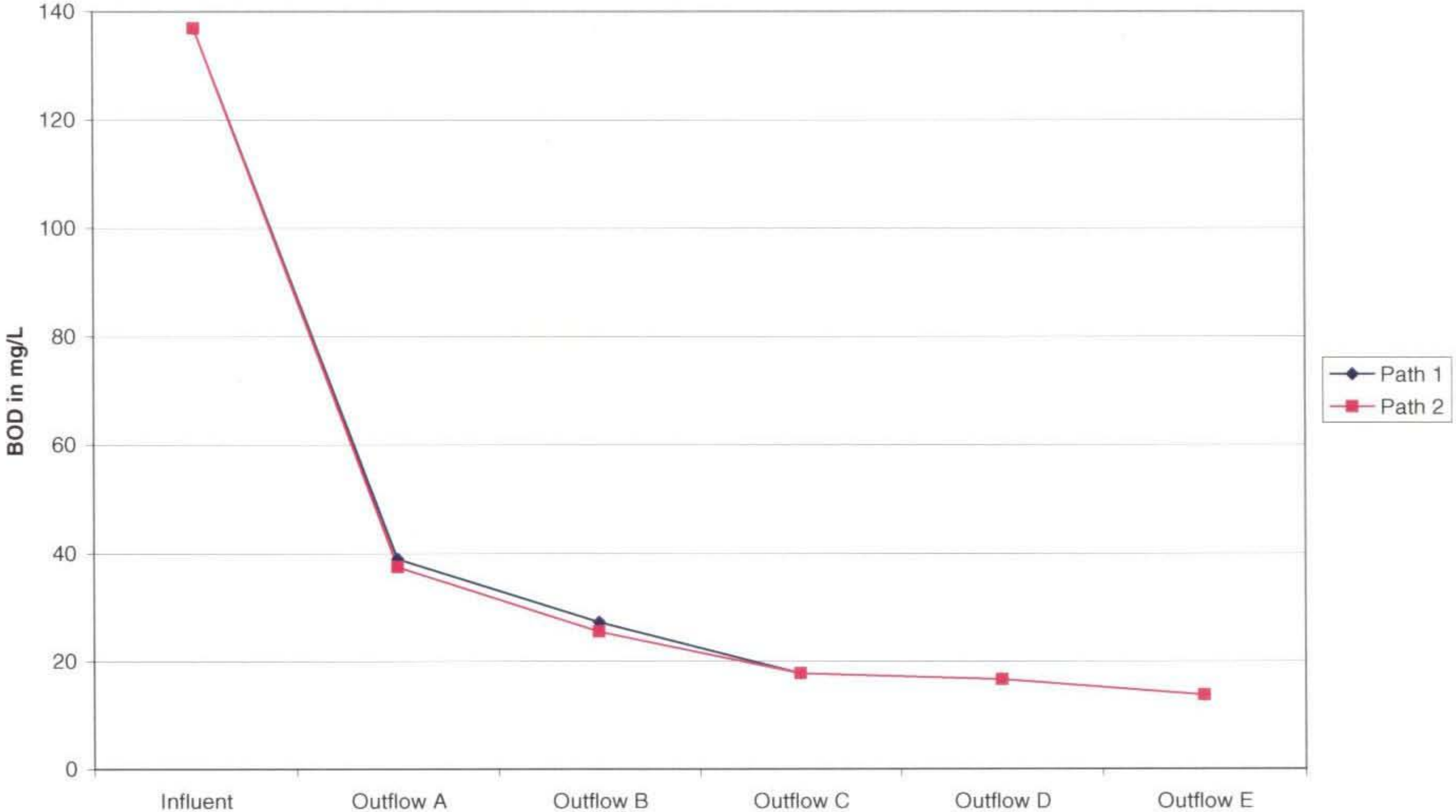


Figure 3-2
Ammonia Levels through Cells (Annual Averages)

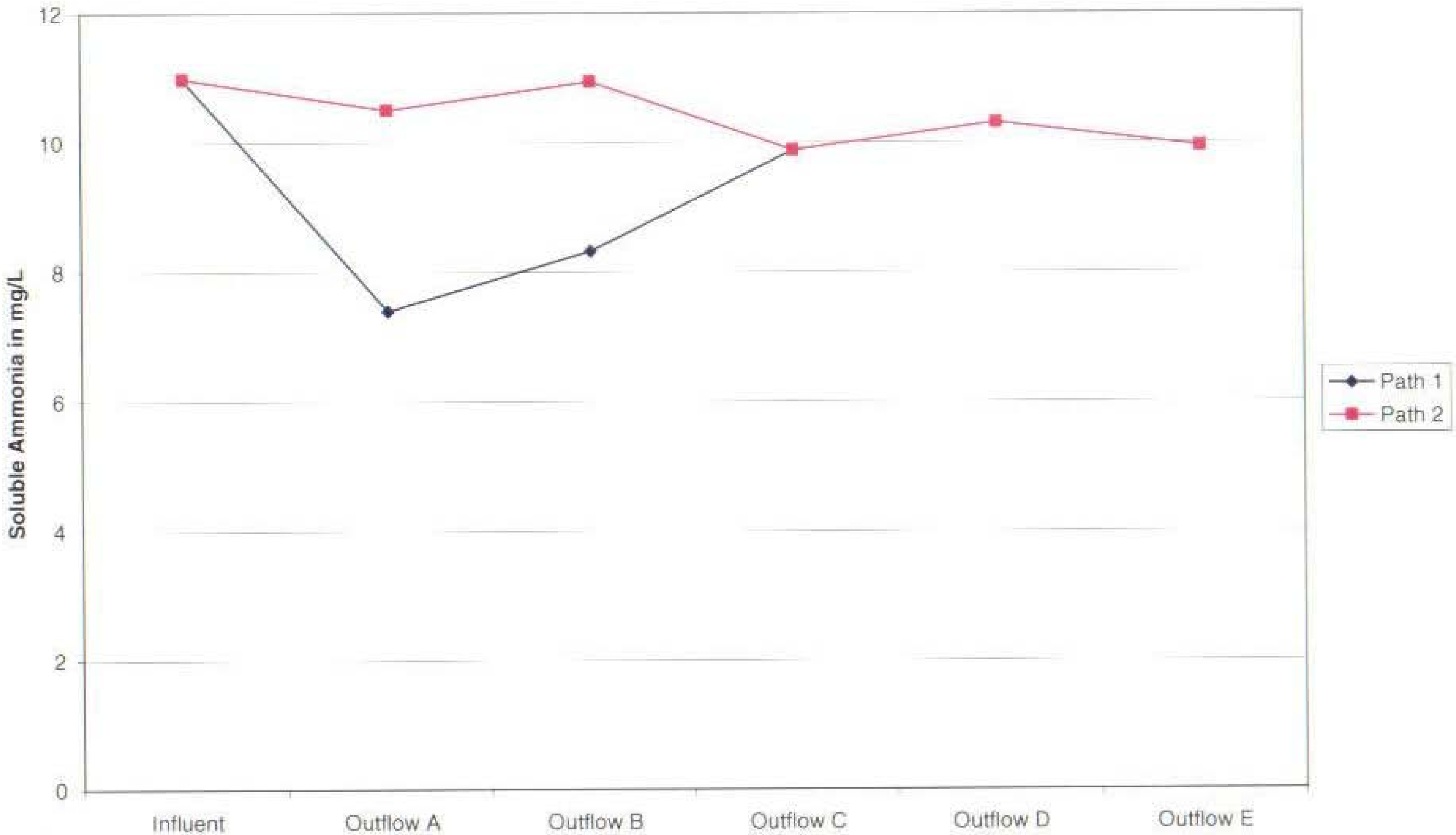
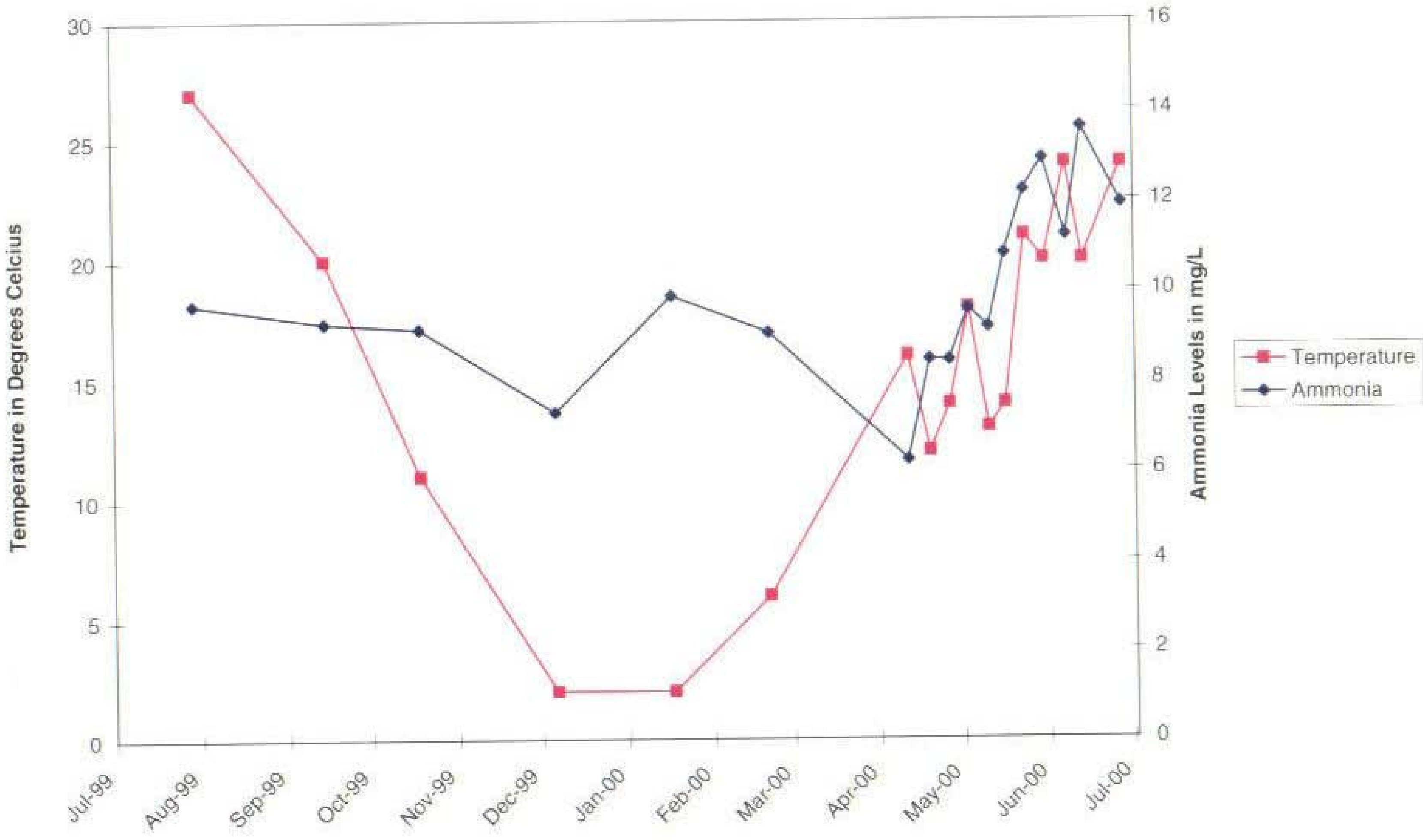


Figure 3-4
Temperature Effects on Ammonia Levels at Lagoon Effluent (Prior to Chlorination)



Problem Statement –
Nutrients in Wastewater Lagoon

- Lagoons are not effective at reducing nitrogen levels.
- High ammonia and nitrate/nitrite levels can be toxic to aquatic organisms.
- Oxidation of ammonia to nitrate requires a significant oxygen demand.
- Nitrogen can stimulate algae growth and cause eutrophication of receiving waters.

Source of Ammonia – Ammonification

$$H_2NCONH_2 + 2H_20 \xrightarrow{enzyme,urease} (NH_4)_2CO_3$$

$$\begin{array}{l} Organic \\ nitrogen \xrightarrow{microorganism} NH_3 / NH_4^+ \end{array}$$

Biological Removal of Ammonia Nitrogen

- Nitrification Process – Two principal genera of *nitrosomonas* and *nitrobacter*
  - Oxidize ammonium to nitrate with intermediate formation of nitrite

$$2NH_4^+ + 3O_2 \xrightarrow{Nitrosomonas} 2NO_2^- + 4H^+ + 2H_2O + energy$$

$$2NO_2^- + O_2 \xrightarrow{Nitrobacter} 2NO_3^- + energy$$

Overall reaction

$$NH_4^+ + 2O_2 \rightarrow NO_3^- + 2H^+ + H_2O + energy$$

Biological Removal of Nitrates/Nitrites

- Denitrification Process- *denitrifiers*
  - Reduction of nitrate to nitrite, and ultimately nitrite to nitrogen gas

$$NO_3^- + 0.33CH_3OH \rightarrow NO_2^- + 0.33CO_2 + 0.67H_2O$$

$$NO_2^- + 0.5CH_3OH \rightarrow 0.5N_2 + 0.5H_2O + OH^- + 0.5CO_2$$

Overall reaction

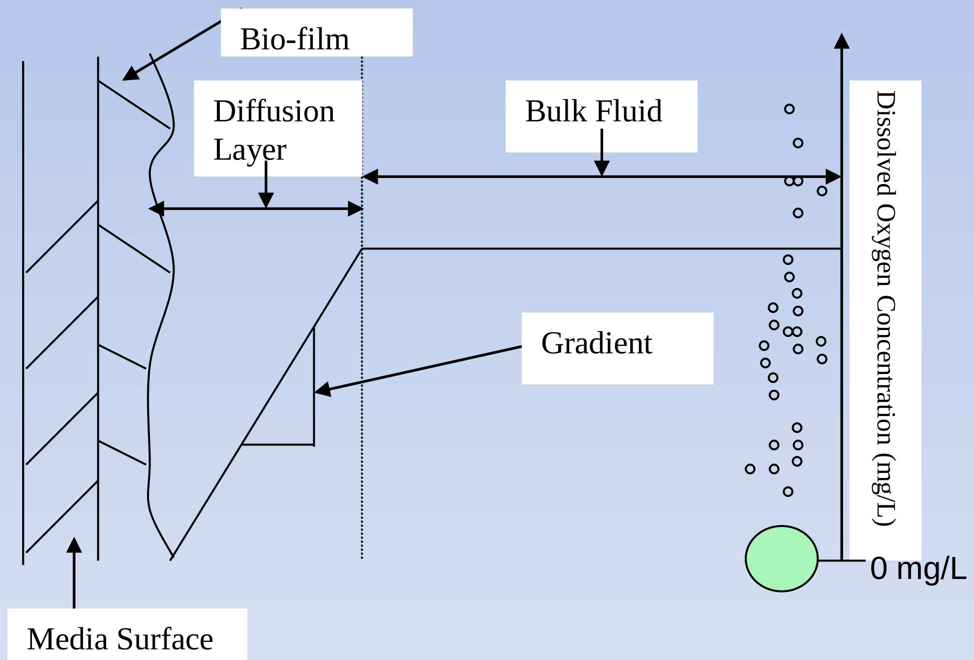
$$NO_3^- + 0.83CH_3OH \rightarrow 0.5N_2 + 0.83CO_2 + 1.17H_2O + OH^-$$

Optimum Factors for Nitrifying Bacteria

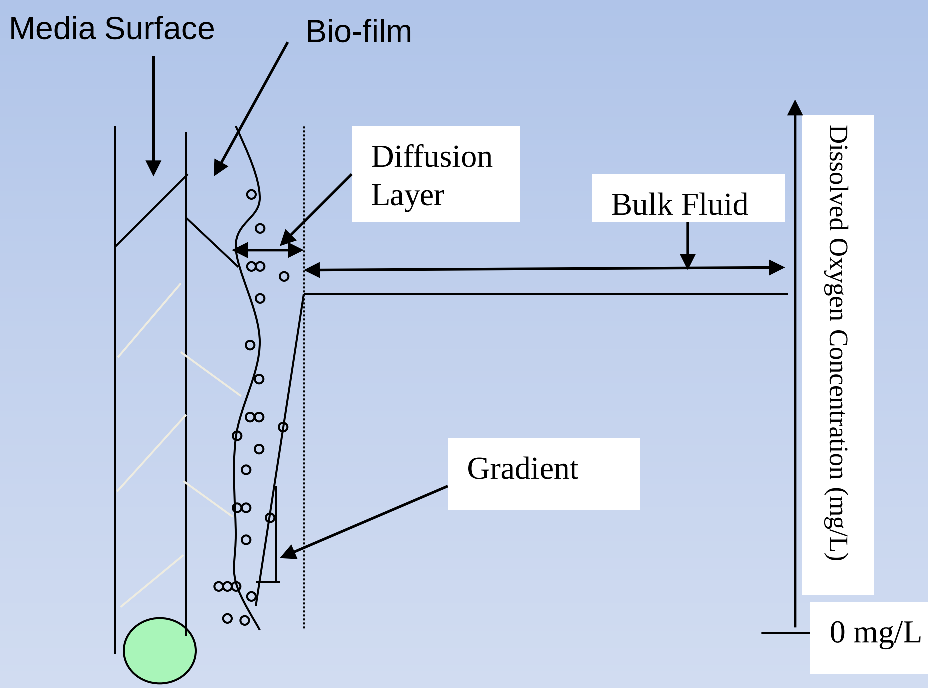
- Optimum temperature is 28^oC to 36^oC
  - Inhibited at less than 10 ^oC
  - No growth below 4 ^oC (Fixed film bacteria at 0 ^oC) and over 54 ^oC
- Optimum pH is between 8.3 and 9.3
  - Inhibited below pH 6.7
- Required dissolved oxygen (DO) is 4.6 mg/L per 1 mg/L NH^+_4 - N

$$NH_4^+ + 2O_2 \rightarrow NO_3^- + 2H^+ + H_2O + energy$$

Hypothetical Comparison of Diffusion Layers in Reactor A and B

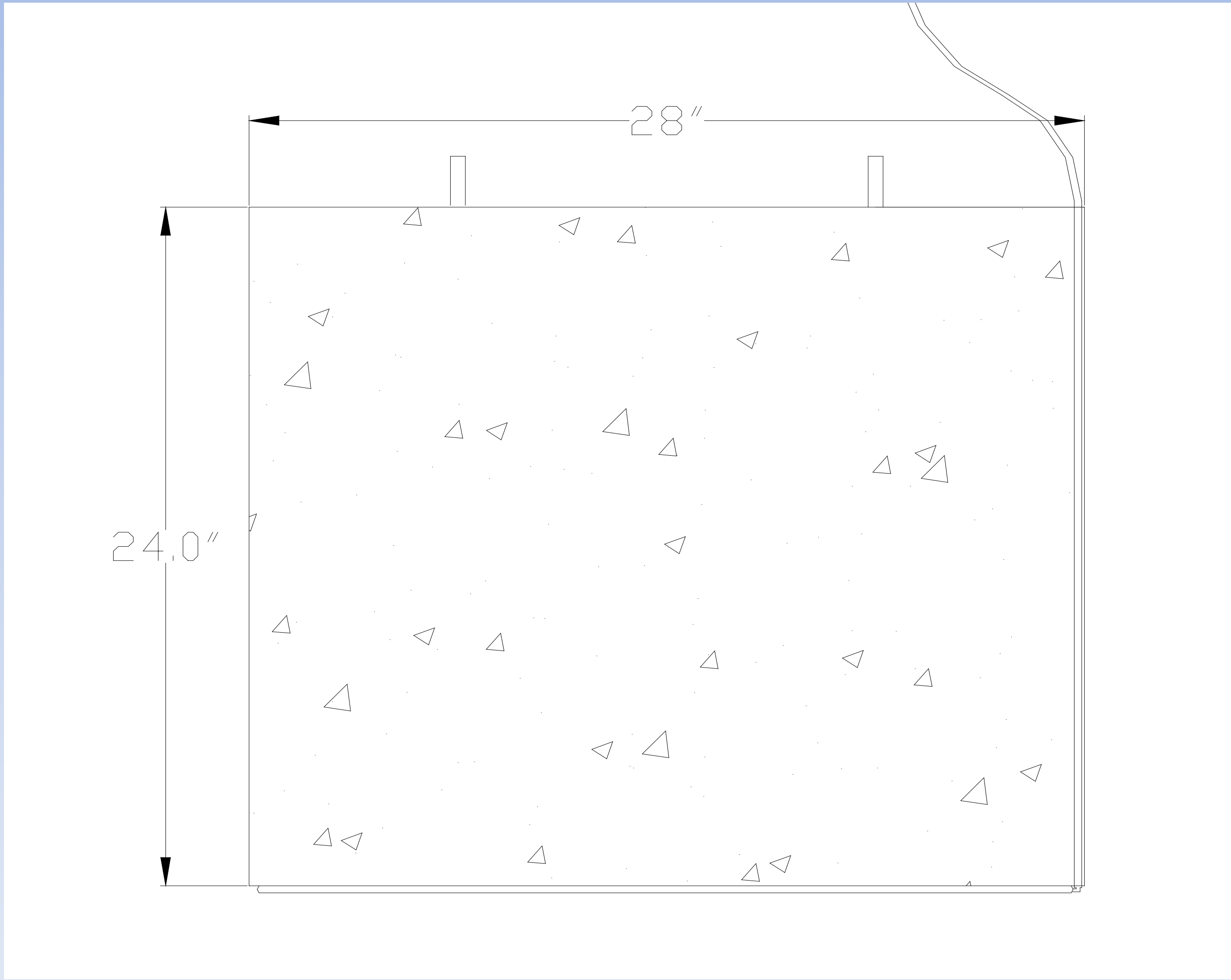


D.O Concentration of Gradient in Bio-Film in Tank B and B’

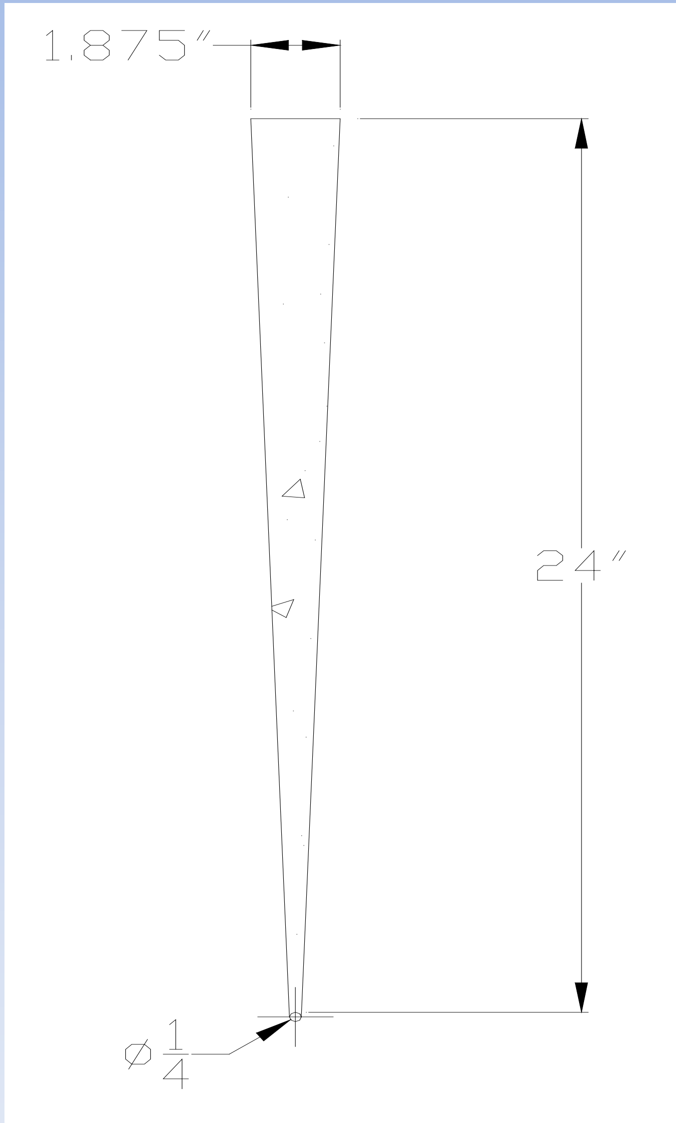


D.O. Concentration of Gradient in Bio-Film in Tank A and A’

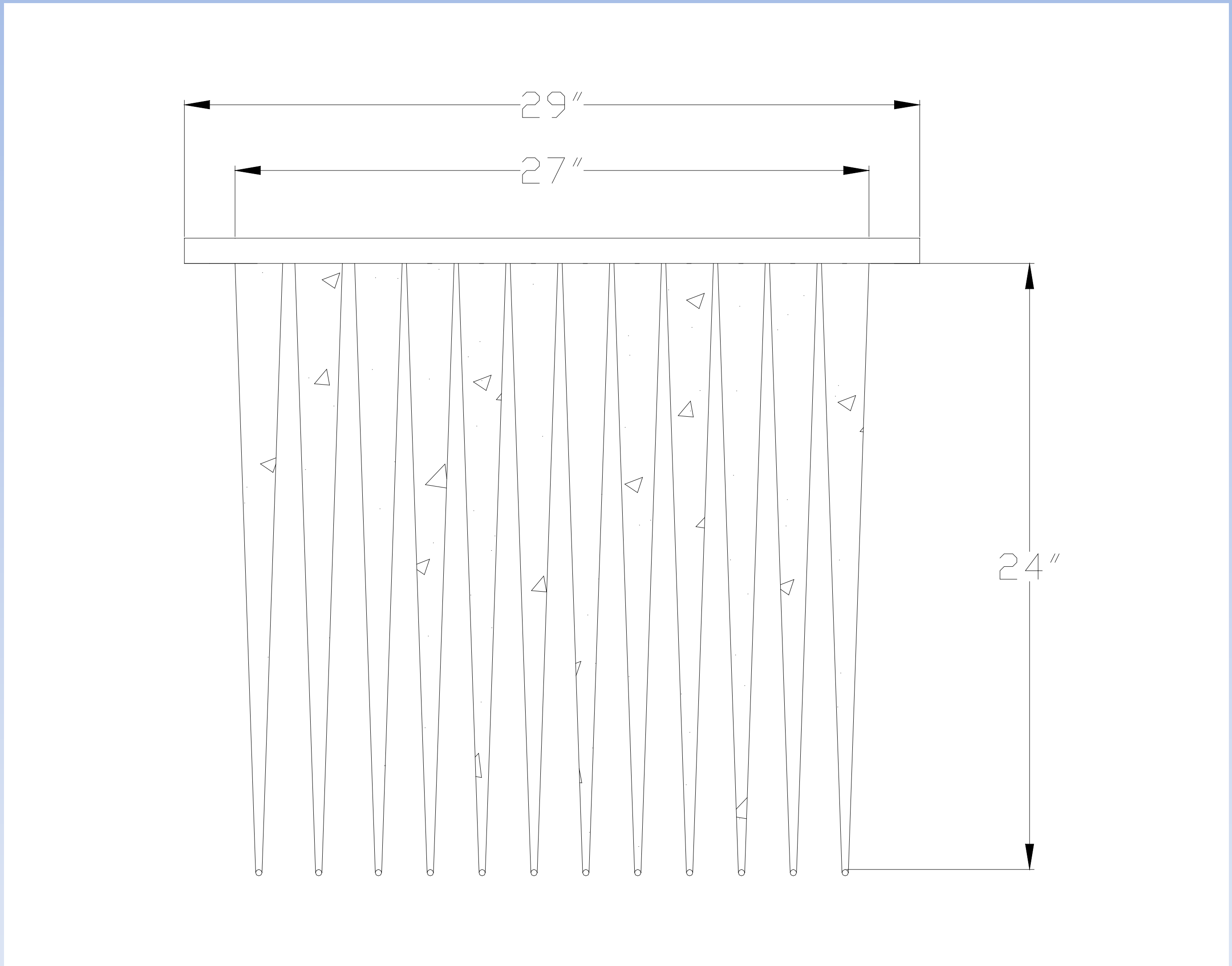
Side View of Panel



End View of Panel



End View of ASBF Module



Transfer for Modules

Install ASBF at CVWRF

Aeration System in ASBF

Cold Temperature Ammonia/Ammonium Removal

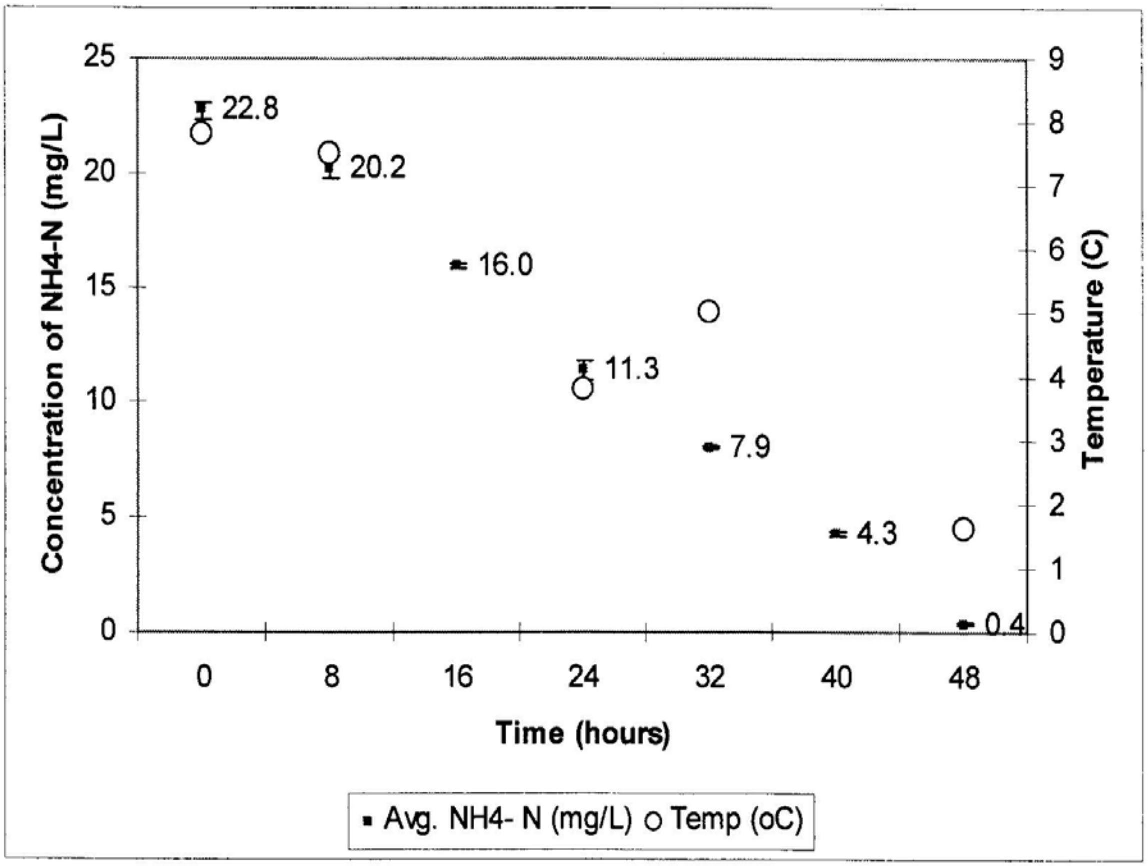
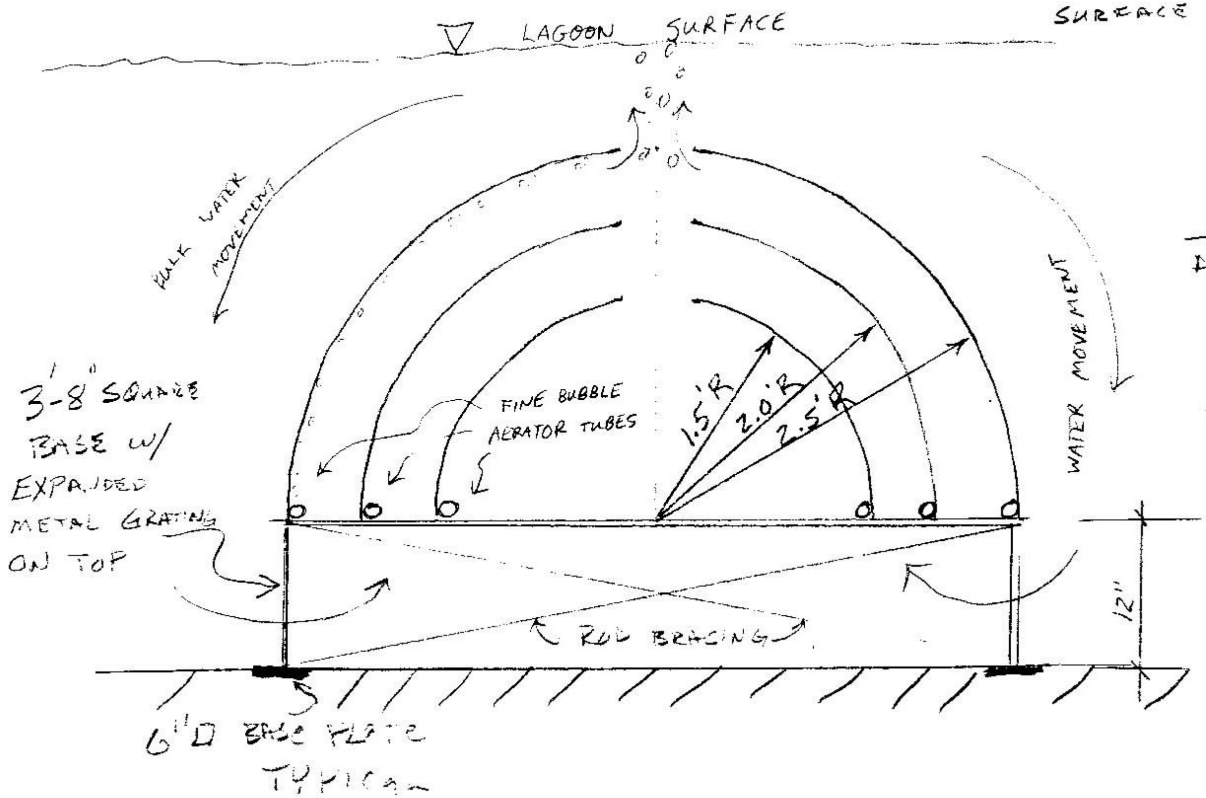


Figure 3.17 NH_4^+ - N Removal in ASBF Batch Run #11, Start Date 12/16/02, Average Water Temperature 5.1°C

CROSS - SECTION

NESTED FIBERGLASS POO-GLOOS

28 Jan 03
JWR



pg 6

SURFACE AREA = $2\pi R^2$

$2(2.5)^2\pi = 39.25$

$2(2.0)^2\pi = 25.12$

$2(1.5)^2\pi = 14.13$

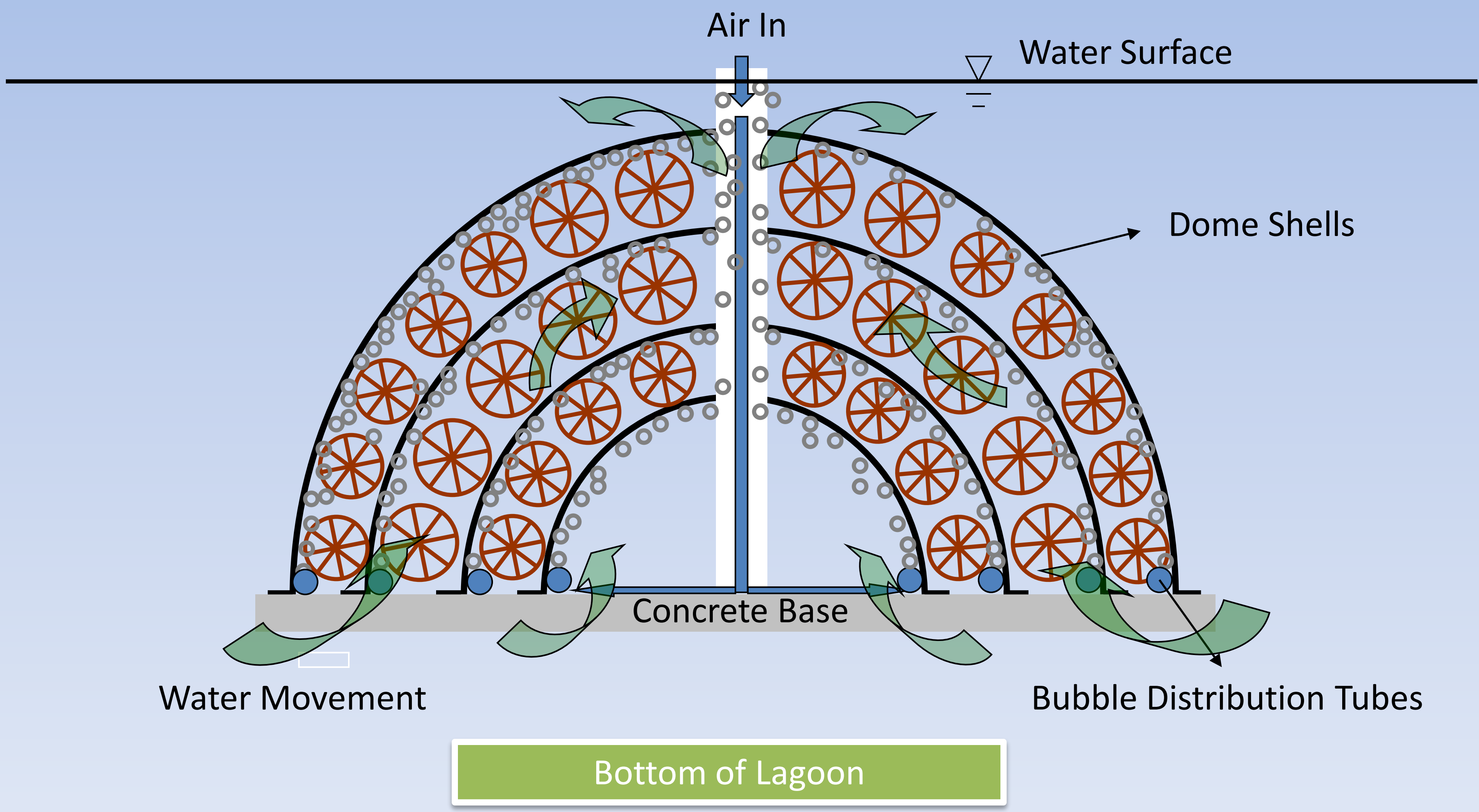
78.50 FT^2

ADDING INSIDE DOMES (2) DOUBLES THE SURFACE AREA

ONE MIGHT ADD ADDITIONAL INTERMEDIATE DOMES TO INCREASE CONTACT AREA

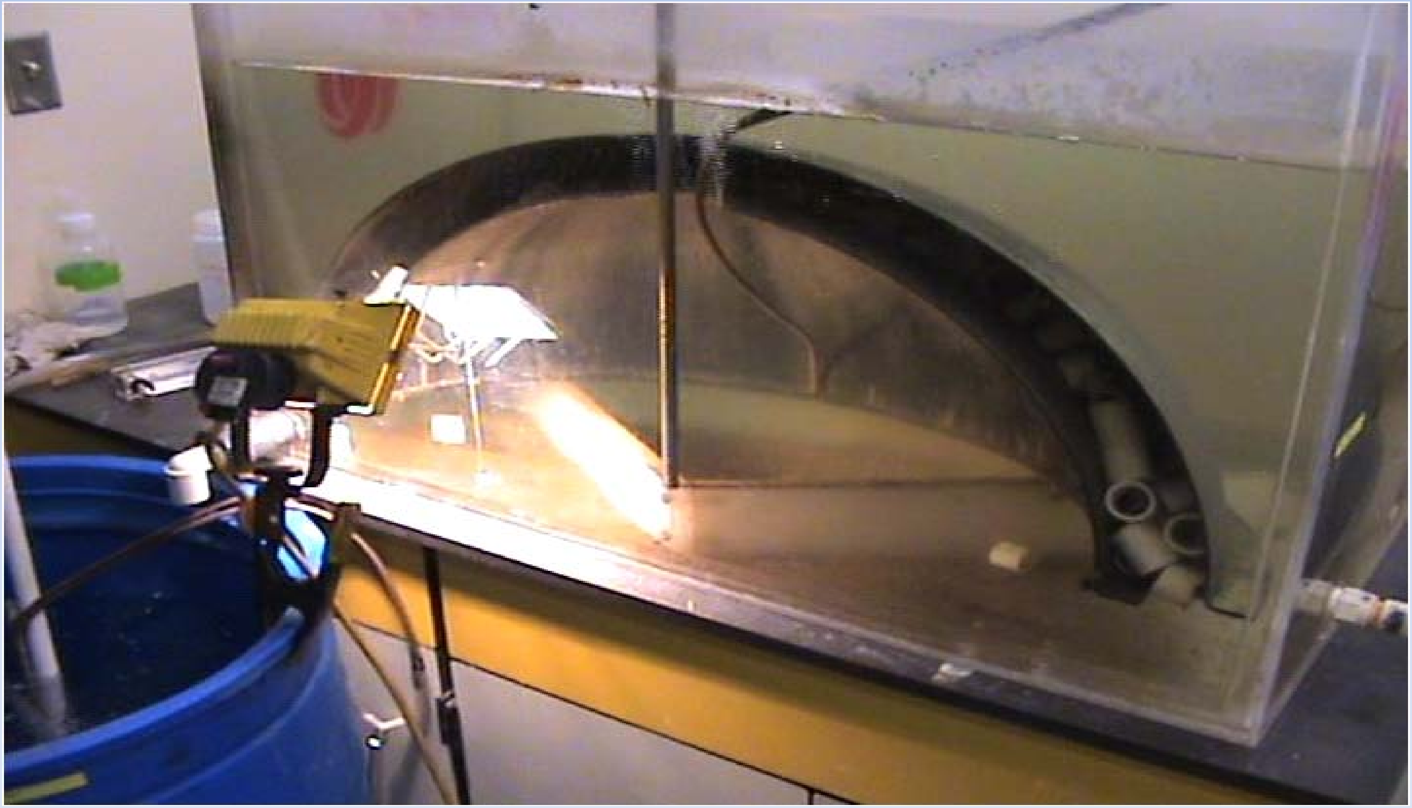
JWR

Diagram of Submergible Poo-Gloo™ Aeration Dome Set



Early Development

University of Utah proof-of-concept laboratory test chamber



Mature Bio-Film after 10 months

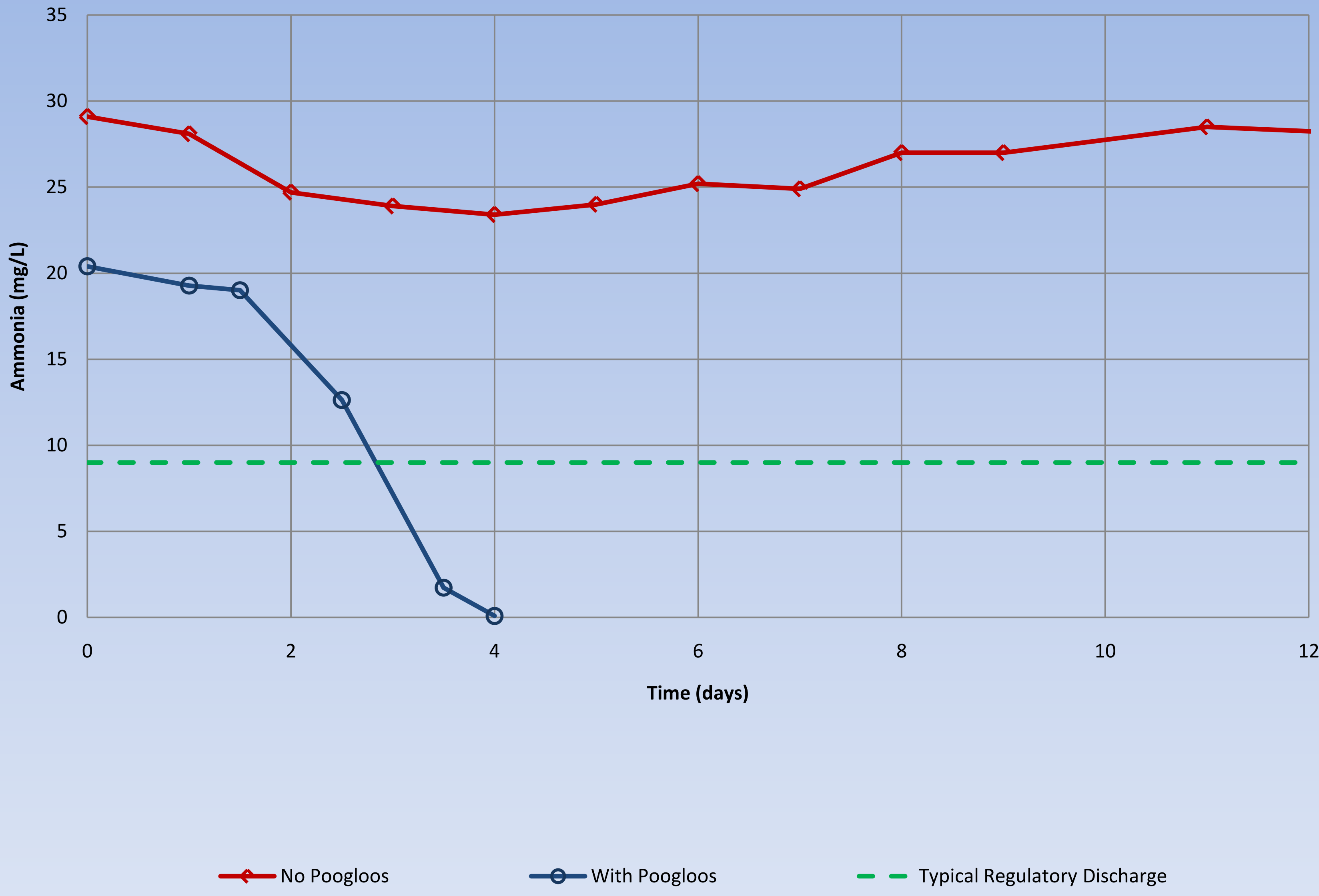
Bio-film inside the domes

Technology Application

Alpha scaled pilot tests 2004-09 Central Valley Treatment Plant

Alpha Tank in Operation

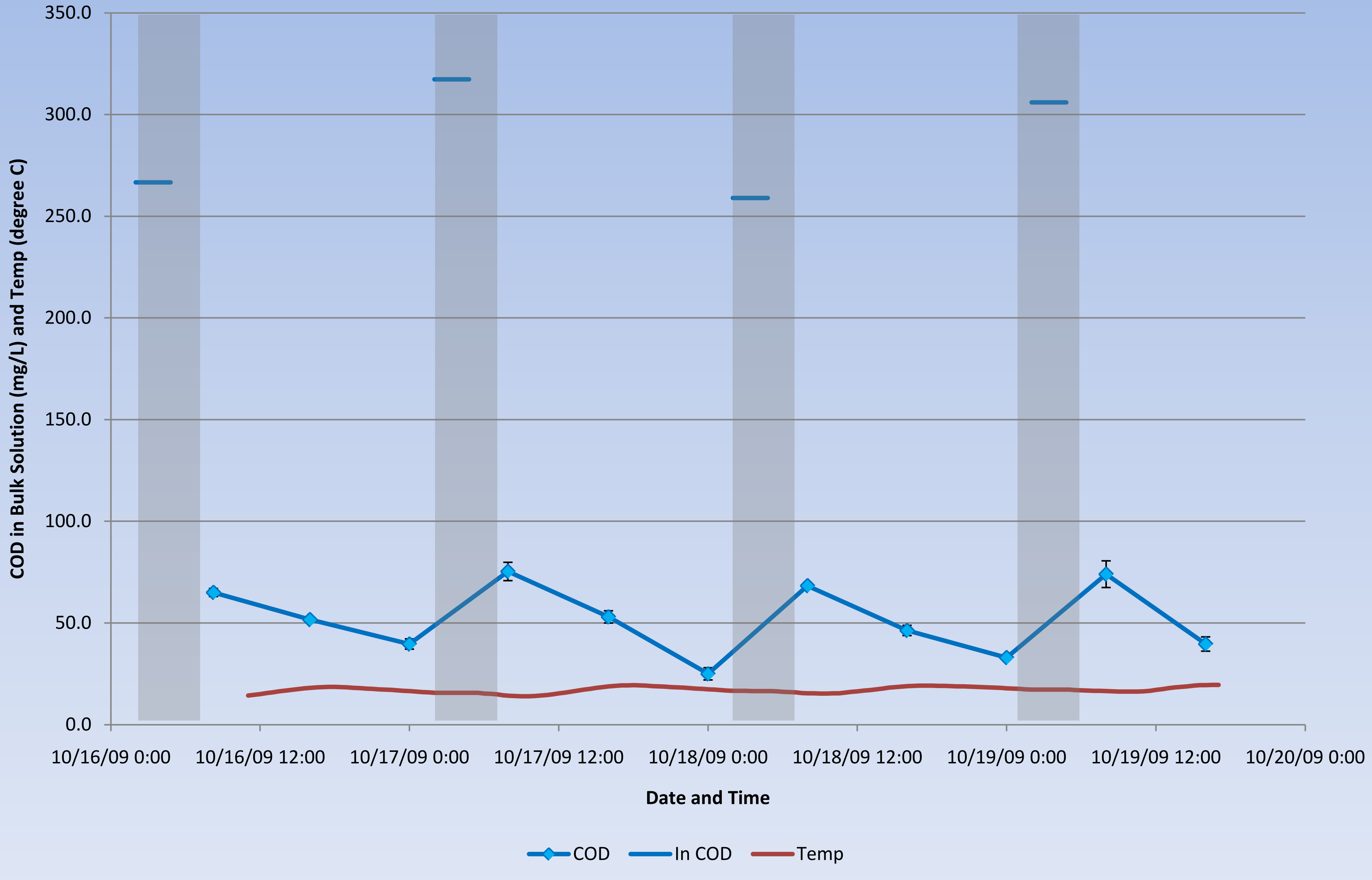
Robust Air-Water Flow out of PG



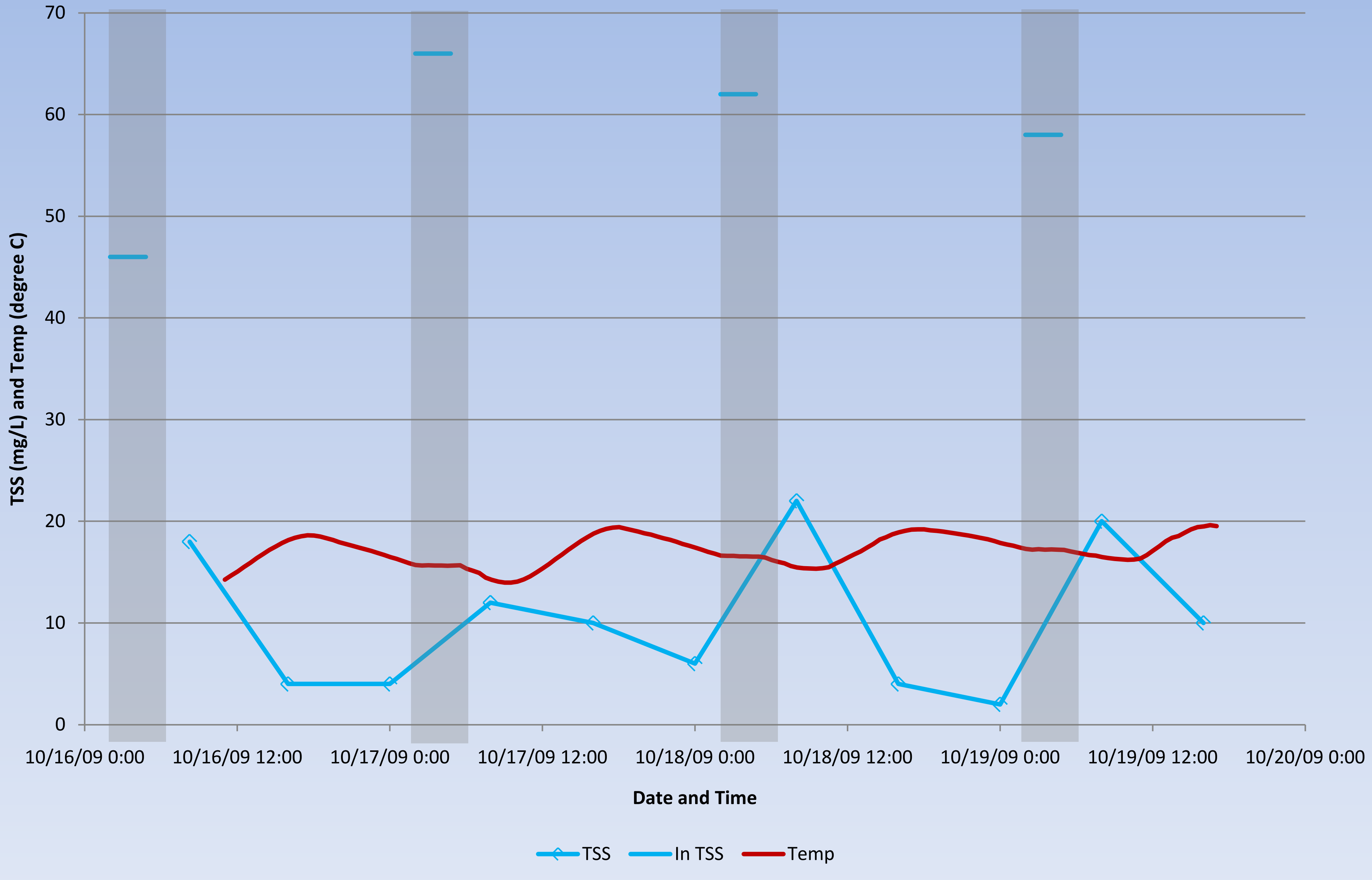
35
30
25
20
15
10
5
0
Ammonia (mg/L)
0
2
4
6
8
10
12
Time (days)
No Poogloos
With Poogloos
Typical Regulatory Discharge

Clarity of Water in Alpha Tank

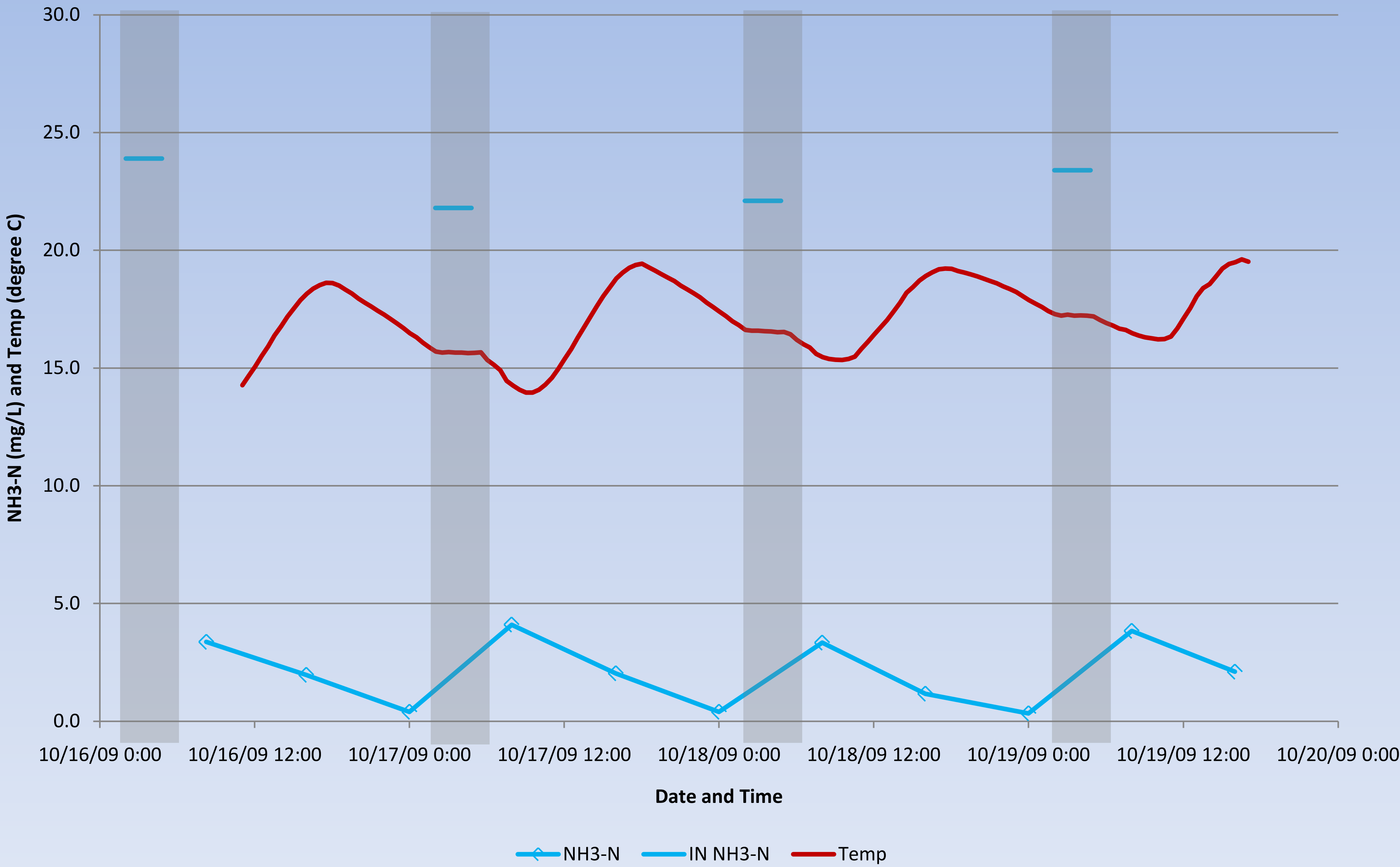
Removal of BOD (measured as COD)



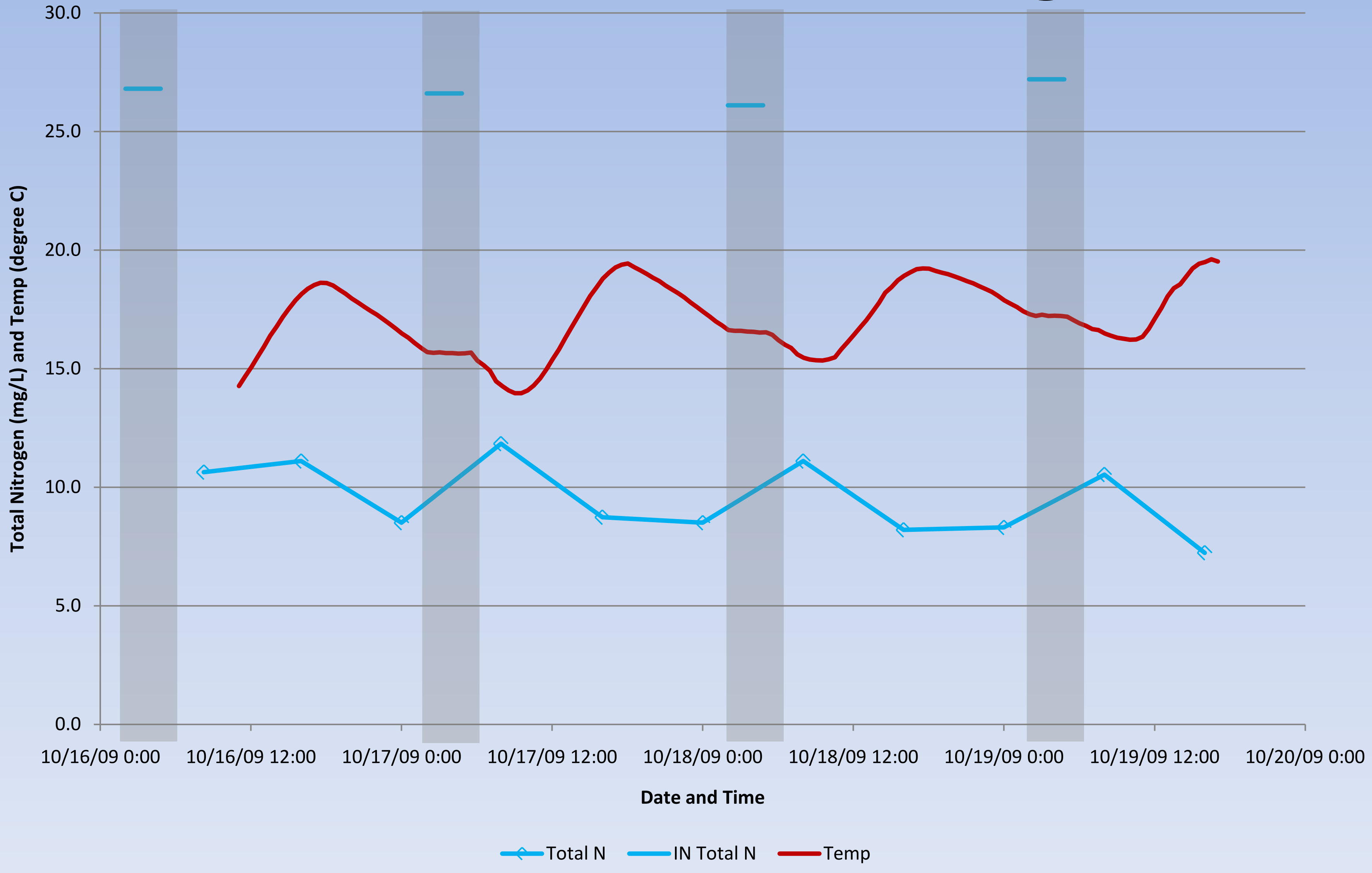
Removal of TSS

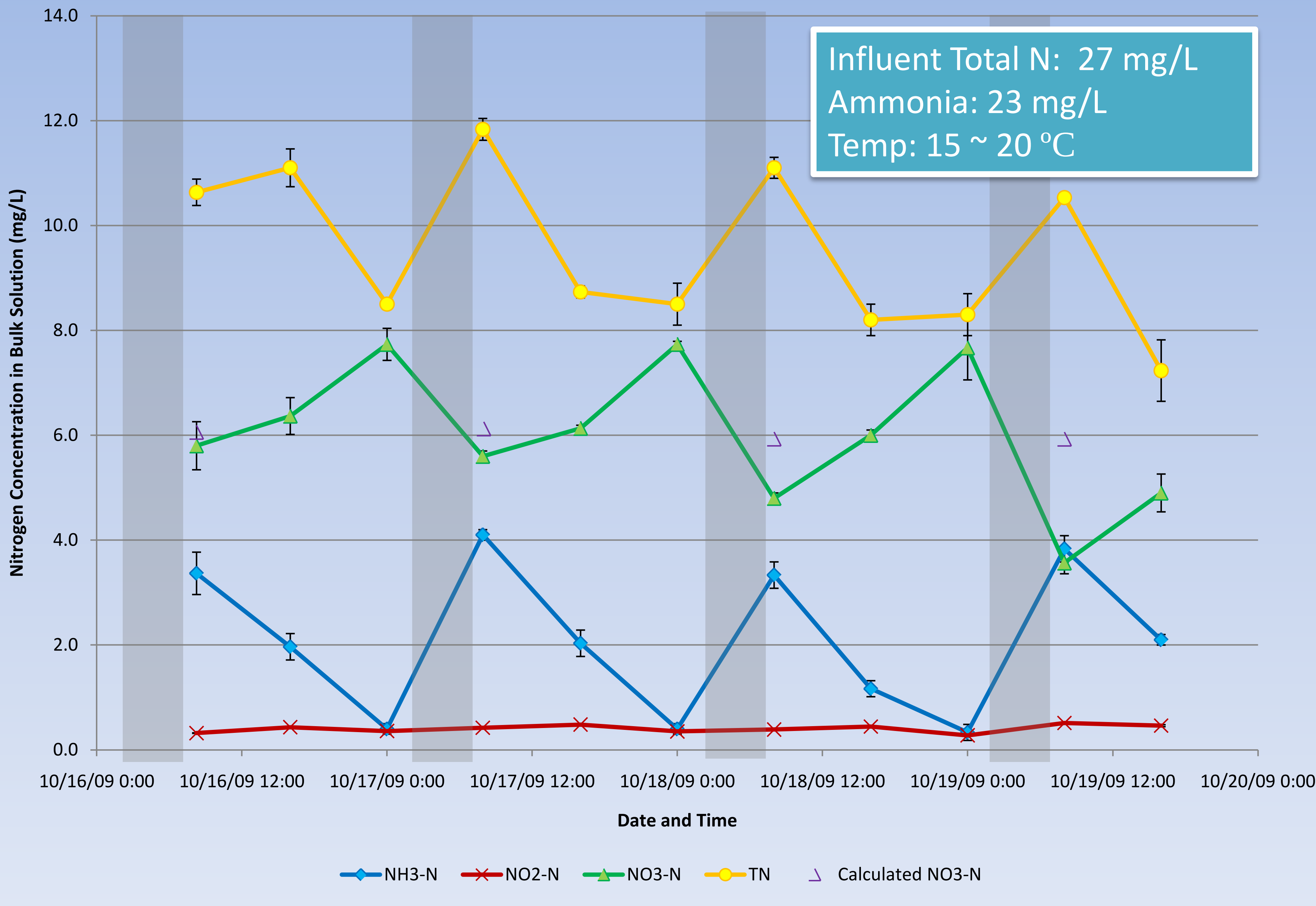


Removal of Ammonia



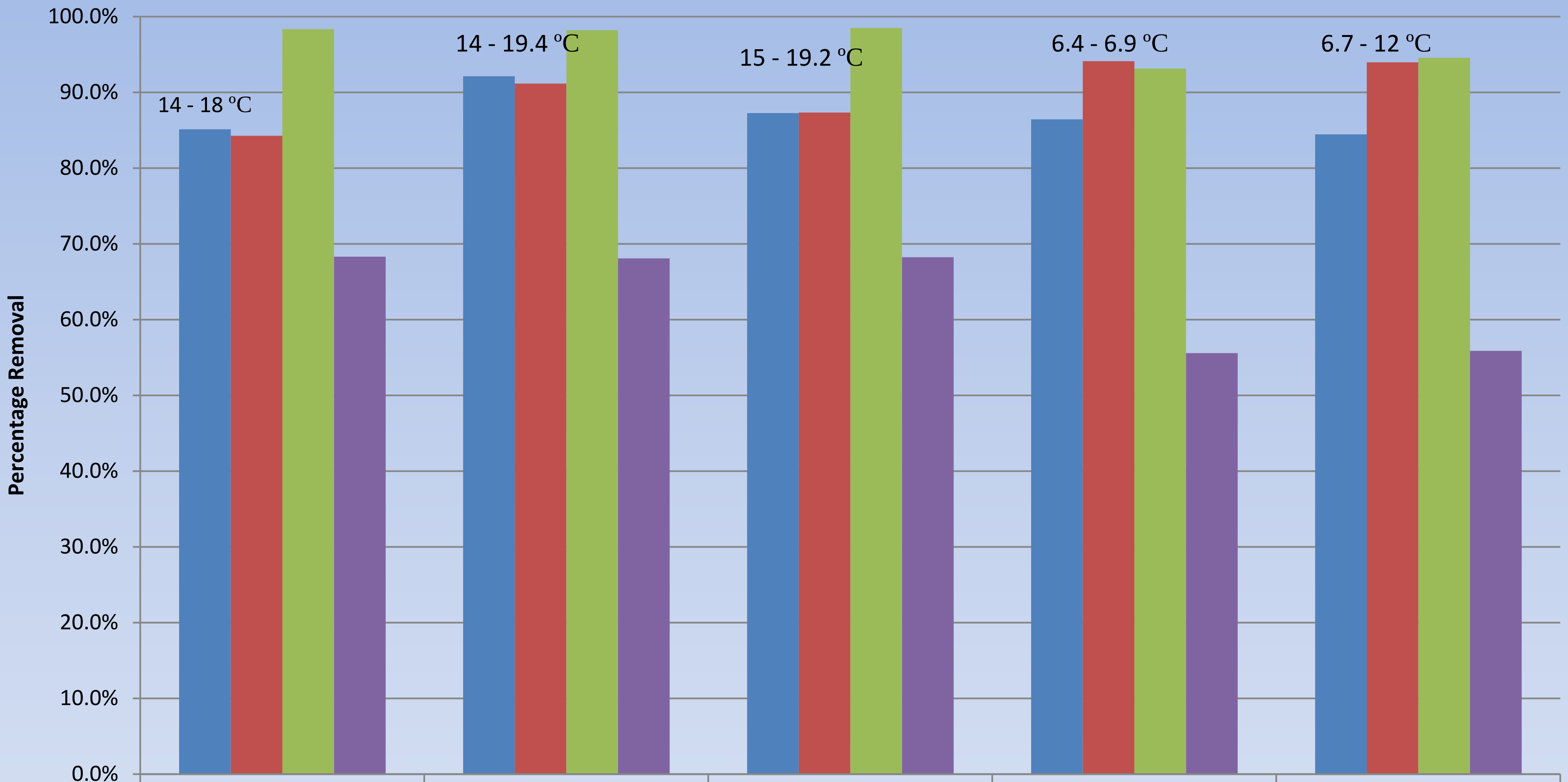
Removal of Total Nitrogen





Influent Total N: 27 mg/L
Ammonia: 23 mg/L
Temp: 15 ~ 20 °C
Nitrogen Concentration in Bulk Solution (mg/L)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
10/16/09 0:00
10/16/09 12:00
10/17/09 0:00
10/17/09 12:00
10/18/09 0:00
10/18/09 12:00
10/19/09 0:00
10/19/09 12:00
10/20/09 0:00
Date and Time
NH3-N
NO2-N
NO3-N
TN
Calculated NO3-N

Percentage Removal



	10/16/2009	10/17/2009	10/18/2009	10/30/2009	10/31/2009
COD	85.1%	92.1%	87.3%	86.4%	84.4%
TSS	84.3%	91.1%	87.3%	94.1%	93.9%
NH3-N	98.3%	98.2%	98.5%	93.1%	94.5%
Total N	68.3%	68.1%	68.2%	55.6%	55.9%

COD TSS NH3-N Total N

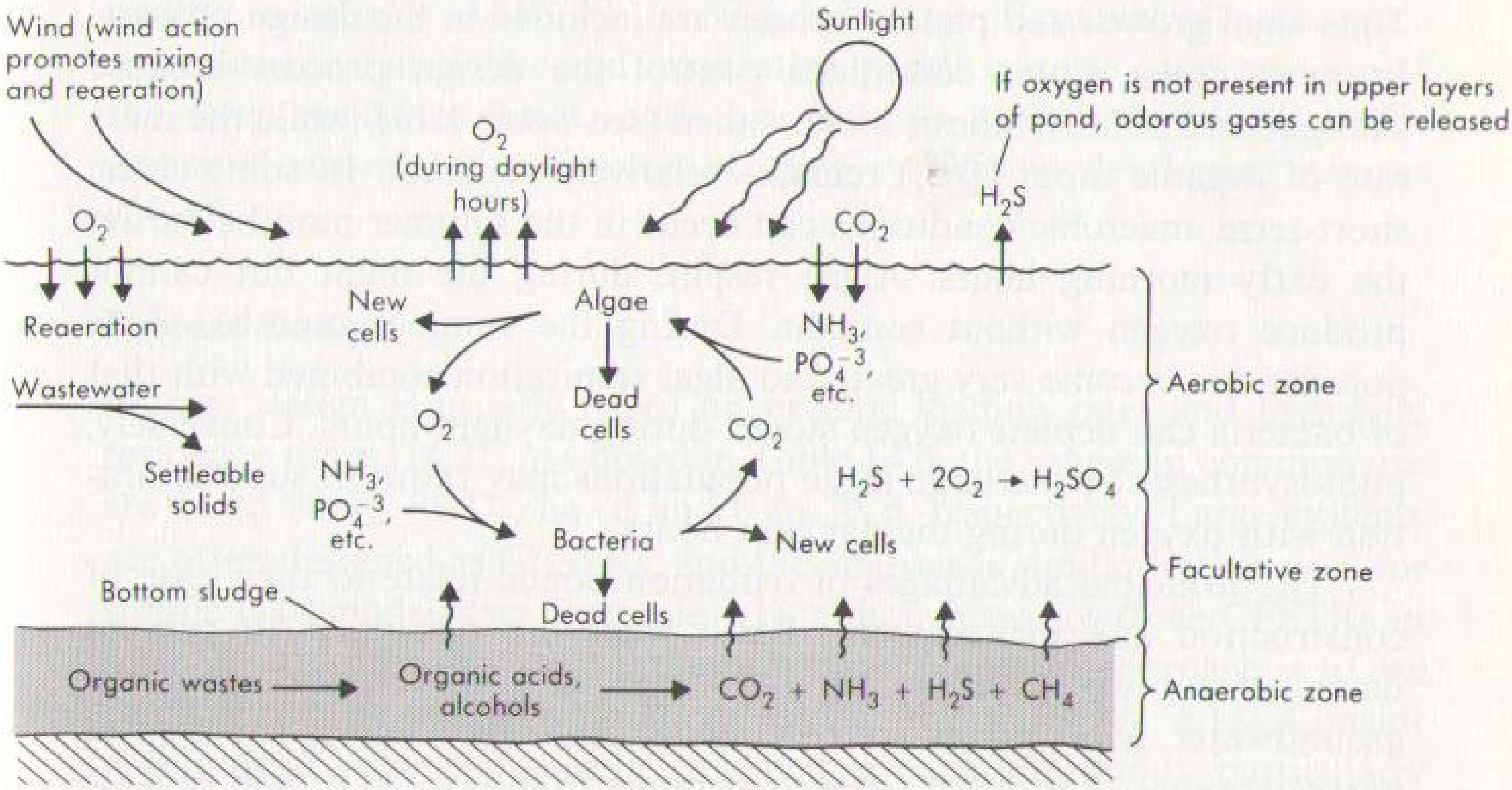

poo-gloo
• Patented Technology
• Developed at the University of Utah

Patented Technology

- Proven science – patented unique application
- Maximize aerated bio-film surface-to-volume area (100: 1)

Operation of Facultative Lagoon

(a)



(b)

Lagoon Remediation

Untreated Inflow

Facultative Lagoon System

Natural, bacterial remediation process & evaporation

+

poo-gloo

Each Poo-Gloo removes

BOD: 1.85 lbs/day @ $0.03*/lb
Ammonia: 0.42 lbs/day @ $0.15*/lb

Compliant Discharge or Ground Seep

* Electricity at $0.07 kW-hr

Table 9–8
Typical design information for rotating biological contactors

Parameter	Unit	Treatment level[a] BOD removal	BOD removal and nitrification	Separate nitrification
Hydraulic loading	$m^3/m^2 \cdot d$	0.08–0.16	0.03–0.08	0.04–0.10
Organic loading	g sBOD/$m^2 \cdot d$	4–10	2.5–8	0.5–1.0
	g BOD/$m^2 \cdot d$	8–20	[illegible]	[illegible]
Maximum 1st-stage organic loading	g sBOD/$m^2 \cdot d$	12–15		
	g BOD/$m^2 \cdot d$	24–30	24–30	
NH_3 loading	g N/$m^2 \cdot d$		0.75–1.5	
Hydraulic retention time	h	0.7–1.5	1.5–4	1.2–3
Effluent BOD	mg/L	15–30	[illegible]	[illegible]
Effluent NH_4-N	mg/L		<2	1–2

[a] Wastewater temperature above 13°C (55°F).

Note: g/$m^2 \cdot d$ × 0.204 = lb/10^3 $ft^2 \cdot d$.

Poo-Gloo: 3.2 g BOD/$m^2 \cdot d$

Poo-Gloo: 0.75 g N/$m^2 \cdot d$

Full Scale Pilot Plant at Jackpot, NV
Fall, 2009


09/29/2009

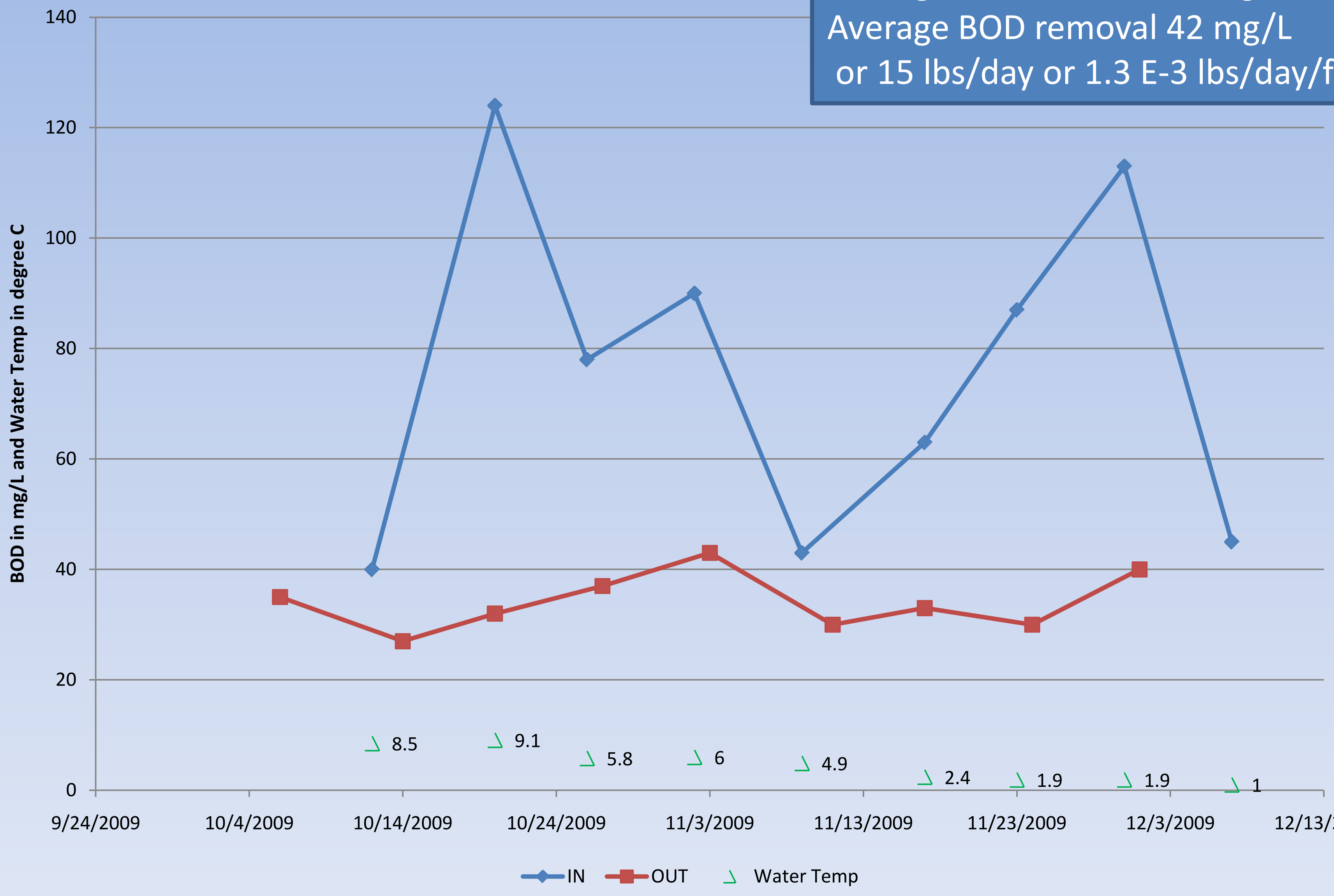

09/29/2009


09/29/2009


30
25
20
15
LPM AIR
10
5

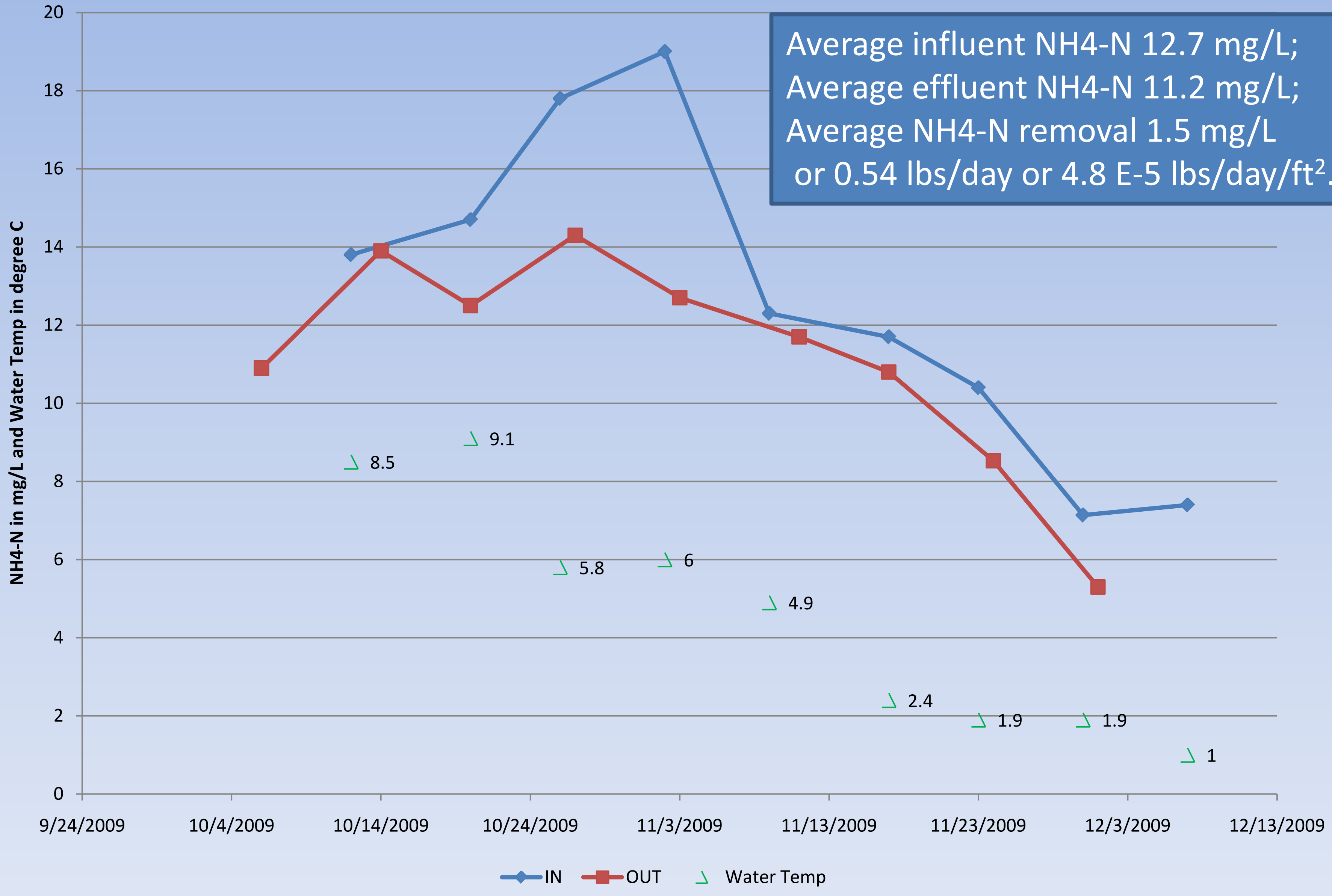
BOD

Average influent BOD 76 mg/L;
Average effluent BOD 34 mg/L;
Average BOD removal 42 mg/L
or 15 lbs/day or 1.3 E-3 lbs/day/ft^2.



NH4-N

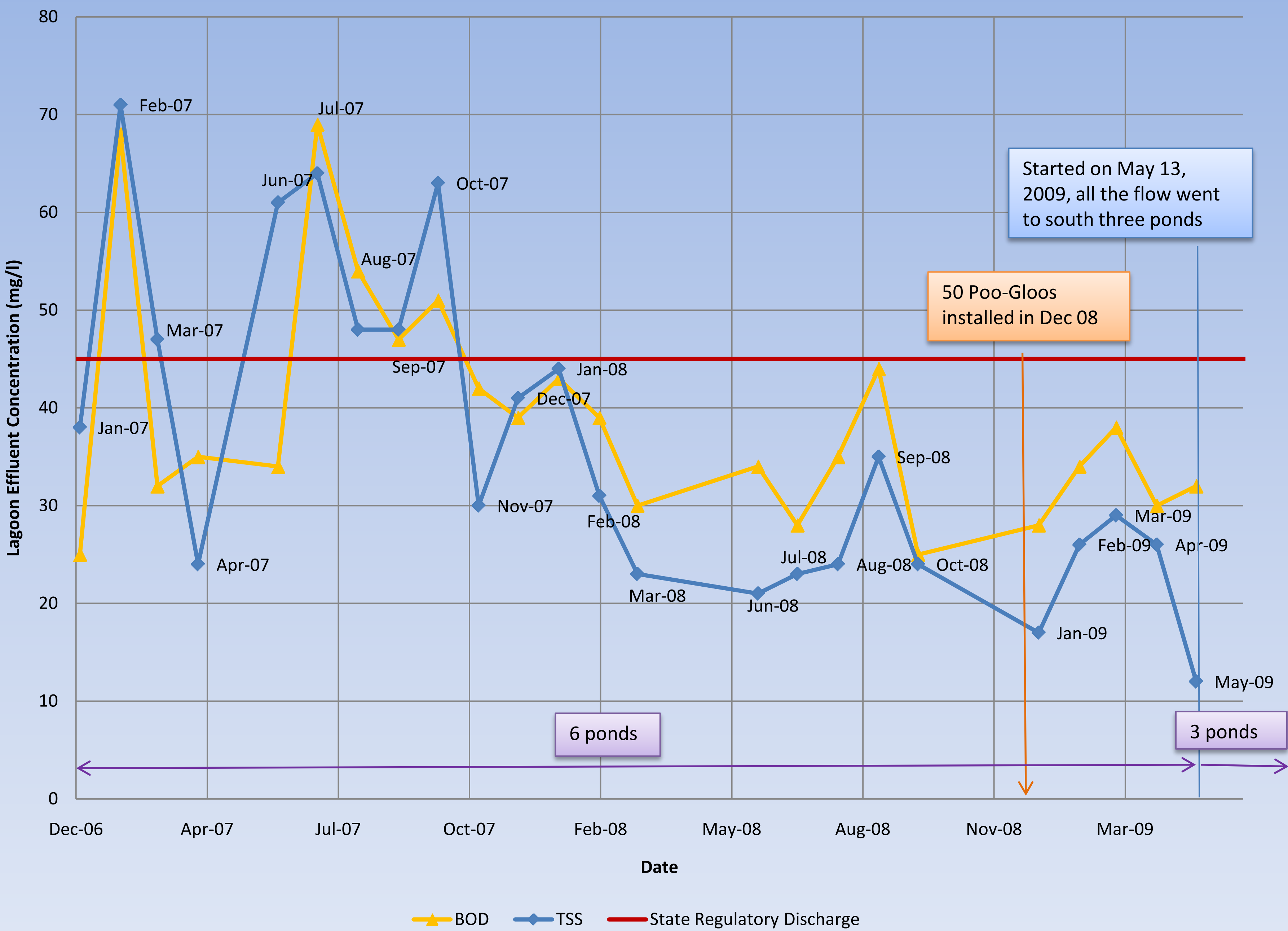
Average influent NH4-N 12.7 mg/L;
Average effluent NH4-N 11.2 mg/L;
Average NH4-N removal 1.5 mg/L
or 0.54 lbs/day or 4.8 E-5 lbs/day/ft^2.



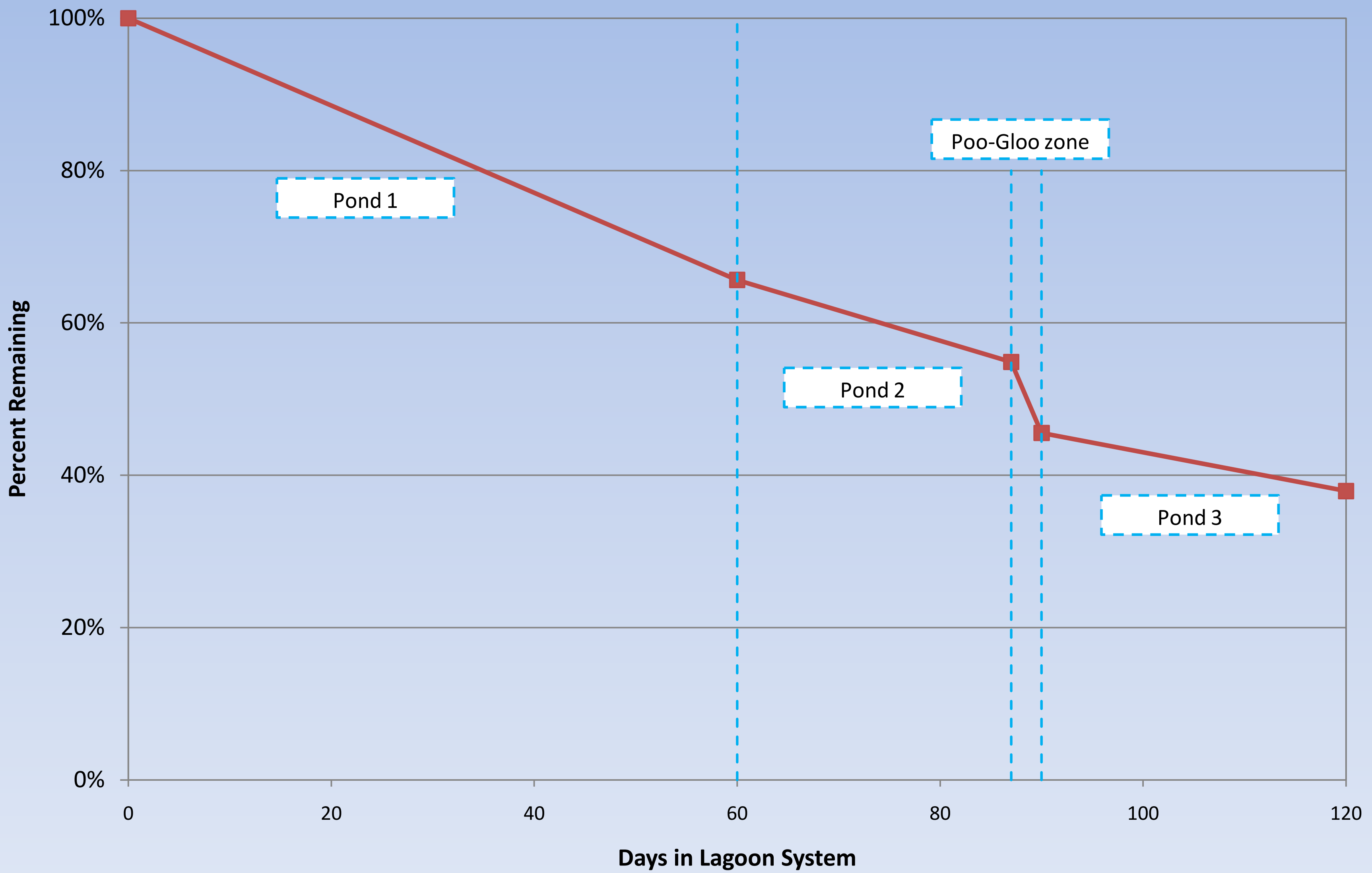
Plain City, UT Lagoon Layout

Plain City Installation

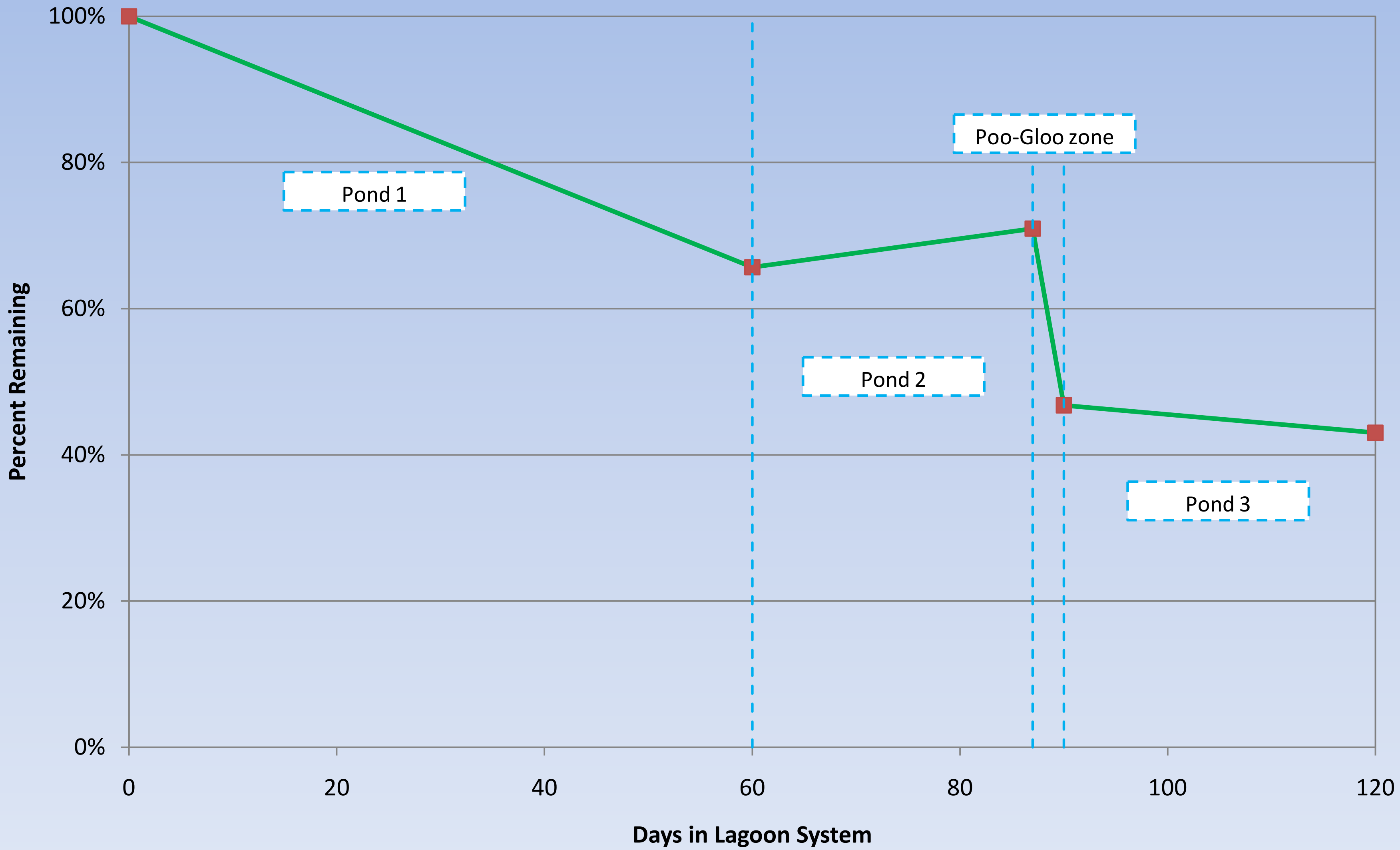
Plain City Video


Lagoon Effluent Concentration (mg/l)
80
70
60
50
40
30
20
10
0
Feb-07
Jul-07
Jun-07
Oct-07
Aug-07
Mar-07
Sep-07
Jan-08
Dec-07
Jan-07
Nov-07
Feb-08
Apr-07
Mar-08
Jun-08
Jul-08
Aug-08
Sep-08
Oct-08
Jan-09
Feb-09
Mar-09
Apr-09
May-09
Started on May 13, 2009, all the flow went to south three ponds
50 Poo-Gloos installed in Dec 08
6 ponds
3 ponds
Dec-06
Apr-07
Jul-07
Oct-07
Feb-08
May-08
Aug-08
Nov-08
Mar-09
Date
BOD
TSS
State Regulatory Discharge

COD in Plain City Lagoon System

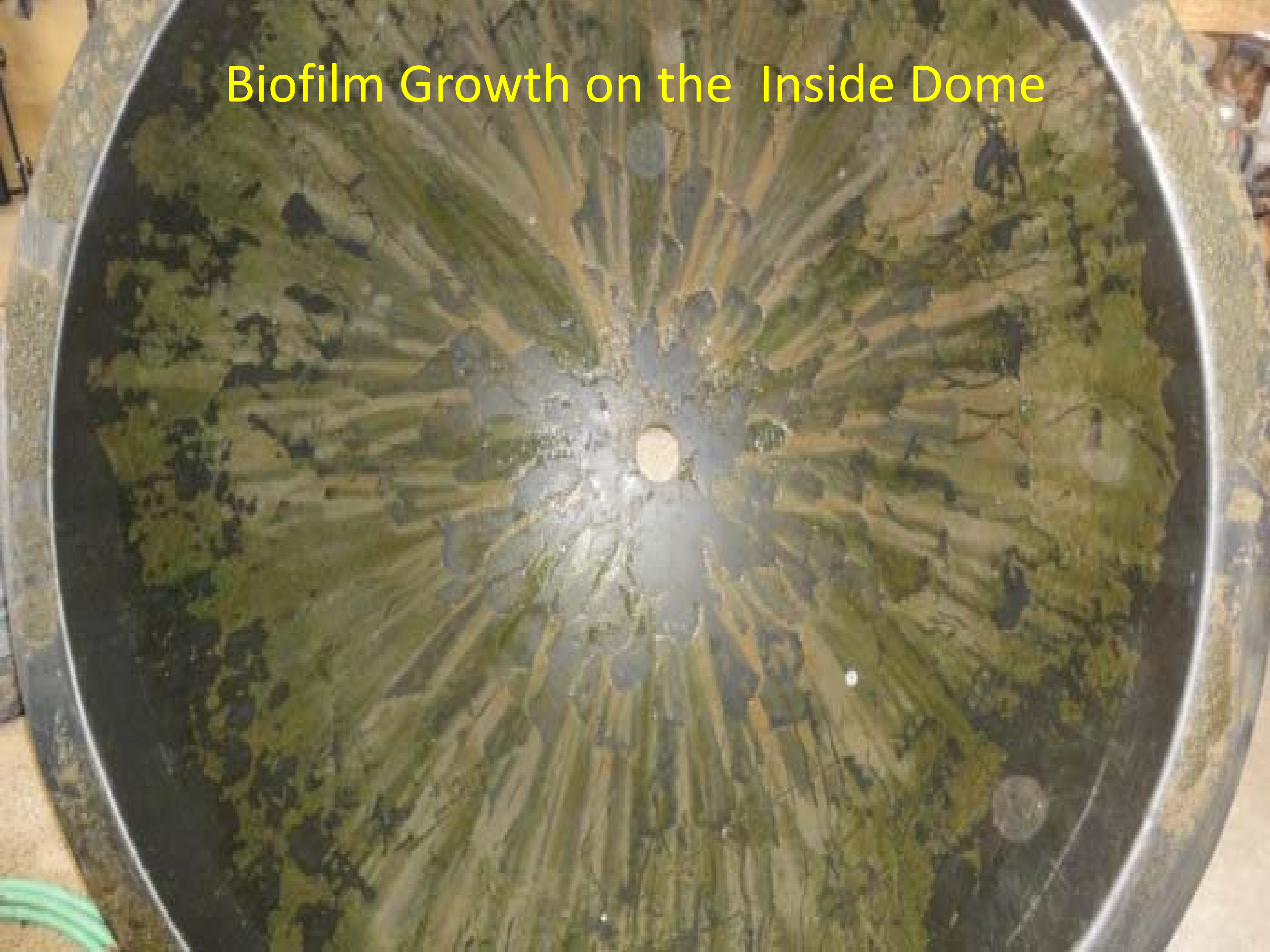


TSS in Plain City Lagoon System

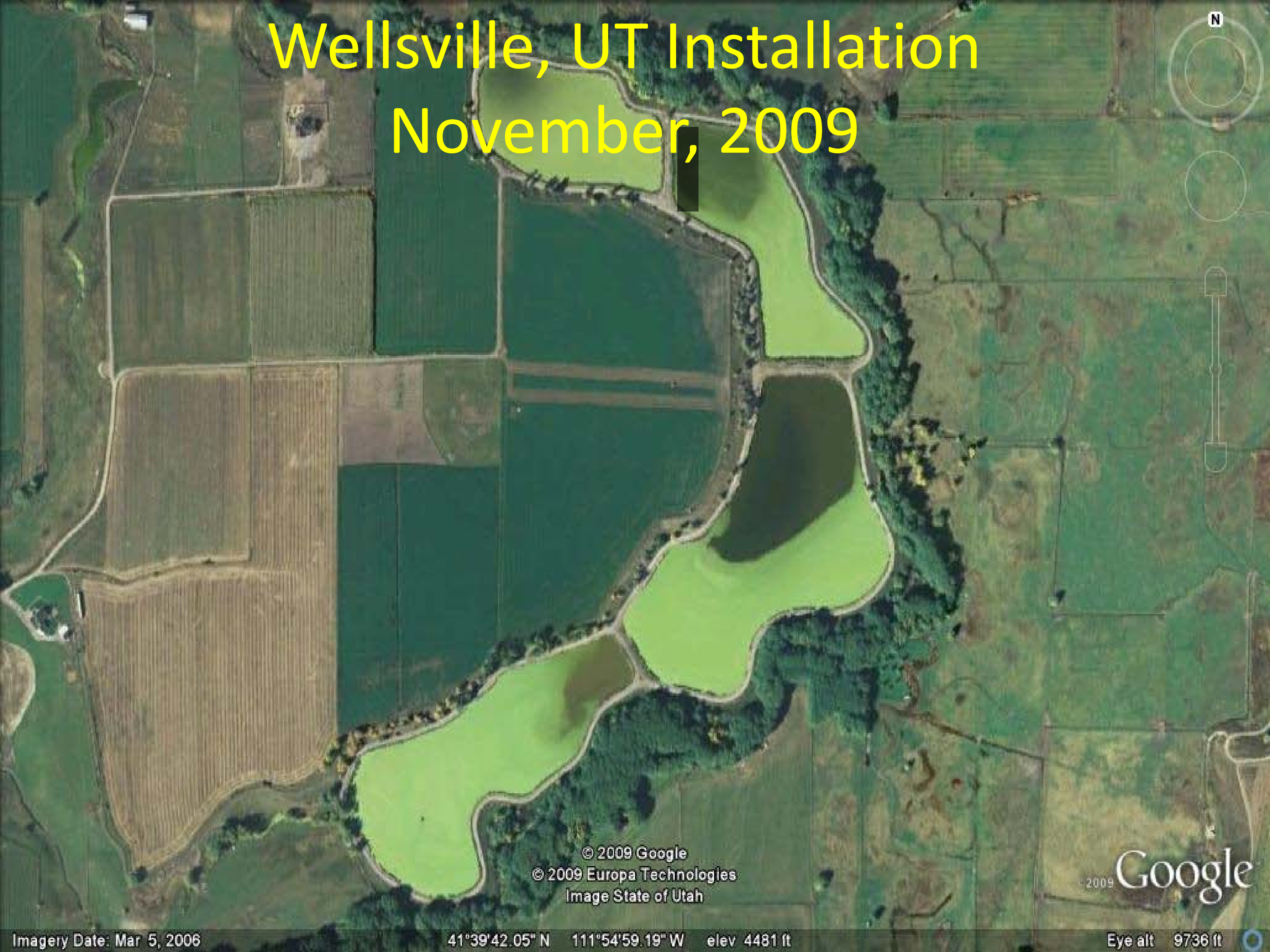


Oxygen Transfer Efficiency Calculation in 6' Water Depth

- Average COD removal in June: 30 mg/L
- 30 mg/L × 0.282 mgd × 8.34 $\frac{lbs/day}{(mg/L)\times mgd}$ = 71 lbs/day
- Air flow rate in each PG 10 L/min
- 50 PGs. 720,000 L air /d or 443.5 lbs O_2/day
- Efficiency = 71 /443.5 = 15.9 %


Biofilm Growth on the Inside Dome

Wellsville, UT Installation
November, 2009




Wellsville: Ice free operation

Wellsville Installation Video

Thank You!

poo-gloo